Water Control Manual

Pactola Dam Pertinent Data

Rapid Creek
Rapid City, South Dakota

U.S. Army Corps of Engineers
Northwestern Division
Omaha, Nebraska

Sep 2019

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, NORTHWESTERN DIVISION
1616 CAPITOL AVENUE, STE 365
OMAHA NE 68102

REPLY TO
ATTENTION OF

CENWD-PDR

5 September 2019

MEMORANDUM FOR Commander, Omaha District (CENWO-ED-HA, Attn: [redacted]

SUBJECT: Request for Review and Approval of Final Draft Water Control Manual, Pactola Dam and Reservoir, Missouri River Basin

1. Reference memorandum dated 3 September 2019, CENWO-ED-HA, subject as above.

2. The subject water control manual is approved.

3. As noted in your memo, the update of this manual did not contain any major changes to the water control plan. Also, an updated and signed field working agreement will be included in the final water control manual.

4. We commend your staff for their professional and dedicated effort in updating this manual. We realize that updating any water control manual is a considerable undertaking.

5. We will retain a final hardcopy of the manual in our office for our use. Please include this signed approval and the signed field working agreement in the electronic version of the manual to HQUSACE for Continuity of Operations (COOP) purposes and redacted electronic version for the national public-facing website.

6. If you have any questions concerning this reply, please contact me at [redacted], or [redacted] of my staff at [redacted]

FOR THE COMMANDER:

[redacted]

Figure 1-1 Pactola Dam and Reservoir

Figure 1-2 Pactola Dam

Figure 1-3 Pactola Reservoir Aerial

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be published in a hard copy binder with 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. Changes to individual pages must carry the date of revision, which is the Division's approval date.

In this water control manual, elevations for reservoir levels and project drawings are based upon the National Geodetic Vertical Datum of 1929 (NGVD29) and have not been converted to the North American Vertical Datum of 1988 (NAVD88) because of the desire to provide elevation data that is consistent with historical events and the original design drawings for the project. If elevations referenced to the NAVD 88 datum are needed for Pactola Dam and Reservoir, use the following conversion: To calculate the NAVD88 at Pactola Dam, add 1.45 feet to the NGVD29 elevation. See Section 1-03 for additional details.

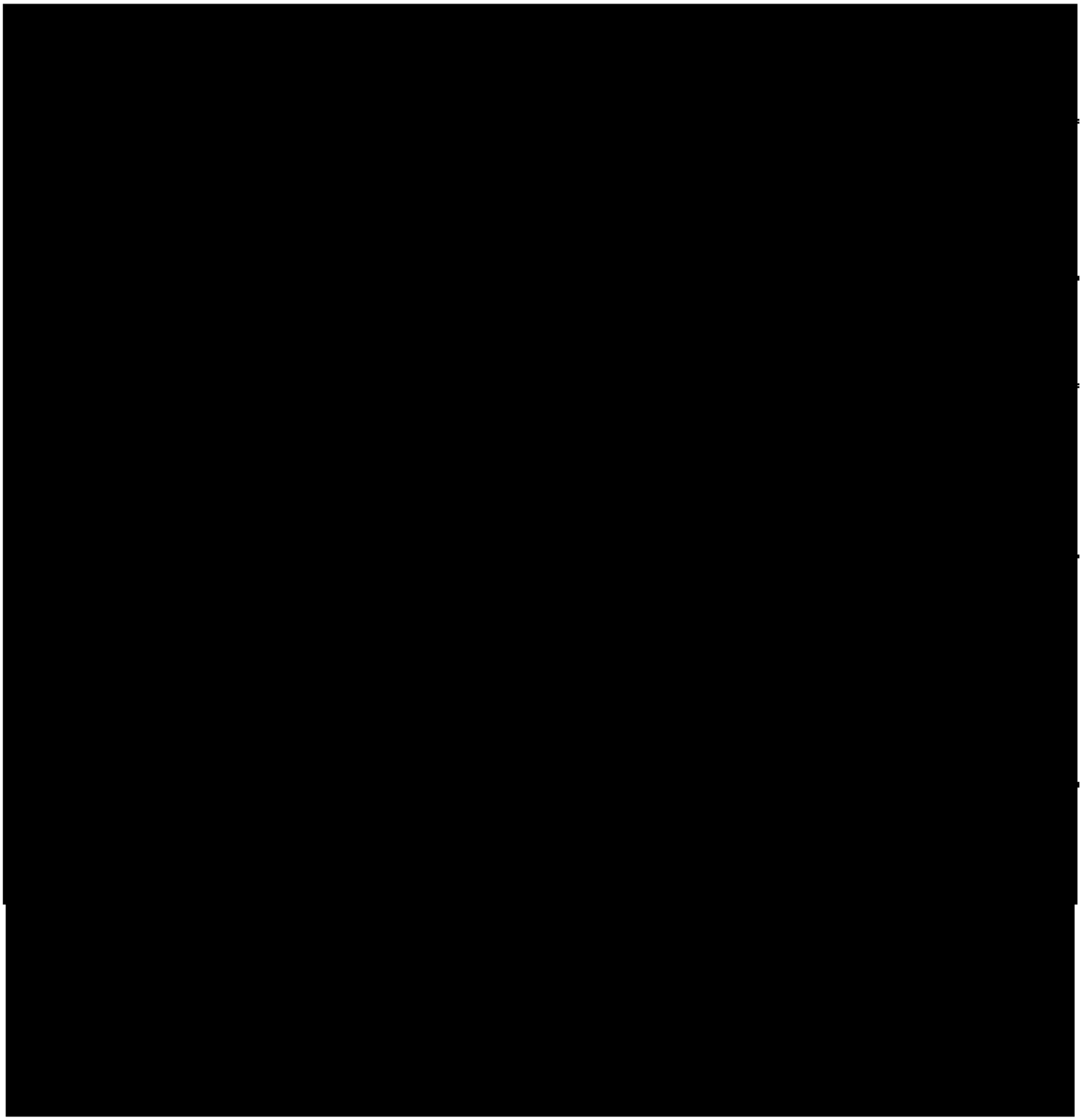
Regulation Assistance Procedures

In the event that unusual conditions arise during non-duty hours, communication can be achieved by contacting, in the order listed, one of the personnel in the following Directory of Regulation Personnel:

REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during non-duty hours, communication can be achieved by contacting, in the order listed, one of the following personnel:

Directory of Regulation Personnel



Organization/Name	Office	FAX	Cell/Pager	Home	Email Address

Other Agencies

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Pactola Dam Pertinent Data

GENERAL

Location of Dam: On Rapid Creek, approximately 15 miles west of Rapid City, Pennington County, SD, at Latitude 44°04'18", Longitude 103°29'18'.

Drainage Area:

Above Deerfield Dam - 95 sq mi	Above Rapid City - 410 sq.mi
Above Pactola Dam - 319 sq.mi	Total Rapid Creek Basin - 710 sq.mi

RESERVOIR

(Values from Reclamation Reservoir Allocations Diagram)

Item	Elevation (feet)	Gross Area (acres)	Gross Storage (acre-ft)	Incremental Storage (acre-ft)
Dam Crest	4655.0	1606		
Top of Surcharge Storage	4651.7	1557	140,921	41,892
Top of Flood Control Storage (Spillway Crest)	4621.5	1232	99,029	43,057
Top of Conservation Storage	4580.2	861	55,972	54,955
Top of Inactive Storage	4456.1	100	1,017	895
Top of Dead Storage	4440.0	25	122	122
Streambed at Dam Axis	4422.0			

DAM

Embankment type	Earth and Rock Fill
Crest elevation	4655.0 feet
Height above streambed	233 feet
Crest length (including dikes)	5,199 feet
Crest width	40 feet

Note: Two dikes, totaling 2,963 feet in length and a maximum 50 feet high, close 2 low spots north of the left abutment of dam.

SPILLWAY

Location	Center of dam
Type	Uncontrolled concrete crest
Crest Elevation	4621.5 feet
Crest Length	425 feet
Number of gates	0
Discharge capacity (elev. 4651.7 top of surcharge)	245,000 cfs

Note: As a result of updated Probable Maximum Flood (PMF) analysis, in 1987, the dam crest was increased by 15 feet, and spillway was widened from 250 feet to 425 feet

Pactola Dam Pertinent Data (cont'd)

OUTLET WORKS

Type: One concrete conduit through left abutment.

Intake: Submerged grated inlet, sill elevation, 4440 feet

Size:

Upstream of gates: 6 ft. dia.

Downstream of gates: horseshoe type 8' wide x 7' high

Gates:

Type: High Pressure, vertical lift, slide gates

Number of Gates: 2 (2 regulating gates each with 1 emergency gate)

Size of Gates: Two 2'9" square regulating gate each with one 2'9" square emergency slide gate.

Gate Capacity of Both Regulating gates:

1,130 cfs at top of flood control zone (Elev. 4621.5 feet)

1,010 cfs at top of conservation zone (Elev. 4580.2 feet)

Bypass Line:

Number: One

Size: 10" diameter

Capacity: 16 cfs (Elev. 4580.2 feet)

Stilling Basin:

Width:	20 feet
Length:	179 feet
Floor elevation:	4403.5 feet
End sill crest elevation:	4413.0 feet

ABBREVIATIONS

af	acre-feet
cfs	cubic feet per second
CFR	Code of Federal Regulations
Corps	Corps of Engineers
CWMS	Corps Water Management System
DCP	data collection platform
DKAO	Dakota Area Office
EM	Engineering Manual
ER	Engineering Regulation
FERC	Federal Energy Regulatory Commission
ft NAVD1988	Feet above North American Vertical Datum of 1988
ft NGVD1929	Feet above National Geodetic Vertical Datum of 1929
FWA	Field Working Agreement
GOES	Geostationary Operational Environmental Satellite
ID	Inner Diameter
MRBWM	Missouri River Basin Water Management (Corps of Engineers)
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWD	Northwestern Division (Corps of Engineers)
NWS	National Weather Service
PMF	Probable Maximum Flood
PMS	Probable Maximum Storm
RCO	Rapid City Office
Reclamation	United States Bureau of Reclamation
Rpm	Revolutions per Minute
RVWCD	Rapid Valley Water Conservancy District
SD GF&P	South Dakota Department of Game, Fish and Parks
SPF	Standard Project Flood
SOP	Standard Operating Procedure
sq.mi.	Square Mile
USGS	United States Geological Survey
WCWQS	Omaha District Water Control and Water Quality Section

CHAPTER 1—INTRODUCTION

1-01 AUTHORIZATION

This manual was prepared in compliance with the following authorities and directives:

- Engineering Regulation (ER) 1110-2-240: Water Control Management, May 30, 2016.
- Section 7 of the Flood Control Act, December 22, 1944.
- 33 CFR Chapter II Part 208, Flood Control Regulations, Section 208.11.

1-02 PURPOSE AND SCOPE

Pactola Dam and Reservoir was constructed by the Bureau of Reclamation (Reclamation) on Rapid Creek upstream of Rapid City, SD. Construction was started in the spring of 1953 and closure and impoundment began in August 1956. This water control manual covers the regulation of the reservoir only for flood control purposes as designated in ER 1110-2-240. This manual also contains current information about the dam and reservoir as well as descriptions of the project and its history, watershed characteristics, the data collection and communications network, and the organizations responsible for collecting data and regulating the reservoir. This report follows the guidance presented in Engineering Manual (EM) 1110-2-3600 “Management of Water Control Systems”, October 10, 2017 and ER 1110-2-8156 “Preparation of Water Control Manuals”, September 30, 2018.

1-03 RELATED MANUALS AND REPORTS

Previous manuals and reports pertinent to reservoir regulation at Pactola Dam are referred below:

a. U.S. Department of the Interior, Bureau of Reclamation, “Pactola Dam - Technical Record of Design and Construction,” 1957.

b. Field Working Agreement for flood control regulations governing the operation of Pactola Dam and Reservoir, Bureau of Reclamation and U.S. Army Corps of Engineers, 27 August 1969 (superseded by updated Field Working Agreement in Exhibit II).

c. Report on Reservoir Regulations for Flood Control, Pactola Dam and Reservoir, Rapid Creek Basin, SD, November 1976 (superseded by this updated water control manual).

d. CFR - Title 33, Chapter II, Section 208.47, Regulations to govern the use of storage capacity for flood control purposes at Pactola Reservoir on Rapid Creek, Pennington, County, SD (superseded by Section 208.11).

e. CFR - Title 33, Chapter II, Section 208.11, Regulations for use of storage allocated for flood control or navigation and/or project operation at reservoirs subject to prescription of rules and regulations by the Secretary of the Army in the interest of flood control and navigation.

f. Bureau of Reclamation, "Standing Operating Procedures - Pactola Dam, South Dakota," December 2011.

g. Bureau of Reclamation, "Emergency Action Plan, Pactola Dam, South Dakota," February 2002.

1-04 PROJECT OWNER

Pactola Dam was planned, designed, and built by Reclamation for the public of the United States of America.

1-05 OPERATING AGENCY

Reclamation's Dakotas Area Manager, Rapid City Office (RCO) manager, and Civil Engineer are responsible for operations.

Reclamation has an agreement with the City of Rapid City to operate and maintain Pactola Dam and Reservoir. The Dam Tender is an employee of the city, who resides adjacent to, and works on-site at Pactola Dam. The Dam Tender visits Pactola Dam and Deerfield Dam, and performs operation and maintenance duties. The City of Rapid City is responsible for the operation of Pactola Reservoir when it is in active conservation storage, below elevation 4580.2 feet. Releases for minimum conservation requirements will be determined by Reclamation and are outlined in Chapter 4 of the Pactola Dam Standard Operating Procedure (SOP). Exhibit VI is the signed agreement outlining the operations, maintenance, and repair arrangements between Rapid City and Reclamation.

Releases during flood control operations, between elevations 4580.2 feet and 4621.5 feet, are designated by the Omaha District Water Control and Water Quality Section (WCWQS) of the Corps of Engineers (Corps). When the reservoir elevation exceeds the top of the flood control zone at elevation 4621.5 feet and enters the surcharge storage, Reclamation is responsible for directing the releases.

1-06 REGULATING AGENCIES

The organization for Pactola Dam and Reservoir is based on a division of regulating responsibility between Reclamation and the Corps. In accordance with the Flood Control Act of 1944, the Corps is responsible for the regulation of storage allocated to flood control. All other regulatory functions are the responsibility of Reclamation's Dakota Area Office (DKAO) in Bismarck, ND. At the time of this writing the DKAO has the Pactola water manager present at the RCO.

1-07 VERTICAL DATUMS

In the original design and construction of Pactola Dam, elevations on design drawings and reservoir levels were referenced to the Sea Level Datum of 1929. This was based on measured water levels at 26 tide stations in the United States and Canada, and commonly referred to as "feet above mean sea level". In 1973 the Sea Level Datum of 1929 was renamed the National Geodetic Vertical Datum of 1929 (NGVD29). The NGVD29 datum

was subsequently replaced by the North American Vertical Datum of 1988 (NAVD88) as the current vertical reference datum used by the National Oceanic and Atmospheric Administration (NOAA). The NAVD88 is based on a single point as the reference point from which all other elevations are measured. The NAVD88 is more accurate than the NGVD29, and takes into account variations in earth surface due to subsidence and rebounding, and distortions caused by gravity. As such, the conversion from the NGVD29 to the NAVD88 varies depending on location. As specified in ER 1110-2-8160, long-term efforts shall be programmed to transition from older datums to NAVD88.

In this water control manual, elevations for reservoir levels and project drawings are based on the NGVD29. **Unless specifically noted, all elevations in this manual are referenced to NGVD29**. The elevations have not been converted to the NAVD88 in an effort to provide elevation data that is consistent with historical events and the original design drawings for the project. To calculate the NAVD88 at Pactola Dam, add 1.45 feet to the NGVD29 elevation.

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CHAPTER 2—DESCRIPTION OF PROJECT

2-01 LOCATION

Pactola Dam is located on Rapid Creek about 15 miles west of Rapid City, SD in Pennington County. Plates 2-1 and 2-2 show drainage basin areas for Pactola Dam and Rapid Creek basin and a location map for Pactola Dam and Reservoir.

2-02 PURPOSE

Pactola Dam and Reservoir was constructed by Reclamation primarily for irrigation, municipal water supply, and flood control. Contract Number 079D620102 between the United States and the City of Rapid City, SD (City) designates the right of the City to beneficially use 49,000 af of Pactola's 55,000 af of conservation storage space with the remaining 6,000 af of conservation storage space being held by Reclamation for conservation uses. The reservoir provides supplemental municipal water for the City, and the City could sell supplemental irrigation water to the Rapid Valley Water Conservancy District (RVWCD) should their contracted water at Deerfield Reservoir not meet their needs. The RVWCD is comprised of private ditch companies located along Rapid Creek downstream from Rapid City, and full development would serve 8,900 acres of privately developed irrigable lands. Presently the RVWCD is irrigating approximately 6,000 acres in Rapid Valley. In addition, the reservoir provides for authorized purposes such as flood control and fish and wildlife conservation. Incidental benefits from recreation on Pactola Reservoir are in the form of boating, swimming, hiking, picnicking, camping, and fishing. Pactola Reservoir is operated as a conservation storage system with Deerfield Reservoir (Rapid Valley Project). Water stored in Deerfield Reservoir is allocated to the City, which has a senior priority of stored water for municipal and industrial purposes, and to the RVWCD, which has a junior priority of stored water for irrigation purposes. Water deliveries are released from Deerfield Dam and routed downstream via Castle Creek and Rapid Creek, through Pactola Reservoir to the City and RVWCD. Reclamation operated and maintained Pactola Dam until 1994. The City and Reclamation executed an agreement in 2007 where the City now operates and maintains Pactola Dam and Deerfield Dam. Exhibit VI contains the Rapid City and Reclamation agreement.

2-03 PHYSICAL COMPONENTS

The physical components of Pactola Dam are shown on the associated plates and described below.

a. Embankment

Pactola Dam (Plates 2-3, 2-4, 2-5, 2-6 and 2-7) consists of a rolled-earth and rock-filled embankment across Rapid Creek and two earth and rock dike embankments across saddles on the left of the main embankment. The dam embankment is approximately 5,199 feet long (including dikes), has a crest width of 40 feet, and a maximum height above streambed of 233 feet. The two dikes have a combined length of 2,963 feet and a maximum height of about 50 feet. The embankment crest also accommodates U.S. Highway No. 385.

b. Spillway

A service spillway is located between the main embankment and the north dike. The spillway consists of an ungated concrete ogee weir and a chute and stilling basin carved in the natural rock abutment. The weir crest was originally 250 feet long at an elevation of 4621.5 feet. In 1987, as a result of an updated Probable Maximum Flood (PMF) analysis, the dam crest elevation was increased by 15 feet, and the spillway was widened from 250 feet to 425 feet. The modified spillway has a design capacity of 245,000 cfs at maximum pool elevation 4651.7 feet. Spillway plan and section views are shown on Plates 2-8, 2-9, and 2-10. The discharge rating curve for the spillway is shown on Plate 2-11.

c. Outlet Works

A 6-foot diameter concrete-lined tunnel through the left abutment performs the function of a service spillway. A reinforced concrete intake structure with a sill at elevation 4440.0 feet provides entrance to the outlet tunnel. Releases through the tunnel are controlled by two 2'-9" x 2'-9" high pressure slide gates located in a gate shaft near the axis of the dam. A 10-inch bypass line in the gate chamber with a capacity of 16 cfs provides a means of releasing small discharges for irrigation and municipal uses without operating the regulating gates. The bypass is also used in conjunction with the regulating gates for "fine" control of project releases. A reinforced concrete stilling basin is provided for the outlet works. Plan and section views of the outlet works are shown on Plate 2-12. Discharge rating curves for the outlet works are shown on Plate 2-13.

d. Water Supply Facilities

There are no special water supply facilities at Pactola Dam. Releases for water supply purposes are made through the outlet works.

e. Reservoir

At elevation 4621.5 feet, the top of the flood control zone, the reservoir has a gross capacity of 99,029 af. The reservoir extends about 4.5 miles upstream, has a maximum depth of 200 feet, and inundates about 1,200 acres. Area-capacity curves are shown on Plate 2-14. Storage allocations for the reservoir are shown in the pertinent data table. Plate 2-15 shows the reservoir flooded areas for the pool elevations of 4621.5 feet (top of flood control zone) and 4651.7 feet (top of surcharge zone). Exhibit IV shows the area-capacity tables in one-foot increments and Exhibit V shows more detailed versions of both tables in tenth-foot increments. Sediment accumulation for 100 years was projected to be 1,000 af, with the sediment accumulated between the bottom of the reservoir and the top of the active conservation storage space. Additional information concerning sediment accumulation in the reservoir is contained in Section 4-04.

2-04 RELATED CONTROL FACILITIES

The only related control facility that operates as an integral part of Pactola Dam is the spillway plunge pool. The structure is described below:

a. Plunge Pool Control Structure.
In 1999 a control structure was installed at the outlet of the spillway plunge pool below Pactola Dam. This structure is a 6-bay check with a single bay check next to it that serves as the control of the bypass channel used for small releases. The control structures at the outlet of the spillway plunge pool control the water elevation of the pool, allowing the pool to be a prime fishery below the dam. The 6-bay check structure is designed for a maximum release of approximately 550 cfs. As releases exceed this amount the structure will be inundated and minor flooding will occur. Plate 2-16 contains an aerial photo with the locations of the control structures.

2-05 REAL ESTATE ACQUISITION

Pactola Dam and Reservoir is wholly within the Black Hills National Forest. Development and administration of withdrawn national forest lands, private lands acquired for the dam and the reservoir is coordinated through a national Master Interagency Agreement (No. 86-SIE-004) between the Commissioner, Reclamation, and the Chief of the Forest Service.

2-06 PUBLIC FACILITIES

Locally, there is a Memorandum of Understanding (dated November 24, 1980) for administration and management of resources at Pactola Reservoir between the Regional Director, Reclamation and the Regional Forester, Forest Service.

Plate 2-17 is Reclamation's operation and maintenance responsibility boundary of lands at Pactola Reservoir. Reclamation has primary jurisdiction over the reservoir water surface and the area around the dam, and the Forest Service administers the national forest lands around the reservoir. Plate 2-18 shows recreation sites in the Pactola Lake vicinity that are administered by the Forest Service. Forest Order 044-98 includes the area around Pactola Reservoir as part of the Concentrated Public Use Areas and Developed Recreational Areas. Within these areas of the Black Hills National Forest, unique camping and boating restrictions are in effect based on this order. Facilities developed at Pactola Reservoir by the Forest Service include the Visitor Center, hiking trails, boat ramps, campgrounds, picnic areas, swimming beach, and other features. Operation and maintenance of recreational facilities, patrolling of the reservoir, enforcement of rules, boat registration, supervision of recreation activities, etc., are the responsibilities of the Forest Service and South Dakota Department of Game, Fish and Parks (SD GF&P).

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CHAPTER 3—HISTORY OF PROJECT

3-01 AUTHORIZATION

In 1949, the city commissioners of Rapid City submitted a resolution to Reclamation requesting storage in the proposed Pactola Reservoir for municipal uses, including water for Ellsworth Air Force Base. The Rapid Valley Unit was included in the plan for development of the Missouri River Basin as outlined in Senate Document 191, 78th Congress, and authorized by the Flood Control Act of 1944 (Public Law 534).

3-02 PLANNING AND DESIGN

In a report prepared by the Corps, published in 1932 as the Cheyenne River Report, House Document No. 190, 72nd Congress, 1st Session, as a part of the "308 Report", a plan of development for power and irrigation in Rapid Creek Valley was referred to as the Pactola Project and included a dam and reservoir at Pactola.

Reclamation submitted a report in 1937 that outlined a plan of development of the Rapid Valley Irrigation Project. This plan made provision for three reservoirs; Deerfield and Pactola upstream on Rapid Creek and Brennen, an offstream site below Rapid City. All three reservoirs would have supplied water from storage to augment the municipal water supply of Rapid City and to increase the supply of irrigation water for about 12,000 acres of irrigable land below Rapid City. This plan, as authorized by the President on October 25, 1940 under provision of the Water Conservation and Utilization Act (Act of August 11, 1939, as amended) contemplated only one of the upstream reservoirs initially and the Brennen Reservoir only after several years of operation.

Construction of Deerfield, one of the upstream reservoirs, was initiated in 1937 and completed in 1945. Reference to the Rapid Valley Unit in Senate Document No. 191 on page 76 is as follows: "The Rapid Valley Project is now under construction by the Bureau of Reclamation, and after the 16,000 af Deerfield Reservoir and one additional reservoir yet to be selected have been constructed, a supplemental water supply for 12,000 acres in the Rapid Creek Valley will be furnished."

By letter dated December 3, 1947, Reclamation requested the Corps determine the storage required for flood control in Pactola Reservoir and the estimated flood control benefits which would accrue as a result of this storage. On March 16, 1951, the Corps transmitted to Reclamation a final, concise report of flood control storage requirements and flood control benefits accruing there from. The report states in part that, "a minimum of 43,000 af of single purpose flood control storage is required in Pactola for flood control use." The estimated annual flood control benefits attributable to Pactola Dam and Reservoir as presented in this report are $339,000.

Brennen Reservoir was never constructed.

3-03 CONSTRUCTION

The contract for construction of Pactola Dam was awarded in October 1952 and construction was started in the spring of 1953. Closure was made and impoundment began in August

1956; however, some flood runoff had been stored temporarily on 28-29 July 1955. Although the project was considered operational in August 1956, it was not 100 percent complete until 1957.

3-04 RELATED PROJECTS

Pactola Dam is part of Reclamation's Rapid Valley Project, whose main feature is Deerfield Dam and Reservoir, and the Rapid Valley Unit, whose main feature is Pactola Dam and Reservoir. They were completed in 1947 and 1956, respectively. Combined they contain 71,700 af of conservation storage. Plate 3-1 shows the locations of the Rapid Valley Project and Unit entities throughout the Rapid Creek basin.

a. Deerfield Dam and Reservoir

The location of Deerfield Dam is shown on Plate 2-2. Deerfield Dam operated by Reclamation is used solely for water supply with no authorized flood control storage. It is a zoned earthfill structure, with a structural height of 171 feet, a crest length of 1,125 feet, and a crest width of 20 feet. A modification of Deerfield Dam to safely pass a revised inflow design flood was started in 1982, with the work consisting of raising the dam by 38 feet, and replacement of the existing spillway. The side-channel spillway was abandoned, and replaced with an uncontrolled 120-foot wide open-cut channel and ungated concrete crest through the right embankment. There is a 10-foot wide notch in the concrete crest structure. The outlet works consists of a 5-foot-diameter concrete conduit through the dam base, extending to a 39-inch-diameter steel pipe contained within a 6.5-foot horseshoe-shaped concrete conduit. The steel pipe has a discharge capacity of 280 cfs. Small releases for fish and wildlife needs can be made through a 6-inch-diameter bypass pipe which parallels the 39-inch-diameter pipe. Pertinent data on the Deerfield project is shown in Table 3-1. An area-capacity table for Deerfield Reservoir is shown on Plate 3-2 and a spillway rating curve on Plate 3-3.

Table 3-1 Deerfield Dam and Reservoir Pertinent Data

Location: Deerfield Dam is located on Castle Creek approximately 70 river miles upstream from Rapid City, SD.	
Drainage Area Above Damsite	96 sq. mi.
Original Construction Period	1942-1947
Dam Safety Modification Constr. Period	1982-1984
Type	Zoned earthfill
Crest Length	1,125 ft.
Storage Capacity	
Dead Storage (5835 to 5839 ft)	151 af
Conservation (5839 to 5908 ft)	15,504 af
Surcharge (5908 to 5953 ft)	26,655 af
Elevations	
Crest of dam	5,958 feet
Maximum water surface	5,953 feet
Top conservation storage (crest of notch in spillway)	5,908 feet
Top dead storage	5,839 feet
Streambed at axis	5,808 feet
Spillway Crest Elev	5912 feet
Spillway Notch Elev	5908 feet
Spillway Capacity (at maximum water surface, elev. 5953 feet)	103,400 cfs
Outlet Capacity (at top conservation storage, elev. 5908 feet)	280 cfs

b. Canyon Lake Dam and Reservoir

Canyon Lake Dam and Reservoir is located on Rapid Creek at the western limits of Rapid City. It is owned by the city of Rapid City and is used for recreational purposes with no authorized flood control storage. It was either damaged or destroyed by floods in 1907, 1932, 1952 and 1972. The dam was rebuilt following the 1972 flood with a spillway capacity of 14,500 cfs while allowing for 3 feet of freeboard. The spillway is 200 foot wide with a concrete chute and ogee crest at elevation 3360.0 feet. The reservoir has a storage capacity of 140 af with the reservoir level at the spillway crest elevation and a maximum storage capacity of 610 af with the reservoir level at the top of dam elevation. Due to some seepage and structural concerns, the spillway was rebuilt in 2015 with the same width and crest elevation. In the embankment to the left of the concrete spillway, there is an auxiliary concrete spillway with a crest elevation of 3364 feet that is buried in the embankment. This auxiliary spillway is covered with a fuse-plug embankment with a crest elevation of 3369 feet. The auxiliary spillway will not begin flowing until the fuse-plug embankment is overtopped and eroded away. Based on the report Canyon Lake Dam Reconstruction, Phase I Engineering Services, City of Rapid City Public Works Department, March 9, 2009, the Canyon Lake embankment and spillways are designed to safely pass half of the Probable Maximum Flood (PMF). The peak discharge of the PMF is 93,783 cfs and half of the PMF is 46,891 cfs. Table 3-2 shows a spillway rating table for Canyon Lake Dam.

Table 3-2 Canyon Lake Dam Storage and Spillway Rating Tables

Reservoir Level (feet)	Storage (af)	Spillway Discharge		
		Primary (cfs)	Auxiliary (cfs)	Total (cfs)
3356.0	54	0	0	0
3357.0	72	0	0	0
3358.0	90	0	0	0
3359.0	113	0	0	0
3360.0	140	0	0	0
3361.0	168	654	0	654
3362.0	200	1816	0	1816
3363.0	233	3230	0	3230
3364.0	271	5040	0	5040
3365.0	315	6982	0	6982
3366.0	355	9383	0	9383
3367.0	400	11785	0	11785
3368.0	445	14186	0	14186
3369.0	495	17092	16697	33789
3370.0	550	19997	21627	41624
3370.6	584	21741	25208	46949
3371.0	603	22903	27596	50499
3372.0	660	25808	33566	59374

c. Cedar Canyon Dam

Cedar Canyon Dam is located on the western outskirts of Rapid City, SD. After construction, dam ownership was turned over to the City of Rapid City, SD. The dam is designed as a detention structure with no permanent storage, but it is authorized for flood control storage, if necessary. However, a small pool may sometimes exist in the dead storage below the invert of the outlet pipe. The dam collects runoff from approximately 261 acres. The outlet and spillway are uncontrolled.

d. Rapid Creek Floodway in Rapid City

Other than Pactola Dam and Cedar Canyon Dam, flood control projects in the basin currently consist largely of local government and private improvements. After the June 1972 flood, the City of Rapid City with the assistance of the Department of Housing and Urban Development undertook an urban renewal program within the city. The main feature of this program is a floodway along Rapid Creek. A floodway was implemented by the City which involved purchasing lands within the 100-year floodplain and removing structures from this area. The 100-year flood had a peak discharge of 14,500 cfs at the Oshkosh Street gage in Rapid City. The program was implemented in the fall of 1972. However, one area of the floodplain was considered too costly to relocate. City officials then asked the Corps to determine the feasibility of protecting this area in lieu of relocating the structures. In September 1975 the Omaha District Engineer recommended a levee and channel alteration project. The project was approved by the Chief of Engineers on May 20, 1976 under authority of Section 205 of the 1948 Flood Control Act, as amended. The project consists of essentially two units: a 4,000-foot levee to provide Standard Project Flood (SPF) protection on the right bank of Rapid Creek from Sheridan Avenue to Canyon Lake Drive. Channel improvements provide 100-year flood protection from Canyon Lake Drive downstream about 2,700 feet through Chicago Street. Construction of the project was completed in September 1981.

e. Missouri River Mainstem Reservoirs

Releases from Pactola Reservoir eventually flow into Oahe Reservoir, one of six Missouri River mainstem reservoirs. Per Missouri River Basin Water Management's Master Manual, during large floods on the Missouri River mainstem reservoirs, releases of flood storage in Pactola Reservoir may be adjusted in order to meet basin-wide flood control goals of the Missouri River system. See Section 7-05 for more information.

3-05 DAM SAFETY HISTORY/ISSUES

Pactola was identified as hydrologically deficient. In 1987 construction was completed on a 15-foot dam raise and the construction of a larger uncontrolled spillway. The project has been hydrologically sufficient since. No other dam safety issues are known at this time.

a. Original Flood Control Plan of Regulation

The original plan of regulation for flood control at Pactola Reservoir was developed concurrently with the design of the project. At that time, the volume of storage required to control the reservoir design flood was determined on the basis of discharging 250 cfs from the reservoir from the beginning of inflow until the peak inflow had occurred.

Thereafter releases were maintained at 1,000 cfs until the flood control storage zone of the reservoir had been evacuated. Table 7-2 was adopted as the plan of operation before the 1976 “Report on Reservoir Regulation for Flood Control – Pactola Dam and Reservoir, South Dakota” was published.

3-06 PRINCIPAL REGULATION PROBLEMS

During flood control releases, as flows move into Rapid City, bike paths below Canyon Lake are inundated. Releases exceeding 500 cfs will impact some out-buildings and yards along Rapid Creek due to encroachment. Section 4-09 describes the channel and floodway characteristics downstream from Pactola Dam and Section 7-02 describes constraints on water management operations at Pactola Dam.

3-07 MODIFICATION TO REGULATIONS

The conservation zone was essentially filled for the first time in June 1963. After completion of the project, an interim field working agreement on flood control regulations was signed between Reclamation’s Regional Director and the Corps' District Engineer on September 30, 1958. Following submission of the Preliminary Information Report on Flood Control Regulations in 1969, the flood control regulations were published in the Federal Register. The date of publication was May 30, 1969. This regulation contained storage zone elevations, storage zone volumes, and guidance to restrict releases to a maximum of 1,000 cfs when the reservoir pool level is in the flood control zone. The regulation also contained generalized guidance on coordination requirements during flood control operations. A final field working agreement implementing the regulations was signed on August 27, 1969. In May of 1976 and again in July of 2012 new generalized regulations (see Exhibit I) were published in the Federal Register. These new regulations superseded the regulations previously published in the Federal Register on May 30, 1969, and contain generalized guidance on use of storage allocated for flood control and a table that lists project purposes, storage zone volumes, areas, and elevations. This new regulation did not result in any changes to the flood control regulation for Pactola Dam.

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CHAPTER 4—WATERSHED CHARACTERISTICS

4-01 GENERAL CHARACTERISTICS

The Rapid Creek basin is centrally located in the Black Hills region of southwestern South Dakota (Plates 2-1 and 2-2). Rapid Creek is formed at the confluence of the North Fork of Rapid Creek and Castle Creek and flows in an easterly direction for about 120 river miles to its junction with the Cheyenne River. It is located between Boxelder and Spring Creeks. The Rapid Creek drainage area is a total of 710 sq. mi. while the drainage area upstream of Pactola Dam is 319 sq. mi.

4-02 TOPOGRAPHY

Rapid Creek is a perennial mountain stream located in Lawrence and Pennington Counties of South Dakota. Rapid Creek is a tributary of the Cheyenne River, which flows into the Missouri River. The drainage area of Rapid Creek is approximately 710 sq. mi. at the confluence with the Cheyenne River. Above Rapid City, SD, the basin is mountainous with elevations as high as 7,000 feet. From the headwaters, the stream drops rapidly to an elevation of 3,200 feet at Rapid City. Between Rapid City and the mouth, the basin varies between elevations 3,200 and 2,450 feet (see Plate 4-1).

4-03 GEOLOGY AND SOILS

The upper basin of the Rapid Creek watershed is comprised of the Madison Group limestone and dolomite deposits, gray to dark-gray phyllite, slate, and mica schist while the major portion of the lower Rapid Creek watershed is made up of Pierre shale, Terrace deposits, and Alluvium.

4-04 SEDIMENT

Sediment accumulation for 100 years in Pactola Reservoir was projected to be 1,000 af, with the sediment accumulated between the bottom of the reservoir and the top of the active conservation storage space. No sediment surveys have been done at Pactola Dam since construction. In May 1988, new elevation-area-capacity table and curves were developed because the dam and dikes were raised 15 feet to elevation 4655.0 feet to enable Pactola Dam to safely pass the Probable Maximum Flood. This study determined that at the top of conservation level of 4580.2 feet, Pactola Reservoir has a storage capacity of 55,972 af and a surface area of 861 acres. At maximum pool level of 4651.7 feet, Pactola Reservoir has a storage capacity of 140,921 af and a surface area of 1,557 acres. Exhibit IV shows the capacity table in one-foot increments. Exhibit V shows the capacity and area tables in both one-foot and 0.1-foot increments. The area-capacity curve is found on Plate 2-14.

4-05 CLIMATE

Climate in the area surrounding Pactola Reservoir is characterized by long, arid summers and long, dry winters, with short, but distinct, spring and autumn seasons. The average annual rainfall in the area varies from about 25 inches in the higher elevations to about 18 inches at Rapid City. Precipitation in the form of rain occurs mainly during the spring and

early summer months of April through June; however, severe rain and hail storms do occur in the middle and late summer. Table 4-1 lists 30-year normal values for temperature, precipitation, and snowfall at Pactola Dam.

Table 4-1 Pactola Dam Average Temperature, Precipitation, and Snowfall (1981-2010)

Month	Ave. Temperature (ºF)	Ave. Precipitation (inches)	Ave. Snowfall Depth (inches)
January	23.6	0.28	4.6
February	24.3	0.48	6.1
March	30.5	1.13	11.2
April	38.3	2.15	12.1
May	47.8	3.97	2.6
June	56.9	3.20	0.2
July	64.2	2.72	0.0
August	62.9	2.26	0.0
September	53.0	1.67	0.5
October	42.1	1.50	3.9
November	31.3	0.61	6.2
December	23.4	0.34	4.2
Annual	**41.6**	**20.31**	**51.6**

Source: National Climatic Data Center, US Department of Commerce
https://www.ncdc.noaa.gov/data-access
Temperature, Precipitation, and snowfall data are at Pactola Dam station

a. Temperature

From early fall through late spring, cold waves with sub-freezing temperatures occur regularly in the Black Hills region of southwestern South Dakota. Temperatures below zero degrees Fahrenheit (º F) are not uncommon during January and February with normal low temperatures during those months averaging between 10º F and 20º F and highs generally in the 30s. Periodic Chinook winds, however, can warm temperatures in the region into the 50s and 60s.

The warmest months of the year are July and August, when hot weather occurs often. Daytime temperatures typically range from the 70s to 90s during these months, with lows

generally in the 40s and 50s. High temperatures in excess of 100º F occur, particularly on breezy days with low humidity levels.

b. Precipitation

While precipitation occurs year-round, the overwhelming bulk of the moisture arrives during the spring and summer months. The 30-year average annual rainfall for Pactola Dam is 20.31 inches. Typically, the greatest amount of precipitation is measured during May and June from rain showers and thunderstorms, although heavy rainfall and severe storms are fairly common in July and August as well.

The wettest year on record was 1962 with 31.87 inches, which succeeded one of the driest years on record (1961) of 11.88 inches. The highest daily rainfall total is 7.16 inches on June 10, 1972, followed by 4.24 inches on May 18, 1981, 3.91 inches on June 15, 1976, and 3.43 inches on May 15, 1965. The June 1972 storm was part of a system that produced an estimated 15 inches of rainfall in six hours approximately eight miles north of Pactola Dam and resulted in extensive flooding near and downstream of the dam.

c. Snow

Heaviest snowfall tends to occur during March and April with a 30-year seasonal average of 51.6 inches. The snowiest season on record was 1996-1997, when 87.9 inches was reported at Pactola Dam. The two highest daily snowfall totals were 24 inches on November 2, 1956 and 18 inches on March 14, 1973.

Late season snowstorms are not uncommon in the region; 14 inches fell on May 9, 1965 and 4 inches fell on June 13, 1968. The May 1965 snowfall occurred days before a heavy rainfall event and contributed to subsequent flooding conditions. July and August are the only two months where snowfall has not been measured at Pactola Dam.

d. Evaporation

Evaporation is accounted for in Reclamation's Hydromet accounting system for the months of May through September. Equations have been developed from weather data that compute evaporation for the months of May through September. The evaporation loss is then computed based on surface area of the reservoir.

Evaporation from Pactola Reservoir is calculated using a physically-based evaporation model implemented in routine calculations in 2012. The model, which was developed by the Corps' Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (ERDC-CRREL), estimates evaporation from the flood control reservoirs in the Omaha District. The model has two components: the first component calculates the evaporation from the water surface using a Bulk Flux Algorithm, and the second component estimates the vertical temperature profile of the reservoir based on a one-dimensional heat budget of the reservoir. The model requires no new instrumentation to be installed in the field, uses available meteorological observations from the National Weather Service (NWS), and is compliant with the Corps Water Management System (CWMS) framework. The model input includes: hourly air

temperature, hourly wind speed, hourly relative humidity, hourly barometric pressure, hourly cloud cover extent and elevation, hourly reservoir depth, reservoir location, current water surface elevation, and the elevation-area relationship. The model has some limitations, which include the inability to accurately calculate evaporation when the reservoir is ice covered. When the reservoir is ice covered, the WCWQS personnel estimate the evaporation.

e. Wind

Severe wind reports, with speeds approximately 60 mph or greater, occur on average 4 to 5 times per year at Pactola Dam. Some of these storms produce large hail, in excess of an inch in diameter, and isolated tornadoes. Prevailing winds in the Black Hills region of southwestern South Dakota are predominately from the northwest.

Between cold waves in the winter there are periods, sometimes greater than a week, of mild and windy weather. These are the result of occasional warm downslope winds that are known as "chinooks" and tend to prevent deep accumulation of snow in the more open country. Chinook winds frequently reach speeds of 25 to 50 miles per hour or more and can persist, with little interruption, for several days. In addition, it should be noted that the unique topography of the region has historically contributed to dramatic effects on Chinook winds and their impacts on wild temperature fluctuations in short time periods across relatively close locations.

4-06 STORMS AND FLOODS

Most major floods in the Rapid Creek basin have been flashy. The potential for this type of flood in the Rapid Creek basin was illustrated as far back as July 5, 1882 when Rapid Creek reportedly rose 5 feet in 30 minutes at Rapid City, SD. During the 1972 flood, the gage above Canyon Lake rose about 12.5 feet in 2 hours. The Rapid City gage rose about 15.5 feet in 3 hours. However, flood crests normally attenuate greatly as they move downstream below the Black Hills boundary. Major reported floods are described in the following sections.

a. Flood of May 17, 1883

Torrential rainfall combined with rapid snowmelt on May 17, 1883 washed out many bridges and caused extensive damage to homes, businesses and streets in the City. The peak discharge was estimated to be 8,400 cfs.

b. Flood of May and June 1907

Flood flows at Pactola for the flood of June 12-16, 1907, were reconstructed from rain values using unit hydrographs developed for sub-areas above the dam. During this storm at Fort Meade, about 25 miles north of Pactola, 8.1 inches of rain fell on June 12-13. Of this, 6.1 inches fell in two and a half hours. Rapid City reported 1.25 inches on June 12. The resultant flood hydrograph at the damsite had a peak flow of about 12,430 cfs and a five-day volume of approximately 28,000 af. Routing this flood through the reservoir, beginning at elevation 4580.2 feet (base of flood control zone), using the release schedule in Section 7-05d (1) results in a maximum pool elevation of 4602.72

feet and a maximum release of 1,000 cfs. Approximately 50 percent of the allocated flood control space was utilized in controlling this flood by the rule curve method and approximately 12 days would be required for evacuation. This routing is shown on Plate 8-6. Damages from this event were extensive, including washing away part of Canyon Lake Dam.

c. Flood of May, 1920

The flood of May 10-12, 1920, was reconstructed by analysis of rainfall records and application of unit hydrographs of basin sub-areas. Rainfall amounts during the three day period were 4.75 inches at Rapid City, 1.70 inches at Deerfield, and 2.32 inches at Rochford. A heavy base flow was present from melting snow cover at the beginning of this flood. Flow records were available for a gage at Big Bend although estimates of discharge in excess of 500 cfs are considered poor. Routing of these sub-area flows into the reservoir resulted in an inflow hydrograph with a peak of about 4,400 cfs and a five-day volume of approximately 22,000 af. Routing this flood through the reservoir, beginning at elevation 4580.2 feet (base of flood control zone), using the release schedule in Section 7-05d (1) results in a maximum pool elevation of 4596.48 feet and a maximum release of 900 cfs. Approximately 35 percent of the allocated flood control space was utilized by the rule curve method. Approximately 10 days would be required for evacuation. This routing is shown on Plate 8-7.

d. Flood of May 6, 1932

The maximum flood of record below Rapid City occurred on May 6, 1932 with an estimated discharge of 16,000 cfs near the mouth at the former Creston gage site. Little is known about the origin of this flood other than it probably occurred from a local cloudburst below Rapid City.

e. Flood of May 1952

The largest streamgaged flood near the Pactola damsite occurred on May 22, 1952. Rainfall reports for May 21-22 at Deerfield Dam totaled 5.08 inches and at the Pactola Ranger Station 6.61 inches. Approximately 100 houses were flooded in Rapid Valley. Road and bridge damage from this flash flood was high. The peak discharge at the Pactola gage was 2,170 cfs on May 22, at the Canyon Lake gage 2,600 cfs on May 23, at the Rapid City gage 2,540 cfs on May 23, and at the Farmingdale gage 1,770 cfs on May 24. During this flood a section of the Canyon Lake spillway washed out.

f. Flood of May-June 1965

The flood of 1965 resulted from heavy rains on May 14-15 falling on snow remaining on the ground from the storm of May 8-10. Rainfall amounts during the two-day period were 3.81 inches at Rapid City, 3.22 inches at Deerfield 5NW, 3.38 inches at Pactola Dam and 3.74 inches at Buskala Ranch. Pactola Reservoir rose above the base of flood control on May 14. The peak inflow was followed by smaller rises on May 26 and June 18 as a result of additional rainfall. A peak inflow of 2,060 cfs was recorded at the Silver City gage just above Pactola Reservoir on May 15. The maximum daily Pactola Reservoir

inflow was 1,110 cfs on May 16. The actual regulation of the flood was attempted following the basic design criteria, which generally provides for releases up to 250 cfs until the peak of the inflow has occurred and then releases of 1,000 cfs to control the remainder of the flood and evacuate the accumulated flood waters. Downstream tributary flows were sufficiently high so that an outflow of 250 cfs was not reached until five days after the start of runoff or three days after the peak of the inflow. Releases were then progressively increased in an attempt to release 1,000 cfs, as called for by the design criteria. Numerous complaints regarding the high releases were received. As the inflow was rapidly falling off and the flood threat had diminished, releases were limited to a maximum of 500 cfs. This regulation resulted in a maximum pool elevation of 4585.93 feet on May 19. The flood control zone was evacuated on June 11.

Subsequent rainfall resulted in additional runoff and a small encroachment of the flood control zone from June 18 to June 30.

Following the event, a study was performed in which the 1965 flood hydrograph was routed through the reservoir, with a starting pool level at elevation 4580.2 feet (base of flood control zone), using the release schedule given in section 7-05d (1), which was developed after the 1965 flood. The pool level attained from the initial peak inflow hydrograph was elevation 4584.93 feet with a peak discharge of 400 cfs. Subsequent inflows increased the flood storage and resulted in an overall maximum pool elevation of 4585.02 feet, with the outflow remaining at the rule curve value of 400 cfs. The routing of this flood is shown on Plate 8-8.

g. Flood of June 9-10 1972

On June 9, a storm formed on a north-south line along the eastern edge of the Black Hills. The storm line passed through the Rapid Creek basin between Pactola Dam and Rapid City and produced up to 15 inches of rainfall in localized areas. Prior area records of maximum rainfall back to 1879 show a high of 7.10 inches that occurred both at Fort Meade on June 13, 1907 and at Custer on April 17, 1920. During the 1972 storm an estimated 15 inches fell in 6 hours near Nemo, just north of the Rapid Creek basin.

Rain began on June 9 northwest of Rapid City in the basin at about 5:00 p.m. and in the City at about 7:00 p.m. As Rapid Creek began to rise, flood warnings were broadcasted on TV and radio, and by 8:00 p.m. firemen, city and county police, and National Guardsmen went into the flood prone areas to alert residents to the flood danger. It was later reported that many did not heed the warnings. It is likely that persons living near the stream viewed the hazard in light of past floods and simply could not comprehend the potential flood magnitude. When the flood crest hit Rapid City about 11:00 p.m., it caught many residents unprepared. Two hundred thirty-eight persons died in the flood at Rapid City; many whose deaths were unconfirmed for several days. Hundreds of cars, trucks, and other vehicles were swept downstream. Impacts included 1,020 flooded homes, including 600 destroyed, 406 mobile homes were flooded, 312 of which were destroyed, and 242 businesses were flooded with 35 being destroyed. At the height of the flood, downed power lines, gas leaks, and fires became secondary hazards to be contended with. Nearly every bridge on Rapid Creek between Pactola Dam and Rapid City was damaged or destroyed; 13 bridges in Rapid City were washed out and 4 were

damaged. Trees of all sizes were uprooted or carried away to lodge downstream at bridges or other constrictions. Residential, commercial, and industrial damages at Rapid City were estimated at $66 million. Total area flood damage, including secondary economic losses, was about $164 million.

Pactola Dam releases were shut off at midnight on June 9 and did not resume until 8:00 p.m. on June 13. Peak inflow into Pactola Reservoir was 2,170 cfs between 8:00 and 9:00 p.m. on June 9. At Canyon Lake Dam, flow over the embankment occurred from 9:30 p.m. to 9.45 p.m. on June 9. This overflow weakened a large section of the embankment which ultimately failed, leaving a 300-foot gap in the embankment. Estimates of the time of its failure vary from 10:45 p.m. to 11:30 p.m. on June 9. Various estimates of flood peak discharges and times on Rapid Creek are listed in Table 4-2.

Table 4-2 Rapid Creek 1972 Flood Peak Discharges

Location	Peak Discharge (cfs)	Time & Date
Above Pactola Reservoir Gage	228	n/a
Peak Inflow at Pactola Reservoir	2,170	8:00 p.m. 9 June
Near Hisega	5,720	n/a
Canyon Lake Gage	31,200	11:00 p.m. 9 June
Rapid City Gage	50,000	12:00 p.m. 9 June
Farmingdale Gage	7,320	2:00 p.m. 10 June

h. Flood of June 1998

Pactola Reservoir initially entered the flood control zone in response to a one-inch rainfall over the Rapid Creek basin that occurred on June 8. This was followed by almost four inches of rainfall over June 17 and 18. The latter event resulted in the second highest mean daily inflow of record, 1,009 cfs, on June 19. This was exceeded only by the inflow recorded on May 16, 1965, of 1132 cfs. Fortunately, the center of the June 17 event was above Pactola Dam, resulting in only minor rises in Rapid Creek through Rapid City. Reservoir releases were generally made using the plan of regulation contained in the water control manual. Additional considerations when setting the releases were as follows:

1. The flow at Canyon Lake was targeted at 500 cfs. At this time flows greater than 500-600 cfs adversely affect recreational facilities located along Rapid Creek through Rapid City.

2. Pactola releases over 440 cfs would overtop a rock dike located on the right bank of the flood control zone possibly eroding the bank and harming fisheries at that location.

3. The Pactola Marina and Forest Service boat ramps are affected by pool elevations 2-3 feet above the Top of Conservation.

4. By setting the Pactola releases at 440 cfs, rather than the 400 cfs called for in the plan, it was hoped that this would prevent the pool from rising above elevation 4585 feet and possibly requiring a 500 cfs release.

5. Pactola releases were reduced from 430 cfs to 310 cfs prior to July 4 because of a request by the City of Rapid City. City officials were afraid that water levels in Rapid Creek were just high enough to submerge the low-flow bank line in the 66 channel and put water up over grassy areas. With Rapid City's "Heritage Days" celebration over the 4th of July weekend, it was felt that children would be playing around the water's edge and could easily fall into deeper water.

A routing of this flood event through Pactola Reservoir is shown on Plate 8-10.

i. Flood of May and June 1999

During the 1999 runoff season, runoff into Pactola Reservoir and flow conditions in general in the Black Hills were at record levels. The bulk of the record flow volume occurred in the wintertime and is an indication of high "base" flows or high spring activity. This is a result of the wet cycle that the Black Hills had been in since 1995. The record inflow that occurred in June 1999 was the direct result of high rainfall from the period of April 1 to June 15. Rainfall during this period equaled the normal total precipitation for the entire year. The maximum daily inflow was 580 cfs, the maximum pool level was 4584.5 feet, and the maximum release was 400 cfs. Considerations when setting the releases were as follows:

1. The flow at Canyon Lake was targeted at 600 cfs. At this time flows greater than 500-600 cfs adversely affect recreational facilities located along Rapid Creek through Rapid City.

2. Releases over 440 cfs would overtop a rock dike located on the right bank of the plunge pool possibly eroding the bank and harming fisheries at that location. This rock dike has been replaced with a 6-bay check structure at the outlet of the spillway plunge pool to control water surface elevations for the fishery.

3. The Pactola Marina and Forest Service boat ramps are affected by pool elevations 2-3 feet above the Top of Conservation pool level.

j. Flood of May and June 2015

During the months of May and June the Rapid Creek basin above Rapid City received 12 to 18 inches of rainfall, which was 6 to 12 inches above normal. Due to the above-normal rainfall that followed the spring snowmelt, the inflow began to rise and on May 11 Pactola Reservoir rose above the base of the flood control zone, elevation 4580.2 feet. As a result the release was slowly increased from 50 cfs to 250 cfs following the rise in inflow as prescribed in the release schedule. Continued rainfall kept the inflow above 700 cfs and on May 27 the reservoir pool elevation exceeded 4585.0 feet requiring an increase in the release to 500 cfs, matching the record release set in 1965. The Corps, Reclamation, and local emergency manager agreed that a cut in the release would be considered if there was a forecast for heavy rainfall in Rapid City with the understanding that there is a travel time of 6 to 8 hours between Pactola and Rapid City. The maximum daily average release for the event was 514 cfs on June 26, a new historical record release.

On May 29 the reservoir exceeded the previous maximum record pool elevation of 4585.9 feet (12% of the flood storage occupied) set in 1965 and 24-hour monitoring of the dam was initiated.

Heavy rainfall in Rapid Creek basin above Rapid City continued in June. The reservoir pool elevation looked to peak several times, but additional rainfall in mid-June to late June forced the inflow back up to 700 cfs by June 24. On June 25 the pool was forecast to peak at 4588.5 feet but the inflow stayed higher than anticipated and the reservoir peaked at 4589.4 feet (19% of the flood storage occupied) on June 29. The 500 cfs release was held until July 24 when about 1% of the flood control zone was occupied. The release was dropped over a 5-day period to 150 cfs to match the inflow at which time the reservoir was operated for conservation purposes.

The daily peak inflow did not surpass the top three historical records, but the total inflow volume for the report period was 111,586 af (295% of normal), which is the highest on record. The previous record was 104,207 af set in water year 1999.

4-07 RUNOFF CHARACTERISTICS

In general, the runoff characteristics above Rapid City are typical of mountainous areas. Here the soil cover is light and losses are relatively low. Combined with steep slopes, these factors tend to produce flash flooding where runoff rates are high and concentration time is very short. Below Rapid City, the topography and land cover tend to retard runoff. Slopes are not as steep and the concentration time is much greater. In general, the highest discharges occur in the spring and early summer months as a result of snowmelt or rainfall or combination of both. Occasionally localized cloudbursts occur during the summer or early fall resulting in flooding. To illustrate the seasonal nature of runoff, Table 4-3 lists monthly average flows at the Rapid Creek gaging station (06410500) above Pactola Reservoir at Silver City. Table 4-3 also lists the maximum and minimum record flows for the month with the associated year of occurrence. Plate 4-2 shows the historical average monthly inflow volume at Pactola Dam, and Plates 4-3a and 4-3b shows in tabular form the historical monthly inflow volumes. Plate 4-4 shows the historical annual inflow volume at Pactola Dam.

Table 4-3 Rapid Creek above Pactola Monthly Discharge in cfs (Oct 1953 - Sep 2015)

	Average	Maximum -Year	Minimum -Year
January	22	83.7 - 1999	8.6 - 1962
February	23	68.4 - 1999	8.3 - 1993
March	38	118.3 - 1996	12.1 - 1962
April	68	231.9 - 1997	16.5 - 1961
May	103	322.2 - 1997	14.5 - 1961
June	107	508.4 - 2015	14.7 - 1961
July	63	301.2 - 2015	15.2 - 1961
August	48	205 - 1997	11.5 - 1961
September	40	117.3 - 1998	10.5 - 1961
October	36	141.5 - 2013	10.2 - 1961
November	27	128.8 - 1998	10.3 - 1961
December	22	102.8 - 1998	7.8 - 1961

An updated flood insurance study was conducted by FEMA for Pennington County including the City of Rapid City with an effective date of June 3, 2013. The following Table 4-4 lists a summary of discharges used for the flood insurance study.

Table 4-4 Rapid Creek Summary of Discharges - Pennington County, SD June 2013 Flood Insurance Study

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharge (cfs)			
		10%	2%	1%	0.2%
At 2,000 feet D/S from Hisega	15.6	390	1,850	3,400	13,000
At 14,800 feet U/S from Rapid City Corporate Limits	33.8	800	3,800	7,000	27,000
Downstream from Victoria Peak	46.8	1,100	5,000	10,000	36,000
At Rapid City Upstream Corp. Limits	49.9	1,150	5,400	10,500	39,000
Upstream from Cleghorn Canyon	52.9	1,200	5,700	11,500	40,000
Upstream from Red Rock Canyon	58.9	1,300	6,500	12,900	44,000
At Oshkosh Street	n/a	1,800	8,200	14,500	47,000
At East St. Patrick Street	n/a	1,845	8,430	14,900	48,250
At Rapid City Downstream Corp. Limit	n/a	1,865	8,540	15,200	49,500
At 2,000 feet D/S from Co. Road L255	144.0	2,050	9,500	16,500	54,000

4-08 WATER QUALITY

The water quality of the Pactola drainage above Pactola Reservoir is very good. Castle Creek, which flows into Deerfield Reservoir and into Rapid Creek above Pactola, is considered a blue ribbon trout fishery. Both Deerfield and Pactola Reservoirs have excellent water quality and support a trout fishery.

Pactola's SOP provides guidelines on the management of releases to meet contractual demands as well as to support the fishery.

The land above Rapid City along Rapid Creek is primarily forest and some livestock pasture so the drainage is set up to provide very good water quality for Rapid Creek.

4-09 CHANNEL AND FLOODWAY CHARACTERISTICS

Detailed location maps of Rapid Creek in the Rapid City area are shown on Plates 4-5a to 4-5i.

a. **Stage-Discharge Relationship**. Rating curves for major streamgage stations in

the Pactola Dam and Reservoir area are shown on Plates 4-6 through 4-11, and are listed in Table 4-5 below. Additional information about these streamgages is listed in Table 5-1.

Table 4-5 Rapid Creek Pertinent Streamgage Stations

Plate No.	Streamgage Location
4-6	Castle Creek above Deerfield Dam near Hill City
4-7	Rapid Creek above Pactola Dam at Silver City
4-8	Rapid Creek below Pactola Dam
4-9	Rapid Creek above Canyon Lake
4-10	Rapid Creek at Rapid City
4-11	Rapid Creek near Farmingdale

b. Channel Capacity. Channel capacities at selected locations along Rapid Creek are shown in Table 4-6.

Table 4-6 Channel Capacities below Pactola Dam

Pactola Dam to Rapid City	500 cfs
Through Rapid City	500 cfs with channel improvement and floodway with 14,500 cfs capacity in some areas.

c. Travel Time. Travel times for various bankfull conditions are given in Table 4-7.

Table 4-7 Approximate Bankfull Travel Times Below Pactola Dam

Pactola Dam to Canyon Lake	4 to 5 hours
Canyon Lake to Rapid City (streamgage)	1 hour
Rapid City (streamgage) to mouth Rapid Creek	1 day
Mouth Rapid Creek to Lake Oahe	1.5 days

In the design of Pactola Dam and Reservoir the non-damaging release and minimum downstream channel capacity on Rapid Creek was considered to be 1,000 cfs. During the period from dam closure in 1956 to 1965, the lack of high flows from the dam resulted in some encroachment on the channel. As a result, complaints were received when flood control releases above 400 cfs were made in 1965 and 1967. Based on these releases and the flood control releases made in 1972 and 1976, the non-damaging discharge between the dam and Rapid City is estimated to be about 500 cfs. At 500 cfs water begins to flow in the garage of one home in the Hisega Area about 12 river miles below the dam. However, it should be noted during the June 1972 flood, the creek level was about 10 feet above the 500 cfs stage at this dwelling. The peak 1972 discharge at Hisega was 5,720 cfs.

Following the 1972 flood, in which virtually all creek crossings below Pactola Dam were destroyed due to local rainfall runoff, all public crossings downstream to Rapid City were permanently rebuilt within a few years to pass at least 1,000 cfs. The capacity of the rebuilt private crossings below Pactola Dam is unknown, although most bridges will safely pass more than 500 cfs. Releases ranging from 500 cfs to 1000 cfs will impact some outbuildings along the creek. Following the 1972 flood, Rapid City undertook a floodplain protection program. The program provided a floodway that can carry 14,500 cfs through the city without major damage. The floodplain has been maintained along Rapid Creek which has become a greenway of parks and recreation areas along the creek. Minor floods can pass through the City without causing any property damage. From the west edge of Rapid City upstream to Pactola, no floodway was zoned and safe channel capacity continues to be about 500 cfs.

In Rapid City, all bridges were rebuilt to pass at least 6,000 cfs, the estimated 50-year flood frequency. Much of the sediment accumulated in the channel downstream of Canyon Lake Dam following its failure during the 1972 flood, which greatly reduced channel capacity in Rapid City, has since moved downstream. The discharge channel capacity in the area of the Rapid City gage in 1976 was estimated between 3,000 cfs and 3,500 cfs. The channel capacity downstream from Rapid City to the mouth of Rapid Creek is estimated to range from 2,000 cfs to 5,000 cfs.

The most recent flood experienced in Rapid City occurred in 2015, surpassing the floods in 1996, 1998 and 1999. From the end of May through the end of July in 2015, the Rapid Creek at Rapid City streamgage was consistently between 600 cfs to 1200 cfs. The release from Pactola Dam was about 500 cfs as required by the water control plan. Only minor impacts were experienced due to the floodway developed following the 1972 flood.

4-10 UPSTREAM STRUCTURES

See Section 3-04, Related Projects.

4-11 DOWNSTREAM STRUCTURES

See Section 3-04, Related Projects.

4-12 ECONOMIC DATA

a. Population

The major population center is Rapid City located on Rapid Creek about 15 miles below Pactola Dam. It is the second largest city in the state of South Dakota. Located between the dam and Rapid City, adjacent to the creek, are also numerous cabin-type vacation homes and year-round residences. Population gain or loss of Rapid City and the state is shown in Table 4-8.

Table 4-8 Rapid City Population Trends

Year	Rapid City	South Dakota
1930	10,404	692,849
1940	13,844	642,961
1950	25,310	652,740
1960	42,399	680,514
1970	43,836	665,507
1980	46,492	690,768
1990	55,553	696,004
2000	59,607	754,844
2010	67,956	814,180

Data source: Census Bureau

Ellsworth Air Force Base is located about 10 miles northeast of Rapid City. It is one of the principal bases of the United States Strategic Command. Opened in July 1942 as an Army Air Force Base, it was named Ellsworth Air Force Base in June 1953. Following World War II, it went into temporary inactive status from September 1946 to March 1947. The base receives water from Pactola Reservoir.

b. Agriculture

Cattle and calves comprise the majority of the livestock in Pennington County, with the main crops being wheat, hay, and grass silage. Table 4-9 highlights the role of agriculture in the area around Pactola Dam.

Table 4-9 2012 Agriculture Data near Pactola Dam and Reservoir

Land in farms (acres)	1,074,103
Number of farms	599
Average size of farm (acres)	1,793
Market Value of Agriculture Products Sold	
Crops	$29,599,000
Livestock, Poultry, and their products	$36,148,000

Data from 2012 Census of Agriculture, USDA, National Agriculture Statistics Service Pennington County

c. Industry

Employment by industry in the areas above and below Pactola Dam is found in Table 4-10.

Table 4-10 Employment by Sector in Rapid City Metro Area

Natural Resources, Mining, Construction	6.1%
Manufacturing	4.0%
Wholesale Trade	2.5%
Retail Trade	11.8%
Transportation, Warehousing & Utilities	16.4%
Information	1.3%
Financial Activities	5.4%
Professional & Business Services	7.2%
Educational & Health Services	15.0%
Leisure & Hospitality	11.0%
Other Services (except Public Administration)	4.2%
Government	15.1%

Data from 2012 Rapid City Economic Development Partnership, http://www.rapiddevelopment.com

d. Flood Damages

Rapid Creek downstream from Pactola Dam has been divided into three reaches for computation of flood damages as follows:

Reach 1	Upstream of Rapid City
Reach 2	Rapid City
Reach 3	Downstream of Rapid City

Discharge damage curves were developed from field surveys and record floods. Zero damage discharges were selected for each reach from a study of recorded stream discharges and flood records. This survey was made prior to 1976. Discharge

damage curves were updated to current price levels in 2012 and are shown on Plate 4-12. Total damages prevented by Pactola Dam since its construction is $10,292,000 in 2018 dollars. Table 4-11 lists annual and accumulative flood damages prevented by Pactola Reservoir.

Table 4-11 Pactola Reservoir Flood Damages Prevented in Thousands of Dollars

Year	Local ($1,000)	Missouri River ($1,000)	Accumulated Total ($1,000)	Year	Local ($1,000)	Missouri River ($1,000)	Accumulated Total ($1,000)
1962	20.0	0.0	204.8	1991	246.3	0.9	535.6
1963	34.0	0.0	337.9	1992	0.0	0.0	0.0
1964	50.0	485.0	0.0	1993	426.7	64.7	797.7
1965	0.0	0.0	0.0	1994	0.0	0.0	0.0
1966	87.7	789.0	0.0	1995	318.5	465.9	154.7
1967	0.0	0.0	0.0	1996	365.5	678.4	6.4
1968	0.0	0.0	0.0	1997	107.5	193.1	0.0
1969	0.0	0.0	0.0	1998	381.9	602.5	82.3
1970	0.0	0.0	0.0	1999	194.9	317.8	20.5
1971	434.0	2,518.4	0.0	2000	0.0	0.0	0.0
1972	0.0	0.0	0.0	2001	1.2	0.0	2.0
1973	0.0	0.0	0.0	2002	0.0	0.0	0.0
1974	31.0	0.0	144.4	2003	10.2	0.0	16.7
1975	0.0	0.0	0.0	2004	0.0	0.0	0.0
1976	0.0	0.0	0.0	2005	0.0	0.0	0.0
1977	16.0	58.8	0.0	2006	0.0	0.0	0.0
1978	0.0	0.0	0.0	2007	71.1	0.0	95.4
1979	0.0	0.0	0.0	2008	184.3	18.3	213.9
1980	0.0	0.0	0.0	2009	0.0	0.0	0.0
1981	7.9	0.0	21.5	2010	60.3	74.7	0.0
1982	0.0	0.0	0.0	2011	114.9	137.1	0.0
1983	0.0	0.0	0.0	2012	0.0	0.0	0.0
1984	0.0	0.0	0.0	2013	4.0	0.0	4.6
1985	383.2	938.5	0.0	2014	49.2	51.2	4.2
1986	0.0	0.0	0.0	2015	165.9	146.6	35.4
1987	0.0	0.0	0.0	2016	2.8	0.0	3.0
1988	0.0	0.0	0.0	2017	0.0	0.0	0.0
1989	0.0	0.0	0.0	2018	70.3	17.3	53.0
1990	20.0	0.0	204.8	Tot	3,839.3	7,558.1	2,733.9

[1]Unadjusted per Building Cost Index

CHAPTER 5—DATA COLLECTION AND COMMUNICATION NETWORKS

5-01 HYDROMETEOROLOGICAL STATIONS

a. Facilities

The Cooperative Streamgaging Program is a joint effort between the Corps, the U.S. Geological Survey (USGS), Reclamation, and local agencies providing remote site satellite data transmissions utilized for water management. Table 5-1 displays a table of hydrologic stations relevant to Pactola Dam with various organizations' ID names, drainage areas, mean values, and record values. Maps of streamgaging stations upstream and downstream of Pactola Dam are presented on Plates 2-1 and 2-2.

Table 5-1 Pertinent Streamgaging Stations (Record through 2018)

Station	Drainage Area (sq.mi.)	Yrs. Of Record	Mean Discharge (cfs)[1]	Peak Flow (cfs)	Date of Peak
Castle Creek above Deerfield Reservoir (06409000)	83	69	12.4	1,120	May 22, 1952
Castle Creek below Deerfield Reservoir (06410000)	96	71	11.6	200	May 22, 1952
Rapid Creek above Pactola Reservoir (06410500)	292	64	47.4	2,060	May 15, 1965
Rapid Creek below Pactola Reservoir (06411500)	320	54	51.8	2,170	May 22, 1952
Rapid Creek above Canyon Lake (06412500)	371	54	50.1	31,200	June 9, 1972
Rapid Creek at Rapid City (06414000)	414	48	69.5	50,000	June 9, 1972
Rapid Creek near Farmingdale (06421500)	605	53	76.9	7,320	June 10, 1972

[1] Mean Discharge is based upon average of annual average discharge.

Information on the streamgaging stations may be obtained from the USGS website.

Real-time rainfall gages located in the Pactola Dam area are listed in Table 5-2 and their locations are shown in Plates 2-1 and 2-2.

Table 5-2 Precipitation Stations

Buskala Ranch
Deerfield 4 NW
Farmingdale 4N
Hill City
Pactola Dam
Rapid City
Rapid City WSO AP
Rochford

b. Reporting

Data from hydrologic stations are obtained from various sources including project offices, NWS, USGS, Reclamation, state offices and data collection platforms (DCP) streamgages. The NWS provides current weather conditions, site-specific seven day forecasts, precipitation reports, river level data, and special hydrologic forecasts including flood warnings.

The NWS has numerous weather models that provide observed and forecast data used in water management. This is especially true related to rainfall, air temperature, snowmelt and hydrologic forecasting.

Periodic discharge measurements made by the USGS are normally furnished to the WCWQS through automated computer exchange but can also be obtained by email or telephone for various stations. These are used to maintain current stage-discharge relationships. Collection and publication of data such as stage and discharge are the primary functions of the cooperative program.

The NRCS publishes the results of the snow course surveys on the first of each month and the results can be obtained by accessing the NRCS website. Real-time SNOTEL updates can be obtained daily.

The automated DCPs located throughout the basin transmit gage information such as real-time river and reservoir levels, precipitation, wind, and temperature data via a Geostationary Operational Environmental Satellite (GOES) to the Omaha District and to the NOAA National Environmental Satellite, Data, and Information Service. The WCWQS computer located in Omaha, NE and Reclamation's computer located in Boise, ID receive this data and store it in water control databases. The computer software allows reservoir regulation personnel to retrieve and view the data in real-time to assist in making reservoir regulation decisions while simultaneously archiving

data for future use. In addition to DCP data, other data streams, such as SNOTEL, have been added to the Omaha District's database for both redundancy and improved information.

Reclamation's Hydromet data is integrated with other sources of information to provide streamflow, forecasting, and current runoff conditions for river and reservoir operations. Reclamation uses the internet to share streamflow, weather, and runoff forecast data with other federal agencies that is used, in turn, to determine reservoir releases. Real-time provisional data is accessible on Reclamation's website.

c. Maintenance

The Corps and Reclamation support the database system by contributing personnel, funds and equipment. Hydromet sites are maintained by Reclamation. The SNOTEL sites are maintained by the NRCS.

The USGS streamgaging maintenance activities are funded through the Cooperative Streamgaging Program, which is funded by the USGS, Corps, Reclamation and local agencies. The Cooperative Streamgaging Program provides financial support for operation and maintenance of multiple streamgaging stations.

5-02 WATER QUALITY STATIONS

The City of Rapid City monitors the water quality on Rapid Creek and compiles an annual drinking water quality report: https://www.rcgov.org/departments/public-works/water-division/water-quality-reports-854.html. The USGS does not monitor for water quality on Rapid Creek, although during routine flow measurements conductivity and water temperature readings are taken.

5-03 SEDIMENT STATIONS

There are no sediment stations located on Rapid Creek.

5-04 RECORDING HYDROLOGIC DATA

The Corps Water Management System (CWMS) is the Omaha District's primary data management system. CWMS was developed by the Hydrologic Engineering Center (HEC) and utilizes an Oracle database to store river, reservoir, and weather data. Another feature of CWMS is the ability to collect data from the Corps' Kansas City District and other Corps offices as a source of backup.

CWMS provides access to both the current observed states of the water system and the results from different forecast scenarios. Observed and forecasted information are displayed in two-dimensional plots and in special graphics using schematic, map, or image backgrounds. This includes special visualization of rivers and reservoirs, and economic impacts of flood or low-flow conditions. Color-coded schematic elements and a messaging system display critical information.

5-05 COMMUNICATION NETWORK

The Dam Tender is an employee of the City, who resides adjacent to, and works on-site at Pactola Dam. The Dam Tender can normally be contacted via cell phone or at the Pactola Dam office, and there is a telephone in the gate house at Pactola Dam. Telephone service may be available during an emergency from the Dam Tender's residence, other nearby residents, or public facilities located in Hill City, SD. The Dam Tender's vehicle is equipped with a 2-way radio for direct communications with the Rapid City Water Division. If telephone communication with the RCO is not operative or telephone service is not accessible to the Dam Tender, then the Dam Tender would use the 2-way mobile radio and call the Rapid City Water Division. The Rapid City Water Division's control center is attended 24 hours per day. The radio dispatcher would then contact and relay messages by telephone or radio to the RCO and Water Division personnel as appropriate.

Satellite phones maintained by the RCO are also available for emergency use, and are stored in the communication center of Reclamation's RCO.

In an emergency situation, it may also be necessary or desirable to utilize the South Dakota Highway Patrol or Sheriff radio facilities.

a. Emergency Warning

Reclamation has an internal Response Levels System to ensure their personnel act quickly, appropriately, and consistently based on the severity of an abnormal situation at Pactola Dam. This system is described in detail in Reclamation's Pactola Dam Emergency Action Plan.

5-06 COMMUNICATION WITH PROJECT

a. Corps of Engineers with Bureau of Reclamation

Telephone, text message, and email are available for communication between the Dam Tender, the RCO, and the WCWQS.

Except for emergency conditions outlined in the Standing Instructions to Dam Tender in Exhibit III, issuance of regulation orders when the reservoir water surface is in the zone reserved for flood control is the function of the WCWQS. Verbal regulation orders issued by the WCWQS to Reclamation's RCO or Pactola's Dam Tender will be confirmed in writing as soon as possible. The written orders are addressed to the Regional Director with the copy sent to the RCO.

The Dam Tender is required to report rapidly rising pool levels and heavy rainfall to the RCO and the WCWQS. In the event the RCO cannot be reached, the Dam Tender will notify the WCWQS. The method, time, and items to be reported are detailed in the Standing Instructions to the Dam Tender in Exhibit III.

5-07 PROJECT REPORTING INSTRUCTIONS

Daily project regulation data and miscellaneous hydrologic information are exchanged between the WCWQS, the RCO, and the Dam Tender as necessary. Cooperation is also

maintained with NWS, USGS, and NRCS relative to the collection and reporting of precipitation, snow water content, stream stages and discharges. The Dam Tender shall report all flood zone releases to the RFCO and WCWQS. The Dam Tender will also report via phone heavy rainfall capable of causing flooding.

5-08 WARNINGS

The RCO is responsible for notifying downstream authorities when releases are expected to approach channel capacity/bankfull stage. The NWS is federally mandated to issue flood warnings.

The procedure for the dissemination of Emergency Public Information is detailed in Reclamation's Pactola Dam and Reservoir Emergency Action Plan, referenced in Section 1-04(g).

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CHAPTER 6—HYDROLOGIC FORECASTS

6-01 GENERAL

Forecasting of the volume of runoff expected into Pactola Reservoir from rainfall and/or the spring snowmelt is done by the NWS, NRCS, Reclamation, and the Corps. The NRCS forecasts seasonal runoff volumes for the March through July period for inflow to Pactola Reservoir and Deerfield Reservoir. This volume forecast is useful in making long-term decisions regarding inflow and releases, but provides less guidance during rain-driven events.

6-02 FLOOD CONDITION FORECASTS

a. Weather Forecast

The WCWQS receives meteorological data from several sources. General weather conditions and forecasts are accessed from the NWS National Center for Environmental Prediction, Weather Prediction Center, Missouri Basin River Forecast Center (MBRFC), and Weather Forecast Office websites. Products available through the NWS include upper air charts, surface synoptic maps, national and local radar summaries and depictions of daily temperature and precipitation for the United States and southern Canada. The MBRFC also provides specialized river gaging and river forecast products.

b. Short Range Runoff Forecast

Forecasts of discharge are made for Rapid City by lagging the Pactola outflow 4 or 5 hours and adding to this an estimated discharge for the runoff from the incremental area between Pactola Dam and Rapid City. The incremental area discharge can be estimated by careful observation of the discharge differences between these two stations. The NWS also provides short-range forecasting of reservoir and tributary inflows. The WCWQS is planning to develop a Hydrologic model which will be used for flood forecasting. The model is expected to be completed by 2021.

c. Forecast to Mainstem Missouri River

In years when Missouri River basin reservoirs prevent or reduce flooding along the mainstem, all principal tributary reservoirs that contribute to this flood control are credited with flood reduction benefits. In determining the contribution of Pactola Dam, reservoir holdouts are routed to Oahe Dam assuming three days travel time.

6-03 DROUGHT FORECAST

Reclamation has responsibility for preparing water conservation forecasts, which are sometimes referred to as drought contingency forecasts.

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CHAPTER 7—WATER CONTROL PLAN

7-01 GENERAL OBJECTIVES

The operating objectives at Pactola Dam and Reservoir are to provide municipal and industrial water supply, irrigation, recreation, and fish and wildlife benefits when pool levels are in the conservation zone, and to provide flood control benefits at all pool elevations. Flood control regulation will be coordinated between Reclamation and the Corps as specified in Chapter 9.

7-02 CONSTRAINTS

Recreation is an important authorized purpose at Pactola. Plate 2-18 shows recreation sites in the Pactola Reservoir vicinity. These sites are administered by the Forest Service. Some of the facilities are located very close to the base of the flood control zone. In-pool impacts are experienced as low as 3 to 5 feet into the flood control zone. These include inundation of parking lots, campsites and access to boat ramps. Also, some vault toilets are not useable when water is stored in the flood control zone. The marina building located on the south side is built on stilts. The floor gets wet at about elevation 4586 feet, nearly 6 feet into the flood control zone. At this level the boat launch areas (parking, etc.) and some picnic tables and grates also become flooded. The shoreline is densely bordered by pine trees. Prolonged storage of water in the flood control zone would likely kill these trees. The Forest Service desires that any inundation be of the shortest time interval possible to minimize the tree kill.

The highway on the crest of the dam just upstream of the spillway will be closed when pool levels approach the top of the flood control zone.

The town of Silver City is located where Rapid Creek flows into Pactola Reservoir as shown on Plates 2-1 and 2-2. Most of the town is located above the top of flood control zone, elevation 4621.5 feet. A small portion of the town along Rapid Creek lies below elevation 4621.5 feet. This portion of the town has a flowage easement in place that stipulates that no buildings for human occupancy shall be erected below elevation 4621.5 feet. This limitation was imposed because flooding to this elevation could occur with very little warning, and the risk to human life and property would be high.

The safe channel capacity of Rapid Creek below Pactola Dam is approximately 500 cfs. Releases in excess of 400 cfs cause bank erosion and scour of Rapid Creek. As these flows move into Rapid City, bike paths below Canyon Lake are inundated. Releases exceeding 500 cfs will impact some out-buildings and yards along Rapid Creek due to encroachment.

7-03 OVERALL PLAN FOR WATER CONTROL

Pactola Dam and Reservoir was constructed by Reclamation primarily for irrigation, municipal water supply, and flood control.

a. Storage Allocations

Reservoir storage allocations are shown in Table 7-1. See Plate 7-1 for a schematic of reservoir allocations.

Table 7-1 Reservoir Storage Allocations

Item	Elevation (feet)	Gross Area (acres)	Gross Storage (af)	Incremental Storage (af)
Dam Crest	4655.0	1606		
Top of Surcharge Storage	4651.7	1557	140,921	41,892
Top of Flood Control Storage (Spillway Crest)	4621.5	1232	99,029	43,057
Top of Conservation Storage	4580.2	861	55,972	54,955
Top of Inactive Storage	4456.1	100	1,017	895
Top of Dead Storage	4440.0	25	122	122
Streambed at Dam Axis	4422.0			

The dead storage space is located below the invert of the outlet works intake structure. The inactive storage space provides for sediment accumulation and a 400 cfs release capability at the bottom of the active conservation space. Active conservation capacity is for municipal and irrigation purposes, and some incidental flood benefits. The exclusive flood control space is below the uncontrolled spillway crest, and the river outlet works controls releases from this zone. The surcharge capacity is above the crest of the spillway. The surcharge space, in combination with the discharge capacities of the outlet works and spillway, provides protection for the dam against extremely large floods.

Sediment accumulation for 100 years was projected to be 1,000 af. The sediment would be accumulated between the bottom of the reservoir and the top of the active conservation.

b. Conservation Regulation

When Pactola Reservoir is in the conservation zone, the reservoir is operated by Reclamation. The operations generally follow the following criteria and limitations:

(1) General Guidelines. Pactola Reservoir is regulated in conjunction with Deerfield Reservoir to furnish a supplemental irrigation supply to about 6,000 acres in the RVWCD and replacement water for Rapid City, which includes

Ellsworth Air Force Base. Operation of the two reservoirs is integrated by a system of bookkeeping so that as much water as possible can be held at the upstream reservoir (Deerfield) and, at the same time, maintain a uniform outflow from Deerfield to maximize fishery benefits in the stream between the reservoirs. Generally, Pactola is used as the regulating reservoir to satisfy the downstream water right demand from the two reservoirs. A single employee working for both the RVWCD and Rapid City advises the Dam Tender of the downstream demand.

Generally the conservation zone is kept as close to the top of the zone as possible. Normally release rates are increased above the minimum release level up to the inflow rate (1) to keep the pool level from getting too high or (2) when there is a downstream demand for it. When the demand is more than the natural inflow the user pays for contracted water out of storage.

(2) Minimum Releases. The existing minimum release criteria was established during the contract renewal process in the 1990s and is documented in the "Addendum to the Draft Environmental Assessment Selected Alternative for the Pactola Reservoir Water Service Contract Renewal Finding of No Significant Impact No. DK600-00-03" dated October 20, 2000. The minimum releases may be altered by Reclamation upon consultation with interested parties based on trends in inflows and precipitation. This will allow adjustments in the minimum releases to react to anticipated increases or decreases in inflows to the reservoir as a result of runoff and weather trends over a three year period. Following are the desired minimum releases based on the contract renewal:

Condition A: Reservoir Storage above 29,000 af

Year Round - 20 cfs

Condition B: Reservoir Storage below 29,000 af

October 1 through April 15 - 15 cfs

April 15 through October 1 - 20 cfs

The Rapid Valley Unit Definite Plan Report (DPR) was prepared in 1952 to obtain approval for constructing Pactola Dam and Reservoir. The DPR stated that releases should be made for fish and wildlife. In the event of a prolonged drought and the depletion of the 6,000 af fisheries, wildlife and recreation zone, releases will revert to the minimum releases from the DPR shown below. More details on minimum release criteria is contained in the SOP for Pactola Dam.

Condition A: Reservoir Storage above 29,000 af

October 1 through March 1 - 15 cfs

March 1 through October 1 - 20 cfs

Condition B: Reservoir Storage below 29,000 af

October 1 through April 15 - 7 cfs

April 15 through October 1 - 20 cfs

(3) Annual Operating Plan. Each year Reclamation publishes a report of reservoir operations during the preceding water year together with their planned operation of reservoirs during the coming year.

7-04 STANDING INSTRUCTION TO DAM TENDER

Refer to Exhibit III for definition of emergency regulation and emergency flood control regulation procedures. If all normal means of communication fail, the Dam Tender shall regulate releases for flood control as explained by the Emergency Release Schedule in Exhibit III, Table - C.

7-05 FLOOD CONTROL

a. Objectives for Flood Control

Pactola Dam and Reservoir will be regulated for flood control to mitigate flood risk to the City of Rapid City and the area between the dam and Rapid City. The project's primary flood control benefit results from the mitigation of floods originating upstream of the dam to the Rapid City area.

b. Classification of Flood Control Regulation

In general, the developed method of flood control regulation of Pactola Dam and Reservoir may be classified as Method C, defined in EM 1110-2-3600. This represents a combination of the concept of reducing downstream damaging stages as much as possible during each flood event with the currently available storage space with consideration of control of floods of project design magnitude.

c. Flood Control Plan of Regulation

Reservoir regulation procedures employed to meet the objectives of flood control are given in paragraphs 1 and 2 below. Documentation of the general regulation plan is contained in the field working agreement between the Regional Director and District Engineer (Exhibit II). Generalized regulations which were published in the Federal Register in 33 CFR Chapter II, Part 208, Flood Control Regulations, Section 208.11 contain authoritative criteria and responsibilities for the plan (Exhibit I).

(1) Release Regulation. This plan, which utilizes a rule curve type schedule, makes use of available storage and avoids making unnecessarily high releases during small encroachments of the flood control zone. The plan is given in the release schedule shown in Table 7-2.

Table 7-2 Reservoir Release Schedule

Reservoir Elevation (feet)		Required Release (cfs)
From	To	
Below 4580.20	4580.20	Conservation Requirement
4580.20	4582.00	Inflows up to 250
4582.01	4583.00	300
4583.01	4585.00	400
4585.01	4590.00	500
4590.01	4595.00	700
4595.01	4600.00	900
4600.01	4621.50	1000

Table 7-2 should be used to set releases as the pool elevation is rising. Once the pool elevation is stationary or begins to fall, the maximum gate setting attained under rising pool conditions shall be maintained until pool level falls to elevation 4580.20 feet.

(2) Non-Release Schedule Regulation. Deviations from the release schedule will be made if conditions at the time are such that improved flood control will result. For example, when (1) downstream flooding or heavy runoff is occurring or appears likely to occur or (2) heavy rainfall has or is occurring (at the rate of 2 inches or more in a six-hour period) at or below Pactola Dam, releases will be immediately reduced to at least the minimum conservation level of 20 cfs. Release reductions should consider the travel time of 6 to 8 hours between Pactola Dam and Rapid City. After recession and stabilization of downstream flows, releases will be made as indicated by the release schedule or at downstream channel capacity levels if this improves the overall project flood control.

(3) Integrated Regulation of All Flood Control Reservoirs in Missouri River basin.

Releases from Pactola Reservoir eventually flow into Oahe Reservoir, one of the six Missouri River mainstem reservoirs. In the quotes below, the USACE Northwestern Division's Missouri River Basin Water Management is abbreviated MRBWM. As per the Missouri River Mainstem Reservoir System Master Water Control Manual (Master Manual), November, 2018, paragraph 7-04.25, "When tributary reservoir regulation affects Missouri River flood flows or navigation on the Missouri River, tributary reservoir regulation will, however, become a direct concern of the MRBWM office. During such periods, the MRBWM office will issue pertinent tributary reservoir regulating instructions so that flood damages may be held to a minimum through integrated regulation of all flood control reservoirs in the Missouri River basin." Additionally, as per Section 208.11 of 33

CFR Chapter II, “The water control plan is subject to temporary modification by the Corps of Engineers if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communication available. The action taken shall be confirmed in writing the same day to the project owner and shall include justification for the action.” As a result of these requirements, during large floods on the Missouri River mainstem reservoirs, releases of flood storage in Pactola Reservoir may be adjusted in order to meet basin-wide flood control goals of the Missouri River system. In the case of Pactola Reservoir, requests for modification will be made to the RCO in Rapid City, SD, which is part of the Great Plains Region. Requests should be made via telephone call or email, and confirmed via an official reservoir regulation order the same day.

d. Further Considerations

See Section 7-02 for discussion of operating constraints.

e. Emergency Flood Control Regulation

Normal flood control regulation of Pactola Reservoir is accomplished by specific regulation orders to the Dam Tender via telephone. However, it is conceivable communication be disrupted with the Dam Tender at times when project events require release changes. So the Dam Tender may have appropriate information and instructions for modifying existing regulation orders, a procedure has been developed to guide determination of project operations under such a communication emergency. This procedure is given in the Standing Instructions to the Dam Tender for Flood Control Regulation (see Exhibit III).

Operation of the reservoir is the responsibility of Reclamation when the reservoir level is above the flood control zone. When it becomes apparent that the pool elevation will exceed the top of the flood control zone (elevation 4621.5 feet) the Regional Director will be notified. For the sake of dam safety a total of 30.2 feet of surcharge with a capacity of 41,892 af has been provided above the flood control zone. When the pool level is above the flood control zone, the District Engineer may make recommendations to the Regional Director for operation in the interest of flood control, but such recommendations shall not be considered mandatory.

7-06 RECREATION

The Corps does not have specific responsibilities related to recreation at Pactola Dam and Reservoir. Section 7-02 explains some of the recreation impacts caused by flood control regulation. See Section 2-06 for more information about public facilities around the Pactola Reservoir.

7-07 WATER QUALITY

The Corps does not have specific responsibilities related to water quality at Pactola Dam and Reservoir. Reclamation will continue its water quality monitoring program for the reservoir while in the flood control zone.

7-08 FISH AND WILDLIFE

The Corps does not have any specific responsibilities related to fish and wildlife at Pactola Dam and Reservoir. Reclamation will continue to coordinate fish and wildlife interests with state, local and other interested parties.

7-09 WATER SUPPLY

Reclamation is responsible for water supply requirements at Pactola Dam and this information is provided for informational purposes. Pactola Reservoir is part of the Rapid Valley Unit, Pick-Sloan Missouri Basin Program, and Deerfield Reservoir is part of the Rapid Valley Project. Both reservoirs operate in conjunction to furnish a supplemental irrigation supply to the RVWCD, to provide replacement water for Rapid City, to provide a supply of domestic water for private water systems both above and below the city, and to provide flood control. The City of Rapid City has contracts for Pactola and Deerfield Reservoir water. The Rapid Valley Sanitation District and Hisega Meadows Water Inc. have contracts for water service with the City from Pactola Reservoir. The majority of prior rights to the flows of Rapid Creek during the irrigation season are held by individuals and ditch companies in the RVWCD.

Water rights for Pactola Reservoir are covered by Certificate of Withdrawal No. U.S. 581-2, executed by the State Engineer on May 5, 1952. The Certificate states, effective April 25, 1952 (priority date for this water right), all unappropriated waters of Rapid Creek and its tributaries located above the outlet of Pactola Reservoir are withdrawn and reserved for utilization in connection with Pactola Reservoir. The State Water Resources Commission (now the South Dakota Department of Environment & Natural Resources (SDDENR), Water Rights Program) received as-built drawings of Pactola Dam in March 1970 for perfection of Reclamation's water right. United States Withdrawal Water License No. 581-2, Pactola Reservoir - Rapid Valley Unit was transmitted by a letter from the Water Rights Commissioner dated November 26, 1973. This water right allowed an initial water storage fill of 55,965 af. The water right also allows an annual replenishment of storage to the top of the active conservation storage space, plus evaporation and natural water losses. South Dakota follows the "one fill rule" for filling a reservoir but will allow additional storage if the water is not needed elsewhere. The Certificate identified all the uses of the stored water allowed by this water right which included municipal and irrigation.

Some domestic use rights, including livestock watering, in South Dakota are considered an exempt right. These rights may not have an actual water right permit or certificate assigned to them, but would still need water released to satisfy them. Administration and enforcement of water rights on Rapid Creek in South Dakota is the responsibility of the Chief Engineer in the SDDENR, Water Rights Program. Downstream surface water

rights on Rapid Creek with an earlier priority than Pactola Reservoir may need a portion of the reservoir inflow bypassed to them if accretions below the dam, along with the reservoir seepage from the dam, and regular releases at the dam are not adequate to meet the needs of the prior rights. The personnel of the SDDENR will contact the Dam Tender if an additional release at the dam is required for senior appropriated water rights on Rapid Creek. This release shall not exceed the natural occurring reservoir inflow for senior water right administration purposes. A Water Master employed by the SDDENR has been assigned to Rapid Creek to oversee the administration of the water rights in this area.

There are 63 appropriators in South Dakota along Rapid Creek with priority dates earlier than the ones for Pactola Dam and Reservoir. These are water permits and irrigation permits and are located along the reach of Rapid Creek extending from Pactola Dam to the east end of the RVWCD area.

7-10 HYDROELECTRIC POWER

There are no hydroelectric facilities at Pactola Dam. Hydroelectric power has not been one of the major factors in connection with the development of the water resources in Rapid Creek basin. The Dakota Power Company operated a 1500 kilowatt capacity plant at Big Bend from 1912 until 1940. This plant, largely a run of river type, had very little effect on the streamflow in Rapid Creek and was discontinued for economic reasons. Other power projects have been proposed at different times but economic studies have indicated that their construction would not be feasible.

7-11 NAVIGATION

Pactola Dam is not regulated for navigation.

7-12 DROUGHT CONTINGENCY PLANS

This water control plan is prepared for occurrences when the pool is in the flood control zone and the Corps is responsible for regulation of the reservoir. Drought contingency planning, under the Corps' regulations, is not within the Corps' area of responsibility at Pactola. Regulation to assist in drought contingency planning would be conducted by Reclamation.

7-13 FLOOD EMERGENCY ACTION PLANS

Reclamation maintains an Emergency Action Plan that is distributed among state, county and local emergency officials. The WCWQS will maintain communications with the RCO during flood control operations. If communications with the RCO are lost, the WCWQS will communicate release decisions directly with the Pactola Dam Tender. Should communications fail between the WCWQS and the Dam Tender, the Dam Tender should use the Standing Instructions to the Dam Tender to operate the project until communications are restored.

7-14 DEVIATION FROM NORMAL REGULATION

a. Emergencies

An emergency situation is defined as a circumstance where failure to act immediately could result in loss of life or significant property damage. Examples of these types of emergencies include dam safety emergencies, downstream chemical spills, drownings, and facility failures. Reclamation's Emergency Action Plan for Pactola Dam covers identification of impending and existing emergencies, emergency operations and repairs and a response level determination matrix. Copies of this plan are maintained at Reclamation offices and in the WCWQS. When an emergency deviation occurs, the WCWQS must inform MRBWM by telephone as soon as practicable. Written confirmation of the deviation and a description of the cause must be furnished to MRBWM.

b. Unplanned Minor Deviations

In accordance with NWDR 1110-2-6 the MRBWM Chief is the responsible approving official for all deviation requests for Pactola Dam and Reservoir. The Division Engineer retains authority to approve or disapprove all deviation requests. Prior approval is required for deviations from this water control manual that do not meet the requirements of paragraph 7-14.a above. Deviation requests should be submitted to the MRBWM Chief as appropriate. All deviations shall be documented in order to respond to any public concerns raised by those deviations. Coordination with federal, state, tribal, local, and private interests should be undertaken as appropriate. At a minimum, deviation requests should discuss the need for coordination and present a plan for that coordination. Informal coordination prior to a deviation request may also be appropriate.

c. Planned Deviations

In accordance with NWDR 1110-2-6, the MRBWM Chief is the responsible approving official for all deviation requests for Pactola Dam and Reservoir. All deviation requests involving controversial regional or nationally significant actions shall be coordinated with the MRBWM Chief prior to approval. The MRBWM Chief retains authority to approve or disapprove all deviation requests. Prior approval is required for deviations from this water control manual that do not meet the requirements of Sections 7-15.a and 7-15.b. Pre-coordination of a potential deviation request should occur between the requesting office and the approving authority to ensure that a deviation is necessary. Deviation requests should be submitted to the MRBWM Chief as appropriate. MRBWM will coordinate with the appropriate district or districts for all division-originated deviation requests. All deviations shall be documented in order to respond to any public concerns raised by those deviations. Coordination with federal, state, tribal, local, and private interests should be undertaken as appropriate. At a minimum, deviation requests should discuss the need for coordination and present a plan for that coordination. Informal coordination prior to a deviation request may also be appropriate.

7-15 RATE OF RELEASE CHANGE

There are no structural or geologic limitations to the rate of filling and drawdown of the reservoir

CHAPTER 8—EFFECT OF WATER CONTROL PLAN

8-01 GENERAL

The following regulation objectives can be met at Pactola Dam and Reservoir by following Chapter 7 Water Control Plan; provide water for irrigation, municipal, and industrial use; provide desired river flow conditions to meet the needs of the downstream river fishery; provide desired conditions for fish, wildlife, and recreational use in the reservoir; and regulate river flow to minimize downstream flood damage.

8-02 FLOOD CONTROL

a. Original Spillway Design Flood

The original spillway design flood was developed by Reclamation, by centering their design storm over the entire area above Pactola Dam and computing the resultant runoff. Any effect that Deerfield Dam would have on retarding this runoff was neglected. Infiltration losses of 0.3 inches per hour were applied. Runoff was determined as 6.2 inches during a 12-hour period. This flood hydrograph had a peak discharge of 68,000 cfs and a 3.5-day volume of 106,800 af. In order to establish certain design capacities of the project, Reclamation routed this flood through the reservoir with the assumptions that the pool elevation was at 4580.2 feet (initial base of flood control zone) at the beginning of flood inflow and that no releases were made until the pool reached an elevation of 4621.5 feet (spillway crest). Only spillway releases were used above elevation 4621.5 feet. This routing determined the maximum pool elevation to be 4633.7 feet and the maximum spillway discharge to be 38,400 cfs. The spillway design flood hydrograph was also routed through the reservoir using the release schedule shown in Table 7-2 and assuming the pool elevation at the beginning of the flood inflow to be elevation 4580.2 feet (base of flood control zone). This routing resulted in a maximum pool elevation of 4633.2 feet, an outlet discharge of 1,000 cfs and a maximum spillway discharge of 36,576 cfs. This routing is shown on Plate 8-1.

b. Updated Spillway Design Flood

As part of the Safety Examination of Existing Structures (Safety of Dams) Program, Reclamation derived and approved a new Probable Maximum Flood (PMF) for Pactola Reservoir in 1981. An updated flood was developed using data and criteria contained in the NWS Hydrometeorological Reports (HMR) No. 51 and 52. The PMF is based on a storm precipitation event resulting from a maximum rainfall event occurring in early summer and incorporated such significant meteorological events as the Rapid City, SD, storm of 1972. The studies showed that the facility could not safely handle the new PMF.

The PMF into Pactola Reservoir consists of two components: a concurrent flood into Deerfield Reservoir with a peak of 107,000 cfs and a 41-hour volume of 54,200 af plus an intervening flood inflow to Pactola Reservoir of 276,700 cfs and a 35-hour volume of 159,800 af. The storm for the intervening flood was centered over the areas between Deerfield and Pactola Dams. The antecedent 100-year flood that is normally added to the PMF was not added to the PMF for Pactola Reservoir as it was considered to be so

small that it would not add appreciably to the PMF event. The Deerfield flood was routed through the Deerfield Dam spillway and combined with the Pactola flood to yield a peak inflow of 321,240 cfs with a 48-hour volume of 212,000 af. For routing purposes at Pactola Reservoir, it is assumed the reservoir is at elevation 4580.2 feet, the top of the active conservation storage. Also, for routing purposes, the maximum release from the outlet works would be limited to 250 cfs until the exclusive flood control storage was full. If the flood was routed through the 425-foot-wide spillway at Pactola Dam, the maximum water surface elevation would be 4651.7 feet with a freeboard of 3.3 feet. The spillway would operate for over one and half days during the PMF routing. A hydrograph of the revised PMF is included and shown on Plate 8-2.

Modification work was completed in 1987 and provided sufficient surcharge storage and spillway capacity to pass the PMF. Modification work consisted of raising the crest of the dam 15 feet, widening the existing rock-cut spillway chute and stilling basin from 240 feet to 425 feet, relocating Highway 385 to the new dam crest, extending the existing gate access shaft to the higher crest elevation, and reconstructing a new two-level gate control house at the higher crest elevation. The spillway crest elevation of 4621.5 feet was not changed.

The Pactola Dam spillway has a design capacity of 245,000 cfs at maximum reservoir water surface elevation 4651.7 feet. The outlet works has a discharge capacity of 1,150 cfs at reservoir water surface elevation 4633.7 feet. At maximum water surface elevation 4651.7 feet, the outlet works have a capacity of 1,220 cfs, which results in a combined spillway and outlet works discharge of 246,220 cfs. Safe channel capacity below Pactola Dam is approximately 500 cfs.

It is estimated that the 40-plus feet of space between the top of the active conservation storage and the spillway crest would give nine hours of warning time during the PMF before the spillway started discharging water. Greater warning times would be expected for floods less than the PMF.

c. Reservoir Design Flood (RDF)

The reservoir design flood used to determine the flood control storage space required in the reservoir was developed by centering a standard project storm over the area above Pactola Dam. This storm assumed 24-hour rain depths of 5.2 inches above Deerfield Dam and 5.3 inches from Deerfield Dam to Pactola Dam. An initial loss of one inch and an infiltration rate of 0.2 inches per hour was used in determining runoff. Runoff was determined as 2.6 inches and 0.2 inches for two 3-hour periods above Deerfield and as 2.6 inches and 0.3 inches for two 3-hour periods from Deerfield Dam to Pactola Dam. The rainfall excess values from this storm analysis were applied to the synthetic unit graphs for the sub-areas above Pactola and routed into the reservoir using the method of successive averages. The resultant design flood has a peak of 21,000 cfs and a 4-day volume of 50,000 af.

During the design studies, this flood was routed through the reservoir starting with an empty exclusive flood control zone and utilizing release rates as follows:

1. First pass inflow up to 250 cfs.

2. Then maintain 250 cfs until peak of inflow has passed. Or as soon as downstream conditions permit, increase releases to 1,000 cfs.

3. Maintain 1,000 cfs until pool recedes to elevation 4580.2 feet. From this routing, it was found that 43,000 af of flood control storage was required. At the average release rate of 1,000 cfs it would require about 22 days to evacuate the flood control zone of the reservoir.

Routing the project design flood through the reservoir using the release schedule, as discussed in Section 7-05, resulted in a maximum water surface of 4620.87 feet and a maximum storage of 98,246 af. This routing is shown on Plate 8-3.

d. Operational History

Utilization of the flood control zone along with other pertinent operational history details are listed in Table 8-1. Plates 8-4a to 8-4f presents 10-year periods of reservoir pool elevations, reservoir monthly inflows and outflows and maximum annual daily reservoir inflows and outflows. Plate 8-5 presents reservoir pool levels and reservoir releases for the period of record.

Plates 8-6 through 8-11 show the routings of historic floods through Pactola Reservoir. Descriptions of the floods and operations can be found in Section 4-06.

Table 8-1 Annual Statistics for Pactola by Water Year

Year	Date(s) in Flood Control Operation Zone[3]	Daily Max. Pool (ft)	Date of Max. Pool	Max. Storage Utilized (FC Zone, af)	Max. % of FC Zone Occupied[4]	Max. Daily Inflow (cfs)	Max. Daily Release (cfs)	Annual Inflow Volume (af)[5]
1956	None	4458.4	31Dec	0	0	113	24	5,435
1957	None	4508.3	31Dec	0	0	195	55	23,404
1958	None	4521.6	07Aug	0	0	84	57	21,114
1959	None	4532.5	01Jan	0	0	138	82	24,710
1960	None	4537.4	25Apr	0	0	106	86	13,034
1961	None	4516.7	03Apr	0	0	50	104	8,271
1962	None	4536.8	01Jan	0	0	455	62	30,853
1963	None	4580.1	05Jul	0	0	610	160	46,703
1964	10Jun-26Jun	4581.3	15Jun	1,037	2%	519	250	42,687
1965	15May-29Jun, 05Oct-13Oct	4585.9	19May	5,140	12%	1,132	500	75,229
1966	None	4580.0	03May	0	0	116	126	27,077
1967	16Jun-03Jul	4584.5	21Jun	3,773	9%	682	400	50,447
1968	None	4579.9	30Apr	0	0	84	63	22,056
1969	None	4580.2	04May	26	0	200	152	24,304
1970	13Jun-16Jun	4580.4	13Jun	190	0	426	311	39,843
1971	None	4580.1	04Jun	0	0	425	355	50,389
1972	09Jun-30Jul	4585.1	22Jun	4,274	10%	437	177	37,185
1973	None	4579.6	05Jun	0	0	178	173	33,853
1974	None	4578.2	01May	0	0	87	116	15,791
1975	None	4579.2	02Jul	0	0	179	85	29,186
1976	16Jun-27Jun	4581.3	20Jun	926	2%	611	250	32,961
1977	None	4580.0	02May	0	0	169	200	28,646
1978	07May-09Jun	4585.4	21May	4,617	11%	480	350	45,658

Year	Date(s) in Flood Control Operation Zone[3]	Daily Max. Pool (ft)	Date of Max. Pool	Max. Storage Utilized (FC Zone, af)	Max. % of FC Zone Occupied[4]	Max. Daily Inflow (cfs)	Max. Daily Release (cfs)	Annual Inflow Volume (af)[5]
1979	None	4579.7	30Oct	0	0	174	98	28,320
1980	None	4580.0	17May	0	0	142	122	21,202
1981	None	4571.2	22Apr	0	0	135	144	17,277
1982	23Jun-02Dec	4581.7	02Jul	1,266	3%	274	142	46,389
1983	05Jun-11Jul	4581.0	18Jun	710	2%	233	255	37,424
1984	30May-14Aug	4581.4	14Jun	989	2%	210	219	41,372
1985	None	4580.0	30Apr	0	0	84	153	22,462
1986	None	4579.9	31Oct	0	0	140	77	32,176
1987	None	4580.2	12Jun	0	0	117	99	25,131
1988	None	4575.6	13May	0	0	78	133	16,473
1989	None	4556.1	18May	0	0	80	123	14,345
1990	None	4543.6	18Jun	0	0	87	110	17,202
1991	None	4568.3	18Jul	0	0	450	91	35,493
1992	None	4567.7	04May	0	0	68	114	19,938
1993	11Jun-01Jul	4582.0	19Jun	1,537	4%	522	250	48,697
1994	None	4580.2	06Jun	0	0	202	180	34,207
1995	09May-23Jun, 16Dec-31Dec	4583.3	15May	2,707	6%	718	350	62,563
1996	01Jan-21Mar, 11Apr-10Jul, 03Nov-12Dec	4585.4	04Jun	4,536	11%	741	438	73,011
1997	21Apr-16Aug	4583.2	07Jun	2,610	6%	553	400	100,753
1998	07Jun-13Aug	4584.8	23Jun	4,006	9%	1,009	438	94,544
1999	21Apr-14May, 06Jun-06Jul, 07Nov-20Dec	4584.5	21Jun	3,756	9%	585	400	92,473
2000	21Jul-24Jul	4580.3	24Jun	78	0	193	150	43,608
2001	None	4579.7	13Jun	0	0	113	90	30,120
2002	10May-22May	4580.4	14May	164	0	105	115	21,587
2003	19May-01Jul	4580.7	17Jun	440	1%	160	110	28,436
2004	None	4573.5	30Apr	0	0	68	87	15,837
2005	None	4564.7	22Jun	0	0	91	99	14,273
2006	None	4561.3	02Jun	0	0	94	107	18,062
2007	None	4553.8	17Jun	0	0	116	100	16,517
2008	None	4574.7	03Dec	0	0	584	55	39,369
2009	12Jun-15Jun	4580.2	03Jul	46	0	223	200	41,332
2010	11May-17Jun	4582.7	31May	2,145	5%	383	302	58,855
2011	21May-18Aug	4584.9	04Jun	4,108	10%	596	415	66,375
2012	None	4579.8	26May	0	0	102	104	27,907
2013	None	4580.1	22 Jun	0	0	107	85	28.675
2014	14Jun-14Jul	4580.7	01Jul	408	1%	270	260	69,626
2015	11May-24Jul	4589.4	29Jun	8,274	19%	720	514	111,586

[1] Elevation, Storage, Inflow, and Outflow data were obtained from Reclamation's Hydromet: Archive Data Access website.

[2] If a project has a joint use zone, storage in the joint use zone is not counted as flood control in this table.

[3] The base of flood control occurs at elevation 4580.2 ft.

[4]These percentages are estimated based on current area capacity curves and existing data. They are provided as a tool for trends and comparisons.

8-03 RECREATION

As water levels rise into the Pactola Reservoir flood control zone impacts to the Forest Service recreation sites occur at 3 feet and less into the flood control zone. The trees along

the shoreline are flooded and at risk of being killed due to flooding. A water rise of 3 to 5 feet into the flood control zone impacts the swimming beach, parking lots, campsites and boat ramp access. See Section 7-02 for more information as water levels in the flood control zone continue to rise.

8-04 WATER QUALITY

The Corps does not have specific responsibilities related to water quality at Pactola Dam and Reservoir. Reclamation will continue its water quality monitoring program for the reservoir.

8-05 FISH AND WILDLIFE

See Section 7-05 for more information on fish and wildlife.

8-06 WATER SUPPLY

See Section 7-06 for more information on water supply.

8-07 HYDROELECTRIC POWER

There are no hydroelectric facilities at Pactola Dam.

8-08 NAVIGATION

Pactola Dam is not regulated for navigation.

8-09 DROUGHT CONTINGENCY PLAN

See Section 7-09 for Drought Contingency details.

8-10 FLOOD EMERGENCY ACTION PLAN

See Section 7-13 and 7-14 for Emergency Action Plan details.

8-11 FREQUENCIES

a. Peak Inflow Probability

See the results of Reclamation's Safety Examination of Existing Structures (Safety of Dams) Program for inflow probability information.

b. Pool Elevation, Duration, and Frequency

A pool elevation frequency curve is shown on Plate 8-12. Historic peak pool elevations, peak releases and annual inflow volume are shown in Table 8-1.

8-12 OTHER STUDIES

a. Other Regulation Studies and Model Development

There are no studies or model development to report.

b. Channel and Floodway Improvement

See Section 4-11b for discussion of Rapid Creek Floodway in Rapid City.

CHAPTER 9—WATER CONTROL MANAGEMENT

9-01 RESPONSIBILITIES AND ORGANIZATION

The organization for regulation of Pactola Dam and Reservoir is based on a division of regulating responsibilities between Reclamation and the Corps. In accordance with the Flood Control Act of 1944, the Corps is responsible for prescribing regulations for the use of storage allocated to flood control. All other regulation functions are the responsibility of Reclamation.

a. Corps of Engineers

ER 1110-2-1400, April 1970, assigns the Corps' reservoir regulation responsibility in the Missouri River basin to the NWD Engineer. The regulations permit delegation of certain reservoir regulation functions to the District Engineer in the project area. The responsibility for assembly and interpretation of data affecting current reservoir regulation and for carrying out flood control regulation of Pactola Reservoir, according to plans agreed on in advance, has been delegated to the Omaha District Engineer. The Omaha District WCWQS has been assigned this District responsibility. In addition, the NWD Engineer, through the MRBWM, monitors and reviews the overall regulation procedures performed by the Omaha District. An organization chart for the Omaha District is shown on Plate 9-1.

When the reservoir level is in the flood control zone, between elevations 4580.2 and 4621.5 feet, the WCWQS is solely responsible for the regulation of the reservoir. This operation is in accordance with 33 CFR Chapter II, Part 208, Flood Control Regulations, Section 208.11, Regulations for use of storage allocated for flood control or navigation and/or project operation at reservoirs subject to prescription of rules and regulations by the Secretary of the Army in the interest of flood control and navigation.

b. Bureau of Reclamation

Reclamation is the construction agency for Pactola Dam and Reservoir and is responsible for coordinating all matters pertaining to the operation and regulation of the project, except flood control. Reclamation is solely responsible for regulation of the reservoir when the pool elevation is below 4580.2 feet or above 4621.5 feet. An organization chart for Reclamation is shown on Plate 9-2.

Reclamation has an agreement with the City of Rapid City to operate and maintain Pactola Dam and Reservoir. The Dam Tender is an employee of the City who resides adjacent to, and works on-site at Pactola Dam. The Dam Tender visits Pactola Dam and Deerfield Dam, and performs operation and maintenance duties. The City of Rapid City is responsible for the operation of Pactola Reservoir when it is in active conservation storage, below elevation 4580.2 feet. Releases for minimum conservation requirements will be determined by Reclamation.

c. National Weather Service

The NWS works closely with the Corps and Reclamation in providing forecasts of reservoir inflows and flood warnings to the public. An organization chart for the NWS is shown on Plate 9-3.

9-02 INTERAGENCY COORDINATION

The organization for regulation of the Pactola Dam and Reservoir is based on a division of regulating responsibility between Reclamation and the Corps. In accordance with the Flood Control Act of 1944, and 33 CFR Chapter II Part 208, Flood Control Regulations, Section 208.11 the Corps is responsible for the regulation of storage allocated to flood control. All other regulation functions are the responsibility of Reclamation.

a. Local Press and Corps Bulletins

Reclamation is responsible for coordination with the press when Pactola is not in flood control operations. When flood control operations are occurring, Reclamation will remain the leader in coordination and the Corps will assist as needed.

b. National Weather Service

Local weather forecasting information is provided by the NWS's Rapid City Weather Forecast Office. The Corps and Reclamation each have working relationships with the NWS and these existing lines of communication will be used during a flood event.

c. U.S. Geological Survey

An existing cooperative streamgaging program between the Corps and the USGS is used to maintain DCPs and streamflow measurements. The Corps and Reclamation each have working relationships with the USGS and these existing lines of communication will be used during a flood event.

d. Other Federal State, or Local Agencies

Reclamation is responsible for coordination with other federal, state and local agencies when Pactola is not in flood control operations. When flood control operations are occurring, Reclamation will remain the leader in coordination and the Corps will assist as needed.

9-03 INTERAGENCY AGREEMENTS

The Field Working Agreement between Reclamation and the Corps is located in Exhibit II.

9-04 REPORTS

The Omaha District WCWQS publishes an Annual Report that describes operation and flood regulation for each project in the Omaha District. Reclamation's Water and Land Operations Division of the DKAO also publishes an Annual Operations Report each year that describes the operation and flood regulation for Pactola.

EXHIBIT I

33 CFR Chapter II Part 208, Flood Control Regulations, Section 208.11

This exhibit contains text and table from 33 CFR Chapter II, Part 208, Flood Control Regulations, Section 208.11, Regulations for use of storage allocated for flood control or navigation and/or project operation at reservoirs subject to prescription of rules and regulations by the Secretary of the Army in the interest of flood control and navigation (7-1-12 Edition). In this document, the text of Section 208.11 has been reformatted (indented) for clarity, and the List of Projects table at the end of document has been shortened to only include reservoirs within the Missouri River basin. Section 208.11 should be reviewed on an annual basis to identify any changes and these changes should be included in an updated exhibit to this manual. Updated editions of Section 208.11 can be found at the following website: http://www.ecfr.gov.

Exhibit I

33 CFR Chapter II Part 208 Flood Control Regulations, Section 208.11 (7-1-12 Edition), Regulations for use of storage allocated for flood control or navigation and/or project operation at reservoirs subject to prescription of rules and regulations by the Secretary of the Army in the interest of flood control and navigation.

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

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

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

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

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

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

(3) Federal Energy Regulatory Commission (FERC), formerly Federal Power Commission (FPC), Licenses.

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

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

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

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

> (1) Section 10(a). ‘‘That the project adopted * * * shall be such as in the judgment of the Commission will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of waterpower development, and for other beneficial public uses * * *.’’
>
> (2) Section 10(c). ‘‘That the licensee shall * * * so maintain and operate said works as not to impair navigation, and shall conform to such rules and regulations as the Commission may from time to time prescribe for the protection of life, health, and property * * *.’’

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

> The operation of any navigation facilities which may be constructed as part of or in connection with any dam or diversion structure built under the provisions of this Act, whether at the expense of a licensee hereunder or of the United States, shall at all times be controlled by such reasonable rules and regulations in the interest of

> navigation; including the control of the pool caused by such dam or diversion structure as may be made from time to time by the Secretary of the Army, * * *.

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

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

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

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

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

(3) The term *letter of understanding* as used herein includes statements which consummate this regulation for any given project and define the general provisions or conditions of the local sponsor, or owner, cooperation agreed to in the authorizing legislative document, and the requirements for

compliance with section 7 of the 1944 Flood Control Act, the Federal Power Act or other special congressional act. This information will be specified in the water control plan and manual. The letter of understanding will be signed by a duly authorized representative of the Chief of Engineers and the project owner. A ''field working agreement'' may be substituted for a letter of understanding, provided that the specified minimum requirements of the latter, as stated above, are met.

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

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

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

(d) *Procedures—*

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

(2) *Corps of Engineers involvement.* If the project owner is responsible for real-time implementation of the water control plan, consultation and assistance will be provided by the Corps of Engineers when appropriate and to the extent possible. During any emergency that affects flood control and/or navigation, the Corps of Engineers may temporarily prescribe regulation of flood control or navigation storage space on a day-to-day (real-time) basis without request of the project owner. Appropriate consideration will be given for other authorized project functions. Upon refusal of the project owner to comply with regulations prescribed by the Corps of Engineers, a letter will be sent to the project owner by the Chief of Engineers or his duly authorized representative describing the

reason for the regulations prescribed, events that have transpired, and notification that the project owner is in violation of the Code of Federal Regulations. Should an impasse arise, in that the project owner or the designated operating entity persists in noncompliance with regulations prescribed by the Corps of Engineers, measures may be taken to assure compliance.

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

(4) *Water control plan and manual.* Prior to project completion, water control managers from the Corps of Engineers will visit the project and the area served by the project to become familiar with the water control facilities, and to insure sound formulation of the water control plan. The formal plan of regulation for flood control and/or navigation, referred to herein as the water control plan, will be developed and documented in a water control manual prepared by the Corps of Engineers. Development of the manual will be coordinated with the project owner to obtain the necessary pertinent information, and to insure compatibility with other project purposes and with surcharge regulation. Major topics in the manual will include: Authorization and description of the project, hydrometeorology, data collection and communication networks, hydrologic forecasting, the water control plan, and water resource management functions, including responsibilities and coordination for water control decision-making. Special instructions to the dam tender or reservoir manager on data collection, reporting to higher Federal authority, and on procedures to be followed in the event of a communication outage under emergency conditions, will be prepared as an exhibit in the manual. Other exhibits will include copies of this regulation, letters of understanding consummating this regulation, and the water control agreements. After approval by the Chief of Engineers or his duly authorized representative, the manual will be furnished the project owner.

(5) *Water control agreement.*

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

(ii) When deemed necessary by the Corps of Engineers, information given on the water control diagram or release schedule will be supplemented by appropriate text to assure mutual understanding on certain details or other important aspects of the water control plan

not covered in this regulation, on the water control diagram or in the release schedule. This material will include clarification of any aspects that might otherwise result in unsatisfactory project performance in the interest of flood control and/or navigation. Supplementation of the agreement will be necessary for each project where the Corps of Engineers exercises the discretionary authority to prescribe the flood control regulation on a day-today (real-time) basis. The agreement will include delegation of the responsibility. The document should also cite, as appropriate, section 7 of the 1944 Flood Control Act, the Federal Power Act and/or other congressional legislation authorizing construction and/or directing operation of the project.

(iii) All flood control regulations published in the FEDERAL REGISTER under this section (part 208) of the code prior to the date of this publication which are listed in § 208.11(e) are hereby superseded.

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

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

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

(8) *Notification of the general public.* The Corps of Engineers and other interested Federal and State agencies, and the project owner will jointly sponsor public involvement activities, as appropriate, to fully apprise the general public of the water control plan. Public meetings or other effective means of notification and involvement will be held, with the initial meeting being conducted as early as practicable but not later than the time the project first becomes operational. Notice of the initial public meeting shall be published once a week for 3 consecutive weeks in one or more newspapers of general circulation published in each county covered by the water control plan. Such notice shall also be used when appropriate to inform the public of modifications in the water control plan. If no

newspaper is published in a county, the notice shall be published in one or more newspapers of general circulation within that county. For the purposes of this section a newspaper is one qualified to publish public notices under applicable State law. Notice shall be given in the event significant problems are anticipated or experienced that will prevent carrying out the approved water control plan or in the event that an extreme water condition is expected that could produce severe damage to property or loss of life. The means for conveying this information shall be commensurate with the urgency of the situation. The water control manual will be made available for examination by the general public upon request at the appropriate office of the Corps of Engineers, project owner or designated operating agency.

(9) *Other generalized requirements for flood control and navigation.*

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

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

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

(iv) The project owner shall monitor current reservoir and hydro- meteorological conditions in and adjacent to the watershed and downstream of the damsite, as necessary. This and any other pertinent information shall be reported to the Corps of Engineers on a timely basis, in accordance with standing instructions to the damtender or other means requested by the Corps of Engineers.

(v) In all cases where the project owner retains responsibility for real-time implementation of the water control plan, he shall make current determinations of: Reservoir inflow, flood control storage utilized, and scheduled releases. He shall also determine storage space and releases required to comply with the water control plan prescribed by the Corps of Engineers. The owner shall report this information on a timely basis as requested by the Corps of Engineers.

(vi) The water control plan is subject to temporary modification by the Corps of Engineers if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communication available. The action taken shall be

confirmed in writing the same day to the project owner and shall include justification for the action.

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

(viii) Advance approval of the Chief of Engineers, or his duly authorized representative, is required prior to any deviation from the plan of regulation prescribed or approved by the Corps of Engineers in the interest of flood control and/or navigation, except in emergency situations provided for in paragraph (d)(9)(vii) of this section. When conditions appear to warrant a prolonged deviation from the approved plan, the project owner and the Corps of Engineers will jointly investigate and evaluate the proposed deviation to insure that the overall integrity of the plan would not be unduly compromised. Approval of prolonged deviations will not be granted unless such investigations and evaluations have been conducted to the extent deemed necessary by the Chief of Engineers, or his designated representatives, to fully substantiate the deviation.

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

(11) *Federal Register.* The following information for each project subject to section 7 of the 1944 Flood Control Act and other applicable congressional acts shall be published in the FEDERAL REGISTER prior to the time the projects becomes operational and prior to any significant impoundment before project completion or * * * at such time as the responsibility for physical operation and maintenance of the Corps of Engineers owned projects is transferred to another entity:

(i) Reservoir, dam, and lake names,

(ii) Stream, county, and State corresponding to the damsite location,

(iii) The maximum current storage space in acre-feet to be reserved exclusively for flood control and/or navigation purposes, or any multiple-use space (intermingled) when flood

control or navigation is one of the purposes, with corresponding elevations in feet above mean sea level, and area in acres, at the upper and lower limits of said space,

(iv) The name of the project owner, and (v) Congressional legislation authorizing the project for Federal participation.

(e) *List of projects.* The following tables, ‘‘Pertinent Project Data—Section 208.11 Regulation,’’ show the pertinent data for projects which are subject to this regulation. Note that the following tables show only those projects within the Missouri River basin, which includes the Omaha District and Kansas City District of the Northwestern Division, Corps of Engineers.

LIST OF PROJECTS

[Missouri River Basin Non-Corps projects with Corps Regulation Requirements]

Project name[1] (1)	State (2)	County (3)	Stream[1] (4)	Project purpose[2] (5)	Storage 1000 AF (6)	Elev limits feet M.S.L.		Area in acres		Authorizing legis.[3] (11)	Proj. owner[4] (12)
						Upper (7)	Lower (8)	Upper (9)	Lower (10)		
Omaha District Projects											
Boysen Dam & Res	WY	Fremont	Wild R	F FEIQ EIQ	150.4 146.1 403.8	4732.2 4725.0 4717.0	4725.0 4717.0 4685.0	22170 19560 16960	19560 16960 9280	PL 78–534	USBR.
Canyon Ferry Dam & Lk	MT	Lewis Clark	Missouri R	F FEI EI	99.5 795.1 711.5	3800.0 3797.0 3770.0	3797.0 3770.0 3728.0	33535 32800 24125	32800 24125 11480	PL 78–534	USBR.
Clark Canyon Dam & Res	MT	Beaverhead	Beaverhead R	F FI I	79.1 50.4 126.1	5560.4 5546.1 5535.7	5546.1 5535.7 5470.6	5900 5160 4495	5160 4495 220	PL 78–534	USBR.
Glendo Dam & Res	WY	Platte	N Platte R	F EIM	271.9 454.3	4653.0 4635.0	4635.0 4570.0	17990 12370	12370 3130	PL 78–534	USBR.
Heart Butte Dm & Lk Tschida	ND	Grant	Heart R	F IQ	147.9 69.0	2094.5 2064.5	2064.5 2030.0	6580 3400	3400 810	PL 78–534	USBR.
Jamestown Dam & Res	ND	Stutsman	James R	F IQ	185.4 28.1	1454.0 1429.8	1429.8 1400.0	13210 2090	2090 160	PL 78–534	USBR.
Keyhole Dam & Res	WY	Crook	Belle Fourche R	F IQ	140.5 185.8	4111.5 4099.3	4099.3 4051.0	13730 9410	9410 820	PL 78–534	USBR.
Pactola Dam & Res	SD	Pennington	Rapid Cr	F IM	43.1 55.0	4621.5 4580.2	4580.2 4456.1	1230 860	860 100	PL 78–534	USBR.
Shadehill Dam & Res	SD	Perkins	Grand R	F IQ	218.3 80.9	2302.0 2271.9	2271.9 2250.8	9900 4800	4800 2800	PL 78–534	USBR.
Tiber Dam & Res	MT	Libert Toole	Marias R	F FIQ IQ	400.9 268.0 121.7	3012.5 2993.0 2976.0	2993.0 2976.0 2966.4	23150 17890 13790	17890 13790 11710	PL 78–534	USBR.
Yellowtail Dam & Bighorn Lk	MT	Big Horn	Bighorn R	F FEIQ EIQ	258.3 240.3 336.1	3657.0 3640.0 3614.0	3640.0 3614.0 3547.0	17280 12600 6915	12600 6915 4150	PL 78–534	USBR PUD
Kansas City District Projects											
Bonny Dam & Res	CO	Yuma	S Fork Republic R	F ICR	128.2 39.2	3710.0 3672.0	3672.0 3638.0	5036 2042	2042 331	PL 78–534 PL 79–732	USBR.
Cedar Bluff Dam & Res	KS	Trego	Smoky Hill R	F IMCR	191.9 149.8	2166.0 2144.0	2144.0 2107.8	10790 6869	6869 2086	PL 78–534	USBR.
Enders Dam & Res	NE	Chase	Frenchman Cr	F ICR	30.0 34.5	3127.0 3112.3	3112.3 3082.4	2405 1707	1707 658	PL 78–534 PL 84–505	USBR.
Glen Elder Dam & Waconda Lk	KS	Mitchel	Solomon R	F IM	722.3 204.8	1488.3 1455.6	1455.6 1428.0	33682 12602	12602 3341	PL 78–534 PL 79–526	USBR.
Kirwin Dam & Res	KS	Phillips	N Fork Solomon R	F ICR	215.1 89.6	1757.3 1729.2	1729.3 1697.0	10640 5080	5080 1010	PL 78–534 PL 79–732; PL 79–526	USBR.
Lovewell Dam & Res	KS	Jewell	White Rock Cr	F ICR	50.5 24.9	1595.3 1582.6	1582.6 1571.7	5025 2986	2986 1704	PL 78–534 PL 79–732	USBR.
Medicine Cr Dam Harry Strunk Lk	NE	Frontier	Medicine Cr	F ICR	52.7 26.8	2386.2 2366.1	2366.1 2343.0	3483 1840	1840 701	PL 78–534 PL 84–505	USBR.
Norton Dam & Kieth Sebelius Lk	KS	Norton	Prairie Dog Cr	F IMRC	98.8 30.7	2331.4 2304.3	2304.3 2280.4	5316 2181	2181 587	PL 78–534 PL 79–526 PL 79–732	USBR.
Red Willow Dam Hugh Butler Lk	NE	Frontier	Red Willow Cr	F IRC	48.9 27.3	2604.9 2581.8	2581.8 2558.0	2682 1629	1629 787	PL 78–534 PL 85–783 PL 84–505	USBR.
Trenton Dam & Res	NB	Hitchcock	Republican R	F IRC	134.1 99.8	2773.0 2752.0	2752.0 2720.0	7940 4922	4922 1572	PL 78–534 PL 84–505	USBR.
Webster Dam & Res	KS	Rocks	S Fork Solomon R	F IRC	183.4 72.1	1923.7 1892.5	1892.5 1860.0	8480 3772	3772 906	PL 78–534 PL 79–526 PL 79–732	USBR

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

(Sec. 7, Pub. L. 78–534, 58 Stat. 890 (33 U.S.C. 709); the Federal Power Act, 41 Stat. 1063 (16 U.S.C. 791(A)); and sec. 9, Pub. L. 83–436, 68 Stat. 303)

[43 FR 47184, Oct. 13, 1978, as amended at 46 FR 58075, Nov. 30, 1981; 55 FR 21508, May 24, 1990]

EXHIBIT II

FIELD WORKING AGREEMENT

PACTOLA DAM AND RESERVOIR

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, OMAHA DISTRICT
1616 CAPITOL AVENUE
OMAHA NE 68102-4901

MEMORANDUM OF AGREEMENT
BETWEEN
U.S. ARMY CORPS OF ENGINEERS, OMAHA DISTRICT
AND
U.S. BUREAU OF RECLAMATION, GREAT PLAINS REGION

SUBJECT: Field Working Agreement for Pactola Dam and Reservoir

1. Flood control regulations governing the operation of Pactola Dam and Reservoir, Rapid Creek, Pennington County, South Dakota, were completed and published in the Federal Register, at Page 8355, Volume 34, issue of May 30, 1969. These regulations have been superseded by regulations published in the Federal Register at 33 CFR Chapter II Part 208, Flood Control Regulations, Section 208.11, (Exhibit 1 in Water Control Manual). It is agreed that the implementation of these regulations shall be in accordance with the criteria which follows, unless and until such criteria shall be amended by mutual agreement. Note that all elevation references in this document are based upon the National Geodetic Vertical Datum of 1929 (NGVD29).

2. Storage Capacity Allocations. The storage capacity allocations of Pactola Reservoir exclusive of surcharge storage capacity above elevation 4621.5 feet, which is provided in combination with spillway capacity to ensure safety of the structures, are defined in the following subparagraphs:

a. Flood Control Storage. Flood control storage capacity allocation shall include the storage capacity between elevation 4580.2 feet and elevation 4621.5 feet (presently amounting to 43,057 acre-feet), for which there have been constructed suitable outlet works to provide discharges as expressly indicated herein.

b. Active Conservation Storage. Active conservation storage capacity allocation shall include the storage capacity between elevation 4456.1 feet and elevation 4580.2 feet (presently amounting to 54,955 acre-feet).

c. Inactive Storage. Inactive storage capacity allocation shall include the storage capacity between elevation 4440.0 feet and elevation 4456.1 feet (presently amounting to 895 acre-feet).

d. Dead Storage. Dead storage capacity allocation shall include the storage capacity between streambed elevation and elevation 4440.0 feet (presently amounting to 122 acre-feet).

The capacity of 55,972 acre-feet between streambed elevation 4422.0 feet and elevation 4580.2 feet includes an allowance of 1,000 acre-feet for storage of accumulated sediment.

3. Storage Reallocations. The Regional Director may at his discretion make necessary field surveys and office studies to prepare estimates of the volume and location of sediment deposits

in the reservoir. If the results of these studies show that the total storage available for flood control and active conservation purposes, respectively, is reduced by an amount exceeding 10 percent of the allocation for either purpose, the operating plan described herein with respect to the elevation limits of the storage allocations shall be reviewed with the view of equitably distributing the loss of reservoir capacity between the primary reservoir uses. Any redistribution of storage capacity allocations is to be contingent on paragraph 7.

4. Plan of Operation. The Regional Director shall regulate Pactola Dam and Reservoir in the interest of flood control in accordance with 33 CFR Chapter II Part 208, Flood Control Regulations, Section 208.11, and Standing Instructions to Dam Tender. Operation of the reservoir with water surface between elevation 4580.2 feet and 4621.5 feet shall be construed as flood control operation, and releases shall be determined by the District Engineer, except for minimum releases for irrigation and other downstream conservation requirements. Flood control releases will be determined using the Corps Water Control Manual. When the reservoir level is in the surcharge or conservation pools, the District Engineer may make recommendations to the Regional Director for operation in the interest of flood control, but such recommendations shall not be considered mandatory inasmuch as operation of such storage is the responsibility of the Regional Director. Instructions issued by the District Engineer for flood control operation shall be issued to Rapid City Office staff who will relay the instructions to the Dam Tender.

5. Integrated Regulation of All Flood Control Reservoirs in Missouri River Basin. Releases from Pactola Reservoir eventually flow into Oahe Reservoir, one of the six Missouri River mainstem reservoirs. In the quotes below, the USACE Northwestern Division's Missouri River Basin Water Management is abbreviated MRBWM. As per the Missouri River Mainstem Reservoir System Master Water Control Manual (Master Manual), November, 2018, paragraph 7-04.25, "When tributary reservoir regulation affects Missouri River flood flows or navigation on the Missouri River, tributary reservoir regulation will, however, become a direct concern of the MRBWM office. During such periods, the MRBWM office will issue pertinent tributary reservoir regulating instructions so that flood damages may be held to a minimum through integrated regulation of all flood control reservoirs in the Missouri River basin." Additionally, as per Section 208.11 of 33 CFR Chapter II, "The water control plan is subject to temporary modification by the Corps of Engineers if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communication available. The action taken shall be confirmed in writing the same day to the project owner and shall include justification for the action." As a result of these requirements, during large floods on the Missouri River mainstem reservoirs, releases of flood storage in Pactola Reservoir may be adjusted in order to meet basin-wide flood control goals of the Missouri River system. In the case of Pactola Reservoir, requests for modification will be made to the Rapid City Office in Rapid City, SD, which is part of the Great Plains Region. Requests should be made via telephone call or email, and confirmed via an official reservoir regulation order the same day.

6. Arrangements for Operating Personnel. Since the resident Dam Tender may be absent from Pactola while performing duties at other projects under his supervision, the Regional Director shall make the necessary arrangements to provide operating personnel as needed whenever the reservoir level exceeds elevation 4580.2 feet.

7. Collection and Assembly of Hydrologic Data and Reporting Arrangements. Available data and reports from precipitation and stream flow stations pertinent to the operation of the Pactola Reservoir that are collected by either party to this agreement, will be made available to both parties by the most expeditious means of communication under such detailed arrangements as may be made from time to time.

8. Design Limitations. It is recognized that any changes in the discharge characteristics of the spillway structure resulting from reallocation of storage capacities, or for any other reason, which are mutually acceptable to the Corps of Engineers and the Bureau of Reclamation, must be approved by the Chief Engineer of the Bureau of Reclamation. It is further recognized, in connection with subparagraph d-9-iii of the flood control regulations in 33 CFR Chapter II Part 208, that the entire flood control storage capacity will be required for safe routing of the inflow design flood. Any water stored in the flood control pool will be evacuated as soon as practical without exceeding the downstream safe channel capacity.

EXHIBIT III

STANDING INSTRUCTIONS TO DAM TENDER FOR FLOOD CONTROL OPERATIONS

PACTOLA DAM AND RESERVOIR

STANDING INSTRUCTIONS TO DAM TENDER
FOR FLOOD CONTROL REGULATION OF PACTOLA DAM AND RESERVOIR

General

1. Responsibilities of the Dam Tender and procedures to be followed in regard to regulation of the Pactola Reservoir while the water level is within the flood control storage zone (between elevations 4580.2 and 4621.5 feet) are given in the following paragraphs. In the original design and construction of Pactola Dam, elevations on design drawings and reservoir levels were referenced to the Sea Level Datum of 1929, which was commonly referred to as "feet above mean sea level". In 1973 the Sea Level Datum of 1929 was renamed the National Geodetic Vertical Datum of 1929 (NGVD29). All elevation references in this document are based upon the NGVD29 datum.

2. Notice to Corps of Engineers of Flood Control Zone Occupation. Whenever the reservoir level rises to elevation 4580.2 feet, or whenever flood control releases appear imminent, the Dam Tender shall report at once by telephone to the District Engineer's Water Control & Water Quality Section, Corps of Engineers, Omaha, Nebraska, or to personnel at their homes as shown on Table D, if during non-office hours, and as requested thereafter until the reservoir level falls below elevation 4580.2 and flood discharges cease.

3. Channels for Issuing Flood Control Regulation Orders. The Omaha District WCWQS is the unit of the Corps designated to prepare and issue regulation orders concerning the flood control operation of Pactola Dam. Regulation orders are prepared by the WCWQS and normally telephoned to Reclamation's Rapid City Office (RCO) in Rapid City, SD or the Dam Tender. Verbal orders will be confirmed in writing as soon as possible. In the event conditions prevent the execution of an order, the Dam Tender will immediately notify personnel of the WCWQS and the RCO of the corrective measures required before execution of the order is possible.

4. Communication Facilities. Telephone, radio and email are available for use in communication with the Dam Tender. In the event of disruption of telephone communications with the Dam Tender and no alternate procedure is apparent, the Dam Tender shall drive to the nearest telephone and attempt to re-establish communication from there. During instances of prolonged telephone disruption, the Corps will also attempt to establish communication with the Dam Tender by dispatching Reclamation and/or Corps personnel.

5. Gate Setting. Regulation orders will designate required reservoir releases in cubic feet per second. The Dam Tender will determine the necessary gate settings to give the required release. The Dam Tender will remain within close driving distance of the project when flood storage is being released through the outlets in accordance with regulation orders, except when necessary to re-establish communications.

6. Precipitation Reports. When the pool level is within the flood control zone the Dam Tender will report immediately to personnel of the WCWQS any time 1/2 inch or more of precipitation occurs within 24 hours at the dam. Additionally when reservoir is in flood control zone and any time precipitation of 2 inches or more occurs within 6 hour period the Dam Tender will immediately notify the WCWQS or the RCO regardless of elevation.

7. Routine Reports. Under normal conditions, precipitation, pool elevation, storage, inflow, and outflow data collected at Pactola Dam will be transmitted to the Corps electronically. In the event electronic communications fail, telephone, fax or mail can be used.

8. Flood Reports. During emergency conditions and periods of flood operation, the Dam Tender will record the following data for use by the WCWQS, copies of which will be furnished to the WCWQS following each flood occurrence or as otherwise requested.

a. Times at which flood inflow to reservoir began.

b. Pool elevation at beginning of flood inflow.

c. Time of each observation and pool elevation observed.

d. Time of changes of gate setting and corresponding discharges.

e. Excess precipitation, wind, and other storm reports received by the Dam Tender from locations in the basin.

9. Flood Forecasts. General weather and flood forecasts in the Black Hills area are available from the National Weather Service Weather Forecast Office at Rapid City website at https://www.weather.gov/unr/. More specific information on precipitation amounts and forecasted flow rates for Rapid Creek can be obtained by calling the Rapid City Weather Forecast Office at 605-341-7435. Additional information on precipitation amounts and flow rates on Rapid Creek can be found at the National Weather Service's Missouri Basin River Forecast Center at https://www.weather.gov/mbrfc/ or by calling 816-540-5151.

10. River Stages. Real-time river stages for Rapid Creek are available from the U.S. Geological Survey (USGS) website at http://waterdata.usgs.gov/sd/nwis/current/?type=flow. Table A lists streamgages where real-time data is available.

Table A
Rapid Creek Pertinent Streamgaging Stations[1]

Station	USGS Station ID	Flood Stage	Mean Discharge (cfs)	Peak Flow (cfs)	Date of Peak
Rapid Creek above Pactola Reservoir at Silver City	06410500	14.0	48	2,060	May 15, 1965
Rapid Creek below Pactola Reservoir	06411500	13.0	52	2,170	May 22, 1952
Rapid Creek above Canyon Lake	06412500	7.0	52	31,200	June 9, 1972
Rapid Creek at Rapid City	06414000	11.0	70	50,000	June 9, 1972
Rapid Creek near Farmingdale	06421500	11.0	78	7,320	June 10, 1972

[1]Data as of 2014

In the event data from these streamgages are not available, the USGS office in Rapid City should be contacted at 605-394-3219 to reestablish the data streams or to make field observations of river stages and flow rates. Personnel from the RCO and the Corps Big Bend Project Office are available to collect such data pertinent to flood runoff, to make field inspections of the flooded area, and to transmit this information to the District Engineer. Phone numbers for personnel in these offices are shown in Table D of this document.

Normal Flood Control Regulation

11. Flood Control Regulation Under Normal Conditions. Normal operating conditions for the purpose of these instructions are defined as a condition whereby the pool elevation is within the Flood Control Zone of the reservoir between elevations 4580.2 and 4621.5 feet, and communications to the dam are not impaired. Normally, whenever necessary to release flood storage through the outlet gates, the WCWQS will issue regulation orders, as outlined in paragraph 3 above. The Dam Tender will make the necessary gate adjustments to provide the releases specified in the regulation orders.

Emergency Flood Control Regulation

12. Flood Control Regulation Under Emergency Conditions. Emergency operating conditions for the purpose of these instructions are defined as a condition where (1) initial flood inflow into the reservoir requires gate openings in accordance with the release schedule shown on Table C prior to receipt of specific regulation instructions from the WCWQS; or (2) a disruption of communications exists between the Dam Tender and both the WCWQS and the RCO; or (3) the Dam Tender receives reports of excessive runoff or flooding in the Rapid Creek basin below the dam (as further defined in paragraph 14).

13. Procedure for Emergency Gate Operation in the Flood Control Zone. Whenever the reservoir level rises to elevation 4580.2 feet, or whenever flood discharges appear imminent, the Dam Tender shall report at once to the WCWQS by telephone, and as requested thereafter until the reservoir level falls to elevation 4580.2 feet or below and flood discharges cease. In the event of disruption of communications with personnel of both the WCWQS and the RCO, as defined in paragraph 12, or prior to receipt of specific regulation instructions from the WCWQS, it shall be the duty of the Dam Tender to make any pool readings or adjustments of the outlet gates. Table B provides the schedule of required pool readings and gate adjustments based on elevation. Table C provides the schedule of project emergency releases. Gate settings should be adjusted as necessary to yield the releases required by Table C, and to take other actions necessary to the proper functioning and safety of the dam. If heavy rains are occurring or forecasted to occur above Pactola Reservoir, the increments in Table B should be cut in half.

Table B
Schedule of Pool Readings and Gate Adjustments

Pool Elev. (feet NGVD29) I. Rising Pool Level	Pool Reading and Gate Adjustment Interval
4580.20 - 4585.00	12 Hours
4585.00 - 4590.00	8 Hours
4590.01 - 4595.00	6 Hours
4595.01 - 4600.00	4 Hours
Above - 4600.00	1 Hour
II. Stationary or Falling Pool Level	
4580.2 or Above	12 Hours

*Note: If heavy rains are occurring or forecasted to occur above Pactola Reservoir, the increments in Table B should be cut in half.

Table C
Pactola Dam and Reservoir
Emergency Release Schedule

Pool Elev. (feet NGVD29) From	To	Required Release (c.f.s.)
Below	4580.20	Conservation Requirement
4580.20	4582.00	Inflow up to 250
4582.01	4583.00	300
4583.01	4585.00	400
4585.01	4590.00	500
4590.01	4595.00	700
4595.01	4600.00	900
4600.01	4621.50	1000

In the event loss of communication extends beyond the inflow period and the reservoir level begins to fall, the regulation procedure for pool drawdown will proceed on the basis of maintaining the maximum gate opening attained during the inflow period until the pool level recedes to elevation 4580.2 feet. Project releases below elevation 4580.2 feet will be in accordance with downstream water requirements. Emergency operation schedules will in no case permit outlet discharges exceeding 1,000 c.f.s. while the pool is within the flood control zone (elevation 4580.2 - 4621.5 feet).

14. Emergency Closure of Outlet Gates. To prevent outlet discharges from contributing to flooding at downstream damage centers during the flood control regulation of Pactola Dam and Reservoir it will be necessary at times to temporarily reduce releases through the outlet gates.

a. The Dam Tender will reduce the outflow to 20 c.f.s. when the following conditions exist (unless the Dam Tender has current instructions which specify this should not be done):

(1) Reports of the occurrence of intense rainfall on the tributaries of Rapid Creek below the dam, especially the Limestone Creek and Cement Plant Creek tributary drainages and the South Canyon, Red Dale Gulch, and Yucca Drive tributary coulee drainages are known to the Dam Tender. (Intense rainfall is defined as 2 inches or more within a six-hour period).

(2) Gage heights at the Rapid Creek gage above Canyon Lake and Rapid Creek gage at Rapid City (Oshkosh Street Bridge) have risen sharply and are likely to exceed 4.5 feet and 6.5 feet respectively. These stages correspond to a flow rate of approximately 700 and 1,085 cfs, based on rating curves developed in 2018.

(3) Reports of bank full stages anywhere on Rapid Creek below the dam and above the Canyon Lake gage are known to the Dam Tender with reports of precipitation or an existing snow cover below the dam.

b. Once the outflow is reduced under the provisions of this paragraph, the gates will not be reopened until orders are received from an authorized representative of the

WCWQS. If such orders are not received within 8 hours after initial closing of the outlet gates, the Dam Tender shall reopen the gates as follows:

(1) Pool Elevation is Below 4580.2 feet.

Open gates to extent required for downstream water requirements.

(2) Pool Elevation is Above 4580.2 feet.

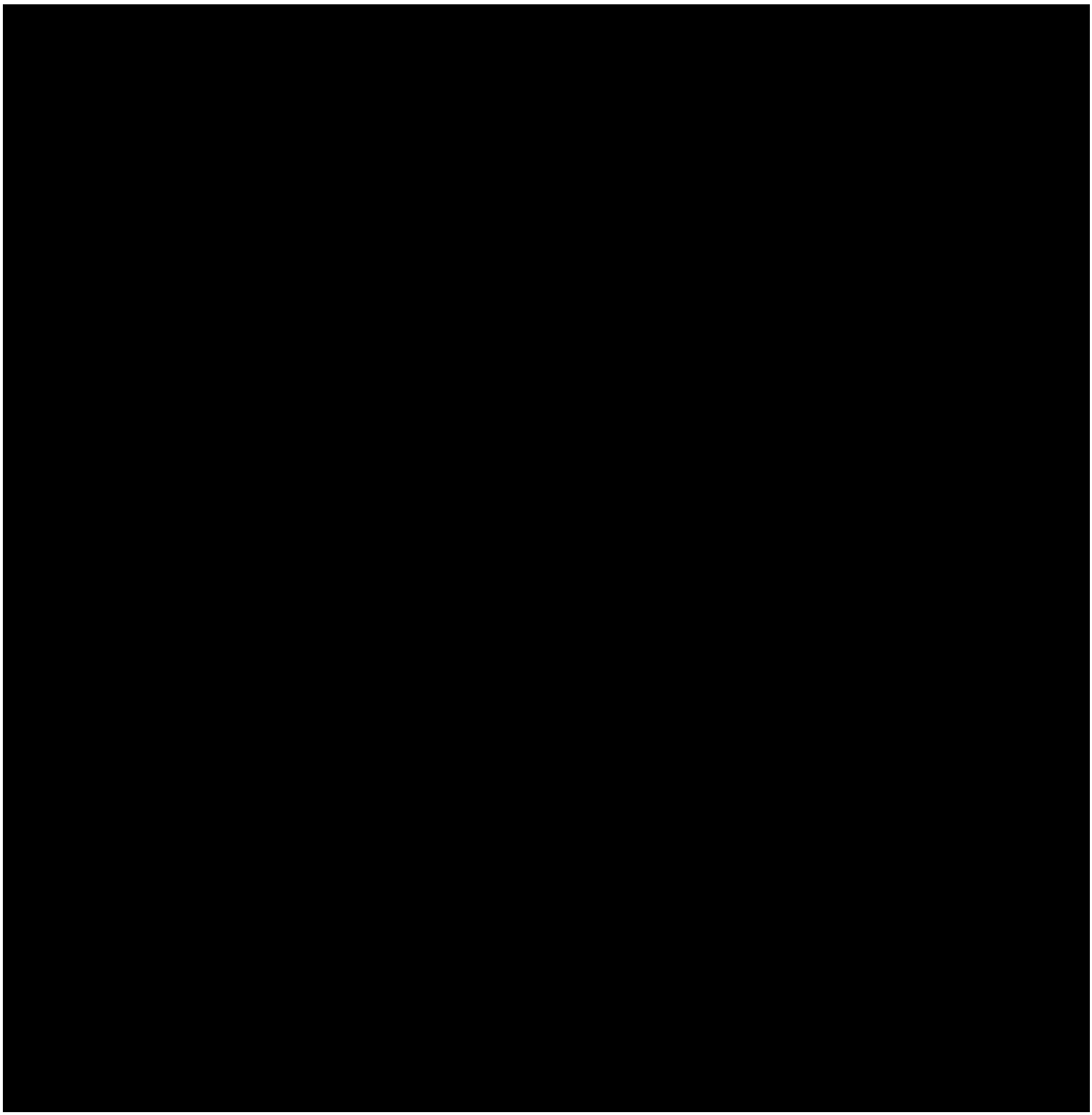
Open gates to extent required by emergency regulation schedule (Table C), the latest regulation order, or downstream water requirements, whichever is the greater.

15. Emergency Surcharge Storage Zone Operations. Good operating practice for flood control recognizes that floods in excess of flood control zone capacity are possible though extremely unlikely. Operations in the zone of the reservoir above elevation 4621.5 feet are not within the jurisdiction of the Corps of Engineers. The function of the Corps of Engineers in the surcharge storage zone is advisory. Therefore, in the event of such an occurrence, the Dam Tender will rely on instructions issued by the Regional Director for determination of project releases.

16. Posting of Emergency Instructions. The Dam Tender will post these instructions as well as the emergency release schedule (Table C), and the names and telephone numbers of the WCWQS personnel (Table D) in a readily accessible place, and is responsible for notifying substitutes or Assistant Dam Tenders of the provisions for flood regulation.

Table D
Pactola Dam & Reservoir Flood Control Regulation Personnel
(If more than one name shown, call in order listed.)

Directory of Regulation Personnel



Organization/Name	Office	FAX	Cell/Pager	Home	Email Address
[redacted]					

EXHIBIT IV

AREA-CAPACITY TABLES IN ONE-FOOT INCREMENTS

PACTOLA DAM AND RESERVOIR

Exhibit IV
Pactola Reservoir
Area-Capacity Tables in One-Foot Increments

Table 1
Pactola Reservoir 1988 Capacity in Acre-Feet

Column 1	Elevation Increment in Feet Above Column 1									
Elevation (ft NGVD29)	0	1	2	3	4	5	6	7	8	9
4420	0	0	0	1	2	2	4	5	6	8
4430	10	13	17	22	29	37	48	62	79	99
4440	122	149	178	211	246	285	327	373	423	477
4450	535	598	667	743	825	912	1007	1109	1219	1336
4460	1460	1591	1728	1872	2022	2177	2339	2507	2681	2861
4470	3047	3239	3437	3641	3851	4067	4289	4517	4751	4991
4480	5237	5489	5745	6005	6270	6540	6814	7093	7376	7663
4490	7955	8251	8551	8856	9165	9477	9795	10116	10441	10771
4500	11105	11443	11785	12131	12481	12835	13193	13555	13922	14293
4510	14667	15047	15431	15820	16214	16612	17016	17424	17836	18253
4520	18675	19102	19535	19975	20421	20872	21330	21794	22264	22740
4530	23222	23710	24204	24704	25209	25720	26237	26760	27288	27822
4540	28362	28909	29461	30019	30584	31155	31732	32316	32906	33502
4550	34105	34715	35332	35957	36590	37230	37878	38533	39196	39867
4560	40545	41231	41923	42623	43330	44045	44767	45496	46232	46976
4570	47727	48488	49258	50039	50831	51632	52445	53268	54101	54945
4580	55800	56664	57535	58413	59299	60192	61093	62002	62918	63841
4590	64772	65713	66663	67623	68594	69575	70566	71568	72580	73602
4600	74635	75678	76729	77789	78859	79937	81025	82122	83228	84343
4610	85467	86601	87742	88893	90052	91220	92397	93582	94777	95980
4620	97192	98414	99646	100888	102140	103403	104675	105957	107250	108552
4630	109865	111188	112521	113864	115216	116580	117953	119336	120729	122132
4640	123546	124969	126404	127850	129308	130777	132258	133750	135254	136769
4650	138295	139834	141389	142958	144541	146140	147749	149364	150985	152612
4660	154245									

Table 2
Pactola Reservoir 1988 Area in Acres

Column 1	Elevation Increment in Feet Above Column 1									
Elevation (ft NGVD 29)	0	1	2	3	4	5	6	7	8	9
4420	0	0	0	1	1	1	1	1	2	2
4430	2	3	5	6	8	9	12	15	19	22
4440	25	28	31	34	37	40	44	48	52	56
4450	60	66	72	79	85	91	98	106	113	121
4460	128	134	140	147	153	159	165	171	177	183
4470	189	195	201	207	213	219	225	231	237	243
4480	249	254	258	263	267	272	276	281	285	290
4490	294	298	302	307	311	315	319	323	328	332
4500	336	340	344	348	352	356	360	364	369	373
4510	377	382	387	391	396	401	406	410	415	419
4520	424	430	436	443	449	455	461	467	473	479
4530	485	491	497	502	508	514	520	526	531	537
4540	543	549	555	562	568	574	580	587	593	600
4550	606	614	621	629	636	644	652	659	667	674
4560	682	689	696	704	711	718	725	733	740	747
4570	755	765	776	786	797	807	818	828	839	849
4580	860	867	875	882	890	897	905	912	920	927
4590	935	945	955	966	976	986	996	1007	1017	1027
4600	1038	1047	1056	1065	1074	1083	1092	1101	1110	1120
4610	1129	1137	1146	1155	1164	1172	1181	1190	1199	1208
4620	1216	1227	1237	1247	1257	1267	1277	1287	1298	1308
4630	1318	1328	1338	1348	1358	1368	1378	1388	1398	1408
4640	1418	1429	1441	1452	1464	1475	1486	1498	1509	1521
4650	1532	1547	1562	1576	1591	1606	1612	1618	1624	1630
4660	1636									

EXHIBIT V

AREA-CAPACITY TABLES IN ONE-FOOT INCREMENTS AND 0.1 FOOT INCREMENTS

PACTOLA DAM AND RESERVOIR

PACTOLA RESERVOIR

MAY 1988

(ACAP85) COMPUTED
05/13/88
11.24.09.

AREA TABLE IN ACRES

ELEVATION INCREMENT IS ONE FOOT

ELEV. FEET	0	1	2	3	4	5	6	7	8	9
4420	0	0	0	1	1	1	1	1	2	2
4430	2	3	5	6	8	9	12	15	19	22
4440	25	28	31	34	37	40	44	48	52	56
4450	60	66	72	79	85	91	98	106	113	121
4460	128	134	140	147	153	159	165	171	177	183
4470	189	195	201	207	213	219	225	231	237	243
4480	249	254	258	263	267	272	276	281	285	290
4490	294	298	302	307	311	315	319	323	328	332
4500	336	340	344	348	352	356	360	364	369	373
4510	377	382	387	391	396	401	406	410	415	419
4520	424	430	436	443	449	455	461	467	473	479
4530	485	491	497	502	508	514	520	526	531	537
4540	543	549	555	562	568	574	580	587	593	600
4550	606	614	621	629	636	644	652	659	667	674
4560	682	689	696	704	711	718	725	733	740	747
4570	755	765	776	786	797	807	818	828	839	849
4580	860	867	875	882	890	897	905	912	920	927
4590	935	945	955	966	976	986	996	1007	1017	1027
4600	1038	1047	1056	1065	1074	1083	1092	1101	1110	1120
4610	1129	1137	1146	1155	1164	1172	1181	1190	1199	1208
4620	1216	1227	1237	1247	1257	1267	1277	1287	1298	1308
4630	1318	1328	1338	1348	1358	1368	1378	1388	1398	1408
4640	1418	1429	1441	1452	1464	1475	1486	1498	1509	1521
4650	1532	1547	1562	1576	1591	1606	1612	1618	1624	1630
4660	1636									

PACTOLA RESERVOIR

MAY 1988

(ACAP85) COMPUTED
05/13/88
11.24.37.

AREA TABLE IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4420	0	0	0	0	0	0	0	0	0	0
4421	0	0	0	0	0	0	0	0	0	0
4422	0	0	0	0	0	0	1	1	1	1
4423	1	1	1	1	1	1	1	1	1	1
4424	1	1	1	1	1	1	1	1	1	1
4425	1	1	1	1	1	1	1	1	1	1
4426	1	1	1	1	1	1	1	1	1	1
4427	1	1	1	1	1	1	2	2	2	2
4428	2	2	2	2	2	2	2	2	2	2
4429	2	2	2	2	2	2	2	2	2	2
4430	2	2	2	2	3	3	3	3	3	3
4431	3	4	4	4	4	4	4	4	5	5
4432	5	5	5	5	5	5	6	6	6	6
4433	6	6	6	7	7	7	7	7	7	7
4434	8	8	8	8	8	8	8	9	9	9
4435	9	9	10	10	10	11	11	11	12	12
4436	12	13	13	13	13	14	14	14	15	15
4437	15	16	16	16	17	17	17	18	18	18
4438	19	19	19	20	20	20	21	21	21	21
4439	22	22	22	23	23	23	24	24	24	25
4440	25	25	26	26	26	26	27	27	27	28
4441	28	28	29	29	29	29	30	30	30	31
4442	31	31	32	32	32	32	33	33	33	34
4443	34	34	35	35	35	36	36	36	36	37
4444	37	37	38	38	38	39	39	39	39	40
4445	40	40	41	41	42	42	42	43	43	44
4446	44	44	45	45	46	46	46	47	47	48
4447	48	48	49	49	50	50	50	51	51	52
4448	52	52	53	53	54	54	54	55	55	56
4449	56	56	57	57	58	58	58	59	59	60
4450	60	61	61	62	62	63	64	64	65	66
4451	66	67	67	68	69	69	70	71	71	72
4452	72	73	74	74	75	75	76	77	77	78
4453	79	79	80	80	81	82	82	83	84	84
4454	85	85	86	87	87	88	89	89	90	90
4455	91	92	92	93	94	95	95	96	97	98
4456	98	99	100	101	101	102	103	104	104	105
4457	106	107	107	108	109	109	110	111	112	112
4458	113	114	115	115	116	117	118	118	119	120
4459	121	121	122	123	124	124	125	126	127	127

For Official Use Only

PACTOLA RESERVOIR

MAY 1988

(ACAP85) COMPUTED
05/13/88
11.24.37.

AREA TABLE IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4460	128	129	129	130	130	131	132	132	133	134
4461	134	135	135	136	137	137	138	139	139	140
4462	140	141	142	142	143	143	144	145	145	146
4463	147	147	148	148	149	150	150	151	152	152
4464	153	153	154	155	155	156	157	157	158	158
4465	159	160	160	161	161	162	163	163	164	164
4466	165	166	166	167	167	168	169	169	170	170
4467	171	172	172	173	173	174	175	175	176	176
4468	177	178	178	179	179	180	181	181	182	182
4469	183	184	184	185	185	186	187	187	188	188
4470	189	190	190	191	191	192	193	193	194	194
4471	195	196	196	197	197	198	199	199	200	200
4472	201	202	202	203	203	204	205	205	206	206
4473	207	208	208	209	209	210	211	211	212	212
4474	213	214	214	215	215	216	217	217	218	218
4475	219	220	220	221	221	222	223	223	224	224
4476	225	226	226	227	227	228	229	229	230	230
4477	231	232	232	233	233	234	235	235	236	236
4478	237	238	238	239	239	240	241	241	242	242
4479	243	244	244	245	245	246	247	247	248	248
4480	249	249	250	250	251	251	252	252	253	253
4481	254	254	255	255	255	256	256	257	257	258
4482	258	259	259	260	260	260	261	261	262	262
4483	263	263	264	264	265	265	266	266	266	267
4484	267	268	268	269	269	270	270	271	271	272
4485	272	272	273	273	274	274	275	275	276	276
4486	276	277	277	278	278	279	279	279	280	280
4487	281	281	282	282	283	283	283	284	284	285
4488	285	286	286	287	287	287	288	288	289	289
4489	290	290	290	291	291	292	292	293	293	294
4490	294	294	295	295	296	296	297	297	297	298
4491	298	299	299	299	300	300	301	301	302	302
4492	302	303	303	304	304	304	305	305	306	306
4493	307	307	307	308	308	309	309	310	310	310
4494	311	311	312	312	312	313	313	314	314	315
4495	315	315	316	316	317	317	318	318	318	319
4496	319	320	320	320	321	321	322	322	323	323
4497	323	324	324	325	325	325	326	326	327	327
4498	328	328	328	329	329	330	330	331	331	331
4499	332	332	333	333	333	334	334	335	335	336

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AREA TABLE IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4500	336	336	337	337	338	338	338	339	339	340
4501	340	340	341	341	342	342	342	343	343	344
4502	344	344	345	345	346	346	346	347	347	348
4503	348	348	349	349	350	350	350	351	351	352
4504	352	352	353	353	354	354	354	355	355	356
4505	356	356	357	357	358	358	359	359	359	360
4506	360	361	361	361	362	362	363	363	364	364
4507	364	365	365	366	366	366	367	367	368	368
4508	369	369	369	370	370	371	371	372	372	372
4509	373	373	374	374	374	375	375	376	376	377
4510	377	377	378	378	379	379	380	380	381	381
4511	382	382	383	383	384	384	385	385	386	386
4512	387	387	388	388	389	389	389	390	390	391
4513	391	392	392	393	393	394	394	395	395	396
4514	396	397	397	398	398	399	399	400	400	401
4515	401	401	402	402	403	403	404	404	405	405
4516	406	406	407	407	407	408	408	409	409	410
4517	410	411	411	412	412	412	413	413	414	414
4518	415	415	416	416	417	417	418	418	418	419
4519	419	420	420	421	421	422	422	423	423	424
4520	424	425	425	426	426	427	428	428	429	430
4521	430	431	431	432	433	433	434	435	435	436
4522	436	437	438	438	439	439	440	441	441	442
4523	443	443	444	444	445	446	446	447	448	448
4524	449	449	450	451	451	452	453	453	454	454
4525	455	456	456	457	457	458	459	459	460	460
4526	461	462	462	463	463	464	465	465	466	466
4527	467	468	468	469	469	470	471	471	472	472
4528	473	474	474	475	475	476	477	477	478	478
4529	479	480	480	481	481	482	483	483	484	484
4530	485	486	486	487	487	488	488	489	490	490
4531	491	491	492	493	493	494	494	495	495	496
4532	497	497	498	498	499	499	500	501	501	502
4533	502	503	504	504	505	505	506	506	507	508
4534	508	509	509	510	511	511	512	512	513	513
4535	514	515	515	516	516	517	517	518	519	519
4536	520	520	521	522	522	523	523	524	524	525
4537	526	526	527	527	528	528	529	530	530	531
4538	531	532	533	533	534	534	535	535	536	537
4539	537	538	538	539	540	540	541	541	542	542

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AREA TABLE IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4540	543	544	544	545	545	546	547	547	548	549
4541	549	550	550	551	552	552	553	554	554	555
4542	555	556	557	557	558	558	559	560	560	561
4543	562	562	563	563	564	565	565	566	567	567
4544	568	568	569	570	570	571	572	572	573	573
4545	574	575	575	576	577	577	578	578	579	580
4546	580	581	582	582	583	584	584	585	586	586
4547	587	587	588	589	589	590	591	591	592	593
4548	593	594	594	595	596	596	597	598	598	599
4549	600	600	601	602	602	603	603	604	605	605
4550	606	607	608	608	609	610	611	611	612	613
4551	614	614	615	616	617	617	618	619	620	620
4552	621	622	623	623	624	625	626	627	627	628
4553	629	630	630	631	632	633	633	634	635	636
4554	636	637	638	639	639	640	641	642	642	643
4555	644	645	646	646	647	648	649	649	650	651
4556	652	652	653	654	655	655	656	657	658	658
4557	659	660	661	661	662	663	664	665	665	666
4558	667	668	668	669	670	671	671	672	673	674
4559	674	675	676	677	677	678	679	680	680	681
4560	682	682	683	684	685	685	686	687	688	688
4561	689	690	690	691	692	693	693	694	695	696
4562	696	697	698	698	699	700	701	701	702	703
4563	704	704	705	706	707	707	708	709	709	710
4564	711	712	712	713	714	715	715	716	717	717
4565	718	719	720	720	721	722	723	723	724	725
4566	725	726	727	728	728	729	730	731	731	732
4567	733	734	734	735	736	736	737	738	739	739
4568	740	741	742	742	743	744	744	745	746	747
4569	747	748	749	750	750	751	752	752	753	754
4570	755	756	757	758	759	760	761	762	763	764
4571	765	766	767	768	769	770	771	773	774	775
4572	776	777	778	779	780	781	782	783	784	785
4573	786	787	788	789	790	791	792	794	795	796
4574	797	798	799	800	801	802	803	804	805	806
4575	807	808	809	810	811	812	813	815	816	817
4576	818	819	820	821	822	823	824	825	826	827
4577	828	829	830	831	832	833	834	836	837	838
4578	839	840	841	842	843	844	845	846	847	848
4579	849	850	851	852	853	854	855	857	858	859

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AREA TABLE IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4580	860	860	861	862	863	863	864	865	866	866
4581	867	868	869	869	870	871	872	872	873	874
4582	875	875	876	877	878	878	879	880	881	881
4583	882	883	884	884	885	886	887	887	888	889
4584	890	890	891	892	893	893	894	895	896	896
4585	897	898	899	899	900	901	902	902	903	904
4586	905	905	906	907	908	908	909	910	911	911
4587	912	913	914	914	915	916	917	917	918	919
4588	920	920	921	922	923	923	924	925	926	926
4589	927	928	929	929	930	931	932	932	933	934
4590	935	936	937	938	939	940	941	942	943	944
4591	945	946	947	948	949	950	951	952	953	954
4592	955	956	957	958	959	960	961	962	964	965
4593	966	967	968	969	970	971	972	973	974	975
4594	976	977	978	979	980	981	982	983	984	985
4595	986	987	988	989	990	991	992	993	994	995
4596	996	998	999	1000	1001	1002	1003	1004	1005	1006
4597	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016
4598	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026
4599	1027	1028	1029	1030	1032	1033	1034	1035	1036	1037
4600	1038	1039	1040	1040	1041	1042	1043	1044	1045	1046
4601	1047	1048	1049	1050	1050	1051	1052	1053	1054	1055
4602	1056	1057	1058	1059	1060	1060	1061	1062	1063	1064
4603	1065	1066	1067	1068	1069	1070	1070	1071	1072	1073
4604	1074	1075	1076	1077	1078	1079	1080	1080	1081	1082
4605	1083	1084	1085	1086	1087	1088	1089	1090	1090	1091
4606	1092	1093	1094	1095	1096	1097	1098	1099	1100	1100
4607	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110
4608	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119
4609	1120	1120	1121	1122	1123	1124	1125	1126	1127	1128
4610	1129	1129	1130	1131	1132	1133	1134	1135	1135	1136
4611	1137	1138	1139	1140	1141	1142	1142	1143	1144	1145
4612	1146	1147	1148	1149	1149	1150	1151	1152	1153	1154
4613	1155	1156	1157	1157	1158	1159	1160	1161	1162	1163
4614	1164	1164	1165	1166	1167	1168	1169	1170	1171	1171
4615	1172	1173	1174	1175	1176	1177	1178	1179	1179	1180
4616	1181	1182	1183	1184	1185	1186	1186	1187	1188	1189
4617	1190	1191	1192	1193	1193	1194	1195	1196	1197	1198
4618	1199	1200	1201	1201	1202	1203	1204	1205	1206	1207
4619	1208	1208	1209	1210	1211	1212	1213	1214	1215	1215

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AREA TABLE IN ACRES

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4620	1216	1218	1219	1220	1221	1222	1223	1224	1225	1226
4621	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236
4622	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246
4623	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256
4624	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266
4625	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276
4626	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286
4627	1287	1288	1289	1290	1291	1292	1293	1294	1296	1297
4628	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307
4629	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317
4630	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327
4631	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337
4632	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347
4633	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357
4634	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367
4635	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377
4636	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387
4637	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397
4638	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407
4639	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417
4640	1418	1419	1420	1421	1423	1424	1425	1426	1427	1428
4641	1429	1431	1432	1433	1434	1435	1436	1437	1439	1440
4642	1441	1442	1443	1444	1445	1446	1448	1449	1450	1451
4643	1452	1453	1454	1456	1457	1458	1459	1460	1461	1462
4644	1464	1465	1466	1467	1468	1469	1470	1472	1473	1474
4645	1475	1476	1477	1478	1480	1481	1482	1483	1484	1485
4646	1486	1488	1489	1490	1491	1492	1493	1494	1496	1497
4647	1498	1499	1500	1501	1502	1503	1505	1506	1507	1508
4648	1509	1510	1511	1513	1514	1515	1516	1517	1518	1519
4649	1521	1522	1523	1524	1525	1526	1527	1529	1530	1531
4650	1532	1533	1535	1536	1538	1539	1541	1542	1544	1545
4651	1547	1548	1550	1551	1553	1554	1556	1557	1559	1560
4652	1562	1563	1565	1566	1568	1569	1570	1572	1573	1575
4653	1576	1578	1579	1581	1582	1584	1585	1587	1588	1590
4654	1591	1593	1594	1596	1597	1599	1600	1602	1603	1605
4655	1606	1607	1607	1608	1608	1609	1610	1610	1611	1611
4656	1612	1613	1613	1614	1614	1615	1616	1616	1617	1617
4657	1618	1619	1619	1620	1620	1621	1622	1622	1623	1623
4658	1624	1625	1625	1626	1626	1627	1628	1628	1629	1629
4659	1630	1631	1631	1632	1632	1633	1634	1634	1635	1635
4660	1636									

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05/13/88
11.24.09.

CAPACITY TABLE IN ACRE FEET — ELEVATION INCREMENT IS ONE FOOT

ELEV. FEET	0	1	2	3	4	5	6	7	8	9
4420	0	0	0	1	2	2	4	5	6	8
4430	10	13	17	22	29	37	48	62	79	99
4440	122	149	178	211	246	285	327	373	423	477
4450	535	598	667	743	825	912	1007	1109	1219	1336
4460	1460	1591	1728	1872	2022	2177	2339	2507	2681	2861
4470	3047	3239	3437	3641	3851	4067	4289	4517	4751	4991
4480	5237	5489	5745	6005	6270	6540	6814	7093	7376	7663
4490	7955	8251	8551	8856	9165	9477	9795	10116	10441	10771
4500	11105	11443	11785	12131	12481	12835	13193	13555	13922	14293
4510	14667	15047	15431	15820	16214	16612	17016	17424	17836	18253
4520	18675	19102	19535	19975	20421	20872	21330	21794	22264	22740
4530	23222	23710	24204	24704	25209	25720	26237	26760	27288	27822
4540	28362	28909	29461	30019	30584	31155	31732	32316	32906	33502
4550	34105	34715	35332	35957	36590	37230	37878	38533	39196	39867
4560	40545	41231	41923	42623	43330	44045	44767	45496	46232	46976
4570	47727	48488	49258	50039	50831	51632	52445	53268	54101	54945
4580	55800	56664	57535	58413	59299	60192	61093	62002	62918	63841
4590	64772	65713	66663	67623	68594	69575	70566	71568	72580	73602
4600	74635	75678	76729	77789	78859	79937	81025	82122	83228	84343
4610	85467	86601	87742	88893	90052	91220	92397	93582	94777	95980
4620	97192	98414	99646	100888	102140	103403	104675	105957	107250	108552
4630	109865	111188	112521	113864	115216	116580	117953	119336	120729	122132
4640	123546	124969	126404	127850	129308	130777	132258	133750	135254	136769
4650	138295	139834	141389	142958	144541	146140	147749	149364	150985	152612
4660	154245									

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CAPACITY TABLE IN ACRE FEET

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4420	0	0	0	0	0	0	0	0	0	0
4421	0	0	0	0	0	0	0	0	0	0
4422	0	0	0	1	1	1	1	1	1	1
4423	1	1	1	1	1	1	1	1	1	2
4424	2	2	2	2	2	2	2	2	2	2
4425	2	3	3	3	3	3	3	3	3	3
4426	4	4	4	4	4	4	4	4	5	5
4427	5	5	5	5	5	6	6	6	6	6
4428	6	7	7	7	7	7	7	8	8	8
4429	8	8	8	9	9	9	9	9	10	10
4430	10	10	10	11	11	11	11	12	12	12
4431	13	13	13	14	14	15	15	15	16	16
4432	17	17	18	18	19	19	20	21	21	22
4433	22	23	24	24	25	26	26	27	28	28
4434	29	30	31	32	32	33	34	35	36	37
4435	37	38	39	40	41	42	43	45	46	47
4436	48	49	51	52	53	55	56	57	59	60
4437	62	63	65	67	68	70	72	73	75	77
4438	79	81	83	85	87	89	91	93	95	97
4439	99	101	104	106	108	110	113	115	118	120
4440	122	125	128	130	133	135	138	141	143	146
4441	149	152	155	158	160	163	166	169	172	175
4442	178	182	185	188	191	194	198	201	204	208
4443	211	214	218	221	225	228	232	236	239	243
4444	246	250	254	258	262	265	269	273	277	281
4445	285	289	293	297	301	305	310	314	318	323
4446	327	331	336	340	345	349	354	359	363	368
4447	373	378	383	388	393	397	403	408	413	418
4448	423	428	433	439	444	449	455	460	466	471
4449	477	483	488	494	500	505	511	517	523	529
4450	535	541	547	553	559	566	572	579	585	592
4451	598	605	611	618	625	632	639	646	653	660
4452	667	675	682	689	697	704	712	720	727	735
4453	743	751	759	767	775	783	791	799	808	816
4454	825	833	842	850	859	868	877	885	894	903
4455	912	922	931	940	949	959	968	978	988	997
4456	1007	1017	1027	1037	1047	1057	1068	1078	1088	1099
4457	1109	1120	1131	1141	1152	1163	1174	1185	1196	1208
4458	1219	1230	1242	1253	1265	1276	1288	1300	1312	1324
4459	1336	1348	1360	1372	1385	1397	1409	1422	1435	1447

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CAPACITY TABLE IN ACRE FEET — ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4460	1460	1473	1486	1499	1512	1525	1538	1551	1564	1578
4461	1591	1605	1618	1632	1645	1659	1673	1687	1700	1714
4462	1728	1742	1757	1771	1785	1799	1814	1828	1843	1857
4463	1872	1887	1901	1916	1931	1946	1961	1976	1991	2006
4464	2022	2037	2052	2068	2083	2099	2114	2130	2146	2162
4465	2177	2193	2209	2225	2242	2258	2274	2290	2307	2323
4466	2339	2356	2373	2389	2406	2423	2440	2456	2473	2490
4467	2507	2525	2542	2559	2576	2594	2611	2629	2646	2664
4468	2681	2699	2717	2735	2753	2771	2789	2807	2825	2843
4469	2861	2880	2898	2917	2935	2954	2972	2991	3010	3029
4470	3047	3066	3085	3104	3124	3143	3162	3181	3201	3220
4471	3239	3259	3279	3298	3318	3338	3358	3377	3397	3417
4472	3437	3458	3478	3498	3518	3539	3559	3580	3600	3621
4473	3641	3662	3683	3704	3725	3746	3767	3788	3809	3830
4474	3851	3873	3894	3916	3937	3959	3980	4002	4024	4046
4475	4067	4089	4111	4133	4156	4178	4200	4222	4245	4267
4476	4289	4312	4335	4357	4380	4403	4426	4448	4471	4494
4477	4517	4541	4564	4587	4610	4634	4657	4681	4704	4728
4478	4751	4775	4799	4823	4847	4871	4895	4919	4943	4967
4479	4991	5016	5040	5065	5089	5114	5138	5163	5188	5213
4480	5237	5262	5287	5312	5337	5363	5388	5413	5438	5463
4481	5489	5514	5540	5565	5591	5616	5642	5667	5693	5719
4482	5745	5771	5796	5822	5848	5874	5900	5927	5953	5979
4483	6005	6032	6058	6084	6111	6137	6164	6190	6217	6244
4484	6270	6297	6324	6351	6378	6405	6432	6459	6486	6513
4485	6540	6567	6594	6622	6649	6677	6704	6731	6759	6787
4486	6814	6842	6870	6897	6925	6953	6981	7009	7037	7065
4487	7093	7121	7149	7177	7205	7234	7262	7290	7319	7347
4488	7376	7404	7433	7462	7490	7519	7548	7577	7605	7634
4489	7663	7692	7721	7750	7779	7809	7838	7867	7896	7926
4490	7955	7984	8014	8043	8073	8103	8132	8162	8192	8221
4491	8251	8281	8311	8341	8371	8401	8431	8461	8491	8521
4492	8551	8582	8612	8642	8673	8703	8734	8764	8795	8825
4493	8856	8887	8917	8948	8979	9010	9041	9072	9103	9134
4494	9165	9196	9227	9258	9289	9321	9352	9383	9415	9446
4495	9477	9509	9541	9572	9604	9636	9667	9699	9731	9763
4496	9795	9827	9859	9891	9923	9955	9987	10019	10051	10084
4497	10116	10148	10181	10213	10246	10278	10311	10343	10376	10409
4498	10441	10474	10507	10540	10573	10606	10639	10672	10705	10738
4499	10771	10804	10838	10871	10904	10938	10971	11004	11038	11071

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CAPACITY TABLE IN ACRE FEET

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4500	11105	11139	11172	11206	11240	11273	11307	11341	11375	11409
4501	11443	11477	11511	11545	11579	11613	11648	11682	11716	11751
4502	11785	11819	11854	11888	11923	11957	11992	12027	12061	12096
4503	12131	12166	12201	12236	12271	12305	12341	12376	12411	12446
4504	12481	12516	12551	12587	12622	12657	12693	12728	12764	12799
4505	12835	12871	12906	12942	12978	13014	13049	13085	13121	13157
4506	13193	13229	13265	13301	13338	13374	13410	13446	13483	13519
4507	13555	13592	13628	13665	13701	13738	13775	13812	13848	13885
4508	13922	13959	13996	14033	14070	14107	14144	14181	14218	14255
4509	14293	14330	14367	14405	14442	14480	14517	14555	14592	14630
4510	14667	14705	14743	14781	14819	14857	14895	14933	14971	15009
4511	15047	15085	15123	15162	15200	15238	15277	15315	15354	15392
4512	15431	15470	15509	15547	15586	15625	15664	15703	15742	15781
4513	15820	15859	15898	15938	15977	16016	16056	16095	16135	16174
4514	16214	16254	16293	16333	16373	16413	16452	16492	16532	16572
4515	16612	16653	16693	16733	16773	16814	16854	16894	16935	16975
4516	17016	17056	17097	17138	17178	17219	17260	17301	17342	17383
4517	17424	17465	17506	17547	17588	17629	17671	17712	17753	17795
4518	17836	17878	17919	17961	18002	18044	18086	18128	18170	18211
4519	18253	18295	18337	18379	18421	18464	18506	18548	18590	18633
4520	18675	18717	18760	18802	18845	18888	18931	18973	19016	19059
4521	19102	19145	19188	19231	19275	19318	19361	19405	19448	19492
4522	19535	19579	19623	19667	19710	19754	19798	19842	19887	19931
4523	19975	20019	20064	20108	20152	20197	20242	20286	20331	20376
4524	20421	20466	20510	20556	20601	20646	20691	20736	20782	20827
4525	20872	20918	20964	21009	21055	21101	21147	21192	21238	21284
4526	21330	21377	21423	21469	21515	21562	21608	21655	21701	21748
4527	21794	21841	21888	21935	21982	22029	22076	22123	22170	22217
4528	22264	22312	22359	22407	22454	22502	22549	22597	22645	22693
4529	22740	22788	22836	22884	22933	22981	23029	23077	23126	23174
4530	23222	23271	23320	23368	23417	23466	23515	23563	23612	23661
4531	23710	23760	23809	23858	23907	23957	24006	24055	24105	24154
4532	24204	24254	24304	24353	24403	24453	24503	24553	24603	24653
4533	24704	24754	24804	24855	24905	24956	25006	25057	25107	25158
4534	25209	25260	25311	25362	25413	25464	25515	25566	25617	25669
4535	25720	25771	25823	25874	25926	25978	26029	26081	26133	26185
4536	26237	26289	26341	26393	26445	26498	26550	26602	26655	26707
4537	26760	26812	26865	26918	26970	27023	27076	27129	27182	27235
4538	27288	27341	27394	27448	27501	27555	27608	27662	27715	27769
4539	27822	27876	27930	27984	28038	28092	28146	28200	28254	28308

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CAPACITY TABLE IN ACRE FEET — ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4540	28362	28417	28471	28526	28580	28635	28689	28744	28799	28854
4541	28909	28964	29019	29074	29129	29184	29239	29295	29350	29405
4542	29461	29516	29572	29628	29684	29739	29795	29851	29907	29963
4543	30019	30076	30132	30188	30245	30301	30357	30414	30471	30527
4544	30584	30641	30698	30755	30812	30869	30926	30983	31040	31098
4545	31155	31212	31270	31327	31385	31443	31501	31558	31616	31674
4546	31732	31790	31848	31907	31965	32023	32082	32140	32199	32257
4547	32316	32375	32433	32492	32551	32610	32669	32728	32787	32847
4548	32906	32965	33025	33084	33144	33203	33263	33323	33382	33442
4549	33502	33562	33622	33682	33743	33803	33863	33923	33984	34044
4550	34105	34166	34226	34287	34348	34409	34470	34531	34592	34653
4551	34715	34776	34838	34899	34961	35023	35084	35146	35208	35270
4552	35332	35394	35457	35519	35581	35644	35706	35769	35832	35894
4553	35957	36020	36083	36146	36209	36273	36336	36399	36463	36526
4554	36590	36653	36717	36781	36845	36909	36973	37037	37101	37166
4555	37230	37294	37359	37424	37488	37553	37618	37683	37748	37813
4556	37878	37943	38008	38074	38139	38205	38270	38336	38402	38467
4557	38533	38599	38665	38731	38797	38864	38930	38997	39063	39130
4558	39196	39263	39330	39397	39464	39531	39598	39665	39732	39799
4559	39867	39934	40002	40069	40137	40205	40273	40341	40409	40477
4560	40545	40614	40682	40750	40819	40887	40956	41024	41093	41162
4561	41231	41300	41369	41438	41507	41576	41645	41715	41784	41854
4562	41923	41993	42063	42132	42202	42272	42342	42412	42483	42553
4563	42623	42694	42764	42835	42905	42976	43047	43118	43188	43259
4564	43330	43402	43473	43544	43615	43687	43758	43830	43902	43973
4565	44045	44117	44189	44261	44333	44405	44477	44550	44622	44694
4566	44767	44839	44912	44985	45058	45130	45203	45276	45350	45423
4567	45496	45569	45643	45716	45790	45863	45937	46011	46085	46158
4568	46232	46306	46381	46455	46529	46603	46678	46752	46827	46901
4569	46976	47051	47126	47201	47276	47351	47426	47501	47576	47652
4570	47727	47803	47879	47955	48031	48106	48183	48259	48335	48411
4571	48488	48564	48641	48718	48795	48872	48949	49026	49103	49181
4572	49258	49336	49414	49491	49569	49647	49725	49804	49882	49961
4573	50039	50118	50197	50275	50354	50434	50513	50592	50671	50751
4574	50831	50910	50990	51070	51150	51230	51310	51391	51471	51552
4575	51632	51713	51794	51875	51956	52037	52119	52200	52282	52363
4576	52445	52527	52609	52691	52773	52855	52937	53020	53102	53185
4577	53268	53351	53434	53517	53600	53683	53767	53850	53934	54018
4578	54101	54185	54269	54353	54438	54522	54606	54691	54776	54860
4579	54945	55030	55115	55200	55286	55371	55457	55542	55628	55714

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ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4580	55800	55886	55972	56059	56145	56231	56317	56404	56490	56577
4581	56664	56750	56837	56924	57011	57098	57185	57273	57360	57447
4582	57535	57622	57710	57797	57885	57973	58061	58149	58237	58325
4583	58413	58501	58590	58678	58767	58855	58944	59032	59121	59210
4584	59299	59388	59477	59566	59656	59745	59834	59924	60013	60103
4585	60192	60282	60372	60462	60552	60642	60732	60822	60913	61003
4586	61093	61184	61275	61365	61456	61547	61638	61729	61820	61911
4587	62002	62093	62184	62276	62367	62459	62551	62642	62734	62826
4588	62918	63010	63102	63194	63286	63379	63471	63563	63656	63749
4589	63841	63934	64027	64120	64213	64306	64399	64492	64585	64679
4590	64772	64866	64960	65054	65148	65241	65335	65430	65524	65618
4591	65713	65807	65902	65997	66091	66186	66281	66377	66472	66567
4592	66663	66758	66854	66950	67046	67142	67238	67334	67430	67527
4593	67623	67720	67817	67913	68010	68107	68204	68302	68399	68496
4594	68594	68692	68789	68887	68985	69083	69181	69280	69378	69476
4595	69575	69674	69772	69871	69970	70069	70169	70268	70367	70467
4596	70566	70666	70766	70866	70966	71066	71166	71266	71367	71467
4597	71568	71669	71770	71870	71972	72073	72174	72275	72377	72478
4598	72580	72682	72784	72886	72988	73090	73192	73294	73397	73499
4599	73602	73705	73808	73911	74014	74117	74220	74324	74427	74531
4600	74635	74739	74843	74947	75051	75155	75260	75364	75468	75573
4601	75678	75782	75887	75992	76097	76202	76307	76413	76518	76623
4602	76729	76835	76940	77046	77152	77258	77364	77470	77577	77683
4603	77789	77896	78003	78109	78216	78323	78430	78537	78644	78751
4604	78859	78966	79074	79181	79289	79397	79505	79613	79721	79829
4605	79937	80046	80154	80263	80372	80480	80589	80698	80807	80916
4606	81025	81135	81244	81353	81463	81573	81682	81792	81902	82012
4607	82122	82232	82343	82453	82563	82674	82785	82895	83006	83117
4608	83228	83339	83450	83562	83673	83784	83896	84008	84119	84231
4609	84343	84455	84567	84679	84792	84904	85016	85129	85242	85354
4610	85467	85581	85694	85807	85920	86033	86147	86260	86374	86487
4611	86601	86715	86828	86942	87056	87171	87285	87399	87513	87628
4612	87742	87857	87972	88087	88202	88317	88432	88547	88662	88777
4613	88893	89008	89124	89240	89355	89471	89587	89703	89819	89936
4614	90052	90168	90285	90401	90518	90635	90752	90869	90986	91103
4615	91220	91337	91455	91572	91690	91807	91925	92043	92161	92279
4616	92397	92515	92633	92752	92870	92988	93107	93226	93345	93463
4617	93582	93701	93821	93940	94059	94178	94298	94417	94537	94657
4618	94777	94897	95017	95137	95257	95377	95498	95618	95739	95859
4619	95980	96101	96222	96343	96464	96585	96706	96827	96949	97070

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ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
4620	97192	97314	97436	97558	97680	97802	97924	98047	98169	98292
4621	98414	98537	98660	98783	98906	99029	99152	99276	99399	99523
4622	99646	99770	99894	100018	100142	100266	100390	100515	100639	100764
4623	100888	101013	101138	101263	101388	101513	101638	101764	101889	102015
4624	102140	102266	102392	102518	102644	102770	102897	103023	103149	103276
4625	103403	103530	103656	103783	103910	104038	104165	104292	104420	104547
4626	104675	104803	104931	105059	105187	105315	105443	105572	105700	105829
4627	105957	106086	106215	106344	106473	106602	106732	106861	106991	107120
4628	107250	107380	107510	107640	107770	107900	108030	108161	108291	108422
4629	108552	108683	108814	108945	109076	109208	109339	109470	109602	109733
4630	109865	109997	110129	110261	110393	110525	110658	110790	110923	111055
4631	111188	111321	111454	111587	111720	111853	111986	112120	112253	112387
4632	112521	112654	112788	112922	113057	113191	113325	113460	113594	113729
4633	113864	113998	114133	114268	114404	114539	114674	114810	114945	115081
4634	115216	115352	115488	115624	115760	115897	116033	116170	116306	116443
4635	116580	116716	116853	116990	117128	117265	117402	117540	117677	117815
4636	117953	118091	118228	118367	118505	118643	118781	118920	119058	119197
4637	119336	119475	119614	119753	119892	120031	120171	120310	120450	120589
4638	120729	120869	121009	121149	121289	121430	121570	121710	121851	121992
4639	122132	122273	122414	122555	122697	122838	122979	123121	123262	123404
4640	123546	123687	123829	123971	124113	124255	124398	124540	124683	124826
4641	124969	125112	125255	125398	125541	125685	125828	125972	126116	126260
4642	126404	126548	126692	126837	126981	127126	127270	127415	127560	127705
4643	127850	127996	128141	128286	128432	128578	128724	128870	129016	129162
4644	129308	129455	129601	129748	129895	130041	130188	130336	130483	130630
4645	130777	130925	131073	131221	131368	131516	131665	131813	131961	132110
4646	132258	132407	132556	132705	132854	133003	133152	133301	133451	133601
4647	133750	133900	134050	134200	134350	134501	134651	134802	134952	135103
4648	135254	135405	135556	135707	135858	136010	136161	136313	136465	136617
4649	136769	136921	137073	137225	137378	137530	137683	137836	137989	138142
4650	138295	138448	138602	138755	138909	139063	139217	139371	139525	139680
4651	139834	139989	140144	140299	140454	140610	140765	140921	141077	141233
4652	141389	141545	141701	141858	142014	142171	142328	142485	142643	142800
4653	142958	143115	143273	143431	143589	143748	143906	144065	144223	144382
4654	144541	144701	144860	145019	145179	145339	145499	145659	145819	145979
4655	146140	146301	146461	146622	146783	146944	147105	147266	147427	147588
4656	147749	147910	148072	148233	148394	148556	148717	148879	149041	149202
4657	149364	149526	149688	149850	150012	150174	150336	150498	150660	150823
4658	150985	151147	151310	151472	151635	151798	151960	152123	152286	152449
4659	152612	152775	152938	153101	153264	153428	153591	153754	153918	154081
4660	154245									

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EXHIBIT VI

PACTOLA OPERATIONS, MAINTENANCE, AND REPAIR AGREEMENT

RECLAMATION AND THE CITY OF RAPID CITY, SD

PACTOLA DAM AND RESERVOIR

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

AGREEMENT FOR THE TRANSFER OF OPERATION, MAINTENANCE, AND REPLACEMENT OF PROJECT WORKS BETWEEN THE UNITED STATES AND THE CITY OF RAPID CITY, SOUTH DAKOTA

RAPID VALLEY UNIT
CHEYENNE DIVISION
PICK-SLOAN MISSOURI BASIN PROGRAM, SOUTH DAKOTA

THIS AGREEMENT made this 31st day of July, 2007, between the UNITED STATES OF AMERICA, hereinafter called the "United States" acting through the Secretary of the Interior pursuant generally to the Act of June 17, 1902 (32 Stat. 388), and acts amendatory or supplementary thereto, particularly Section 5 of the Reclamation Extension Act of August 13, 1914 (38 Stat. 687), and Subsection G of the Fact Finders' Act of December 5, 1924 (Section 4 of the Second Deficiency Act, Fiscal Year 1924) (43 Stat. 702), collectively referred to as the Federal Reclamation laws, and Rapid City, South Dakota, hereinafter called the "City". The United States and the City hereinafter are referred to collectively as the "Parties" or "Party".

WITNESSETH, THAT:

The following statements are made in explanation:

EXPLANATORY RECITALS

a. WHEREAS, the United States constructed the Rapid Valley Unit (Unit) of the Pick-Sloan Missouri Basin Program (P-SMBP), South Dakota, which includes Pactola Dam and Reservoir, pursuant to the Act of December 22, 1944 (58 Stat. 887), as set forth in House

Document 475 and Senate Document 191, as revised and coordinated by Senate Document 247, 78th Congress, Second Session, for irrigation, municipal and industrial uses, fish and wildlife, recreation, and flood control; and

b. WHEREAS, the United States and the City have entered into Contract No. 079D620102, dated 2007 hereinafter called the "existing contract" for the furnishing of a Project water supply and for repayment and Operation, Maintenance and Replacement (OM&R) of the Unit water supply; and

c. WHEREAS, the OM&R responsibility of the Project Works of the Unit has been transferred to the City; and

d. WHEREAS, the OM&R functions for both Deerfield Dam and Reservoir and Pactola Dam and Reservoir were temporarily transferred to the City by Cooperative Agreement No. 5-FC-60-05570 dated March 20, 1995. This Agreement supersedes and replaces the portion of Cooperative Agreement No. 5-FC-60-05570 that deals with OM&R functions for Pactola Dam and Reservoir. OM&R functions for Deerfield Dam are explained in Contract No. Ilr-1413 among the United States, the City and Rapid Valley Water Conservancy District (District).

e. WHEREAS, the Parties herein wish to enter into this Agreement to formally transfer the responsibility for the OM&R of the water supply works of the Unit to the City and to clarify the specific responsibilities of the Parties; and

f. WHEREAS, this Agreement will supersede and replace any prior agreements between the Parties relating to the OM&R of the Unit; and

g. WHEREAS, the United States is responsible for complying with all applicable Federal laws and regulations and Reclamation policies and instructions existing, or hereinafter enacted or promulgated, including but not limited to, Environmental laws and cultural resource regulations concerning Federal Project lands, Project waters, or Project Works.

NOW, THEREFORE, in consideration of the mutual and dependent covenants herein contained, it is hereby mutually agreed as follows:

GENERAL DEFINITIONS

1. Where used in this Agreement, the terms:

a. "City" or "Contractor" shall mean the City of Rapid City, South Dakota.

b. "Environmental laws and cultural resource regulations" include all applicable Federal and State laws, statutes, and regulations enacted for the purpose of protecting the quality of the environment, including but not limited to, the National Environmental Policy Act (NEPA), Endangered Species Act (ESA), National Historic Preservation Act, Archaeological Resources Protection Act, Native American Graves Protection and Repatriation Act, Clean Water Act, and others.

c. "Federal Reclamation Laws" shall mean the Act of June 17, 1902 (32 Stat. 388), and all acts amendatory thereof and supplementary thereto.

d. "OM&R costs" shall mean all expenses incurred in connection with the water control, and OM&R of the Project Works, including appropriate charges for associated indirect costs and administration as determined by the Contracting Officer, and shall include such additional costs as hereinafter provided. Such expenses shall include those required to remedy conditions brought about by ordinary use of the Project Works or to restore or replace components of the existing Project water facilities, and shall not include expenses to increase or enlarge such works beyond the purposes for which they were originally authorized and constructed.

e. "Project" shall mean the Unit, Cheyenne Division, P-SMBP, South Dakota.

f. "Project Works or Transferred Works" shall mean shall mean Pactola Dam and Reservoir.

g. "Secretary" or "Contracting Officer" shall mean the Secretary of the United States Department of the Interior, or the Secretary's duly authorized representative.

h. "Year" shall mean the period January 1 through the following December 31.

EFFECTIVE DATE

2. This Agreement shall become effective upon the date it is signed, and on that date shall supersede and replace the portion of Cooperative Agreement No. 5-FC-60-05570 or the portion of any other prior agreements relating to the OM&R of the Project Works; *Provided, That* this Agreement may be terminated at any time by written notification of either Party at least twelve months in advance of termination.

CITY'S RESPONSIBILITIES

3. a. The City shall be responsible for the OM&R of the Project Works which are transferred herein and any additional work items requested by the United States and within the City's capabilities including, but not limited to:

(1) The listing of normal duties and responsibilities for the Project Works as provided in Exhibit A, attached hereto and by this reference made a part hereof. Exhibit A may be periodically revised or amended upon mutual agreement of both Parties hereto.

(2) Maintenance of the Project Works shall be performed in accordance with standard practice for maintenance of irrigation and drainage systems and in such a manner that the facilities are capable of efficiently delivering water to the City and other users upon demand.

b. The City shall comply with all applicable Federal, State, and local laws and Federal regulations and Reclamation policies and instructions existing, or hereafter enacted or promulgated, including but not limited to Environmental and cultural resource regulations concerning Federal Project lands, Project waters, or Project Works.

c. The City shall annually submit, before January 31 of each Year, an OM&R work plan, which lists all planned major or extraordinary maintenance activities as well as anticipated standard or routine activities of the City on the Project Works, the anticipated or estimated start date for these planned activities, and an estimated schedule of the OM&R costs that will be incurred in the upcoming Year. The City may request the United States to verify those items on the estimated schedule of the OM&R costs that the United States shall reimburse. Upon receipt, the United States will review the OM&R work plan and schedule of the OM&R costs within 30 days. Shortly thereafter, the United States will discuss with the City the activities that will require additional information and/or work activities to comply with Federal, State, and local laws and regulations and Reclamation policies and instructions existing, or hereafter enacted or promulgated. The United States will be the responsible party to see that the appropriate actions are taken to ensure compliance with Federal law.

d. The OM&R of the Project Works that is transferred herein will be accomplished in accordance with: sound engineering and OM&R practices; the "Standing Operating Procedures" (SOP), which is a living document that defines the operations of the Dam and Reservoir and may be updated periodically; the requirements contained in Exhibit A; and any other special written instructions prepared by the United States and accompanied by this Agreement or provided to the City at any time during the term of this Agreement. All OM&R shall be accomplished in full compliance with the terms of this Agreement and in such a manner that the Project Works remain in good condition suitable for the efficient storage, regulation, and delivery of water.

e. The United States may require certain City personnel to successfully complete a background investigation. The United States will administer the background investigation and determine the results. The United States may also require City personnel that will have access to

restricted information and documents to certify acknowledgement of responsibility and instructions for handling and safeguarding the restricted documents entrusted to them. Additionally, when deemed necessary, the United States may require that certain City personnel receive a security clearance from the United States. The City agrees to cooperate with the United States in this effort. The City further agrees that successfully completing a background investigation, certifying acknowledgement of responsibility and instructions for handling and safeguarding restricted documents, and if deemed necessary, maintaining a United States security clearance, will be a requirement of continued employment with the City for positions which the United States determines such requirements are necessary.

f. Certain documents, including but not limited to documents relating to the coordination of planning, design, construction, and OM&R processes for the Project Works, may contain information considered to be "security sensitive" and it will be necessary for the City to appropriately safeguard the information. These documents, or copies of them, will therefore be intended for the City's use only and will not be distributed to any other entities without the prior written consent and approval of the United States.

UNITED STATES RESPONSIBILITIES

4. a. The United States will retain the responsibility for such items of work as are not within the City's capabilities on the Project Works.

b. Upon receipt of the OM&R work plan, the United States will review the plan within 30 days. Shortly thereafter, the United States will discuss with the City the activities that will require additional information and/or work activities to comply with Federal, State, and local laws and regulations and Reclamation policies and instructions existing, or hereafter enacted or promulgated. The United States will be the responsible Party to see that the appropriate actions are taken to ensure compliance with Federal law and will provide the City with any special written instructions for the compliance responsibilities.

OPERATION AND MAINTENANCE COSTS

5. a. The OM&R costs covered by the provisions of this Agreement shall be defined as including all the expenses of whatsoever kind or nature in connection with, growing out of, or resulting from the OM&R of the Project Works. Such costs shall include, but not be limited to direct costs of labor and fringe benefits, materials and supplies, travel, equipment depreciation, and all other appropriate overhead and items or services purchased directly for OM&R. Indirect costs charged to the OM&R shall be those normal and necessary administrative and general expenses incurred by the United States as are chargeable to such works in the opinion of the Secretary. The City may also include those normal and necessary administrative and general expenses incurred by the City that are equitably allocable to the performance of OM&R activities pursuant to this Agreement.

b. The OM&R costs of the Project Works shall be shared by the United States and the City based on the current "Allocation of OM&R Expenses". This allocation may be modified by the United States as studies are performed that indicate such modifications are warranted. Subject to appropriations, the United States shall reimburse to the City a share of the OM&R costs incurred by the City which the United States would have incurred had the United States been performing the OM&R. The City shall provide the United States on or before April 1 of each year the schedule of actual costs incurred for the previous calendar year. The United States shall annually review the City's OM&R costs and shall reimburse to the City the United States' share of the approved portion of the City's OM&R costs within 60 days upon receipt of the schedule of actual costs.

c. The City shall provide the equipment necessary to perform its OM&R duties under this Agreement in whichever manner is most cost effective; *Provided, That* any and all equipment, except in the case of an emergency, with a purchase price over $10,000 or a total rental or lease payment in excess of $10,000 for which the City will seek reimbursement from the United States shall be included in the annual estimated schedule of costs as required pursuant to Subarticle 3c., above. In the event of an emergency, the City will seek verbal approval by the

United States with written approval following the emergency. The Parties hereto shall mutually agree on the most cost effective manner to acquire the use of such equipment.

ENVIRONMENTAL AND CULTURAL RESOURCES

6. a. To ensure that compliance activities for environmental and cultural resources are completed by the United States in a timely manner, the City shall provide notification to the United States of its planned OM&R activities in the annual OM&R work plan as required pursuant to Subarticle 3c., above. If the City undertakes an unplanned and unforeseen OM&R activity in response to emergency conditions the City shall then notify the United States if time is available before taking action; but in no case later than 48 hours after taking the emergency action. Emergency conditions are defined as sudden occurrences that would not normally develop over a period of weeks and involve imminent loss of life or property. For major or extraordinary activities that are unplanned and not emergencies, the City will give the United States as much notice as possible so that any required environmental compliance can be completed by the United States prior to the action being undertaken.

b. The City shall immediately provide an oral notification to the United States of any discovery of human remains or a Native American cultural item within the Project. The City shall forward a written report of its findings to the United States within 48 hours by certified mail. The City shall cease activity, stabilize, and protect such discoveries until authorized to proceed by the United States. Protective and mitigative measures specified by the United States and provided to the City as special written instructions shall be the responsibility of the City. The City is the responsible Party to see that any subcontractor abide by these measures.

c. The City shall exercise care so as not to disturb or damage any cultural resources discovered during the performance of its duties under this Agreement, and shall provide such cooperation and assistance as may be necessary to preserve the findings for removal or other disposition by the United States. The City shall not resume work in the area of a discovery until written notice to proceed is received from the United States.

STANDARD CONTRACT ARTICLES

OPERATION AND MAINTENANCE OF TRANSFERRED WORKS-- PAYMENT OF MISCELLANEOUS COSTS

7. a. The OM&R functions for Pactola Dam and Reservoir and associated facilities have been transferred to the City by Cooperative Agreement No. 5-FC-60-05570 (OM&R Agreement) dated March 20, 1995. The Agreement supersedes and replaces the portion of Cooperative Agreement No. 5-FC-60-05570 that deals with OM&R functions for Pactola Dam and Reservoir. Title to the Transferred Works will remain in the name of the United States, unless otherwise provided by the Congress of the United States.

b. The City, without expense to the United States except as provided in this Agreement, shall OM&R the Transferred Works in full compliance with the terms of this Agreement and in a manner that the Transferred Works remain in good and efficient condition.

c. Necessary repairs of the Transferred Works shall be made promptly by the City. In case of unusual conditions or serious deficiencies in the care, operation, and maintenance of the Transferred Works threatening or causing interruption of water service, the Contracting Officer may issue to the City a special written notice of those necessary repairs. Except in the case of an emergency, the City will be given 60 days to either make the necessary repairs or submit a plan for accomplishing the repairs acceptable to the Contracting Officer. In the case of an emergency, or if the City fails to either make the necessary repairs or submit a plan for accomplishing the repairs acceptable to the Contracting Officer within 60 days of receipt of the notice, the Contracting Officer may cause the repairs to be made, and the cost of those repairs shall be paid by the City as directed by the Contracting Officer.

d. The City shall not make any substantial changes in the Transferred Works without first obtaining written consent of the Contracting Officer. The City shall ensure that no unauthorized encroachment occurs on project land and rights-of-way.

e. The City agrees to indemnify the United States for, and hold the United States and all of its representatives harmless from, all damages resulting from suits, actions, or claims of any character brought on account of any injury to any person or property arising out of any act, omission, neglect, or misconduct in the manner or method of performing any construction, care, operation, maintenance, supervision, examination, inspection, or other duties of the City or the United States on Transferred Works required under this Agreement, regardless of who performs those duties. The City does not agree to indemnify the United States for any damages arising from intentional torts or malicious actions committed by employees of the United States.

f. The City shall cooperate with the Contracting Officer in implementing an effective safety of dam program. The United States agrees to provide the City and the appropriate agency of the State of South Dakota with design data, designs, and an operating plan for the dam and related facilities consistent with the current memorandum of understanding between the United States and the State of South Dakota relating to the coordination of planning, design, construction, operation, and maintenance processes for dams and related facilities.

g. In the event the City is found to be operating the Transferred Works or any part thereof in violation of this Agreement or the City is found to be failing any financial commitments or other commitments to the United States under the terms and conditions of this Agreement, then upon the election of the Contracting Officer, the United States may take over from the City the care, operation, and maintenance of the Transferred Works by giving written notice to the City of such election and the effective date thereof. Thereafter, during the period of operation by the United States, upon notification by the Contracting Officer the City shall pay to the United States, annually in advance, the cost of operation and maintenance of the works as determined by the Contracting Officer. Following written notification from the Contracting Officer the care, operation, and maintenance of the works may be transferred back to the City.

h. In addition to all other payments to be made by the City under this Agreement, the City shall reimburse to the United States, following the receipt of a statement from the Contracting Officer, all miscellaneous costs incurred by the United States for any work involved in the administration and supervision of this Agreement.

EXAMINATION, INSPECTION, AND AUDIT OF PROJECT WORKS, RECORDS, AND REPORTS FOR DETERMINING ADEQUACY OF OPERATION AND MAINTENANCE

8. a. The Contracting Officer may from time to time, examine the following: the City's books, records, and reports; the Project Works being operated by the City; the adequacy of the operation, maintenance, and safety of dams programs; the reserve fund; and the water conservation program including the water conservation fund, if applicable. Notwithstanding title ownership, where the United States retains a financial, physical, or liability interest in facilities either constructed by the United States or with funds provided by the United States, the Contracting Officer may examine any or all of the Project Works providing such interest to the United States.

b. The Contracting Officer may or the City may request the Contracting Officer to, conduct special inspections of any Project Works being operated by the City and special audits of the City's books and records to ascertain the extent of any operation and maintenance deficiencies to determine the remedial measures required for their correction and to assist the City in solving specific problems. Except in an emergency, any special inspection or audit shall be made only after written notice thereof has been delivered to the City by the Contracting Officer.

c. The City shall provide access to the Project Works, operate any mechanical or electrical equipment, and be available to assist in the examination, inspection, or audit.

d. The Contracting Officer shall prepare reports based on the examinations, inspections, or audits and furnish copies of such reports and any recommendations to the City.

e. The costs incurred by the United States in conducting operation and maintenance examinations, inspections, and audits and preparing associated reports and recommendations related to high- and significant hazard dams and associated facilities shall be nonreimbursable. Associated facilities include carriage, distribution, and drainage systems; pumping and pump-generating plants; powerplant structures; tunnels/pipelines; diversion and storage dams (low hazard); Type 2 bridges which are Reclamation-owned bridges not located on a public road; regulating reservoirs (low hazard); fish passage and protective facilities, including hatcheries; river channelization features; rural/municipal water systems; desalting and other water treatment plants; maintenance buildings and service yards; facilities constructed under Federal loan programs (until paid out); and recreation facilities (reserved works only); and any other facilities as determined by the Contracting Officer.

f. Expenses incurred by the City, as applicable, in participating in the operation and maintenance site examination will be borne by the City.

g. Requests by the City for consultations, design services, or modification reviews, and the completion of any operation and maintenance activities identified in the formal recommendations resulting from the examination (unless otherwise noted) are to be funded as Project operation and maintenance and are reimbursable by the City to the extent of current Project operation and maintenance allocations.

h. Site visit special inspections that are beyond the regularly scheduled operation and maintenance examinations conducted to evaluate a particular concern(s) or problem(s) and provide assistance relative to any corrective action (either as a follow up to an operation maintenance examination or when requested by the City) shall be nonreimbursable.

i. The Contracting Officer may provide the State an opportunity to observe and participate in, at its own expense, the examinations and inspections. The State may be provided copies of reports and any recommendations relating to such examinations and inspections.

NOTICES

9. Any notice, demand, or request authorized or required by this Agreement shall be deemed to have been given, on behalf of the City, when mailed, postage prepaid, or delivered to the:

Regional Director
Bureau of Reclamation
Great Plains Region
P.O. Box 36900
Billings, MT 59107-6900

and on behalf of the United States, when mailed, postage prepaid, or delivered to the:

City of Rapid City
300 Sixth Street
Rapid City, SD 57701

The designation of the addressee or the address may be changed by notice given in the same manner as provided in this Article for other notices.

CONTINGENT UPON APPROPRIATION OR ALLOTMENT OF FUNDS

10. The expenditure or advance of any money or the performance of any obligation of the United States under this Agreement shall be contingent upon appropriation or allotment of funds. Absence of appropriation or allotment of funds shall not relieve the City from any obligations under this Agreement. No liability shall accrue to the United States in case funds are not appropriated or allotted.

OFFICIALS NOT TO BENEFIT

11. No Member of or Delegate to the Congress, Resident Commissioner, or official of the City shall benefit from this Agreement other than as a water user or landowner in the same manner as other water users or landowners.

ASSIGNMENT LIMITED--SUCCESSORS AND ASSIGNS OBLIGATED

12. The provisions of this Agreement shall apply to and bind the successors and assigns of the Parties hereto, but no assignment or transfer of this Agreement or any right or interest therein by either party shall be valid until approved in writing by the other Party.

BOOKS, RECORDS, AND REPORTS

13. The City shall establish and maintain accounts and other books and records pertaining to administration of the terms and conditions of this Agreement, including: the City's financial transactions; water supply data; project operation, maintenance, and replacement logs; project land and rights-of-way use agreements; the water users' land-use (crop census), land-ownership, land-leasing, and water-use data; and other matters that the Contracting Officer may require. Reports shall be furnished to the Contracting Officer in such form and on such date or dates as the Contracting Officer may require. Subject to applicable Federal laws and regulations, each party to this Agreement shall have the right during office hours to examine and make copies of the other Party's books and records relating to matters covered by this Agreement.

ADMINISTRATION OF FEDERAL PROJECT LANDS

14. a. The lands and interests in lands acquired, withdrawn, or reserved and needed by the United States for the purposes of care, operation, and maintenance of Federal Project Works may be used by the City for such purposes. The City shall ensure that no unauthorized encroachment occurs on Federal project lands and rights-of-way. The City does not have the

authority to issue any land-use agreement or grant that conveys an interest in Federal real property, nor to lease or dispose of any interest of the United States.

b. The City may, subject to the written approval of the Contracting Officer, issue permits, licenses, or similar land use documents only to the extent they do not grant an interest in Federal real property.

PROTECTION OF WATER AND AIR QUALITY

15. a. Project facilities used to make available and deliver water to the City shall be operated and maintained in the most practical manner to maintain the quality of the water at the highest level possible as determined by the Contracting Officer: *Provided, That* the United States does not warrant the quality of the water delivered to the City and is under no obligation to furnish or construct water treatment facilities to maintain or improve the quality of water delivered to the City.

b. The City shall comply with all applicable water and air pollution laws and regulations of the United States and the State of South Dakota; and shall obtain all required permits or licenses from the appropriate Federal, State, or local authorities necessary for the delivery of water by the City; and shall be responsible for compliance with all Federal, State, and local water quality standards applicable to surface and subsurface drainage and/or discharges generated through the use of Federal or City facilities or project water provided by the City within the City's Project Water Service Area.

c. This Article shall not affect or alter any legal obligations of the Secretary to provide drainage or other discharge services.

CONTAMINATION OR POLLUTION OF FEDERAL PROPERTY

16. a. The City shall not allow contamination or pollution of Federal Project lands, Project waters, or Project Works of the United States or administered by the United States and

for which the City has the responsibility for care, operation, and maintenance by its employees or agents. The City shall also take reasonable precautions to prevent such contamination or pollution by third parties.

b. The City shall comply with all applicable Federal, State, and local laws and regulations, and Reclamation policies and instructions existing, or hereafter enacted or promulgated, concerning any hazardous material that will be used, produced, transported, stored, or disposed of on or in Federal Project lands, Project waters, or Project Works.

c. "Hazardous material" means any substance, pollutant, or contaminant listed as hazardous under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 U.S.C. § 9601, *et seq.*, and the regulations promulgated pursuant to that Act. In addition, hazardous material shall include thermal pollution, refuse, garbage, sewage effluent, industrial waste, petroleum products, mine tailings, mineral salts, misused pesticides, pesticide containers, or any other pollutants.

d. Upon discovery of any event which may or does result in contamination or pollution of Federal Project lands, Project water, or Project Works, the City shall initiate emergency measures to protect health and safety and the environment if necessary, and shall report such discovery with full details of the actions taken to the Contracting Officer. Reporting shall be within a reasonable time period but shall not exceed 24 hours from the time of discovery if it is an emergency and the first working day if it is a nonemergency.

e. If violation of the provisions of this Article occurs and the City does not take immediate corrective action as determined by the Contracting Officer, the City may be subject to remedies imposed by the Contracting Officer, which may include termination of this Agreement.

f. The City shall be liable for the cost of full and complete remediation and/or restoration of any Federal Project lands, Project waters, or Project Works that are adversely affected as a result of such violation, and/or termination of this Agreement, unless otherwise agreed to by the Contracting Officer.

g. Reclamation agrees to provide information necessary for the City, using reasonable diligence, to comply with the provisions of this Article.

EQUAL EMPLOYMENT OPPORTUNITY

17. During the performance of this Agreement, the City agrees as follows:

a. The City will not discriminate against any employee or applicant for employment because of race, color, religion, sex, disability, or national origin. The City will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex, disability, or national origin. Such action shall include, but not be limited to the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The City agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Contracting Officer setting forth the provisions of this nondiscrimination clause.

b. The City will, in all solicitations or advertisements for employees placed by or on behalf of the City, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, disability, or national origin.

c. The City will send to each labor union or representative of workers with which it has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the Contracting Officer, advising the labor union or workers' representative of the City's commitments under Section 202 of Executive Order 11246 of September 24, 1965, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

d. The City will comply with all provisions of Executive Order No. 11246 of September 24, 1965, and of the rules, regulations, and relevant orders of the Secretary of Labor.

e. The City will furnish all information and reports required by Executive Order 11246 of September 24, 1965, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the Contracting Agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

f. In the event of the City's noncompliance with the nondiscrimination clauses of this Agreement or with any of such rules, regulations, or orders, this Agreement may be canceled, terminated, or suspended in whole or in part and the City may be declared ineligible for further Government contracts in accordance with procedures authorized in Executive Order 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in Executive Order 11246 of September 24, 1965, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

g. The City will include the provisions of paragraphs (a) through (g) in every subcontract or purchase order unless exempted by the rules, regulations, or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. The City will take such action with respect to any subcontract or purchase order as may be directed by the Secretary of Labor as a means of enforcing such provisions, including sanctions for noncompliance: *Provided, however,* that in the event the City becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction, the City may request the United States to enter into such litigation to protect the interests of the United States.

COMPLIANCE WITH CIVIL RIGHTS LAWS AND REGULATIONS

18. a. The City shall comply with Title VI of the Civil Rights Act of 1964 (42 U.S.C. 2000d), Section 504 of the Rehabilitation Act of 1973 (P.L. 93-112, as amended), the Age Discrimination Act of 1975 (42 U.S.C. 6101, *et seq.*), Title II of the Americans with Disabilities Act of 1990, and any other applicable civil rights laws, as well as with their respective implementing regulations and guidelines imposed by the U.S. Department of the Interior and/or Bureau of Reclamation.

b. These statutes require that no person in the United States shall be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving financial assistance from the Bureau of Reclamation on the grounds of race, color, national origin, disability, or age. By executing this Agreement, the City agrees to immediately take any measures necessary to implement this obligation, including permitting officials of the United States to inspect premises, programs, and documents.

c. The City makes this Agreement in consideration of and for the purpose of obtaining any and all Federal grants, loans, contracts, property discounts, or other Federal financial assistance extended after the date hereof to the City by the Bureau of Reclamation, including installment payments after such date on account of arrangements for Federal financial assistance which were approved before such date. The City recognizes and agrees that such Federal assistance will be extended in reliance on the representations and agreements made in this Article and that the United States reserves the right to seek judicial enforcement thereof.

d. Complaints of discrimination against the City shall be investigated by the Contracting Officer's Office of Civil Rights.

RELOCATION ASSISTANCE AND REAL PROPERTY ACQUISITION

19. When acquiring land or an interest in land and relocating persons or personal property in connection with the construction, operation, and maintenance of Project facilities, the

City shall comply with the provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (84 Stat. 1894) and Department of Transportation regulations (49 CFR Part 24).

PEST MANAGEMENT

20. The City shall take appropriate steps to prevent the introduction and spread of, and to otherwise control undesirable plants and animals, as defined by the Contracting Officer, on Federal Project lands, Project waters, and Project Works for which the City has operation and maintenance responsibility. The City is responsible for inspecting its vehicles and equipment for reproductive and vegetative parts, foreign soil, mud or other debris that may cause the spread of weeds, invasive species and other pests, and for removing such materials before moving its vehicles and equipment onto any Federal land or out of any area on Federal project land where work is performed. Where decontamination is required prior to entering Federal project land, it shall be performed at the point of prior use, or at an approved offsite facility able to process generated cleaning wastes. Upon the completion of work, decontamination shall be performed within the work area before the vehicles and equipment are removed from Federal Project lands. Programs for the control of these undesirable plants and animals on Federal Project lands, Project waters, and Project Works for which the City has operation and maintenance responsibility will incorporate Integrated Pest Management (IPM) concepts and practices. IPM refers to a systematic and environmentally compatible program to maintain pest populations within economically and environmentally tolerable levels. In implementing an IPM program, the City will adhere to applicable Federal and State laws and regulations, and Department of the Interior and Bureau of Reclamation policies, directives, guidelines, and manuals.

CLEAN AIR AND WATER

21. a. The City agrees as follows:

1. To comply with all the requirements of Section 114 of the Clean Air Act, as amended (42 U.S.C. 1857, *et seq.*, as amended by Public Law 91-604), and Section 308 of the Federal Water Pollution Control Act (33 U.S.C. 1251 *et seq.*, as amended by Public

Law 92-500), respectively, relating to inspection, monitoring, entry, reports, and information, as well as other requirements specified in Section 114 of the Air Act and Section 308 of the Water Act, respectively, and all regulations and guidelines issued thereunder before the execution of this Agreement.

2. That no portion of the work required by this Agreement will be performed in a facility listed on the Environmental Protection Agency List of Violating Facilities on the date when this Agreement was executed unless and until the Environmental Protection Agency eliminates the name of such facility or facilities from such listing.

3. To use its best efforts to comply with clean air standards and clean water standards at the facility where the contract work is being performed.

4. To insert the substance of the provisions of this Article into any nonexempt subcontract, including this paragraph (a)(4).

b. The terms used in this article have the following meanings:

1. The term "Air Act" means the Clean Air Act, as amended (42 U.S.C. 1857 *et seq.*, as amended by Public Law 91-604).

2. The term "Water Act" means the Federal Water Pollution Control Act, as amended (33 U.S.C. 1251 *et seq.*, as amended by Public Law 92-500).

3. The term "clean air standards" means any enforceable rules, regulations, guidelines, standards, limitations, orders, controls, prohibitions, or other requirements which are contained in, issued under, or otherwise adopted pursuant to the Air Act or Executive Order 11738, an applicable implementation plan as described in Section 110(d) of the Air Act (42 U.S.C. 1857c-5(d)), an approved implementation procedure or plan under Section 111(c) or Section 111(d), respectively, of the Air Act (42 U.S.C. 1857c-6(c) or (d)), or an approved implementation procedure under Section 112(d) of the Air Act (42 U.S.C. 1857c-7(d)).

4. The term "clean water standards" means any enforceable limitation, control, condition, prohibition, standard, or other requirement which is promulgated pursuant to the Water Act or contained in a permit issued to a discharger by the Environmental Protection Agency or by a state under an approved program, as authorized by Section 402 of the Water Act (33 U.S.C. 1342), or by local government to ensure compliance with pretreatment regulations as required by Section 307 of the Water Act (33 U.S.C. 1317).

5. The term "comply" means compliance with clean air or water standards. Comply shall also mean compliance with a schedule or plan ordered or approved by a court of competent jurisdiction, the Environmental Protection Agency, or an air or water pollution control agency in accordance with the requirements of the Air Act or Water Act and regulations issued pursuant thereto.

6. The term "facility" means any building, plant, installation, structure, mine, vessel or other floating craft, location, or site of operations owned, leased, or supervised by a City or subcontractor to be utilized in the performance of a contract or subcontract. Where a location or site of operations contains or includes more than one building, plant, installation, or structure, the entire location or site shall be deemed to be a facility except where the Director, Office of Federal Activities, Environmental Protection Agency, determines that independent facilities are collocated in one geographical area.

MEDIUM FOR TRANSMITTING PAYMENTS

23. a. All payments from the City to the United States under this Agreement shall be the medium requested by the United States on or before the date payment is due. The required method of payment may include checks, wire transfers, or other types of payment specified by the United States.

b. Upon execution of this Agreement, the City shall furnish the Contracting Officer with the City's taxpayer identification number (TIN). The purpose for requiring the

EXHIBIT A

The following is a listing of the duties and responsibilities to be accomplished by the City as such duties and responsibilities relate to the Operation, Maintenance and Replacement (OM&R) Transfer Agreement No. 07XX620102 dated July 31, 2007. This listing has many of the requirements of the Standing Operating Procedures (SOP) for Pactola Dam and Reservoir and any requirements not included in this list but delineated in the SOP shall be considered part of this list by reference. The Parties shall annually, or as otherwise agreed, review this list and may amend it at any time by mutual agreement.

A. Pactola Dam and Reservoir

The City shall:

- OM&R Pactola Dam in accordance with the SOP. Review the SOP annually, and if needed, provide written comments to the lead engineer in the Facility OM&R Division, Dakotas Area Office.

- Attend Reclamation's Dam Operator classroom training every three years, and onsite Dam Operator training every six years, or prior to placing a newly hired City Dam Operator on duty.

- Participate in Annual Site Inspections, Periodic Facility Reviews, and Comprehensive Facility Reviews. Prepare a schedule for timely completion of recommendations contained in inspection reports and provide this schedule in writing to the lead engineer in the Facility OM&R Division, Dakotas Area Office. Update this schedule annually to provide information on completion of recommendations and the status of incomplete recommendations.

- Provide facility surveillance in accordance with Reclamation security guidelines and threat condition response measures and report suspicious activities to the United States in accordance with written instructions.

- Participate in Emergency Action Plan (EAP) Exercises. Review the EAP annually and if needed provide written comments to the lead engineer in the Facility OM&R Division, Dakotas Area Office.

- Provide and pay for utilities (electricity, water, telephone and gas).

- Grade and maintain roads at the dam.

- Regulate water releases through the outlet works as directed.

- Operate and maintain or assist in the maintenance of reservoir level gauging equipment, water flow recording equipment, and associated electronic data collection and transmission equipment.

- Exercise, repair, and maintain mechanical equipment as required by the SOP for Pactola Dam.

- Spray or otherwise control noxious weeds, trees, and other vegetation on upstream and downstream slopes of Pactola Dam.

- Inspect reservoir shoreline for evidence of trespass or unusual erosion. Inspect for slope movement or unusual significant increase in seepage associated with Pactola Dam.

- Read, record, and report instrumentation data as required in Reclamation Form L-23. Perform ongoing visual inspections and report results to Rapid City Field Office as required in Reclamation Form L-23.

- Repair minor erosion or slough areas.

- Perform dam operator duties as outlined in and at the frequency specified in the SOP for Pactola Dam.

- Inspect the outlet works and the 10 inch bypass pipe. Annually clean the weep holes in the outlet works.

- Annually exercise the emergency and regulating gates and the 10 inch bypass pipe valve.

- Perform elevator inspections as required.

- Annually exercise the gates on the 6 bay check structures at the outlet of the spillway plunge pool. The City will operate and maintain both check structures, however any maintenance costs incurred will be borne by the Bureau of Reclamation. (Note: The check structure was installed to maintain flows to Rapid Creek for the fishery so maintenance costs of the structure are not the responsibility of the City.

- As directed by Reclamation, provide monthly and annual water accounting reports on use of water from Pactola by the City, Reclamation, and the District.

Residence and Shop

- Furnish materials and maintain the buildings and equipment in their current condition, less normal wear and tear.

- Make the Damtender's office, shop, and storage space available for any Reclamation employees that are temporarily working at this area. The City will provide heat, lights, and all other utilities, maintenance, repair, and upkeep.

- Complete improvements to or replacements of buildings or equipment as mutually agreed upon.

- Remove trash and litter.

- Spray or otherwise control noxious weeds, trees, and other vegetation.

Operations Area - See Map Attached

- Repair and generally maintain existing fences in the operations area. This includes posts, gates, and other access control features areas including security fences and gates.

- Blade, replace gravel, and otherwise maintain interior roads and storage areas.

- Mow below dam and roadways as needed during summer months and remove snow from roads, walkways, and access areas during winter months.

Personnel Requirements

- Report to Reclamation's Rapid City Field Office any unusual events (vandalism, accidents, security related, etc.) as indicated in the SOP.

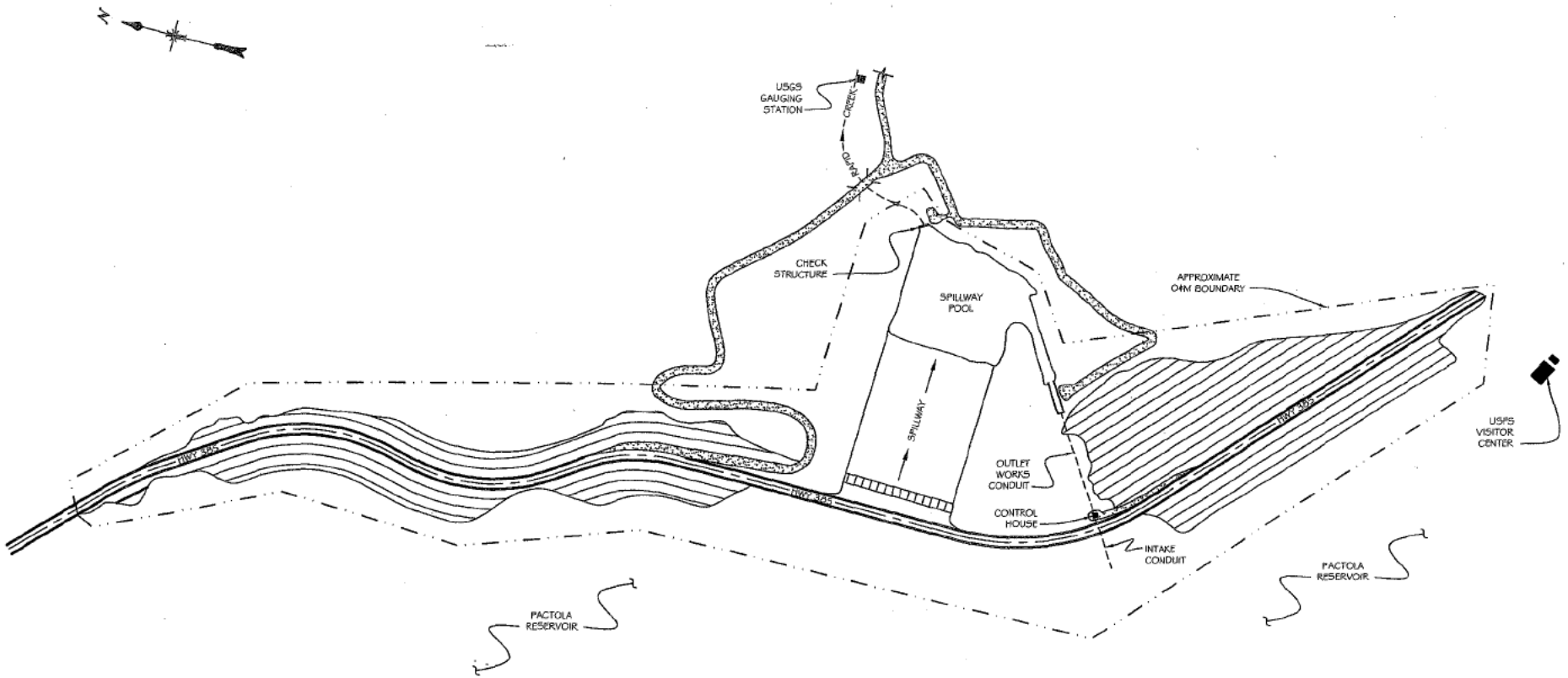
- Ensure occupancy of reservoir residence all year by City representative.

- Ensure attendance of Reclamation training and safety meetings related to reservoir operations by City representative.

Other Agreements

- The pooled storage operation of Pactola and Deerfield Reservoirs is explained in the current Memorandum of Understanding between Reclamation, the City, and the Rapid Valley Water Conservancy District (District). See the Pactola SOP for further information.

- The lands around Pactola Reservoir are managed by an interagency operating agreement between the Bureau of Reclamation and the Forest Service. The Memorandum of Understanding (MOU) is dated November 24, 1980 and was supplemented on April 1985 to reflect modification of Pactola Dam and Reservoir. The MOU discusses administration and management of resources at Pactola Dam. See the Pactola SOP for further information.



ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RAPID VALLEY UNIT
SOUTH DAKOTA

PACTOLA DAM

DAM OPERATIONS O&M BOUNDARY

PLAN VIEW

DESIGNED G. ANDERSON — DETAILED
DRAWN T. PATES — TECH. APPR.
APPROVED
RAPID CITY, SD — DATE 2023-03-30 — SHEET 1 OF 1

494-651-20

DUPLICATE ORIGINAL

Agreement No. 07XX620102
Amendment No. 1

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Rapid Valley Unit
Cheyenne Division
Pick-Sloan Missouri Basin Program, South Dakota

AGREEMENT AMENDMENT BETWEEN THE UNITED STATES AND THE CITY OF RAPID CITY, SOUTH DAKOTA TO ADD A "CONTRACTS WITH THIRD PARTIES" ARTICLE

THIS AMENDMENT, made this 30th day of JANUARY, 2009 ~~2008,~~ between the UNITED STATES OF AMERICA, hereinafter called the "United States" acting through the Secretary of the Interior pursuant generally to the Act of June 17, 1902 (32 Stat. 388), and acts amendatory or supplementary thereto, particularly Section 5 of the Reclamation Extension Act of August 13, 1914 (38 Stat. 687), and Subsection G of the Fact Finders' Act of December 5, 1924 (Section 4 of the Second Deficiency Act, Fiscal Year 1924) (43 Stat. 702), collectively referred to as the Federal Reclamation laws, and RAPID CITY, SOUTH DAKOTA, hereinafter referred to as the "City". The United States and the City hereinafter are referred to collectively as the "Parties".

WITNESSETH, THAT:

The following statements are made in explanation:

EXPLANATORY RECITALS

a. WHEREAS, on July 31, 2007, the portion of Cooperative Agreement No. 5-FC-60-05570 that dealt with the operation, maintenance, and replacement (OM&R) functions for Pactola Dam and Reservoir was superseded and replaced by Agreement No. 07XX620102 and Agreement No. 08XX620127 supersedes and replaces the remaining portion of Cooperative Agreement No. 5-FC-60-05570 which dealt with the OM&R functions for Deerfield Dam and Reservoir, thus Cooperative Agreement No. 5-FC-60-05570 will be completely superseded by the combination of the two agreements; and

b. WHEREAS, Agreement No. 08XX620127 has an additional article titled "Contracts with Third Parties," which was not included in Agreement No. 07XX620102.

c. WHEREAS, the Parties desire to amend Agreement No. 07XX620102 to include this additional article in order to keep the two agreements consistent.

NOW, THEREFORE, in consideration of the mutual covenants herein contained, it is hereby mutually agreed as follows:

1. The following article titled "Contracts with Third Parties" is hereby added to the Agreement No. 07XX620102 subsequent to Article 24 as follows:

CONTRACTS WITH THIRD PARTIES

25. a. The Contractor shall advertise each construction (as construction is defined in the Federal Acquisition Regulations), equipment, or supply contract exceeding $25,000 (twenty-five thousand dollars) for competitive bidding. Any action proposed by the Contractor other than making the award to the lowest responsible bidder shall be subject to review by the Contracting Officer.

b. For all construction contracts exceeding $100,000 (one hundred thousand dollars), the Contractor shall require construction contractors to furnish performance bonds equal to at least 100 percent of the contract price and payment bonds equal to (1) at least 50 percent of the contract price for contracts not exceeding $1,000,000 (one million dollars), (2) at least 40 percent of the contract price for contracts exceeding $1,000,000 (one million dollars) but not exceeding $5,000,000 (five million dollars), and (3) $2,500,000 (two million five hundred thousand dollars) for contracts exceeding $5,000,000 (five million dollars). Supply and equipment contractors may be required to furnish performance bonds on supply or equipment contracts exceeding $100,000 (one hundred thousand dollars) when the contract calls for substantial progress payments before delivery of end items.

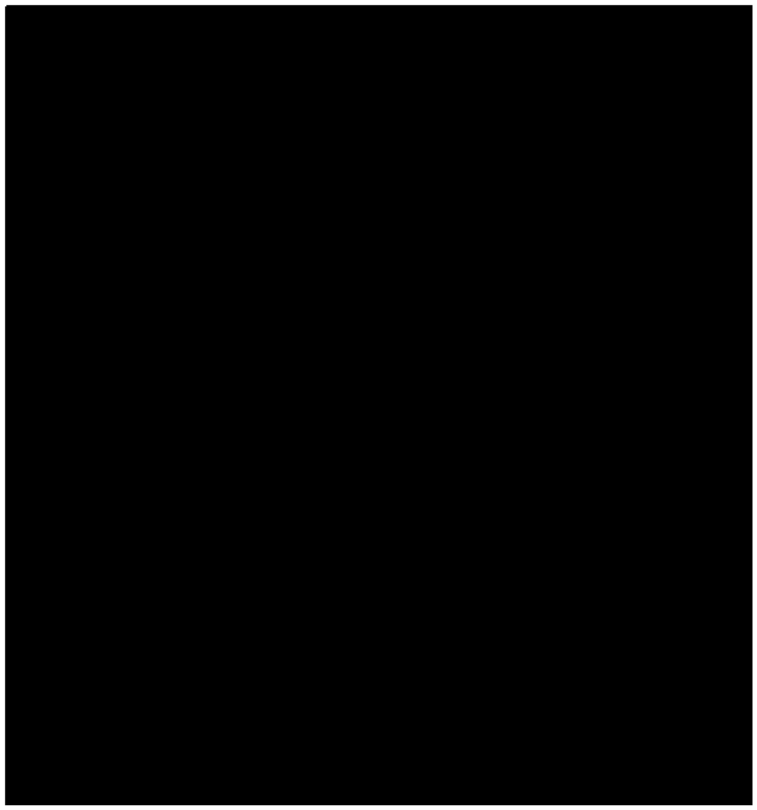
c. The United States shall not be a party to or obligated in any manner by contracts entered into between the Contractor and other parties pursuant to this contract.

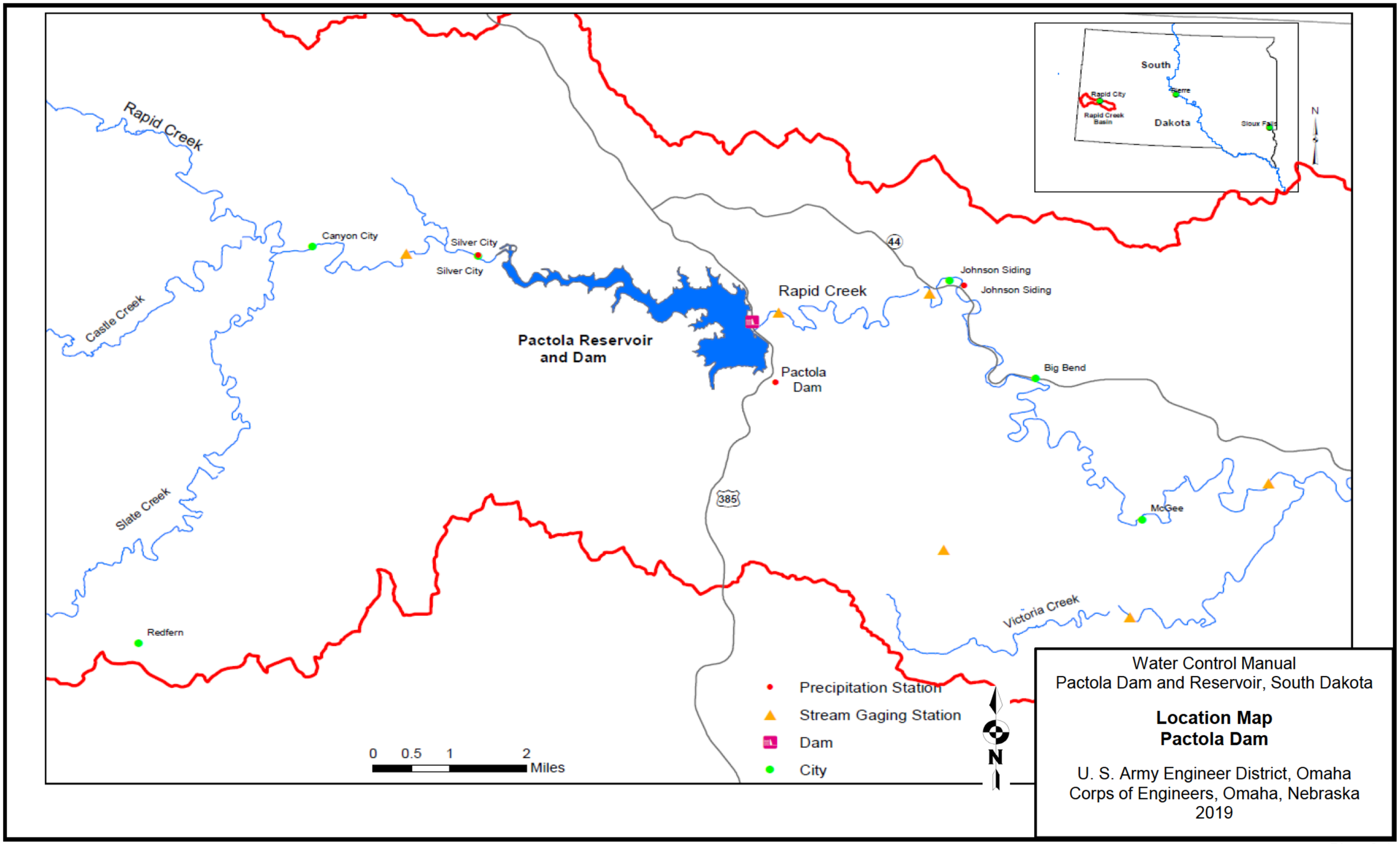
EXISTING AGREEMENT TO REMAIN IN FORCE

2. Except as provided herein, the existing contract shall remain in full force and effect.

By signing below, the Parties agree to the terms and conditions of this Amendment No. 1.

THE UNITED STATES OF AMERICA



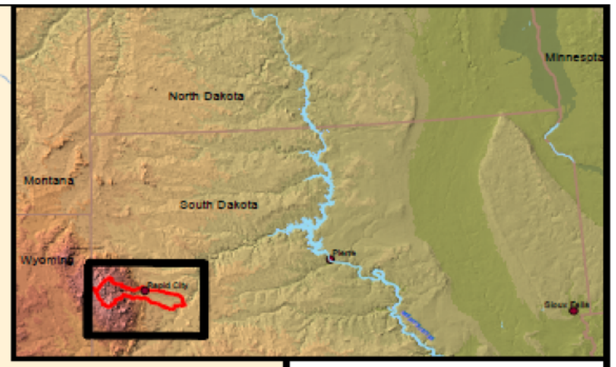


Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Pactola Dam

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

Plate 2-1



Water Control Manual
Pactola Reservoir and Dam
South Dakota

Location Map
Rapid Creek Basin

- Watershed Boundary
- Pactola Reservoir
- Stream
- Major Highways
- Highways
- Counties
- City
- Dam
- Precipitation Gage
- Stream Gage
- SNOTEL

0 25 50 100

Lawrence County
Meade County
Pennington County
Custer County

Rochford
Silver City
Rapid City
Colonial Pine Hills
Caputa
Farmingdale

North Fork Rapid Creek
Rapid Creek
Deer Creek
Castle Creek
Slate Creek
Victoria Creek
Antelope Creek

14 14A 85 385 90 16

Stream Gages

Station	Type
Rapid CR Near Farmingdale SD	Stream Gage
Castle Cr Above Deerfield Res Near Hill City	Stream Gage
Victoria Cr Below Victoria Dam Nr Rapid City	Stream Gage
Rapid CR BL Sewage Treatment Pl Nr Rapid	Stream Gage
Castle Cr Below Deerfield Dam SD	Stream Gage
Victoria Cr Above Dam Victoria Dam Nr Rapi	Stream Gage
Rapid Creek Ab Victoria Cr Nr Rapid City SD	Stream Gage
Rapid Cr Above Canyon Lake Near Rapid Cit	Stream Gage
Cleghorn Springs at Rapid City SD	Stream Gage
Rapid Cr Below Hawthorn Ditch At Rapid City	Stream Gage
Rapid Cr Below Pactola Dam SD	Stream Gage
Rapid Cr Abv Johnson Siding Blw Pactola Da	Stream Gage
Rapid Cr Above Pactola Res At Silver City S	Stream Gage
Rapid Cr At Rapid City SD	Stream Gage
South Canyon Near Rapid City SD	Stream Gage
Rhoads Fork Near Rochford SD	Stream Gage

Precipitation Gages

Station	Type
Deerfield 3 SE	Precipitation
Pactola Dam	Precipitation
Johnson Siding	Precipitation
Rapid City Rgnl	Precipitation
Caputa	Precipitation
Creston	Precipitation
Deerfield	Precipitation
Farmingdale	Precipitation
Rapid City	Precipitation
Rochford	Precipitation
Silver City	Precipitation

Snotel Gages

Station	Type
Blind Park	Snotel
North Rapid Creek	Snotel

N

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Rapid Creek Basin
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

Plate 2-2

Plate 2-4

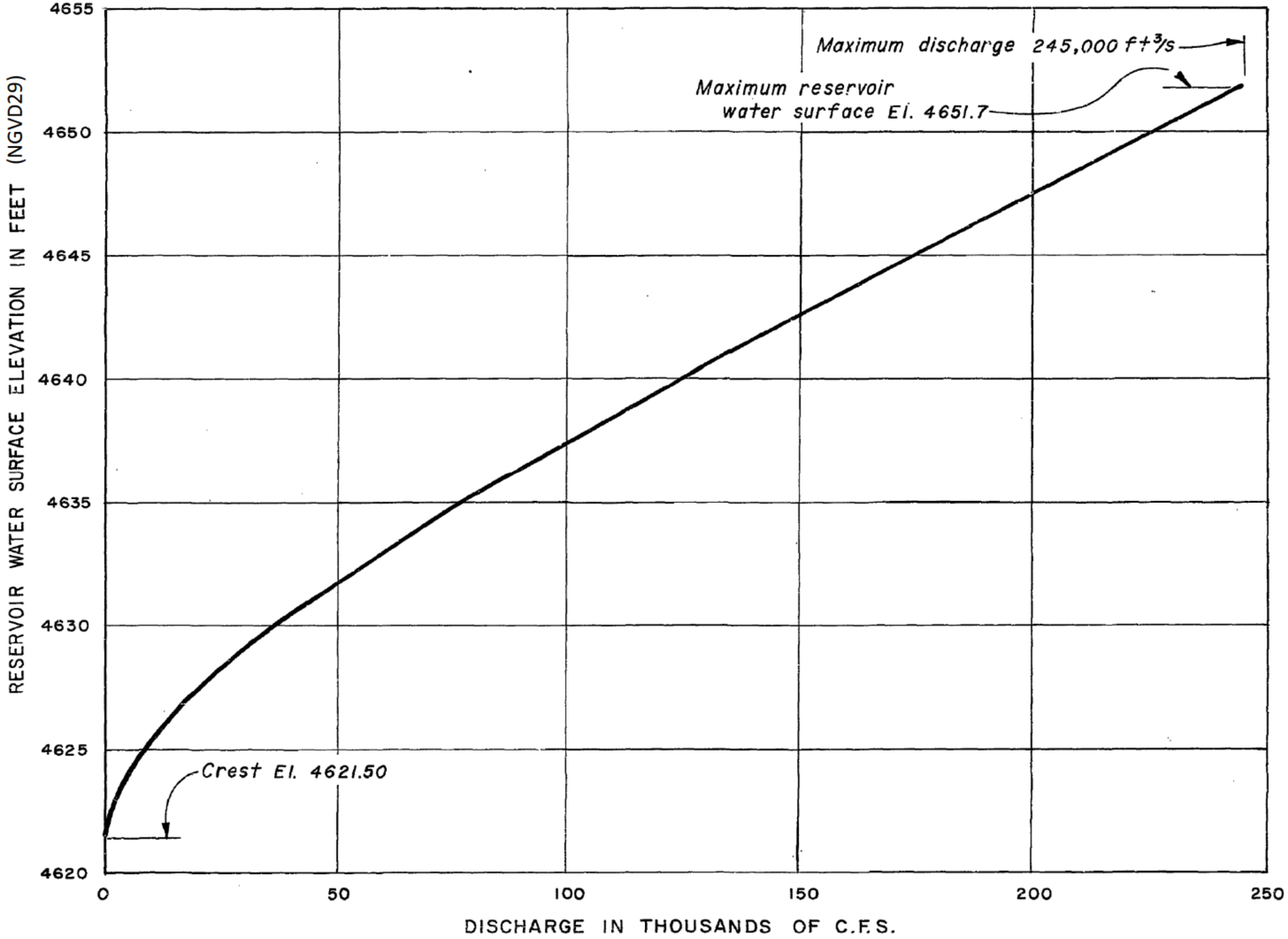
Plate 2-5

Plate 2-6

Plate 2-7

Plate 2-9

Plate 2-10



Scanned from Drawing 494-D-153 Bureau of Reclamation
Pactola Reservoir Standing Operating Procedures Dec. 2007

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Pactola Dam Modification
Spillway Discharge Curve

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

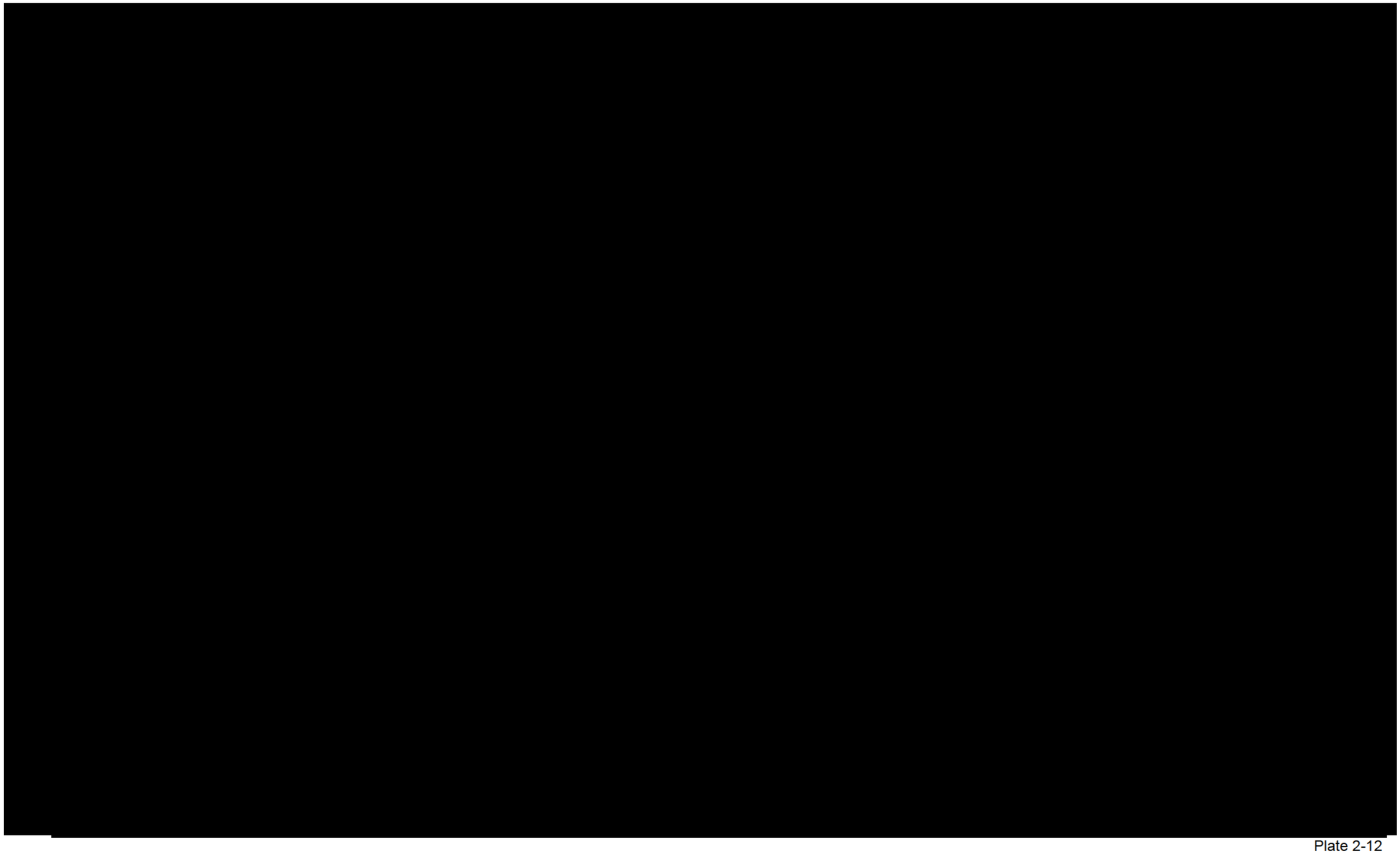
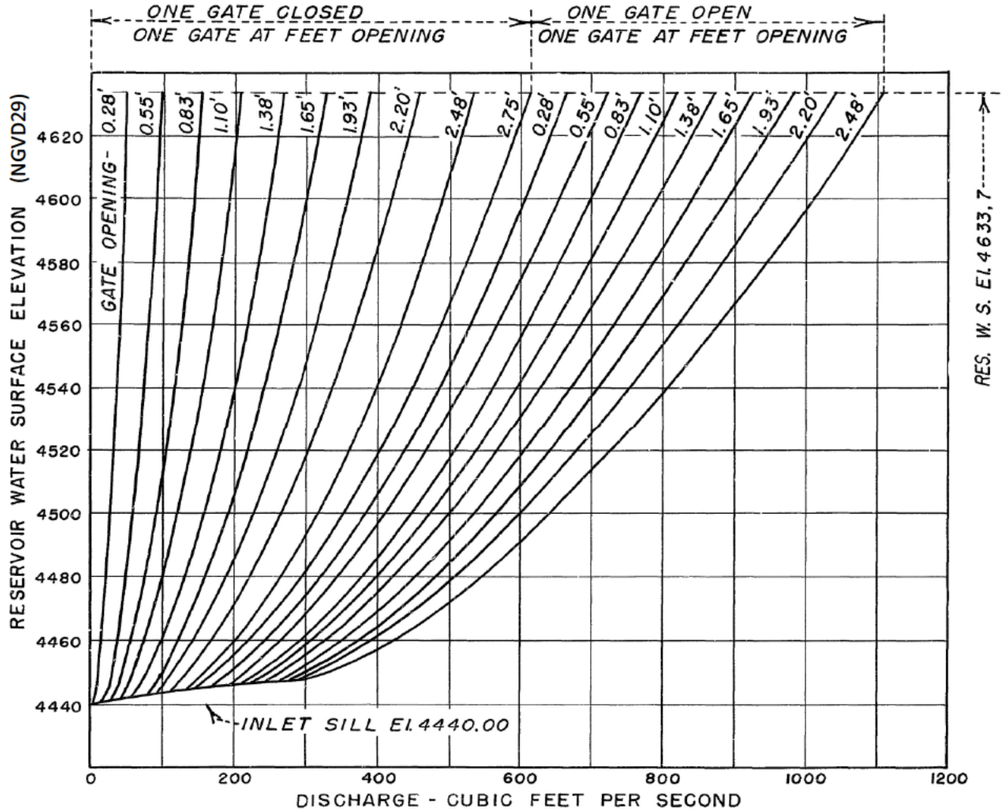
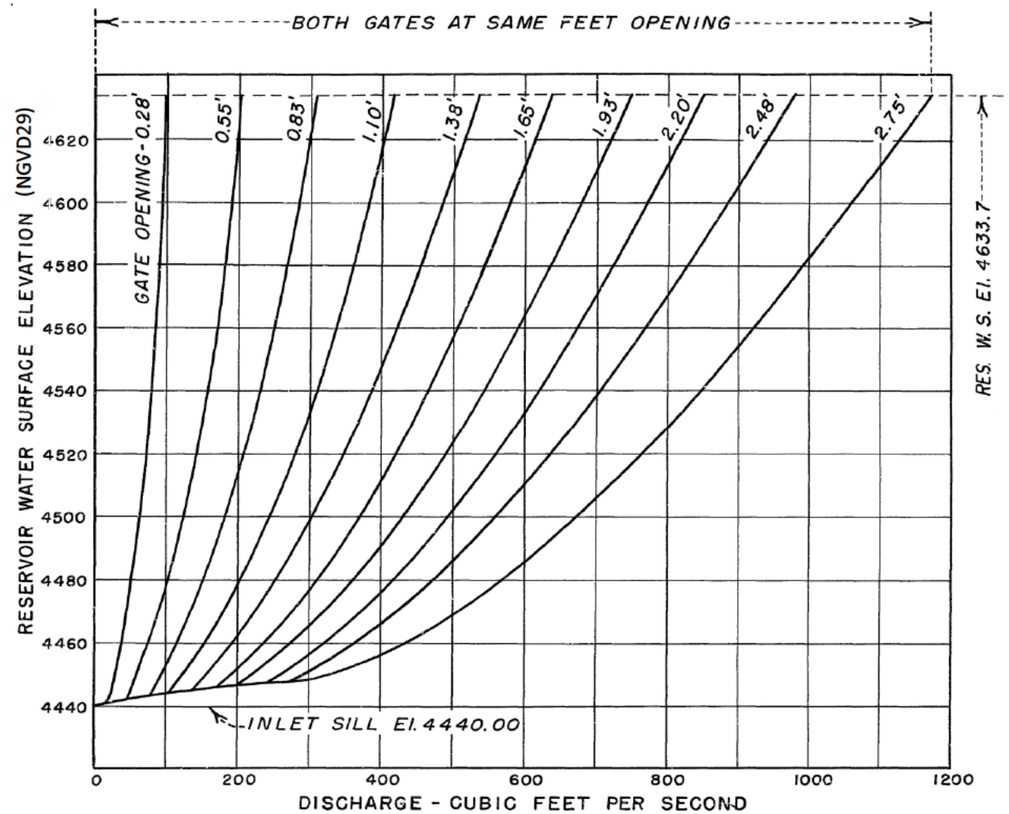


Plate 2-12





NOTES

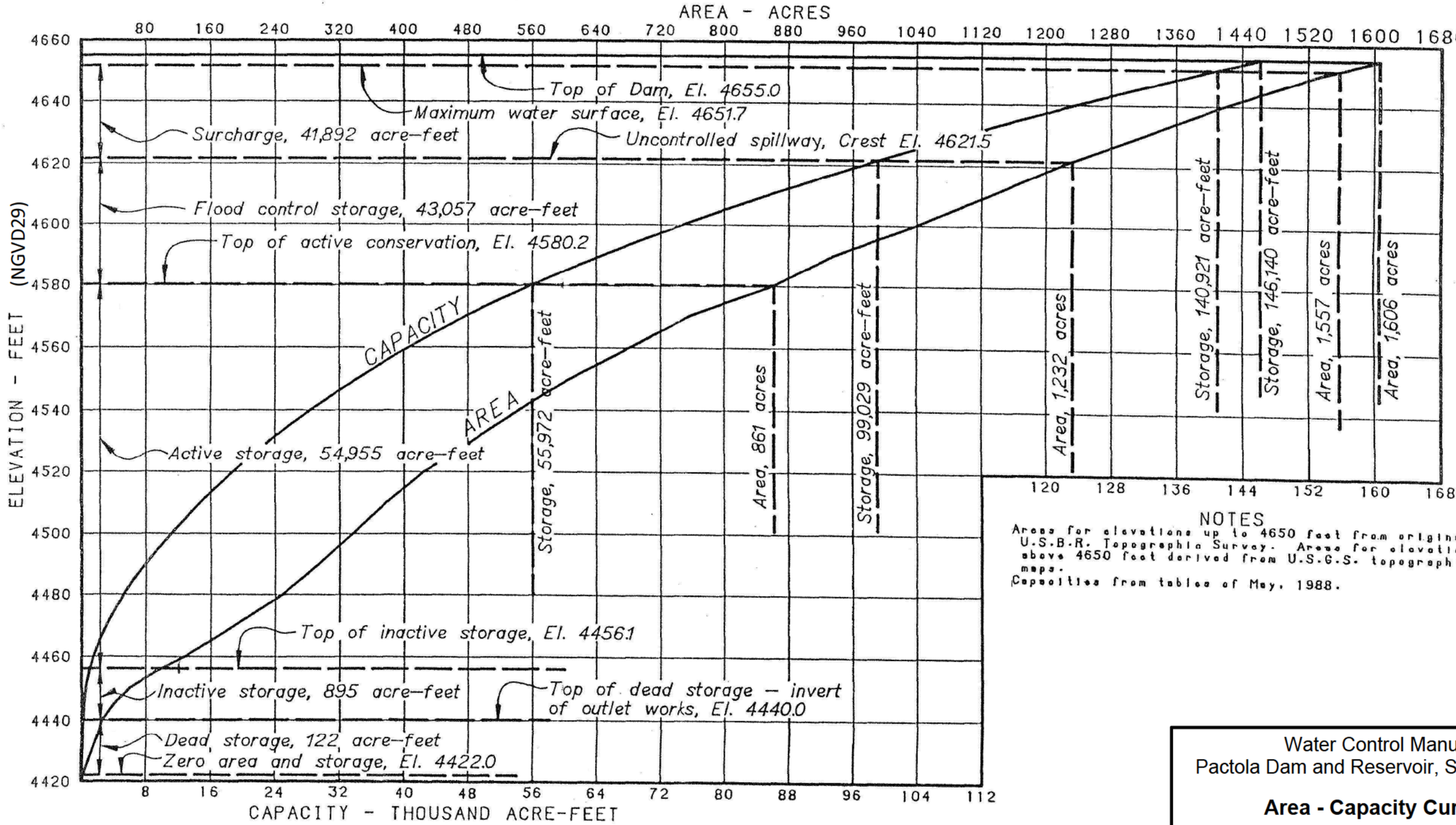
Regulating gates: 2-2'-9" x 2'-9" High pressure slide gates.
Discharges are computed values.
Any variations in discharge from these curves as determined by measurements of flow downstream from the outlet works should be reported to the Chief Engineer.
Maximum reservoir water surface increased to elevation 4651.7.
Observe tailwater conditions for the outlet works when releases are made above reservoir elevation 4621.5.

Scanned from Drawing 494-D-124 Bureau of Reclamation Pactola Reservoir Standing Operating Procedures Dec. 2007

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Outlet Works
Discharge Rating Curves

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019



NOTES

Areas for elevations up to 4650 feet from original U.S.B.R. Topographic Survey. Areas for elevations above 4650 feet derived from U.S.G.S. topographic maps.

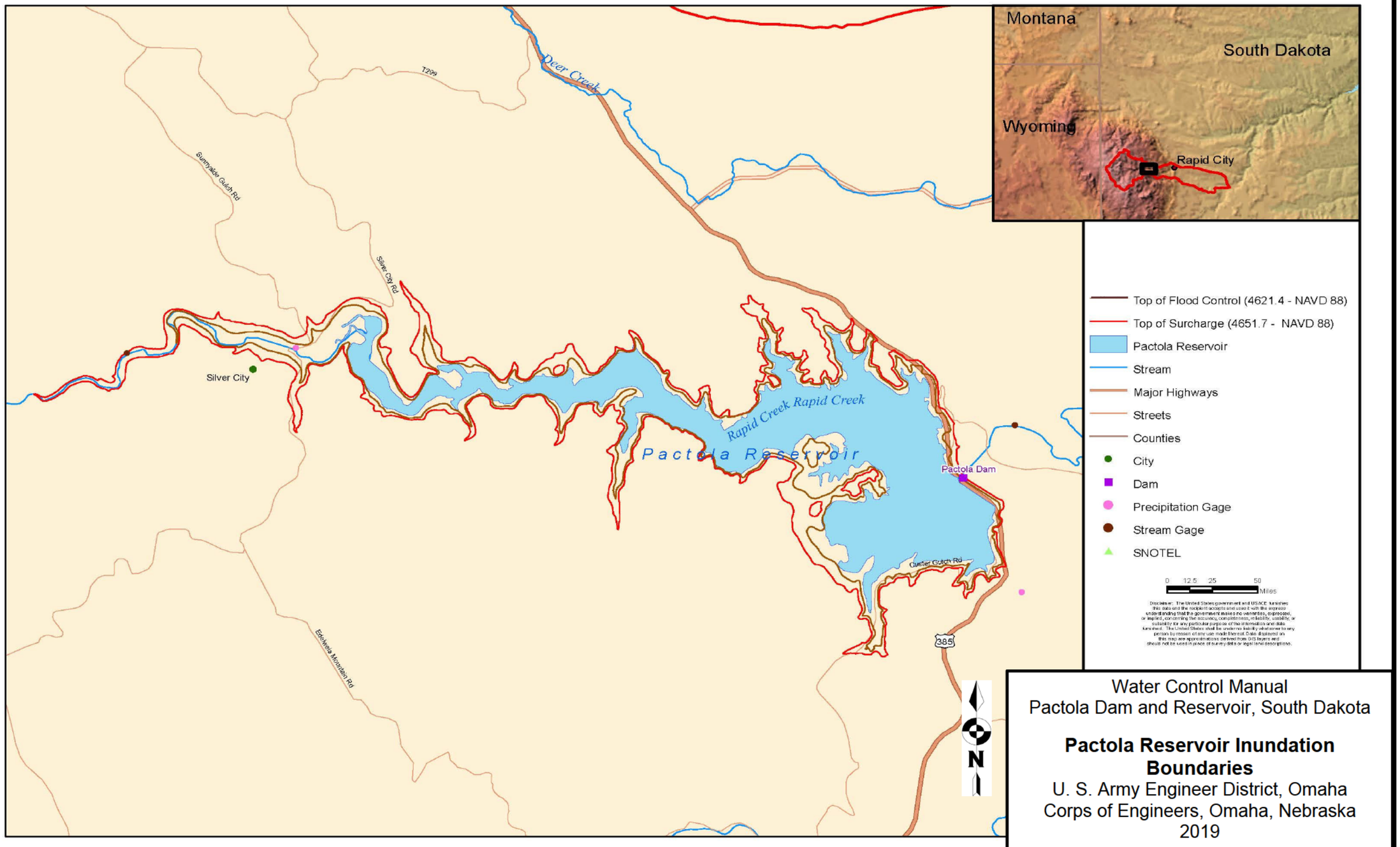
Capacities from tables of May, 1988.

Scanned from Drawing 494-600-43 Bureau of Reclamation Pactola Reservoir
Standing Operating Procedures Dec. 2007

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Area - Capacity Curves

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019



Water Control Manual
Pactola Dam and Reservoir, South Dakota

Pactola Reservoir Inundation Boundaries

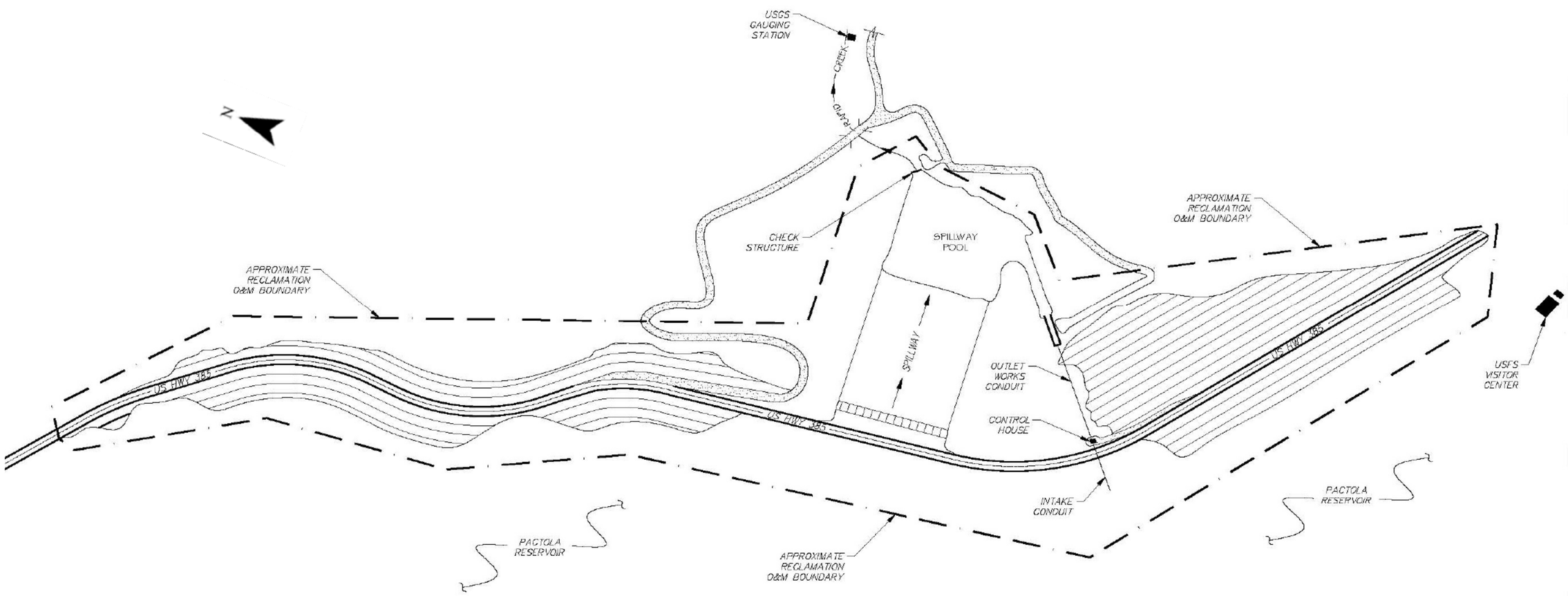
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

Plate 2-15

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Aerial Photo
Spillway Plunge Pool Area

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

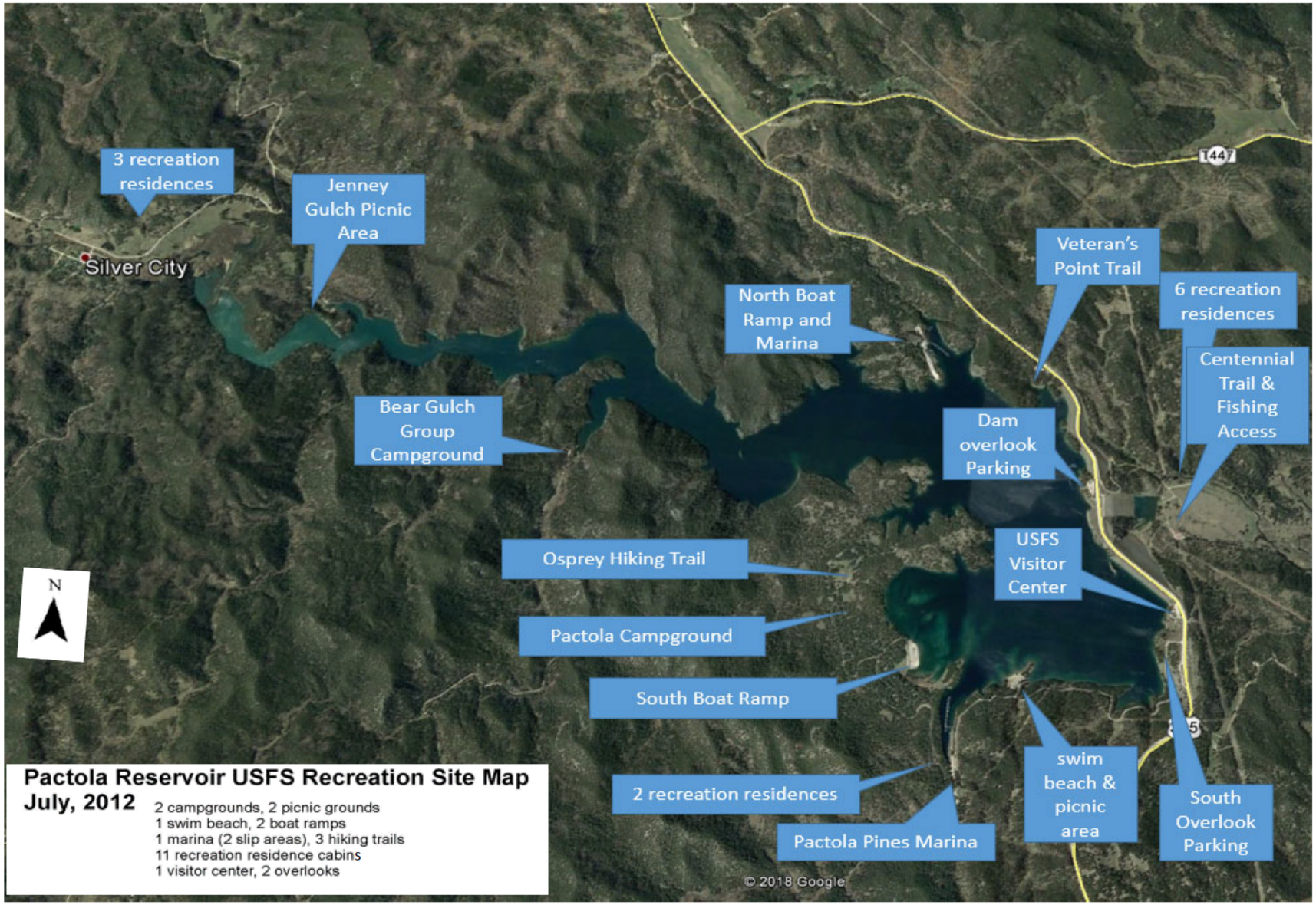


Water Control Manual
Pactola Dam and Reservoir, South Dakota

Reclamation O&M Boundary

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

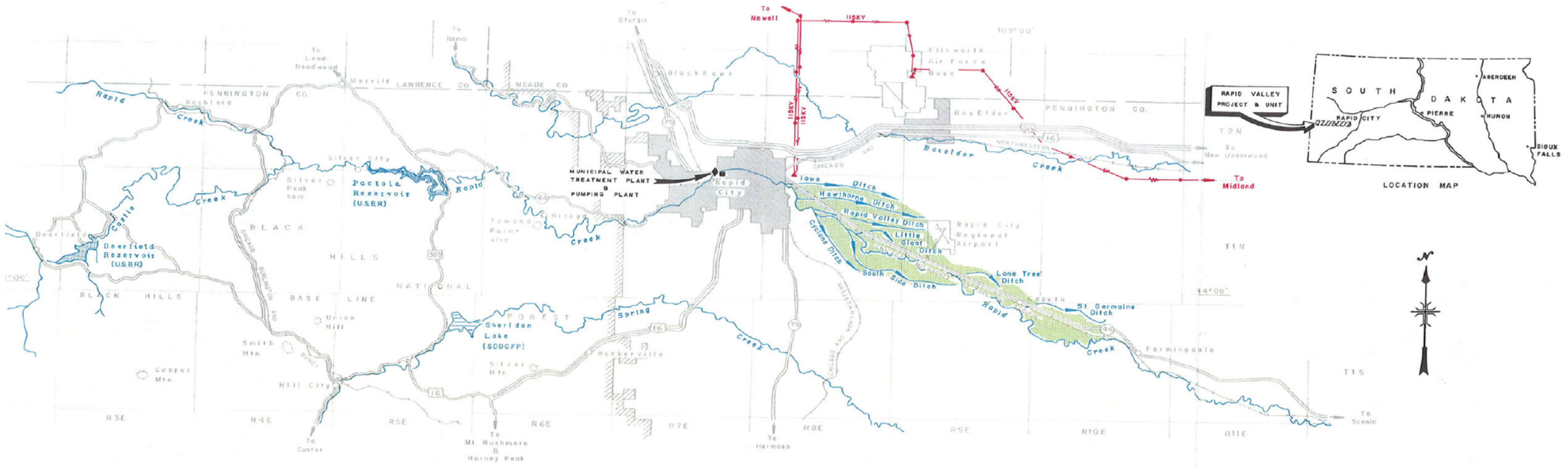
Plate 2-17



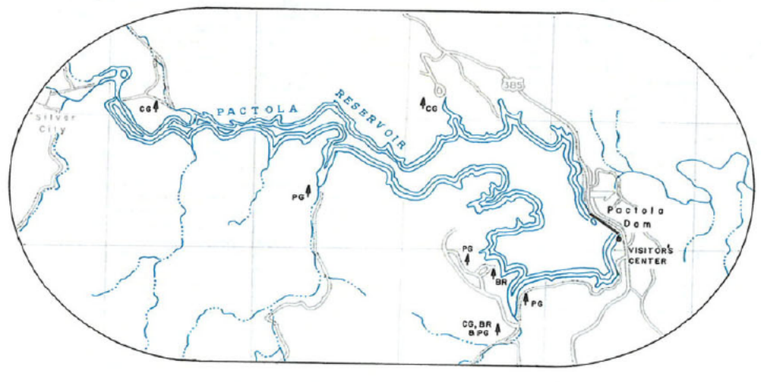
Water Control Manual
Pactola Dam and Reservoir, South Dakota

Pactola Reservoir
Facilities in Reservoir Pool Area

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019



DEERFIELD RESERVOIR
RAPID VALLEY PROJECT
SCALE OF MILES



PACTOLA RESERVOIR
RAPID VALLEY UNIT
PICK-SLOAN MISSOURI BASIN PROGRAM
SCALE OF MILES

EXPLANATION

- RESERVOIR - RAPID VALLEY PROJECT
- RESERVOIR - RAPID VALLEY UNIT
- RESERVOIR - SOUTH DAKOTA DEPARTMENT OF GAME, FISH AND PARKS
- SUBSTATION - WAPA
- TRANSMISSION LINE - WAPA
- BLACK HILLS NATIONAL FOREST BOUNDARY
- PG PICNIC GROUNDS
- CG CAMPGROUNDS
- BR BOATRAMP
- STREAM

NON-FEDERAL PROJECT DEVELOPMENT

- MUNICIPAL WATER TREATMENT PLANT
- PUMPING PLANT
- DITCHES
- IRRIGATED AREA (PRIVATELY DEVELOPED LANDS ARE PART OF RAPID VALLEY UNIT LANDS. PICK-SLOAN MISSOURI BASIN PROJECT)

ABBREVIATIONS

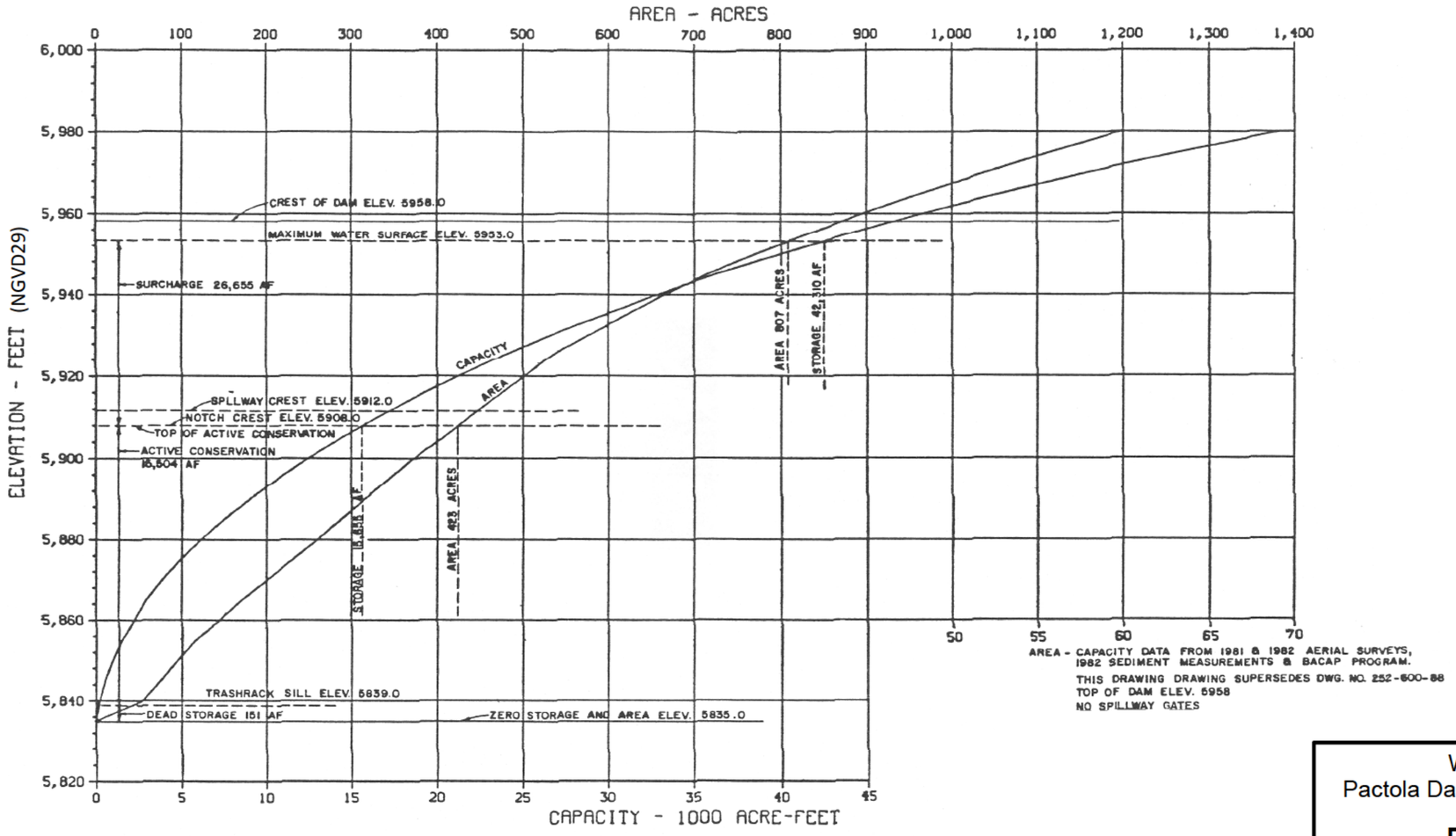
USBR UNITED STATES BUREAU OF RECLAMATION
SDDGF SOUTH DAKOTA DEPARTMENT OF GAME, FISH AND PARKS
WAPA WESTERN AREA POWER ADMINISTRATION

USBR Map No. 494-602-460

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Rapid Valley Project
Rapid Valley Unit

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019



AREA - CAPACITY DATA FROM 1981 & 1982 AERIAL SURVEYS, 1982 SEDIMENT MEASUREMENTS & BACAP PROGRAM.

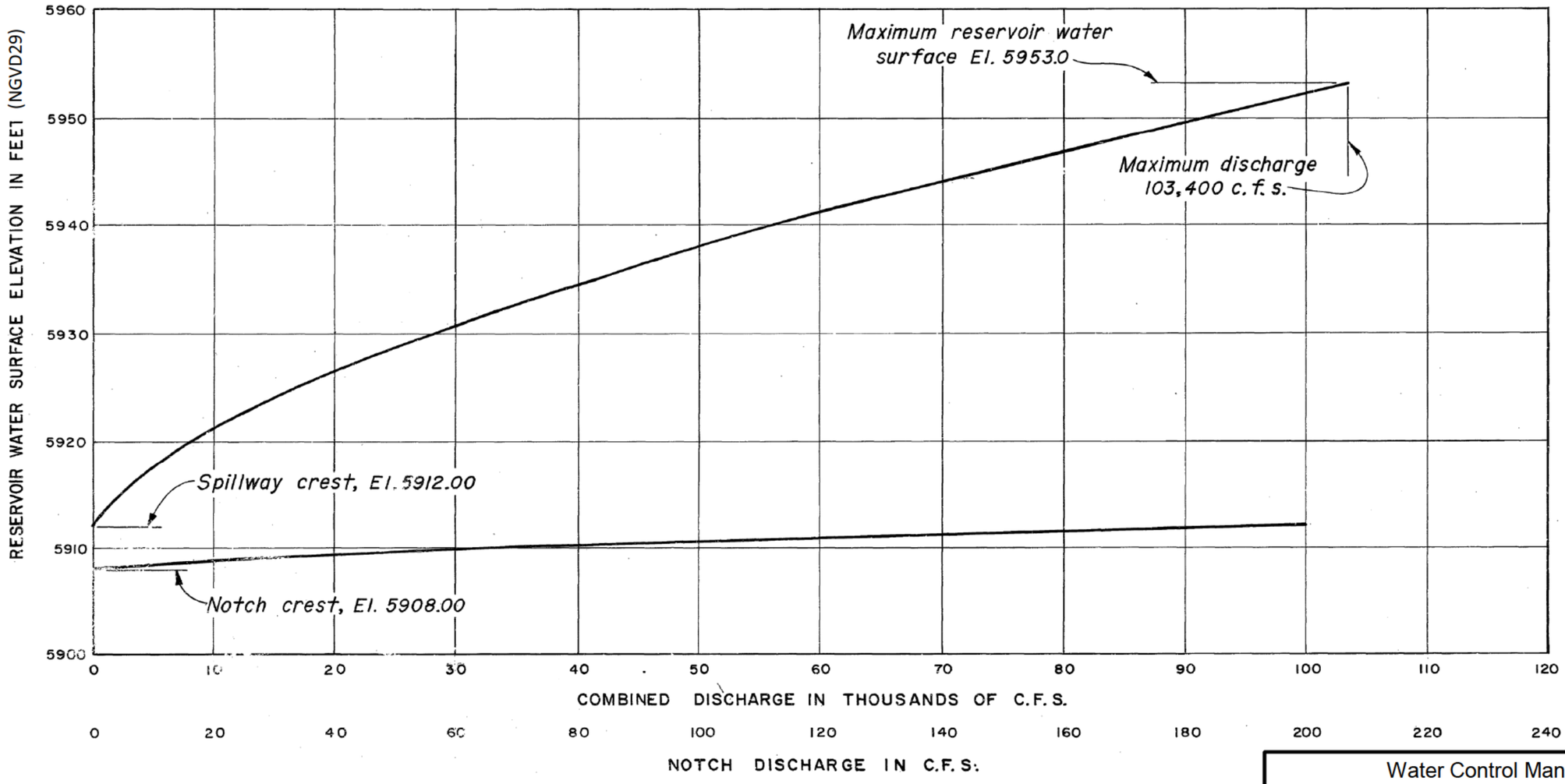
THIS DRAWING DRAWING SUPERSEDES DWG. NO. 252-600-88
TOP OF DAM ELEV. 5958
NO SPILLWAY GATES

Scanned from Drawing 252-600-89 Bureau of Reclamation Deerfield Reservoir

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Deerfield Reservoir
Area - Capacity Curve

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

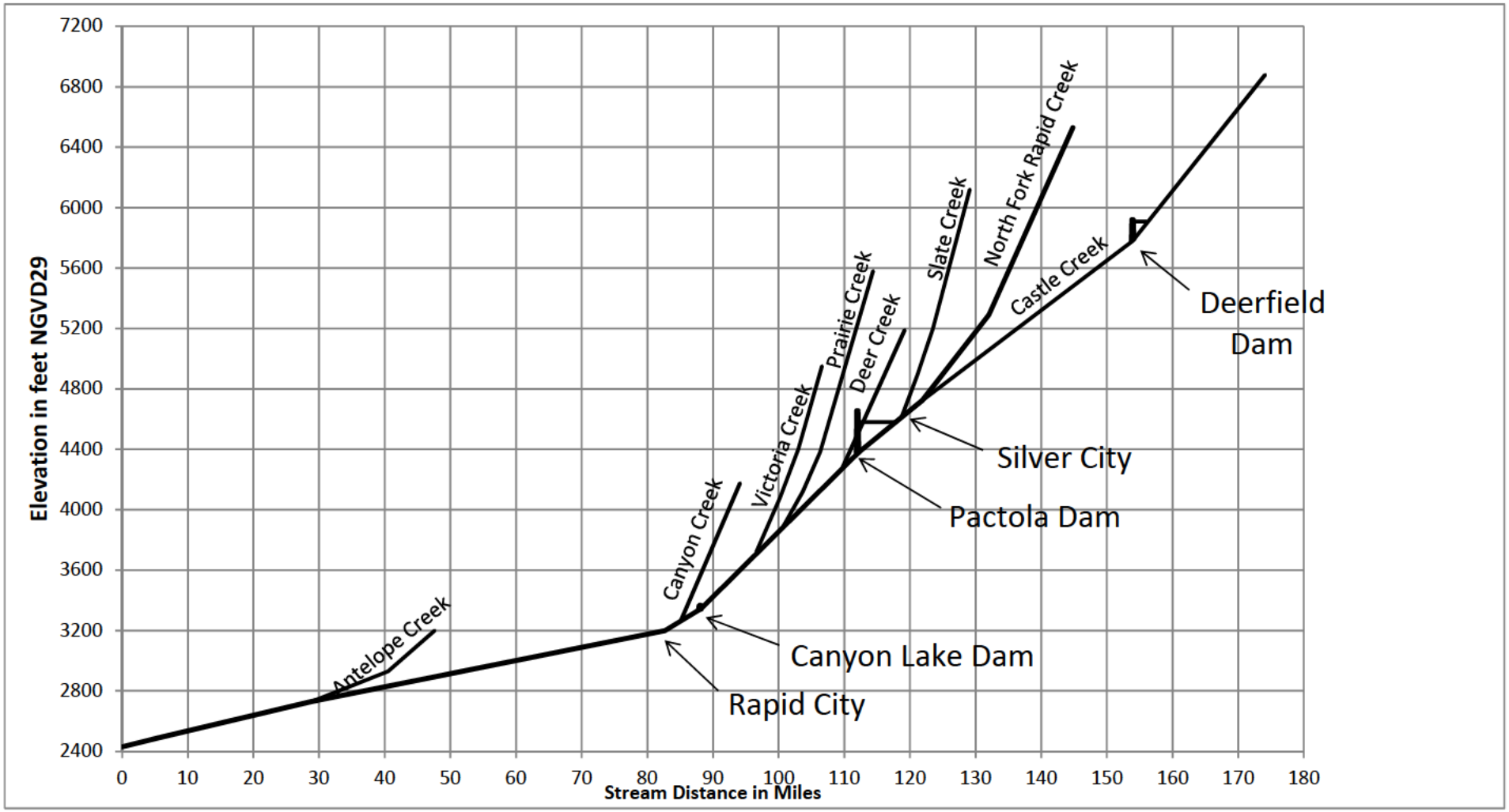


Scanned from Drawing 252-D-232 Bureau of Reclamation Deerfield Reservoir Standing Operating Procedures July 1999

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Deerfield Dam Modification
Spillway Discharge Curve

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019



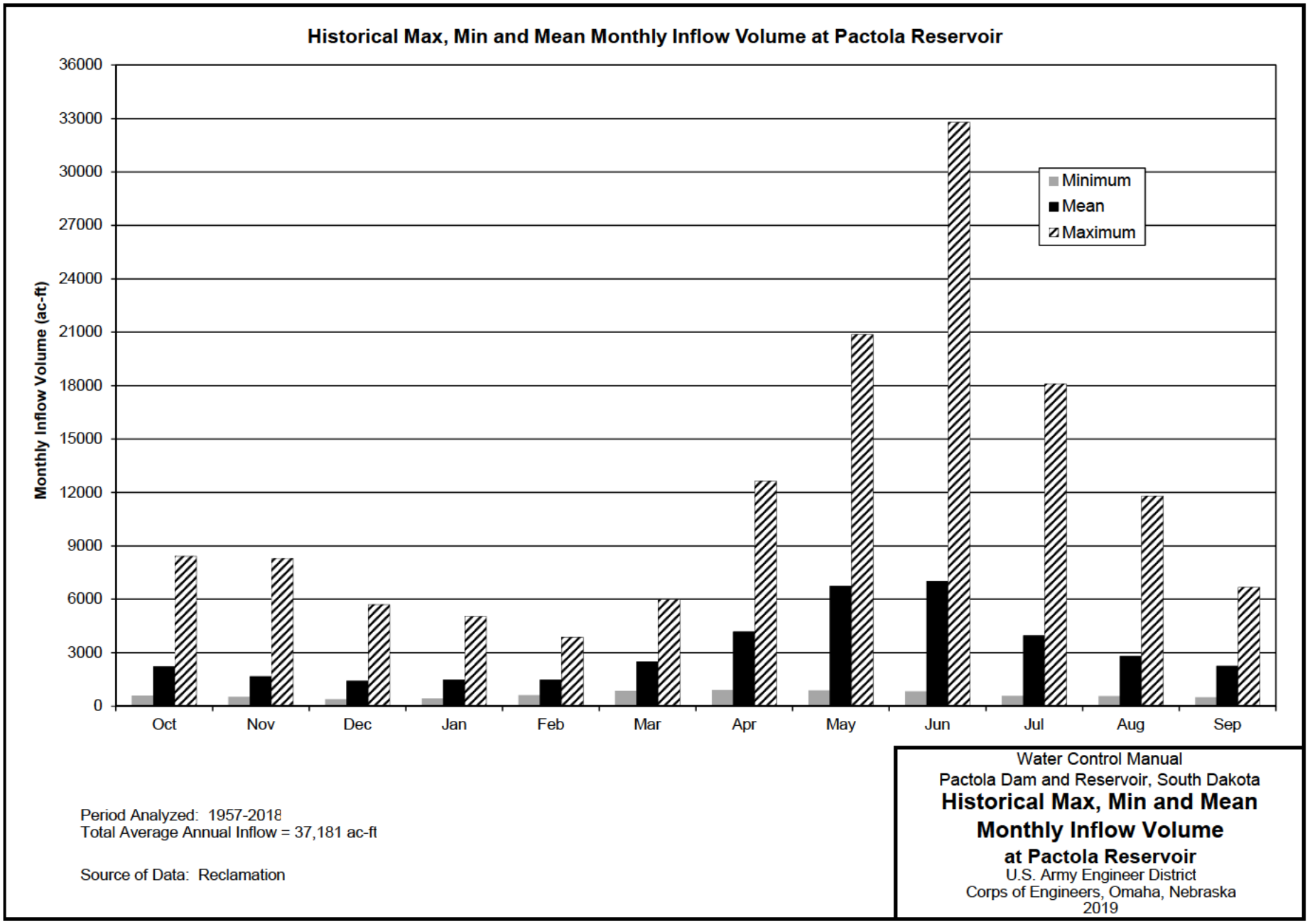
Prepared from scanned document from Report on Reservoir Regulation for Flood Control, Pactola Dam and Reservoir, Corps of Engineers, 1976

Water Control Manual
Pactola Reservoir and Dam, South Dakota

Stream Profile of Rapid Creek

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

Plate 4-1



Period Analyzed: 1957-2018
Total Average Annual Inflow = 37,181 ac-ft

Source of Data: Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Historical Max, Min and Mean Monthly Inflow Volume at Pactola Reservoir

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 4-2

Pactola Reservoir

Historical Monthly Inflow Volumes (ac-ft)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1956	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	892	1,164
1957	1,617	1,009	743	731	716	1,189	1,798	4,199	5,047	2,842	2,561	1,280
1958	1,132	995	881	760	909	1,236	1,974	2,413	3,534	2,838	2,267	1,919
1959	1,463	990	753	614	723	1,181	2,903	2,876	2,856	3,113	3,868	4,110
1960	955	734	746	755	785	1,836	1,782	1,476	1,476	965	658	606
1961	1,514	560	582	659	605	993	901	879	824	659	660	588
1962	583	519	390	430	804	841	1,169	4,209	11,036	4,600	2,858	1,539
1963	1,433	1,000	836	853	1,065	2,674	4,532	7,275	17,054	5,575	2,150	2,280
1964	1,149	1,116	939	1,123	1,095	1,274	3,823	5,623	11,956	5,952	3,582	3,001
1965	2,356	1,300	1,584	1,399	1,343	1,254	4,278	19,543	19,603	10,534	5,605	4,269
1966	4,258	1,709	1,416	1,244	1,466	3,482	4,569	3,715	2,086	1,547	1,797	3,418
1967	1,699	1,032	973	1,266	1,094	2,800	3,691	5,616	14,932	8,004	4,352	4,158
1968	1,806	1,360	1,294	1,453	1,358	2,399	2,410	2,305	2,848	2,026	1,434	2,227
1969	1,866	843	876	951	881	1,428	3,476	4,344	2,371	3,069	2,188	2,832
1970	1,040	877	827	962	928	1,219	4,568	11,935	7,662	3,229	3,099	2,575
1971	1,170	1,336	1,149	1,199	1,316	2,149	11,434	12,128	8,888	2,675	1,864	3,032
1972	3,502	1,242	898	947	1,072	2,782	2,994	4,059	9,042	4,830	3,375	3,006
1973	2,768	1,067	1,207	1,086	1,054	1,771	4,942	8,132	4,599	3,083	2,200	2,686
1974	2,173	1,088	1,025	1,083	1,050	1,672	2,434	2,058	1,373	986	1,154	1,055
1975	1,474	782	630	845	811	1,265	5,658	7,342	5,022	2,883	1,133	1,019
1976	1,339	761	1,044	969	1,166	1,845	3,197	3,452	10,617	4,061	1,884	1,579
1977	2,241	834	1,089	1,138	1,073	1,654	6,571	6,025	2,527	1,883	2,500	1,555
1978	1,472	1,099	1,107	1,167	1,497	2,606	3,725	17,366	5,742	3,798	2,817	2,305
1979	2,233	1,194	1,178	1,240	1,670	2,787	3,362	2,660	2,439	4,108	3,115	2,421
1980	2,383	1,047	1,053	989	1,142	1,873	3,552	3,253	2,430	1,120	1,152	1,812
1981	2,032	758	1,054	740	722	1,195	1,457	2,732	1,554	1,778	2,653	1,788
1982	1,136	789	618	747	820	1,481	4,211	7,394	7,035	7,020	6,363	4,943
1983	2,808	2,078	1,417	1,351	1,252	2,724	5,161	10,531	5,892	2,411	2,457	1,316
1984	1,911	1,335	1,045	1,466	1,509	1,972	3,568	9,025	7,746	4,842	4,021	2,266
1985	2,177	1,426	1,308	1,317	1,049	3,160	3,315	2,104	1,900	1,675	2,303	1,509

Source of Data: Reclamation

Pactola Dam and Reservoir, South Dakota

Table of Historical Monthly Inflow Volumes

at Pactola Reservoir

U.S. Army Engineer District

Corps of Engineers, Omaha, Nebraska

2019

Plate 4-3a

Pactola Reservoir

Historical Monthly Inflow Volumes (ac-ft)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1986	1,402	1,556	1,151	1,116	1,330	2,604	4,104	5,390	3,727	2,285	1,690	2,993
1987	3,559	2,405	975	947	1,190	3,026	4,999	4,066	2,334	1,315	2,127	1,362
1988	1,669	1,332	774	697	937	1,555	2,756	3,326	1,364	1,155	1,225	938
1989	945	917	614	666	696	1,737	2,139	2,398	936	953	1,154	1,338
1990	1,009	632	688	690	697	1,553	3,328	3,807	2,170	1,193	699	941
1991	957	635	537	636	799	1,226	2,797	6,973	13,241	3,661	1,879	1,699
1992	844	957	773	739	894	2,619	2,459	2,731	2,382	2,706	2,007	1,139
1993	872	689	691	818	765	1,834	3,618	9,680	14,565	6,170	3,530	2,903
1994	2,458	1,131	1,215	1,244	1,165	3,924	5,821	8,280	3,927	2,464	1,761	1,140
1995	2,010	1,336	1,127	940	1,533	3,379	3,335	16,760	16,946	7,009	3,246	2,270
1996	2,707	2,690	1,718	2,247	2,469	4,822	8,663	13,463	16,190	5,305	3,985	3,519
1997	3,820	4,877	3,588	3,942	3,601	5,982	12,644	20,266	16,908	9,136	11,799	5,536
1998	4,453	3,461	3,007	3,317	3,391	5,726	8,316	5,943	16,025	12,323	10,369	6,666
1999	8,418	8,298	5,702	5,031	3,867	5,924	12,091	13,173	20,950	9,584	6,688	4,480
2000	3,948	3,617	3,168	3,137	3,783	4,015	5,528	7,118	4,583	3,893	2,239	1,741
2001	2,560	2,562	2,471	2,483	2,264	2,879	4,705	3,498	2,667	3,199	1,744	1,395
2002	1,886	1,788	1,623	1,910	1,757	2,296	3,487	3,156	1,896	596	802	1,411
2003	1,536	1,414	1,282	1,641	1,442	3,183	3,744	6,578	4,411	1,639	764	1,177
2004	1,242	1,251	1,352	1,375	1,433	2,143	2,158	1,653	1,171	1,119	742	1,007
2005	1,061	959	1,020	1,293	1,069	1,433	1,520	2,015	1,682	627	709	484
2006	1,141	1,109	1,151	1,278	1,183	1,991	3,372	3,679	1,629	570	559	1,093
2007	978	923	819	885	889	2,308	1,922	2,586	2,905	856	919	809
2008	922	768	825	927	939	1,231	2,014	7,194	8,075	8,518	2,889	1,943
2009	1,829	2,004	1,686	1,774	1,685	3,417	9,001	7,263	4,371	2,877	2,188	2,007
2010	2,473	2,151	1,774	1,850	1,588	2,558	4,337	14,199	13,121	6,603	3,786	2,369
2011	2,350	1,981	2,092	2,312	2,046	3,298	4,850	14,890	14,861	6,725	3,808	2,806
2012	3,021	2,871	2,637	2,685	2,505	3,804	3,334	3,371	2,138	1,402	1,247	1,037
2013	1,424	1,678	1,551	1,902	1,735	2,176	2,901	3,798	3,569	1,989	2,676	1,778
2014	7,891	5,387	3,168	2,635	2,216	3,893	6,819	11,955	8,825	6,294	5,518	4,098
2015	4,984	3,348	3,230	3,489	3,113	4,245	4,304	20,865	32,778	18,094	6,981	4,173

Source of Data: Reclamation HydroMet database

Water Control Manual

Pactola Dam and Reservoir, South Dakota

Table of Historical Monthly Inflow Volumes

at Pactola Reservoir

U.S. Army Engineer District

Corps of Engineers, Omaha, Nebraska

2019

Plate 4-3b

Pactola Reservoir

Historical Monthly Inflow Volumes (ac-ft)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2016	4,510	3,526	3,095	3,375	3,365	3,703	3,691	3,186	1,781	1,776	1,956	1,982
2017	2,021	1,894	1,640	2,265	2,298	2,817	3,211	3,605	3,125	2,004	1,997	1,940
2018	2,216	2,440	1,831	1,995	1,777	2,828	3,839	6,365	9,920	9,732	6,014	3,099
Mean	2,207	1,669	1,414	1,479	1,474	2,498	4,182	6,740	7,020	3,966	2,804	2,247
Min.	583	519	390	430	605	841	901	879	824	570	559	484
Max.	8,418	8,298	5,702	5,031	3,867	5,982	12,644	20,865	32,778	18,094	11,799	6,666

Source of Data: Reclamation HydroMet database

Water Control Manual

Pactola Dam and Reservoir, South Dakota

Table of Historical Monthly Inflow Volumes

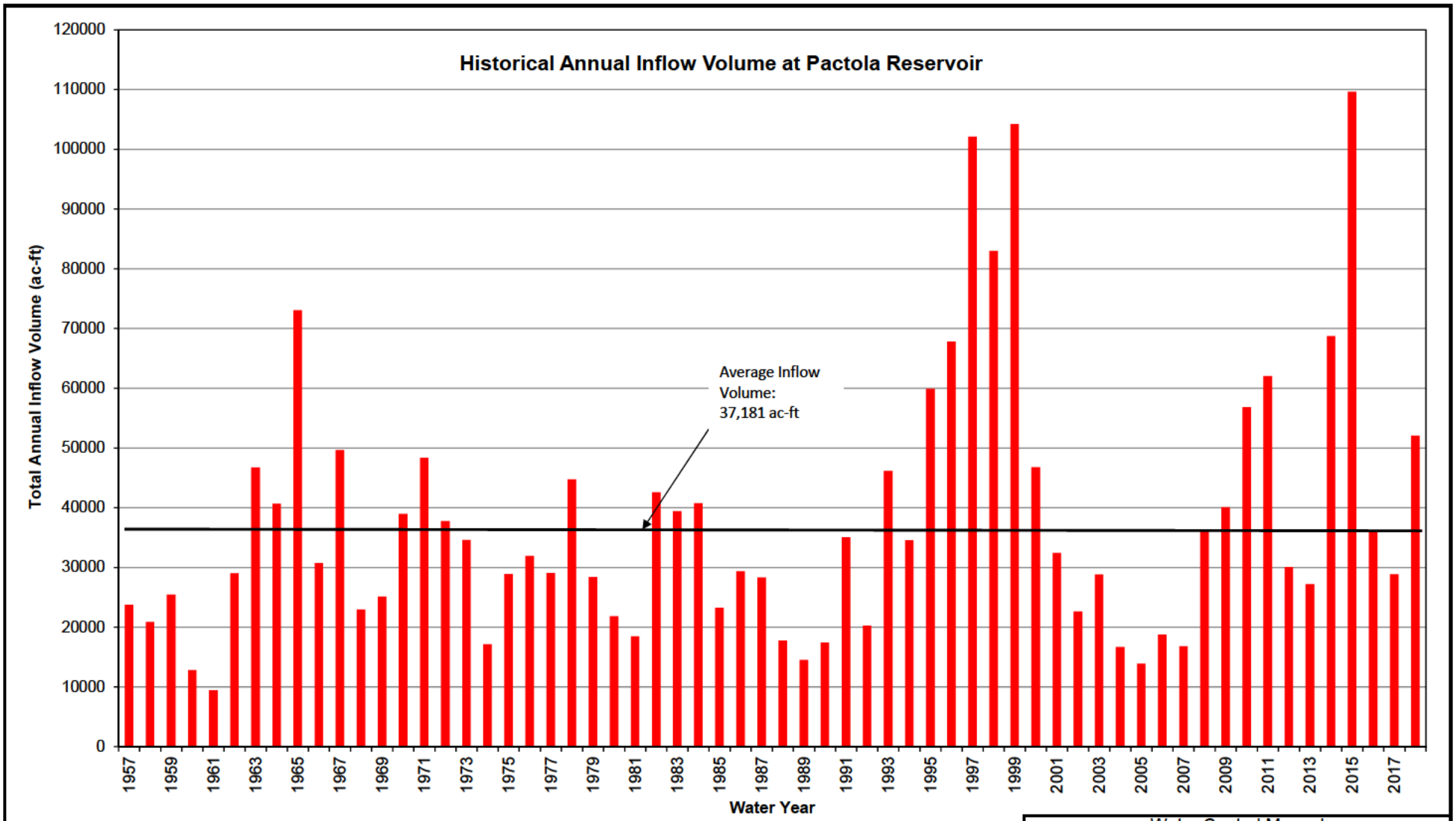
at Pactola Reservoir

U.S. Army Engineer District

Corps of Engineers, Omaha, Nebraska

2019

Plate 4-3c



Annual Inflow Volume is an accumulation of average monthly inflows over a water year (Oct.-Sept.).

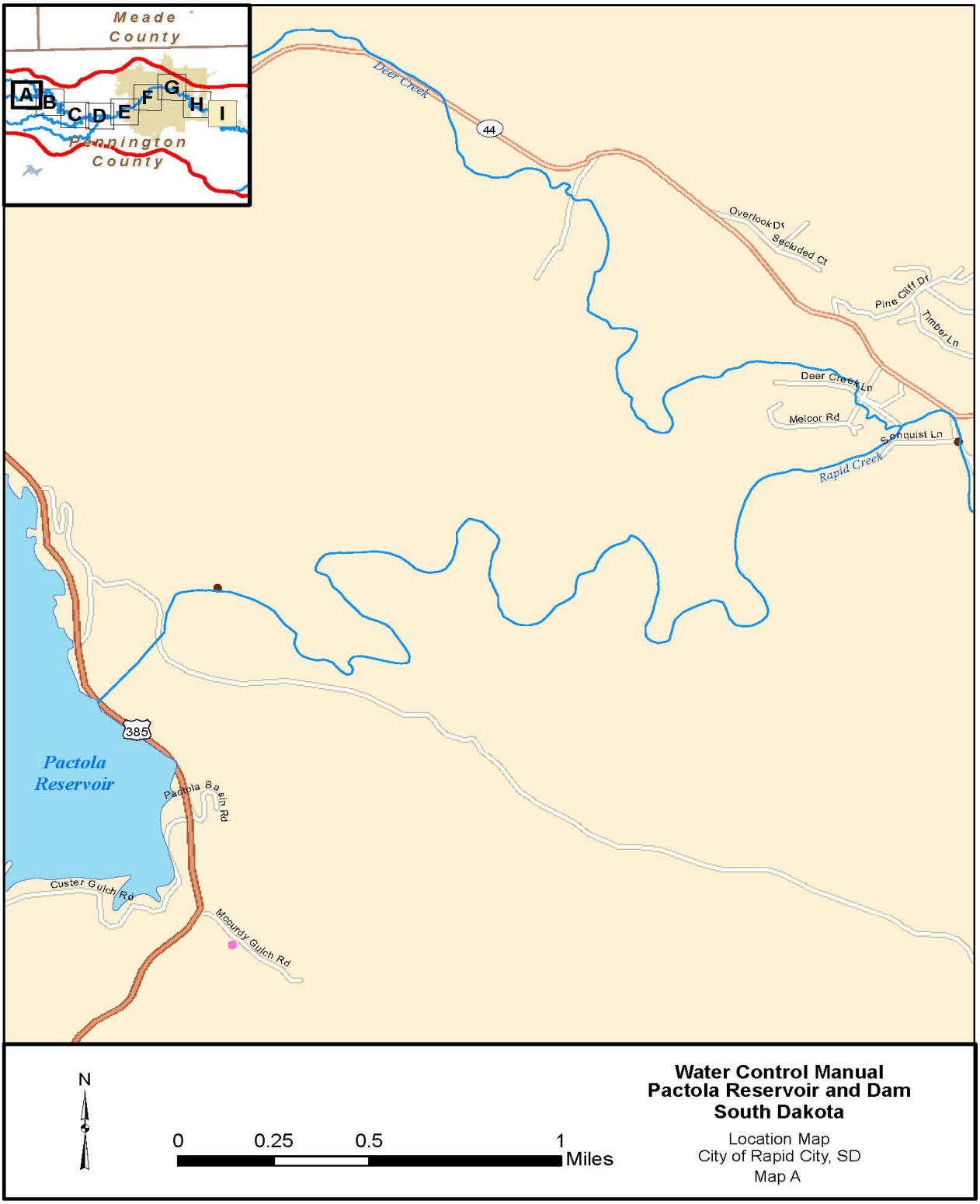
Source of Data: Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Historical Annual Inflow Volume at Pactola Reservoir

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

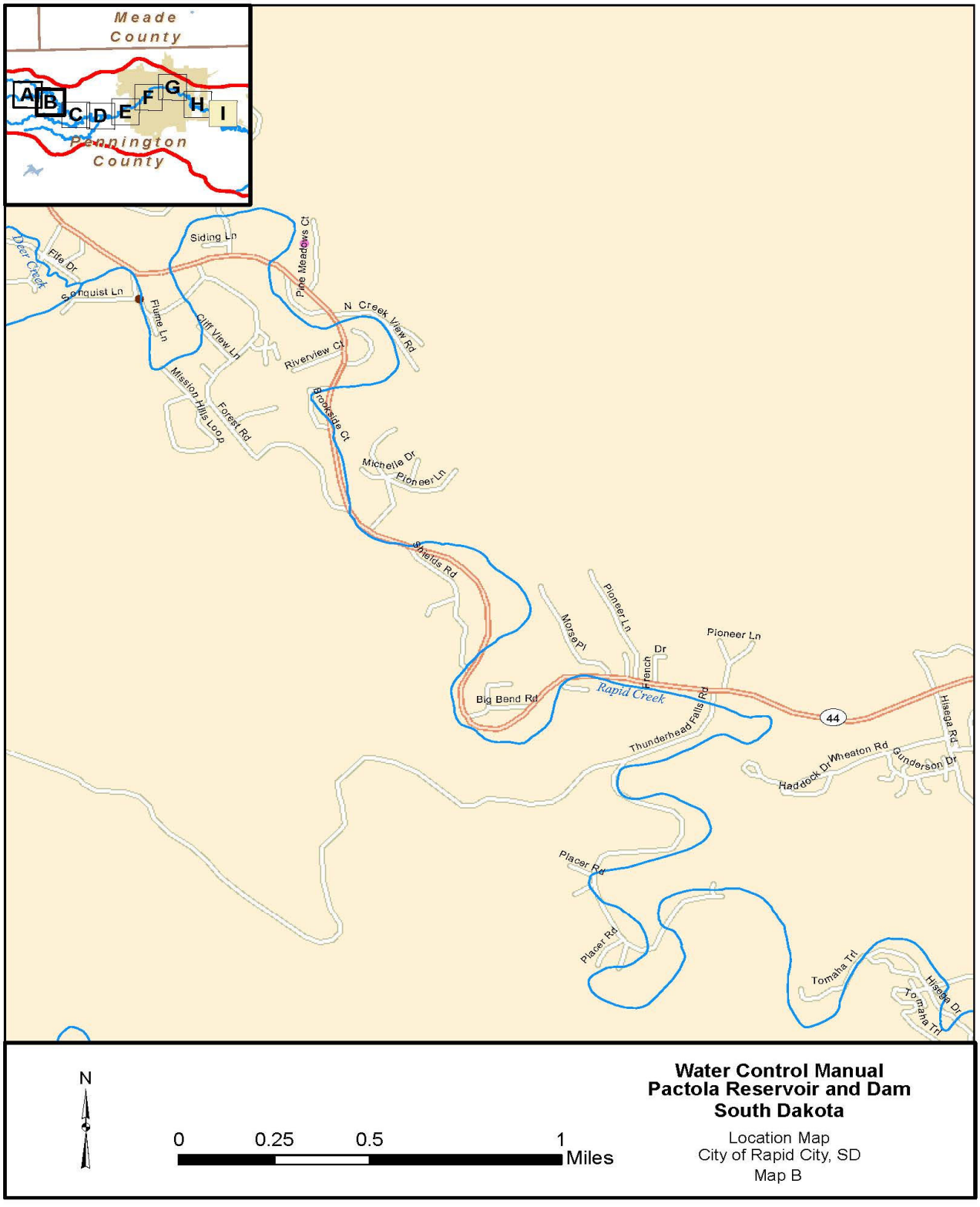
Plate 4-4



Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Pactola Dam to Rapid City
Map A

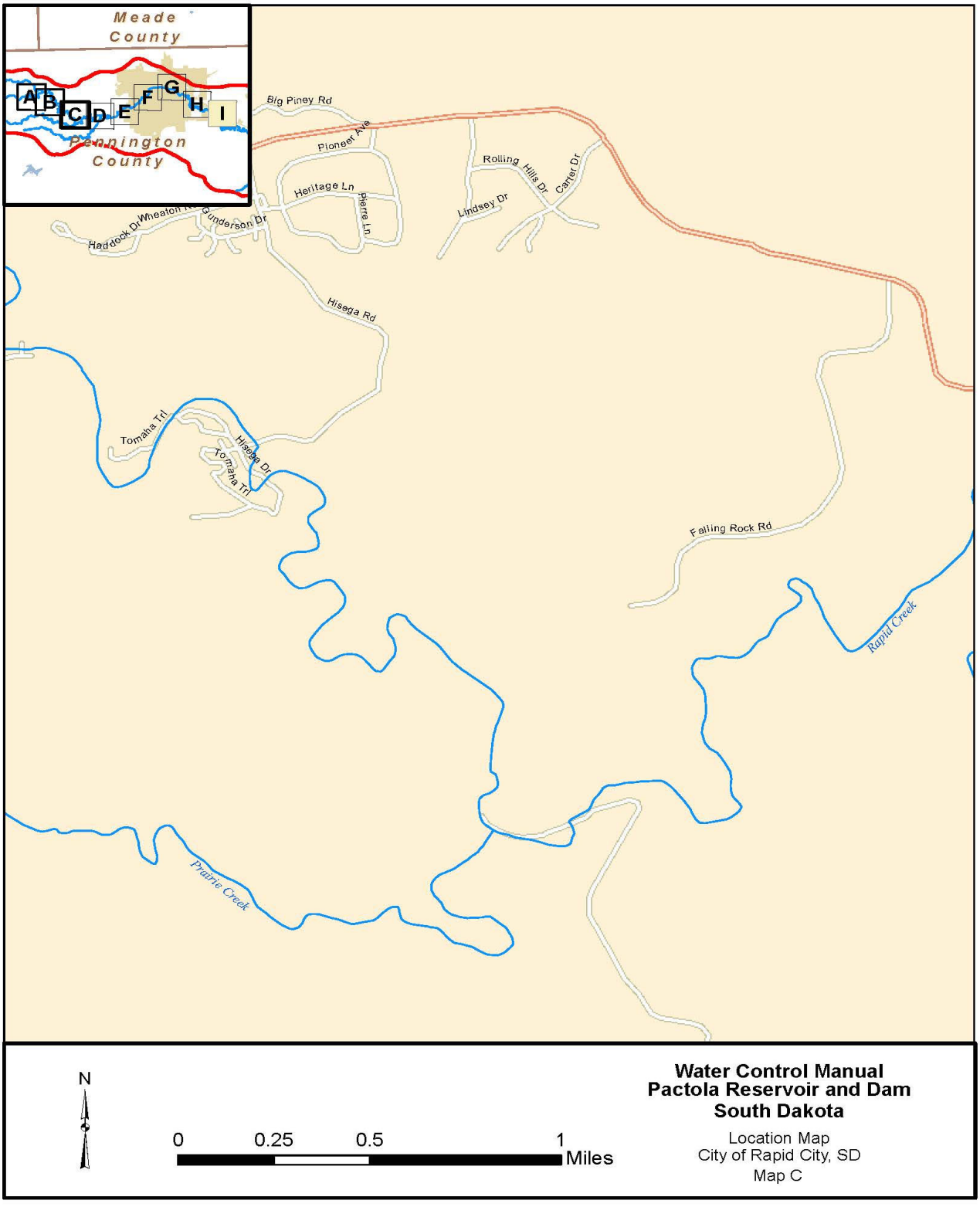
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Pactola Dam to Rapid City
Map B

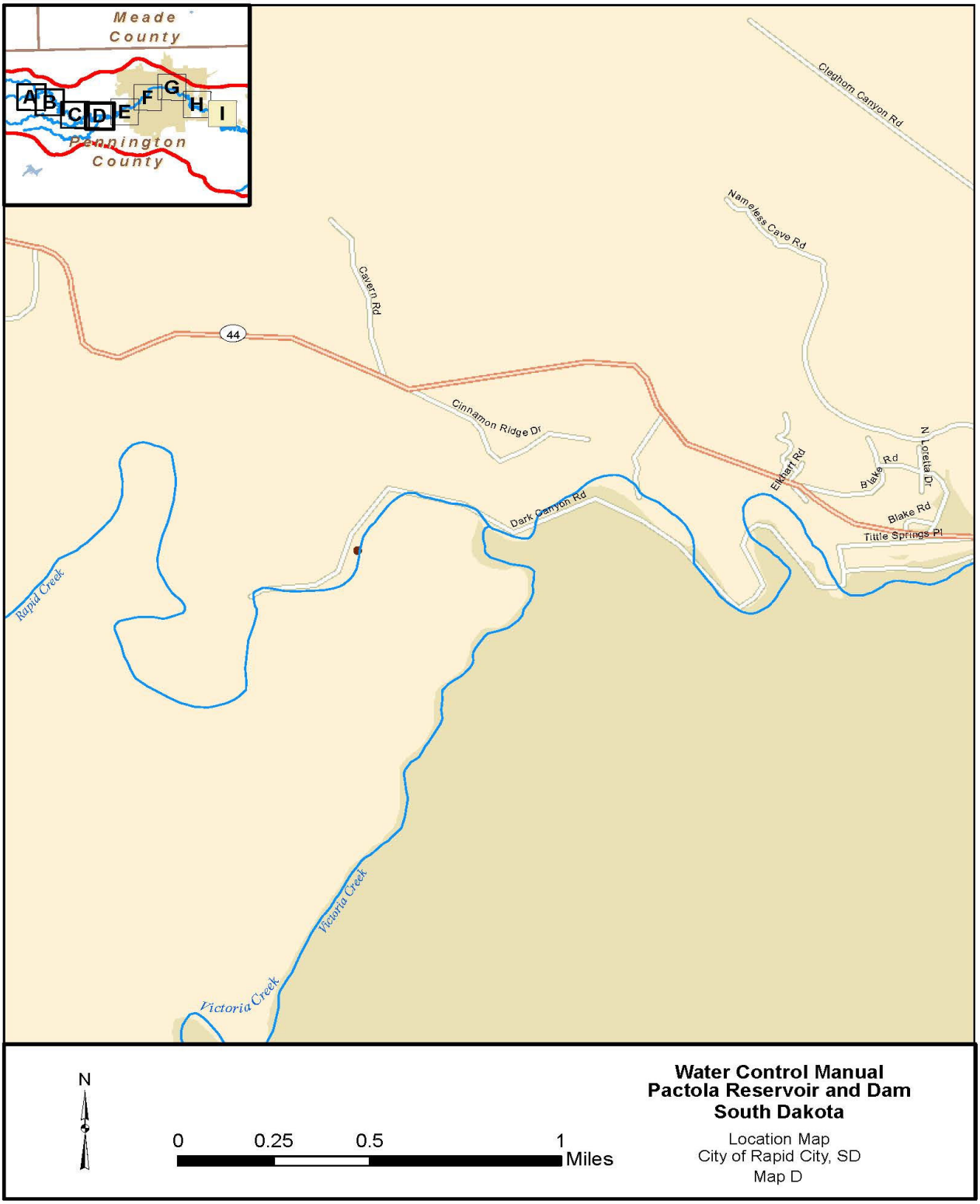
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Pactola Dam to Rapid City
Map C

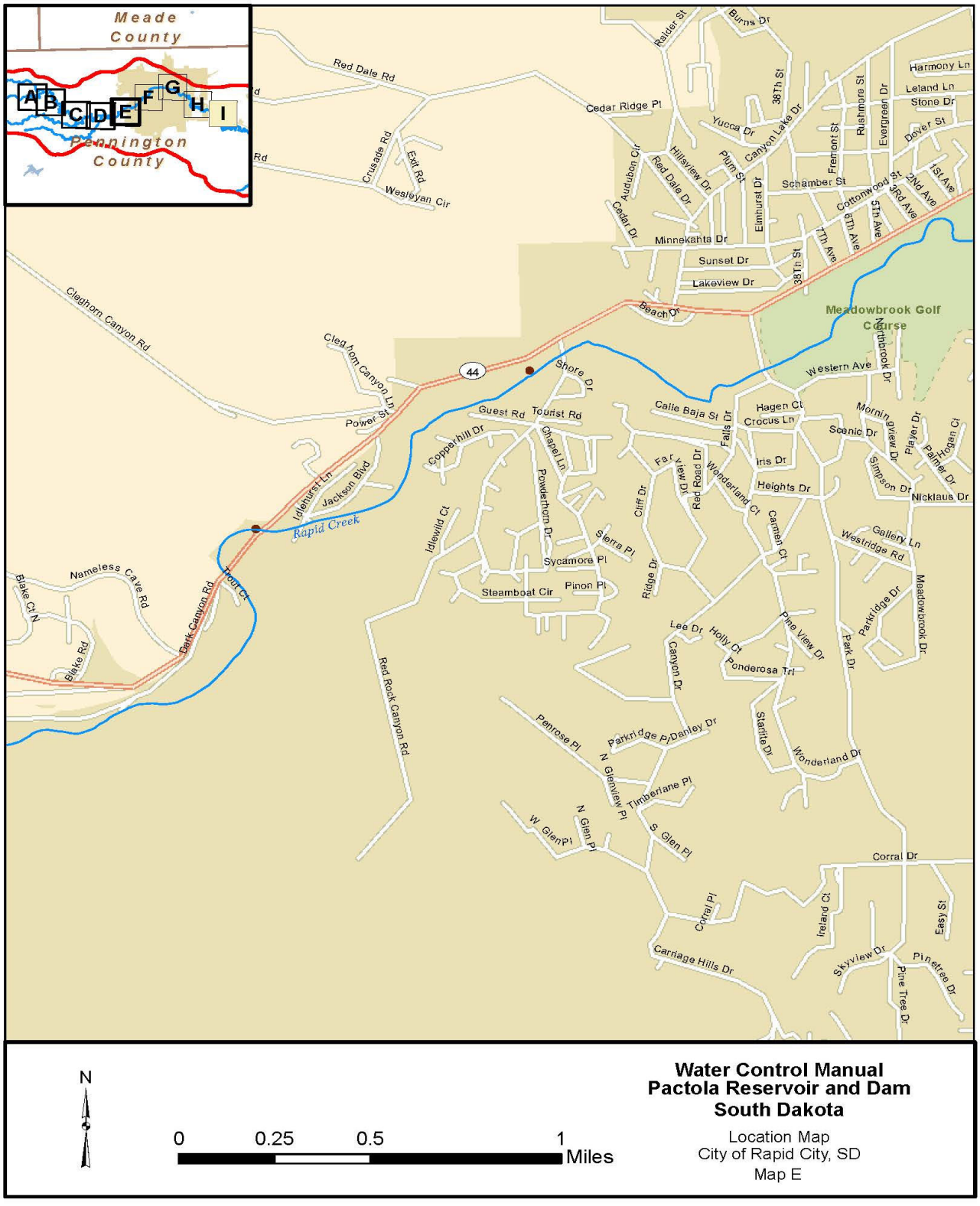
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Pactola Dam to Rapid City
Map D

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



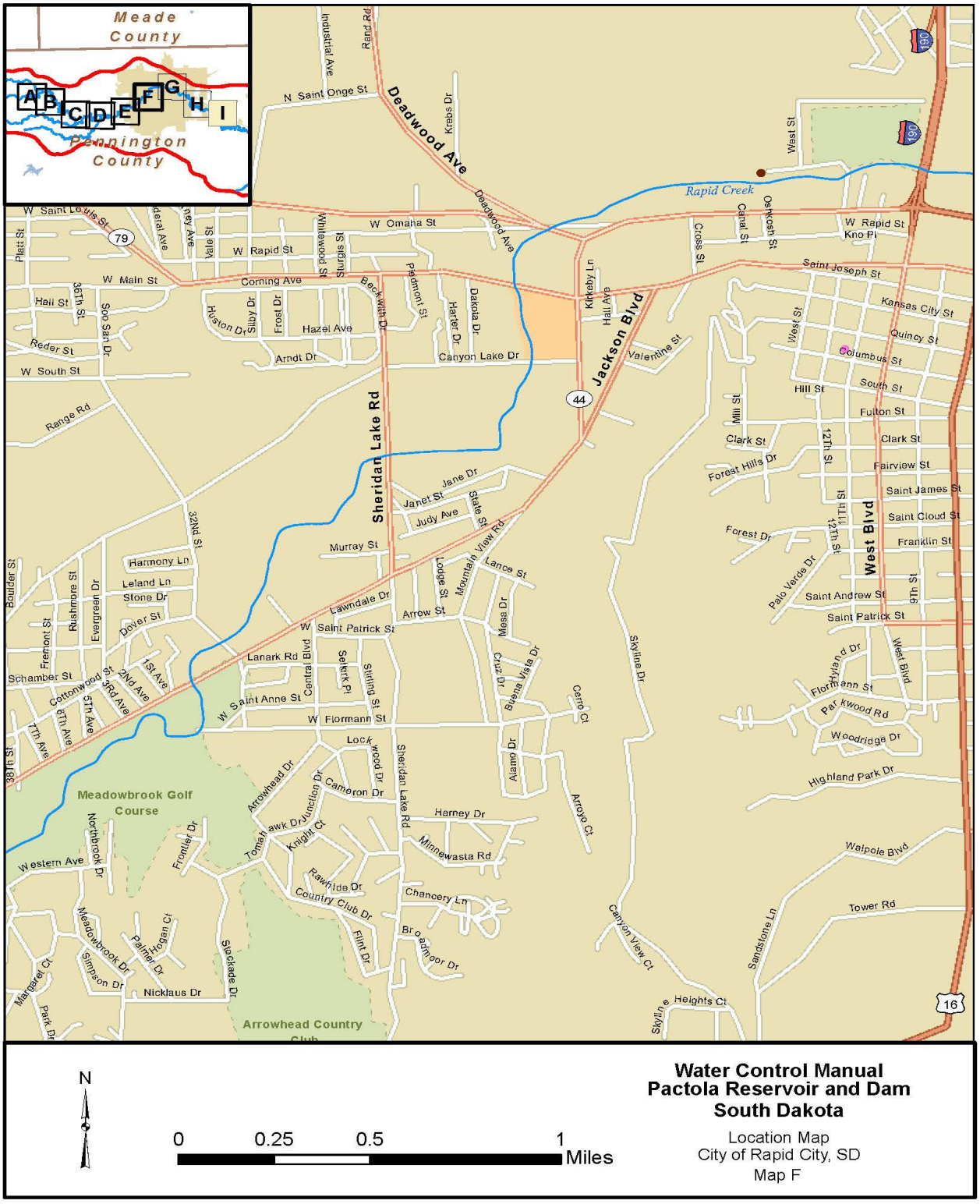
Water Control Manual
Pactola Reservoir and Dam
South Dakota

Location Map
City of Rapid City, SD
Map E

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Pactola Dam to Rapid City
Map E

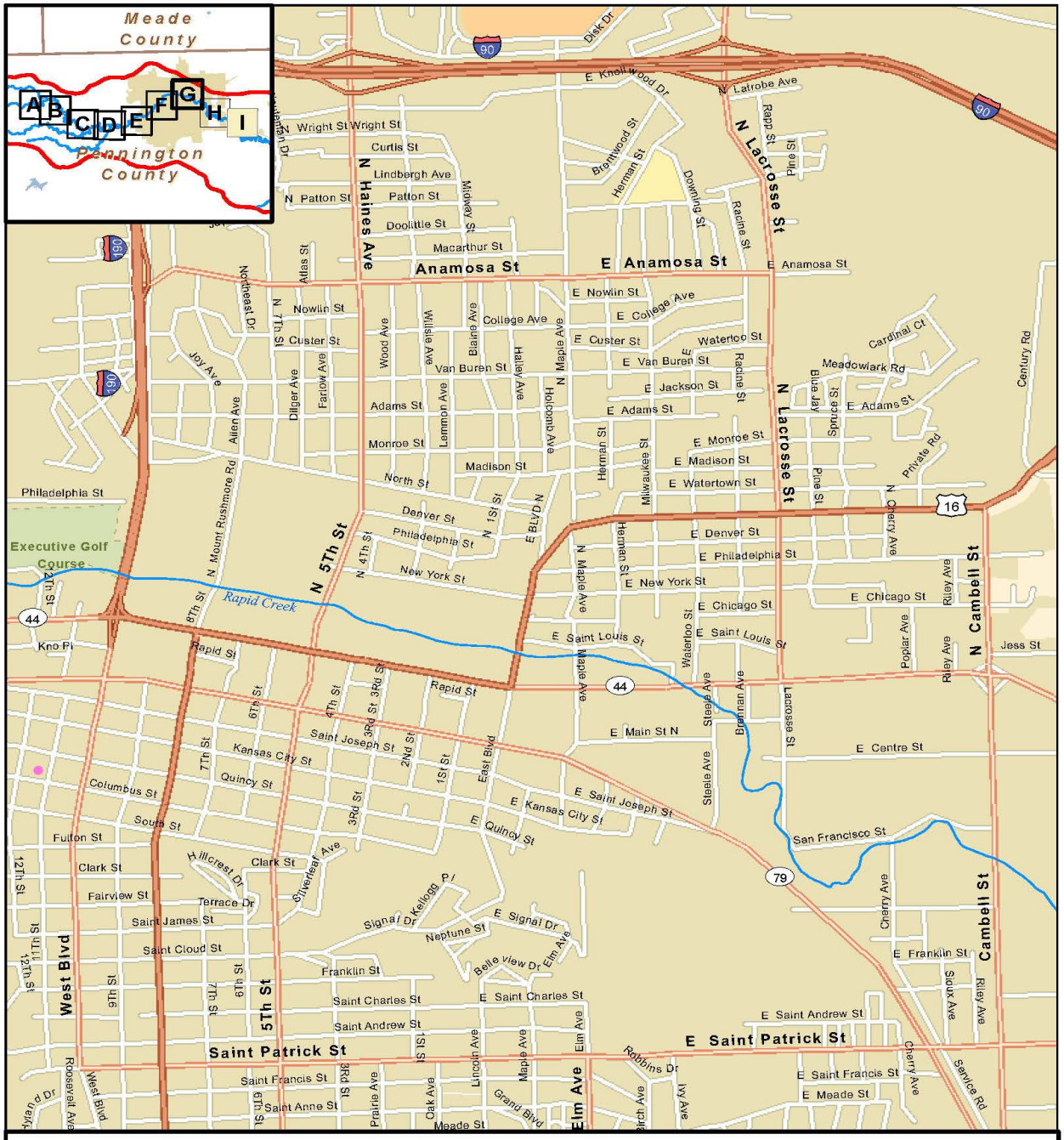
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Pactola Dam to Rapid City
Map F

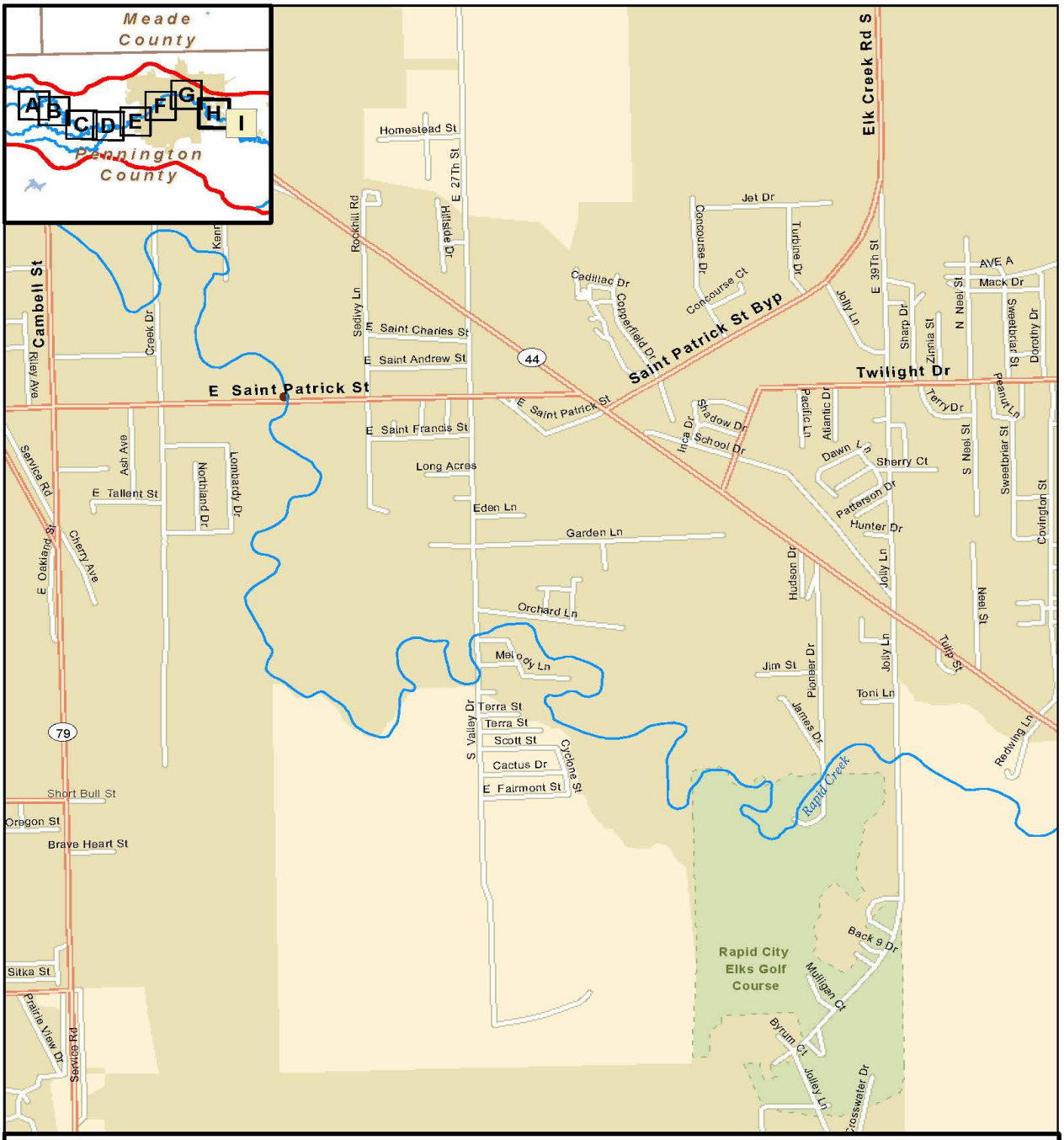
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Pactola Dam to Rapid City
Map G

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



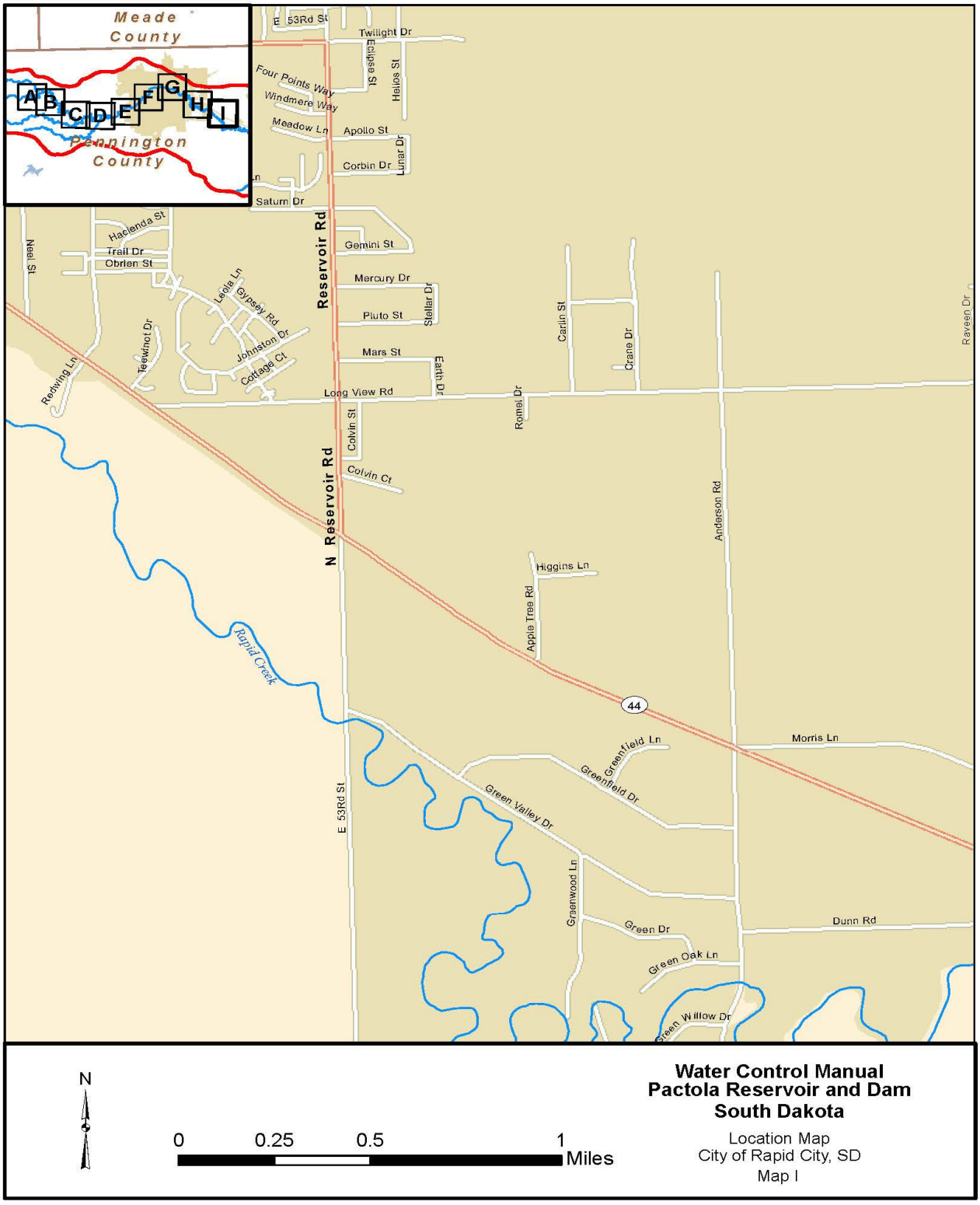
Water Control Manual
Pactola Reservoir and Dam
South Dakota

Location Map
City of Rapid City, SD
Map H

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Pactola Dam to Rapid City
Map H

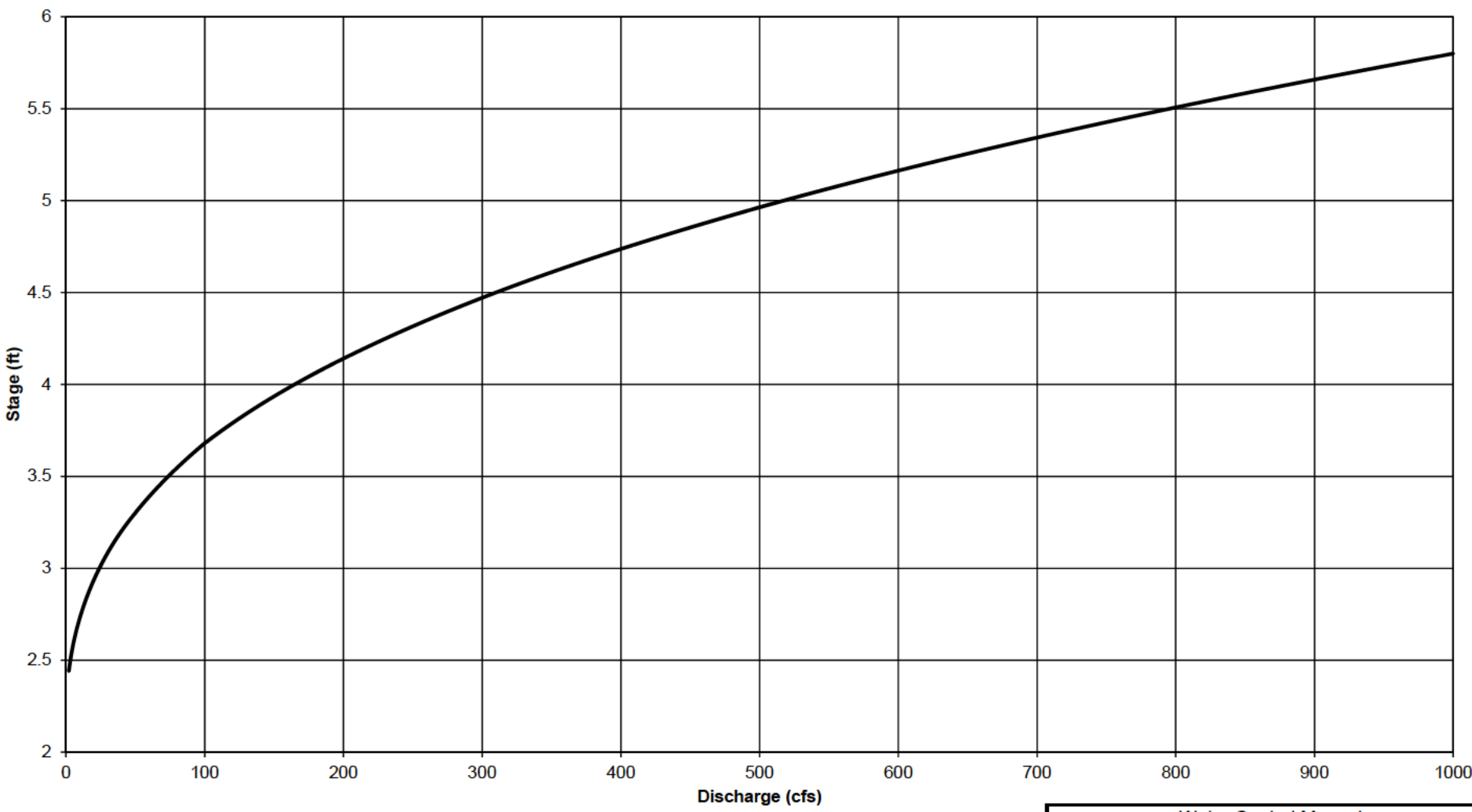
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



Water Control Manual
Pactola Dam and Reservoir, South Dakota

Location Map
Pactola Dam to Rapid City
Map I

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



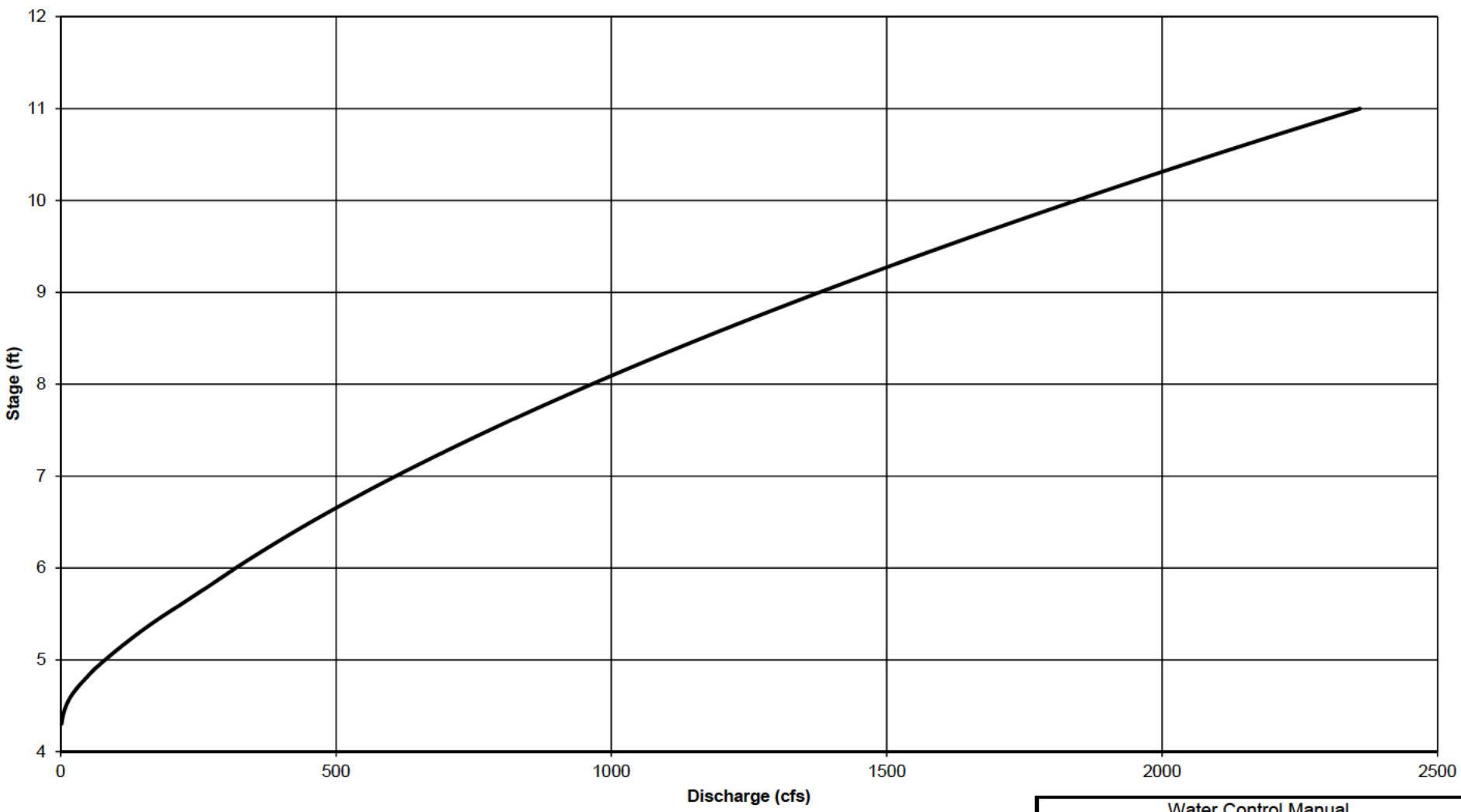
Gage Datum: 5,920.00 feet NGVD29

Rating curve data obtained from the USGS ADAPS computer system.
Rating ID: 11.1

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Rating Curve
Castle Creek near Hill City, SD

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



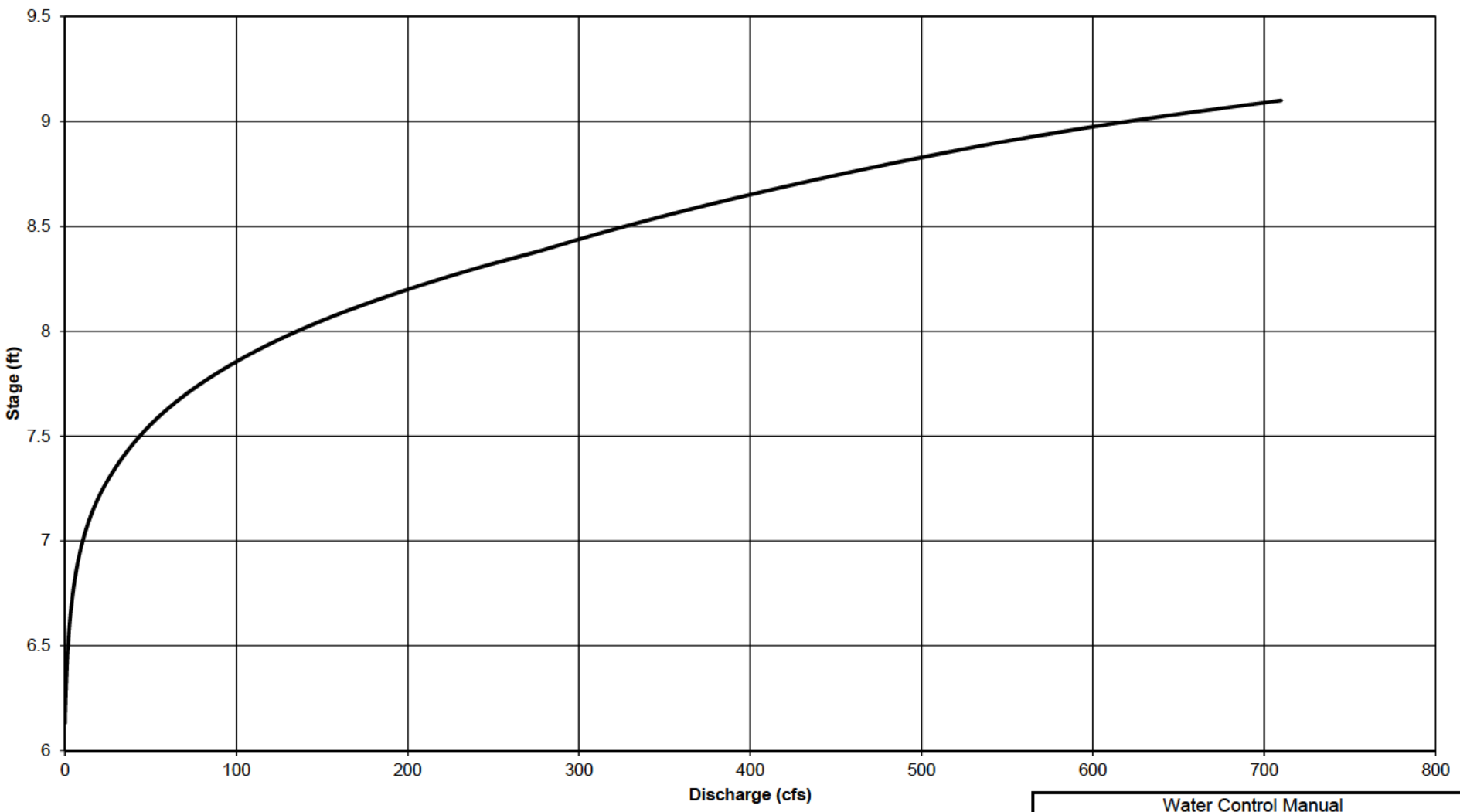
Gage Datum: 4,620.00 feet NGVD29

Rating curve data obtained from the USGS ADAPS computer system.
Rating ID: 11.0

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Rating Curve
for Rapid Creek at Silver City

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



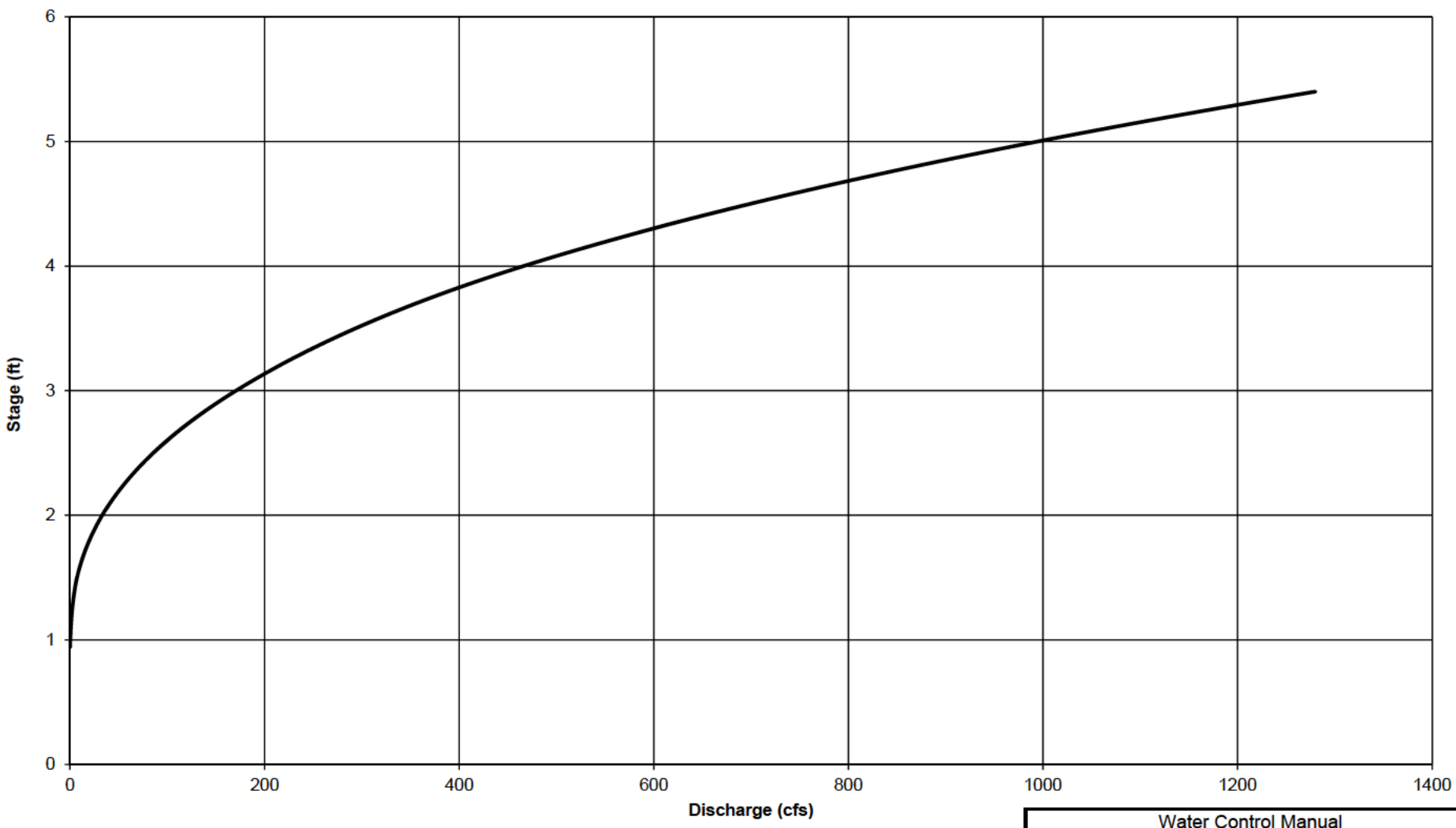
Gage Datum: 4,407.82 feet above NAVD88

Rating curve data obtained from the USGS ADAPS computer system.
Rating ID: 11.0

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Rating Curve
for Rapid Creek below Pactola Dam

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



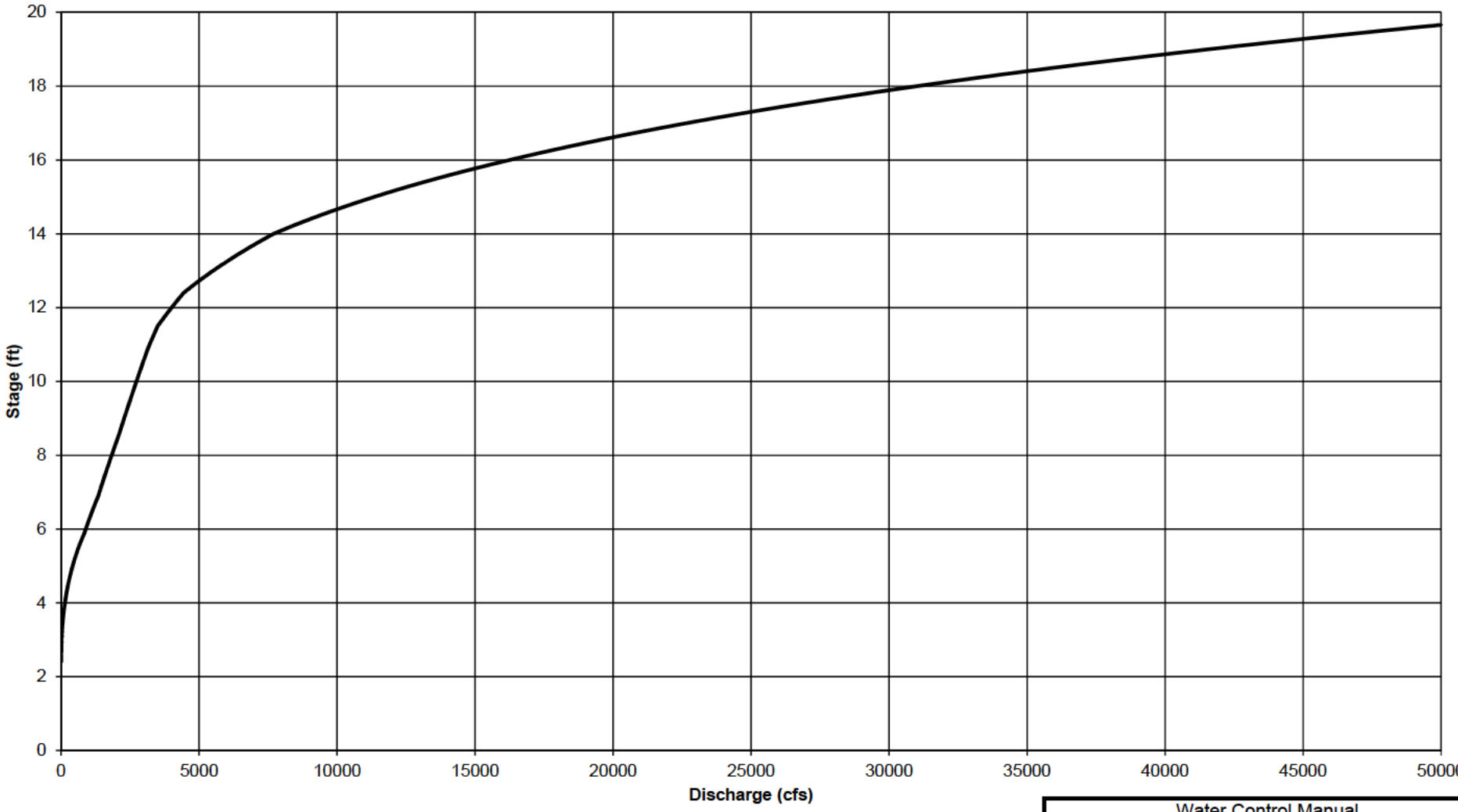
Gage Datum: 3,401.20 feet above NAVD88

Rating curve data obtained from the USGS ADAPS computer system.
Rating ID: 28.0

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Rating Curve
for Rapid Creek above Canyon Lake

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



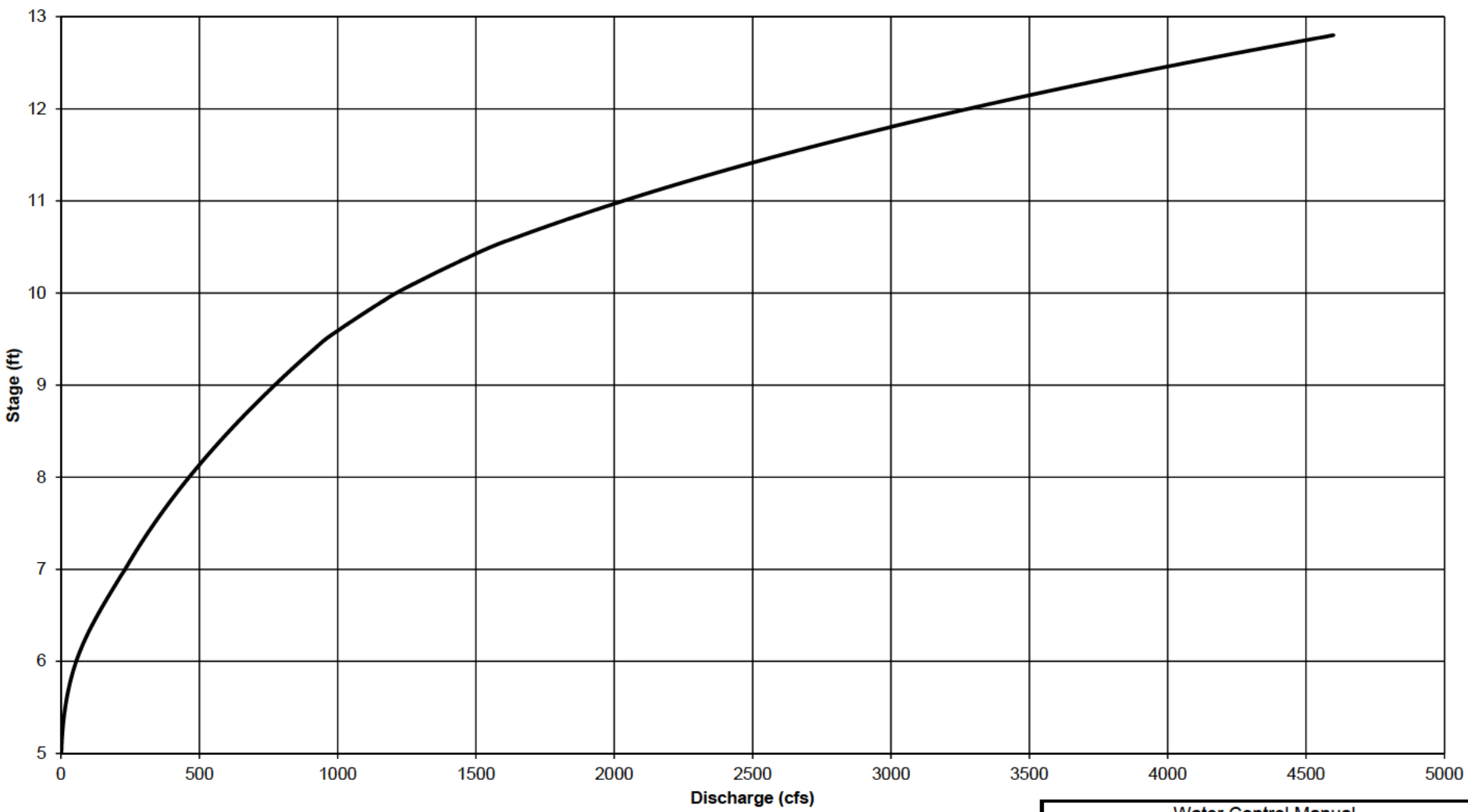
Gage Datum: 3,240.14 feet NGVD29

Rating curve data obtained from the USGS ADAPS computer system.
Rating ID: 28.0

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Rating Curve
for Rapid Creek at Rapid City

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



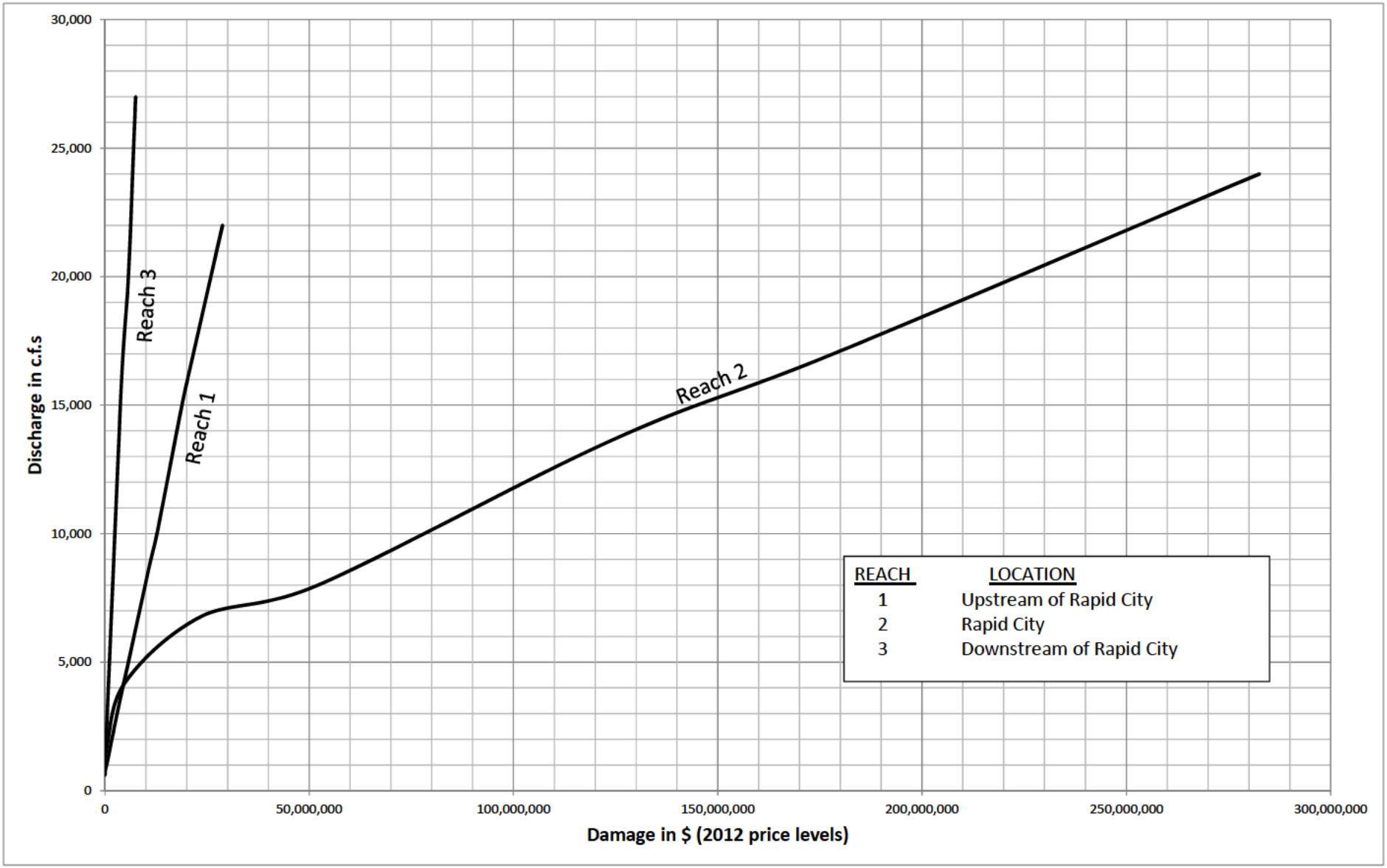
Gage Datum: 2,699.74 feet above NAVD88

Rating curve data obtained from the USGS ADAPS computer system.
Rating ID: 26.0

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Rating Curve
for Rapid Creek near Farmingdale

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019



Prepared from Omaha District stage damage tables for Rapid Creek downstream from Pactola Reservoir. Curves are based upon 1976 land use, updated to 2012 price levels.

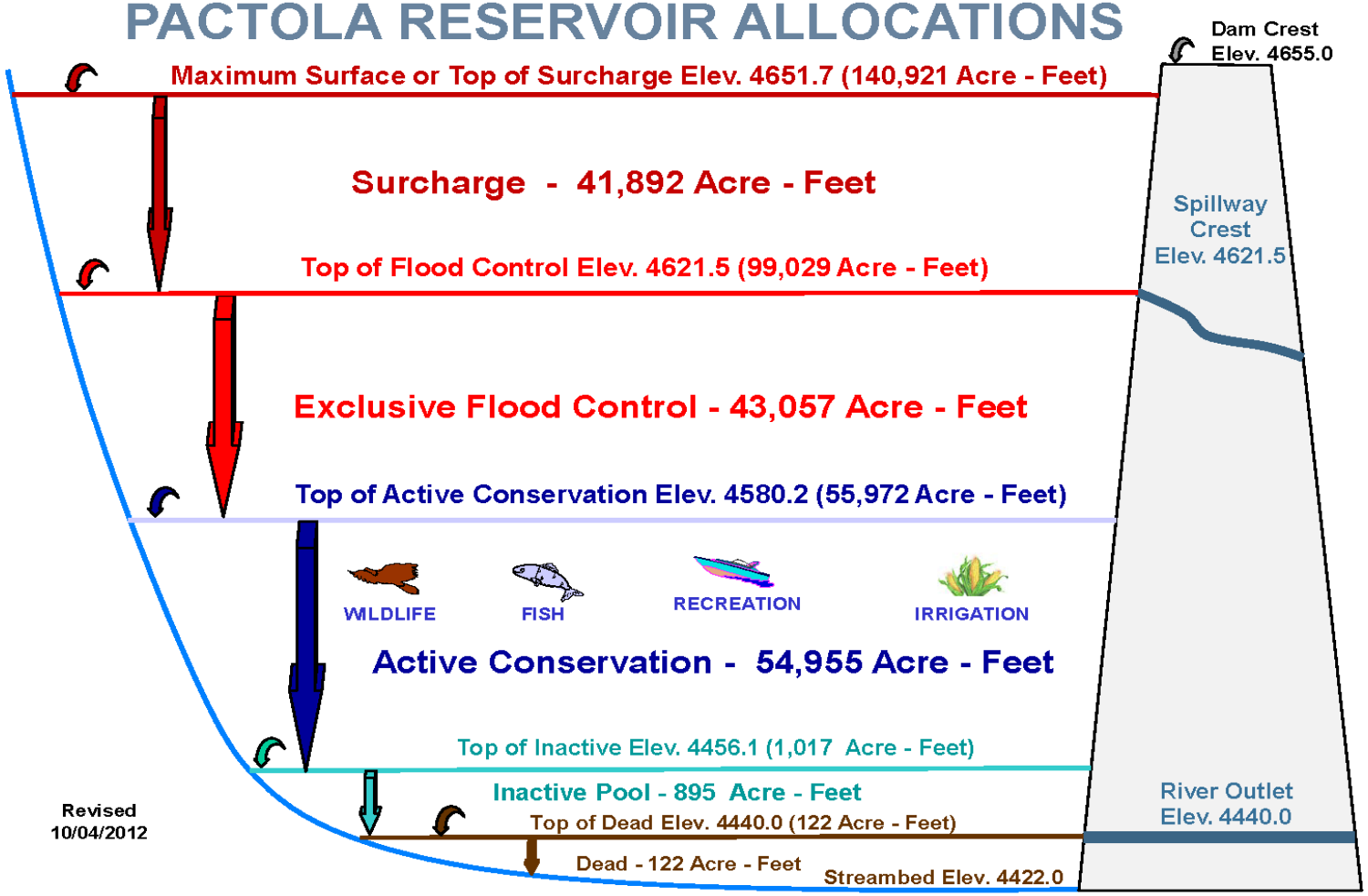
Water Control Manual
Pactola Dam and Reservoir, South Dakota

Rapid Creek
Discharge - Damage Curves

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

Plate 4-12

PACTOLA RESERVOIR ALLOCATIONS



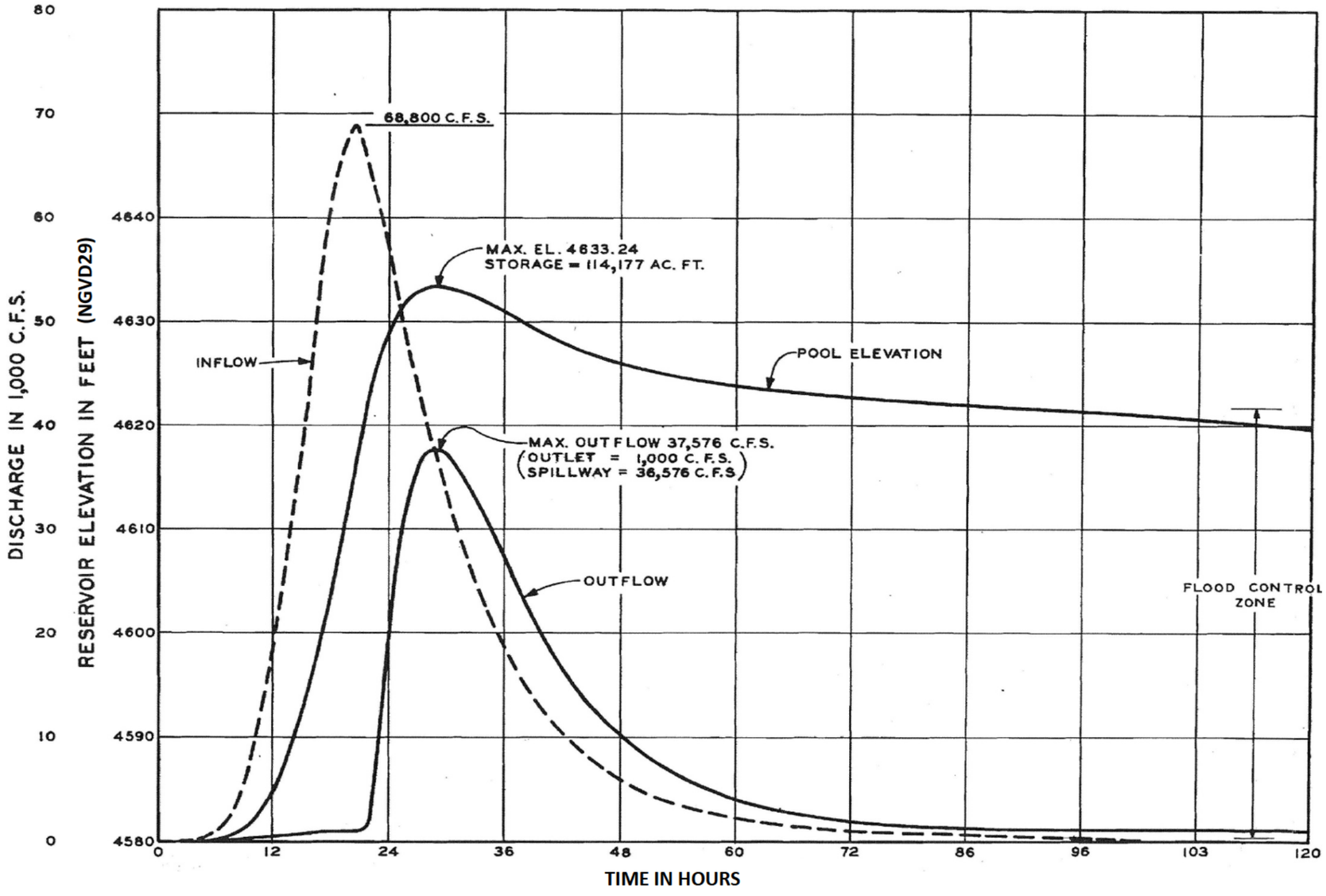
Source of Data: US Bureau of Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Reservoir Storage Allocations for Pactola Reservoir

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 7-1



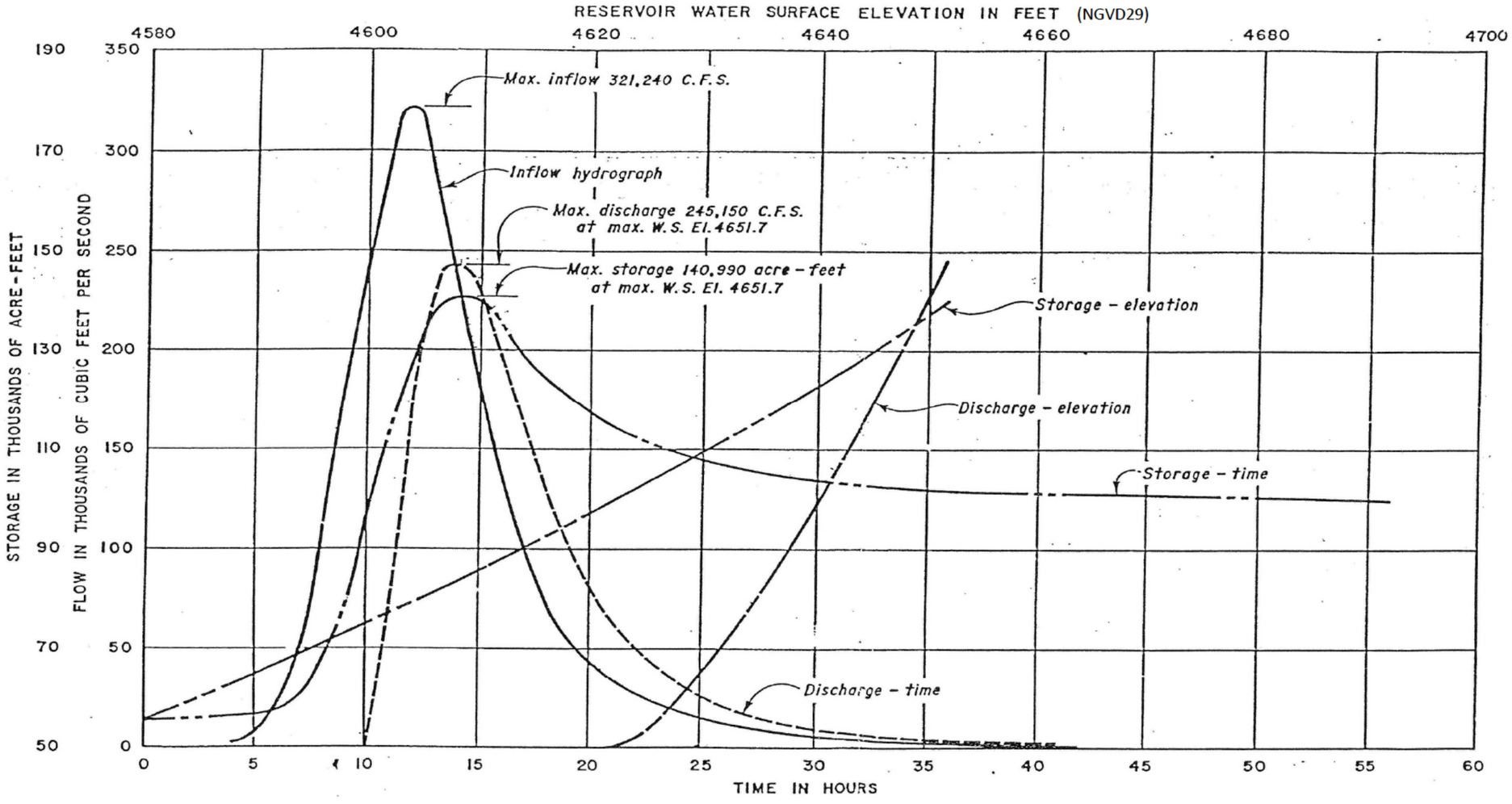
Note: This spillway design flood routing has been revised. Updated spillway design flood routing is shown on Plate 8-2.

Scanned from Plate 19, Pactola Dam and Reservoir Reservoir Regulations for Flood Control. November 1976

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Pactola Dam Modification
Original Spillway Design Flood Routing Curves

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019



FLOOD ROUTING CRITERIA

The reservoir is assumed to be at W.S. El. 4580.2 (top of active conservation capacity) at the beginning of the inflow design flood.

Discharge for routing of the IDF is limited to the spillway when the reservoir is in the surcharge pool.

The inflow hydrograph is the result of combining the maximum probable flood into Pactola Reservoir with the discharge from Deerfield Dam (using a concurrent flood and a 2.5 hour channel routing time).

NOTE

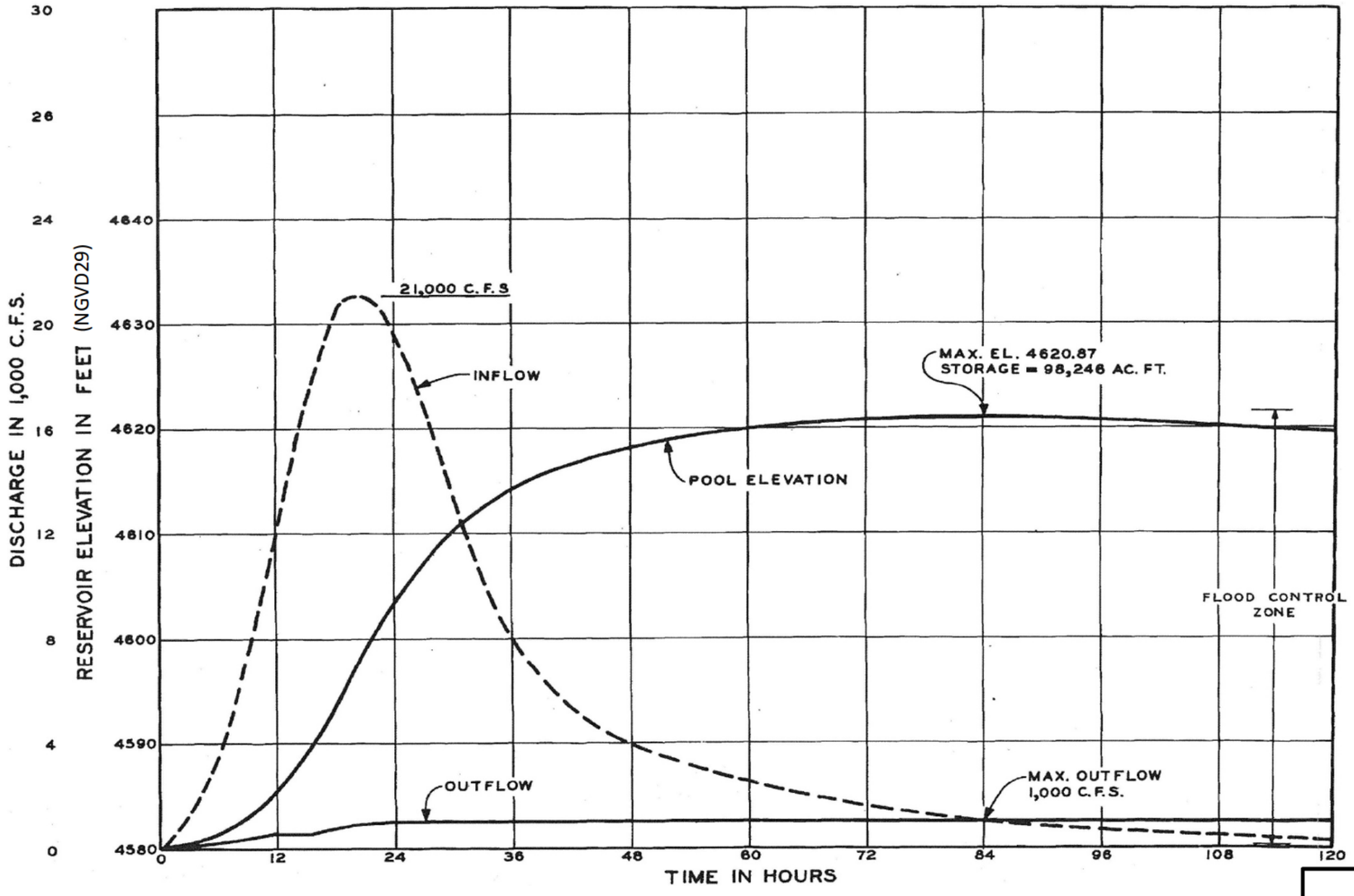
The "STORAGE-ELEVATION" curve is based on the capacity table developed by the Regional Office in July, 1983.

Scanned from Drawing 494-D-154 Bureau of Reclamation Pactola Reservoir Standing Operating Procedures Dec. 2007

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Pactola Dam
Updated Spillway Design Flood
Flood Routing Curves

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

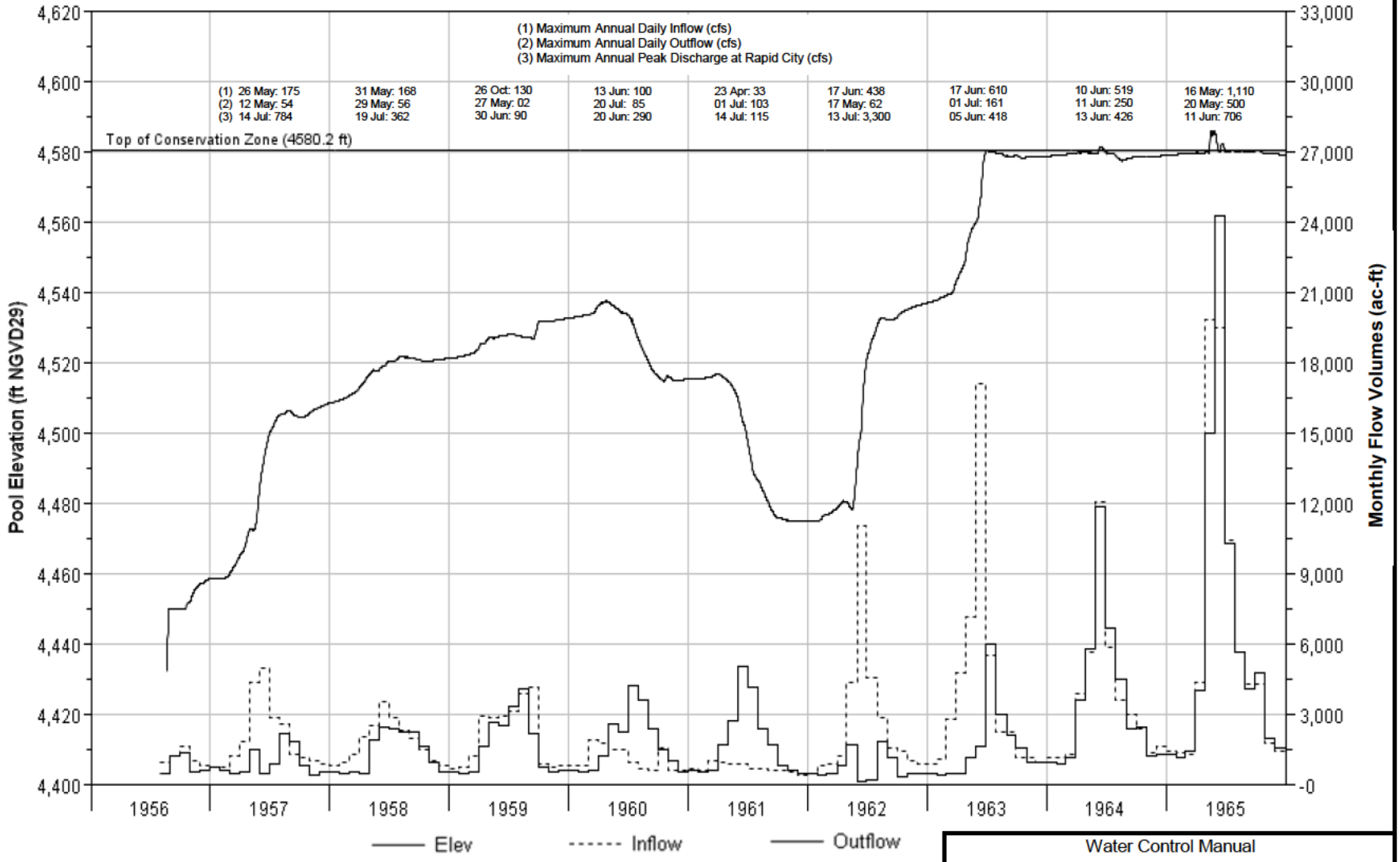


Scanned from Plate 18, Pactola Dam and Reservoir Reservoir Regulations for Flood Control. November 1976

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Reservoir Design Flood

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019



Flow Volumes are an accumulation of daily average flows in ac-ft.

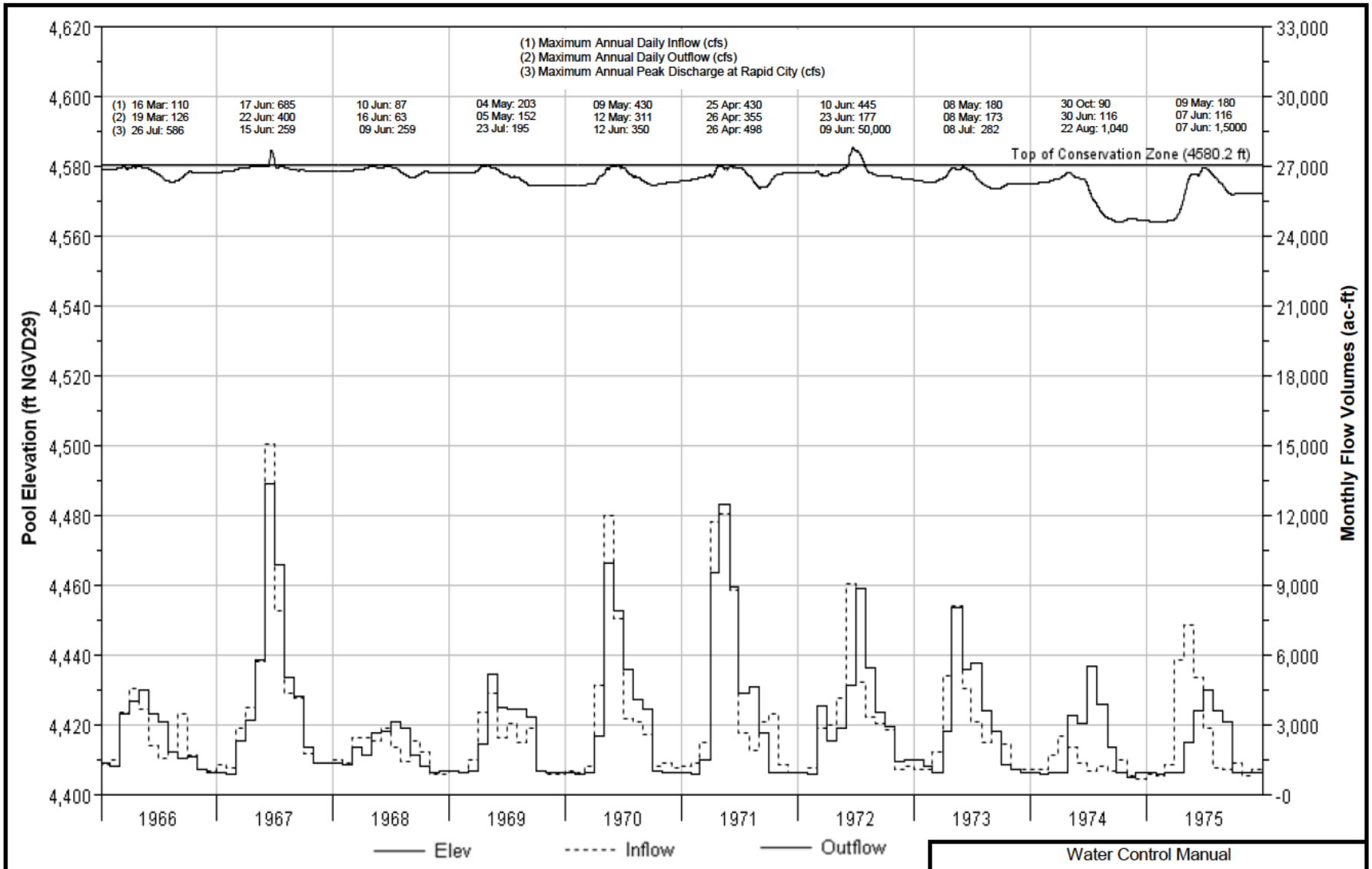
Source of Data: Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Historical Pool Elevation, Inflows, and Releases
1956-1965

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 8-4a



Flow Volumes are an accumulation of daily average flows in ac-ft.

Source of Data: Reclamation

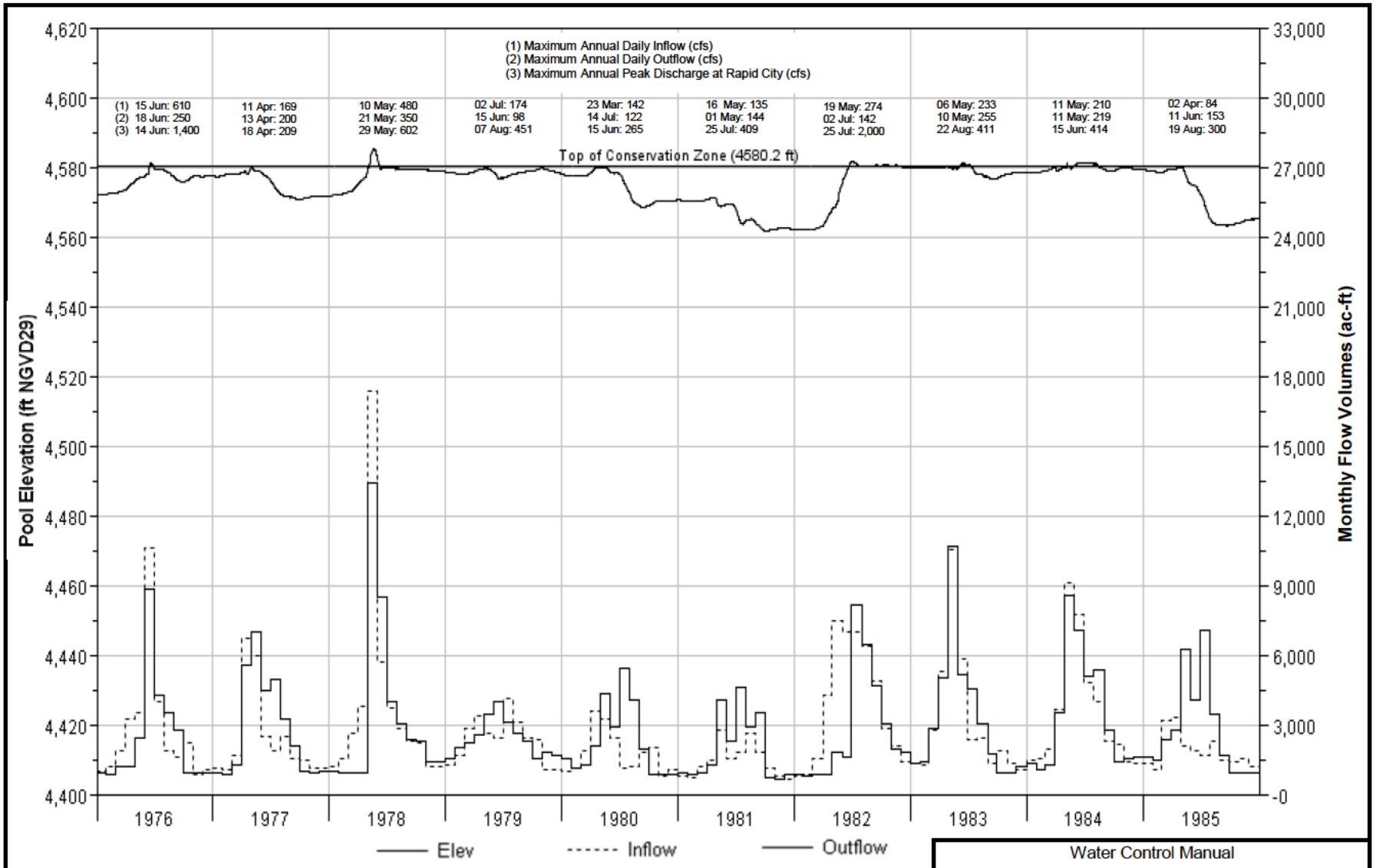
Water Control Manual
Pactola Dam and Reservoir, South Dakota

Historical Pool Elevation, Inflows, and Releases

1966-1975

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 8-4b



Flow Volumes are an accumulation of daily average flows in ac-ft.

Source of Data: Reclamation

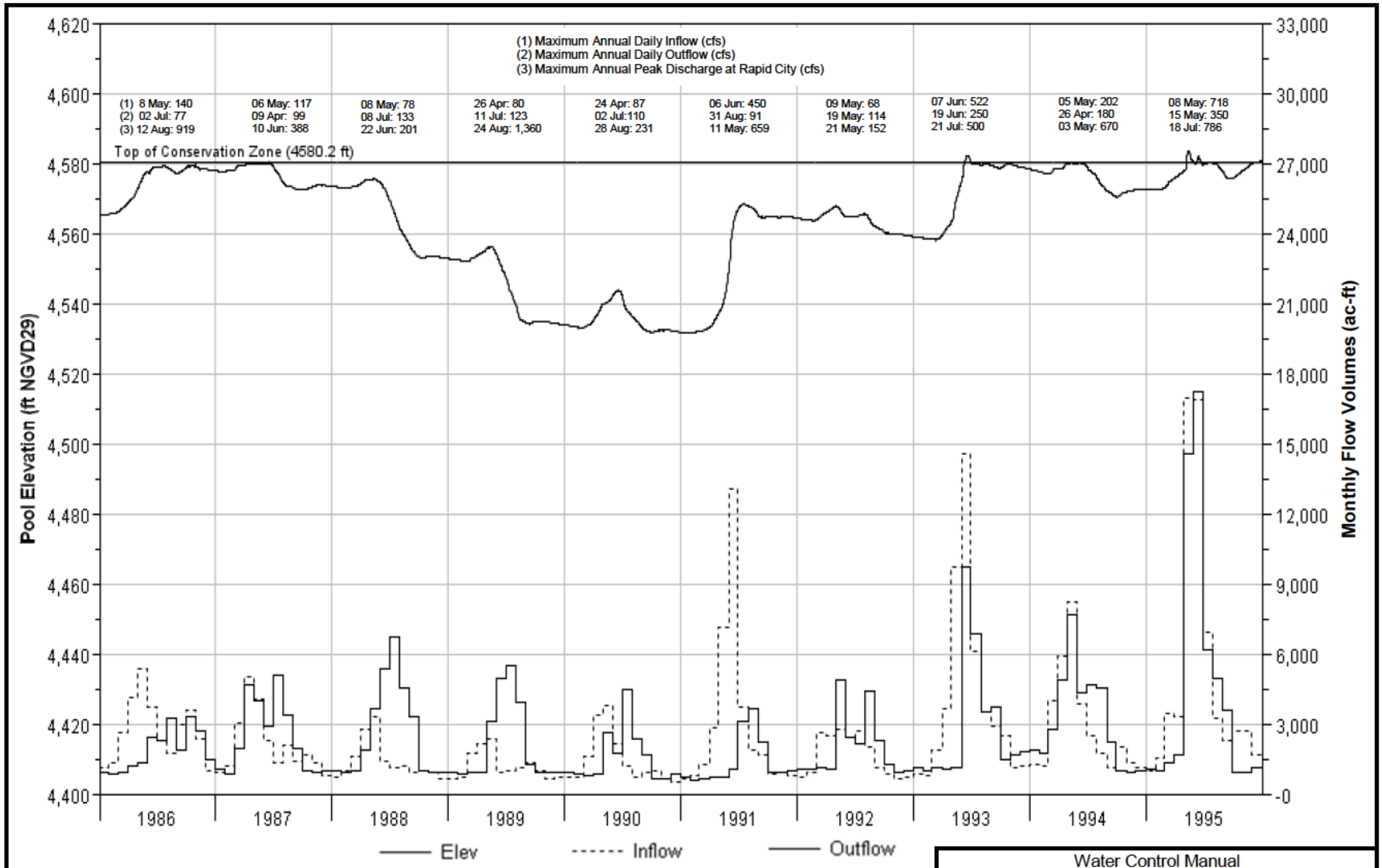
Water Control Manual
Pactola Dam and Reservoir, South Dakota

Historical Pool Elevation, Inflows, and Releases

1976-1985

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 8-4c



Flow Volumes are an accumulation of daily average flows in ac-ft.

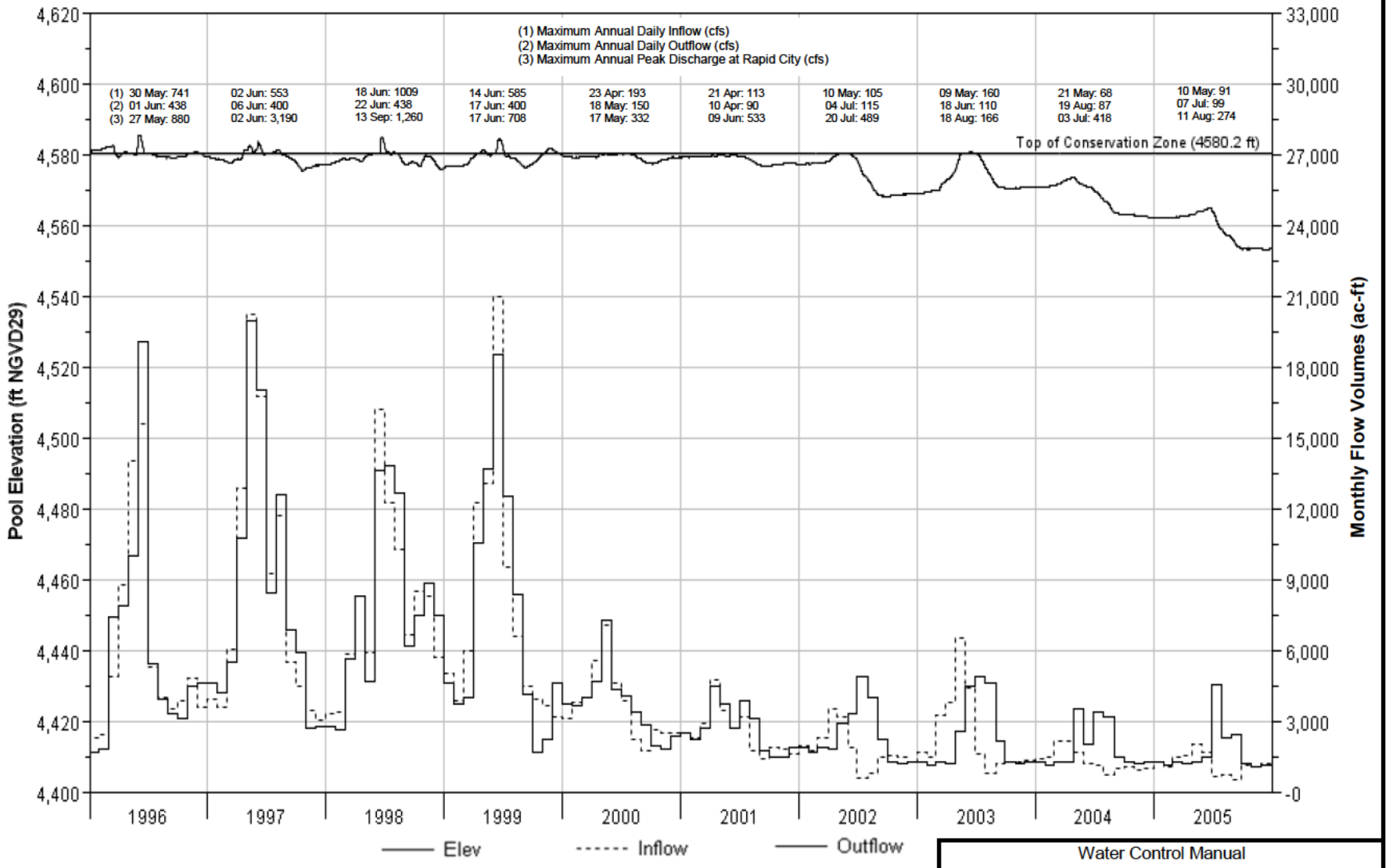
Source of Data: Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Historical Pool Elevation, Inflows, and Releases
1986-1995

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 8-4d



Flow Volumes are an accumulation of daily average flows in ac-ft.

Source of Data: Reclamation

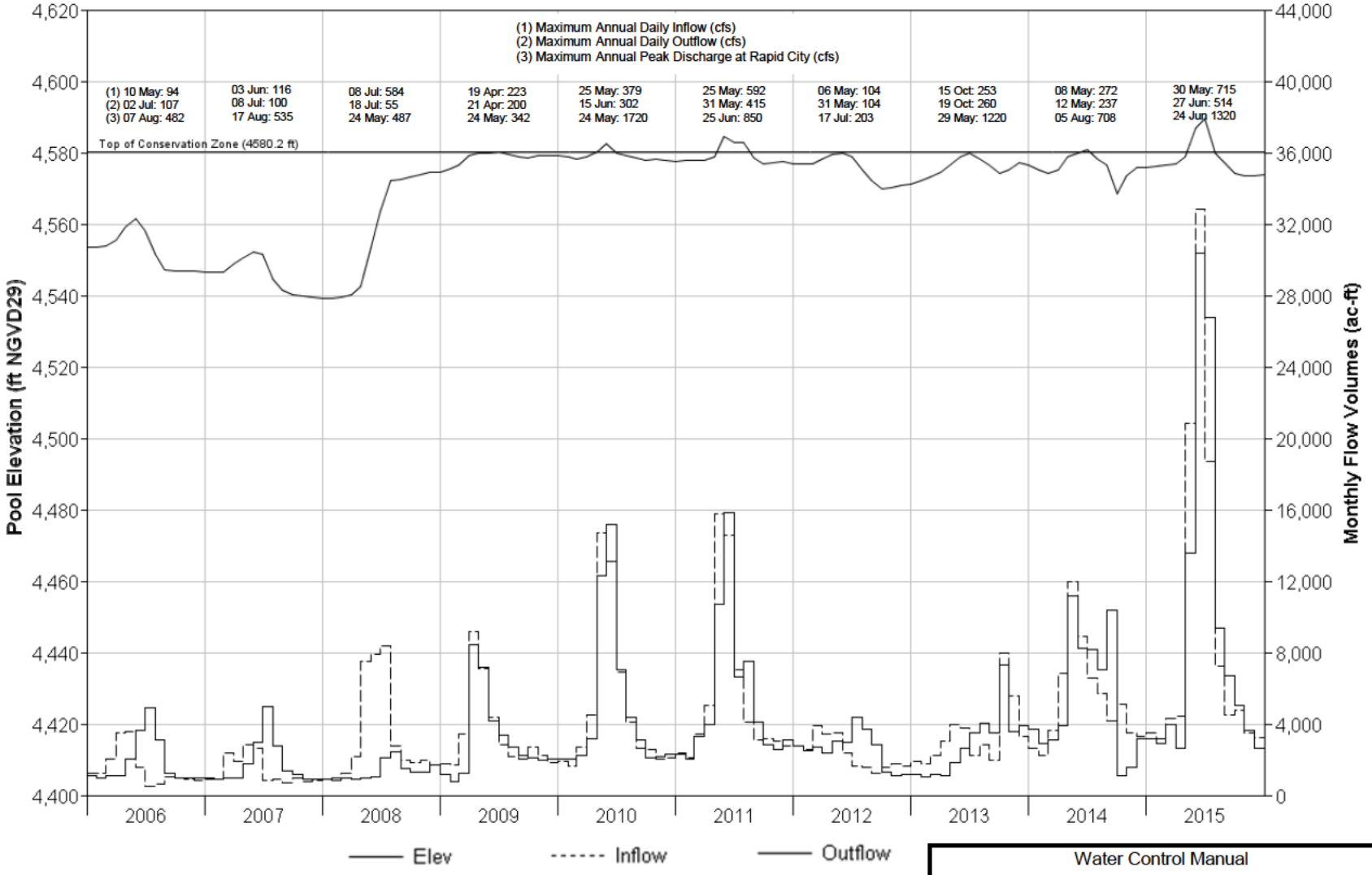
Water Control Manual
Pactola Dam and Reservoir, South Dakota

Historical Pool Elevation, Inflows, and Releases

1996-2005

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 8-4e



Flow Volumes are an accumulation of daily average flows in ac-ft.

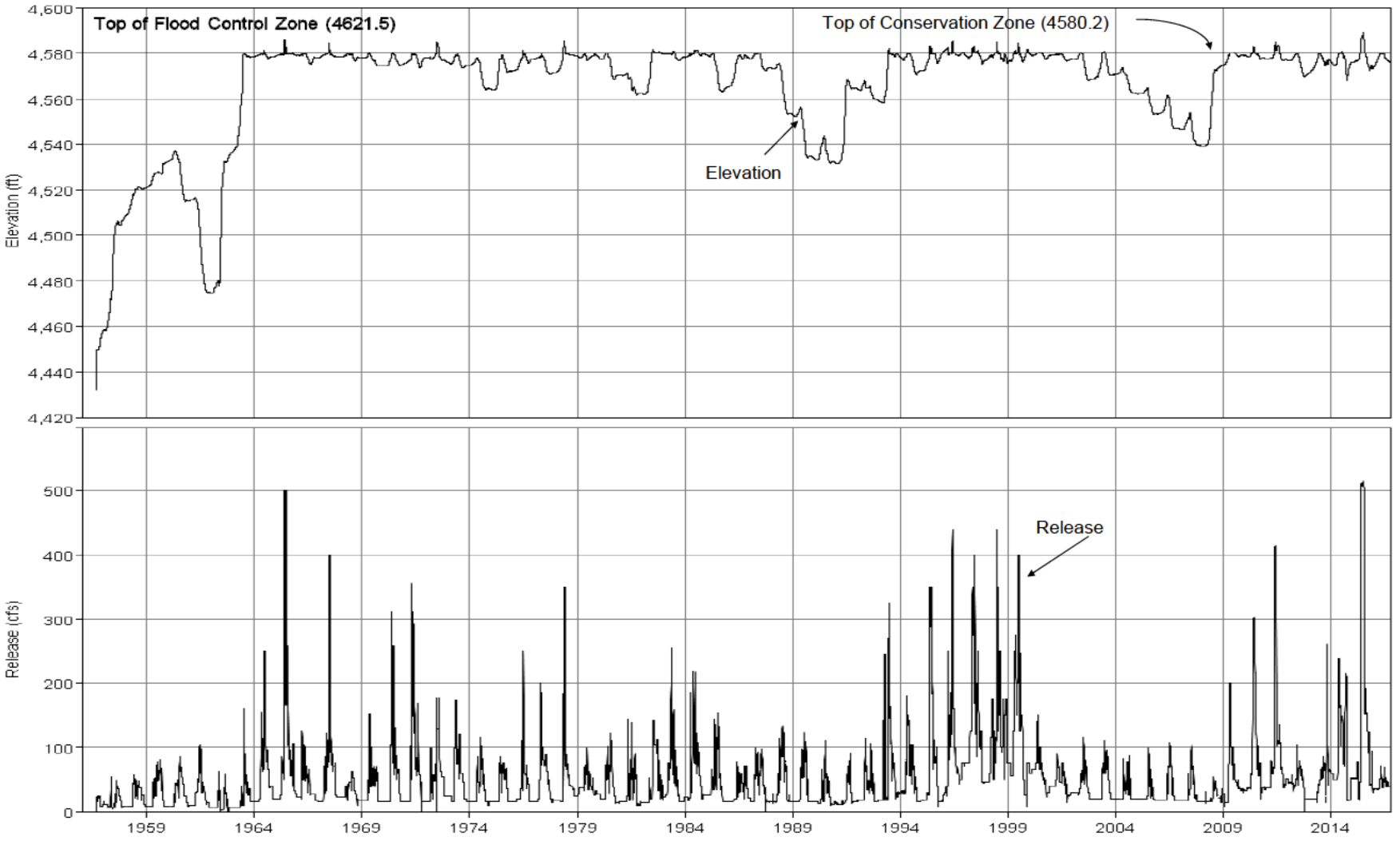
Source of Data: Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Historical Pool Elevation, Inflows, and Releases
2006-2015

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 8-4f



Note: Reservoir pool elevations are based upon the NGVD29 vertical datum.

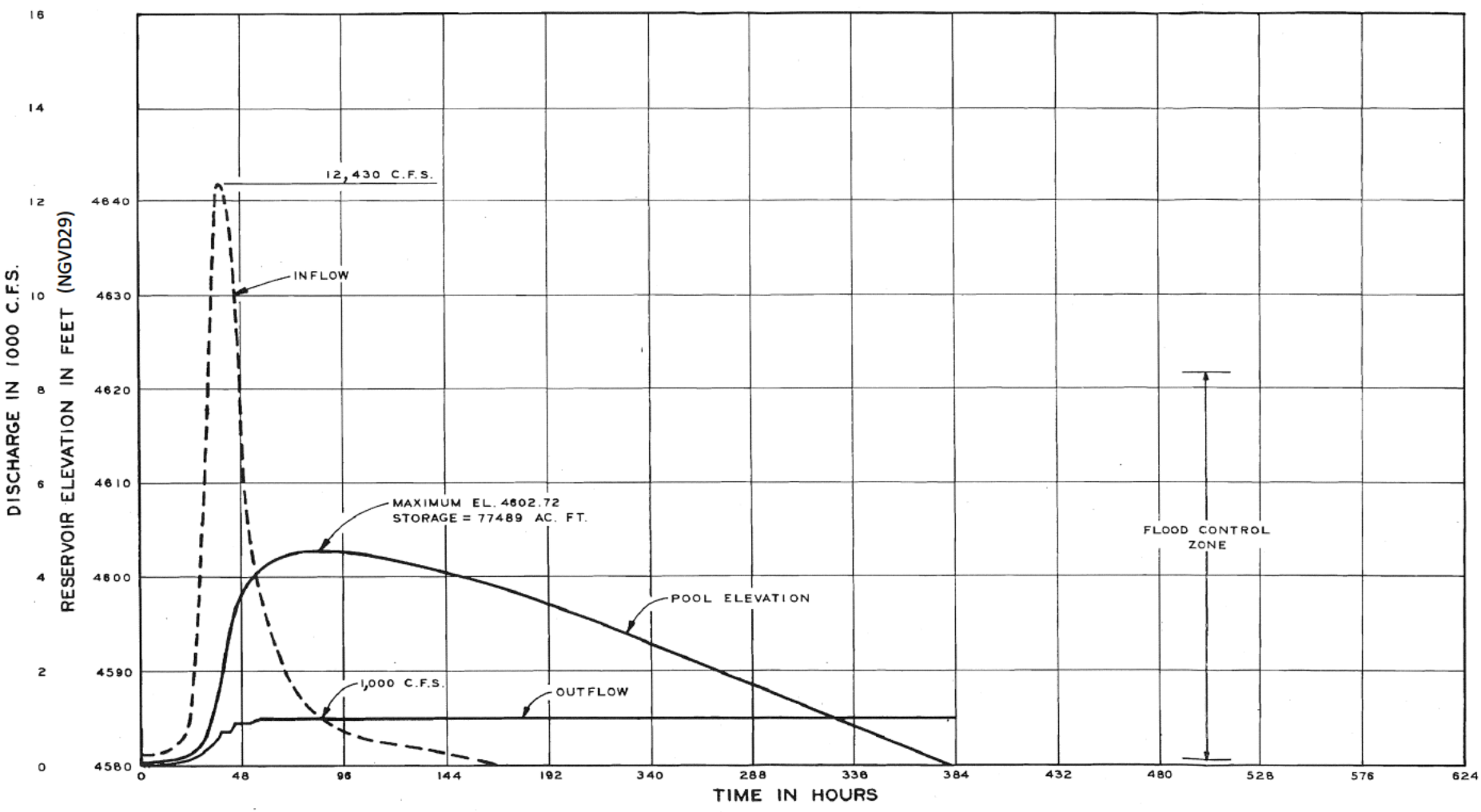
Source of data: Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Historical Pool Elevation and Releases
Period of Record

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 8-5



Note: This event predated Pactola Dam. Routing is hypotheical.

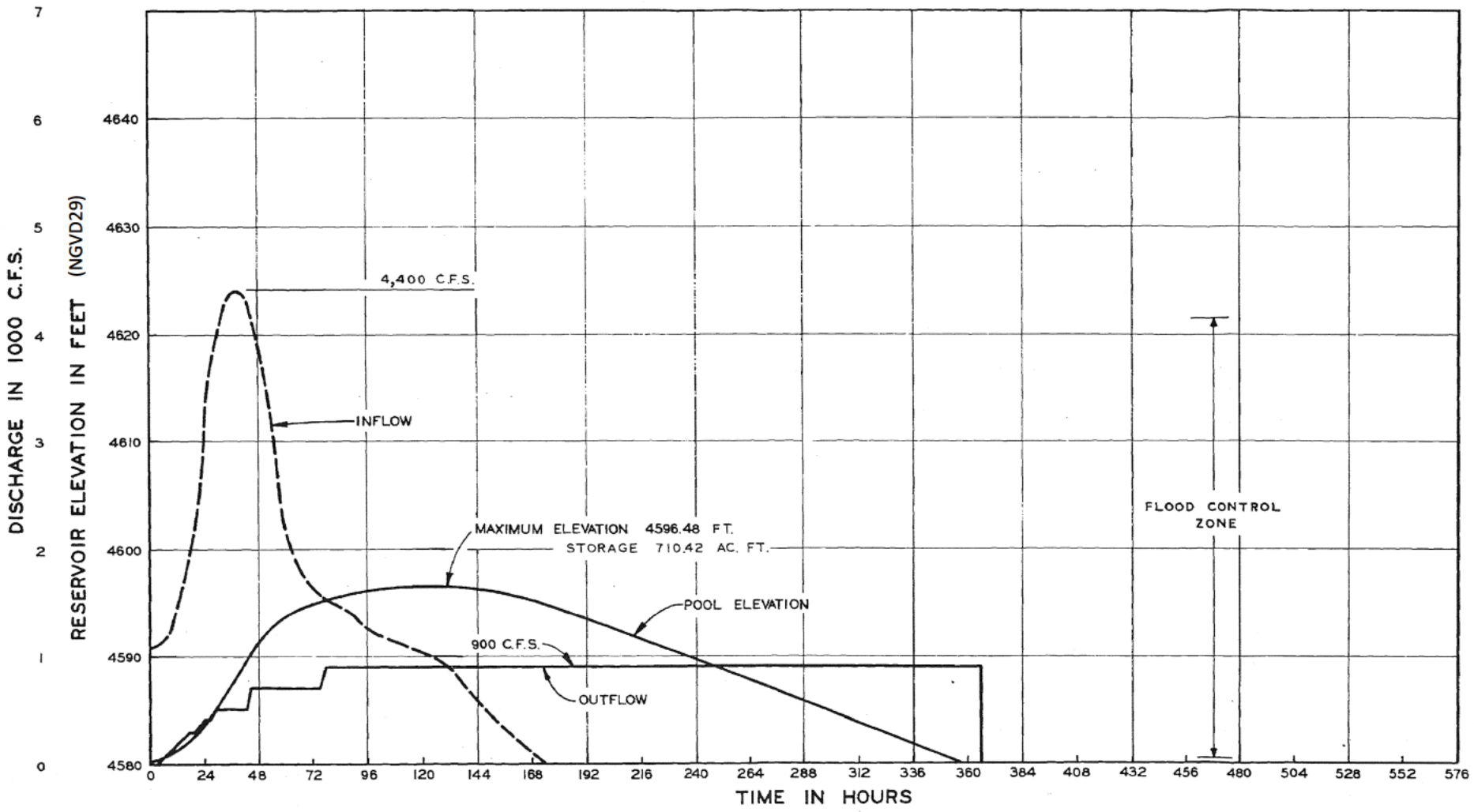
Scanned from Pactola Dam and Reservoir Regulation for Flood Ctonrol.
Pactola Dam and Reservoir." Nov 1976

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Reservoir Routing
June 1907 Flood

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 8-6



Note: This event predated Pactola Dam. Routing is hypotheical.

Scanned from Pactola Dam and Reservoir Regulation for Flood Ctonrol.
Pactola Dam and Reservoir." Nov 1976

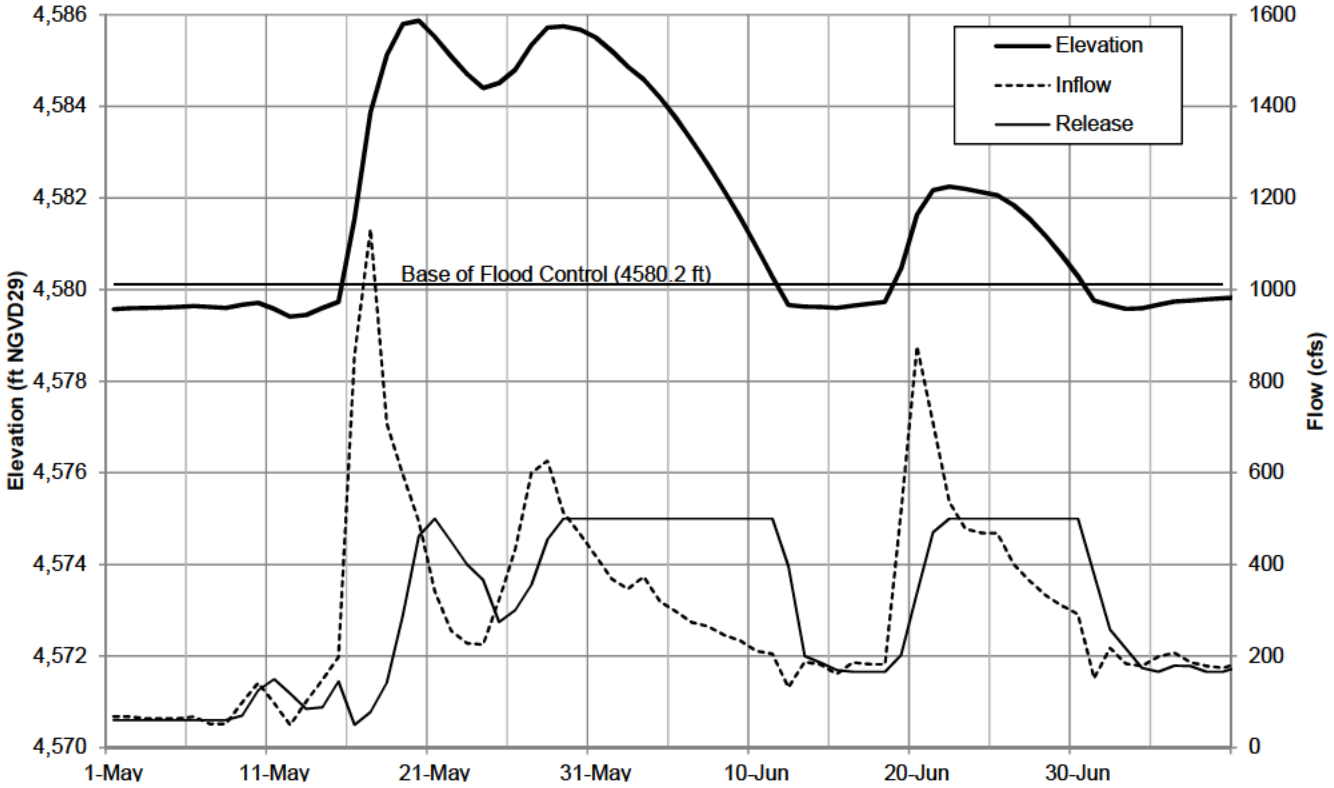
Water Control Manual
Pactola Dam and Reservoir, South Dakota

Reservoir Routing
May 1920 Flood

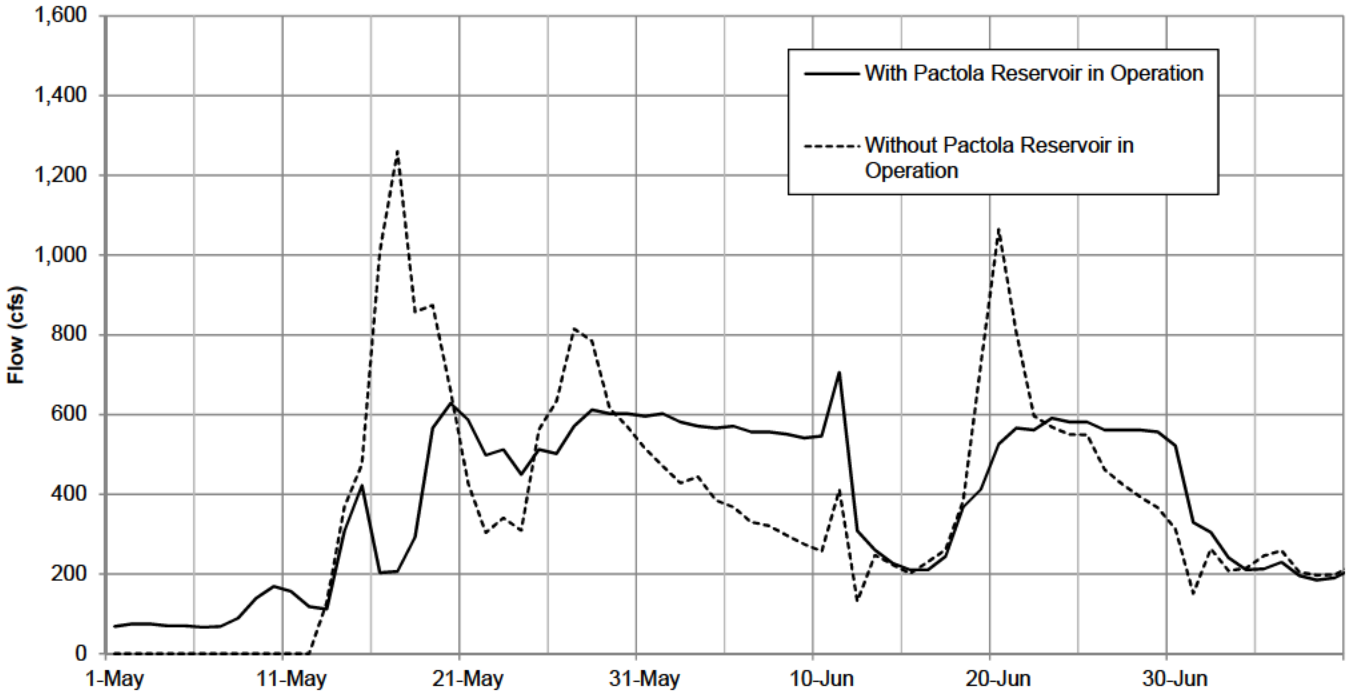
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 8-7

Pactola Reservoir



Rapid City Stream Gage



NOTE: All discharge values are daily average values except the peak streamflow value.

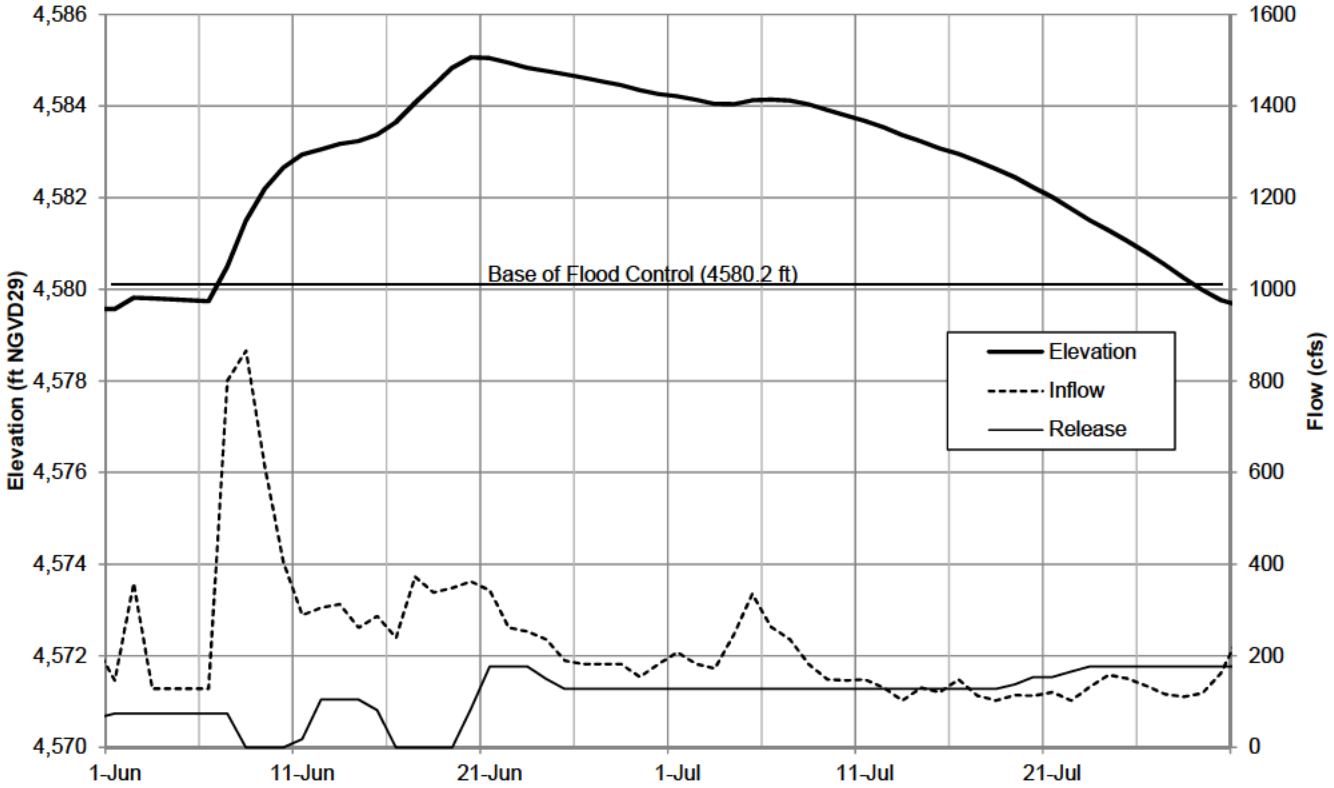
Source of data: Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

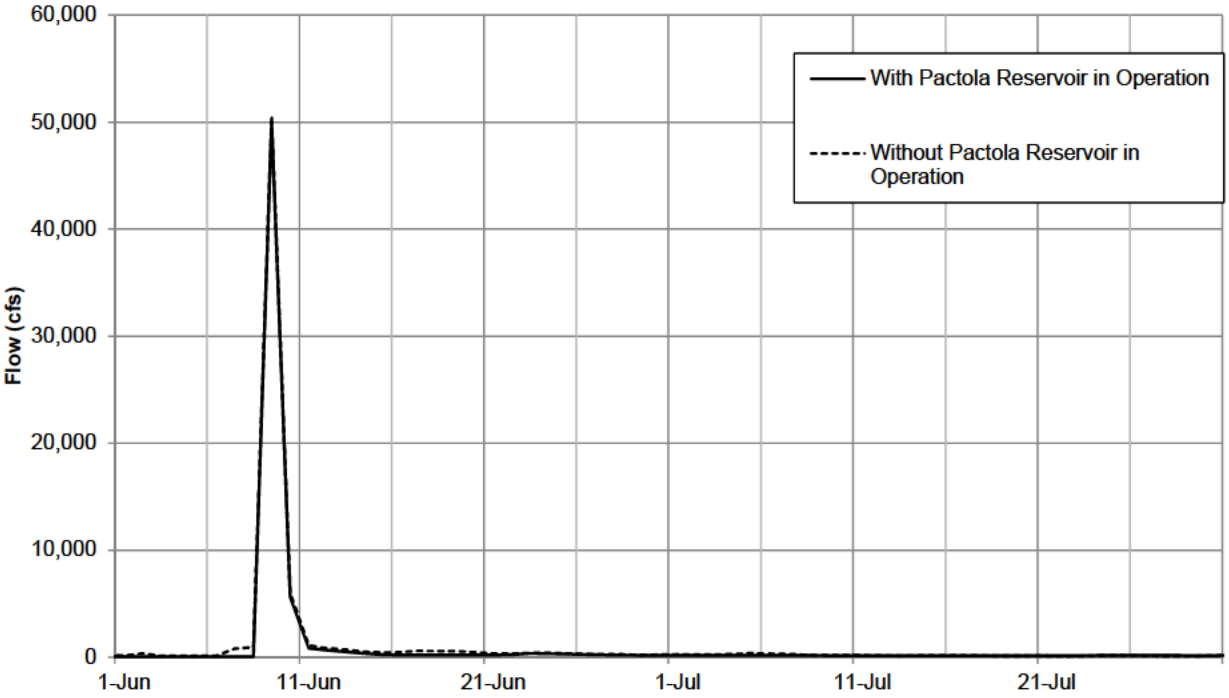
Reservoir Routing
May - June 1965

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Pactola Reservoir



Rapid City Stream Gage



NOTE: All discharge values are daily average values except the peak streamflow value.

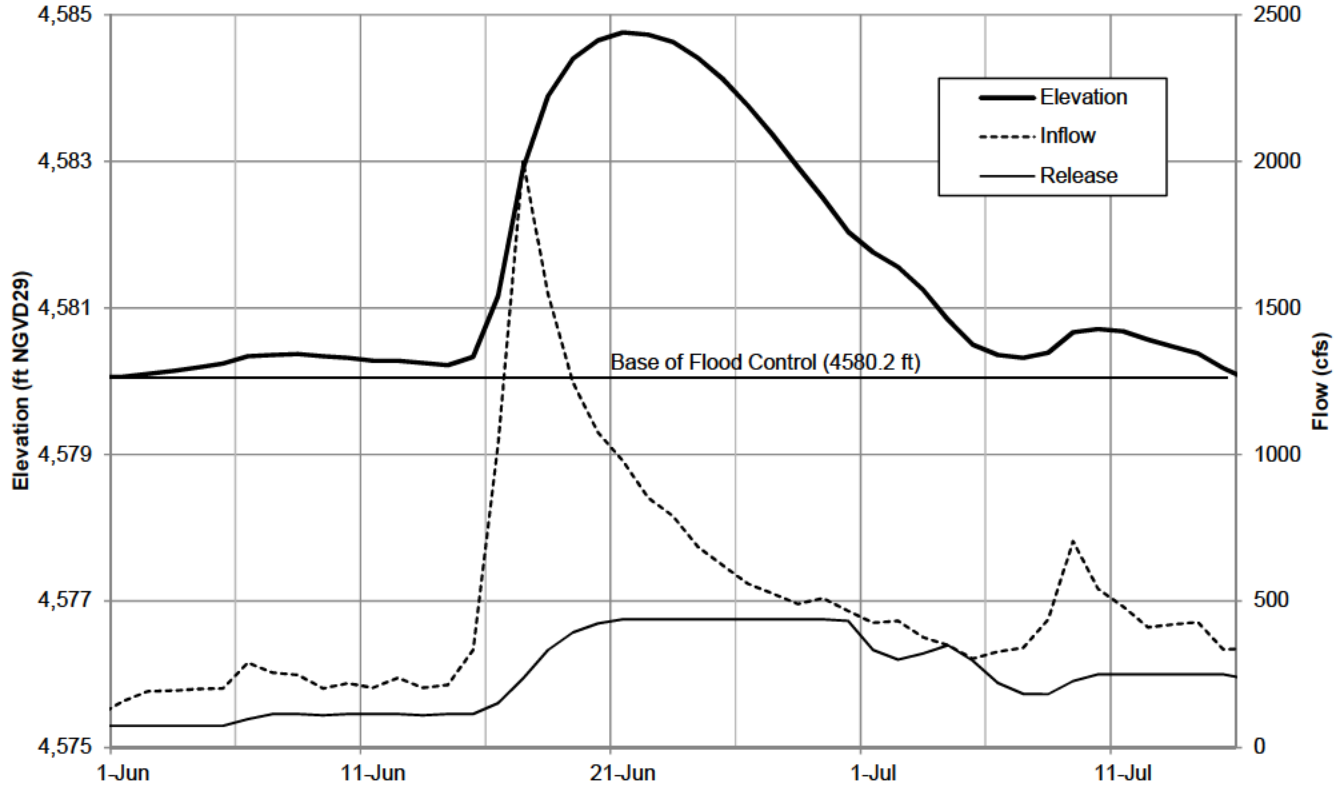
Source of data: Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

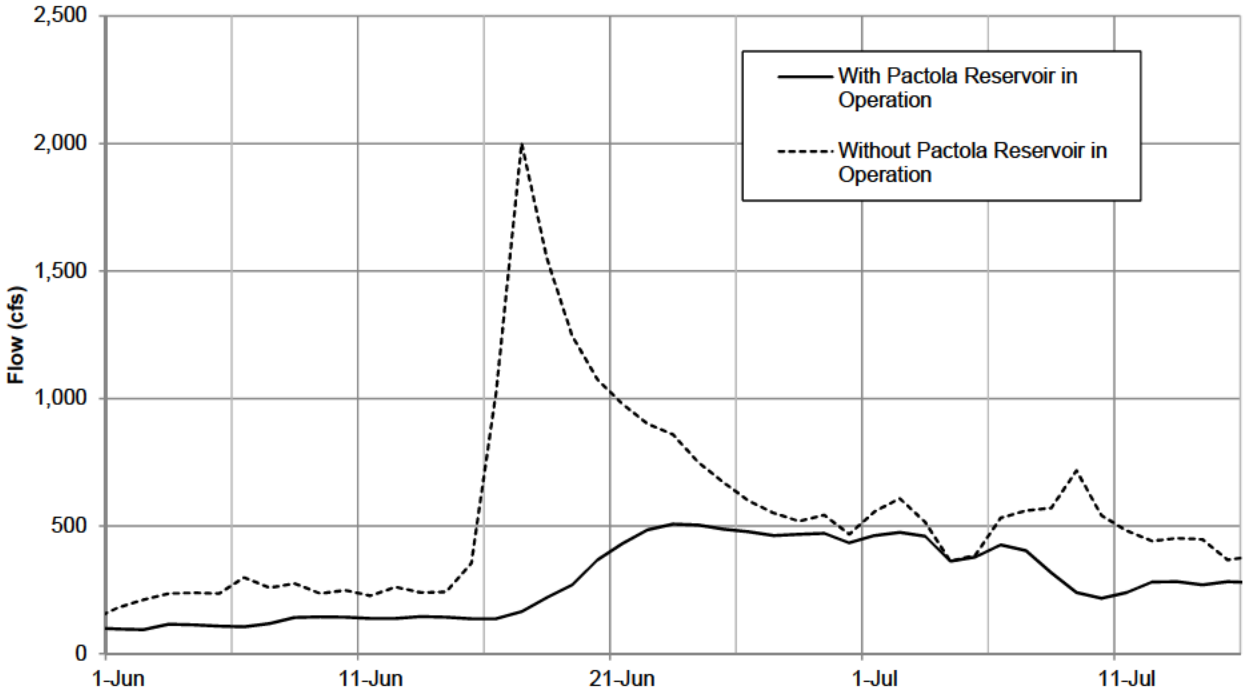
Reservoir Routing
June 1972 Flood

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Pactola Reservoir



Rapid City Stream Gage



NOTE: All discharge values are daily average values except the peak streamflow value.

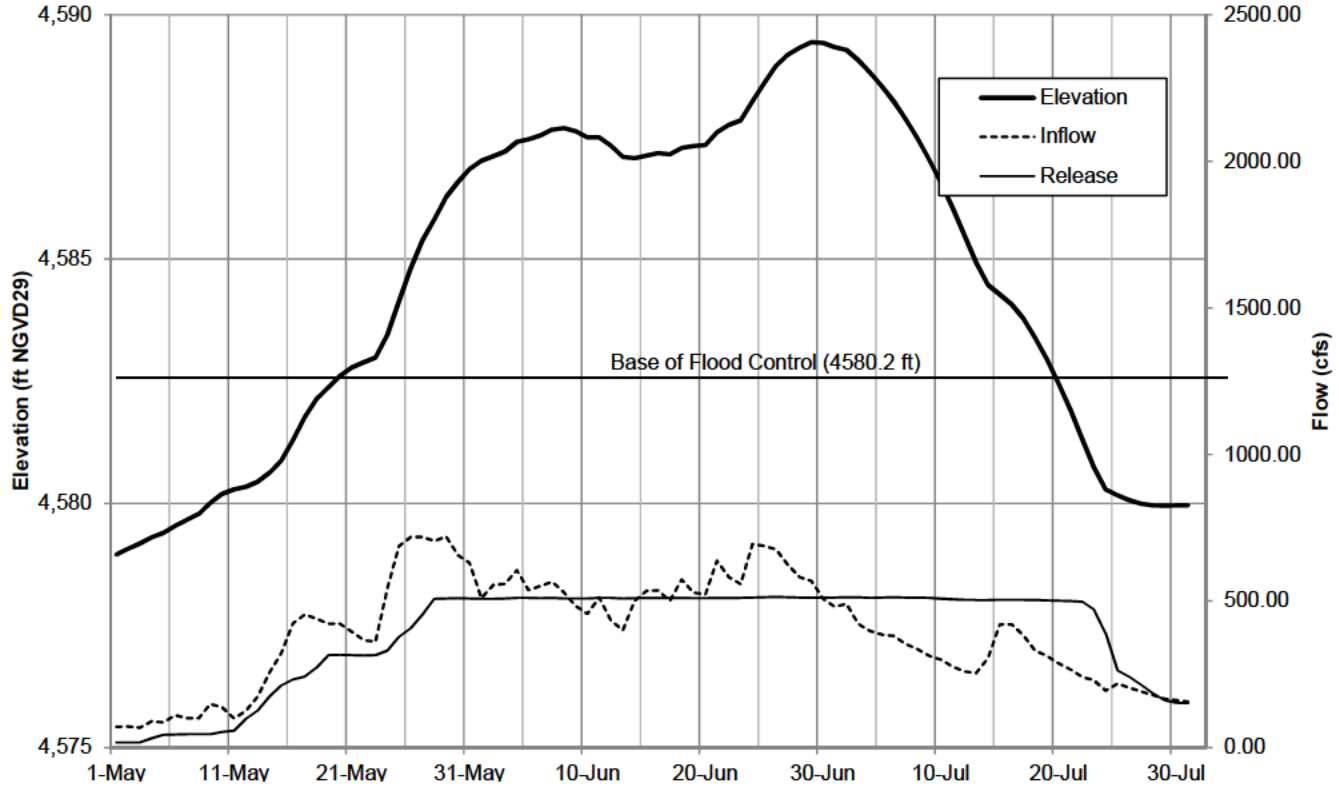
Source of data: Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

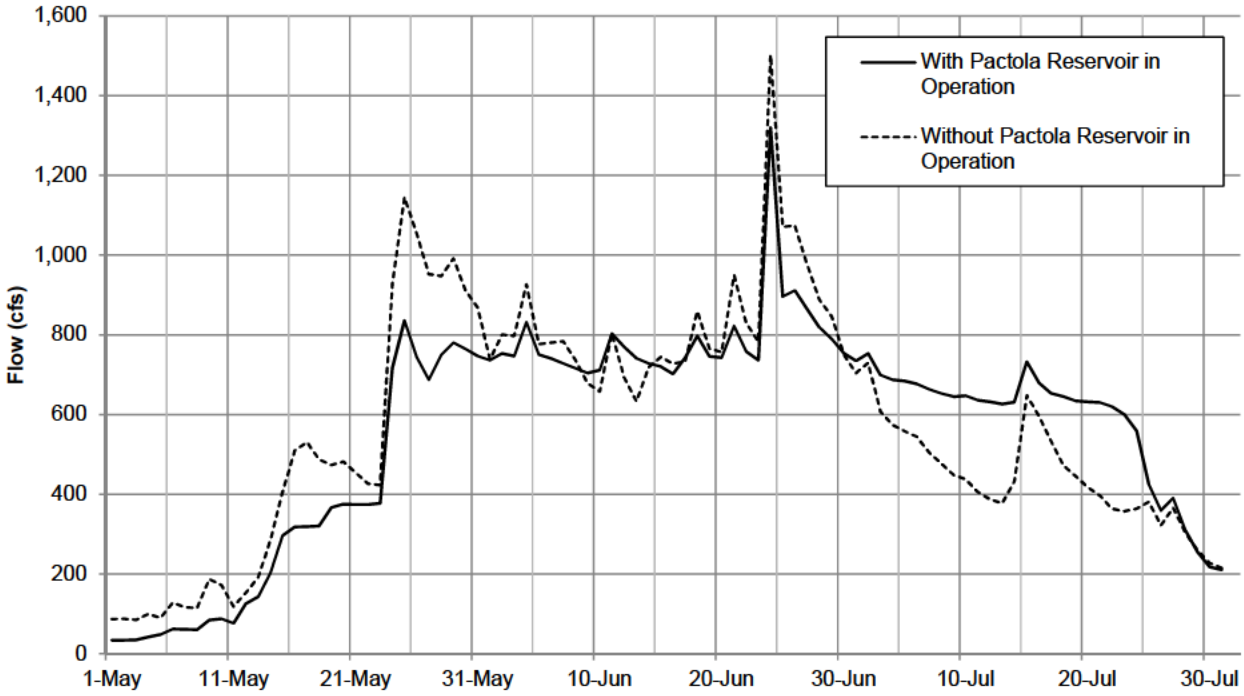
Reservoir Routing
June 1998 Flood

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Pactola Reservoir



Rapid City Stream Gage



NOTE: All discharge values are daily average values except the peak streamflow value.

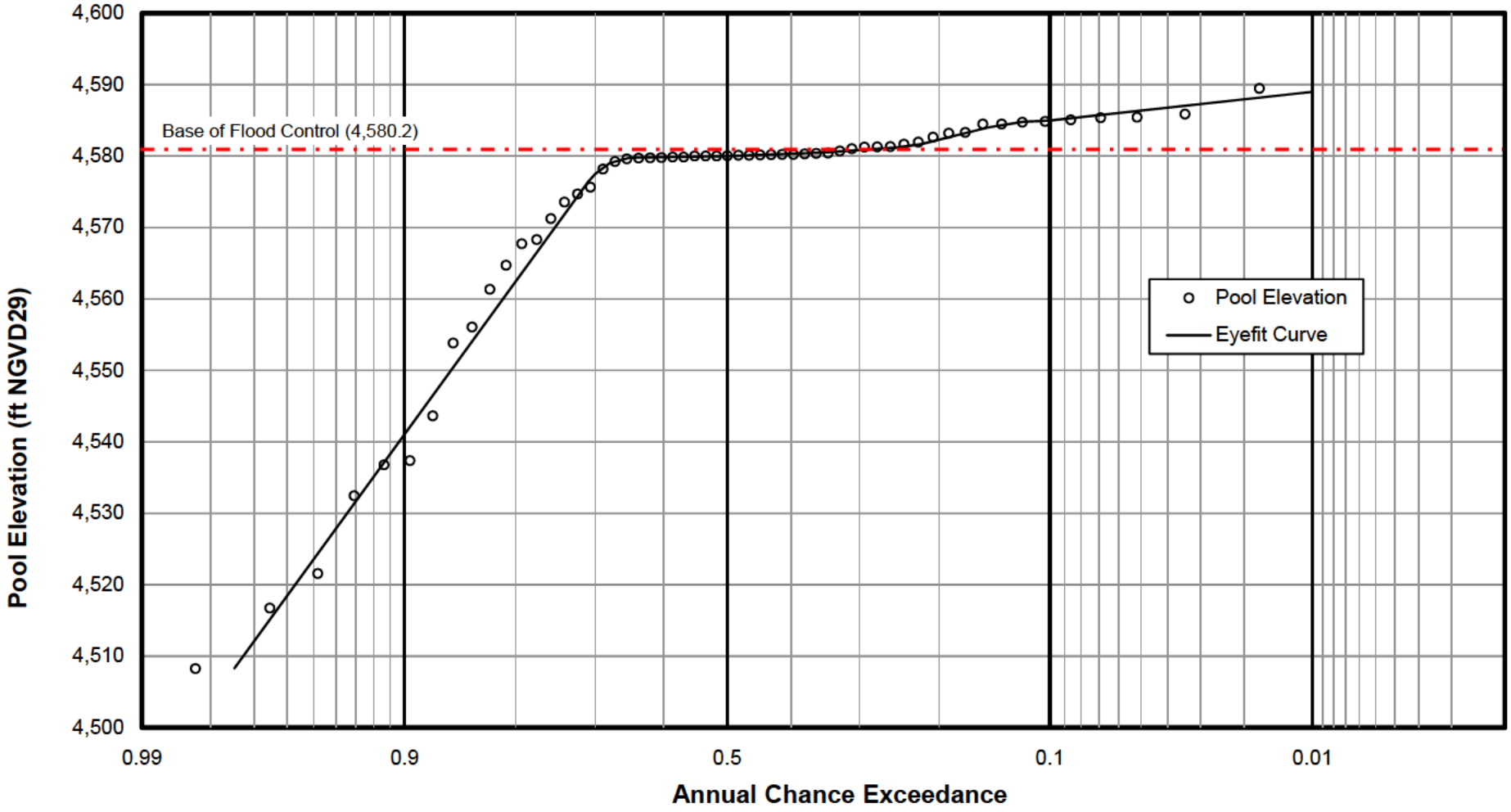
Source of data: Reclamation

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Reservoir Routing
May - June 2015 Flood

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Pactola Dam Pool Probability Plot



NOTE: The above plot was created based only on historical pool levels from 1957-2015; no modeling or routing was used to compute data points. The curve was plotted using the eyefit method.

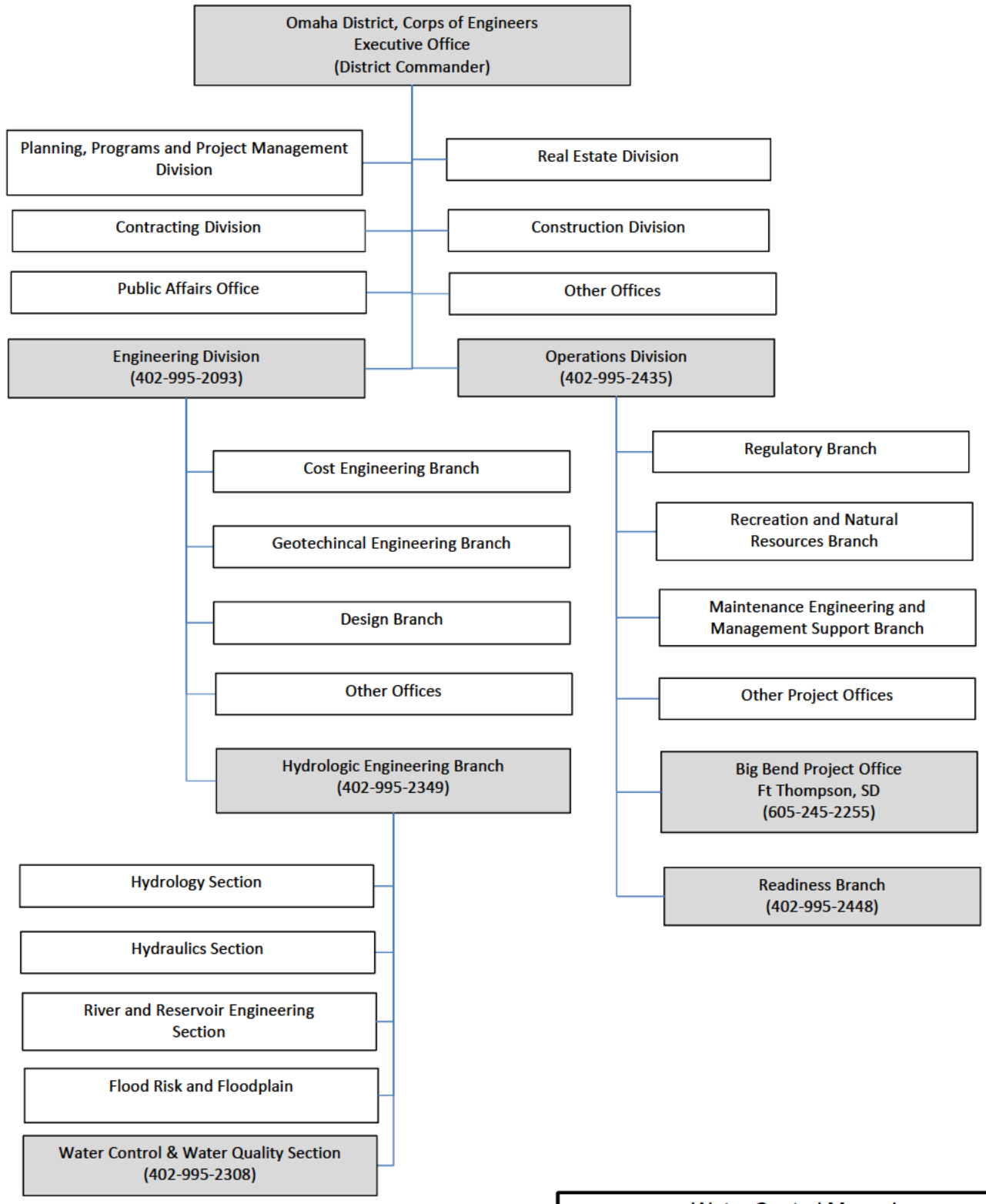
Top of Dam: 4655.0 ft Spillway Crest: 4621.5 ft

Water Control Manual
Pactola Dam and Reservoir, South Dakota

Pool Probability Plot
for Pactola Reservoir

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
2019

Plate 8-12

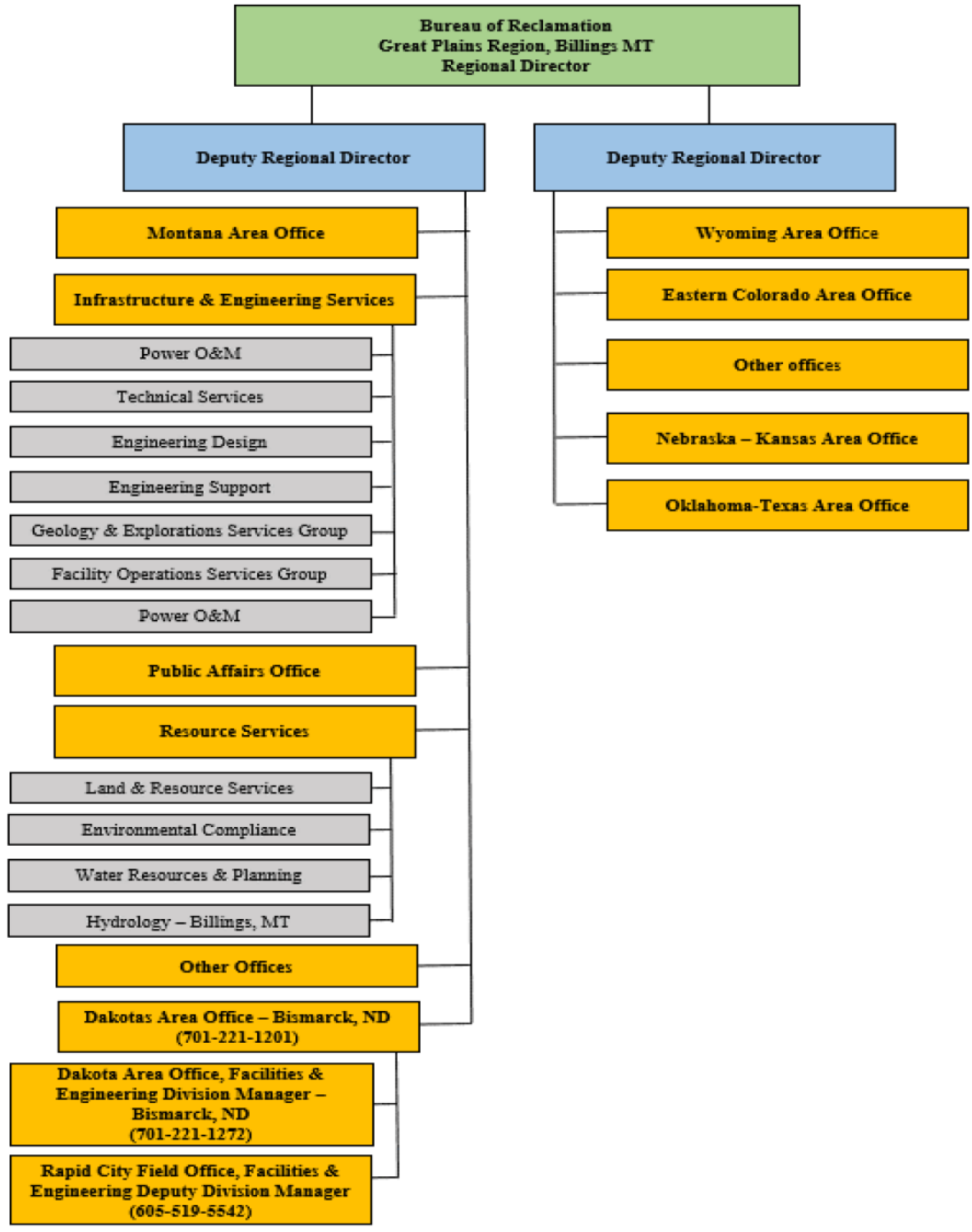


Water Control Manual
Pactola Dam and Reservoir, South Dakota

Omaha District
Corps of Engineers
Organization Chart

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

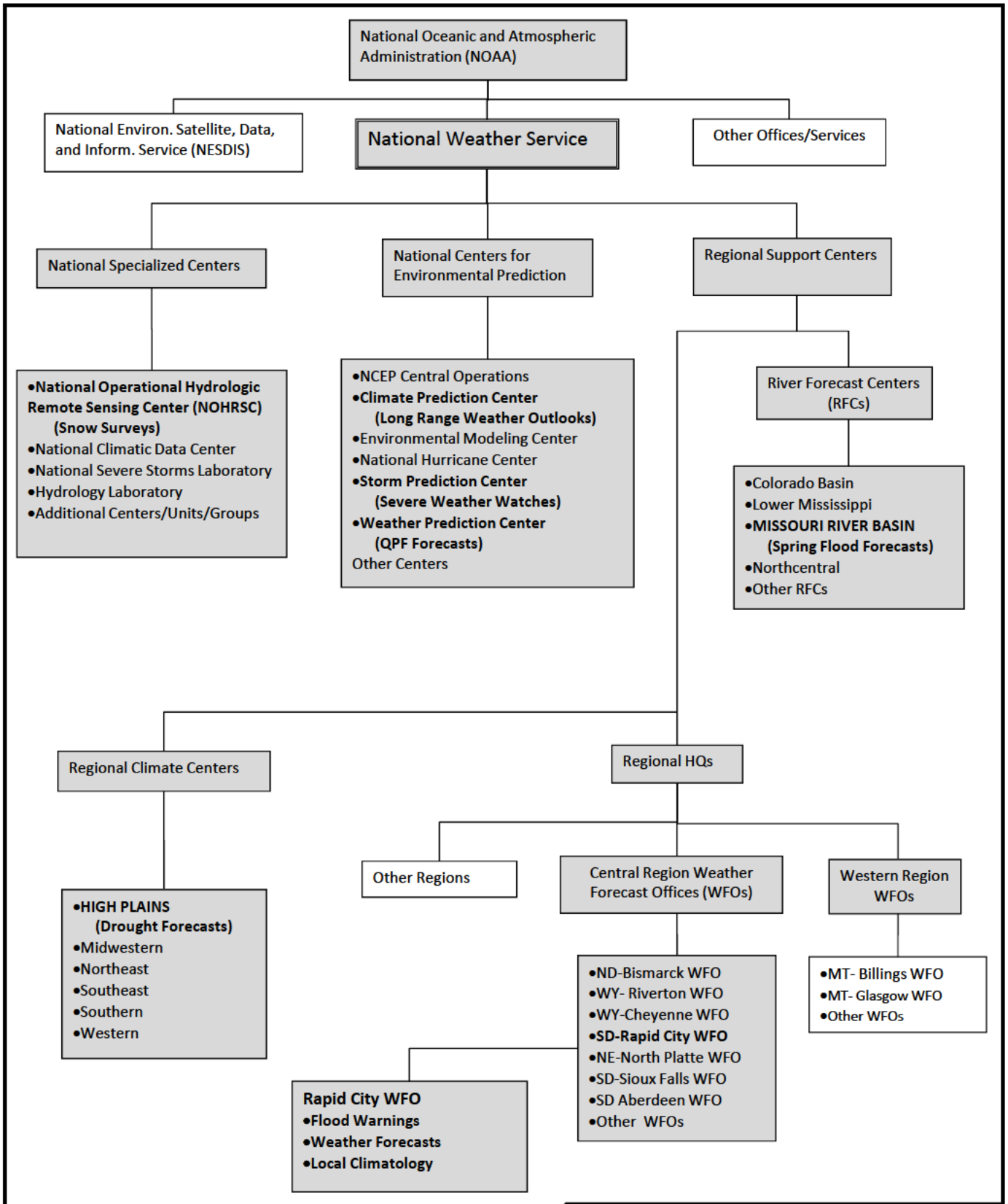
Plate 9-1



Water Control Manual
Pactola Dam and Reservoir, South Dakota

Great Plains Region
Bureau of Reclamation
Organization Chart

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019



Water Control Manual
Pactola Dam and Reservoir, South Dakota

National Weather Service Organization Chart

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
2019

Plate 9-3