



US Army Corps
of Engineers ®

Fort Worth District

**TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE
NECHES RIVER
NECHES RIVER BASIN, TEXAS**

**WATER CONTROL MANUAL
APPENDIX A
MASTER RESERVOIR REGULATION MANUAL**

**DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
FORT WORTH DISTRICT**

JANUARY 2016

ORIGINAL MARCH 1956



TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be used in loose-leaf form, and only those sections or parts thereof requiring changes will be revised and printed. Therefore, this copy should be preserved in good condition so that inserts can be made to keep the manual current. All elevations referred to in this Water Control Manual, unless noted otherwise, are in feet, National Geodetic Vertical Datum of 1929 (NGVD29). The datum conversion from NGVD29 to NAVD88 is: NGVD29 + 0.0 feet = NAVD88 for Town Bluff Dam and B.A. Steinhagen Lake.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

Assistance with the flood control regulations of Town Bluff Dam will be provided during duty hours by the Fort Worth District Water Management Branch 817-886-1551. During non-duty hours, assistance can be obtained by contacting the Primary Regulator (817) 791-0973 cell number and in the order listed, one of the following persons:

EMERGENCY PERSONNEL ROSTER

Title and Name	Residence/Cell Telephone
Chief, Water Resources Branch Redacted PII	817-886-1542
Chief, Water Management Section Redacted PII	817-886-1682
Chief, E&C Division Redacted PII	Redacted PII
Chief, Operations Division Redacted PII	Redacted PII
Manager, Piney Woods Cluster Manager Redacted PII	Redacted PII
Manager, B.A. Steinhagen Lake Redacted PII	Redacted PII
Water Management, Southwestern Division–Dallas CESWD-RBT-W (Water Management and Infrastructure Safety)	
Chief, Redacted PII	Redacted PII
Hydraulic Engineer, Redacted PII	Redacted PII

**TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE
NECHES RIVER BASIN, TEXAS**

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Pertinent Data – Town Bluff Dam and B.A. Steinhagen Lake

(See Exhibit A for Supplementary Pertinent Data)

LOCATION: In Jasper County, R. M. 113.7 on the Neches River, 12 miles below the mouth of the Angelina River, ½ mile north of Town Bluff, TX, and 93 river miles north of Beaumont, Texas.

DRAINAGE AREA:

7,573 square miles
One inch of runoff 403,893 acre-feet

DAM:

Type: Paved earth fill
Length (including spillway): 6,698 feet
Maximum Height: 45 feet
Top Width: 25 feet

SPILLWAY (Gated):

Crest Elev.: 50.0 feet NGVD29
Length: 240 feet
Type: Broad-crested Weir
Control: 6 tainter gates, 40 feet x 35 feet

SPILLWAY (UNCONTROLLED):

Crest Elevation: 85.0 feet NGVD29
Crest Length: 6,600 feet

INFLOW:

Spillway Design Flood peak, cfs (1947 Study, w/o Sam Rayburn) 220,000
Spillway Design Flood volume, ac-ft (1947 Study, w/o Sam Rayburn) 6,189,400
Spillway Design Flood runoff, inches (1947 Study) 15.32

Probable Maximum Flood peak, cfs (1980 Study) 657,519
Probable Maximum Flood volume, ac-ft (1980 Study) 9,564,194
Probable Maximum Flood runoff, inches (1980 Study) 23.68

OUTFLOW:

Total routed peak outflow, cfs (1947 Study) **218,300**
Probable Maximum Flood total, cfs (1980 Study) 657,481

OUTLET WORKS:

Type: Two conduits in right abutment of spillway
Dimensions: 4 feet by 6 feet
Invert Elev: 52.0 feet NGVD29
Control: 2 tractor-type gates, 4 feet x 6 feet

POWER FEATURES: Power online estimated at FY 88. Construction and commercial operation began November 1989.

Units: 2-3,840 KW
Installed Capacity: 7,680 KW
Dependable Capacity: 6,000 KW

Feature	Elev. Feet* (NGVD29)	Reservoir Area (acres)	Reservoir Capacity			Total Spillway Capacity (cfs)
			Accumulative (ac-ft)	Runoff (inches)	Incremental (ac-ft)	
Top of Dam	95.0	30,800	365,500	0.90		
PMF Design Water Surface (1980 Study)	93.31	28,625	315,280	0.78		657,481
Max. Design Water Surface (1947 Study)						
Top of Gates and Uncontrolled Spillway (1980 Study)	85.0	16,830	124,700	0.31		
Normal Pool (upper) (2003 Survey)	83.0	10,687	66,972	0.17	18,818	
Normal Pool (lower) (2003 Survey)	81.0	9,000	48,154	0.12	31,554	
Invert at Sluice Intake (2003 Survey)	52.0	4	11	0		
Sediment Reserve					16,600	
Total Cumulative Storage					66,972	
Gate Sill and Streambed (2003 Survey)	50.0	2	6	0		

* The elevations listed on the pertinent data sheet is based on the datum of NGVD29. The datum conversion from NGVD29 to NAVD88 is: NGVD29 + 0.0 feet = NAVD88.

AUTHORIZATION: River and Harbor Act 2 Mar 45 (PL 79-14) (SD 98/76/1)
Mod by R&H Act 30 Jun 48 (PL 80-858).

FINAL PROJECT COST (OCT 54):

Federal:	\$6,749,000
Non-Federal:	<u>2,000,000</u>
Total:	\$8,749,000

ANNUAL O&M COST (FY 81):

Federal:	\$508,075
Non-Federal:	<u>None*</u>
Total:	\$508,075

COST ALLOCATION METHOD: Law

LOCAL AGENCY: Lower Neches Valley Authority

LAND ACQUISITION (Updated 1984):

	: Guide Contour (NGVD29)	: Area (Acres)
Fee Simple	88.0	21,644
Easement		<u>1,157</u>
Total		22,801

FLOOD DATA – NECHES RIVER:

Date	Peak Inflow (cfs)
May 1884	120,000**
May 1944	99,700
May 1953	90,900
May 1982	286,000

**Estimated channel capacity below dam: 20,000 cfs.

STATUS OF PROJECT: Construction initiated Mar 1947. Dam and outlet works were completed and deliberate impoundment of water began 16 Apr 1951. Project is complete and operational.

*NON-FEDERAL PARTICIPATION AND LOCAL COOPERATION:

As a unit of the four reservoir plan for Neches - Angelina River Basin, this project was constructed subject to contribution by local interest of \$5,000,000 toward the first cost of the system upon completion of the entire system. The Lower Neches Valley Authority (LNVA) furnished assurances that it was willing to contribute \$2,000,000 towards completion of Town Bluff Dam and B.A. Steinhagen Lake, exclusive of power facilities, and \$3,000,000 upon completion of Sam Rayburn Reservoir. Public Law 858 provides that the sponsoring agency will be permitted to withdraw from B.A. Steinhagen Lake not to exceed 2,000 cfs for its own use. The LNVA also pays \$200,000 per year for 50 years toward total cost of the two projects. A contract with LNVA was approved 22 Jan 57 embodying the above provisions.

LNVA pays no O&M costs except on features and appurtenances which may be provided and owned by the Authority.

REMARKS: B.A. Steinhagen Lake serves as a regulation project for hydropower releases from Sam Rayburn Reservoir.

Annual Visitation (10-year average projected, 2004-2014): 275,235

Shoreline at top of conservation pool: 160 miles

**TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE
NECHES RIVER, TEXAS
WATER CONTROL MANUAL**

CHAPTER I – INTRODUCTION

1-01. Authorization. This manual is submitted as required by Engineering Regulation (ER) 1110-2-240, Water Control Management, dated 30 May 2016, and is prepared in accordance with ER 1110-2-8156, Engineering and Design, Preparation of Water Control Manuals, dated 31 August 1995.

1-02. Purpose and Scope. The purpose of this manual is to document the Town Bluff Dam and B.A. Steinhagen Lake regulation plan. This manual also provides a concise reference source for higher authority personnel who will be concerned with or responsible for reservoir regulations during the life of the project. This manual also includes the regulation plan for Town Bluff Dam and B.A. Steinhagen Lake and the background material necessary to understand the purpose and application of the plan. Town Bluff Dam and B.A. Steinhagen Lake were originally identified as “Dam B”.

1-03. Related Manuals and Reports. This manual is Appendix A to the Neches River Basin Water Control Master Manual. A full report on the public hearing and the report on the preliminary examination of the Neches River and tributaries were submitted to the Chief of Engineers by the District Engineer, Galveston District, on 10 April 1937. A subsequent report titled Senate Document Number 98, 76th Congress, 1st Session was published on 14 April 1939, in this report, the District Engineer recommended the construction of four dams (Rockland Dam, McGee Bend Dam, Dam A, and Dam B) for the purpose of regulating the flow of the river for the benefit of navigation, the control of floods, the conservation of water, and the development of hydroelectric power. In 1945, Town Bluff Dam was authorized by the River and Harbor Act of 1945 (Public Law 14, 79th Congress, 1st Session). The Definite Project Report for Town Bluff Dam was submitted to the Chief of Engineers on 22 September 1947. The initial development provided for construction of the dam and reservoir only, however, the report provided for the ultimate development of hydroelectric power which was eventually added in 1985. In March 1956, the Fort Worth District (SWF) of the United States Army Corps of Engineers (USACE) published a reservoir regulation manual for Town Bluff Dam and B.A. Steinhagen Lake. The manual contains plans and procedures for regulation of the reservoir during both normal and flood conditions.

The reports and design memorandums important to the regulation of Town Bluff Dam and B.A. Steinhagen Lake are listed in Table 1-1.

TABLE 1-1

Related Manuals and Reports for Town Bluff Dam and B.A. Steinhagen Lake

	Title	Date
1.	Definite Project Report on McGee Bend, Dam "B," Rockland, and Dam "A" Reservoirs - Volume I of 5 Volumes - General - Volume II of 5 Volumes - McGee Bend Reservoir - Volume III of 5 Volumes - Dam "B" Reservoir - Volume IV of 5 Volumes - Rockland Reservoir - Volume V of 5 Volumes - Dam "A" Reservoir	September - October 1947
2.	Definite Project Report (Revised) on McGee Bend Reservoir - Real Estate Section	July 1951
3.	McGee Bend Reservoir - Brief Report on Angelina River Project - Reinvestigation of McGee Bend Reservoir, Angelina River, TX - 1st revision - 2nd revision	January 1952 November 1952 July 1953
4.	Dam B Reservoir - Reservoir Regulation Manual	March 1956
5.	McGee Bend Reservoir - Survey Data - Dam Site Work Areas and Reservoir Area	July 1961
6.	McGee Bend Reservoir - Design Memorandum No. 1 - Construction for Fiscal Year 1956	May 1958
7.	McGee Bend Reservoir - Design Memorandum No. 2 - General Design - General Design (Revised)	December 1955 April 1961
8.	McGee Bend Reservoir - Design Memorandum No. 3 Real Estate - Construction Area Part I - First Increment - Construction Area Part I - Second Increment Relocations (Real Estate) - Part I - Gulf Coast & S.F. Railroad - Part II - First Increment (Hwy 147) - Part II - Second Increment (Hwy 147) - Part III - Highway 96 Reservoir Area - Part I - Part II - Part III - Part IV - Part V	January 1957 February 1957 August 1957 March 1957 July 1957 August 1959 December 1957 August 1958 February 1959 April 1960 September 1960

TABLE 1-1

Related Manuals and Reports for Town Bluff Dam and B.A. Steinhagen Lake (continued)

	Title	Date
9.	McGee Bend Reservoir - Design Memorandum No. 4 Relocations: - Part I - Pipelines (Section A, B, C, D, E) - Part II - Highways (Section A, B, C, D, E, F) - Part III - County Roads and Forest Service Roads - Supplement No. 1 - Part IV - Railroads: - GC and SF Railway - A and NR Railroad - Part V - Power & Telephone Lines: - (Section A) - Texas Power & Light Co. - (Section B) - Deep East Texas Electric Coop. Inc. - (Section C) - Jasper-Newton Coop. - Part VI - Cemeteries: - (Section A) - Cemeteries No. 1 through 16 - (Section B) - Cemeteries	September 1958 May 1959 Oct 1957 February 1960 November 1961 September 1958 January 1960
10.	McGee Bend Reservoir - Design Memorandum No. 5 - Spillway	August 1956
11.	McGee Bend Reservoir - Design Memorandum No. 6 - Availability of Materials	September 1956
12.	McGee Bend Reservoir - Design Memorandum No. 7 - Earthen Dam	November 1956
13.	McGee Bend Reservoir - Design Memorandum No. 8 - Hydro Power Studies	July 1959
14.	McGee Bend Reservoir - Design Memorandum No. 10 - Clearing (Part I) - Clearing (Part II)	November 1960 January 1962
15.	McGee Bend Reservoir - Design Memorandum No. 11 - Power Plant Preliminary Design Report No. 11-1 - Flood Control Outlet and Power Intake Works Design Report No. 11-2 - (Inlet Channel, Outlet Channel, Retaining Walls, Stilling Basin, and Earthen Dam) - Flood Control Outlet Works, Power Intake, and Power Plant Design Memorandum Report No. 11-3 - Volume No. 1 - Volume No. 2 - Volume No. 3 - Volume No. 4 - Volume No. 5 - Volume No. 6	January 1960 January 1960 January 1960 February 1962 April 1962 June 1961 June 1961 June 1961 August 1961

TABLE 1-1

Related Manuals and Reports for Town Bluff Dam and B.A. Steinhagen Lake (continued)

Title	Date
16. Design Memorandum Report No. 11-4 - Flood Control Outlet & Power Intake (Quantity & Cost Estimate)	March 1962
17. McGee Bend Reservoir - Design Memorandum No. 12 Operational Buildings & Utilities - Revised Addition	August 1961 November 1962
18. McGee Bend Reservoir - Design Memorandum No. 13 Recreation Facilities: - Preliminary Recreation Plan (Section A) - Construction Design Memo (part of Master Plan) (Sect. B) - Joint Master Plan (Design Memorandum No. 13B) - Revised No. 13B - Part One (Updated Joint Master Plan - No. 13C) - Appendix A (Cost Estimates for Joint Master Plan - No. 13C) - Appendix B (Updated Joint Master Plan - No. 13C) - Appendix A-A (Updated Joint Master Plan - No. 13C)	December 1956 May 1962 July 1962 January 1966 September 1970 September 1970 September 1970 October 1972
19. McGee Bend Reservoir - Design Memo. No. 14 - Brookeland	March 1959
20. McGee Bend Reservoir - Design Memo. No. 15 - Hydrology (Revised)	November 1958
21. McGee Bend Reservoir - Design Memo. No. 16 - Cost Allocation - First Revised Addition - Second Revised Addition	November 1965 September 1989 August 1996
22. McGee Bend Reservoir - Design Memo. No. 17 - West Access Road	December 1960
23. McGee Bend Reservoir - Design Memo. No. 18, - Cathodic Protection of Flood Control & Power Intake Gates	March 1962
24. McGee Bend Reservoir - Design Memo. No. 19, - Shelter for Fallout Protection	Indefinite
25. McGee Bend Reservoir - Design Memo. No. 20, - Exhibition and Guided Tour	March 1971
26. McGee Bend Reservoir - Design Memo. No. 21 - Shoreline Erosion	September 1975
27. McGee Bend Reservoir - Analysis of Design	November 1962
28. Analysis of Design - Appendix A, - General, Foundation Treatment, and Hydraulics - Computations	November 1962
29. Analysis of Design - Appendix B, - Structural, Part I - Computations	November 1962
30. Analysis of Design - Appendix C, - Structural, Part 2 - Computations	November 1962
31. Analysis of Design - Appendix D, - Gates and Guides - Computations	November 1962
32. Analysis of Design - Appendix E, - Mechanical & Electrical Computations	November 1962

TABLE 1-1

Related Manuals and Reports for Town Bluff Dam and B.A. Steinhagen Lake (continued)

Title	Date
33. Analysis of Design - Appendix F, - Two Transfer Arrangement Computations	November 1962
34. Neches River Saltwater Barrier - Miscellaneous Paper H-74-9	March 1956
35. Neches River Master Manual	
36. Sam Rayburn Reservoir - Reservoir Regulation Manual	May 1971
37. Sam Rayburn Reservoir - Instructions for Regulating Storage in Sam Rayburn Reservoir	March 1965
38. Sam Rayburn Reservoir - Pool Raise (approved April 1972) - Raising the Top of Conservation Pool Level at Sam Rayburn Reservoir	April 1972
39. Sam Rayburn Dam and Reservoir - Reconnaissance Report, - Dam Safety Assurance Program	May 1984
40. Submission of Design Analysis Report (DAR) for Addition of Hydropower to Town Bluff Dam	1984
41. Sam Rayburn Dam and Reservoir - Storage Reallocation Study	June 1986
42. Sam Rayburn Dam and Reservoir - Spillway Erodibility, - Reconnaissance Report for Major Rehab. Program - Reconnaissance Report (Revised) - Reconnaissance Report (Revised) - Reconnaissance Re-Evaluation Report - Reconnaissance Re-Evaluation Report	September 1986 April 1988 March 1990 April 1991 July 1991
43. Sam Rayburn Dam and Reservoir - Flood Emergency Plan	
44. Sam Rayburn Dam and Reservoir - Storage Reallocation Study	
45. Sam Rayburn Dam and Reservoir - Dam Safety Assurance Program - Spillway Modification and Freeboard Restoration	October 1992

1-04. Project Owner. USACE-SWF owns and operates Town Bluff Dam and B.A. Steinhagen Lake.

1-05. Operating Agency. USACE-SWF is the operating agency for Town Bluff Dam and B.A. Steinhagen Lake. The Lake Manager at Town Bluff Dam has the responsibility for its operations and management of the lake. The Fort Worth District Engineer, through the Water Resources Branch of the Engineering and Construction Division, directs water control activities.

USACE operates the hydropower facilities at the dam in coordination with Southwestern Power Administration, which markets the hydroelectric capacity and energy from the project.

The project is staffed during normal working hours throughout the year. The Lake Manager at Town Bluff Dam has the responsibility for its operations. Park Rangers are also available on holidays and weekends to provide assistance with the lake operations. The project will be staffed 24 hours a day when the lake level is, or is forecast to rise above elevation 85.0 feet.

The Lake Manager will have a current list of the Water Resources Branch personnel including home telephone numbers to contact when necessary. The Lake Manager will furnish the Water Resources Branch a list of project personnel, giving their office and home telephone numbers. The Lake Manager resides as close to the project as is considered prudent to carry out his official duties.

1-06. Regulating Agencies. USACE is the regulatory agency for Town Bluff Dam and B.A. Steinhagen Lake. The regulation of the dam and hydropower is the responsibility of the Water Resources Branch of the Engineering and Construction Division, Fort Worth District.

CHAPTER II – DESCRIPTION OF PROJECT

2-01. Location. Town Bluff Dam and B.A. Steinhagen Lake are located on the Neches River at river mile 113.7 about 12.4 miles below the mouth of the Angelina River and approximately 0.5 miles north of Town Bluff, Texas. The lake straddles Jasper and Tyler Counties. The total drainage area above Town Bluff Dam is 7,573 square miles, which includes the entire Angelina drainage basin and 4,017 square miles of the drainage basin of the Neches River. The location of the dam and lake is shown on Plates 2-1a and 2-1b, respectively.

2-02. Purpose. Town Bluff Dam and B.A. Steinhagen Lake are a multi-purpose project used for flood control, water supply, hydropower, navigation, fish and wildlife, and recreation. The project is a unit of the Neches-Angelina River Basin System, which consists of four USACE lakes and various channel improvements and levees operated to provide flood protection along the Neches-Angelina River. The purposes of Town Bluff Dam and B.A. Steinhagen Lake are to assist Sam Rayburn Reservoir in providing flood control to the Angelina and Neches River Basin system in Southeast Texas, re-regulate flows from Sam Rayburn Dam's hydropower generation, supply water to the Lower Neches Valley Authority (LNVA) and the Beaumont area, and produce a clean source of electric generation. An aerial view of Town Bluff Dam is shown in Figure 2-1.



Figure 2-1. Aerial View of Town Bluff Dam

2-03. Physical Components. Town Bluff Dam consists of a non-overflow section, a gated spillway, outlet works, hydropower facility, and a paved compacted earth overflow section that serves as an uncontrolled spillway. The total length of the paved earthfill dam is 6,698 feet. The general plan of the embankment and spillway is shown on Plate 2-2. Additional information on Town Bluff Dam and B.A. Steinhagen Lake is provided in Exhibit A, Supplementary Pertinent Data.

a. Embankment. The embankment consists of a 6,698 feet long compacted earthfill structure with a 6-inch protective concrete slab. Approximately 6,600 feet of the embankment is designed to serve as an uncontrolled spillway (overflow spillway). The maximum height of the nonoverflow section of the embankment, on the right abutment, is about 45 feet. The top of the nonoverflow section is at elevation 95.0 feet and the top of the uncontrolled spillway (overflow section of embankment) is at elevation 85.0 feet. The upstream and downstream views of embankment are shown in Figures 2-2 and 2-3.



Figure 2-2. Upstream Side of Embankment



Figure 2-3. Downstream Side of Embankment

b. Spillway. The spillway consists of the gated and uncontrolled spillway. The gated spillway is near the right abutment of the dam in the river channel and consists of a low sill spillway with a clear opening of 240 feet, controlled by six 40-foot by 35-foot tainter gates with sill at elevation 50.0 feet. The discharge capacity of the gated spillway is 80,000 cubic feet per second (cfs) when the water surface elevation is at 85 feet. To permit passage of major floods, the gated spillway is supplemented by an uncontrolled spillway on the left side. The uncontrolled spillway is considered the major portion of the originally built embankment and was 6,600 feet long before the powerhouse was added. The crest of the uncontrolled spillway is at elevation 85.0 feet and the crest width is 25 feet. During flood periods, the gated spillway is operated to pass the inflow to avoid the overtopping of the uncontrolled spillway before the establishment of a safe tailwater depth. When the inflow to the reservoir exceeds the capacity of the gates fully opened, the uncontrolled spillway is overtopped, and the total flow is divided between the gated spillway and the uncontrolled spillway. A maximum swellhead (the difference between the headwater elevation necessary to pass the flood through the proposed structure and

the tailwater elevation below the structure) of 2.0 feet has been set as the design criterion for the gated spillway. The purpose of this limitation is to ensure that the uncontrolled spillway is not required to operate under excessive head differentials that would result in damaging velocities over the paved earthfill. The spillway plan and structure are shown on Plates 2-3 through 2-5. The upstream and downstream views of gated spillway are shown in Figures 2-4 and 2-5. The spillway concrete road, emergency stoplog, and downstream riprap are shown in Figures 2-6 through 2-8.



Figure 2-4. Upstream Side of Gated Spillway



Figure 2-5. Downstream Side of Gated Spillway



Figure 2-6. Spillway Concrete Road



Figure 2-7. Upstream Side of Emergency Stoplog Spillway Gate



Figure 2-8. Riprap and Concrete Blocks of Gated Spillway



Figure 2-9. Gated Spillway Stilling Basin and Discharge Channel

c. Outlet Works. The outlet works consist of two parallel rectangular conduits with the intake in the right spillway abutment. The conduit discharges are controlled by two 4-foot by 6-foot slide gates with sill at elevation of 52.0 feet. The crown of each conduit is dropped 7 inches near the exit portal to prevent negative pressures within the conduit. These outlet works are no longer operational.

d. Stilling Basin. The stilling basin is 50 feet long and 345 feet wide. The floor of the stilling basin is at elevation of 40.0 feet. The basin has two rows of baffle blocks and an end sill to assist in the dissipation of kinetic energy and reduce erosion velocities in the existing downstream channel. The stilling basin and downstream view of the discharge channel are shown in Figure 2-9.

e. Hydropower Facilities. The hydropower facility at Town Bluff Dam is named the Robert D. Willis Hydropower Project (Willis). Southwestern Power Administration markets the hydropower output from the project. Construction was started in March 1987 and became available for commercial operation on November 17, 1989. The project is a first-of-its-kind partnership between private enterprise and the U.S. government in that the Sam Rayburn Municipal Power Agency (SRMPA) paid for the entire project in advance rather than reimbursing the Federal government over the life of the project. The powerhouse and its discharge channel are shown in Figures 2-10 through 2-13.



Figure 2-10. Upstream Side of Powerhouse



Figure 2-11. Downstream Side of Powerhouse and Stilling Basin



Figure 2-12. Powerhouse Discharge Channel



Figure 2-13. Powerhouse Discharge Channel

f. Water Supply Facilities. There are no water supply intake facilities within the lake.

2-04. Related Control Facilities. B.A. Steinhagen Lake is part of the Neches River Basin system, which consists of two USACE projects, Sam Rayburn Dam and Town Bluff Dam (also known as Dam B). The two dams are operated to control floods, conserve water, regulate stream flow for water supply and navigation on the Neches River downstream of Town Bluff Dam, and generate hydroelectric power.

USACE built a Permanent Salt Water Barrier across the Neches River downstream of Town Bluff Dam in Jefferson and Orange Counties near Beaumont, Texas. The saltwater barrier is operated by LNVA. Daily coordination between USACE and LNVA is necessary to ensure that the project purpose of stream flow regulation for water supply in the vicinity of Beaumont is met.

2-05. Real Estate Acquisition. A total of 22,801 acres of land were acquired for the operation of the Town Bluff Dam. The real estate take line is based on a guide contour elevation of

88.0 feet. This level was determined by routing the standard project flood through the reservoir starting at normal pool elevation of 83.0 feet.

2-06. Public Facilities. Five recreation areas around the lake are operated by USACE for public use. The areas are listed in Table 2-1 and the parks operated by USACE are shown on Plate 2-6. Facilities provided at these parks consist of roads, parking areas, boat ramps, camping and picnicking facilities, walkways, sanitation facilities, potable water, and swimming areas.

TABLE 2-1

Recreation Areas at Town Bluff Dam and B.A. Steinhagen Lake

1. Sandy Creek Park
2. Magnolia Ridge Park
3. Bluff View Park
4. Campers Cove Park
5. East End Park

CHAPTER III – HISTORY OF PROJECT

3-01. Authorization. Congressional authority for the construction of Town Bluff Dam (Dam B) and B.A. Steinhagen Lake on the Neches River was authorized by the River and Harbor Act approved March 2, 1945 (Public Law 14, 79th Congress, 1st Session). The River and Harbor Act of 1945 was approved in accordance with recommendations made by the Chief of Engineers contained in House Document Number 403 (77th Congress, 1st Session). Authority to initiate advance planning is contained in a letter by the Chief of Engineers to the Division Engineer, Southwestern Division, dated April 2, 1945, subject "Advance Planning of River and Harbor Projects Authorized in the Act Approved 2 March 1945".

By letter dated 12 July 1945, the War Production Board formally recommended the immediate construction of Town Bluff Dam (Dam B), exclusive of power facilities, in accordance with the plan and the purposes (flood control, navigation, conservation and hydropower development) presented in Senate Document 98 (refer to Section 3-02, second paragraph) and authorized by the River and Harbor Act of 1945. The recommendation was based on the need for an adequate water supply to meet production and essential civilian requirements in the Lower Neches Valley. The letter stated adequate priorities would be granted for the construction of the project upon receipt of a breakdown of the cost together with an estimate of the material and equipment requirements. The authority for priorities was withdrawn after the cessation of World War II hostilities in September 1945. Advance planning funds for the Neches-Angelina Rivers project were made available by Congress for FY 1946, and definite project studies were begun at that time.

In July, 1967, "Dam B" was renamed Town Bluff Dam and B.A. Steinhagen Lake. Town Bluff Dam is derived from being in the close proximity to the community in Tyler County of that name. B.A. Steinhagen was a prominent citizen of Beaumont, Texas who was active in initial planning, authorization, and other water conservation activities. The Robert D. Willis Hydropower Project is named in memory of Willis who served as executive director of the Sam Rayburn Municipal Power Agency (SRMPA) from May 1980 to May 1988.¹

According to the "Town Bluff Dam Design Report Addition of Hydropower", the addition of hydropower was authorized under Section 216 of Public Law 91-611.

3-02. Planning and Design. A public hearing was held in Jacksonville, Texas on 9 September 1936, for the purpose of affording all interested parties an opportunity to present their views concerning improvement of the Neches River and its tributaries in connection with the preliminary examination and review of reports on the Neches River, Texas. At this public hearing and in further correspondence and conferences, local interest, represented by both the Sabine-Neches Conservation District, a state-authorized agency, and LNVA requested

¹ "History of Town Bluff Dam", U.S. Army Corps of Engineers.

improvements in the Neches River watershed for flood control, water conservation, and allied purposes.

A full report of the aforementioned public hearing along with the report on preliminary examination of the Neches River and tributaries was submitted to the Chief of Engineers by the District Engineer, Galveston District, on 10 April 1937. Subsequently printed as Senate Document 98, Seventy-sixth Congress, First Session, the District Engineer recommended the construction of four dams for the purposes of flood control, navigation, conservation and hydropower development on the lower watershed. The dams recommended for construction were as follows:

- a. Rockland Dam at river mile 160.4 on the Neches River
- b. McGee Bend (now Sam Rayburn) Dam at river mile 25.2 on the Angelina River
- c. Dam A at river mile 142.0 on the Neches River
- d. Dam B (now Town Bluff) at river mile 113.7 on the Neches River

The Chief of Engineers' recommendation was made subject to the provision that, before construction was started upon any element of the project, the State of Texas or other responsible local agency give assurances satisfactory to the Secretary of War (the Army), that upon completion of the entire project the agency would contribute the sum of \$5,000,000 towards the first cost of the work.

In a later report on survey of the Neches River and tributaries dated 15 December 1939, the District Engineer considered the feasibility of other improvements requested by local interests, concluded that none were economically justifiable at that time, and recommended that no improvements be undertaken by the Federal Government other than those requested in Senate Document 98.

Subsequent to the preparation of the survey report but prior to authorization for construction of the project, the Lower Neches Valley Authority (LNVA) submitted an application to the Federal Government for a permit to construct an earthen dam across the Neches River near Rockland, Tyler County, Texas. At the time the application for the permit was under consideration by the Office, Chief of Engineers, the 1945 River and Harbor Bill was being formulated. Since the bill contained the authorization of the Neches and Angelina Rivers project, LNVA was willing for USACE to construct the project in accordance with the plan contained in Senate Document 98, in lieu of being granted a permit to construct Rockland Dam. The granting of the permit was therefore held in abeyance in compliance with the desires of LNVA. The River and Harbor Act authorizing construction of the Neches-Angelina project was approved 2 March 1945 (Public Law 14, Seventy-ninth Congress, Chapter 19, 1st Session, S. 35).

A public hearing was held in Jasper, Texas, on 13 November 1946 to give information to all interested parties concerning the project plan for improvement of the Neches and Angelina Rivers, Texas and to obtain their views thereon. Most of the opinions expressed at the hearing favored USACE's proposal, but there was some opposition to the construction of the large

reservoirs, Rockland and McGee Bend (now Sam Rayburn).

The Definite Project Report for the Neches and Angelina Rivers, Texas project was being formulated in 1946 and it became evident that Dam B and one of the two large reservoirs could be constructed with benefits exceeding costs. The combination of McGee Bend Dam and Dam B sans power facilities had the highest B/C ratio. With a recommendation forthcoming that construction of the Rockland and Dam A reservoirs be deferred, a 15 November 1946 letter from the District Engineer to LNVA notes that “the storage capacities of McGee Bend and Dam B Reservoirs are now designed to meet fully the existing multiple water demands of the lower Neches River valley under conditions of severe drought, plus a reasonable allowance for future increase water uses.” The letter went on to suggest that LNVA furnish assurances that it would contribute \$5,000,000 toward the first cost of McGee Bend and Dam B at the time of their completion instead of at the time all four reservoirs are constructed. In reply to this suggestion, the Authority furnished assurances that it was willing to contribute \$2,000,000 toward completions of Town Bluff Dam and B.A. Steinhagen Lake, exclusive of hydropower facilities, and \$3,000,000 upon completion of the Sam Rayburn Reservoir. The assurances were forwarded to the Office, Chief of Engineers, on 10 February 1947 and accepted by the Under Secretary of War (the Army) on 27 March 1947.

According to the “Addition of Hydropower”, to the Town Bluff dam and spillway, the original location for the hydropower plant was to be located on the right abutment. However, due to issues with sloughing and the unstable nature of the soils, the placement of the hydropower facility was located on the uncontrolled spillway along with the construction of a new discharge channel.

3-03. Construction. The Definite Project Report for Town Bluff Dam (Dam B), submitted to the Chief of Engineers on 22 September 1947, provides for the ultimate development of hydroelectric power as proposed in the project document. The initial development, however, consists of the construction of the dam and reservoir only. Construction of Town Bluff Dam began in March 1947. The dam and outlet works were completed and storage of water was started in April 1951. However, during the period December 1951 to March 1952, storage was limited to below elevation 72.0 feet to permit the completion of necessary construction. In March 1952 the storage limitation was removed and the reservoir was permitted to fill to elevation 83.0 feet. Maintaining the reservoir level at elevation 83.0 feet resulted in damage to the fill of U.S. Highway 190 across B.A. Steinhagen Lake (Dam B reservoir) due to wave action. From June 1952 to September 1952, storage was limited so as not to exceed elevation 81.0 feet in order to minimize damage to the highway fill. During this period the reservoir level was drawn down by releases for irrigation in accordance with requests by LNVA. In order to permit permanent repairs to the highway fill, the reservoir was regulated so as not to exceed elevation 72.0 feet from September 1952 to April 1953. When work was completed, all restrictions on storage to the normal pool level, elevation 83.0 feet, were removed.

The construction of the Robert D. Willis hydroelectric facility at Town Bluff Dam began in March 1987, and the hydropower facilities became available for commercial operation on

17 November 1989. Table 3-1 outlines the important dates in the construction and repair of Town Bluff Dam. Figure 3-1 through Figure 3-6 show different phases of dam construction.



Figure 3-1. Embankment Construction



Figure 3-2. Spillway Construction



Figure 3-3. Tainter Gates Construction



Figure 3-4. Tainter Gates Construction



Figure 3-5. Front Structure Construction



Figure 3-6. Downstream Channel Construction

TABLE 3-1

Resume of Construction Activities

Activity	Date
Construction began	March 1947
Construction completed	April 1951
Deliberate impoundment began	16 April 1951
Conservation pool filled	June 1954
Construction of warehouses and facilities	July 1955
Gate hoist conversion	November 1983
Construction of the hydropower facility	March 1987
Construction of rock protection, right bank	December 1988
Overhead crane replacement	April 1989
Repair channel erosion	August 2000
Repair and repaint tainter gates	April 2005
Emergency embankment concrete repairs	August 2007
Cellular cofferdam, jet grouting repair	November 2009

3-04. Related Projects. Town Bluff Dam is one of four dams authorized in the Neches-Angelina River Basin by the River and Harbor Act of 1945 (Public Law 14, 79th Congress, 1st Session). The four dams are known as Rockland Dam, McGee Bend Dam (Sam Rayburn Dam and Reservoir), Dam A, and Dam B (Town Bluff Dam and B.A. Steinhagen Lake). In 1955, Congress approved the funding for McGee Bend Dam and Reservoir, and construction began in 1957. Congress changed the name of McGee Bend Dam to Sam Rayburn Dam and Reservoir in 1963, and it was formally dedicated in 1965. Rockland Dam and Dam A, which were to be located on the Neches River upstream from the confluence of the Neches and Angelina Rivers, were deferred on the basis of economic studies until justified by future conditions. In July, 1967, "Dam B" was renamed Town Bluff Dam and B.A. Steinhagen Lake. The dam and lake projects of the Neches River basin are listed in Table 3-2.

TABLE 3-2

Neches-Angelina River Basin Projects

Project	Stream	Year of Completion / Status
Sam Rayburn Dam (McGee Bend Dam)	Angelina River	1965
Dam A	Neches River	Deauthorized (November 1988)
Rockland Dam	Neches River	Deauthorized (November 1988)
Town Bluff Dam (Dam B)	Neches River	1951

3-05. Modification to Regulations. There have been three modifications to the regulations since the construction of Town Bluff Dam.

The River and Harbor Act of 1948 (Public Law 858, Eightieth Congress, 2nd Session) modified the existing project as follows:

“Sec. 104. That the existing project for the Neches and Angelina Rivers, Texas, adopted in the River and Harbor Act approved March 2, 1945, is hereby modified so as to provide that the local agency which gives assurances that upon completion of the entire project it will contribute toward the first cost of the work the sum of \$5,000,000 shall be permitted to withdraw from the pool of Dam B not to exceed two thousand cubic feet of water per second for its own use.”

The Robert D. Willis Hydropower Project was added to Town Bluff Project as an authorized project purpose. The powerhouse was constructed in 1988 and became available for commercial operation on 17 November 1989. After the construction of powerhouse, flood releases up to about 3,000 cfs were released through the turbines instead of the flood gates to maximize the generation of power.

Due to construction of the Permanent Salt Water Barrier, releases no longer are necessary to prevent saltwater intrusion into the city of Beaumont and LNVA water intake structures for water supply except for times of high tide caused by storms such as hurricanes or tropical storm events.

3-06. Principal Regulation Problems. The pool elevation has been lowered from 83.0 to 82.5 feet during the summer and 81.5 feet in the winter to prevent erosion of the embankment from wave run-up. The wave run-up on the embankment slope was washing out embankment material from under the concrete pavement and creating voids in the embankment. Due to the existence

of these voids within the embankment, the dam has been classified with a rating of Dam Safety Action Class (DSAC) II (Urgent). For further details of the timeline of the pool elevation restrictions, refer to Chapter 7-14 Other.

Based on historical records, the low flow outlets have not been operable since early 1960s.

The regulation of the storage for B.A. Steinhagen Lake requires that the tailwater elevation must be built up sufficiently to assure a minimum of head differential during the floods. As a result, the turbines cannot be operated under high tailwater elevation conditions. Refer to Chapter 7-02.a.(4) for further detailed information.

CHAPTER IV – WATERSHED CHARACTERISTICS

4-01. General Characteristics. The Neches River originates in Van Zandt County approximately 60 miles southeast of Dallas, Texas, and flows in a southeasterly direction for approximately 416 miles to empty into Sabine Lake, 20 miles southeast of Beaumont, Texas. The watershed lies in the southeastern portion of Texas, between north latitude 29° 59' and 32° 33' and west longitude 93° 51' and 95° 56'. The watershed of the Neches River has a total drainage area of 10,011 square miles. The main river system has two principal branches above the junction with the Angelina River: the Neches River, with a length of about 290 miles, and the Angelina River, with a length of about 205 miles. The slope of the Neches River in the vicinity of Town Bluff Dam is about 0.7 feet per mile. The Angelina River runs southeast to the Neches River, entering at river mile 126.4. Above their confluence, the Neches River has a drainage area of 4,017 square miles, and the Angelina River has a drainage area of 3,556 square miles (Angelina River at mouth). The drainage area between the confluence of the two rivers and the mouth is approximately 2,438 square miles. The watershed and the location of the dam are shown on Plate 4-1. .

The Neches River has been improved for navigation as far upstream as the city of Beaumont. The basin is crossed by a network of highways and railroads. Numerous oil and gas fields are located within the basin and oil refineries are found near the fields. There is a concentration of refineries and associated petroleum industries at Beaumont and Port Arthur and along the waterway between those cities. Agriculture is of primary importance in the basin with over one-third of the area in farm land. The Angelina National Forest lies within the basin as do portions of the Sabine and Davy Crockett National Forests. Over one-half of the watershed area is classified as timber land. Commercial timber is produced in large quantities with lumber mills and wood product manufacturing plants located throughout the basin. The population of the basin was approximately 870,000 in 2010.

4-02. Topography. The Neches River and its principal tributary, the Angelina River, rise in a region of rolling hills and flow through an area of moderately to extremely hilly relief to the vicinity of Jasper and Woodville where the rolling terrain abruptly changes to the flat coastal prairie. About one-half of the watershed area is classified as timber land and one-third is agricultural land. The remaining area is a combination of residential, industrial, and transportation land. Plate 4-2 and Plate 4-3 present the natural profiles of Neches River and the Angelina River, respectively.

4-03. Geology and Soils. B.A. Steinhagen Lake is on a roughly 10-mile wide strip of Holocene Alluvium soil that flanks the Neches River. This alluvial band crosses perpendicular bands of the Quaternary Lissie formation, the Miocene Fleming/Oakville formations, and the Pliocene Willis formation.

Soils at Town Bluff Dam have a well-developed, moderately deep profile. The origin of these soils is both alluvial (sandy to fine loam) and marine (silty clay to blackland clay). Major soil

associations include the Bienville-Cart-Wrightsville (loamy fine sand-fine sandy loam), the Gardner-Susquehanna (fine sandy loam on a firm plastic clayey B horizon), and the Urbo-Mantachie (loamy clay loam). Major limitations include low permeability, high water table, frequent flooding, and high erodibility.

4-04. Sediment. A system of 14 sedimentation ranges and 6 degradation ranges was established, surveyed, and monumented on the reservoir area and below the dam during the design of the dam. This methodology was similarly used for the 1947, 1951, and the 1960 surveys. A schedule prepared in the Office of the Division Engineer, Southwestern Division indicates that resurveys were planned for about 5-year intervals. However, currently sediment surveys are done periodically depending on need and available funding. The locations of the ranges are shown on Plate 4-4.

In 1991, the Texas Legislature authorized the Texas Water Development Board (TWDB) to develop a non-profit, self-supporting, reservoir volumetric survey program, which is named the Hydrographic Survey Program. The program includes a standard volumetric survey and a sedimentation survey. Since 1992, TWDB's Hydrographic Survey Program has completed 161 hydrographic surveys on 106 unique reservoirs. This includes 85 of the 114 water supply reservoirs monitored for inclusion in TWDB's monthly Water Conditions Report. The TWDB web site is: (<http://www.twdb.texas.gov/surfacewater/surveys/index.asp>).

The TWDB performed a standard volumetric survey for B.A. Steinhagen Lake in 2003. Results from the survey indicate B.A. Steinhagen Lake encompasses 10,687 surface acres and contains a total volume of 66,972 ac-ft at conservation pool elevation 83.0 feet.

Original design information was based on a 1947 USACE survey. Records indicate that B.A. Steinhagen Lake had a total surface area of 13,700 acres and a volume of 94,200 ac-ft of water at the top of conservation pool elevation 83.0 feet. In 1951 the USACE determined the area and volume totals at 83.0 feet to be larger, the surface area increased to 13,842 acres and the volume increased to 100,595 ac-ft. This is probably due to use of an improved calculation methodology.

In 1960 the USACE performed a resurvey of B.A. Steinhagen Lake. The results of that survey show that the surface area had reduced to 13,712 acres but the volume had again increased, to 101,814 ac-ft of water at top of conservation pool elevation. The 2003 TWDB survey results indicate that the total volume at the conservation pool elevation is 66,972 ac-ft of water. The inactive pool or dead pool storage, below elevation 50.0 feet, contains 6 ac-ft of water and thus the conservation storage or capacity found in this survey is 66,966 ac-ft. B.A. Steinhagen Lake lost 34,842 ac-ft of water or 34 percent in conservation storage compared to the 1960 USACE resurvey. The difference in storage indicated the sediment fill during the fiscal years from 1960 to 2003. Comparisons between the historical USACE 1947 original design, the 1951 adjusted, the 1960 resurvey and the 2003 TWDB volumetric survey are presented in Table 4-1

TABLE 4-1**Area and Capacity Comparisons of B.A. Steinhagen Lake**

Feature	USACE Original Design	USACE Survey	USACE Survey	TWDB Latest Survey
Year	1947	1951	1960	2003
Surface Area at Conservation Pool Elevation 83.0 feet NGVD29 (acres)	13,700	13,842	13,712	10,687
Volume at Conservation Pool Elevation 83.0 feet NGVD29 (acre-feet)	94,200	100,595	101,814	66,972
Inactive Storage below Elevation 50.0 feet NGVD29 (acre-feet)	0	190	198	6
Conservation Capacity Elevation 50.0 - 83.0 feet NGVD29 (acre-feet)	94,200	100,405	101,616	66,966
Sediment Reserve in Conservation Storage Space (acre-feet)	16,600	16,600		
Usable Conservation Capacity (acre-feet) at 83.0 feet NGVD 29	77,600	83,805		

NOTE: Data is obtained from "Volumetric Survey Report of B.A. Steinhagen Lake, TWDB 2004."

4-05. Climate. The Neches River Watershed is in the southeastern part of the state of Texas. The climate over the entire basin is generally mild, and temperatures are moderate. Freezing temperatures and snowfall are rare in the coastal section of the basin but occur occasionally in the northern part of the watershed.

a. Temperature. The mean annual temperature over the basin is about 67 degrees Fahrenheit. January, the coldest month, has an average minimum daily temperature of about 38 degrees, August, the warmest month, has an average maximum daily temperature of about 93 degrees. Temperatures in the watershed have ranged from a maximum of 112 degrees recorded

at San Augustine to a minimum of minus 8 degrees recorded at Tyler. The average length of the growing season between killing frosts is about 250 days. Table 4-2 gives temperature data for several National Weather Service (NWS) stations in or near the Neches River Basin.

TABLE 4-2
Temperatures in/near the Neches River Basin

Station	Period of Record	Temperatures (°F)				
		Mean Annual	Average January Minimum	Average August Maximum	Minimum Recorded	Maximum Recorded
Town Bluff Dam	1970-2013	66.6	38.2	92.9	6	109
Sam Rayburn Dam	1968-2013	65.9	37.0	93.6	9	109
Jasper	1954-1972, 1981-2010**	66.2	37.1	93.0	6	105
Lufkin	1949-2013	66.9	38.3	94.1	-2	112
San Augustine	1981-2013	65.8	35.9	93.7	17	112
Nacogdoches	1949-2013	65.8	36.2	95.1	3	112
Tyler	1984-2013	66.6	37.5	94.6	-8*	108

NOTES: 1. Minimum, maximum, and averages are for the period of record shown.
 2. *The data is from “Reservoir Regulation Manual for Dam B Reservoir, Neches River, Texas, Corps of Engineers, U.S. Army, March 1956.”
 3. **Period of available NOAA data ends in 2010.

b. Precipitation. The normal annual precipitation over the Town Bluff Dam drainage area varies from 45.25 inches at Lufkin, near the center, to 56.69 inches at Jasper, in the southern portion of the drainage area. The monthly distribution of the average annual precipitation at the six NWS stations in the watershed area is shown in Table 4-3.

TABLE 4-3**Average Monthly and Annual Rainfall in/near the Neches River Basin**

Month	Precipitation (Inches)					
	Town Bluff Dam	Jasper	Woodville	Lufkin	Nacogdoches	San Augustine
	1970-2010	1952-2010	1981-2010	1949-2010	1974-2010	1981-2010
January	4.73	4.27	4.72	4.13	4.39	4.47
February	4.25	4.54	4.32	3.52	4.32	4.96
March	4.24	4.09	4.65	3.57	4.13	4.50
April	4.20	4.13	3.65	3.58	3.64	3.69
May	5.13	4.92	4.23	4.68	4.55	5.25
June	5.60	5.01	6.33	4.06	4.25	5.32
July	3.65	4.00	3.85	2.88	3.05	3.39
August	3.52	3.77	4.40	2.92	3.00	3.59
September	4.31	4.38	4.30	3.73	3.86	4.07
October	4.62	3.57	4.95	3.81	4.22	4.87
November	5.20	5.04	5.93	4.20	4.52	5.02
December	5.43	5.27	5.36	4.29	4.40	5.44
Total	54.88	52.99	56.69	45.37	48.33	54.57
Precipitation	32.29	32.08	39.90	26.49	22.27	34.55
Minimum Yearly	(2011)	(1962)	(2010)	(1963)	(2010)	(2005)
Precipitation	83.01	79.06	76.52	79.04	71.36	70.01
Maximum Yearly	(2004)	(1991)	(2004)	(2004)	(1979)	(2004)

NOTES: 1. The total annual precipitation is computed by summation of the monthly averages.

2. Data reflect "Climatological Data" from the NWS. *Data as of 2014.

c. Snowfall. Minor accumulations of snowfall occur periodically during the winter months, however, snowfall does not contribute significantly to area precipitation or runoff.

d. Evaporation. A NWS “Class A” evaporation pan has been established at Town Bluff Dam and records are available from July 1953 to present. From measurements collected between February 1954 and December 2013, the estimated average annual evaporation from the lake is about 44 inches. The average monthly and annual evaporation from B.A. Steinhagen Lake are given in Table 4-4A. The highest recorded annual evaporation was 74.93 inches in 2011, while the lowest was 50.25 in 1994. The highest evaporation during a single month was 10.97 inches in August 2011. The four foot diameter by 16 inch deep pan heats up much faster than the lake, thus the difference.

A longer period of record, however, is desirable for estimating average evaporation rates. The State of Texas maintained a Bureau of Plant Industry sunken-type evaporation station at the Agricultural Experiment Station at Nacogdoches, Texas, about 65 miles north of Town Bluff Dam. Table 4-4B lists the average monthly and average annual evaporation derived from 1915 through 1947.

The TWDB has collected lake evaporation data from 1954 through 2013 from the National Oceanic and Atmospheric Administration (NOAA) and the National Climatic Data Center (NCDC). The average monthly and annual evaporation from TWDB data are given in Table 4-4C. The evaporation rates for the Neches River Watershed are computed using the pan coefficients in the ThEvap program for quadrangle 713.

Figures 4-1 through 4-2 show the evaporation pan at B.A. Steinhagen Lake.



Figure 4-1. Evaporation Pan and Rain Gauge



Figure 4-2. Evaporation Pan

TABLE 4-4A

B.A. Steinhagen Lake Average Monthly and Annual Evaporation (Jul 1953 - Dec 2015)

Month	Reservoir Evaporation (Inches)		
	Measured Pan Evaporation	Monthly Pan Coefficient	Calculated Reservoir Evaporation
January	2.33	0.75	1.75
February	2.89	0.73	2.11
March	4.46	0.73	3.26
April	5.53	0.72	3.98
May	6.79	0.67	4.55
June	7.37	0.72	5.31
July	7.76	0.73	5.66
August	7.42	0.73	5.42
September	5.66	0.75	4.24
October	4.51	0.78	3.52
November	2.86	0.79	2.26
<u>December</u>	<u>2.25</u>	<u>0.78</u>	<u>1.76</u>
Annual	59.83	0.74	43.82

NOTES: Reservoir evaporation is calculated using the measured pan evaporation multiplied by the monthly pan coefficient given in Texas Department Water Resources Report 64 for a NWS Class A Pan.

TABLE 4-4B

The State of Texas - Bureau of Plant Industry, Nacogdoches, Texas

Average Monthly Evaporation Data, 1915-1947

Pan coefficient = 0.94			
Month	Observed pan evaporation (inches)	Evaporation from reservoir surface (inches)	Observed precipitation (inches)
January	1.56	1.47	4.67
February	2.06	1.94	3.88
March	3.10	2.91	4.30
April	3.89	3.66	4.80
May	4.68	4.40	5.51
June	5.48	5.15	3.70
July	5.83	5.48	3.98
August	5.82	5.47	2.86
September	4.62	4.34	2.71
October	3.67	3.45	3.05
November	2.27	2.13	4.73
<u>December</u>	<u>1.68</u>	<u>1.58</u>	<u>5.13</u>
Annual	44.66	41.98	49.32

NOTE: Corresponding to period for which evaporation records are available.

TABLE 4-4C

TWDB Average Monthly and Annual Evaporation B.A. Steinhagen Lake, 1954-2015

Month	Quadrangular pan Evaporation rate (inches)	Monthly Pan Coefficients for quadrangle 713 of ThEvap Program
January	1.79	0.75
February	2.13	0.73
March	3.29	0.73
April	4.03	0.72
May	4.63	0.67
June	5.39	0.72
July	5.70	0.73
August	5.46	0.73
September	4.40	0.75
October	3.77	0.78
November	2.50	0.79
<u>December</u>	<u>1.89</u>	<u>0.78</u>
Annual	44.98	0.74

e. Wind. The prevailing winds over the watershed are from the south. However, during the winter months, the influence of high-pressure systems moving from the northwest causes the wind to shift from the north. Severe winds have been experienced near B.A. Steinhagen Lake. The fastest recorded peak gust velocity at the NWS station at Port Arthur, Texas, approximately 61 miles south of the dam site, was 116 miles per hour, reached during Hurricane Rita in September 2005.² (Data provided by NOAA NCDC for the period 1950-2015).

From the "B.A. Steinhagen Lake, Neches River Basin, Spillway Design Flood Study, Hydrology, August 1980" report, the design wind speed is 45 mph, the fetch for wind setup is 7.4 miles and the computed required freeboard is 6.2 feet. This freeboard was computed for a Probable Maximum Flood (PMF) elevation of 93.31 feet. For this PMF elevation, the provided freeboard is inadequate. The average annual wind movement over B.A. Steinhagen Lake is about 87,600 miles, which is an average wind speed of approximately 10 miles per hour.

4-06. Storms and Floods. The Neches River Watershed is subject to three general types of flood-producing rainfall: thunderstorms, frontal rainfall, and tropical cyclones. Generally, the highest 24-hour and monthly precipitation periods have occurred during tropical cyclones.

² www.nws.noaa.gov/om/data/pdfs/Rita.pdf

However, there are some instances of heavy precipitation resulting from local thunder storms. The maximum 24-hour rainfall reported in or adjacent to the basin was 17.76 inches, which occurred at Port Arthur (just outside the basin) on 28 July 1943. The maximum monthly rainfall reported was 26.79 inches, which occurred at San Augustine in August 1915. The major storms experienced over the watershed for which rainfall data are available, together with the average rainfall depths produced on the watershed above the dam, are listed in Table 4-5.

Table 4-6 lists the pertinent data for major lakes and dams and gages in the Neches River basin. Table 4-7 gives stages and discharges for top 14 major floods recorded at gages on the Neches River.

TABLE 4-5

Major Storms on the Neches River Basin, 1908-2013

Storm Date	Precipitation in Inches				
	Town Bluff Dam Gage	Jasper Gage	Woodville Gage	Lufkin Gage	Rockland Gage
1908, May 12-18	—	—	—	5.6	—
1914, April 24-28	—	—	—	4.8	—
1929, May 24-31	—	—	—	—	11.1
1932, Feb 16-21	—	—	—	7.0	—
1935, May 16-20	—	—	—	7.4	—
1940, Nov 21-26	—	—	—	16.6	—
1944, April 29-May 4	—	—	—	10.6	—
1953, Apr 28-May 5	11.5	11.3	—	—	8.9
1953, May 11-19	—	9.7	—	6.7	12.6
1973, June 10-17	6.6	9.4	—	8.7	—
1974, Jan 22-29	9.2	—	—	8.6	—
1979, Sep 13-20	7.5	7.3	—	5.2	—
1981, May 31-Jun 6	10.5	12.0	—	2.6	—
1989, Jun 24-July 2	14.7	15.5	13.7	9.3	—
1994, Oct 15-22	9.2	8.9	—	14.3	—
1996, Sep 25-27	9.2	8.9	13.6	2.5	—
1998, Sep 11-17	9.7	12.6	10.7	5.0	—
2001, Jun 1-7	9.3	8.0	10.2	10.2	—
2001, Aug 28-Sep 5	8.1	7.1	7.6	4.5	—
2004, Nov 18-24	4.9	7.9	11.4	11.8	—
2005, Sep 24	—	7.6	—	5.3	—
2006, Oct 6-19	12.6	14.9	14.6	6.0	—
2013, Oct 13-14	10.7	10.2	8.0	8.0	—

NOTE: The rainfall data were tabulated from published precipitation records from the NWS.

TABLE 4-6**Pertinent Data for Major Lakes and Dams and Gages in the Neches River Basin**

Station	Stream	Period of Record	Miles Above Mouth	Datum (ft)	Drainage Area (Sq. Mi.)	Maximum Floods of Record		
						Date	Gage Height (ft)	Peak Discharge (cfs)
near Rockland	Angelina River	1884-2015	32.4	88.41	3,636	May 1884	—	61,300
						6 May 1944	35.04	49,800
						22 May 1953	27.70	34,400
near Town Bluff	Neches River	1884-2015	113.7	—	7,573	May 1884	—	120,000
						May-Jun 1944	—	99,700
						22 May 1953	82.85	90,900
near Evadale	Neches River	1884-2015	55.6	8.25	7,951	May 1884	26.20	125,000
						11 May 1944	23.58	92,100
						22 May 1953	22.53	80,300
						Maximum Lake Elevation		
						Date	Elev.(ft)	Volume (ac-ft)
Sam Rayburn Reservoir	Angelina River	1965 - 2015	25.2	—	3,449	9 May 1992	174.95	4,283,000
B.A. Steinhagen Lake	Neches River	1884 - 2015	113.7	—	7,573	22 May 1953	85.21	128,400

NOTE: The information is derived from the United States Geological Survey (USGS) Annual Water-Data Reports.

TABLE 4-7**Top 14 Recorded Major Floods on the Neches River Watershed, 1884-2013**

Date	Neches River near Rockland		Neches River near Town Bluff		Neches River near Evadale	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1884, May	34.90	62,000	86.80	120,000	26.20	125,000
1915, Aug 16-21	21.40	13,300	—	—	24.50	102,000
1922, Apr 2-6	28.90	45,200	—	—	21.80	71,500
1929, Jun 1	26.80	31,200	—	—	22.20	83,800
1932, Feb 24-29	26.70	33,600	—	—	21.45	73,400
1935, May 22-27	28.90	39,700	—	—	20.60	64,100
1940, Nov 30-Dec 5	25.50	25,900	—	—	20.78	59,600
1944, May 6-11	31.84	49,800	—	—	23.58	92,100
1953, May 21-24	27.70	34,400	82.85	90,900	22.53	80,300
1969, May 10-16	27.64	34,000	75.52	30,500	18.56	31,300
1989, July 2-6	33.20	42,000	78.49	49,200	20.79	47,900
1994, Oct 20-25	33.29	42,300	76.17	35,400	19.33	41,400
2012, Mar 15-23	25.53	18,600	67.64	19,500	17.31	25,700
2013, May 12-Jun 7	8.70	3,470	—	—	10.96	6,400

NOTES: 1. Data retrieved from USGS Peak Streamflow for Texas database.

2. The Top 14 floods were generally basin wide flood events at most of the gages, however certain gages may not have experienced a Top 14 Flood during the same event. For more details on all major floods refer to Table 4-8 (pg. 4.8-1).

3. The deliberate impoundment of B.A. Steinhagen Lake began 16 April 1951. The deliberate impoundment of Sam Rayburn Reservoir began 1 May 1968.

4. *The information for Neches River near Rockland and for Neches River near Evadale for period 1884 to 1953 is obtained from “Reservoir Regulation Manual for Dam B Reservoir, March 1956”. The information for Neches River near Rockland and for Neches River near Evadale for period 1969 to 2013 is derived USGS database.

Historical descriptions of the major floods that have been experienced in the Neches River watershed are as follows:

a. Storm of May 1884. The flood of May 1884 produced the highest known stages in the Neches River near Diboll, which is near Rockland, at Evadale, and on the Angelina River near Lufkin. The stages for the flood of May 1884 have been established from identified flood marks. However, no information is available concerning the May 1884 flood stages on the Neches River above Diboll or below Evadale. A comparison of the May 1884 stages with the stages of the other major floods indicates that the flood of May 1884 was probably the greatest flood that has occurred in the Neches River from city of Reese to the mouth of the river. The peak discharge for this flood is estimated to be 62,000 cfs near Rockland, 125,000 cfs at Evadale, and 130,000 cfs near Lufkin on the Angelina River.

b. Storm of August 1915. This flood resulted from the storm of 16-21 August 1915. The storm was centered at San Augustine, where the total depth of rainfall was 19.8 inches for a 4-day period. The flood of August 1915 produced the highest known stages at Horger, on the Angelina River, and near Kountze, on Village Creek, and produced near-maximum stages in the Neches River below the mouth of the Angelina River. This flood reached a stage of 39.50 feet on the Horger gage. The USGS has estimated the peak discharge for this flood at Horger to be 82,000 cfs. The maximum average daily stage and discharge for this flood at the Rockland gaging station was 21.40 feet and 13,300 cfs, respectively. Flood marks indicate that the August 1915 flood stage at Evadale was about 1.70 feet lower than the May 1884 flood at this point. The highest stage of record at Beaumont resulting from the August 1915 flood was 14.0 feet.

c. Storm of March-April 1922. The 25 March to 04 April 1922 storm produced an average depth of rainfall over the Neches River Basin at about 8.60 inches. The storm had a center of 11.35 inches at Rockland. The flood produced by this storm reached stages of 28.90 feet near Rockland and 11.20 feet at Beaumont. The peak discharge for this flood near Rockland was 45,200 cfs. No information is available concerning the peak stages and discharges of this flood on the Angelina River.

d. Storm of May-June 1929. The storm of 24-31 May 1929 had a depth of 12.87 inches at Rockland and depths exceeding 5 inches throughout the major portion of the basin. The maximum station rainfall recorded for a 1-day period for the storm was 11.05 inches at Rockland. The flood produced by this storm reached stages of 26.80 feet near Rockland, 22.20 feet at Evadale, 13.40 feet at Beaumont on the Neches River and 34.50 feet at Horger on the Angelina River. The peak discharges for this flood at Horger, Rockland, and Evadale were 33,300, 31,200, and 83,800 cfs, respectively.

e. Storm of January-March 1932. General rains occurred over the Neches River Basin during January and February 1932. The principal storm period was 13-23 February 1932. The rainfall for this period exceeded 5 inches over the major portion of the basin and had a center of 9.26 inches at Nacogdoches. The flood resulting from this storm reached stages of 26.70 feet near Rockland, 21.45 feet at Evadale, 9.00 feet at Beaumont on the Neches River, and 36.35 feet

at Horger on the Angelina River. The peak discharges for this flood at Horger, Rockland, and Evadale were 48,800, 33,600, and 73,400 cfs, respectively.

f. Storm of May-June 1935. Rainfall was frequent and general over the entire Neches River Basin during May 1935. The principal storm periods were 2-6 May and 15-20 May 1935. The average depth of rainfall over the greater part of the watershed was about 5 inches for the first storm period and more than 4 inches for the second storm period. These storms produced a flood that reached stages of 28.90 feet near Rockland, 20.60 feet at Evadale, 7.70 feet at Beaumont on the Neches River, and 33.10 feet at Horger on the Angelina River. The peak discharges for this flood at Horger, Rockland, and Evadale were 29,100, 39,700, and 64,100 cfs, respectively.

g. Storm of November-December 1940. Heavy rains occurred over the Neches River Basin during the period 21-26 November 1940. The storm had centers at Lufkin and Appleby, where 16.60 and 17.50 inches, respectively, were recorded. The flood produced by this storm reached stages of 25.50 feet near Rockland, 20.78 feet at Evadale, 8.80 feet at Beaumont on the Neches River and 34.50 feet at Horger on the Angelina River. The peak discharges at Horger, Rockland, and Evadale were 36,200, 25,900, and 59,600 cfs, respectively.

h. Storm of May-June 1944. From 29 April to 5 May 1944, heavy rains occurred over the Neches River Basin, with 16.00, 15.91, and 12.00 inches at Pollok, Jackson Hill, and Flint, respectively. The flood of May-June 1944 was the maximum of record near Rockland and at Evadale on the Neches River and at Horger on the Angelina River. This flood reached stages of 31.84 feet near Rockland, 23.58 feet at Evadale, 8.20 feet at Beaumont on the Neches River and 36.90 feet at Horger on the Angelina River. The peak discharges of this flood at Horger, Rockland, and Evadale were 49,900, 49,800, and 92,100 cfs, respectively.

i. Storm of April-May 1953. General rains occurred over the Neches River Basin during April and May 1953. The principal storm periods were 28 April to 5 May and 11-19 May. The rainfall for the storm period of 28 April to 5 May ranged from about 1 to 11.50 inches on the Neches River Basin, with the heaviest rainfall of 11.50 inches occurring at Horger and Spurger Dam B. The rainfall for the storm period of 11-19 May ranged from about 3.00 to 12.80 inches, with the heaviest rainfall of 12.80 inches occurring at Horger. The maximum stages produced by these storms were 36.20 feet at Horger, 27.70 feet at Rockland, 82.85 feet at Town Bluff, and 22.53 feet at Evadale. The peak discharges for this flood at Horger, Rockland, Town Bluff and Evadale were 46,000, 34,400, 90,900, and 80,300 cfs, respectively.

j. Storm of May 1969. The flood event occurred during the period of 10-16 May 1969. The maximum stages produced by these storms were 27.64 feet at Rockland, 75.52 feet at Town Bluff, and 18.56 feet at Evadale. The peak discharges for this flood at Rockland, Town Bluff, and Evadale were 34,000, 30,500, and 31,300 cfs, respectively.

k. Storm of July 1989. The flood event occurred during the period of 02-06 July 1989. The maximum stages produced by these storms were at 33.20 feet at Rockland,

78.49 feet Town Bluff, and 20.79 feet at Evadale. The peak discharges for this flood at Rockland, Town Bluff, and Evadale were 42,000, 49,200, and 47,900 cfs, respectively.

l. Storm of October 1994. The flood event occurred during the period of 23-25 October 1994. The maximum stages produced by these storms were 33.29 feet at Rockland, 76.17 feet at Town Bluff, and 19.33 feet at Evadale. The peak discharges for this flood at Rockland, Town Bluff, and Evadale were 42,300, 35,400, and 41,400 cfs, respectively.

m. Storm of March 2012. The flood event occurred during the period of 21-23 March 2012. The maximum stages produced by these storms were 25.53 feet at Rockland, 67.64 feet at Town Bluff, and 17.31 feet at Evadale. The peak discharges for this flood at Rockland, Town Bluff, and Evadale were 18,600, 19,500, and 25,700 cfs, respectively.

n. Storm of May-June 2013. The flood event occurred during the period of 12 May - 7 June 2013. The maximum stages produced by these storms were 8.70 feet at Rockland and 10.96 feet at Evadale. The peak discharges for this flood at Rockland and Evadale were 3,470, and 6,400 cfs, respectively.

The USGS historical information of all Major Floods is listed in Supplementary Table 4-8 (pg. T4.8-1). The data shown in the table covers the period 1884 to 2013.

Figures 4-9 through 4-14 are scenes of 2008 and 2013 floods at B.A. Steinhagen Lake.



Figure 4-9. 2008 Flood - High Water Level



Figure 4-10. 2008 Flood - Lake Elevation near Gated Spillway



Figure 4-11. 2013 Flood - Downstream of Gated Spillway



Figure 4-12. 2013 Flood - Upstream of Gated Spillway



Figure 4-13. 2013 Flood - Upstream of Powerhouse



Figure 4-14. 2013 Flood - Powerhouse Discharge Channel

4-07. Runoff Characteristics. The period of most frequent flooding in the Neches River Basin occurs from November to June. However, floods may occur at almost any time of year. The

large natural storage basins provided by the wide, shallow valley with gentle slopes retard the runoff and tend to regulate the flow. Except in the headwater region and in the small tributaries, rapid variation in runoff in the basin is unusual. Because of the slow rate of runoff and the small conveyance capacity of the natural channel, it is not unusual for floods to prevail above bankfull stages for several weeks. For example, the flow of the Neches River exceeded the bankfull capacity at Evadale (20,000 cfs) during the floods of November–December 1940, May–June 1944, January 1945, March 1945, May 1953, February–April 1992, December 1994–April 1995, March–April 2001, February–March 2005 for periods ranging from 4 to 8 weeks.

The computed monthly and annual inflow volumes, based on change in lake storage, are shown in Table 4-9 (pg. T4.9-1). The monthly inflow volume exceedence frequency curves, based on data from 1952 to 2015 are shown on Plates 4-4 through 4-15. Table 4-10 shows the monthly inflow volume frequency for the 5-, 10-, 25-, and 50-year events.

TABLE 4-10

B.A. Steinhagen Lake Monthly Inflow Volume Frequency

MONTH	Inflow Volume in Acre-Feet Frequency of Occurrence in Years			
	5	10	25	50
January	708,323	836,695	1,159,858	1,228,103
February	731,744	1,000,103	1,116,148	1,143,915
March	976,839	1,094,655	1,212,850	1,645,469
April	790,036	1,024,825	1,176,263	1,199,450
May	757,937	1,015,933	1,134,307	1,440,217
June	638,693	965,656	1,041,798	1,044,581
July	443,357	713,555	759,701	1,320,729
August	221,516	361,886	525,818	724,264
September	210,428	262,631	337,775	364,976
October	194,200	255,044	500,483	785,238
November	258,321	463,527	653,004	723,050
December	500,622	586,980	854,636	1,143,443

NOTE: Based on computed inflows for period January 1965 to December 2013.

4-08. Water Quality. Texas Commission on Environmental Quality (TCEQ) publishes the assessment reports for the quality of surface waters for Neches River Basin. The available data indicate that there are no water quality concerns in B.A. Steinhagen Lake. The fish consumption use is not supported because of a restricted-consumption advisory issued in January 2014 by the

Texas Department of State Health Services due to elevated levels of mercury and dioxins in fish tissue. The United States Environmental Protection Agency (EPA) also released the water body reports and water quality assessment for B.A. Steinhagen Lake for period 1994 to 2010. The designated uses of the lake that were assessed were general use to be “good” and fish consumption use to be “impaired” in the reports. Fecal coliform levels spike during the summer, but still remain below the maximum allowed 200 colony count per 100 ml. The summer spike is probably due to an increase in wildlife activity that takes place around the lake during the summer months. *E. coli* bacteria levels have only been elevated three times since 2002 and the contact recreation is fully supported in B.A. Steinhagen Lake.

The USGS sampled four sites for B.A. Steinhagen Lake on six different occasions in 1981-1982 (13 January 1981, 20 May 1981, 18 August 1981, 26 January 1982, 2 June 1982, and 31 August 1982) for various biological and chemical parameters. The mean concentrations of the various parameters are shown in Table 4-11A. The sampling results indicate that the levels of the various biological and chemical constituents monitored are generally within the criteria set by the TCEQ. Samples taken during the summer months, when the lake becomes thermally stratified, were found to have levels of some parameters that were outside the standards.

In 2012, the TCEQ prepared an integrated report for the Neches River Basin (Basin 6), which included measurements and classifications of various water quality parameters in the basin. The TCEQ assigns designations to water bodies in Texas based on the body’s ability to support its designated uses. For the B.A. Steinhagen Lake, all measured parameters were assigned designations of “Fully Supporting” or “No Concern”. The results of this report are reproduced in Table 4-11B.

TABLE 4-11A**USGS Water Quality Sampling, 1981-1982**

Major Constituents	Mean Concentrations (1)			
	Station AC	Station BC	Station CC	Station DC
Dissolved Oxygen @ 1.0 ft depth	7.9	7.4	7.2	6.6
Dissolved Oxygen @ 10.0 ft depth	7.7	7.6	7.7	6.2
Specific Conductance, mho/cm	159.3	176.5	160.0	214.7
Total Dissolved Solids	97.8	106.3	—	129.0
pH (Standard Units)	7.0	6.7	6.6	6.6
Temperature, F	72.8	71.0	70.1	72.1
Alkalinity (mg/L as CaCO ₃)	18.7	17.3	—	27.2
Hardness, non-carbonate (mg/L as CaCO ₃)	11.3	15.2	—	13.7
Transparency (M)	0.5	0.6	0.9	0.4
Ammonia Nitrogen (mg/L as N)	0.8	0.8	0.7	1.0
Nitrate + Nitrite Nitrogen (NO ₂ + NO ₃) (mg/L as N)	0.1	0.1	0.1	0.2
Sodium (dissolved) mgL as Na	18.8	20.7	—	24.3
Potassium (dissolved) K	2.8	2.9	—	3.5
Chloride (CL)	23.0	25.2	—	31.2
Sulfate (SO ₄)	21.3	24.3	—	23.7
Calcium (Ca)	6.6	7.3	—	10.0
Magnesium (Mg)	3.3	3.6	—	23.0
Silica (SiO ₂)	11.8	12.5	—	15.8
Fluoride (F)	0.1	—	—	—
Manganese (Mn)	0.0	0.1	0.1	0.1
Fecal coliform	(colony count/100 mL)			
Winter	2.0	5.0	—	16.5
Spring	6.0	17.0	—	46.0
Summer	10.0	142.3	—	71.7

(1) Measurements are in mg/L unless otherwise stated. Mean are taken at a 1.0-foot depth unless otherwise stated.

NOTE: The water quality sampling for all parameters was conducted on the following dates: Winter: 13 Jan 1981; Spring: 20 May 1981; and Summer: 2 June 1981 and 31 August 1981.

TABLE 4-11B**TCEQ Integrated Assessment Report General Use and Aquatic Life Basin 6, 2012**

Major Constituents	Mean Concentration	LOS
Dissolved Oxygen Screening Level	4.9	NC
E. coli	9.9	FS
Total Dissolved Solids	113.3	FS
pH (Standard Units)	M	FS
Temperature, F	M	FS
Ammonia Nitrogen (mg/l as N)	M	NC
Nitrate (NO ₄)	0.1	NC
Chloride (CL)	16.2	FS
Sulfate (SO ₄)	19.5	FS
Fluoride (F)	0.1	FS
Orthophosphorus	0.12	NC
Phosphorus	0.36	NC

M: Meets TCEQ criteria

LOS: Level of Support

NC: No Concern

FS: Fully Supporting Designated Use

4-10. Channel and Floodway Characteristics. The channel capacity of the Neches River from Town Bluff Dam to the mouth of the river is 20,000 cfs. However, in the vicinity of Beaumont, discharges of 40,000 cfs or less cause only minor damage. At Evadale, directly downstream from Town Bluff Dam, a minor flood stage will inflict minimal damages, with some residential flooding at river flows above 20,000 cfs.

The estimated travel time for flood flows from Town Bluff Dam (river mile 113.7) to the gage at Evadale (river mile 54.6) is about 3 days and from Evadale to the gage at Salt Water Barrier is about 2 days. The existing channel capacities along the Neches River are given in Table 4-12.

The locations of the USGS stream gages in the Neches River Basin are shown on Plate 5-1. Discharge rating curves for the key control points are shown on Plates 4-17 to 4-19. These curves are only valid for rough use. The rating curves used by the Water Resources Branch are adjusted by the USGS for changing conditions and reflect the current stage-flow relationships at the gages.

TABLE 4-12

Channel Capacities on the Neches River

Reach	Channel Capacity (cfs)
Neches River from Town Bluff Dam to mouth	20,000
In the vicinity of Beaumont	40,000

Table 4-13 and Plate 4-19 show flood peak travel times between upstream gages and Town Bluff Dam and between Town Bluff Dam and the gage at Salt Water Barrier.

TABLE 4-13

**Flood Peak Travel Times between B.A. Steinhagen Lake
and the Gage at Salt Water Barrier**

Reach	Average Travel Time in Hours	Cumulative Travel Time in Hours
B.A. Steinhagen Lake (RM 113.7) to the Evadale Gage (RM 54.6)	72	72
The Evadale Gage (RM 54.6) to Salt Water Barrier (RM 27.7)	48	120

4-11. Upstream Structures. The USACE Fort Worth District operates the Sam Rayburn Reservoir, which is located on the Angelina River, approximately 20 miles upstream from B.A. Steinhagen Lake. Sam Rayburn Reservoir has a conservation capacity of 2.85 million acre-feet and has authorized purposes of flood control, water supply, hydropower and recreation. Town Bluff Dam was constructed to reregulate surges due to hydropower releases from Sam Rayburn Reservoir.

Lake Palestine, one of two major reservoirs on the Neches River, is located near the headwaters of Neches River in Henderson, Smith, Cherokee, and Anderson Counties.

4-12. Downstream Structures. The Salt Water Barrier (RM 27.7) near Beaumont is downstream of Town Bluff Dam on the Neches River. The structure is to prevent salt water intrusion from the Gulf of Mexico and protect the fresh water supplies of LNVA and the city of Beaumont.

4-13. Economic Data. The Neches River Watershed is rural, with an economy based on agriculture and manufacturing. The B.A. Steinhagen Lake drainage area comprises parts of 16 counties in southeast Texas.

Based on the information published by U.S. Census Bureau Texas State Data Center, the population within the Neches River basin has continually increased over the last 50 years. Population projections indicate that growth is anticipated to continue. County Business Patterns (CBP), a database published by the U.S Census Bureau provides valuable information on the number of industrial and business establishments within a particular county. Sectors that are

typically heavy consumers of water include: agriculture, forestry, fishing and hunting, mining, manufacturing, professional, scientific and technical services, health care and social assistance, and accommodation and food services. For some of the major counties in the basin, CBP data was reviewed for a 12-year period from 2000 to 2012. The number of industries in many of the heavy water-consumer sectors has shown an overall increase in the number of establishments across the counties. The number of industries involved in mining sector which is known to be a fairly heavy user of water has shown a marked increase, and has compensated for the slight downturn in the manufacturing sector in this region. The healthcare sector is also showing an increase in total number of establishments.

The following sections provide information on population, agricultural production, and industries in the counties in the Neches River Basin and surrounding areas.

a. Population. B.A. Steinhagen Lake is near the border of Jasper and Tyler counties. Tyler County has a population of 21,766, of which 12 percent, or 2,544 people, are in Woodville, the county seat. Jasper County has a population of 35,710, of which 22 percent, or 7,682 people are in Jasper, the county seat. Woodville is 16 miles west of the lake, and Jasper is 20 miles northeast of the lake.

The population growth of the 16 counties within the Neches River Basin since the construction of Town Bluff Dam is shown in Table 4-14. Although varying proportions of the total population of the counties listed lie within the watershed boundaries, the entire population of each county is provided.

TABLE 4-14**Population Growth of Counties within the Neches River Basin**

County	1960	1970	1980	1990	2000	2010
Anderson	28,162	27,789	38,381	48,024	55,109	58,458
Angelina	39,814	49,349	64,172	69,884	80,130	86,771
Cherokee	33,120	32,008	38,127	41,049	46,659	50,845
Hardin	24,629	29,996	40,721	41,320	48,073	54,635
Henderson	21,786	26,466	42,606	58,543	73,277	78,532
Houston	19,376	17,855	22,299	21,375	23,185	23,732
Jasper	22,100	24,692	30,781	31,102	35,604	35,710
Nacogdoches	28,046	36,362	46,786	54,753	59,203	64,524
Polk	13,861	14,457	24,407	30,687	41,133	45,413
Rusk	36,421	34,102	41,382	43,735	47,372	53,330
San Augustine	7,722	7,858	8,785	7,999	8,946	8,865
Shelby	20,479	19,672	23,084	22,034	25,224	25,448
Smith	86,350	97,096	128,366	151,309	174,706	209,714
Trinity	7,539	7,628	9,450	11,445	13,779	14,585
Tyler	10,666	12,417	16,223	16,646	20,871	21,766
Van Zandt	19,091	22,155	31,426	37,944	48,140	52,579

NOTE: Source: Census.gov

b. Agriculture. One-half of the Neches River basin is classified as timberland and one-third is agricultural land. The majority of the farmland is used for livestock. Also, a large percentage of the cropland grown in the area is classified as “forage,” which is land used for hays, grasses, and greenchop. According to the 2011 East Texas Region Water Plan, irrigation and livestock comprises about 25 percent of the region’s water use. This amount of water use is projected to hold constant in coming decades. Table 4-15 lists the acreage of cropland planted in each major crop, the total agricultural acreage, the quantity of livestock, and the agricultural income for each county during the year 2007.

TABLE 4-15**Agricultural Production for Major Counties in the Neches River Basin, 2007**

Product	Jasper County	Angelina County	Tyler County	Nacogdoc hes County	Cherokee County	Anderson County
Corn (acres)	0.023	0.015	0.007	D	—	—
Cotton (acres)	—	—	—	D	D	D
Oats (acres)	D	—	—	—	—	D
Sorghum (acres)	—	—	—	—	—	—
Wheat (acres)	—	—	D	D	—	—
Cropland Planted (acres)	20	43	20	75	77	75
Land in Farms and Ranches (acres)	96	115	84	535	294	346
Cattle (1000 head)	14	22	17	46	63	60
Crop Market Value*	2,910	2,021	D	5,349	89,095	12,885
Livestock Market Value*	3,753	27,417	D	311,938	51,162	26,475
All Agriculture Market Value*	6,663	29,438	21,763	317,287	140,256	39,361

NOTES: 1. (D) Withheld to avoid disclosing data for individual farms.
 2. Data from 2007 Census of Agriculture, prepared by National Agricultural Statistics Service, U.S. Department of Agriculture.
 3. *Quantity given in \$1,000s.

c. Industry. Due to the size of the Neches River Basin, a large variety of industries are represented in the area. According to the 2011 East Texas Region Water Plan, manufacturing and mining comprises about 45 percent of the region's total water use, and is projected to increase to above 60 percent by 2030. Table 4-16 gives the estimated number of people employed in various industries in each county, as compiled by the 2000 United States Census.

TABLE 4-16

Employment in Counties within the Neches River Basin, 2000

Industry	Number Employed					
	Jasper County	Angelina County	Tyler County	Nacogdoc hes County	Cherokee County	Anderson County
Agriculture, Forestry, Fishing & Hunting	730	1,103	469	1,301	1,553	1,008
Construction, Mining, Oil & Gas	1,662	2,477	891	1,543	1,578	1,012
Manufacturing	1,915	6,549	911	3,478	2,907	984
Trade, Transportation & Utilities	2,810	7,243	1,321	5,052	3,818	4,348
Finance, Insurance, & Real Estate	603	1,260	232	1,051	751	614
Professional, Scientific & Business Services	446	1,591	291	1,436	820	762
Education & Healthcare	2,731	7,825	1,524	7,103	4,008	3,643
Arts, Leisure & Hospitality	780	1,964	183	1,865	893	1,064
Communication & Information	235	953	101	447	282	225
Public Administration	758	1,203	532	1,093	1,230	2,580
Other Services	657	1,689	372	1,268	851	806
Total	13,327	33,857	6,827	25,637	18,691	17,046

NOTE: Data from the United States Census, 2000.

d. **Flood Damages.** The damages prevented in the Neches River Basin by Sam Rayburn Dam and Town Bluff Dam as a system during fiscal year 2013 was estimated to be \$218,000 with \$32,700 by Sam Rayburn Dam and \$185,300 by Town Bluff Dam respectively. These low damages are due to the continuing Texas drought. The cumulative damages prevented since the completion of the projects in 1965 through 2013 are \$1,074,501,177, and the average is \$22.4 million per year. Table 4-17 and Table 4-18 show discharge versus damages incurred for agricultural and non-agricultural on Neches River at both Evadale and Beaumont. The damages shown in the tables are estimated to occur at the various discharge levels, as the exact amount of damage will vary.

TABLE 4-17

Discharge versus Damages on Neches River at Evadale, 2013

Discharge (cfs)	Damages (X\$1,000)						
	Crops (1)	Crops (2)	Crops (3)	Crops (4)	Crops (C)	Other ag.	Non-ag.
24,000	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0
30,000	\$214.6	\$250.2	\$186.0	\$241.4	\$206.4	\$119.6	\$104.5
40,000	\$457.8	\$352.7	\$594.5	\$527.0	\$402.5	\$202.6	\$2,924.5
60,000	\$690.7	\$786.3	\$499.7	\$648.5	\$565.0	\$318.1	\$8,042.5
80,000	\$803.4	\$920.2	\$609.9	\$791.6	\$686.0	\$430.1	\$12,184.3
100,000	\$868.7	\$996.7	\$668.7	\$867.9	\$751.0	\$533.7	\$15,924.1
120,000	\$917.9	\$1,052.9	\$705.4	\$915.5	\$792.4	\$631.9	\$19,866.5
140,000	\$959.3	\$1,099.9	\$734.8	\$953.7	\$825.5	\$729.0	\$23,711.4
200,000	\$1,033.8	\$1,184.5	\$787.7	\$1,022.5	\$885.1	\$903.8	\$30,632.2

Crops (1) = Jan, Feb, Dec

Crops (2) = Mar, Nov

Crops (3) = Apr, May, Oct

Crops (4) = Jun, Jul, Aug, Sep

NOTES: 1. This table is estimated on roughly available data.

2. Price levels are for September 2013. To convert the prices to a different year, average annual cost indexes must be applied.

TABLE 4-18

Discharge versus Damages on Neches River at Beaumont, 2013

Discharge (cfs)	Damages (X\$1,000)						
	Crops (1)	Crops (2)	Crops (3)	Crops (4)	Crops (C)	Other ag.	Non-ag.
20,000	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	\$0.0	0
25,000	\$253.0	\$291.4	\$170.9	\$213.9	\$179.6	\$116.7	0
30,000	\$406.5	\$479.5	\$325.1	\$418.2	\$378.8	\$196.9	1
40,000	\$662.8	\$793.1	\$580.1	\$745.9	\$666.6	\$357.0	7
60,000	\$991.1	\$1,142.2	\$895.6	\$1,151.6	\$1,018.4	\$626.4	52
80,000	\$1,110.2	\$1,359.8	\$1,111.1	\$1,428.7	\$1,229.7	\$978.8	163
100,000	\$1,227.1	\$1,509.4	\$1,257.2	\$1,616.4	\$1,426.0	\$1,112.4	377
120,000	\$1,322.1	\$1,630.3	\$1,372.7	\$1,764.8	\$1,544.9	\$1,335.3	1,062
158,000	\$1,466.4	\$1,812.6	\$1,541.7	\$1,982.2	\$1,733.5	\$1,775.3	3,047

Crops (1) = Jan, Feb, Dec

Crops (2) = Mar, Nov

Crops (3) = Apr, May, Oct

Crops (4) = Jun, Jul, Aug, Sep

NOTES: 1. This table is estimated on roughly available data.

2. Price levels are for September 2013. To convert the prices to a different year, average annual cost indexes must be applied.

CHAPTER V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations.

a. Facilities. The Water Resources Branch of the USACE, Fort Worth District, the NWS, and the USGS cooperate to collect hydrometeorological data and maintain a reliable communication network. Plate 5-1 shows the locations of the USGS stream gages in the Neches River basin. Commercial television weather services provide current radar and forecasted weather conditions to assist the Water Resource Branch in monitoring storm events.

1. Precipitation Gages. The NWS and USGS maintain a network of rain gages and observers throughout the Neches River basin. The NWS precipitation gages used to forecast runoff in the Elm Fork Trinity River watershed are listed in Table 5-1 and are shown on Plate 6-1, respectively.

TABLE 5-1

Upstream NWS Precipitation Gages

Name of Station	Description
San Augustine	Recording
Nacogdoches	Recording
Lufkin	Recording
Woodville	Recording
Town Bluff Dam	Recording
Jasper	Recording

2. Weather Radar Sites. The NWS maintains 12 Doppler radar sites across Texas for surveillance of immediate weather conditions. The NWS also cooperates with the Department of Defense to obtain radar information from four military sites in Texas.

3. Stream Gages. The USGS maintains 23 stream gages in the Neches River basin. The gages are listed in Table 5-2A. The stream gages designated as key stations for forecasting and regulating Town Bluff Dam are listed in Table 5-2B. A hydrologic gage network was established for use in connection with the operation of the Town Bluff Dam. The hydrologic gage network for the Neches River basin is shown on Plate 5-1. The travel times for flows from B.A. Steinhagen Lake to the Neches River Saltwater Barrier at Beaumont are shown on Plate 5-2.

TABLE 5-2A**USGS Stream Gages in the Neches River Basin**

Station Number	Name of Station	Description
08031290	Lake Athens near Athens	Recording
08031400	Lake Palestine near Frankston	Recording
08032000	Neches River near Neches	Recording
08032200	Lake Jacksonville near Jacksonville	Recording
08032500	Neches River near Alto	Recording
08033000	Neches River near Diboll	Recording
08033500	Neches River near Rockland	Recording
08033900	East Fork Angelina River near Cushing	Recording
08034000	Lake Tyler near Whitehouse	Recording
08034500	Mud Creek near Jacksonville	Recording
08036500	Angelina River near Alto	Recording
08036700	Lake Nacogdoches near Nacogdoches	Recording
08037050	Bayou Lanana at Nacogdoches	Recording
08038000	Attoyac Bayou near Chireno	Recording
08039100	Ayish Bayou near San Augustine	Recording
08039300	Sam Rayburn Reservoir near Jasper	Recording
08040000	B.A. Steinhagen Lake at Town Bluff	Recording
08040600	Neches River near Town Bluff	Recording
08041000	Neches River at Evadale	Recording
08041500	Village Creek near Kountze	Recording
08041700	Pine Island Bayou near Sour Lake	Recording
08041749	Pine Island Bayou above BI Pump Plant, Beaumont	Recording
08041780	Neches River Saltwater Barrier at Beaumont	Recording

TABLE 5-2B

Key Regulating Stations for Town Bluff Dam

Station Number	USGS Gage Station	Method of Reporting
08032000	Neches River near Neches	Satellite Telemeter
08033000	Neches River near Diboll	Satellite Telemeter
08033500	Neches River near Rockland	Satellite Telemeter
08040600	Neches River near Town Bluff	Satellite Telemeter
08041000	Neches River near Evadale	Satellite Telemeter

b. Reporting. Data Collection Platforms (DCPs) have been installed at all USACE Fort Worth District lakes, and at numerous stream gages and precipitation stations. The DCPs transmit hydrometeorological data using the Geostationary Operational Environmental Satellite (GOES) to the NOAA Center in Wallops Island, Virginia. The data are then decoded and re-transmitted using Domestic Satellites (DOMSATs), making the data available for nationwide reception. The Water Management Office captures, processes, and stores the data in the Fort Worth District's Water Control Data System (WCDS).

The Water Management Office collects and stores the majority of hydrometeorological data in the WCDS. Thus, hourly lake elevations and stream gage stages are stored in the WCDS network. Some meteorological and hydropower data are collected by telephone. Project personnel collect precipitation, evaporation, and, maximum and minimum air temperature data from weather stations. The information is reported to the Water Management Office by e-mail or sometimes by facsimile and telephone.

The Water Management Office personnel use the data in the WCDS to operate the 27 lakes that the Fort Worth District manages. All the data entered into the WCDS is stored in a database and used for water management decisions, to generate reports, and to conduct hydrologic studies. The Water Management Office also serves as a source of hydrologic data for state and local government agencies and the general public.

c. Maintenance. Maintenance costs are shared among the USGS, NWS, USACE, TWDB, and various river authorities. Maintenance and repair of the weather station instrumentation are the responsibilities of the NWS. Maintenance and repair of stream gaging stations are the responsibility of the USGS. Assistance in gage repair can be obtained by contacting the USGS in Fort Worth, Texas, at (817) 263-9545.

5-02. Water Quality Stations. TCEQ collects data and monitors the water quality in B.A. Steinhagen Lake at one station near the dam. In addition, in three major tributaries (Angelina River, Sandy Creek, and Wolf Creek) of B.A. Steinhagen Lake, TCEQ, LNVA, and Angelina-Neches River Authority monitor water quality using 113 active monitoring stations.³

a. Facilities. The four designated sites where USGS water quality samples are taken for Lewisville Lake are Stations AC, BC, CC, and DC. The chemical, biological, and field parameters are measured at these eight sites. Table 4-11A shows the most recent data for constituents sampled on B.A. Steinhagen Lake.

The Neches River Basin is divided into 14 classified segments and 28 unclassified water bodies by TCEQ to report water quality information. The Segment 0603, from Town Bluff Dam to a point immediately upstream of confluences of Hopson Mill Creek on the Neches River and Indian Creek on the Angelina River Arm, is designated to provide the water quality data for the reservoir.

b. Reporting. The USGS summarizes and publishes its collected water quality data annually in the “Water Resources Data: Texas” book for its current sampling locations. However, Lewisville Lake is not sampled yearly and only years for which it was sampled are published in the yearly data book.

The “Texas Integrated Report of Surface Water Quality,” formerly called the “Texas Water Quality Inventory and 303(d) List,” evaluates the quality of surface waters in Texas, and provides resource managers with a tool for making informed decisions when directing agency programs. The TCEQ publishes the report every 2 years (in even-numbered years). The water quality assessment results for Lewisville Lake are included in the report.

c. Maintenance. Maintenance and calibration of the equipment related to water quality are conducted or monitored by USGS and TCEQ.

5-03. Sedimentation and Degradation Ranges.

a. Facilities. The sedimentation ranges, which are needed to determine the rate of sedimentation and the location of sediment deposits, were established as directed in Engineer Regulation (ER) 1100-2-240 and Engineer Manual (EM) 1100-2-4000.

1. Sedimentation Ranges. There are 14 sedimentation ranges in the B.A. Steinhagen Lake area (Plate 4-2). The ranges cross the lake normal to the original stream flow as practical. The elevations and locations of the monuments are referenced to appropriate datum systems established by other Federal agencies. Monuments are used at multiple locations for future survey at common reference points. Sedimentation ranges have not been utilized at Lewisville Lake since the 1965 survey. The TWDB uses bathymetric survey independent of the USACE established sedimentation ranges.

³ <https://www.tceq.texas.gov/waterquality/assessment/02twqi/basins/brazos.html>

2. Degradation Ranges. There are six degradation ranges downstream of Town Bluff Dam and B.A. Steinhagen Lake (Plate 4-2). Each range consists of two or more permanent monuments placed at selected locations along the discharge channel downstream of the dam.

b. Reporting. The frequency of sedimentation surveys will depend on hydrologic conditions and the need for determining sediment deposition and storage depletion. Normally, a period of no more than 20 years would elapse between sedimentation surveys. However, sedimentation surveys are currently done periodically depending on need and funding availability. Complete or partial surveys will be made of degradation ranges, as found necessary on the basis of reconnaissance.

For B.A. Steinhagen Lake, four surveys have been performed since 1947, including the historical 1947 USACE original design, the 1951 adjusted design, the 1960 resurvey, and the 2003 TWDB volumetric survey. The 2003 TWDB survey results indicated that the surface area had reduced from 13,700 acres in the original design to 10,687 acres and the volume reduced from 94,200 acre-feet of water in the original design to 66,972 acre-feet of water at top of the conservation pool elevation 83.0 feet.

c. Maintenance. Project personnel will visit the ranges to determine any special developments. A report will be forwarded to the Water Management Office following the inspection that describes the condition of the monuments not found, destroyed, or otherwise disturbed. Monuments and witness points that have been damaged or are missing will be replaced and reset. Completion of monument surveys is dependent on funds and personnel availability.

5-04. Recording Hydrologic Data. Hydrologic information is recorded as the Water Management Office receives it. The recording procedures for each type of data are as follows:

a. Stages and Lake Elevations. Stream stage and lake stage data are recorded every 15 minutes and transmitted every hour by the DCPs through a GOES Satellite to Wallops Island, VA, then retransmitted to a DOMSAT. The District's WCDS accesses the data by a downlink. The recorded data and monthly data summaries are kept in the reservoir logbooks and in other Water Management Office files. Additional data sets from non-Corps reservoirs are received from the Internet, by facsimile, and/or by telephone.

b. Precipitation. Hourly precipitation data from numerous DCPs across the state are transmitted to the Water Management Office in the manner described in paragraph 5-04.a. The Water Management Office also receives precipitation data from the NWS and other precipitation observers through the Automated Field Observations and Services (AFOS) system and stores the data in the WCDS. The NWS daily state precipitation summary is filed and retained for approximately 1 year. The Water Management Office receives daily rainfall and weather reports from 22 of the 25 District lakes, including B.A. Steinhagen Lake.

c. Temperature Data. The lake personnel record the daily maximum and minimum air temperatures at the lake.

d. Radar Reports. The Water Management Office receives radar images and weather information from commercial weather services by cable TV. This information is used primarily for short-term decision making. The weather reports are updated throughout the day by the NWS.

e. Hydropower. The Water Management Office requires hydropower release data and megawatts produced. The data is provided daily (Monday through Thursday) by email or fax from the powerhouse to the Water Management Office for hydropower generation occurring during the previous 24 hour period.

5-05. Communication Network. B.A. Steinhagen Lake is served by telephone, facsimile, email, and cell phone. The telephone number for the Lewisville Lake project office is (469) 645-9100.

The National Telecommunications and Information Administration (NTIA), Department of Commerce, assigned radio frequencies exclusively to the USACE. The assigned VHF FM frequencies are 163.5125 and 163.4375 MHz. Both of the VHF FM frequencies are maintained at most project offices and in some vehicles assigned to the Fort Worth District. The radio equipment using the VHF FM frequencies will only transmit about 20 miles. Therefore, radio communications cannot be made between the Lewisville project office and the Fort Worth District Office, or between the other district lakes.

If necessary, the Fort Worth District Emergency Operation Center (EOC) can contact other districts in the SWD by HF side-band radio during an emergency. This radio frequency is good for communications between the EOCs in Fort Worth, Texas, Galveston, Texas, Little Rock, Arkansas, and Tulsa, Oklahoma.

5-06. Communication with the Project.

a. Water Resources Branch with Project Office. The primary mode of communication between the Lewisville Lake project office and the Water Resources Branch is by telephone. In addition, the project is served by facsimile, email, and cell phone as backups to the primary mode of telephone. Should communication between the project and the District be disrupted, the Lake Manager would direct regulation of the lake on his or her own initiative in accordance with the Emergency Rules and Regulations listed in Section 7-05 and Exhibit E of this manual.

b. Between Project Office and Others. The Lake Manager will maintain a current list of the residents and/or property endangered or inconvenienced by large and/or prolonged releases in order to give adequate warning before such releases. Warning of possible flood conditions can be conveyed by telephone, radio, television, citizens-band radio, use of law enforcement personnel, and civil defense agencies and their communications systems. National Guard,

Reserve Military Units, and citizen volunteers may also be needed to convey warning messages. Plate 5-3 shows a schematic of the primary lines of communication for use in routine communications and in case of an emergency.

5-07. Project Reporting Instructions. Both daily lake operation information and emergency lake operation information will be submitted to the Water Management Office of the Fort Worth District.

a. Daily Operations. Daily reservoir data will be submitted to the Water Management Office on regular working days by facsimile or electronic mailing between 0800 and 0845 hours each morning for transmission of hydrologic data. For electronic mailing, the Internet Web site is: (<http://www.swf-wc.usace.army.mil>). Project personnel will confirm gate changes and promptly report all scheduled or unscheduled equipment outages affecting water control by telephone at (817) 886-1551 or by facsimile at (817) 886-6472 or by email at CESWF-OD-L@usace.army.mil. The Water Resources Branch may request additional information as needed.

Daily data reported to the District Office include the following: (1) As of 0800 hours – Reservoir elevation: number of gates open and increments of opening, precipitation and evaporation for the preceding 24 hours, weather conditions and maximum and minimum temperatures, if required. (2) Each gate operation – All changes in gate operation, including time of gate operation, increments of opening, and reservoir elevation at time of each gate operation for the preceding 24 hours. (3) Stage report – During flood periods, besides the regular 0800-hour reading from the reservoir and reporting gages (Rockland, Sam Rayburn, Diboll, B.A. Steinhagen Lake, and Town Bluff), include the 0000-hour reading, which may be read from the recorder charts. The Sam Rayburn powerhouse provides the daily data (Monday through Thursday) of hydropower generation occurring during the previous 24 hour period by email or fax.

b. Emergency Operations. In the event of an emergency or flood situation, the Lake Manager will notify key personnel in the Fort Worth District Water Management Office. A list of these names will be posted on the project bulletin board. These names are shown on page iii, Notice to Users of This Manual. If unusual conditions arise during non-working hours, one of the persons listed on page iii should be contacted.

5-08. Warnings. Before any major increase in discharge due to operation of the gates, warning of such operation shall be given to parties in the immediate area downstream of the dam. A warning horn will be sounded for 10 seconds to alert people downstream at least 2 minutes before any appreciable increase or decrease in the release rate from the dam. After the horn sounds, the operator will observe the downstream area to ensure that no one remains there. Signs in the discharge area shall state the meaning of the warning signal. A warning horn will be sounded from the powerhouse only during the initial releases. The law enforcement agencies shown in Table 5-3 may also be contacted to assist in warning the public and evacuating downstream areas.

TABLE 5-3

Law Enforcement and Key Town Bluff Project Telephone Numbers

Agency	Telephone Number
Texas Department of Public Safety, Jasper, Texas	(409) 384-5712
City of Jasper Police Dispatch	(409) 384-3471
B.A. Steinhagen Lake Manager	(409) 429-4161
B.A. Steinhagen Lake Rangers	(409) 920-8449
LNVA Office Dispatch	(409) 892-4011
Permanent Salt Water Barrier	(409) 898-0561
Sheriff, Tyler County	(409) 283-2172
Sheriff, Jasper County	(219) 866-7344

CHAPTER VI – HYDROLOGIC FORECASTS

6-01. General. Hydrologic forecasts of stream flow amounts are made daily to maintain the current status of the Neches River basin for flood control and water supply.

a. Role of Corps of Engineers. Hydrologic forecasts are made by the Water Management Office for use in the regulation of lakes to maximize flood control, water supply, and other authorized purposes. The forecasts are furnished to project personnel and other USACE personnel with a need for this information. Planned changes in the release rates are furnished to the National Weather Service River Forecast Center (NWS-RFC) in Fort Worth, Texas. The Public Affairs Office, which is kept informed of the lake conditions, makes news releases.

b. Role of Other Agencies. The NWS-RFC provides information about river flow and flood forecasts to the USACE and the general public. The NWS Weather Wire circuit disseminates this information to subscribing government agencies and news media. The National Weather Service-Weather Service Forecast Offices (NWS-WSFO) issues routine reports containing the following information:

1. Weather forecasts (daily forecasts, severe weather forecasts, and 5-day extended forecasts).
2. Quantitative precipitation forecasts: Four successive 6-hour precipitation forecasts are updated every 12 hours. Three successive 24-hour precipitation forecasts are updated every 12 hours.
3. Three-day river stage forecasts, when conditions warrant, from the NWS-RFC.
4. Urgent priority messages such as severe weather warnings, severe weather watches and statements, and instructions from civil defense centers during emergency situations.
5. Other information reports, on a periodic basis:
 - (a). Winter weather and road conditions
 - (b). River and flood warning bulletins
 - (c). Damage reports
 - (d). Thirty-day weather forecasts

6-02. Flood Control Forecasts.

a. Requirements. Flood forecasts are required whenever substantial rainfall has fallen above or below Sam Rayburn Dam and Town Bluff Dam or during the evacuation of the flood pool from Sam Rayburn Dam.

b. Methods. Water Managers continually monitor and adjust water releases at USACE projects based on ever-changing hydrometeorological conditions. The Corps Water Management System (CWMS) is the automated decision support tool developed for USACE Water Managers. CWMS tracks the hydrologic cycle and performs scenario-based forecasts that can include stage and flow forecasts, project release scheduling and release review, emergency activation alerts, inundation mapping and economic damage reporting. The CWMS Automated Information System was developed by USACE Hydrologic Engineering Center (HEC) under funding from the Water Management Community of Practice and has been implemented to varying degrees at various USACE Water Management Offices. A CWMS forecasting model has been developed for the Elm Fork Trinity River basin by the Fort Worth District, HEC, and USACE MMC (Modeling, Mapping, and Consequences) Production Center. The USACE makes the following forecasts with assistance from the NWS.

1. Predicting Inflow into B.A. Steinhagen Lake. A rainfall-runoff HEC-HMS model was developed within CWMS by the Fort Worth District for the Neches River basin above the Salt Water Barrier gage. This model is used to predict the inflow into Sam Rayburn Reservoir and B.A. Steinhagen Lake. The inflow forecasting model consists of HEC-METVUE and HEC-HMS models that are linked to real-time data with CWMS. Both models use a 1-hour time interval.

Precipitation estimates are available from two main sources: precipitation gages and radar. The NWS uses the data from these sources to produce a suite of hydrologic forecasts. Weather Surveillance Radar-1988 Doppler (WSR-88D), also known as Next Generation Weather Radar (NEXRAD), observes the presence of severe weather and calculates the speed and direction of the weather. The WSR-88D also provides estimated quantitative area precipitation amounts.

The NWS adds to the accuracy of the WSR-88D quantitative precipitation estimates (QPE) through a procedure for improving the radar estimates of rainfall that is referred to as “ground truthing.” The precipitation data set produced from the ground truthing is known as the Multi-sensor Precipitation Estimate (MPE). The NWS and other agencies may poll some automated gages on a 4-hour basis, and the poll results may also be used for ground truthing.

Hourly NWS gridded rainfall data is downloaded from the NWS West Gulf Forecasting Center in real-time and processed into HEC-DSS format using HEC-METVUE. The HEC-HMS model is then used to compute runoff from the gridded precipitation. Initial and uniform losses are adjusted to real-time basin conditions within CWMS. These losses are subtracted from the precipitation hyetograph at each subbasin grid cell to obtain the rainfall runoff hyetograph. Each grid cell hyetograph is then routed and combined by the HEC-HMS model to obtain the total

inflow hydrograph for Sam Rayburn Reservoir and B.A. Steinhagen Lake. The Neches River Model subbasins are shown on Plate 4-1.

There is a DCP at Sam Rayburn Reservoir and B.A. Steinhagen Lake which records the lake elevation. An inflow hydrograph can be computed using observed lake elevations, an elevation-capacity table, and hourly lake releases.

The HEC-HMS model is executed with forecast time and an initial estimate of loss rates as determined by the user. The computed hydrographs at Sam Rayburn Reservoir and B.A. Steinhagen Lake are compared with observed runoff volume, shape, and time of peak. If the comparison is not favorable, then subbasin loss rates are adjusted accordingly and the HEC-HMS model is re-executed. This calibration process is repeated until the comparisons are favorable. This process ultimately results in a forecasted inflow into Sam Rayburn Reservoir and B.A. Steinhagen Lake.

2. Predicting Lake Levels. The forecasted inflows as computed by the HEC-HMS model are routed into Sam Rayburn Reservoir and B.A. Steinhagen Lake. The model will add the routed inflows to the storage in the lake and subtract the releases to forecast the lake elevations.

3. Predicting Flow at Downstream Control Points. The flood forecasting system is used to predict flows in the Neches River above the Salt Water Barrier Gage. The predicted flows for the control points located downstream of the project are computed by combining the estimated local flow in the river channel and the potential routed releases from Sam Rayburn Reservoir and B.A. Steinhagen Lake. If the predicted flows exceed the downstream channel capacity, no releases will be made.

(a). Estimating Local Flow. Local flow forecasts can be obtained from two sources: the NWS-RFC's river forecast model or Water Management Office HEC-HMS model. If the latter method is used, the subbasin hydrographs for the uncontrolled areas below Sam Rayburn Reservoir and B.A. Steinhagen Lake are computed using the same procedure discussed in paragraph 6-02.b.(1).

(b). Routing Reservoir Releases to Downstream Control Points. The HEC-HMS model is used to route releases from Sam Rayburn Reservoir and B.A. Steinhagen Lake to downstream points by using the Modified Puls and Muskingum flow routing methods. The releases are determined based on the predicted available channel capacity at the downstream control points. The determined releases are then incorporated into the HEC-HMS model. The observed flows at the downstream control points on the Neches River are provided by stream gages. The downstream control points are located on the Neches River near Town Bluff gage and Evadale gage. Plate 4-19 shows flood crest travel times in the Neches River Basin.

(c). Regulated Flow. The releases from Sam Rayburn Reservoir and B.A. Steinhagen Lake combine with flows from the Neches River and are measured by the gage

at Neches River near Town Bluff and at Evadale.

6-03. Conservation Purpose Forecast. The LNVA has contracted for conservation storage in B.A. Steinhagen Lake. The conservation storage is used for water supply, hydropower, irrigation, fish and wildlife, and general recreation. Conservation storage forecasts are made when needed based on forecasted inflow, historical average evaporation, and estimated demand. The maximum authorized rate of withdrawal from the reservoir for the use by the LNVA and their customers is 2,000 cubic feet of water per second. Releases from the reservoir for conservation purposes will be made through the turbines on receipt of written daily requests from the LNVA unless the turbines are inoperable or request exceeds turbine capacity, then releases will be made through a combination of turbines and tainter gates. In the event that the LNVA finds it necessary to modify its schedules for releases because of varied demands during any period, then its designated representative will contact Water Management Office and indicate the revised demands, a confirmation of which will be furnished in writing to the Water Management Office.

6-04. Long-Range Forecast. Long-range weather forecasts are made by the NWS Climate Prediction Center, and available at the “Outlooks Index” in the website http://www.cpc.ncep.noaa.gov/products/OUTLOOKS_index.shtml. The outlooks website contains both temperature and precipitation forecast for “Monthly to Seasonal” and “Extended Range” categories. Special products, such as current UV index forecast and soil moisture outlooks are also available on this website.

6-05. Drought Forecast. Appendix III, Drought Contingency Plan, for the Neches River Basin Master Manual provides information on historical droughts in the basin and methods to determine the severity of a drought. In general, the three factors used to determine the severity of a drought are the lake content, lake inflow, and the Palmer Drought Severity Index (PDSI). The PDSI reflects the cumulative excess or deficiency in moisture relative to seasonal norms and typically ranges from +4 to -4 but may exceed these values. A PDSI of -4 indicates that abnormally dry conditions have prevailed. The NWS publishes the PDSI about once a week. Drought conditions can be accessed at this website:
http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.shtml

CHAPTER VII – WATER CONTROL PLAN

7-01. General Objectives. Town Bluff Dam and B.A. Steinhagen Lake were constructed for re-regulating surges due to hydropower releases from Sam Rayburn Dam, in the interest of navigation, and in conjunction with the conservation storage provided by Sam Rayburn Dam, to provide water supply. Incidental purposes are to protect and enhance fish, wildlife and aquatic habitat, and provide general recreation. Town Bluff Dam is a run-of-the-river project with no flood control storage provided in its design. *During flood events, the operational goal is to protect the integrity of the structure. Due to the design of the uncontrolled spillway structure, the tailwater level must be built up sufficiently to ensure the differential between the headwater elevation and the tailwater elevation is not greater than about two feet when the uncontrolled spillway begins to overtop.*

7-02. Project Constraints.

a. Outlet Works.

(1). Low-Flow Outlets. The low-flow outlets, designed for making conservation releases, have been non-operational since electrical power was disconnected circa the year 2000. *Historically, the low-flow outlets were rarely used, and there are no plans to restore them to operational status.* The two parallel curvilinear 4.0' x 6.0' low-flow outlet conduits are approximately 80 feet in length and drop from elevation 52.0 at the inlet to elevation 40.0 at the outlet in a reverse vertical curve. The conduits are located adjacent to the right end of the gated spillway structure and discharge into the right side of the stilling basin at a 45-degree angle. When operational, each is controlled by a 4.0' x 6.0' slide gate with sill at elevation 52.0. The crown of each conduit is dropped seven inches near the exit portal to prevent negative pressures within the conduit. Energy dissipation is accomplished by discharging into the stilling basin below design minimum tailwater elevation 50.0. When operational, the conduits may be operated singly or in tandem. When the conduits are operated in tandem, a maximum gate opening differential of one-foot between the conduits is generally recommended to mitigate risk of potentially undesirable flow patterns in the stilling basin. Although the low-flow outlets are not currently available for use, low-flow outlet gate rating curves for partial and fully open gates are shown on Figure 2 of Plate 7-1.

(2). Gated Spillway. The low sill gated spillway is located near the right abutment of the dam, in the river channel. The gated spillway has a clear opening of 240 feet, controlled by six 40' x 35' tainter gates with sill at elevation 50.0, the approximate elevation of the streambed. A level concrete approach at elevation 50.0 extends approximately 40 feet upstream of the gate sills. The concrete exit-way drops from elevation 50.0 at the gate sills to the stilling basin floor, elevation 40.0, in a parabolic curve over a distance of approximately 40 feet. Normal minimum gate opening height is 0.5-feet and the gates will be operated to spread the flow uniformly over the stilling basin. In order to permit passage of major floods, the gated spillway is supplemented by a paved, earth fill overflow section on the left overbank that serves as an uncontrolled

spillway. *During flood periods, the gated spillway will be operated to pass inflow in order to avoid overtopping of the uncontrolled spillway prior to establishment of a safe tailwater depth.* The purpose of this limitation is to ensure the uncontrolled spillway will not be required to operate under excessive head differentials, which will result in damaging velocities over the paved earth fill. *A design objective of the gated spillway and the plan of regulation described herein is to ensure the differential between the headwater elevation and the tailwater elevation is not greater than about two feet as the pool rises above the crest of the uncontrolled spillway.* Gate rating curves for partial and fully open spillway gates are shown on Plates 7-2 thru 7-4. The contribution of the fully opened gated spillway to total spillway discharge is shown on Figure 1 of Plate 7-1.

(3). Uncontrolled Spillway. The uncontrolled spillway is a paved compacted earth fill overflow section located on the left overbank, measuring 6,600 feet in length which includes the horseshoe loop constructed to facilitate the R.D. Willis Hydropower plant. Although the crest is at elevation 85.0 for its entire length, a parapet wall ranging from about 1.8 to 3.0 feet in height sits atop the overflow section in the vicinity of the R.D. Willis hydropower plant, reducing the effective overflow length at elevation 85.0 to 5,600 feet. A discharge rating for the uncontrolled spillway is shown on Figure 1 of Plate 7-1.

(4). Hydropower Facilities. The R.D. Willis hydroelectric power plant, located about 1,600 feet left (east) of the gated spillway, is built into the center of a horseshoe in the left overbank overflow section that loops downstream of the primary alignment of the overflow section. Completed in 1990, the plant is equipped with two turbine generators that are operated remotely from the Sam Rayburn Dam powerhouse control room.

Rated generation capacity is 4.0 MW per unit, and a minimum of 25 feet of head differential is required to attain rated generation capacity. However, lesser rates of power are commonly generated with lesser head differentials. The minimum generation threshold is about 400 KW (0.4 MW). Under normal operating procedures, power generation, and therefore discharge, ceases when head differential recedes below 12 feet, and is not recommenced until 15 feet of head differential is available.

The generators are rarely operated at greater than 90% of rated maximum generation for any given amount of available head differential because increasing generation above this threshold often causes the generators to exceed some limiting operational criterion, resulting in an automatic shutdown. A problem in the power distribution system to which the generators are connected can also cause an automatic shutdown. When a failsafe shutdown occurs, a technician must travel to the site to assess conditions and manually restart the generators, if possible. If the generators are expected to be shut down for four or more hours, discharge through the dam's gated outlets may have to be adjusted to compensate for the loss of generation discharge.

Discharge through the turbines varies with available head differential and level of power generation. Head differential is reduced during periods of high rates of gated spillway release due to the associated rise in tailwater elevation. Rated turbine discharge for selected amounts of

head differential and levels of power generation are presented in Table 7-1.

TABLE 7-1

Rated Turbine Discharge for Selected Head Differentials and Levels of Power Generation

Head Differential [ft]	Rated Discharge For One Turbine [cfs]			Notes
	At 100% Power (1)	At 90% Power	At Minimum Power (0.4 MW)	
12	1,000	900	730	Generation ceases when head differential falls below 12 feet
15	1,400	1,200	590	A minimum of 15 feet of head differential is required to commence generation
20	1,800	1,600	320	
25	3,500	2,900	240	Maximum discharge
30	2,200	1,700	170	
33	1,800	1,600	140	Maximum design head differential

- (1) 100% power in the context of this table is defined as maximum rated generation for a given amount of head differential. 100% power equals rated generation capacity (4.0 MW) for head differentials of 25 feet or more. The magnitude of 100% power decreases from 4.0 MW as head differential decreases from 25 feet.

(5). Maximum Available Gated Discharge Rates. These rates reflect the upper physical limit of how much water can be discharged through the gated outlets. When the low-flow conduit gates were operational (see paragraph 7-02.a. (1)), with both conduit gates fully open, and all spillway gates closed, a combined maximum release rate of 3,000 cfs could be made through the low-flow outlet conduits at top of conservation pool elevation 83.0 feet. With all six tainter gates full open, a combined maximum release rate of 67,000 cfs can be made through the gated spillway at top of conservation pool elevation 83.0 feet. Combined maximum gated spillway release for the pool at uncontrolled spillway crest elevation 85.0 feet is 80,000 cfs. As the pool rises above elevation 85.0 feet, gated spillway discharge decreases as the tailwater rises due to increasing overflow of the uncontrolled spillway. This reduction in gated spillway discharge with rising tailwater is illustrated on Figure 1 of Plate 7-1.

(6). Rate of Change in Release. The spillway tainter gates will normally be opened at a rate not to exceed one gate-foot per half hour, and closed at a rate not to exceed one-half gate-foot per half hour. Releases so controlled will not produce sudden changes in downstream stage due to reservoir operation. Stages so controlled will give ample warning of change in stage to

downstream interests, and will reduce the potential for bank sloughing when stage is receding. Additionally, releases so controlled will ensure a gradual build-up of tailwater, thus producing sufficient tailwater depth so that velocities over the uncontrolled spillway will not be excessive. The normal rates of change in release may be exceeded at the discretion of the Chief, Water Management Office. Additionally, the Fort Worth District Water Management Office, or the Lake Manager, at their discretion, may exceed the normal rates of change in release in the event of drowning, accidents, failure of operational facilities, severe weather, or other emergencies deemed to require a more rapid rate of increase or decrease in the rate of release.

b. Downstream Conditions. Town Bluff Dam is a run-of-the-river project with no flood control storage provided in its design. Therefore, there are no designated controlling discharges or stages downstream of the dam. However, discharges above about 15,000 cfs begin to inconvenience some near downstream residents and users by reducing boating and river access, and flooding a few private drives and trails. The nominal channel capacity of the Neches River from Town Bluff Dam to the mouth is 20,000 cfs. Discharges in excess of 20,000 cfs will begin to cause flooding of some homes along the right bank in the near vicinity of the dam. Therefore, releases from the dam should not cause downstream channel capacity to be exceeded during events for which the peak pool can be held to a maximum elevation of 83.0 with lesser releases, based on best available observed or forecasted inflow data.

c. Conservation Pool Elevation Range. B.A. Steinhagen Lake's top of conservation pool is at elevation 83.0. As a part of normal operations, the pool may be allowed to fluctuate between elevation 81.0 and elevation 83.0 to provide flexibility, as required, for attenuating minor floods and effectively re-regulating high rates of intermittent power generation discharge from Sam Rayburn Dam. Maximum recreation benefits are generally realized in the 82.2 to 82.8 range, with elevation 82.5 being the ideal condition, particularly from spring through mid-summer when recreational use is at its peak.

7-03. Overall Plan for Water Control. The storage of B.A. Steinhagen Lake is limited, and releases must therefore be equal to inflow during passage of all but minor floods. For purposes of this water control plan of regulation, a minor flood is defined as one for which the reservoir can be operated so that the pool level will not exceed elevation 83.0 feet with a maximum release of 20,000 cfs. A major flood is defined as one that will cause elevation 83.0 feet to be exceeded.

The design of the uncontrolled overflow spillway structure is such that the tailwater level must be built up sufficiently to ensure a minimum of head differential during overtopping events. During flood events, the operational objective is to protect the integrity of the structure. This objective is achieved by operating the project in accordance with the plan of regulation described herein.

The regulation schedules presented in this manual apply mainly to the regulation of storage above elevation 83.0 feet. The Lower Neches Valley Authority (LNVA) requests releases from the conservation storage for municipal, industrial, and agricultural use. Reservoir release via power generation is the preferred and primary means of meeting these requests from conservation

storage until the rate of inflow to the reservoir exceeds available generation discharge capacity. Generation discharge capacity varies primarily with available head differential but is also often affected by the accumulation of debris and vegetation in the vicinity of the intake trash racks. In practice, available generation discharge capacity typically ranges from about 1,000 cfs to about 3,500 cfs.

7-04. Standing Instructions to Project Personnel. The Fort Worth District Water Management Office will give instructions for making releases from Town Bluff Dam to project personnel or hydropower operators, as applicable. For gated releases, project personnel will make gate changes as necessary to provide the required rate of release. For releases made via the R.D. Willis power plant, hydropower operators will increase or decrease generation as necessary, and possible, to provide the required rate of release. The lake will normally be regulated in accordance with the plan of regulation presented in paragraph 7-05 of this chapter. Should an emergency situation occur, such as a power outage, inoperable gates, unexpected powerhouse shutdown, or a drowning accident, the Fort Worth District Water Management Office will be notified immediately. In the event communications with the Fort Worth District Water Management Office are disrupted, the lake regulation will become the responsibility of the Lake Manager, in accordance with Exhibit C - Standing Instructions to Lake Manager, of this water control manual. The Lake Manager will immediately make every effort to re-establish communications with the Fort Worth District Water Management Office.

7-05. Flood Control.

a. General. When the reservoir is at or below elevation 83.0 feet, releases for conservation purposes will be made to satisfy requests by local interests as represented by the LNVA. The storage of B.A. Steinhagen Lake is limited, with no flood control storage provided. Releases must therefore be approximately equal to inflow during passage of all but minor floods. *Due to the design of the uncontrolled spillway structure, the tailwater level must be built up sufficiently to ensure the differential between the headwater elevation and the tailwater elevation is not greater than about two feet when the uncontrolled spillway begins to overtop.* Downstream channel capacity is 20,000 cfs. Releases from the dam should not cause downstream channel capacity to be exceeded during events for which the peak pool can be held to a maximum elevation of 83.0 with lesser releases, based on best available observed or forecasted inflow data. Key downstream USGS gaging stations are listed in Table 7-2.

TABLE 7-2

Key Downstream USGS Gaging Stations

USGS Gage ID	USGS Gage Name	Distance below Dam [River Miles]	Estimated Flood Flow Travel Time
08040600	Neches River near Town Bluff, TX	1.8	6 hours
08041000	Neches River at Evadale, TX	59.1	3 days

b. Regulation of Conservation Storage. The maximum authorized rate of withdrawal from B.A. Steinhagen Lake for the use of the LNVA is 2,000 cfs. When the reservoir level is at or below elevation 83.0, controlled releases, for conservation purposes, will not exceed 2,000 cfs, and releases will generally be managed to maintain the pool level at about elevation 82.5 insofar as practicable. See also Table 7-3, Town Bluff Dam Reservoir Regulation Schedule, Regulation Schedule A - Conservation Releases (Pg 7-11).

Releases from the reservoir for conservation purposes will be made upon receipt of written requests from the LNVA. Releases for conservation purposes will normally be made via generation discharge from R.D. Willis power generating station. Changes in the rate of generation discharge from R.D. Willis are made by informing the Sam Rayburn Dam powerhouse duty operator of the required rate of generation discharge. The powerhouse duty operator will perform the actions necessary to provide the requested rate of generation discharge.

The water manager must remain cognizant of possible discrepancies between rated turbine discharge and discharge as determined from the prevailing stage-discharge relationship at USGS Gage #08040600 - Neches River near Town Bluff, TX (aka “the near gage”). Based on the experienced relationship of rated (reported) generation discharge versus rated discharge at the near gage, the water manager may be required to adjust their request for generation discharge such that generation discharge will produce the desired rate of reservoir release as defined by the near gage stage-discharge relationship. During periods of local rainfall, runoff from the drainage area between the dam and the near gage can also contribute to the discrepancy between reported generation discharge and rated discharge at the near gage.

c. Regulation of Minor Floods. A minor flood is one for which the reservoir can be operated so that the pool level will not exceed elevation 83.0 with a maximum release of 20,000 cfs. During minor floods, release from the reservoir will be controlled as described in paragraph 7-02.a (6) – Rate of Change in Release, and Table 7-3, Town Bluff Dam Reservoir Regulation Schedule, Regulation Schedule B – Minor Floods (Pg 7-11). Release from the reservoir will

equal the inflow when the pool level is at elevation 83.0 and inflow is in excess of conservation release requirements, until the rate of release exceeds the downstream channel capacity of 20,000 cfs.

In order to provide the additional storage space required to regulate a given minor flood without exceeding downstream channel capacity, it may be desirable to draw the pool down to as low as about elevation 81.0 (the lower limit of the normal operational pool range), if forecasts indicate a sufficient volume of inflow to satisfy conservation release requirements and to fill the reservoir to elevation 83.0 (the upper limit of the normal pool range) after passage of the flood peak.

d. Regulation of Major Floods. A major flood will cause pool elevation 83.0 feet to be exceeded. During major flood periods, reservoir release will be controlled as described in paragraph 7-02.a (6) – Rate of Change in Release, and Table 7-3, Town Bluff Dam Reservoir Regulation Schedule, Regulation Schedule C – Major Floods (Pg 7-12). When the inflow is greater than 20,000 cfs and the pool level is at or approaching elevation 83.0 and rising, release will be increased gradually to induce surcharge storage until the spillway gates are fully open with the pool level at elevation 84.0, in accordance with the Induced Surcharge Envelope Curve shown on Plate 7-5. This will prevent sudden or excessive increase in outflow until a surcharge elevation of 84.0 is reached. When the inflow exceeds the capacity of the gated spillway at pool elevation 84.0, the spillway gates will be fully open, the pool level will begin to rise, and no further operation of the gates is required until the pool level has receded to elevation 83.0. Between pool elevations 84.0 and uncontrolled spillway crest elevation 85.0, outflow becomes a function of the pool level and the gated spillway capacity. Above elevation 85.0, the outflow is a function of the pool level and the capacity of the gated and the uncontrolled spillways

e. Emergency Reservoir Regulation. If communications between the Fort Worth District Water Management Office and the Town Bluff Dam Project Office are disrupted, the Lake Manager, on his own initiative, will direct regulation of the reservoir as described in Exhibit C - Standing Instructions to Lake Manager until communication is restored.

7-06. Recreation.

a. Upstream Recreation. All recreation area access roads for both USACE-managed and out-granted areas are constructed above the top of conservation pool elevation 83.0. Access roads may be inundated as the lake level rises into the surcharge above elevation 83.0. This may cause some or all parks and recreation facilities to be temporarily closed. Several boat ramps become unusable as the lake level falls below elevation 81.0, and only one is usable between elevations 79.0 and 76.0. At elevation 76.0, no boat ramps remain usable.

b. Downstream Recreation. Requests for special releases will be considered as planned deviations in accordance with Section 7-15.d. The project office receives periodic inquiries concerning projected downstream flows by recreational users, but to date no requests have been made to adjust flows to accommodate recreation activities.

7-07. Water Quality. Although water quality is not an authorized purpose for Town Bluff Dam, compliance with Public Law 92-500 requires that all federal facilities be managed, operated, and maintained to protect and enhance the quality of water and land resources through conformance with applicable federal, state, interstate, and local substantive standards.

7-08. Fish and Wildlife. Fish and wildlife resources are managed by the State of Texas Parks and Wildlife Department. USACE support activities with regard to fish and wildlife include active management of invasive aquatic vegetation in cooperation with Texas Parks and Wildlife and the LNVA. . USACE also is responsible as the primary manager for all fee lands (including leases, licenses and easements), and provides timber management/oversight for timber stand improvement and salvage harvests, as well as the fire management program, both of which enhance wildlife value of federal lands.

7-09. Water Supply. The LNVA, a conservation and reclamation district, and an agency of the State of Texas, is engaged in the sale and distribution of Neches River waters to municipal, industrial, and agricultural consumers. The LNVA contributed \$5,000,000 toward the first cost of construction of Town Bluff Dam and Sam Rayburn Dam. As per the River and Harbor Act of 1948 (Public Law 858, Eightieth Congress, 2nd Session), Section 104, the LNVA is permitted to withdraw from the pool of Dam B (now Town Bluff Dam) not to exceed 2,000 cfs for its own use.

7-10. Hydroelectric Power. The R.D. Willis hydroelectric power plant, located about 1,600 feet left (east) of the gated spillway, is built into the center of a horseshoe in the left overbank overflow section that loops downstream of the primary alignment of the overflow section. Completed in 1990, the plant is equipped with two turbine generators that are operated remotely from the Sam Rayburn Dam powerhouse control room. Rated generation capacity is 4.0 MW per unit, and a minimum of 25 feet of head differential is required to attain rated generation capacity. The minimum generation threshold is about 400 KW (0.4 MW).

7-11. Navigation. Although the dam itself is not navigable, Town Bluff Dam and B.A. Steinhagen Lake were authorized as a part the Neches River-Angelina River Project, for which navigation is an authorized purpose. The re-regulation of the daily fluctuation in discharge from Sam Rayburn Dam serves downstream navigation interests in the vicinity of Beaumont by contributing to more consistent flows and stages in the lower Neches River.

7-12. Drought Contingency Plans. When the drainage basin is in a drought condition and the lake levels are lower than normal, refer to the Drought Contingency Plan for the Neches River Basin, Texas, Appendix III of the Neches River Master Manual. The plan presents a broad outline of actions necessary to manage the water resources of the Neches River Basin during a drought.

7-13. Flood Emergency Action Plans. The Flood Emergency Plan (FEP) contains detailed instructions and procedures to be followed by USACE personnel at the Town Bluff Dam Project Office to properly handle any event at the project that could develop into an emergency

condition. The most current edition of the FEP is located in the Geotechnical Office – Fort Worth District and is dated August 2013. Copies of this FEP are also available in the Fort Worth District Water Management Office and at the Town Bluff Dam Project Office.

7-14. Other. Under the USACE system for Dam Safety Action Classification (DSAC) ratings, Town Bluff Dam is currently rated as DSAC II, a rating of unsafe or potentially unsafe, characterized as “failure initiation foreseen or very high risk”. This classification was assigned during the Screening for Portfolio Risk Analysis (SPRA) effort, primarily due to potential for breaching of the uncontrolled spillway embankment section due to piping in the foundation or discharge at the overflow section causing failure of the overlay slab and then loss of underlying embankment. There is also concern that over-wash of the overflow section by heavy wave action in winter, when winds blow predominately from the north, might be a contributor to the void spaces and damage to the concrete overlay that led to emergency repairs in 2007. The Interim Risk Reduction Measure Plan (IRRMP) for Town Bluff Dam, last updated in April 2010, provides for a target maximum elevation of 81.5 from 01 November thru 31 March, and a target maximum elevation of 82.5 from 01 April thru 31 October. Following preliminary results of a Semi-Quantitative Risk Analysis (SQRA) conducted in 2013 and 2014, this pool restriction was modified to 81.5 from 01 December thru 28 February, and 82.5 from 01 March thru 30 November. The April 2010 version of the IRRMP also provides for daily dam safety inspections when the pool level rises to elevation 84.0 and 24-surveillance when the pool level rises to elevation 84.5.

7-15. Deviation from Normal Regulation. There are occasions when it is necessary or desirable to deviate from the water control plan for short periods of time. Prior approval for a deviation is obtained from the Southwestern Division Water Management Office (CESWD-RBT-W). The requirement for prior approval of action from CESWD may be suspended in emergencies. All deviations will be recorded and will be stored in electronic format. Analysis of the expected impacts of a proposed deviation will include consideration of its effect on dam safety. Deviation requests usually fall into the following categories:

a. **Emergencies.** Emergencies that can occur are drowning(s), failure of the operation facilities, and flushing of pollutants. Under emergency conditions necessary action is taken immediately by the Lake Manager (in cooperation with the Sam Rayburn Powerhouse Superintendent if involving the R.D. Willis Powerhouse), unless such an action creates an equal or worse condition. For emergencies, the Fort Worth District Water Management Office will be informed as soon as practicable as to the nature of the emergency and the subsequent response by telephone, email, or fax. A follow-up written documentation explaining the deviation will be furnished to the Southwestern Division Water Management Office as soon as practical.

b. **Unplanned Minor Deviations.** There are unplanned instances that create a temporary need for minor deviations from the normal regulation of the lake. These unplanned instances are not considered emergencies and require prior approval for deviations. Construction accounts for the majority of unplanned deviations. Possible reasons for unplanned deviations include stream crossings of pipelines, bridge work, embankment repair, utility placement, and other major

construction contracts. Requests for changing release rates can vary from a few hours to a few days.

Each request is analyzed on its own merit. Consideration is given to upstream and downstream watershed conditions, potential flood threats, conditions of the lake, and possible alternative measures. In the interest of maintaining good public relations, the requests for deviation are usually approved, provided that there are no adverse effects on the overall operation of the project, or other projects. Approval of these minor deviations will be obtained from the Southwestern Division Water Management Office.

c. Unplanned Major Deviations. There are unplanned instances that may be considered for major deviations from the normal regulation plan, but are not emergencies. Requests for changes in release rates generally involve short time periods ranging from a few hours to a few days in an effort to minimize damages or optimize benefits. Flood control releases account for the major portion of these incidents and typical examples include project pre-releases or flows exceeding downstream channel capacity.

Each request is analyzed on its own merit. In evaluating the proposed deviation, consideration must be given to the upstream and downstream watershed conditions, potential flood threats, condition of the lakes, and possible alternative measures that can be taken. Approval of these major deviations will be obtained from the Southwestern Division Water Management Office.

d. Planned Deviations. Each planned deviation is analyzed on its own merit. Sufficient data on flood potential, lake and watershed conditions, possible alternate measures, benefits to be expected and possible effects on other authorized and useful purposes will be presented with each deviation. Each recommended deviation is submitted in writing to the Southwestern Division Water Management Office for review and approval. An example of a planned deviation is a need to maintain or inspect an aspect of the project. Approval of such deviations will only be granted when the evaluations have been fully reviewed and verified to be necessary. Any concerns with “Dam Safety” will be taken into consideration as well with deviation approvals.

7-16. Rates of Release Change. The spillway tainter gates will normally be opened at a rate not to exceed one gate-foot per half hour, and closed at a rate not to exceed one-half gate-foot per half hour. See 7-02.a (6) for additional information regarding rate of change in release.

7-17. Operation Curves and Tables. Low-Flow Conduit, Full Open Gated Spillway, and Uncontrolled Spillway Rating Curves are shown on Plate 7-1. Partial Opening Spillway Gate Operation Rating Curves are shown on Plates 7-2 thru 7-4. Reservoir Regulation Curves for Major Floods (Outflow vs. Inflow) are shown on Plate 7-5. Emergency Reservoir Regulation Curves for Major Floods (Outflow vs. Rate of Pool Rise) are shown on Plate 7-6. Evaporation Curves for B.A. Steinhagen Lake are shown on Plate 7-7. The reservoir Area and Capacity Curves are shown on Plate 7-8. The tabulated Area and Capacity values are shown on pages T7.1-1 of this water control manual.

TABLE 7-3

Town Bluff Dam Reservoir Regulation Schedule

Regulation Schedule	Pool Elevation [ft]	Conditions	Operations
A - Conservation Release	Rising, Standing, or Falling	I. Pool level at or below elevation 83.0	Release at the rate requested by the LNVA, but not to exceed 2,000 cfs.
	Rising, Standing, or Falling	II. Pool level above elevation 83.0	Required flood release will normally be greater than 2,000 cfs; therefore, no special operation for conservation release is required.
B – Minor Floods (1)	Rising	I. Pool level below elevation 83.0 and forecasted not to exceed elevation 83.0 with release made under Schedule A, Condition I.	Same as Schedule A, Condition I.
	Rising	II. Pool level below elevation 83.0 and forecasted to exceed elevation 83.0 if the operation defined for Schedule B, Condition I is followed, but not to exceed elevation 83.0 if rates of release up to 20,000 cfs are made.	Base release on forecasted inflow, using Plate 7-5 as a guide to ensure pool elevation 83.0 will be attained at the end of the flood.
	83.0	III. Pool level at elevation 83.0 and inflow forecasted not to exceed 20,000 cfs.	Maintain pool level at elevation 83.0 by releasing inflow or required conservation release, whichever is greater.

TABLE 7-3 (continued)

Town Bluff Dam Reservoir Regulation Schedule

Regulation Schedule	Pool Elevation [ft]	Conditions	Operations
B – Minor Floods (cont.) (1)	Falling	IV. Pool level at or below elevation 83.0.	Same as Schedule A, Condition I.
C – Major Floods (2)	Rising	I. Pool level at or below elevation 84.0, or forecasted to exceed elevation 83.0 if release is held to a maximum of 20,000 cfs.	Releases will be made in accordance with Plate 7-5.
	Rising	II. Pool level above elevation 84.0.	No further operations are required since, under Schedule C, Condition I, all gates will be fully open when the pool level reaches elevation 84.0.
	Falling	III. Pool level above elevation 83.0.	No further operations are required until the pool level recedes to elevation 83.0; then maintain elevation 83.0 by releasing inflow or the required conservation release, whichever is greater.
(1) A minor flood is one for which the reservoir can be operated so that the pool level will not exceed elevation 83.0 with a maximum release of 20,000 cfs. (2) A major flood will cause pool elevation 83.0 feet to be exceeded.			

CHAPTER VIII – EFFECT OF WATER CONTROL PLAN

8-01. General. Town Bluff Dam is a multiple-purpose project that is used for surge regulation and is operated in conjunction with Sam Rayburn Dam as a water supply system for users in the Lower Neches River Basin. The lake is used for conservation storage, hydropower generation, recreation and wildlife management.

8-02. Flood Control.

a. Spillway Design Flood. A Spillway Design Flood study was performed for Town Bluff Dam at the time it was initially designed. A Definite Project Report on “McGee Bend, Dam “B”, Rockland, and Dam “A” Reservoir, Neches and Angelina Rivers, Texas, in 5 Volumes, Volume III, Dam “B” Reservoir” was prepared by USACE, Jasper Project Office in 1947. The Spillway Design Flood hydrographs for Town Bluff Dam (Dam “B”) and B.A. Steinhagen Lake were discussed in Appendix I, Hydrology of the report.

1. Spillway Design Storm. The selection of the Spillway Design Storm was based on the maximum storms that have occurred in the region of the Neches River Basin. Rainfall depth-duration curves for these storms were submitted to the Hydrometeorological Section of the River and Flood Division, National Weather Service for analysis. From their analysis, the Hydrometeorological Section submitted as their preliminary estimate of the maximum possible precipitation over the watershed above Town Bluff Dam site a total average depth of 18.9 inches in 72 hours. The depth-duration relation as recommended by the Hydrometeorological Section has been adopted as a basis for the Spillway Design Storm. The 6-hour values of rainfall scaled from the adopted depth-duration relation and the critical arrangement of the 6-hour values which were used as the Spillway Design Storm distribution for the Neches River Basin above the Town Bluff Dam site.

2. Minimum Infiltration Rates. The computed infiltration rates for the Neches River Basin above the principal gaging stations vary from a minimum of 0.02 to a maximum of 0.16 inch per hour. In estimating the run-off from the Spillway Design Storm a uniform infiltration rate of 0.05 inch per hour has been assumed. The assumption gave an estimated run-off 15.3 inches or 81.0 percent of the rainfall for the Spillway Design Storm. The rainfall-excess for the Spillway Design Storm is shown in Plate 8-1.

3. Unit Hydrographs. A study was made of the storms and hydrographs of run-off at the principal gaging stations in the Neches River Basin in order to determine unit hydrographs. Synthetic unit hydrographs were computed for selected gaging stations in the watershed and for the watershed above Town Bluff Dam site by use of Snyder Unit Hydrograph method. Values of coefficients (C_t and C_p) in Snyder’s equation were derived by a trial and error procedure at selected gaging stations in the Neches River Basin in connection with the hydrology studies for Rockland and Sam Rayburn Reservoirs. In these studies synthetic unit hydrographs were developed at the following selected gaging stations: Neches River near

Rockland, Diboll, and Neches, Angelina River at Horger and Lufkin, Striker Creek near Summerfield, and Attoyac Bayou near Chireno. The values of Ct and Cp were varied within reasonable limits until the synthetic unit hydrographs would reproduce the hydrographs for some of the larger floods at the above gaging stations. A synthetic unit hydrograph for natural flow at the Town Bluff Dam site was developed for 6-hour rainfall-excess by using a lag of 147 hours, a base length of 23 days, Ct of 6.00, and Cp of 310.

4. Spillway Design Flood Hydrographs. In order to determine the critical conditions of Spillway Design Flood at the Town Bluff Dam site, the Spillway Design Storm was distributed uniformly over the watershed above Town Bluff Dam and flood hydrographs were constricted under four conditions. Condition 1 is for natural conditions, with no authorized projects in operation on the watershed. Condition 2 assumes the authorized Rockland Reservoir to be in operation. Condition 3 assumes the authorized Sam Rayburn Reservoir to be in operation. Condition 4 assumes the authorized Rockland and Sam Rayburn Reservoirs to be in operation. As Rockland Dam was classified as deauthorized, the conditions 2 and 4 are not discussed in this section.

Under condition 1, a Spillway Design Flood hydrograph was determined for natural flow at the Town Bluff Dam site, based on synthetic unit hydrograph derived for the 7,585 square miles of drainage area above Town Bluff Dam site, 6-hour rates of rainfall-excess and a base flow of 2,000 cfs. The computed hydrograph has a peak discharge of 245,500 cfs and volume of 6,291,500 ac-ft. Under condition 3, it was assumed that spillway for the proposed Sam Rayburn Dam would be uncontrolled and had a net length of 400 feet with crest at elevation 173.0. Inflow hydrographs for the proposed Sam Rayburn Reservoir was computed for conditions of flow into full reservoir. The computed hydrograph has a peak discharge of 190,000 cfs. Plate 8-1 shows the Spillway Design Flood hydrographs under above two conditions.

In March 1956, a manual on “Reservoir Regulation Manual for Dam B Reservoir, Neches River, Texas” prepared for Town Bluff Dam and B.A. Steinhagen Lake, contained plans and procedures for regulation of the reservoir during both normal and flood conditions. The Spillway Design Flood hydrographs for Town Bluff Dam were discussed in Section II. As per the manual, the Chief of Engineers recommended that in view of the uncertainty regarding the sequence in which the authorized Rockland, Sam Rayburn and Town Bluff project were to be constructed, 220,000 cfs was adopted as the Spillway Design Flood peak discharge for the design of Town Bluff Dam under natural flow regime at the dam, even though 245,500 cfs computed as the peak discharge in 1947’s study. A spillway design peak discharge 190,000 cfs was adopted for Town Bluff Dam which includes Sam Rayburn Reservoir. This discharge was identical to the one adopted in the 1947’s study.

b. Standard Project Flood. In August 1980, a Spillway Design Flood study for B.A. Steinhagen Lake was prepared under the Dam Safety Assurance Program outlined in Draft ER 1130-2-417. The purpose of the study was to review the adequacy of Town Bluff Dam with respect to the hydrologic criteria provided in Hydrometeorological Report No. 51 (HMR-51) criteria, June 1978, subject: “Probable Maximum Precipitation Estimates, United States East of

the 105th Meridian”. The study consisted of hydrologic analysis for Town Bluff Dam Probable Maximum Flood (PMF) and Standard Project Flood (SPF), as discussed in the following sections. A new Spillway Design Flood study is currently being conducted by USACE, Fort Worth District. The information in this section will be updated once the new study is complete.

For the Standard Project Flood study, it was assumed that a Standard Project Storm would occur 5 days prior to the Probable Maximum Storm (discussed in Section 8-02, c. 1). The antecedent Standard Project Storm was assumed to have a total rainfall amount equal to 50 percent of the full Probable Maximum Storm rainfall amount. The Standard Project Storm rainfall was 14.17 inches or 50 percent of the full Probable Maximum Storm rainfall of 28.33 inches. It was assumed that the Standard Project Storm was centered in the same location as the Probable Maximum Storm and possessed the same ellipse characteristics as the Probable Maximum Storm. The details of Probable Maximum Storm are discussed in Section 8-02, c. 1.

The SPF hydrograph representing flow into full pool was computed using the same parameters in PMF analysis discussed in Section 8-02, c. 4 except rainfall was one-half of the Probable Maximum Storm rainfall distributed according to the Southwestern Division (SWD) distribution. The computed SPF hydrograph has a peak discharge of 150,863 cfs and a volume of 2,770,000 acre-feet. The SPF was routed through Lake Palestine, Sam Rayburn Reservoir and B.A. Steinhagen Lake through a series of flood control outlets. The reservoir level of B.A. Steinhagen Lake continued to rise during passage of the SPF and had reached elevation 84.28 feet by the beginning of the Probable Maximum Storm.

c. Probable Maximum Flood. The following paragraphs describe the details of PMF analysis in the 1980 study.

1. Probable Maximum Storm. The Spillway Design Storm rainfall above the Town Bluff Dam Site was determined in accordance with the method described in HMR-51. A Hopbrook reduction factor of 0.25 percent was applied to the Spillway Design Storm rainfall to account for shape and target effects. A hypothetical elliptical transposition of the PMF was used in the study. The resulting average over the area for a 96 hour rainfall total is based on critical centering of the hypothetical elliptical Probable Maximum Precipitation (PMP) at a location approximately 10 miles west of the town of Nacogdoches. The storm pattern is shown in Plate 8-2.

2. Minimum Infiltration Rates. The adopted infiltration rates were taken from “The Definite Project Report on McGee Bend, Dam “B”, Rockland, and Dam “A” Reservoirs, Neches and Angelina Rivers, Texas - Volume III, Dam B reservoir, Appendix I, Hydrology”. The adopted rates include an initial loss of 0.6 inches and a uniform loss rate of 0.05 inches per hour. Application of these assumed losses to the Spillway Design Storm rainfall produced an estimated runoff of 23.68 inches, or 83.6 percent of the total rainfall for the Spillway Design Storm.

3. Unit Hydrographs. Unit hydrograph determinations were made for a total of 18 storms at 7 gages in and around the Neches River Basin. These unit hydrograph determinations were used as the basis for the adoption of a C_p 640 of 400. This value and the average time to peak, determined for each sub-area were adopted for use in Snyder's equations which were used as the basis for the derivation of synthetic unit hydrographs for each sub-area.

4. Unit Hydrograph for Flow into Full Lake. The total drainage area of 7,573 square miles above the Town Bluff dam site was divided into 25 sub-areas. The sub-area layout is shown in Plate 8-2. The method used for developing the unit hydrograph for these areas was as follows:

(a). The Lake Palestine surface area at the top of conservation pool (elevation 345.0) is 25,560 acres or about 39.9 square miles. The Sam Rayburn Reservoir surface area at the top of flood-control storage (elevation 173.0) is 142,700 acres or about 223 square miles. The B.A. Steinhagen Lake surface area at the top of gates and uncontrolled spillway (elevation 85.0) is 16,830 acres or about 26.3 square miles. The runoff from three lake surfaces was not included in the unit hydrograph for flow into full reservoir, but runoff rates for the lake surfaces areas were assumed equal to the rainfall rates and added directly to the computed SPF hydrograph.

(b). Unit hydrographs for the remaining sub-areas were determined using the method mentioned in Section 8-02, c. 3.

5. Routing Reach Parameters. Eleven routing reaches were used in the development of B.A. Steinhagen hydrologic model. Reach routings were performed using a modified puls method based upon a linear storage-discharge relationship for each reach. The linear storage-discharge relationship is a function of routing reach travel time. Travel time for each reach were estimated from the equation using a principal component regression analysis of 104 flood events on 12 reaches of the Neches, Angelina, and Sabine Rivers.

6. Reproduced Flood Hydrograph. The unit hydrographs and the routing reach storage-discharge relationships were tested by reproducing the hydrograph at the Neches near Rockland gage, and the Angelina near Lufkin gage for the storm of April 22 to May 3, 1966 centered near Swan, Texas. Initial infiltration losses used in the reproduction varied from 2.73 inches to 5.77 inches. Uniform infiltration loss rates used varied from 0.02 inches/hour to 0.15 inches/ hour. Observed travel times were used for the gaged routing reaches. The peak discharge of reproduced flood is 27,632 cfs at Neches River near Rockland gage and 29,298 cfs at Angelina River near Lufkin gage.

7. Probable Maximum Flood Hydrographs. The PMF hydrographs representing flow into full pool was computed using the unit hydrograph developed for each sub-area, the routing reach parameters discussed above, the rainfall from HMR-51 was distributed according to the SWD distribution, the infiltration rates discussed above, and the runoff equal to the rate of rainfall from a lake surface of 39.9 square miles for Lake Palestine, 223 square miles

for Sam Rayburn Reservoir, and 26.3 square miles for B.A. Steinhagen Lake. The routing computations for flow into a full reservoir indicated that the lake would rise to a maximum level of 93.31 feet and the peak inflow would be 657,519 cfs and volume 9,564,194 acre-feet. Plate 8-3 shows the PMF inflow-outflow hydrographs and the reservoir surface elevations.

d. Other Floods. Based on historical data, the maximum known flood in the vicinity of the dam on Neches River was that of May 1953. The peak discharge during the period of record is 90,900 cfs and highest record pool elevation is 85.21 feet on 22 May 1953. Additional information on historical floods can be found in Section 4-06 of this manual.

8-03. Recreation. Facilities such as public boat ramps, docks, restrooms, picnic shelters, fishing piers, and campsites have been provided. Public use of USACE lakes is governed by Title 36 of the Code of Federal Regulations. The 10-year average annual visitation to B.A. Steinhagen Lake is 275,235.

A rise or fall in the pool elevation at B.A. Steinhagen Lake has some effect on the lands surrounding the lake, recreational facilities, and project visitation. A rise above elevation 83.0 temporarily restricts the use of many recreational facilities due to inundation or loss of access. Other effects associated with high water levels include the accumulation of driftwood, the degradation of surrounding vegetation, and increased shoreline erosion.

A substantial lowering of the pool elevation, due to water supply requirements or drought, exposes aesthetically unpleasing banks and mud flats, and creates a boating hazard due to increased shallow areas. Boat ramps and beaches may also become unusable during drawdown periods. Although fluctuation of the pool level is unavoidable, the effects on recreational opportunities can be reduced by placing roads, utilities, and recreational facilities in locations less prone to flooding.

A number of invasive plant species have been detected on B.A. Steinhagen Lake with a detrimental effect on recreation, including Alligatorweed, Giant Salvinia, Hydrilla, and Water Hyacinth. In 2006, the lake was drained in an attempt to expose and freeze the plants during the winter months. An October 2007 survey conducted by the Texas Parks and Wildlife Department estimated that the extent of both Alligatorweed and Salvinia exceeded 3,000 acres. In 2012, a weevil that feeds exclusively on giant salvinia successfully destroyed about 150 acres of the invasive plant on B.A. Steinhagen Lake near Woodville in East Texas, according to a statewide giant salvinia management program.

8-04. Water Quality. Water Quality is not an authorized purpose at B.A. Steinhagen Lake, but available data indicates that generally good water quality conditions exist. Additional water quality data can be found in Section 4-08.

8-05. Fish and Wildlife. The management of fish and wildlife resources is conducted in cooperation with the Texas Parks and Wildlife Department and U.S. Fish and Wildlife. The species of fish that the Texas Parks and Wildlife Department has stocked the lake with are:

largemouth bass, spotted bass, catfish, crappie, white bass, and sunfish. Resident wildlife on lands surrounding the lake include species such as alligator, white-tailed deer, gray squirrel, fox squirrel, swamp rabbit, cottontail rabbit, otter, mink, raccoon, bobcat, red fox, gray fox, opossum, nutria, beaver, and eastern skunk. Game birds include Bob White quail, mourning dove, wild turkey, American wood cock, mallard, wood duck, American widgeon, gadwall, pintail, blue and green-winged teal, scaup, redhead, canvas back, ring-billed duck, Canada geese, snow geese, and blue geese.

8-06. Water Supply. The Lower Neches Valley Authority (LNVA), an agency of the State of Texas, contributed \$2,000,000 toward the construction of the Town Bluff Project. In return, LNVA is authorized to draw from the lake a maximum of 2,000 cfs. This water allotment is available to the agency whenever needed, and in the instances of demand, the water is discharged through the Town Bluff Dam tainter gates and the hydropower facility (refer to Chapter 7). However, if the lake's normal pool capacity is not adequate to satisfy the requirements over an extended period of time, Sam Rayburn Dam can release conservation water into B.A. Steinhagen Lake, in coordination with the Southwestern Power Administration, which will in turn release the water to meet downstream demands.

8-07. Hydroelectric Power. B.A. Steinhagen Lake provides head for the R.D. Willis hydroelectric power and diversion into a hydropower discharge channel. The Southwestern Power Administration, U. S. Department of Energy, markets the power and energy generated by the hydropower plant to the Sam Rayburn Municipal Power Agency for distribution to its customers in Jasper, Liberty and Livingston, Texas.

8-08. Navigation. Town Bluff Dam operates with Sam Rayburn Dam to regulate the flow of the river for the benefit of navigation.

8-09. Drought Contingency Plans. The purpose of the Drought Contingency Plan is to provide a basic reference for water management decisions and responses to a water shortage in the Neches River Basin due to a drought. The Drought Contingency Plan provides a plan for implementing actions necessary for conservation of water supply depending on the severity of the drought and the reservoir level. This plan enables the Water Resources Branch to effectively coordinate with the public and other district elements during drought conditions.

8-10. Flood Emergency Action Plan. The Flood Emergency Plan (FEP) contains detailed instructions and procedures to be followed by USACE personnel at the Town Bluff Dam Project Office to properly handle any event at the project that could develop into an emergency condition. The most current edition of the FEP is located at the Geotechnical Office – Fort Worth District and is dated August 2013. Copies of this FEP are also available in the Fort Worth District Water Management Office and at the Town Bluff Dam Project Office.

8-11. Frequencies. B.A. Steinhagen Lake levels for the period of record, since deliberate impoundment began on 16 April 1951, are displayed in Plate 8-4.

a. Annual Peak Elevation Frequency. The annual peak lake levels for the period 1951 through 2014 were tabulated. The annual peak elevations were arranged in descending order and assigned median plotting positions. The elevation probability was derived from studies based on methods discussed in "Statistical Methods in Hydrology," by Leo R. Beard, dated January 1962. The annual peak elevation frequency curve is shown on Plate 8-4. Data from this analysis indicated that the fifty-year and the hundred-year flood frequency pool level to be 84.50 feet and 85.00 feet, respectively.

b. Lake Elevation Duration. The pool elevation duration curve shown on Plate 8-5 is based on the midnight lake elevations for the period 1 January 1965 to 30 June 2014. 15 March 1952 is the date B.A. Steinhagen Lake reached the top of the conservation pool for the first time. The curve shows the percent of time that the lake level equals or exceeds a given elevation.

c. Key Control Points. Key control points are located on Neches River at Evadale and Neches River near Town Bluff. Rating curves for the key control points are shown on Plate 4-17 to Plate 4-19, respectively.

8-12. Other Studies. The vision for the CWMS National Implementation Effort is to have all USACE watersheds fully modeled within CWMS. These models will be operated daily to provide decision support to local Water Managers and to have results automatically consolidated into standardized briefing tools within a CorpsMap for executive and public use. CorpsMap viewer supports visualization and analysis of the USACE infrastructure, and real-time display of atmospheric, coastal, critical infrastructure, and watershed data.

The CWMS Automated Information System was developed by the HEC under funding from the Water Management Community of Practice and has been implemented to varying degrees at USACE Water Management Offices. USACE offices apply CWMS data flow elements (data acquisition, verification, validation, transformation, storage, visualization, dissemination elements). For this effort, USACE Leadership, the Critical Infrastructure Protection and Resilience (CIPR) Program, and the Dam Safety Program have recognized the value of these watershed models to the Nation and have committed funding for watershed model development to support the needs of multiple programs.

CHAPTER IX - WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organizations.

a. Corps of Engineers. B.A. Steinhagen Lake is owned by the USACE. As the owner of the project, the Corps of Engineers is responsible for the overall operation and maintenance of the lake. The Lake Manager, operating through the Town Bluff Lake Office, Woodville, Texas, and the Engineering and Construction Division, is directly responsible for the Lake's maintenance and operation. Project reporting instructions are presented in Chapter V, and project operating instructions are presented in Chapter VII of this manual.

1. Responsibilities and Duties During Normal Operations. The Water Resources Branch, Engineering and Construction Division, Fort Worth District is charged with the following responsibilities and duties under the general supervision of the SWD Office in Dallas, Texas.

(a). Regulation of lakes and dissemination of data.

(b). Investigations and refinement of regulation procedures, including the following:

(1). Analysis of past floods.

(2). Reconnaissance to determine channel capacities.

(3). Improvement of forecasting techniques.

(4). Plan and coordinate the hydrometeorologic reporting network with the NWS and the USGS.

(c). Train personnel in flood control duties, including the following:

(1). Periodic visits to projects by the branch personnel to familiarize themselves with regulation facilities and become acquainted with the operating personnel.

(2). Instruct personnel of other branches in flood control procedures to supplement the Water Resources Branch during flood emergencies, when necessary.

(d). Prepare reports on lake regulation.

(1). Recurring reports.

(2). Water Control Manuals.

(3). Post Flood reports.

2. Responsibilities and Duties During Flood Emergencies. During flood emergency, the Water Resources Branch is responsible for the following:

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

(b). Provide analysis of the storm and effects of the flooding to the District Engineer and other District personnel.

(c). When necessary, furnish personnel to assist lake personnel in flood regulations.

(d). Regulation of lakes in accordance with flood control schedules.

(e). Furnish information to higher authority, which will include:

(1). Initial reports to the SWD and Office of the Chief of Engineers by telephone or E-mail.

(2). Provide information for situation reports.

3. Assignment of Personnel. During non-flood periods, personnel of the Water Resources Branch issue instructions for the routine regulation of the lake. However, during flood periods, assistance from other personnel may be required to maintain effective regulation of the lakes. The area and magnitude of the flood will determine the number of people engaged in each particular activity. Plate 9-1 shows the organization during flood control regulation.

4. Provision for 24-Hour Alert. The NWS and Lake Manager have been provided with a list of names and telephone numbers of key personnel of the Engineering and Construction Division with instruction to provide warning if unusual conditions occur. Responsible personnel are on duty at the Fort Worth District Office 24 hours a day during flood emergencies and/or whenever project conditions warrant. Responsible personnel will be on duty or on call at the lake at all times.

5. Role of the Lake Manager. The Lake Manager will regulate the lake according to instructions issued by personnel of the Water Resources Branch. The instructions will follow the "Normal Regulations for Flood Control" and "Emergency Regulations for Flood Control" contained in Chapter VII and Exhibit E of this manual. If the Lake Manager loses communication with the District Office, he will immediately make every effort to reestablish communication while initiating emergency regulations for flood control. The Lake Manager will

make daily observations at the lake project's weather station and report those observations as directed in paragraph 5-07.

b. Other Federal Agencies. The NWS is officially responsible for issuing flood warnings to the public. The NWS provides weather and river forecast information, which is used to make real time operation decisions for B.A. Steinhagen Lake. The USGS develops and maintains stage versus discharge curves for each stream gage. The USGS also collects and maintains reservoir storage and water quality data for the USACE lakes in the Fort Worth District. The SWPA, U. S. Department of Energy, markets the power and energy generated by the hydropower plant to the Sam Rayburn Municipal Power Agency for distribution to its customers in Jasper, Liberty, and Livingston, Texas.

9-02. Interagency Coordination. The USACE, NWS, and the USGS cooperate to accumulate rainfall and streamflow data used in forecasting river stages, stream flows and lake levels. The Fort Worth District's Supplement A to ER 500-1-1 gives a list of Federal Agencies with which the District will coordinate in emergencies. The SWPA coordinates with USACE regrading releases from the project through the hydropower turbines.

a. Local Press and Corps Bulletins. The USACE, through their Public Affairs Office, makes press releases to the news media of flood situations in the area of concern. The Water Resources Branch may supplement this information with observed conditions and technical advice to enable local interests to obtain optimum flood protection and to perform rescue and relief functions. USACE further assists in flood fighting, through the office of the Emergency Operations, who furnishes sandbags and other necessary equipment based on equipment on hand and need.

b. National Weather Service. The NWS and USACE exchange hydrometeorologic data and reports in obtaining and disseminating data. This exchange of data is discussed in great detail in Chapter VI of this manual.

c. United States Geological Survey. The USGS and USACE cooperate in a program for the operation and maintenance of stream gages throughout the Fort Worth District. During floods, the USGS and USACE coordinate field activities to maximize the number of stream discharge measurements.

d. Other Federal, State, or Local Agencies. The Fort Worth District exchanges information with State government officials, Texas Department of Public Safety (TxDPS) Highway Patrol Division, and others during flood emergencies. The Fort Worth District also coordinates with State agencies concerning fish and wildlife throughout normal operation.

Since one of the functions of B.A. Steinhagen Lake is to reregulate the releases of Sam Rayburn reservoir, all releases from the two reservoirs are coordinated.

9-03. Interagency Agreements. The LNVA, an agency of the State of Texas, contributed \$2,000,000 toward the construction of the Town Bluff Project. In return, LNVA is authorized to draw from the lake a maximum of 2,000 cfs. This water allotment is available to the agency whenever needed, and in the instances of demand, the water is taken directly through the Town Bluff Dam tainter gates. However, if the lake's normal pool capacity is not adequate to satisfy the requirements over an extended period of time, Sam Rayburn Dam can release conservation water into B.A. Steinhagen Lake, in coordination with the Southwestern Power Administration, which will in turn release the water to meet downstream demands.

The Robert D. Willis Hydropower Project construction started in March, 1987 and the hydropower facilities became available for commercial operation on 17 November 1989. The hydropower project is a first-of-its-kind partnership between private enterprise and the U. S. Government in that the Sam Rayburn Municipal Power Agency (SRMPA) paid for the entire project in advance, rather than reimbursing the Federal Government over the life of the project. SRMPA is owned by the cities of Liberty, Livingston, and Jasper.

9-04. Commissions, River Authority, Compacts, and Committees. The TCEQ issues and regulates permits for water use in the State of Texas. The LNVA is informed of the lake regulations at B.A. Steinhagen Lake.

9-05. Non-Federal Hydropower. There are no non-federal hydropower facilities at B.A. Steinhagen Lake.

9-06. Reports. Table 9-1 lists reports prepared by the Water Resources Branch. The tabulation also describes when each report is required and the regulation requiring the report.

TABLE 9-1

Tabulation of Reports

Name of Report	When Required	Regulation Requiring Report
Daily Report	Daily	—
Monthly Reservoir Report	Monthly	ER 1110-2-240
Flood Situation Reports	During Floods	ER 500-1-1

Post Flood Reports	Following a Flood Causing Major Damage	ER 500-1-1
Annual Reports	Annually	ER 1110-2-240

a. Daily Report. The daily report is prepared by the Water Resources Branch. It contains water control information on most of the major lakes in the Fort Worth District. An example of daily report is shown on Plate 9-2. Copies of the report are sent to all subscribing offices and agencies. The daily report is also posted on the Internet at the following URL address: <http://www.swf-wc.usace.army.mil/>.

b. Monthly Reports. The Water Resources Branch prepares monthly reservoir reports in accordance with ER 1110-2-240. The monthly report, shown on Plate 9-3, is a tabular record of lake operations. It is prepared for all lakes under the supervision or of direct interest to the Fort Worth District.

c. Flood Situation Reports. The Water Resources Branch supplies the Emergency Operations Center (EOC) in the Fort Worth District with information in accordance with ER 500-1-1. This report contains hydrometeorological conditions for the area, the name of the lake, pertinent lake data, lake elevation, predicted maximum elevation and anticipated data, inflow and outflow rates in cfs, percent of flood control storage utilized to date, and any other data relevant to the flood situation. The EOC then provides the information to the appropriate government officials and community organizations concerned or effected by the flooding.

d. Post Flood Reports. The post flood reports are prepared in accordance with ER 500-1-1, when a flood has resulted in major damage. The report describes flood emergency operations performed by the USACE. Included are available hydrologic information, damage estimates, and other engineering data considered essential for flood control and flood plain studies performed to review possible damage claims against the United States. The report is prepared using information compiled by the Water Resources Branch and when completed, includes a paragraph on the final damage costs from the flood event, including damages to USACE property, parks, and other structures.

e. Annual Report. The Water Resources Branch prepares an annual report for the SWD Reservoir Control Center. The report summarizes general river basin conditions and the activities and accomplishments of the Water Resources Branch during the preceding year.

EXHIBIT A
SUPPLEMENTARY PERTINENT DATA

B.A. STEINHAGEN LAKE

EXHIBIT A

SUPPLEMENTARY PERTINENT DATA

B.A. STEINHAGEN LAKE

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1. GENERAL INFORMATION

Item	Description
Other Name for Project	Originally identified as “Dam B”, change to the name to “Town Bluff Dam and B.A. Steinhagen Lake” in July, 1967
Location	Neches River Basin, Texas Neches River, at river mile 113.7
Type of Project	Dam and Lake
Objective of Regulations	Multipurpose lake project for Water Supply, Hydropower, Fish and Wildlife, and Recreation.
Project Owner	USACE
Operating Agency	USACE The working hours of operation for weekdays are 0800 to 1645; Working hours for weekends and holiday vary. During flood emergency conditions 24-hour per day duty is the general procedure.
Regulating Agency	USACE
Water Supply Contracts	The Lower Neches Valley Authority (LNVA) has contracted with the Corps of Engineers for drawing from the lake a maximum of 2,000 cfs with an initial payment of \$2,000,000 toward the construction of the Town Bluff Project (Contract No. DA-41-443-CIVENG-57-20 dated 24 August 1956).
Project Cost	\$8,749,000
Deliberate Impoundment Date	April, 1951
Federal Power Marketing Administration	SWPA

2. LAKE INFORMATION

Feature	Elevation (Feet NGVD29)	Lake Area (Acres)	Storage (Acre-Feet)	Runoff (Inches)
Top of Dam	95.0	30,800	365,500	0.90
PMF Design Water Surface Elevation (1980 Study)	93.31	28,625	315,280	0.78
Maximum Design Water Surface Elevation (1947 Study)				
Top of Gates and Uncontrolled Spillway (1980 Study)	85.0	16,830	124,700	0.31
Normal Pool (upper) (2003 Survey)	83.0	10,687	66,972	0.17
Normal Pool (lower) (2003 Survey)	81.0	9,000	48,154	0.12
Invert of Sluice Intake (2003 Survey)	52.0	4	11	0
Gate sill and streambed (2003 Survey)	50.0	2	6	0
Conservation Storage	83.0	—	66,966	—

Item	Description
Real Estate (Fee Title)	Upper guide contour of elevation 88.0 feet. Fee simple title includes 21,644 acres
Real Estate (Flowage Easement)	Upper guide contour of elevation 88.0 feet. Flowage easement includes 1,157 acres
Range of Clearing	Below elevation 86.0 feet

2. LAKE INFORMATION (CONTINUED)

Item	Description
Lake length at top of conservation pool	8.0 miles from the dam to the most upstream shoreline
Shoreline length at top of normal pool	160 miles
Safety aspects	A warning horn will sound for 10 seconds to alert those downstream at least 2 minutes before significant changes in discharge.
Datum	All elevations referred to in Exhibit A, unless noted otherwise, are in feet, National Geodetic Vertical Datum of 1929 (NGVD29). The datum conversion from NGVD29 to NAVD88 is: NGVD29 + 0.0 feet = NAVD88 for Town Bluff Dam and B.A. Steinhagen Lake.

3. HYDROLOGY

Item	Description
Drainage Area	7,573 square miles
Volume from One-Inch Runoff	403,893 ac-ft
Spillway Design Flood (1947 Study)	
Design water surface elev.	93.0 feet
Duration of Storm	72 hours
Average Infiltration Rate	0.05 inches/hour
Total Volume of Rainfall	18.9 inches
Total Volume of Runoff	15.3 inches
Total Volume of Runoff (w/o Sam Rayburn)	6,189,400 ac-ft
Peak Inflow	220,000 cfs
Storm Type	Spillway Design Storm
Probable Maximum Flood (1980 Study)	
Maximum Water Design Surface elev.	93.31 feet
Duration of Storm	96 hours
Average Infiltration Rate	0.05 inches/hour
Total Volume of Rainfall	28.33 inches
Total Volume of Runoff	23.68 inches
Volume into full pool	9,564,194 ac-ft
Peak Inflow to full pool	657,519 cfs
Peak Outflow (reservoir level 93.31 feet)	
Gated spillway	39,000 cfs
Uncontrolled Spillway	618,481 cfs
Total	657,481 cfs
Storm Type	Probable Maximum Storm determined from HMR- 51 guidelines
Standard Project Flood (1980 Study)	
Maximum Design Water Surface elev.	84.28 feet
Duration of Storm	96 hours
Total Volume of Rainfall	14.17 inches
Peak Inflow	150,863 cfs
Total Volume	2,770,000 ac-ft
Climate	Moderate, with hot summers, and cool winters

3. HYDROLOGY (CONTINUED)

Item	Description
Average Precipitation (Gages listed in Table 4-3)	55 inches per year (1970-2010)
Average Evaporation from lake (Data listed in Table 4-4A)	44 inches per year (1954-2013)
Storm Type	Primarily local thunderstorms, frontal storms, and occasional Gulf Coast and Pacific hurricanes.
Flood Seasons	Primarily March through June, but floods can occur at any time of year
Low Flood Seasons	July through October
Minimum Monthly Inflow and Date of Occurrence	Zero (0) flow has occurred on many occasions
Minimum Annual Inflow and Date of Occurrence	620,598 ac-ft (in CY 2011)
Mean Annual Inflow	1,670,700 ac-ft (Oct 1961-Dec 2013 records)
Maximum Annual Inflow and Date of Occurrence	7,985,829 ac-ft (CY 1973)
Maximum Monthly Inflow and Date of Occurrence	2,983,312 ac-ft (May 1953)
Maximum Average Daily Inflow and Date of Occurrence	98,655 cfs (6 May 1944)
Maximum Instantaneous Inflow and Date of Occurrence	175,000 cfs (May 1884)
Maximum Flood Volume and Date of Occurrence	2,000,000 ac-ft between December 1991 and February 1992 (for period 1966-2010)

3. HYDROLOGY (CONTINUED)

Item	Description
Names and Locations of Key Stream Flow Stations	Upstream Neches River near Neches Neches River near Diboli Neches River near Rockland Mud Creek near Jacksonville Angelina River near Alto Attoyac Bayou near Chireno Ayish Bayou near San Augustine Downstream: Neches River near Town Bluff Neches River near Evadale Village Creek near Kountze Pine Island Bayou near Sour Lake Pine Island Bayou above BI Pump Plant, Beaumont Neches River Saltwater Barrier at Beaumont
Type of Hydrometeorologic Data Recorded at Damsite	Automatic water stage recorders to furnish continuous records of lake levels and river stage below the dam. Tile staff gages provide lake level and tailwater elevations. NWS station at the dam consists of: a rain gage, recording rain gage, Type A evaporation pan, anemometer and maximum-minimum thermometer.
Precipitation Stations Used in Hydrologic Forecasting (NWS)	San Augustine - Recording gage Nacogdoches – Recording gage Lufkin - Recording gage Woodville – Recording gage Town Bluff Dam – Recording gage Jasper – Recording gage
Number of Sediment Ranges	14 (Periodic surveys)
Number of Degradation Ranges	6 (Periodic surveys)

4. **EMBANKMENTS**

Item	Description
Location	Neches River Basin of the Neches River at river mile 113.7
Purpose	Impoundment
Type	Earth fill with protective concrete slab
Type of Fill	Compacted earth fill
Slope Protection	Lined with concrete slab
Height	95 feet above streambed
Length	6,698 feet including spillway
Top Elevation	95.0 feet
Freeboard	2.0 Feet
Used for Roadway	No
Elevation of Streambed	50.0 feet
Closure date	16 April 1951

5. SPILLWAY

Item	Description
Location	Right abutment in the river channel
Gated Spillway	
Crest Elevation	50.0 feet
Length	240 feet
Type	Concrete Ogee weir
Control	6 tainter gates, 40 feet by 35 feet
Capacity	39,000 cfs
(1980 Study, Lake elev. 93.31 feet)	
Uncontrolled Spillway	
Crest Elevation	85.0 feet
Length (Uncontrolled)	6,600 feet
Maximum outflow (1980 Study)	618,481 cfs
(1980 Study, Lake elev. 93.31 feet)	
Type of Energy Dissipator	Stilling basin with baffle blocks

6. OUTLET FACILITIES

Item	Description
<u>A. Control Gates</u>	
Location	On spillway structure
Purpose	Regulation of outflow
Type	Tainter gates operating machinery
Number and Size of Gates	Six 40 feet by 35 feet tainter gates
Entrance Invert Elevation	50.0 feet
<u>B. Low Flow Outlets Works (Non-Operational)</u>	
Location	Two parallel rectangular conduits in the right spillway abutment
Purpose	Discharge of conservation releases, and minor flood control
Type and Size of Outlet	Two 4 feet by 6 feet rectangular conduits
Type of Gate Control	Two tractor-type gates
Invert Elevation	52.0 feet

7. CONTROL POINTS

Item	Description
A. <u>Neches River at Evadale Gage, No. 08041000</u>	
Location	River mile 132.1 of the Neches River downstream of B.A. Steinhagen Lake
Purpose of control	To indicate the total flow at the gage, including releases from upstream reservoirs and local flow
Channel description	The bed and banks are composed of uniform loose sand with scattered sunken logs. The banks are steep. The overflow plan is heavily wooded. The channel is straight for 500 feet upstream and 200 feet downstream.
Drainage area	7,951 square miles
Treatment of uncontrolled runoff.	Contributes to target flow at gage
Target Flow Rate	20,000 cfs at Evadale Gage
Time of Water Travel From B.A. Steinhagen Lake	3 days to the Evadale Gage
Time of Water Travel from Evadale gage	2 days to Salt Water Barrier
Monitoring provisions	Recording river gage with DCP
Dikes or levees downstream	None

8. HYDROELECTRIC POWER FACILITIES

Item	Description
Location	Both Jasper and Tyler Counties
Purpose	Discharge for water supply and hydroelectric power generation
Type of Facility	Hydropower plant continuous runs to meet normal river flow
Maximum Output Capacity	Two 3,840 kilowatts generators
Type of Unit	Two horizontal Kaplan Turbines
Power on Line Date	17 November 1989
Normal Plan for Generation	Demand for downstream water supply and flood releases will be used to generate power
Speed	163.5 RPM
Rated Head	34 feet
Rated Flow	3,520 cfs with both units
Maximum Flow through Turbine:	
Max discharge based on 34 feet of head	3,250 cfs
Minimum discharge	1,280 cfs

8. DOWNSTREAM CONTROL STRUCTURES

Item	Description
A. <u>Neches River Salt Water Barrier at Beaumont, Texas</u>	
Location	Salt Water Barrier, river mile 27.7 on Neches River crossing Jefferson and Orange Counties, Texas
Purpose	Prevent salt water from intruding in the Neches River upstream of the city Beaumont, Texas
Type	Rolled earth fill dam 760 feet long, and 24.5 feet high
Navigation passages	Controlled by 2 sector gates 56 x 30 feet
Gate flow passages	Gate bays controlled by five 45 x 24.5 foot tainter gates. Net length 122.5 feet
Flood flow passage	650 feet overflow earthen with concrete broad crested weir 20 feet wide crest elevation 4.5 feet
Project owner	LNVA
Regulating agency	LNVA
Operation	The permanent salt water barrier went into operation in 2003. The salt water barrier control room is staffed 12 hours a day, 7 days a week and may be contacted at: (409) 898-0646.

EXHIBIT B

CONTRACT BETWEEN THE SOUTHWESTERN POWER ADMINISTRATION

AND THE UNITED STATES DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

OPERATING ARRANGEMENT

FOR

TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE, TEXAS

EXHIBIT "B"

OPERATING ARRANGEMENT

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OPERATING ARRANGEMENT
(Reservoir Regulation and Power Scheduling)

1. Authority. This Arrangement states the principles and procedures relating to reservoir regulation and power scheduling of Corps of Engineers Hydroelectric Projects within the Southwestern Division (SWD) and the Southwestern Power Administration (SWPA). This Arrangement was developed in compliance with Paragraph 4 of the Memorandum of Understanding (MOU) dated 23 July 1980 and the authority therein.

2. Revision or Termination. This Operating Arrangement shall be effective commencing on the date of execution and shall remain in effect until terminated upon 90 days prior written notice by either party. It is provided further, that this Operating Arrangement may be amended with the mutual written consent of both parties.

3. Obligations. SWD and SWPA agree on the following obligations:

a. Obligations of SWPA:

(1) The marketing and transmission of surplus (in excess of project requirements) power.

(2) The preparation of monthly estimates of generation requirements for each SWD project.

(3) The scheduling of power plants to meet system requirements.

(4) To contract for the sale of power generated at SWD projects.

b. Obligations of SWD:

(1) The regulation of SWD projects for authorized purposes and in accordance with Presidential directives.

(2) The daily operation and maintenance of electric generation and switchyard facilities at each SWD power plant.

(3) The planning of hourly, daily and monthly regulations of SWD projects.

(4) The preservation of project integrity.

c. SWD and SWPA agree to consult on load and resource requirements.

d. SWD and SWPA agree to undertake improvements in their respective computer facilities.

4. Procedures.

a. Power Allocations and Monthly Meetings.

(1) A monthly hydropower meeting will be held by SWPA on or before the last Thursday of each month to develop a 30-day operational plan, including allocations for the next month, and to review current operations, planned outages, transmission limitations, reservoir conditions (current and projected), and other items of mutual concern. The meeting may be conducted by telephone conference, providing each party approves.

(2) SWD will furnish SWPA recommended monthly available energy along with maximum and minimum energy quantities for their projects for the following month. Recommended monthly hydropower energies will consider the individual project rule curve, system guide curve, projected reservoir condition, and other beneficial reservoir uses. This information will be provided formally within four (4) working days prior to the monthly hydropower meeting.

(3) SWPA will furnish SWD its anticipated energy needs for the following month from SWD projects. Monthly hydropower needs will consider load requirements, the condition of the interconnected reservoir system, system guide curve, projected reservoir conditions, available capacity, inflow trends and the ability to obtain energy at a reasonable cost from other sources. This data will be available for two (2) days before the monthly hydropower meeting.

(4) Prior to each month's operations, an agreement between SWPA and SWD as to the proposed generation (hydropower allocation) to be accomplished at each SWD project will be obtained. A written confirmation of that agreement will be provided to SWD by SWPA. In the event that an agreement cannot be obtained at the monthly meeting, negotiations between the Administrator and Division Commander will commence.

b. Operation.

(1) General.

(a) SWPA will schedule the monthly hydropower production in accordance with the monthly agreement. However, in the event of special conditions or unforeseen events, SWPA may schedule hydropower production differently than specified in the monthly agreement, provided that these changes are arranged with the responsible SWD District Office prior to scheduling.

(b) Operation of SWD projects for hydropower operations within approved regulations will be handled between SWPA and the appropriate SWD District Office. Only in cases of disagreement concerning operations, will SWD become involved in the day-to-day operations described herein.

(c) Energy generation will commence or be adjusted when the dispatcher makes a request to the power plant operator. The power plant operator will verify that the request is within the limits agreed to between the two agencies and that it does not violate any special instructions issued by the District office. If these conditions are satisfied, the operator will commence generation to the requested limits as rapidly as conditions and equipment will permit. If the request exceeds the limits or violates the conditions previously established, the power plant operator will advise the dispatcher as to what generation is available from the power plant. It is the intent that, to the extent possible, dispatchers and power plant operators relay all problems to the respective control offices.

(d) Daily (prior to 10.00 a.m.), SWD District Offices will provide SWPA a 4-day forecast of inflow, pool elevations and any limiting constraints for each project.

(2) Flood Control Operations.

(a) During flood control operations, SWD District Office will furnish to SWPA a weekly statement of flood control objectives for the next seven days relative to individual pool regulations and planned release volumes. The release schedule will be furnished by phone until adequate computer interconnections are available.

(b) SWPA will plan its weekly generation schedule compatible with stated flood control release schedules for the week.

(c) SWD District Offices will make a daily declaration to SWPA of energy available or required releases. The minimum hydropower releases are listed in Table 1. Only under flood conditions as defined in paragraph 4(b)(4)(e) herein may generation be limited to less than shown in Table 1.

(d) SWD District Offices will provide SWPA, when possible, 48-hour notice of a change in operation that will affect power production.

(e) SWPA will reschedule generation between projects and/or obtain non-hydropower to meet its needs as expeditiously as possible to effect any reductions in project releases required by SWD District Offices for flood control needs.

(3) Conservation Operation.

(a) Each day prior to 3.30 p.m., SWPA will furnish the SWD District Offices updated hourly generation schedules for each project for the remainder of the current day and for the following day. Weekend and holiday generation schedules will be furnished by 3.30 p.m., on the last working day prior to the weekend or holiday and will also include the schedule for the next working day.

(b) SWPA will be responsible for daily hydropower operations to meet the needs of their customers and downstream release requirements shown in Table 2. Table 3 shows desirable downstream release requirements to be accomplished providing hydrologic conditions are favorable. Favorable hydrologic conditions are included in Table 3.

(c) SWPA will furnish SWD a weekly statement of their generation plans and objectives relative to pool manipulations, balancing operations, thermal purchases and other details which will provide an understanding of scheduling and generation patterns and the effects to be expected at each project. The weekly statement will be provided, if possible, by 2:00 p.m., on the preceding Friday and will include an estimate of daily release volumes from each project. This will be by telephone until such time as adequate computer interconnections are available.

(d) Release schedules by SWPA and the districts will consider project and system guide curves, pool zone criteria, drawdown limits, current and projected pool conditions, downstream needs, and the needs of other authorized uses of the project.

(e) Table 4 shows maximum drawdown rates within the conservation pool for applicable Corps projects.

(4) Special Operations.

(a) General. Normally, special operations will be coordinated by SWD Districts and documented in the minutes of the monthly hydropower meeting. Those special operations which have significant impacts on SWPA will be coordinated by SWD. If an emergency does not exist, SWD will consult with SWPA on alternatives and the impacts of these alternatives on the economics and reliability of the federal hydropower system. SWD will notify SWPA of the special operating limits which are necessary for the operation of its projects. Notification will be provided as soon as each special operating limit is determined. Written or teletype confirmation of each special operation limit will be transmitted by SWD to SWPA. Such notifications and confirmations will include the nature of the limit, the firmness of the limit, its probable duration, and the reason for the limit.

(b) Short Term Power Emergency. It is recognized that certain situations which adversely affect system reliability may occur. Such circumstances demand a rapid response to prevent deterioration of the system reliability. The necessary response may involve a deviation from previously agreed to schedules. These situations (short term emergencies) typically involve overloaded facilities and/or low voltage and may arise slowly, as when due to high power demands, or suddenly, as when due to the loss of a line, station, or generator on the SWPA or a neighboring system. When possible, the response deemed necessary by the SWPA dispatcher will be coordinated prior to scheduling with the appropriate SWD District office.

When the required response time does not permit prior coordination the power plant operator will follow the direction of the SWPA dispatcher within limits specified in Table 5 and the safe operating limits of the generating, transforming and switching equipment, and the necessary coordination will begin as soon as practical. Table 5 lists the minimum time required for each project to respond to a generation change under normal and emergency conditions.

(c) Declared Power Emergency. It is recognized that SWPA has obligations to its customers, the Southwest Power Pool, and the regional power industry to maintain its reliability and prevent power failures and brownouts. In the event that conditions arise which require power and energy in excess of the amount which the Division Commander and Administrator have mutually agreed to be available from hydro sources, and in excess of that normally available from thermal sources, the Administrator will act to acquire needed power and energy from other sources. If this is not sufficient, the Administrator, after advising the Division Commander, may declare a power emergency. The Division Commander's concurrent declaration of operating limits will be based on relaxation of the five limitations listed in this paragraph to the maximum extent that the emergency justifies and considering any unusual situations that may exist at that time.

- (i) Would not require the safe limits of the generating, transforming and switching facilities, and appurtenant equipment of said projects to be exceeded or otherwise cause damage to the same.
- (ii) Would not conflict with the statutory requirements for the operation of said projects with regard to authorized purposes such as flood control, navigation, irrigation, water supply, and recreation, etc,
- (iii) Would avoid, insofar as practicable, harmful effects on the environment, including established fish and wildlife resources and recreation.
- (iv) Would not infringe upon the vested property rights of third parties.
- (v) Would not be inconsiderate of the effect on any major downstream construction or maintenance activities by public or private entities.

(d) Short Term Emergency. Short term emergencies requiring a reduction in releases such as for drowning, imminent loss of life or property, emergency maintenance or to preserve the

integrity of the project may be coordinated directly between SWD powerhouse personnel and SWPA dispatcher. Information documenting the emergency and the actions taken shall be forwarded to SWPA at the earliest possible time.

(e) Flood Constraints. SWPA recognizes that the SWD has the responsibility to minimize flooding to the extent possible by the regulation of Federal projects. Hydropower generation will be constrained to the extent possible during flood periods to prevent reservoir releases from adding to downstream flood damages. Normally, the constraints on power generation at SWD projects during flood periods will not be less than the minimum hydropower releases as shown on Table 1. However, conditions may occur where it is desirable for reservoir releases to be reduced below the Table 1 values to prevent or reduce downstream flooding. In this event, the SWD district office will notify SWPA of the restriction and its estimated duration. SWPA, if possible, will take action to reschedule generation such that the restriction can be accomplished. If this proposed restriction of power generation results in a determination by SWPA that a significant economic loss to the Federal Government or to SWPA customers would result, SWPA shall report that impact to the SWD district. Upon receipt of the SWPA finding of significant economic impact, the district shall increase the permissible release to the Table 1 value or request SWD to formally establish the constraint with documentation to SWPA describing the need, duration, and impacts of the constraint. If under such constraints as established by SWD, SWPA determines there is not enough power and energy available to maintain electric service to consumers in the marketing area, the Division Commander, based on the information provided by the respective SWD district offices and SWPA, will declare sufficient energy available by project to meet minimum needs.

(5) Individual Project Regulation and System Hydropower Operation. To enhance the working relationship between SWD and SWPA and to form a basis for general concurrence on how the individual projects and the power system will be operated, the following will be undertaken:

(a) SWD will provide Water Control Manuals to SWPA for information and comment before final adoption. Table 6 is a list of applicable projects.

(b) SWD will provide operating guide curves and pool zone criteria for each of the SWD hydroelectric projects within the SWPA marketing area. Subsequent changes of and addition to operating guide curves will be transmitted by letter from the Division Commander to SWPA. The SWPA will comment by letter.

(c) The parties will undertake cooperative effort to establish a system guide curve that will reflect SWPA and SWD needs, including defining the periods that supplemental power may be purchased to offset the power demands.

(d) SWD will provide any update of plant efficiency curves (included in this agreement by reference) for maximizing power performance at individual projects as shown in Table 7.

(e) The Administrator will furnish SWD power sales contract for information. In addition, those contracts providing for the sale of power generation from Projects listed by name in the contracts will be furnished to the Division Commander for comment prior to final approval.

(6) Generation Scheduling. Request for actual generation at a power plant will be given to the power plant operator by the SWPA dispatcher or dispatcher designated in writing by SWPA. To the maximum extent possible, these directions will conform with the generation guidelines agreed to by the appropriate representatives of SWPA and the SWD.

(7) Generating Equipment Maintenance Schedule. The planned outage schedule will be prepared by the SWD in January each year and will be furnished to SWPA by February 1. The SWD will make every effort to avoid scheduling outages during power system peak load periods (Jun 15 - Sep 15 and Dec 15 - Mar 15). SWPA requests for schedule changes shall be submitted to SWD in writing within 30 days after receipt of the schedule. SWD will accommodate the requests to the maximum extent practicable within available resources, including manpower resources. SWPA requests for rescheduling during the course of the year due to unanticipated load requirements or water conditions, shall be transmitted to the SWD by letter. SWD will furnish a timely response. Changes to the schedule initiated by SWD during the course of the year will be coordinated with SWPA. A revised schedule will be prepared and distributed if any significant changes are made during the year. The SWD will give SWPA as much advance notice as possible in the event of unplanned or forced outages.

(8) Switching Activities. All switching at SWD power plants which may affect the high-voltage transmission system or the availability of a unit will be coordinated with each party. Detailed procedures governing clearance and hold orders will be developed and included as a part of the Arrangement.

c. Reporting. The following summary of reporting requirements is not intended to include all aspects of data and information exchange needed between the SWPA and SWD elements.

(1) Daily observed hydrologic data, forecasts, flood control release requirements and schedules will be supplied by telephone between SWPA and SWD District Offices. Summary confirmations will be supplied on the computer data file program to the extent possible.

(2) Weekly plans and schedules will be exchanged by SWPA and SWD District Offices by telephone until adequate computer interconnections are available. At that time, these will be furnished through the interconnected facilities.

(3) Notifications of constraints, emergencies or revisions will be furnished by telephone with computer data file confirmation. All elements will be included in the notification for coordinated approvals and actions. Follow-up teletypes or letters may be required for official documentation.

(4) Special needs or operations will be furnished by telephone with follow-up teletype or letter between SWPA and SWD with copies to appropriate SWD District Office. When possible these may be covered in monthly hydropower meetings and documented in the meeting minutes without additional correspondence.

(5) Monthly hydropower meeting minutes (including pre-meeting summaries, agenda, needs, recommendations and follow-up allocations) will be furnished by teletype or letter to all elements.

(6) Record of actual hydropower generated during the previous month will be provided for each project by SWPA by mail until adequate computer connections are available.

(7) Records of hourly generation and water releases for each power plant will be furnished to SWPA.

TABLE 1
MINIMUM HYDROPOWER RELEASES
DURING FLOOD CONDITIONS

<u>Reservoir</u>	<u>Allowable Daily Release</u>	
	<u>Volume (DSF)</u>	<u>Energy (MWH) (1)</u>
Beaver	950	332
Broken Bow	850	290
Bull Shoals	3,750	1,352
Denison	2,300	429
Eufaula	2,150	358
Fort Gibson	1,800	197
Greers Ferry	1,200	404
Keystone	1,500	216
Norfork	1,300	410
Sam Rayburn	1,150	161
Table Rock	2,550	943
Tenkiller Ferry	600	160
Whitney	500	86

(1) Energy values represent the energy produced by the daily release volume when pool elevation is at top of power pool.

TABLE 2

WATER RELEASE REQUIREMENTS
FOR INTSTREAM FLOW NEEDS

Project	Period of Time in Effect	Forecast Air Temperature (Degrees Fahrenheit)							
		90 or Below		91 - 95		96 - 104		105 and above	
		Generation (MWH)	Discharge (DSF)	Generation (MWH)	Discharge (DSF)	Generation (MWH)	Discharge (DSF)	Generation (MWH)	Discha. (DSF)
Beaver1/	May 1 - Oct 15	29	85	43	125	56	165	68	200
Table Rock	May 1 - Dec 1	34	100	48	140	60	175	68	200
Bull Shoals	May 1 - Oct 15	80	250	120	375	160	500	240	750
Norfork	May 1 - Oct 15	40	145	60	218	80	290	100	360
Greers Ferry2/	May 1 - Oct 15	35	115	45	150	54	175	69	225
Keystone	Jan - Dec	Minimum release is 140 MWH, 1,000 DSF three times/week. Example: Monday, Wednesday, and Friday; Tuesday, Thursday, and Saturday.							
Broken Bow	Jan - Dec	Maintain 100 CFS from re-regulation structure, require minimum of 250 MWH, 750 DSF twice a week (separate by 3 days).							

1/ If feasible, minimum one hour morning and afternoon.

2/ Increase required release by 50 percent on one day of a 3-day period.

TABLE 3

DESIRABLE
WATER RELEASE REQUIREMENTS
FOR INSTREAM FLOW NEEDS

PROJECT	PERIOD OF TIME IN EFFECT	WATER RELEASE REQUIREMENTS	FAVORABLE HYDROLOGIC CONDITIONS
Dardanelle	Jan - Dec	Maximum 50-hour down time (minimum generation is 1,750 MWH 1/ per week, or inflow, whichever is less). Use at least 25 percent weekly total on Monday and Friday when minimum weekly generation scheduled.	Not restricted.
Denison	Jan - Dec	Generate at least one hour with one unit every fourth day, or as needed to replenish oxygen content of water in the tailrace and stilling basin.	Above elevation 612.0
Eufaula	Jan - Dec	Generate at least one hour with one unit every fourth day, or as needed to replenish oxygen content of water in the tailrace and stilling basin.	Not restricted.
Tenkiller Ferry	Oct 16 - May 31 Jun 1 - Oct 15	One Hour 10 MW Morning and Afternoon. One Hour 10 MW Morning and Afternoon.	Not restricted.
Bull Shoals	May 1 - Oct 15	The minimum combined operation at Bull Shoals and Norfolk shall not be less than a 3-day summation of 6,000 DSF (approximately 2,000 MWH). This applies for all air temperature conditions at or above 85 .	Above elevation 649.0
Norfolk	May 1 - Oct 12	Same as above.	Above elevation 545.0

1/ Minimum generation is based on 3,000 DSF.

TABLE 4
MAXIMUM DRAWDOWN
RATES IN CONSERVATION POOL

<u>Project</u>	Maximum Drawdown Per Week (ft)	Maximum Drawdown In Any Consecutive 4-Week Period (ft)
Beaver	2.0	6.0
Norfolk	1.5	5.0
Greers Ferry	1.0	4.0
Table Rock	1.5	4.5
Bull Shoals	1.5	4.5
Keystone	1.0	3.0
Tenkiller Ferry	1.5	4.5
Eufaula	1.0	3.0
Denison	1.0	3.0
Broken Bow	2.0	6.0
Sam Rayburn	1.0	2.0
Whitney	1.0	3.0

EXHIBIT C

CONTRACT BETWEEN THE LOWER NECHES VALLEY AUTHORITY OF TEXAS

AND THE UNITED STATES OF AMERICA

FOR

WATER STORAGE SPACE IN B.A. STEINHAGEN LAKE, TEXAS

CONTRACT
CONSERVATION STORAGE
McGEE BEND DAM AND DAM B RESERVOIRS

CMB

Contract No. DA-11-143-CIVENG-57-20

This contract entered into this 24th day of August, 1956, by and between the UNITED STATES OF AMERICA (hereinafter called the Government) represented by the Contracting Officer executing this contract, and the LOWER NECHES VALLEY AUTHORITY, an agency of the State of Texas in the City of Beaumont, Texas (hereinafter called the Authority), WITNESSETH THAT:

WHEREAS, in Senate Document Numbered 98, 76th Congress, 1st Session, the Chief of Engineers recommended construction of Rockland Reservoir on the Neches River, McGee Bend Reservoir on the Angelina River, and two power re-regulating dams, A and B on the Neches River below Rockland Dam, for the benefit of navigation, the control of floods, the conservation of water, the generation of hydroelectric power, and for other beneficial purposes incidental thereto, subject to the provision that, before construction was started on any element of the project, the State of Texas or other responsible local agency give assurances satisfactory to the Secretary of War that upon completion of the entire project it would contribute toward the first cost of the work the sum of \$5,000,000; and,

WHEREAS, construction of the improvements, in accordance with the plan presented in Senate Document 98, is authorized by the River and Harbor Act approved March 2, 1945 (Public Law 11, 79th Congress, 1st Session); and,

WHEREAS, the River and Harbor Act of 1948, approved June 30, 1948 (Public Law 858, 80th Congress, 2d Session) modified the existing project for the Neches and Angelina Rivers, Texas, adopted in the River and Harbor Act approved March 2, 1945, "so as to provide that the local agency which gives assurances that upon completion of the entire project it will contribute toward the first cost of the work the sum of \$5,000,000 shall be permitted to withdraw from the pool of Dam B not to exceed 2,000 cubic feet of water per second for its own use"; and,

WHEREAS, the Authority is a duly authorized and created State governmental agency, body politic and corporate, created as essential for the accomplishment of the purposes of Section 59 of Article 16 of the Constitution of the State of Texas, to the extent authorized in the creating act; and,

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WHEREAS, the Authority, on January 29, 1947, in compliance with provisions contained in Public Law 114 and Senate Document 98, enacted a resolution assuring the Secretary of War that upon completion of Dam B Reservoir on the Neches River, it would contribute \$2,000,000 toward the first cost of the work and upon completion of McGee Bend Dam and its reservoir on the Angelina River, it would contribute \$3,000,000 toward the first cost of the work; and,

WHEREAS, the aforesaid assurances were accepted by the Under Secretary of War on March 27, 1947; and,

WHEREAS, the Authority, by resolution enacted September 26, 1947, amended the resolution of January 29, 1947, to provide for assurance to the Secretary of War that, at any time after the Congress appropriated sufficient funds for the construction of Dam B and its reservoir which would by the addition of \$2,000,000 be sufficient to complete Dam B and its reservoir that, upon demand by the Secretary of War the Authority would contribute the said \$2,000,000 toward the cost of construction of Dam B and its reservoir and upon completion of McGee Bend Dam and its reservoir on the Angelina River it would contribute \$3,000,000 toward the first cost of the work; and,

WHEREAS, the amended assurance was accepted by the Secretary of the Army on November 13, 1947, and the Authority paid to the Government the sum of \$1,500,000 on October 3, 1949, and \$500,000 on July 17, 1950 for the completion of Dam B; and,

WHEREAS, the Authority, by resolution enacted September 8, 1955, amended and supplemented assurances theretofore made, and assured the Secretary of War (Army) that upon completion of McGee Bend Dam and its reservoir, in addition to the \$3,000,000 in cash which the Authority had theretofore assured that it would pay to the Government, that each year thereafter the Authority would pay to the Government the sum of \$200,000 per year for a period of fifty (50) years.

NOW, THEREFORE, the parties hereto do mutually agree as follows:

ARTICLE 1. WATER RELEASES.- The Government agrees, to the extent that water is available in the McGee Bend Reservoir above elevation 1149, to make releases of water from McGee Bend Reservoir as required for the generation of power, with such releases at least sufficient to generate power equivalent to 42,200 kilowatts for a minimum period of 75 hours per month for each of the six monthly periods from mid-April through mid-October of each year. The Government reserves the right to utilize the releases made from McGee Bend Reservoir as may be necessary for the operation of a pumped storage installation to meet scheduled power demands if such an installation is provided.

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The Authority shall have the right to order releases from Dam B, subject to the provisions of Section 104, Public Law 858, 80th Congress, 2nd Session, to be made by the Government at any time so long as such releases when combined with local runoff below Dam B will not cause flooding, ~~and to the extent that such releases from Dam B are compatible with successful operation of a pumped storage installation at McGee Bend Reservoir if such an installation is provided.~~

The Government reserves the right to take such measures as may be necessary in the operation of McGee Bend Reservoir and Dam B Reservoir to preserve life or property.

(See Insert "A" attached hereto)

INSERT "A"

The obligation of the Government under Article 1 is subject to such limitations as are imposed by Federal statute including the Rivers and Harbors Act of March 2, 1945 (P.L. 14, 79th Congress) and, without affecting any of the obligations of the Authority, the Government will be relieved of its obligation to make releases of water in accordance with Article 1 in the event the Authority does not have or fails to obtain the right to use such water.

~~provided by the generation of hydroelectric power at McGee Bend Reservoir,~~ and in consideration of the previous payment by the Authority to the Government of \$2,000,000 toward the cost of construction of Dam B, receipt of which is hereby acknowledged, it is agreed the Authority shall pay to the Government:

(1) \$3,000,000 upon demand by the Secretary of the Army at any time after the Congress has appropriated sufficient funds for the construction of McGee Bend Reservoir which would, by the addition of \$3,000,000, be sufficient to complete the McGee Bend Reservoir.

(2) \$200,000 on the first day of January following completion of McGee Bend Reservoir and \$200,000/each year thereafter for a total period of fifty (50) years.

(3) In the event of delay or default in the payments contained in paragraph (2) of this Article, the Authority shall pay interest on such overdue payments at the rate of two and one-half percent (2½%) per annum thereon, compounded annually, and such interest shall be charged from the date such payments are due until paid.

ARTICLE 5. PERIOD OF CONTRACT. The period of this contract shall be fifty (50) years from the date the first payment of \$200,000 is due.

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The Authority shall have the right to order releases from Dam B, subject to the provisions of Section 104, Public Law 858, 80th Congress, 2nd Session, to be made by the Government at any time so long as such releases when combined with local runoff below Dam B will not cause flooding, ~~and to the extent that such releases from Dam B are compatible with successful operation of a pumped storage installation at McGee Bend Reservoir if such an installation is provided.~~

The Government reserves the right to take such measures as may be necessary in the operation of McGee Bend Reservoir and Dam B Reservoir to preserve life or property.

(See Insert "A" attached hereto)

ARTICLE 2. FEDERAL AND STATE LAWS.- This contract should not be construed to relieve the Authority from complying with any applicable Federal or State laws.

ARTICLE 3. REGULATION OF THE USE OF WATER.- The regulation of the use of water released from Dam B Reservoir shall be the responsibility of the Authority and shall not be considered a part of this contract.

ARTICLE 4. CONSIDERATION AND PAYMENT.- In consideration of the benefits anticipated to accrue to the Authority from the regulated flow provided by the generation of hydroelectric power at McGee Bend Reservoir, and in consideration of the previous payment by the Authority to the Government of \$2,000,000 toward the cost of construction of Dam B, receipt of which is hereby acknowledged, it is agreed the Authority shall pay to the Government:

(1) \$3,000,000 upon demand by the Secretary of the Army at any time after the Congress has appropriated sufficient funds for the construction of McGee Bend Reservoir which would, by the addition of \$3,000,000, be sufficient to complete the McGee Bend Reservoir.

(2) \$200,000 on the first day of January following completion of McGee Bend Reservoir and \$200,000/each year thereafter for a total period of fifty (50) years.

on the first day of January of

(3) In the event of delay or default in the payments contained in paragraph (2) of this Article, the Authority shall pay interest on such overdue payments at the rate of two and one-half percent (2½%) per annum thereon, compounded annually, and such interest shall be charged from the date such payments are due until paid.

ARTICLE 5. PERIOD OF CONTRACT. The period of this contract shall be fifty (50) years from the date the first payment of \$200,000 is due.

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ARTICLE 6. RENEWALS.- It is the understanding and expectation of the parties hereto that upon expiration of this contract the Authority shall have the right, subject to any required approval of appropriate State authorities, to negotiate for releases and other flows, then available, from the McGee Bend and Dam B Reservoirs. The terms of the new contract shall be subject to mutual agreement at the time.

ARTICLE 7. DEFAULT.- In the event that the Authority refuses or fails to comply with any of the terms of this contract, including the foregoing provisions with respect to payments, the Government reserves the right to terminate this contract, subject to the provision that delays in payment under Article 4(3) not in excess of three (3) years will not constitute default.

ARTICLE 8. OPERATION AND MAINTENANCE.- The Government shall operate and maintain the McGee Bend and Dam B Reservoirs owned by the Government. The Authority shall be responsible for operation and maintenance of all features and appurtenances which may be provided and owned by the Authority.

ARTICLE 9. RELEASE OF CLAIMS.- The Authority shall hold and save the Government, including its officers, agents, and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the releases made for or by the Authority as provided in Article 1, or as a result of the construction, operation or maintenance of any features or appurtenances owned and operated by the Authority.

ARTICLE 10. TRANSFER OR ASSIGNMENT.- The Authority shall not transfer or assign this contract nor any rights acquired thereunder nor grant any interest, privilege, or license whatsoever in connection with this contract without permission in writing from the Secretary of the Army; provided that this restriction shall not be construed to apply to any water which may be obtained from the releases from Dam B Reservoir by the Authority and furnished to any third party or parties nor any method of allocation thereof.

ARTICLE 11. OFFICIALS NOT TO BENEFIT.- No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE 12. COVENANT AGAINST CONTINGENT FEES.- The Authority warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or

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bona fide established commercial or selling agencies maintained by the Authority for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this contract without liability or in its discretion to add to the contract price or consideration the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 13. DISPUTES.- Except as otherwise provided in this contract, any dispute concerning a question of fact arising under this contract which is not disposed of by agreement shall be decided by the Contracting Officer, who shall reduce his decision to writing and mail or otherwise furnish a copy thereof to the Authority. Within 30 days from the date of receipt of such copy, the Authority may appeal by mailing or otherwise furnishing to the Contracting Officer a written appeal addressed to the Secretary, and the decision of the Secretary or his duly authorized representative for the hearing of such appeals shall, unless determined by a court of competent jurisdiction to have been fraudulent or capricious or arbitrary or so grossly erroneous as necessarily to imply bad faith, or not supported by substantial evidence, be final and conclusive; provided that, if no such appeal is taken, the decision of the Contracting Officer shall be final and conclusive. In connection with any appeal proceeding under this clause, the Authority shall be afforded an opportunity to be heard and to offer evidence in support of its appeal. Pending final decision of a dispute hereunder, the Authority shall proceed diligently with the performance of the contract and in accordance with the Contracting Officer's decision.

ARTICLE 14. APPROVAL OF CONTRACT.- This contract shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

ARTICLE 15. DEFINITIONS.- (a) The term "Secretary" means the Secretary of the Army; the terms "Secretary of the Army" or "Head of the Department" as used herein shall have one and the same meaning, and the term "his duly authorized representative" means the Chief of Engineers, Department of the Army, or an individual or board designated by him.

(b) The term "Contracting Officer" as used herein shall include his duly appointed successor or his authorized representative.

ARTICLE 16. ALTERATIONS.- The following alterations have been made in the provisions of this contract:

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

THE UNITED STATES OF AMERICA

By

Harry O. Fischer

HARRY O. FISCHER
Colonel, CE
Contracting Officer

(SEAL)

ATTEST:

G. R. Bauer

Nome Texas

(Address)

LOWER NECHES VALLEY AUTHORITY

By

W. F. Wood

President, Board of Directors

Approved:

22 Jan 1957

RECEIVED

Wilbur M. Baucke
Secretary of the Army

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I, G. R. Bauer, certify that I am
the Secretary of the Lower Neches Valley Authority, that W. F. Weed
who signed this contract on behalf of the Authority,
was then President, Board of Directors of said Lower Neches Valley Authority;
that said contract was duly signed for and on behalf of said Lower Neches
Valley Authority by authority of its governing body and is within the scope
of its legal powers.

IN WITNESS WHEREOF, I have hereunto affixed my hand and the seal of
said Lower Neches Valley Authority, this 24th day of Aug.,
1956.

(CORPORATE SEAL)

G. R. Bauer
Secretary

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EXHIBIT D

STANDING INSTRUCTIONS TO LAKE MANAGER

TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE

EXHIBIT D

STANDING INSTRUCTIONS TO LAKE MANAGER

TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE

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STANDING INSTRUCTIONS TO LAKE MANAGER TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE

I. GENERAL

1. Instructions. Detailed instructions to the project personnel at Town Bluff Dam and B.A. Steinhagen Lake are presented below.

a. Regulation. The Fort Worth District Water Management Office will normally issue instructions for the storage and discharge of water. In the event communications with the Fort Worth District Water Management Office are disrupted, the Lake Manager will direct regulation in accordance with the Emergency Regulation guidance provided in Section II of this exhibit.

b. Data Reporting. The Water Management Office is staffed from 0700 hours to 1600 hours daily, and 0700 hours to 1100 hours on weekends and holidays (except Christmas Day). During these hours reservoir regulators may be reached via telephone at 817-886-1551, via e-mail at ceswf-od-l@usace.army.mil, or (as a backup) via FAX at 817-886-6472. Outside of these hours the Water Management Office Duty Regulator may be reached via mobile telephone at 817-791-0973, or, as a backup, via the above e-mail address. The Sam Rayburn Powerhouse Duty Operator may be reached 24-hours per day via telephone at 409-384-5292, or via FAX at 409-384-9754.

(1). Daily Report. Each day lake and hydrometeorological data will be submitted to the Fort Worth District Water Management Office between 0800 and 0830 hours. The primary means of submission will be the Internet at <http://www.swf-wc.usace.army.mil>. The secondary means of submission will be via telephone, and FAX may be used as a backup. The following data should be included in the daily report.

(a). Weather. For the 24-hour period preceding 0800 hours each day, report cumulative precipitation and evaporation values, in inches, and the maximum and minimum experienced temperature readings.

(b). Gate Settings. Gate number of each open gate, with the height of opening in feet as of 0800 hours on the date of report.

(c). Spillway Discharge. In the event discharge occurs over the uncontrolled spillway, report the respective dates and times discharge begins and ends.

(d). Hydropower. Hydropower release information will be included in the daily report.

(2). Reporting Severe Weather. During normal project duty hours, including weekends as applicable, severe weather will be reported as it develops, to include information and data that may be requested by the Water Management Office. Severe weather conditions outside of normal project duty hours will be reported when and as requested by the Water Management

Office.

(3). Reporting Gate Operations. Upon completion of any change in gate settings, details of the gate operations will be reported to the Water Management Office via telephone, e-mail, or FAX (as backup). The report shall include the gate settings prior to change, the date and time of beginning of change, the date and time of completion of change, and the gate settings upon completion of change.

c. Reporting Unusual Events. Events or conditions not normally encountered in the routine operation of the dam and lake that might endanger the integrity of the dam or necessitate temporary or permanent revision of the operating procedures shall be promptly reported to the Operations Division and the Water Management Office. Settlement, movement, or cracking of the earth embankment or abutments, unusual change in seepage rates or development of new seepage areas, landslides, rockslides, displacement of riprap, or indication of an impending movement should be reported to the Dam Safety Program Manager in the Geotechnical Office. Any changes to the outlet works or spillway including structural settlement or movement, cracking, or vibrations, mechanical malfunction or failure shall be reported immediately to the Water Management Office and the Dam Safety Coordinator. Reference the Town Bluff Dam **Flood Emergency Plan** should an event occur indicating any degree of jeopardy to the safety of the dam or to the safety of the public. The stilling basin and protected/armored downstream areas must be visually monitored closely during all high releases. Outside of normal duty hours one of the persons listed on the Fort Worth District Notification List for B.A. Steinhagen Lake will be notified, and the Duty Regulator of the Water Management Office will be notified at mobile phone 817-791-0973.

d. Warnings. It is the responsibility of the Lake Manager to maintain a list in current status of residents, and/or property, which would be endangered or inconvenienced by large and/or prolonged releases, and to give adequate warning of such impending releases. Notification will be made by whatever means are available, in accordance with current Fort Worth District emergency notifications protocol. In every case, before an increase in release rate is made, a warning horn shall be sounded and the area immediately below the stilling basin visually checked for person(s) in a dangerous area.

e. Gate Changes. Gate changes will normally be directed by the Water Management Office. In the event communications with the Fort Worth District Office are disrupted, the Lake Manager will direct gate changes. During flood periods, gate changes may be required as often as every half hour. Only under unusual circumstances will gate changes be required more frequently than every half hour. Examples of such unusual circumstances include unexpectedly high rates of change in inflow to the reservoir, or a required response to a dam safety issue. The gates will be operated in a manner prescribed by the manufacturer. A complete log of all gate operations will be kept for each gate.

II. REGULATION PROCEDURES

1. Normal Regulation. Normally, instructions for storage and release of water for conservation and flood control purposes will be issued by the Water Management Office in accordance with the plan of regulation prescribed in Chapter 7 of this water control manual.

2. Emergency Regulation. In the event of disruption of communications with the Fort Worth District Water Management Office, the Lake Manager will, on his own initiative, direct operation of the reservoir in accordance with the rules outlined below:

a. Make conservation releases in accordance with the current request from the LNVA as last related by the Water Management Office prior to loss of communications. Since conservation release requirements are commonly met via hydropower generation at R.D. Willis generating station, which is operated remotely from the Sam Rayburn Dam powerhouse, ensuring continuance of the conservation release may require direct coordination with the Sam Rayburn Dam powerhouse Duty Operator.

b. Take immediate steps to re-establish communication with the Fort Worth District Water Management Office.

c. Until communications are restored, regulate the reservoir in accordance with Exhibit 7-1, Town Bluff Dam Reservoir Regulation Schedule, except base flood releases on Plate 7-6, Emergency Reservoir Regulation for Major Floods – Outflow vs. Rate of Rise, rather than Plate 7-5. During the passage of flood waters, gate changes will be required at frequent intervals in order to maintain the pool in its normal operating range, insofar as possible. When induced surcharge operation begins, both frequent gate changes and close monitoring of the event will be required to ensure that the tailwater elevation is built up sufficiently to prevent excess velocities when flow over the uncontrolled spillway begins.

3. Temporary Deviations. During the course of normal or emergency regulation of the reservoir, the Lake Manager may temporarily deviate from the current release rates in the event an immediate short-term departure is deemed necessary to protect the safety of the dam, or to avoid serious hazards to life. As soon as practicable, the Fort Worth District Water Management Office will be informed via telephone, e-mail, or FAX, as to the nature of the emergency and the subsequent response. If the deviation is conducted in the interest of dam safety, the Dam Safety Coordinator will also be notified as soon as practicable. Such actions shall be confirmed in writing, as soon as practicable, to the Fort Worth District Water Management Office and the Southwestern Division Water Management Office, and shall include justification for the action.

EXHIBIT E

URS-FNI-HZ TEAM

QUALITY MANAGEMENT SYSTEM (QMS) FORMS

EXHIBIT E

URS-FNI-HZ TEAM

QUALITY MANAGEMENT SYSTEM (QMS) FORMS

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4	95% Submittal Independent Technical Review Form	E-6

Quality - It's Good Business		QMS Form 3-4 (MM) Rev. 2013 QMS Date: 28 Feb 2013
IE QMS - Americas		Detail Check
Project Name	Update Water Control Manual for Town Bluff Dam	Client
		USACE Fort Worth District
Project Location	Van Zandt County, Texas	PM
		Jinwei Qiu, PE
Project Number	25336613	PIC
		Thandav Murphy, PE

Identifying Information	(This section is to be completed by the Project Manager or the PM's Designee.) Assigned Checker: Janis Murphy, PE Comments Required by: June 27, 2014 Work Product Originator: Jinwei Qiu and Preston Kutney Work Product to be Checked: Town Bluff Dam Water Control Manual Chapters 1 to 6 ☒ This Detail Check is a check for correctness, completeness and technical accuracy. ☐ This Detail Check is only a technical edit for format, spelling, grammar, pagination and readability. Specific Instructions: Enter specific instructions for the work product Submitted by: <u></u> <u>06/25/2014</u> Project Manager Signature Date
Comments	(This Section is to be completed by the Checker.) Select: A. ☐ Checker has no comments. or B. ☒ Comments have been provided on: ☒ Marked directly on work product ☐ Comment and Disposition Form 3-5 ☐ Other; Specify: Click here to enter text <u></u> <u>6/27/14</u> Checker Signature Date
Verification	(This section is to be completed by the Checker after verification of comment incorporation, if box B is checked off above.) Select: C. ☐ Verification of comment incorporation has been performed by Checker. There are no outstanding issues. or D. ☐ Verification of comment incorporation has been performed by Checker. Unresolved issues have been submitted to the Project Manager or Designee for final resolution. and E. ☐ Checker asserts that the work product review is complete. _____ Checker Signature _____ Date

APPROVAL and DISTRIBUTION	
☐ Detail Check is complete. Click here to enter a date. _____ Project Manager or Designee Signature _____ Date	
Distribution: Project Central File – Quality File Folder Other – Specify: Enter names here.	



IE QMS - Americas

Independent Technical Review

Project Name	Update Water Control Manual for Town Bluff Dam	Client	USACE Fort Worth District
Project Location	Van Zandt County, Texas	PM	Jinwei Qiu, PE
Project Number	25336613	PIC	Thandav Murphy, PE

Identifying Information	(This section is to be completed by the Project Manager or the PM's Designee.)	
	Assigned Reviewer: Anand Prakash, PE	Comments Required by: June 27, 2014
	Work Product Originator: Jinwei Qiu and Preston Kutney	
	Work Product to be Reviewed: Town Bluff Dam Water Control Manual Chapters 1 to 6	
	Review Scope: Review for correctness, completeness and technical accuracy	
	Specific Instructions: Enter specific instructions for the work product.	
	Submitted by: <u><i>Jinwei Qiu</i></u>	<u>06/25/2014</u>
	Project Manager Signature	Date

Comments	(This Section is to be completed by the Reviewer.)	
	Select:	
	A. ☐ Reviewer has no comments.	
	or	
	B. ☒ Comments have been provided on:	
	☒ Marked directly on work product	
	☐ Comment and Disposition Form 3-5	
	☐ Other, Specify: Click to enter text.	
	<u><i>Anand Prakash</i></u>	<u>6/26/2014</u>
	Reviewer Signature	Date

Verification	(This section is to be completed by the Reviewer after verification of comment incorporation, if box B is checked off above.)	
	Select:	
	C. ☒ Verification of comment incorporation has been performed by Reviewer. There are no outstanding issues.	
	or	
	D. ☐ Verification of comment incorporation has been performed by Reviewer. Unresolved issues have been submitted to the Project Manager or Designee for resolution.	
	and	
	E. ☒ Reviewer asserts that the work product ITR is complete.	
	<u><i>Anand Prakash</i></u>	<u>6/30/2014</u>
	Reviewer Signature	Date

APPROVAL and DISTRIBUTION

☒ ITR is complete.

Jinwei Qiu

Project Manager or Designee Signature

Click here to enter a date

06/30/2014

Date

Distribution:

Project Central File - Quality File Folder

Other - Specify: Enter names here

Quality - It's *Good* Business

QMS Form 3-4 (MM)

Rev. 2013 QMS
Date: 28 Feb 2013

IE QMS - Americas

Detail Check

Project Name	Update Water Control Manual for Town Bluff Dam	Client	USACE Fort Worth District
Project Location	Van Zandt County, Texas	PM	Jinwei Qiu, PE
Project Number	25336613	PIC	Thandav Murphy, PE

Identifying Information

(This section is to be completed by the Project Manager or the PM's Designee.)

Assigned Checker: Janis Murphy, PE

Comments Required by: August 22, 2014

Work Product Originator: Jinwei Qiu and Preston Kutney

Work Product to be Checked: Town Bluff Dam Water Control Manual Chapters 1 to 6 and Chapters 8 to 9

☒ This Detail Check is a check for correctness, completeness and technical accuracy.☐ This Detail Check is only a technical edit for format, spelling, grammar, pagination and readability.

Specific Instructions: Enter specific instructions for the work product.

Submitted by:

Project Manager Signature

Date

08-22-2014

Comments

(This Section is to be completed by the Checker.)

Select:

A. ☐ Checker has no comments.

or

B. ☒ Comments have been provided on:☒ Marked directly on work product☐ Comment and Disposition Form 3-5☐ Other; Specify: Click here to enter text.

Checker Signature

Date

Janis Murphy

8/29/14

Verification

(This section is to be completed by the Checker after verification of comment incorporation, if box B is checked off above.)

Select:

C. ☒ Verification of comment incorporation has been performed by Checker. There are no outstanding issues.

or

D. ☐ Verification of comment incorporation has been performed by Checker. Unresolved issues have been submitted to the Project Manager or Designee for final resolution.

and

E. ☒ Checker asserts that the work product review is complete.

Checker Signature

Date

Janis C. Murphy

8/31/14

APPROVAL and DISTRIBUTION

☐ Detail Check is complete.

Project Manager or Designee Signature

Click here to enter a date.

Date

Jinwei Qiu

08-31-2014

Distribution:

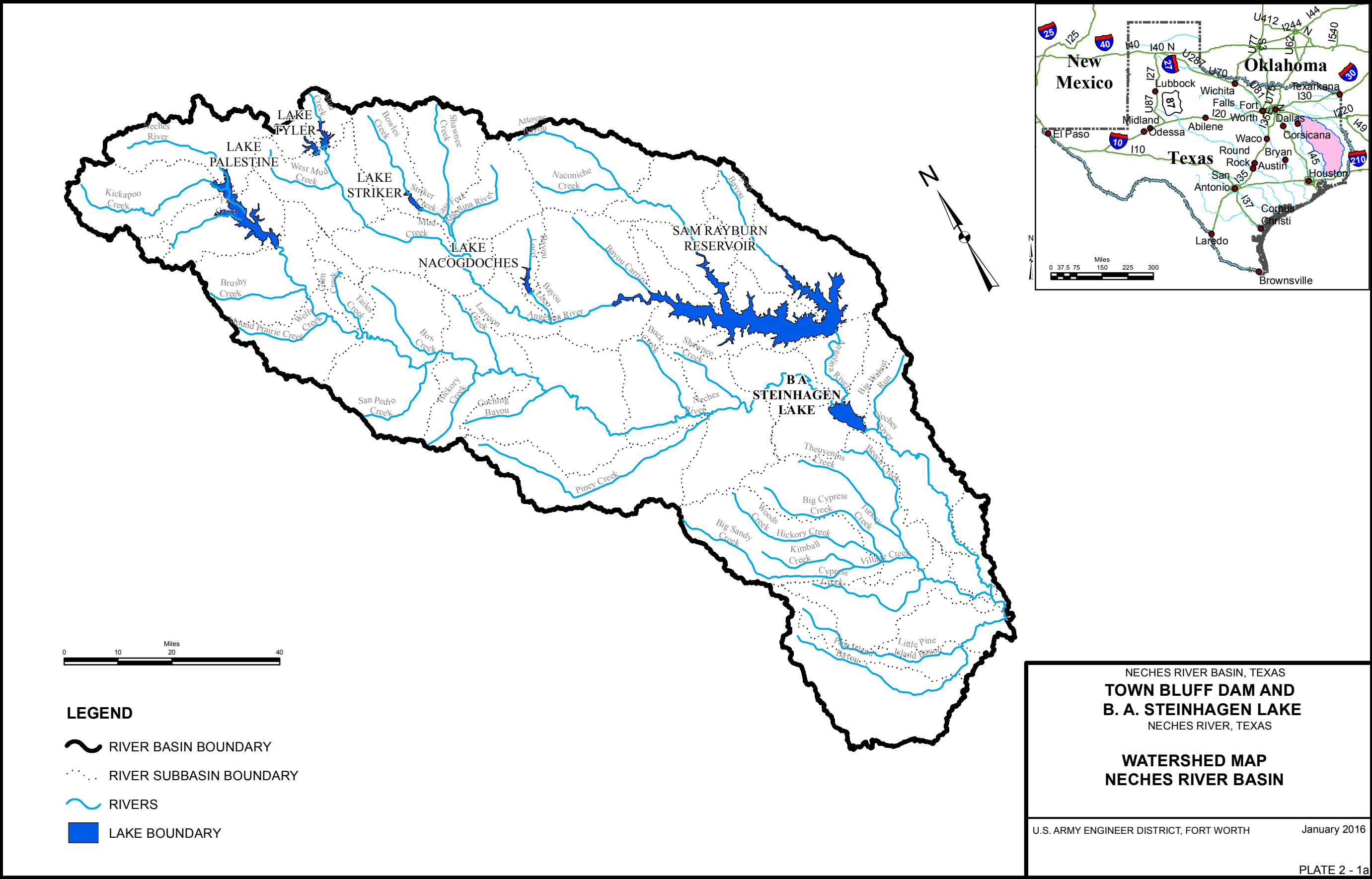
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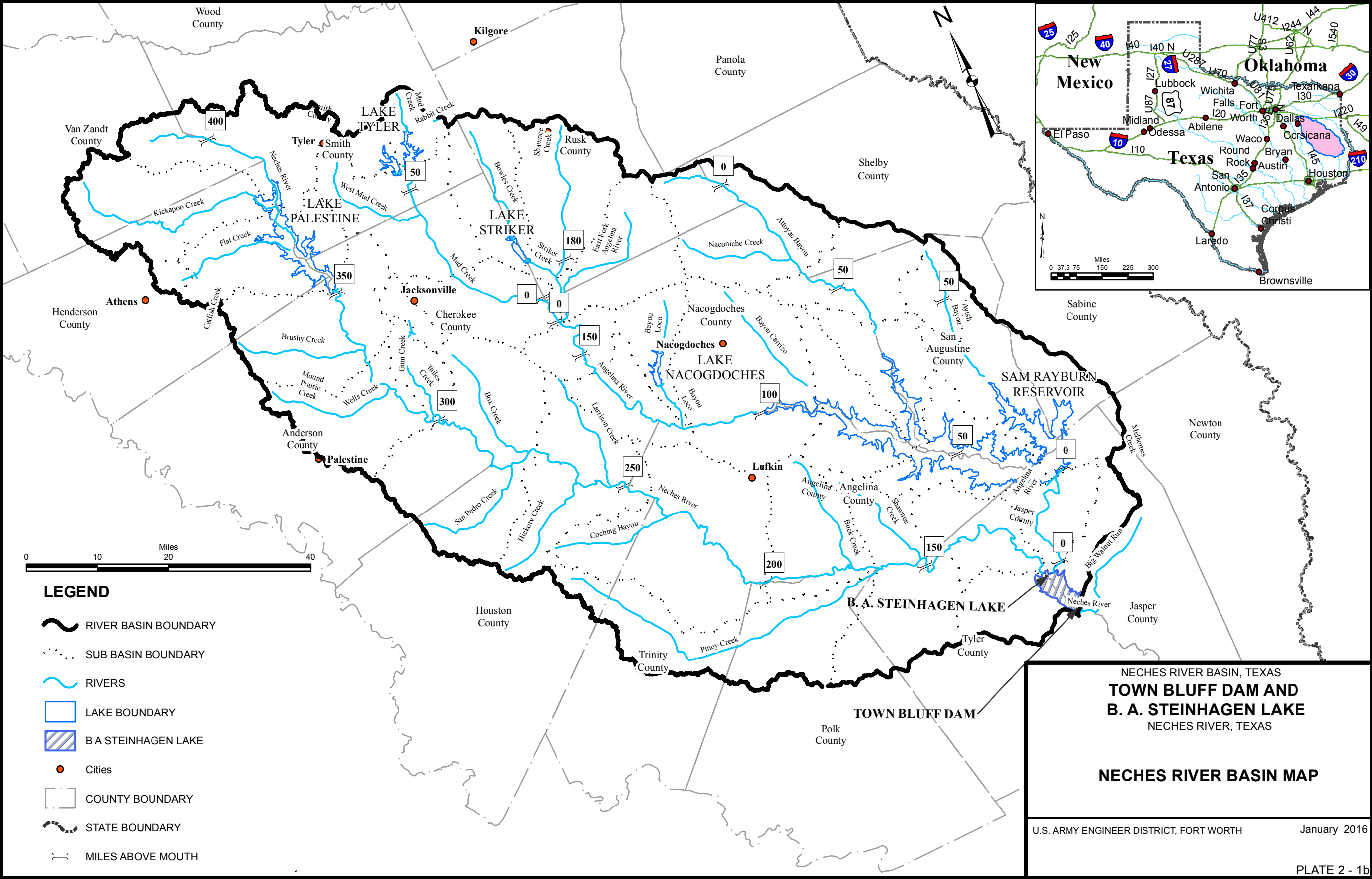
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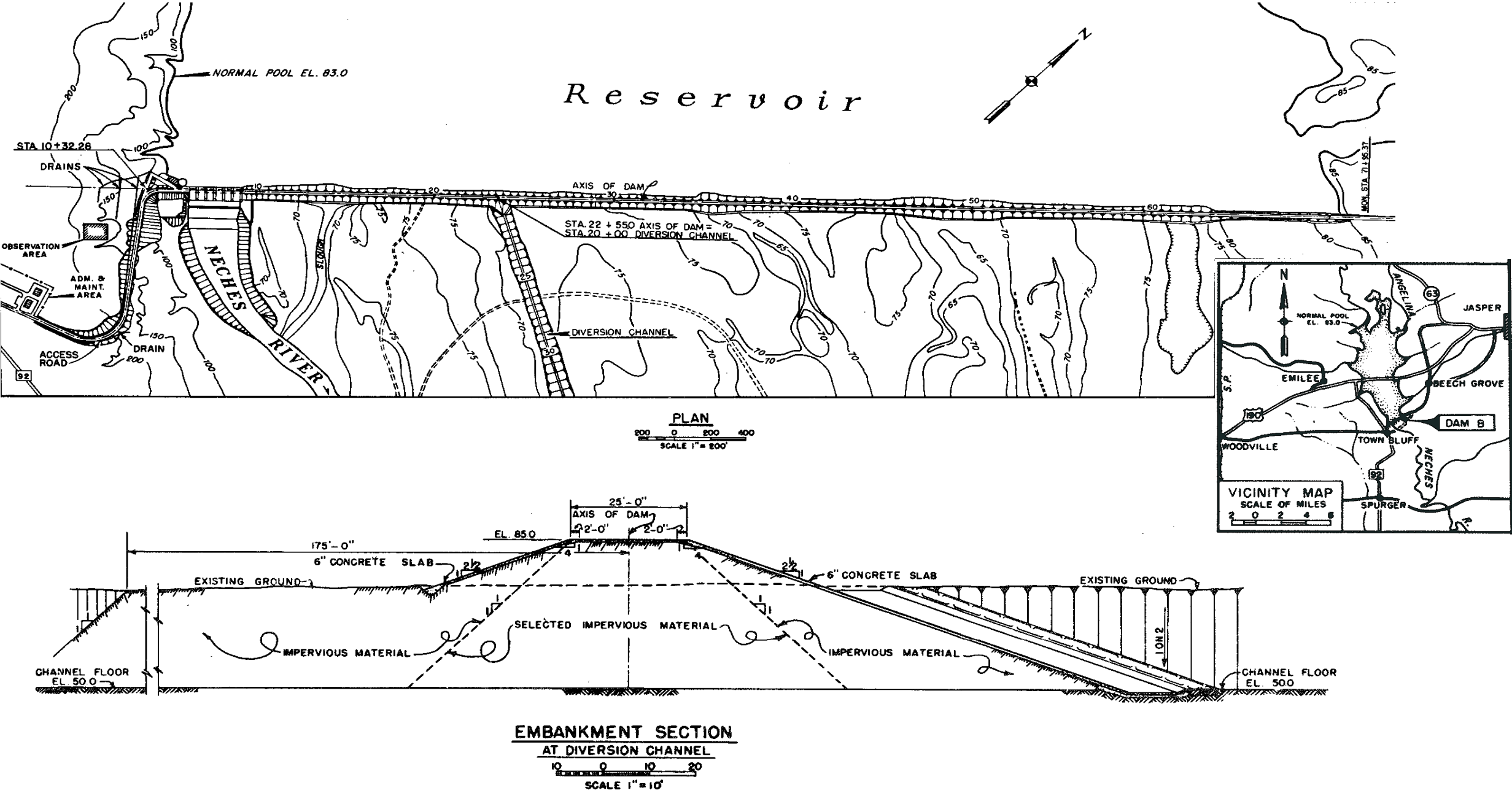
Quality - It's Good Business		QMS Form 3-6 (MM) Rev. 2013 QMS Date: 28 Feb 2013
IE QMS - Americas		Independent Technical Review
Project Name	Update Water Control Manual for Town Bluff Dam	Client
		USACE Fort Worth District
Project Location	Van Zandt County, Texas	PM
		Jinwei Qiu, PE
Project Number	25336613	PIC
		Thandav Murphy, PE

Identifying Information	<i>(This section is to be completed by the Project Manager or the PM's Designee.)</i> Assigned Reviewer: Anand Prakash, PE Comments Required by: August 22, 2014 Work Product Originator: Jinwei Qiu and Preston Kutney Work Product to be Reviewed: Town Bluff Dam Water Control Manual Chapters 1 to 6 and Chapters 8 to 9 Review Scope: Review for correctness, completeness and technical accuracy Specific Instructions: Enter specific instructions for the work product. Submitted by: <u></u> <u>08-22-2014</u> Project Manager Signature Date
Comments	<i>(This Section is to be completed by the Reviewer.)</i> Select: A. ☐ Reviewer has no comments. or B. ☒ Comments have been provided on: ☐ Marked directly on work product ☐ Comment and Disposition Form 3-5 ☒ Other; Specify: Click to enter text. <u></u> <u>8/26/14</u> Reviewer Signature Date
Verification	<i>(This section is to be completed by the Reviewer after verification of comment incorporation, if box B is checked off above.)</i> Select: C. ☒ Verification of comment incorporation has been performed by Reviewer. There are no outstanding issues. or D. ☐ Verification of comment incorporation has been performed by Reviewer. Unresolved issues have been submitted to the Project Manager or Designee for resolution. and E. ☒ Reviewer asserts that the work product ITR is complete. <u></u> <u>8/29/14</u> Reviewer Signature Date

APPROVAL and DISTRIBUTION	
☐ ITR is complete.	
<u></u> Project Manager or Designee Signature	Click here to enter a date. <u>08/29/2014</u> Date
Distribution: Project Central File – Quality File Folder Other – Specify: Enter names here.	







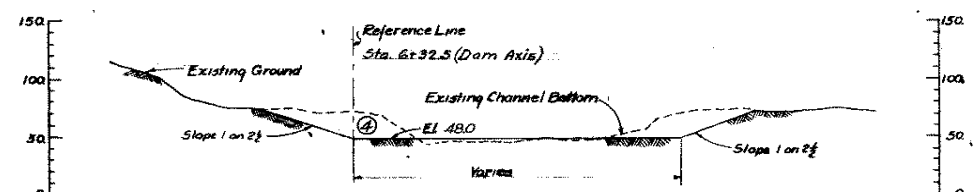
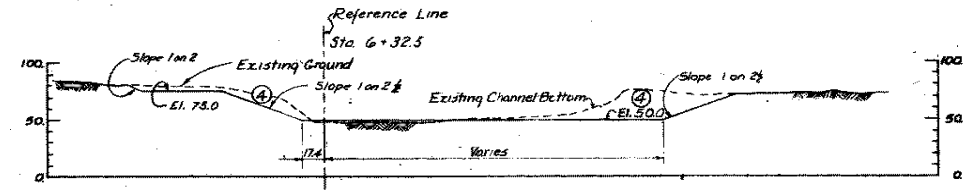
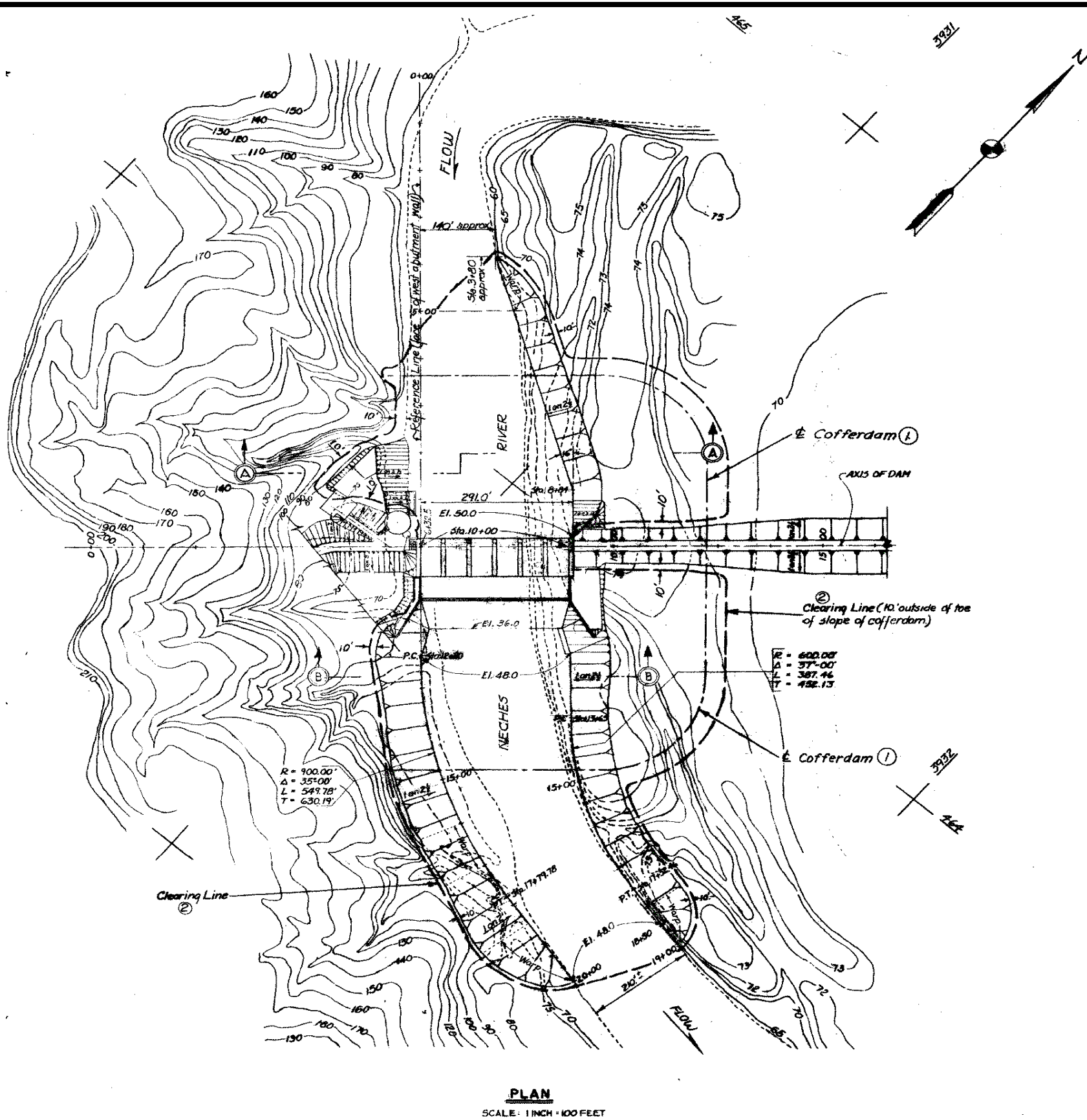
ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE.

NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

EMBANKMENT PLAN AND SECTION

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016



GENERAL NOTES:

- Clearing will be paid for under item ②
- Clearing and grubbing will be paid for under item ③
- Excavation for approach and exit channels will be paid for under item ④
- Excavation for spillway will be paid for under item ⑤. For limits of excavation to be paid for under item ⑤, see DWG No. 40/8.

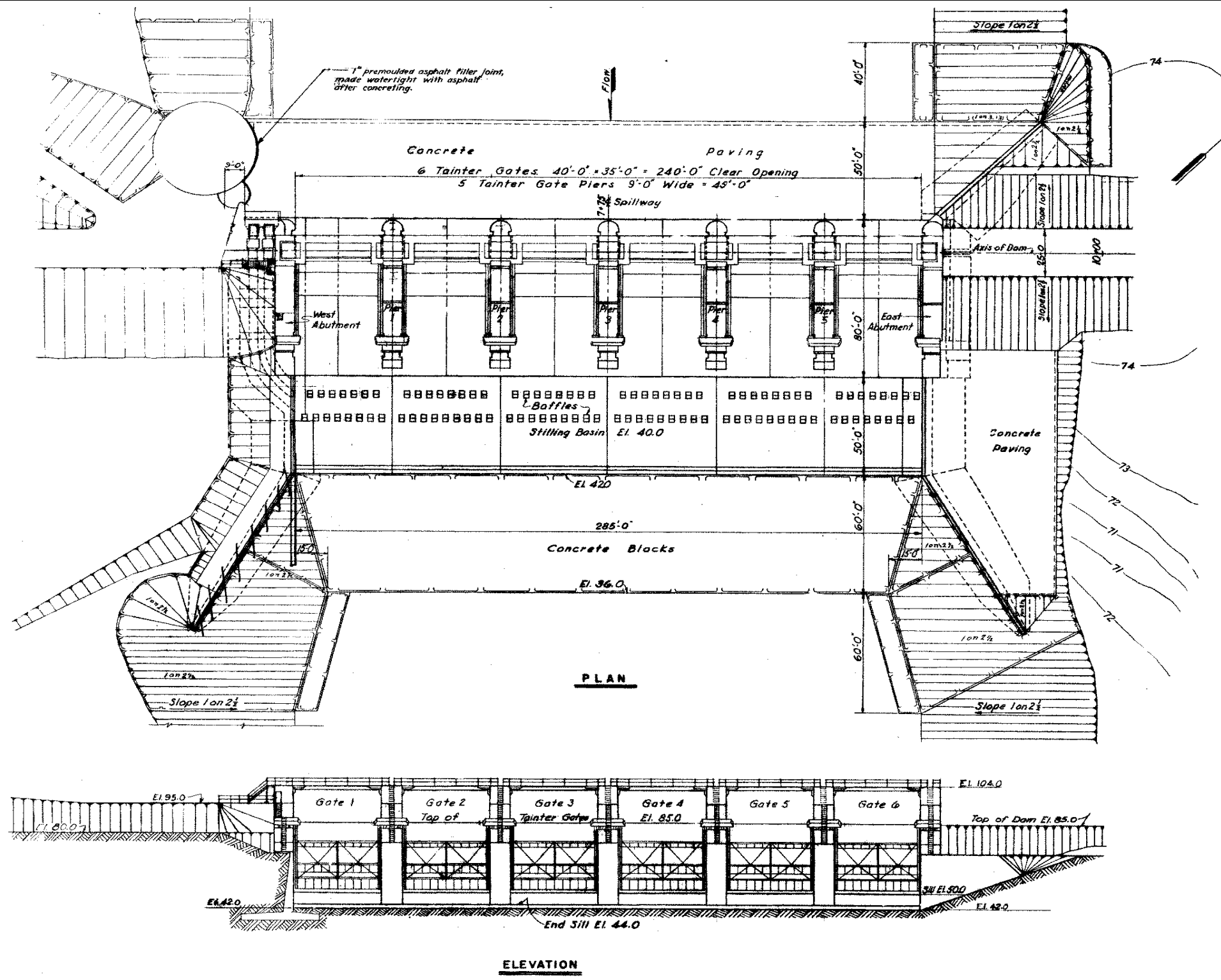
REFERENCE SHEETS:

- General Plan of Dam, see DWG No. 20/1
- Spillway - Plan and Elevation, see Dwg. No. 40/2.

ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE.

NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

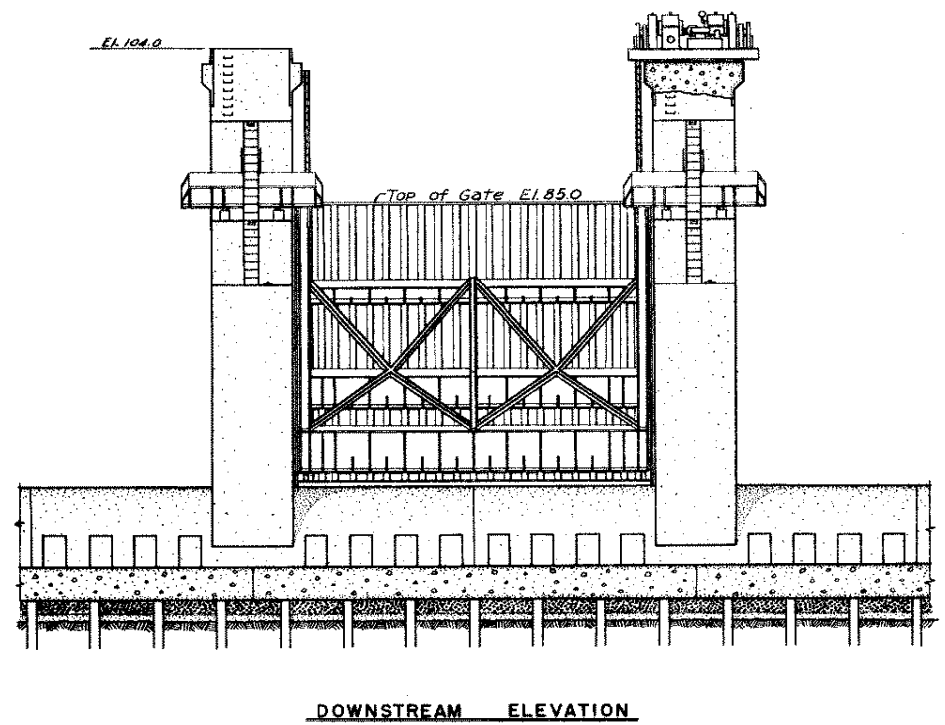
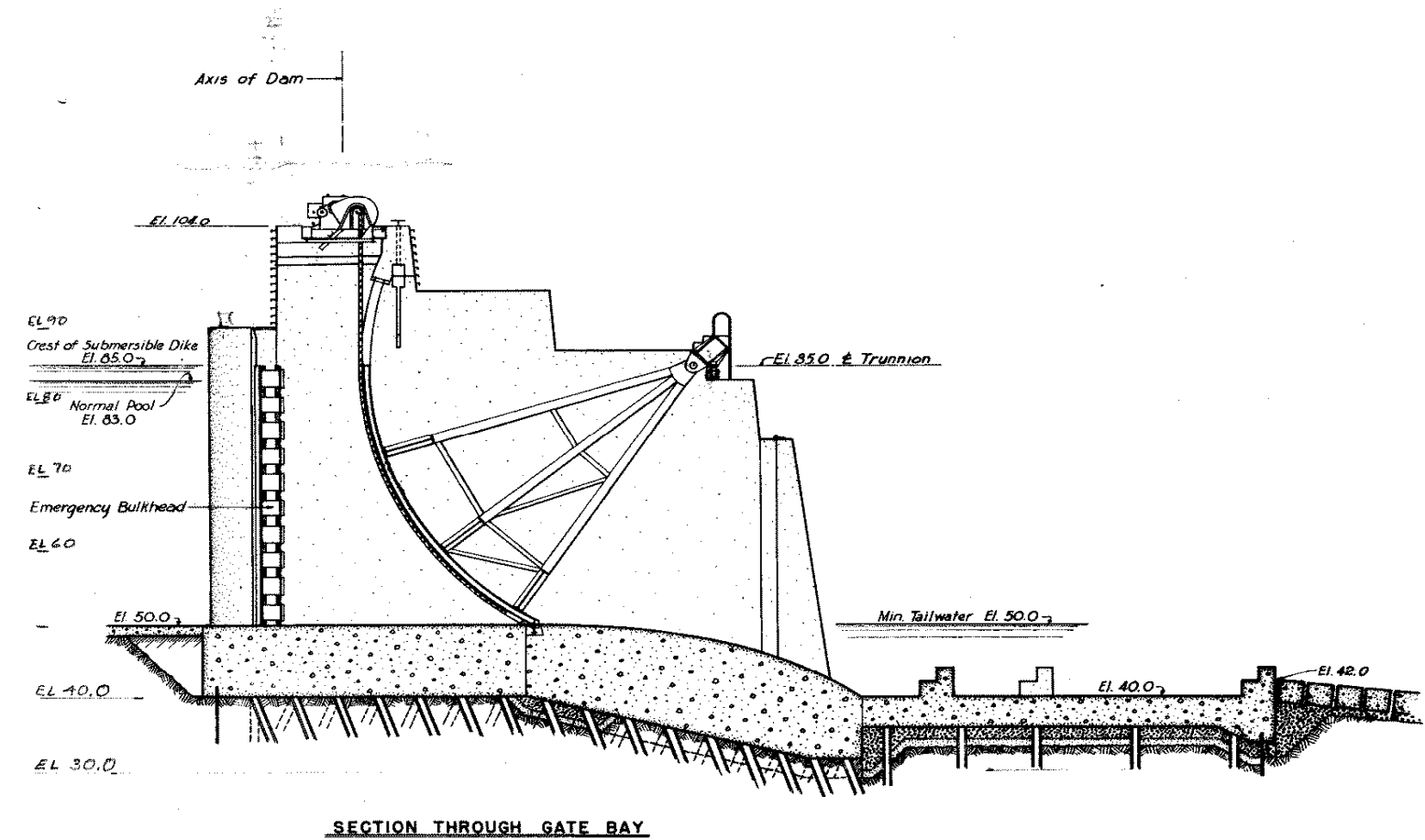
SPILLWAY PLAN AND SECTION



NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**SPILLWAY STRUCTURE
PLAN AND ELEVATION**

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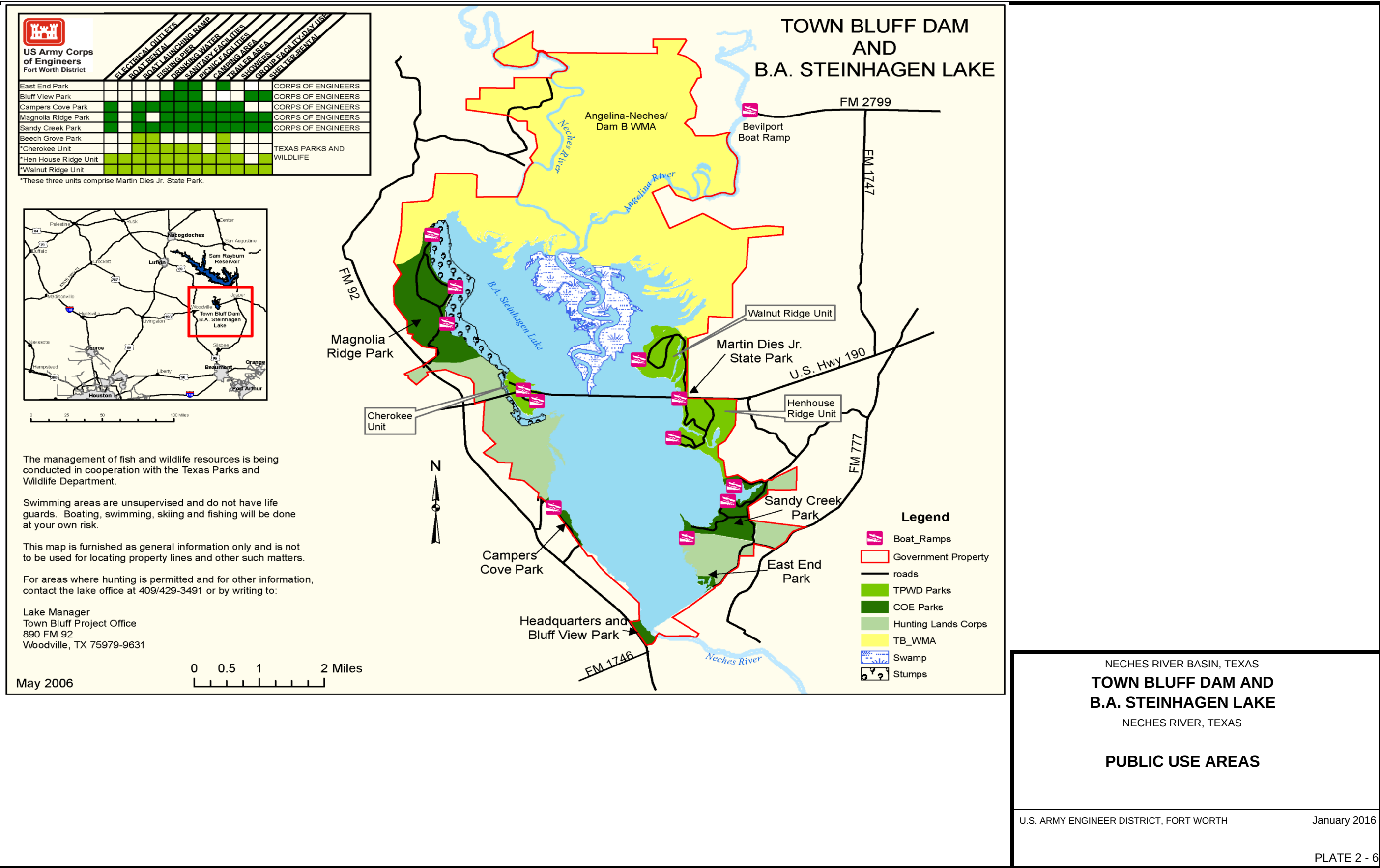
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**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

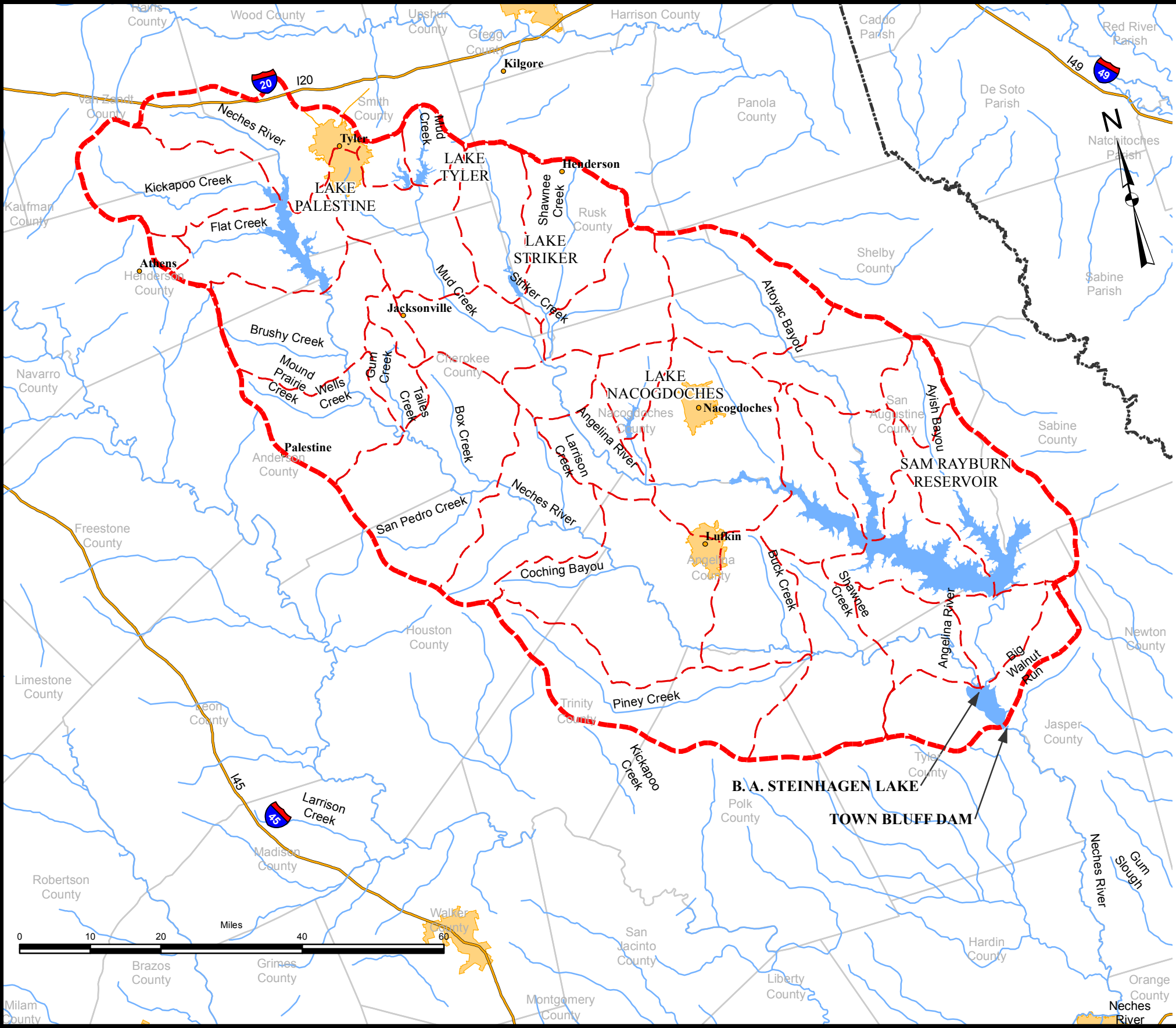
TANTER GATE AND STILLING BASIN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 2 - 5



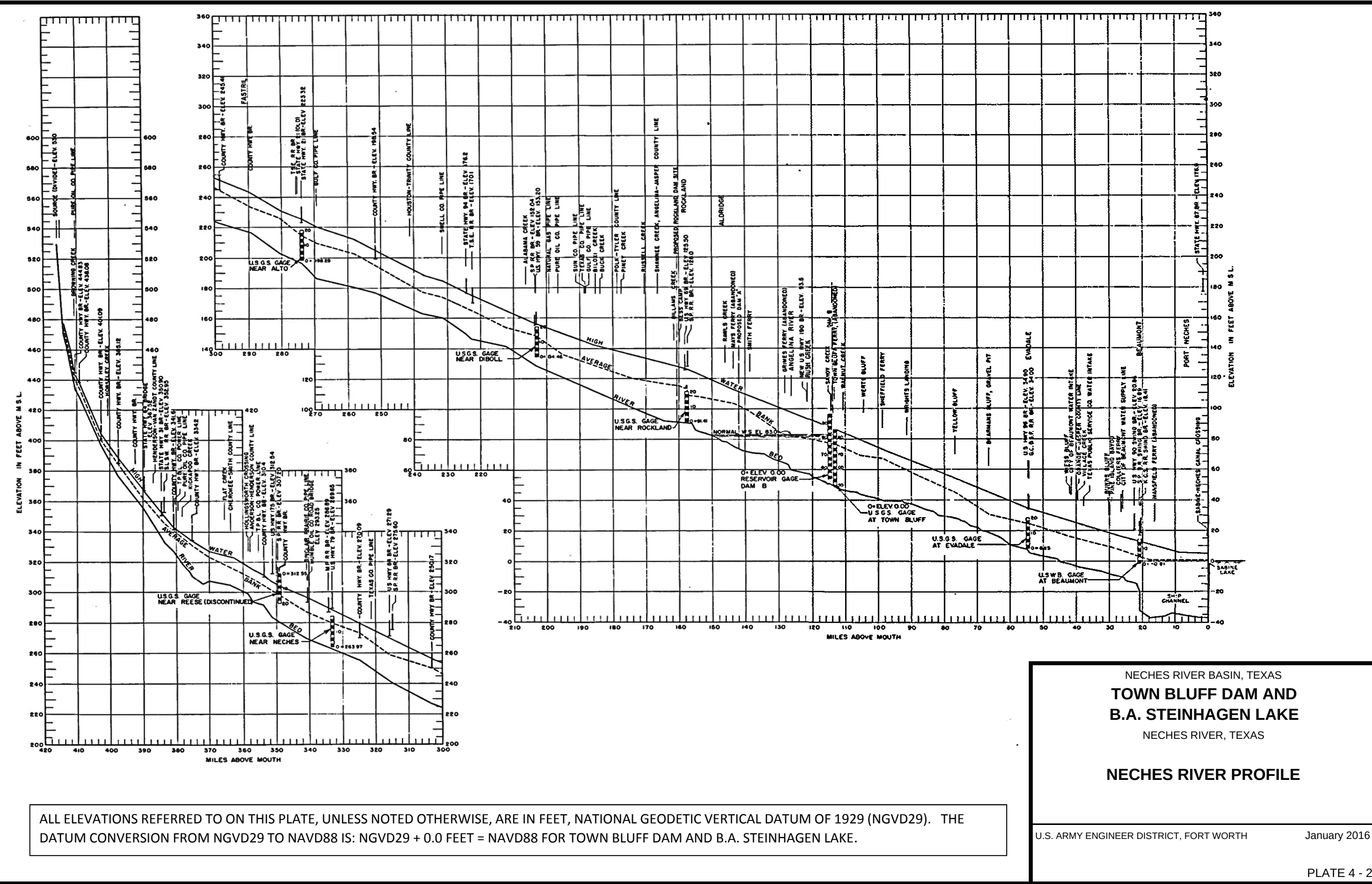


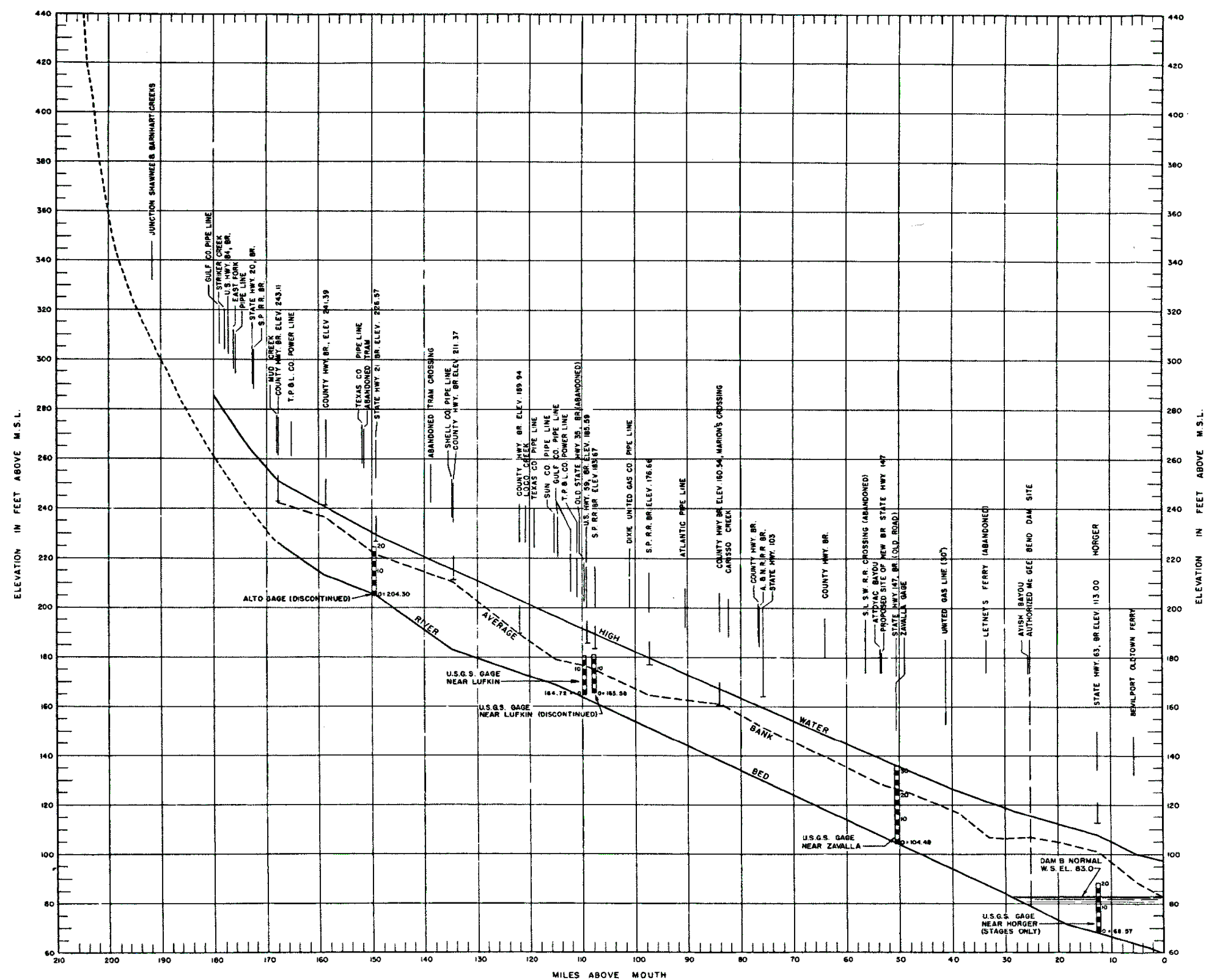
LEGEND

- RIVER BASIN BOUNDARY
- SUB BASIN BOUNDARY
- RIVERS
- LAKE BOUNDARY
- CITIES
- INTERSTATE
- METRO AREAS
- STATE BOUNDARY

NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
 B. A. STEINHAGEN LAKE**
 NECHES RIVER, TEXAS

LOCAL WATERSHED MAP

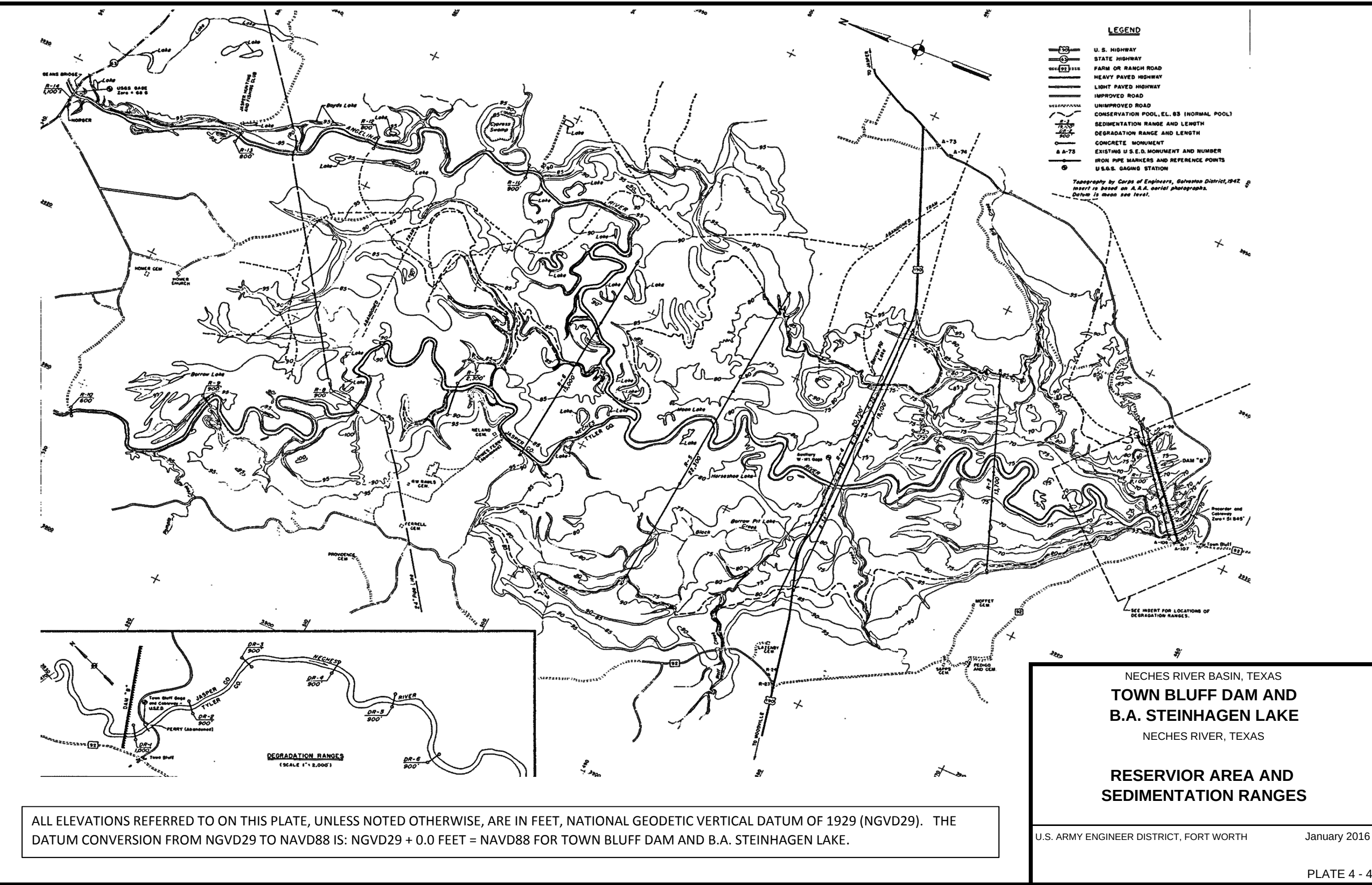


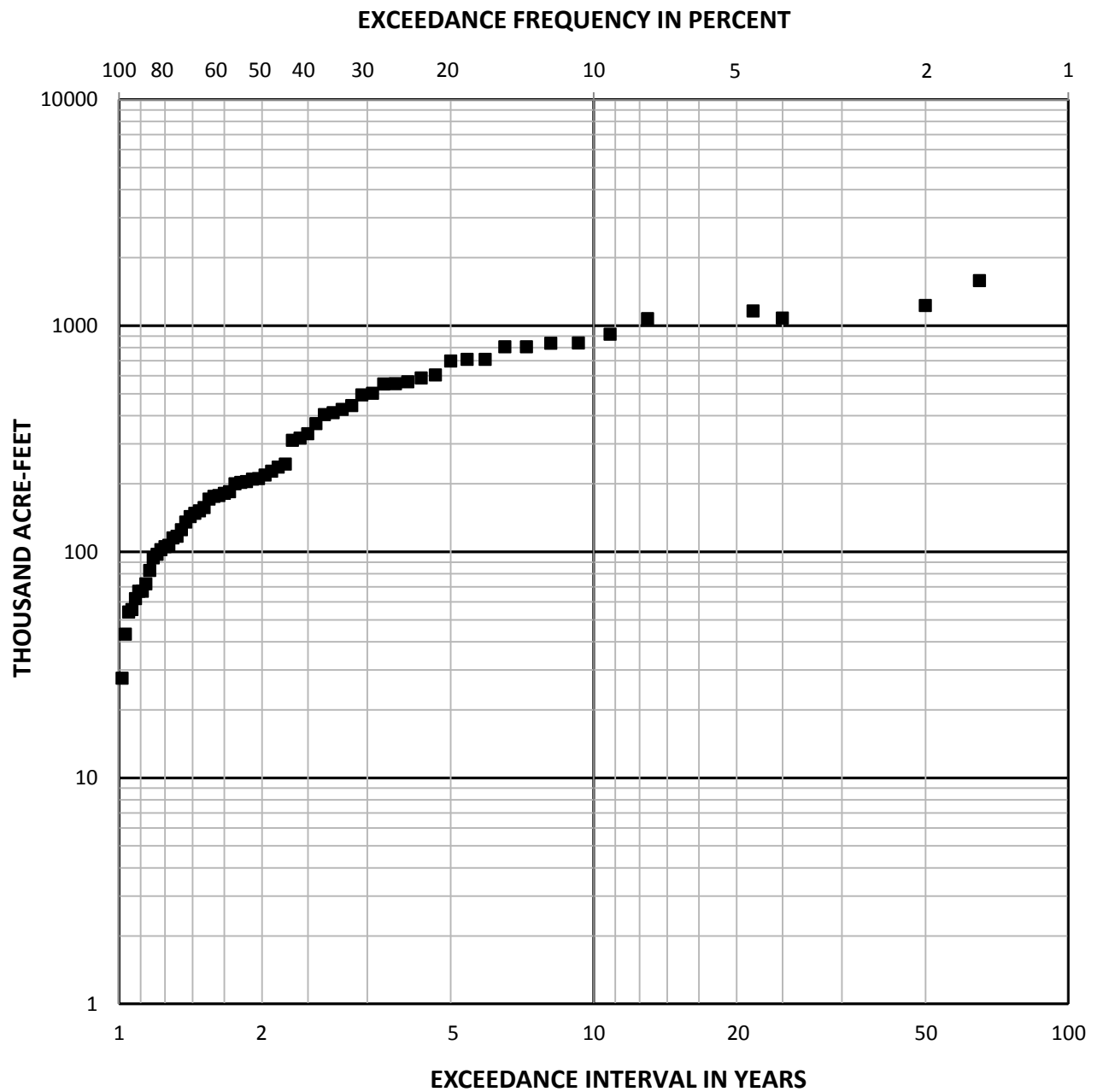


NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

ANGELINA RIVER PROFILE

ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE.





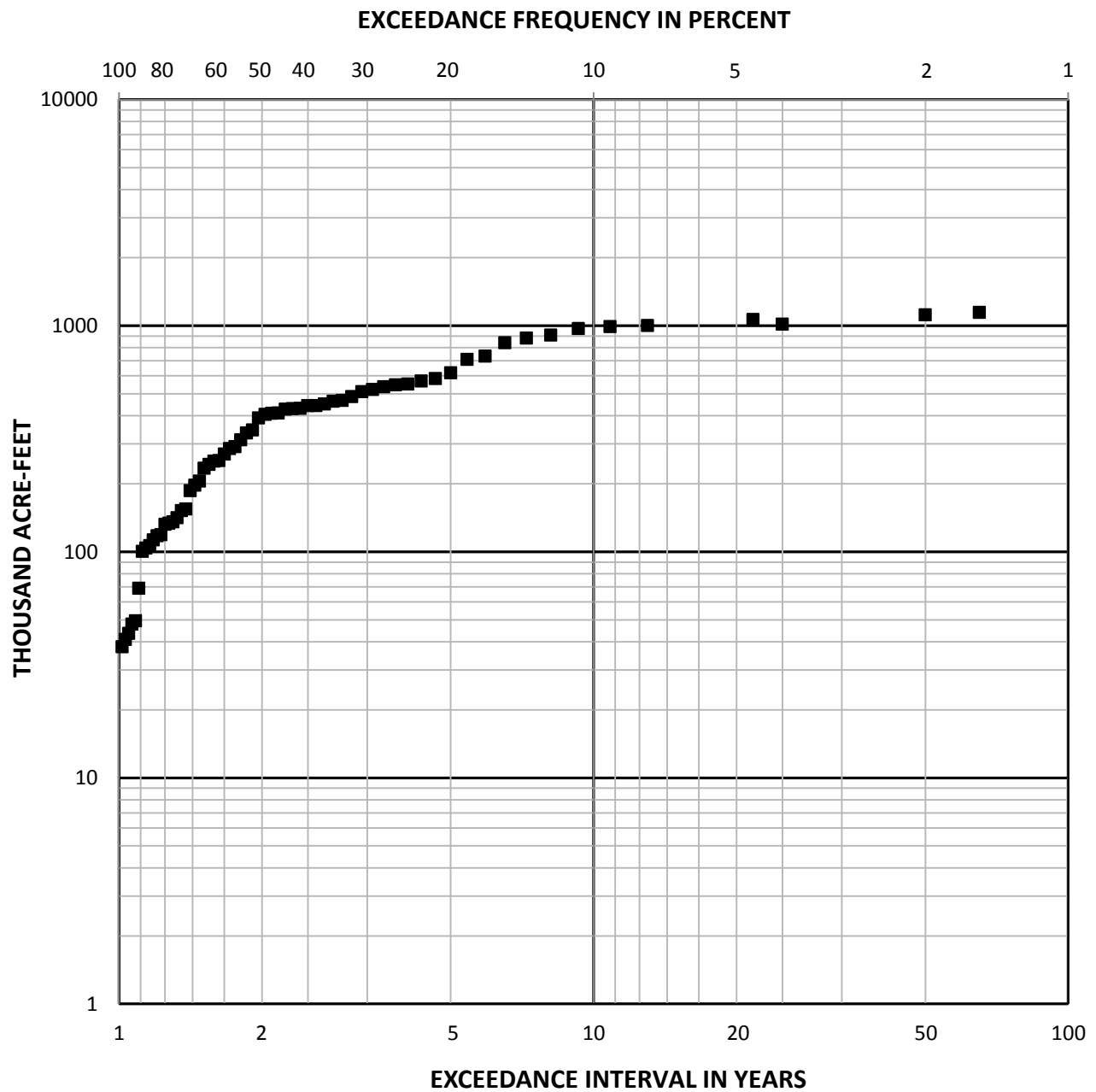
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**JANUARY INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 5



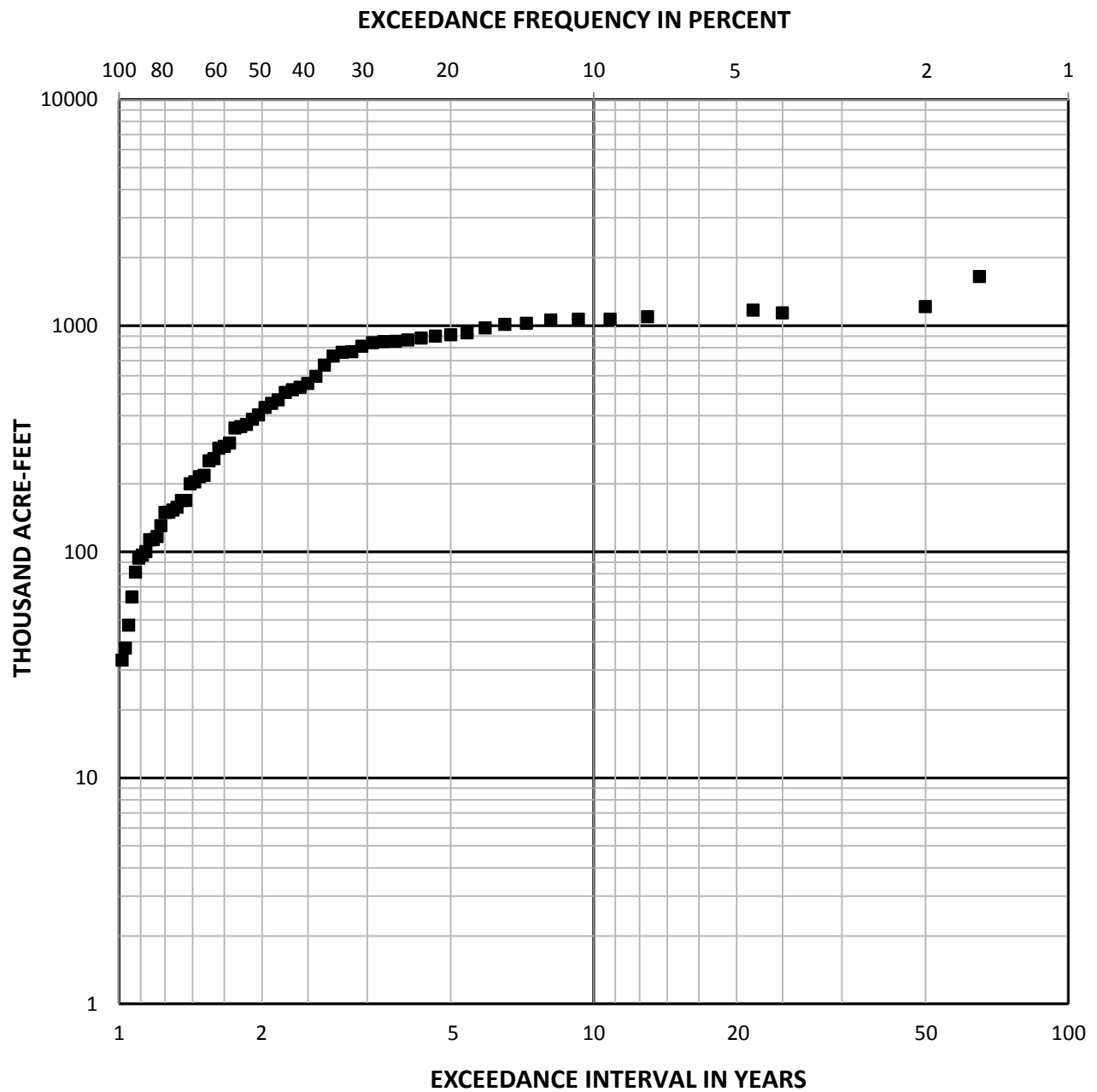
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**FEBRUARY INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 6



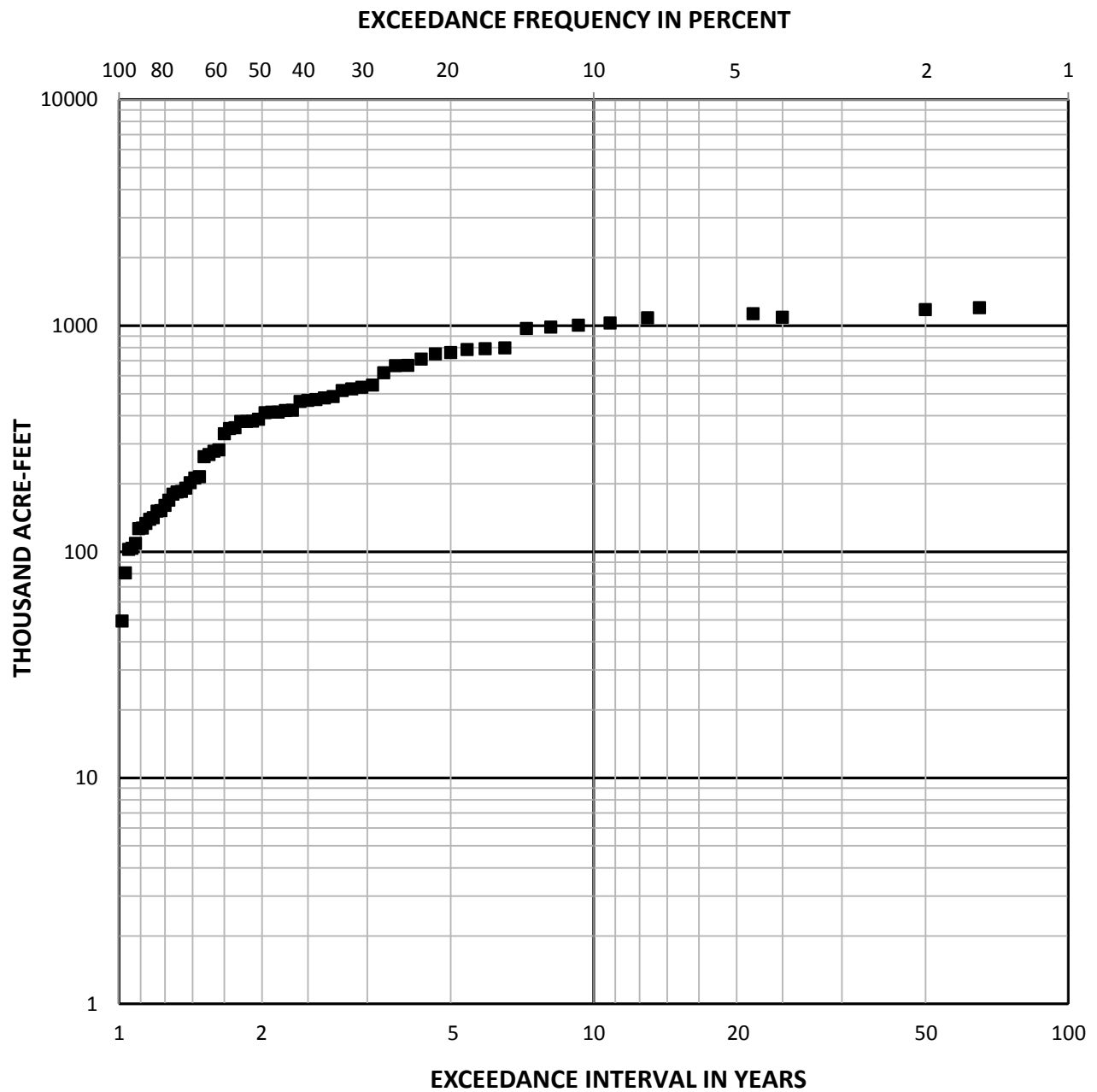
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**MARCH INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 7



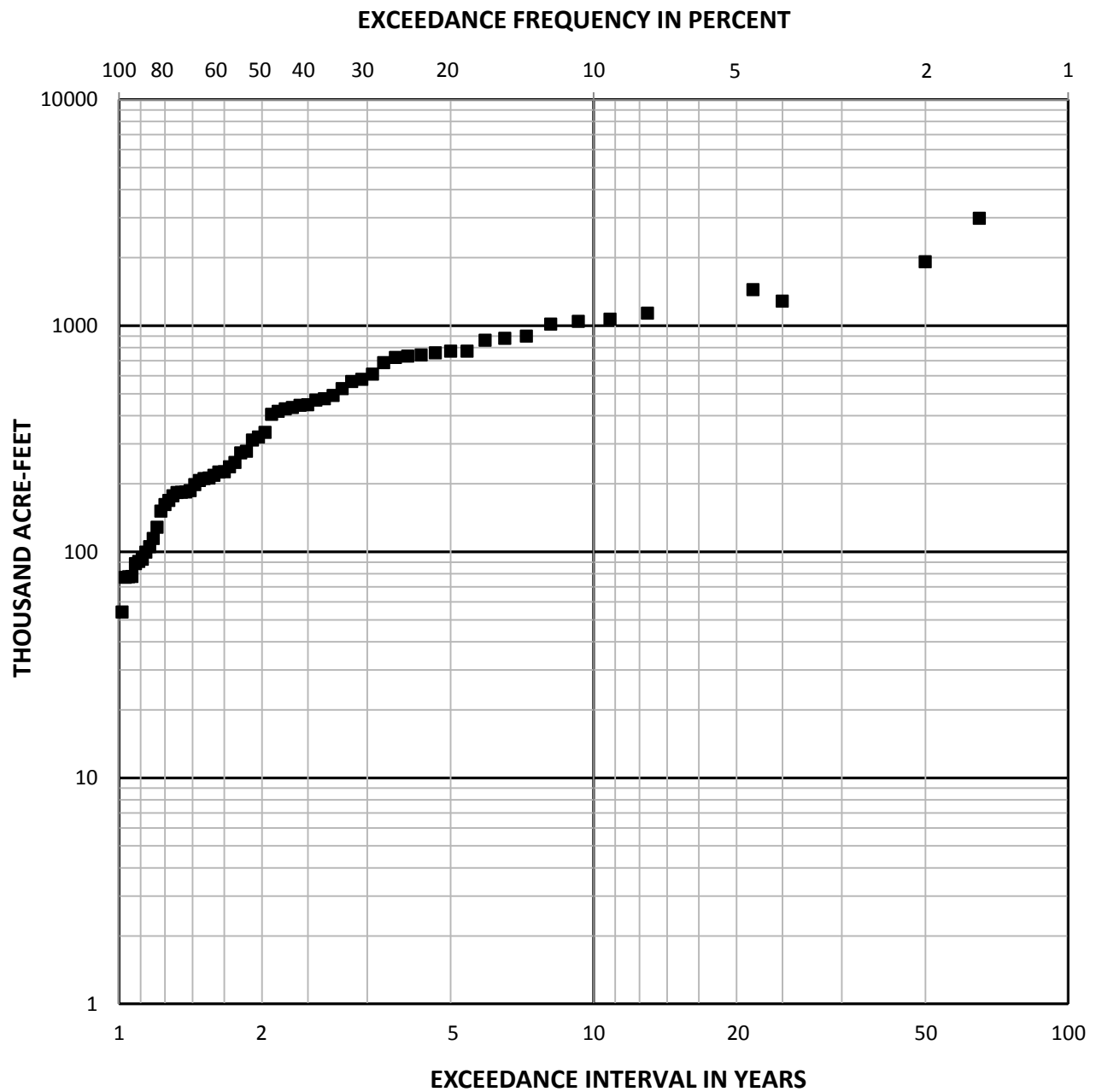
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**APRIL INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 8



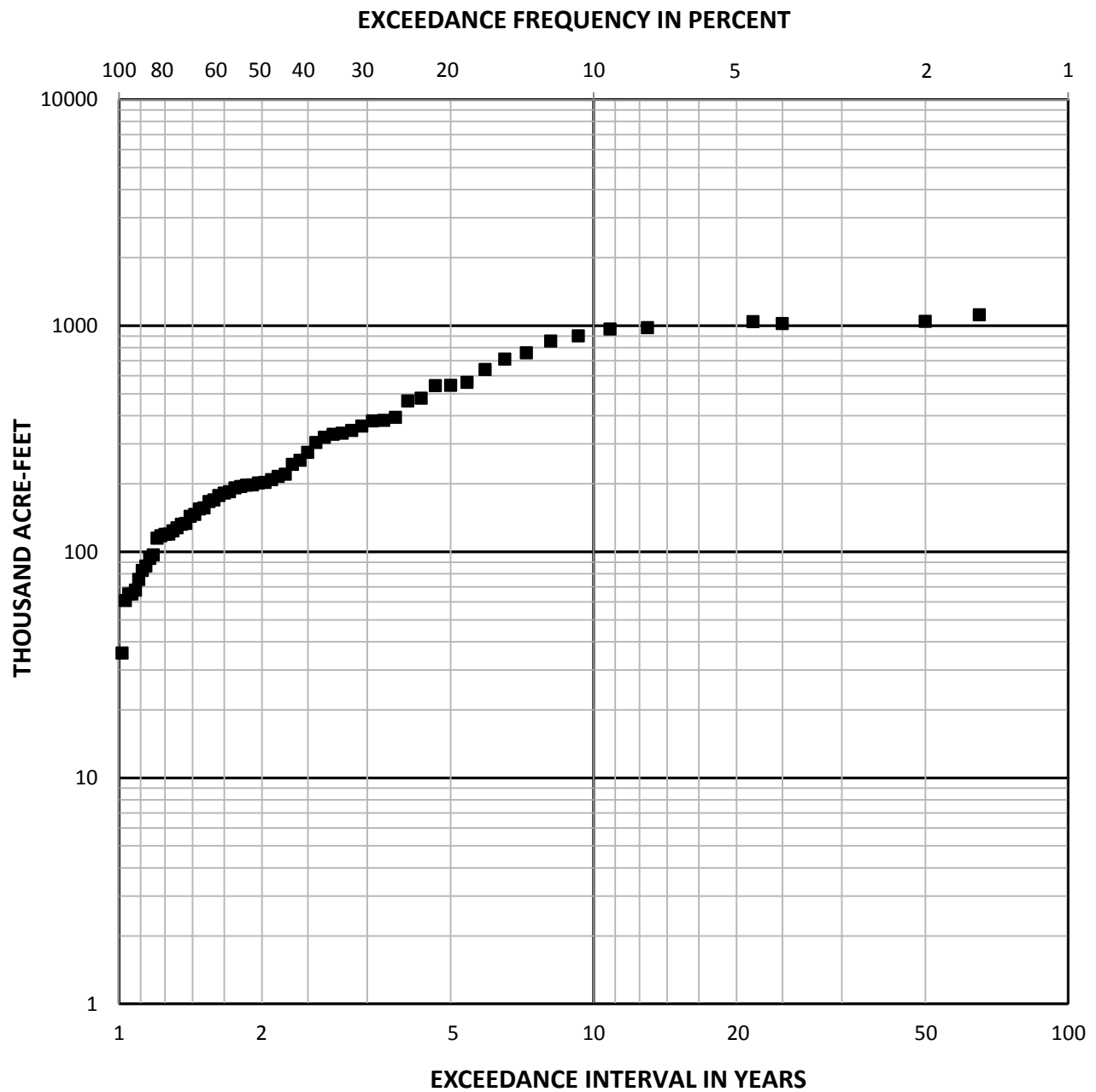
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**MAY INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 9



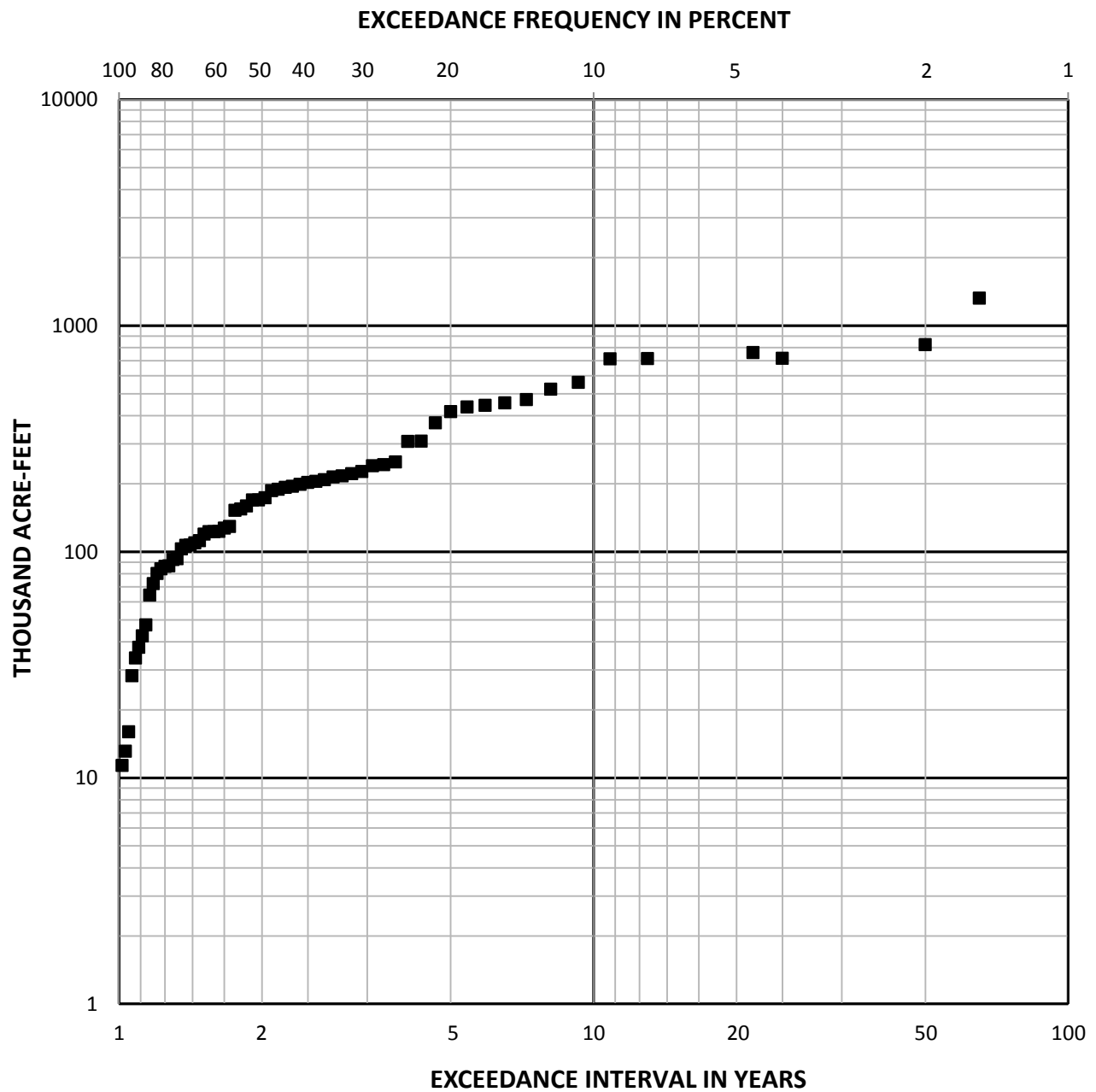
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**JUNE INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 10



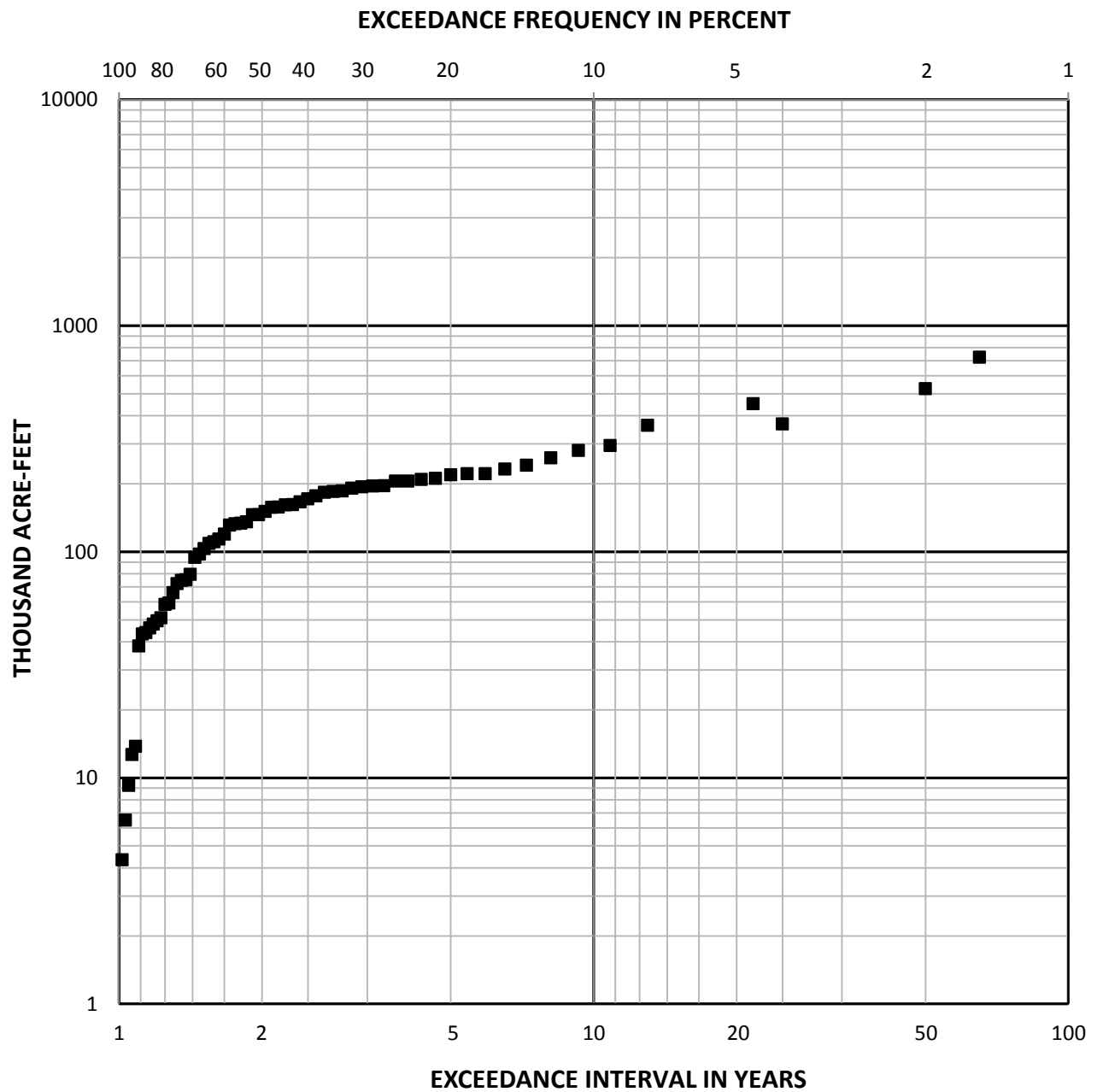
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**JULY INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 11



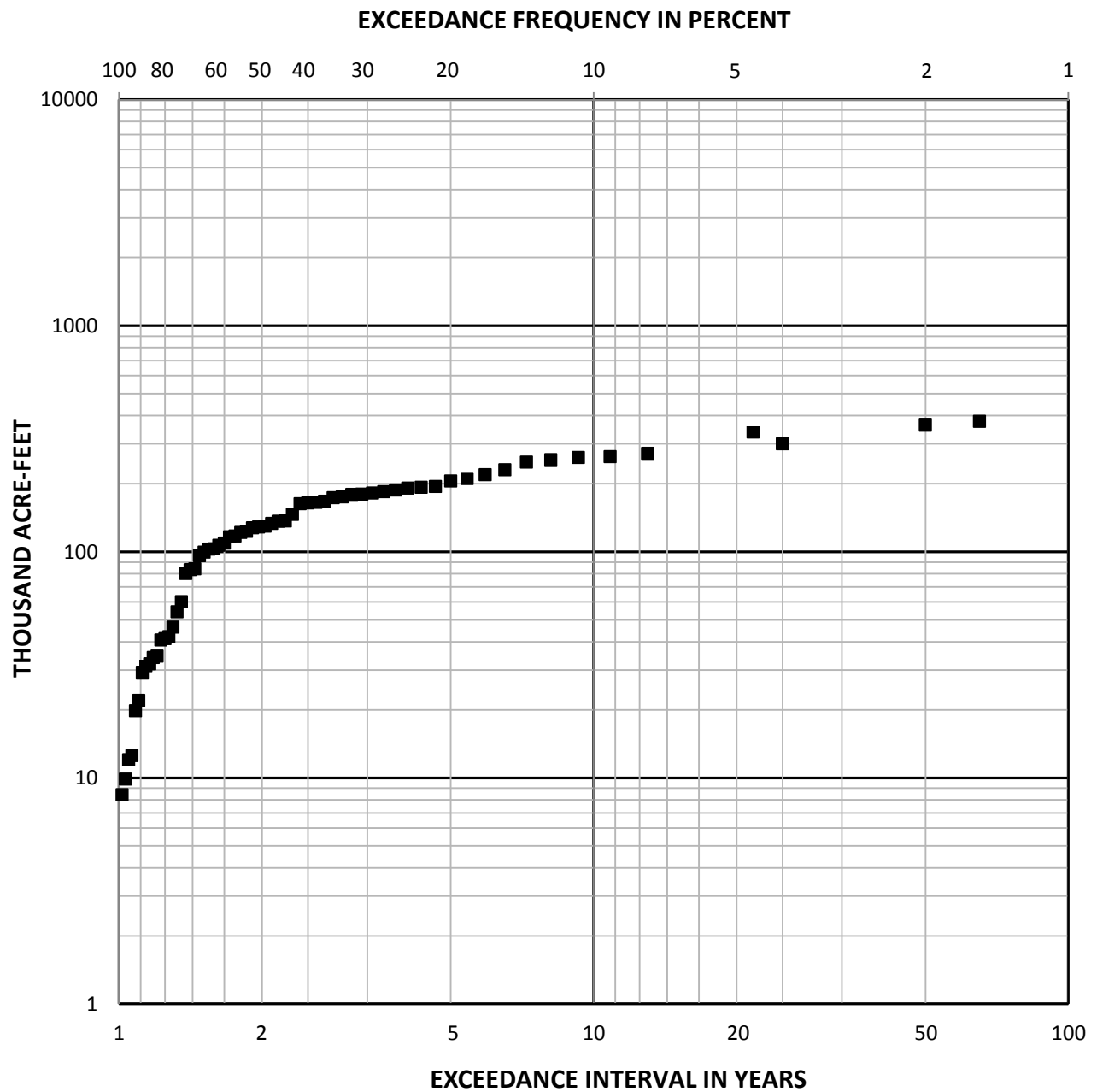
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**AUGUST INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 12



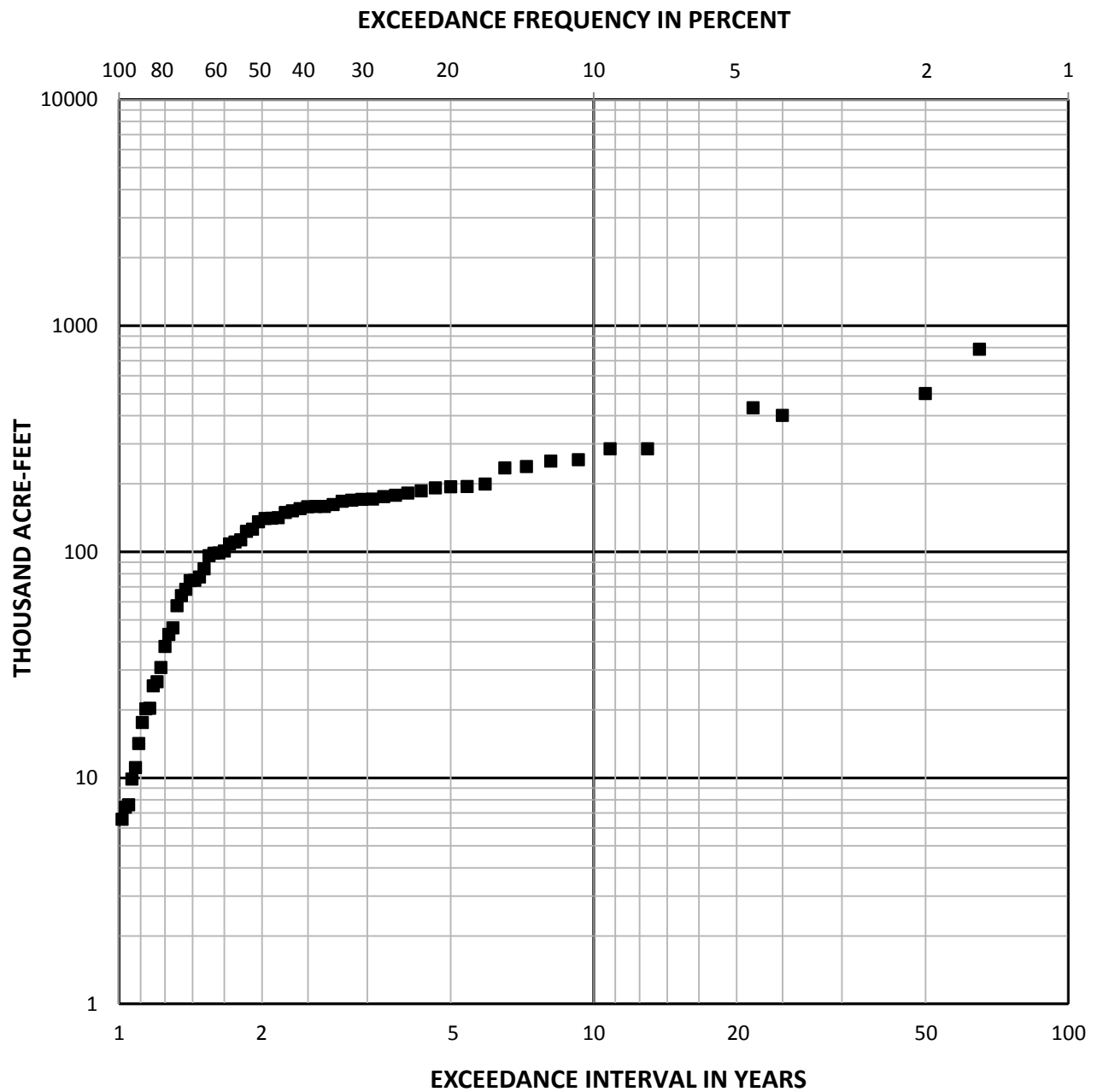
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**SEPTEMBER INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 13



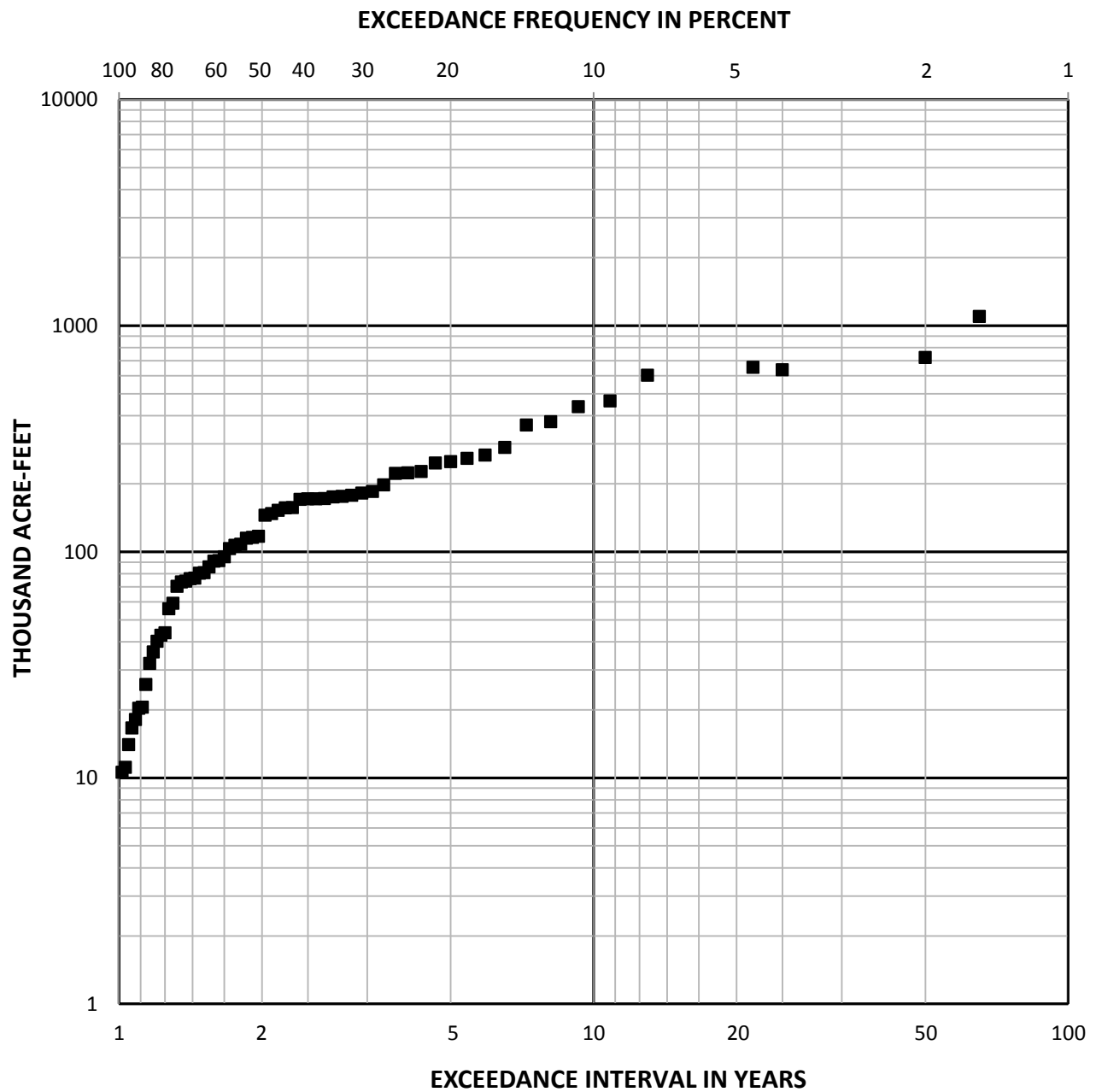
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**OCTOBER INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 14



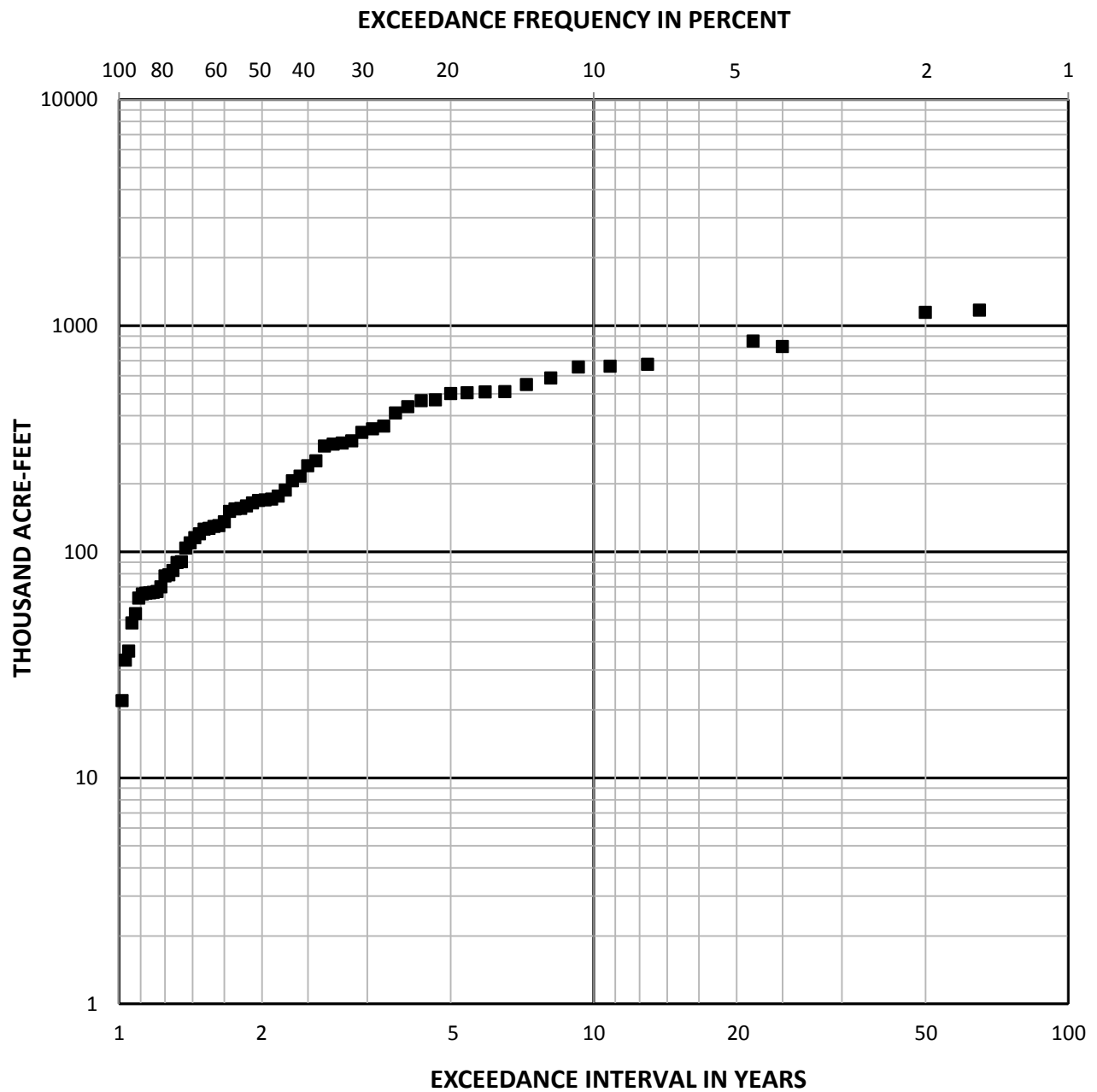
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**NOVEMBER INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 15



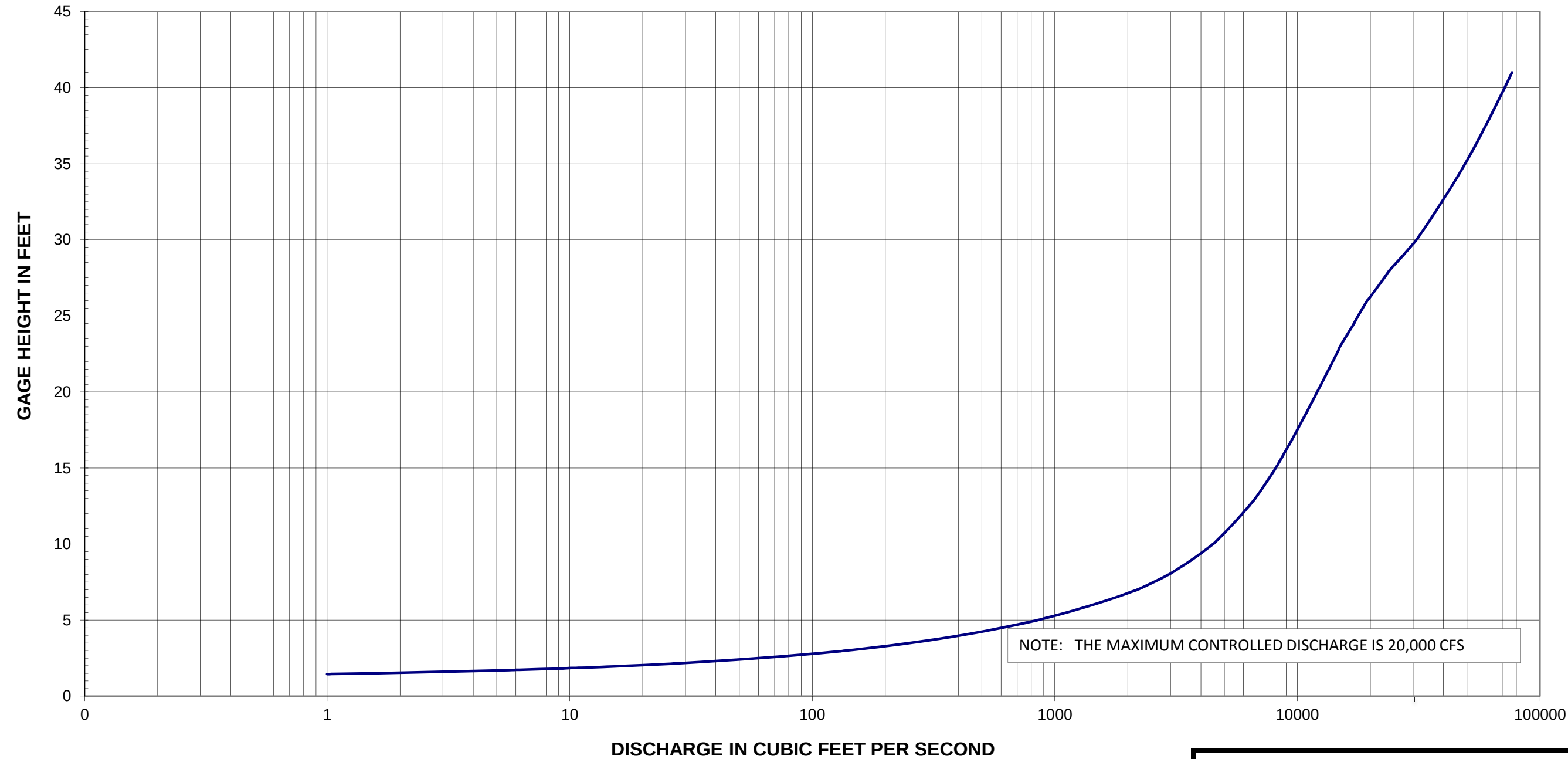
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**DECEMBER INFLOW FREQUENCY
1952-2015**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 16



ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE.

NECHES RIVER BASIN, TEXAS

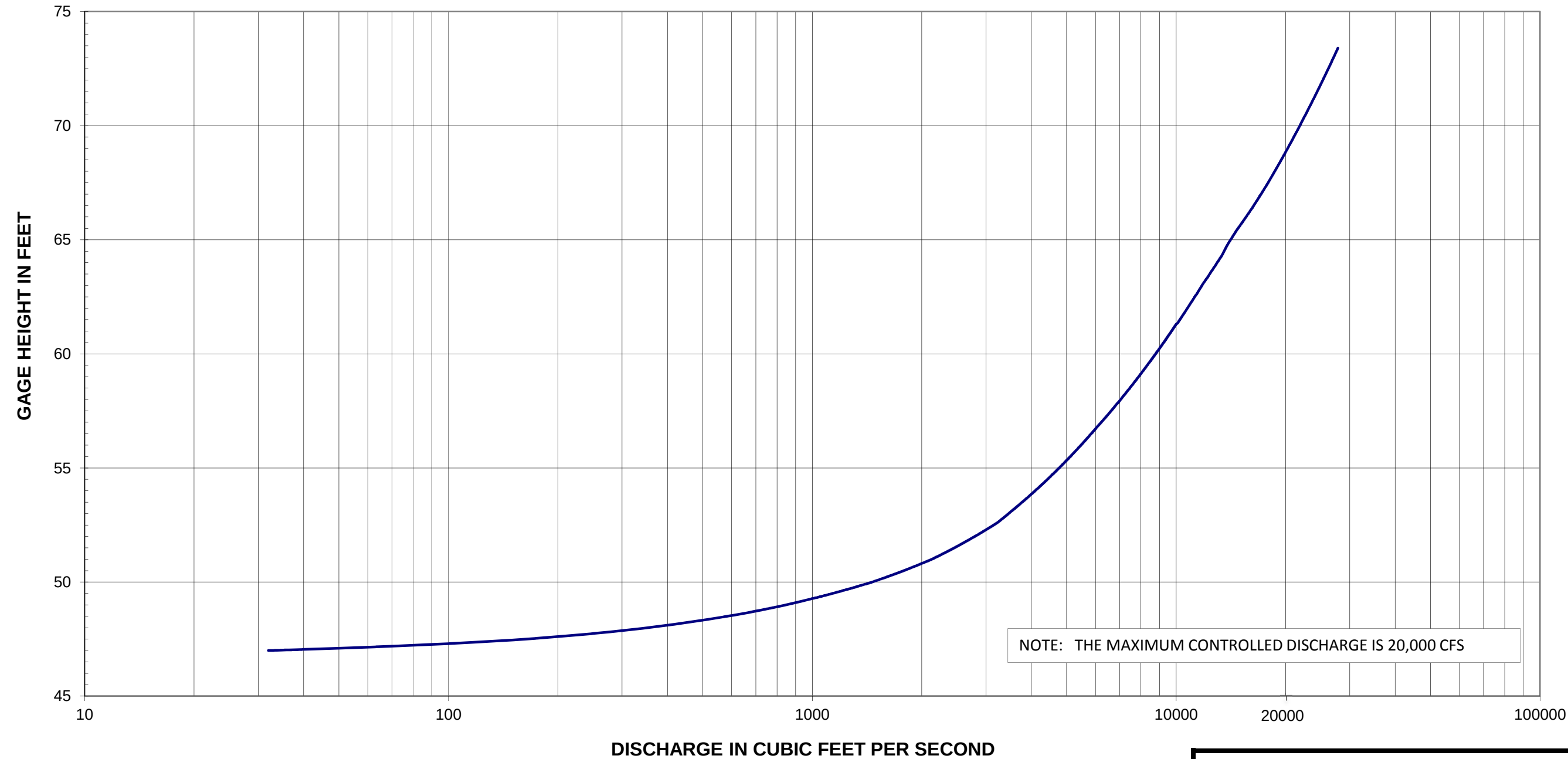
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**

NECHES RIVER, TEXAS

**RATING CURVE
NECHES RIVER NEAR ROCKLAND
USGS GAGE NO. 08033500**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016



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NECHES RIVER BASIN, TEXAS

**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**

NECHES RIVER, TEXAS

RATING CURVE

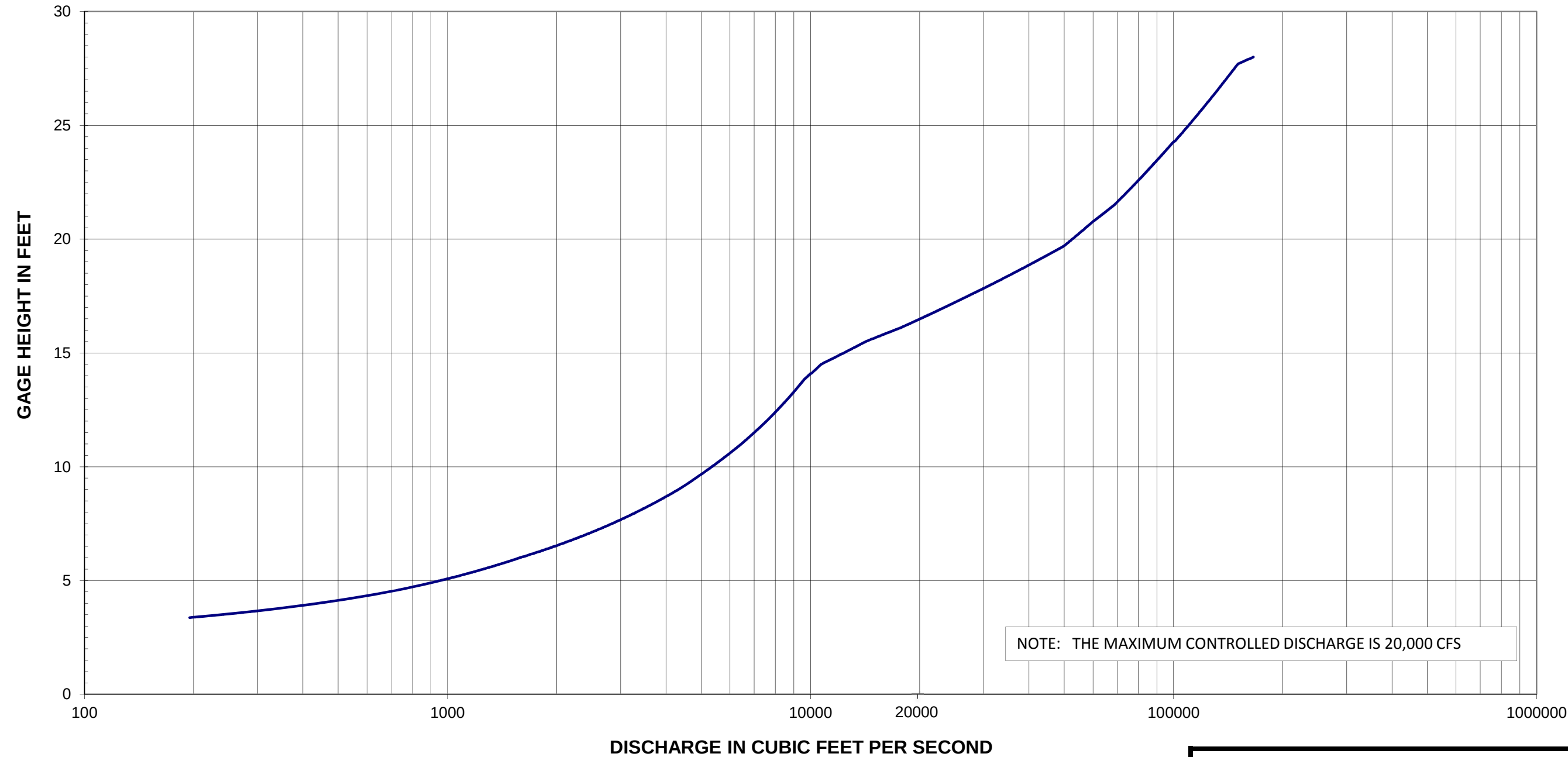
NECHES RIVER NEAR TOWN BLUFF

USGS GAGE NO. 08040600

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 4 - 18



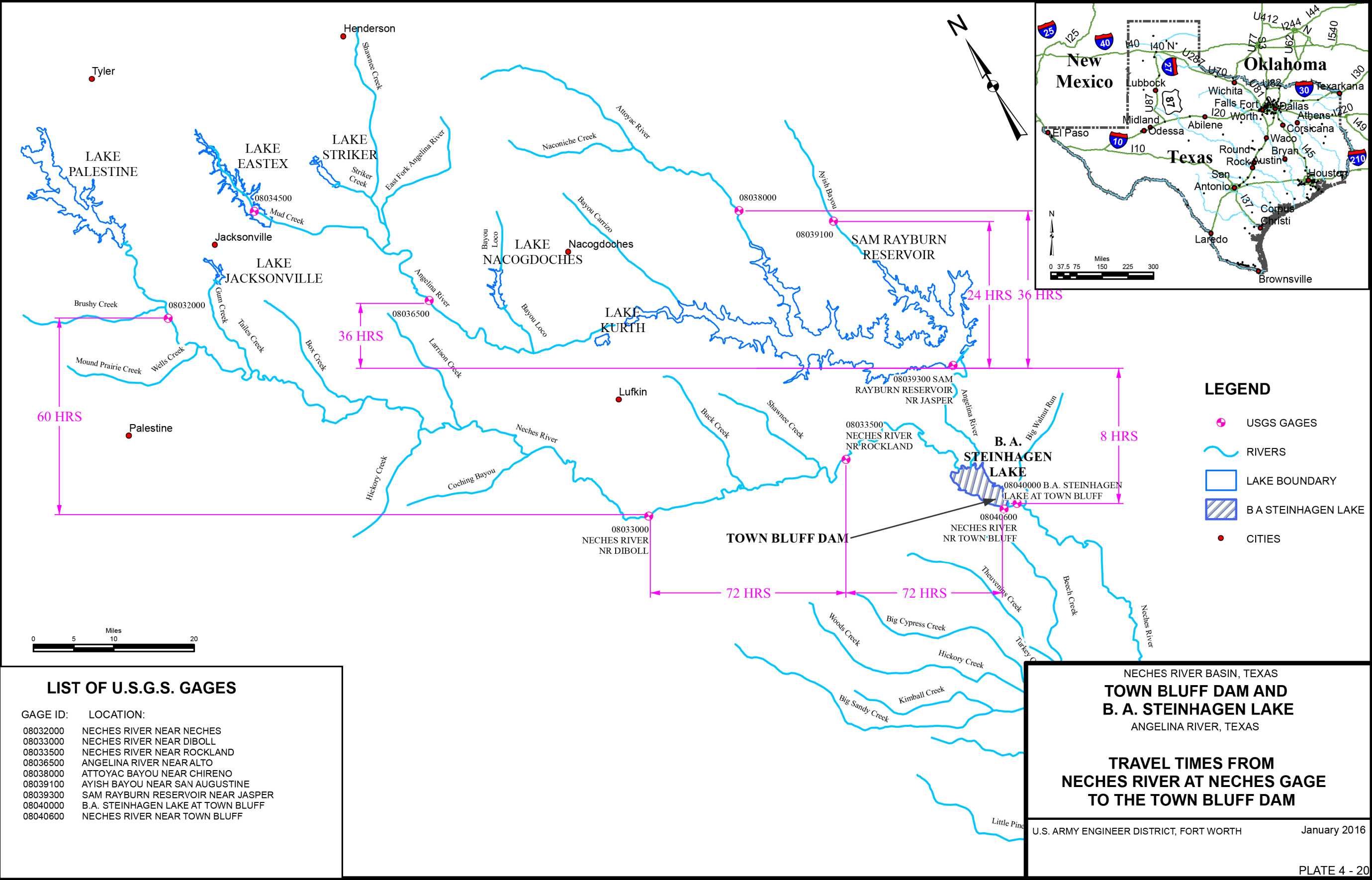
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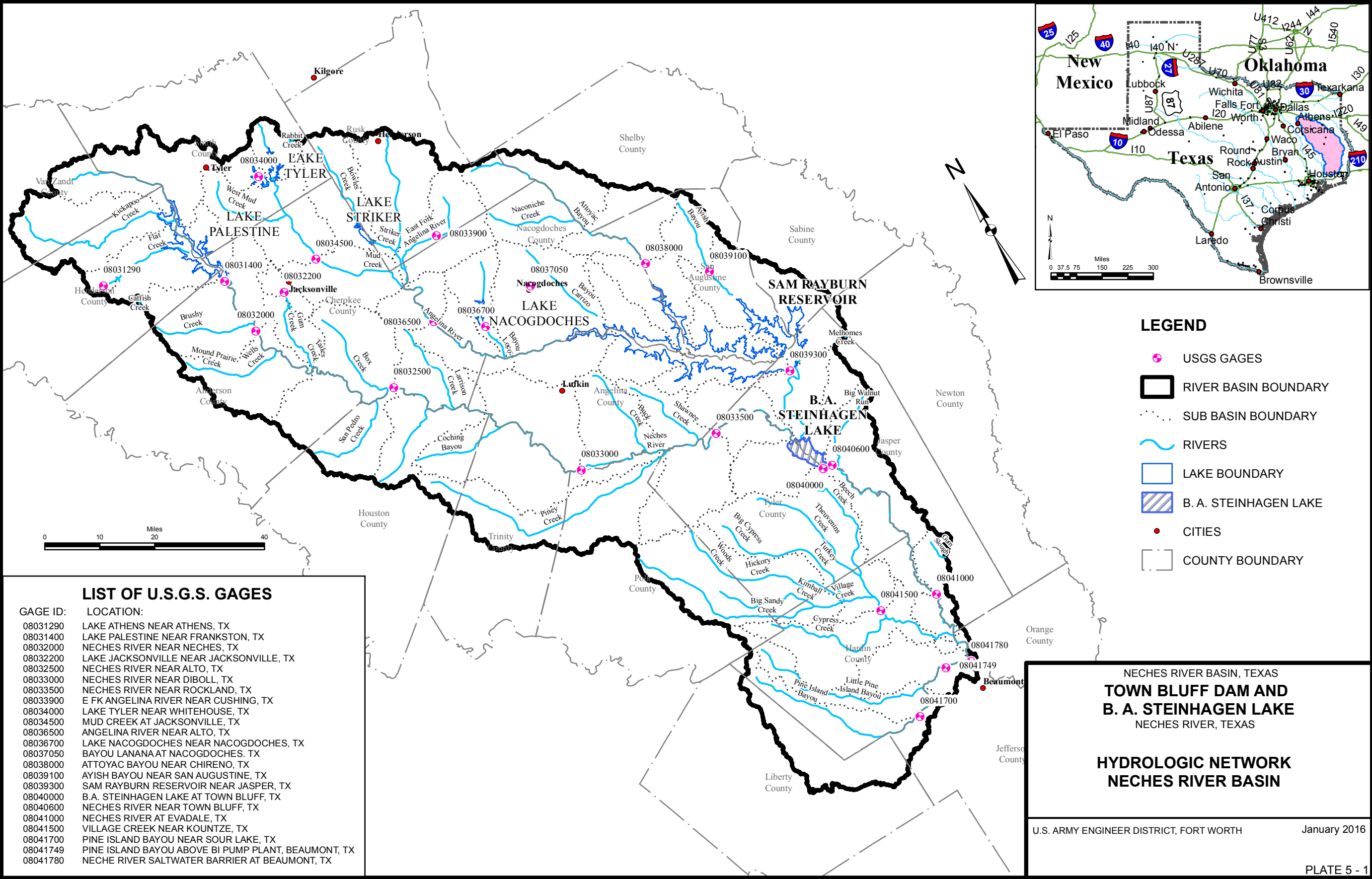
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

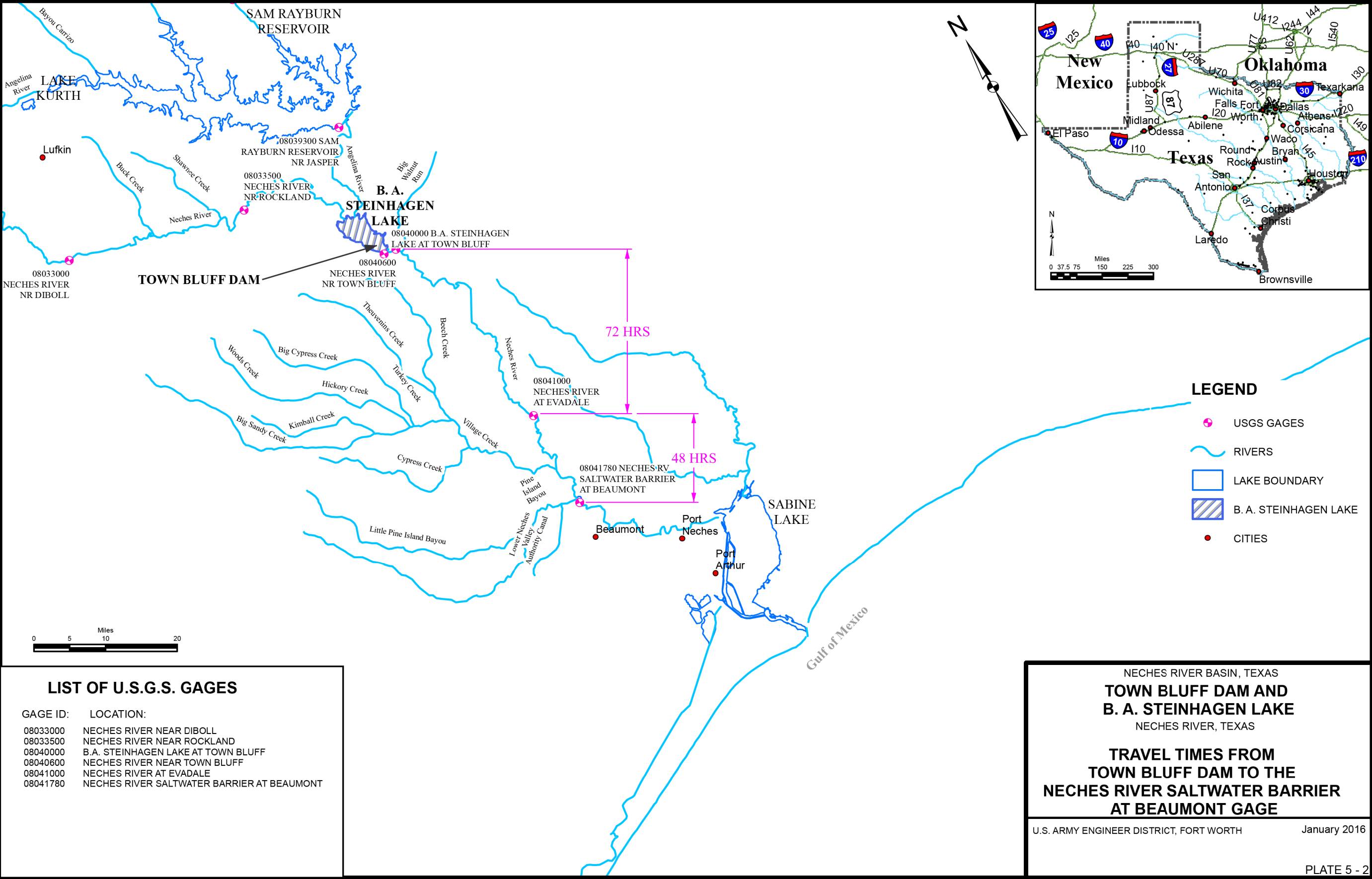
RATING CURVE
NECHES RIVER AT EVADALE
USGS GAGE NO. 08041000

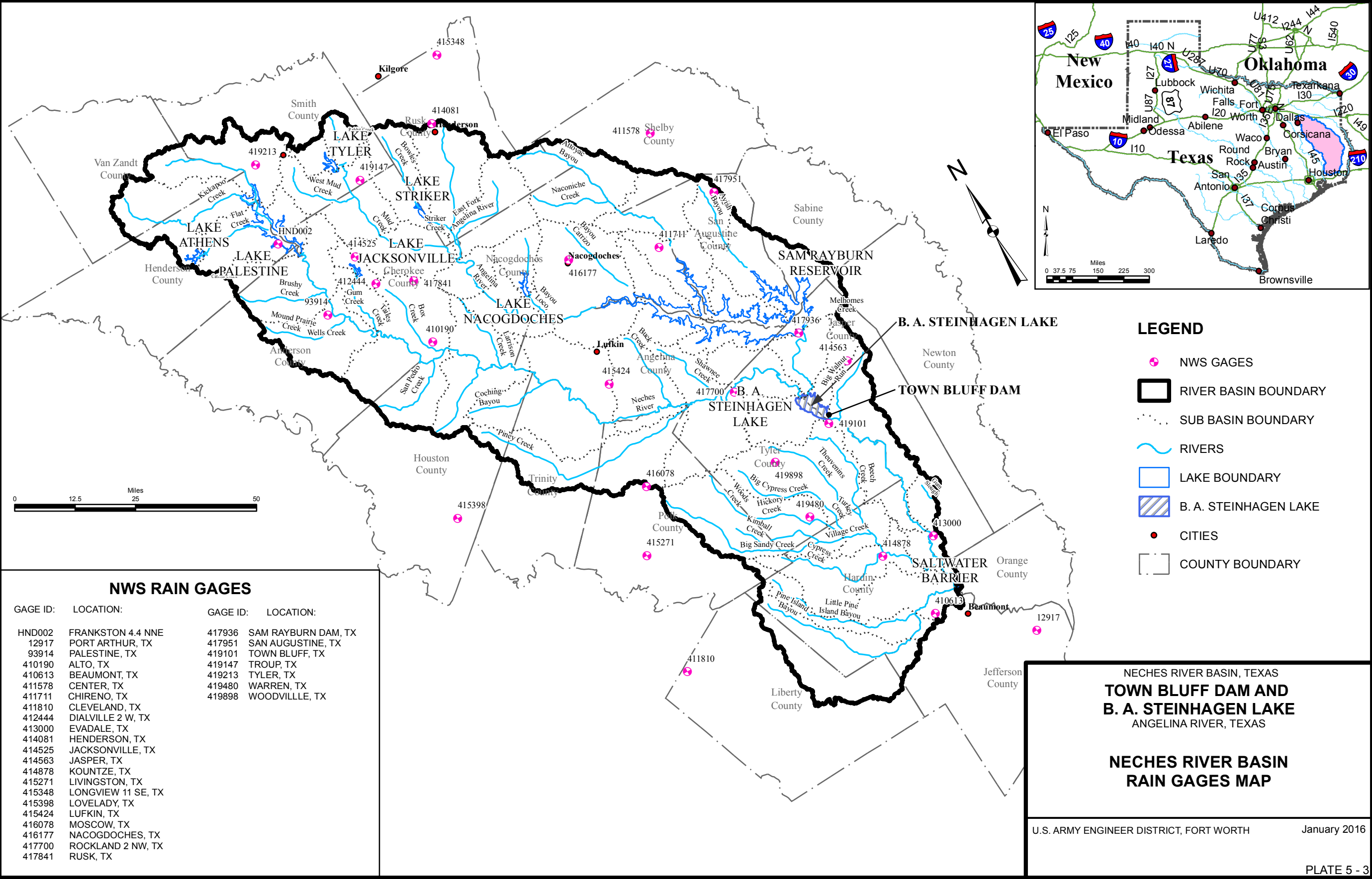
U.S. ARMY ENGINEER DISTRICT, FORT WORTH
January 2016

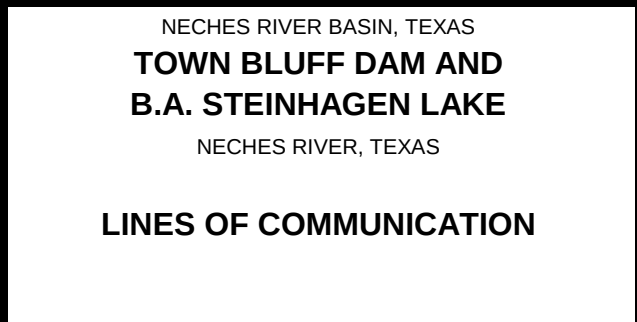
PLATE 4 - 19

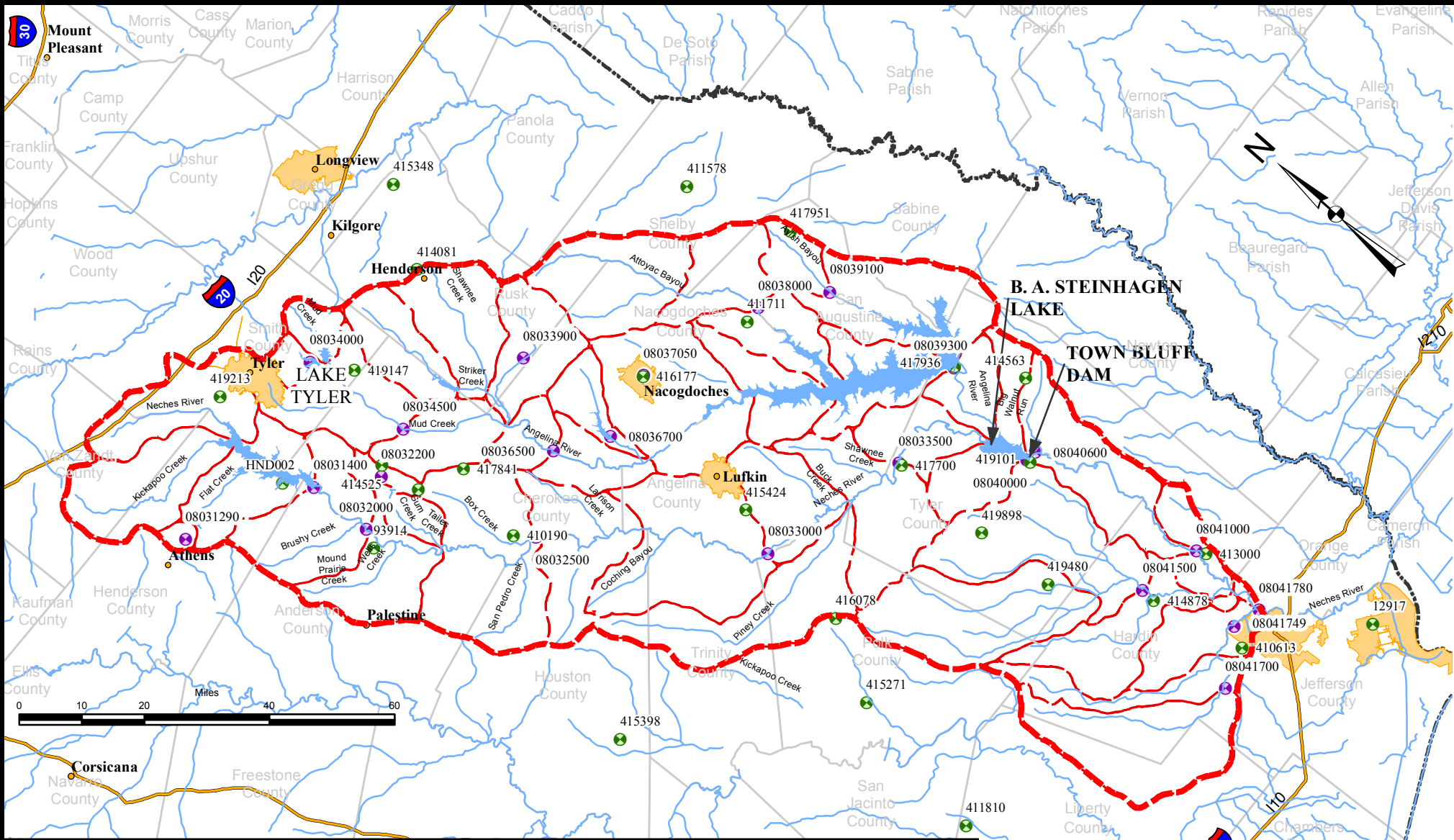












LEGEND

- RIVER BASIN BOUNDARY
- SUB BASIN BOUNDARY
- RIVERS
- LAKE BOUNDARY
- NWS GAGES
- USGS GAGES
- CITIES
- INTERSTATE
- METRO AREAS
- STATE BOUNDARY

NWS RAIN GAGES

GAGE ID:	LOCATION:	GAGE ID:	LOCATION:
HND002	FRANKSTON 4.4 NNE	415348	LONGVIEW 11 SE, TX
12917	PORT ARTHUR, TX	415398	LOVELADY, TX
93914	PALESTINE, TX	415424	LUFKIN, TX
410190	ALTO, TX	416078	MOSCOW, TX
410613	BEAUMONT, TX	416177	NACOGDOCHES, TX
411578	CENTER, TX	417700	ROCKLAND 2 NW, TX
411711	CHIRENO, TX	417841	RUSK, TX
411810	CLEVELAND, TX	417936	SAM RAYBURN DAM, TX
412444	DIALVILLE 2 W, TX	417951	SAN AUGUSTINE, TX
413000	EVADALE, TX	419101	TOWN BLUFF, TX
414081	HENDERSON, TX	419147	TROUP, TX
414525	JACKSONVILLE, TX	419213	TYLER, TX
414563	JASPER, TX	419480	WARREN, TX
414878	KOUNTZE, TX	419898	WOODVILLLE, TX
415271	LIVINGSTON, TX		

LIST OF U.S.G.S. GAGES

GAGE ID:	LOCATION:
08031290	LAKE ATHENS NEAR ATHENS, TX
08031400	LAKE PALESTINE NEAR FRANKSTON, TX
08032000	NECHES RIVER NEAR NECHES, TX
08032200	LAKE JACKSONVILLE NEAR JACKSONVILLE, TX
08032500	NECHES RIVER NEAR ALTO, TX
08033000	NECHES RIVER NEAR DIBOLL, TX
08033500	NECHES RIVER NEAR ROCKLAND, TX
08033900	E FK ANGELINA RIVER NEAR CUSHING, TX
08034000	LAKE TYLER NEAR WHITEHOUSE, TX
08034500	MUD CREEK AT JACKSONVILLE, TX
08036500	ANGELINA RIVER NEAR ALTO, TX
08036700	LAKE NACOGDOCHES NEAR NACOGDOCHES, TX
08037050	BAYOU LANANA AT NACOGDOCHES, TX
08038000	ATTOYAC BAYOU NEAR CHIRENO, TX
08039100	AYISH BAYOU NEAR SAN AUGUSTINE, TX
08039300	SAM RAYBURN RESERVOIR NEAR JASPER, TX
08040000	B.A. STEINHAGEN LAKE AT TOWN BLUFF, TX
08040600	NECHES RIVER NEAR TOWN BLUFF, TX
08041000	NECHES RIVER AT EVADALE, TX
08041500	VILLAGE CREEK NEAR KOUNTZE, TX
08041700	PINE ISLAND BAYOU NEAR SOUR LAKE, TX
08041749	PINE ISLAND BAYOU ABOVE BI PUMP PLANT, BEAUMONT, TX
08041780	NECHE RIVER SALTWATER BARRIER AT BEAUMONT, TX

NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B. A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

REAL TIME WATER CONTROL
BASE MAP

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

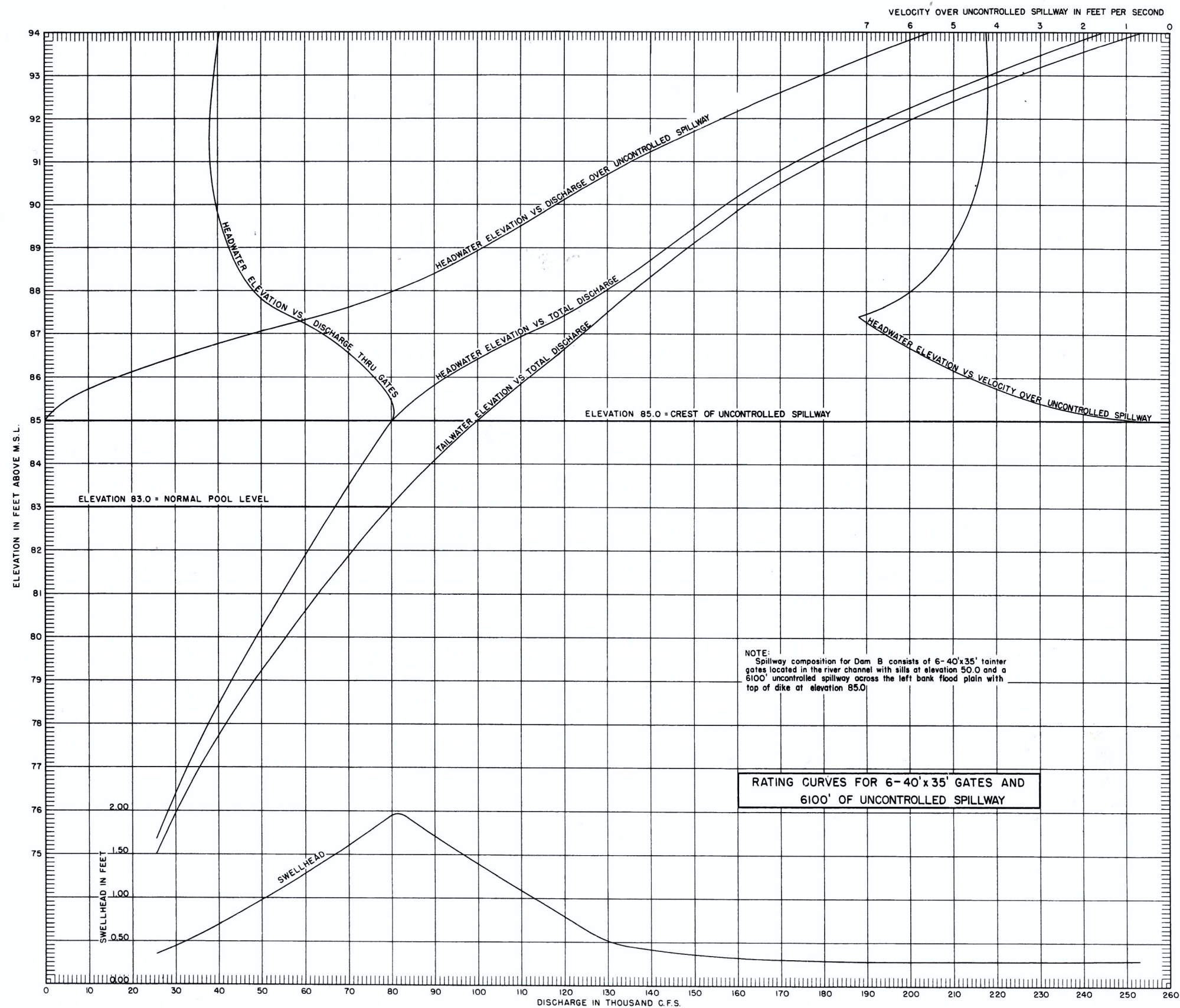


FIG. 1

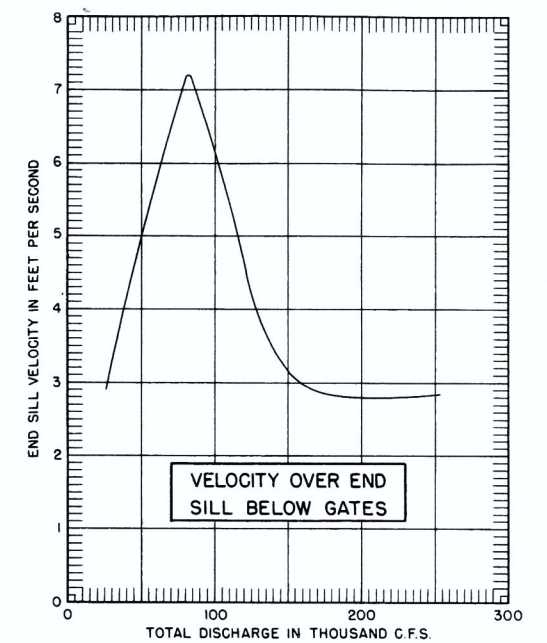


FIG. 3

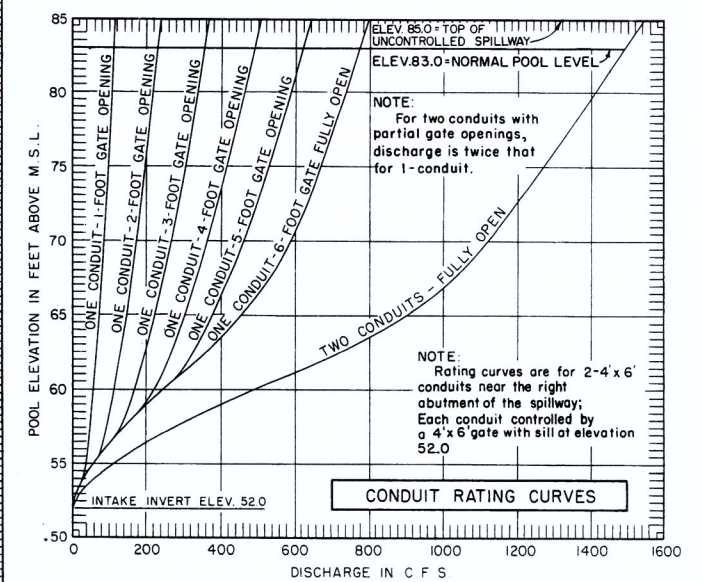
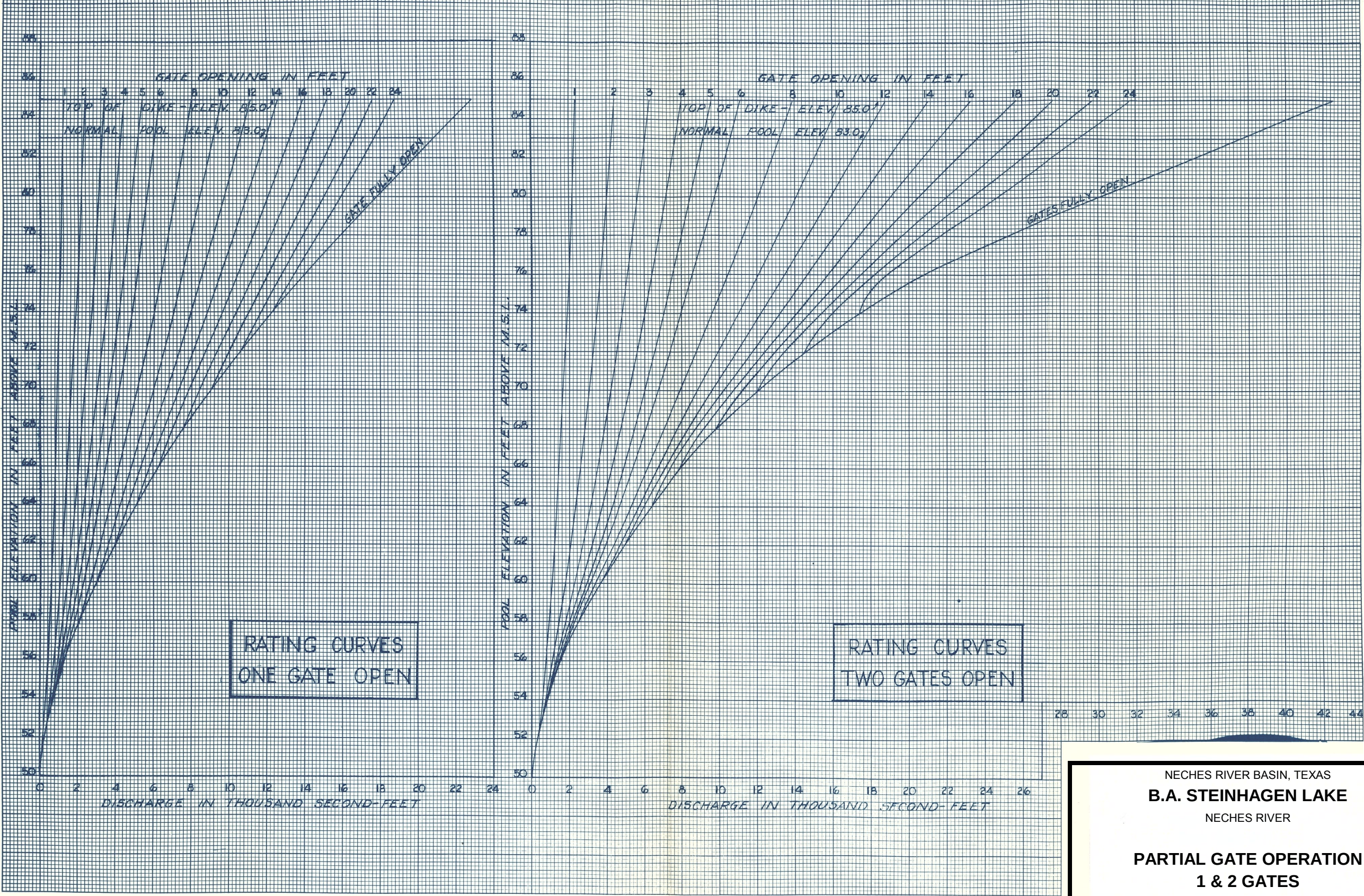
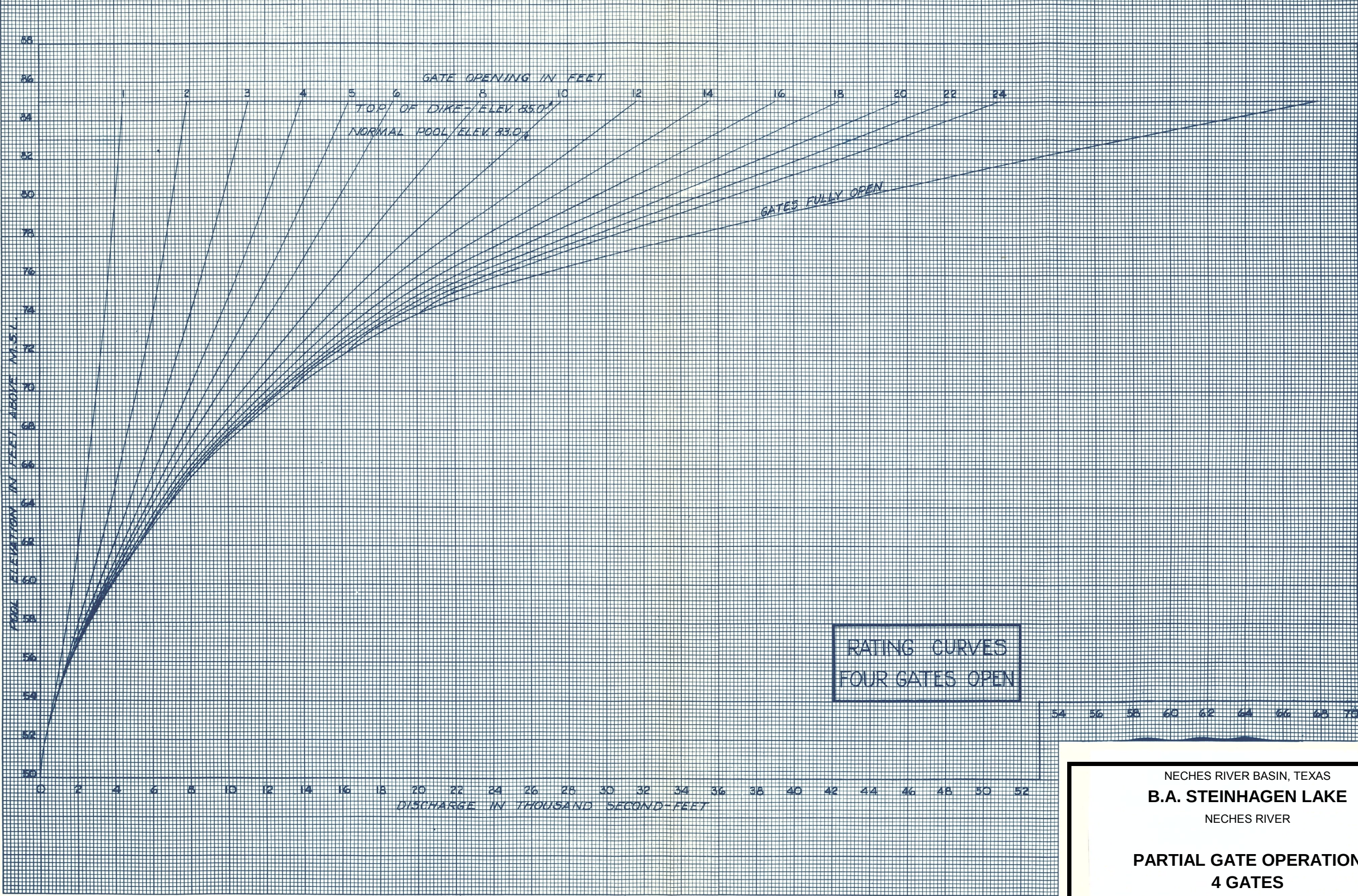


FIG. 2

NECHES RIVER BASIN, TEXAS
B.A. STEINHAGEN LAKE
 NECHES RIVER
GENERAL HYDRAULIC DATA





NECHES RIVER BASIN, TEXAS

B.A. STEINHAGEN LAKE

NECHES RIVER

PARTIAL GATE OPERATION

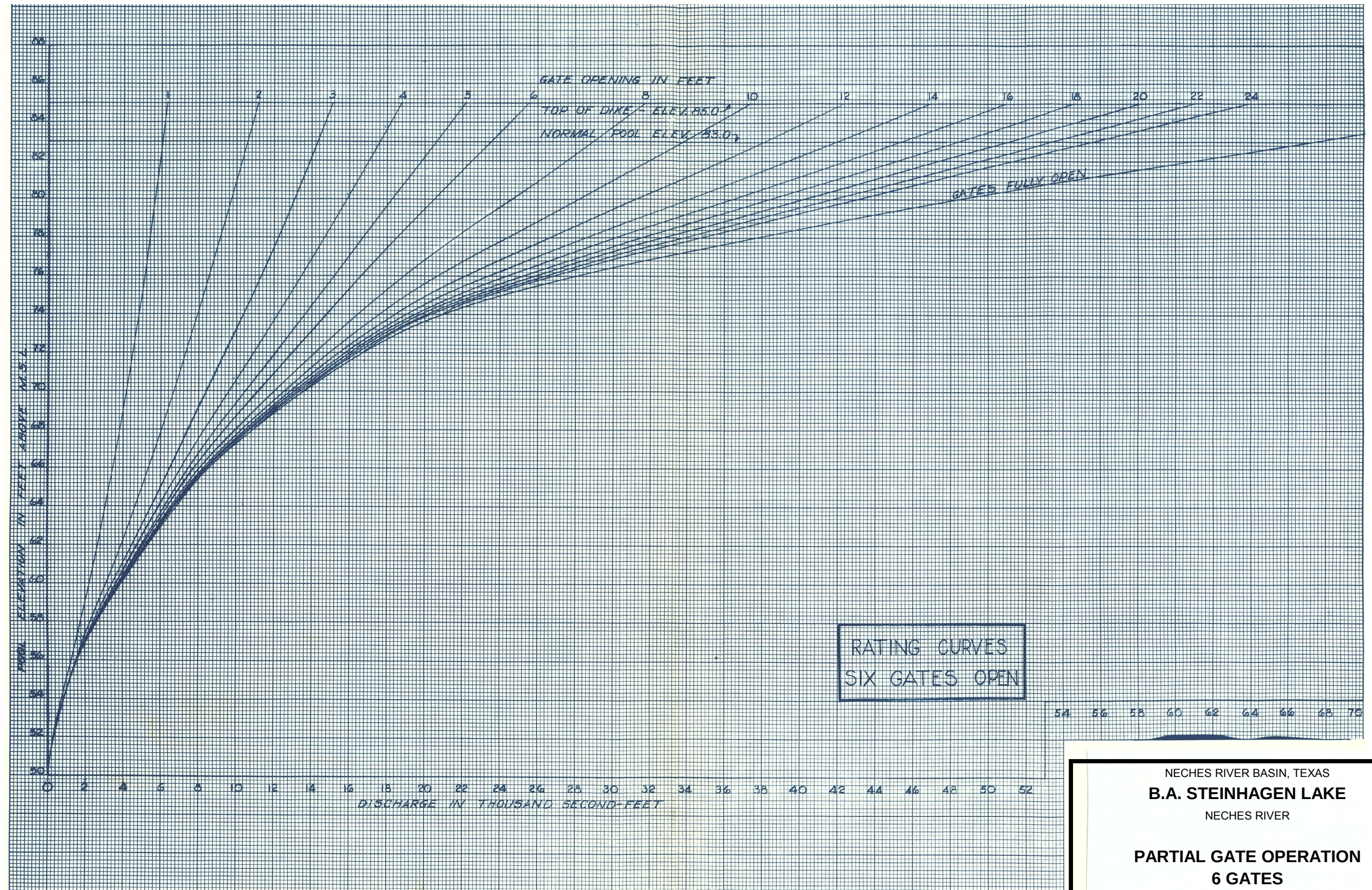
4 GATES

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

SEP 2014

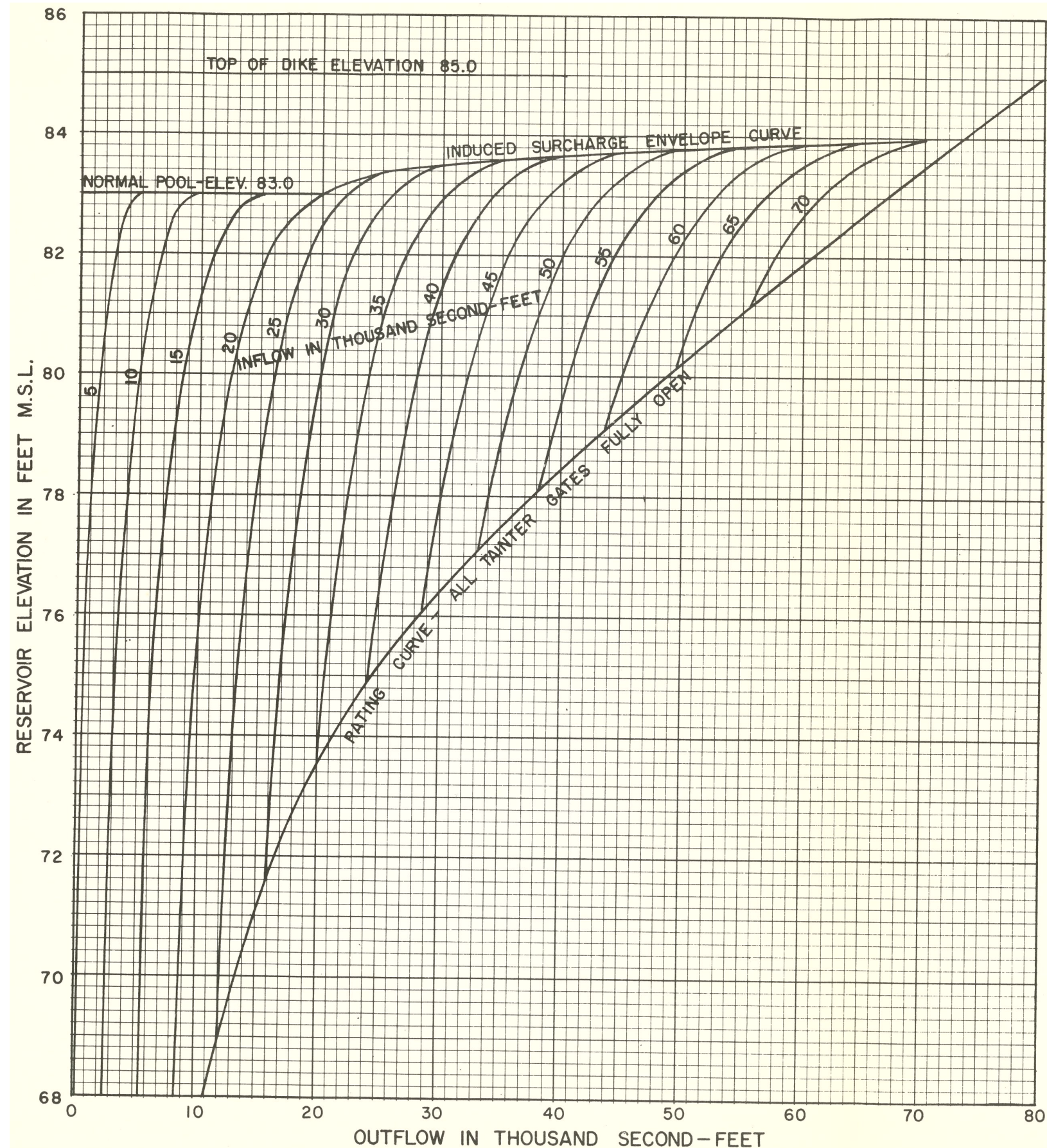
From March 1956 WCM

PLATE 7 - 3



NECHES RIVER BASIN, TEXAS
B.A. STEINHAGEN LAKE
NECHES RIVER

**PARTIAL GATE OPERATION
6 GATES**



OPERATING INSTRUCTIONS

1. Make conservation releases as instructed in Reservoir Regulation Schedule, Exhibit 7-1.
2. Make regular flood-control releases as instructed in the Regulation Schedule until larger releases are indicated by these curves.
3. When the reservoir begins to rise, adjust the outflow each hour on the basis of the average inflow for the preceding three hours and the current reservoir elevation as indicated by the curves until the gates are fully open. As long as the reservoir level continues to rise, do not reduce current rate of releases by closing gates.
4. When the reservoir level is above elevation 83.0 and starts to fall, maintain current gate openings until the reservoir level recedes to elevation 83.0 and then close gates sufficiently to reduce releases and maintain elevation 83.0.
5. A minor flood is one in which the reservoir can be operated so that the pool level will not exceed elevation 83.0 with a maximum release of 20,000 second-feet. A major flood will cause elevation 83.0 to be exceeded.

NECHES RIVER BASIN, TEXAS
B.A. STEINHAGEN LAKE
 NECHES RIVER

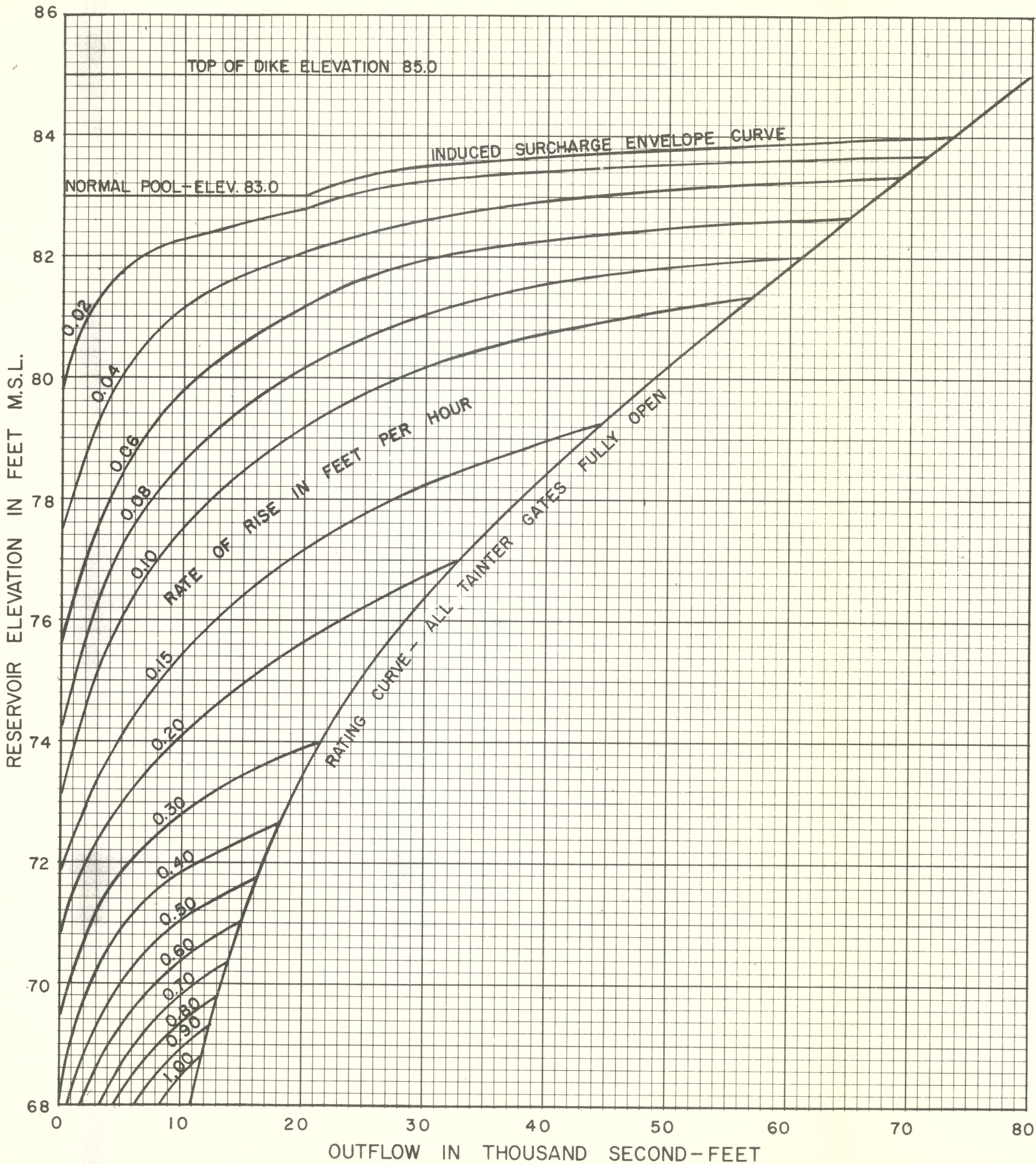
**RESERVOIR REGULATION
 FOR MAJOR FLOODS
 OUTFLOW VS. INFLOW**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

SEP 2014

From March 1956 WCM

PLATE 7 - 5

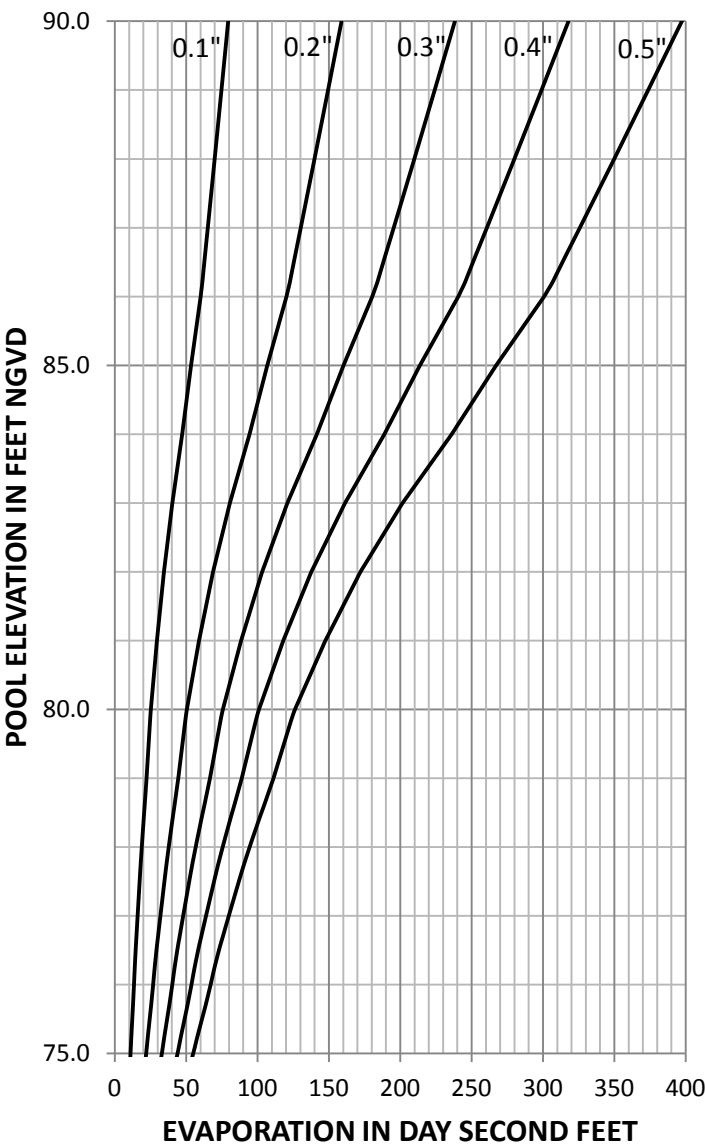
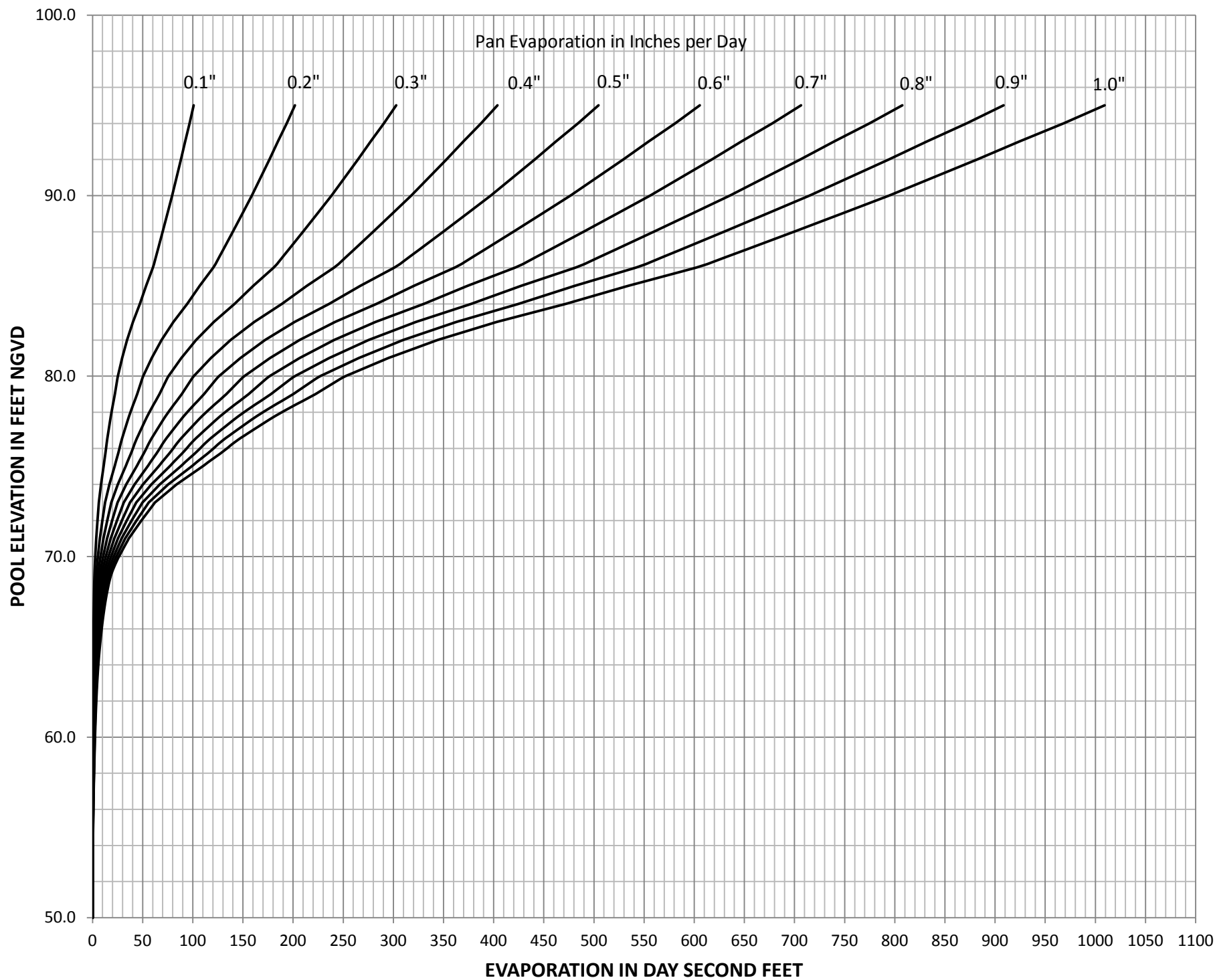


EMERGENCY
OPERATING INSTRUCTIONS

For operation when communications with District Office fail.

1. Make conservation releases as instructed in the Reservoir Regulation Schedule, Exhibit 7-1.
2. Make regular flood-control releases as instructed in the Regulation Schedule until larger releases are indicated by these curves.
3. When the reservoir begins to rise, adjust the outflow each hour on the basis of the average rate of rise for the preceding three hours and the current reservoir elevation as indicated by the curves until the gates are fully open. As long as the reservoir level continues to rise, do not reduce current rate of releases by closing gates.
4. When the reservoir level is above elevation 83.0 and starts to fall, maintain current gate openings until the reservoir level recedes to elevation 83.0 and then close gates sufficiently to reduce releases and maintain elevation 83.0.

NECHES RIVER BASIN, TEXAS
B.A. STEINHAGEN LAKE
NECHES RIVER
**EMERGENCY
RESERVOIR REGULATION
FOR MAJOR FLOODS
OUTFLOW VS. RATE OF RISE**

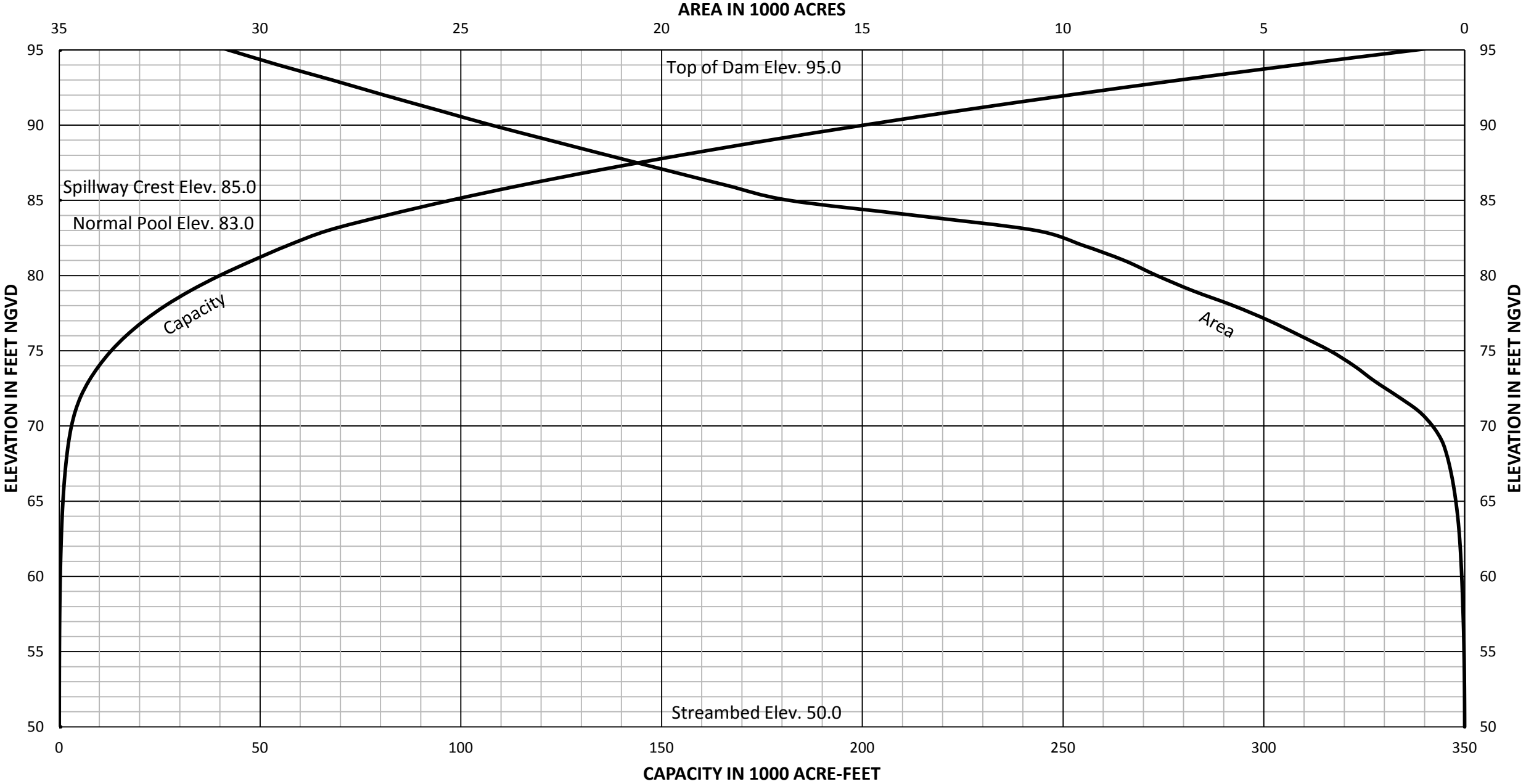


NECHES RIVER BASIN, TEXAS
B.A. STEINHAGEN LAKE
NECHES RIVER

LAKE EVAPORATION CURVES

U.S. ARMY ENGINEER DISTRICT, FORT WORTHSEP 2014

PLATE 7 - 7

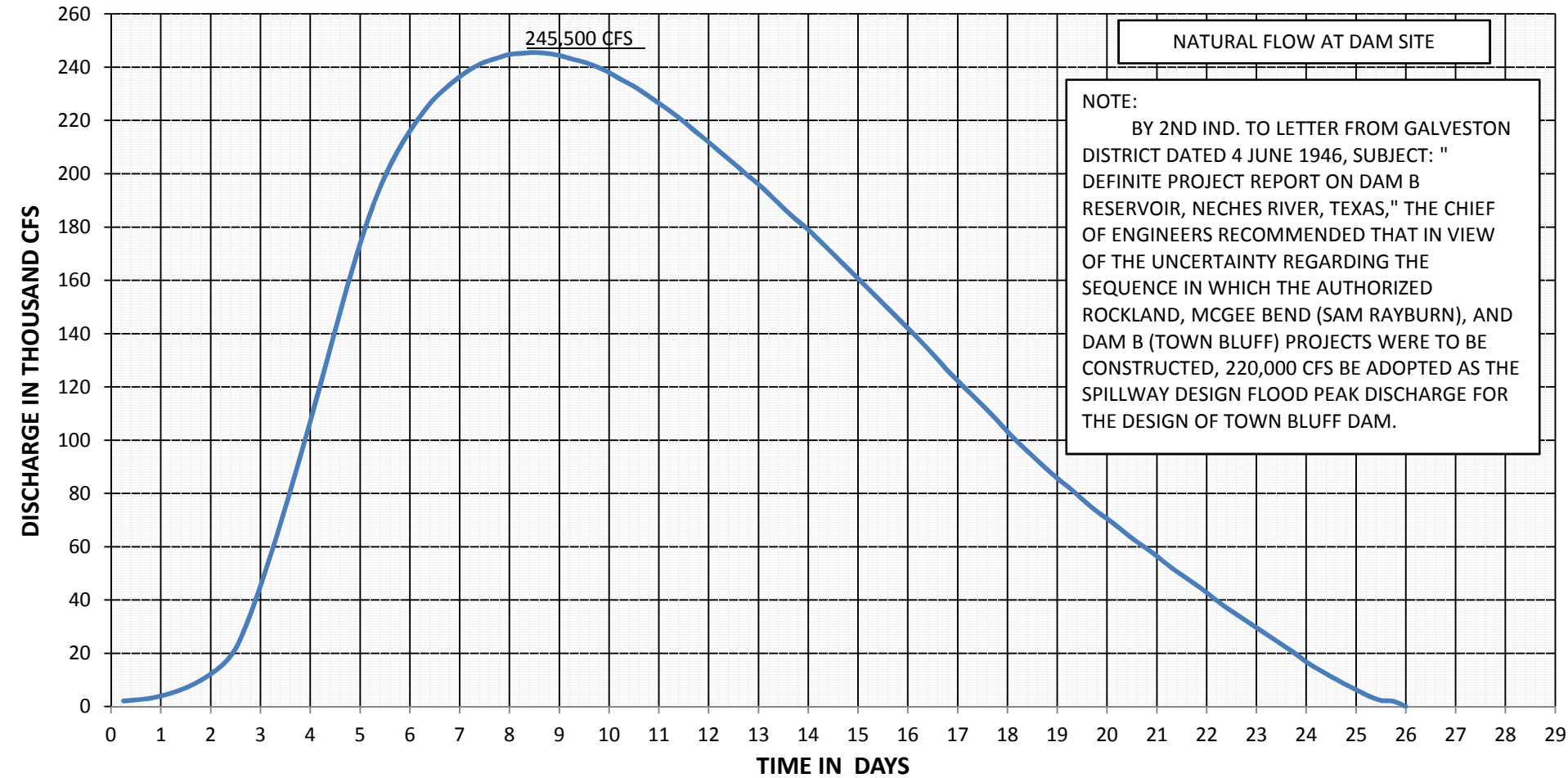


NECHES RIVER BASIN, TEXAS
B.A. STEINHAGEN LAKE
NECHES RIVER

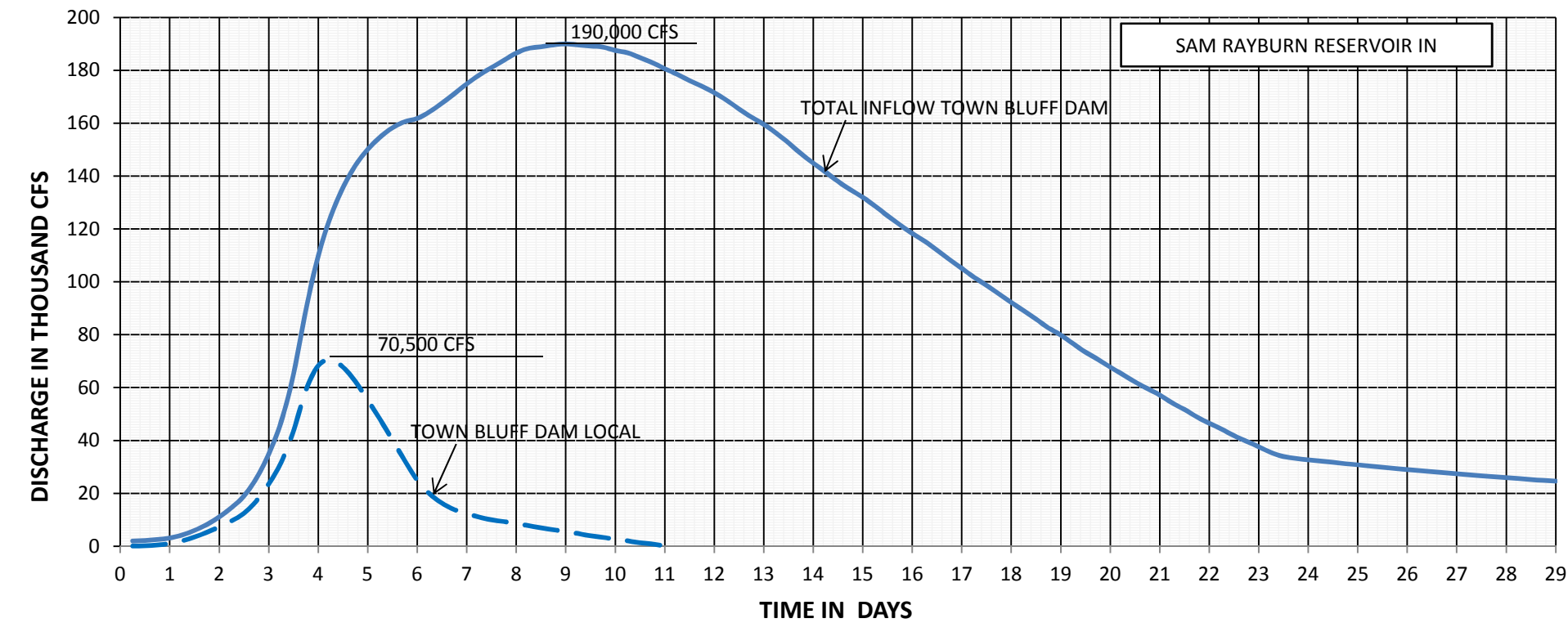
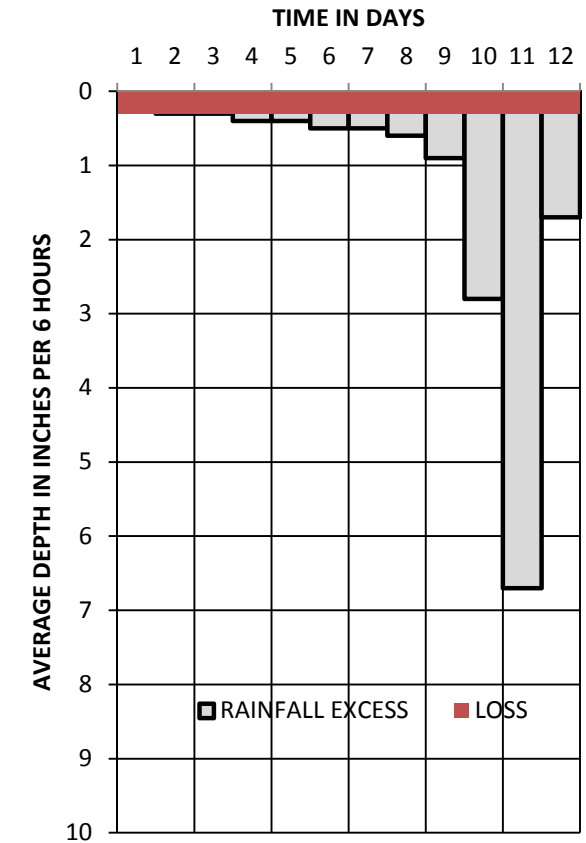
AREA AND CAPACITY CURVES
Survey 2003

U.S. ARMY ENGINEER DISTRICT, FORT WORTH SEP 2014

PLATE 7 - 8



HYETOGRAPH (INCHES)	
RAINFALL TOTAL-----	18.90
LOSS TOTAL-----	3.60
RAINFALL - EXCESS TOTAL-----	15.30
INFILTRATION INDEX (F. A. V. G)-----	0.05

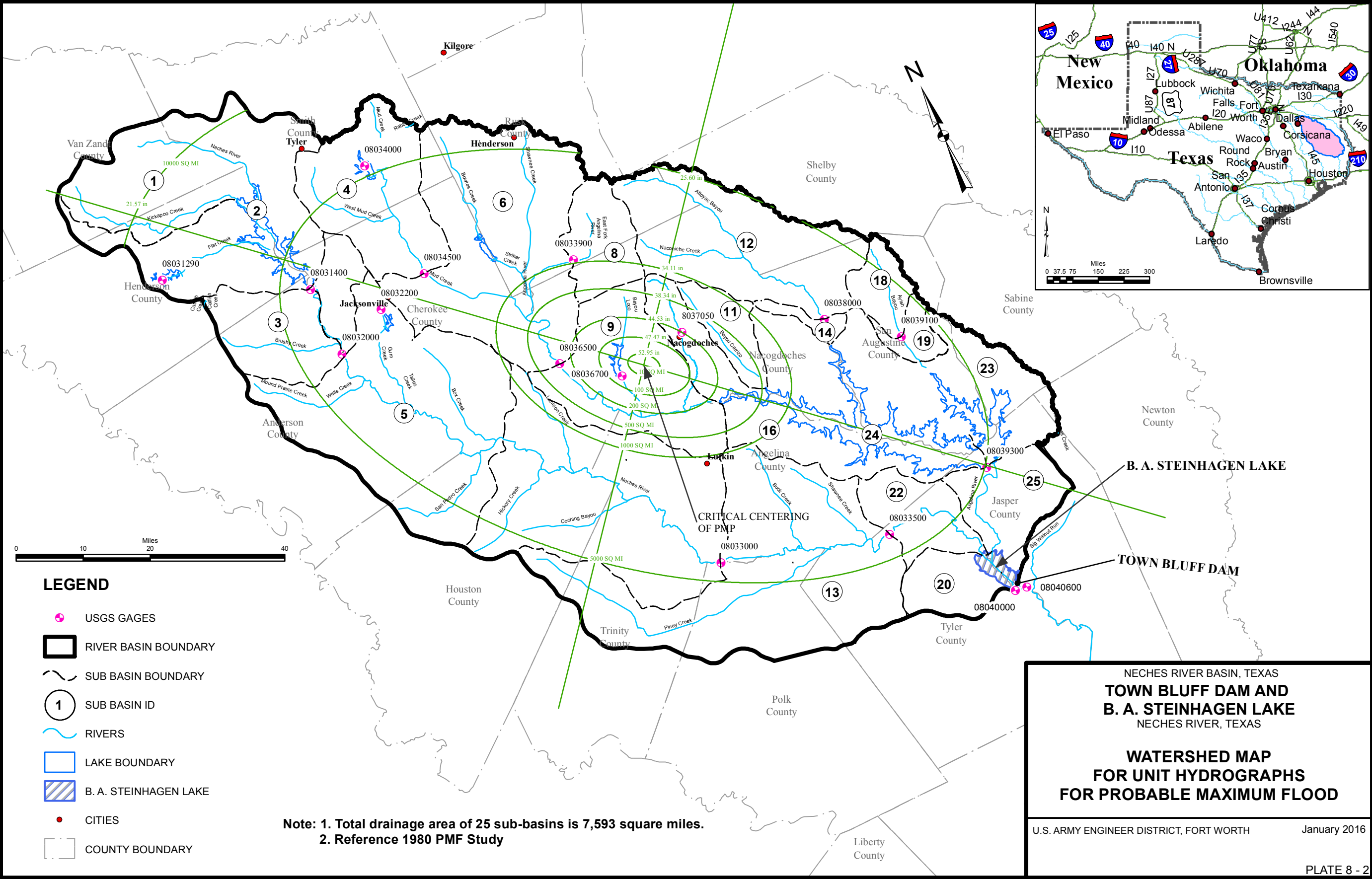


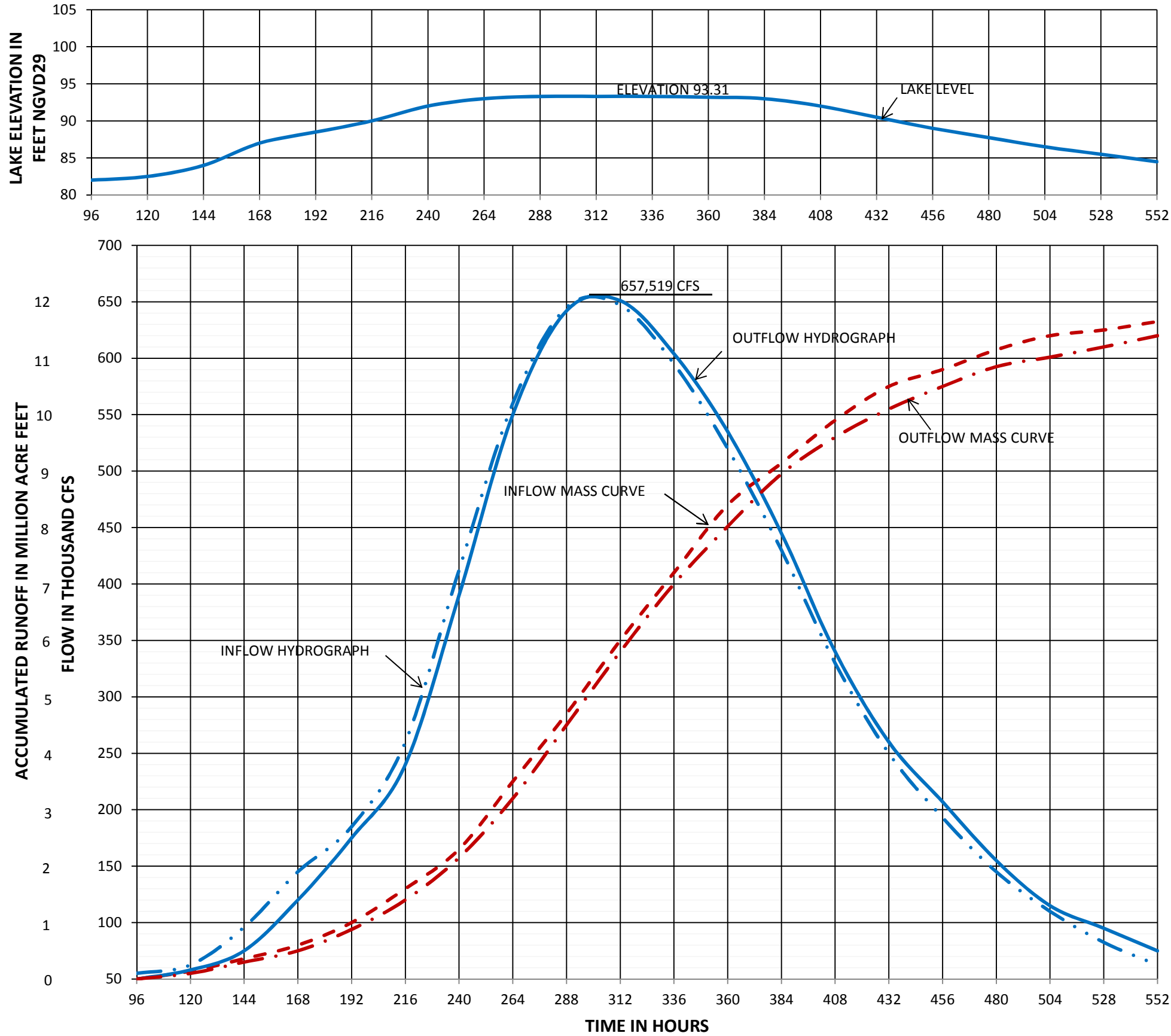
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

SPILLWAY DESIGN FLOOD

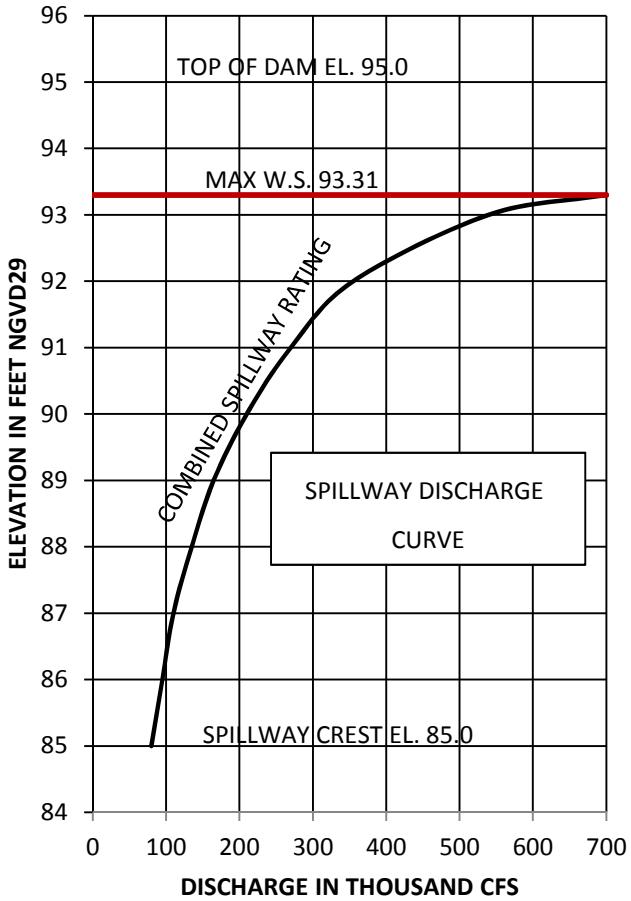
U.S. ARMY ENGINEER DISTRICT, FORT WORTH
January 2016

PLATE 8 - 1





HYETOGRAPH (INCHES)	
RAINFALL	28.30
LOSS	4.62
RAINFALL - EXCESS	23.68
INITIAL LOSS	0.60
INFILTRATION INDEX (F. A. V. G)	0.05



NECHES RIVER BASIN, TEXAS

**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**

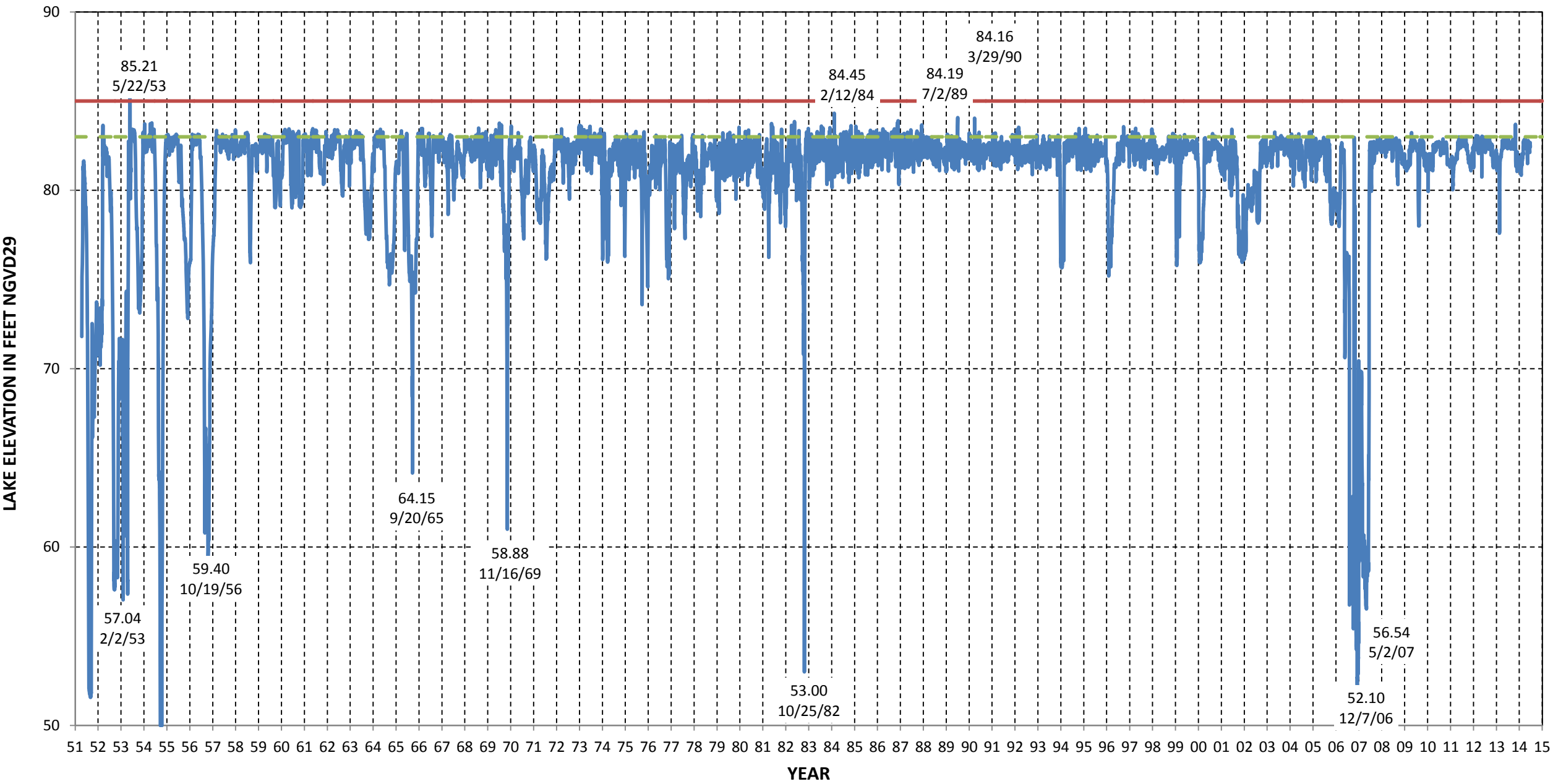
NECHES RIVER, TEXAS

**PROBABLE MAXIMUM FLOOD
INFLOW-OUTFLOW HYDROGRAPHS**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 8 - 3



DELIBERATE IMPOUNDMENT BEGAN: 04/16/1951

RECORD LAKE ELEVATION AND DATE: 85.21 NGVD29, 05/22/1953

ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE.

NECHES RIVER BASIN, TEXAS

**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**

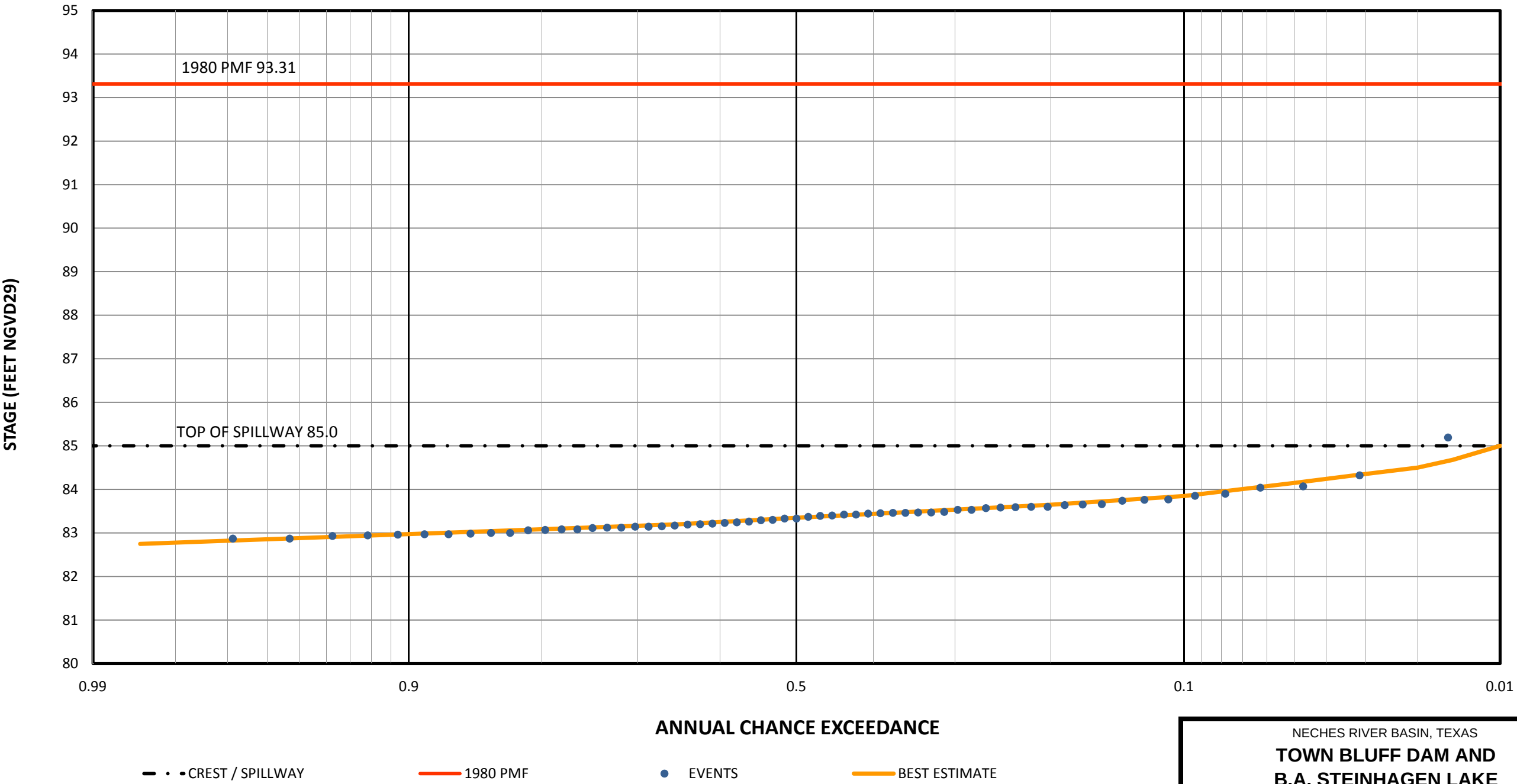
NECHES RIVER, TEXAS

PERIOD OF RECORD LAKE LEVEL

U.S. ARMY ENGINEER DISTRICT, FORT WORTH January 2016

PLATE 8 - 4

B.A. STEINHAGEN LAKE STAGE FREQUENCY



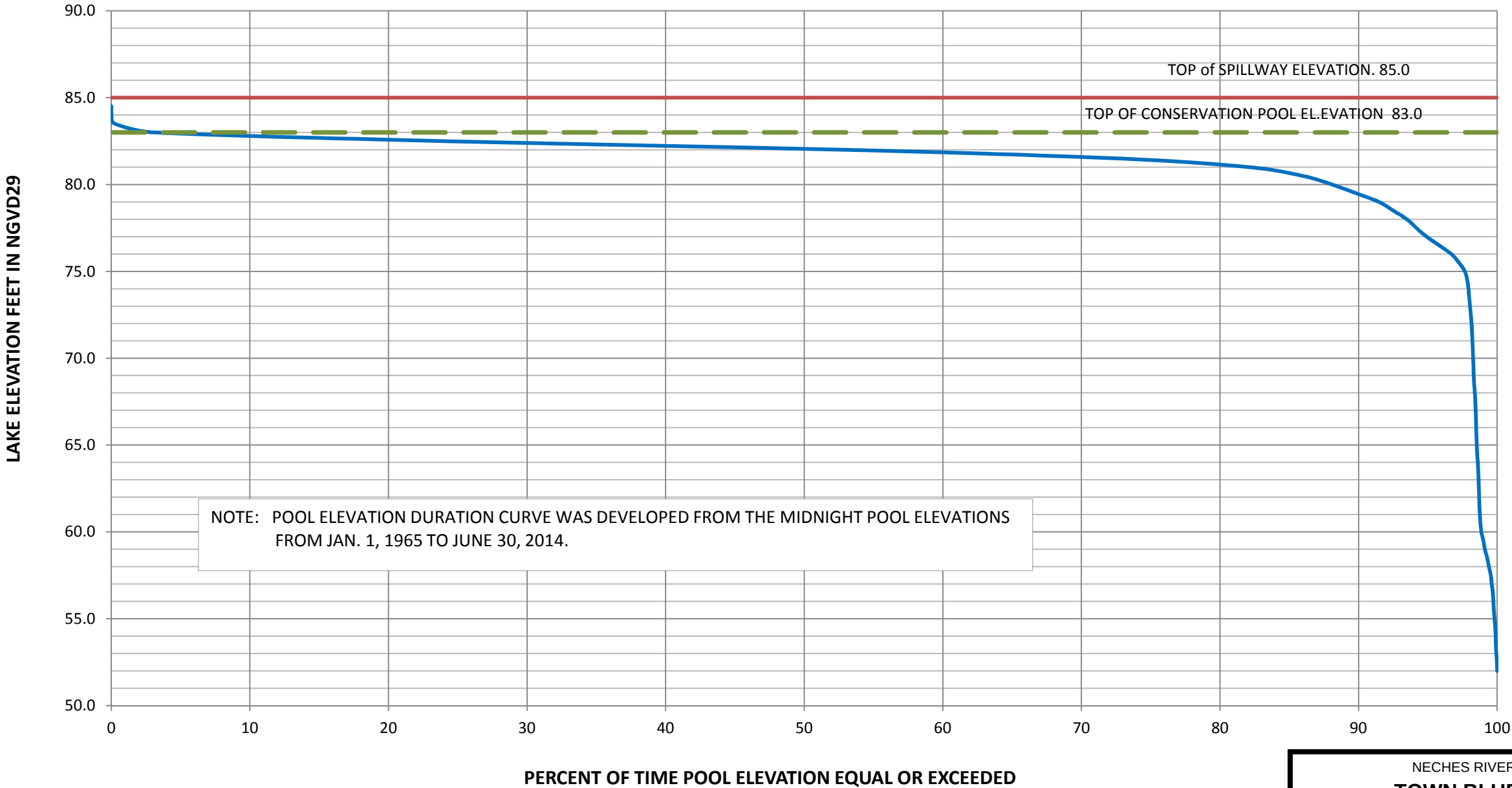
ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE.

NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**ANNUAL PEAK
ELEVATION FREQUENCY**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH January 2016

B.A. STEINHAGEN LAKE



ALL ELEVATIONS REFERRED TO ON THIS PLATE, UNLESS NOTED OTHERWISE, ARE IN FEET, NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29). THE DATUM CONVERSION FROM NGVD29 TO NAVD88 IS: NGVD29 + 0.0 FEET = NAVD88 FOR TOWN BLUFF DAM AND B.A. STEINHAGEN LAKE.

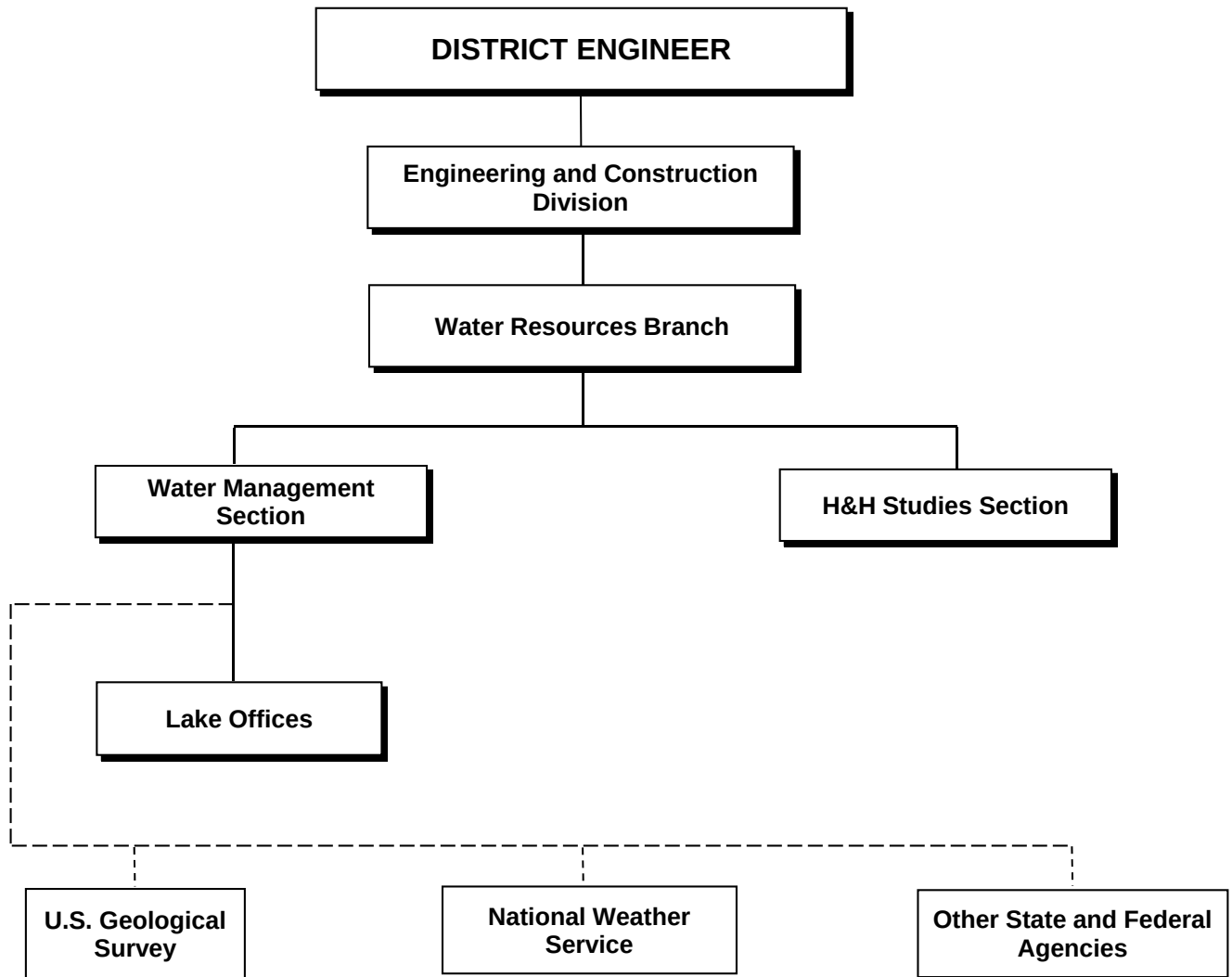
NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

LAKE ELEVATION DURATION

U.S. ARMY ENGINEER DISTRICT, FORT WORTH
January 2016

PLATE 8 - 6

**FORT WORTH DISTRICT
ORGANIZATION FOR LAKE REGULATION**



— LINES OF COMMAND AUTHORITY

- - - - LINES OF DIRECT COMMUNICATION

NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

**ORGANIZATION FOR
FLOOD CONTROL REGULATION**

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

FORT WORTH DISTRICT CORPS OF ENGINEERS
RESERVOIR REPORT FOR WEDNESDAY 24SEP2014

RESERVOIR	ELEVATION 0800 FT-NGVD	TOP CONS POOL	MEAN INFLOW DSF	MEAN TURBINE DSF	DAILY PUMP MGD	RELEASES OTHER DSF	RAIN INCHES	EVAP CFS	0800 RELEASE CFS	POOL OCCUPIED %	A-F
-----------	------------------------------	---------------------	-----------------------	------------------------	----------------------	--------------------------	----------------	-------------	------------------------	-----------------------	-----

RED RIVER BASIN

Cooper	429.18	440.0	-100	--	108.819	4	0.00	.16	4	39 C	102657
Wright Patm	225.62	225.2	45	--	42.279	112	0.00	.13	112	0 F	10999
Bob Sandlin	335.12	337.5	-183	--	--	0	--	--	0	89 C	180254
Lake O Pine	228.61	229.1	-133	--	--	53	0.00	--	53	97 C	241863
Caddo	167.69	168.5	-256	--	--	0	0.00	--	0	84 C	107779

NECHES RIVER BASIN

Sam Rayburn	162.67	164.4	-1520	2229	--	0	0.00	.13	0	87 F	1218321
B.A. Steinh	82.52	83.0	2468	2000	--	0	0.00	.21	1990	93 C	61739

TRINITY RIVER BASIN

Bridgeport	812.63	836.0	-42	--	--	0	0.00	--	0	38 C	138542
Eagle Mount	639.13	649.0	17	--	50.300	131	0.00	--	131	59 C	107378
Lake Worth	590.46	594.0	111	--	55.100	0	0.00	--	0	70 C	25731
Benbrook	686.18	694.0	2	--	2.786	4	0.00	.25	13	64 C	45628
Joe Pool	520.55	522.0	-5	--	6.250	5	0.00	.20	5	93 C	132233
Mountain Ck	457.02	457.0	-21	--	--	0	--	--	0	-- S	54
Ray Roberts	625.66	632.5	117	--	11.949	65	--	--	65	77 C	608520
Lewisville	515.54	522.0	160	0	49.358	341	0.00	--	341	72 C	403002
Grapevine	523.72	535.0	-14	--	--	34	0.00	.31	35	56 C	82022
Lavon	479.52	492.0	-6	--	279.844	0	0.00	.24	0	48 C	193614
Ray Hubbard	425.82	435.5	-99	--	82.500	54	0.00	--	54	61 C	297358
Cedar Creek	316.77	322.0	-17	--	90.350	0	0.00	--	0	76 C	508579
Navarro Mil	423.09	424.5	11	--	8.200	0	0.00	.26	0	87 C	43401
Bardwell	419.30	421.0	-19	--	5.631	0	0.00	.16	0	89 C	40929
Richland Cr	305.76	315.0	278	--	189.940	0	0.00	--	5	68 C	747569

BRAZOS RIVER BASIN

Possum King	983.77	999.0	153	--	--	35	0.00	.30	35	61 C	315171
Granbury	684.68	692.7	26	--	52.410	17	0.00	.27	2	61 C	77483
Whitney	523.41	533.0	-614	8	--	25	0.00	.26	25	22 P	51206
Aquilla	536.10	537.5	-15	--	--	1	--	--	1	87 C	27082
Waco	459.63	462.0	-45	--	38.613	10	0.00	.28	10	90 C	162100
Proctor	1149.75	1162.0	11	--	2.044	4	0.00	.32	4	24 C	11825
Belton	582.85	594.0	-13	--	39.151	50	--	--	39	68 C	259463
Stillhouse	610.16	622.0	-8	--	32.090	1	0.00	.21	1	71 C	158311
Georgetown	775.16	791.0	-5	--	30.314	0	0.00	.20	0	54 C	19728
Granger	504.33	504.0	43	--	4.350	0	0.00	.23	0	1 F	1366
Somerville	237.38	238.0	-72	--	3.375	1	0.00	.22	1	95 C	140964
Limestone	361.43	363.0	-137	--	--	6	0.00	.22	6	91 C	189047

COLORADO RIVER BASIN

Twin Buttes	1894.35	1940.2	-1	--	--	0	0.00	--	0	5 C	7929
O.C. Fisher	1853.82	1908.0	-2	--	0.000	0	0.00	.24	0	3 D	1110
O.H. Ivie	1510.92	1551.5	--	--	--	--	--	--	--	17 C	92871
Hords Creek	1885.17	1900.0	1	--	0.000	1	0.00	.28	1	23 C	1577
Buchanan	986.65	1020.5	--	--	--	--	--	--	--	31 C	264522
Marshall Fo	625.06	681.0	136	0	--	0	0.00	.15	0	34 C	373892

GUADALUPE RIVER BASIN

Canyon	898.20	909.0	-25	0	--	64	0.00	.20	64	78 C	293795
--------	--------	-------	-----	---	----	----	------	-----	----	------	--------

Pumpage below dam (MGD): Grapevine 7.348, and Belton 16.432.
Total outflow includes this and pumpage tabulated.
Preliminary data--Inflow not adjusted for wind effect, etc.

D = Sediment Pool
C = Conservation Pool
P = Power Pool
F = Flood Pool
S = Surcharge Pool
nr = Not reported today

NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**

NECHES RIVER, TEXAS

DAILY REPORT

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

PLATE 9 - 2

B.A. Steinhagen
Monthly Report
APR2013

DAY:	ELEVATIONS		:STORAGE:	EVAP:	PUMP:	RELEASES		: ADJ. :	RAIN
:	0800	: 2400	: 2400 :	:	:	:TURBINE:	OTHER :	INFLOW:	:
:	FEET-NGVD		: A-F :	DSF:	DSF:	DSF :	DSF :	DSF :	INCH
1	82.28	82.34	59997	30	0.0	1220	0	1539	0.65
2	82.29	82.35	60093	43	0.0	1200	0	1292	0.00
3	82.61	82.55	62044	26	0.0	1200	0	2210	1.38
4	82.71	82.73	63858	16	0.0	1688	0	2619	0.00
5	82.71	82.76	64166	24	0.0	2200	0	2380	0.00
6	82.71	82.76	64166	47	0.0	2080	0	2127	0.00
7	82.70	82.75	64063	46	0.0	2100	0	2095	0.00
8	82.73	82.72	63756	57	0.0	1898	0	1801	0.00
9	82.68	82.73	63756	57	0.0	1739	0	1797	0.00
10	82.59	82.65	63045	57	0.0	2040	0	1739	0.00
11	82.70	82.81	64682	27	0.0	2080	300	3233	3.16
12	82.80	82.80	64579	33	0.0	1910	2824	4715	0.08
13	82.65	82.78	64372	63	0.0	1890	2033	3883	0.00
14	82.58	82.64	62944	46	0.0	1890	1400	2617	0.00
15	82.51	82.58	62343	67	0.0	2020	0	1784	0.00
16	82.42	82.49	61452	63	0.0	2040	0	1655	0.02
17	82.32	82.36	60188	41	0.0	2040	0	1445	0.02
18	82.27	82.33	59901	28	0.0	1700	0	1584	0.00
19	82.45	82.52	61747	70	0.0	1430	0	2431	0.89
20	82.46	82.51	61648	37	0.0	1369	0	1356	0.00
21	82.47	82.51	61648	55	0.0	1400	0	1456	0.00
22	82.48	82.52	61747	53	0.0	1400	0	1503	0.00
23	82.44	82.51	87711	73	0.0	1400	0	1456	0.00
24	82.56	82.51	87711	69	0.0	1400	0	1470	0.31
25	82.45	82.52	87841	48	0.0	1400	0	1514	0.00
26	82.42	82.49	87452	59	0.0	1400	0	1263	0.00
27	82.47	82.50	87581	59	0.0	1100	0	1224	0.00
28	82.52	82.58	88624	56	0.0	1060	0	1642	0.00
29	82.52	82.58	88624	77	0.0	1100	0	1177	0.00
30	82.56	82.61	89017	70	0.0	1100	0	1369	0.00
MONTHLY TOTAL	(DSF)			1513	0	48494.	6557.	71484.	6.51
	(A-F)	29199	3001	0	0	96186	13005	141786	

NECHES RIVER BASIN, TEXAS
**TOWN BLUFF DAM AND
B.A. STEINHAGEN LAKE**
NECHES RIVER, TEXAS

MONTHLY RESERVOIR REPORT

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

January 2016

TABLE 4-8

All Recorded Major Floods in the Neches River Watershed, 1884-2016

Table 4-8 All Recorded Major Floods In The Neches River Watershed, 1884-2016

Date	Neches River Near Rockland (1884-2013)		Neches River Near Town Bluff (1884-2013)		Neches River Near Evadale (1884-2013)	
	Gage Height	Peak Discharge	Gage Height	Peak Discharge	Gage Height	Peak Discharge
	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)
1884, May	34.90	62,000	86.80	120,000	26.20	125,000
1904, May 9	14.50	7,750	—	—	—	—
1905, May 18-23	25.00	24,600	—	—	23.60	35,400
1906, Jan 11-13	15.50	8,450	—	—	21.10	16,300
1907, May 12	23.30	17,200	—	—	—	—
1907, Nov 23	26.10	30,400	—	—	—	—
1910, Feb 11	13.80	7,260	—	—	—	—
1911, May 2	18.80	10,800	—	—	—	—
1914, May 17	23.20	16,900	—	—	—	—
1915, May 8	24.80	23,600	—	—	—	—
1915, Aug 16-21	21.40	13,300	—	—	24.50	102,000
1916, May 6	25.20	25,600	—	—	—	—
1919, Jul 1	23.20	16,900	—	—	—	—
1920, Jan 27	27.10	35,800	—	—	—	—
1921, Apr 16-27	22.40	14,700	—	—	17.10	26,800
1922, Apr 2-6	28.90	45,200	—	—	21.80	71,500
1923, Apr 15-19	27.40	37,500	—	—	21.50	68,500
1924, Jun 2-4	22.10	14,200	—	—	19.00	40,600
1926, Apr 10-26	22.70	15,100	—	—	17.66	30,800
1927, Apr 21	22.00	14,100	—	—	—	—
1929, Jun 1	26.80	31,200	—	—	22.20	83,800
1930, Feb 14	—	—	—	—	16.15	20,600
1930, May 30	18.50	10,500	—	—	—	—
1931, Jan 12-18	14.70	7,800	—	—	15.76	17,900
1932, Feb 24-29	26.70	33,600	—	—	21.45	73,400
1933, Mar 9-14	16.40	8,990	—	—	16.07	19,900
1934, Feb 11	—	—	—	—	16.70	24,800
1934, Mar 7	20.80	12,400	—	—	—	—

Table 4-8 All Recorded Major Floods In The Neches River Watershed, 1884-2016 (Continued)

Date	Neches River Near Rockland (1884-2013)		Neches River Near Town Bluff (1884-2013)		Neches River Near Edavale (1884-2013)	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1935, May 22-27	28.90	39,700	—	—	20.60	64,100
1935, Dec 14	—	—	—	—	16.30	21,900
1936, Jul 5	19.70	11,400	—	—	—	—
1937, Jan 24-28	13.70	7,190	—	—	15.42	19,300
1938, Apr 12-18	22.82	15,900	—	—	18.32	39,200
1939, Mar 1-6	17.26	9,820	—	—	16.08	21,400
1939, Dec 29	17.30	9,670	—	—	—	—
1940, Feb 21	—	—	—	—	16.38	22,600
1940, Nov 30-Dec 5	25.50	25,900	—	—	20.78	59,600
1941, Nov 1-10	25.10	25,300	—	—	19.50	47,100
1944, May 6-11	31.84	49,800	—	—	23.58	92,100
1945, Apr 11-15	28.37	37,500	—	—	19.89	53,000
1946, Feb 13-18	26.56	32,300	—	—	20.30	57,000
1947, Jan 25	—	—	—	—	17.88	34,600
1947, Mar 15	22.92	17,700	—	—	—	—
1948, Feb 16-24	15.34	8,520	—	—	16.10	22,800
1949, Mar 28-Apr 4	18.58	11,500	—	—	16.28	24,400
1950, Jun 6-11	24.66	23,500	—	—	19.26	46,600
1952, May 25-29	13.78	8,120	73.00	21,400	15.55	19,500
1953, May 21-24	27.70	34,400	82.85	90,900	22.53	80,300
1955, Apr 13-17	19.52	12,700	73.22	21,000	16.10	23,200
1956, Feb 10-13	—	—	65.55	12,200	13.18	10,900
1957, May 3-10	25.34	29,700	80.04	62,000	20.55	55,300
1957, Nov 26-Dec 2	21.84	16,000	77.14	35,700	18.41	35,600
1959, Apr 20-25	17.62	11,000	74.79	26,200	16.98	28,600
1960, Feb 29-Mar 3	14.70	8,790	71.14	21,100	16.05	20,500
1961, Jan 16-20	23.07	18,800	77.14	35,700	18.63	40,400
1962, May 5-11	20.26	13,600	73.52	23,300	16.75	23,900

Table 4-8 All Recorded Major Floods In The Neches River Watershed, 1884-2016 (Continued)

Date	Neches River Near Rockland (1884-2013)		Neches River Near Town Bluff (1884-2013)		Neches River Near Edavale (1884-2013)	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1962, Dec 29-31	8.88	4,880	67.29	14,500	—	—
1963, Jan 3	—	—	—	—	14.35	14,200
1964, Apr 29-May 2	15.35	9,280	71.77	23,900	17.21	21,300
1965, Apr 1-3	—	—	62.35	9,900	13.72	8,660
1965, Jun 1	12.96	7,600	—	—	—	—
1966, Feb 10-14	—	—	74.11	27,200	18.12	27,300
1966, May 7	25.60	26,800	—	—	—	—
1968, Apr 12-Jun 2	23.55	20,200	70.47	20,200	17.19	21,300
1969, May 10-16	27.64	34,000	75.52	30,500	18.56	31,300
1970, May 2-5	10.32	5,920	63.13	10,900	14.63	11,700
1972, Mar 21-25	11.20	6,380	64.06	12,000	14.58	11,400
1973, Jun 17-23	28.00	33,600	75.85	31,600	18.58	31,100
1974, Jan 20-Feb 1	25.35	27,700	72.94	24,900	18.12	27,500
1975, Jan 27	—	—	—	—	16.74	19,800
1975, Mar 5	—	—	69.14	18,800	—	—
1975, May 11	19.27	12,100	—	—	—	—
1976, May 8-13	18.81	9,340	64.91	14,000	15.69	14,300
1977, Apr 23-May 10	16.10	7,320	64.61	13,200	15.60	14,800
1978, Jan 24-28	12.00	4,800	60.60	8,900	14.39	10,000
1979, Apr 4-24	27.42	24,400	69.76	20,600	18.03	27,600
1980, May 20-29	25.80	19,400	67.77	17,600	16.40	17,900
1981, Jun 7-11	17.00	7,900	65.67	14,900	16.03	16,100
1982, Apr 26-May 23	22.18	12,400	69.32	19,800	16.63	19,000
1982, Dec 30	—	—	—	—	17.60	24,600
1983, May 22-24	24.56	16,300	70.74	21,900	—	—
1984, Feb 12-16	16.35	7,480	73.50	26,500	17.85	26,300
1985, Mar 2-6	19.10	10,000	63.35	13,000	15.63	14,600
1986, Jun 9-12	24.42	16,200	65.64	15,600	16.71	19,400

Table 4-8 All Recorded Major Floods In The Neches River Watershed, 1884-2016 (Continued)

Date	Neches River Near Rockland (1884-2013)		Neches River Near Town Bluff (1884-2013)		Neches River Near Edavale (1884-2013)	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
1986, Nov 26-28	23.96	15,400	72.43	25,300	18.02	27,500
1987, Nov 26 -Dec 8	14.03	6,380	63.77	13,500	—	—
1988, Apr 8	—	—	—	—	15.28	13,300
1989, Jul 2-6	33.20	42,000	78.49	49,200	20.79	47,900
1990, Mar 30-Apr 2	—	—	71.06	23,900	17.44	22,100
1990, Jun 5	28.59	25,900	—	—	—	—
1991, Jan 20-25	27.73	23,000	69.33	20,800	—	—
1991, May 31	—	—	—	—	17.40	24,500
1992, Mar 7-12	29.00	27,300	75.73	34,000	19.33	37,500
1993, Apr 4-7	—	—	67.76	18,500	17.31	22,800
1993, Jun 29	27.11	21,700	—	—	—	—
1994, Mar 10-15	21.01	12,000	66.69	17,900	16.51	18,400
1994, Oct 20-25	33.29	42,300	76.17	35,400	19.33	41,400
1995, Dec 21	14.63	6,380	—	—	15.21	14,000
1996, Sep 28	—	—	67.27	19,800	—	—
1997, Mar 13-15	23.12	14,500	67.38	19,900	16.96	22,500
1998, Jan 8-11	27.17	21,800	71.46	26,200	17.76	26,900
1998, Nov 16-22	29.12	27,800	—	—	17.89	28,300
1999, Mar 14	—	—	73.45	29,600	—	—
2000, May 5-11	11.14	4,680	58.99	9,460	12.02	7,180
2001, Mar 19	—	—	—	—	17.95	31,700
2001, Jun 13-17	29.25	28,200	73.16	29,100	—	—
2001, Dec 14-17	23.61	15,400	66.61	20,300	17.18	27,000
2002, Nov 5-7	—	—	68.38	23,100	17.59	29,600
2003, Feb 27	25.78	18,600	—	—	—	—
2004, Feb 15-16	23.42	14,800	—	—	16.93	22,100
2004, May 19	—	—	66.64	20,300	—	—
2004, Nov 27-Dec 3	28.33	25,100	69.77	25,600	17.40	24,700

Table 4-8 All Recorded Major Floods In The Neches River Watershed, 1884-2016 (Continued)

Date	Neches River Near Rockland (1884-2013)		Neches River Near Town Bluff (1884-2013)		Neches River Near Edavale (1884-2013)	
	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)	Gage Height (ft)	Peak Discharge (cfs)
2006, Jul 27	12.89	5,770	—	—	—	—
2006, Oct 20-21	—	—	72.27	26,900	19.46	33,800
2007, Jan 19	26.86	21,100	—	—	—	—
2008, Feb 23-26	21.56	13,500	64.21	15,200	15.49	13,800
2009, Apr 22-May 4	18.50	10,800	66.42	18,400	16.06	17,400
2009, Nov 3-Dec 25	23.74	16,000	65.38	18,300	16.16	18,000
2012, Mar 15-23	25.53	18,600	67.64	19,500	17.31	25,700
2013, May 12-Jun 7	8.70	3,470	—	—	10.96	6,400
2013, Nov 1-4	14.78	7,990	70.89	23,300	16.87	22,500
2015, May 28-Jun 1	29.39	28,700	73.50	28,000	18.58	31,200
2016, Mar 11-Jun 5	29.64	29,600	76.06	30,000	19.67	39,700

TABLE 4-9

Town Bluff Dam and B.A. Steinhagen Lake Monthly and Annual Inflow Volumes in Acre-feet

TABLE 4-9

Town Bluff Dam and B.A. Steinhagen Lake Monthly and Annual Inflow Volumes in Acre-Feet

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1951					132121	57051	28405	17677	27903	20452	25626	75144	384,379
1952	82677	252896	452455	545657	609145	201525	37783	6496	12541	7585	20273	89472	2,318,506
1953	218168	334911	839539	461996	2983312	477820	107008	65962	34060	17574	35984	176164	5,752,497
1954	226701	154358	100076	160375	416923	119105	13097	9249	9864	9864	76038	78992	1,374,642
1955	151359	442790	252420	618868	211753	166469	42393	50957	21997	20170	10568	33122	2,022,866
1956	55394	251794	116594	191125	273481	35574	11351	4332	8406	6549	11119	21919	987,639
1957	27564	68928	214463	376742	1914299	542090	109499	47887	34576	285334	1098198	806755	5,526,334
1958	914973	569329	402230	262661	861621	123548	102837	43291	376978	399850	107964	109248	4,274,531
1959	105332	390464	301971	664806	578548	320154	198278	133835	40673	74382	117035	336799	3,262,277
1960	586631	617579	732989	201638	161339	127456	106637	59284	41252	125796	250088	1170702	4,181,391
1961	1581730	908400	1059425	782503	206307	154665	308110	49450	219072	63866	115495	673959	6,122,982
1962	493144	463204	365700	268504	731831	197639	83887	43841	54178	38083	59173	170555	2,969,739
1963	210728	196861	217493	183852	77090	60839	33856	12662	29088	7396	31995	65740	1,127,601
1964	101923	103702	384763	422241	321372	67513	15977	13795	12034	14152	18079	48379	1,523,930
1965	43164	118895	199585	179556	151240	196693	28292	38235	31968	11082	25855	187430	1,211,993
1966	147911	430064	93616	126972	771340	117576	92170	94387	84004	98668	73976	65568	2,196,251
1967	61936	47821	47242	138807	114442	114585	64284	79494	42040	26614	14001	53155	804,422
1968	177056	135479	203774	667220	757937	638693	455460	205384	109158	167185	222982	500622	4,240,950
1969	425615	466728	898006	1199450	1440217	757079	122612	119558	83328	46038	80634	126803	5,766,068
1970	156502	133539	292001	282002	236973	86239	93152	58411	60024	77284	80277	62251	1,618,654
1971	66724	37997	81213	102405	77720	64947	47383	46007	31105	25505	20537	135499	737,042
1972	170874	106496	130306	133470	168587	156216	86473	103184	102863	57711	106651	164152	1,486,984
1973	403450	484617	668047	1129525	1015933	1044581	717435	231993	364976	433428	637210	854636	7,985,829
1974	1228103	1116148	929036	413667	278084	253599	221004	191139	230184	135538	375294	509105	5,880,901
1975	804948	879643	761577	466865	896632	464539	415807	367408	183866	193446	76370	90180	5,601,280
1976	106723	100284	149395	184435	446945	379025	371760	361886	272241	100647	91333	251984	2,816,658
1977	331874	243169	356763	420970	443708	220126	173324	157065	129693	83901	55902	69848	2,686,342
1978	181119	205069	113199	103428	92481	146013	152215	97464	19801	20303	40179	65058	1,236,329
1979	310962	551393	863988	985612	1043966	977811	436548	525818	337775	141445	144736	348918	6,668,972
1980	368733	583394	468629	709975	740667	544098	226481	161193	121690	108218	103134	115301	4,251,512
1981	93953	40969	37466	80606	77334	274984	122626	131107	106673	149070	85583	82465	1,282,835
1982	114960	117570	112713	350430	526108	202300	204922	145837	128505	158596	222038	410598	2,694,576
1983	564097	708900	911406	470935	491131	854570	470935	211166	136679	122822	177735	292742	5,413,120
1984	202665	521670	880524	278277	210363	191587	202248	165882	133303	237862	175418	119869	3,319,668
1985	203808	345891	554203	478802	311651	169372	169495	171360	146085	194200	197173	438216	3,380,255
1986	199839	426914	168464	168879	428620	710172	523630	176497	167131	157890	362753	548556	4,039,345
1987	697033	442066	976839	377861	176689	193912	154619	183247	179443	181438	226110	299212	4,088,469
1988	442284	233986	533791	376338	186313	208153	214052	208534	192528	170313	156754	168472	3,091,518
1989	243931	270750	257792	484849	566146	965656	1320729	451257	165277	177683	181805	215480	5,301,355
1990	317786	510627	520421	760094	770525	1041798	239550	221250	181493	161306	147175	155423	5,027,446
1991	835584	989418	1066175	797012	1134307	1020303	443357	294579	255279	169053	171166	469406	7,645,638
1992	1073615	1063124	1645469	1176263	433468	330079	194606	195880	164047	191333	171751	301908	6,941,542
1993	551165	291187	809643	971174	685953	392192	713555	205154	187182	158598	152307	159509	5,277,619
1994	209103	408990	765326	332644	468458	304213	207882	221516	194172	785238	437918	661783	4,997,242
1995	1159858	1014174	1138831	1080918	1067789	333675	242850	185667	174708	175021	171132	169331	6,913,954
1996	97222	141465	157287	151743	88606	93300	85993	72238	117203	43071	42655	130379	1,221,163
1997	184316	536320	1067400	1024825	723485	380509	249209	218916	205093	170664	156254	359421	5,276,411
1998	1080247	1000103	1171229	516341	225772	181376	192619	195425	162787	234527	602931	586980	6,150,340
1999	805069	1143915	1023859	790036	248112	359601	307753	193541	190790	185625	170535	150690	5,569,526
2000	116785	112853	62997	108823	225027	184185	119685	74779	80110	74602	258321	308632	1,726,799
2001	605415	547444	1212850	1002979	474103	899496	561207	157722	299516	284820	184762	655428	6,885,741
2002	708323	428838	286393	750081	217503	176824	159471	161702	173028	199210	463527	504293	4,229,194
2003	708585	404949	1094655	523916	197901	215240	188610	240956	262631	151394	174545	129431	4,292,814
2004	236295	731744	848294	533799	878033	561358	715192	260194	179006	251756	723050	1143443	7,062,163
2005	552492	971912	1011090	413641	182840	119726	127113	150518	210428	110297	73470	66125	3,989,651
2006	66754	186234	149022	126246	105086	82500	123058	110491	102641	500483	289380	205833	2,047,728
2007	836695	840803	434178	353659	404755	343452	759701	724264	260685	140507	114835	154413	5,367,946
2008	125010	410592	352576	411154	183786	132246	129271	184865	248850	95962	90740	103771	2,468,823
2009	71952	43509	152892	384918	337126	75404	72178	113821	116196	255044	653004	509603	2,785,649
2010	411659	449732	505587	211731	128356	143212	186323	135652	136205	68053	43751	36292	2,456,553
2011	54137	49529	33148	49359	54044	64959	79983	75128	46393	30756	16610	66553	620,598
2012	142732	285493	595765	214373	90559	96879	169408	145696	99497	112651	70342	78002	2,101,397
2013	135322	132206	96585	141328	99421	133109	111695	108660	95946	140075	246299	240097	1,680,745
2014	175685	151879	168465	151149	182387	243366	216180	132855	127513	98308	94791	125591	1,868,167
2015	502157	312687	851836	1089051	1280829	1115360	823587	280346	123035	154888	267421	465710	7,266,905
TOTAL	24,268,547	26,664,397	33,351,665	29,519,556	32,018,601	21,608,333	15,706,813	10,304,044	8,877,395	9,311,182	11,900,746	17,971,116	
AVG	379,196	416,631	521,120	461,243	492,594	332,436	241,643	158,524	136,575	143,249	183,088	276,479	3,715,421

TABLE 7-4

Area and Capacity Curves

TABLE 7-4
Area and Capacity Curves

B.A. STEINHAGEN LAKE - ELEVATION vs. AREA

AREA (IN THOUSAND ACRES)										
ELEV	0	1	2	3	4	5	6	7	8	9
40					0.001	0.001	0.001	0.001	0.002	0.002
50	0.002	0.003	0.005	0.008	0.012	0.018	0.025	0.035	0.047	0.060
60	0.075	0.093	0.114	0.141	0.176	0.222	0.278	0.349	0.439	0.567
70	0.801	1.153	1.686	2.254	2.757	3.355	4.095	4.872	5.763	6.782
80	7.669	8.478	8.997	10.687	13.700	15.210	18.390	19.880	21.350	22.800
90	24.240	25.580	26.920	28.210	29.550	30.800	32.080	33.400	34.640	36.000
100	37.360									
ELEV	0	1	2	3	4	5	6	7	8	9

B.A. STEINHAGEN LAKE - ELEVATION vs. CAPACITY

CAPACITY (IN THOUSAND ACRE-FEET)										
ELEV	0	1	2	3	4	5	6	7	8	9
40					0.000	0.001	0.002	0.003	0.004	0.006
50	0.008	0.011	0.015	0.022	0.032	0.046	0.068	0.098	0.139	0.192
60	0.260	0.344	0.448	0.575	0.734	0.932	1.182	1.496	1.890	2.393
70	3.077	4.054	5.474	7.444	9.949	13.005	16.730	21.214	26.531	32.804
80	40.029	48.102	56.840	66.972	78.876	93.332	110.132	129.266	149.882	171.956
90	195.476	220.386	246.636	274.202	303.082	333.256	364.696	397.436	431.456	466.776
100	503.456									
ELEV	0	1	2	3	4	5	6	7	8	9

ELEVATIONS IN FEET-NGVD