CESWD-ED-WR (CESWT-EC-HR/30 Oct 92) (1110-2-240b) 5th End
Mr. Escobar/md/(214) 767-2387
SUBJECT: Updated Water Control Manual for Pensacola Reservoir, Grand (Neosho) River, Oklahoma

CDR, Southwestern Division, U.S. Army Corps of Engineers, 1114 Commerce St., Dallas, Texas 75242-0216 18 NOV 1992

FOR Commander, Tulsa District, ATTN: CESWT-EC-HR

The revised water control manual for Pensacola Reservoir, Grand (Neosho) River, Oklahoma is approved.

FOR THE COMMANDER:

for Arthur F. Jones

ARTHUR D. DENYS, P.E.
Director, Directorate of Engineering

Encl (2 cys)
wd 1 cy

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
POST OFFICE BOX 61
TULSA, OKLAHOMA 74121-0061

REPLY TO
ATTENTION OF:

CESWT-EC-HR(CESWT-EC-HR/27 Jan 93) 4th Ed 30 October 1992

MEMORANDUM FOR Commander, Southwestern Division,
ATTN: CESWD-ED-WR

SUBJECT: Updated Water Control Manual for Pensacola Reservoir, Grand River, Oklahoma

1. Two copies of the subject revised water control manual (Encl 1) are submitted in accordance with ER 1110-2-240.

2. The letter of understanding and water control agreement (Exhibits B and C, respectively) are awaiting signature and may be inserted after being signed.

3. I recommend this water control manual be approved.

FOR THE COMMANDER:

Frank W. Parker

Encl

FRANK W. PARKER, P.E.
Chief, Engineering and
Construction Division

PENSACOLA RESERVOIR
GRAND (NEOSHO) RIVER, OKLAHOMA

WATER CONTROL MANUAL
APPENDIX E
PART I OF III
TO
WATER CONTROL MASTER MANUAL
ARKANSAS RIVER BASIN

AUGUST 1992

DEPARTMENT OF THE ARMY
TULSA DISTRICT, CORPS OF ENGINEERS
OKLAHOMA

PERTINENT DATA

LOCATION:
In Mayes, Delaware and Ottawa Counties, R.M. 77.0 on the Grand (Neosho) River, about 13 miles southeast of Vinita, Oklahoma.

DRAINAGE AREA: 10,298 sq. mi. above the dam
7,283 sq. mi. uncontrolled drainage area below John Redmond Dam
One inch of runoff = 549,227 ac-ft

DAM: Type: Concrete multiple arch
Length: 6565 (including spillways)
Max. height: 147 feet

SPILLWAY: Crest El: 730.0 Main spillways
740.0 East spillways
Length: 756 feet Main spillway
777 feet East spillways
Type: Gate controlled concrete overflow
Control: 21-36x25 gates, Main spillway
21-37x15 gates, East spillways

LAND ACQUISITION:

	GUIDE CONTOUR	AREA ACRES	AGENCY
Fee Simple	750.0	52,300	G.R.D.A.
Easement	757.0	12,016	C of E

OUTLET WORKS: None

POWER FEATURES: 6 - 16,000 kw generators

FEATURE	ELEV. FEET (1)	LAKE AREA (ACRES)	CAPACITY (AC-FT)	EQUIVALENT RUNOFF (INCHES)(2)	SPILLWAY CAPACITY (c.f.s.)
Top of Dam	757.0				
Max. des. water surface	755.0	59,200	2,197,000	4.00	525,000
Top of flood control pool	755.0	59,200	2,197,000	4.00	525,000
Flood control storage	745.0-755.0	-	525,000	0.96	
Top of power pool	745.0	46,500	1,672,000	3.04	188,000
Power storage	705.0-745.0	-	1,192,000	2.17	365,500
Dead storage	705.0	17,000	480,000	0.87	606,500

(1) All elevations are Pensacola datum utilized in H.D. 107. Add 1.07 feet to convert to Mean Sea Level (National Geodetic Vertical Datum).
(2) From 10,298 square miles of drainage area above the dam.

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be used in looseleaf 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.

EMERGENCY 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 Reservoir Control Section. Tulsa District Office (918/581-7666). If the above office cannot be contacted, assistance can be achieved by contacting, in the order listed, one of 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 powerhouse office and must be displayed on the bulletin board at all times.

EMERGENCY PERSONNEL ROSTER

TITLE AND NAME	TELEPHONE AND RESIDENCE
Coordinator (b) (6)	(b) (6)
Backup Coordinator (b) (6)	(b) (6)
Chief, Arkansas River Subsection (b) (6)	(b) (6)
Chief, Reservoir Control Section (b) (6)	(b) (6)
Chief, Hydrology-Hydraulics Branch (b) (6)	(b) (6)

PENSACOLA RESERVOIR

PENSACOLA RESERVOIR

PENSACOLA RESERVOIR
GRAND (NEOSHO) RIVER, OKLAHOMA

WATER CONTROL MANUAL
APPENDIX E
PART I OF III
TO
WATER CONTROL MASTER MANUAL
ARKANSAS RIVER BASIN

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PENSACOLA RESERVOIR

GRAND (NEOSHO) RIVER, OKLAHOMA

WATER CONTROL MANUAL
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ARKANSAS RIVER BASIN

I - INTRODUCTION

1-01. Authorization. This manual is submitted in accordance with ER 1110-2-240 and prepared in accordance with EM 1110-2-3600 and Guide for Preparing Water Control Manuals, SWD, March 1967, Revised October 1977.

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 lake during the life of the project.

1-03. Related manuals and reports. This manual is Appendix E, Part I of III, to the Arkansas River Basin Master Manual. Other related water control manuals in this District are:

Appendix E, Part II of III - Markham Ferry	(Future submittal)
Appendix E, Part III of III - Fort Gibson	(Future submittal)
Appendix G, Tenkiller	(July 1976)
Appendix J, Wister	(March 1974)
Appendix L, Oologah	(December 1975)
Appendix M, Keystone	(November 1989)
Appendix N, Eufaula	(September 1962)
Appendix O, Part I - Council Grove	(February 1973)
Appendix O, Part II - Marion	(July 1974)
Appendix O, Part IV - John Redmond	(September 1976)
Appendix T, Kaw	(December 1977)
GRDA Emergency Action Plan, Pensacola Dam	(Under Review)
Arkansas River Basin Water Control Master Manual	(July 1980)

The location of existing and authorized projects is shown on plate 1-1. Since Pensacola Dam was constructed by the Grand River Dam Authority, no design memorandums or master plan were prepared by the Corps of Engineers.

1-04. Project owner. Pensacola Reservoir is owned by the Grand River Dam Authority. The Grand River Dam Authority was created by an act of the Oklahoma Legislature (1935) to store and control the waters of the Grand River.

1-05. Operating agency. The Grand River Dam Authority is the operating agency for Pensacola Reservoir. The project is normally manned 8 hours per day, 5 days per week. If needed during flood emergencies, the project can be manned around the clock. The hydropower facilities are remotely operated from Markham Ferry Reservoir (Kerr Dam).

1-06. Regulating agencies. The Grand River Dam Authority is the regulatory agency for Pensacola Reservoir when the pool elevation is at 745.0 Pensacola Datum, top of power pool, or below. The Corps of Engineers, by authority of Section 7 of the Flood Control Act of 1944 (Public Law 78-534, 58 Stat. 890, 33 U.S.C. 709) is responsible for prescribing regulations for the use of the flood control storage in the lake between elevations 745.0 and 755.0 feet. Exhibit D contains the Section 7 Flood Control Regulation as extracted from the Code of Federal Regulations, Title 33, Chapter II (7-1-89 Edition).

II - DESCRIPTION OF PROJECT

2-01. Location. Pensacola Dam is located at mile 77.0 on the Grand (Neosho) River, approximately 13 miles southeast of Vinita, in Mayes County, Oklahoma. The project vicinity map is shown on plate 2-1.

2-02. Purpose. Pensacola Reservoir is a multiple-purpose project for flood control, generation of hydroelectric power, water supply, and allied water uses. Furthermore, it is a unit of the multiple-purpose system which provides flood control, power, navigation, water supply, water quality, recreation, fish and wildlife conservation and other beneficial water uses on the Arkansas River and its tributaries.

2-03. Physical components.

a. Dam. The dam consists of a concrete gravity non-overflow section 471 feet long and a concrete multiple arch non-overflow section 4,347 feet long with a maximum height of 147 feet. The top of the non-overflow section of the dam is 757.0 feet Pensacola datum, (add 1.07 feet to convert to mean sea level). A section of the dam is shown on plate 2-2.

b. Spillway. The main spillway, is a concrete gravity spillway with a gross width of 861 feet and a net overflow width of 756 feet. Flows over this spillway are controlled by 21 - 36'x25' tainter gates. There are two auxiliary concrete gravity spillway sections about one mile east of the left abutment of the dam. These auxiliary spillway sections have a net overflow width of 777 feet. Flows over these sections are controlled by 21 - 37'x15' tainter gates. The gates on the main spillway are operated by two traveling gate hoists and the gates on the auxiliary spillways are operated by one hoist for each of the two auxiliary spillways. Spillway sections are shown on plate 2-2.

c. Powerhouse. The powerhouse is located at the right abutment. It contains six 16,000-kilowatt generators. Plan, downstream elevation and section through the powerhouse and intake structures are shown on plate 2-2.

d. Outlet works. There are no multilevel outlets for water quality control. Supplemental pertinent data is shown in exhibit A.

2-04. Related control facilities. There are no related control facilities in the immediate vicinity of Pensacola Reservoir. Above the lake, at the town of Wyandotte, a flood control levee has been constructed.

2-05. Real estate acquisitions. The Grand River Dam Authority acquired the land for Pensacola Reservoir to elevation 750.00. A perpetual flowage easement was acquired on 12,016 acres of land between elevations 750.0 and 757.0 by the Federal Government in order to permit storage for flood waters to elevation 755.0. These elevations are Pensacola datum. Add 1.07 feet to convert to mean sea level.

2-06. Public facilities. The Federal Government does not provide recreational facilities for Pensacola Reservoir. Recreational facilities owned by the State of Oklahoma include Twin Bridges, Honey Creek, Cherokee, Bernice, and Little Blue recreation areas.

III - HISTORY OF PROJECT

3-01. Authorization. Pensacola Reservoir was authorized by the Flood Control Act approved 18 August 1941. Pensacola, Markham Ferry (Hudson) and Fort Gibson Lakes were incorporated in the Arkansas River multiple-purpose plan by the River and Harbor Act of 24 July 1946 (Project Document - H. D. 107, 76th Congress, 1st Session).

3-02. Planning and design. A report titled "Control of Floods in the Alluvial Valley of the Lower Mississippi River" was published as House Document No. 798, 71st Congress, 3rd Session. This report was a review of the projects included in the Flood Control Act approved by Congress, 15 May 1928, for flood control and navigation of the Mississippi River and its alluvial valley. It considered a system of lakes in the Arkansas River Basin, but was unfavorable for their construction. Additional survey reports and legislative action follow.

a. **"308" Report.** A report on the Grand (Neosho) River, Kansas, Oklahoma, Missouri and Arkansas, dated 19 June 1931, was included in the comprehensive report "Arkansas River and Tributaries" published in 1936 as House Document No. 308, 74th Congress, 1st Session. This report discussed flood control in the Grand (Neosho) River Basin, together with other benefits which would be derived from the controlled storage of flood water, by means of levees, flood-control lakes, channel rectifications, flood control and power lakes. The report stated that the water resources of the Grand (Neosho) River for the development of hydroelectric power could be utilized to the best advantage by the construction of a three-lake system in the lower reaches of the valley. The report further stated that development of power by the three-lake system was economically feasible, but in the absence of a ready power market, there could be no economic justification for its construction at that time. The report also considered operation of the system for the dual purpose of power development and flood control. The flood control and incidental benefits, which would accrue to the three-lake system, were not commensurate with the cost of the projects at the time. The report recommended that there be no participation by the United States in the control of floods in the Grand (Neosho) River watershed.

b. House Document No. 259. Pensacola, Markham Ferry (Hudson) and Fort Gibson Lakes were mentioned as part of a system of lakes considered in the "Comprehensive Report on Reservoirs in Mississippi River Basin," dated 15 December 1934, and published as House Document No. 259, 74th Congress, 1st Session. This report was unfavorable for construction and operation of the lake system entirely at Federal expense.

c. **Flood Control Committee Document No. 4**. This report entitled "Flood Control and Power Projects in the Arkansas Basin," dated 1935, was an economic report on the power possibilities of Pensacola Reservoir, and an analysis of the applicable power market. This report was favorable for the project.

d. **Preliminary Examination Report**. This report entitled "Preliminary Examination Report, Pensacola, Markham Ferry and Fort Gibson Reservoirs, Grand (Neosho) River, Oklahoma," dated 21 September 1937, indicated that the three-lake system offered possibilities of development for flood control; development of hydro-electric power; or development as a dual-purpose project. The report recommended that there be further investigations of the three-lake system.

e. **House Document No. 107**. A survey report on "Pensacola, Markham Ferry and Fort Gibson Reservoirs, on Grand (Neosho) River, Oklahoma," was published as House Document No. 107, 76th Congress, 1st Session. This report recommended that the three-lake system be constructed at Federal expense for the combined purpose of flood control and water power.

f. **Survey Report**. This report was authorized by the Flood Control Acts approved 22 June 1936 and 28 August 1937, and by a Resolution adopted 13 April 1938, by the Commission of Flood Control of the House of Representatives. This survey report on flood control, Grand (Neosho) River and tributaries, Oklahoma, Kansas, Missouri and Arkansas, was prepared by the Tulsa District office and forwarded to higher authority on 4 September 1941. The Division Office, Southwestern Division, Dallas, Texas, by first endorsement dated 24 January 1942, concurred, in general, with the recommendations of the District Office. In addition to other recommendations for the control of floods and the development of hydroelectric power in the Grand (Neosho) River valley, this report recommended that the plan for the Fort Gibson Lake, as reported in House Document No. 107, be revised to provide 906,000 acre-feet of flood control storage. This report pointed out that the construction and present operation of the Pensacola Reservoir were not in accordance with the plan recommended in House Document No. 107, and made the above-mentioned recommendations with the view of regaining for the three-lake system the flood control storage lost in the Pensacola Reservoir, as now operated.

3-03. Construction. A résumé of construction activities for Pensacola Reservoir is presented in Table 3-1.

TABLE 3-1

RÉSUMÉ OF CONSTRUCTION ACTIVITIES

ACTIVITY	DATE
Construction began	July 1938
Date of Closure	March 20, 1940
Final Storage began	March 21, 1940
Power pool filled	April 19, 1941

3-04. Operation. The Pensacola Reservoir was placed in operation under the provision of Federal Power Commission License No. 1494, dated 26 July 1939, which specified that the top of the power pool be at elevation 745.0 and that the flood control pool be above that elevation. The dam was constructed to provide for the storage of water to elevation 755.0; however, the Grand River Dam Authority was not required to purchase lake lands above elevation 750.0, and consequently the initial development only provided for flood control storage between elevations 745.0 and 750.0. The operating control of the Pensacola project was transferred from the Grand River Dam Authority to the Federal Works Agency by Executive Order 8944, dated 19 November 1941. The War Department in December 1941 initiated the acquisition of necessary lands to permit storage of floodwaters in Pensacola Reservoir to elevation 755.0. In compliance with the President's directive dated 19 February 1943, the acquisition of these additional lands for the Pensacola Reservoir was transferred to the Federal Works Agency. The operating control of the project, including additional land acquisition, was transferred from the Federal Works Agency to the Department of the Interior by Executive Order 9366, dated 30 July 1943. Public Law 573, 79th Congress, 2nd Session, approved 31 July 1946, returned the operating control of Pensacola Reservoir to the Grand River Dam Authority effective 1 September 1946. Under the terms of the Flood Control Act of 1944 the regulation of flood control storage in the lake is a responsibility of the War Department (now Department of Defense). Design and construction of the project was accomplished by the Grand River Dam Authority.

3-05. Related projects. The Pensacola Reservoir is an integral unit of the multiple-purpose plan for flood control, generation of hydroelectric power, navigation, and other beneficial water uses on the Arkansas River and its tributaries in Kansas, Oklahoma, and Arkansas. Pensacola Reservoir, together with Markham Ferry Reservoir and Fort Gibson Lake on the Grand

(Neosho) River, Oologah on the Verdigris River, Copan and Hulah on the Caney River, Keystone and Kaw on the Arkansas River, Tenkiller on the Illinois River, Eufaula on the Canadian River, and Wister on the Poteau River, directly impact flows through the navigation system. Other related projects in the regulation of Pensacola Reservoir are Marion Lake on the Cottonwood River and Council Grove and John Redmond Lakes on the Grand (Neosho) River.

3-06. Modifications to regulations. The regulation of Pensacola Reservoir has been modified to coincide with the present Arkansas River System Operating Plan as discussed in the Arkansas River Basin Water Control Master Manual.

3-07. Principal regulation problems. The government purchased flowage easements in most of the flood control pool at Pensacola between elevation 750-757; nevertheless, many homes, cabins, boat docks, elaborately landscaped yards, roads and other improvements have been built in the flood control pool. Some of the lower access roads start flooding at elevation 749.0. Some basements start flooding at elevation 752. It is probable that most of the improvements have been built since the date of purchase of the flowage easements. When significant runoff occurs above the three lake system, Pensacola, Hudson, and Fort Gibson Lakes should be operated for balanced flood control storage utilized, keeping within normal regulation techniques and approved procedures.

IV - WATERSHED CHARACTERISTICS

4-01. General characteristics. The Grand (Neosho) River, know as the Neosho River above the mouth of Spring River (mile 130.6), is approximately 480 miles long and has its source in the Flint Hill region of east central Kansas, near Parkerville. From its source, the stream flows in a southeasterly direction to the Kansas-Oklahoma state line near Commerce, Oklahoma; thence in a southerly direction to its confluence with the Arkansas River near Muskogee, Oklahoma at mile 459.5 (navigation mile 394). The total drainage area is 12,520 square miles of which 10,298 square miles are above Pensacola Dam (mile 77.0). Contributing drainage area between Pensacola Dam and John Redmond Dam is 7,283 square miles. The basin falls from an elevation of about 1,450 feet in the headwater area to 480 feet at the mouth. The valley slope is approximately 4.5 feet per mile in the reach from the source to the mouth of the Cottonwood River (mile 382.8). From this point to Commerce, Oklahoma (mile 153.4), near the headwater of Pensacola Reservoir, the fall averages about 1.3 feet per mile. Below this point the slope increases to about 1.7 feet per mile. The watershed is roughly rectangular in shape, averaging about 18 miles wide and 60 miles long above John Redmond Dam and 25 miles wide and 90 miles long between John Redmond Dam and the Kansas-Oklahoma state line. The Grand (Neosho) River valley flood plain has a width of approximately 1 mile from the source to the vicinity of Emporia, Kansas (mile 398.0). At that point, the valley widens to 3 or 4 miles, then narrows again to about 1 mile at Burlington, Kansas (mile 399.0). From Burlington to the vicinity of the Oklahoma-Kansas state line, the valley varies from 1 to 4 miles in width. The river channel varies in width from 50 feet in the upper reaches to about 700 feet in the lower reaches. The banks are generally stable and vary in height from 15 to 30 feet, and usually support a growth of timber and brush along the low water line. The streambed is composed largely of gravel and boulders and is generally stable. The principal tributaries are Spring, Cottonwood and Elk Rivers and Rock, Allen, Big, Deer, Owl, Lighting, Labette, Cherry, Flat Rock, Big Cabin, Spavinaw, Pryor, Spring and Fourteen Mile Creeks. Spring River, the largest tributary of the Grand (Neosho) River, rises near Aurora, Missouri, and flows in a southwesterly direction, joining the main stem at river mile 130.6, near Wyandotte, Oklahoma. The watershed is about 60 miles in length, averages about 45 miles in width, and drains an area of about 2,581 square miles. Cottonwood River, the second largest tributary, rises in east-central Kansas, near Marion and flows in a easterly direction to its confluence with the Grand (Neosho) River. The watershed is about 70 miles long, averaging about 26 miles in width, and drains an area of approximately 1,908 square miles. The third largest tributary of the Grand (Neosho) River is the Elk River, known locally as Cowskin Creek. Its source is

near Seligman, Missouri, flows in a westerly direction and joins the main stem at river mile 113.6, near Grove, Oklahoma. The watershed is about 48 miles long, averages 21 miles in width and drains an area of about 1,033 square miles. See table 4-1.

4-02. Topography. The flood plain of the Grand (Neosho) River above Pensacola Dam and below John Redmond Dam varies in width from 1 to 4 miles. Beyond the valley floor the terrain varies from gently rolling to rough, hill country. Spring and Elk Rivers, however, have their source in the rugged terrain of the Boston Mountains of the Ozark uplift and flow westward through the extremely rough area of southwestern Missouri and northwestern Arkansas. Stream profiles on the Grand (Neosho) River, and Spring and Elk Rivers, are shown on plates 4-1 and 4-2.

TABLE 4-1

SUMMARY OF CONTRIBUTING DRAINAGE AREAS
PENSACOLA DAM AND RESERVOIR

	Sq.Mi.
Total Area Above Pensacola Dam	10,298
Area Above John Redmond Dam	3,015
Contributing Drainage Area Between Pensacola Dam and John Redmond Dam	7,283
Spring River Tributary	2,581
Elk River Tributary	1,033
Grand (Neosho) River and Remaining Tributaries, Pensacola Dam to John Redmond Dam	3,669

4-03. Geology and soils. The Flint Hill area in the upper reaches of the Grand (Neosho) River watershed is a prominent escarpment of flint-bearing limestone. The underlying formations in this area are essentially of the Permian and Pennsylvanian periods and lie in long, flat belts underlain with shale. The thin, rather impervious soil cover of the region is well suited to the production of native blue stem grass pasture for which this area is well known. Outcroppings, predominately of limestone, shales and some sandstone are found along the central portion of the basin. A large portion of the upland soils of this area is poor and depleted; however, the rich alluvial soils of the stream valleys are very fertile and are largely in cultivation, despite frequent flood losses. In the lower, eastern portion of the basin the Spring and Elk Rivers have cut deeply into the Boone limestone and the Mississippi

Chattanooga shale on the western flank of the Ozark uplift. The rocks in this portion have been faulted and folded, some underground drainage systems and caverns have been developed principally in the Boone limestone. The soils of this area are predominantly thin and gravelly.

4-04. Sediment. Due to the predominance of clay loams rather than sandy soils, erosion is not a major problem in the Grand (Neosho) River basin. Much of the cropland has been terraced and bank caving is not extensive, hence, the Grand (Neosho) River does not carry a large sediment load.

4-05. Climate. The Grand (Neosho) River watershed lies in a region characterized by moderate winters and comparatively long summers with relatively high temperatures. Summer rains are generally in the form of thunderstorms of short duration and limited extent but with high intensities. The winter rains are generally less intense but cover larger areas and may last for several days. The Gulf of Mexico is the feeding source for much of the precipitation which falls on the basin. High winds and tornados are often encountered in the watershed. Climate characteristics for the basin above Pensacola Dam are shown in the following tabulation:

a. Temperature

Mean annual	57.9° F
Maximum recorded (Burlington, Kansas 18 July 1936)	117° F
Minimum recorded (Neosho, Missouri, 22 January 1930)	-31° F

b. Precipitation

Average annual	40.8 inches
Maximum annual (1973)	57.2 inches
Minimum annual (1963)	21.3 inches
Percent during growing season (April through September)	65 %

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

TABLE 4-2

AVERAGE MONTHLY AND ANNUAL RAINFALL AND RUNOFF

Month	Average Rainfall (Inches)	%Average Annual Rainfall	AVERAGE RUNOFF(1)(2) Acre-Feet	Inches	% of Average Annual Runoff
January	1.73	4.3	258,000	0.66	5.2
February	1.73	4.3	317,200	0.82	6.3
March	2.91	7.2	492,000	1.27	9.8
April	4.02	10.0	679,700	1.75	13.6
May	5.15	12.6	703,800	1.81	14.1
June	5.26	13.0	732,400	1.89	14.6
July	3.58	8.9	391,700	1.01	7.8
August	3.39	8.4	174,200	0.45	3.6
September	4.64	11.5	256,600	0.66	5.1
October	3.39	8.4	373,200	0.96	7.5
November	2.71	6.7	357,000	0.92	7.1
December	1.89	4.7	264,400	0.68	5.3
Total	40.40	100%	5,000,000	12.88	100%

(1) Drainage area between John Redmond and Pensacola Dams = 7,283 square miles.

(2) Period of Record January 1930 through December 1980.

c. Snowfall.

Mean annual 13.0 inches

d. Evaporation. The estimated monthly evaporation at Pensacola Reservoir is shown in Table 4-3.

TABLE 4-3

ESTIMATED MONTHLY PAN EVAPORATION

PENSACOLA RESERVOIR

Month	Evaporation inches (1) Normal Conditions (2)	Drought Conditions (3)
January	1.89	1.86
February	2.47	2.48
March	4.48	4.60
April	6.68	9.43
May	7.33	7.49
June	8.81	11.91
July	9.62	15.17
August	9.31	14.94
September	6.81	12.08
October	5.08	6.36
November	3.09	3.83
December	2.16	2.56
Total inches per year	67.73	92.71

(1) National Weather Service class "A" pan.
(2) Period of Record - 1942 through 1977.
(3) Using April 1954 - March 1955 as a typical drought year.

e. Wind. The prevailing wind is from a southerly direction, with the greatest wind movements occurring in the spring months. A study of available wind velocity data indicates that for 1-minute and 1-hour durations, the highest wind velocities that can reasonably be expected are 75 and 53 miles per hour.

4-06. Storms and floods. Most of the flood-producing storms over the Grand (Neosho) River watershed have been from 3 to 8 days duration. The longer storms have generally been made up of two or three periods of intense precipitation, with moderate precipitation on the intervening days saturating the watershed and resulting in a high percentage of runoff from subsequent periods of heavy

precipitation. The winter months have less frequent flood producing precipitation. Rainfall is maximum in May and June, with a noticeable decrease in the average rainfall in late July and early August, with an increase again in September. Antecedent precipitation, season of the year, and many other factors influence storm runoff so that floods have frequently followed periods of relatively small amounts of recorded rainfall. Conversely, storms of greater amounts of recorded rainfall have caused minor flooding. Storms with an average precipitation of 3 inches or more over the area between John Redmond Dam and Pensacola Dam are shown in table 4-4. The averages were computed from precipitation records of stations in and adjacent to the watershed. These records do not necessarily record the center of intense storms. The Grand (Neosho) River Basin is comparatively long and narrow, with no major tributary from John Redmond Dam to Commerce, Oklahoma. This portion of the basin covering 2,861 square miles is oriented at right angles to the axes of most major storms; hence, the larger floods along this reach are frequently of short duration and crest flows are substantially reduced by the large valley storage in this reach. Major floods at the Commerce, Quapaw and Tiff City gages are shown in table 4-5.

TABLE 4-4
MAJOR STORMS
JANUARY 1923 THROUGH OCTOBER 1986
(John Redmond Dam to Pensacola Dam)

Inclusive Dates	Average Rainfall (Inches)	Inclusive dates	Average Rainfall (Inches)
14-25 May 1923	4.16	3-14 June 1949	3.29
6-11 June 1923	4.91	6-13 July 1950	3.93
15-20 Sept 1923	3.42	9-13 July 1950	3.34
12-18 Oct 1923	3.79	16-20 July 1950	3.30
11-15 July 1924	4.35	20-24 June 1951	3.13
21-26 Sept 1925	3.45	29-30 June 1951	3.60
3-5 Sept 1926	5.21	9-13 July 1951	3.73
25 Sept-4 Oct 1926	6.76	9-13 Sept 1951	3.52
8-15 April 1927	6.69	20-28 May 1955	3.96
17-21 June 1927	4.30	22-30 Sept 1955	4.73
12-17 Aug 1927	3.06	16-23 April 1957	3.08
23 Sept-2 Oct 1927	6.96	16-25 May 1957	7.38
16-23 June 1928	4.29	29 May-2 June 1957	3.16
13-20 April 1929	4.65	8-13 June 1957	3.33
11-13 May 1929	3.02	15-26 June 1958	3.68
26-30 April 1930	3.01	4-8 July 1958	3.16
17-23 Nov 1931	4.13	11-17 July 1958	3.86
22-24 Dec 1932	4.37	24-31 July 1958	3.05
18-22 May 1935	3.25	15-18 Sept 1958	3.03
26-30 May 1935	3.86	12-18 July 1959	4.28
1-7 June 1935	4.02	24 Sept-5 Oct 1959	10.67
11-17 June 1935	3.22	30 April-9 May 1961	8.58
14-19 July 1937	3.48	4-5 Sept 1961	3.46
4-10 Sept 1937	3.39	12-13 Sept 1961	4.21
19-23 May 1938	3.23	1-10 Sept 1962	4.08
7-17 June 1938	4.57	4-6 April 1964	3.44
8-18 Aug 1940	4.06	10-15 June 1964	5.21
20-26 Nov 1940	3.71	2-6 April 1965	4.81
14-19 April 1941	6.33	1-15 June 1965	4.18
6-10 June 1941	4.24	30 April-1 May 1970	3.50
5-9 Sept 1941	5.82	10-13 Oct 1970	5.05
1-7 Oct 1941	5.28	28 Feb-11 Mar 1973	4.45
14-20 Oct 1941	3.12	9-11 Mar 1974	3.71
29-31 Oct 1941	3.83	4-9 June 1974	4.69
6-10 April 1942	3.92	2-10 Nov 1974	4.00
5-13 June 1942	3.33	2-4 July 1976	4.73
15-21 June 1942	4.35	18-26 June 1977	5.30
3-8 Sept 1942	4.18	21-22 Nov 1979	3.15
7-10 May 1943	5.83	12-18 Oct 1981	3.77
15-20 May 1943	9.63	17-23 Oct 1983	5.51
8-11 April 1944	3.36	13-21 Oct 1984	3.75
20-26 Aug 1944	3.90	21-24 Feb 1985	4.60
1-5 Oct 1944	3.00	1-7 June 1985	3.74
11-16 April 1945	6.03	17-24 Aug 1985	5.09
22-30 Sept 1945	8.83	9-19 Oct 1985	3.91
15-25 May 1947	4.38	12-20 Nov 1985	6.09
21-29 June 1948	7.97	30 Sept-7 Oct 1986	8.86
15-21 May 1949	3.32		

TABLE 4-5

MAJOR FLOODS OF PERIOD OF RECORD

COMMERCE (1) Flood Stage 15.0 Feet			QUAPAW Flood Stage 15.0 Feet			TIFF CITY Flood Stage 15.0 Feet		
DATE	STAGE (ft)	DISCHARGE (cfs)	DATE	STAGE (ft)	DISCHARGE (cfs)	DATE	STAGE (ft)	DISCHARGE (cfs)
4- -27	20.20	(2)	3-13-35	30.00	(2)	4-16-41	21.46	48,000
5- -35	20.80	(2)	4-16-41	20.40	26,300	4-19-41	28.40	137,000*
5- -38	19.80	(2)	4-17-41	19.99	25,300	10-31-41	19.69	36,400
4-19-41	20.08	36,800	4-20-41	29.66	63,200	10-31-42	16.70	23,000
6-11-41	20.26	38,400	10-06-41	27.92	50,300	5-10-43	23.45	62,400***
9-11-41	19.44	31,900	10-17-41	20.36	25,900	5-18-43	23.60	62,900
10-07-41	21.07	49,000	11-01-41	29.31	56,200	5-19-43	21.28	44,500
10-18-41	19.02	31,000	4-09-42	20.27	25,700	4-11-44	15.36	18,500
11-01-41	22.06	64,800	12-27-42	22.18	30,800	3-03-45	17.54	26,200
6-23-42	19.24	32,200	12-18-42	21.42	29,600	3-19-45	16.16	21,700
12-28-42	17.75	34,500	5-11-43	28.20	54,500	4-13-45	16.28	20,800
5-12-43	20.46	43,900	5-19-43	43.40	190,000*	4-15-45	23.50	63,200
5-20-43	25.12	105,200***	6-21-44	22.77	36,100	5-17-45	15.83	20,500
3-22-44	18.93	31,600	4-14-45	25.76	50,100	12-10-46	15.94	20,800
4-12-44	20.00	41,300	4-16-45	29.60	67,900	4-25-47	16.10	21,400
4-29-44	21.85	70,000	5-28-45	20.26	30,200	1-14-50	15.13	18,500
12-16-44	18.72	30,400	6-07-45	22.25	36,600	5-11-50	21.72	45,900
4-17-45	19.63	37,200	9-25-45	26.81	54,300	7-20-50	17.52	24,000
4-23-45	22.17	73,300	5-31-46	22.26	37,000	8-06-50	19.60	33,000
9-27-45	20.22	39,800	4-26-47	26.46	53,000	2-19-51	17.00	22,000
10-02-45	19.22	32,300	6-23-48	30.20	74,600	5-15-56	23.14	49,900
1-08-46	19.14	31,600	7-27-48	21,85	35,600	4-04-57	18.37	23,900
6-24-48	23.38	85,000	8-29-50	27.59	54,800	5-21-57	24.72	70,800**
7-28-48	24.43	93,200	2-21-51	21.52	33,800	7-26-58	18.50	26,000
7-21-50	20.08	37,500	6-30-51	20.80	31,600	5-05-61	17.57	23,200
7-03-51	20.51	42,000	6-28-55	20.20	29,800	5-07-61	21.48	40,500
7-15-51	34,03	267,000*	5-23-57	21.37	34,900	6-14-64	32.58	48,600
9-14-51	20.68	48,400	5-25-57	25.40	49,700	4-03-65	18.63	29,000
5-25-57	19.71	36,200	6-03-57	20.59	32,100	2-02-68	17.68	23,400
6-16-57	20.22	41,000	6-11-57	27.00	56,000	1-30-69	18.14	24,900
7-14-58	20.05	39,000	6-15-57	21,80	36,300	5-01-70	21.03	33,200
7-17-59	19.51	32,300	7-12-58	20.20	20,800	11-02-72	17.01	18,000
5-08-61	22.38	78,603	7-25-58	21,70	36,000	3-11-73	19.37	26,500
9-22-61	19.26	37,100	10-03-59	25.35	49,600	6-03-73	19.18	25,700

TABLE 4-5

MAJOR FLOODS OF PERIOD OF RECORD

COMMERCE (1) Flood Stage 15.0 Feet			QUAPAW Flood Stage 15.0 Feet			TIFF CITY Flood Stage 15.0 Feet		
DATE	STAGE (ft)	DISCHARGE (cfs)	DATE	STAGE (ft)	DISCHARGE (cfs)	DATE	STAGE (ft)	DISCHARGE (cfs)
6-15-64	20.24	40,000	10-13-59	21.80	34,900	11-25-73	21.76	36,000
4-05-65	19.39	35,300	5-09-61	29.12	66,200	12-04-73	18.25	24,000
5-02-70	19.51	34,200	6-14-64	25.03	49,100	3-11-74	16.71	19,300
12-17-71	19.27	34,200	4-04-65	22.25	37,900	6-09-74	22.32	40,000
1-23-73	18.86	30,000	5-02-70	24.20	44,300	11-04-74	23.32	53,200
3-12-73	18.89	30,200	11-02-72	24.69	47,900	4-24-76	17.47	23,900
3-27-73	19.47	34,200	1-22-73	20.10	30,700	6-24-76	18.08	22,700
3-12-74	22.42	66,700	3-11-73	22.26	38,100	7-04-76	18.91	25,700
6-08-74	19.65	36,600	5-07-73	22.02	37,200	4-12-79	16.91	20,600
11-05-74	21.49	55,500	11-26-73	23.44	42,700	12-03-82	16.63	20,200
7-04-76	21.72	58,400	12-05-73	21.17	34,200	4-30-83	20.70	35,200
6-24-77	21.67	57,700	3-12-74	30.24	78,400	1-01-85	20.08	31,900
11-23-79	20.14	40,700	6-09-74	24.63	48,600	2-24-85	20.31	33,100
6-06-82	18.98	33,800	11-05-74	26.41	57,000	3-31-85	20.31	33,100
4-07-83	18.64	31,400	7-04-76	32.94	104,500***	3-31-85	18.69	26,500
4-24-83	19.96	40,200	6-22-77	21.39	35,400	5-01-85	16.15	16,900
3-21-84	18.92	30,500	3-25-78	19.43	29,400	11-19-85	20.09	31,500
1-01-85	18.80	30,000	5-22-79	19.76	30,600	10-01-86	20.09	31,500
2-24-85	22.84	72,200	11-23-80	21.74	37,800			
6-07-85	19.50	34,900	4-23-83	21.04	35,200			
8-26-85	19.43	34,300	1-01-85	21.56	37,100			
11-20-85	21.02	50,600	2-26-85	33.86	105,500***			
10-06-86	26.23	120,700**	4-01-85	20.02	31,500			
2-17-87	19.34	36,100	11-20-85	26.36	57,800			
3-03-87	19.10	34,500	10-02-86	33.24	101,900			
			3-02-87	21.23	35,900			

(1) Floods listed only include flows over 30,000 cfs.
(2) Stage only recorded.

* Largest flood of record.
** 2nd largest flood of record.
*** 3rd largest flood of record.

4-07. Runoff characteristics. The Grand (Neosho) River Basin between John Redmond Dam and Pensacola Reservoir produces moderate runoff. During design studies, it was found that 1.0 to 2.5 inches of rainfall generally was needed to satisfy initial losses before significant runoff begins. The contributing drainage area of this portion of the watershed is 3,669 square miles. No major tributaries enter the upper portion of this area. Spring and Elk Rivers, the main tributaries entering the stream in the lower reaches, have their source in the Ozark uplift in southwestern Missouri and northwestern Arkansas. The runoff from the drainage areas of these tributaries is very rapid and accounts for a major portion of the flood flows in the lower portion of the main stem. Since these streams are fed by springs, they produce most of the flow in the lower reaches during the summer months, hence, very low flows are less frequent in this portion of the stream than in the upper reaches. The largest tributary is the Spring River which has a drainage area of 2,581 square miles. It enters near the head of Pensacola Reservoir. The time of concentration from the period of most intense rainfall for major floods is about 36 to 48 hours and the flood travel time to Pensacola Dam for natural conditions is about 6 hours. The other major tributary is the Elk River which has a drainage area of 1,033 square miles and enters the lake about 15 miles above the dam. The time of concentration from the period of most intense rainfall for major floods is about 18 to 24 hours and the flood travel time to Pensacola Dam for natural conditions is about 6 hours. Pertinent data for stream gaging stations in the basin above Pensacola Dam are given in table 4-6. Estimated monthly and annual flows at Pensacola Reservoir for the period from 1923 through 1988 are shown in table 4-7. The inflow volume frequency (volume by months) is shown in table 4-8. A graphical display of crest travel times is shown on plate 4-3.

TABLE 4-6
PERTINENT DATA FOR STREAM GAGING STATIONS

STATION	STREAM	MILES ABOVE MOUTH	DRAINAGE AREA (SQ.MI.)	ELEVATION OF ZERO OF GAGE	FLOOD STAGE (FT.)	DISCHARGE AT FLOOD STAGE(CFS)	MINIMUM OF RECORD			MAXIMUM OF RECORD			AGENCY	PERIOD OF RECORD
							STAGE	DISCHARGE	DATE	STAGE	DISCHARGE	DATE		
Burlington, KS	Grand(Neosho) River	338.3	3042(1)	983.53	21.6	12,000	(2)	0	11/28/80	31.53	26,200	9/13/61	USGS	06/61-Present
Leroy, KS	Grand(Neosho) River	324.9	3171	(3)	23.0	18,000	(3)	(3)	(3)	34.55	(4)	7/12/51	KSHD	1940 -Present
Iola, KS	Grand(Neosho) River	284.4	3818	914.77	19.0	17,500	(2)	0	(3)	43.0	436,000	7/13/51	USGS	10/17-Present
Chanute, KS	Grand(Neosho) River	271.1	4195	887.94	22.0	18,500	(2)	0	09/25/63	32.09	41,600	4/20/70	USGS	10/62-Present
Parsons, KS	Grand(Neosho) River	201.4	4905	810.25	19.0	22,000	(2)	0	1934,36,39	40.20	410,000	7/14/51	USGS	10/21-Present
Oswego, KS	Grand(Neosho) River	187.2	4947	790.86	17.0	(4)	(2)	(3)	09/17/13	32.50(6)	(4)	7/14/51	NWS	09/04-Present
Commerce, OK	Grand(Neosho) River	153.4	5876	748.97	15.0	20,000	(2)	0	1953,54,56	34.03	267,000	7/15/51	NWS	06/39-Present
Carthage, MO	Spring River	68.0	445	923.68	14.0	11,800	2.38	37	7/26-27/72	17.15	24,800	11/01/72	COE/ USGS	10/45-09/50 & 10/50-Present
Waco, MO	Spring River	47.6	1164	833.23	19.0	17,500	(2)	4	08/28/54	30.94	103,000	05/19/43	USGS	04/24-Present
Joplin, MO	Shoal Creek	13.2	427	886.87	14.0	13,400	(2)	12	09/07/54	16.8(7)	62,100	05/18/43	USGS	09/41-Present
Quapaw, MO	Spring River	13.9	2510	746.25	20.0	30,500	(2)	6	07/08/54	43.4	190,000	05/19/43	USGS	07/39-Present
Tiff City, MO	Elk River	15.8	872	750.61	15.0	15,900	(2)	5	9/5-6/54	28.4	137,000	04/13/41	USGS	10/39-Present

FOOTNOTES:
(1) Includes Rock Creek
(2) Not significant at extreme low flow
(3) Not determined
(4) No discharge
(5) Discontinued as a discharge station on 09/30/75
(6) Point wire-weight gage
(7) Zero of gage at 902.37

COE - U.S. Army Corps of Engineers
KSHD - Kansas State Highway Department
USGS - U.S. Geological Survey
NWS - National Weather Service

TABLE 4-7
ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET
PENSACOLA RESERVOIR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1923	18000	214060	307040	61570	616570	1653000	179760	17030	53300	554580	433500	749390	4857800
1924	154390	504660	390770	347700	775180	841380	442340	482100	160260	106450	112400	123400	4441030
1925	305470	240020	175380	387630	172410	130260	54950	49800	88600	105630	188520	56200	1954870
1926	111250	108270	142570	376720	117860	285310	81490	127280	1186850	1591000	382000	406060	4916660
1927	555740	365230	623020	3537000	709140	1125700	394160	1408000	243070	965350	236460	322420	10485290
1928	187040	397710	440190	800710	321100	2686100	483670	643350	106950	89840	554330	513750	7224740
1929	619460	263650	364160	1877000	2348000	1134800	472260	116870	60000	84880	66330	57520	7464930
1930	167450	525490	115630	87530	737240	530110	68960	35930	208770	74820	78320	264480	2894730
1931	75550	134220	169850	262740	325480	139510	106950	133560	38590	67940	547230	254150	2255770
1932	432510	201000	136700	120750	80340	489950	394740	73380	28140	25900	30080	439200	2452690
1933	292830	122980	168520	613430	1137000	154300	73030	104390	175710	163000	109260	140420	3254870
1934	111410	42150	64220	216710	180760	68760	16490	8360	204150	162320	399530	172660	1647520
1935	251830	223730	826500	244560	1109000	3420900	300020	69670	100420	207200	566730	354820	7675380
1936	110260	82250	74780	48380	227370	70730	58400	7630	316880	499370	361920	100170	1958140
1937	903360	674340	408130	425070	311590	1113300	183730	101820	225720	45080	30900	56700	4479740
1938	92730	574910	425980	688720	1140000	1571200	177860	106950	50280	24720	41400	30080	4924830
1939	29210	72410	101740	136540	719960	368870	120340	69920	15860	12280	16340	18510	1681980
1940	16610	23640	32690	233800	216300	121000	87010	104800	94970	22580	109900	168700	1232000
1941	568800	317900	102200	1452000	169200	1160000	120200	199500	885100	2938000	1599000	389500	9901400
1942	201300	430200	281600	1165000	444900	1198000	333400	206700	806000	445800	474700	739800	6727400
1943	358100	208400	288600	359200	4751000	1229000	175600	37500	44140	125200	37800	75900	7690440
1944	81500	222300	1097000	1867000	1277000	620800	139500	343400	201200	548900	97500	681200	7177300
1945	124100	260200	1568000	3062000	1225000	1029000	670100	284700	1186700	919000	127000	76300	10532100
1946	756800	547400	322200	282700	523900	409600	79700	15300	52800	16800	348500	302220	3657900
1947	99300	42500	425900	2009000	818600	692100	210800	18700	26100	4500	15680	44700	4407880
1948	34420	70600	690000	151100	373900	1516000	1752000	642900	121400	20800	107900	48900	5529920
1949	875000	1174000	559200	454000	954300	642500	464200	60200	202900	257700	52400	119900	5816300
1950	572000	229100	193300	139200	753600	533900	1519000	1338000	595800	236700	58000	42600	6211200
1951	68000	760200	353800	332700	743700	1170400	3846000	356600	1284000	359900	955000	260900	10491200
1952	282400	558700	754000	573800	241900	57900	14000	107700	28610	16930	20240	23990	2680170
1953	26420	30650	203500	329800	189100	37300	37830	9210	6450	21090	10240	10060	911650
1954	18970	16620	16410	84270	440600	88700	4280	2540	20360	455840	56600	91150	1296340
1955	197300	272600	359300	134400	383100	477100	131600	49900	60900	214300	13180	19300	2312980
1956	15910	26620	9940	41390	228800	200200	74300	19900	8260	6240	15750	38460	685770
1957	28030	114300	223300	1158500	2241000	1913000	256600	47100	50100	55910	90720	72000	6250560

TABLE 4-7 (CONT.)
ESTIMATED MONTHLY AND ANNUAL FLOWS IN ACRE-FEET
PENSACOLA RESERVOIR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1958	69280	83360	1178900	580000	536400	323700	1870000	234500	258600	63700	134800	45410	5378650
1959	91520	214200	381400	288830	533800	126700	650000	55600	170300	1786000	256400	242700	4797450
1960	266000	299300	720700	581100	837400	270500	115400	174700	87700	156100	258000	296900	4063800
1961	70500	178100	521000	840300	3673000	469700	389600	204400	1248000	416400	1064100	376400	9451500
1962	342500	469300	507000	307000	168400	629400	154400	36800	875100	446650	144210	142440	4223200
1963	182320	78920	320210	95310	117090	166930	81020	28130	15320	4520	18250	20920	1128940
1964	24730	29900	56390	382840	145450	1018670	45280	76550	33760	11040	208460	100290	2133360
1965	124500	87150	287480	1314200	233100	907410	345550	38930	509740	143030	39590	90440	4121120
1966	155550	247620	184930	325170	368570	151290	37590	80640	147200	16720	28880	29810	1773970
1967	52010	59150	45850	231060	223630	751760	857170	75950	174050	512540	432300	328270	3743740
1968	347450	522000	696330	464000	556530	439540	374580	282890	53610	207580	853660	557640	5355810
1969	599660	422100	785950	779760	661140	881560	675000	149920	211570	581650	158330	128810	6035450
1970	92200	86630	275180	1021540	1127850	877880	125390	43590	382310	481410	230570	176320	4920870
1971	400090	322100	321600	148360	249980	724610	448990	136680	107030	227450	161630	874450	4122970
1972	176150	121070	86020	295090	31770	55950	297310	44960	221470	316250	1384880	448720	3479640
1973	1294440	707280	2664720	2306880	1031860	726940	188370	55180	463520	1171180	1350500	1415440	13376310
1974	671890	485000	1786210	367360	583900	1392580	94230	145040	426220	317100	1914780	474670	8658980
1975	486760	1130950	1411850	533100	334600	911100	270910	84160	107720	62720	50350	243860	5628080
1976	78350	63780	222860	826740	528830	428670	1459970	71280	47980	44090	34970	32970	3840260
1977	35810	51400	154480	131580	327220	1233220	633350	218790	664210	269730	757100	205340	4682230
1978	85633	285812	1099843	935537	740214	378736	119798	61870	22600	14300	80638	57600	3882581
1979	199900	362100	606100	582900	477600	697800	644300	201600	57550	35702	612991	111471	4590014
1980	94809	219173	505586	802909	213024	119404	26380	44429	17851	53950	27966	36495	2161976
1981	25590	30150	48790	74380	149650	446680	397880	179700	143700	247160	521060	248320	2513060
1982	332231	652958	472561	141123	832066	1203768	254479	127735	58611	34512	85884	551008	4746936
1983	184859	465123	426743	1979900	1333685	574214	314380	40264	27371	359206	333421	268561	6307727
1984	228099	283834	1589553	1531438	639074	425851	123173	30446	20231	287008	299702	763239	6221648
1985	824330	1811504	1424925	657322	849917	1370181	262435	702545	330049	925090	2416794	1017434	12592526
1986	229685	471867	290975	915570	494836	283438	284429	124958	599127	3246644	640760	374082	7956371
1987	416330	1016826	1532528	511933	596429	315669	287900	153917	96793	62280	622909	1363735	6977249
1988	467900	298115	861818	1519933	162049	75768	165322	56132	115040	52260	299500	294350	4368187
MEAN	263553	327421	513403	689936	693393	716065	386664	172166	252029	363644	360132	281570	5019971
MAX	1294440	1811504	2664720	3537000	4751000	3420900	3846000	1408000	1284000	3246644	2416794	1415440	13376310
MIN	15910	16620	9940	41390	31770	37300	4280	2540	6450	4500	10240	10060	685770

TABLE 4-8
PENSACOLA RESERVOIR
INFLOW VOLUME FREQUENCY (1923-1988) (1)

FREQUENCY OF OCCURRENCE	MONTHLY VOLUME OF INFLOW IN ACRE-FEET											
(YEARS)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2Y	158000	207000	317000	430000	471000	474000	202000	88000	121000	134000	160000	158000
5Y	400000	501000	801000	1014000	990000	1117000	547000	237000	355000	493000	507000	419000
10Y	643000	787000	1288000	1573000	1448000	1732000	912000	393000	616000	960000	916000	691000
25Y	1060000	1264000	2119000	2495000	2157000	2745000	1558000	667000	1100000	1934000	1702000	1169000
50Y	1457000	1710000	2911000	3347000	2782000	3682000	2191000	935000	1591000	3022000	2526000	1633000
100Y	1934000	2238000	3863000	4348000	3489000	4782000	2970000	1263000	2210000	4497000	3592000	2201000

(1) Based on Table 4-7, Estimated Monthly and Annual Flows in Acre-Feet at Pensacola Reservoir Log Pearson Type III Distribution, skew=0.10

4-08. Water Quality. The overall water quality of Grand (Neosho) River is relatively good. Organic pollution is normally alleviated by stream regulation from conservation storage in upstream lakes combined with secondary or better treatment of organic waste prior to discharge. Pollution by chemical waste is of significance due to brine discharge from oil fields primarily in the central portion of the watershed, and acid waste from coal and metal mining in the western portion of the Spring River Basin. In recent years, however, the oil fields have become depleted and mining activity curtailed to such an extent that pollution from these sources has decreased materially. Physical characteristics of the Grand (Neosho) River favor rapid stream purification; hence, aquiculture and industrial pollution from the lower Grand (Neosho) River watershed have little effect on the water quality of Pensacola Reservoir. Pollution abatement has little effect on the operation of Pensacola Reservoir.

4-09. Channel and Floodway Characteristics. The channel capacity of the Grand (Neosho) River below Pensacola Reservoir is estimated at 100,000 c.f.s. The roadway approach to the bridge at Langley, Oklahoma, just downstream of the Pensacola Dam is under water at flows in excess of 130,000 c.f.s. It is estimated that flows of about 230,000 or less would not inundate any property not covered by a flowage easement. Since the tailwater of Pensacola Dam is contiguous with the upper limits of Lake Hudson, and since the tailwater of Lake Hudson is contiguous with the upper limits of Fort Gibson Lake, and due to the proximity of Fort Gibson Dam to the confluence of the Grand (Neosho) River with the Arkansas River, damages and benefits are insignificant on the Grand (Neosho) River below Pensacola Dam. Stream profiles on the Grand (Neosho), Spring and Elk Rivers are shown in plates 4-1 and 4-2. Discharge rating curves for Burlington, Iola, Chanute, Parsons and Commerce on the Grand (Neosho) River, Waco and Quapaw on the Spring River, Joplin on Shoal Creek, Tiff City on the Elk River, and Big Cabin on Big Cabin Creek, are shown on plates 4-4 through 4-12.

4-10. Upstream Structures. There are three upstream structures that affect the regulation of Pensacola Reservoir. Marion Lake on the Cottonwood River has a drainage area of 200 square miles. Council Grove and John Redmond Lakes on the Grand (Neosho) River have total drainage areas of 246 and 3,015 square miles, respectively. All three lakes are regulated by the Corps of Engineers.

4-11. Downstream Structures. Structures downstream from Pensacola Reservoir include Hudson and Fort Gibson Lakes on the Grand (Neosho) River, with total drainage areas of 11,533 and 12,492 square miles, respectively, and the locks and dams of the McClellan-Kerr Navigation System on the Arkansas River. Fort Gibson Lake and the navigation structures are owned by the Federal government. Lake Hudson is owned by the Grand River Dam Authority, an agency of the state of Oklahoma. The flood control storage in Lake Hudson is regulated by the Corps of Engineers by authority of Section 7 of the 1944 Flood Control Act.

4-12. Economic Data.

a. Population. The population of the counties and larger cities in the Grand (Neosho) River Basin are shown on table 4-9.

b. Agriculture. Agriculture and stock raising are the principal occupations of the basin as a whole. The principal crops grown in the Kansas portion of the basin are soybeans, sorghum, wheat and hay, with a small percentage of cropland devoted to corn and oats production. Beef cattle is the principal livestock grown in the upper portion of the basin, in east central Kansas, with much of the area being native grasses used exclusively for grazing cattle.

In the Oklahoma portion of the basin, principal crops include hay, soybeans, sorghum and wheat. Beef cattle is also the principal livestock activity in this area. Principal crops grown in the southwest Missouri portion of the basin include hay, soybeans and wheat, with livestock activities including cattle, hogs and poultry. In northwest Arkansas cropland is devoted principally to hay, soy beans, wheat and some fruit and nut production. Livestock include poultry, cattle and hogs. Individual farm acreage ranges from a county-wide average of over 1,100 acres in east central Kansas to about 120 acres in northwest Arkansas. In the basin as a whole, a very small percentage of the cropland is irrigated. The only significant exception is Benton County, Arkansas, where approximately 40 percent of the cropland is irrigated. In Harvy and McPherson Counties, Kansas, where wheat, soybean and sorghum are the principal crops, approximately 7 to 8 percent of the cropland is irrigated. Less than 4 percent of the cropland is irrigated in the remainder of the basin.

Production and annual value of crops grown in the flood plain below Fort Gibson Dam are shown in table 4-10.

c. Industry. Agriculture is the chief industry in the Grand (Neosho) River watershed, with the production and processing of petroleum being the largest non-agricultural industry. The large deposits of lead and zinc formerly found in the northeastern corner of Oklahoma, southeastern corner of Kansas and the adjacent section of Missouri have been largely depleted and strip mining of coal in the region is substantially reduced from the production levels of the past.

d. Flood Damages. The estimated average annual damages, estimated average annual damages prevented, and the estimated average residual damages attributable to Pensacola, Markham Ferry and Fort Gibson Lakes are shown in table 4-11. Prices for structures and crops are based on October 1986 prices. Structural loss and area curves are shown on plates 4-13 and 4-14.

TABLE 4-9

POPULATION OF COUNTIES AND CITIES IN THE GRAND (NEOSHO) RIVER BASIN

County City	1960	1970	1980	% Change 1970-1980
OKLAHOMA COUNTIES				
Cherokee	17,762	23,174	30,684	32.41%
Craig	16,303	14,722	15,014	1.98%
Vinita	6,027	5,847	6,740	15.27%
Delaware	13,198	17,767	23,946	34.78%
Mayes	20,073	23,302	32,261	38.45%
Muskogee	61,866	59,542	66,939	12.42%
Ottawa	28,301	29,800	32,870	10.30%
Miami	12,869	13,700	14,237	3.92%
Picher	2,553	2,363	2,180	-7.74%
Rogers	20,614	28,425	46,436	63.36%
Wagoner	15,673	22,163	41,801	88.61%
Oklahoma Counties Total	**193,790**	**218,895**	**289,951**	**32.46%**
KANSAS COUNTIES				
Allen	16,369	15,043	15,654	4.06%
Iola	6,885	6,493	6,938	6.85%
Anderson	9,035	8,501	8,749	2.92%
Bourbon	16,090	15,215	15,969	4.96%
Butler	38,395	38,658	44,782	15.84%
Chase	3,921	3,408	3,309	-2.90%
Cherokee	22,279	21,549	22,304	3.50%
Coffey	8,403	7,397	9,370	26.67%
Crawford	37,032	37,850	37,916	0.17%
Pittsburg	18,678	17,600	18,770	6.65%
Greenwood	11,253	9,141	8,764	-4.12%
Harvey	25,865	27,236	30,531	12.10%
Labette	26,805	25,775	25,682	-0.36%
Parsons	13,929	11,900	12,898	8.39%
Lyon	26,928	32,071	35,108	9.47%
Emporia	18,190	22,200	25,287	13.91%
McPherson	24,285	24,778	26,855	8.38%
Marion	15,143	13,935	13,522	-2.96%
Morris	7,392	6,432	6,419	-0.20%
Neosho	19,455	18,812	18,967	0.82%
Chanute	10,849	10,341	10,506	1.60%
Osage	12,886	13,352	15,319	14.73%
Wabaunsee	6,648	6,397	6,867	7.35%
Wilson	13,077	11,317	12,128	7.17%
Woodson	5,423	4,789	4,600	-3.95%
Kansas Counties Total	**346,684**	**341,656**	**362,815**	**6.19%**
MISSOURI COUNTIES				
Barry	18,921	19,597	24,408	24.55%
Barton	11,113	10,431	11,292	8.25%
Christian	12,359	15,124	22,402	48.12%
Dade	7,577	6,850	7,383	7.78%
Jaspar	78,863	79,852	86,958	8.90%
Carthage	10,792	11,035	11,104	0.63%
Joplin	38,958	40,100	38,893	-3.01%
Webb City	6,740	6,923	7,309	5.58%
Lawrence	23,260	24,585	28,973	17.85%
McDonald	11,798	12,357	14,917	20.72%
Newton	30,093	32,981	40,555	22.96%
Neosha	7,452	7,517	9,493	26.29%
Missouri Counties	**193,984**	**201,777**	**236,088**	**17.40%**
ARKANSAS COUNTIES				
Benton	36,272	50,476	78,115	54.76%
TOTAL OF ALL COUNTIES	**770,730**	**812,804**	**967,769**	**19.07%**

TABLE 4-10

ANNUAL VALUE OF CROPS
(October 1986 Price Basis)

ARKANSAS RIVER (1)						
	GRAND RIVER TO ILLINOIS RIVER		R.S. KERR L&D #15 TO FT. SMITH, ARKANSAS		TOTAL	
CROPS	ACRES	VALUE	ACRES	VALUE	ACRES	VALUE
SOYBEANS	11,680	$1,730.600	34,020	$5,042,300	45,700	$6,772,900
WHEAT	12,810	966,900	37,330	2,817,300	50,140	3,784,200
ALFALFA	3,320	802,800	9,680	2,338,900	13,000	3,141,700
VEGETABLES	1,280	456,400	3,710	1,329,800	4,990	1,786,200
OTHER CROPS	750	242,400	2,180	706,300	2,930	948,700
TOTAL	29,840	$4,199,100	86,920	$12,234,600	116,760	$16,433,700

NOTE:

(1) Since the tailwater of Pensacola Dam is contiguous with the upper limits of Markham Ferry Reservoir, and since the tailwater of Markham Ferry Dam is contiguous with the upper limits of Fort Gibson Reservoir, and due to the proximity of Fort Gibson Dam to the confluence of the Grand (Neosho) River with the Arkansas River, crop acreage on the Grand River are insignificant.

TABLE 4-11

AVERAGE ANNUAL DAMAGES, DAMAGES PREVENTED AND RESIDUAL DAMAGES BELOW LOWER GRAND (NEOSHO) RIVER THREE-LAKE SYSTEM (Based on October 1986 Prices)

Reach and Item	Estimated Avg. Annual Damages (1)	Estimated Avg. Annual Damages Prevented	Estimated Avg. Annual Residual Damages
	$	$	$
On Arkansas River From Grand (Neosho) River to Ft. Smith, Arkansas (2)			
Structures	4,376,000	4,272,000	104,000
Crops	1,367,000	1,045,000	322,000
TOTALS	5,743,000	5,317,000 (3)	426,000

(1) Without upstream reservoirs

(2) Since the tailwater of Pensacola Dam is contiguous with the upper limits of Markham Ferry Reservoir, and since the tailwater of Markham Ferry Dam is contiguous with the upper limits of Fort Gibson Reservoir, and due to the proximity of Fort Gibson Dam to the confluence of the Grand (Neosho) River with the Arkansas River, damages and benefits are insignificant on the Grand (Neosho) River.

(3) Not detailed in totals are $133,000 of Mississippi River flood control benefits allocated to these three lakes.

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological stations.

a. Facilities. The Reservoir Control Section, Hydrology-Hydraulics Branch, Tulsa District Office, the National Weather Service (NWS) and the U.S. Geological Survey (USGS) cooperate to collect data and to maintain a reliable communication network. All pertinent reporting observation stations are shown on plate 5-1. The pool elevation of Pensacola Reservoir is provided by digital and graphic water-stage recorders, in a standard metal half-shelter, over a 12-inch No. 10-gage butt-welded iron pipe stilling well attached to the lake side of pier on the intake structure near the right (west) end of the dam. The inside tape is referenced to the lake datum by adding 715.00 feet to the tape reading. Pertinent elevations:

Bottom of well	710.00	ft. lake datum
Top of pipe	760.00	ft. lake datum
Instrument shelf	761.775	ft. lake datum

The outside gage is a wire-weight gage attached to the left guard rail of the walkway between the dam roadway and the intake structure. Elevation of the check-bar is 758.90 ft. lake datum, or 760.00 ft., Corps of Engineers 1929 Datum. The following stream gages are key stations used in forecasting inflows to Pensacola Reservoir: Burlington, Iola, Chanute, Parsons and Commerce on the Grand (Neosho) River; Waco and Quapaw on the Spring River; Joplin on Shoal Creek; and Tiff City on the Elk River. The key stations for regulation purposes are located on the Arkansas River at Muskogee, Oklahoma, and Van Buren, Arkansas. All these stream gaging stations are automated gages consisting of floatwells or bubble gage manometers geared to digital recorders and data collection platforms. Observer gages are located on smaller streams and at less important stations and generally consist of wire weight gages read by local observers under the instructions of the NWS. The facilities located at each of the key forecasting stations are summarized in the following:

Neosho River at Burlington, Kansas

Gage Type:	Bubble, 50-ft range
Recording:	Stevens ADR digital (reference), Stevens A-35 graphic
Automation:	Sutron DCP, shaft encoder
Rain Gage:	Tipping Bucket
Shelter:	4'x4'x8' steel
Outside Gage:	Type A wire-weight

Neosho River at Iola, Kansas

Gage Type:	Bubble, 50-ft range
Recording:	Stevens digital (reference), Stevens graphic
Automation:	Sutron DCP, shaft encoder
Rain Gage:	Tipping Bucket
Shelter:	4'x4'x8' steel
Outside Gage:	Multiple Staff gages

Neosho River Near Chanute, Kansas

Gage Type:	Bubble, 50-ft range, regular and high level bubble orifices
Recording:	Stevens A-35 graphic
Automation:	Sutron DCP, shaft encoder
Shelter:	4'x4'x8' steel
Outside Gage:	Type A wire-weight

Neosho River Near Parsons, Kansas

Gage Type:	Bubble, 50-ft range
Recording:	Fisher-Porter digital (reference), Stevens A-71 graphic
Automation:	Sutron DCP
Rain Gage:	Tipping Bucket
Shelter:	4'x4'x8' fiberglass
Outside Gage:	Type A wire-weight

Neosho River Near Commerce, Oklahoma

Gage Type:	24" CMP stilling well
Recording:	Stevens 2000 digital
Automation:	Sutron DCP, shaft encoder, solar Panel.
Rain Gage:	Tipping Bucket
Shelter:	Standard half shelter
Outside Gage:	Wire-weight
Auxiliary Gage:	24" stilling well, standard half shelter and encoder, 1000' left of base gage, start operation at about 21', automated by buried cable with base gage.

Spring River Near Waco, Missouri

Gage Type:	18" CMP stilling well
Recording:	Digital
Automation:	Sutron DCP, shaft encoder
Shelter:	Standard half shelter
Outside Gage:	Type A wire-weight

Spring River Near Quapaw, Oklahoma

Gage Type:	Bubble, low, medium, and high orifices.
Recording:	Digital
Automation:	Sutron DCP
Shelter:	Hexagonal metal house
Outside Gage:	Multiple staff gages

Elk River Near Tiff City, Missouri

Gage Type:	Bubble, Low, Middle, and High orifices
Recording:	Digital
Automation:	Sutron DCP, shaft encoder
Rain Gage:	Weathertronics Tipping Bucket
Shelter:	4'x4'x8' metal
Outside Gage:	Wire-weight

b. Reporting. The reporting procedure for precipitation and stream gaging stations is on a cooperative basis with the NWS. The reporting criteria for the pertinent precipitation and stream gaging stations are shown in table 5-1. Hydrometeorological data collected by the dam personnel at Pensacola Reservoir will be submitted to the Reservoir Control Section, Hydrology - Hydraulics Branch, Tulsa District Office, [telephone (918) 581-7666]. Detailed instructions on reporting criteria are presented in paragraph 5-07 and in exhibit F, Standing Instructions to Damtender.

TABLE 5-1

REPORTING CRITERIA FOR STATIONS

STATION	REPORT TO	TIMES OF REPORT
Rainfall Stations		
Airport Stations	National Weather Service	6-hr rainfall as of 6 a.m., 12 noon, 6 p.m., & 12 midnight
Corps of Engineers Dams	Corps of Engineers	Reporting criteria identical to that listed in subparagraph 5.07.
Pensacola Dam	Grand River Dam Authority	
All other stations	National Weather Service	7 a.m. daily, 7 a.m., 1 p.m., 7 p.m. when 0.5 inch has accumulated.
Stream Gaging Stations		
Grand (Neosho) River		
Burlington	Data Collection Platform	Every 4 hrs. or every 15 minutes if threshold exceeded.
Iola	Data Collection Platform	"
Chanute	Data Collection Platform	"
Parsons	Data Collection Platform	"
Commerce	Data Collection Platform	"
Spring River		
Waco	Data Collection Platform	"
Quapaw	Data Collection Platform	"
Shoal Creek		
Joplin	Data Collection Platform	"
Elk River		
Tiff City	Data Collection Platform	"
Observer Stations	National Weather Service	7 a.m. when stage reaches threshold level, 7 p.m. when stage reaches additional threshold level
Radar Stations	National Weather Service	Hourly

c. **Maintenance**. Maintenance and repair of the weather station instrumentation at the dam is the responsibility of the Grand River Dam Authority. Maintenance and repair of weather station instrumentation operated by NWS is the responsibility of the G.R.D.A. The Hydraulic Engineering Section, Hydrology-Hydraulics, Tulsa District, is responsible for equipment owned by the Corps of Engineers.

d. **Automation**. The reporting of data from pool elevation and stream gaging stations has been automated through the use of Data Collection Platform's (DCP's) which record data hourly and transmit the data every four hours. The data is currently transmitted via satellite and downlink to a NOAA-NESS nationwide control computer in Washington, D.C., owned and operated by the National Oceanic and Atmospheric Administration (NOAA). The data is transferred to the Tulsa District water control computer using telephone modems. When received, the river stages are converted to flow, the lake elevations are converted to storage, and all the data is stored in a data base in the water control computer and available to all computers in the Reservoir Control Section. The computer is also connected to the NWS AFOS network which allows access to NWS rainfall data, weather warnings, forecasts, etc. Observer rainfall data is also collected into the computer for use in forecasting. Observers phone the NWS offices in this region and the NWS then encodes the data into a Standard Hydrologic Exchange Format (SHEF). Weather data is then transferred to the Corps water control computer using telephone modems and a dedicated phone line to the Tulsa River Forecast Center. Once the data is received, it is decoded and handled similarly to the DCP data. Informative display of all this data is possible through the use of several versatile computer programs developed for use on the water control computer.

e. **Radar and satellite reports**. Current computer enhanced satellite images, weather charts, and national radar summaries are automatically received into the Reservoir Control Section's water control computer. Also, a computer enhanced image of the real-time radar scope image, depicting cloud coverage and relative intensity is available from the National Weather Service and is routinely received from Oklahoma City. NWS locations with this capability in addition to Oklahoma City, are Kansas City and Monett, Missouri; Garden City and Wichita, Kansas; and Amarillo, Texas. Hard copies of any of this data are available by use of several plotters located in the Reservoir Control Section.

5-02. Water quality stations.

a. **Facilities**. Pertinent water quality stations reporting comprehensive water quality data above and below Pensacola

Reservoir are shown in table 5-2. In addition to the two NASQAN (National Stream Quality Accounting Network) stations shown in table 5-2, water quality monitoring is performed at gaging stations throughout the basin, as follows:

In Kansas, bi-monthly monitoring of specific conductance, temperature and pH is performed at the following gaging stations:

Neosho River at Council Grove
Neosho River near Dunlap
Neosho River near Americus
Cottonwood River below Marion Lake
Cottonwood River at Marion
Cottonwood River near Florence
Cedar Creek near Cedar Point
Cottonwood River near Plymouth
Neosho River at Burlington
Neosho River near Iola

In Oklahoma, several observations of temperature, specific conductance and pH are made during the year at the following gaging stations:

Neosho River near Commerce, Oklahoma
Spring River near Quapaw, Oklahoma
Elk River near Tiff City, Missouri
Neosho River near Langley, below Pensacola Dam

TABLE 5-2

PERTINENT REPORTING WATER QUALITY STATIONS

Name and Location	Station	Type	Recording Non-Recording	Period of Record	Frequency of Sample Analysis	Operating Agency
Neosho River near Parson, Kansas	07183500	Specific (1) Conductance	Recording	1964-1968 1979-1981	Continuous Continuous	USGS USGS
		Temperature (1)	Recording	1963-1968 1979-1981		
		Chemical & Biochemical (2)	Non-Recording	1962 to date	Bi-Monthly	USGS
Neosho River Below Ft. Gibson Dam near Ft. Gibson, Oklahoma	07193500	Specific (1) Conductance	Recording	1951-1963 1973-1982	Continuous	USGS
		Temperature (1)	Recording	1951-1963& 1973-1982	Continuous	USGS
		Chemical & Biochemical (2)	Non-Recording	1952 to date	Bi-Monthly	USGS

NOTES: (1) Continuous recording of Specific Conductance and Temperature has been disconnected and is available only for the periods shown.

(2) Approximately 65 chemical and biochemical analysis are performed bi-monthly as a part of the U.S. Geological Survey's nationwide data collection network, National Stream Quality Accounting Network (NASQAN).

In Missouri, water quality data has been collected intermittently in the period of 1965 to 1982, at the following stations, but is not currently being collected at any locations within the watershed.

Spring River near Waco
Shoal Creek above Joplin

No water quality data is recorded from the lake property or at the dam site. The Tulsa District Office does not perform water quality sampling in the Grand (Neosho), Spring or Elk River basins. All water quality sampling is performed by the U.S. Geological Survey from offices located in the respective states.

b. Reporting. Water quality data is published annually, by state, by the U.S. Geological Survey in a publication entitled "Water Resources Data," having the state and water year included in the title. The NASQAN data for the stations in table 5-2 is published each year in these publications. In the state of Kansas, as of water year 1987, the bimonthly data described in paragraph 5-02(a) is published. In the State of Oklahoma, the observations described in paragraph 5-02(a) are not published, but are available at the U.S. Geological Survey District office. In the State of Missouri, water quality data for the prior years in which data was collected can be obtained from the U.S. Geological Survey District office.

c. Maintenance. Maintenance and repair of the water quality monitoring stations and facilities are the responsibility of the U.S. Geological Survey.

5-03. Sediment stations.

a. Facilities. There is a large volume of sediment data available with the Grand (Neosho), Spring and Elk River basins. In the publication "Sediment Data for Mid-Arkansas and Upper-Red River Basins through 1980, U.S. Geological Survey Open-File Report 83-692," records in the form of tables and graphs for all suspended sediment data collected between 1930 and 1980 are provided. Data has been collected and compiled through the cooperative effort of the U.S. Geological Survey, U.S. Army Corps of Engineers, Tulsa District, and U.S. Department of Agriculture. For purposes of this manual, only the mainstem sediment stations of the Grand (Neosho), Spring and Elk Rivers are being identified, with the period of record shown. Many of the sediment stations listed are currently inactive and stations which are active in 1990 are noted.

- Neosho River, John Redmond Reservoir Near Burlington, Kansas (Lake outflow); 1965-1976.

- Neosho River at Burlington, Kansas; 1944-45, 1961-78, 1980.
- Neosho River near Iola, Kansas; 1940, 1944-49, 1951-52, 1958, 1961.
- Neosho River near Parsons, Kansas; 1958, 1961-62, 1975-80. (Active Station in 1990)
- Neosho River near Commerce, Oklahoma; 1944-50, 1979-80.
- Spring River near Quapaw, Oklahoma; 1944-50.
- Elk River near Tiff City, Missouri; 1944-50
- Neosho River near Chouteau, Oklahoma; 1940-48.
- Neosho River near Wayner, Oklahoma; 1930-31, 1938-48, (inundated since 1953 by Fort Gibson Lake).
- Neosho River below Fort Gibson Lake near Fort Gibson, Oklahoma; 1973-80 (Active Station in 1990).

In addition to the above listed, numerous sediment stations have been located on the Grand (Neosho) and Cottonwood Rivers above John Redmond Reservoir and on tributaries of the Grand (Neosho), Spring and Elk Rivers below John Redmond Reservoir.

b. Reporting. Sediment data has been compiled and published by the U.S. Geological Survey through 1980 in the open-file report identified in paragraph 5-03(a), which is on file with the Tulsa District. Data provided in tables included suspended sediment concentration, in milligrams per liter (mg/l), and suspended sediment discharge, in tons/days, as well as the date, time and discharge at the time of sample collection. The data are shown graphically by plots relating suspended sediment concentration (mg/lt) to water discharge (c.f.s), and where a relationship exists a second plot relating suspended-sediment discharge (tons/day) to water discharge (c.f.s) is provided. This data can also be accessed through the USGS National Water Data Storage and Retrieval System (WATSTORE).

Two sediment stations which were active in 1990, the Parsons, Kansas, and Fort Gibson, Oklahoma, stations are part of the USGS NASQAN system. Sediment data for these stations are published annually, by state, with the water quality data in the USGS "Water Resources Data" publication referenced in paragraph 5-02 (b). At Commerce, Oklahoma, USGS collects sediment samples for analysis and evaluation, but the data is not routinely published.

c. Maintenance. Maintenance and repair of sampling and laboratory facilities is the responsibility of the agency owning and operating the facilities.

5-04. Recording hydrologic data. Hydrologic information is recorded as received by the Reservoir Control Section as follows:

a. Stages and discharges. The raw data which the Water Control Computer receives from the DCP's is stored as it is received. This raw data is then sorted by station and stored again. Several computer programs convert the raw data into stage/pool elevation data and corresponding flow/storage values as determined from rating curves. This processed data is then stored in two data bases. As the data bases fill they are occasionally archived on tape for permanent storage. Stream flow measurements made by the USGS are called in and entered into a computer program for storage.

b. Precipitation. Precipitation data from the DCP stations and the project are combined with NWS observer precipitation data and stored in the data base with the stage/discharge data. This data can then be accessed by computer programs for plotting distribution, determining basin rainfall, and forecasting runoff (see Chapter VI).

c. Water quality data. Water quality data are recorded annually by the USGS and received at the Tulsa District Office in the form of an annual report entitled "Water Resource Data."

d. Weather, satellite, RADAP II and NEXRAD reports. Charts of current and forecasted weather information (developed by the NWS) are posted on the status board for analysis and evaluation. This data includes radar summaries, quantitative precipitation forecasts, etc. Semi-hourly satellite photographs showing cloud coverage and intensity are also available in the Reservoir Control Section. Computer-generated rainfall reports from radar data are currently received from NWS network radar sites which have Radar Data Processor Systems (RADAP II). When NEXRAD products become available, the RADAP II transmissions will cease. Color displays with map background can be produced on a computer terminal which display real-time rainfall intensity areal coverage, and a range of rainfall accumulations for durations of up to 24 hours. Rainfall accumulations are archived for later recall to the CRT or line-printer.

5-05. Communications network. Communications facilities at Pensacola Dam include local (Southwestern Bell) and long distance telephone, and in-house microwave telephone system and two-way radio. Communication with the Tulsa District office is entirely by local and long distance telephone. The GRDA facilities, as well as with other facilities such as Southwestern Power Administration and Keystone Lake, have two-way radios, including three low-frequency bands, a VHF and UHF band, all used to dispatch equipment and other system operations.

Maintenance of local and long distance telephone system is the responsibility of the companies providing service to GRDA. GRDA performs all maintenance on their microwave telephone and radio systems. Their systems are inspected annually and repairs are made as conditions warrant. To alert the public of impending gate changes, warning horns are located at both the main spillway and the east spillways. At both the main structure and at each of the east sections, rotating red lights visible on the lake side, warn boaters of flow being taken through the dam. Additionally, one civil defense siren is located on the west end of the dam and another at the east side of the dam.

In the event of an emergency or disaster, telephone services may become overloaded and unreliable. GRDA has a microwave telephone link to Keystone Lake, which in turn has radio communication with the Tulsa District office, thus providing an alternative means of communication between the Tulsa District office and the Project.

5-06. Communications with project.

a. Regulating office with project office. Instructions for the storage and release of water from the flood control pool at Pensacola Reservoir are communicated by the Reservoir Control Section to the project personnel for the implementation of the provisions set forth in section IX of this manual. This communication will be made by long distance telephone. The reports by the project office, described in paragraph 5-07 and exhibit F of this manual, Standing Instructions to Damtender, will be communicated to the Reservoir Control Section. Should communication between the project and the District office be disrupted, the project personnel will make every reasonable attempt to re-establish communications radio/microwave telephone links (paragraph 5.05) or by any means possible. Until communications are resumed, the responsible person at the project will, on his own initiative, direct regulation of the lake in accordance with the emergency rules of regulations as required in section VII and exhibit F of this manual. A chart, "Organization for Flood Control Regulation - Pensacola Dam and Reservoir," is shown on plate 5-2.

b. Between project office and others. Communication between project personnel and other Federal, State, and local agencies will be sufficient to effect the coordination described in section IX of this manual.

5-07. Project reporting instructions. Daily lake data from the Project Office (example on plate 5-3) will be submitted to the Reservoir Control Section, Hydrology - Hydraulics Branch, Tulsa District, telephone (918) 581-7666. The Reservoir Control

Section is staffed from 7:00 a.m. to 4:30 p.m. daily and at various hours on weekends and holidays. Data for non-working days shall be read from the recorder charts and submitted the following workday. The wire-weight pool elevation gage should be read weekly to verify the accuracy of the recording gage. In the event that unusual conditions arise during non-working hours, one of the persons listed in the Emergency Personnel Roster (see page i) should be contacted. The following data should be included in the daily report.

a. **As of 8 a.m.** Pool elevation at 8 a.m. and for the previous day at 12 noon, 4 p.m., and 12 midnight; 24-hour power discharge; 8 a.m. instantaneous power discharge; height of tainter gates open; precipitation and evaporation in inches for the preceding 24 hours (7 a.m. to 7 a.m.), and wind direction and velocity.

b. **Each gate operation.** Date and time of gate operation, number and height of gates open before and after operation, and reservoir elevation. Confirmation of gate changes shall be made immediately after completion of the changes requested by the Reservoir Control Section. Any malfunction of the spillway gate operating machinery or other circumstances which might impair the discharge capacity of the spillway must be reported to the Reservoir Control Section at once.

c. **During flood periods.** In addition to subparagraphs a and b above, additional reports should be made as instructed by the Reservoir Control Section.

d. **Rainfall reports.** Rainfall reports should be made as follows:

(1) At 8 a.m. all precipitation that occurred during the preceding 24 hours, 7 a.m. to 7 a.m. by six hour increments, as shown on plate 5-3 (covered by routine report on working days).

(2) At 1 p.m. whenever 1 inch or more precipitation has occurred since 7 a.m. or if it has continued to rain since reporting at 8 a.m.

(3) At 7 p.m. whenever 1 inch or more precipitation has occurred since 8 a.m. report and no 1 p.m. report was made, or if it has continued to rain since reporting at 1 p.m.

(4) Report at once the occurrence of 2.00 inches or more precipitation that occurs during a period of six hours or less. During non-working hours, the report should be made to one of the Reservoir Control Section Personnel, in the order listed on the Emergency Personnel Roster (see page i).

(5) During non-working hours, rainfall reports should be made as indicated in (4) above. In addition, rainfall reports should be made to the NWS, Tulsa, Oklahoma (telephone 1-800-722-2778).

5-08. Warnings. It is the responsibility of the Grand River Dam Authority to provide warning when release conditions are expected that could produce severe property damage or be potentially dangerous to life. Technical information and support will be provided by the Corps of Engineers as described in the Letter of Understanding (see exhibit B). The project personnel authorized to make gate changes will maintain a list of current residents and property which could be endangered or inconvenienced by large or prolonged releases (exceeding channel capacity) and give them adequate warning of such impending releases. Notification will be made by whatever means available and may require use of media such as radio, television, telephone, citizen band radio, use of the law enforcement and civil defense agencies and their communication systems, National Guard and reserve units. The Emergency Action Plan for Pensacola Dam prepared by GRDA contains instructions for notifying downstream interests and the media during flood emergencies. In every case when a change in flood release rate is made, a warning horn is blown to give warning to people immediately downstream who are within hearing distance of the horn blast.

5-09. Frequency of gate changes. During flood periods, gate changes may be directed by the Reservoir Control Section at any time. When the floodwaters have significantly risen into the flood control pool, gate changes can be expected two or three times daily. When the pool level is at or near the top of the flood control pool, gate changes may occur every hour. Only under the most unusual circumstances will gate changes be ordered more frequently than once every hour.

VI - HYDROLOGIC FORECASTS

6-01. General. Hydrologic forecasts are necessary in predicting streamflow above and below Pensacola Dam and Reservoir to determine what releases should be made.

a. Role of Corps of Engineers. Hydrologic forecasts are prepared by the Hydrologic Engineering Section, Tulsa District. It is the responsibility of the Reservoir Control Section to evaluate the forecasts and to utilize them in the regulation of lakes for flood control and other authorized purposes and for the benefit of Corps of Engineers' construction projects and flood control activities. The District furnishes information to the public on current and forecasted lake levels and lake releases, weather, streamflow, or other available information on observed conditions along with technical advice. The District does not provide weather forecasts or flood forecasts to the public except to relay information already made available by the National Weather Service. On weekdays the Reservoir Control Section prepares a telephone recording (918-581-7662) to provide the public a means of obtaining current lake information on pool levels, releases and rising and falling conditions of the lakes. General news releases are made by the Public Affairs Office, Tulsa District, which is kept fully informed of hydrologic situations when appropriate. Further discussion of Corps of Engineers hydrologic forecasting is presented in section V of the Water Control Master Manual for the Arkansas River Basin.

b. Role of other agencies. The National Weather Service, Oklahoma City, Oklahoma, is the agency responsible for making flood forecast information available to the public. This information is disseminated to the Corps of Engineers and other subscribing Government agencies and the various news media through the NWS Automated Field Operations System (AFOS). 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 - two 6-hour, one 24-hour and one 48-hour quantitative precipitation forecast).

(4) Three-day river stage forecasts (when available).

(5) Rainfall required to produce bankfull stages (weekly).

(6) Urgent priority messages such as severe weather warnings, watches, forecasts, and statements and instructions from Civil Defense during emergency conditions are transmitted immediately, regardless of scheduled traffic. Unscheduled traffic, including the following, is sent any time the circuit is idle.

(a) Damage reports.

(b) Road information and winter weather conditions.

(c) River and flood warning bulletins, forecasts, and statements.

(d) Thirty-day forecasts.

(7) Percent chance of precipitation (twice daily).

6-02. Flood condition forecasts.

a. Requirements. Flood conditions forecasts are necessary whenever substantial rainfall has fallen on the basin above or below Pensacola Dam. The requirements for timely and accurate inflow forecasts will vary depending on the severity of the storm and the condition of the reservoir.

b. Methods. The Hydrologic Engineering Section makes individual lake inflow forecasts and forecasts of flow for the uncontrolled areas below the dams. These forecasts are made using the computer program HEC-1F.

(1) Forecasting river stages. The official forecast of river stages for dissemination to the public are made by the NWS. Forecasts are confirmed by the Reservoir Control Section for its own use by applying the peak flow determined by the procedures described below to stage-discharge curves.

(2) Forecasting flows. Separate computer models exist for the drainage area above Pensacola Dam and for the Arkansas River above the Van Buren, Arkansas gage. These models are used separately or together to predict inflow to Pensacola Reservoir and/or flows at downstream control points.

(a) Runoff estimate. Precipitation data is received from the NWS, automated stream gages and the project offices. Estimates of the average precipitation over each model subarea are made from computer generated displays of this data. Precipitation data from data collection platforms is automatically collected and stored in the computer. Rainfall amounts and distributions from the Oklahoma City, Oklahoma, and Wichita, Kansas, radar images are used to improve the basin average rainfall. After reviewing the rainfall data from all

available sources and adjusting the information as necessary, the data is used in the forecast models. The first estimate of runoff is made by judgement since the inflow models are easily changed to conform to subsequent flow and inflow reports.

(b) Computer Model. The HEC-1F model for Pensacola Reservoir consists of eight subareas as shown on plate 6-1. Runoff from the eight subareas is combined and routed into and through the lake by storage routing. A sample of the input is shown in exhibit E.

(c) Inflow computations. Computation of the inflow and pool elevations is accomplished by the HEC-1F computer model. Input requirements are runoff, or rainfall and loss rates, initial base flow if any, starting pool elevation, and controlled releases. The model is run interactively on the Water Control Data System computer network located in the Hydrology and Hydraulics Branch of the Tulsa District office. The model is also available on tape which can be loaded on a compatible computer in the Tulsa District Data Processing Center or on the SWD WCDS computer. The tape is used as a backup if the primary computer is down. A sample of the summary output is shown in exhibit E. After the actual pool elevation is reported by the project, the observed inflow is computed and compared to the predicted inflow hydrograph for the lake which is adjusted as necessary to conform with the developing observed inflow hydrograph.

6-03. Conservation purpose forecasts.

a. Requirements. Conservation forecasts may be required to predict pool levels during droughts, fish spawning season, recreation events, and water supply withdrawals. Forecasts may also be required for water quality.

b. Methods. Forecasts for conservation purposes during the non-flood periods would rely largely on statistical interpretation of historical data. Estimated flows at the damsite under natural conditions for the period January 1923 through December 1988, shown in table 4-2, the flow duration curve, plate 4-6, and the inflow probability curve (natural river conditions, plate 8-5), would be considered in conjunction with NWS forecast in making conservation forecasts during non-flood periods.

6-04. Long-range forecasts.

a. Requirements. A foreknowledge of the water volume to be handled would facilitate decisions involved in evacuating stored floodwater, sustaining yield during low flow periods, and maintaining constant or slowly changing pool levels for conservation purposes.

b. Methods. Reliable methods for long-range runoff forecasts are not presently available. The NWS publishes an "Average Monthly Weather Outlook" semimonthly 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 6-01b are more useful in a shorter range.

VII - WATER CONTROL PLAN

7-01. General objectives. The primary objectives of Pensacola Reservoir are flood control and hydroelectric power production. The flood control operations of Pensacola Reservoir are directed by the Secretary of the Army through the U.S. Army Corps of Engineers, and operated by the Grand River Dam Authority (G.R.D.A.). For flood control, the normal procedure assumes operation of Pensacola, Markham Ferry, and Ft. Gibson reservoirs as a system of reservoirs, utilizing similar percentages of the flood control storage in each project. This system of reservoirs is operated in conjunction with the remaining reservoirs in the Arkansas River basin to provide maximum benefits as described as method "A" in paragraph 3-03c(2)(b) of EM 1110-02-3600, 30 November 1987.

7-02. Major constraints. The spillway capacity is about 192,000 c.f.s. at elevation 745.0 (top of conservation pool) and about 525,000 c.f.s. at elevation 755.0 (top of flood control pool). The spillway crest elevation is 740.0 for the east spillways and 730.0 for the main spillway. The downstream channel capacity is estimated to be about 100,000 c.f.s. Discharges in excess of 130,000 c.f.s. overtop the roadway approach to the Highway 82 bridge over the Grand (Neosho) River south of Langley, Oklahoma. Releases of about 230,000 c.f.s., while well above bank full, would not inundate property not covered by a flowage easement. Channel capacity on the Grand (Neosho) downstream of Fort Gibson is 100,000 c.f.s. The system constraint is at Van Buren, Arkansas, where the channel capacity varies but is presently about 125,000 c.f.s.

7-03. Overall plan for water control.

a. General. Pensacola Reservoir is regulated as a unit in a multipurpose system for the benefit of water resources in the Arkansas River Basin. Development of these water resources is discussed in the Arkansas River Basin Water Control Master Manual, while the specific purposes of each of the various projects are detailed in the appropriate appendix. The specific objectives and regulation procedures for the various project purposes at Pensacola are discussed in the following paragraphs.

b. System regulation. Pensacola Reservoir is a component of the Grand (Neosho) River - Arkansas River Flood Control System to control floods on the lower Grand (Neosho) River and on the Arkansas River from Muskogee, Oklahoma, to Van Buren, Arkansas. Pensacola, Markham Ferry, and Ft. Gibson Reservoirs are regulated as a subsystem of the Arkansas River System, with similar percentages of the total flood control storage in each

project utilized during periods of high inflow. The system will be balanced by percentage of flood control storage utilized during evacuation as well. Situations may arise which require deviation from the normal procedure. Significant deviations will be approved by Southwestern Division. Priority for releases, as shown on curve "A" of plate 7-54 of the Arkansas River Basin Water Control Master Manual, will be given to the lakes with the least amount of flood storage available, considering predicted inflow into the lake and conditions downstream. During nonflood situations, the generation of hydropower is under the control of the G.R.D.A.

7-04. Standing instructions to project personnel. During flood periods the lake will be regulated in accordance with the normal regulations for flood control as directed in subparagraph 7-05 (a) of this manual. Instructions for the storage and discharge of flood water will be issued by the Reservoir Control Section. In the event communication with the Tulsa District is disrupted, the lake regulation will become the responsibility of the G.R.D.A. personnel at Pensacola Dam. The Pensacola Dam personnel will, on their own initiative, direct operation of the reservoir in accordance with the following rules of operation until communication is restored. In addition, the Pensacola Dam personnel will immediately make every effort possible to re-establish communications with the Tulsa District Office, and if necessary send information to the District Office by automobile or other means of transportation. The project personnel will make daily observations of the weather station and report those observations. Should an emergency exist, such as inoperable gates, drowning accident, excessive trash in the gates, broken buoy line, or power outage, the Reservoir Control Section will be notified immediately.

7-05. Flood Control.

a. Normal Flood Control Regulations. Table 7-1 shows the normal flood control regulations for Pensacola Reservoir. These regulations are used by the Reservoir Control Section when communication with Pensacola Dam is not disrupted.

b. Emergency Flood Control Regulations. Should communication with the Tulsa District office be disrupted, the Pensacola Dam personnel will, on their own initiative, direct operation of the reservoir in accordance with the instructions shown in table 7-2 until communication is restored. In addition, the Pensacola Dam personnel will immediately make every effort possible to re-establish communications with the District Office, and if necessary send information to the District Office by automobile or other means of transportation.

c. **Constraints**. There are two hoists to operate the main spillway gates and two hoists for the east spillway gates. For the main spillway gates, it takes fifteen minutes to raise one gate, three minutes to disconnect and two minutes to move to the next gate and connect. For the east spillway gates, it takes ten minutes to raise one gate, three minutes to disconnect and two minutes to move to the next gate and connect. The power supply can accommodate all four hoists operating at once and auxiliary power from an emergency generator is also available. Spillway warning sirens are installed and operated at each increased discharge operation.

7-06. Recreation. Recreation is not an authorized project purpose although there are tremendous recreation opportunities on Pensacola Reservoir. Whenever spillway releases are cut off, many fish become stranded in the spillway exit channels in numerous holes and shallows. Catching those stranded fish by hand is a very popular sporting event. To accommodate the public interest in this activity, the Reservoir Control Section tries to notify the NWS at least one day prior to the gate closings. The NWS in turn makes a notice of the scheduled gate closings available to the news media via AFOS.

7-07. Water Quality. Water quality is not a project purpose.

TABLE 7-1
NORMAL FLOOD CONTROL REGULATION SCHEDULE
PENSACOLA RESERVOIR OF GRAND (NEOSHO) RIVER, OKLAHOMA AND ARKANSAS

Lake Stage	Pool Condition	Regulations
Below 745.0	Rising	Hydropower released will be made by G.R.D.A. to meet its power requirements. If the pool is forecasted to exceed elevation 745, the Corps may direct that flood control releases be made, provided that there is a sufficient volume of water indicated by stages at the upstream gages to fill the power pool.
745.0 - 755.0 & forecasted not to exceed 755.0	Rising	Release will not exceed 100,000 c.f.s. below the dam and will be made in such a manner as to balance, as much as practical and within a reasonable time, the percentage of the flood control storage utilized in Pensacola Reservoir, Markham Ferry Reservoir, and Fort Gibson Lake.
745.0-755.0 & forecasted to exceed 755.0	Rising	Releases will be made to reduce as much as practical the flood damage below the dam and to limit the pool elevation to 755.0. Plate 7-1, Spillway Gate Regulation Schedule Inflow Parameter, may be used as a guide to determine releases.
755.0 or above *	Rising	Spillway gates will be opened to maintain the pool at elevation 755.0 or until all the gates are fully open.
755.0 or above *	Falling	The maximum discharge attained shall be held until the pool recedes to elevation 755.0.
745.0 - 755.0	Falling	Releases will not exceed 100,000 c.f.s. and will be made in such a manner as to balance the percent of the flood control storage utilized in the 3-reservoir system. Evacuation of the flood control storage in this system will be governed by the provisions of Chapter 7 of the Arkansas River Basin Master Manual.

***NOTE:** The Grand River Dam Authority (GRDA) is responsible for regulation above elevation 755.0. The Corps will provide technical assistance if requested.

TABLE 7-2
EMERGENCY FLOOD CONTROL REGULATION SCHEDULE
PENSACOLA RESERVOIR OF GRAND (NEOSHO) RIVER, OKLAHOMA AND ARKANSAS

Lake Stage	Pool Condition	Regulations
Below 745.0	Rising	Continue the releases being made at the time communication is lost.
745.0 - 755.0	Rising	Maintain releases being made until communication is restored or 12 hours have elapsed. If communication is not restored after 12 hours or the pool rises to elevation 752.5 during the 12 hour waiting period, determine average 6-hour discharge using Plate 7-3 (Discharge Rating Curves-Main Spillway) and Plate 7-4 (Discharge Rating Curves-East Spillway). Proceed to Plate 7-2 (Inflow vs. Rate of Rise-Nomograph) to determine inflows and then proceed to Plate 7-1 (Spillway Gate Regulation Schedule) to determine outflows. At no time shall releases be reduced if the pool is rising. If the pool is above 752.5, the releases shall not be less than indicated by the minimum discharge curve on plate 7-1.
755.0 or above	Rising	Spillway gates will be opened as necessary to maintain the pool at elevation 755.0 or until all gates are fully opened.
755.0 or above	Falling	The maximum discharge attained shall be held until the pool recedes to elevation 755.0.
755.0 - 752.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 100,000 c.f.s. whichever is greater.
752.5 - 750.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 60,000 c.f.s. whichever is greater.
750.0 - 747.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 40,000 c.f.s. whichever is greater.
747.5 - 745.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 20,000 c.f.s. whichever is greater.
Near 745.0		Releases shall be gradually reduced to equal inflow by the time the pool recedes to elevation 745.0.

7-08. Fish and Wildlife. Fish and Wildlife is not a project purpose although Pensacola Reservoir provides a good habitat for both fish and wildlife.

7-09. Water Supply. The Grand River Dam Authority is responsible for all water supply contracts for Pensacola Reservoir.

7-10. Water Rights. The Grand River Dam Authority is responsible for water rights in the Grand (Neosho) River including Pensacola Reservoir.

7-11. Hydroelectric Power. Hydroelectric power generation at Pensacola Reservoir is under the supervision of the Grand River Dam Authority. Flow through the turbines may be restricted when in the judgement of the Corps of Engineers curtailment of power generation will make a significant contribution to alleviating flood damages.

7-12. Navigation. Authority for operating Pensacola Reservoir to benefit navigation is confirmed by a recent (October 1989) review of statutory authorities by Office of Counsel, Department of the Army. Pensacola Reservoir is an integral element of the overall plan of development for the Arkansas River basin, and is operated in accordance with the Arkansas River Basin Master Manual to benefit navigation.

7-13. Sedimentation. There are no regulation procedures for sediment control.

7-14. Deviation From Normal Regulation. In many cases it may be prudent to deviate from the normal regulation of the lake. Prior approval for deviation is obtained from the Southwestern Division Office (SWD) except as noted in subparagraph a below. Deviation requests usually fall into the following categories:

a. Emergencies. Some emergencies that may occur are drownings and other accidents, failure of operation facilities, fishkills, and flushing of pollution. Necessary action under emergency conditions is taken immediately when in the judgement of the District it will alleviate or improve the condition. The Southwestern Division is informed as soon as practicable. A written confirmation showing the deviation and conditions will be furnished to CESWD-ED-WR (Form SWD 898) as shown on Plate 7-6.

b. **Unplanned minor deviations.** There are unplanned instances that create a temporary need for minor deviations from the normal regulation of the lake, although they are not considered emergencies. Construction accounts for the major portion of the incidents and includes utility stream crossings, bridge work, and major construction contracts. Changes in releases are sometimes necessary for maintenance and inspection. Requests for changes of releases rates are generally from a few hours to a few days. Each request is analyzed on its own merits. Consideration is given to upstream watershed conditions, potential flood threat, conditions of lakes, and possible alternative measures. Approval for these minor deviations will normally be obtained from SWD by telephone. A written confirmation showing the deviation and condition will be furnished to CESWD-ED-WR (Form SWD 898) as shown on Plate 7-6.

c. **Planned deviations.** Each deviation request should be analyzed on its merits. Sufficient data on flood potential, lake and watershed conditions, possible alternative measures, benefits to be expected, and probable effects on other authorized and useful purposes will be presented by letter, telephone or teletype to Southwestern Division along with recommendations for review and approval.

7-15. Rate of release change. The increase and decrease in releases from the lake shall be accomplished in a manner which minimizes damage to the reservoir area and downstream channel, generally as shown in table 7-3. Every reasonable precaution will be made to eliminate bank sloughing, undercutting, excessive erosion, and danger to human and animal lives, if possible. Situations will arise which will not allow orderly increases or decreases in releases. Examples of these situations are large flood releases as described in paragraph 7-05, and drownings which occur downstream of the dam.

TABLE 7-3
RELEASE RATE CHANGES

Increasing Releases to Channel Capacity (1)

Current release range (c.f.s.)	Maximum increase (c.f.s.)	Minimum time between changes (hours) (2)
0 - 100,000	17,000	2

Current release range (c.f.s.)	Maximum decrease (c.f.s.)	Minimum time between changes (hours) (2)
100,000 - 0	17,000	3

(1) See paragraph 7-05(a) for releases that will exceed channel capacity and also decrease in releases above channel capacity.
(2) A maximum of 3 gate changes per day.

7-16. Operational Curves. The Spillway Gate Regulation Schedule-Inflow Parameter is shown on plate 7-1. The "Inflow vs. Rate-of-Rise Nomograph" is shown on plate 7-2. The spillway discharge rating curves are shown on plates 7-3 and 7-4. Evaporation curves are shown on plate 7-5. Elevation versus capacity data are compiled in table 7-4 and shown on pages 7-12 through 7-23. Rating curves used by the Reservoir Control Section are adjusted for changing conditions and are maintained in current status.

TABLE 7-4

ELEVATION VERSUS STORAGE CAPACITY DATA

PENSACOLA RESERVOIR

CAPACITY IN 1,000 ACRE-FEET

MARCH 12, 1949

POOL ELEVATION FT. (MSL)	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
714.0	655.6	655.8	656.0	656.3	656.5	656.7	656.9	657.2	657.4	657.6
714.1	657.8	658.0	658.3	658.5	658.7	658.9	659.2	659.4	659.6	659.8
714.2	660.0	660.3	660.5	660.7	660.9	661.2	661.4	661.6	661.8	662.0
714.3	662.3	662.5	662.7	662.9	663.2	663.4	663.6	663.8	664.0	664.3
714.4	664.5	664.7	664.9	665.2	665.4	665.6	665.8	666.0	666.3	666.5
714.5	666.7	666.9	667.1	667.4	667.6	667.8	668.0	668.3	668.5	668.7
714.6	668.9	669.1	669.4	669.6	669.8	670.0	670.3	670.5	670.7	670.9
714.7	671.1	671.4	671.6	671.8	672.0	672.3	672.5	672.7	672.9	673.1
714.8	673.4	673.6	673.8	674.0	674.3	674.5	674.7	674.9	675.1	675.4
714.9	675.6	675.8	676.0	676.3	676.5	676.7	676.9	677.1	677.4	677.6
715.0	677.8	678.0	678.3	678.5	678.7	678.9	679.2	679.4	679.6	679.9
715.1	680.1	680.3	680.5	680.8	681.0	681.2	681.5	681.7	681.9	682.1
715.2	682.4	682.6	682.8	683.0	683.3	683.5	683.7	684.0	684.2	684.4
715.3	684.6	684.9	685.1	685.3	685.6	685.8	686.0	686.2	686.5	686.7
715.4	686.9	687.2	687.4	687.6	687.8	688.1	688.3	688.5	688.7	689.0
715.5	689.2	689.4	686.7	689.9	690.1	690.3	690.6	690.8	691.0	691.3
715.6	691.5	691.7	691.9	692.2	692.4	692.6	692.9	693.1	693.3	693.5
715.7	693.8	694.0	696.2	694.4	694.7	694.9	695.1	695.4	695.6	695.8
715.8	696.0	696.3	696.5	696.7	697.0	697.2	697.4	697.6	697.9	698.1
715.9	698.3	698.6	698.8	699.0	699.2	699.5	699.7	699.9	700.1	700.4
716.0	700.6	700.8	701.1	701.3	701.5	701.8	702.0	702.2	702.5	702.7
716.1	702.9	703.2	703.4	703.6	703.9	704.1	704.3	704.6	704.8	705.1
716.2	705.3	705.5	705.8	706.0	706.2	706.5	706.7	706.9	707.2	707.4
716.3	707.6	707.9	708.1	708.3	708.6	708.8	709.0	709.3	709.5	709.7
716.4	710.0	710.2	710.4	710.7	710.9	711.1	711.4	711.6	711.8	712.1

716.5	712.3	712.5	712.8	713.0	713.2	713.5	713.7	713.9	714.2	714.4
716.6	714.6	714.9	715.1	715.3	715.6	715.8	716.0	716.3	716.5	716.8
716.7	717.0	717.2	717.5	717.7	717.9	718.2	718.4	718.6	718.9	719.1
716.8	719.3	719.6	719.8	720.0	720.3	720.5	720.7	721.0	721.2	721.4
716.9	721.7	721.9	722.1	722.4	722.6	722.8	723.1	723.3	723.5	723.8
717.0	724.0	724.2	724.5	724.7	725.0	725.2	725.4	725.7	725.9	726.2
717.1	726.4	726.6	726.9	727.1	727.4	727.6	727.8	728.1	728.3	728.6
717.2	728.8	729.0	729.3	729.5	729.8	730.0	730.2	730.5	730.7	731.0
717.3	731.2	731.4	731.7	731.9	732.2	732.4	732.6	732.9	733.1	733.4
717.4	733.6	733.8	734.1	734.3	734.6	734.8	735.0	735.3	735.5	735.8
717.5	736.0	736.2	736.5	736.7	737.0	737.2	737.4	737.7	737.9	738.2
717.6	738.4	738.6	738.9	739.1	739.4	739.6	739.8	740.1	740.3	740.6
717.7	740.8	741.0	741.3	741.5	741.8	742.0	742.2	742.5	742.7	743.0
717.8	743.2	743.4	743.7	743.9	744.2	744.4	744.6	744.9	745.1	745.4
717.9	745.6	745.8	746.1	746.3	746.6	746.8	747.0	747.3	747.5	747.8
718.0	748.0	748.2	748.5	748.7	749.0	749.2	749.5	749.7	750.0	750.2
718.1	750.4	750.7	750.9	751.2	751.4	751.7	751.9	752.2	752.4	752.7
718.2	752.9	753.1	753.4	753.6	753.9	754.1	754.4	754.6	754.9	755.1
718.3	755.4	755.6	755.8	756.1	756.3	756.6	756.8	757.1	757.3	757.6
718.4	757.8	758.0	758.3	758.5	758.8	759.0	759.3	759.5	759.8	760.0
718.5	760.2	760.5	760.7	761.0	761.2	761.5	761.7	762.0	762.2	762.5
718.6	762.7	762.9	763.2	763.4	763.7	763.9	764.2	764.4	764.7	764.9
718.7	765.2	765.4	765.6	765.9	766.1	766.4	766.6	766.9	767.1	767.4
718.8	767.6	767.8	768.1	768.3	768.6	768.8	769.1	769.3	769.6	769.8
718.9	770.0	770.3	770.5	770.8	771.0	771.3	771.5	771.8	772.0	772.3
719.0	772.5	772.8	773.0	773.2	773.5	773.8	774.0	774.2	774.5	774.8
719.1	775.0	775.2	775.5	775.8	776.0	776.2	776.5	776.8	777.0	777.2
719.2	777.5	777.8	778.0	778.2	778.5	778.8	779.0	779.2	779.5	779.8
719.3	780.0	780.2	780.5	780.8	781.0	781.2	781.5	781.8	782.0	782.2
719.4	782.5	782.8	783.0	783.2	783.5	783.8	784.0	784.2	784.5	784.8
719.5	785.0	785.2	785.5	785.8	786.0	786.2	786.5	786.8	787.0	787.2
719.6	787.5	787.8	788.0	788.2	788.5	788.8	789.0	789.2	789.5	789.8
719.7	790.0	790.2	790.5	790.8	791.0	791.2	791.5	791.8	792.0	792.2
719.8	792.5	792.8	793.0	793.2	793.5	793.8	794.0	794.2	794.5	794.8
719.9	795.0	795.2	795.5	795.8	796.0	796.2	796.5	796.8	797.0	797.2

720.0	797.5	797.8	798.0	798.3	798.5	798.8	799.0	799.3	799.6	799.8
720.1	800.1	800.3	800.6	800.8	801.1	801.4	801.6	801.9	802.1	802.4
720.2	802.6	802.9	803.2	803.4	803.7	803.9	804.2	804.4	804.7	805.0
720.3	805.2	805.5	805.7	806.0	806.2	806.5	806.8	807.0	807.3	807.5
720.4	807.8	808.0	808.3	808.6	808.8	809.1	809.3	809.6	809.8	810.1
720.5	810.4	810.6	810.9	811.1	811.4	811.6	811.9	812.1	812.4	812.7
720.6	812.9	813.2	813.4	813.7	813.9	814.2	814.5	814.7	815.0	815.2
720.7	815.5	815.7	816.0	816.3	816.5	816.8	817.0	817.3	817.5	817.8
720.8	818.1	818.3	818.6	818.8	819.1	819.3	819.6	819.9	820.1	820.4
720.9	820.6	820.9	821.1	821.4	821.7	821.9	822.2	822.4	822.7	822.9
721.0	823.2	823.5	823.7	824.0	824.3	824.5	824.8	825.0	825.3	825.6
721.1	825.8	826.1	826.4	826.6	826.9	827.2	827.4	827.7	828.0	828.2
721.2	828.5	828.7	829.0	829.3	829.5	829.8	830.1	830.3	830.6	830.9
721.3	831.1	831.4	831.6	831.9	832.2	832.4	832.7	833.0	833.2	833.5
721.4	833.8	834.0	834.3	834.6	834.8	835.1	835.3	835.6	835.9	836.1
721.5	836.4	836.7	836.9	837.2	837.5	837.7	838.0	838.2	838.5	838.8
721.6	839.0	839.3	839.6	839.8	840.1	840.4	840.6	840.9	841.2	841.4
721.7	841.7	841.9	842.2	842.5	842.7	843.0	843.3	843.5	843.8	844.1
721.8	844.3	844.6	844.8	845.1	845.4	845.6	845.9	846.2	846.4	846.7
721.9	847.0	847.2	847.5	847.8	848.0	848.3	848.5	848.8	849.1	849.3
722.0	849.6	849.9	850.1	850.4	850.7	851.0	851.2	851.5	851.8	852.0
722.1	852.3	852.6	852.9	853.1	853.4	853.7	853.9	854.2	854.5	854.7
722.2	855.0	855.3	855.6	855.8	856.1	856.4	856.6	856.9	857.2	857.5
722.3	857.7	858.0	858.3	858.5	858.8	859.1	859.4	859.6	859.9	860.2
722.4	860.4	860.7	861.0	861.3	861.5	861.8	862.1	862.3	862.6	862.9
722.5	863.2	863.4	863.7	864.0	864.2	864.5	864.8	865.0	865.3	865.6
722.6	865.9	866.1	866.4	866.7	866.9	867.2	867.5	867.8	868.0	868.3
722.7	868.6	868.8	869.1	869.4	869.7	869.9	870.2	870.5	870.7	871.0
722.8	871.3	871.6	671.8	872.1	872.4	872.6	872.9	873.2	873.4	873.7
722.9	874.0	874.3	874.8	874.8	875.1	875.3	875.6	875.9	876.2	876.4
723.0	876.7	877.0	877.3	877.5	877.8	878.1	878.4	878.6	878.9	879.2
723.1	879.5	879.8	880.0	880.3	880.6	880.9	881.1	881.4	881.7	882.0
723.2	882.3	882.3	882.5	882.8	883.1	883.4	883.6	884.2	884.5	884.8
723.3	885.0	885.0	885.3	885.6	886.2	886.4	886.7	887.0	887.3	887.5
723.4	887.8	888.1	888.4	888.7	888.9	889.2	889.5	889.8	890.0	890.3
723.5	890.6	890.9	891.2	891.4	891.7	892.0	892.3	892.5	892.8	893.1

723.6	893.4	893.7	893.9	894.2	894.5	894.8	895.0	895.3	895.6	895.9
723.7	896.2	896.4	896.7	897.0	897.3	897.6	897.8	898.1	898.4	898.7
723.8	898.9	899.2	899.5	899.8	900.1	900.3	900.6	900.9	901.2	901.4
723.9	901.7	902.0	902.3	902.6	902.8	903.1	903.4	903.7	903.9	904.2
724.0	904.5	904.8	905.1	905.4	905.6	905.9	906.2	906.5	906.8	907.1
724.1	907.4	907.6	907.9	908.2	908.5	908.8	909.1	909.4	909.6	909.9
724.2	910.2	910.5	910.8	911.1	911.4	911.6	911.9	912.2	912.5	912.8
724.3	913.1	913.4	913.7	913.9	914.2	914.5	914.8	915.1	915.4	915.7
724.4	915.9	916.2	916.5	916.8	917.1	917.4	917.7	917.9	918.2	918.5
724.5	918.8	919.1	919.4	919.7	919.9	920.2	920.5	920.8	921.1	921.4
724.6	921.7	921.9	922.2	922.5	922.8	923.1	923.4	923.7	923.9	924.2
724.7	924.5	924.8	925.1	925.4	925.7	926.0	926.2	926.5	926.8	927.1
724.8	927.4	927.7	928.0	928.2	928.5	928.8	929.1	929.4	929.7	930.0
724.9	930.2	930.5	930.8	931.1	931.4	931.7	932.0	932.2	932.5	932.8
725.0	933.1	933.4	933.7	934.0	934.3	934.6	934.9	935.2	935.4	935.7
725.1	936.0	936.3	936.6	936.9	937.2	937.5	937.8	938.1	938.4	938.7
725.2	939.0	939.3	939.5	939.8	940.1	940.4	940.7	941.0	941.3	941.6
725.3	941.9	942.2	942.5	942.8	943.1	943.4	943.6	943.9	944.2	944.5
725.4	944.8	945.1	945.4	945.7	946.0	946.3	946.6	946.9	947.2	947.5
725.5	947.8	948.0	948.3	948.6	948.9	949.2	949.5	949.8	950.1	950.4
725.6	950.7	951.0	951.3	951.6	951.9	952.1	952.4	952.7	953.0	953.3
725.7	953.6	953.9	954.2	954.5	954.8	955.1	955.4	955.7	956.0	956.2
725.8	956.5	956.8	957.1	957.4	957.7	958.0	958.3	958.6	958.9	959.2
725.9	959.5	959.8	960.1	960.3	960.6	960.9	961.2	961.5	961.8	962.1
726.0	962.4	962.7	963.0	963.3	963.6	963.9	964.2	964.5	964.8	965.1
726.1	965.4	965.7	966.0	966.3	966.6	966.9	967.2	967.5	967.8	968.1
726.2	968.4	968.7	969.0	969.3	969.6	969.9	970.2	970.5	970.8	971.1
726.3	971.4	971.7	972.0	972.3	972.6	972.9	973.2	973.5	973.8	974.1
726.4	974.4	974.7	975.0	975.3	975.6	975.9	976.2	976.5	976.8	977.1
726.5	977.4	977.7	978.0	978.3	978.6	978.9	979.2	979.5	979.8	980.1
726.6	980.4	980.7	981.0	981.3	981.6	981.9	982.2	982.5	982.8	983.1
726.7	983.4	983.7	984.0	984.3	984.6	984.9	985.2	985.5	985.8	986.1
726.8	986.4	986.7	987.0	987.3	987.6	987.9	988.2	988.5	988.8	989.1
726.9	989.4	989.7	990.0	990.3	990.6	990.9	991.2	991.5	991.8	992.1

727.0	992.4	992.7	993.0	993.3	993.6	993.9	994.2	994.5	994.9	995.2
727.1	995.5	995.8	996.1	996.4	996.7	997.0	997.3	997.6	997.9	998.2
727.2	998.5	998.8	999.2	999.5	999.8	1,000.1	1,000.4	1,000.7	1,001.0	1,001.3
727.3	1,001.6	1,001.9	1,002.2	1,002.5	1,002.8	1,003.1	1,003.5	1,003.8	1,004.1	1,004.4
727.4	1,004.7	1,005.0	1,005.3	1,005.6	1,005.9	1,006.2	1,006.5	1,006.8	1,007.1	1,007.4
727.5	1,007.8	1,008.1	1,008.4	1,008.7	1,009.0	1,009.3	1,009.6	1,009.9	1,010.2	1,010.5
727.6	1,010.8	1,011.1	1,011.4	1,011.7	1,012.0	1,012.4	1,012.7	1,013.0	1,013.3	1,013.6
727.7	1,013.9	1,014.2	1,014.5	1,014.8	1,015.1	1,015.4	1,015.7	1,016.0	1,016.3	1,016.7
727.8	1,017.0	1,017.3	1,017.6	1,017.9	1,018.2	1,018.5	1,018.8	1,019.1	1,019.4	1,019.7
727.9	1,020.0	1,020.3	1,020.6	1,021.0	1,021.3	1,021.6	1,021.9	1,022.2	1,022.5	1,022.8
728.0	1,023.1	1,023.4	1,023.7	1,024.0	1,024.4	1,024.7	1,025.0	1,025.3	1,025.6	1,025.9
728.1	1,026.2	1,026.6	1,026.9	1,027.2	1,027.5	1,027.8	1,028.1	1,028.4	1,028.8	1,029.1
728.2	1,029.4	1,029.7	1,030.0	1,030.3	1,030.6	1,031.0	1,031.3	1,031.6	1,031.9	1,032.2
728.3	1,032.5	1,032.8	1,033.1	1,033.5	1,033.8	1,034.1	1,034.4	1,034.7	1,035.0	1,035.5
728.4	1,035.7	1,036.0	1,036.3	1,036.6	1,036.9	1,037.2	1,037.5	1,037.9	1,038.2	1,038.5
728.5	1,038.8	1,039.1	1,039.4	1,039.7	1,040.1	1,040.4	1,040.7	1,041.0	1,041.3	1,041.6
728.6	1,041.9	1,042.3	1,042.6	1,042.9	1,043.2	1,043.5	1,043.8	1,044.1	1,044.5	1,044.8
728.7	1,045.1	1,045.4	1,045.7	1,046.0	1,046.3	1,046.6	1,047.0	1,047.3	1,047.6	1,047.9
728.8	1,048.2	1,048.5	1,048.8	1,049.2	1,049.5	1,048.8	1,050.1	1,050.4	1,050.7	1,051.0
728.9	1,051.4	1,051.7	1,052.0	1,052.3	1,052.6	1,052.9	1,053.2	1,053.6	1,053.9	1,054.2
729.0	1,054.5	1,054.8	1,055.1	1,055.5	1,055.8	1,056.1	1,056.4	1,056.7	1,057.1	1,057.4
729.1	1,057.7	1,058.0	1,058.3	1,058.7	1,059.0	1,059.3	1,059.6	1,059.9	1,060.3	1,060.6
729.2	1,060.9	1,061.2	1,061.5	1,061.9	1,062.2	1,062.5	1,062.8	1,063.1	1,063.5	1,063.8
729.3	1,064.1	1,064.4	1,064.7	1,065.1	1,065.4	1,065.7	1,066.0	1,066.3	1,066.7	1,067.0
729.4	1,067.3	1,067.6	1,067.9	1,068.3	1,068.6	1,068.9	1,069.2	1,069.5	1,069.9	1,070.2
729.5	1,070.5	1,070.8	1,071.1	1,071.5	1,071.8	1,072.1	1,072.4	1,072.7	1,073.1	1,073.4
729.6	1,073.7	1,074.0	1,074.3	1,074.7	1,075.0	1,075.3	1,075.6	1,075.9	1,076.3	1,076.6
729.7	1,076.9	1,077.2	1,077.5	1,077.9	1,078.2	1,078.5	1,078.8	1,079.1	1,079.5	1,079.8
729.8	1,080.1	1,080.4	1,080.7	1,081.1	1,081.4	1,081.7	1,082.1	1,082.3	1,082.7	1,083.0
729.9	1,083.3	1,083.6	1,083.9	1,084.3	1,084.6	1,084.9	1,085.2	1,085.5	1,085.9	1,086.2
730.0	1,086.5	1,086.8	1,087.2	1,087.5	1,087.8	1,088.1	1,088.4	1,088.8	1,089.1	1,089.4
730.1	1,089.8	1,090.1	1,090.4	1,090.7	1,091.0	1,091.4	1,091.7	1,092.0	1,092.4	1,092.7
730.2	1,093.0	1,093.3	1,093.6	1,094.0	1,094.3	1,094.6	1,095.0	1,095.3	1,095.6	1,095.9
730.3	1,096.2	1,096.6	1,096.9	1,097.2	1,097.6	1,097.9	1,098.2	1,098.5	1,098.8	1,099.2
730.4	1,099.5	1,099.8	1,100.2	1,100.5	1,100.8	1,101.1	1,101.4	1,101.8	1,102.1	1,102.4
730.5	1,102.8	1,103.1	1,103.4	1,103.7	1,104.0	1,104.4	1,104.7	1,105.0	1,105.4	1,105.7

730.6	1,106.1	1,106.3	1,106.6	1,107.0	1,107.3	1,107.6	1,108.0	1,108.3	1,108.6	1,108.9
730.7	1,109.2	1,109.6	1,109.9	1,110.2	1,110.6	1,110.9	1,111.2	1,111.5	1,111.8	1,112.2
730.8	1,112.5	1,112.8	1,113.2	1,113.5	1,113.8	1,114.1	1,114.4	1,114.8	1,115.1	1,115.4
730.9	1,115.8	1,116.1	1,116.4	1,116.7	1,117.0	1,117.4	1,117.7	1,118.0	1,118.4	1,118.7
731.0	1,119.0	1,119.3	1,119.7	1,120.0	1,120.3	1,120.6	1,121.0	1,121.3	1,121.6	1,122.0
731.1	1,122.3	1,122.6	1,123.0	1,123.3	1,123.6	1,124.0	1,124.3	1,124.6	1,124.9	1,125.0
731.2	1,125.6	1,125.9	1,126.3	1,126.6	1,126.9	1,127.2	1,127.6	1,127.9	1,128.2	1,128.6
731.3	1,128.9	1,129.2	1,129.6	1,129.9	1,130.2	1,130.6	1,130.9	1,131.2	1,131.5	1,131.9
731.4	1,132.2	1,132.5	1,132.9	1,133.2	1,133.5	1,133.8	1,134.2	1,134.5	1,134.8	1,135.2
731.5	1,135.5	1,135.8	1,136.2	1,136.5	1,136.8	1,137.2	1,137.5	1,137.8	1,138.1	1,138.5
731.6	1,138.8	1,139.1	1,139.5	1,139.9	1,140.1	1,140.4	1,140.8	1,141.1	1,141.4	1,141.8
731.7	1,142.1	1,142.4	1,142.8	1,143.1	1,143.4	1,143.8	1,144.1	1,144.4	1,144.7	1,145.1
731.8	1,145.4	1,145.7	1,146.1	1,146.4	1,146.7	1,147.0	1,147.4	1,147.7	1,148.0	1,148.4
731.9	1,148.7	1,149.0	1,149.4	1,149.7	1,150.0	1,150.4	1,150.7	1,151.0	1,151.3	1,151.7
732.0	1,152.0	1,152.3	1,153.7	1,153.0	1,153.4	1,153.7	1,154.0	1,154.4	1,154.7	1,155.1
732.1	1,155.4	1,155.7	1,156.1	1,156.4	1,156.8	1,157.1	1,157.4	1,157.8	1,158.1	1,158.5
732.2	1,158.8	1,159.1	1,159.5	1,159.8	1,160.2	1,160.5	1,160.8	1,161.2	1,161.5	1,161.9
732.3	1,162.2	1,162.5	1,162.9	1,163.2	1,163.6	1,163.9	1,164.2	1,164.6	1,164.9	1,165.3
732.4	1,165.6	1,165.9	1,166.3	1,166.6	1,167.0	1,167.3	1,167.6	1,168.0	1,168.3	1,168.7
732.5	1,169.0	1,169.3	1,169.7	1,170.0	1,170.4	1,170.7	1,171.0	1,171.4	1,171.7	1,172.1
732.6	1,172.4	1,172.7	1,173.1	1,173.4	1,173.8	1,174.1	1,174.4	1,174.8	1,175.1	1,175.5
732.7	1,175.8	1,176.1	1,176.5	1,176.8	1,177.2	1,177.5	1,177.8	1,178.2	1,178.5	1,178.9
732.8	1,179.2	1,179.5	1,179.9	1,180.2	1,180.6	1,180.9	1,181.2	1,181.6	1,181.9	1,182.3
732.9	1,182.6	1,182.9	1,183.3	1,183.6	1,184.0	1,184.3	1,184.6	1,185.0	1,185.3	1,185.7
733.0	1,186.0	1,186.4	1,186.7	1,187.0	1,187.4	1,187.8	1,188.1	1,188.4	1,188.8	1,189.2
733.1	1,189.5	1,189.8	1,190.2	1,190.6	1,190.9	1,191.2	1,191.6	1,192.0	1,192.3	1,192.6
733.2	1,193.0	1,193.4	1,193.7	1,194.0	1,194.4	1,194.8	1,195.1	1,195.4	1,195.8	1,196.2
733.3	1,196.5	1,196.8	1,197.2	1,197.6	1,197.9	1,198.2	1,198.6	1,199.0	1,199.3	1,199.6
733.4	1,200.0	1,200.4	1,200.7	1,201.0	1,201.4	1,201.8	1,202.1	1,202.4	1,202.8	1,203.2
733.5	1,203.5	1,203.8	1,204.2	1,204.6	1,204.9	1,205.2	1,205.6	1,206.0	1,206.3	1,206.6
733.6	1,207.0	1,208.4	1,207.7	1,208.0	1,208.4	1,208.8	1,209.1	1,209.4	1,209.8	1,210.2
733.7	1,210.5	1,210.8	1,211.2	1,211.6	1,211.9	1,212.2	1,212.6	1,213.0	1,213.3	1,213.6
733.8	1,214.0	1,214.4	1,214.7	1,215.0	1,215.4	1,215.8	1,216.1	1,216.4	1,216.8	1,217.2
733.9	1,217.5	1,217.8	1,218.2	1,218.6	1,218.9	1,219.2	1,219.6	1,220.0	1,220.3	1,220.6

734.0	1,221.0	1,221.4	1,221.7	1,222.1	1,222.4	1,222.8	1,223.2	1,223.5	1,223.9	1,224.2
734.1	1,224.6	1,225.0	1,225.3	1,225.7	1,226.0	1,226.4	1,226.8	1,227.1	1,227.5	1,227.8
734.2	1,228.2	1,228.6	1,228.9	1,229.3	1,229.6	1,230.0	1,230.4	1,230.7	1,231.1	1,231.4
734.3	1,231.8	1,232.2	1,232.5	1,232.9	1,233.2	1,233.6	1,234.0	1,234.3	1,234.7	1,235.0
734.4	1,235.4	1,235.8	1,236.1	1,236.5	2,136.8	1,237.2	1,237.6	1,237.9	1,238.3	1,238.6
734.5	1,239.0	1,239.4	1,239.1	1,240.1	1,240.4	1,240.8	1,241.2	1,241.5	1,241.9	1,242.2
734.6	1,242.6	1,243.0	1,243.3	1,243.7	1,244.0	1,244.4	1,244.8	1,245.1	1,245.5	1,245.8
734.7	1,246.2	1,246.6	1,246.9	1,247.3	1,247.6	1,248.0	1,248.4	1,248.7	1,249.1	1,249.4
734.8	1,249.8	1,250.2	1,250.5	1,250.9	1,251.2	1,251.6	1,252.0	1,252.3	1,252.7	1,253.0
734.9	1,253.4	1,253.8	1,254.1	1,254.5	1,254.8	1,255.2	1,255.6	1,255.9	1,256.3	1,256.6
735.0	1,257.0	1,257.4	1,257.7	1,258.1	1,258.5	1,258.8	1,259.2	1,259.6	1,260.0	1,260.3
735.1	1,260.7	1,261.1	1,261.4	1,264.8	1,262.2	1,262.6	1,262.9	1,263.3	1,263.7	1,264.0
735.2	1,264.4	1,264.8	1,265.1	1,265.5	1,265.9	1,266.2	1,266.6	1,267.0	1,267.4	1,267.7
735.3	1,268.1	1,268.5	1,268.8	1,269.2	1,269.6	1,270.0	1,270.3	1,270.7	1,271.1	1,271.4
735.4	1,271.8	1,272.2	1,272.5	1,272.9	1,273.3	1,273.6	1,274.0	1,274.7	1,274.8	1,275.1
735.5	1,275.5	1,275.9	1,276.2	1,276.6	1,277.0	1,277.4	1,277.7	1,278.1	1,278.5	1,278.8
735.6	1,279.2	1,279.6	1,279.9	1,280.3	1,280.7	1,281.0	1,281.4	1,281.8	1,282.2	1,282.5
735.7	1,282.9	1,283.3	1,283.6	1,284.0	1,284.4	1,284.8	1,285.1	1,285.5	1,285.9	1,286.2
735.8	1,286.6	1,287.0	1,287.3	1,287.7	1,288.1	1,288.4	1,288.8	1,289.2	1,289.6	1,289.9
735.9	1,290.3	1,290.7	1,291.0	1,291.4	1,291.8	1,292.2	1,292.5	1,292.9	1,293.3	1,293.6
736.0	1,294.0	1,294.4	1,294.8	1,295.1	1,295.5	1,295.9	1,296.3	1,296.7	1,297.0	1,297.4
736.1	1,297.8	1,298.2	1,298.6	1,298.9	1,299.3	1,299.7	1,300.1	1,300.5	1,300.8	1,301.2
736.2	1,301.6	1,302.0	1,302.4	1,302.7	1,303.1	1,303.5	1,303.9	1,304.3	1,304.6	1,305.0
736.3	1,305.4	1,305.8	1,306.2	1,306.5	1,306.9	1,307.3	1,307.7	1,308.1	1,308.4	1,308.8
736.4	1,309.2	1,309.6	1,310.0	1,310.3	1,310.7	1,311.1	1,311.5	1,311.9	1,312.2	1,312.6
736.5	1,313.0	1,313.4	1,313.8	1,314.1	1,314.5	1,314.9	1,315.3	1,315.7	1,316.0	1,316.4
736.6	1,316.8	1,317.2	1,317.6	1,317.9	1,318.3	1,318.7	1,319.1	1,319.5	1,319.8	1,320.2
736.7	1,320.6	1,321.0	1,321.4	1,321.7	1,322.1	1,322.5	1,322.9	1,323.3	1,323.6	1,324.0
736.8	1,324.4	1,324.8	1,225.2	1,325.5	1,325.9	1,326.3	1,326.7	1,327.1	1,327.4	1,327.8
736.9	1,328.2	1,328.6	1,329.0	1,329.3	1,329.7	1,330.1	1,330.5	1,330.9	1,331.2	1,331.6
737.0	1,332.0	1,332.4	1,334.8	1,333.2	1,333.6	1,334.0	1,334.3	1,334.7	1,335.1	1,335.5
737.1	1,335.9	1,336.3	1,336.7	1,337.1	1,337.5	1,337.8	1,338.2	1,338.6	1,339.0	1,339.4
737.2	1,339.8	1,340.2	1,340.6	1,341.0	1,341.4	1,341.8	1,342.1	1,342.5	1,342.9	1,343.3
737.3	1,343.7	1,344.1	1,344.5	1,344.9	1,345.3	1,345.6	1,346.0	1,346.4	1,346.8	1,347.2
737.4	1,347.6	1,348.0	1,348.4	1,348.8	1,349.2	1,349.6	1,349.9	1,350.3	1,350.7	1,351.1
737.5	1,351.5	1,351.9	1,352.3	1,352.7	1,353.1	1,353.4	1,353.8	1,354.2	1,354.6	1,355.0

737.6	1,355.4	1,355.8	1,356.2	1,356.6	1,357.0	1,357.4	1,357.7	1,358.1	1,358.5	1,358.9
737.7	1,359.3	1,359.7	1,360.1	1,360.5	1,360.9	1,361.2	1,361.6	1,362.0	1,362.4	1,362.8
737.8	1,363.2	1,363.6	1,364.0	1,364.4	1,364.8	1,365.2	1,365.5	1,365.9	1,366.3	1,366.7
737.9	1,367.1	1,367.5	1,367.9	1,368.3	1,368.7	1,369.0	1,369.4	1,369.8	1,370.2	1,370.6
738.0	1,371.0	1,371.4	1,371.8	1,372.2	1,372.6	1,373.0	1,373.4	1,373.8	1,374.2	1,374.6
738.1	1,375.0	1,375.4	1,375.8	1,376.2	1,376.6	1,377.0	1,377.4	1,377.8	1,378.2	1,378.6
738.2	1,379.0	1,379.4	1,379.8	1,380.2	1,380.6	1,381.0	1,381.4	1,381.6	1,382.2	1,382.6
738.3	1,383.0	1,383.4	1,383.8	1,384.2	1,384.6	1,385.0	1,385.4	1,385.8	1,386.2	1,386.6
738.4	1,387.0	1,387.4	1,387.8	1,388.2	1,388.6	1,389.0	1,389.4	1,389.8	1,390.2	1,390.6
738.5	1,391.0	1,391.4	1,391.8	1,392.2	1,392.6	1,393.0	1,393.4	1,393.8	1,394.2	1,394.6
738.6	1,395.0	1,395.4	1,395.8	1,396.2	1,396.6	1,397.0	1,397.4	1,397.8	1,398.2	1,398.6
738.7	1,399.0	1,399.4	1,399.8	1,400.2	1,400.6	1,401.0	1,401.4	1,401.8	1,402.2	1,402.6
738.8	1,403.0	1,403.4	1,403.8	1,404.2	1,404.6	1,405.0	1,405.4	1,405.8	1,406.2	1,406.6
738.9	1,407.0	1,407.4	1,407.8	1,408.2	1,408.6	1,409.0	1,409.4	1,409.8	1,410.2	1,410.6
739.0	1,411.0	1,411.4	1,411.8	1,412.2	1,412.6	1,413.0	1,413.5	1,413.9	1,414.3	1,414.7
739.1	1,415.1	1,415.5	1,415.9	1,416.3	1,416.7	1,417.2	1,417.6	1,418.0	1,418.4	1,418.8
739.2	1,419.2	1,419.6	1,420.0	1,420.4	1,420.8	1,421.2	1,421.7	1,422.1	1,422.5	1,422.9
739.3	1,423.3	1,423.7	1,424.1	1,424.5	1,424.9	1,425.4	1,425.8	1,426.2	1,426.6	1,427.0
739.4	1,427.4	1,427.8	1,428.2	1,428.6	1,429.0	1,429.4	1,429.9	1,430.3	1,430.7	1,431.1
739.5	1,431.5	1,431.9	1,432.3	1,432.7	1,433.1	1,433.6	1,434.0	1,434.4	1,434.8	1,435.2
739.6	1,435.6	1,436.0	1,436.4	1,436.8	1,437.2	1,437.6	1,438.1	1,438.5	1,438.9	1,439.3
739.7	1,439.7	1,440.1	1,440.5	1,440.9	1,441.3	1,441.8	1,442.2	1,442.6	1,443.0	1,443.4
739.8	1,443.8	1,444.2	1,444.6	1,445.0	1,445.4	1,445.8	1,446.3	1,446.7	1,447.1	1,447.5
739.9	1,447.9	1,448.3	1,448.7	1,449.1	1,449.5	1,450.0	1,450.4	1,450.8	1,451.2	1,451.6
740.0	1,452.0	1,452.4	1,452.8	1,453.3	1,453.7	1,454.1	1,454.5	1,454.9	1,455.4	1,455.8
740.1	1,456.2	1,456.6	1,457.0	1,457.5	1,457.9	1,458.3	1,458.9	1,459.1	1,459.6	1,460.0
740.2	1,460.4	1,460.8	1,461.2	1,461.7	1,462.1	1,462.5	1,462.9	1,463.3	1,463.8	1,464.2
740.3	1,464.6	1,465.0	1,465.4	1,465.9	1,466.3	1,466.7	1,467.1	1,467.5	1,468.0	1,468.4
740.4	1,468.8	1,469.2	1,469.6	1,470.1	1,470.5	1,470.9	1,471.3	1,471.7	1,472.2	1,472.6
740.5	1,473.0	1,473.4	1,473.8	1,474.3	1,474.7	1,475.1	1,475.5	1,475.9	1,476.4	1,476.8
740.6	1,477.2	1,477.6	1,478.0	1,478.5	1,478.9	1,479.3	1,479.7	1,480.1	1,480.6	1,481.0
740.7	1,481.4	1,481.8	1,482.2	1,482.7	1,483.1	1,483.5	1,483.9	1,484.3	1,484.8	1,485.2
740.8	1,485.6	1,486.0	1,486.4	1,486.9	1,487.3	1,487.7	1,488.1	1,488.5	1,489.0	1,489.4
740.9	1,489.8	1,490.2	1,490.6	1,491.1	1,491.5	1,491.9	1,492.3	1,493.7	1,493.2	1,493.6

741.0	1,494.0	1,494.4	1,494.9	1,495.3	1,495.7	1,496.2	1,496.6	1,497.0	1,497.4	1,497.9
741.1	1,498.3	1,498.7	1,499.2	1,499.6	1,500.0	1,500.4	1,500.9	1,501.3	1,501.7	1,502.2
741.2	1,502.6	1,503.0	1,503.5	1,503.9	1,504.3	1,504.8	1,505.2	1,505.6	1,506.0	1,506.5
741.3	1,506.9	1,507.3	1,507.8	1,508.2	1,508.6	1,509.0	1,509.5	1,509.9	1,510.3	1,510.8
741.4	1,511.2	1,511.6	1,512.1	1,512.5	1,512.9	1,513.4	1,513.8	1,514.2	1,514.6	1,515.1
741.5	1,515.5	1,515.9	1,516.4	1,516.8	1,517.2	1,517.6	1,518.1	1,518.5	1,518.9	1,519.4
741.6	1,519.8	1,520.2	1,529.7	1,521.1	1,521.5	1,522.0	1,522.4	1,522.8	1,523.2	1,523.7
741.7	1,524.1	1,524.5	1,525.0	1,525.4	1,525.8	1,526.2	1,526.7	1,527.1	1,527.5	1,528.0
741.8	1,528.4	1,528.8	1,529.3	1,529.7	1,530.1	1,530.6	1,531.0	1,531.4	1,531.8	1,532.3
741.9	1,532.7	1,533.1	1,533.6	1,534.0	1,534.4	1,534.8	1,535.3	1,535.7	1,536.1	1,536.6
742.0	1,537.0	1,537.4	1,537.9	1,538.3	1,538.8	1,539.2	1,539.6	1,540.1	1,540.5	1,541.0
742.1	1,541.4	1,541.8	1,542.3	1,542.7	1,543.2	1,543.6	1,544.0	1,544.5	1,544.9	1,545.4
742.2	1,545.8	1,546.2	1,546.7	1,547.1	1,547.6	1,548.0	1,548.4	1,548.9	1,549.3	1,549.8
742.3	1,550.2	1,550.6	1,551.0	1,551.5	1,552.0	1,552.4	1,552.8	1,553.3	1,553.7	1,554.2
742.4	1,554.6	1,555.0	1,555.5	1,555.9	1,556.4	1,556.8	1,557.2	1,557.7	1,558.1	1,558.6
742.5	1,559.0	1,559.4	1,559.9	1,560.3	1,560.8	1,561.2	1,561.6	1,562.1	1,562.5	1,563.0
742.6	1,563.4	1,563.8	1,564.3	1,564.7	1,565.2	1,565.6	1,566.0	1,566.5	1,566.9	1,567.4
742.7	1,567.8	1,568.2	1,568.7	1,569.1	1,569.6	1,570.0	1,570.4	1,570.9	1,571.3	1,571.8
742.8	1,572.2	1,572.6	1,573.1	1,573.5	1,574.0	1,574.4	1,574.8	1,575.3	1,575.7	1,576.2
742.9	1,576.6	1,577.0	1,577.5	1,577.9	1,578.4	1,578.8	1,579.2	1,579.7	1,580.1	1,580.6
743.0	1,581.0	1,581.4	1,581.9	1,582.4	1,582.8	1,583.2	1,583.7	1,584.2	1,584.6	1,585.0
743.1	1,585.5	1,586.0	1,586.4	1,586.8	1,587.3	1,587.8	1,588.2	1,588.6	1,589.1	1,589.6
743.2	1,590.0	1,590.4	1,590.9	1,591.4	1,591.8	1,592.2	1,592.7	1,593.2	1,593.6	1,594.0
743.3	1,594.5	1,595.0	1,595.4	1,595.8	1,596.3	1,596.8	1,597.2	1,597.6	1,598.1	1,598.6
743.4	1,599.0	1,599.4	1,599.9	1,600.4	1,600.8	1,601.2	1,601.7	1,602.2	1,602.6	1,603.0
743.5	1,603.5	1,604.0	1,604.4	1,604.8	1,605.3	1,605.8	1,606.2	1,606.6	1,607.1	1,607.6
743.6	1,608.0	1,608.4	1,608.9	1,609.4	1,609.8	1,610.2	1,610.7	1,611.2	1,611.6	1,612.0
743.7	1,612.5	1,613.0	1,613.4	1,613.8	1,614.3	1,614.8	1,615.2	1,615.6	1,616.1	1,616.6
743.8	1,617.0	1,617.4	1,617.9	1,618.4	1,618.8	1,619.2	1,619.7	1,620.2	1,620.6	1,621.0
743.9	1,621.5	1,622.0	1,622.4	1,622.8	1,623.3	1,623.8	1,624.2	1,624.6	1,625.1	1,625.6
744.0	1,626.0	1,626.5	1,626.9	1,627.4	1,627.8	1,628.3	1,628.8	1,629.2	1,629.7	1,630.1
744.1	1,630.6	1,631.1	1,631.5	1,632.0	1,632.4	1,632.9	1,633.4	1,633.8	1,634.3	1,634.7
744.2	1,635.2	1,635.7	1,636.1	1,636.6	1,637.0	1,637.5	1,638.0	1,638.4	1,638.9	1,639.3
744.3	1,639.8	1,640.3	1,640.7	1,641.2	1,641.6	1,642.1	1,642.6	1,643.0	1,643.5	1,643.9
744.4	1,644.4	1,644.9	1,645.3	1,645.8	1,646.2	1,646.7	1,647.2	1,647.6	1,648.1	1,648.5
744.5	1,649.0	1,649.5	1,649.9	1,650.4	1,650.8	1,651.3	1,651.8	1,652.2	1,652.7	1,653.1

744.6	1,653.6	1,654.1	1,654.5	1,655.0	1,655.4	1,655.9	1,656.4	1,656.8	1,657.3	1,657.7
744.7	1,658.2	1,658.7	1,659.1	1,659.6	1,660.0	1,660.5	1,661.0	1,661.4	1,661.9	1,662.3
744.8	1,662.8	1,663.3	1,663.7	1,664.2	1,664.6	1,665.1	1,665.6	1,666.0	1,666.5	1,666.9
744.9	1,667.4	1,667.9	1,668.3	1,668.8	1,669.2	1,669.7	1,670.2	1,670.6	1,671.1	1,671.5
745.0	1,672.0	1,672.5	1,672.9	1,673.4	1,673.9	1,674.4	1,674.8	1,675.3	1,675.8	1,676.2
745.1	1,676.7	1,677.2	1,677.6	1,678.1	1,678.6	1,679.0	1,679.5	1,680.0	1,680.5	1,680.9
745.2	1,681.4	1,681.9	1,682.3	1,682.8	1,683.3	1,683.8	1,684.2	1,684.7	1,685.2	1,685.6
745.3	1,686.1	1,686.6	1,687.0	1,687.5	1,688.0	1,688.4	1,688.9	1,689.4	1,689.9	1,690.3
745.4	1,690.8	1,691.3	1,691.7	1,692.2	1,692.7	1,693.2	1,693.6	1,694.1	1,694.6	1,695.0
745.5	1,695.5	1,696.0	1,696.4	1,696.9	1,697.4	1,697.8	1,698.3	1,698.8	1,699.3	1,699.7
745.6	1,700.2	1,700.7	1,701.1	1,701.6	1,702.1	1,702.6	1,703.0	1,703.5	1,704.0	1,704.4
745.7	1,704.9	1,705.4	1,705.8	1,706.3	1,706.8	1,707.2	1,707.7	1,708.2	1,708.7	1,709.1
745.8	1,709.6	1,710.1	1,710.5	1,711.0	1,711.5	1,712.0	1,712.4	1,712.9	1,713.4	1,713.8
745.9	1,714.3	1,714.8	1,715.2	1,715.7	1,716.2	1,716.6	1,717.1	1,717.6	1,718.1	1,718.5
746.0	1,719.0	1,719.5	1,720.0	1,720.4	1,720.9	1,721.4	1,721.9	1,722.4	1,722.8	1,723.3
746.1	1,723.8	1,724.3	1,724.8	1,725.2	1,725.7	1,726.2	1,726.7	1,727.2	1,727.6	1,728.1
746.2	1,728.6	1,729.1	1,729.6	1,730.0	1,730.5	1,731.0	1,731.5	1,732.0	1,732.4	1,732.9
746.3	1,733.4	1,733.9	1,734.4	1,734.8	1,735.3	1,735.8	1,736.3	1,736.8	1,737.2	1,737.7
746.4	1,738.2	1,738.7	1,739.2	1,739.6	1,740.1	1,740.6	1,741.1	1,741.6	1,742.0	1,742.5
746.5	1,743.0	1,743.5	1,744.0	1,744.4	1,744.9	1,745.4	1,745.9	1,746.4	1,746.8	1,747.3
746.6	1,747.8	1,748.3	1,748.8	1,749.2	1,749.7	1,750.2	1,750.7	1,751.2	1,751.6	1,752.1
746.7	1,752.6	1,753.1	1,753.6	1,754.0	1,754.5	1,755.0	1,755.5	1,756.0	1,756.4	1,756.9
746.8	1,757.4	1,757.9	1,758.4	1,758.8	1,759.3	1,759.8	1,760.3	1,760.8	1,761.2	1,761.7
746.9	1,762.2	1,762.7	1,763.2	1,763.6	1,764.1	1,764.6	1,765.1	1,765.6	1,766.0	1,766.5
747.0	1,767.0	1,767.5	1,768.0	1,768.5	1,769.0	1,769.4	1,769.9	1,770.4	1,770.9	1,771.4
747.1	1,771.9	1,772.4	1,772.9	1,773.4	1,773.9	1,774.4	1,774.8	1,775.3	1,775.8	1,776.3
747.2	1,776.8	1,777.3	1,777.8	1,778.3	1,778.8	1,779.2	1,779.7	1,780.2	1,780.7	1,781.2
747.3	1,781.7	1,782.2	1,782.7	1,783.2	1,783.7	1,784.2	1,784.6	1,785.1	1,785.6	1,786.1
747.4	1,786.6	1,787.1	1,787.6	1,788.1	1,788.6	1,789.0	1,789.5	1,790.0	1,790.5	1,791.0
747.5	1,791.5	1,792.0	1,792.5	1,793.0	1,793.5	1,794.0	1,794.4	1,794.9	1,795.4	1,795.9
747.6	1,796.4	1,796.9	1,797.4	1,797.9	1,798.4	1,798.8	1,799.3	1,799.8	1,800.3	1,800.8
747.7	1,801.3	1,801.8	1,802.3	1,802.8	1,803.3	1,803.8	1,804.2	1,804.7	1,805.2	1,805.7
747.8	1,806.2	1,806.7	1,807.2	1,807.7	1,808.2	1,808.6	1,809.1	1,809.6	1,810.1	1,810.6
747.9	1,811.1	1,811.6	1,812.1	1,812.6	1,813.1	1,813.6	1,814.0	1,814.5	1,815.0	1,815.5

748.0	1,816.0	1,816.5	1,817.0	1,817.5	1,818.0	1,818.5	1,819.0	1,819.5	1,820.0	1,820.5
748.1	1,821.0	1,821.5	1,822.0	1,822.5	1,823.0	1,823.5	1,824.0	1,824.5	1,825.0	1,825.5
748.2	1,826.0	1,826.5	1,827.0	1,827.5	1,828.0	1,828.5	1,829.0	1,829.5	1,830.0	1,830.5
748.3	1,831.0	1,831.5	1,832.0	1,832.5	1,833.0	1,833.5	1,834.0	1,834.5	1,835.0	1,835.5
748.4	1,836.0	1,836.5	1,837.0	1,837.5	1,838.0	1,838.5	1,839.0	1,839.5	1,840.0	1,840.5
748.5	1,841.0	1,841.5	1,842.0	1,842.5	1,843.0	1,843.5	1,844.0	1,844.5	1,845.0	1,845.5
748.6	1,846.0	1,846.5	1,847.0	1,847.5	1,848.0	1,848.5	1,849.0	1,849.5	1,850.0	1,850.5
748.7	1,851.0	1,851.5	1,852.0	1,852.5	1,853.0	1,853.5	1,854.0	1,854.5	1,855.0	1,855.5
748.8	1,856.0	1,856.5	1,857.0	1,857.5	1,858.0	1,858.5	1,859.0	1,859.5	1,860.0	1,860.5
748.9	1,861.0	1,861.5	1,862.0	1,862.5	1,863.0	1,863.5	1,864.0	1,864.5	1,865.0	1,865.5
749.0	1,866.0	1,866.5	1,867.0	1,867.5	1,868.0	1,868.6	1,869.1	1,869.6	1,870.1	1,870.6
749.1	1,871.1	1,871.6	1,872.1	1,872.6	1,873.1	1,873.6	1,874.2	1,874.7	1,875.2	1,875.7
749.2	1,876.2	1,876.7	1,877.2	1,877.7	1,878.2	1,878.8	1,879.3	1,879.8	1,880.3	1,880.8
749.3	1,881.3	1,881.8	1,882.3	1,882.8	1,883.3	1,883.8	1,884.4	1,884.9	1,885.4	1,885.9
749.4	1,886.4	1,886.9	1,887.4	1,887.9	1,888.4	1,889.0	1,889.5	1,890.0	1,890.5	1,891.0
749.5	1,891.5	1,892.0	1,892.5	1,893.0	1,893.5	1,894.0	1,894.6	1,895.1	1,895.6	1,896.1
749.6	1,896.6	1,897.1	1,897.6	1,898.1	1,898.6	1,899.2	1,899.7	1,900.2	1,900.7	1,901.2
749.7	1,901.7	1,902.2	1,902.7	1,903.2	1,903.7	1,904.2	1,904.8	1,905.3	1,905.8	1,906.3
749.8	1,906.8	1,907.3	1,907.8	1,908.3	1,908.8	1,909.4	1,909.9	1,910.4	1,910.9	1,911.4
749.9	1,911.9	1,912.4	1,912.9	1,913.4	1,913.9	1,914.4	1,915.0	1,915.5	1,916.0	1,916.5
750.0	1,917.0	1,917.5	1,918.1	1,918.6	1,919.1	1,919.6	1,920.2	1,920.7	1,921.2	1,921.8
750.1	1,922.3	1,922.8	1,923.4	1,923.9	1,924.4	1,925.0	1,925.5	1,926.0	1,926.5	1,927.1
750.2	1,927.6	1,928.1	1,928.7	1,929.2	1,929.7	1,930.2	1,930.8	1,931.3	1,931.8	1,932.4
750.3	1,932.9	1,933.4	1,934.0	1,934.5	1,935.0	1,935.6	1,936.1	1,936.6	1,937.1	1,937.7
750.4	1,938.2	1,938.7	1,939.3	1,939.8	1,940.3	1,940.8	1,941.4	1,941.9	1,942.4	1,943.0
750.5	1,943.5	1,944.0	1,944.6	1,945.1	1,945.6	1,946.2	1,946.7	1,947.2	1,947.7	1,948.3
750.6	1,948.8	1,949.3	1,949.9	1,950.4	1,950.9	1,951.4	1,952.0	1,952.5	1,953.0	1,953.6
750.7	1,954.1	1,954.6	1,955.2	1,955.7	1,956.2	1,956.8	1,957.3	1,957.8	1,958.3	1,958.9
750.8	1,959.4	1,959.9	1,960.5	1,961.0	1,961.5	1,962.0	1,962.6	1,963.1	1,963.6	1,964.2
750.9	1,964.7	1,965.2	1,965.8	1,966.3	1,966.8	1,967.4	1,967.9	1,968.4	1,968.9	1,969.5
751.0	1,970.0	1,970.5	1,971.1	1,971.6	1,972.2	1,972.7	1,973.2	1,973.8	1,974.3	1,974.9
751.1	1,975.4	1,975.9	1,976.5	1,977.0	1,977.6	1,978.1	1,978.6	1,979.2	1,974.7	1,980.3
751.2	1,980.8	1,981.3	1,981.9	1,982.4	1,983.0	1,983.5	1,984.0	1,984.6	1,985.1	1,985.7
751.3	1,986.2	1,986.7	1,987.3	1,987.8	1,988.4	1,988.9	1,989.4	1,990.0	1,900.5	1,991.1
751.4	1,991.4	1,992.1	1,992.7	1,993.2	1,993.8	1,994.3	1,994.8	1,995.4	1,995.9	1,996.5
751.5	1,997.0	1,997.5	1,998.1	1,998.6	1,999.2	1,999.7	2,000.2	2,000.8	2,001.3	2,001.9

751.6	2,002.4	2,002.9	2,003.5	2,004.0	2,004.6	2,005.1	2,005.6	2,006.2	2,006.7	2,007.3
751.7	2,007.8	2,008.3	2,008.9	2,009.4	2,010.0	2,010.5	2,011.0	2,011.6	2,012.1	2,012.7
751.8	2,013.2	2,013.7	2,014.3	2,014.8	2,015.4	2,015.9	2,016.4	2,017.0	2,017.5	2,018.1
751.9	2,018.6	2,019.1	2,019.7	2,020.2	2,020.8	2,021.3	2,021.8	2,022.4	2,022.9	2,023.5
752.0	2,024.0	2,024.6	2,025.1	2,025.7	2,026.2	2,026.8	2,027.4	2,027.8	2,028.3	2,029.0
752.1	2,029.6	2,030.2	2,030.7	2,031.3	2,031.8	2,032.4	2,033.0	2,033.5	2,034.1	2,034.6
752.2	2,035.2	2,035.8	2,036.3	2,036.9	2,037.4	2,038.0	2,038.6	2,039.1	2,039.7	2,040.2
752.3	2,040.8	2,041.4	2,041.9	2,042.5	2,043.0	2,043.6	2,044.2	2,044.7	2,045.3	2,045.8
752.4	2,046.4	2,047.0	2,047.5	2,048.1	2,048.6	2,049.2	2,049.8	2,050.3	2,050.9	2,051.4
752.5	2,052.0	2,052.6	2,053.1	2,053.7	2,054.2	2,054.8	2,055.4	2,055.9	2,056.5	2,057.0
752.6	2,057.6	2,058.2	2,058.7	2,059.3	2,059.8	2,060.4	2,061.0	2,061.5	2,062.1	2,062.6
752.7	2,063.2	2,063.8	2,064.3	2,064.9	2,065.4	2,066.0	2,066.6	2,067.1	2,067.7	2,068.2
752.8	2,068.8	2,069.4	2,069.9	2,070.5	2,071.0	2,071.6	2,072.2	2,072.7	2,073.3	2,073.8
752.9	2,074.4	2,075.0	2,075.5	2,076.1	2,076.6	2,077.2	2,077.8	2,078.3	2,078.9	2,079.4
753.0	2,080.0	2,080.6	2,081.2	2,081.7	2,082.3	2,082.9	2,083.5	2,084.1	2,084.6	2,085.2
753.1	2,085.8	2,086.4	2,087.0	2,087.5	2,088.1	2,088.7	2,089.3	2,089.9	2,090.4	2,091.0
753.2	2,091.6	2,092.2	2,092.8	2,093.3	2,093.9	2,094.5	2,095.1	2,095.7	2,096.2	2,096.8
753.3	2,097.4	2,098.0	2,098.6	2,099.1	2,099.7	2,100.3	2,100.9	2,101.5	2,102.0	2,102.6
753.4	2,103.2	2,103.8	2,104.4	2,104.9	2,105.5	2,106.1	2,106.7	2,107.3	2,107.8	2,108.4
753.5	2,109.0	2,109.6	2,110.2	2,110.7	2,111.3	2,111.9	2,112.5	2,113.1	2,113.6	2,114.2
753.6	2,114.8	2,115.4	2,116.0	2,116.5	2,117.1	2,117.7	2,118.3	2,118.9	2,119.4	2,120.0
753.7	2,120.6	2,121.2	2,121.8	2,122.3	2,122.9	2,123.5	2,124.1	2,124.7	2,125.2	2,125.8
753.8	2,126.4	2,127.0	2,127.6	2,128.1	2,128.7	2,129.3	2,129.9	2,130.5	2,131.0	2,131.6
753.9	2,132.2	2,132.8	2,133.4	2,133.9	2,134.5	2,135.1	2,135.7	2,136.3	2,136.8	2,137.4
754.0	2,138.0	2,138.6	2,139.2	2,139.8	2,140.4	2,141.0	2,140.5	2,142.1	2,142.7	2,143.3
754.1	2,143.9	2,144.5	2,145.1	2,145.7	2,146.3	2,146.8	2,147.4	2,148.0	2,148.6	2,149.2
754.2	2,149.8	2,150.4	2,151.0	2,151.6	2,152.2	2,152.8	2,153.3	2,153.9	2,154.5	2,155.1
754.3	2,155.7	2,156.3	2,156.9	2,157.5	2,158.1	2,158.6	2,159.2	2,159.8	2,160.4	2,161.0
754.4	2,161.6	2,162.2	2,162.8	2,163.4	2,164.0	2,164.6	2,165.1	2,165.7	2,166.3	2,166.9
754.5	2,167.5	2,168.1	2,168.7	2,169.3	2,169.9	2,170.4	2,171.0	2,171.6	2,172.2	2,172.8
754.6	2,173.4	2,174.0	2,174.6	2,175.2	2,175.8	2,176.4	2,176.9	2,177.5	2,178.1	2,178.7
754.7	2,179.3	2,179.9	2,180.5	2,181.1	2,181.7	2,182.2	2,182.8	2,183.4	2,184.0	2,184.6
754.8	2,185.2	2,185.8	2,186.4	2,187.0	2,187.6	2,188.2	2,188.7	2,189.3	2,189.9	2,190.5
754.9	2,191.1	2,191.7	2,192.3	2,192.9	2,193.5	2,194.0	2,194.6	2,195.2	2,195.8	2,196.4
755.0	2,197.0	2,197.6	2,198.2	2,198.8	2,199.4	2,200.0	2,200.5	2,201.1	2,201.7	2,202.3
755.1	2,202.9	2,203.4	2,204.1	2,204.7	2,205.3	2,205.9				

VIII - EFFECT OF WATER CONTROL PLAN

8-01. General. The effects of emergency flood control regulations on the Probable Maximum Flood, the spillway design flood, the standard project flood, and an example of the normal and emergency regulations for the October 1986 flood are presented in the following paragraphs. The floods were selected to show the effects of the flood control regulations for Pensacola Reservoir on a variety of possible flood conditions.

8-02. Flood Control.

a. Probable maximum flood. The probable maximum flood was generated by applying the probable maximum precipitation from Hydrometerological Report No. 52 through the HEC-1 runoff model to the Pensacola drainage basin. The flood has a volume of 2,462,000 acre-feet with a peak inflow to Pensacola Dam of 653,100 c.f.s. The flood was routed through the project on both a full and empty flood control pool. The resulting maximum release was 596,700 (full flood control pool) and 567,200 (empty flood control pool). The corresponding maximum pool elevations were 756.7 and 756.0, respectively. Plate 8-1 shows the operational hydrographs for the probable maximum flood routed through Pensacola by emergency regulations on both an empty and full flood control pool.

b. Spillway design flood. The spillway design flood as presented in the original water control manual has a peak inflow of 590,000 c.f.s. and a total volume of 4,284,300 acre-feet including base flow. Hydrographs for spillway design flood routed through Pensacola Reservoir operated under emergency regulations on empty and full flood control pools are shown on plate 8-2.

c. Standard project flood. The standard project flood (one-half spillway design flood) flows were routed through the lake and were operated under emergency regulations on full flood control pool. The peak inflow was 295,000 c.f.s. with a volume of 2,142,150 acre-feet. Hydrographs for the standard project flood (one-half spillway design flood) routed through Pensacola Lake under emergency regulations on empty and full flood control pools are shown on plate 8-3.

d. Flood of October 1986. This flood was the result of a stalled cold front followed by the remnants of a hurricane that resulted in basin average rainfall of 8.3 inches from 27 September to 4 October. The flood had a volume of 3,125,000 acre-feet with a peak inflow into Pensacola Reservoir of 178,000 c.f.s. Plate 8-4 shows the operational hydrographs for Pensacola Reservoir for both experienced and emergency regulations.

8-03. Recreation. There are several privately-owned marinas, resorts and camping facilities which have been developed around the lake and lie within the flood control pool. At elevation 750, agricultural lands become flooded, and at elevation 752, houses and other structures become flooded.

8-04. Water quality. Water quality releases are made as needed to respond to water quality problems downstream, which usually occur during the summer.

8-05. Fish and wildlife. Pensacola Reservoir replaced the existing stream fishery with an improved reservoir-type fishery. The impoundment provides an excellent fishery and, being located in a scenic area, attracts fishermen from a widespread area. The downstream fishery is improved by releases from the lake. Waterfowl habitat has increased and the lake provides hunting opportunities for these species. There have been some losses of squirrel and deer habitat. However, because of the vast acreage of these habitat types in the general area, the minor loss does not have significant effect on the hunting of these species in the area. The lake provides a greater diversification of fish and wildlife habitat and specific losses are replaced by wildlife management of the lake perimeter lands.

8-06. Water supply. Water supply is not a project purpose, however, several entities purchase water from G.R.D.A. The quality of water in the Grand (Neosho) River is considered good, requiring only conventional treatment to be suitable for domestic and industrial use. Withdrawals for water supply purposes will have no major effects on the lake.

8-07. Hydroelectric power. The regulation plan for the Arkansas River basin described in the Master Manual enhances power production at all the hydropower plants in the basin by providing a tapered recession of flood control storage evacuation. This provides more days of generation time before the flood control storage is depleted. The hydropower operation provides flows for the downstream run-of-river hydropower projects Markham Ferry, Fort Gibson, Webbers Falls, Robert S. Kerr, Ozark and Dardanelle.

8-08. Navigation. The coordination of releases from Pensacola Reservoir with other reservoirs (discussed in Chapter VII of the Arkansas River Basin Water Control Manual) will significantly benefit navigation along the McClellan-Kerr Navigation system by providing a tapered recession of flows along the system. This controlled recession will enable navigation to continue while shoals are removed from the navigation channel. The practice by G.R.D.A. of continuing to draw the pool below top of conservation pool provides additional water necessary to complete the navigation taper.

8-09. Frequencies.

a. Peak inflow probability. Estimated natural flows taken from "super" run A88X07 at the dam site for the period January 1940 through December 1986 were used to compute the maximum annual peak daily inflow probability. The inflow probability was derived in accordance with Bulletin 17B, "Guidelines for Determining Flood Flow Frequency," dated September 1981, with SWD requirements as stated in DF dated 22 August 1979, the peak daily inflow probability curve (natural conditions) is shown on plate 8-5. The skew used for the analysis is -0.3.

b. Pool elevation duration and probability. Pool elevation duration and probability curves developed from SUPER run number A88X07 are shown on plates 8-6 and 8-7.

8-10. Other Studies.

a. Examples of regulation. Studies are in progress to improve the forecasting techniques presented in section VI of this manual. Computer programs have been developed to forecast inflows into the lake, the resulting pool elevations and the effects of releases at the downstream gage. Use of these programs with time-sharing computer facilities has greatly shortened the reaction time in preparing regulation schedules.

b. Channel and floodway improvement. Channelization projects exist below Pensacola Reservoir on the Arkansas River with the majority related to the Arkansas River navigation system. Ground and aerial reconnaissance are made as required to determine if revised channel capacities and maximum discharge limits are warranted.

IX - WATER CONTROL AGREEMENT

9-01. Responsibilities and organizations.

a. Corps of Engineers. By authority of Section 7 of the 1944 Flood Control Act, the Tulsa District Corps of Engineers is responsible for prescribing and directing the flood control operation of Pensacola Reservoir. Project reporting instructions and an organization chart are presented in Chapter V. Project regulating instructions are presented in Chapter VII of this manual.

(1) Responsibilities and duties during normal operations. The Reservoir Control Section, Hydrology-Hydraulics Branch (H&H), Tulsa District Office, is charged with the following responsibilities and duties:

(a) Regulation of reservoirs and dissemination of 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 National Weather Service and the U.S. Geological Survey (USGS).

(c) Train personnel in flood control duties.

1. Periodic visits to projects by personnel of the section to familiarize themselves with regulation facilities, become acquainted with the operating personnel, discuss emergency regulation procedures with operating personnel, and provide the background for improving facilities and methods.

2. Instruct personnel of the H&H Branch in flood control procedures to supplement the Reservoir Control Section during flood emergencies, when necessary.

(d) Prepare reports on reservoir regulation.

1. Recurring reports.

2. Water control manuals.

3. Post flood reports.

(2) Responsibilities and duties during flood emergencies. 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. During flood emergencies, the Reservoir Control Section is responsible for the following:

(a) Evaluation of current hydrologic and meteoro-logical data.

(b) Presentation of storm and flood analysis to the District Commander and other interested District personnel.

(c) Regulation of reservoirs in accordance with flood control regulation schedules.

(d) Furnish information to higher authority as requested.

(e) Furnish information to the Tulsa District Reservoir Information Control Center (RICC). As part of these procedures, the Reservoir Information Control Center is activated and is the H&H Branch point of contact for public information during periods of flooding. Telephone lines normally reserved for public calls to the Reservoir Control Section are transferred to the center, which is manned by available personnel from other parts of the Tulsa District Office. This allows timely and orderly dissemination of data to the public while freeing project operating personnel to accomplish the flood operation. The duties of the project operating personnel under flood conditions are set forth in Chapter VII of this manual.

(3) Assignment of personnel. Plate 5-2 shows the organization of the Reservoir Control Section for Pensacola Project. To accomplish flood control operations, the Reservoir Control Section will often be manned 24 hours a day. During critical decision-making periods, personnel more specifically familiar with flood control operations will direct the operation and see that appropriate gate changes are made and other necessary measures are taken. During late evening and night hours, personnel from other areas of H&H Branch will often be assigned to assist Reservoir Control personnel. This is done after a clear plan of action has been undertaken for the

project. If the flooding is widespread enough, assistance from other areas of the H&H Branch could be provided on an as-needed basis at all hours.

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

b. Other Federal Agencies. The National Weather Service (NWS) and USGS cooperate together with the Reservoir Control Section, H&H Branch, Tulsa District Office, to accumulate rainfall and streamflow data. The NWS is the point of contact for observers of cooperative weather stations, and data is shared via computer. These stations supplement data already directly accessed by the H&H Branch computer to provide a more accurate rainfall representation. The NWS River Forecast Centers are responsible for forecasting river stages and disseminating associated warnings to the public and civil defense offices. The USGS is responsible for maintenance, construction, and measurement at approximately 90 percent of Tulsa District stream gages. The USGS shares streamflow data by satellite, computer, or telephone during flood periods.

c. Grand River Dam Authority. Pensacola Reservoir is owned and operated by the Grand River Dam Authority.

(1) Responsibilities and duties during normal operations. GRDA is responsible for the operation of the conservation pool including scheduling and producing hydropower and administering water supply storage and withdrawal contracts. As the project owner GRDA is responsible for the proper maintenance of all water control features of the project.

(2) Responsibilities and duties during flood emergencies. During flood control operations GRDA is responsible for carrying out the instructions issued by the Reservoir Control Section, including making gate changes in a timely manner and reporting hydrometeorological data as requested. GRDA must assure that sufficient personnel are on duty or on call to promptly carry out those instructions. GRDA is responsible for implementing the emergency flood control regulations described in chapter 7 should communications with the Reservoir Control Section be disrupted. While the Corps of Engineers is responsible for directing the regulation of the lake while it is in the flood control pool, GRDA is responsible for the lake regulation once the flood control storage has been exceeded. During these surcharge operations the

Corps of Engineers will provide assistance as requested by GRDA. The safety of the structure remains the responsibility of GRDA. The Emergency Action Plan for Pensacola Dam dated 1 December 1989 and prepared by GRDA describes their emergency notification plan and responsibilities.

9-02. Interagency coordination. Cooperative arrangements with other Federal and State agencies and local interests are discussed in section X of the Water Control Master Manual, Arkansas River Basin, Tulsa District, dated 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, streamflow, and pool elevations. Local press will be provided with information of flood forecasts by the NWS (officially responsible for issuing flood warnings). This information will be supplemented by the Corps of Engineers bulletins on observed conditions, forecasted pool elevations, and technical advice to enable local interests, within the limits of their capabilities, to obtain flood protection and to perform rescue and relief functions. The Corps of Engineers further assists in flood fighting, through the office of the Emergency Operations Manager, who can furnish sandbags and other necessary equipment based on equipment on hand and need.

b. National Weather Service. The Tulsa District Office exchanges data with the NWS offices which maintain AFOS gates within the District Boundaries. Offices which participate in this program are in Tulsa and Oklahoma City, Oklahoma, and Topeka, Kansas. The exchange of hydrometerologic information prevents duplication of effort in obtaining and disseminating data. The exchange program is discussed in greater detail in Chapter VI of this manual.

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 efficiently obtain all critical stream discharge measurements. Priorities for measurements are set by joint efforts of the USGS and the Corps of Engineers to determine what measurements are most critical and in what order they should be made. Communication is normally conducted by telephone to offices in Lawrence and Garden City, Kansas; Oklahoma City, Tulsa, and Woodward, Oklahoma; and Rolla, Missouri. Method of coordination is the same for all offices.

d. Power marketing agency. The Grand River Dam Authority is responsible for the sale and delivery to utility companies of all electric power generated at Pensacola Dam.

e. **Other Federal, State, or local agencies.** The Tulsa District Office and GRDA exchange information with state and local government officials, the State Highway Department, Oklahoma State Highway Patrol, the State Civil Defense, and others during flood emergencies. The District office accomplishes this coordination through the Emergency Management office, which communicates directly with local government offices.

9-03. Interagency agreements. A letter of Understanding (exhibit B) and a Water Control Agreement (exhibit C) have been agreed upon and signed by the Grand River Dam Authority and the Corps of Engineers.

9-04. Commissions, river authorities, compacts, and committees.

a. **Arkansas River Basin Compact, Kansas-Oklahoma.** This compact was established between the States of Kansas and Oklahoma. The major purposes stated in the compact are:

- To promote interstate comity between the States of Kansas and Oklahoma.

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

- To provide an agency for administering the water apportionment agreed to in the compact.

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

b. **Arkansas River Basin Coordinating Committee.** 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 on an as-needed basis to discuss recent activities and to exchange information and ideas to better serve specific project purposes.

9-05. Reports.

a. **Morning Reports.** This report is prepared in accordance with TDR 1130-2-12 by the Reservoir Control Section daily, 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 regulation of reservoirs, field investigations, stream gaging, and construction of flood control projects affected by releases from reservoirs, answering public inquiries, and preparing public releases. The report is prepared on SWT Forms 56 and 57 and includes a summary of hydrologic

conditions as of 8 a.m. of that date, weather forecast, including the extended outlook for the next four days, any quantitative precipitation forecasts or general rainfall data, and lake data for the previous and present days. The report is completed and dispatched from the Hydrology-Hydraulics Branch by 10 a.m. daily under normal conditions.

b. **Monthly Lake Reports**. The Reservoir Control Section, in accordance with paragraph 6-04 of EM 1110-2-3600 and paragraph 13(c) of ER 1110-2-208, prepares the monthly lake regulation tabulation. These reports are a record of lake regulation for all flood control, navigation, or multiple-purpose storage lakes that are under supervision of, or of direct interest to, the District Office. Supplemental information on the regulation of the lakes, such as explanation of deviations from approved schedules, is added as a note on the tabulation 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. Each month a copy is forwarded to SWD for their records.

c. **Flood situation reports**. The Reservoir Control Section submits data for situation reports during floods in accordance with ER 500-1-1, paragraph 4-4c. The report contains various types of information relative to the floods. Pertinent data specifically required for reservoirs are as follows: name of reservoir, reservoir stage, predicted maximum stage and anticipated date, rates of inflow and outflow in c.f.s., percent of flood control storage utilized to date and at predicted maximum stage, and any special information particularly pertinent to the flood situation.

d. **After-Action report**. This report is prepared in accordance with ER 500-1-1, paragraph 4-4, as soon as practicable after a flood causing major damage. The report describes flood emergency operations by the Corps of Engineers and others. Included in summary are available hydrologic information, damage estimates, and other engineering data considered to be pertinent concerning the flood control operations. The report is prepared by the District Office Emergency Management personnel, using information compiled and prepared by the Reservoir Control Section. The report should be completed within approximately 60 days after most emergency activities are complete.

e. **Annual report**. This report is prepared by the Reservoir Control Section. The report contains a summation of the general conditions of the river basins and the individual projects in the District for the preceding fiscal year. Included is information on flood and low flow regulation, rainfall, maximum and minimum lake levels and river stages experienced, flood reductions, navigation, and power production. The report also presents the activities and accomplishments of the Reservoir Control Center 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 lakes in the Tulsa District.

TABLE 9-1

SUMMARY OF REPORTS

NAME OF REPORT	WHEN REQUIRED	FORM NUMBER	REGULATION REQUIRING REPORTING
Morning Report	Daily, except Saturday, Sunday, and holidays	SWT Forms 56 and 57	TDR 1130-2-12
Monthly Lake Report	Monthly		EM 1110-2-3600 6-04 ER 1110-2-240, 13d
Flood Situation Report	During floods	-	OM 500-1-6, 4-7f ER 500-1-1, 4-4
After-Action Report	Following a damage	-	OM 500-1-6, 4-7g ER 500-1-1, 4-4
Annual Report	Annually	-	ER 1110-2-1400

EXHIBITS

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

PENSACOLA RESERVOIR

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

PENSACOLA RESERVOIR

TABLE OF CONTENTS

1 - GENERAL INFORMATION

Other names for project	Grand Lake O'the Cherokees
Location	Mayes, Delaware, and Ottawa Counties, Grand (Neosho) River, river mile 77.0
Type of project	Dam and lake.
Objectives of regulations	Multipurpose - Flood control, power, navigation.
Project owner	Grand River Dam Authority (GRDA).
Operating agency	Grand River Dam Authority. The Project is manned 24 hours a day, however, working hours of operation for weekdays are 8:00 a.m. to 4:30 p.m.; 7:00 a.m. to 3:30 p.m. during the summer. Working hours for weekends, holidays and nights vary, normal working hours are the same as weekdays and flood emergency conditions are 24 hours.
Regulating agency	GRDA is responsible for normal daily regulation procedures, regulation of the flood control pool is directed by the Corps of Engineers, Tulsa District.
Federal Power Commission License	# 1494
Water supply contracts	a. Afton Public Works Authority: 6,000,000 gallons/month. b. Grand Bluffs Development Company: 596 acre-feet per year. c. Grand Lake Public Works Authority: 18,000,000 gallons per month. d. Ketchum Public Works Authority: Up to 200,000 gallons per day.

	e. Langley Public Works Authority: 10,000,000 gallons per month.
	f. Pine Island R.V. Resort, Inc.: 420,000 gallons per month.
	g. Port Duncan Resort Marina, Ltd.: 1,800,000 gallons per month.
	h. City of Vinita (resale contracts): amount unknown.
	i. Rural Water District #3, Delaware County: 1,500,000 gallons per month.
	j. Rural Water District #3, Mayes County: Amount unknown
	k. City of Miami (secondary source).
Water rights	a. City of Vinita: Not to exceed 3,500,000 gallons per day.
	b. City of Miami: 7,000 gallons per minute.
	From below the dam: Town of Fort Gibson (1.543 cubic feet per second); Town of Salina (3.6 cubic feet per second); City of Muskogee (5 cubic feet per second); and City of Wagoner (2 cubic feet per second).
Project cost	$22,000,000
Closure date	March 21, 1940

2 - LAKE INFORMATION

ELEVATIONS, AREAS AND STORAGES

Feature	Pool Elevation [1]	Area (Acres)	Storage [2] Acre-Feet	Storage [2] Inches
Top of dam	757.0	-	-	-
Top of gates and flood control pool	755.0	59,200	2,197,000	4.00
Top of power pool	745.0	46,500	1,672,000	3.04
Spillway crest				
1. Main spillways	730.0	32,300	1,086,000	1.98
2. East spillways	740.0	40,900	1,452,000	2.64
Flood control storage	745.0 - 755.0	-	525,000	0.96
Power storage	705.0 - 745.0	-	1,192,000	2.17
Dead storage	705.0	17,000	480,000	0.87

[1] All elevations are Pensacola datum utilized in H.D. 107. Add 1.07 feet to convert to National Geodetic Vertical Datum.

[2] From 10,298 square miles of drainage area above the dam. One inch of runoff = 549,200 acre-feet

MAJOR FLOODS PAST DAMSITE

Date	Peak Inflow (c.f.s.)	Volume (acre-feet)	Runoff (inches) (1)
8 - 31 May 1943	313,000	4,712,700	8.58
27 Sep - 4 Oct 1986	178,000	3,125,000	5.69

(1) One inch of runoff = 549,200 acre-feet.

Real estate taking line for fee title	Fee title was acquired to the nearest subdivision line above elevation 750.0 feet, for a total of 52,300 acres.
Real estate taking line for easement	Flowage easement was acquired from elevation 750.0 feet, up to the elevation 757.0 feet. Total easement acreage is 12,016.
Range of clearing	To elevation 750.0 feet.
Pool elevation corresponding to discharge capability of maximum nondamaging flow rate downstream	Nondamaging channel capacity immediately below Pensacola Reservoir estimated at 100,000 cfs. This flow rate can be discharged when the lake level is at elevation 739.5 feet, and above.
Reservoir length at top of conservation pool	59.9 miles.
Reservoir length at the top of flood pool	64.2 miles.
Shoreline length at top of conservation pool	Estimated at 1300 miles.
Safety aspects possibly requiring warning	There are permanent structures as low as 750.0 feet. Access roads and even more structures are affected above 752.5 feet.
Emergency drawdown	The minimum time required to empty from the top of power pool (elevation 745.0 feet), to main spillway crest (elevation 730.0 feet) is 4.8 days.

3 - HYDROLOGY

Drainage area	10,298 square miles.
Probable maximum flood	
Maximum water surface elevation	756.70 feet.
Peak inflow (into full pool)	653,000 cfs.
Total storm runoff (into full pool)	4.48 inches.
Volume (into full pool)	2,462,000 acre-feet.
Maximum outflow	596,700 cfs.
Flood duration	7 days.
Spillway design flood	
Maximum water surface elevation	755.8 feet.
Peak inflow (into full pool)	590,000 cfs.
Total storm runoff (into full pool)	7.80 inches.
Volume (into full pool)	4,284,000 acre-feet.
Maximum outflow	558,700 cfs.
Flood duration	8 days.
Standard project flood	
Maximum water surface elevation	755.0 feet.
Peak inflow (into full pool)	295,000 cfs.
Total storm runoff	3.90 inches.
Volume (into full pool)	2,142,000 acre-feet.
Maximum outflow	243,000 cfs.
Flood duration	7 days.
Climate	Moderate.
One-inch runoff	549,200 acre-feet.
Storm types	Primarily thunderstorms.
Flood seasons	Primary flood period March through June with a secondary flood period of September through November; however, floods have occurred in every month of the year.
Low flow season	August, December through February; however, low flow can occur at any time of the year.

Minimum daily flow	Period 1940 through 1986 zero cfs has occurred on many occasions.
Minimum monthly flow	4,280 acre-feet in Jul 1954
Minimum annual flow and date	685,800 acre-feet in 1956.
Average annual flow	5,019,971 acre-feet (1923-1988).
Maximum annual flow and date	13,376,300 acre-feet in 1973
Maximum monthly flow and date	4,751,000 acre-feet in May 1943.
Maximum daily	285,000 cfs in May 1943.
Maximum instantaneous flow and date	303,000 cfs on 19 May 1943.
Maximum flood volume and date	4,713,000 acre-feet from 7 May - 2 Jun 1943.
Name and location of key streamflow stations	Muskogee, OK, Arkansas River (river mile 457.8) Van Buren, AR, Arkansas River (river mile 353.4).
Type of hydrometerologic data recorded at damsite	Maximum and minimum temperatures, recording and standard rainfall measurements, wind speed and direction, weather conditions, pool elevations and tailwater stages.
Number of precipitation stations used in hydrologic forecasting of Markham Ferry Reservoir	20 DCP recording, 23 AFOS observer.
Number of sediment ranges	0
Number of degradation ranges	0

4 - EMBANKMENTS

Location	Grand (Neosho) River, river mile 77.0.
Purpose	Impoundment, flood protection of agricultural lands, rural and urban structures, protection against loss of life and property, hydropower, navigation.
Type	Nonoverflow embankment.
Type of fill	Rolled impervious and random earthfill.
Slope protection	Riprap upstream and grassed downstream.
Height	147 feet above streambed.
Length	6,565 feet (including dam and spillways).
Top elevation	757.0 feet.
Design flood	Spillway design flood.
Freeboard	1.20 feet above design flood peak.
Used for roadway	State Highway 28 extends across the top of the dam.
Elevation of streambed	610.0 feet.

5 - DIKES

Number and location	One on east side of reservoir near Wyandotte, Oklahoma
Purpose	Protection of Wyandotte Public School from pool elevation rises.
Type	Rolled earth-fill, non-overflow.
Height	10 feet.
Length	1,300 feet.
Top elevation	760.0

6 - MAIN SPILLWAY

Location	Valley
Type	Gated concrete, gravity ogee weir.
Crest elevation	730.0 feet.
Net overflow length	756 feet.
Number and size of gates	Twenty-one, 36′ wide x 25′ high.
Type of gates	Tainter.
Top of gate elevation	755.0 feet, in closed position.
Induced surcharge	None.
Design head	25 feet.
Discharge capacity (Maximum pool elevation)	361,000 cfs at 755.0 feet Pensacola Datum
Type of energy dissipator	Stilling Basin.
Time required to open and close all gates	Traveling gate hoists are provided to operate the tainter gates. The time required to fully open a gate is about 20 minutes.

Type of emergency closure	Bulkhead.
Spillway activation	The tainter gates, except for periodic maintenance, are activated only during flood conditions. During normal conditions, all discharges are released through the powerhouse.

7 - EAST SPILLWAY

Location	Left abutment
Type	Gated concrete, gravity ogee weir.
Crest elevation	740.0 feet.
Net overflow length	777 feet.
Number and size of gates	Twenty-one, 37′ wide x 15′ high.
Type of gates	Tainter.
Top of gate elevation	755.0 feet, in closed position.
Induced surcharge	None.
Design head	15 feet.
Discharge capacity (Maximum pool elevation)	162,000 cfs at 755.0 feet Pensacola Datum
Type of energy dissipator	Concrete chute to limestone channel
Time required to open and close all gates	Traveling gate hoists are provided to operate the tainter gates. The time required to fully open a gate is about 20 minutes.
Type of emergency closure	Bulkhead.
Spillway activation	The tainter gates, except for periodic maintenance, are activated only during flood conditions. During normal conditions, all discharges are released through the powerhouse.

8 - OUTLET FACILITIES

WATER SUPPLY

Location	Through right abutment
Type of outlet and size	Circular 30-inch diameter
Type of gate	Hand operated gate valve
Entrance invert elevation	673.8 feet, Pensacola Datum

9 - HYDROELECTRIC POWER FACILITIES

Location	Near right abutment.
Type	Season storage
Installed capacity	9,600 kW.
Number, type and capacity	Six, 1,600 kilowatt generators.
Power on-line date	April 1940
Load factor	50 percent
Number and size of penstocks	Six, 16′ circular inlets per power unit.
Turbine discharge	Top of Power pool; 1870 cfs with one unit running, 11,240 cfs with all six running.
Design head (net head)	115.0 ft.
Max gross head for power	130.0 ft.
Average net head Power pool full Power pool empty	 110.0′ feet. N/A
Minimum flow required for generation	1000 cfs.

Minimum peaking capability	101,000 kW
Dependable capacity	90,000 kW
Average annual energy	366,000 MWH
Minimum annual energy	101,000
Critical tailwater elevation	652.0 ft.

10 - CONTROL POINTS

a - MUSKOGEE GAGE

Location	On U.S. Highway 62 Bridge, 3.5 miles N.E. of Muskogee, Oklahoma at rivermile 457.8 on Arkansas river.
Purpose of gage	Provide stage and precipitation data and serve as a control point for flood releases from Fort Gibson Lake and other upstream reservoirs.
Channel and flood plain description	The channel is well defined and fairly straight in the vicinity of the gage, the flood plain is broad with trees, cultivated crops and some rural development.
Drainage area	96,674 square miles, of which 12,541 are non-contributing.
Target flow rate	Bankfull stage 26.0 feet in the reach, 150,000 cfs.
Time of crest travel	Fort Gibson Dam to Muskogee gage -2 hours (approximate).
Monitoring provisions	Water surface elevation is recorded by a Sutron Data Collection Platform.
Zero of Gage	471.38 ft.
Channel usage	Navigation, water supply, fishing and fish spawning.

b - VAN BUREN GAGE

Location	Near left bank on upstream side of U.S. Highway 64 bridge at Van Buren, Arkansas at rivermile 353.4 on Arkansas River.
Purpose of gage	Provide stage and precipitation data and serve as a control point for flood releases from Fort Gibson Lake and other upstream reservoirs.
Channel and flood plain description	The channel is well defined and straight downstream of the gage. The left bank is high, and the right bank is a combined levee and floodwall that protects properties on the right overbank.
Drainage area	150,483 square miles of which 22,241 square miles are non-contributing.
Target flow rate	Bankfull stage 22.0 feet, 125,000 cfs (current rating).
Time of crest travel	Fort Gibson Dam to Van Buren gage 38 hours. (approximate)
Monitoring provisions	Water surface elevation is recorded by a Sutron Data Collection Platform.
Zero of Gage	372.36 ft.
Channel usage	Navigation, water supply, fishing and fish spawning.

EXHIBIT B

LETTER OF UNDERSTANDING

PENSACOLA DAM AND RESERVOIR

LETTER OF UNDERSTANDING
PENSACOLA DAM AND RESERVOIR

WHEREAS, Pensacola Dam and Reservoir, Grand (Neosho) River, Mayes County, Oklahoma, was authorized by Flood Control Act approved August 18, 1941, PL 77-228, and the project was placed in operation under the provision of Federal Power Commission License No. 1894, dated July 26, 1939, and was constructed by the Grand River Dam Authority with 525,000 acre-feet of flood control storage which is regulated in accordance with Section 7 of the 1944 Flood Control Act, and,

WHEREAS, Section 7 of the Flood Control Act of 1944, Public Law 78-534, 58 Stat 890, 33 USC 709 directs the Secretary of the Army to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds, and,

WHEREAS, The Flood Control Regulations, (33 CFR 208.11) further prescribes the policy and procedures for regulating the use of storage allocated for flood control or navigation purposes at all reservoirs capable of such regulation and constructed wholly or in part with Federal funds provided on the basis of such purposes,

NOW THEREFORE, this Letter of Understanding shall consummate the provisions of Section 7 of the 1944 Flood Control Act for Pensacola Dam and Reservoir, Grand (Neosho) River, Mayes County, Oklahoma. In addition to the responsibilities of the Project Owner, Grand River Dam Authority (hereinafter called the Authority), and the Corps of Engineers (hereinafter called the Corps) spelled out in accordance with 33 CFR, 208.11, it is agreed or understood that:

a. The Authority has the responsibility for the physical operation of the flood control facilities for the purpose of releasing floodwaters between elevations 745.0 and 755.0 feet Pensacola Datum as directed by the Corps.

b. The Corps is responsible for directing real-time implementation of the flood control plan and until further notice shall direct the regulation of the project for storage and release of flood waters in the flood control pool in accordance with the approved Water Control Plan.

c. Since the Authority is responsible for the structural safety of Pensacola Dam, the Authority shall be responsible for directing storage and release of all waters when the lake level is above the top of the flood control pool, elevation 755.0 feet, Pensacola Datum. The Corps shall provide technical assistance during this time if the Authority requests it.

d. The Authority shall be responsible for directing storage and release of all waters in the conservation pool. The Corps will advise the Authority when inflow rates are anticipated which will raise the pool above elevation 745.0 feet, NGVD, at the dam. The Corps will also advise the Authority of any essential increase in the flood control storage capacity of the reservoir which should be provided by drawing the pool down below elevation 745.0 feet, NGVD, at the dam in order to obtain maximum flood control benefits, with the provision that the suggested reduction in power storage shall at no time exceed the replacement volume of flow indicated by the gages in the streams above the reservoir.

e. The Authority shall be responsible for the operation and maintenance of the flood control facilities. The Authority shall maintain capabilities of the flood control facilities in accordance with the construction specifications and the "as built" drawings.

f. The Authority will provide observations required by the Corps for flood control regulation of Pensacola Dam and Reservoir. The Authority will record and transmit hydrometeorological and lake data to the Corps on a real-time basis and will furnish a daily report by telephone to the Corps office in Tulsa, Oklahoma. Reports for weekends and holidays will be furnished on Monday or the day after the holiday unless otherwise instructed by the Corps. These reports shall reach the Corps office in Tulsa, Oklahoma, by 8:30 a.m. each day. This report will include the headwater elevation at noon, 4:00 p.m., and midnight of the previous day and 8:00 a.m of the day of the report; the number of tainter gates in operation with their respective openings and releases; the 24-hour average power discharge; measured pan evaporation data; and precipitation in inches for the preceding 24-hour period. Whenever the lake level rises to elevation 745.0 feet Pensacola Datum and releases for flood regulation are necessary or appear imminent, the Authority shall report at once to the Tulsa District Engineer or his duly authorized representative by telephone to receive instructions. The Authority will confirm by telephone all gate changes ordered by the Corps' reservoir control personnel at the time the gate change is completed. This confirmation will include the headwater elevation, the time of the gate change, and the number of tainter gates in operation with their respective openings and releases.

g. The flood control regulations, insofar as they govern the use of the flood control storage capacity between elevations 745.0 and 755.0 feet Pensacola Datum are subject to temporary modification by the Corps in time of flood. Such modifications would be consistent with emergency requirements for protecting the dam and reservoir from major damage and with the safe routing of the probable maximum flood. The modification shall be communicated to the representative of the Authority in immediate charge of operation at Pensacola Dam and Reservoir by the best available means of communication, and shall be confirmed in writing at the request of the General Manager of the Authority.

h. Flood control regulation shall not restrict municipal and industrial uses and downstream releases for authorized users as determined by the Authority or others.

i. The Authority shall be responsible for keeping current all data contained in its flood warning plan.

j. The Corps and the Authority shall provide warnings that will start immediately when a water condition is expected that could produce severe damage to property and be potentially dangerous to life. The following paragraphs identified the action to be taken by each agency.

(1) Corps. The Corps shall furnish the Authority with the projected lake levels and the expected flood control releases. The Corps shall furnish the Authority with all pertinent hydrologic facts concerning Pensacola Dam and Reservoir, and known conditions downstream of the project for its use in warning the public within and below the project. The Corps shall dispatch personnel to Pensacola Dam as required.

(2) Authority. The Authority shall initiate its flood warning plan at its discretion. The Authority shall release information furnished by the Corps to the public in the lake area, and will advise the public below the dam.

k. The Water Control Manual for Pensacola Dam and Reservoir will contain the Water Control Agreement and this Letter of Understanding. In addition, the manual will contain instructions for reporting data necessary for flood control regulation of the project and communications procedures between the Authority and the Corps. The manual contains instructions to be followed for flood control regulation. The manual will serve as a detailed guide to personnel involved in the flood control regulation of

Pensacola Dam and Reservoir during the life of the project. Portions of the manual will be updated as conditions warrant. Revisions to the Water Control Manual and all associated documents will be in accordance with the provisions of 33 CFR 208.11 (d) (10).

(Name)

ROBERT L. HERNDON
Brigadier General, USA
Commanding
Southwestern Division
Corps of Engineers
Authorized Representative
of the Chief of Engineers

11/6/92
(Date)

(Name)

RON COKER

General Manager
Grand River Dam Authority

July 22, 1992
(Date)

EXHIBIT C

WATER CONTROL AGREEMENT

PENSACOLA DAM AND RESERVOIR

WATER CONTROL AGREEMENT
PENSACOLA RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

Pursuant to Section 7 of the Flood Control Act of 1944, (58 Stat 890, USC 709) and further prescribed in 33 CFR 208.11 (d)(5)(i), Title 33, of ...e Code of Federal Regulations (55 FR 21508, May 24, 1990) the following water control release schedules will govern the use of the water storage at Pensacola Reservoir on the Grand (Neosho) River, Oklahoma.

NORMAL FLOOD CONTROL REGULATION SCHEDULE
PENSACOLA RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATIONS
Below 745.0	Rising	Hydropower released will be made by Grand River Dam Authority (G.R.D.A.) to meet its power requirements. If the pool is forecasted to exceed elevation 745, the Corps may direct that flood control releases be made, provided that there is a sufficient volume of water then in sight at the upstream gages to fill the power pool.
745.0 - 755.0 & forecasted not to exceed 755.0	Rising	Release will not exceed 100,000 c.f.s. below the dam and will be made in such a manner as to balance, as much as practical, the percentage of the flood control storage utilized in Pensacola Reservoir, Markham Ferry Reservoir, and Fort Gibson Lake.
745.0 - 755.0 & forecasted to exceed 755.0	Rising	Releases will be made to reduce as much as practical the flood damage below the dam and to limit the pool elevation to 755.0. Plate 7-1, Spillway Gate Regulation Schedule Inflow Parameter, may be used as a guide to determine releases.
755.0 or above *	Rising	Spillway gates will be opened to maintain the pool at elevation 755.0 or until all the gates are fully open.
755.0 or above *	Falling	The maximum discharge attained shall be held until the pool recedes to elevation 755.0.
7[illegible].0 - 755.0	Falling	Releases will not exceed 100,000 c.f.s. and will be made in such a manner as to balance, as much as practical, the percent of the flood control storage utilized in the 3-reservoir system. Evacuation of the flood control storage in this system will be governed by provisions of Chapter 7 of the Arkansas River Basin Master Manual.

* NOTE: The Grand River Dam Authority is responsible for regulation above ...vation 755.0 feet. The Corps will provide technical assistance if ...quested.

EMERGENCY FLOOD CONTROL REGULATION SCHEDULE
PENSACOLA RESERVOIR, GRAND (NEOSHO) RIVER, OKLAHOMA

LAKE STAGE	POOL CONDITIONS	REGULATIONS
Below 745.0	Rising	Continue the releases being made at the time communication is lost.
745.0 - 755.0	Rising	Maintain releases being made until communication is restored or 12 hours have elapsed. If communication is not restored after 12 hours or the pool rises to elevation 752.5 during the 12-hour waiting period, determine average 6-hour discharge using Plate 7-3 (Discharge Rating Curves-Main Spillway) and Plate 7-4 (Discharge Rating Curves-East Spillway). Proceed to Plate 7-2 (Inflow vs Rate Of Rise-Nomograph) to determine inflows and then proceed to Plate 7-1 (Spillway Gate Regulation Schedule) to determine outflows. At no time shall releases be reduced if the pool is rising. If the pool is above 752.5, the releases shall not be less than indicated by the minimum discharge curve on plate 7-1.
755.0 or above	Rising	Spillway gates will be opened as necessary to maintain the pool at elevation 755.0 or until all the gates are fully opened.
755.0 or above	Falling	The maximum discharge attained shall be held until the pool recedes to elevation 755.0.
755.0 - 752.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 100,000 c.f.s., whichever is greater.
752.5 - 750.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 60,000 c.f.s., whichever is greater.
750.0 - 747.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 40,000 c.f.s., whichever is greater.
747.5 - 745.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 20,000 c.f.s., whichever is greater.
Near 745.0	Falling	Releases shall be gradually reduced to equal inflow by the time the pool recedes to elevation 745.0.

(Name)

ROBERT L. HERNDON
Brigadier General, USA
Commanding
Southwestern Division
Corps of Engineers
Authorized Representative
of the Chief of Engineers

11/6/92
(Date)

(Name)

RON COKER
General Manager
Grand River Dam Authority

July 22, 1992
(Date)

EXHIBIT D

SECTION 7 FLOOD CONTROL REGULATION

EXTRACTED FROM CODE OF FEDERAL REGULATIONS, TITLE 33, PART 208 (55 FR 21508, MAY 24, 1990)

DEPARTMENT OF THE ARMY
U. S. Army Corps of Engineers
Washington, D. C. 20314-1000

CECW-EH-W

ER 1110-2-241
33 CFR Part 208
Sec 208.11

Regulation
No. 1110-2-241

24 May 1990

Engineering and Design
USE OF STORAGE ALLOCATED FOR FLOOD CONTROL
AND NAVIGATION AT NON-CORPS PROJECTS

1. Purpose. This regulation prescribes the responsibilities and general procedures for regulating reservoir projects for flood control or navigation and the use of storage allocated for such purposes. Excepted projects are those owned and operated by the Corps of Engineers; the International Boundary and Water Commission, United States and Mexico; and those under the jurisdiction of the International Joint Commission, United States and Canada, and the Columbia River Treaty. The intent of this regulation is to establish an understanding between project owners, operating agencies and the Corps of Engineers.

2. Applicability. This regulation applies to HQUSACE/OCE elements, major subordiante commands, districts, laboratories, and field operating activities (FOA) having Civil Works responsibilities.

3. References.

a. Section 7 of the Flood Control Act approved 22 December 1944 (58 Stat. 890; U.S.C. 709).

b. Section 9 of Public Law 43-83d Congress (68 Stat. 303).

c. The Federal Power Act, approved 10 June 1920, as amended (41 Stat. 1063; 16 U.S.C. 791(a)).

d. The Fish and Wildlife Coordination Act of 1958, Public Law 85-624.

e. The Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500 (86 Stat. 816, 33 U.S.C. 1251).

f. The Federal Power Commission Order No. 540, issued 31 October 1975 and published 7 November 1975 (40 FR 51998), amending Section 2.9 of the Commission's General Policy and Interpretations prescribing Standardized Conditions (Forms) for Inclusion in Preliminary Permits and Licenses Issued under Part I of the Federal Power Act.

g. ER 1110-2-240

This regulation supercedes ER-1110-2-241, 8 December 1978

4. Responsibilities. The basic responsibilities of the Corps of Engineers regarding project operation are set out in the cited authority and described in the following paragraphs:

a. Section 7 of the Flood Control Act of 1944 (58 Stat. 890, 33 U.S.C. 709) directs the Secretary of the Army to prescribe regulations for flood control and navigation in the following manner:

"Hereafter, it shall be the duty of the Secretary of War to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds provided on the basis of such purposes, and the operation of any such project shall be in accordance with such regulations: Provided, that this section shall not apply to the Tennessee Valley Authority, except that in case of danger from floods on the lower Ohio and Mississippi Rivers the Tennessee Valley Authority is directed to regulate the release of water from the Tennessee River into the Ohio River in the release of water from the Tennessee River into the Ohio River in accordance with such instructions as may be issued by the War Department."

b. Section 9 of Public Law 436-83d Congress (68 Stat. 303) provides for the development of the Coosa River, Alabama and Georgia, and directs the Secretary of the Army to prescribe rules and regulations for project operation in the interest of flood control and navigation as follows:

"The operation and maintenance of the dams shall be subject to reasonable rules and regulations of the Secretary of the Army in the interest of flood control and navigation."

NOTE. - This Regulation will also be applicable to dam and reservoir projects operated under provisions of future legislative acts wherein the Secretary of the Army is directed to prescribe rules and regulations in the interest of flood control and navigation. The Chief of Engineers, U.S. Army Corps of Engineers, is designated the duly authorized representative of the Secretary of the Army to exercise the authority set out in the Congressional Acts. This Regulation will normally be implemented by letters of understanding between the Corps of Engineers and project owner and will incorporate the provisions of such letters of understanding prior to the time construction renders the project capable of significant impoundment of water. A water control agreement signed by both parties will follow when deliberate impoundment first begins or at such time as the responsibilities of any Corps-owned projects may be transferred to another entity. Promulgation of this Regulation for a given project will occur at such time as the name of the project appears in the Federal Register in accordance with the requirements of paragraph 6k. When agreement on a water control plan cannot be reached between the Corps and the project owner after coordination with all interested parties, the project name will be entered in the Federal Register and the Corps of Engineers plan will be the official water control plan until such time as differences can be resolved.

c. Federal Energy Regulatory Commission (FERC), formerly Federal Power Commission (FPC), Licensees.

(1) Responsibilities of the Secretary of the Army and/or the Chief of Engineers in FERC licensing actions are set forth in reference 3c above and pertinent sections are cited herein. The Commission may further stipulate as a licensing conditions, that a licensee enter into an agreement with the Department of the Army providing for operation of the project during flood times, in accordance with rules and regulations prescribed by the Secretary of the Army.

(a) Section 4(e) of the Federal Power Act requires approval by the Chief of Engineers and the Secretary of the Army of plans of dams or other structures affecting the navigable capacity of any navigable waters of the Unites States, prior to issuance of a license by the Commission as follows:

"The Commission is hereby authorized and empowered to issue licenses to citizens...for the purpose of constructing, operating and maintaining dams, water conduits, reservoirs, powerhouses, transmission lines, or other project works necessary or convenient for the development and improvement of navigation and for the development, transmission, and utilization of power across, along, from or in any of the streams or other bodies of water over which Congress has jurisdiction . . . Provided further, that no license affecting the navigable capacity of any navigable waters of the United States shall be issued until the plans of the dam or other structures affecting navigation have been approved by the Chief of Engineers and the Secretary of the Army."

(b) Sections 10(a) and 10(c) of the Federal Power Act specify conditions of project licenses including the following:

Section 10(a). "That the project adopted . . . shall be such as in the judgment of the Commission will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of waterpower development, and for other beneficial public uses . . . ."

Section 10(c). "That the licensee shall . . . so maintain and operate said works as not to impair navigation, and shall conform to such rules and regulations as the Commission may from time to time prescribe for the protection of life, health, and property . . . ."

(c) Section 18 of the Federal Power Act directs the operation of any navigation facilities built under the provision of that Act, be controlled by rules and regulations prescribed by the Secretary of the Army as follows:

"The operation of any navigation facilities which many be constructed as part of or in connection with any dam or diversion structure built under the provisions of this Act, whether at the expense of a licensee hereunder or of

the United States, shall at all times be controlled by such reasonable rules and regulations in the interest of navigation; including the control of the pool caused by such dam or diversion structure as may be made from time to time by the Secretary of the Army, . . . "

(2) Federal Power Commission Order No. 540 issued 31 October 1975 and published 7 November 1975 (40 FR 51998), amending Section 2.9 of the Commission's General Policy and Interpretations prescribed Standardized Conditions (Forms) for Inclusion in Preliminary Permits and Licenses Issued Under Part I of the Federal Power Act. As an example, Article 12 of Standard Form L-3, titled: "Terms and Conditions of License for Constructed Major Projects Affecting Navigable Waters of the United States," sets forth the Commission's interpretation of appropriate sections of the Act, which deal with navigation aspects, and attendant responsibilities of the Secretary of the Army in licensing actions as follows:

"The United States specifically retains and safeguards to the right to use water in such amount, to be determined by the Secretary of the Army, as may be necessary for the purposes of navigation on the navigable waterway affected; and the operations of the Licensee, so far as they affect the use, storage and discharge from storage of waters affected by the license, shall at all times be controlled by such reasonable rules and regulations as the Secretary of the Army may prescribe in the interest of navigation, and as the Commission may prescribe for the protection of life, health, and property, . . . and the Licensee shall release water from the project reservoir at such rate . . . as the Secretary of the Army may prescribe in the interest of navigation, or as the Commission may prescribe for the other purposes hereinbefore mentioned."

5. Scope and Terminology. This regulation applies to Federal authorized flood control and/or navigation storage projects, and to non-Federal projects which require the Secretary of the Army to prescribe regulations as a condition of the license, permit or legislation, during the planning, design and construction phases, and throughout the life of the project. In compliance with the authority cited above, this regulation defines certain activities and responsibilities concerning water control management throughout the nation in the interest of flood control and navigation. In carrying out the conditions of this regulation, the owner and/or operating agency will comply with applicable provisions of Public Law 85-624, the Fish and Wildlife Coordination Act of 1958, and Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972. This regulation does not apply to local flood protection works governed by 33 Code of Federal Regulations (CFR) Part 208.10, or to navigation facilities and associated structures which are otherwise covered by 33 CFR Part 207 (Navigation Regulations). Small reservoirs, containing less than 12,500 acre-feet of flood control or navigation storage, may be excluded from this regulation and covered under 33 CFR Part 208.10, unless specifically required by law or conditions of the license or permit.

a. The terms "reservoir" and "project" as used herein include all water resource impoundment projects constructed or modified, including natural lakes, that are subject to this regulation.

b. The term "project owner" refers to the entity responsible for maintenance, physical operation, and safety of the project, and for carrying out the water control plan in the interest of flood control and/or navigation as prescribed by the Corps of Engineers. Special arrangements may be made by the project owner for "operating agencies" to perform these tasks.

c. The term "letter of understanding" as used herein includes statements which consummate this regulation for any given project and define the general provisions or conditions of the local sponsor, or owner, cooperation agreed to in the authorizing legislative document, and the requirements for compliance with Section 7 of the 1944 Flood Control Act, the Federal Power Act or other special Congressional Act. This information will be specified in the water control plan and manual. The letter of understanding will be signed by a duly authorized representative of the Chief of Engineers and the project owner. A "field working agreement" may be substituted for a letter of understanding, provided that the specified minimum requirements of the latter, as stated above, are met.

d. The term "water control agreement" refers to a compilation of water control criteria, guidelines, diagrams, release schedules, rule curves and specifications that basically govern the use of reservoir storage space allocated for flood control or navigation and/or release functions of a water control project for these purposes. In general, they indicate controlling or limiting rates of discharge and storage space required for flood control and/or navigation, based on the runoff potential during various seasons of the year.

e. For the purpose of this regulation, the term "water control plan" is limited to the plan of regulation for a water resources project in the interest of flood control and/or navigation. The water control plan must conform with proposed allocations of storage capacity and downstream conditions or other requirements to meet all functional objectives of the particular project, acting separately or in combination with other projects in a system.

f. The term "real-time" denotes the processing of current information or data in a sufficiently timely manner to influence a physical response in the system being monitored and controlled. As used herein the term includes information the analyses for and execution of water control decisions for both minor and major flood events and for navigation, based on prevailing hydrometeorological and other conditions and constraints, to achieve efficient management of water resource systems.

6. Procedures.

a. Conditions during Project Formulation. During the planning and design phases, the project owner should consult with the Corps of Engineers regarding the quantity and value of space to reserve in the reservoir for flood control and/or navigation purposes, and for utilization of the space, and other requirements of the license, permit or conditions of the law. Relevant matters that bear upon flood control and navigation accomplishment include: runoff potential, reservoir discharge capability, downstream channel characteristics, hydrometeorological data collection, flood hazard, flood damage characteristics, real estate acquisition for flowage requirements (fee and easement), and resources required to carry out the water control plan. Advice may also be sought on determination of and regulation for the probable maximum or other design flood under consideration by the project owner to establish the quantity of surcharge storage space, and freeboard and top of dam or embankment elevation for safety of the project.

b. Corps of Engineers Involvement. If the project owner is responsible for real-time implementation of the water control plan, consultation and assistance will be provided by the Corps of Engineers when appropriate and to the extent possible. During any emergency that affects flood control and/or navigation, the Corps of Engineers may temporarily prescribe regulation of flood control or navigation storage space on a day-to-day (real-time) basis without request of the project owner. Appropriate consideration will be given for other authorized project functions. Upon refusal of the project owner to comply with regulations prescribed by the Corps of Engineers, a letter will be sent to the project owner by the Chief of Engineers or his duly authorized representative describing the reason for the regulations prescribed, events that have transpired, and notification that the project owner is in violation of the Code of Federal Regulations. Should an impasse arise, in that the project owner or the designated operating entity persists in noncompliance with regulations prescribed by the Corps of Engineers, measures may be taken to assure compliance.

c. Corps of Engineers Implementation of Real-Time Water Control Decisions. The Corps of Engineers may prescribe the continuing regulation of flood control storage space for any project subject to this regulation on a day-to-day (real-time) basis. When this is the case, consultation and assistance from the project owner to the extent possible will be expected. Special requests by the project owner, or appropriate operating entity, are preferred before the Corps of Engineers offers advice on real-time regulation during surcharge storage utilization.

d. Water Control Plan and Manual. Prior to project completion, water control managers from the Corps of Engineers will visit the project and the area served by the project to become familiar with the water control facilities, and to insure sound formulation of the water control plan. The formal plan of regulation for flood control and/or navigation, referred to

herein as the water control plan, will be developed and documented in a water control manual prepared by the Corps of Engineers. Development of the manual will be coordinated with the project owner to obtain the necessary pertinent information, and to insure compatibility with other project purposes and with surcharge regulation. Major topics in the manual will include: authorization and description of the project, hydrometeorology, data collection and communication networks, hydrologic forecasting, the water control plan, and water resource management functions, including responsibilities and coordination for water control decision-making. Special instructions to the damtenders or reservoir manager on data collection, reporting to higher Federal authority, and on procedures to be followed in the event of a communication outage under emergency conditions, will be prepared as an exhibit in the manual. Other exhibits will include copies of this regulation, letters of understanding consummating this regulation, and the water control agreements. After approval by the Chief of Engineers or his duly authorized representative, the manual will be furnished to the project owner.

e. Water Control Agreement.

(1) A water control diagram (graphical) will be prepared by the Corps of Engineers for each project having variable space reservation for flood control and/or navigation during the year; e.g., variable seasonal storage, joint-use space, or other rule curve designation. Reservoir inflow parameters will be included on the diagrams when appropriate. Concise notes will be included on the diagrams prescribing the use of storage space in terms of release schedules, runoff, nondamaging or other controlling flow rates downstream of the damsite, and other major factors as appropriate. A water control release schedule will be prepared in tabular form for projects that do not have variable space reservation for flood control and/or navigation. The water control diagram or release schedule will be signed by a duly authorized representative of the Chief of Engineers, the project owner, and the designated operating agency, and will be used as the basis for carrying out this regulation. Each diagram or schedule will contain a reference to this regulation.

(2) When deemed necessary by the Corps of Engineers, information given on the water control diagram or release schedule will be supplemented by appropriate text to assure mutual understanding on certain details or other important aspects of the water control plan not covered in this regulation, on the water control diagram or in the release schedule. This material will include clarification of any aspects that might otherwise result in unsatisfactory project performance in the interest of flood control and/or navigation. Supplementation of the agreement will be necessary for each project where the Corps of Engineers exercises the discretionary authority to prescribe the flood control regulation on a day-to-day (real-time) basis. The agreement will include delegation of the responsibility. The document should also cite, as appropriate, Section 7 of the 1944 Flood Control Act, the Federal

Power Act and/or other Congressional legislation authorizing construction and/or directing operation of the project.

(3) All flood control regulations published in the Federal Register under this Section (Part 208) of the Code prior to the date of this publication which are listed in paragraph 208.11(e) are hereby superseded.

(4) Nothing in this regulation prohibits the promulgation of specific regulations for a project in compliance with the authorizing Acts, when agreement on acceptable regulations cannot be reached between the Corps of Engineers and the owner.

f. Hydrometeorological Instrumentation. The project owner will provide instrumentation in the vicinity of the damsite and will provide communication equipment necessary to record and transmit hydrometeorological and reservoir data to all appropriate Federal authorities on a real-time basis unless there are extenuating circumstances or are otherwise provided for as a condition of the license or permit. For those projects where the owner retains responsibility for real-time implementation of the water control plan, the owner will also provide or arrange for the measurement and reporting of hydrometeorological parameters required within and adjacent to the watershed and downstream of the damsite, sufficient to regulate the project for flood control and/or navigation in an efficient manner. When data collection stations outside the immediate vicinity of the damsite are required, and funds for installation, observation, and maintenance are not available from other sources, the Corps of Engineers may agree to share the costs for such stations with the project owner. Availability of funds and urgency of data needs are factors which will be considered in reaching decisions on cost sharing.

g. Project Safety. The project owner is responsible for the safety of the dam and appurtenant facilities and for regulation of the project during surcharge storage utilization. Emphasis upon the safety of the dam is especially important in the event surcharge storage is utilized, which results when the total storage space reserved for flood control is exceeded. Any assistance provided by the Corps of Engineers concerning surcharge regulation is to be utilized at the discretion of the project owner, and does not relieve the owner of the responsibility for safety of the project.

h. Notification of the General Public. The Corps of Engineers and other interested Federal and State agencies, and the project owner will jointly sponsor public involvement activities, as appropriate, to fully apprise the general public of the water control plan. Public meetings or other effective means of notification and involvement will be held, with the initial meeting being conducted as early as practicable but not later than the time the project first becomes operational. Notice of the initial public meeting shall be published once a week for three consecutive weeks in one or more newspapers of general circulation published in each county covered by the water control plan. Such notice shall also be used when appropriate to inform the public of

modifications in the water control plan. If no newspaper is published in a county, the notice shall be published in one or more newspaper of general circulation within that county. For the purposes of this Section a newspaper is one qualified to publish public notices under applicable state law. Notice shall be given in the event significant problems are anticipated or experienced that will prevent carrying out the approved water control plan or in the event that an extreme water condition is expected that could produce severe damage to property or loss of life. The means for conveying this information shall be commensurate with the urgency of the situation. The water control manual will be made available for examination by the general public upon request at the appropriate office of the Corps of Engineers, project owner or designated operating agency.

i. Other Generalized Requirements for Flood Control and Navigation.

(1) Storage space in the reservoirs allocated for flood control and navigation purposes shall be kept available for those purposes in accordance with the water control agreement, and the plan of regulation in the water control manual.

(2) Any water impounded in the flood control space defined by the water control agreement shall be evacuated as rapidly as can be safely accomplished without causing downstream flows to exceed the controlling rates; i.e., releases from reservoirs shall be restricted insofar as practicable to quantities which, in conjunction with uncontrolled runoff downstream of the dam, will not cause water levels to exceed the controlling stages currently in force. Although conflicts may arise with other purposes, such as hydropower, the plan or regulation may require releases to be completely curtailed in the interest of flood control or safety of the project.

(3) Nothing in the plan of regulation for flood control shall be construed to require or allow dangerously rapid changes in magnitudes of releases. Releases will be made in a manner consistent with requirements for protecting the dam and reservoir from major damage during passage of the maximum design flood for the project.

(4) The project owner shall monitor current reservoir and hydrometeorological conditions in and adjacent to the watershed and downstreamof the damsite, as necessary. This and any other pertinent information shall be reported to the Corps of Engineers on a timely basis, in accordance with standing instructions to the dam tenders or other means requested by the Corps of Engineers.

(5) In all cases where the project owner retains responsibility for real-time implementation of the water control plan, he shall make current determinations of: reservoir inflow, flood control storage utilized, and scheduled releases. He shall also determine storage space and releases required to comply with the water control plan prescribed by the Corps of

Engineers. The owner shall report this information on a timely basis as requested by the Corps of Engineers.

(6) The water control plan is subject to temporary modification by the Corps of Engineers if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communication available. The action taken shall be confirmed in writing the same day to the project owner and shall include justification for the action.

(7) The project owner may temporarily deviate from the water control plan in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of the dam, or to avoid other serious hazards. Such actions shall be immediately reported by the fastest means of communication available. Actions shall be confirmed in writing the same day to the Corps of Engineers and shall include justification for the action. Continuation of the deviation will require the express approval of the Chief of Engineers, or his duly authorized representative.

(8) Advance approval of the Chief of Engineers, or his duly authorized representative, is required prior to any deviation from the plan of regulation prescribed or approved by the Corps of Engineers in the interest of flood control and/or navigation, except in emergency situations provided for in paragraph 6i(7) above. When conditions appear to warrant a prolonged deviation from the approved plan, the project owner and the Corps of Engineers will jointly investigate and evaluate the proposed deviation to insure that the overall integrity of the plan would not be unduly compromised. Approval of prolonged deviations will not be granted unless such investigations and evaluations have been conducted to the extent deemed necessary by the Chiefs of Engineers or his designated representatives to fully substantiate the deviation.

j. Revisions. The water control plan and all associated documents will be revised by the Corps of Engineers as necessary, to reflect changed conditions that come to bear upon flood control and navigation, e.g., reallocation of reservoir storage space due to sedimentation or transfer of storage space to a neighboring project. Revision of the water control plan, water control agreement, water control diagram, or release schedule requires approval of the Chief of Engineers or his duly authorized representative. Each such revision shall be effective upon the date specified in the approval. The original (signed document) water control agreement shall be kept on file in the approprate Division or District Office, Corps of Engineers, Department of the Army. Copies of these agreements may be obtained from the office of the project owner, or by contacting the appropriate Division Commander, U.S Army Corps of Engineers.

k. Federal Register. The following information for each project subject to Section 7 on the 1944 Flood Control Act and other applicable Congressional acts shall be published in the Federal Register prior to the time the projects

become operational and prior to any significant impoundment before project completion or . . . at such time as the responsibility for physical operation and maintenance of the Corps of Engineers owned projects is transferred to another entity: (a) dam and reservoir or lake names, (b) stream, county and state corresponding to the damsite location, (c) the maximum current active storage space in acre-feet to be reserved exclusively for flood control and/or navigation purposes, or any multiple-use space (intermingled) when flood control or navigation is one of the purposes, with corresponding elevations in feet above mean sea level, and area in acres, at the upper and lower limits of said space, (d) the name of the project owner, and (e) Congressional legislation authorizing the project for Federal participation.

7. List of Projects. Appendix A shows the pertinent data for projects which are subject to this regulation.

FOR THE COMMANDER:

ALBERT J. GENETTI, JR.
Colonel, Corps of Engineers
Chief of Staff

1 Appendix
APP A - List of Projects

Appendix A
LIST OF PROJECTS

Non-Corps projects with Corps Regulation Requirements

PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD		AREA IN ACRES		AUTHORIZING LEGIS 3/	PROJ OWNER 4/
					upper	lower	upper	lower		
Col No 1	2 3	4	5	6	7	8	9	10	11	12
Agency Valley Dam & Res	OR Malheur	N Fork Malheur R	FICR	60.0	3340.0	3263.0	1900	0	PL 68-292	USBR
Alpine Dam	IL Winnebago	Keith Cr	F	0.6	796.0	760.0	52	0	PWA Proj	Rkfd IL
Altus Dam & Res	OK Jackson	N Fork Red R	F	19.6	1562.0	1559.0	6800	6260	PL 761	USBR
			IMR	132.6	1559.0	1517.5	6260	735		
Anderson Ranch Dam & Res	ID Elmore	S Fk Boise R	FEI	423.2	4196.0	4039.6	4740	1150	Act of 1939 53 Stat 1187	USBR
Arbuckle Dam & Res	OK Murray	Rock Cr	F	36.4	885.3	872.0	3130	2350	PL 594	USBR
			MRC	62.5	872.0	827.0	2350	606		
Arrowrock Dam & Res	ID Elmore	Boise R	FI	286.6	3216.0	2974.0	3100	200	Act of 1902 32 Stat 388	USBR
Bear Cr Dam	MO Marion Ralls	Bear Cr	F	8.7	546.5	520.0	540	0	PL 83-780	Nrbl MO
Bear Swamp Fife Brook(Lo)	MA Franklin	Deerfield R	E	6.9	870.0	830.0	152	115	FERC 2669	NEPC
Bear Swamp PS (Upper)	MA Franklin	Deerfield R Trib	E	8.9	1600.0	1550.0	118	102	Fed Pwr Act	NEPC
Bellows Falls Dam & Lk	VT Cheshire	Connecticut R	E	7.5	291.6	273.6	2804	836	FERC 1885	NEPC
Big Dry Creek and Div	CA Fresno	Big Dry Cr & Dog Cr	F	16.2	425.0	393.0	1530	0	PL 77-228	Rclm B CA
Blue Mesa Dam & Res	CO Gunnison	Gunnison R	FER	748.5	7519.4	7393.0	9180	2790	PL 84-485	USBR
Boca Dam & Res	CA Nevada	Little Truckee R	I	32.8	5596.0	5521.0	873	52	PL 61-289	USBR
			FI	8.0	5605.0	5596.0	980	873	PL 68-292	
Bonny Dam & Res	CO Yuma	S Fork Republican R	F	128.2	3710.0	3672.0	5036	2042	PL 78-534	USBR
			ICR	39.2	3672.0	3638.0	2042	331	PL 79-732	
Boysen Dam & Res	WY Fremont	Wild R	F	150.4	4732.2	4725.0	22170	19560	PL 78-534	USBR
			FEIQ	146.1	4725.0	4717.0	19560	16960		
			EIQ	403.8	4717.0	4685.0	16960	9280		
Brantley Dam & Res	NM Eddy	Pecos R	FIRQ	348.5	3283.0	3210.7	21294	38	PL 92-515	USBR
Brownlee Dam & Res	OR Baker ID Washington	Snake R	FE	975.3	2077.0	1976.0	13840	6650	FERC No 1971-C	ID Pwr
Bully Cr Dam & Res	OR Malheur	Bully Cr	FI	31.6	2516.0	2456.8	1082	140	PL 86-248	USBR
Camanche Dam & Res	CA San Joaquin	Mokelumne R	FRIE	200.0	235.5	205.1	7600	5507	PL 86-645	EB-MUD
			RIE	230.9	205.1	92.0	5507	0		
Canyon Ferry Dam & Lk	MT Lewis Clark	Missouri R	F	99.5	3800.0	3797.0	33535	32800	PL 78-534	USBR
			FEI	795.1	3797.0	3770.0	32800	24125		
			EI	711.5	3770.0	3728.0	24125	11480		
Cedar Bluff Dam & Res	KS Trego	Smoky Hill R	F	191.9	2166.0	2144.0	10790	6869	PL 78-534	USBR
			IMCR	149.8	2144.0	2107.8	6869	2086		

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Non-Corps projects with Corps Regulation Requirements

PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD		AREA IN ACRES		AUTHORIZING LEGIS 3/	PROJ OWNER 4/
					upper	lower	upper	lower		
Col No 1	2 3	4	5	6	7	8	9	10	11	12
Cheney Dam & Res	KS Sedgwick	N Fork Ninnescah R.	F	80.9	1429.0	1421.6	12420	9540	PL 86-787	USBR
			MC	151.8	1421.6	1392.9	9540	1970		
				0.0	0.0	0.0	0	0		
Clark Canyon Dam & Res	MT Beaverhead	Beaverhead R	F	79.1	5560.4	5546.1	5900	5160	PL 78-534	USBR
			FI	50.4	5546.1	5535.7	5160	4495		
			I	126.1	5535.7	5470.6	4495	220		
Del Valle Dam & Res	CA Alameda	Alameda Cr	F	37.0	745.0	703.1	1060	710	PL 87-874	DWR
			FIM	1.0	703.1	702.2	710	700		CA
			IMR	29.0	702.2	635.0	700	275		
Don Pedro Dam & Lk	CA Tuolumne	Tuolumne R	FEIR	340.0	830.0	802.0	12900	11260	PL 78-534	M&T
			EIR	1381.0	802.0	600.0	11260	3520		Irr
			IR	308.0	600.0	342.0	3520	29		
East Canyon Dam & Res	UT Morgan	East Canyon Cr	FEIM	48.0	5705.5	5578.0	684	130	PL 81-273	USBR
Echo Dam & Res	UT Summit	Weber R	FEIM	74.0	5560.0	5450.0	1455	0	PL 81-83	USBR
Emigrant Dam & Res	OR Jackson	Emigrant Cr	FIR	39.0	2241.0	2131.5	801	80	PL 83-606	USBR
Enders Dam Res	NE Chase	Frenchman Cr	F	30.0	3127.0	3112.3	2405	1707	PL 78-534	USBR
			ICR	34.5	3112.3	3082.4	1707	658	PL 84-505	
Folsom Dam Lk	CA Sacramento	American R	FEIM	400.0	466.0	427.0	11450	9040		USBR
			EIM	610.0	427.0	210.0	9040	0		
Fort Cobb Dam & Res	OK Caddo	Pond (Cobb) Cr	F	63.7	1354.8	1342.0	5980	4100	PL 419	USBR
			IMCR	78.3	1342.0	1300.0	4100	337		
Foss Dam & Res	OK Custer	Washita R	F	180.6	1668.6	1652.0	13140	8800	PL 419	USBR
			IMRC	243.8	1652.0	1597.2	8800	1360		
Friant Dam & Millerton Lk	CA Fresno	San Joaquin R	FEIM	390.5	578.0	466.3	4850	2101	PL 75-392 PL 76-868	USBR
Galesville Dam	OR Douglas	Cow Cr	FEMCR	42.2	1881.5	1780.0	760	150	FERC No 71 61001	Dgls CO
Gaston Dam & Res	NC Halifax Northamp-ton	Roanoke R	FE	63.0	203.0	200.0	22500	20300	Fed Pwr Act	VA Pwr
Glen Elder Dam & Waconda Lk	KS Mitchel	Solomon R	F	722.3	1488.3	1455.6	33682	12602	PL 78-534	USBR
			IM	204.8	1455.6	1428.0	12602	3341	PL 79-526	
Glendo Dam & Res	WY Platte	N Platte R	F	271.9	4653.0	4635.0	17990	12370	PL 78-534	USBR
			EIM	454.3	4635.0	4570.0	12370	3130		
Grand Coulee Dam FDR Lk	WA Okanogan Grant	Columbia R	FEI	5185.5	1290.0	1208.0	82280	45592	PL 89-561	USBR
H Neely Henry Dam & Res	AL Calhoun St. Clair	Coosa R	FE	49.7	508.0	502.5	11235	7632	PL 83-436	AL Pwr
Harris Dam & Res	AL Randolph	Tallapoosa R	FE	215.0	793.0	785.0	10661	9012	PL 89-789	AL Pwr
Heart Butte Dm & Lk Tschida	ND Grant	Heart R	F	147.9	2094.5	2064.5	6580	3400	PL 78-534	USBR
			IQ	69.0	2064.5	2030.0	3400	810		
Hells Canyon Dam & Res	OR Wallowa ID Adams	Snake R	EN	11.7	1688.0	1683.0	2380	2280	FERC No 1971-A	ID Pwr

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LIST OF PROJECTS

Non-Corps projects with Corps Regulation Requirements

PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD		AREA IN ACRES		AUTHORIZING LEGIS 3/	PROJ OWNER 4/
					upper	lower	upper	lower		
Col No 1	2 3	4	5	6	7	8	9	10	11	12
Hoover Dam & Lk Mead	NV Clark AZ Mohave	Colorado R	F FEIMCAR	1500.0 15.8	1229.0 1219.6	1219.6 1083.0	162700 156500	156500 83500	PL 70-642	USBR
Hungry Horse Dam & Res	MT Flathead	S Fork Flathead R	FEI	2982.0	3560.0	3336.0	23800	5400	PL 78-329	USBR
Indian Valley Dam & Res	CA Lake	N Fork Cache Cr	FIMR IMR	40.0 260.0	1485.0 1474.0	1474.0 1334.0	3975 3734	3734 308	PL 84-984	Yolo FC&W
Jamestown Dam & Res	ND Stutsman	James R	F IQ	185.4 28.1	1454.0 1429.8	1429.8 1400.0	13210 2090	2090 160	PL 78-534	USBR
Jocassee Dam & Res	SC Pickens	Keowee R	PRFC	1160.0	1110.0	1080.0	7565	6815	FERC 2503	USBR Pwr
Keowee Dam & Lk	SC Pickens	Keowee R	FPMCAR	392.0	800.0	775.0	18372	13072	FERC 2503	Duke Pwr
Kerr Dam Flathead Lk	MT Lake	Flathead R	FER	1219.0	2893.0	2883.0	125560	120000	FERC No 5	MT Pwr
Kerr Dam & Lk Hudson(Markham Ferry Project)	OK Mayes	Grand Neosho R	F E	244.2 48.6	636.0 619.0	619.0 599.0	18800 10900	10900 4500	PL 76-476	GRD Auth
Keyhole Dam & Res	WY Crook	Belle Fourche R	F IQ	140.5 185.8	4111.5 4099.3	4099.3 4051.0	13730 9410	9410 820	PL 78-534	USBR
Kirwin Dam & Res	KS Phillips	N Fork Solomon R	F ICR	215.1 89.6	1757.3 1729.2	1729.3 1697.0	10640 5080	5080 1010	PL 78-534 PL 79-732 PL 79-526	USBR
L Thunderbird (Norman Res)	OK Cleveland	Little R	F M	196.2 0.0	1064.7 0.0	1039.0 0.0	13850 0	8800 0	PL 86-529	USBR
Lake Kemp Dam & Res	TX Wichita	Wichita R	F MI	234.9 268.0	1156.0 1144.0	1144.0 1114.0	23830 15590	15590 3350	SD 144	WF&C WID2
Leesville Dam & Res	VA Campbell Pttsylvnia	Roanoke R	EQ	37.8	613.0	600.0	3235	2400	Fed Pwr Act	Appl Pwr
Lemon Dam & Res	CO LA Plata	Florida R	FIM	39.0	8148.0	8023.0	622	62	PL 84-485	USBR
Lewis M Smith Dam & Res	AL Walker Cullman	Sipsey Fork Black Warrior R	F E	280.6 394.3	522.0 510.0	510.0 488.0	25700 21200	21200 15097	Fed Pwr Act	AL Pwr
Little Wood	ID Blain	Little Wood R	FI	30.0	5237.3	5127.4	572	0	PL 84-993	USBR
Logan Martin Dam & Res	AL Talladega	Coosa R	F E	245.3 67.0	477.0 465.0	465.0 460.0	26310 15263	15260 11887	PL 83-436	AL Pwr
Los Banos Dam & Detention Res	CA Merced	Los Banos Cr	F R	14.0 20.6	353.5 327.8	327.8 231.2	619 467	467 0	PL 86-488	USBR
Lost Creek Dam & Res	UT Morgan	Lost Cr	FEIM	20.0	6005.0	5912.0	365	93	PL 81-273	USBR
Lovewell Dam & Res	KS Jewell	White Rock Cr	F ICR	50.5 24.9	1595.3 1582.6	1582.6 1571.7	5025 2986	2986 1704	PL 78-534 PL 79-732	USBR
Marshall Ford Dam & Res	TX Travis	Colorado R	F MEIM	779.8 810.5	714.0 681.0	681.0 618.0	29060 18955	18955 8050	PL 73-392 PL 78-534	USBR
Mayfield Dam & Res	WA Lewis	Cowlitz R	FER	21.4	425.0	415.0	2250	2030	FPC No 2016-A	Tac LN

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Non-Corps projects with Corps Regulation Requirements

PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD		AREA IN ACRES		AUTHORIZING LEGIS 3/	PROJ OWNER 4/
					upper	lower	upper	lower		
Col No 1	2 3	4	5	6	7	8	9	10	11	12
McGee Creek Dam & Res	OK Atoka	McGee Cr	F	85.3	595.5	577.1	5540	3810	PL 94-423	USBR
			MCR	108.0	577.7	515.1	3810	370		
Medicine Cr Dam Harry Strunk Lk	NE Frontier	Medicine Cr	F	52.7	2386.2	2366.1	3483	1840	PL 78-534	USBR
			ICR	26.8	2366.1	2343.0	1840	701	PL 84-505	
Mossyrock Dam Davisson Lk	WA Lewis	Coulitz R	FER	1397.0	778.5	600.0	11830	4250	FERC No 2016-B	Tac LN
Mt Park Dam Tom Steed Res	OK Kiowa	W Otter Cr	F	20.3	1414.0	1411.0	7130	6400	PL 90-503	USBR
			MRC	89.0	1411.0	1386.3	6400	1270		
Navajo Dam & Res	NM San Juan Rio Arriba	San Juan R	FEIRQ	1036.1	6085.0	5990.0	15610	7400	PL 84-485	USBR
New Bullards Bar Dam & Res	CA Yuba	Yuba R	FEIMR	170.0	1956.0	1918.3	4809	4225	PL 89-298	YCWA
			EIMR	790.9	1918.3	1447.5	4225	129		
New Exchequer Dam & Lk	CA Tuolumne	Merced R	FEIR	400.0	867.0	799.7	7110	4849	PL 86-645	Mrcd Irr
			EIR	451.6	799.7	660.0	4849	1900		
			IR	171.0	660.0	467.0	1900	150		
New Melones Dam & Lk	CA Tuolumne Calaveras	Stanislaus R	FEIMR	450.0	1088.0	1049.5	12500	10900	PL 87-874	USBR
			EIMR	1670.0	1049.5	808.0	10900	3500		
			IMR	300.0	808.0	540.0	3500	0		
Northfield Mt (Up) PS	MA Franklin	Connecticut	E	14.0	965.0	938.0	196	134	FERC 1889	NMEC
Norton Dam & Kieth Sebelius Lk	KS Norton	Prairie Dog Cr	F	98.8	2331.4	2304.3	5316	2181	PL 78-534	USBR
			IMRC	30.7	2304.3	2280.4	2181	587	PL 79-526	
									PL 79-732	
Ochoco Dam & Res	OR Crook	Ochoco Cr	FICR	52.5	3136.2	0.0	1130	130	PL 84-992	USBR
Oroville Dam & Lk	CA Butte	Feather R	FEIMAR	750.0	900.0	848.5	15800	13346	PL 85-500	CA
			EIMAR	2788.0	848.5	210.0	13346	0		
Pactola Dam & Res	SD Pennington	Rapid Cr	F	43.1	4621.5	4580.2	1230	860	PL 78-534	USBR
			IM	55.0	4580.2	4456.1	860	100		
Palisades Dam & Res	ID Bonneville	Snake R	FIE	1202.0	5620.0	5452.0	16100	2170	PL 81-864	USBR
Paonia Dam & Res	CO Gunnision	Muddy Cr	FIR	17.0	6447.5	6373.0	334	120	PL 80-177	USBR
									PL 84-485	
Pensacola Dam Grand Lake O' the Cherokees	OK Mayes	Grand(Neosho) R	F	525.0	755.0	745.0	59200	46500	PL 77-228	GRD Auth
			E	1192.0	745.0	705.0	46500	17000		
Pineview Dam & Res	UT Weber	Odgen R	FEIM	110.0	4900.0	4818.0	2874	0	PL 81-273	USBR
Platoro Dam & Res	CO Conejos	Conejos R	F	6.0	10034.0	10027.5	947	920	PL 76-640	USBR
			IR	54.0	10027.5	9911.0	920	0		
Priest Rapids Dam & Res	WA Grant	Columbia R	FER	44.0	488.0	481.5	7600	6500	FERC No 2114-A	Grnt PUD
Prineville Dam & Res	OR Crook	Crooked R	FIRC	233.0	3257.9	3114.0	3997	140	PL-84-992	USBR
Prosser Cr Dam & Res	CA Nevada	Prosser Cr	C	8.6	5703.7	5661.0	334	86	PL 84 858	USBR
			FC	20.0	5761.0	5703.7	745	334	PL 85 706	

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PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT PURPOSE 2/	STORAGE 1000 AF	ELEV LIMITS FEET, NGVD		AREA IN ACRES		AUTHORIZING LEGIS 3/	PROJ OWNER 4/
					upper	lower	upper	lower		
Col No 1	2 3	4	5	6	7	8	9	10	11	12
Pueblo Dam & Res	CO Pueblo	Arkansas R	F	93.0	4898.7	4880.5	5671	4640	PL 87-590	USBR
			IR	261.4	4880.5	4764.0	4640	421		
Red Willow Dam Hugh Butler Lk	NE Frontier	Red Willow Cr	F	48.9	2604.9	2581.8	2682	1629	PL 78-534	USBR
			IRC	27.3	2581.8	2558.0	1629	787	PL 85-783 PL 84-505	
Ririe Dam & Res	ID Bonneville	Willow Cr	FIRC	99.0	5119.0	5023.0	150	360	PL 87-874	USBR
Roanoke Rapids Dam & Res	NC Halifax	Roanoke R	EC	16.8	132.0	128.0	4600	4100	FPC 2009	VA Pwr
Rocky Reach Dam Lk Entiat	WA Chelan	Columbia R	FER	36.0	707.0	703.0	9920	9490	FERC No 2145	Chln PUD
Rocky River PS Lk Candlewood	CT Litchfield	Housatonic R	E	142.5	430.0	418.0	5608	4692	FERC 2576	CLPC
Ross Dam & Res	WA Whatcom	Skagit R	E	1052.0	1602.5	1475.0	11700	4450	FERC 553	Sttl
Sanford Dam & Lk Meredith	TX Hutchison	Canadian R	F	462.1	2965.0	2941.3	21640	17320	PL 81-898	USBR
			IMCRQ	761.3	2941.3	2860.0	17320	4500		
Savage River Dam & Res	MD Garrett	Savage R	FMA	20.0	1468.5	1317.0	366	0	PL 78-534	Ptmc Comm
Scoggins Dam Henry Hagg Lk		Scoggins Cr	FIR	56.3	305.8	235.3	116	4	PL 89-596	USBR
Shadehill Dam & Res	SD Perkins	Grand R	F	218.3	2302.0	2271.9	9900	4800	PL 78-534	USBR
			IQ	80.9	2271.9	2250.8	4800	2800		
Shasta Dam Lk	CA Shasta	Sacramento R	FEIA	1300.0	1067.0	1018.6	29570	23894	PL 75-392	USBR
			EIA	3241.0	1018.6	735.8	23894	2200		
Shepaug Dam & Lk	CT Litchfield	Housatonic R	E	5.0	200.0	172.0	1882	1125	FERC 2576	CLPC
Smith Mtn Dam & Res	VA Bedford Franklin Roanoke Pttsylvnia	Roanoke R	E	40.8	795.0	793.0	20600	20200	Fed Pwr Act	Appl Pwr
Stampede Dam & Res	CA Sierra	Little Truckee R	FEM	22.0	5949.0	5942.1	3430	3230	PL 84-858	USBR
			EM	199.4	5942.0	5798.0	3230	210		
Starvation Dam and Res	UT Duchesne	Strawberry R	FIM	165.3	5712.0	5595.0	3310	689	PL 84-485	USBR
Stevens Creek Dam & Res	GA Columbia	Savannah River	P	10.5	187.5	183.0	4300	0	FERC 2535	SC E&G
Stevenson Dam Lk Zoar	CT Litchfield	Housatonic R	E	5.0	108.0	80.0	1148	516	FERC 2576	CLPC
Summer Dam & Lk	NM De Baca	Pecos R	FI	51.4	4261.0	4200.0	2835	0	PL 83-780	USBR
Tat Momolikot Dam & Lake	AZ Pinal	Santa Rosa Wash	FIC	198.5	1539.0	1480.0	11790	0	PL 89-298	BIA
Tiber Dam & Res	MT Libert Toole	Marias R	F	400.9	3012.5	2993.0	23150	17890	PL 78-534	USBR
			FIQ	268.0	2993.0	2976.0	17890	13790		
			IQ	121.7	2976.0	2966.4	13790	11710		
Trenton Dam & Res	NB Hitchcock	Republican R	F	134.1	2773.0	2752.0	7940	4922	PL 78-534	USBR
			IRC	99.8	2752.0	2720.0	4922	1572	PL 84-505	

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PROJECT NAME /1	STATE/COUNTY	STREAM 1/	PROJECT STORAGE PURPOSE 1000 AF 2/		ELEV LIMITS FEET, NGVD		AREA IN ACRES		AUTHORIZING LEGIS 3/	PROJ OWNER 4/
					upper	lower	upper	lower		
Col No 1	2 3	4	5	6	7	8	9	10	11	12
Turners Falls (Low) Dam & Lk	MA Franklin	Connecticut R	E	8.7	185.0	176.0	2110	1880	FERC 1889	WMEC
Twin Buttes Dam & Lake	TX Tom Green	Concho R	F	454.4	1969.1	1940.2	23510	23510	PL 85-152	USBR
			IM	150.0	1940.2	1885.0	9080	670	PL 78-534	
Twitchell Dam & Res	CA Santa Barbara	Cuyama R	F	89.8	651.5	623.0	3671	2556	PL 83-774	USBR
			IM	135.6	623.0	504.0	2556	0		
Upper Baker Dam Baker Lk	WA Whatcom	Baker R	FE	184.6	724.0	674.0	4985	2375	PL 89-298	Pgt
									FERC 2150B	P&L
Vallecito Dam & Res	CO La Plata	Los Pinos R	FEI	125.4	7665.0	7582.5	2720	350	PL 61-288	USBR
									PL 68-292	
Vernon Dam & Lk	VT Windham	Connecticut R	E	18.3	220.1	212.1	2550	1980	FERC 1904	NEPC
Wanapum Dam & Res	WA Grant	Columbia R	FER	151.6	571.5	560.0	14300	13350	FERC No	Grnt
									2114-B	PUD
Wanship Dam & Rockport	UT Summit	Weber R	FEIM	61.0	6037.0	5930.0	1077	121	PL 81-273	USBR
Warm Springs Dam & Res	OR Malheur	Middle Fork Malheur R	FICR	191.0	3406.0	3327.0	460	90	PL 78-534	Vale
										USBR
Waterbury Dam & Res	VT Washington	Little R	FP	27.7	617.5	592.0	1330	890	PL 78-534	VT
Webster Dam & Res	KS Rocks	S Fork Solomon R	F	183.4	1923.7	1892.5	8480	3772	PL 78-534	USBR
			IRC	72.1	1892.5	1860.0	3772	906	PL 79-526	
									PL 79-732	
Weiss Dam & Res	AL Cherokee	Coosa R	F	397.0	574.0	564.0	50000	30200	PL 83-436	AL
			E	148.4	564.0	558.0	30200	19545		Pwr
Wells Dam L Pateros	WA Douglas	Columbia R	FER	74.0	781.0	771.0	10000	8000	FERC No	Dgls
									2149	PUD
Wilder Dam & Lk	VT Windsor	Connecticut R	E	13.3	385.0	380.0	3100	2240	FERC 1893	NEPC
Yellowtail Dam & Bighorn Lk	MT Big Horn	Bighorn R	F	258.3	3657.0	3640.0	17280	12600	PL 78-534	USBR
			FEIQ	240.3	3640.0	3614.0	12600	6915		PUD
			EIQ	336.1	3614.0	3547.0	6915	4150		

1. Cr - Creek; CS - Control Structure; Div - Diversion; DS - Drainage Structure; FG - Floodgate; Fk - Fork; GIWW - Gulf Intercoastal Waterway; Lk - Lake; L&D - Lock & Dam; PS - Pump Station; R - River; Res - Reservoir
2. F - Flood Control; N - Navigation; P - Corps Hydropower; E - Non Corps Hydropower; I - Irrigation; M - Municipal and/or Industrial Water Supply; C - Fish and Wildlife Conservation; A - Low Flow Augmentation or Pollution Abatement; R - Recreation; Q - Water Quality or Silt Control
3. FCA - Flood Control Act; FERC - Federal Energy Regulatory Comm; HD - House Document; PL - Public Law; PW - Public Works; RHA - River & Harbor Act; SD - Senate Document; WSA - Water Supply Act
4. Appl Pwr - Appalacian Power; Chln PUD - Chelan Cnty PUD 1; CLPC - CT Light & Power Co; Dgls PUD - Douglas Cnty PUD 1; DWR - Department of Water Resources; EB-MUD - East Bay Municipal Utility Dist; GRD - Grand River Dam Auth; Grnt PUD - Grant Cnty PUD 2; Hnbl - city of Hannibal; M&T Irr - Modesto & Turlock Irr; Mrcd Irr - Merced Irr; NEPC - New England Power Co; Pgnt P&L - Pugent Sound Power & Light; Ptmc Comm - Upper Potomac R Comm; Rclm B - Reclamation Board; Rkfd - city of Rockford; Sttl - city of Seattle; Tac - City of Tacoma; Vale USBR - 50% Vale Irr 50% USBR; WF&CWID - City of Wichita Falls and Wichita Cnty Water Improvement District No. 2; WMEC - Western MA Electric Co; YCWA - Yuba City Water Auth; Yolo FC&W - Yolo Flood Control & Water Conserv Dist

1. Cr - Creek; CS - Control Structure; Div - Diversion; DS - Drainage Structure; FG - Floodgate; Fk - Fork; GIWW - Gulf Intercoastal Waterway; Lk - Lake; L&D - Lock & Dam; PS - Pump Station; R - River; Res - Reservoir
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EXHIBIT E

PENSACOLA RESERVOIR HEC-1F MODEL

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ID      PENSACOLA                    COOK,  MAR 1982
ID      INFLOW PREDICTION PROGRAM HEC-1
ID      MODIFIED FOR DSS ZREAD AND ZWRITE DEC 84 BSM
ID      MODIFIED FOR TOTDSS RELEASES MAY 1989 P.A.T.
*FREE
IT      120                          100
IO        5
VSCMERCE        QUAPAW               IN RELESE        OUT
VV      2.11    2.11                 2.11             7.11
VS      IOLA PARSON                  WACO JOPLIN      QUAPAW  TIFF     LOCAL
VV      5.11    5.11                 5.11    5.11     5.11    5.11     5.11
VS      JRED    IOLA     PARSON      WACO JOPLIN      TIFF    TIFF     LOCAL
VV      2.11    2.11     2.11        2.11    2.11     2.11    2.11     2.11
FP        1
KK      JRED JOHN REDMOND RELEASES (BA=3015)
BA        1
ZR=QI   A=POSITIVE B=JOHN C+FLOW-RES OUT F=OBS
KKRTIOLA JOHN REDMOND RELEASES ROUTED TO IOLA
RS          5       0       -1
SV          0    450000
SQ          0    200000
KKILALOC  IOLA LOCAL FLOWS
BA         803
* B       BASE FLOW FOR IOLA
BF          0     -1     1.02
* L            LOSS RATE CARD FOR THE IOLA SUBAREA
LU          0      0
PB          0
ZR=PI   A=PENSACOLA LAKE B=ILALOC C=PRECIP - INC F=ADJUST
US         24      8
KK      IOLA TOTAL FLOW AT IOLA
HC          2
ZW      A=NEOSHO B=IOLA C=FLOW-LOC CUM F=CALC
KKPARSN IOLA FLOWS ROUTED TO PARSONS
RS          8      0     -1
SV          0   720000
SQ          0   200000
KKPARLOC PARSONS LOCAL FLOWS
* B     BASE FLOW FOR PARSONS
BF          0     -1     1.02
BA       1087
* L            LOSS RATE CARD FOR THE PARSONS SUBAREA
LU          0      0
PB          0
ZR=PI   A=PENSACOLA LAKE B=PARLOC C=PRECIP-INC F=ADJUST
US         36      75
KKPARSON TOTAL FLOWS AT PARSONS
HC          2
ZW      A=NEOSHO B=PARS C=FLOW-LOC CUM F=CALC
KKCOMRCE PARSONS FLOWS ROUTED TO COMMERCE
RS          6      0       -1
SV          0   600000
SQ          0   200000
KKCOMLOC COMMERCE LOCAL FLOWS
* B      BASE FLOW FOR COMMERCE
BF       0      -1      1.02
BA       971
* L      LOSS RATE CARD FOR THE COMMERCE SUBAREA
LU       0       0
PB       0
```

```
ZR=PI    A=PENSACOLA LAKE B=COMLOC       C=PRECIP - INC f=ADJUST
US       39       75
KKCMERCE TOTAL FLOWS AT COMMERCE
HC       2
KK       WACO WACO COMPUTED FLOWS
* B       BASE FLOW FOR WACO
BF               0        -1       1.02
BA       1164
* L                        LOSS RATE CARD FOR THE WACO SUBAREA
LU       0        0
PB       0
ZR=PI A=PENSACOLA LAKE B=WACO C=PRECIP - INC F=ADJUST
US       36       75
ZW       A=GRAND B=WACO C=FLOW-LOC CUM F=CALC
ZR=PI    A=PENSACOLA LAKE B=JOPLIN C=PRECIP-INC F=ADJUST
US       30       6
KK       QPAW JOPLIN FLOWS ROUTED TO QUAPAW
RS       2        0        -1
SV       0        240000
SQ       0        200000
KKQPALOC QUAPAW LOCAL FLOWS
* b      BASE FLOW FOR QUAPAW
BF       0        -1       1.02
BA       919
* L              LOSS RATE CARD FOR THE QUAPAW SUBAREA
LU       0        0
PB       0
ZR=PI    A=PENSACOLA LAKE B=QUALOC C=PRECIP-INC F=ADJUST
US       24       7
KKQUAPAW TOTAL FLOWS AT QUAPAW
HC       3
ZW       A=GRAND B=QUAP C=FLOW-LOC CUM F=CALC
KK       TIFF COMPUTED FLOWS AT TIFF CITY ON ELK RIVER
* B      BASE FLOW FOR TIFF
BF       0        -1       1.02
BA       872
* L      LOSS RATE CARD FOR THE TIFF CITY SUBAREA
LU       0        0
PB       0
ZW       A=GRAND B=TIFF  C=FLOW-LOC CUM F=CALC
ZR=PI    A=PENSACOLA LAKE B=TIFF C=PRECIP-INC F=ADJUST
US       33       7
KK       LOCAL PENSACOLA LOCAL FLOWS
BA       1040
* B      BASE FLOW FOR LOCAL
BF       0                                                    -05      1.02
* L      LOSS RATE FOR PENSACOLA LOCAL AREA (7% OF SUBBASIN IS LAKE E.T. NO LO
LU       0        0
PB       0
ZR=PI    A=PENSACOLA LAKE B=LOCAL C=PRECIP-INC F=ADJUST
UI       56000    56000    56000    21000    21000    21000    12000    12000    12000
UI        8000     8000     5500     5500     5500     4000     4000     4000     2500
UI        2500     1500     1500     1500     1000     1000     1000      500      500
KK        IN INFLOW
HC         4
ZW               A=GRAND B=PENS C=FLOW-RES IN F=CALC
KKRELESE RELEASES (24 HOUR AVERAGE)
BA       1
ZR=PI    A=PENSACOLA LAKE B=TIFF C=PRECIP-INC F=ADJUST
US       33       7
```

```
KK       LOCAL PENSACOLA LOCAL FLOWS
BA       1040
* B      BASE FLOW FOR LOCAL
BF       0                                                    -05      1.02
* L LOSS RATE FOR PENSACOLA LOCAL AREA (7% IF SYBBASUB US KAJE E.G. NO LOSS)
LU       0        0
PB       0
ZR=PI    A=PENSACOLA LAKE B=LOCAL C=PRECIP-INC F=ADJUST
UI       56000    56000    56000    21000    21000    21000    12000    12000    1200
UI        8000     8000     5500     5500     5500     4000     4000     4000    2500
UI        2500     1500     1500     1500     1000     1000     1000      500     500
KK       IN INFLOW
HC       4
ZW       A=GRAND B=PENS C=FLOW-RES IN F=CALC
KKRELESE RELEASES (24 HOUR AVERAGE)
BA       1
ZR=QI    A=POSITIVE B=PENS C=FLOW-RES OUT F=OBS
KK       NET NET INFLOW
HC       2
KK       OUT ROUTING THRU LAKE
* r               PENSACOLA LAKE
RS       1        ELEV     745.0
SV480000          655600   904500   1221000 1672000 2197000 2516000
SE       705      714      724      734      745      755      760
SQ         0        0
SE       705      760
ZW                A=GRAND B=PENS C=ELEV F=CALC
ZZ
```

TABLE 1		STATION	CMERCE FLOW	QUAPAW FLOW	IN FLOW	RELESE FLOW	OUT STAGE
PER	DAY MON	HRMN					
1	29 JAN	0700	158.17	86.35	1113.54	-10340.00	744.39
2	29 JAN	0900	335.27	662.97	36550.37	-10340.00	744.42
3	29 JAN	1100	800.28	2055.39	59918.87	-10340.00	744.58
4	29 JAN	1300	1453.96	3969.51	62477.53	-10340.00	744.78
5	29 JAN	1500	2217.33	6187.20	44539.37	-10340.00	744.96
6	29 JAN	1700	3055.04	8616.98	35371.51	-10340.00	745.06
7	29 JAN	1900	3944.98	11204.91	39685.63	-10340.00	745.14
8	29 JAN	2100	4872.05	13896.54	38768.04	-10340.00	745.24
9	29 JAN	2300	5825.60	16488.11	39968.48	-10340.00	745.33
10	30 JAN	0100	6798.20	18720.28	44222.34	0.00	745.44
11	30 JAN	0300	7784.98	20516.79	45658.95	0.00	745.58
12	30 JAN	0500	8782.78	21893.01	47629.70	0.00	745.73
13	30 JAN	0700	9777.46	22839.61	50544.53	0.00	745.89
14	30 JAN	0900	10704.21	23292.93	51211.30	0.00	746.05
15	30 JAN	1100	11509.75	23059.01	51491.36	0.00	746.21
16	30 JAN	1300	12198.92	22219.20	51807.51	0.00	746.37
17	30 JAN	1500	12783.34	21306.80	50872.63	0.00	746.53
18	30 JAN	1700	13273.34	20613.22	50250.02	0.00	746.69
19	30 JAN	1900	13677.39	20102.03	50091.86	0.00	746.85
20	30 JAN	2100	14001.36	19739.98	48890.80	0.00	747.01
21	30 JAN	2300	14247.27	19500.45	48027.30	0.00	747.16
22	31 JAN	0100	14410.79	19362.46	47137.87	0.00	747.31
23	31 JAN	0300	14474.22	19307.84	46204.65	0.00	747.45
24	31 JAN	0500	14373.77	19319.31	45243.39	0.00	747.60
25	31 JAN	0700	14083.58	19379.40	44205.45	0.00	747.74
26	31 JAN	0900	13772.53	19470.08	43236.78	0.00	747.88
27	31 JAN	1100	13580.09	19572.90	42453.89	0.00	748.01
28	31 JAN	1300	13495.73	19669.56	41823.78	0.00	748.14
29	31 JAN	1500	13508.06	19742.61	41313.73	0.00	748.28
30	31 JAN	1700	13604.97	19776.10	40892.17	0.00	748.40
31	31 JAN	1900	13773.85	19756.25	40529.39	0.00	748.53
32	31 JAN	2100	14001.83	19671.85	40198.28	0.00	748.66
33	31 JAN	2300	14276.02	19514.51	39874.81	0.00	748.79
34	1 FEB	0100	14583.85	19278.80	39538.35	0.00	748.91
35	1 FEB	0300	14913.26	18962.20	39171.96	0.00	749.03
36	1 FEB	0500	15252.94	18694.77	38892.20	0.00	749.16
37	1 FEB	0700	15592.51	18334.43	38544.55	0.00	749.28
38	1 FEB	0900	15922.61	17884.90	38121.53	0.00	749.40
39	1 FEB	1100	16235.02	17355.97	37622.93	0.00	749.52
40	1 FEB	1300	16522.67	16758.92	37051.40	0.00	749.64
41	1 FEB	1500	16779.66	16106.02	36411.80	0.00	749.75
42	1 FEB	1700	17001.19	15409.91	35710.64	0.00	749.87
43	1 FEB	1900	17183.52	14683.04	34955.35	0.00	749.98
44	1 FEB	2100	17323.80	13937.22	34153.72	0.00	750.09
45	1 FEB	2300	17419.98	13183.25	33313.41	0.00	750.19
46	2 FEB	0100	17470.61	12430.71	32441.59	0.00	750.30
47	2 FEB	0300	17474.78	11687.84	31544.64	0.00	750.40
48	2 FEB	0500	17432.00	10961.46	30628.05	0.00	750.49
49	2 FEB	0700	17342.09	10257.11	29723.07	0.00	750.59
50	2 FEB	0900	17205.20	9579.01	28825.62	0.00	750.68

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS. AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	JRED	152.	2.00	152.	152.	53.	1.00		
ROUTED TO	RTIOLA	152.	2.00	152.	152.	109.	1.00		
HYDROGRAPH AT	ILALOC	14891.	36.00	14775.	13148.	7106.	803.00		
2 COMBINED AT	IOLA	15035.	36.00	14920.	13283.	7199.	804.00		
ROUTED TO	PARSN	10108.	78.00	10070.	9549.	6711.	804.00		
HYDROGRAPH AT	PARLOC	13954.	46.00	13865.	12960.	8676.	1087.00		
2 COMBINED AT	PARSON	17645.	58.00	17606.	17239.	14192.	1891.00		
ROUTED TO	COMRCE	15841.	96.00	15813.	15495.	13092.	1891.00		
HYDROGRAPH AT	COMLOC	12867.	38.00	12801.	12014.	7969.	971.00		
2 COMBINED AT	CMERCE	17475.	92.00	17457.	17203.	15642.	2862.00		
HYDROGRAPH AT	WACO	16409.	44.00	16339.	15333.	10368.	1164.00		
ROUTED TO	GPAW	13867.	68.00	13826.	13234.	9828.	1164.00		
HYDROGRAPH AT	JOPLIN	6126.	30.00	6056.	5443.	3532.	427.00		
ROUTED TO	GPAW	5035.	44.00	5014.	4725.	3387.	427.00		
HYDROGRAPH AT	GPALOC	19716.	24.00	19387.	16510.	8860.	919.00		
3 COMBINED AT	QUAPAW	23293.	26.00	22960.	21177.	19228.	2510.00		
HYDROGRAPH AT	TIFF	12301.	34.00	12223.	11120.	7005.	872.00		
HYDROGRAPH AT	LOCAL	56869.	4.00	49432.	24007.	10001.	1040.00		
4 COMBINED AT	IN	62478.	6.00	54314.	49491.	44945.	7284.00		
HYDROGRAPH AT	RELESE	0.	18.00	0.	0.	0.	1.00		
2 COMBINED AT	NET	52138.	6.00	51447.	49491.	42929.	7285.00		
ROUTED TO	OUT	0.	2.00	0.	0.	0.	7285.00	752.47	198.00

EXHIBIT F

STANDING INSTRUCTION TO DAMTENDER

PENSACOLA RESERVOIR

STANDING INSTRUCTIONS TO DAMTENDER

PENSACOLA RESERVOIR

1. GENERAL

a. **Project Reporting Instructions** - Daily lake data (example on plate 5-3) will be submitted to the Reservoir Control Section, Hydraulics Branch, Tulsa District Office, (telephone 918-581-7666). The Reservoir Control Section office is manned from 7:00 a.m. to 4:30 p.m. daily and various hours on weekends and holidays. Data for nonworking days shall be read from the recorder chart and submitted the following workday. In the event that unusual conditions arise during nonworking hours, one of the persons listed on page i of the Pensacola Water Control Manual should be contacted. The following data should be included in the daily report.

(1) As of 8:00 a.m. - Lake elevation at 12:00 noon, 4:00 p.m., and 12:00 midnight of the previous day and the 8:00 a.m. elevation of the current day; number and height of spillway gates open; 24-hour average turbine discharges (12:00 midnight to 12:00 midnight); precipitation and evaporation in inches for the preceding 24 hours (7:00 a.m. to 7:00 a.m.); wind direction and velocity.

(2) Each gate operation - Date and time of gate operation, number and height of gates open before and after operation, lake pool elevation and spillway discharge, before and after each operation. Confirmation of gate changes shall be made immediately after completion of the requested change.

(3) During flood periods - In addition to subparagraphs (1) and (2) above, reports should be made when instructed by the Reservoir Control Section.

(4) Rainfall reports - Rainfall reports shall be made as follows:

(a) At 8:00 a.m. all precipitation that has occurred during the preceding 24 hours, 7:00 a.m. to 7:00 a.m. as shown on plate 5-3.

(b) At 1:00 p.m. when 0.50 inch or more precipitation has occurred since 7:00 a.m. or if it has continued to rain since reporting at 8:00 a.m.

(c) At 7:00 p.m. when 0.50 inch or more precipitation has occurred since 8:00 a.m. and no 1:00 p.m. report was made, or if it has continued to rain since reporting at 1:00 p.m.

(d) Report at once the occurrence of 1.00 inch or more of precipitation that occurs during a period of 6 hours or less.

(e) After office hours and on nonworking days, rainfall reports should be made to the National Weather Service, Tulsa, Oklahoma, (telephone 1-800-722-2778).

b. Warnings - It is the responsibility of the personnel at Pensacola Dam to implement the warning plan described in G.R.D.A.'s Pensacola Emergency Action Plan.

c. Reporting unusual events - Events or conditions not normally encountered in the routine operation of the dam and lake which might endanger the dam or necessitate temporary or permanent revision of the operating procedures such as unusual changes in seepage rates or development of new seepage areas; mechanical malfunction or failure; structural settlement, movement, cracking, or vibration; landslides, rockslides, or indication 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 Reservoir Control Section.

2. Regulation Procedures

a. Normal regulation procedures - Under normal procedures, instructions for storage and release of water for flood control will be issued by the Tulsa District,Reservoir Control Section. The implementation of the instructions are to be confirmed back to the Reservoir Control Section as soon as the required action is completed. INSTRUCTIONS ORIGINATING FROM ANY OTHER SOURCE SHOULD NOT BE PROCESSED. The damtender may temporarily deviate from the current release rates in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of the dam or to avoid serious hazards to life. Such actions shall be immediately reported to the Reservoir Control Section. Continuation of the deviation will require the express approval of the Reservoir Control Section.

b. Emergency regulation procedures - When communication with the Tulsa District Office is disrupted, the damtender will, on his own initiative, direct regulation of the lake in accordance with the following schedule until communication is restored. In addition, the damtender will make every effort to reestablish communication with the Tulsa District Office.

EMERGENCY FLOOD CONTROL REGULATION SCHEDULE
PENSACOLA RESERVOIR OF GRAND (NEOSHO) RIVER, OKLAHOMA AND ARKANSAS

Lake Stage	Pool Condition	Regulations
Below 745.0	Rising	Continue the releases being made at the time communication is lost.
745.0 - 755.0	Rising	Maintain releases being made until communication is restored or 12 hours have elapsed. If communication is not restored after 12 hours or the pool rises to elevation 752.5 during the 12 hour waiting period, determine average 6-hour discharge using Plate 7-3 (Discharge Rating Curves-Main Spillway) and Plate 7-4 (Discharge Rating Curves-East Spillway). Proceed to Plate 7-2 (Inflow vs. Rate of Rise-Nomograph) to determine inflows and then proceed to Plate 7-1 (Spillway Gate Regulation Schedule) to determine outflows. At no time shall releases be reduced if the pool is rising. If the pool is above 752.5, the releases shall not be less than indicated by the minimum discharge curve on plate 7-1.
755.0 or above	Rising	Spillway gates will be opened as necessary to maintain the pool at elevation 755.0 or until all gates are fully opened.
755.0 or	Falling	The maximum discharge attained shall above be held until the pool recedes to elevation 755.0.
755.0 - 752.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 100,000 c.f.s. whichever is greater.
752.5 - 750.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 60,000 c.f.s. whichever is greater.
750.0 - 747.5	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 40,000 c.f.s. whichever is greater.
747.5 - 745.0	Falling	Every 2 hours adjust the discharge to equal the previous 6-hour inflow or 20,000 c.f.s. whichever is greater.
Near 745.0		Releases shall be gradually reduced to equal inflow by the time the pool recedes to elevation 745.0.

CIVIL WORKS LEGEND

- CIVIL WORKS BOUNDARY
- COMPLETED PROJECTS
- PROJECTS UNDER CONSTRUCTION
- PROJECTS AUTHORIZED
- LOCK AND DAM
- LOCAL PROTECTION PROJECTS & OTHERS
- VII SALT AREAS
- NAVIGATION SYSTEMS

MILITARY LEGEND

- MILITARY BOUNDARY
- USAF INSTALLATION
- USA INSTALLATION
- DOE INSTALLATION

TULSA DISTRICT PROJECTS

OKLAHOMA, TEXAS, & KANSAS

SCALE OF MILES

25 0 25 50 75

DEPARTMENT OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS

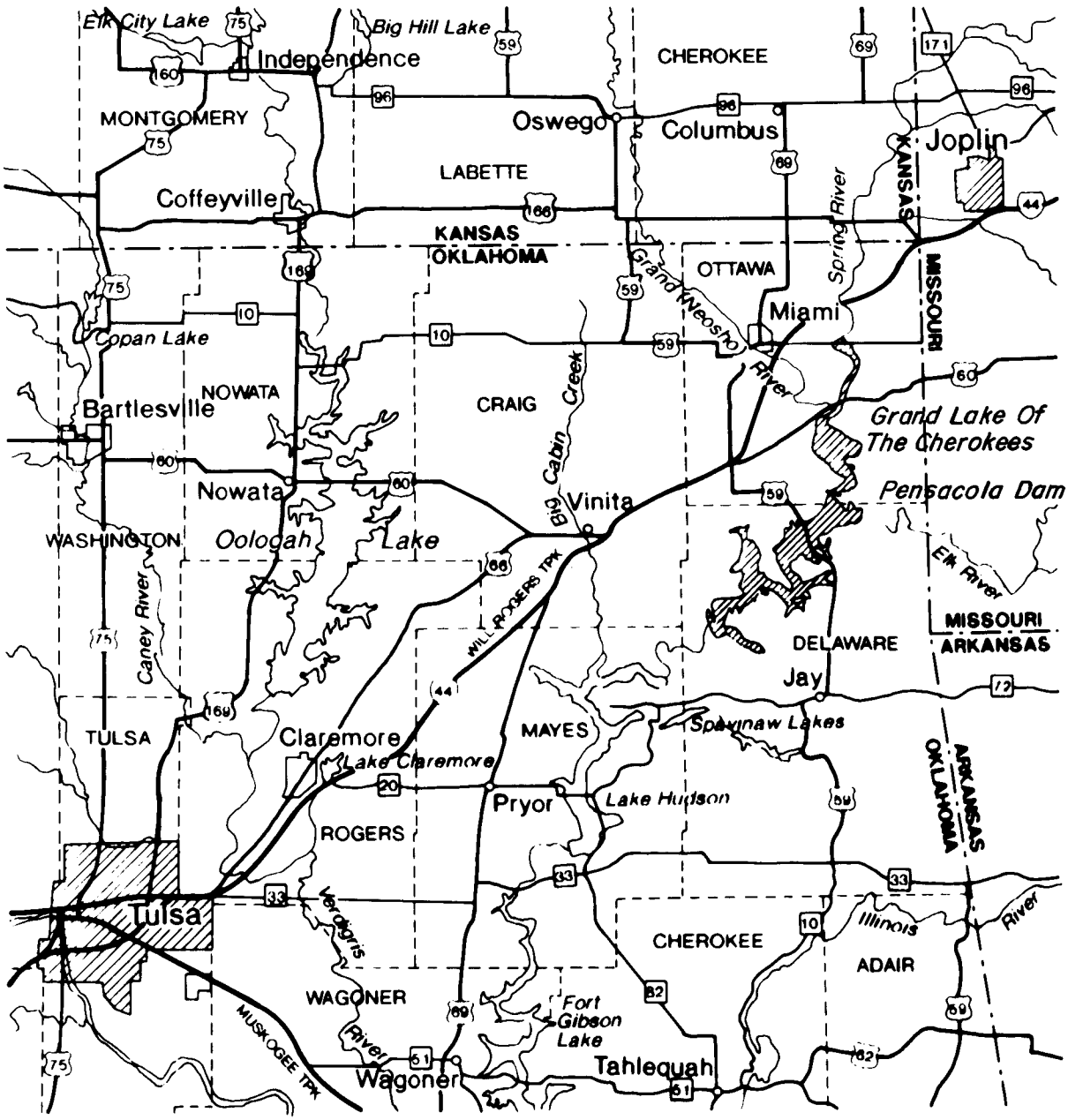
FEBRUARY 1990

G. David Steele
CHIEF, PLANNING DIVISION

D.W. Parker
CHIEF, ENGINEERING AND CONSTRUCTION DIVISION

J. Lee Lovell Jr.
DISTRICT ENGINEER

0000-M5-1/1



VICINITY MAP

SCALE OF MILES

0 5 10 20 30 40 50 Mi

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

PROJECT VICINITY MAP

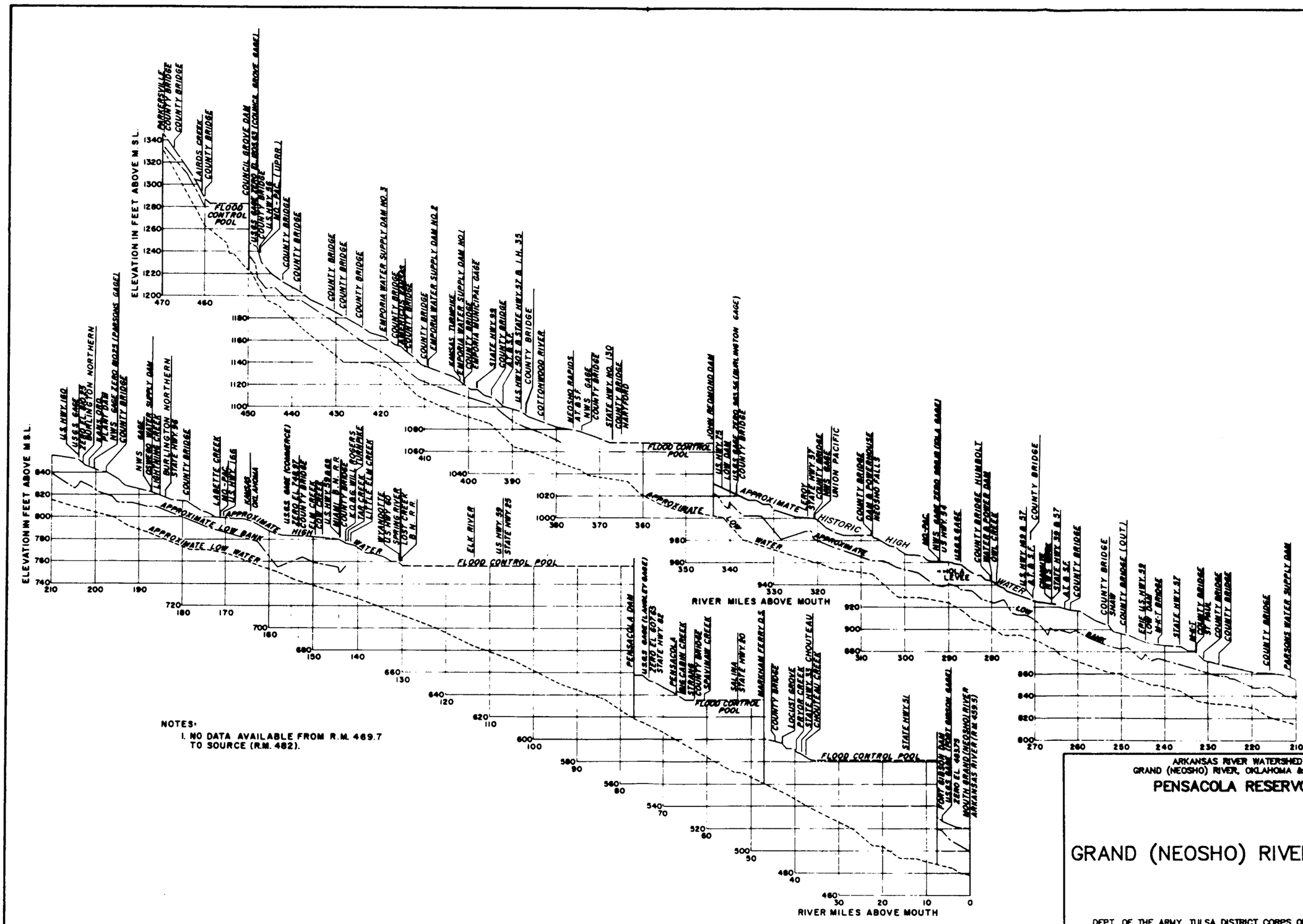
DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:

(b) (7)(F)

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS
PENSACOLA RESERVOIR

GENERAL PLAN
AND
SECTIONS OF DAM

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1960
DRAWN: CHECKED:



NOTES:

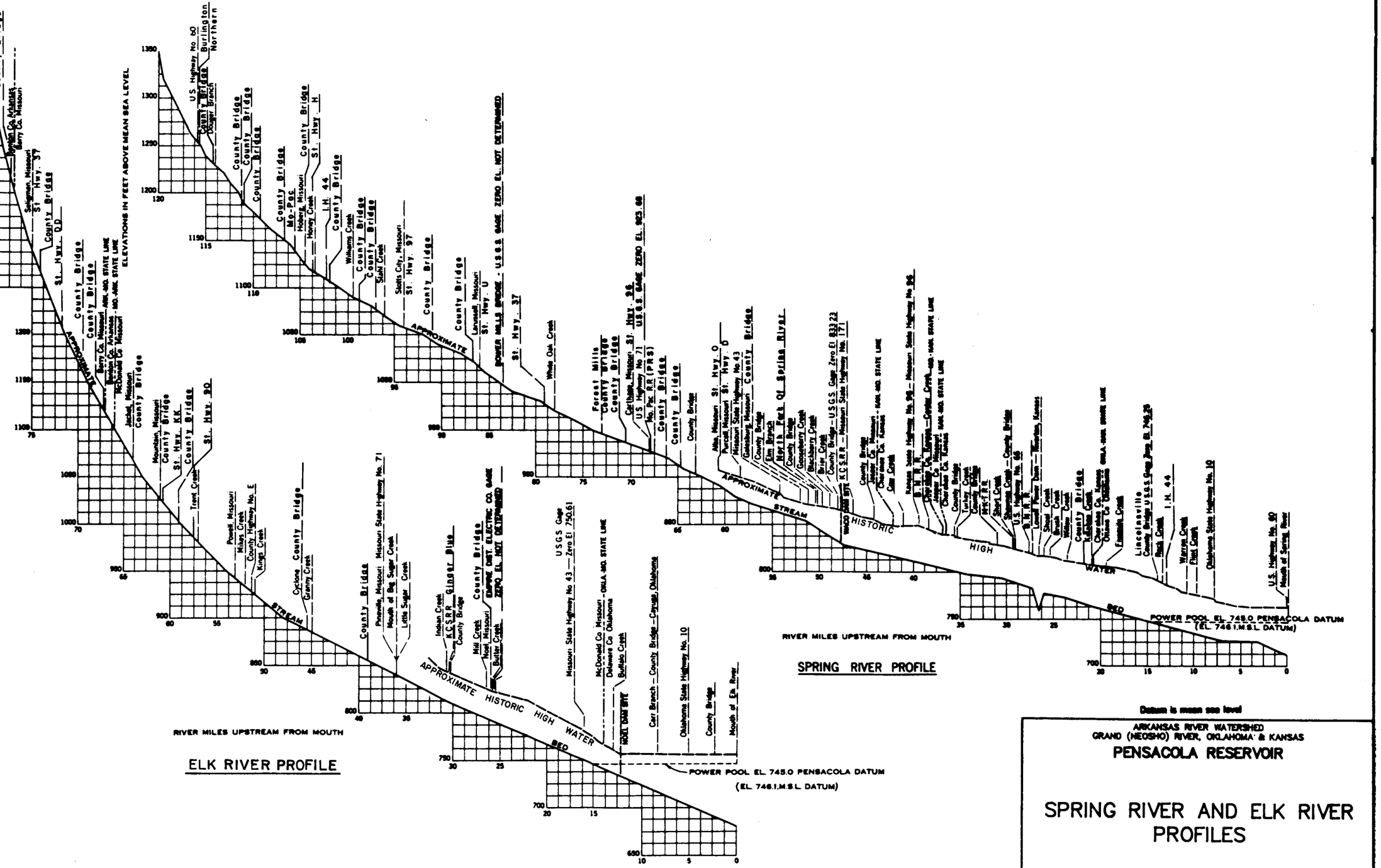
1. NO DATA AVAILABLE FROM R.M. 469.7 TO SOURCE (R.M. 482).

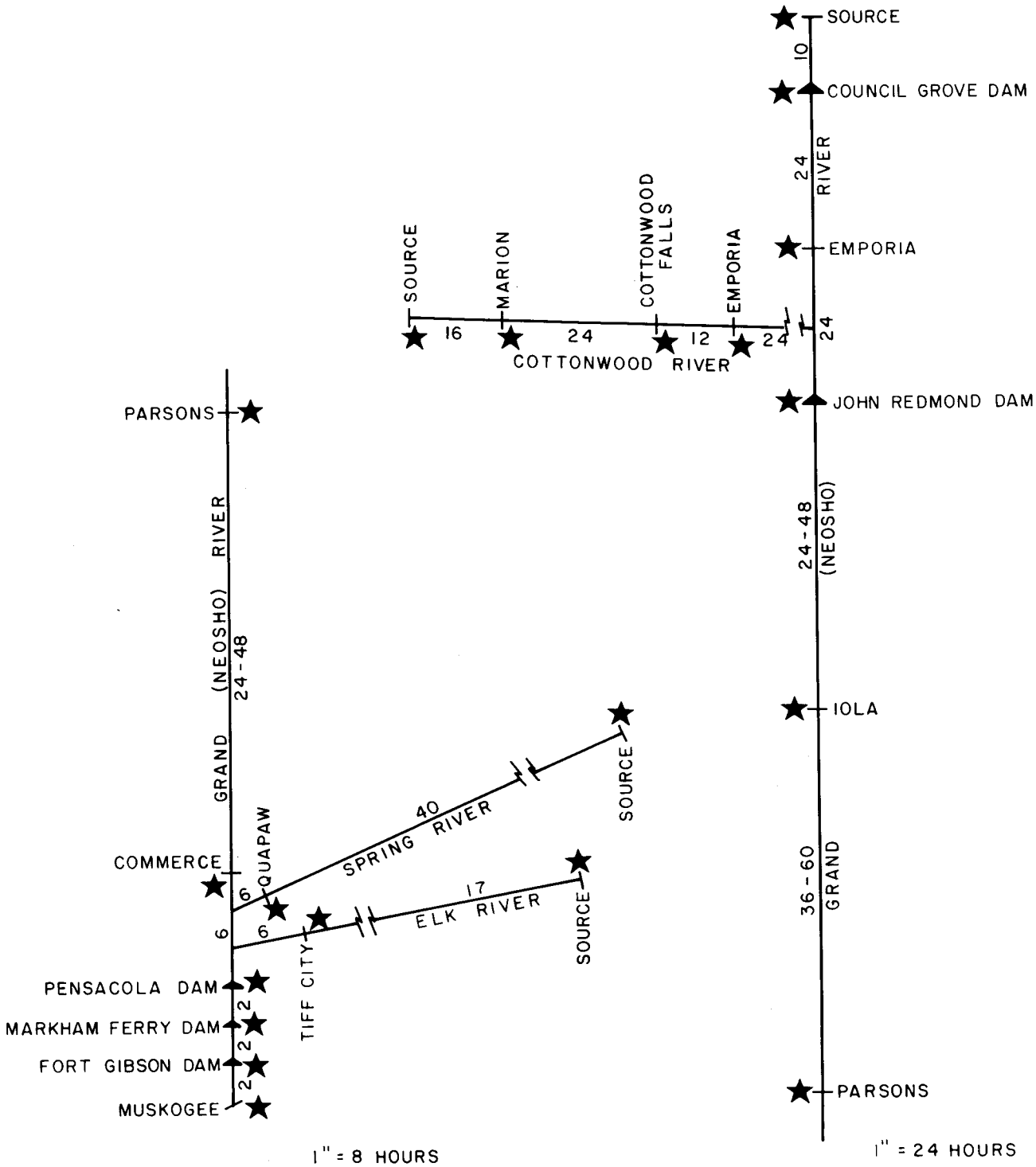
ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

GRAND (NEOSHO) RIVER PROFILE

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:


ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
County Bridge
Berryville, Arkansas
Berry Co. Arkansas
Berry Co. Missouri
Seligman, Missouri
St. Hwy. 37
County Bridge
St. Hwy. OD
County Bridge
County Bridge
Berry Co. Missouri
Boone Co. Arkansas
ARK.-MO. STATE LINE
McDonald Co. Missouri - MO.-ARK. STATE LINE
Jacket, Missouri
County Bridge
Mountain, Missouri
County Bridge
St. Hwy. KK
County Bridge
St. Hwy. 90
Powell, Missouri
Miles Creek
County Highway No. E
Kings Creek
Trent Creek
Cyclone County Bridge
Granny Creek
STREAM
APPROXIMATE
Pineville, Missouri Missouri State Highway No. 71
Mouth of Big Sugar Creek
Little Sugar Creek
County Bridge
Indian Creek
KCS&R Ginger Blue
County Bridge
Mill Creek
Noel, Missouri
Butler Creek
County Bridge
EMPIRE DIST. ELECTRIC CO. GAGE
ZERO EL. NOT DETERMINED
USGS Gage
Missouri State Highway No. 43 — Zero El. 750.61
McDonald Co. Missouri - ORLA.-MO. STATE LINE
Delaware Co. Oklahoma
Buffalo Creek
ROBE DAM SITE
Carr Branch — County Bridge — Cayuga, Oklahoma
Oklahoma State Highway No. 10
County Bridge
Mouth of Elk River
APPROXIMATE HISTORIC HIGH WATER BED
POWER POOL EL. 745.0 PENSACOLA DATUM
(EL. 746.1 M.S.L. DATUM)
RIVER MILES UPSTREAM FROM MOUTH
ELK RIVER PROFILE
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
U.S. Highway No. 60
County Bridge
Burlington Northern
Roger Branch
County Bridge
County Bridge
County Bridge
Mo. Pac.
Hoberg, Missouri
Horsey Creek
County Bridge
St. Hwy. H
I.H. 44
County Bridge
Williams Creek
County Bridge
County Bridge
Slahi Creek
Shotts City, Missouri
St. Hwy. 97
County Bridge
APPROXIMATE
County Bridge
Lanagan, Missouri
St. Hwy. U
POWER MILLS BRIDGE - U.S.G.S. GAGE ZERO EL. NOT DETERMINED
St. Hwy. 37
White Oak Creek
Forest Mills
County Bridge
County Bridge
Certain, Missouri St. Hwy. 86
U.S. Highway No. 71
Mo. Pac. R.R. (PRS)
County Bridge
County Bridge
Allen, Missouri St. Hwy. O
Purcell, Missouri St. Hwy. 6
Missouri State Highway No. 43
Galesburg, Missouri County Bridge
County Bridge
Elm Branch
North Fork Of Spring River
Gooseberry Creek
Blackberry Creek
Brier Creek
County Bridge - USGS Gage Zero El 833.23
KCS&RR — Missouri State Highway No. 171
County Bridge
Jasper Co. Missouri
Cherokee Co. Kansas
Lone Elm
Kansas State Highway No. 96 — Missouri State Highway No. 96
B.N.R.R.
Cherokee Co. Kansas — Crowley Creek
Jasper Co. Missouri - KANS.-MO. STATE LINE
Cherokee Co. Kansas
County Bridge
Turkey Creek
Spring River
B.N.R.R.
Short Creek
Shermon Creek — County Bridge
U.S. Highway No. 66
B.N.R.R.
Lone Pine, Kan. — Timmons, Kansas
Shoal Creek
Brush Creek
Willow Creek
County Bridge
Kellum Creek
Cherokee Co. Kansas
Crawford Co. Oklahoma
Franklin Creek
Lincolnsville
County Bridge U.S.G.S. Gage Zero El. 746.28
Rock Creek
I.H. 44
Warren Creek
Flint Creek
Oklahoma State Highway No. 10
U.S. Highway No. 60
Mouth of Spring River
APPROXIMATE STREAM
HISTORIC HIGH WATER BED
POWER POOL EL. 745.0 PENSACOLA DATUM
(EL. 746.1 M.S.L. DATUM)
RIVER MILES UPSTREAM FROM MOUTH
SPRING RIVER PROFILE
Datum is mean sea level
ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS
PENSACOLA RESERVOIR
SPRING RIVER AND ELK RIVER PROFILES
DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN:
CHECKED:



NOTES:

TIME OF TRAVEL IN HOURS FOR LARGE RISES IS SHOWN BETWEEN STARS (★ 24 ★)

TIME SHOWN ABOVE UPSTREAM STATIONS IS AVERAGE TIME TO CREST AFTER BEGINNING OF RUNOFF

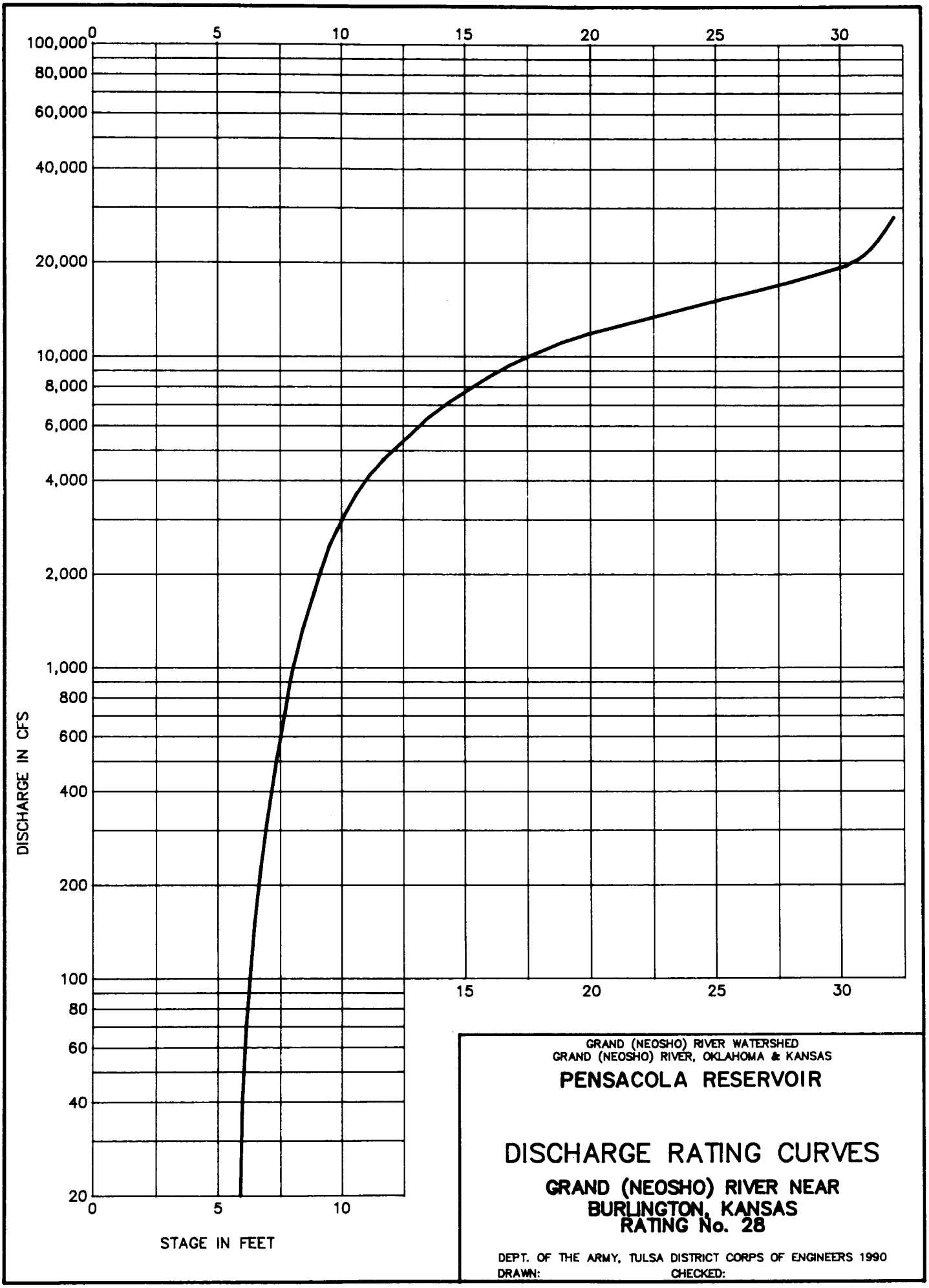
SCALE AS SHOWN

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

TIME OF CREST TRAVEL

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



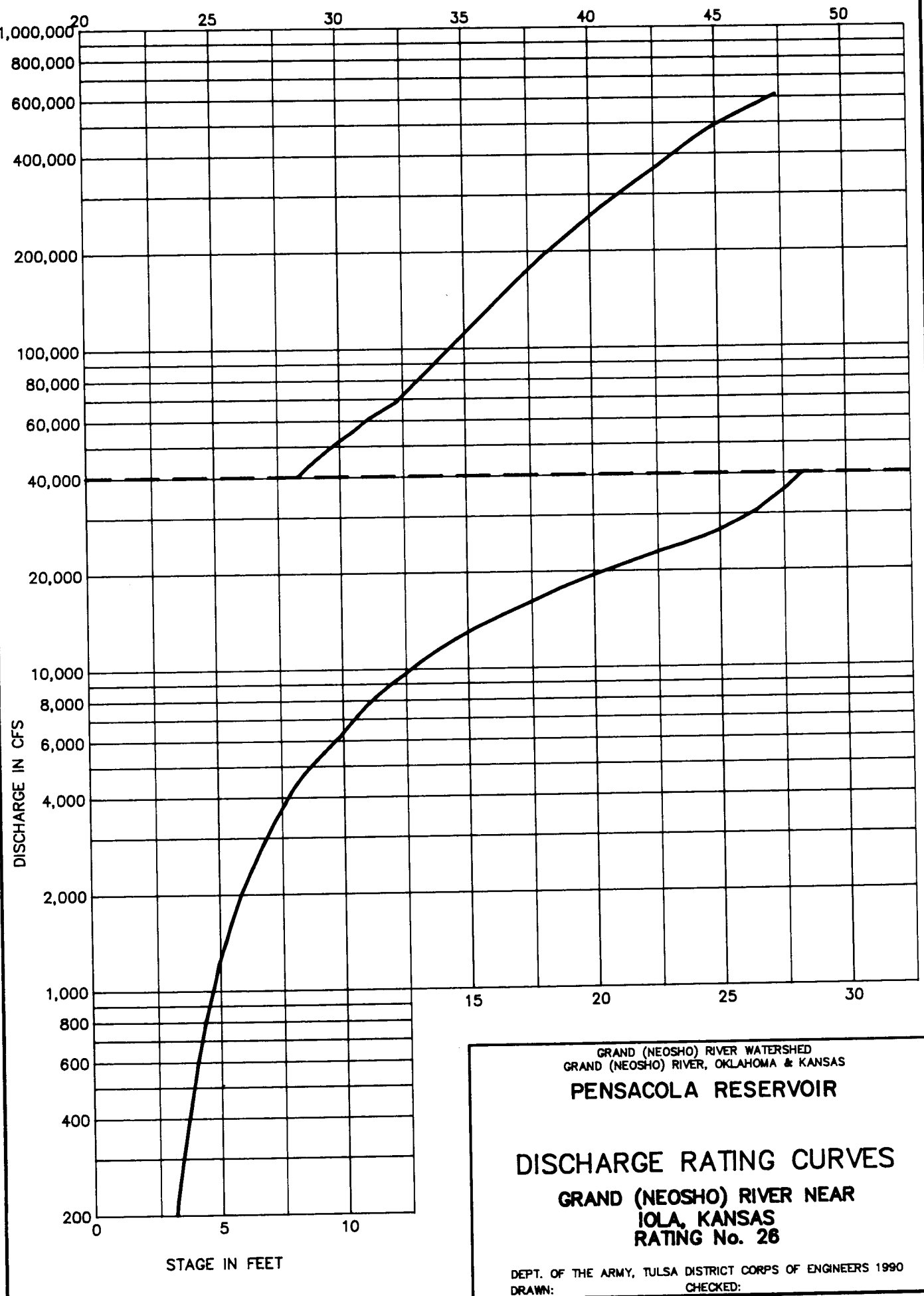
GRAND (NEOSHO) RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES

GRAND (NEOSHO) RIVER NEAR BURLINGTON, KANSAS
RATING No. 28

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



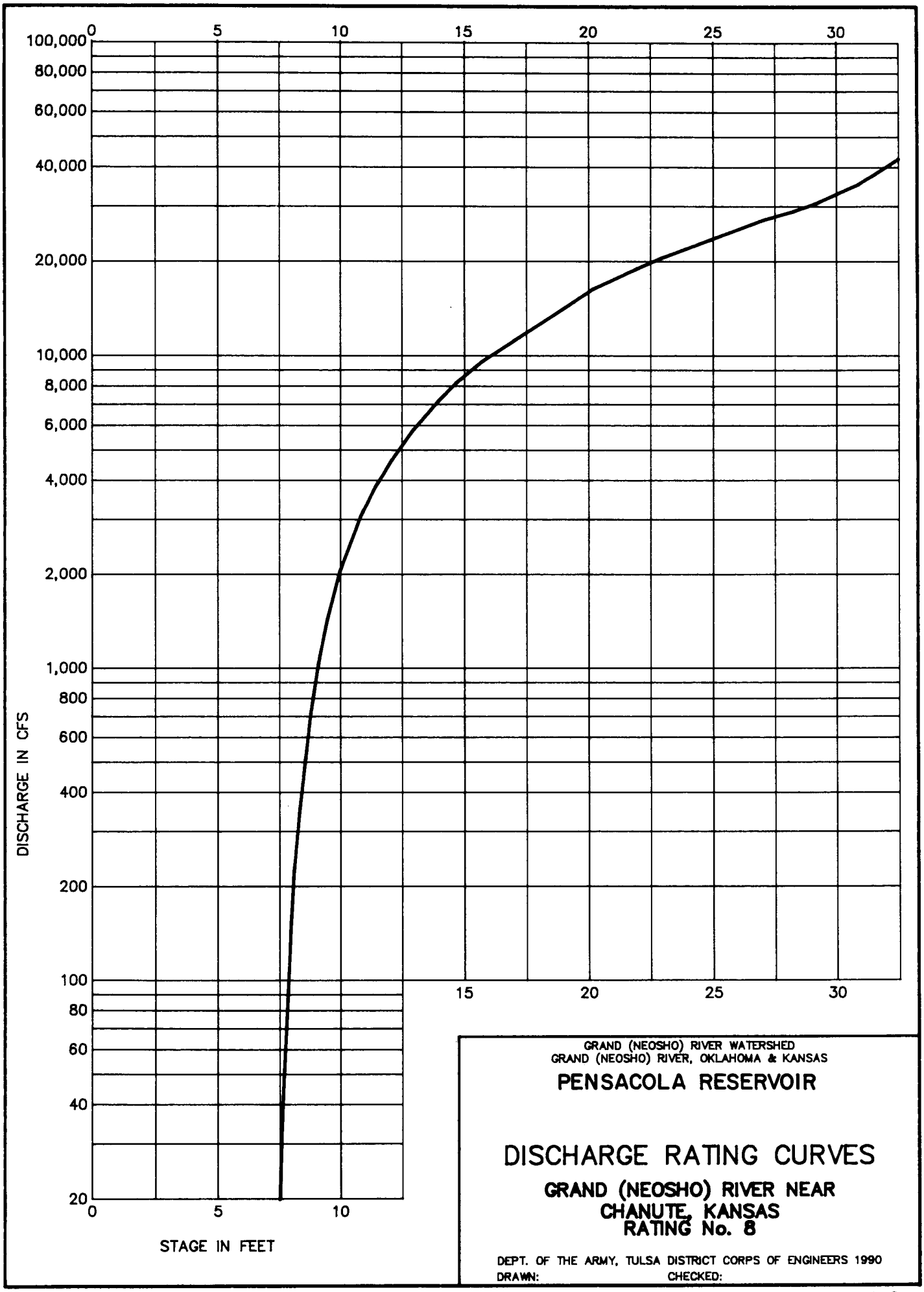
GRAND (NEOSHO) RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES

GRAND (NEOSHO) RIVER NEAR IOLA, KANSAS
RATING No. 26

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



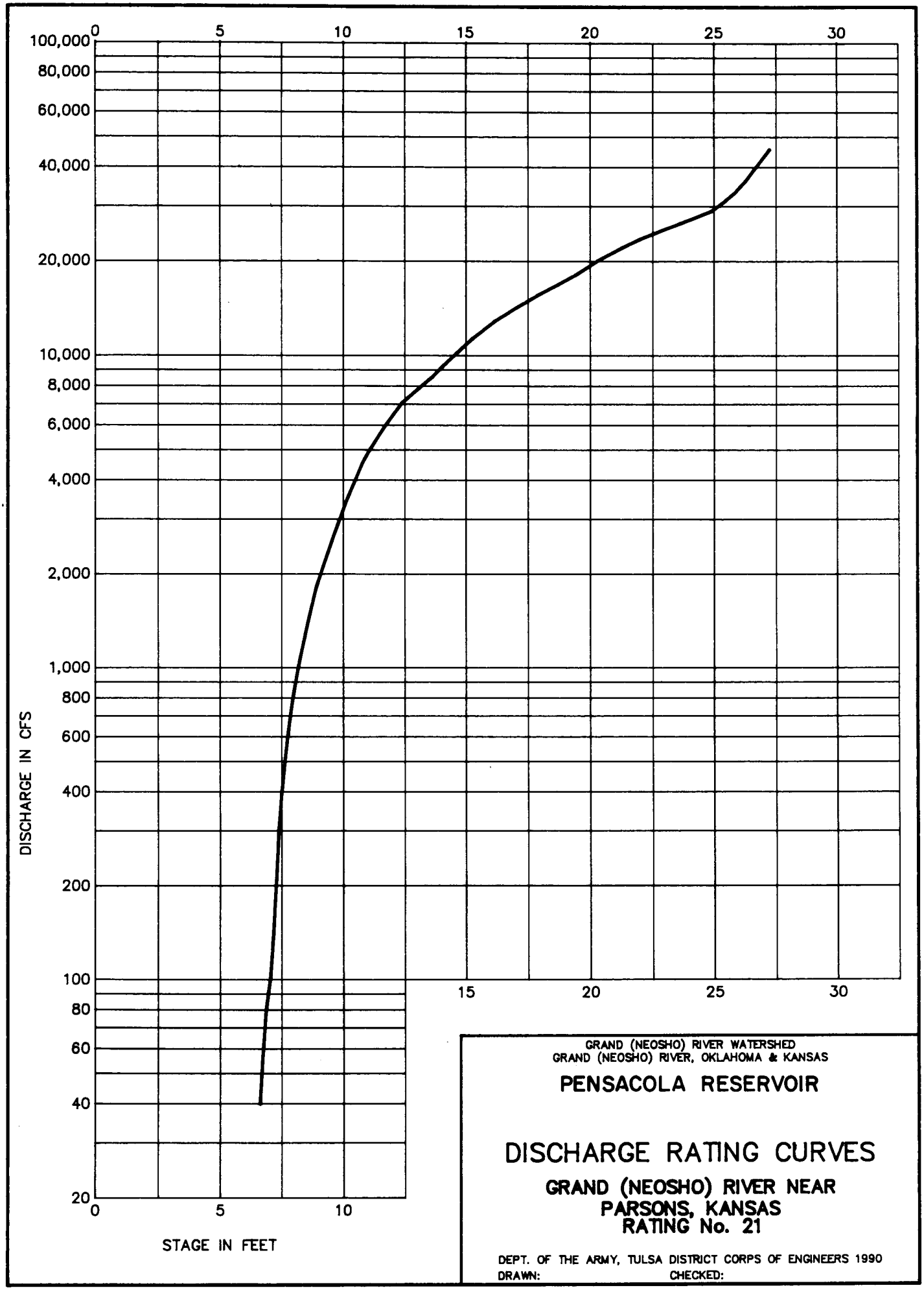
GRAND (NEOSHO) RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES

GRAND (NEOSHO) RIVER NEAR CHANUTE, KANSAS
RATING No. 8

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



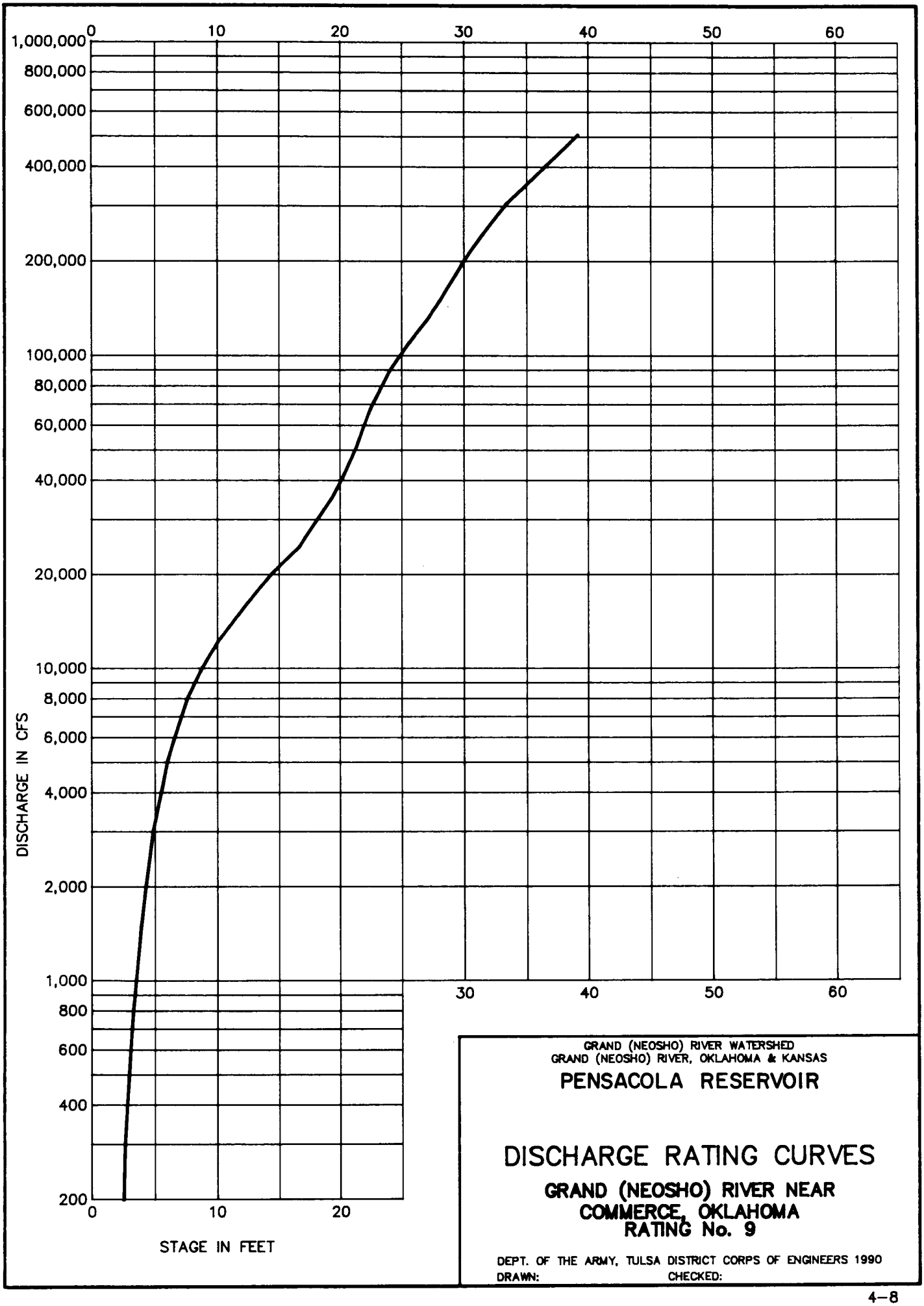
GRAND (NEOSHO) RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES

GRAND (NEOSHO) RIVER NEAR PARSONS, KANSAS RATING No. 21

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



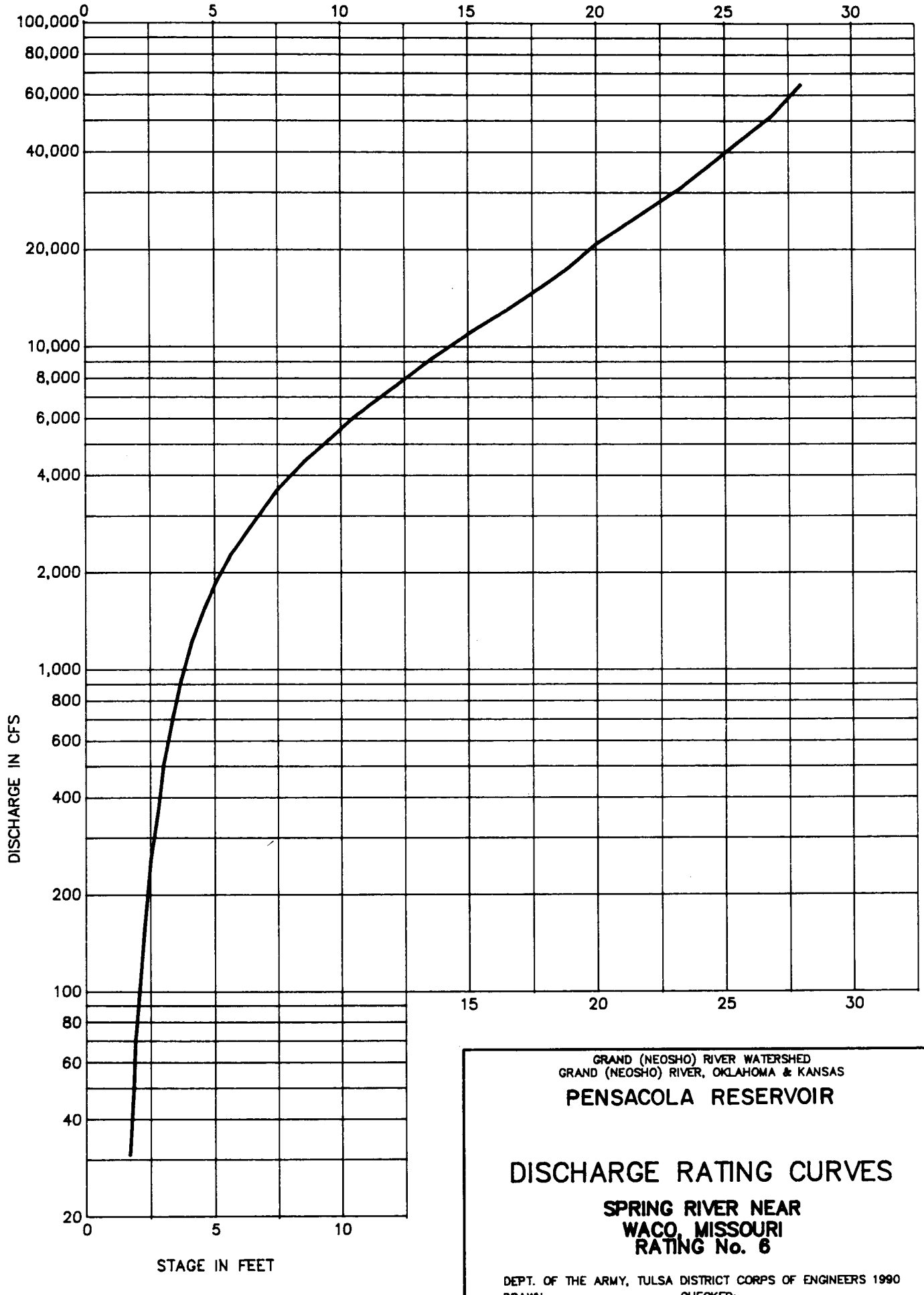
GRAND (NEOSHO) RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES

GRAND (NEOSHO) RIVER NEAR COMMERCE, OKLAHOMA
RATING No. 9

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



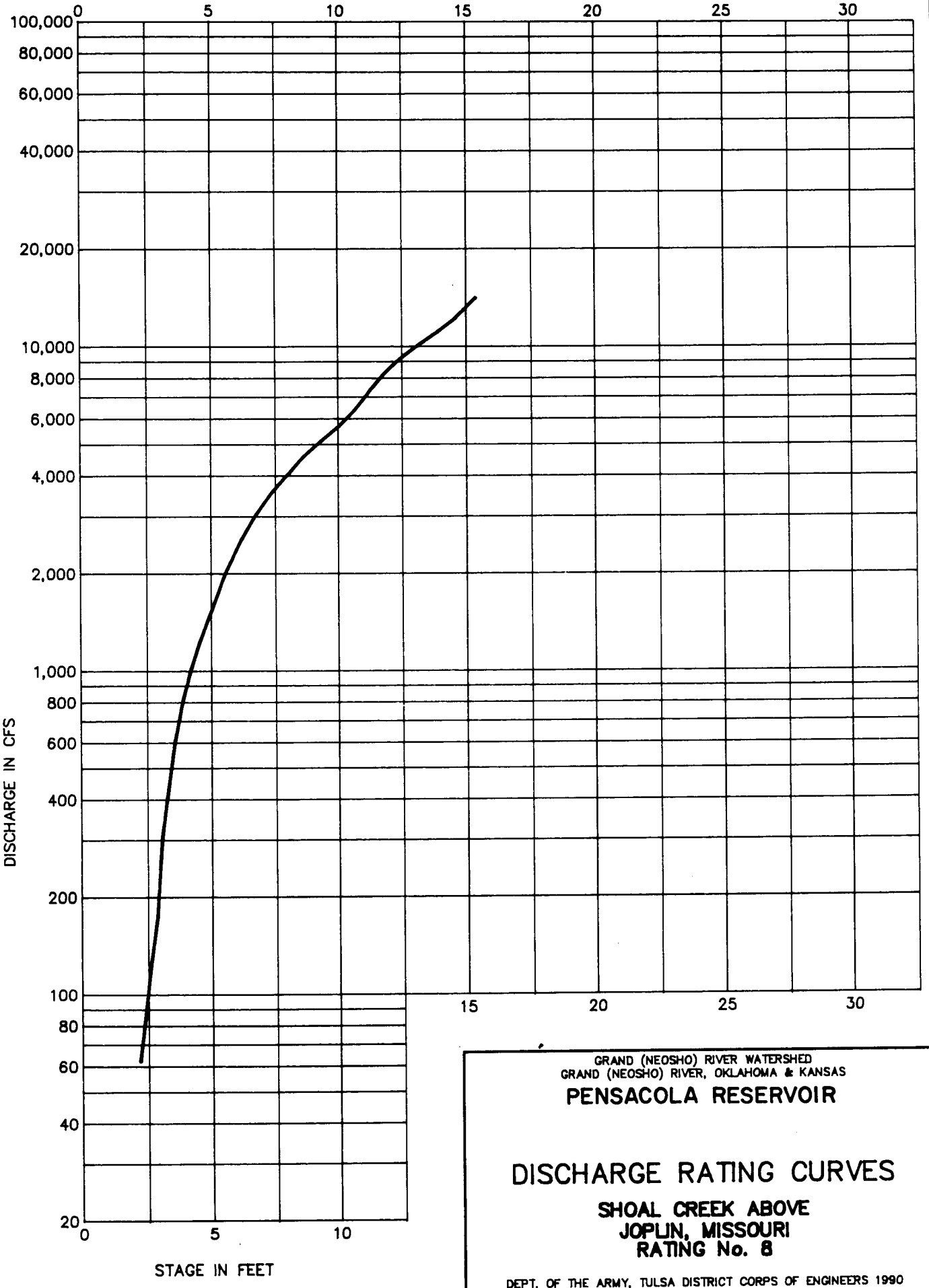
GRAND (NEOSHO) RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES

SPRING RIVER NEAR WACO, MISSOURI
RATING No. 6

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



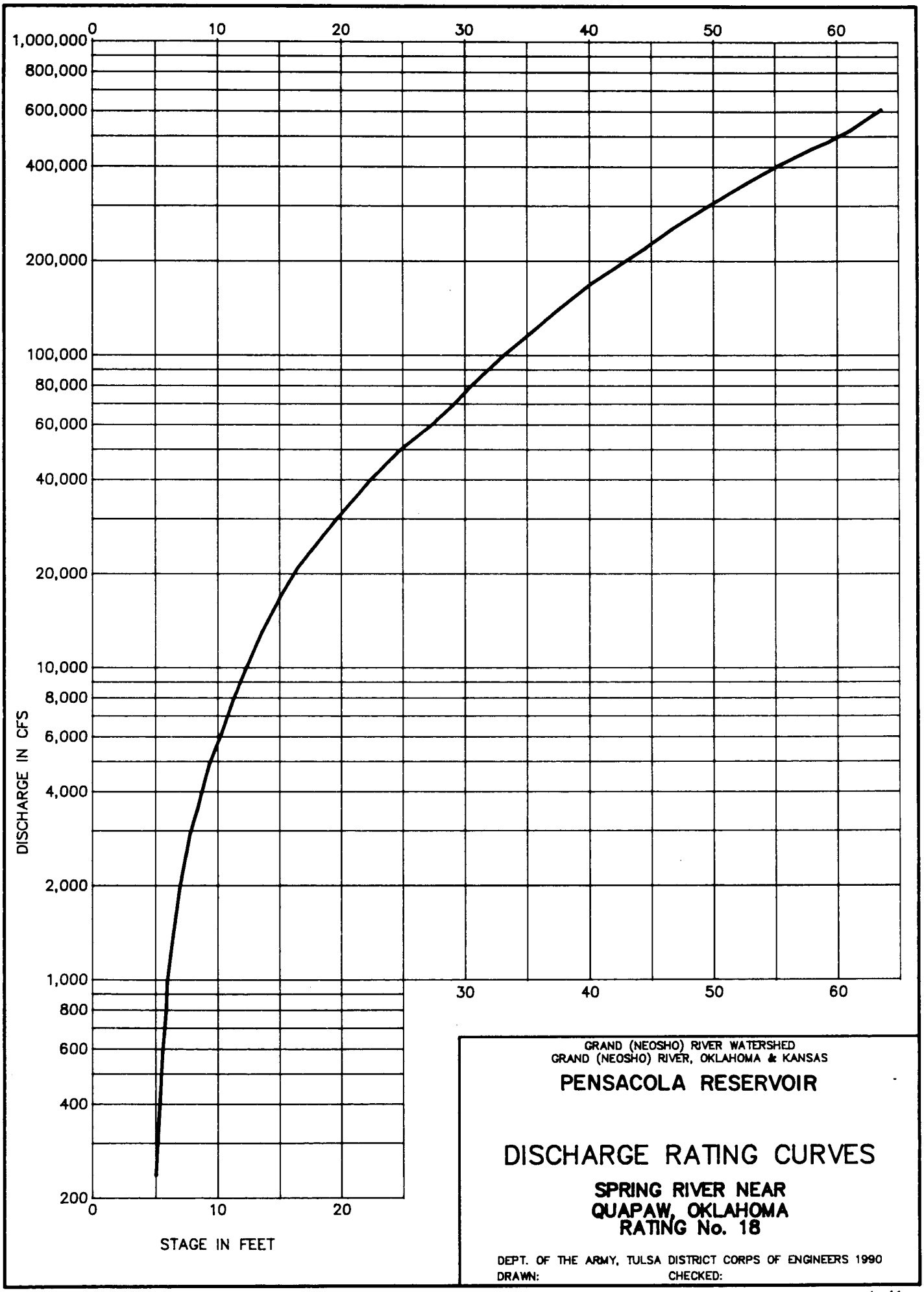
GRAND (NEOSHO) RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES

SHOAL CREEK ABOVE JOPLIN, MISSOURI RATING No. 8

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



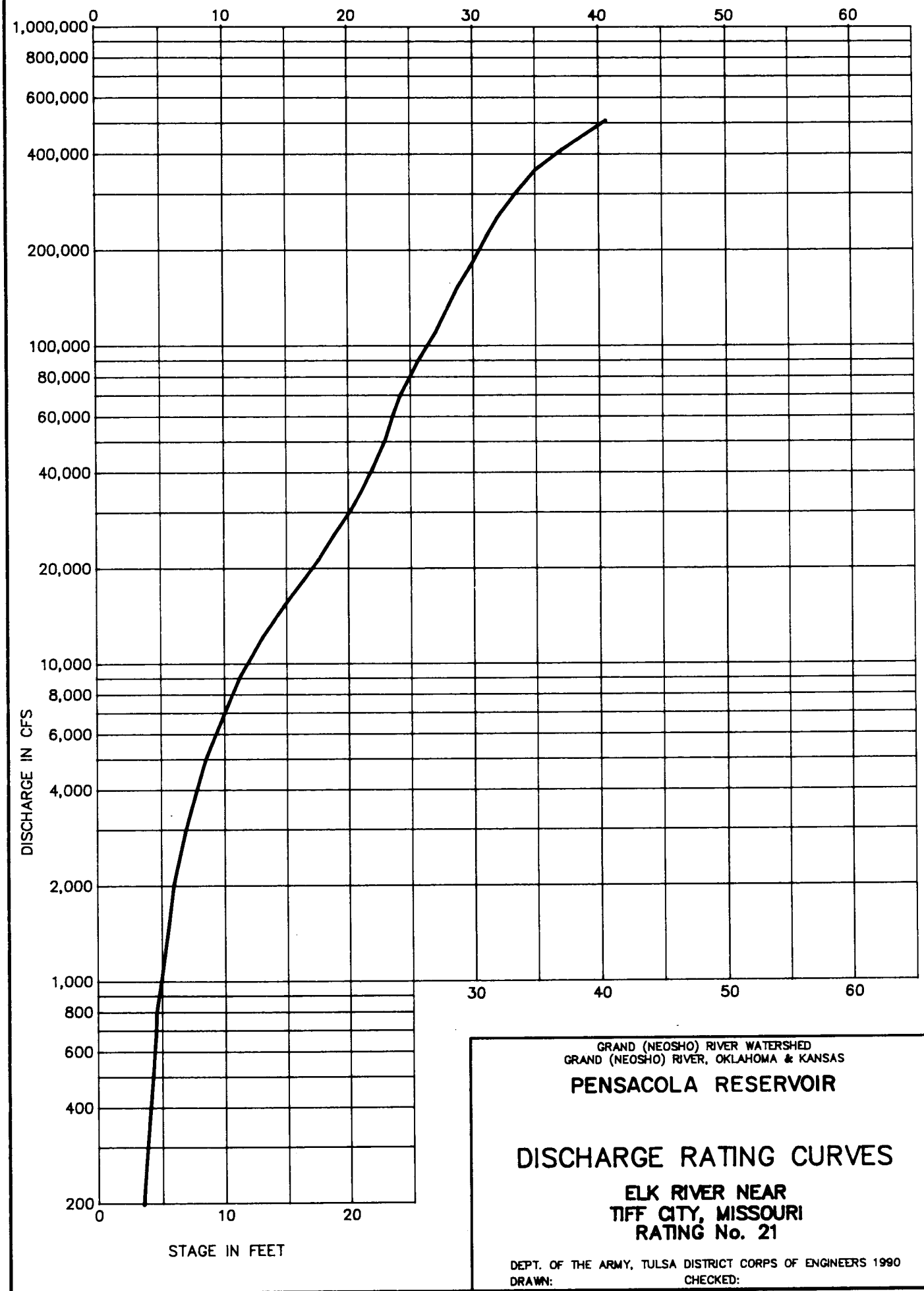
GRAND (NEOSHO) RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES

SPRING RIVER NEAR QUAPAW, OKLAHOMA RATING No. 18

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



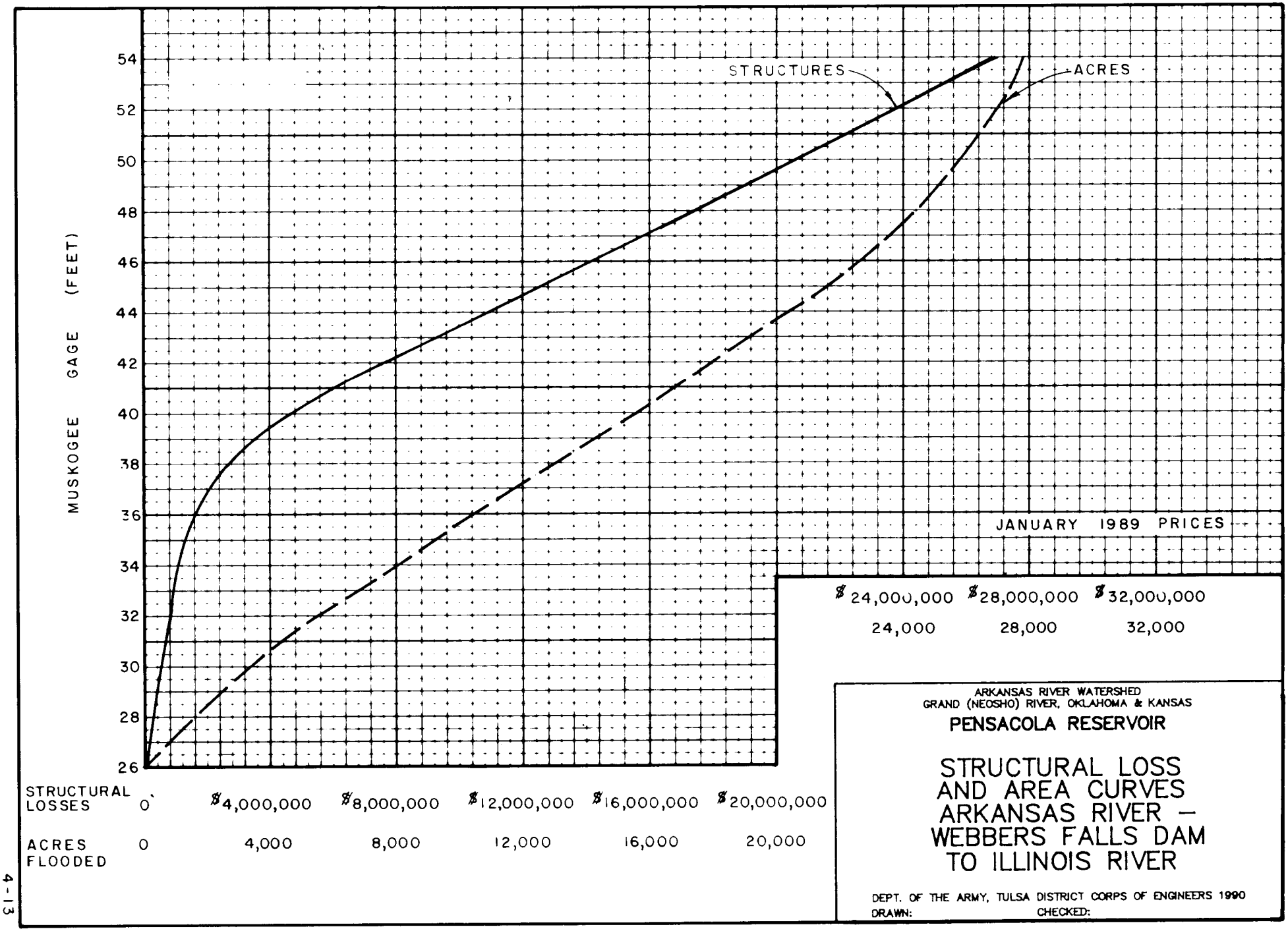
GRAND (NEOSHO) RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES

ELK RIVER NEAR TIFF CITY, MISSOURI RATING No. 21

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:

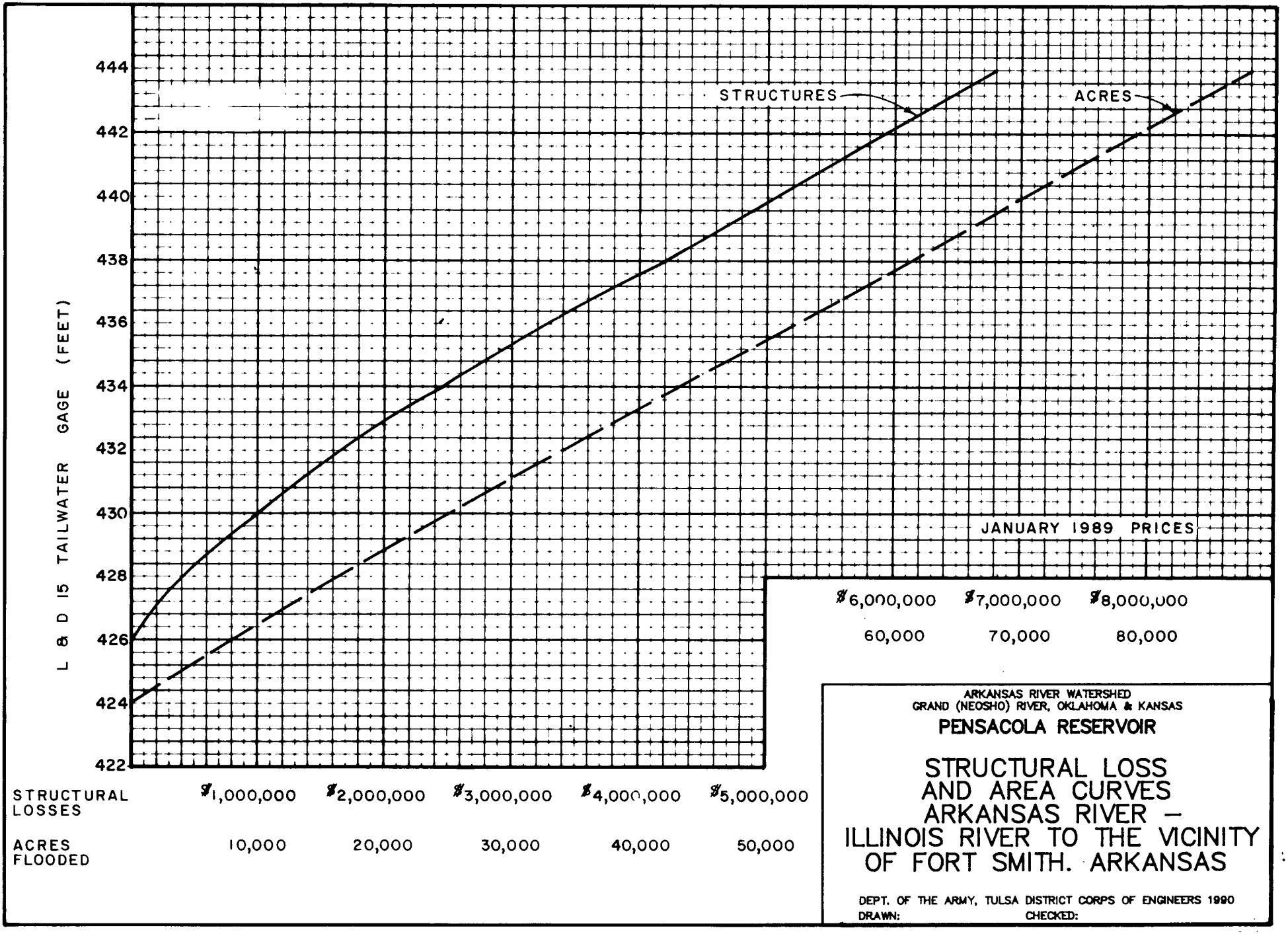


ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

STRUCTURAL LOSS AND AREA CURVES ARKANSAS RIVER – WEBBERS FALLS DAM TO ILLINOIS RIVER

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:

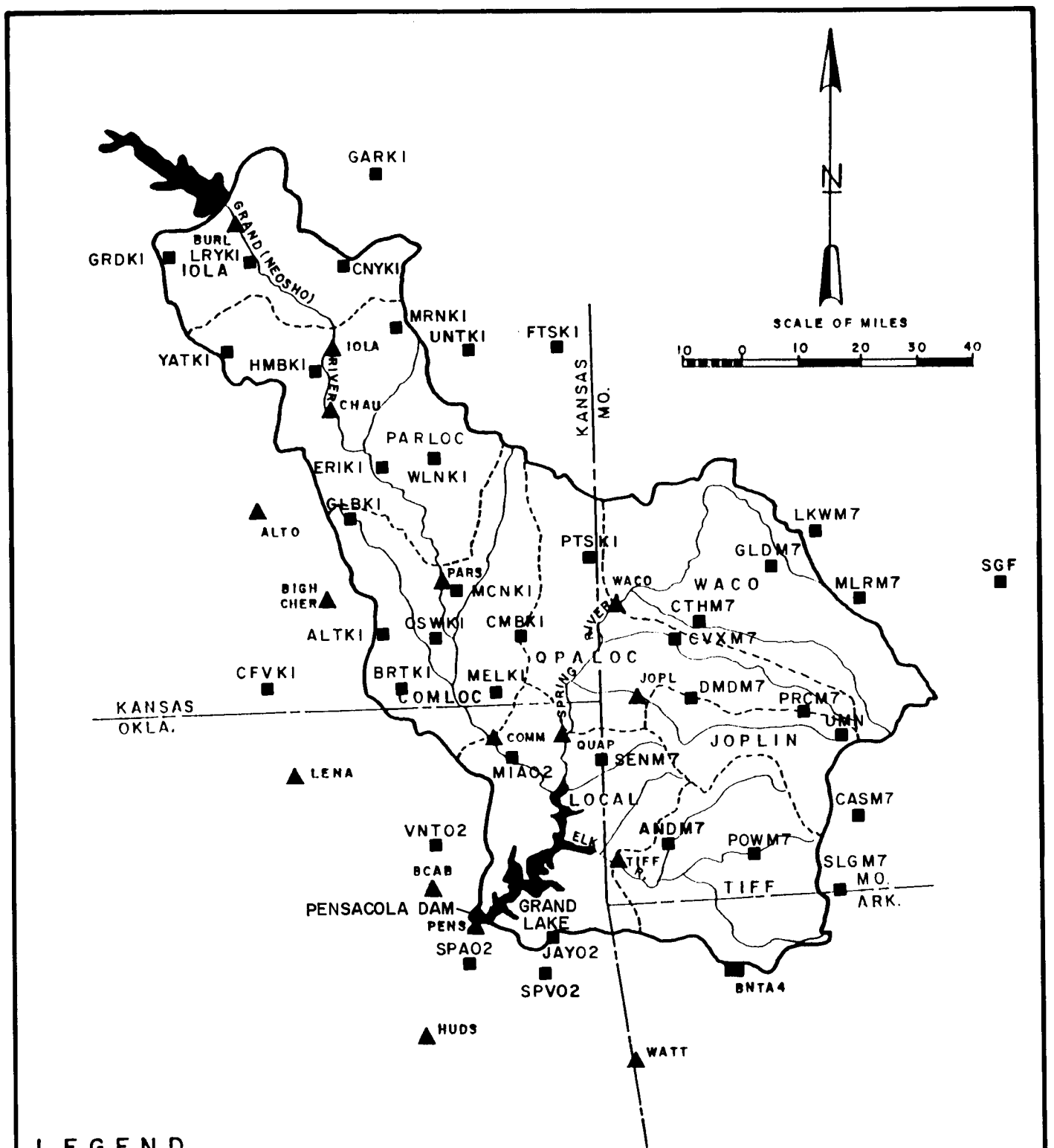


ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

STRUCTURAL LOSS AND AREA CURVES ARKANSAS RIVER – ILLINOIS RIVER TO THE VICINITY OF FORT SMITH. ARKANSAS

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



LEGEND

▲ DCP's USED FOR TIME DISTRIBUTION

■ OBSERVER GAGES

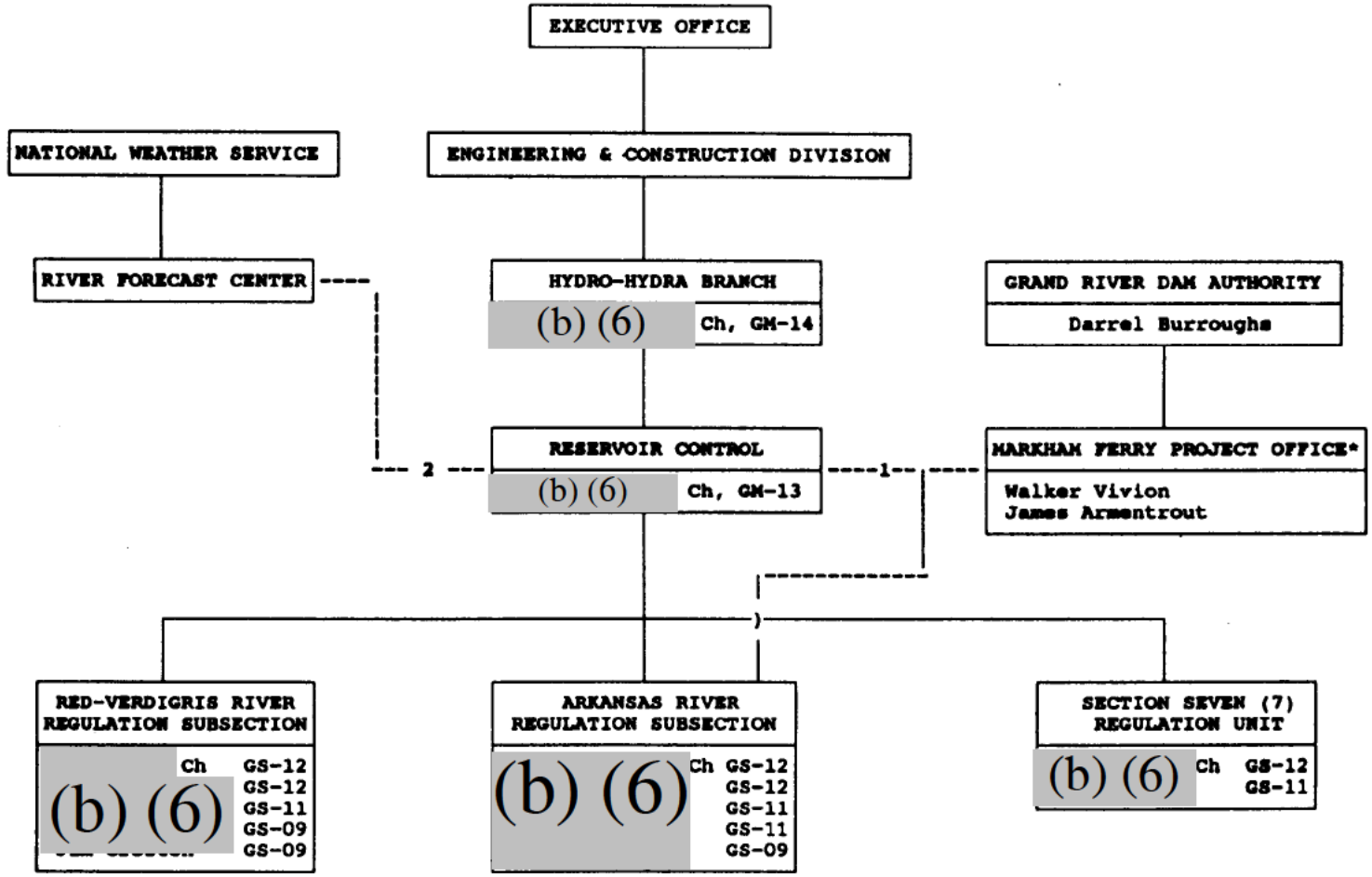
ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

PRECIPITATION STATIONS AND STREAM GAGING STATIONS

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:

ORGANIZATION FOR FLOOD CONTROL REGULATION
PENSACOLA RESERVOIR
TULSA DISTRICT



1. DIRECT COMMUNICATIONS ARE MAINTAINED BETWEEN THE LAKES AND THE RESERVOIR CONTROL SECTION FOR TRANSMISSION OF LAKE DATA AND INSTRUCTIONS.

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

*3. WATER CONTROL OFFICE FOR PENSACOLA RESERVOIR HAS BEEN TRANSFERRED TO MARKHAM FERRY RESERVOIR.

LAKE DATA

APRIL 15, 19

LINE NUMBER	ITEM	TIME		PENS							
1	POOL ELEVATION	12M		747.15							
2	POOL ELEVATION	4PM		747.21							
3	POOL ELEVATION	12M		747.30							
4	POOL ELEVATION	8AM		747.29							
5	TAILWATER ELEVATION	8AM									
6	24 HR. AVE POWER DISCHARGE	12M		11200							
7	24 HR. AVE TOTAL ELEVATION	12M		21300							
8	NET POWER GENERATION	12M									
9	GEN# 1 HRS. OF USE	12M									
	GEN# 2 HRS. OF USE	12M									
	GEN# 3 HRS. OF USE	12M									
	GEN# 4 HRS. OF USE	12M									
10	INSTANTANEOUS POWER DISCHARGE	8AM		11300							
11	INSTANTANEOUS TOTAL DISCHARGE	8AM		26450							
12	LAKE CONDITIONS	8AM									
13	WEATHER CONDITIONS	8AM									
14	TOTAL PROCEDING 6 HOUR PRECIPITATION ENDING AT	1PM									
		7PM		.15							
		1AM		.21							
		7AM									
15	TOTAL 24 HOUR PRECIPITATION	7AM		.36							
16	COMMENTS ON PRECIP. DIST.			4PM-10PM							
17	EVAPORATION 24 HOURS	8AM		.14							
18	WIND DIRECTION	8AM		SOUTH							
19	WIND VELOCITY	8AM		B-2							
20	WATER SUPPLY										
21	GATE SETTINGS NO.TYPE. OPENING	8AM		6 EG							
22	GATE CHANGES - DATE TIME			4/14 12:00 N							
23	POOL ELEVATION			747.15							
24	FROM: GATE SETTING			2 EG							
25	TO: GATE SETTING			6 EG							
26	GATE CHANGES - DATE TIME										
27	POOL ELEVATION										
28	FROM: GATE SETTING										
29	TO: GATE SETTING										
30	RIVER STAGE - LOW FLOW WEIR										

T FORM 813
REVISED JAN 1985

REPLACES EDITION
OF APR 1983

PROPONENT SWTED--HR

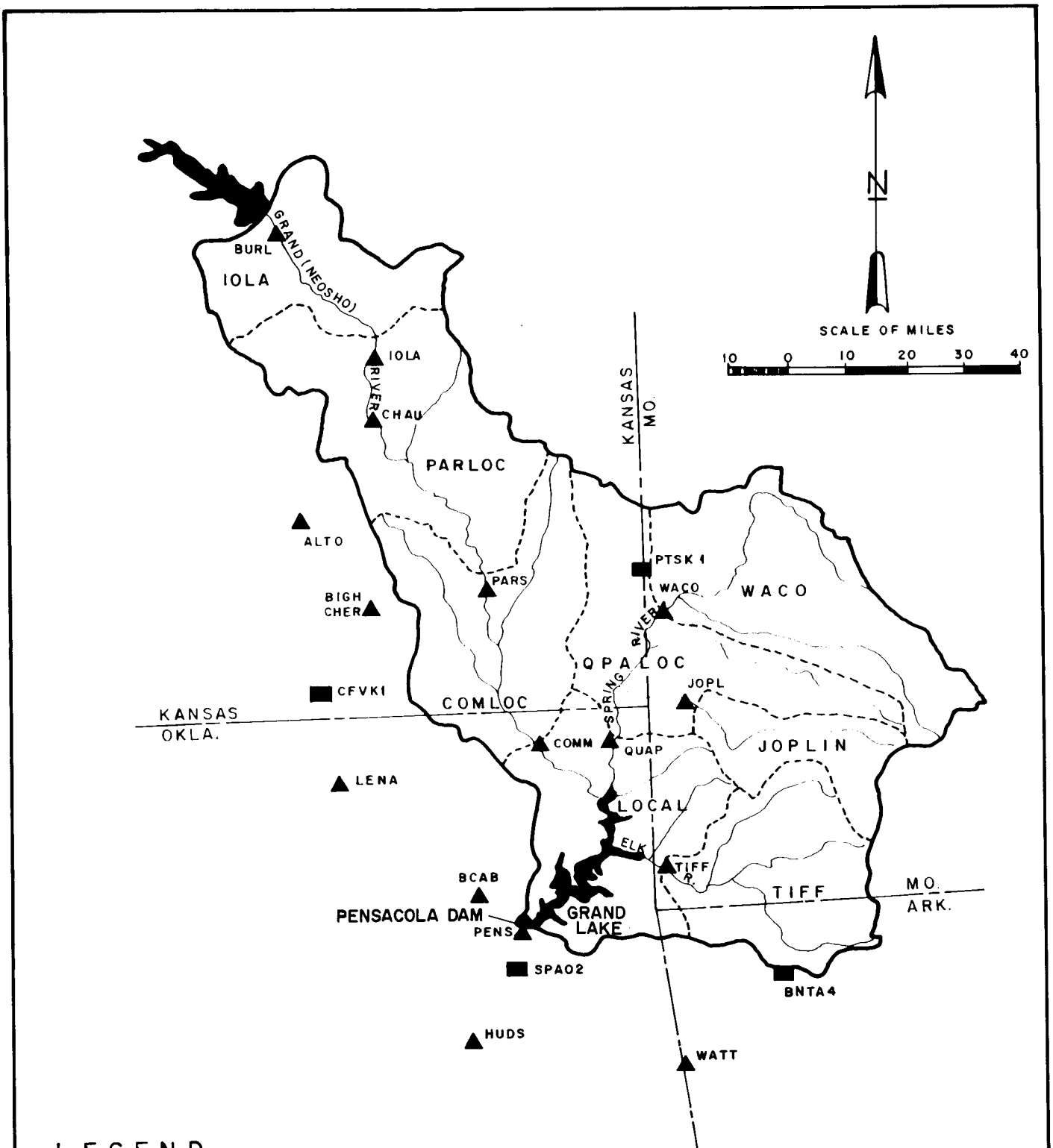
ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DAILY LAKE DATA REPORT

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990

DRAWN: CHECKED:



LEGEND

▲ DCP's USED FOR TIME DISTRIBUTION

■ OBSERVER GAGES

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

FORECAST SUBAREAS

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:

POOL ELEVATION IN FEET (PENSACOLA DATUM)

MINIMUM DISCHARGE

INFLOW IN THOUSANDS OF CFS

60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600

TOP OF GATES AND FLOOD CONTROL POOL ELEV. 755.0

FREE SPILLWAY DISCHARGE 21 MAIN GATES & 21 EAST GATES FULLY OPEN.

TOP OF POWER POOL ELEV. 745.0

EXAMPLE: TO DETERMINE A DISCHARGE FOR A POOL ELEVATION OF 749.5 WITH A 6–HOUR COMPUTED INFLOW OF 230,000 CFS.

1) AT ELEVATION 749.5 READ ACROSS TO THE INTERSECTION OF THE 230,000 INFLOW CURVE.

2) READ DOWN TO FIND THE APPROPRIATE DISCHARGE WHICH IS 70,000 CFS.

DISCHARGE IN THOUSANDS OF CFS

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

SPILLWAY GATE REGULATION SCHEDULE INFLOW PARAMETER

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:

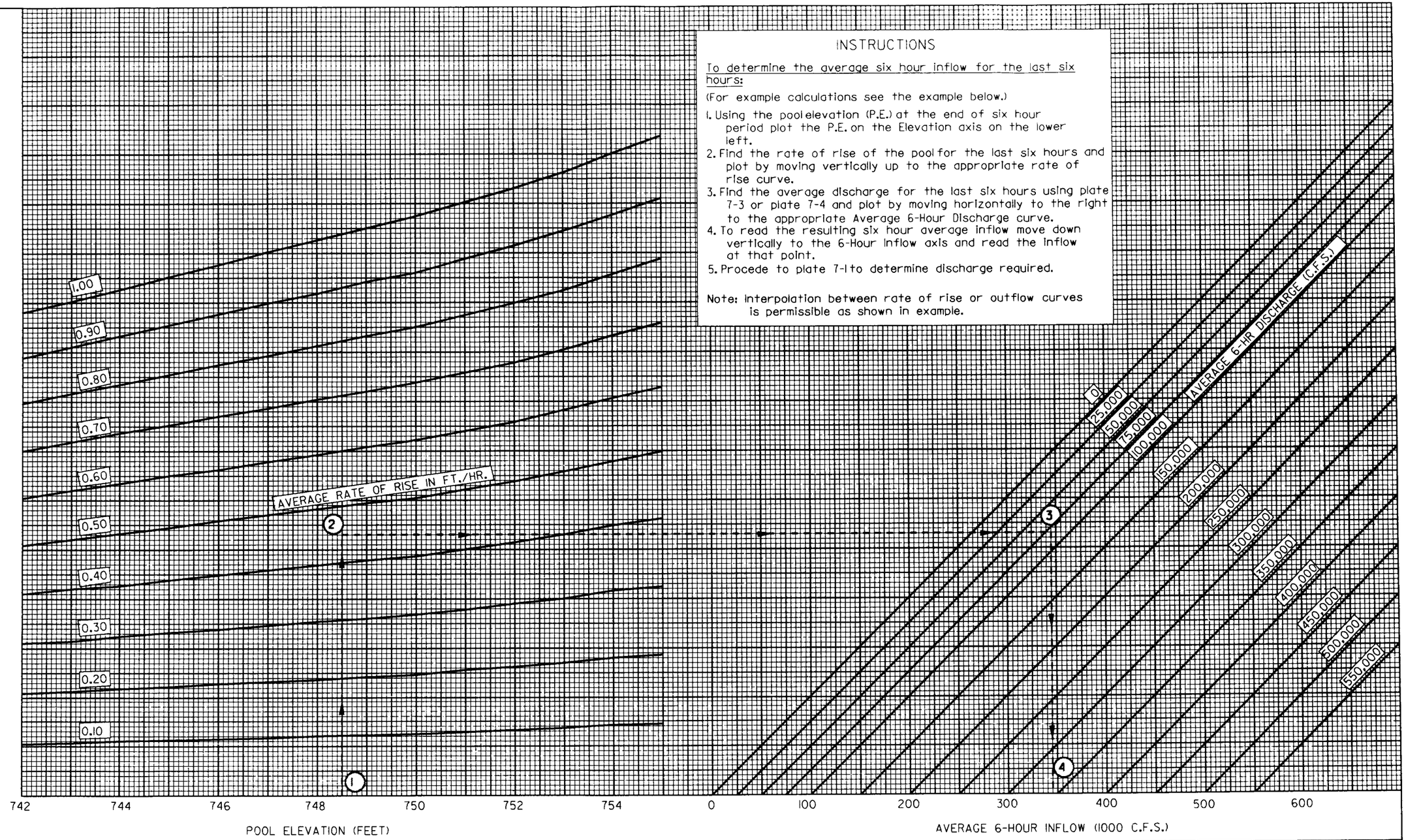
INSTRUCTIONS

To determine the average six hour inflow for the last six hours:

(For example calculations see the example below.)

1. Using the pool elevation (P.E.) at the end of six hour period plot the P.E. on the Elevation axis on the lower left.
2. Find the rate of rise of the pool for the last six hours and plot by moving vertically up to the appropriate rate of rise curve.
3. Find the average discharge for the last six hours using plate 7-3 or plate 7-4 and plot by moving horizontally to the right to the appropriate Average 6-Hour Discharge curve.
4. To read the resulting six hour average inflow move down vertically to the 6-Hour Inflow axis and read the inflow at that point.
5. Procede to plate 7-1 to determine discharge required.

Note: Interpolation between rate of rise or outflow curves is permissible as shown in example.



EXAMPLE CALCULATION

1. The current pool elevation is 748.5 ft. Find this on the pool elevation axis (1.)
2. Six hours ago it was 745.8 ft. The average rate of rise for this six hours is: (748.5-745.8)/6hrs.=0.45ft. per hour. Move up vertically from (1) to find the rate of rise on the rate of rise curves (2.)
3. Six hours ago the discharge was 50,000 cfs, five hours ago it was changed to 65,000 cfs. and three hours ago it was changed to 100,000 cfs. The average discharge for the last six hours is [1hr.(50,000 cfs) + 2 hrs.(65,000 cfs) + 3 hrs.(100,000)]/6 = 80,000 cfs. Move horizontally to read this six hour average disharge on the Outflow curves (3.)
4. From (3) read down vertically that the inflow for the last six hours is 345,000 cfs. (4.)

ARKANSAS RIVER WATERSHED — GRAND (NEOSHO) RIVER, OKLAHOMA

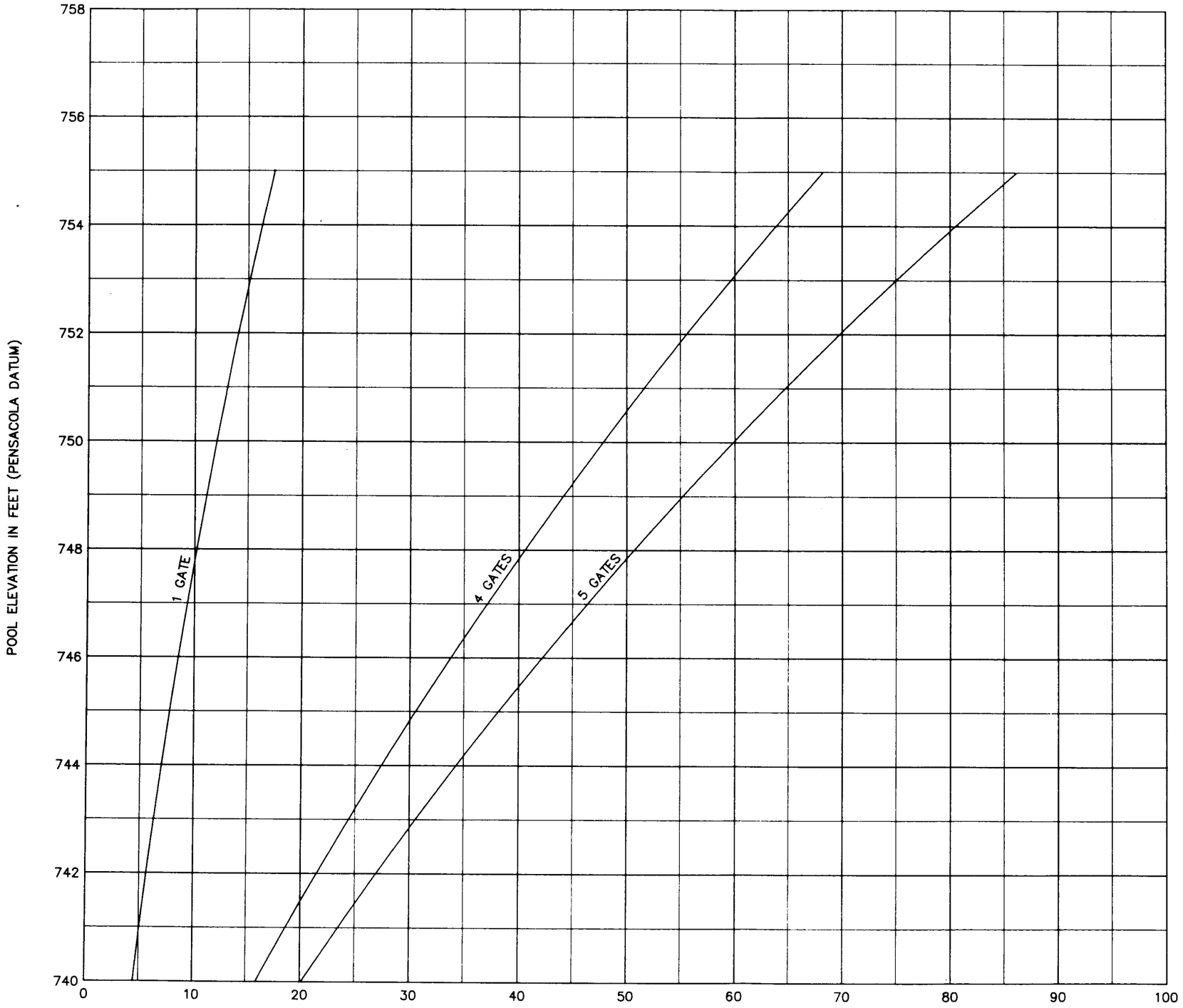
PENSACOLA RESERVOIR

INFLOW VS. RATE OF RISE NOMOGRAPH

DEPARTMENT OF THE ARMY, TULSA DISTRICT, CORPS OF ENGINEERS 1992

DRAWN BY: SKG

CHECKED BY: J.W.C.



NOTES:

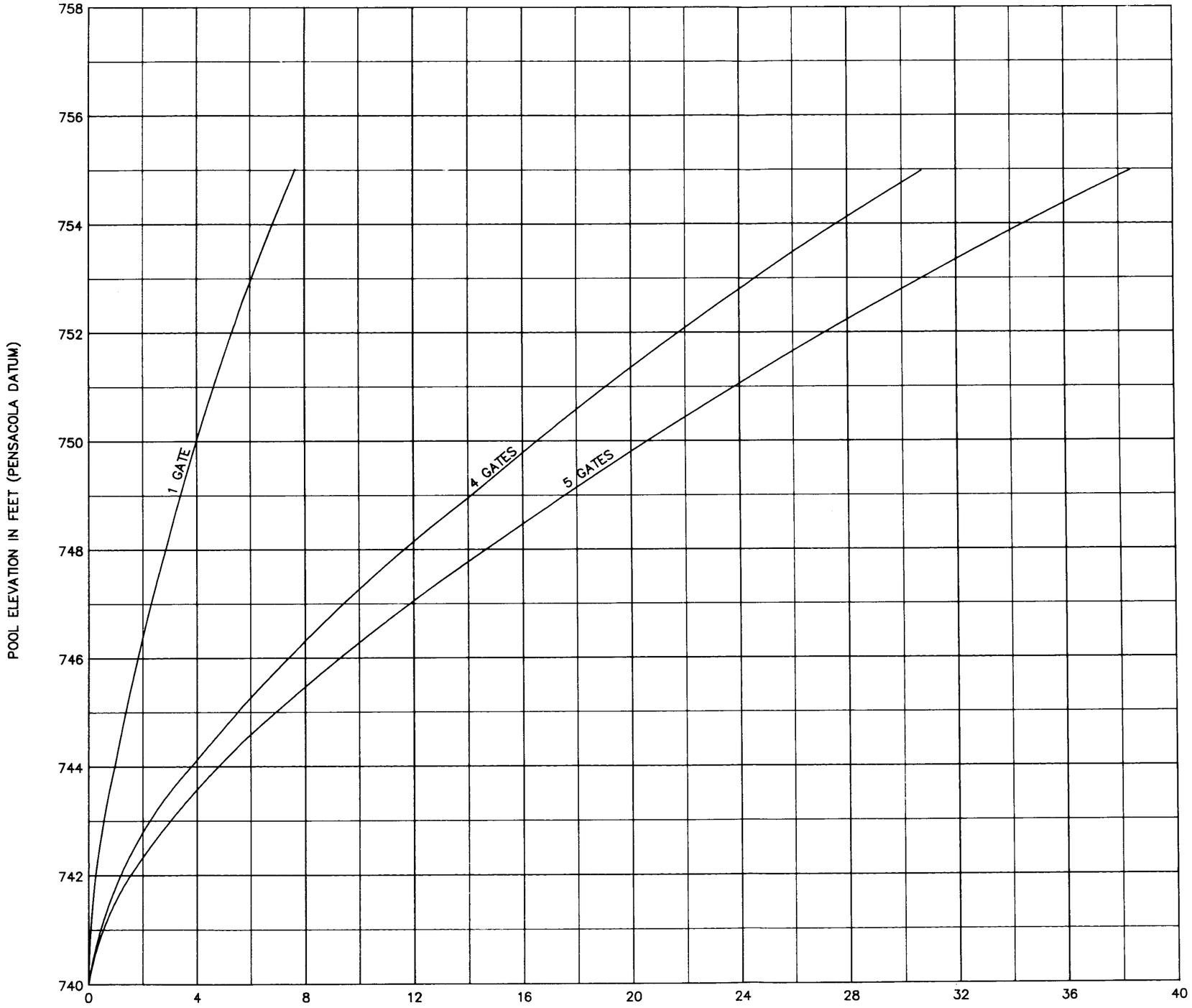
GATES FULLY OPEN 21–36'x 25' GATES
CREST ELEVATION 730.0 (PENSACOLA DATUM)
TOP OF GATES 755.0 (PENSACOLA DATUM).

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES MAIN SPILLWAY

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



NOTES:

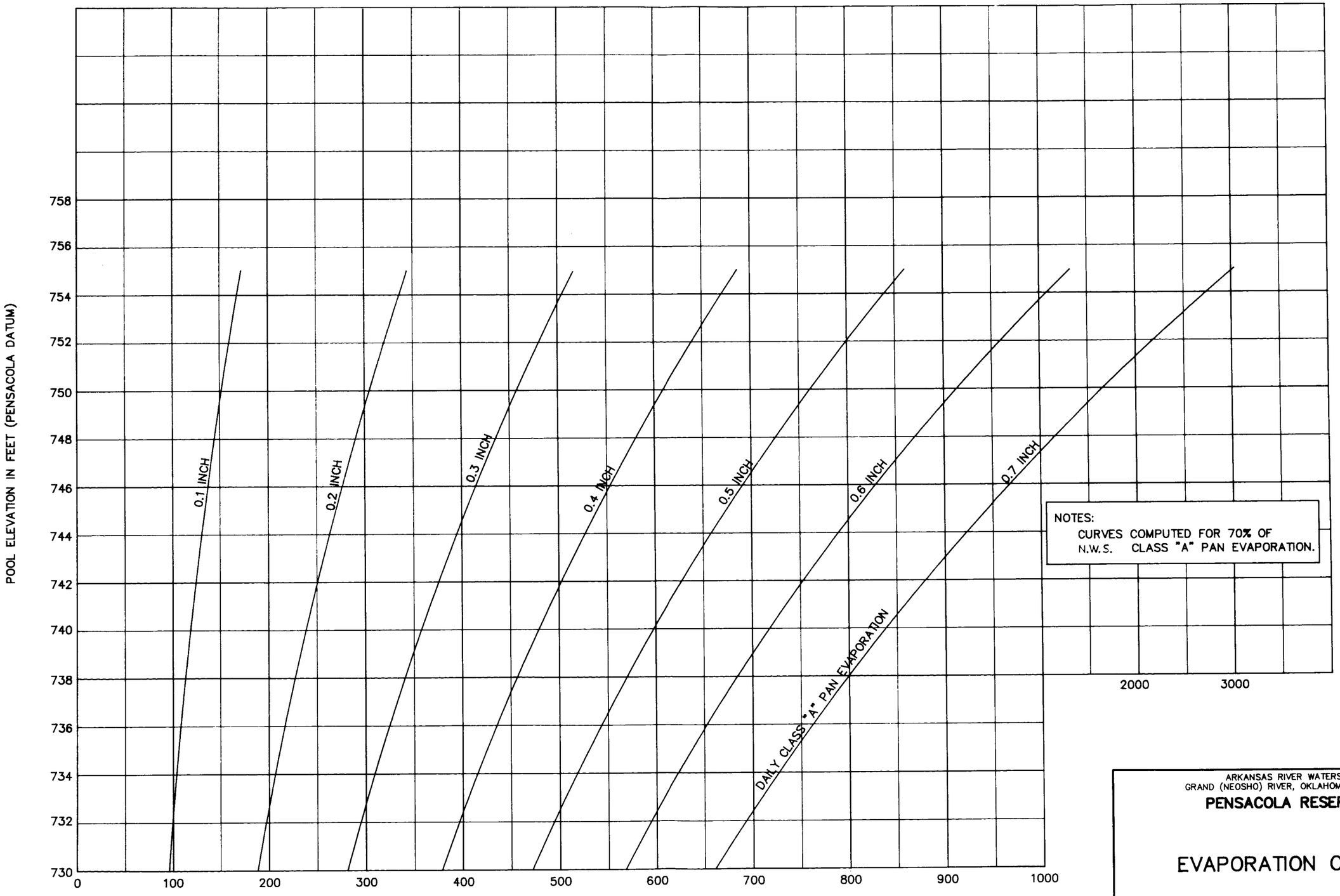
GATES FULLY OPEN
21–37'x 15' GATES
CREST ELEVATION 740.0 (PENSACOLA DATUM)
TOP OF GATES ELEVATION 755.0 (PENSACOLA DATUM).

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

DISCHARGE RATING CURVES EAST SPILLWAY

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

EVAPORATION CURVES

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:

_____Mail to: Southwestern Division
ATTN: SWDED-WR

RECORD OF DEVIATION FROM APPROVED
WATER CONTROL PLAN

DATE_____

DEVIATION_____
(Lake, Reservoir, or System)

1. This is to confirm the following verbal request from

_____to _____ via
(Name) (Name)

telephone for approval for a deviation from the approved water control plan.

2. _____

_____

_____

_____

_____

_____

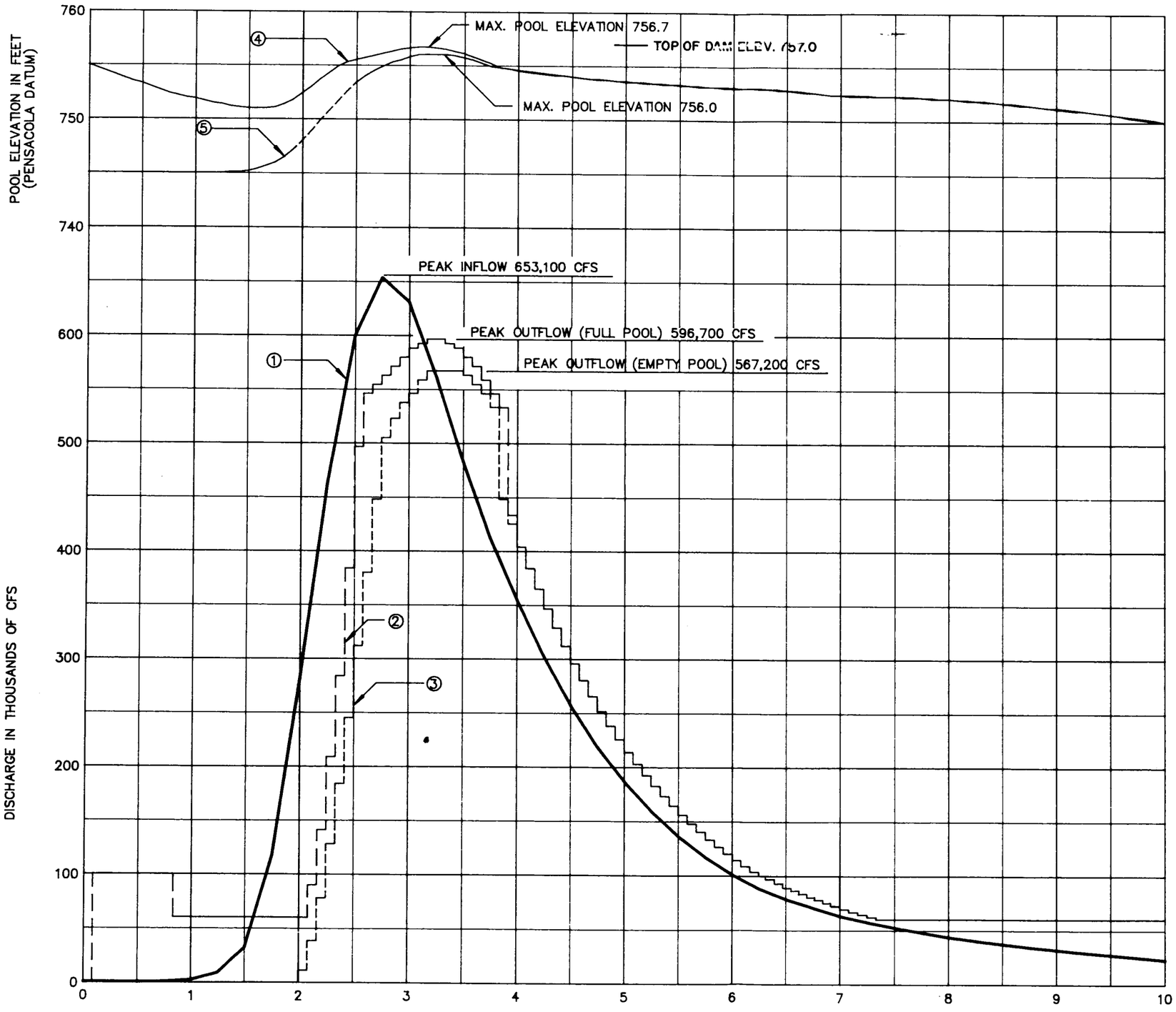
_____

_____

_____

_____

SWD 898
1 NOV 77



NOTE: EMERGENCY OPERATION
THE FLOOD CONTROL POOL WOULD HAVE EMPTIED DURING THE 22nd DAY FROM THE BEGINNING OF RAIN

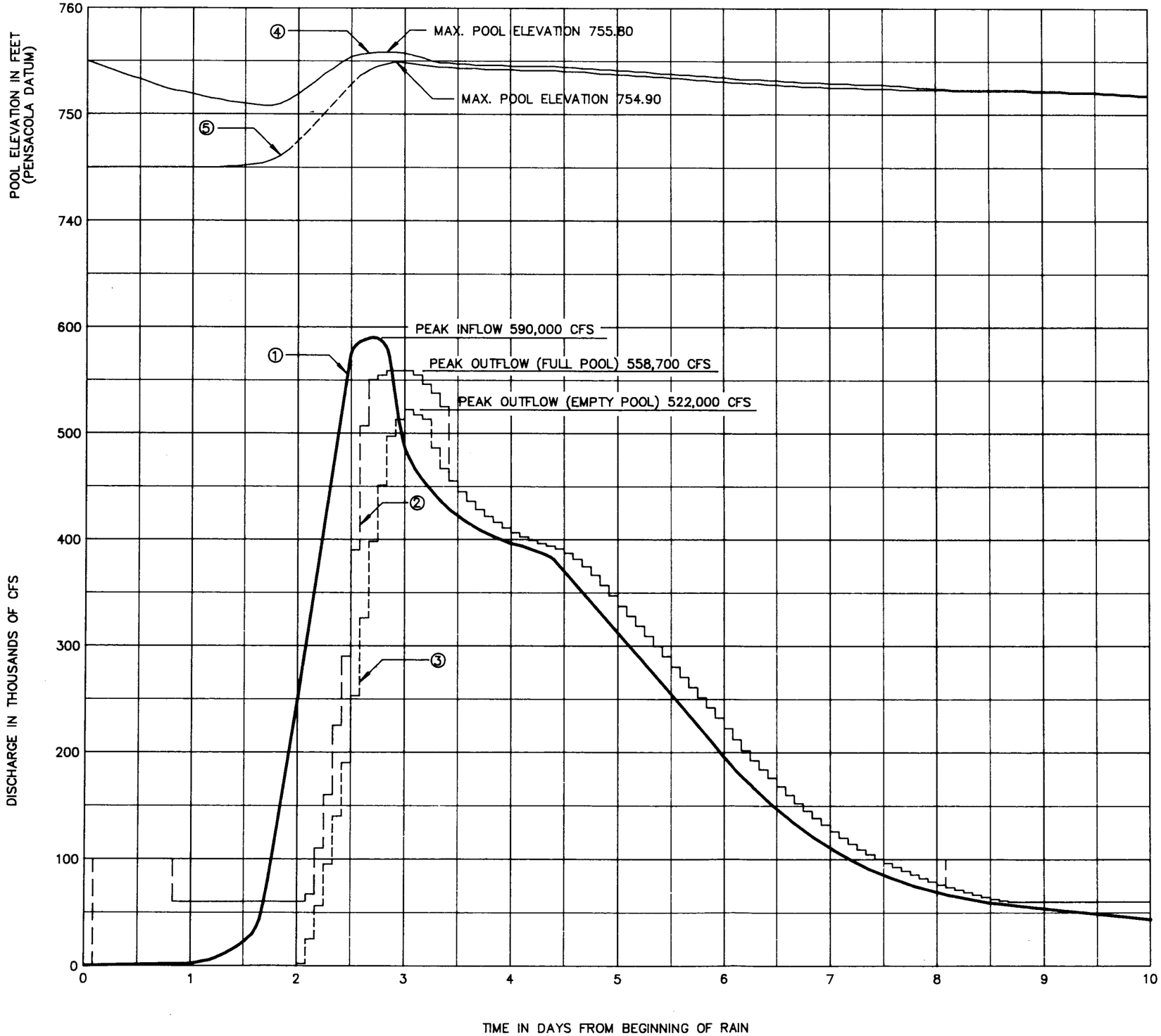
EMERGENCY REGULATION (PARA. 8.01)

① INFLOW HYDROGRAPH
② OUTFLOW – FLOOD ON FULL POOL
③ OUTFLOW – FLOOD ON EMPTY POOL
④ POOL STAGE – FLOOD ON FULL POOL
⑤ POOL STAGE – FLOOD ON EMPTY POOL

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS
PENSACOLA RESERVOIR

OPERATIONAL HYDROGRAPHS PROBABLE MAXIMUM FLOOD

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



NOTE: EMERGENCY OPERATION
THE FLOOD CONTROL POOL WOULD HAVE EMPTIED DURING THE 22nd DAY FROM THE BEGINNING OF RAIN

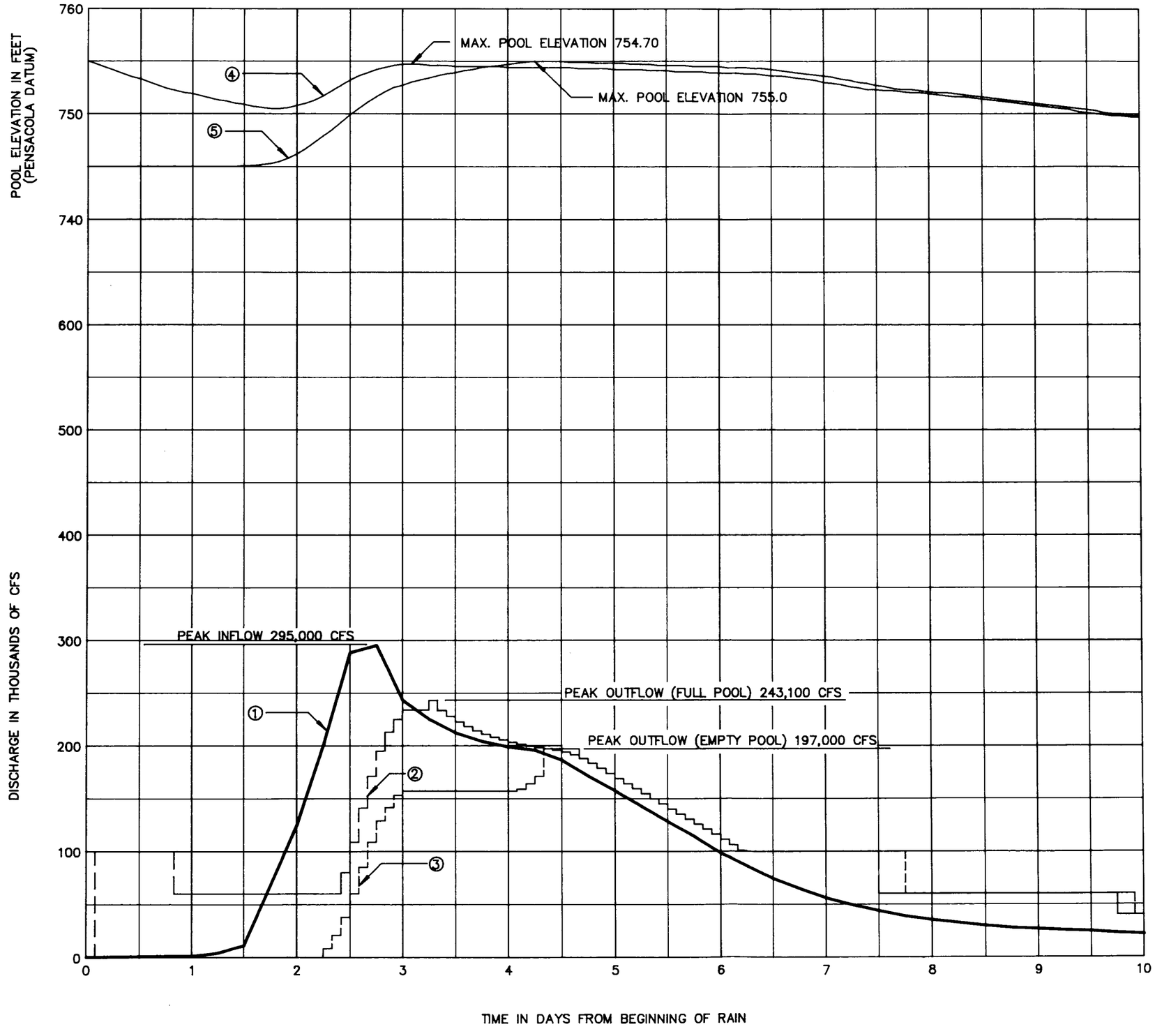
EMERGENCY REGULATION (PARA. 8.01)

① INFLOW HYDROGRAPH
② OUTFLOW – FLOOD ON FULL POOL
③ OUTFLOW – FLOOD ON EMPTY POOL
④ POOL STAGE – FLOOD ON FULL POOL
⑤ POOL STAGE – FLOOD ON EMPTY POOL

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS
PENSACOLA RESERVOIR

OPERATIONAL HYDROGRAPHS SPILLWAY DESIGN FLOOD

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



NOTE: EMERGENCY OPERATION
THE FLOOD CONTROL POOL WOULD HAVE EMPTIED DURING THE 21st DAY FROM THE BEGINNING OF RAIN

EMERGENCY REGULATION (PARA. 8.01)

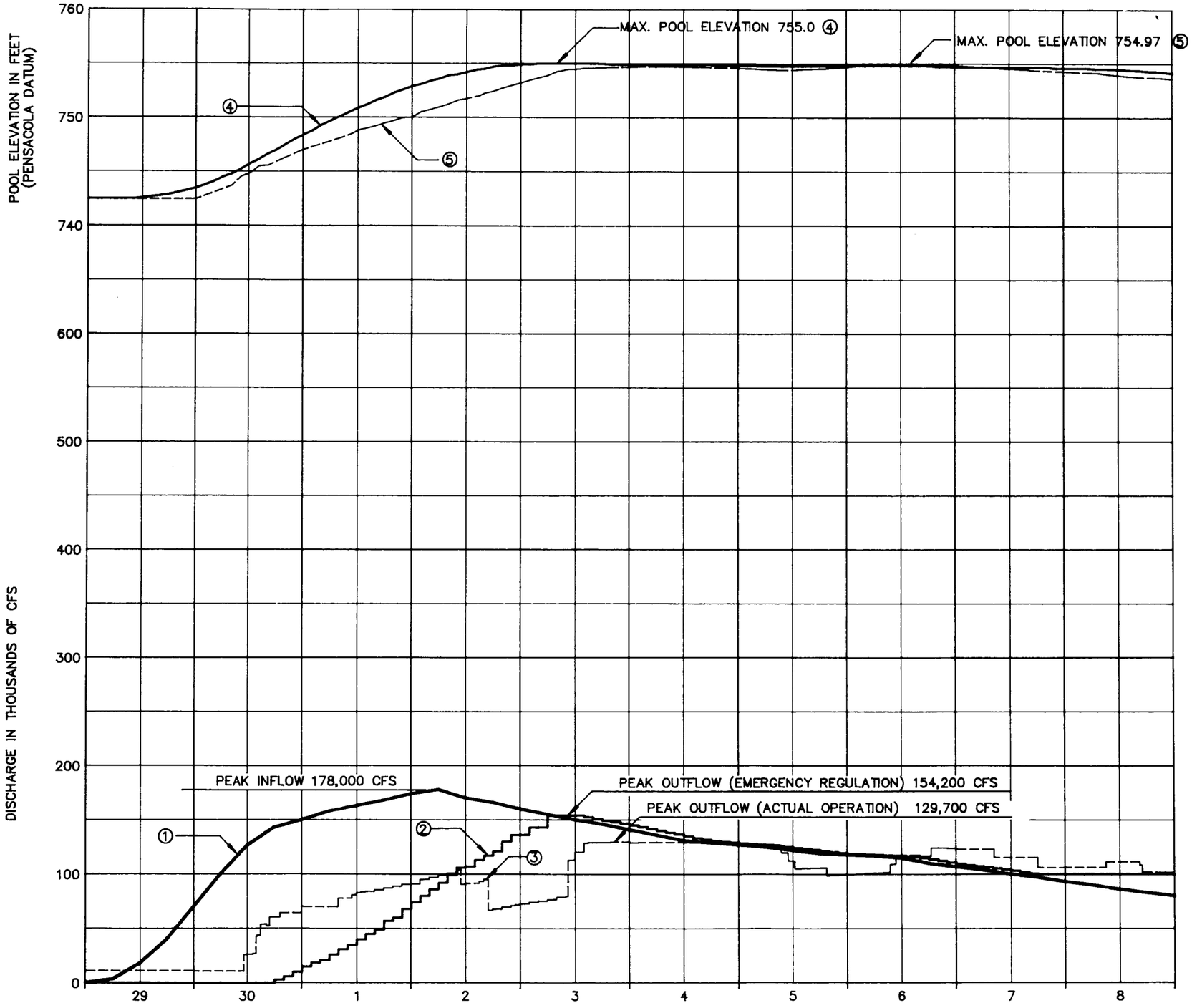
① INFLOW HYDROGRAPH
② OUTFLOW – FLOOD ON FULL POOL
③ OUTFLOW – FLOOD ON EMPTY POOL
④ POOL STAGE – FLOOD ON FULL POOL
⑤ POOL STAGE – FLOOD ON EMPTY POOL

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

OPERATIONAL HYDROGRAPHS STANDARD PROJECT FLOOD (1/2 SPILLWAY DESIGN FLOOD)

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



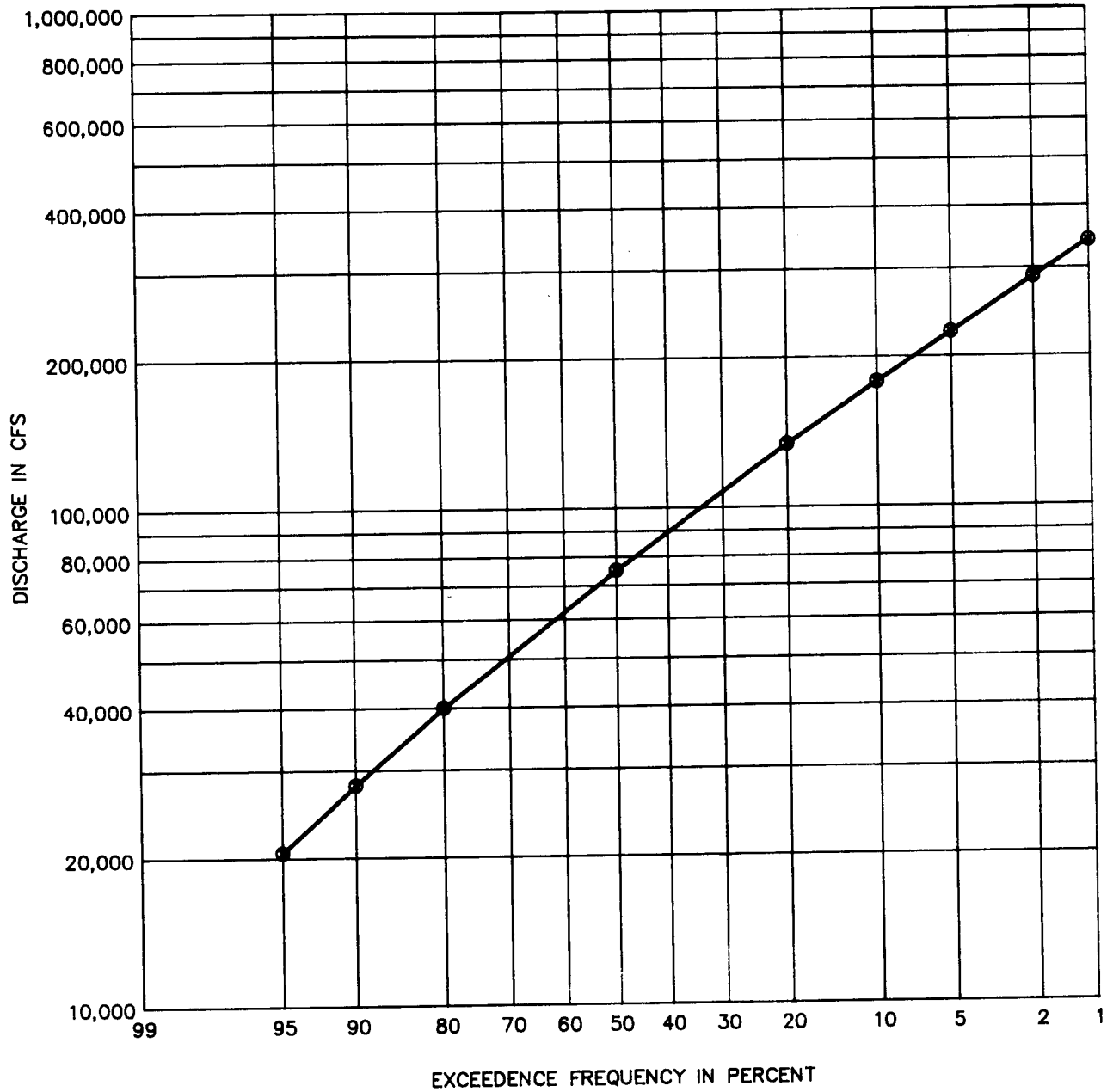
① INFLOW HYDROGRAPH
② OUTFLOW – EMERGENCY REGULATION
③ OUTFLOW – ACTUAL OPERATION
④ POOL STAGE – EMERGENCY REGULATION
⑤ POOL STAGE – ACTUAL OPERATION

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

OPERATIONAL HYDROGRAPHS FLOOD OF OCTOBER 1986

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



NOTES:

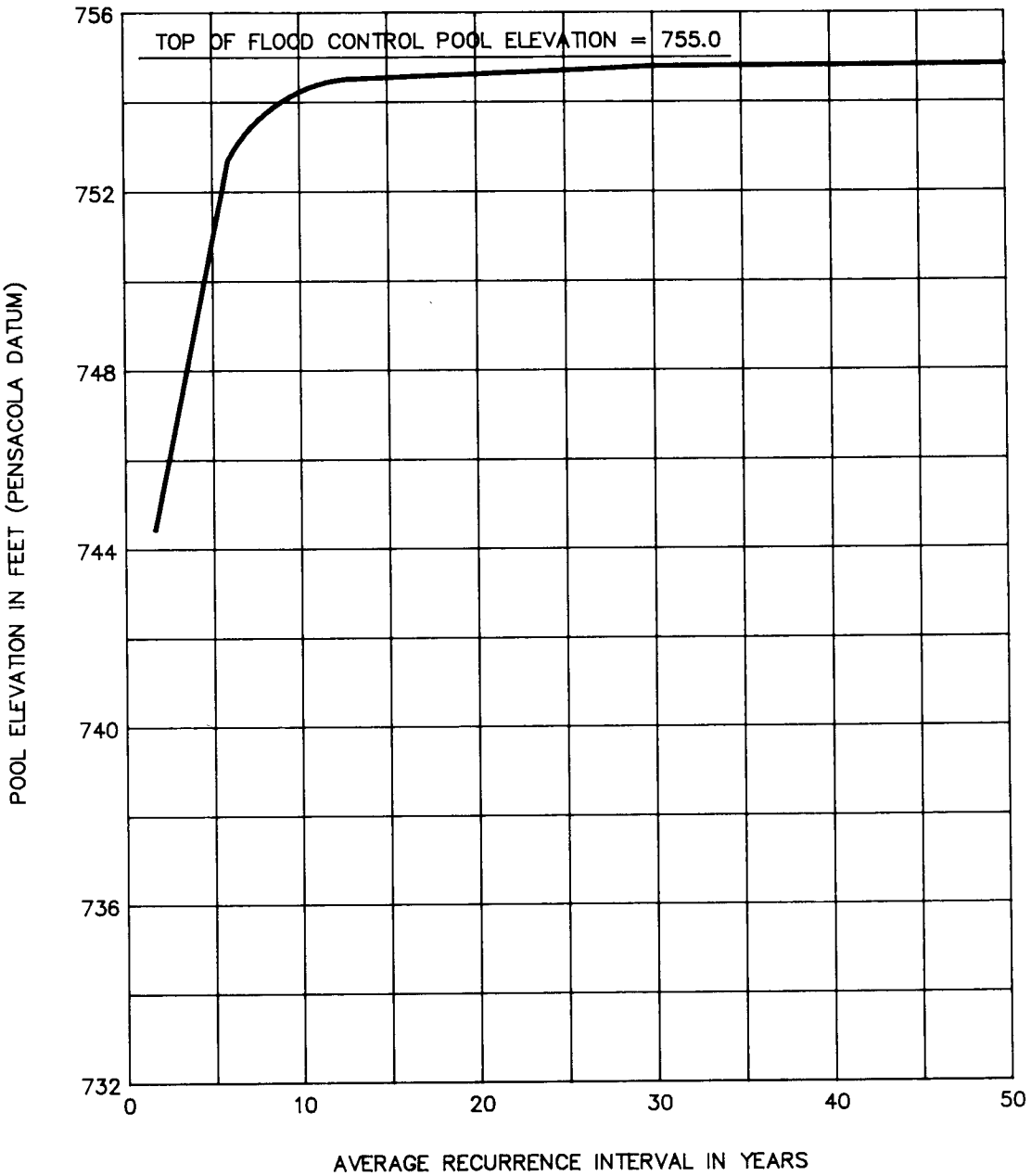
1. BASED ON PERIOD OF RECORD JAN 1940 THRU DEC 1986 FROM SUPER RUN A90X02.
2. BULLETIN NO. 17B FLOOD FLOW FREQUENCY GUIDELINES WERE USED.
3. ADOPTED SKEW COEFFICIENT OF -0.3 WAS USED

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

PEAK DAILY INFLOW PROBABILITY CURVE

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



NOTE:

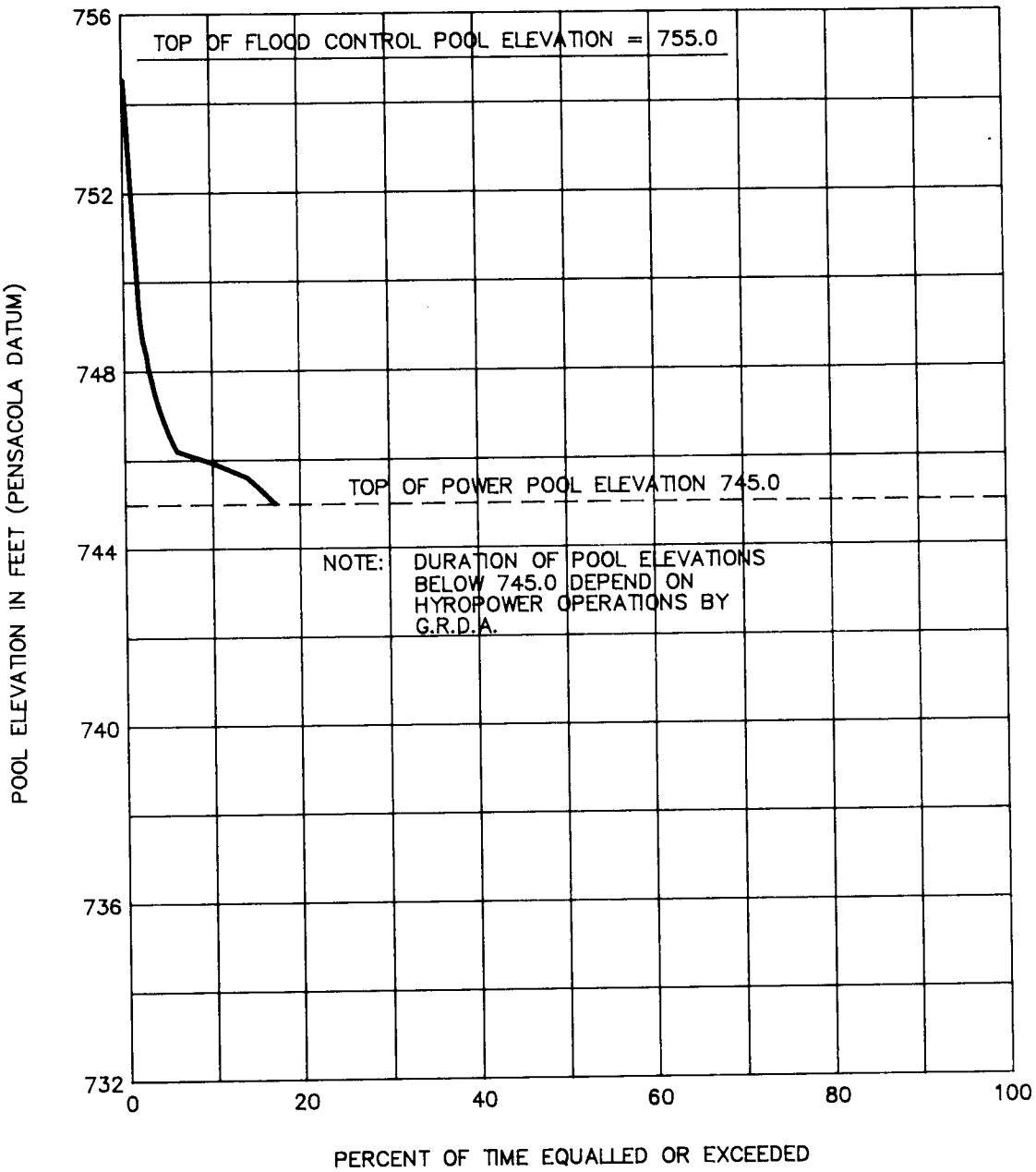
BASED ON PERIOD OF RECORD
JAN 1940 THROUGH DEC 1986 FROM
SUPER RUN A88X07

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

POOL ELEVATION PROBABILITY CURVE

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED:



NOTE:

BASED ON PERIOD OF RECORD
JAN 1940 THROUGH DEC 1986 FROM
SUPER RUN A88X07

ARKANSAS RIVER WATERSHED
GRAND (NEOSHO) RIVER, OKLAHOMA & KANSAS

PENSACOLA RESERVOIR

POOL ELEVATION DURATION CURVE

DEPT. OF THE ARMY, TULSA DISTRICT CORPS OF ENGINEERS 1990
DRAWN: CHECKED: