

WATER CONTROL MANUAL
CANYON FERRY DAM AND RESERVOIR
Missouri River Basin
Montana

U.S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT
NORTHWESTERN DIVISION
OMAHA, NEBRASKA

December 2016

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REPLY TO
ATTENTION OF

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

CENWD-PDR

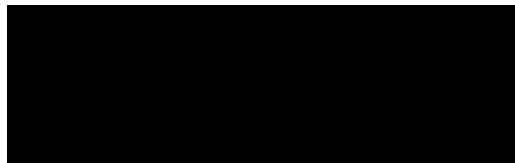
13 January 2017

MEMORANDUM FOR Commander, Omaha District, ATTN: CENWO-ED-HA

SUBJECT: Final Approval of Water Control Manual for Canyon Ferry Dam and Reservoir, Missouri River Basin

1. This office has reviewed the latest revisions to the subject manual and we approve this manual for use as a final Water Control Manual for Canyon Ferry Dam and Reservoir.
2. We commend your staff for their professional and dedicated effort in updating this manual. We realize that updating a water control manual is a considerable undertaking.
3. We will retain a final hardcopy of the manual in our office for our use and will provide an electronic version of this manual to HQUSACE for Continuity of Operations (COOP) purposes.
4. If you have any questions, please contact Kevin Grode of my staff at (402) 996-3870 or kevin.r.grode@usace.army.mil.

FOR THE COMMANDER:



Chief, Missouri River Basin Water
Management Division

CF:



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Canyon Ferry Reservoir and Missouri River to Great Falls, MT



Canyon Ferry Dam and Reservoir



Canyon Ferry Dam



Canyon Ferry Dam and Reservoir

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 NAVD88 datum are needed for Canyon Ferry Dam, use the following conversion: NGVD29 elevation + 3.2 feet = NAVD88 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 following personnel:

DIRECTORY OF REGULATION PERSONNEL

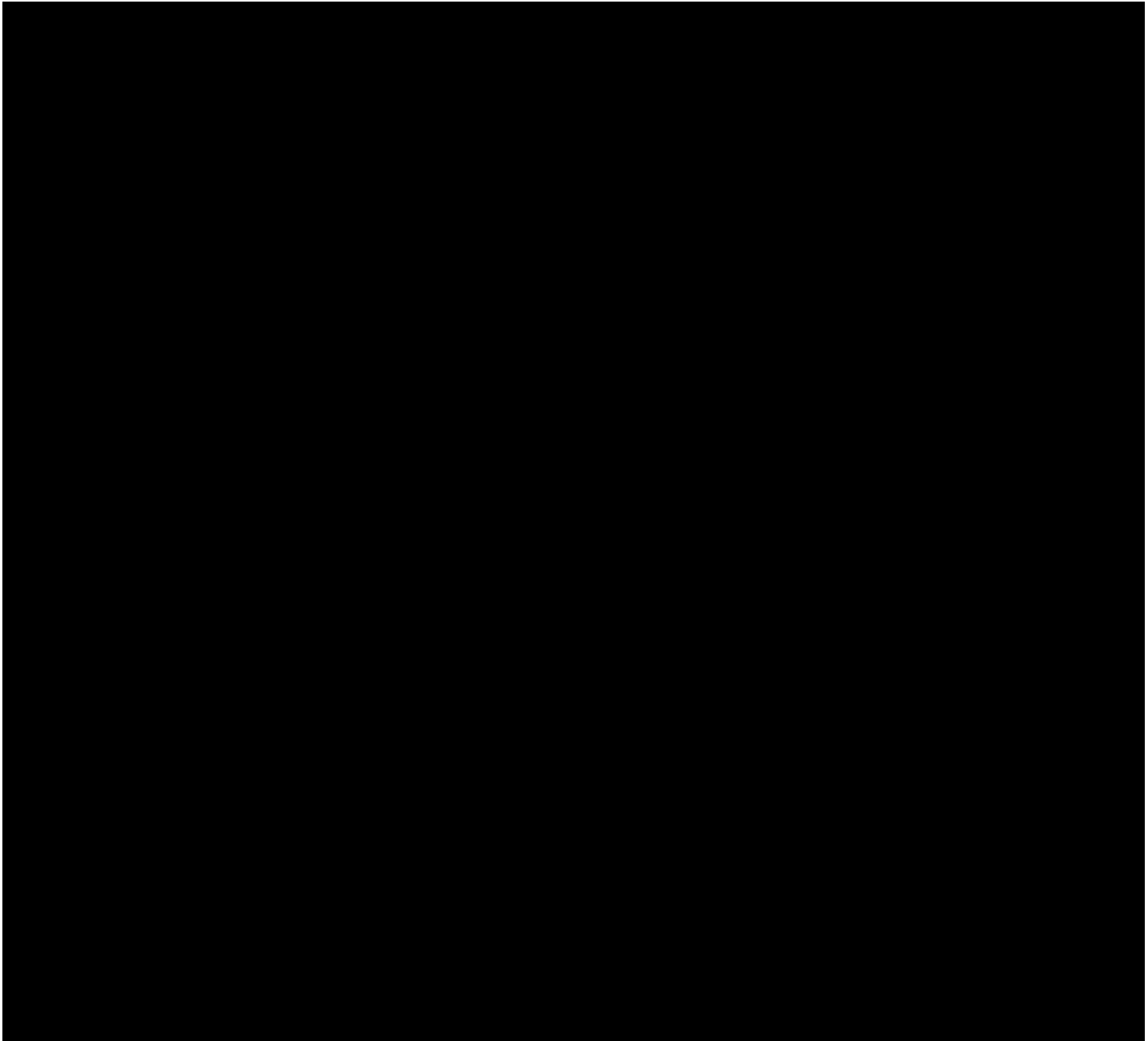


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Exhibit II	Field Working Agreement
Exhibit III	Standing Instructions to Dam Tender for Flood Control Operations
Exhibit IV	Area Capacity Tables in One-Foot Increments
Exhibit V	Area Capacity Tables in 0.1 Foot Increments
Exhibit VI	Agreement for Coordination of Hydroelectric Operations of the United States of America and Northwestern Energy
Exhibit VII	Seasonal Runoff Forecast Procedure
Exhibit VIII	Determination of Seasonal Flood Control Storage Requirements
Exhibit IX	Agreement Concerning Unscheduled Power Plant Outages

Canyon Ferry Dam Pertinent Data

<u>GENERAL</u>	
Location of Dam	17 miles northeast of Helena, MT
County	Lewis and Clark
River and River Mile	Missouri River, 481.5 miles above Fort Peck Dam
Drainage area above Canyon Ferry Dam (sq. mi)	15,904
Drainage area above Fort Peck Dam (sq. mi)	57,500
<u>DAM</u>	
Type	Concrete Gravity
Crest elevation (feet, NGVD29)	3808.5
Maximum base width (feet)	173
Top width (feet)	20
Height above streambed (feet)	172
Length (feet)	1,000
Date of closure	Water storage began March 1953
<u>SPILLWAY</u>	
Location	Center of Dam
Type	Overflow
Crest Elevation (feet, NGVD29)	3766.0
Number of gates	4
Type of gates	Radial
Width of gates (feet)	51
Height of gates (feet)	34.5
Type of gate operating machinery hoist	Motor driven gate
Discharge capacity at max. water surface elev. 3800 feet NGVD29	150,000 cfs
<u>OUTLET WORKS</u>	
Power Penstocks	3 – 13.5-foot inside diameter
Location	Right abutment of dam
Rated capacity (120 feet of head)	5,970 cfs (total)
Intake elevation	3706 feet NGVD29
River outlets	4 – 7.0-foot inside diameter
Location	Center of dam below spillway
Discharge capacity (Max pool 3800 feet)	9,500 cfs
Intake elevation CL	3653.5 feet NGVD29
Pump and Turbine Intakes	1-13-foot inside diameter
Location	Left abutment of dam
Discharge (at Res. El. 3800 feet)	600 cfs (pump and turbine total)
Intake elevation CL	3690.0 feet NGVD29
<u>POWER PLANT</u>	
Turbines	3-Francis Type @ 23,500 HP
Generators	3-Vertical Shaft @ 16,667 kW
Plant Capacity (kW)	50,000
Maximum Head (feet)	160
<u>STORAGE ALLOCATIONS</u>	
	Elevation Limits (feet NGVD29) Capacity (af)
Exclusive Flood Zone	3797.0 – 3800.0 101,089
Replacement-Local Flood Control-Joint Use Zone	3783.0 – 3797.0 445,564
Local Flood Control-Joint Use Zone	3770.0 – 3783.0 348,725
Active Conservation Zone	3728.0 – 3770.0 701,568
Inactive Conservation Zone	3650.0 – 3728.0 394,971
Dead Zone	3636.5 – 3650.0 1,060

<u>RESERVOIR POOLS</u>	Elevation (feet NGVD29)	Area (acres)	Storage (af)
Top of Exclusive Flood Control Storage	3800.0	34,048	1,992,977
Top of Replacement-Local Flood Control/Joint Use Storage	3797.0	33,345	1,891,888
Top of Local Flood Control/Joint Use Storage	3783.0	29,777	1,446,324
Top of Active Conservation Storage	3770.0	23,964	1,097,599
Top of Inactive Conservation Storage	3728.0	10,978	396,031
Top of Dead Storage	3650.0	144	1,060
Streambed Elevation	3635.5	16	58
<u>DESIGN FLOODS</u>			
Spillway Design Flood (approved 25 October 1985) 15 Day Storage Requirement	2,035,000 af		
Standard Project Flood 60 Day Storage Requirement	2,620,000 af		

Abbreviations and Acronyms

af	Acre-Feet
cfs	Cubic Feet per Second
CFWMA	Canyon Ferry Wildlife Management Area
Corps	Corps of Engineers
Co-op	The Cooperative Stream Gaging Program
CWMS	Corps Water Management System
DCP	Data Collection Platform
EM	Engineering Manual
ER	Engineering Regulation
° F	Degrees Fahrenheit
FERC	Federal Energy Regulatory Commission
FWA	Field Working Agreement
GOES	Geostationary Operational Environmental Satellite
HEC	Hydrologic Engineering Center
HMR	Hydrometeorological Report
ID	Inner Diameter
kW	kilowatt
MRBWMD	Missouri River Basin Water Management Division
MPC	Montana Power Company
MTAO	Montana Area Office
MDNRC	Montana Department of Natural Resources and Conservation
NESDIS	National Environmental Satellite, Data, and Information Service

NGVD29	National Geodetic Vertical Datum of 1929
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWE	Northwestern Energy
NWS	National Weather Service
NWO	Corps Northwestern Division Omaha District
PMF	Probable Maximum Flood
PMS	Probable Maximum Storm
P-SMBP	Pick-Sloan Missouri Basin Program
RDF	Reservoir Design Flood
Reclamation	United States Bureau of Reclamation
rpm	Revolutions per Minute
SDF	Spillway Design Flood
SPF	Standard Project Flood
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
WCWQS	NWO Water Control and Water Quality Section

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I - 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, 30 May 2016.
- Section 7 of the Flood Control Act, 22 December 1944.
- 33 CFR Chapter II Part 208, Flood Control Regulations, Section 208.11.

1-02 PURPOSE AND SCOPE. Canyon Ferry Dam and Reservoir was constructed by the Bureau of Reclamation (Reclamation) on the Missouri River and was completed in 1953. This Water Control Manual (WCM) 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", 30 November 1987 and ER 1110-2-8156 "Preparation of Water Control Manuals", 31 August 1995.

1-03 ELEVATION DATUM. In the original design and construction of Canyon Ferry Dam, elevations on design drawings and reservoir levels referenced 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). **Unless specifically noted, all elevations in this manual are referenced to 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's 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 the NAVD88.

In this water control manual, elevations for reservoir levels and project drawings are based upon the NGVD29 datum and have not been converted to the NAVD88 datum 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 NAVD88 datum are needed at Canyon Ferry Dam, the following conversion of 3.2 feet applies: NGVD29 elevation + 3.2 feet = NAVD88 elevation.

1-04 RELATED MANUALS AND REPORTS. Previous manuals and reports pertinent to reservoir regulation at Canyon Ferry Dam are referred below:

- a. U.S. Department of the Interior, Bureau of Reclamation, "Canyon Ferry Dam and Power Plant Technical Record of Design and Construction," 1957.
- b. Field Working Agreement for allocation of flood control storage between U.S. Bureau of Reclamation and U.S. Army Corps of Engineers, 10 February 1966.
- c. Field Working Agreement for water control between Bureau of Reclamation and U.S. Army Corps of Engineers, 3 August 1971.
- d. U.S. Army Corps of Engineers, Omaha District, "Preliminary Information Report on Reservoir Regulation for Canyon Ferry Dam and Lake," March 1972.
- e. Agreement for Coordination of Hydroelectric Operations of the U.S. and the Montana Power Company, 30 March 1972.
- f. Field Working Agreement for water control between Bureau of Reclamation and U.S. Army Corps of Engineers, 23 May 1977.
- g. Bureau of Reclamation, "Standing Operating Procedures - Canyon Ferry Dam, Montana," November 1999.
- h. Bureau of Reclamation, "Emergency Action Plan, Canyon Ferry Dam, Montana," December 2014.
- i. Field Working Agreement for water control between Bureau of Reclamation and U.S. Army Corps of Engineers, 15 December, 2016.

1-05 PROJECT OWNER. Canyon Ferry Dam was planned, designed, and built by Reclamation for the public of the United States of America.

1-06 OPERATING AGENCY. The Reclamation Montana Area Office (MTAO) is responsible for the operation and maintenance of the Canyon Ferry Facility. Forecasting reservoir inflows and directing water releases associated with the reservoir during normal operations is performed by the Facility Operations and Maintenance Division of the MTAO. The Casper Control Center is responsible for the remote daily operation of the generating units, river outlet gates, and for monitoring and reporting reservoir level, inflow, river releases and power generation. The Casper Control Center is responsible for most of the remote changes which are scheduled and directed by the Facility Operations and Maintenance Division of the MTAO. The spillway gates cannot be remotely operated from the Casper Control Center and must be manually operated from the dam. All releases for power generation and river flows are closely coordinated with Western Area Power Administration.

1-07 REGULATING AGENCIES. Reclamation is the regulating agency for Canyon Ferry Dam. During periods of flood control regulation, it becomes the responsibility of the U.S. Army Corps of Engineers (Corps) to regulate the reservoir according to the WCP. ER 1110-2-1400, dated September 30, 1993, assigns the Corps reservoir regulation responsibilities in the Missouri River basin to the Northwestern Division (formerly known as Missouri River Division) Engineer. This engineering regulation permits delegation of certain reservoir regulation responsibilities to the District Engineer. The responsibilities for assembly or interpretation of data affecting current reservoir regulation and for carrying out routine regulation of Canyon Ferry Reservoir, according to plans agreed on in advance, have been delegated to the District Engineer of the Omaha District. The Omaha District Water Control and Water Quality Section (WCWQS) makes recommendations to the District Engineer concerning specific releases from the reservoirs. The Division Engineer, through the Northwestern Division's Missouri River Basin Water Management (MRBWM) office, monitors and reviews the regulation activities performed by the Omaha District. All other regulatory functions are the responsibility of Reclamation's MTAO. Personnel from these offices are listed in the directory of regulation personnel on page vii, Regulation Assistance Procedures.

The Corps, Reclamation, and the Natural Resources Conservation Service (NRCS) prepare an independent spring runoff volume forecast each month from January through June. Based upon an evaluation of these forecasts, the joint use requirements for conservation and flood control storage are determined. Further information on forecasts is in Chapter 6.

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II- DESCRIPTION OF PROJECT

2-01 LOCATION. Canyon Ferry Dam is located at River Mile 2253 on the main stem of the Missouri River in the Upper Missouri River Basin. This dam is positioned in Lewis and Clark County, Montana, 17 miles northeast of the State capitol, Helena. Plate 2-1 shows the immediate area surrounding Canyon Ferry Dam and Reservoir. The areas upstream and downstream of Canyon Ferry Dam are shown in Plates 2-2 and 2-3, respectively.

2-02 PURPOSE. The Canyon Ferry Unit of the Pick-Sloan Missouri Basin Program (P-SMBP) was authorized through the Flood Control Act of 1944 as a multiple-purpose project providing hydropower generation, flood control, and irrigation in the Upper Missouri River Basin. Canyon Ferry Dam's primary purpose is to regulate the flow of the Missouri River so that irrigation development could take place without interfering with existing downstream water rights. Additional benefits include fish and wildlife enhancement, recreation, and municipal and industrial water supply. In 1966 Reclamation and the Corps officially agreed to allocate the top 3 feet of storage space for flood control purposes. Reservoir storage space is regulated to provide a firm degree of flood protection to the Missouri River downstream from the dam and for "replacement" purposes, designed to replace a portion of the annual flood control and multiple-use space provided in the downstream Missouri River mainstem reservoir system.

2-03 PHYSICAL COMPONENTS. The physical components of Canyon Ferry Dam are shown on Plate 2-4 and described below.

a. **Embankment.** Canyon Ferry Dam is a concrete gravity embankment approximately 1,000 feet in length, 173 feet wide at the base, and 20 feet wide at the crest. The crest elevation is 3808.5 feet and the structural height is 225 feet. A 21-foot roadway over the dam crosses the spillway overflow section on a structural steel bridge. The dam is constructed of 414,400 cubic yards of concrete.

b. **Dikes.** The Conservation and Wildlife Enhancement Program at Canyon Ferry Reservoir was initiated in 1972 to alleviate a serious dust problem at the upper end of the reservoir near Townsend, Montana. As the reservoir was drawn down during the fall and winter to provide power production and storage space for spring runoff, winds blew dust from the exposed beaches, causing severe air pollution. A series of dust abatement dikes were constructed which created 1,900 acres of marshland and a valuable waterfowl habitat.

c. **Spillway.** The spillway is an overflow section in the central portion of the dam controlled by four radial gates. The spillway is 222 feet in width with a crest elevation at 3766 feet. The discharge is controlled by four 51-foot by 34.5-foot radial gates, having a maximum total capacity of 150,000 cubic feet per second (cfs) at 3800 feet. The top elevation of the radial gates in the fully closed position is 3800 feet. The spillway general installation drawings are shown on Plate 2-5. A rating

curve and rating table for all four spillway gates fully open can be found on Plate 2-6 and a rating curve for one spillway gate fully open or partially open can be found on Plate 2-7.

d. **Outlet Works.** Four river outlet conduits are located through the base of the spillway section of the dam. Each outlet consists of an 84-inch inside diameter (I.D.) cast iron conduit liner, a 77-inch steel regulating gate, and a steel horseshoe shaped conduit liner. The 84-inch conduit liners extend from the upstream face of the dam for a distance of approximately 16 feet to the regulating gates. The steel horseshoe shaped conduit liners start at the downstream side of the regulating gates and extend a distance of about 56 feet to the downstream face of the dam at the base of the spillway area. The design capacity of the river outlet works is 9,500 cfs at elevation 3800 feet; however, a restriction has been placed on the river outlet works of 2,000 cfs or 500 cfs per gate. Refer to Plate 2-8 for general installation drawings of one pair of river outlets and Plate 2-9 for a diagram and rating curve for the river outlets. See Section 7-02.b for a description of restrictions on releases.

e. **Hydroelectric Power Facilities.** The 50,000-kilowatt (kW) capacity Canyon Ferry Power Plant is located on the right bank of the river adjacent to the spillway stilling basin at the toe of the dam. The power plant houses three 16,667-kW generating units, each driven by a 23,500-horsepower Francis-type turbine at 150 revolutions per minute (rpm) under a rated head of 125 feet. There are three 162-inch (13.5 feet) diameter penstocks approximately 164 feet long located in the right abutment of the dam, supplying three turbines in the power plant located at the toe of the dam. One 12.78-foot by 21.78-foot fixed-wheel gate is installed at the upstream face of the dam at the entrance of each penstock. Three draft tubes convey water from the three turbines to the tailrace. The Canyon Ferry 115-kilovolt switchyard is a steel structure mounted on the roof of the power plant. Canyon Ferry's average annual power generation is 367,341,000 kW-hours.

f. **Water Supply Facilities.** A 13-foot diameter pump intake and penstock located in the left abutment of the dam serves hydraulic turbine-driven pumps in the Helena Valley Pumping Plant (see Section 2-04 for further detail).

g. **Reservoir.** At elevation 3800.0 feet, the top of the flood control pool, the reservoir has a gross capacity of 1,992,977 acre-feet (af). It will extend about 23 miles upstream, have a maximum depth of 165 feet, and will inundate about 34,048 acres. Area-capacity curves are shown on Plate 2-10. Storage allocations for the reservoir are shown on the Pertinent Data on Page xvi and on Plates 2-10 and 7-1. Plate 2-11 shows the reservoir flooded areas for the pool elevations of 3797.0 feet (top of joint use zone) and 3800.0 feet (top of flood control and top of surcharge zone). In 1997, hydrographic and topographic surveys were conducted and a new elevation-area-capacity table and curve were developed. Exhibit IV shows the area and capacity tables in one-foot increments and Exhibit V shows more detailed versions of both tables in tenth-foot increments. Additional information concerning sediment accumulation in the reservoir is contained in Section 4-04.

2-04 RELATED CONTROL FACILITIES. The Canyon Ferry Unit provides storage of water which allows for the downstream water supply diversion for the Helena Valley Pumping Plant described below in paragraph a. There is also upstream diversion of water for irrigation in the Crow Creek Pump Unit and the East Bench Unit, both of the P-SMBP, described in paragraphs b and c.

a. Helena Valley Pumping Plant. The Helena Valley Pumping Plant is located 500 feet downstream from Canyon Ferry Dam on the left bank of the Missouri River. Water flows through the dam in a 13-foot diameter steel penstock, which reduces to 10-foot diameter immediately downstream of the dam. The penstock branches into two 78-inch diameter penstocks, which again branch at each unit to supply the turbine and the pump. The water feeding the pump is sent to the irrigation district. The water passing through the turbine is discharged downstream to the Missouri River. Two vertical-shaft, Francis-type hydraulic turbines are directly connected to two vertical-shaft, double-volute type, centrifugal pumps. Each pump is designed to deliver irrigation water at 150 cfs at a total head of 145 feet.

Two 4-foot diameter steel pipe discharge lines from the pumping plant converge into a single 6-foot 3-inch diameter discharge pipe that delivers water to the Helena Valley Tunnel inlet at elevation 3878.92 feet. This discharge pipeline, which is anchored onto concrete piers set in the steep canyon wall, terminates at the inlet portal of the 2.7-mile long Helena Valley Tunnel. The 7-foot diameter Helena Valley Tunnel conveys the water through the Spokane Hills into the 32-mile long Helena Valley Canal. The first 8 mile long section of the canal extends to a dam and regulating reservoir. An outlet built into the Helena Valley Dam supplies supplemental municipal water to the City of Helena. From the reservoir, the water flows into the canal along the south and west sides of the bowl-shaped valley, terminating on the north side with a waste way into Helena Valley Reservoir (Lake Helena). The lateral system has a total length of about 58 miles.

b. Crow Creek Pump Unit. The Crow Creek Pump Unit was developed at the request of the Commissioners of Broadwater County to provide facilities to irrigate an area of land equal to that inundated by Canyon Ferry Reservoir before the land in the reservoir area was taken out of production. This is part of the 23,400 acres of new irrigable land in the Crow Creek Unit of the Three Forks Division and the Broadwater-Missouri Unit described in Senate Document 191.

The Crow Creek Pumping Plant is on the left bank of the Missouri River about 6 miles upstream from Toston, Montana. The controlled water surface at the Broadwater-Missouri Diversion Dam, located approximately 1.5 miles below the pump site, maintains a water depth at the pumping plant of more than 5 feet. There are 6,248 acres of land in the Crow Creek Pump Unit that are being irrigated and require an average annual diversion of 16,800 af at a maximum rate of 100 cfs. Operation and maintenance functions are performed by the Toston Irrigation District.

c. East Bench Unit. The East Bench Unit is in southwestern Montana along the Beaverhead River. The unit provides full irrigation service to 21,800 acres and supplemental irrigation service to 28,000 acres. About 17,200 acres of irrigable land on East Bench are served through a system of laterals, and the remaining acreage on the bench is served directly from the East Bench Canal. Operation and maintenance functions are the responsibility of the East Bench Irrigation District.

d. Clark Canyon Dam and Reservoir. Clark Canyon Dam and Reservoir, located near Dillon, Montana, is the only reservoir with allocated flood control storage space upstream of Canyon Ferry Reservoir. Clark Canyon Dam has 79,000 af of storage allocated exclusively for flood control storage.

e. Missouri River Mainstem Reservoirs. Releases from Canyon Ferry Dam eventually flow into Fort Peck Reservoir, the uppermost of the six Missouri River mainstem reservoirs. Additional information about Fort Peck Reservoir and the Missouri River Mainstem Reservoir System is contained in Section 4-11.

2-05 REAL ESTATE ACQUISITION. The cost summary, from completion reports submitted by the project office as of 15 September 1956, was \$2,882,453 for land and land rights and \$526,023 for relocation of property. By placing the maximum pool level at elevation 3800 feet, no relocations of railroads, towns, and major highways were required. Required relocations included: about 7 miles of Montana Power Company (MPC) transmission line, 12 miles of Vigilante Electric Cooperation power facilities, local telephone lines, the Canyon Ferry Cemetery, and isolated buildings such as a forest ranger station and a church.

2-06 PUBLIC FACILITIES. Canyon Ferry Reservoir has become one of Montana's foremost recreation areas because of its proximity to Helena, Missoula, Bozeman, Great Falls and Butte. The reservoir has 33,345 surface acres of lake and 96 shoreline miles at the top of the joint use pool (elevation 3797 feet) and offers excellent fishing opportunities for rainbow trout, perch, ling, and walleye, including year-round fishing for trout and salmon.

There are 25 Reclamation-maintained recreation sites around the reservoir. In addition to fishing, Canyon Ferry offers a variety of recreational opportunities including camping, boating, sailing, wind surfing, sightseeing, picnicking, hiking, hunting, waterskiing, nature study, wildlife viewing, photography, swimming, and winter sports. Concrete boat ramps, campgrounds, day-use areas, shelters, a visitor center, and three marinas are also available. Boat access is available at all of the campsites and a number of additional public boat launch areas are located near the dam on the north end and near Townsend on the south end. Dining facilities, entertainment, cabins, beaches, house boats, showers, a laundromat and grocery stores are available in the area.

Reclamation's Canyon Ferry Resource Management Plan guides all recreational, wildlife, and management activities on Canyon Ferry Reservoir lands. It establishes management goals and objectives and provides a baseline for measuring the progress and success of suggested management. The plan can be accessed on Reclamation's website at <http://www.usbr.gov/gp/rmp/>.

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III - HISTORY OF PROJECT

3-01 AUTHORIZATION. The Canyon Ferry Project is a part of the Missouri River Basin Project as authorized under Section 9 of the Act approved 22 December 1944 (58 Stat. 887), referred to as the Flood Control Act of 1944. It was included in the list of units recommended for the initial stage of construction as presented in Senate Document 191, 78th Congress, 2nd Session, and so authorized. Senate Document 191 presents the overall plan for Reclamation for conservation, control, and use of water resources of the Missouri River Basin. This plan was coordinated with the Corps of Engineers, Department of the Army, as presented in House Document 475, and the coordinated and revised plan, contained in Senate Document 247, 78th Congress, 2nd session, was approved by the Flood Control Act of 1944.

3-02 PLANNING AND DESIGN. Numerous sites for water storage were studied. The most logical site was found to be in the current vicinity of Canyon Ferry Dam. The preliminary exploratory drilling revealed the possibility of a fault intersecting the initially proposed dam site, resulting in the dam site being moved upstream approximately 250 feet. The selected site is a narrow rock-walled canyon and the abutments for the dam are formed by the canyon walls that rise steeply on either side. The Empire shale foundation rock had lost most of the shaly structure by the time of construction and had taken on a dense uniform fine-grained crystalline character. Early plans called for a rolled earthfill dam, but further studies disclosed that due to the cost of the outlet tunnel and spillway for the proposed earthfill dam, a concrete dam would be more economical. The risk of faults, the crystalline nature of the foundation, and the economics all contributed to the decision to build a concrete dam.

3-03 CONSTRUCTION. Construction started in June 1949. The river diversion was made on 27 November 1949. Initial storage began in March 1953. Unit 1 of the Canyon Ferry Power Plant began operation in December 1953; Units 2 and 3 began operation in March 1954. The project was substantially completed in April 1954.

3-04 RELATED PROJECTS.

a. **Missouri River Mainstem Reservoirs.** Releases from Canyon Ferry Dam eventually flow into Fort Peck Reservoir, the uppermost of the six Missouri River mainstem reservoirs. Per the Missouri River Mainstem Reservoir System Master Water Control Manual (Master Manual), during large floods on the Missouri River mainstem reservoirs, releases of flood storage in Canyon Ferry Reservoir may be adjusted in order to meet basin-wide flood control goals of the Missouri River system. More detailed information on these requirements is contained in Section 4-11. Additionally, Canyon Ferry Reservoir has designated replacement storage for the Missouri River Mainstem Reservoir System (see Section 7-03.a).

b. **Other Flood Control Storage Dams.** Clark Canyon Dam and Reservoir is the only reservoir with allocated flood control storage space above Canyon Ferry Reservoir. From Canyon Ferry downstream to Fort Peck Reservoir, only Tiber Dam

and Reservoir has allocated flood control storage space. Due to storage and operating restrictions arising from problems with the spillway at Tiber Dam, flood control regulation for Tiber was curtailed from May 1966 until October 1981. In October 1981 modification of the spillway was completed and the reservoir became available for unrestricted use. Table 3-1 shows storage capabilities for Clark Canyon and Tiber. Regulation of other Reclamation projects upstream of Fort Peck Reservoir, such as Hebgen and Gibson, will yield some incidental flood control benefits even though they have no allocated flood control storage space. Additional information about Hebgen and Gibson reservoirs can be found in Table 4-6.

Table 3-1
Flood Control Storage for Clark Canyon and Tiber Reservoirs

Type of Storage	Clark Canyon Reservoir	Tiber Reservoir (Lake Elwell)
Exclusive local flood control including mainstem replacement storage (af)	79,075	403,075
Joint use flood control and conservation (af)	50,207	258,436
Total flood control storage (af)	129,282 *	661,511 **

* Storage from pool level 5535.7 feet to 5560.4 feet

** Storage from pool level 2976.0 feet to 3012.5 feet

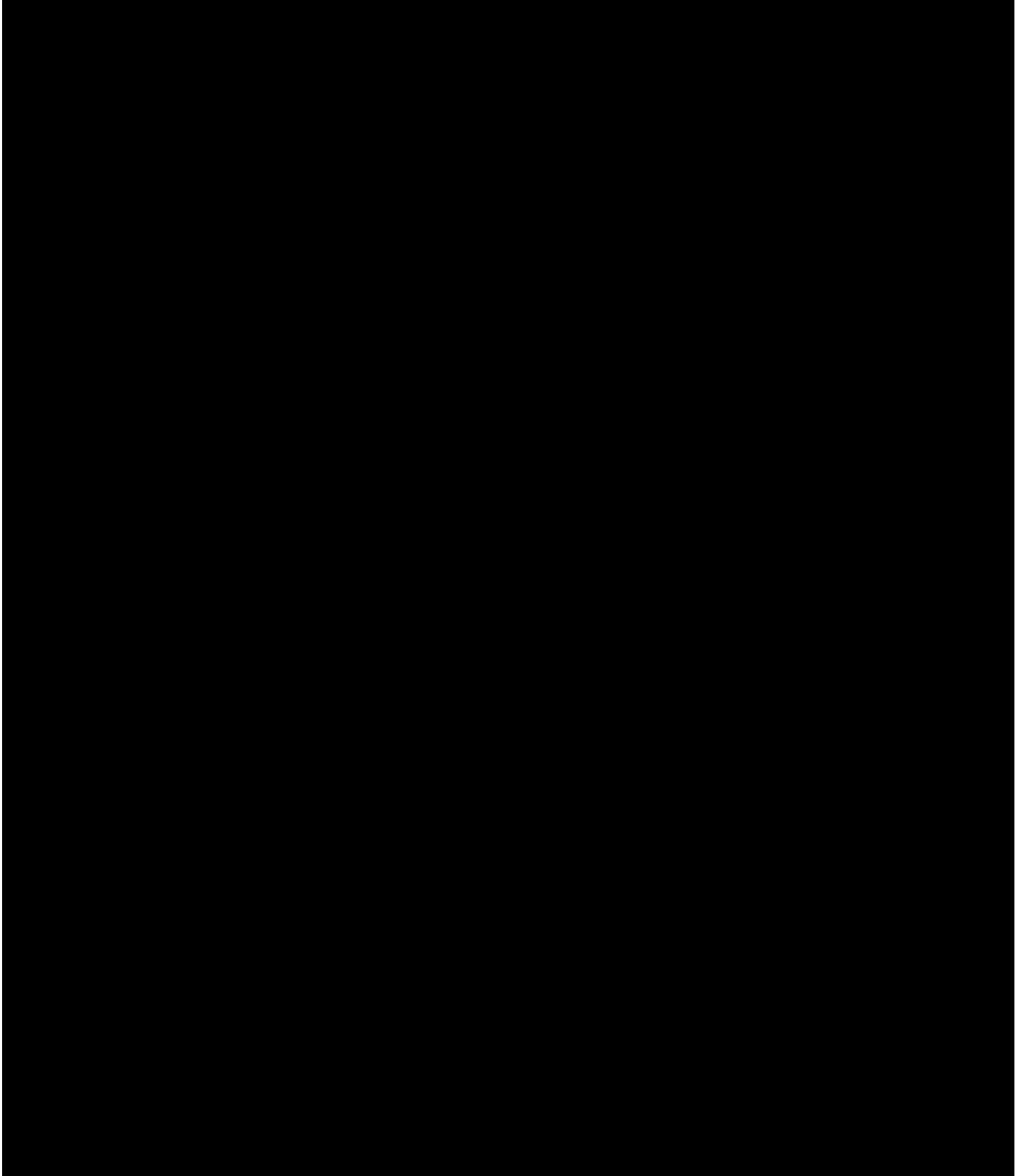
c. Hydroelectric Power. Montana's first hydroelectric power plant of importance was built at Black Eagle Falls on the Missouri River near the City of Great Falls in 1891. In 1908, hydroelectric power plants were built at Canyon Ferry (Lake Sewell, which was inundated by Canyon Ferry Reservoir) on the Missouri River, 17 miles from Helena, and on the Big Hole River, 21 miles from Butte. These three early plants formed the nucleus of MPC's system. They were soon followed by plants at Rainbow Falls in 1910, Ryan Dam in 1916, and Morony Dam in 1930 on the Missouri River just below Great Falls, Hauser Dam in 1911, Hebgen Dam in 1915 (used for storage only), and Holter Dam in 1930 above Great Falls. The latest major addition to the MPC system, now owned by NWE (Northwestern Energy), was the plant at Cochrane Dam on the Missouri River below Great Falls completed in 1958.

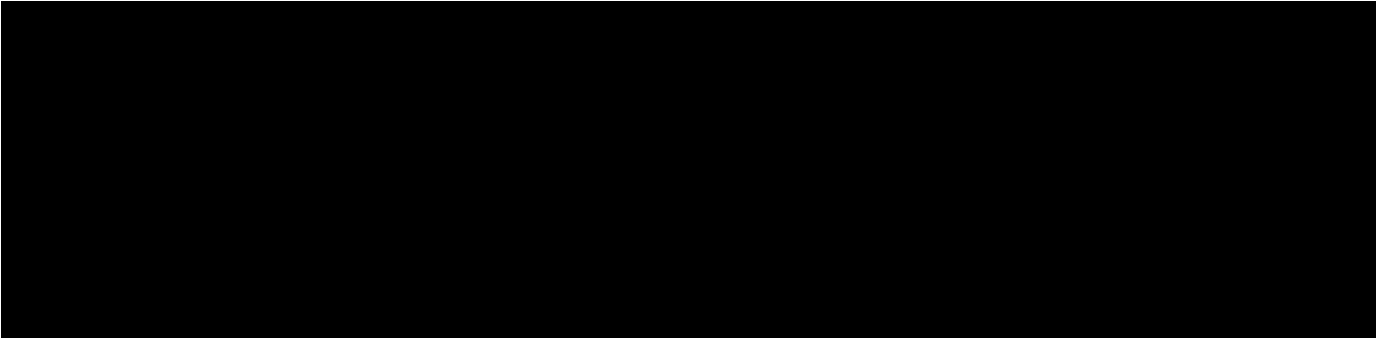
Power facilities in the transmission and operating area of Canyon Ferry Reservoir consist of both public and privately-owned systems. Canyon Ferry Power Plant is a federal plant owned by Reclamation (public). The Broadwater Power Plant near Toston, Montana is owned by the Montana Department of Natural Resources and Conservation (MDNRC). The privately-owned power plants in the area consist chiefly of facilities now owned by NWE. In 1957, there were 25 electric generating plants in the state of Montana. Of these, 19 were privately owned, four federally owned, and two were cooperative-owned projects; 18 were hydroelectric plants, four were steam plants, and three were internal combustion plants. In 2013, there were 54 electric generating facilities in the state of Montana. Of these projects, 41 were privately owned, five federally owned, seven were cooperative owned and one was a Tribal-owned project; 26 were hydroelectric plants, seven were coal plants, nine were gas fired plants, nine were wind facilities and three were alternative-fuels facilities. Descriptions of the existing hydroelectric generating facilities above Fort

Peck Reservoir are shown in Table 3-2.

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Table 3-2
HYDROELECTRIC GENERATING FACILITIES ON MISSOURI RIVER ABOVE
FORT PECK RESERVOIR





a. **10 February 1966 Field Working Agreement.** Correspondence between the Corps and Reclamation regarding the allocation of storage at Canyon Ferry Dam for flood control began in 1946 and continued until 1966 when the FWA was signed. Principle actions include:

1) Prior to 1948 it appeared to be the consensus of opinion that flood control benefits, which might accrue from Canyon Ferry regulation, were negligible. This is exemplified by the Corps Fort Peck District's letter of 10 July 1946 to Reclamation stating that there was no justification for a flood control allocation in the project and Reclamation's concurrence of this assumption in their letter of 12 March 1948.

2) Following a rather large flood in 1948, it became evident to the agencies that some flood control storage in Canyon Ferry Reservoir could be advantageous. By letter of 22 April 1949 Reclamation suggested that flood control storage space of 90,000 acre-feet (af) be available on 31 January with additional space, up to a maximum of 900,000 af, evacuated on the basis of forecasts of subsequent runoff. They asked the Fort Peck District to assign benefits to this type of regulation.

3) In reply to Reclamation's proposal, the Corps suggested that 100,000 af be evacuated by 31 January, with a minimum of 500,000 af and maximum of 700,000 af evacuated seasonally on a forecast basis. This letter of 23 June 1949 further stated that studies would be continued on the benefits attributable to such a type of regulation.

4) By letter of 24 September 1952 Reclamation furnished the Fort Peck District their regulation study 3-A for evaluation of incidental benefits to flood control from Canyon Ferry's regulation. This appeared to be a "hindsight" regulation study. From this study, it appeared that incidental benefits from Canyon Ferry regulation would approximate \$50,000 annually; however, Reclamation was informed that benefits in excess of \$300,000 would accrue from firm seasonal allocations of 800,000 to 1,000,000 af of flood control storage.

5) On 12 October 1953, a public hearing was held in Townsend, Montana with the primary purpose of selecting the maximum pool levels. At this hearing, the Fort Peck District Engineer stated that flood control storage in Canyon Ferry

Reservoir would be of great value for the downstream reaches. The benefit values and corresponding storage allocations given in the above paragraph were cited. He also mentioned the possibility for benefits resulting from a coordinated regulation with the downstream mainstem reservoirs.

6) In April 1957, the Corps Garrison District conducted a flood control study of Canyon Ferry Reservoir. This study recommended that up to 900,000 af of storage be evacuated seasonally on a forecast basis. Average annual benefits attributable to such a storage allocation would amount to \$675,000. Reclamation was furnished this value by letter of 22 May 1958.

7) On 26 November 1957 at a Corps-Reclamation conference in Billings, Montana, the study results were presented to Reclamation. At this time Reclamation appeared interested in providing the flood control storage, but indicated that they needed to compare the power revenue losses with flood control benefit gains before accepting the procedures involved. At a further conference in the Corps Missouri River Division, now known as Northwestern Division (NWD), offices on 6 May 1959 between Reclamation and Corps personnel, Reclamation stated preliminary studies indicated the Corps proposals would result in no loss to firm power benefits, but it would result in a loss of \$100,000 in non-firm power benefits. However, with the \$675,000 benefits to flood control, it still appeared that the benefits would far outweigh the losses to power revenue. Reclamation's analysis was not yet complete and they needed to complete the analysis prior to making a definite commitment.

8) By letter of 19 August 1960 Reclamation informed the Corps that: "Economic evaluations show that such an operation would improve the cost-benefit ratio. However, financial evaluations indicate that some problems would be encountered." Reclamation suggested that further consideration of the proposals (for flood control storage allocation) be postponed until more progress had been made on the investigation of the Missouri River between Great Falls and Fort Peck Reservoir.

9) Ice jam flooding on the Missouri River at Townsend at the head of Canyon Ferry Reservoir in February 1963 resulted in renewed interest in allocation of flood control storage. Local Broadwater County officials wrote letters to U.S. Senators protesting alleged negligent regulation of Canyon Ferry by Reclamation. The officials maintained that high pool levels at Canyon Ferry caused a "backwater" effect on the Missouri River, exacerbating the ice jam flooding at Townsend. However, a 28 February 1963 letter from Missouri River Division to the Corps Omaha District (District) office stated that flood control regulation at Canyon Ferry would benefit downstream interests and not necessarily Townsend. The Missouri River Division recommended a local flood protection project at Townsend.

10) A 25 November 1964 letter from the Corps Omaha District to Missouri River

Division referenced a Reclamation Canyon Ferry flood control regulation study. Reclamation's recommendations were very similar to the Corps 1957 Garrison District study.

11) A 24 November 1965 letter from the Omaha District to Reclamation requested a Reclamation signature to the FWA. On 10 February 1966 the District returned a copy of the FWA to Reclamation with the signature of the Missouri River Division's Commander and Reclamation's Director.

b. **3 August 1971 Field Working Agreement.** This agreement outlined storage capacities for replacement and local flood control as explained in Section 7-03 with the condition that storage elevations could be adjusted based on volume and location of sediment deposits over time. The evacuation of the joint use space was set to begin on or about 1 August each year with the goal to evacuate the replacement storage portion of the joint use pool by the following 1 March. The District Engineer was to notify Reclamation by 10 January if replacement storage would be required with actual needs relayed on 10 January and 10 February. Specific procedures for forecasting inflows and joint use storage requirements were outlined.

c. **23 May 1977 Field Working Agreement.** This agreement was modified to remove the specific procedures for forecasting inflows and joint use storage requirements. The following additions were made:

1) Local Flood Control. Project releases will be restricted to the amount which, in conjunction with incremental inflows below the dam, will not result in damaging discharges on the Missouri River from the dam downstream to Fort Peck Reservoir. The damage stages and discharges at downstream control points in the Missouri River are estimated as follows: Cascade (73.5 feet and 20,000 cfs), Ulm 6E (13.8 feet and 25,000 cfs), and Fort Benton (13.4 feet and 77,000 cfs).

2) Data. Proposed schedules of conservation releases and storage changes, if available, and current operating data shall be provided to the District Engineer by Reclamation. Operating data shall be tabulated daily and furnished periodically as required and shall include such items as: reservoir elevation, reservoir storage, inflow, discharge and other pertinent available hydrologic data.

d. **Current Field Working Agreement.** This agreement was modified to better define integrated system regulation during large floods. The additions are outlined in Section 7-05.a.3.

3-06 PRINCIPAL REGULATION PROBLEMS. Canyon Ferry Dam is unable to pass the revised Probable Maximum Flood (PMF) through the spillway gates, as discussed in further detail in Section 8-02.b. Additional regulation problems are the spillway radial gates should not be overtopped, releases through the river outlet works should not exceed 2,000 cfs during normal operations, and changes in releases when the downstream channel is ice-covered should be limited. These issues are discussed in Section 7-02, Constraints.

IV - WATERSHED CHARACTERISTICS

4-01 GENERAL CHARACTERISTICS. The Missouri River basin is located in portions of ten states in the north central part of the United States. The drainage area above Canyon Ferry Dam occupies part of the intermountain basin known as the Townsend Basin, lying between the Big Belt and Elkhorn Mountains. These mountains are considered subsidiary ranges of the Rocky Mountains and lie east of the Continental Divide.

Canyon Ferry's drainage area is about 15,900 square miles and is bounded on the west and south by the Continental Divide, on the east by the divide between the Madison River and Gallatin River drainage areas and Yellowstone River and Musselshell River drainage areas, and on the north by ridges between minor streams that flow directly to Canyon Ferry Reservoir. The drainage area above Canyon Ferry is largely a high mountainous region with maximum elevations exceeding 11,000 feet. Canyon Ferry Reservoir, which is about 25 miles long with a maximum width of 4.5 miles, lies between the Big Belt and Elkhorn mountains, which have maximum elevations exceeding 8000 feet. Canyon Ferry Dam is located about 58 miles downstream from Three Forks, Montana, the point at which the Jefferson, Madison and Gallatin Rivers join to form the Missouri River.

Although regulation of Canyon Ferry Dam will provide local flood protection along the Missouri River as far downstream as Fort Peck Reservoir (340 river miles downstream of Canyon Ferry Dam), it will primarily affect the first 130 miles below the dam to Great Falls, Montana. In the upstream 40 miles of this 130-mile reach, the Missouri River flows through mountainous terrain where it is impounded by NWE's Hauser and Holter Dams. Along the remaining 90 miles, the Missouri River flows through a generally rolling plains area typical of northeastern Montana. Downstream from Great Falls, the Missouri River slope falls rapidly for about 15 miles near the vicinity of NWE's Morony Dam. Detailed maps of this reach of the Missouri River are shown on Plates 4-1A through 4-1Q.

4-02 TOPOGRAPHY. Ten subbasins have been identified by Reclamation and are shown in Plate 4-2. Each subbasin's topography is discussed separately below.

- a. **Upper Big Hole River.** The Upper Big Hole River basin, the most western subbasin, extends from the confluence of the North Fork of Big Hole River and Big Hole River to the Continental Divide. The subbasin is characterized by a broad valley floor with relatively steep sides. The floor is used for grazing and hay production and contains some irrigation canals. Surrounding mountains are covered by grass and sagebrush with some forested areas. Some areas of standing water suggest a possible high water table or tight soils. The mountains and foothills around the basin have some stream gulying, but these side streams become lost in the valley floor.

b. **Lower Big Hole River.** The Lower Big Hole River subbasin extends from the confluence of the North Fork of the Big Hole River and the Big Hole River to the mouth at Twin Bridges, Montana. In this subbasin, the Lower Big Hole River flows through a steep, narrow canyon, which results in high channel velocities. Canyon walls along this reach exhibit considerable exposed rock. The forest cover in this subbasin is heavier than in the Upper Big Hole River subbasin. The soils in the upper part are gravely and sandy and support a good grass and sage cover. The irrigated part of the basin is used for hay production. A field inspection conducted in the 1947 study suggested a higher runoff potential in the Lower Big Hole River subbasin than in the surrounding subbasins. Observations made in May 1985 confirm this.

c. **Clark Canyon.** The Clark Canyon subbasin includes the Red Rock River and Prairie Creek tributaries. Red Rock River and Horse Prairie Creek join at the site of Clark Canyon Dam to form the Beaverhead River. The Red Rock River drainage, which is most of this subbasin drainage area, is characterized by a very wide U-shaped valley. The steep sides of this valley show evidence of erosion, but the watercourses disappear in the valley floor. The Red Rocks Lake National Wildlife Refuge is located in the Centennial Valley and includes several natural lakes and swampy areas. Lima Dam, a privately owned structure built in the early part of the 1900s, is at the lower end of the swampy areas. The drainage area above Clark Canyon Dam has only scattered forested areas. Most of this area is covered with grass and sagebrush. Soils are predominately gravely and sandy with very little exposed rock. The major land use is grazing with a small amount of hay production.

d. **Lower Beaverhead River.** The Lower Beaverhead River subbasin extends from Clark Canyon Dam to the mouth of Beaverhead River. The eastern portion of this subbasin is drained by the Ruby River, which flows into the Beaverhead River near the mouth at Twin Bridges, Montana. The upper part of the subbasin is steep with some rock outcrops. The soils are sandy and gravely and have little water holding capacity. A sparse tree cover exists and most of the land cover is sage brush and thin grass. Some hay is grown in meadows along the valley floors. There are large areas of tailings along the river banks left over from dredging operations during the gold production era. Ruby Reservoir, which has a storage capacity of 38,500 af and is a state-owned storage facility used for irrigation, is located on the upper Ruby River. Lower Beaverhead River Valley is more developed with road, railroad, and canal embankments that would retard flow. Hay farming is more prevalent in the lower Beaverhead River subbasin. The higher slopes above the valley floor are similar to those further upstream, with the exception that there is less exposed rock.

e. **Lower Jefferson River.** The Lower Jefferson River subbasin extends from the confluence of the Big Hole and Beaverhead Rivers to the mouth of the Jefferson River at Three Forks, Montana. This subbasin is not as steep as the upstream tributaries. It contains considerable areas between the valley floor and the steep bordering mountains that are rolling to steeply rolling where dry-land agriculture is practiced. The valley floor is used for irrigated agriculture, hay being the principal

crop. There are many man-made embankments that will impede flood flow. A good stand of cottonwood and willow trees along the river will further slow flood flows. The surrounding mountains support a better grass cover and sagebrush than seen in the upper areas.

f. **Upper Madison River.** The Upper Madison River headwaters are within the area of Old Faithful Geyser in Yellowstone National Park. This subbasin extends downstream to the mouth of the canyon area below Earthquake Lake. The upper part of this subbasin is mountainous, with the steepest mountains confined to the area along the Gallatin River divide and a range below Hebgen Dam. Most of this area is composed of fairly steep rolling hills with a good forest cover. The principal tributaries to the Madison River are the Gibbon and Firehole Rivers in Yellowstone Park. The Firehole River, in particular, produces a steady base flow from the geysers and springs within the park. Hebgen Dam and Lake was constructed by MPC, now NWE, and is operated to regulate flows for Ennis Power Plant. Hebgen Reservoir is large and has a storage capacity of 377,500 af. Due to the method of its regulation, Hebgen would offer little, if any, reduction in flood inflows into Canyon Ferry. Below Hebgen, the Madison River flows through a relatively steep canyon. Earthquake Lake, which was formed by an August 1959 earthquake, has only minor storage and no regulation and thus will not provide any reduction in downstream flows during a major flood.

g. **Lower Madison River.** The Lower Madison River basin extends from the mouth of a steep canyon below Earthquake Lake to its confluence with the Missouri River near Three Forks, Montana. This basin has rolling topography within a much wider valley floor than the upper Madison basin. Vegetative cover is primarily sagebrush and grass with moderately forested upslopes on the drainage boundary. Ennis Lake is a small impoundment (capacity 27,200 af) owned and operated by NWE and is located in the middle of this basin. Cliff and Wade Lakes are natural lakes located within the Madison River drainage but they are within a closed portion of the basin. However, the non-contributing area is not large enough to have an impact on the runoff.

h. **Upper Gallatin River.** The Upper Gallatin River rises in the northwest corner of Yellowstone National Park and flows through steep, mountainous country to a point below Spanish Creek. The canyon of the river is very steep and has much exposed rock. There are many stands of pine and aspen forest. Most of the river and tributaries are lined by cottonwood and willow trees. Above the riverbanks, the surrounding area flattens and land cover consists of large areas of sagebrush and grass. There is considerable development in the Big Sky ski area, which is located in the lower part of this subbasin.

i. **Lower Gallatin River.** The Lower Gallatin River subbasin is the area from Gallatin Canyon to the mouth and includes the East Gallatin River. This subbasin is probably the least mountainous subbasin of the entire basin above Canyon Ferry. The valley floor is broad and is used for hay production and grazing. There are

many canals and highways that would retard flood flows. The surrounding hills are also used for farming and grazing. The Lower Gallatin River subbasin lacks the steep, mountainous areas along the divides with adjacent rivers. River channels are lined by large cottonwood trees.

j. **Missouri River.** The Missouri River basin from its formation at Three Forks to Canyon Ferry is in a broad, U-shaped valley. Most of the valley is used for crop production or grazing. The valley is cut with canal, highway and railroad embankments that create temporary ponding areas following heavy rains. The soils are sandy and rocky, but have enough moisture holding capacity to support agriculture. Surrounding hills are moderately steep and only lightly forested. There are extensive areas of sagebrush and grass and most of the steeper area is used for grazing.

4-03 GEOLOGY AND SOILS.

a. **Geology.** Canyon Ferry Dam is located in a narrow section of the canyon at the head of Hauser Lake Reservoir. The bottom width of the canyon at the dam site averages 365 feet wide at the river level. The eastern side of the area is on the west flank of the Belt Mountains. The oldest exposed rocks are the pre-Cambrian sedimentary formations of the Belt series. On the western side of the area, there is a complexly-faulted synclinal structure known as Spokane Hills. This structure merges with the east flank of the range of mountains known as the Casey Peaks or Elkhorn Range. Numerous large outcroppings of granitic-type rocks occur in this section. Between these two structural highs, a structural basin or valley has been formed by the down-warping of pre-Cambrian and Cambrian sedimentary formations. These ancient sedimentary rocks have been intruded by masses of granitic-type igneous rocks, and the basin is partially filled with water-lain Tertiary volcanoes and Quaternary alluvium. The surrounding groundwater table is tributary to the river, and because the alluvium appears tight, serious reservoir leakage is not anticipated.

b. **Soils.** Soils range from gravelly and sandy to tight soils. In the Upper Big Hole River subbasin, standing water suggests a possible high water table or tight soils. Lower Big Hole River subbasin contains soils that are gravelly and sandy and support a good grass cover. Clark Canyon subbasin includes soils that are predominately gravelly and sandy with very little exposed rock. Lower Beaverhead River and Ruby River soils are sandy and gravelly and have little water holding capacity. The Missouri River subbasin soils are sandy and rocky, but have enough moisture holding capacity to support agriculture.

4-04 SEDIMENT. In 1997, hydrographic and topographic surveys were conducted and a new elevation-area capacity table and curve were developed. The 1997 survey determined that Canyon Ferry Reservoir has a storage capacity of 1,992,977 af and a surface area of 34,048 acres at reservoir elevation 3800 feet. Since closure in 1953, the reservoir has accumulated a sediment volume of 59,746 af below reservoir elevation

3800 feet. This volume represents about a 3 percent loss in capacity and an average annual loss of 1,346 af. The revised area-capacity table was put into effect on 1 October 1998 and reflects the updated new storage levels. Table 1 in Exhibit IV shows the capacity table in one-foot increments and Table 2 in Exhibit IV shows the area table in one-foot increments. Exhibit V shows more detailed versions of both tables in tenth-foot increments. The area-capacity curve is found on Plate 2-10.

4-05 CLIMATE. The climate in the area surrounding Canyon Ferry Reservoir varies from semiarid in the intermountain valleys to sub-humid in the higher mountainous sections. Lower sections of the intermountain basins and the plains area below Great Falls generally have comparatively low rainfall and humidity, great temperature extremes, a large number of sunny days, and considerable wind. Table 4-1 presents 30-year monthly average values for temperature and precipitation at Canyon Ferry Dam and the average snowfall depth measured near Canyon Ferry Dam in Helena, Montana.

Table 4-1
30-Year Average Climate Values for Canyon Ferry Dam (1981-2010)

Month	Temperature (° F)	Precipitation (inches)	Snowfall Depth (inches)
January	22.5	0.45	6.2
February	27.6	0.31	5.0
March	36.0	0.55	6.2
April	44.8	0.94	3.7
May	53.3	1.96	0.9
June	61.2	1.83	Trace
July	67.7	1.47	0.0
August	67.5	1.30	0.3
September	57.9	1.11	1.3
October	47.2	0.66	2.4
November	34.3	0.46	4.8
December	25.1	0.46	7.3
Annual	45.4	11.50	38.1

Source: National Climatic Data Center, US Department of Commerce

Temperature and Precipitation data is at Canyon Ferry Dam station

Snowfall data is from the National Weather Service for Helena, Montana

- a. **Temperature.** Cold waves are common in the Canyon Ferry area several times per year with temperatures falling below 0° F. During the summer months hot weather occurs fairly often. Temperatures of over 100° F sometimes occur, but are accompanied by low humidity levels resulting in comfortable summer nights.
- b. **Precipitation.** Precipitation varies widely and depends largely upon topographic influences. Generally, half of the average rain falls from May through July. In the mountainous areas the annual precipitation can exceed 30 inches.

c. **Snow.** The majority of precipitation in mountainous areas is in the form of snow. Most snow falls during the November through April period, but heavy snowstorms can occur as early as mid-September or as late as early June in the higher elevations.

d. **Evaporation.** Evaporation was historically estimated using a 4-foot Class A evaporation pan. Evaporation is now calculated using a bulk flux evaporation estimate developed by the Corps Cold Regions Research and Environmental Lab (CRREL). This estimate uses real-time hydrometeorological data collected at the Helena Regional Airport along with Canyon Ferry's physical properties to calculate an evaporated volume. Tale 4-2 lists the input and output parameters needed to calculate evaporation.

Table 4-2 Canyon Ferry Reservoir Evaporation Estimate Input and Output

Inputs	Unit	Parameter Name
Percentage of sky covered by high level clouds	%	%-Cloud-High
Percentage of sky covered by mid level clouds	%	%-Cloud-Mid
Percentage of sky covered by low level clouds	%	%-Cloud-Low
Relative Humidity	%	%-Rel-Hum
Elevation of high level clouds	meters	Elev-Cloud-High
Elevation of mid level clouds	meters	Elev-Cloud-Mid
Elevation of low level clouds	meters	Elev-Cloud-Low
Air pressure	kPA	Pres-Air
Wind Speed	m/s	Speed-Wind
Air Temperature	C	Temp-Air
Reservoir Area	meters	Area
Reservoir Elevation	meters	Elev
Outputs		
Irrad Sensible Heat	W/m ²	Irrad-Heat-Sensible
Irrad Latent Heat	W/m ²	Irrad-Heat-Latent
Short Wave Radiation Flux	W/m ²	Irrad-Flux-Solar
Long Wave Radiation Flux in	W/m ²	Irrad-Flux-IR
Long Wave Radiation Flux out	W/m ²	Irrad-Flux-IR-Out
Water Temperature (estimated at every half meter)	C	Temp-Water-Surface or Temp-Water-x,xm
Hourly Evaporation	mm	Evap
Daily Evaporation	mm	Evap
Daily Evaporated Volume	cms	Flow-Evap

e. **Wind.** Severe windstorms of a general nature are rare but can occur locally several times per year. Prevailing winds are predominately from the southwest.

However, the area is in or near the path of principal storms from the northwest. Between cold waves in the winter there are periods, sometimes longer than 10 days, of mild but often windy weather. These occasional warm, downslope winds 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.

4-06 STORMS AND FLOODS. Flooding on the upper Missouri River usually results from one of the following causes:

- 1) Ice jams occurring during the winter,
- 2) Runoff from mountain snowmelt usually occurring in the May-June period, or
- 3) Runoff from mountain snowmelt augmented by rainfall runoff usually occurring in the May-June period.

The most damaging floods in the vicinity have been the result of mountain snowmelt augmented by rainfall runoff usually occurring in June. The floods of significance in the area above Fort Peck occurred in 1881, 1886, 1887, 1892, 1894, 1908, 1916, 1917, 1927, 1943, 1947, 1948, 1952, 1953, 1964, 1967, 1975, 1981, 1984, 1986, 1991, 1993, 1997, 1998 and 2011.

The 1908 flood was the greatest flood of record in the reaches below Canyon Ferry Dam. The Missouri River peak flow at the Canyon Ferry site was estimated at 47,000 cfs. At Fort Benton, the Missouri River peak flow was 140,000 cfs. Heavy damage occurred in the urban areas of Fort Benton, Great Falls, and Cascade with water 3 to 4 feet deep on the main street of Fort Benton. Several lives were lost during this flood.

The greatest flood of recent record near the dam site occurred in May-June 1948 when a Missouri River crest flow of 32,000 cfs was recorded at the Toston gage. The greatest floods of recent record from Great Falls downstream to the headwaters of Fort Peck Reservoir occurred in June 1953 and June 1964. They resulted from heavy rains coincidental with the mountain snowmelt. During the June 1964 flood there was considerable flooding on the downstream Dearborn and Sun rivers. Severe flooding to the City of Great Falls was caused primarily by the Sun River. Canyon Ferry Reservoir was credited with the prevention of \$60,000 in flood damages in Montana. Canyon Ferry was also credited with preventing an additional \$763,000 in damages along the main stem of the Missouri River below Fort Peck Dam. Total flood damages prevented in 1964 for all purposes (local and replacement storage) were \$823,000.

The greatest flood above Canyon Ferry since the dam was constructed occurred in 1997 when peak inflows into the reservoir reached 35,300 cfs. Total damages prevented in 1997 were \$27,817,000.

Since the first FWA came into effect in 1966, the floods of the greatest consequence from the standpoint of flood control regulation occurred in 1967, 1974, 1975, 1981, 1984, 1997, 1998, and 2011. A description of the floods and the regulation of Canyon Ferry is found in the following paragraphs.

a. Flood of 1967. Based on above average snowpack, the most probable April-July inflow into Canyon Ferry Reservoir was estimated to be 2,195,000 af. Based on statistics, the existing snow cover had one chance in three of producing inflows during April-July not to exceed 2,063,000 af. Reservoir operation was scheduled based on the 2,063,000 af. Beginning on 12 June, releases were gradually increased to rates estimated to be equivalent of inflow when the conservation pool was full. The peak inflow of 24,500 cfs occurred on 24 June. The maximum content for the year was 1,990,500 af at elevation 3798.3 feet on 1 July. The maximum estimated reduction in flow near Ulm 6E attributable to the regulation of Canyon Ferry Dam was 11,000 cfs, which occurred on 15 June. Only minor flooding was reported on the Missouri River during this time, when there would have been extensive flooding without Canyon Ferry Dam. Canyon Ferry Dam reduced local flood damages by \$506,800 and reduced damages downstream on the Missouri River below Fort Peck Reservoir by \$13,210,000. See Plate 8-7 for a graphical depiction of the 1967 flood routing.

b. Flood of 1974. The April-July inflow to the reservoir was estimated to be 2,709,000 af. The 1 May forecast indicated 51,000 af of assured excess water should be spilled. Total project releases of 7,600 cfs from 11 May through 6 June accomplished this spill. Starting on 6 June, the 7,600 cfs release was continued until actual inflows and storage space remaining dictated the assured excess was spilled. By 20 June, inflow to the reservoir was 27,600 cfs and the joint use zone was almost full. Total releases were increased to 17,000 cfs. This release, combined with downstream incremental flows, resulted in only minor overbank flow in some low-lying rural areas between Canyon Ferry Dam and Great Falls, Montana. A peak storage of 2,006,828 af at elevation 3798.7 feet occurred on 25 June. Canyon Ferry Dam reduced local flood damages by \$419,000 and reduced damages downstream on the Missouri River below Fort Peck Reservoir by \$1,055,000. See Plate 8-8 for a graphical depiction the 1974 flood routing.

c. Flood of 1975. The 1 April forecast indicated that April-July runoff would be about 2,261,000 af. By 8 June inflows exceeded 20,000 cfs. By 15 June the total release was increased to 17,000 cfs. The total release was reduced to 10,500 cfs on 19 June in an effort to reduce the flood peak at Great Falls. By 6 July the total releases were again increased to 22,000 cfs because inflows averaging 23,000 cfs over the past two weeks had filled the reservoir to near maximum storage. The maximum storage occurred on 9 July, 2,049,500 af at elevation 3799.9 feet, reaching the highest storage level since the space between elevations 3797 and 3800 feet was reallocated to exclusive flood control in 1966. The 22,000 cfs maximum release was the highest since the flood of June 1964. The peak daily net inflow was 25,900 on 25 June. Canyon Ferry

Dam reduced local flood damages by \$975,000 and reduced damages downstream on the Missouri River below Fort Peck Reservoir by \$5,969,000. See Plate 8-9 for a graphical depiction of the 1975 flood routing.

d. Flood of 1981. The 1 May forecast, based on remaining mountain snow pack, indicated that the May-June inflow would be only 57 percent of normal. On 18 May the inflow forecast was revised upward to 65 percent of normal. On 24 May, inflows to Canyon Ferry Reservoir reached a record peak net inflow of 29,100 cfs following a heavy rainfall event. Releases were raised to 7,460 cfs by 25 May. As tributary flows below Canyon Ferry receded, releases from Canyon Ferry Dam were increased to hold the river stage at Great Falls at no more than 1 foot above flood stage. The outflow from Canyon Ferry Dam peaked at 25,700 cfs on 13 June. Canyon Ferry Reservoir rose sharply during May and early June to a peak storage of 2,038,988 af at elevation 3799.7 feet on 4 June. The effect of Canyon Ferry Reservoir storage on the Missouri River stage at Ulm 6E was to make releases such that the Missouri River stage at Ulm 6E was no more than 1 foot above flood stage. Without the flood control provided by Canyon Ferry, the Missouri River at Ulm 6E would have reached a maximum stage of 23.0 feet and a peak discharge of 50,000 cfs. Canyon Ferry Dam reduced local flood damages by \$5,000,000 and reduced damages downstream on the Missouri River below Fort Peck Reservoir by \$7,200,000. See Plate 8-10 for a graphical depiction of the 1981 flood routing.

e. Flood of 1984. The 1 April water supply forecast, based on mountain snow pack, indicated the April-July runoff in Canyon Ferry Reservoir would be about normal. After large late-April snowfall the water supply forecast was revised on 1 May to indicate a nearly 20 percent increase in the April-July runoff. Heavy rains in early May, accompanied by the mountain snowmelt runoff, caused inflows to increase sharply from 7,000 cfs on 10 May to nearly 21,000 cfs on 17 May, and remain above 18,000 cfs for eight consecutive days. To control the rate of fill in Canyon Ferry Reservoir, releases were increased to 11,500 cfs on 22 May. Heavy rains during the first and third weeks of June contributed to the second highest June runoff of record. For the second time, inflows rose to over 20,000 cfs and 4 June releases were increased to 14,000 cfs. More rain and warm weather during the third week of June caused inflows to reach the peak for the year of 26,100 cfs on 26 June. To best mitigate the high runoff and control the pool elevation rise at Canyon Ferry, the releases were gradually increased beginning 14 June and peaked at 21,100 cfs on 4 July. Storage entered the exclusive flood pool on 20 June and on 1 July crested at elevation 3799.1 feet at a volume of 2,022,200 af. Canyon Ferry Reservoir was very effective in controlling the third highest inflow volume of record. Regulation of Canyon Ferry during the high inflow period resulted in the prevention of major flood damages downstream and in and around Great Falls. The Missouri and Sun rivers remained below flood stage during the entire high spring runoff period. Canyon Ferry Dam reduced local flood damages by \$656,000 and prevented an additional \$9,624,000 in damages downstream on the Missouri River below Fort

Peck Reservoir. See Plate 8-11 for a graphical depiction of the 1984 flood routing.

f. Flood of 1997. In early January, Reclamation determined that the reservoir needed to be lowered to near elevation 3770 feet, 27 feet below the base of the exclusive flood control pool. This action was in response to the heavy December 1996 snowfall, both in the mountains and on the plains. Reclamation discerned that additional storage would be needed to safely store the snowmelt runoff without requiring large releases that would cause downstream flooding. As the threat of ice-jam flooding passed in the first few days of January, releases were gradually increased from 5,200 cfs to 6,200 cfs from 3-6 January. Releases were increased to 7,300 cfs on 23 January in response to colder weather requiring additional energy demands. Releases were maintained at higher-than-normal levels, about 7,500 cfs, through March as mountain and plains snowpack continued to accumulate at much higher-than-normal levels. By 17 April Canyon Ferry Reservoir had been drawn down to elevation 3769.2 feet, the second lowest level recorded since the reservoir initially filled in 1954.

The mountain snowmelt runoff began in mid-April. Daily average inflows increased from 5,000 cfs to over 11,000 cfs by the end of the month. The snowmelt runoff, accompanied by above-normal spring precipitation, resulted in a steady increase of inflow to over 26,600 cfs on 27 May. May releases averaged 10,900 cfs, which is an approximate volume of 670,800 af. Monthly inflow averaged 17,600 cfs, which is an approximate volume of 1,082,000 af. The volume increase of over 400,000 af resulted in the reservoir elevation increasing to 3782 feet by Memorial Day weekend. The May inflow was the second highest monthly volume of record, only 48,300 af less than the record monthly inflow (May 1976).

As the pool level continued to rise, Reclamation gradually increased releases from about 11,000 cfs on 27 May to near 20,000 cfs on 7 June. By 5 June, inflow had risen to over 31,500 cfs and basin and river conditions indicated that it would continue to rise. On 12 June, inflow reached a peak of 35,300 cfs, the highest daily peak inflow recorded since construction. On 13 June, the pool was at elevation 3796.2 feet, 0.8 foot below the base of the 3-foot exclusive flood control pool, and rising. The release was increased to 25,000 cfs on 13 June. The annual peak release of 25,400 cfs was recorded on 22 June. June average releases of 20,500 cfs totaled a record high volume of 1,217,700 af. June average inflows of 26,500 cfs totaled a record high volume of 1,574,400 af. Total May-June inflow was a record high 2,656,400 af, more than two times normal.

Canyon Ferry Reservoir entered the exclusive flood pool, elevation 3797 feet, on 14 June. The maximum pool of 3798.5 feet was reached on 21 June. Over the next week total releases of 25,000 cfs were gradually reduced, but generally kept about 3,000 cfs higher than inflows, to draw the pool level down to the base of

the exclusive flood control pool. By 30 June, the pool elevation was 3797.2 feet, 0.2 foot above the base of the exclusive flood control pool.

However, large inflows from the Yellowstone and Missouri rivers had begun placing heavy demands on the storage capacities of the Missouri River mainstem reservoirs. Storage in the Fort Peck and Garrison reservoirs was near the top of their respective exclusive flood pools and still rising. With the threat of high runoff into Canyon Ferry finally diminishing, the Corps was able to provide some relief to the mainstem reservoirs by temporarily decreasing releases from Canyon Ferry and storing additional water in the 3-foot exclusive flood control pool. The total release was gradually reduced from 15,700 cfs on 29 June to about 8,600 cfs on 5 July. This reduction in release caused the pool level to increase to a second peak of 3798.4 feet on 7 July. Once this elevation was reached, the total releases were increased to match inflows, about 10,500 cfs. Once inflows began to recede the releases were gradually reduced, but generally kept about 1,500 cfs higher than inflows, to draw the pool level down to the base of the exclusive flood control pool. The pool level dropped below 3797 feet on 29 July.

Due to the regulation of Canyon Ferry, the Missouri River peak flow at Ulm 6E was 28,100 cfs, almost 12,000 cfs less than if Canyon Ferry had not been in place.

The April-July inflow to Canyon Ferry was a record high 3,608,639 af. Annual runoff into Canyon Ferry Reservoir was also the highest of record totaling 5,775,900 af, 147 percent of normal. Canyon Ferry reduced local flood damages by \$2,165,000 and prevented an additional \$25,652,000 in flood damages downstream on the Missouri River below Fort Peck Reservoir for a total of \$27,817,000. This is the highest amount of annual flood damages prevented annually since the construction of Canyon Ferry Dam in 1953. See Plate 8-12 for a graphical depiction of the 1997 flood routing.

g. Flood of 1998. Due to plains snowmelt, inflows began to increase from about 4,100 cfs in early March to over 12,500 cfs by 7 May. The mountain snowpack above Canyon Ferry peaked at slightly below normal levels in mid-April. Because releases were held reasonably steady at about 8,000 cfs over this 2-month period, the pool level remained between 3785 and 3787 feet. The May 1 April-July inflow forecast indicated that releases needed to be reduced to assure the reservoir of filling to the top of the conservation pool by the end of June. From 5-12 May, releases were gradually reduced to about 6,300 cfs. By Memorial Day weekend Canyon Ferry was near elevation 3789.5 feet, 7.5 feet below the base of the exclusive flood control zone. During the first couple weeks of June, inflows rose to approximately 10,000 cfs and releases were further reduced to about 5,800 cfs to ensure that the remaining 7.5 feet of the conservation pool was filled. By 14 June, the pool level had risen to 3794.5 feet.

Significant rains fell in mid-June, and combined with the remaining high elevation snowmelt runoff, caused inflows to steadily increase to over 15,000 cfs by 17 June. Heavy rains continued to frequent the basin over the next 10 days. The pool level entered the exclusive flood pool, elevation 3797 feet, on 19 June. Inflows rose to a peak of 23,300 cfs on 27 June and releases were gradually increased to a peak of 20,200 on 6 July. The peak pool elevation of 3799.4 feet, just 0.6 foot from the top of the 3-foot exclusive flood control pool, was reached on 30 June. This peak was the fourth highest peak of record since Canyon Ferry officially became a flood control project in 1966 (see Table 8-3). The pool elevation fell below the exclusive flood control pool on 21 July.

April-July inflow was 127 percent of normal totaling 2,538,465 af, which was 1,070,174 af less than in 1997. Annual runoff totaled 4,830,500 af, 123 percent of normal, and 945,400 af less than experienced during 1997. Due to the regulation of Canyon Ferry, the Missouri River peak flow at Ulm 6E was 22,500 cfs, 4,300 cfs less than if Canyon Ferry had not been in place. Canyon Ferry reduced local flood damages by \$554,800 and prevented an additional \$4,292,000 in flood damages downstream on the Missouri River below Fort Peck Reservoir for a total of \$4,846,800. See Plate 8-13 for a graphical depiction of the 1998 flood routing.

h. Flood of 2011. On 1 March, snowpack conditions in the Missouri River Basin upstream of Canyon Ferry were 106 percent of average. Releases were reduced to 5,100 cfs in early March in preparation of the spring runoff and assure filling Canyon Ferry Reservoir to the top of the joint use pool by the end of June. Several spring storms frequented much of Montana during April, producing heavy precipitation in the valleys and increasing the mountain snowpack accumulation. Over the month of April the mountain SWE had increased from 113 percent of average (on 1 April) to 140 percent of average (on 1 May). This significant increase in mountain SWE prompted Reclamation to increase releases out of Canyon Ferry to create available storage for the mountain snowpack runoff. From 1-18 May the releases were increased from 7,200 cfs to 11,800 cfs. Inflows ranged from 6,000 cfs to 12,800 cfs during the same 18-day period. The pool elevation decreased from 3780.2 feet on 1 May to 3778.4 feet on 18 May.

Temperatures remained cooler than normal during April and May, significantly delaying the beginning of the mountain snowmelt. Mountain snowpack normally peaks in mid-April. By May 1, the mountain SWE in the Missouri River Basin upstream of Canyon Ferry was continuing to accumulate and had increased to 24.1 inches, about 7 inches higher than average. The Corps' May 1 inflow forecast indicated the May-July runoff into Canyon Ferry to be about 2,168,000 af, 129 percent of average. Reclamation continued to evacuate storage, in anticipation of well above-normal snowpack runoff. About the second week of May, the high elevation snowmelt finally began. The pool level reached 3778.2 feet on 22 May, the lowest elevation of the year.

As the mountain SWE was beginning to melt in early May, typical spring rains fell in the basin above Canyon Ferry. As it normally occurs during the spring, Missouri River and tributary flow around the Helena and Great Falls area had increased accordingly. From 20-22 May, historic rains fell just east of the Canyon Ferry basin in the eastern and central portions of Montana and northern Wyoming (see Figure 4-1).

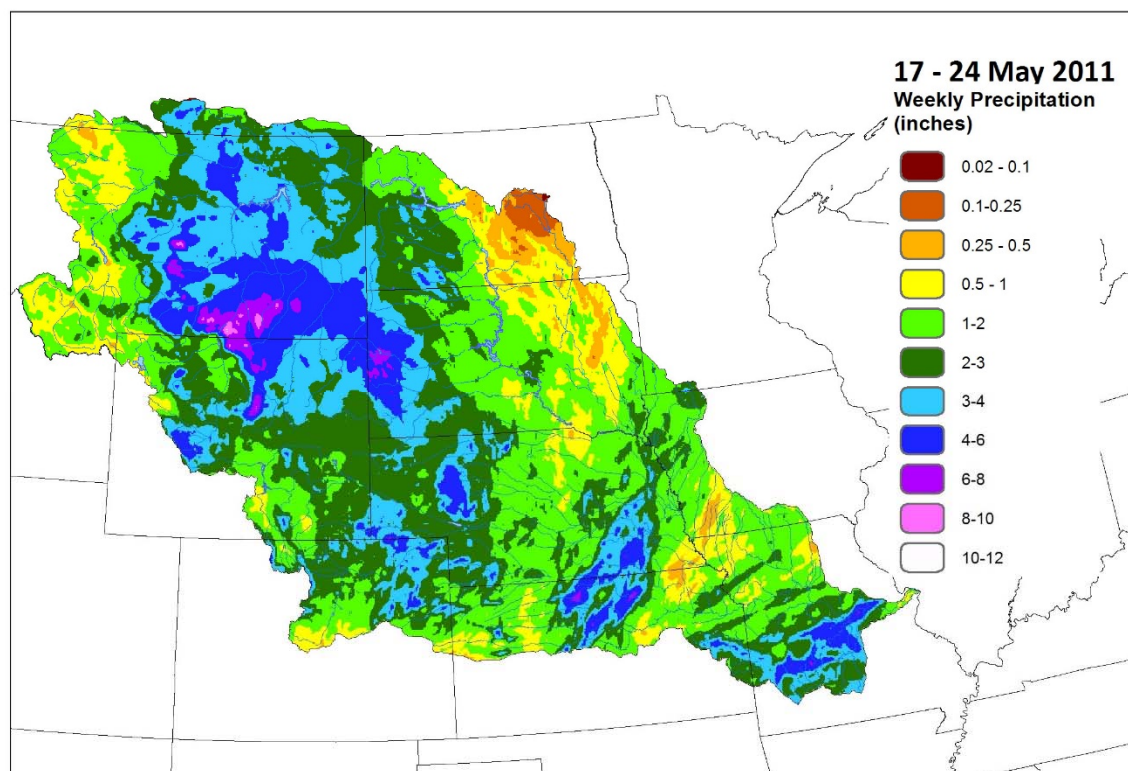


Figure 4-1. Precipitation in inches from 17-24 May 2011.

To minimize downstream flooding along the Missouri River, releases out of Canyon Ferry Dam were temporarily decreased and maintained in the range of 11,000-13,000 cfs starting on 26 May. The reduced releases continued through 13 June. During this 2-week period, inflows increased to over 30,000 cfs resulting in a pool rise to 3790.0 feet on 14 June. The peak inflow of 32,500 cfs occurred on 15 June, the second highest daily peak inflow on record.

Record runoff in the upper Missouri River basin above Sioux City, Iowa prompted the Corps to inform Reclamation on 13 June that all available flood control storage space at Reclamation's Section 7 projects would be used to the extent practical to lessen downstream flooding impacts in the Missouri River basin. Operation plans were made to maintain storage in the projects' exclusive flood control zones for as long as possible, including Canyon Ferry. By 22 June, storage in Canyon Ferry had reached the top of the joint use pool and began filling the exclusive flood pool. June inflow into Canyon Ferry totaled 1,508,322 af and was the second highest June inflow of record.

To control the rate of fill of storage in the exclusive flood control pool, releases were gradually increased from 13,000 cfs (15 June) to 23,700 cfs (3 July), the annual peak release for the year. During this period, inflows ranged from 32,500 cfs to 24,500 cfs and the elevation increased from 3791.2 feet to 3799.7 feet, just 0.3 foot from the top of the exclusive flood control zone. About 89 percent of the 3-foot exclusive flood control storage zone was occupied at the peak pool.

The April-July inflow into Canyon Ferry during 2011 totaled 3,459,571 af, which is the second highest total April-July inflow of record into Canyon Ferry, 149,100 af less than the record April-July 1997 inflow.

Canyon Ferry played a major role in reducing flood impacts along the upper Missouri River during the spring runoff of 2011. During the peak of the runoff period, the reservoir stored about 64 percent of the total flow in the Missouri River at Canyon Ferry Dam. Without this control, the flow of the Missouri River at Ulm 6E would have peaked at 48,100 cfs, almost 20,000 cfs higher than the actual peak of 28,600 cfs. Canyon Ferry reduced local flood damages by \$7,155,100 and prevented an additional \$11,258,200 in flood damages downstream on the Missouri River below Fort Peck Reservoir for a total of \$18,413,300 during 2011. See Plate 8-14 for a graphical depiction the 2011 flood routing.

4-07 RUNOFF CHARACTERISTICS. A major part of the runoff above Canyon Ferry Reservoir is derived from melting snows in the high mountains during early summer. About one half of the annual runoff occurs during April-July. Plate 4-3 shows historical monthly maximum, mean and minimum inflow volume to Canyon Ferry Reservoir and Plates 4-4 to 4-4b present the record of historical monthly inflow volumes. The historic annual inflow volume for the period of record is graphically represented in Plate 4-5. Table 4-3 depicts the period of record average Missouri River monthly flow at the Toston, Montana streamgaging station which indicates the seasonal nature of streamflow in the basin. Normally, the daily inflow to Canyon Ferry Reservoir will approximate the morning (8 a.m.) discharge at the Missouri River at Toston streamgaging station. However, this may not be the case during the snowmelt period when inflow to the reservoir is increasing and afternoon flows are higher than morning flows.

Table 4-3
Average Monthly Flows at Toston, MT (cfs)

January	3,369	May	8,562	September	3,271
February	3,657	June	12,133	October	4,252
March	4,045	July	5,046	November	4,560
April	5,478	August	2,626	December	3,679

USGS Missouri River at Toston, MT gage 1910-2015. No data was available from 1917-1941.

Downstream from Canyon Ferry Dam, the Dearborn, Smith, and Sun rivers have a

similar seasonal runoff pattern. The Dearborn and Smith rivers peak between mid-May and mid-June 95 percent of the time. The Sun River normally peaks one to two weeks later.

4-08 WATER QUALITY. The water quality of Canyon Ferry Reservoir is suitable for drinking, culinary, and food processing purposes after conventional treatment; bathing, swimming, and recreation; growth and propagation of coldwater fish and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

4-09 CHANNEL AND FLOODWAY CHARACTERISTICS. Based on past floods below Canyon Ferry Dam, estimated channel capacities as of April 2013 are 20,000 cfs at Cascade, 25,000 cfs at Ulm 6E, and 77,000 cfs at Fort Benton, which match the targets in the Field Working Agreement. Rating curves for major streamgaging stations in the Canyon Ferry Dam and Reservoir area are shown on Plates 4-6 through 4-18.

Channel capacities between these points may be considerably different. However, any overbank flow is generally confined to lowland areas and is minor in nature. Travel times for various bankfull conditions are given in Tables 4-4 and 4-5 and are shown on Plate 4-19.

Table 4-4
Approximate Bankfull Travel Times Below Canyon Ferry Dam

Canyon Ferry Dam to Ulm (Great Falls)	1 to 1 ^{1/4} days
Canyon Ferry Dam to Fort Benton	1 ^{1/2} to 1 ^{3/4} days
Canyon Ferry Dam to Virgelle	2 to 2 ^{1/4} days
Canyon Ferry Dam to Robinson Bridge	3 to 3 ^{1/2} days
Gibson Dam to Great Falls	1 ^{1/2} to 2 days

Table 4-5
Approximate Bankfull Travel Times Above Canyon Ferry Dam

Sappington to Canyon Ferry Reservoir	1 day
Logan to Canyon Ferry Reservoir	^{3/4} day
Norris Dam (Ennis Reservoir) to Canyon Ferry Reservoir	1 ^{1/4} days

The U.S. Department of Agriculture (USDA) Soil Conservation Service (now the NRCS) authorized and provided funding to the Corps for construction of bank stabilization structures on the Missouri River near Great Falls under Section 216 of the Flood Control Act of 1950. The work consisted of constructing approximately 3,000 feet of bankline revetment to prevent continuing bank erosion on the vicinity of Woodland Estates at a cost of \$210,000. The Cascade County Conservation District was the local sponsor and was responsible for acquisition of the construction rights-of-way. The project was completed in May 1979.

Downstream from Canyon Ferry, a Corps-built levee, which was completed in November 1964, protects the sewage lagoons of Fort Benton from erosion by the Missouri River.

A Corps-built levee on the Sun River, completed in 1987, protects West Great Falls, Montana from flooding. The levee was constructed on the left bank of the Sun River 6 miles upstream from the confluence with the Missouri River. The levee has 3 feet of freeboard with a design flow of 65,000 cfs in the Sun River, with a coincident flow on the Missouri River of 100,000 cfs.

4-10 UPSTREAM STRUCTURES. A number of reservoirs have been constructed in the drainage area above Canyon Ferry Dam by federal, state, and private agencies. Table 4-6 lists reservoirs upstream of Canyon Ferry Dam and downstream to Fort Peck Dam having a storage capacity of more than 5,000 af. In addition, there are numerous reservoirs and ponds of less capacity constructed for irrigation and other conservation purposes. All of these reservoirs, along with many natural lakes in the basin, have some effect in the reduction of spring and summer runoff. However, except for the larger ones, they are usually full before the peaks from large floods occur and offer little reduction to the higher peak flows.

Table 4-6
Reservoirs in the Upper Missouri River Basin (over 5,000 af capacity)

Reservoir	Basin	Storage (af)		Year Completed	Operated By
Lima	Jefferson	84,050	(1)	1934	Private
Clark Canyon	Jefferson	329,000	(2)	1964	Reclamation
Ruby River	Jefferson	37,600	(1)	1938	MDNRC
Delmoe Park	Jefferson	6,600	(2)	1913	Private
Willow Creek	Jefferson	18,000	(2)	1938	MDNRC
Hebgen	Madison	377,500	(2)	1915	NWE
Earthquake Lake	Madison	35,000	(2)	(3)	---
Ennis Lake	Madison	27,200	(2)	1900	NWE
Middle Creek	Gallatin	10,200	(2)	1950	MDNRC
Canyon Ferry	Missouri	1,993,000	(2)	1954	Reclamation
Hauser Lake	Missouri	111,060	(2)	1911	NWE
Lake Helena	Missouri	10,600	(2)	1945	NWE
Holter	Missouri	240,400	(1)	1918	NWE
Smith River	Smith	11,500	(1)	1936	MDNRC
Gibson	Sun	99,060	(1)	1940	Reclamation
Pishkun	Sun	46,670	(1)	1940	Reclamation
Willow Creek	Sun	32,300	(2)	1941	Reclamation
Nilan	Sun	10,090	(1)	1951	MDNRC
Morony	Missouri	13,600	(1)	1930	NWE
Bynum	Teton	75,000	(2)	1926	Private
Lower Two Medicine Lake	Marias	11,880	(1)	1967	BIA
Four Horns	Marias	19,250	(1)	1932	BIA
Swift	Marias	30,000	(1)	1967	Private
Lake Frances	Marias	116,900	(2)	1913	Private
Tiber	Marias	1,555,900	(1)	1956	Reclamation
Ackley Lake	Judith	6,700	(1)	1938	MDNRC
Fort Peck	Missouri	18,688,000	(2)	1940	Corps
Toston Dam	Missouri	4,100	(1)	1940	MDNRC

MDNRC - Montana Department of Natural Resources & Conservation

BIA - Bureau of Indian Affairs

NWE – Northwestern Energy (formerly Montana Power Company)

(1) Usable storage - storage available for release below the maximum controllable level

(2) Gross storage – total storage available including dead zone

(3) Formed by earthquake in August 1959.

4-11 DOWNSTREAM STRUCTURES. Detailed maps of the Missouri River from Canyon Ferry Dam to Great Falls, MT are shown on Plates 4-1A to 4-1Q. Releases from Canyon Ferry Reservoir eventually flow into Fort Peck Reservoir, the uppermost of the six Missouri River mainstem reservoirs. A description of the integrated operations with other flood control reservoirs in the Missouri River Basin is outlined in the FWA and Section 3-05.d.

4-12 ECONOMIC DATA.

a. **Population.** In the area downstream from Canyon Ferry Dam, the majority of towns and areas having the greatest density of rural population are located along the larger rivers and streams. The populations of the larger towns and counties on the river below Canyon Ferry Dam are displayed in Table 4-7.

Table 4-7
Population along the Missouri River below Canyon Ferry

<i>Town</i>	1950	1960	1970	1980	1990	2000	2010
Craig	66	50	50	(a)	56	(a)	43
Cascade	447	604	714	773	729	819	685
Ulm	75	350	494	(a)	389	750	738
Great Falls	46,500	38,500	60,091	56,884	55,125	56,690	58,505
Black Eagle	1,449	2,200	2,300	(a)	927	914	904
Fort Benton	1,522	1,887	1,863	1,693	1,660	1,594	1,464
<i>County</i>							
Cascade	53,027	73,418	81,804	80,696	77,691	80,357	81,327
Choteau	6,974	7,348	6,473	6,092	5,452	5,970	5,813
Lewis and Clark	24,540	28,006	33,281	43,039	47,495	55,716	63,395

(a) – Data unavailable

Source of Data: U.S. Department of Commerce, Bureau of the Census 2010

b. **Agriculture.** Table 4-8 highlights the role of agriculture in the area around Canyon Ferry Dam. Irrigation plays a major role; a quarter of the irrigated land in Montana lies in the watershed counties of Canyon Ferry and two-thirds of the harvested cropland in the watershed is irrigated (407,102 acres). Cattle comprise the major form of livestock in the watershed and 59 percent of Montana's potatoes are grown in Canyon Ferry's drainage basin. Downstream of the dam, hogs are the prominent form of livestock and major crops include wheat and barley.

Table 4-8
2007 Agricultural Data near Canyon Ferry Dam and Reservoir

	Watershed	Downstream
Land in farms (acres)	4,123,375	4,628,727
Market Value of Agriculture Products Sold	\$282,503,000	\$263,908,000
% Crops	33	67
% Livestock, Poultry, and their products	67	33
Irrigated land (acres)	489,497	97,903
% Harvested Cropland Irrigated	66	86

Data from 2007 Census of Agriculture, USDA, National Agriculture Statistics Service

Watershed counties include: Beaverhead, Broadwater, Deer Lodge, Gallatin, Jefferson, Madison, and Silver Bow

Downstream counties include: Cascade, Chouteau, and Lewis and Clark

c. **Industry.** Employment by industry in the areas above and below Canyon Ferry Dam are found in Table 4-9.

Table 4-9
Employment by Industry near Canyon Ferry Dam and Reservoir

	Above Canyon Ferry Dam	Below Canyon Ferry Dam
Service-Providing	47.5%	50.6%
Leisure and Hospitality	11.8%	9.2%
Goods-Producing	10.4%	6.4%
Education and Health Services	9.2%	12.1%
Construction	4.9%	3.8%
Professional and Business Services	6.5%	6.9%
Manufacturing	3.5%	1.8%
Financial Activities	3.0%	4.3%
Public Administration	0.0%	0.0%
Other Services	2.3%	3.3%
Information	0.9%	1.6%

Data from Sept. 2011 Quarterly Census of Employment and Wages, Montana Dept of Labor and Industry

Counties above Canyon Ferry include: Beaverhead, Broadwater, Deer Lodge, Gallatin, Jefferson, Madison, and Silver Bow

Counties below Canyon Ferry include: Cascade, Chouteau, and Lewis and Clark

d. **Flood Damages.** The Missouri River downstream from Canyon Ferry Dam has been divided into four reaches for computation of flood damages:

Reach 1 - Canyon Ferry Dam to Holter Dam, approximately 42 river miles

Reach 2 - Holter Dam to mouth of Sun River, approximately 89 river miles

Reach 3 - Mouth of Sun River to mouth of Marias River, approximately 70 river miles

Reach 4 - Mouth of Marias River to Fort Peck Reservoir, approximately 179 river miles

Index stations for each reach were selected to reflect discharges within the reach. Discharge damage curves were developed from field surveys and floods of record. Zero damage discharges were selected for each reach from a study of recorded stream discharges and flood records. The field survey disclosed a negligible potential damage in Reach 1 because most of the reach is in canyons and used for reservoir storage. This survey was made prior to 1954. However, the curves were updated in 2013 to reflect current price levels and are shown on Plate 4-20. Annual flood damages prevented by Canyon Ferry Dam since construction for both local and the Missouri River Mainstem System are shown in Table 4-10. Total damages prevented by Canyon Ferry Dam since its construction is \$546,191,000 in September 2014 dollars.

Table 4-10
Flood Damages Prevented by Canyon Ferry Dam (X \$1,000)

Year	Unadjusted (x\$1,000)			Adjusted to 2014 \$ (x\$1,000)		
	Local	Mainstem	Total	Local	Mainstem	Total
1953	0	350	350	0	4,500	4,500
1954	0	0	0	0	0	0
1955	0	0	0	0	0	0
1956	0	71	71	0	801	801
1957	0	478	478	0	5,204	5,204
1958	0	0	0	0	0	0
1959	0	570	570	0	5,760	5,760
1960	0	617	617	0	6,116	6,116
1961	0	0	0	0	0	0
1962	0	494	494	0	4,719	4,719
1963	0	489	489	0	4,562	4,562
1964	60	763	823	543	6,908	7,452
1965	310	0	310	2,740	0	2,740
1966	0	1,218	1,218	0	10,383	10,383
1967	507	13,210	13,717	4,154	108,281	112,435
1968	150	224	374	1,153	1,722	2,874
1969	0	98	98	0	687	687
1970	156	547	703	1,034	3,626	4,660
1971	170	277	447	994	1,617	2,610
1972	500	3,038	3,538	2,644	16,061	18,704
1973	0	311	311	0	1,516	1,516
1974	419	1,055	1,474	1,927	4,851	6,778
1975	975	5,969	6,944	4,137	25,325	29,462
1976	473	845	1,318	1,839	3,286	5,125
1977	0	0	0	0	0	0
1978	215	433	648	720	1,451	2,171
1979	391	5	395	1,128	14	1,141
1980	918	141	1,059	2,621	403	3,023
1981	5,000	7,200	12,200	13,212	19,025	32,237
1982	950	2,631	3,581	2,356	6,525	8,881
1983	701	1,728	2,429	1,629	4,016	5,646
1984	656	9,624	10,280	1,504	22,064	23,567
1985	0	175	175	0	399	399
1986	4,574	0	4,574	10,207	0	10,207
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	0	0	0	0	0	0
1990	2,072	0	2,072	4,226	0	4,226
1991	1,201	2,493	3,694	2,383	4,947	7,330

Year	Unadjusted (x\$1,000)			Adjusted to 2014 \$ (x\$1,000)		
	Local	Mainstem	Total	Local	Mainstem	Total
1992	0	190	190	0	369	369
1993	201	7,166	7,368	370	13,196	13,567
1994	9	707	717	17	1,258	1,274
1995	2,091	532	2,623	3,713	945	4,657
1996	1,249	5,785	7,034	2,132	9,876	12,008
1997	2,165	25,652	27,817	3,544	41,991	45,535
1998	555	4,292	4,847	906	7,013	7,919
1999	958	4,280	5,237	1,514	6,767	8,282
2000	0	1,485	1,485	0	2,321	2,321
2001	0	832	832	0	1,278	1,278
2002	509	2,210	2,720	772	3,351	4,123
2003	0	1,815	1,815	0	2,705	2,705
2004	0	0	0	0	0	0
2005	79	10,607	10,686	103	13,857	13,960
2006	1,848	108	1,956	2,340	137	2,477
2007	0	2,787	2,787	0	3,407	3,407
2008	2,103	25,919	28,022	2,413	29,753	32,167
2009	1,165	3,179	4,344	1,355	3,697	5,052
2010	1,240	8,435	9,674	1,399	9,518	10,917
2011	7,155	8,312	15,467	7,777	9,035	16,812
2012	174	3,091	3,264	185	3,297	3,482
2013	0	2,244	2,244	0	2,352	2,352
2014	2,123	13,112	15,235	2,175	13,433	15,608
TOTAL	44,019	187,792	231,811	91,867	454,324	546,191

Source: USACE Omaha District, Environmental, Economics, and Cultural Resources Section

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V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01 HYDROMETEOROLOGICAL STATIONS.

a. **Facilities.** Maps of stream gaging stations upstream and downstream of Canyon Ferry Dam are presented on Plates 5-1 and 5-2, respectively.

The Cooperative Stream Gaging (Co-op) Program is a joint effort between the Corps, Reclamation, and the U.S. Geological Survey (USGS) providing remote site, satellite data transmissions utilized for water management. Plate 5-3 displays a table of several reservoirs and hydrologic stations relevant to Canyon Ferry Dam with various organizations' identification names, drainage areas, mean values, and periods of record.

Reclamation's HydroMet system forms a complementary network of nearly 400 real-time hydrologic and meteorological data stations dedicated to forecasting and managing the water supply in the northwestern U.S. HydroMet stations at various locations within the Missouri River Basin associated with the regulation of Canyon Ferry Reservoir are identified on Plate 5-3.

An automated weather station operated by the NOAA is located at the Canyon Ferry Power Plant and provides weather data to the HydroMet System.

Mountain snow courses are measured monthly from 1 January through 15 June by various government agencies. Since 1964 the NRCS has also established automated SNOW TELemetry (SNOTEL) stations or snow pillows in the mountain areas. The locations of these SNOTEL stations are shown on Plate 5-4. The Lick Creek, Calvert Creek, Rocker Peak, Shower Falls and Saddle Mountain snow pillow stations have been selected for predicting the timing of the snowmelt runoff recession, as described in Section 6-02.c. Plains snow depth measurements are obtained from the National Weather Service (NWS).

Plate 5-5 contains a table of snow water equivalent (SWE) values for Montana SNOTEL stations located in the upstream basin of Canyon Ferry Dam. It shows average values for each SNOTEL station and can be used to track the progress of the snowpack accumulation. Table 5-1 shows precipitation data for the same SNOTEL stations given in Plate 5-5.

A table of data including monthly precipitation averages for NWS precipitation stations is shown on Plate 5-6. A map showing precipitation gage locations is shown on Plate 5-4.

Table 5-1
Average Monthly Precipitation Data for SNOTEL Stations Above Canyon Ferry Dam and Reservoir

SNOTEL Site Name	Average Precipitation in Inches (1981-2010)												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Albro Lake	3.8	2.7	3.1	2.6	2.5	3.7	5.2	5.2	4.6	1.5	1.8	1.8	38.5
Barker Lakes	2.6	2.7	2.5	2.1	2.1	3.5	4.3	4.7	3.9	2.2	2.2	2.1	34.9
Basin Creek	1.8	1.5	1.3	1.1	1.1	2.3	3.1	4.0	3.3	1.6	1.7	1.7	24.5
Beagle Springs	1.9	1.6	1.5	1.4	1.3	2.1	2.8	3.4	3.0	1.6	1.5	1.5	23.6
Beaver Creek	2.6	3.2	3.7	3.6	2.8	3.0	3.1	3.3	3.0	1.8	1.6	1.6	33.3
Black Bear	4.0	6.6	7.3	7.1	5.8	5.8	5.1	4.6	3.2	1.7	1.5	2.0	54.7
Bloody Dick	2.0	2.8	2.5	2.4	2.0	2.2	2.7	3.0	2.4	1.2	1.2	1.4	25.8
Boulder Mountain	2.7	3.4	3.6	3.4	2.7	3.8	4.5	4.5	4.2	2.2	1.8	2.4	39.2
Brackett Creek	4.1	3.9	3.9	4.4	3.6	4.1	5.2	5.7	5.6	1.8	2.1	2.4	46.8
Calvert Creek	1.3	2.0	2.2	2.0	1.6	1.6	1.3	2.0	1.7	0.9	1.2	1.3	19.1
Carrot Basin	3.2	4.3	4.7	4.5	3.9	4.4	4.5	4.6	3.4	2.1	1.9	2.0	43.5
Clover Meadow	2.8	2.8	2.6	2.6	2.4	3.3	3.9	4.1	3.2	2.0	2.1	2.2	34.0
Darkhorse Lake	3.2	5.0	4.8	5.1	3.7	4.3	4.5	4.8	4.0	1.6	1.9	2.2	45.1
Divide	1.9	1.7	1.9	1.8	1.6	2.3	2.5	2.9	3.3	1.5	1.5	1.6	24.5
Elk Peak*	*	*	*	*	*	*	*	*	*	*	*	*	*
Frohner Meadow	1.8	1.7	1.6	1.4	1.3	1.9	2.3	3.3	3.0	1.8	1.7	1.9	23.7
Lakeview Ridge	2.2	2.4	2.5	2.1	1.9	2.6	2.9	3.5	2.9	1.8	1.4	1.7	27.9
Lemhi Ridge	2.0	2.2	2.0	2.0	1.6	2.5	3.0	3.4	2.8	1.1	1.2	1.4	25.2
Lick Creek	2.4	2.2	2.1	1.9	1.8	2.9	3.8	4.4	3.6	1.6	1.7	1.8	30.2
Lone Mountain	3.0	2.7	2.8	2.8	2.3	2.9	3.7	3.8	3.9	2.2	2.0	2.0	34.1
Lower Twin	3.2	3.5	3.4	3.1	2.5	3.8	4.8	5.2	4.3	2.3	2.1	2.1	40.3
Madison Plateau	2.9	4.3	5.3	4.9	3.7	4.0	3.7	4.2	2.9	1.3	1.4	1.6	40.2
Mule Creek	2.2	2.8	2.8	2.8	2.2	2.8	3.1	3.5	3.2	1.6	1.6	1.7	30.3
Peterson Meadow	1.8	1.9	1.8	1.4	1.8	2.6	3.3	3.6	3.7	0.9	1.6	1.8	26.2
Pickfoot Creek	2.4	2.6	2.4	2.2	1.7	2.7	3.3	3.7	3.4	2.0	1.6	2.1	30.1
Porcupine	2.0	1.9	1.8	1.8	1.6	2.3	3.2	3.7	3.4	1.6	1.7	1.8	26.8
Rocker Peak	2.1	2.2	2.2	2.0	1.9	2.8	3.4	3.8	3.7	1.9	1.9	2.0	29.9
S Fork Shields	3.1	3.3	3	3.1	2.7	3.9	5.2	5.2	4.7	2.3	2.2	2.4	41.1
Sacajawea	4.2	3.3	3.8	3.3	3.2	3.4	4.6	5.6	6.3	1.6	2.0	2.5	43.8
Saddle Mtn	2.1	4.1	4.5	4.5	3.6	3.7	3.8	3.3	2.6	1.3	1.2	1.4	36.1
Short Creek	1.7	1.2	1.1	1.0	1.0	1.3	1.7	2.2	2.5	1.4	1.5	1.3	17.9
Shower Falls	3.6	3.8	3.5	3.4	3.3	4.5	5.5	5.9	5.3	3.0	2.4	2.7	46.9
Tepee Creek	2.0	2.6	2.7	2.3	2.1	2.6	2.5	2.8	2.9	1.8	1.5	1.6	27.4
Tizer Basin	2.0	1.8	1.6	1.4	1.2	2.1	3.0	3.5	4.0	2.1	1.9	1.7	26.3
Warm Springs	3.0	3.9	3.8	3.6	3.1	4.1	4.0	4.6	4.5	1.8	2.2	2.6	41.2
West Yellowstone	1.9	2.3	3.0	2.6	2.0	1.9	2.5	2.5	2.1	1.2	1.1	0.9	24.0
Whiskey Creek	2.4	3.4	4.0	3.5	3.0	3.1	3.0	3.3	2.9	1.4	1.2	1.6	32.8
AVERAGE	2.5	2.7	2.8	2.6	2.3	2.9	3.5	3.9	3.6	1.7	1.7	1.8	31.9

Source - Natural Resources Conservation Service (NRCS) National Water and Climate Center,

www.nrcs.usda.gov

* Elk Peak data collection began in 2008. Elk Peak data will be incorporated into SNOTEL calculations after a 30 year record has been collected.

Real-time rainfall gages located in the Canyon Ferry Dam area are listed in Table 5-2 and their locations are shown on a map in Plate 5-4.

Table 5-2
Real-Time Rainfall Gages near Canyon Ferry Dam and Reservoir

Station Name	Elevation (feet NGVD29)	NESDIS ID	NWS ID	Owner	HydroMet ID	Period of Record
Gallatin River nr Logan	4086	CE78ADF2	LOGM8	USGS	LGMT	1988-present
Madison R at McAllister nr Ennis	4689	D10F72F8	MADM8	USGS	MAMT	1988-present
Missouri R nr Toston	3906	CE78BE84	TOSM8	USGS	TOMT	1988-present
Clark Canyon Reservoir	5580	3462D178	CLKM8	USBR	CCR	1989-present
Dillon 11NE AgriMet	5100	F23044BC	DWSM8	USBR	DLNM	1997-present
Madison R blw Hebgen Dam nr West Yellowstone	6650	F0010078	HBDM8	USBR	HEBR	1988-present
Lima Reservoir near Lima		34867130	LRRM8	USBR	LIMR	1988-present
Antelope RAWS nr Lima	6795	325363B0	LMRM8	USFS	-	1991-present
Brenner RAWS nr Grant	6350	325AA0F2	BRRM8	USFS	-	1985-present
Ennis RAWS	4939	323F909A	ENNM8	USFS	-	2001-present
Galena RAWS nr Boulder	6860	32335418	GAAM8	USFS	-	1992-present
Ginger RAWS nr Townsend	4370	3253F6D2	GINM8	USFS	-	1991-present
Hebgen Lake RAWS nr West Yellowstone	6667	323FC0E6	HBRM8	USFS	-	2001-present
Helena RAWS	3840	32568782	HRWM8	USFS	-	2000-present
Red Rock RAWS nr Lakeview	6690	325FE438	RRDM8	USFS	-	1987-present
Whitehall RAWS	4360	323FB676	WHHM8	USFS	-	2001-present
Wise River RAWS	5704	3272D32A	WRSM8	USFS	-	2001-present
Yellow Mule RAWS nr Big Sky	9200	323FF57C	YLWM8	USFS	-	2001-present
Bozeman 6W exp Farm*	4780	-	BZMM8	NWS	-	1966-present
Bozeman Gallatin Fld*	4460	-	KBZN	NWS	-	1941-present
Bozeman MT State U*	4860	-	BZEM8	NWS	-	1965-present
Butte Bert Mooney AP*	5540	-	KBTM	NWS	-	1986-present
Dillon AP*	5239	-	KDLN	NWS	-	1939-present
Helena Rgnl AP*	3874	-	KHLN	NWS	-	1938-present

* Precipitation data used in the Corps' long-range runoff volume forecast described in Section 6-04. Some are not real-time.

RAWS = National Interagency Remote Automated Weather Stations (mostly used for fire related forecasting)

AgriMet = (agricultural and meteorology) is a cellular-based network of automated agricultural weather stations in irrigated agricultural areas throughout the Pacific Northwest operated and maintained by Reclamation.

Sources:

<http://amazon.nws.noaa.gov/hads/charts/MT.html>

<http://www.usbr.gov/gp>

United States Forest Service is abbreviated as USFS in the table above.

<http://www.waterdata.usgs.gov/mt/nwis>

US Department of Commerce National Climatic Data Center

b. Reporting. Data from hydrologic gages for water management are obtained from various sources including contract observers, project offices, NWS, USGS, Reclamation, and state offices. The NWS provides current weather conditions, one-to five-day precipitation, temperature and river stage and flow forecasts, observed precipitation reports, river level data, and special hydrologic forecasts including flood warnings.

There are many websites that provide a variety of weather products including universities, NWS, and commercial vendors of weather products. Products range from raw data (i.e., precipitation, temperature) to upper air maps and forecast products containing "value-added" graphics.

Periodic discharge measurements made by the USGS are normally furnished to the WCWQS through automated computer exchange but can also be obtained by mail, email, fax, or telephone for various stations. These are used to maintain current stage-discharge relationships. Collection and publication of data such as stage, discharge, sediment, water quality, and groundwater records are the primary functions of the Co-op 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. Daily SNOTEL updates can also be obtained from the NRCS website.

The automated Data Collection Platforms (DCP) located throughout the basin transmit real-time information such as river and reservoir levels, precipitation, wind, and water and air temperature data via a Geostationary Operational Environmental Satellite (GOES) to the Omaha District and to the NOAA National Environmental Satellite, Data, and Information Service (NESDIS). The WCWQS data system located in Omaha, Nebraska and Reclamation's computer located in Boise, Idaho receive this data and store it in their respective databases. Computer software allows reservoir regulation personnel to retrieve and view the data in real-time and to assist in making system 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 each maintain a database system by contributing personnel, funds and equipment. Streamgaging sites are maintained by Reclamation, the Corps, and USGS. SNOTEL sites are maintained by the NRCS.

Omaha District WCWQS staff coordinate the District streamgaging program with assistance from the USGS. The USGS' activities are funded through the Co-op (FC-33) executed by the WCWQS. The Co-op Program provides financial support for operation and maintenance of multiple streamgaging stations. DCPs are installed and maintained by the USGS, Reclamation, and the Corps WCWQS personnel.

5-02 WATER QUALITY STATIONS.

- a. **Facilities.** USGS Station 06054500, “Missouri River at Toston, Montana”, includes water quality and biological sampling.
- b. **Reporting.** Data is transmitted as described in Section 5-01.b via the GOES satellite.
- c. **Maintenance.** USGS Station 06054500 is owned and operated by the USGS.

5-03 SEDIMENT STATIONS. The Corps, under the Co-op Program, operated one Missouri River suspended sediment sampling station from 1971 to 2006 at the Missouri River near Landusky, Montana. No sediment monitoring has occurred upstream of Canyon Ferry Dam.

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 Corps Hydrologic Engineering Center (HEC) and utilizes an Oracle database to store river, reservoir, and weather data.

CWMS collects and presents the District’s data in a clear, concise, and comprehensive manner. It provides access to both the current observed data and the results from forecast scenarios. Observed and forecasted information are displayed in two-dimensional plots and in special graphics using schematic, map, or image backgrounds.

5-05 COMMUNICATION NETWORK. There are several standard telephones available for use in the Canyon Ferry facility. In addition, a satellite phone is located in the Canyon Ferry Field Office. There are two transmitter/receiver radio base station units, one located in the power plant and one located in the facility office; one repeater station located on top of “Goon Hill”, east of the dam; and six vehicle-mounted mobile transmitter/receiver units (one mutual aid and five hand-carried transmitter/receiver units). The Montana State Common Mutual Aid radio operates on frequency 153.905 MHZ. The frequency was established for incident on the scene, interagency vehicle to vehicle communication. These units have been assigned call sign “KOC 878”.

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 Canyon Ferry Dam. This System is described in detail in the Canyon Ferry Dam Emergency Action Plan (EAP).

- a. **Emergency Warning.** The Water and Facilities Management Group of Reclamation’s MTAO, dam operating personnel, and/or the Casper Control Center are responsible for notifying downstream authorities when releases or natural flows are expected to approach channel capacity/bankfull stage; and they can take whatever action is necessary to further notify and protect the public located along the river. As a minimum, notification must be made to the Lewis and Clark County

Dispatch, Montana Disaster and Emergency Services (MTDES), NWS, NWE, and the Corps. The NWS is federally mandated to issue flood warnings.

b. **Emergency Situations.** Section 7-15 describes deviations from normal regulation during emergency situations. When these or any other emergency situations arise, the MTAO Area Manager and Water and Facilities Management Group should be immediately notified and informed of all information pertaining to the incident. If the incident should occur after normal office hours, individuals listed as emergency contacts for MTAO in the Communications Directory shall be contacted by calling their cell or home telephone numbers. The local county sheriff and MTDES Representative shall also be immediately notified of the accident. During an emergency activity when the reservoir is in the flood control pool, the District will inform NWD MRBWMD of its activities as soon as possible. Written confirmation of the deviation, including a description of the cause of the emergency, will be furnished to the NWD MRBWMD office.

c. **Remote Control.** The remote supervision of the Canyon Ferry Power Plant and the river outlet works is set up to be controlled from the Casper Control Center in Mills, Wyoming and/or the control room of the Canyon Ferry Power Plant. Canyon Ferry remote regulation control from the Casper Control Center in Mills, Wyoming, began in the fall of 1995. This has resulted in the power plant being completely unattended most of the time, with the exception of Monday through Thursday when the dam operating personnel are on duty between 0700 and 1730 hours local time.

5-06 COMMUNICATION WITH PROJECT.

a. **Corps of Engineers with Bureau of Reclamation.** Telephone, fax, and email are available for communication between the Canyon Ferry Power Plant, Reclamation's Reservoir and River Operations Branch in Billings, Montana, and the Omaha District 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 Corps WCWQS. Verbal regulation orders issued by the Corps WCWQS to Reclamation's MTAO or Canyon Ferry's Facility Manager will be confirmed in writing as soon as possible. The written orders will be sent via email to the MTAO Water and Facilities Management Group who shares the information with the Facility Manager and the Great Plains Regional Office. During the runoff season, release forecasts are shared with the MRBWMD.

Dam operating personnel are required to report rapidly rising pool levels and heavy rainfall to the MTAO Water and Facilities Management Group. In the event the

MTAO cannot be reached, the Dam Operator will notify the WCWQS or the Corps Fort Peck Project Manager. The method, time, and items to be reported are detailed in the Standing Instructions to the Dam Operator in Exhibit III.

b. **Reclamation and Other.** Reclamation participates in annual meetings each spring in Helena, Montana, hosted by Montana Fish, Wildlife & Parks, to advise interested parties of the planned regulation of Canyon Ferry Reservoir and proposed operations of the Missouri River Basin downstream of Canyon Ferry. The proposed annual operating plan for the coming year and the results of the previous year's operation are presented during this meeting.

All changes in release rates shall be coordinated with NWE in regard to their hydroelectric facilities downstream and any other downstream interest that is deemed appropriate. The MTAO Water and Facilities Management Group is responsible for notifying NWE in Butte, Montana, and the Watertown Operations Office of the Western Area Power Administration (Western) in Watertown, South Dakota, of all scheduled water release and power generation changes.

The Casper Control Center and NWE's Dispatch Center in Butte, Montana, are responsible for notifying Hauser Dam of all scheduled water release changes. However, during emergencies when Canyon Ferry is regulated by personnel at Canyon Ferry Power Plant, the Canyon Ferry Power Plant operator will directly notify the Hauser Dam operating personnel.

5-07 PROJECT REPORTING INSTRUCTIONS. Daily project regulation data and miscellaneous hydrologic information are exchanged between the Omaha District WCWQS, Reclamation's MTAO, and the Canyon Ferry Facility Manager. 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 WCWQS publishes an Annual Report that covers regulation details and shows charts of pool elevation and releases for the year and for the history of the project.

5-08 WARNINGS. The Water and Facilities Management Group of Reclamation's MTAO, dam operating personnel, and/or the Casper Control Center are responsible for notifying downstream authorities when releases or natural flows 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 the Canyon Ferry Dam and Reservoir EAP.

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VI - HYDROLOGIC FORECASTS

6-01 GENERAL. Forecasting the volume of runoff expected from the spring snowmelt is done independently by Reclamation, NRCS, and the Corps. Reclamation takes all three forecasts into consideration when scheduling conservation or multi-purpose releases and development of their monthly operation plans. The Corps uses its forecast as described in Section 6-04 with consideration of the Reclamation and NRCS forecasts when determining the joint use space and exclusive flood control requirements. The NWS releases short-term inflow forecasts as part of their mission as official forecaster. This forecast is generally limited to an inflow forecast with a five-day forecast window and six-hour time step increments. Both Reclamation and the Corps use this information as a guide when forecasting inflow and making operational decisions.

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 following NWS websites and offices: Climate Prediction Center (CPC), Weather Prediction Center (WPC), Missouri Basin River Forecast Center (MBRFC), and local Weather Forecast Offices (WFO). NWS products 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.** Quantitatively forecasting amounts of rainfall runoff from the contributing areas above the reservoir is difficult due to the large areas involved, the variation in terrain, and the scarcity of precipitation reporting stations. Precipitation reports form a basis for qualitative estimates and serve as an alert for increased stream flow both above and below the dam. This information is used along with NWS Doppler radar to provide observed precipitation estimates.

Short range forecasting will improve as development of an HEC-HMS runoff model begins in 2018. The HEC-HMS runoff model uses observed precipitation and streamflow and predicted precipitation to forecast runoff. Until the HEC-HMS model is developed for Canyon Ferry Reservoir, short range estimates of inflows resulting from mountain snowmelt runoff are made by translating and extrapolating flows observed at the tributary gaging stations, coupled with the total volume forecast as obtained by procedures described in Section 6-04. The temperatures occurring at the time will affect the rate of snowmelt runoff and should be taken into consideration. Once inflows have crested, short range forecasts are based upon typical recessions of past floods. In general, a recession rate of discharges equivalent to 93 percent of the previous day's discharge appears to be a normal value as indicated by the recession hydrographs shown on Plate 6-1. However, this recession rate is affected by the time of occurrence during the flood season. A crest occurring in May or early June will usually have a much slower recession rate than

one occurring in late June or July. Techniques which utilize recession forecasts for reservoir regulation are given in Chapter VII.

c. **Using SNOTEL to Predict Peak Inflow Timing.** Prediction of the estimated date of peak inflow is determined by monitoring specific SNOTEL stations. As indicated by the analyses shown on Plate 6-2 through 6-3c, a recession in Canyon Ferry inflows can be expected approximately three weeks after the Lick Creek SNOTEL station has indicated all snow has melted (e.g. 0.0 inches of SWE). Plate 6-4 through 6-5c indicate a recession in Canyon Ferry inflows should occur about five weeks after the Calvert Creek SNOTEL station has indicated all snow has melted. Inflows can be expected to peak on or around the day when Saddle Mountain and Rocker Peak SNOTEL stations reach “half melt” – current SWE is half of that year’s peak SWE. Peak inflows generally occur 2 days before Shower Falls SNOTEL station reaches half melt. These analyses are shown in Plate 6-6 through 6-6d. Careful observation of the stages at Big Hole River at Melrose (approximately 2 days travel time above Canyon Ferry) will also aid in defining the start of the inflow recession. Normally, inflow recession will occur after the 5-week period following 0.0” SWE at the Calvert Creek SNOTEL station or the 3-week period following 0.0” SWE at the Lick Creek SNOTEL station, followed by a fall in the Big Hole River at Melrose stage for 3 or 4 consecutive days.

d. **Short Range Stage and Discharge Forecast.** Missouri River flow forecasts are made for Cascade, Ulm, and Great Falls locations (above the Sun River) area by lagging the Canyon Ferry outflow one day and adding the estimated runoff from the incremental area between Canyon Ferry Dam and the station desired. The discharge at or just below the confluence of the Sun River with the Missouri River can be estimated by adding the outflow of Gibson Dam (lagging it one and a half days) and the Sun River incremental discharge in this reach to the above mentioned forecast. The incremental area discharges can be estimated by careful observation of the discharge differences between stations. Missouri River flow forecasts can be made for Fort Benton and stations further downstream in a similar manner utilizing the travel times given in Section 4-09.

6-03 CONSERVATION PURPOSE FORECASTS. Reclamation has responsibility for preparing water conservation forecasts, which are sometimes referred to as drought contingency forecasts.

6-04 LONG RANGE FORECASTS.

a. **Long Range Runoff Volume Forecast.** A major portion of the annual inflow into Canyon Ferry Reservoir results from the mountain snowmelt. On a monthly basis from January through July, the Corps prepares an inflow forecast for the April-July period. The April-July forecast is used to determine the required joint use storage evacuation volume. The long range runoff volume forecast method, which is presented in Exhibit VII, utilizes historical and current SNOTEL station data (see Section 5-01), daily precipitation data (see Section 5-01), and historical April-July

and October-November Canyon Ferry inflow. Additionally, the forecast method uses reservoir holdouts from Lima, Hebgen, and Clark Canyon. Similar long range runoff forecasts are independently prepared by Reclamation and the NRCS. Evaluation of all three forecasts is conducted by the Corps to determine the joint use evacuation required to meet the flood control mission. A more detailed explanation of the required joint use evacuation is in Exhibit VIII.

b. Long Range Stage and Discharge Forecast. Estimates of Missouri River peak flows at the Toston streamgaging station, the upstream inflow station (see Section 4-07), can be made utilizing Plate 6-7. As shown in this plate, the actual April-July calculated inflow volume at Canyon Ferry and the peak flow at Toston, Montana. The long range forecast of actual April-July inflow into Canyon Ferry, as determined from Exhibit VII, is used in estimating the peak early summer flow from snowmelt. The following equation can be used to calculate a Toston April-July runoff.

$$\text{Toston April-July runoff (million af)} = (\text{Canyon Ferry April-July runoff (million af)} - 0.4) / 1.08$$

c. Estimates of Winter and Spring Flow. Estimates of monthly runoff into Canyon Ferry Reservoir can be made using the average natural monthly inflows as shown in Table 6-1. Flows to be estimated are assumed to follow a similar pattern as previous monthly flows (future flows will be the same percent of average as past flows).

Table 6-1
Average Natural Monthly Canyon Ferry Inflows

Month	Average Natural Flow (1000 af)
January	214
February	212
March	263
April	341
May	553
June	728
July	292
August	130
September	186
October	267
November	277
December	228

*Averages are for 1954-2014 period and represent the actual Canyon Ferry inflow plus the storage holdout by Lima, Clark Canyon and Hebgen Reservoirs. Values are in 1000 af. Note Lima data was first available in 1989 and Clark Canyon was closed in 1965.

6-05 DROUGHT FORECAST. Reclamation has responsibility for preparing water conservation forecasts, which are sometimes referred to as drought contingency forecasts.

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VII - WATER CONTROL PLAN

7-01 GENERAL OBJECTIVES. The operating objectives at Canyon Ferry Dam and Reservoir are to provide desired river and reservoir regulation to maximize the power generation benefit at Canyon Ferry and the six downstream NWE power plants; 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 mitigate downstream flood risk. Power operations will be coordinated with NWE as specified in Exhibit VI. Flood regulation will be coordinated between Reclamation and the Corps as specified in Chapter IX.

Section 9 of the Flood Control Act of 1944 authorized the Canyon Ferry Dam and Reservoir project as a Department of Interior project that is managed by Reclamation. Under Section 7 of this act, the Corps is directed to regulate all federally constructed projects when water is in the flood control zone.

7-02 CONSTRAINTS.

a. **Operation of Spillway Radial Gates.** When in a closed position, the elevation of the top of the spillway radial gates is 3800 feet. Flood control operation plans should be made to avoid exceeding elevation 3800 feet. During actual flood control operations, the spillway radial gates should be operated in an open position to prevent the gates from being overtopped. The spillway radial gates should be used to pass all spilled flows exceeding 2,000 cfs to minimize the risk of scour in the stilling basin during normal operation. Equal discharges should be made through all four radial gates. Two-gate symmetrical operation shall be used when the flows would require all four radial gates to be set at less than minimum gate openings. Operating the spillway gates at small openings may cause vibrations in the gates. The minimum gate opening of the spillway radial gates is 0.5 foot.

b. **Operation of River Outlet Works.** The four river outlet works have a design capacity of 9,500 cfs at elevation 3800 feet. To eliminate scouring of the concrete in the stilling basin floor and walls, the maximum release through the river outlet works should not exceed 2,000 cfs, equally distributed among the operating outlet work gates during normal operation. Under emergency conditions, outlet works releases could exceed 2,000 cfs for short time periods. Except under emergency conditions, flow from the river outlet works and the spillway should not occur simultaneously to minimize scouring to the stilling basin. The minimum gate opening of the river outlet gates is 3 inches or 3.9 percent.

c. **Stilling Basin Maintenance.** As required under Canyon Ferry's Facility Review Program, the underwater portion of the spillway stilling basin shall be periodically examined by divers or by remote, underwater-operated vehicles. The purpose of examination is to determine the extent of any damage to the concrete or the

presence of any accumulations of sand, gravel, rocks, or other foreign material within the stilling basin. Any such accumulations should be removed as necessary. Past operations have shown that abrasive action from gravel and rock within the stilling basin during spillway operation can cause severe damage to concrete surfaces.

d. **Power Plant Turbines.** The power plant turbines should not be operated below reservoir elevation 3728 feet. Operating below this elevation can cause severe damage to the turbines and greatly reduces power plant efficiency.

f. **Upstream Ice-Jam Problems.** To reduce the potential for ice jams to occur near the upper end of Canyon Ferry Reservoir, it is desirable to maintain the level of Canyon Ferry Reservoir below elevation 3794 feet from 1 December through the remainder of the winter season. In March 2000 the Corps completed the study "Evaluation of Ice Jam Problems Along the Missouri River Near Townsend, Montana". Conclusions of the study included:

- Ice jams occurred prior to the impoundment of Canyon Ferry Reservoir and have occurred since it was built, during times with high pool elevations and when the lake levels were relatively low. The reservoir elevation may have an impact on ice jam flooding when the pool level is greater than 3794 feet, but it appears to be coincidental.

- The Townsend area is naturally prone to ice jamming, with or without the reservoir, due to natural variation in river morphology as the Missouri River flows downstream from the confluence of rivers at Three Forks, Montana. Near Townsend, the river slows down and goes from a steep channel to a braided and meandering stream, with many island sandbar obstructions and bends. This makes the reach at Townsend one of the first to experience ice-jam problems as the river begins to freeze.

f. **Downstream Ice-Jam Problems.** Releases are generally made to minimize the potential for ice-jam flooding. However, ice jams can occur very quickly and with little notice. If ice jams develop downstream, releases should be made to reduce, or at least not further aggravate, the problems downstream. Normally, fluctuations of project releases are avoided during periods of actual breakup. Releases in excess of power plant capacity should be made only if some required evacuation of the joint use zone is occurring and only when the downstream channel is free of ice. Release rates are generally not changed more than 1,000 cfs during a 6-hour period when the river is ice covered.

Releases are coordinated with NWE in situations when extreme cold weather is forecasted two to five days out. Coordination discussions may consist of increasing river releases by 1,000 to 1,500 cfs for a few days to let the river freeze over at a higher level. Once the river is frozen, the project releases can be reduced to the original scheduled release in an attempt to create an ice bridge over the river. Also

during cold periods, water can turn into ice storage and directly reduce power generation at NWE's facilities. Therefore, NWE may request Reclamation to increase releases at Canyon Ferry to make up for lost generation during these cold periods. Historically, this type of operation has prevented or reduced the potential for ice jams to develop or occur.

7-03 OVERALL PLAN FOR WATER CONTROL.

a. **Storage Allocations.** The storage space in Canyon Ferry Reservoir has been allocated as shown in Table 7-1 (see Plate 7-1 for a schematic of reservoir allocations). Different types of storage are discussed in the following paragraphs.

Table 7-1
Reservoir Storage Allocations (1998 Survey)

Reservoir Use	Elev. Limits (feet)	Capacity (af)
Exclusive Flood Control Storage	3797-3800	101,089
Replacement-Local Flood Control/Joint Use Storage	3783-3797	445,564
Local Flood Control/Joint Use Storage	3770-3783	348,725
Conservation Storage	3728-3770	701,568
Inactive Storage	3650-3728	394,971
Dead Storage	3636.5-3650	1,060

1) **Total Flood Control Allocation.** As detailed in Section 3-05, 900,000 af was allocated for flood control, which at that time was from elevation 3770 feet to 3800 feet. The flood control allocation can be broken up into two zones, exclusive flood control zone and joint use zone. The joint use zone also has a sub zone called the replacement storage zone.

2) **Exclusive Flood Control Allocation.** Historically, most of the major runoff producing storms occur in June and are the biggest factor that can cause the seasonal forecasts to be low. To provide flood protection from such occurrences, the top three feet of the flood control pool (about 100,000 af) has been allocated exclusively for flood control purposes. The exclusive flood control storage provides space to compensate for forecast error in regulating the joint use flood control space. It also lowers the normal operating pool level and mitigates complaints from headwaters areas of the reservoir that high pool levels had contributed to past ice-jam flooding.

3) **Joint Use Allocation.** The joint use storage zone can be evacuated between January and May to minimize flooding in both the local area below Canyon Ferry (Local Flood Control) and Missouri River Mainstem Reservoir System (Replacement Flood Control). Plate 7-6 provides a diagram further explaining the release responsibilities in the joint use zone.

a. **Replacement Storage History.**

The Corps Missouri River Mainstem Reservoir System, located downstream from Canyon Ferry Reservoir, was designed in the 1940s and construction of the system was essentially completed by the mid-1960s. This is a multipurpose system serving both flood risk management and water supply functions. The flood control storage space provided in the mainstem system was developed on the basis that no upstream storage space was in existence, although it was recognized that as this upstream space became available, a reevaluation of the mainstem system's space requirements would be necessary. Continuing analysis of inflows into the mainstem system and into tributary reservoirs constructed upstream from the system has indicated that in certain instances, particularly when inflows are distinctly seasonal in nature, storage space provided in upstream reservoirs could effectively replace a portion of the annual flood control and multiple-use space initially provided in the mainstem system. Reclamation and the Corps coordinate forecasts and project releases to best utilize the storage provided by the upstream reservoirs. This upstream storage has been designated as "replacement flood control storage space."

b. **Replacement Storage in the Joint Use Zone.** Replacement storage is intended to provide additional vacated storage in Canyon Ferry in years where high inflows are forecasted for Canyon Ferry and the Missouri River Mainstem System. To be effective for replacement purposes, tributary replacement storage space should be evacuated by 1 March, the start of the normal flood season in the Missouri River Basin. This is the date by which mainstem annual flood control storage space is evacuated. Studies indicated that a major portion of the seasonal flood control space could be evacuated by this date, on a forecast basis, with reasonably assured subsequent refill. However, to give more assurance to subsequent refill after 1 March, it was agreed by Reclamation and the Corps that replacement storage space to be evacuated by 1 March on the basis of forecasts of future inflows would be limited to no more than 445,000 af (elevation 3783.0 feet). The replacement storage zone also benefits local flood control and can be evacuated for local flood control needs if runoff expectations above Canyon Ferry Dam dictate. A more detailed explanation of how replacement storage is calculated and adjudicated is found in Section 7-05.d and Exhibit VIII.

c. **Local Flood Control / Joint Use Allocation.** The remaining portion of the total flood control allocation, amounting to about 350,000 af of space, has been allocated specifically for local flood control purposes. It will be evacuated after 1 March on the basis of subsequent refill of this space as well as the replacement/joint use space during the following flood season. Evacuation of storage for local flood control purposes will be limited to elevation 3770.0 feet. A more detailed explanation of how joint use

storage is calculated and adjudicated is found in Section 7-05.d and Exhibit VIII.

b. Normal Regulation Plan. Except for special circumstances, the reservoir is generally regulated under the following criteria and limitations:

- 1) As soon as the spring runoff reservoir storage has peaked, usually in June or July, power releases are adjusted so that the pool will be drawn to near elevation 3783 feet (1,416,767 af) by 1 March the following year. Each month, inflows are re-evaluated and releases are adjusted accordingly. Releases to meet this schedule are limited to power plant capacity. When possible, water is generally not spilled to provide this drawdown.
- 2) In accordance with NWE's Federal Energy Regulatory Commission (FERC) re-licensing of their hydroelectric plants, most of the water that will be released from Hebgen Lake (NWE's reservoir) is released during October through March and storage of this water in Canyon Ferry Reservoir may cause the reservoir to rise. However, NWE tries to limit the Hebgen drawdown during these months in an effort to maintain Canyon Ferry Reservoir below 3794 feet after 1 December. Storage below elevation 3794 feet (1,792,884 af) prior to winter freeze up is desired to minimize potential for ice-jam problems at the head end of Canyon Ferry Reservoir.
- 3) Beginning near 1 January and at least monthly thereafter through June, estimated spring inflow forecasts are made, based on the snow cover and precipitation. When these forecasts become available, regulation procedures are changed if necessary. Releases are set based on the most probable spring inflow forecast to allow the reservoir to fill to elevation 3797 feet (1,891,888 af) near the end of June. A more detailed explanation of how these forecasts are used is listed in Section 7-05.
- 4) If spilling is required, it is made only to the extent that current inflow and the reservoir content indicate that additional spills are required.
- 5) Based on inflow forecasts and when the spring runoff begins, releases may draw the pool as low as elevation 3770 feet (1,097,599 af). In a series of dry years the pool may be drawn as low as elevation 3728 feet (396,031 af) to meet firm power generation requirements and satisfy NWE's prior water rights. If storage is drawn below elevation 3728 feet (396,031 af), the power plant is considered to be inoperable.
- 6) Whenever an adequate water supply is available, releases from Canyon Ferry Dam to the Missouri River will be maintained at rates required to sustain river flows equal to or greater than the minimum desired flow of 4,100 cfs below Holter Dam to minimize impacts to downstream river fisheries and recreation activities. During below normal runoff years, it may be necessary to reduce the

releases to lower rates that will provide a desired minimum river flow of 3,000 cfs, or even less than 3,000 cfs, to fulfill contractual obligations with NWE.

7) During times when the reservoir pool is above elevation 3728 feet NGVD29 (396,031 af) all releases other than irrigation discharges to the Helena Valley Pumping Plant are discharged through the power plant up to its capacity, which is 5,500 to 6,000 cfs depending upon reservoir elevation. Normally the power plant will be operated at full capability throughout the year, unless there is a scheduled or forced unit outage. This results in an annual pool drawdown in the fall and winter when the releases for power usually exceed inflows.

7-04 STANDING INSTRUCTIONS 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 operating personnel shall regulate releases for flood control as explained by the Emergency Release Schedule in Exhibit III.

7-05 FLOOD CONTROL.

a. **Flood Control Regulation Objectives.** Canyon Ferry releases will be adjusted as necessary to achieve the following objectives, insofar as practicable:

1) **Local Flood Control.** Project releases will be restricted to the amount which, in conjunction with incremental inflows below the dam, will minimize damaging discharges on the Missouri River from the dam downstream to Fort Peck Reservoir. The damage stages and discharges at downstream control points in the Missouri River are estimated as follows:

Cascade	12.0 feet	20,000 cfs
Ulm 6E	13.8 feet	25,000 cfs
Fort Benton	13.4 feet	77,000 cfs

2) **Replacement Flood Control.** In years when utilization of a major portion of the flood control and multiple-use storage space within the downstream Fort Peck Reservoir is anticipated, Canyon Ferry will assist in flood control along the Missouri River below Fort Peck by storing inflows to withhold or delay flood water from reaching Fort Peck Reservoir. Additional details about replacement flood control can be found in Section 7-03.b.3 and 7-05.d.

3) **Integrated Regulation of All Flood Control Reservoirs in Missouri River Basin.** Releases from Canyon Ferry Reservoir eventually flow into Fort Peck Reservoir, the uppermost of the six Missouri River mainstem reservoirs. The quotes below, The USACE Northwestern Division's Reservoir Control Center (RCC) has been renamed the Missouri River Basin Water Management Division (MRBWMD). As per the Missouri River Mainstem Reservoir System Master Water Control Manual (Master Manual), March, 2006, paragraph 7-04.23, "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 RCC. During such periods, the RCC 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 Canyon Ferry Reservoir may be adjusted in order to meet basin-wide flood control goals of the Missouri River system. In the case of Canyon Ferry Reservoir, requests for modification will be made to the Montana Area Office Facility Operations and Maintenance Division, Bureau of Reclamation in Billings, MT, which is part of the Great Plains Region. Requests should be made via conference call or email, and confirmed via an official reservoir regulation order the same day.

b. Storage Capacity Allocation. To achieve the objectives specified in paragraph 1.a, storage space between elevations 3770.0 feet and 3800.0 feet (currently amounting to 895,378 acre-feet) is utilized for flood control purposes. Of this amount, the space between elevations 3797.0 feet and 3800.0 feet (currently amounting to 101,089 acre-feet) is for exclusive flood control. Joint use space for replacement flood control, local flood control and conservation purposes is between elevations 3783.0 feet and 3797.0 feet (currently amounting to 445,564 acre-feet). Joint use space for local flood control and conservation purposes is between elevations 3770.0 feet and 3783.0 feet (currently amounting to 348,725 acre-feet). The joint use space will be made available for flood control purposes during the January through July period on the basis of anticipated April through July inflows and conservation releases in accordance with the attached Flood Control Storage Reservation Diagram dated December 15, 2016.

c. Flood Control Regulation Criteria and Procedures. The Montana Area Office, Bureau of Reclamation, will regulate the reservoir in the interest of flood control in accordance with the following procedures:

- 1) Regulation of the reservoir when the pool level is in the exclusive flood control zone or in that portion of the joint use zone when required for flood control shall be construed as flood control regulation and releases or flood control regulation criteria shall be determined by the District Commander, Omaha District, Corps of Engineers. At all other pool levels, the District Commander may make recommendations to the Montana Area Office for operating in the interest of flood risk mitigation, but such recommendations shall not be considered mandatory.

2) On or about August 1 each year the Montana Area Office will begin evacuation of the joint use storage space. Between this time and January 10, releases up to power plant capacity will be scheduled to target evacuation of the replacement flood control storage portion of the joint use space by March 1, if subsequent forecasts and storage conditions on January 1 and February 1 warrant.

3) Forecasts of inflow to the reservoir for the April through July period will be made as of January 1 and monthly thereafter during the January through July period and will be exchanged between the District Commander and Regional Director as soon after the first of each month as practicable. Estimates of Canyon Ferry release requirements for power generation and other conservation purposes will be developed monthly by the Bureau of Reclamation commencing on January 1 and extending from the current date through July 31. These will be furnished to the District Commander.

4) The District Commander will notify the Montana Area Office prior to January 10 if continued evacuation of the replacement storage space is required. This is to be determined by the MRBWMD based on the anticipated storage conditions in the Missouri River Mainstem Reservoir System. On or prior to January 10 and February 10 the District Commander will notify the Montana Area Office of the actual amount of space required for replacement purposes. This is to be determined from forecasts of assured inflow (85-90% exceedance probability) and estimates of conservation release requirements for the April through July period. Upon receipt of such notice, the Montana Area Office will modify releases (including spills in excess of power requirements, if necessary) to provide the required space by March 1. Evacuation of storage for replacement purposes will be limited to elevation 3783.0 feet.

5) The District Commander will also utilize the assured inflow forecasts as the basis for advising the Montana Area Office on or prior to January 10 and monthly thereafter of the amount of joint use storage space required for local flood control purposes on May 1, June 1, or July 1 as appropriate. Upon receipt of such notice the Montana Area Office will schedule releases from the joint use storage zone (including spills in excess of power requirements, if necessary) to provide the required joint use space as indicated. Evacuation rates shall be selected so as not to result in damaging stages or to minimize damaging stages below the dam.

6) Whenever the reservoir level rises to elevation 3797.0 feet or into the portion of the joint use storage zone reserved for flood control, or whenever damaging downstream discharges appear imminent, the Montana Area Office shall report as soon as practicable to the District Commander and as requested thereafter until the reservoir level falls below elevation 3797.0 feet, or falls below the joint use storage space reserved for flood control and damaging downstream discharges cease.

d. Special Provisions.

1) The flood control regulation criteria and procedures given above are subject

to temporary modification by the District Commander if found necessary in time of emergency.

2) Nothing in this agreement shall prohibit the Montana Area Office from making the releases as are required to meet irrigation, power, or other project purpose requirements.

3) Oral instructions issued by the District Commander to the Montana Area Office shall be confirmed in writing as soon as possible.

4) Proposed schedules of conservation releases and storage changes, if available, and current operating data shall be provided to the District Commander by the Montana Area Office. Operating data shall be tabulated daily, furnished periodically as required, and shall include such items as: reservoir elevation, reservoir storage, inflow, discharge and other pertinent available hydrologic data.

5) The discharge characteristics of the river outlet works and the spillway (having a combined capacity of 141,200 cfs with reservoir level at elevation 3797.0 feet shall be maintained in accordance with the as-constructed drawings Bureau of Reclamation Drawing No. 296-D-927 dated February 18, 1953, and No. 296-D-1058 dated July 1, 1953).

6) Nothing in these regulations shall be construed to require that releases shall be made at rates or in a manner inconsistent with requirements for protecting the dam and reservoir from major damage, inconsistent with the safe routing of the spillway design flood, or to require dangerously rapid changes in releases.

e. Classification of Flood Control Regulation. In general, the developed method of flood control regulation of Canyon Ferry 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 with the currently available storage space, with consideration of control of floods of project design magnitude. Plate 7-2 was developed using EM 1110-2-3600. More information on Plate 7-2 is provided in Section 7-05.g.

f. Aids for Fill of Joint Use Zone. Release and elevation schedules that may be utilized for refill of the joint use zone are given below. The schedules are based on anticipated mountain snowmelt recession inflows. The anticipated inflows were developed from analysis of the volume under the recession arm of historical hydrographs. Since their development is based on the hydrograph recession, their application should also be limited to the hydrograph recession. Any application of the hydrograph aids prior to their peak would result in an early fill of the joint use zone and weaken the project flood control function. However, any time the recession curves indicate a greater release than that used for determination of assured refill (regression forecast release), the increase should be made. Based on analysis of the SNOTEL stations, as illustrated on Plates 6-2 through 6-6d, these

recession tools should not be used until the melt has reached the thresholds outlined in Section 6-02.c and Plates 6-2 through 6-6d, as this represents the approximate lag time to the peak of the mountain snowmelt flow. Careful observation of the Big Hole River at Melrose stage will also aid in determining when the Canyon Ferry inflows have peaked as explained in Section 6-02.c. Three different methods are presented below to give the user three different approaches for comparative purposes. Note that these are guides to help make release decisions, but results from these methods should always be cross checked with conditions on the ground and engineering judgment.

1) **Release Schedule Based on a Recession Constant of 0.93.** Following the peak inflow into Canyon Ferry, the inflow from snowmelt runoff follows a similar recession that can be generalized for most runoff events. Plate 6-1 shows these hydrograph recessions and finds the most representative recession constant of 0.93. Following peak inflow, multiplying today's inflow by 0.93 can provide a forecasted inflow for tomorrow. And multiplying tomorrow's inflow by 0.93 can provide a forecast for two days into the future. This can be used as a guide when setting a release to avoid overfilling the joint use zone. Plate 7-3 provides a family of curves that calculates the necessary release based on current pool elevation and an expected 0.93 recession of the peak inflow for the remainder of the snowmelt inflow hydrograph. Note Plate 7-3 should not be used until the peak snowmelt inflow has occurred.

2) **Release Schedule Based on Expected Length of Recession.** Four separate release schedules based on 5-, 15-, 25-, and 35-day recessions are presented on Plate 7-4. This method was developed as described in EM 1110-2-3600. The expected length of the recession is to be estimated by the user based on actual conditions. The possible times that each set of curves may be used are as follows:

Table 7-2 Use of Recession Curves

Time Period	Type of Recession Curve	Recession Factor
May or early June	35-day	0.97
Early to mid-June	25-day	0.96
Late June	15-day	0.93
Late July / rainfall only	5-day	0.80

The date ranges above provide a best estimate of when each of these curves would be in effect. The water manager should take extra care to select the curve that most closely matches current state of the runoff. Recessions above the 0.93 recommended in the previous section are used in early June and May to provide a more conservative inflow scenario while rainfall forecasts are the least predictable.

3) **Elevation Schedule Based on Actual Flow Recessions and a Release of 6000 cfs.** A 5,800 cfs release represents the highest release that maximizes

conservation and hydropower benefits to the project. It is preferred releases stay at or below 6,000 cfs to maximize project benefits. Plate 7-5 shows at the time of peak inflow the pool elevation needed to hold releases at 6,000 cfs. If the intersection of peak inflow and date of peak inflow is at or below the current pool elevation curve, then a release of 6,000 cfs is not expected to overfill the joint use zone. If the intersection of peak inflow and date of peak inflow is above the current pool elevation curve, then a release of 6,000 cfs will likely require increased release rates or the use of the Exclusive Flood Control zone.

g. Emergency Regulation Schedule. During large floods or emergency conditions, refer to the emergency flood control regulation curves (see Plate 7-2). These curves were developed per Section 4-05.d of EM 1110-2-3600. Refer to Exhibit III for the definition of emergency regulation and emergency flood control regulation procedures. They will serve as a basis for regulation when other information may not be available. The emergency flood control regulation curves should only be used once the inflow has peaked, unless the Standing Instructions to Dam Tender are in effect. The curves present the minimum releases that should be made to assure effective use of the total flood control storage. By setting the releases at the minimum level outlined in Plate 7-2, there is a reasonable assurance that (1) the entire flood control zone will be filled, (2) the maximum flood release will be reduced, and (3) the magnitude of changes in release rates will be lessened. Average daily inflows should be computed on a daily basis, based on change of volume and release. If the average daily inflows exceed 50,000 cfs, inflows will be computed at 6-hour intervals.

The curves are based on a flood hydrograph with a 15-day recession, which is representative of a mountain snowmelt runoff hydrograph. If the actual event's recession from the peak inflow to selected release takes less than 15 days, all the available flood control storage will not be utilized. If the actual event's recession from the peak inflow to the selected release is greater than 15 days, all the available flood control storage will be prematurely occupied and releases will need to be increased.

Since the schedule is based on a recession volume, it should not be used prior to the inflow recession and relied upon to provide effective flood control. For example, the normal snowmelt inflow hydrograph into Canyon Ferry has a high broad type crest, resulting in most of the inflow volume occurring before the final recession begins. If the curves are utilized throughout the entire normal flood period, this results in the pool being filled to such a degree that by the time recession flows begin, damaging releases may be necessary to keep from overtopping the dam. As stated above it is intended for use primarily during large floods with high pool levels and should not be used during normal annual joint use regulation in that it provides for fill to the top of the dam. Flood protection is best offered by maintaining assured refill joint use storage requirements prior to and during the runoff season and/or prior to recession flows. After recession flows definitely begin, aids given in section 7-05.f may then be used in that they provide fill to the top of the joint use zone.

h. **Further Considerations.** Water released from the flood control zone should not be released at a rate greater than the peak flood inflow from which it occurred unless dam safety concerns are present. In an effort to maintain downstream channel capacity for flood control (discourage human encroachment in the area of the channel) releases of 15,000 cfs should be made as often as safely practicable.

7-06 RECREATION. The Corps does not have specific responsibilities related to recreation at Canyon Ferry. A reservoir level at or above 3785 feet allows for full use of most of the marina facilities and boat ramps. When conditions allow, Reclamation will attempt to maintain Canyon Ferry Reservoir at or above this level during the prime recreation season of Memorial Day through Labor Day.

7-07 WATER QUALITY. The Corps does not have specific responsibilities related to water quality at Canyon Ferry. Reclamation will continue its water quality monitoring program for the reservoir. Emphasis will be given to monitoring drinking water supplies at developed recreation areas and other specific sites, as appropriate.

7-08 FISH AND WILDLIFE. The Corps does not have any specific responsibilities related to fish and wildlife at Canyon Ferry. Contract 14-06-600-476A with NWE entitled, "Principles to be Followed in the Operation of, and in the Determination of the Energy Content Curve for, Canyon Ferry Reservoir", includes a section outlining the reservoir's needs for the downstream Missouri River Fishery. Three Missouri River "flow levels" below Holter Dam have been identified:

- 1) 4,100 cfs flow level. A minimum Missouri River flow level of 4,100 cfs below Holter Dam will provide good spawning, rearing, and cover conditions in the Missouri River and all major side channels. This flow is desired year round; however, if there is not an adequate water supply available, as determined by Reclamation, then the Canyon Ferry releases should be reduced to the next available flow level.
- 2) 3,000 cfs flow level. A minimum flow of 3,000 cfs in the Missouri River below Holter Dam protects the main channel habitat but not important side channels.
- 3) 2,800 cfs flow level. A minimum flow of 2,800 cfs protects the main channel but results in minimal wetting of the side channels and may result in a decline in fish population.

October through March is the important spawning season for brown trout in the Missouri River. April through June is the important spawning season for rainbow trout. During these periods, it is desirable to maintain constant or increasing river levels. Significant changes in releases to the stream below the dam should be made in incremental changes, when possible, to minimize disturbance of the stream aquatic life.

7-09 WATER SUPPLY. The Corps does not have any specific responsibilities related to water supply at Canyon Ferry, but as stated in the Field Working Agreement, this document "will not prohibit the Regional Director from meeting irrigation, power

generation and other downstream conservation requirements.” The Helena Valley Unit includes a pumping plant. The plant is located about 500 feet downstream from Canyon Ferry Dam and provides a supplemental municipal water supply for the City of Helena. Additional information is provided in Section 2-04.

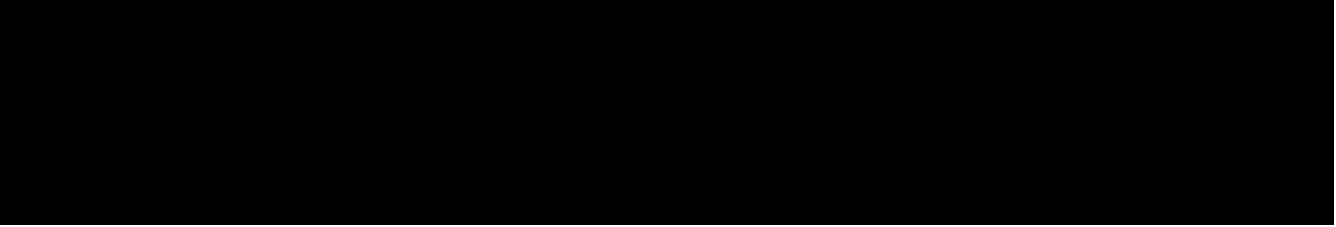
a. **Water Rights.** The Montana state water rights laws are known as the Doctrine of Prior Appropriation. The main points of consideration under these statutes are: (1) the use of water may be acquired by both riparian and non-riparian landowners; (2) diversion of water is allowed regardless of the reduction of the water supply in the stream; (3) the value of the right is determined by the priority of the appropriation, first in time is first in right; (4) the right is limited by the state to the use of water for beneficial purposes; and (5) a right to the use of water is considered real property only in the sense that it may be bought or sold and that its owner may not be deprived of it except by due process of law. The state legislature has provided procedures for the acquisition, determination of priority, and administration of the water rights.

The major water rights claimed for Canyon Ferry Reservoir are either storage type rights or direct diversion rights. Some of the uses provided by the storage water include irrigation, municipal and industrial (M&I), recreation, fish and wildlife, and power generation. The storage right claims made by Reclamation have a priority of 23 March 1953, for storage of 1,952,059 af, the initial capacity of the reservoir at the top of the joint use zone at elevation 3797 feet. As part of the contract for acquisition of MPC’s old Canyon Ferry Dam site, MPC retained ownership of and a water right for 47,500 af of storage in Canyon Ferry Reservoir. This was the capacity of the reservoir (Lake Sewell) behind the old Canyon Ferry Dam. This right has a claimed priority date of 31 October 1898 and is now owned by NWE.

The direct diversion right claims include: 380 cfs for the Helena Valley pumps with a priority date of 17 March 1959; 420 cfs for the pump turbines with a priority date of 17 March 1959; 1,290 cfs for the power turbines with a priority date of 23 March 1953; and 5,100 cfs for the power turbines with a priority date of 31 October 1898. The 1898 water right claim is based on a water right filed by MPC for their old Canyon Ferry site, obtained by Reclamation as part of the Canyon Ferry site acquisition.

b. **Irrigation.** Irrigation development in the area above Fort Peck Dam consists of numerous community or privately owned projects developed by Reclamation, the Montana Department of Natural Resources and Conservation, or the Bureau of Indian Affairs. Prior to Canyon Ferry Dam being built, irrigation upstream from the dam had been restricted by vested water rights on the Missouri River. One benefit of constructing Canyon Ferry Reservoir was that new irrigation development could take place without interfering with existing downstream water rights. Canyon Ferry created the option to replace the natural flow diverted by the new developments with water purchased from storage in Canyon Ferry Reservoir. See Section 2-04 for additional information regarding the Crow Creek Pump Unit and East Bench Unit.

7-10 HYDROELECTRIC POWER. The Corps does not have any specific responsibilities related to hydroelectric power generation at Canyon Ferry. Descriptions of the other existing hydroelectric generating facilities above Fort Peck Reservoir are contained in Chapter III and are shown in Table 3-2.



Hydroelectric generation is dependent upon turbine discharge and head. At Canyon Ferry Reservoir sufficient head is available above elevation 3781 feet to operate Canyon Ferry Power Plant at its full capability of 50 Megawatts (MW). However, at elevations below 3781 feet, capability is restricted to less than 50 MW, and if significant amounts of reactive power are required, loss of capability can start at 3783 feet. For this reason, it is generally desirable to maintain reservoir storage above 3783 feet whenever there is a sufficient water supply and additional evacuation is not needed in the spring for flood control or to maximize the use of the available water supply for power generation. The minimum operating head for the power plant is 3728 feet.

7-11 NAVIGATION. Canyon Ferry is not regulated for navigation.

7-12 DROUGHT CONTINGENCY PLAN. Drought contingency planning, under the Corps' regulations, is not within the Corps' area of responsibility at Canyon Ferry. Regulation to assist in drought contingency planning would be conducted by Reclamation.

7-13 FLOOD EMERGENCY ACTION PLAN. The Corps will normally issue coordinated release instructions through the Facility Operations and Maintenance Group of the MTAO. However, in an emergency, when communication cannot be established, the Corps may issue instructions directly to the Canyon Ferry Dam Tender. If conditions dictate that the Corps is responsible for the regulation of Canyon Ferry Dam, the Dam Tender shall act upon the order from the Corps. If all normal means of communication fail, the Canyon Ferry Dam Operating Personnel shall regulate releases for flood control as explained by the Emergency Release Schedule in the Standing Instructions to Dam Tender in Exhibit III. The Dam Tender shall continue every possible effort to reestablish communication with the MTAO and the Corps. This may require the use of any available federal, state, or private means of communication.

7-14 OTHER. During runoff periods flows in the Missouri River and the water elevation in Canyon Ferry Reservoir enable mosquito habitats to develop. At reservoir elevations greater than 3796 feet, water begins to back up into vegetation in the south end of the reservoir. This results in the formation of ephemeral pools and the subsequent production of an abundant mosquito population. Very few mosquitoes are produced in

the Canyon Ferry Wildlife Management Area (CFWMA) and adjacent areas during years when the reservoir does not reach 3796 feet. The Montana Fish, Wildlife, and Parks (MFWP) manage the CFWMA and are responsible for mosquito control in this area. The MFWP have a mosquito management plan which includes the use of larvicide treatments.

7-15 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. Occasional non-flood emergencies can occur where deviation from the normal operating procedures would assist other interests in managing the emergency. Examples of these types of emergencies include dam safety emergencies, downstream chemical spills, drowning, and facility failures. The Emergency Action Plan for Canyon Ferry Dam covers identification of impending and existing emergencies, emergency operations, and repairs and a response level determination matrix. This plan is contained in Canyon Ferry Dam and Reservoir Emergency Action Plan, US Department of the Interior, US Bureau of Reclamation, Great Plains Region, MTAO, Billings, MT. Copies of this plan are maintained at Reclamation offices and in the Corps WCWQS. If the water control actions taken during an emergency are not covered in the WCM, the Omaha District must inform MRBWMD as soon as practicable. Written confirmation of the deviation and a description of the cause must be furnished to MRBWMD.
- b. **Unplanned Minor Deviations.** In some instances, activities of other interests create the potential need for unplanned deviations from normal operations. These activities usually require deviations that are very temporary, usually from a few hours to a few days. A typical example of activities that would create the potential for unplanned minor deviations would be modifications of bridge and utility crossings or maintenance and inspection of reservoir project facilities. Each request should be analyzed on its own merits to determine if it is covered by the WCM. If the proposed action is not covered by the WCM, a deviation will be required. An evaluation of the proposed action should be included in the deviation request, including consideration of upstream watershed conditions, potential flood threats, the amount of water in storage at Canyon Ferry Reservoir, and whether any alternative measures could be taken that would not require a deviation. Each deviation request will be evaluated to ensure that any potential adverse impacts to authorized project purposes are identified and considered prior to implementation. Approval for these minor deviations normally will be obtained from MRBMWD by email. Post-deviation written documentation to MRBWMD should contain an explanation of the deviation and its cause. In turn, a written response to the deviation request will be provided by MRBWMD.
- c. **Planned Deviations.** In accordance with NWDR 1110-2-6, the Chief of MRBWMD is the responsible approving official for all deviation requests for Canyon

Ferry Dam and Reservoir. All deviation requests involving controversial regional or nationally significant actions shall be coordinated with the Chief of MRBWMD prior to approval. The Chief of MRBWMD retains authority to approve or disapprove all deviation requests. Prior approval is required for deviations from this WCM 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 Chief of MRBWMD as appropriate. MRBWMD 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.

d. **Unscheduled Power Plant Outages.** On 18 December, 1995, a meeting involving Reclamation, MPC (now NWE), and the Montana Fish, Wildlife and Parks was held to discuss unscheduled power plant outages and river flow restoration to the Missouri River below Canyon Ferry Dam. As a result of that meeting, it was mutually agreed that if releases from Canyon Ferry Dam to the Missouri River cannot be restored within one hour of an unscheduled power plant outage, then Reclamation will begin releasing 2,000 cfs through the river outlet works. If it appears the power plant outage will be offline for a longer period of time, Reclamation will restore the full scheduled releases to the river, utilizing established criteria for operation of the river outlet works and the spillway gates. A copy of agreement is contained in Exhibit VI.

7-16 RATE OF RELEASE CHANGE. Release rates will not be changed more than 1,000 cfs in 6 hours when the downstream channel is ice covered. During open water conditions, changes are limited to 5,000 cfs in 6 hours.

VIII - EFFECT OF WATER CONTROL PLAN

8-01 GENERAL. The following regulation objectives can be met at Canyon Ferry Dam and Reservoir by following the Water Control Plan: a) provide desired river and reservoir regulation to maximize the power generation benefit at Canyon Ferry and the six downstream NWE power plants; b) provide water for irrigation, municipal, and industrial use; c) provide desired river flow conditions to meet the needs of the downstream river fishery; d) provide desired conditions for fish, wildlife, and recreational use in the reservoir; and e) regulate river flow to mitigate downstream flood risk.

8-02 FLOOD CONTROL.

a. **Original Spillway Design Flood.** The original spillway design flood (SDF) was derived by Reclamation. The SDF was based on a design storm that was assumed to occur on a partially snow-covered area. The SDF design storm is an envelopment of the separate effects of two major historical rainstorms: 6-8 June 1906 at Warrick Montana, and 3-6 June 1908 at Evans, Montana. These storms were adjusted for maximum potential moisture charge and transposed to center the storms over the northern 5,200 square miles of drainage area above Canyon Ferry Dam. The SDF has a peak inflow of 150,000 cfs and a 15-day volume of 2,100,000 af. It was based on routing combinations of snowmelt runoff from 4.0 inches of SWE over 7,000 square miles between elevations of 6,000 feet and 8,000 feet, and an average rainfall of 2.89 inches over the entire 15,860-square mile drainage area above Canyon Ferry Dam. Because of the small amount of exclusive flood control storage and no surcharge storage being available, Canyon Ferry Reservoir will have little effect on this flood and reservoir releases will be essentially the same as inflows. Routing of this flood through the reservoir resulted in a maximum pool elevation of 3800 feet and a maximum spillway discharge of 150,000 cfs. This routing is shown on Plate 8-1. For more information regarding the SDF and reservoir design flood contact Reclamation's MTAO.

b. **Updated Spillway Design Flood.** The SDF was reviewed and updated by Reclamation in a 1985 study. The study was completed using meteorological procedures contained in Hydrometeorological Report 55 (HMR55), and updated stream gage records through 1983. This study produced a probable maximum flood (PMF) hydrograph representing a probable maximum storm (PMS) combined with a 100-year snowmelt flood originating in the higher elevations of the basin. The major thrust of the PMS was positioned over the lowest subbasin to optimize the peak runoff value. This flood has a peak of 506,000 cfs and a 15-day volume of 2,035,000 af. Plate 8-2 illustrates this flood.

Two flood routing schemes were performed, based on different spillway operating procedures, to determine which operating scheme would result in the most critical condition. The PMF routings were based on the following criteria:

Case 1: The spillway gates remained closed until elevation 3797 feet is exceeded, at which point the spillway gates are opened to maintain outflow equal to inflow until the gates are fully opened.

Case 2: The outflow was adjusted at 6-hour intervals on the basis of the average inflow for the previous 24 hours and the current pool elevation until the reservoir elevation reached 3800 feet. At that point the radial gates were raised to their full open position allowing free flow conditions through the spillway.

The starting elevation for the PMF routing was chosen to be 3797 feet, the top of joint use zone. Because of the small exclusive flood control storage and no available surcharge storage, Canyon Ferry Reservoir will have little effect on this flood and releases will be essentially the same as inflows. Canyon Ferry Dam would be overtopped during the PMF. The overtopping should not adversely affect the safety of the dam due to its adequate structural stability. However, passage of the PMF would cause the failure or loss of the spillway bridge, radial gates, power plant, stilling basin retaining walls, and the stilling basin. These losses would result in very high release and the inability to regulate releases from the reservoir. Table 8-1 shows additional flood routings using percentages of the PMF.

Table 8-1
Summary of PMF Routing

Flood	Max Pool Elev. (feet)	Power Plant Discharge (cfs)	Spillway Discharge (cfs)	Flow over the Dam (cfs)	Total Discharge (cfs)	Max Depth Overtopping (feet)**	Duration of Overtopping (hr)
Case 1: PMF	3811.17	4400	241,795	686	246,881	0.48	0.5
99% PMF	3810.69**	4400	237,532		241,932		
90% PMF	3808.5*	4400	218,735		223,135		
Case 2: PMF	3811.66	4400	255,023	5667	265,090	0.97	4.0
94% PMF	3810.69**	4400	237,568		241,968		
85% PMF	3808.5*	4400	218,725		223,125		

* The dam crest is at elevation 3808.5 feet NGVD29

** Top of the parapet wall is at elevation 3810.69 feet. A gap exists between the right abutment and the end of the parapet wall. The width of the gap varies from approximately 28 inches at elevation 3809.23 feet to approximately 19 feet at elevation 3812.5 feet.

c. **Reservoir Design Flood (RDF).** The design flood for flood control was verified and developed from the maximum amount of storage Reclamation would allocate for flood control, 900,000 af, provided it be used on a seasonal basis. To qualify this amount as satisfactory for flood control, a determination was made of the frequency

of the event this storage would protect. Examination of runoff patterns indicated that the maximum monthly inflow volume would provide an index to the flood event. A frequency curve of maximum monthly natural volumes was determined. From the allowable storage (900,000 af) and discharge of 15,000 cfs (850,000 af) a monthly inflow volume of 1,750,000 af could be provided for. The frequency curve indicated this event could be expected to occur about once in 300 years. This recurrence interval appeared satisfactory for the purpose of providing flood protection. The design flood which corresponds to the 300-year volume and crest is shown on Plate 8-3, together with the design pool routing of the flood using a release of 15,000 cfs. This flood has a 60-day volume of 2,620,000 af and a peak flow of 46,000 cfs. This plate is included only to illustrate the design concept. Flood control is achieved as described in Section 7-05. For comparison purposes, shown in Table 8-2 are high flow volumes and corresponding peak inflows for selected floods. Routing of the design flood using the regulation schedule on Plate 7-2 is referred to in Section 7-05 and shown on Plate 8-4.

Table 8-2
High Flow Volumes and Peak Inflows for Selected Floods

Flood	Station	Days	Volume (1,000 af)	Peak Inflow (cfs)	Peak Release (cfs)	Max Pool Elevation (feet)
Original SDF	Canyon Ferry	15	2,100	150,000		3800.0
1985 SDF	Canyon Ferry	15	2,035	506,000		3811.2
RDF	Canyon Ferry	60	2,620	46,000		3798.2
2011	Canyon Ferry	60	2,640	32,500	23,700	3799.7
1998	Canyon Ferry	60	1,626	23,300	20,200	3799.4
1997	Canyon Ferry	60	2,677	35,300	25,400	3798.5
1984	Canyon Ferry	60	2,147	26,100	21,100	3799.1
1981	Canyon Ferry	60	1,954	29,100	25,700	3799.7
1975	Canyon Ferry	60	2,155	25,900	22,000	3799.9
1974	Canyon Ferry	60	1,598	27,600	17,000	3798.7
1967	Canyon Ferry	60	1,930	24,500	17,100	3798.3
1948	Toston	60	2,120	32,000		-
1943	Toston	60	1,770	26,000		-
1927	Hauser Dam	60	2,030	33,300		-
1908	Cascade	60	3,060	54,200		-

d. **Operational History.** Table 8-3 presents Canyon Ferry annual peak information – elevation, storage, usage of flood control storage, inflow, and release. Plates 8-5 to 8-5f present 10-year periods of daily reservoir pool elevations, average monthly inflows and releases and annual maximum daily reservoir inflows and releases. Plate 8-6 presents the period of record reservoir pool elevations and releases. Plates 8-7 through 8-14 show historic flood regulations and are described in more detail in Section 4-6.

Table 8-3
Annual Statistics¹ for Canyon Ferry Reservoir² by Water Year

Year	Dates in Flood Control Operation Pool	Daily Max. Pool (feet)	Date of Max. Pool	Max. Storage Utilized (FC Pool, af)	Max. Percent of FC Pool Occupied³	Max. Daily Inflow (cfs)	Max. Daily Release (cfs)	Water Year Inflow Volume (af)
1953	None	3755.3	30Sep	0	0	25,200	8,200	2,205,300
1954	None	3780.3	07Sep	0	0	15,400	7,300	3,007,500
1955	04Jul-01Sep	3800.0	15Jul	101,160	100%	14,500	6,600	2,956,900
1956	05Jun-06Aug	3800.0	02Jul	101,160	100%	27,100	24,000	3,814,700
1957	05Jun-31Jul	3799.2	13Jun	75,196	74%	18,300	17,100	3,519,300
1958	14Jun-30Jul	3798.9	29Jun	64,068	63%	14,800	8,400	3,455,700
1959	07Jun-01Sep,19Sep-30Sep	3799.9	17Jul	99,137	98%	19,100	18,200	3,374,900
1960	01Oct-30Nov, 05Apr-16Jul	3799.9	26Oct	40,127	40%	13,300	15,800	3,897,200
1961	None	3788.4	01Oct	0	0	9,500	6,000	2,197,500
1962	25Jun-26Sep	3800.0	16Jul	101,160	100%	15,600	13,200	3,686,500
1963	21Oct-05Aug	3799.7	06Jan	91,044	90%	17,500	15,100	3,785,000
1964	10Jun-27Sep	3800.0	23Jun	101,160	100%	24,400	24,400	4,200,000
1965	12Oct-11Dec, 24Jun-30Sep	3799.9	26Jul	98,708	98%	23,100	18,000	4,986,100
1966	01Oct-07Oct	3798.6	01Oct	8,289	8%	8,200	10,000	2,948,600
1967	24Jun-25Jul	3798.3	29Jun	41,793	41%	24,500	17,100	4,204,300
1968	05Jul-10Jul	3797.1	08Jul	1,711	2%	21,700	11,000	4,336,100
1969	11Jun-14Jul	3797.6	30Jun	18,607	18%	19,000	15,000	4,820,700
1970	02Jul-16Jul	3797.1	03Jul	1,711	2%	26,900	15,000	4,742,200
1971	30Jun-07Jul	3797.5	02Jul	13,090	13%	22,400	15,000	5,021,600
1972	23Jun-30Jun	3797.3	27Jun	8,608	9%	23,800	12,000	4,507,500
1973	None	3796.6	04Jul	0	0	11,800	6,300	3,356,600
1974	20Jun-10Jul	3798.7	25Jun	53,960	53%	27,600	17,000	4,348,900
1975	24Jun-18Aug	3799.9	09Jul	98,708	98%	25,900	22,000	5,175,800
1976	23Oct-13Nov, 22Jun-26Jul	3798.2	26Jun	39,012	39%	24,000	15,000	5,652,700
1977	23Nov-04Dec	3797.1	27Nov	3,336	3%	10,300	6,000	2,948,000
1978	28Jun-26Jul	3797.9	09Jul	28,951	29%	16,400	9,900	4,280,800
1979	None	3796.2	05Jul	0	0	17,400	6,700	3,479,700
1980	29May-18Jul	3799.2	25Jun	72,432	72%	19,700	17,000	3,899,500
1981	27May-18Jul	3799.7	04Jun	89,248	88%	29,100	25,700	4,360,000
1982	27Jun-03Aug	3798.8	02Jul	59,521	59%	25,700	20,000	4,970,000
1983	20Jun-01Aug	3798.3	14Jul	41,098	41%	18,600	13,100	4,650,000
1984	20Jun-03Aug	3799.1	01Jul	71,031	70%	26,100	21,100	5,758,700
1985	None	3791.7	14Jun	0	0	12,000	8,800	3,416,900
1986	21Jun-26Jun	3797.3	25Jun	10,547	10%	23,000	13,100	3,883,200
1987	None	3792.9	30Oct	0	0	7,600	6,000	2,695,800
1988	None	3791.9	17Jun	0	0	9,900	5,100	2,394,600
1989	None	3785.9	30Jun	0	0	11,000	4,900	2,619,000
1990	None	3794.4	08Jul	0	0	11,700	5,300	2,744,700
1991	20Jun-13Jul	3798.0	02Jul	35,892	36%	22,900	15,000	3,009,800
1992	None	3786.8	10Dec	0	0	8,300	4,600	2,419,400
1993	10Jun-04Aug	3797.9	18Jun	32,593	32%	17,100	15,000	4,180,900
1994	None	3794.7	01Oct	0	0	9,400	6,500	2,729,200
1995	01Jul-29Jul	3798.8	11Jul	62,695	62%	26,700	15,200	4,531,100
1996	16Jun-21Jun, 30Jun-18Jul	3797.9	09Jul	30,248	30%	28,800	21,100	4,919,800
1997	14Jun-27Jul	3798.5	20Jun	51,409	51%	35,300	25,400	5,775,900
1998	19Jun-20Jul	3799.4	30Jun	81,004	80%	23,300	20,200	4,830,500
1999	None	3796.8	10Jul	0	0	20,500	11,300	4,150,000
2000	None	3790.1	28Jun	0	0	10,200	5,500	2,726,500
2001	None	3789.5	26Jun	0	0	7,200	4,600	2,264,400
2002	None	3796.5	08Jul	0	0	16,400	6,100	2,403,300
2003	13Jun-01Jul	3797.7	25Jun	22,056	22%	20,400	10,000	2,655,300

Table 8-3
Annual Statistics¹ for Canyon Ferry Reservoir² by Water Year

Year	Dates in Flood Control Operation Pool	Daily Max. Pool (feet)	Date of Max. Pool	Max. Storage Utilized (FC Pool, af)	Max. Percent of FC Pool Occupied ³	Max. Daily Inflow (cfs)	Max. Daily Release (cfs)	Water Year Inflow Volume (af)
2004	None	3786.3	01Oct	0	0	9,400	3,900	2,128,500
2005	23Jun-16Jul	3798.5	02Jul	50,618	50%	12,700	6,700	2,696,700
2006	None	3796.4	28Jun	0	0	16,800	6,400	3,131,100
2007	None	3796.8	21Jun	0	0	10,000	5,500	2,572,200
2008	28Jun-02Aug	3798.3	06Jul	44,896	44%	19,200	15,100	3,621,300
2009	21Jun-26Jul	3798.9	27Jun	63,775	63%	19,000	11,400	3,631,100
2010	13Jun-20Jul	3799.2	28Jun	75,280	74%	24,000	18,600	3,871,000
2011	22Jun-14Aug	3799.7	03Jul	90,204	89%	32,500	23,700	5,325,300
2012	13Jun-29Jun	3797.4	19Jun	14,358	14%	14,000	9,100	3,406,000
2013	None	3790.3	06Jul	0	0	8,800	4,800	2,455,800
2014	29Jun-16Jul	3797.7	05Jul	22,056	22%	21,100	10,800	3,611,700

¹ Elevation, Storage, Inflow, and Outflow data were obtained from the Reclamation HydroMet: Archive Data Access website.

² The base of exclusive flood control occurs at elevation 3797.0 feet, established in 1966.

³ The 'Max % of FC Pool Occupied' and 'Max Storage Utilized (FC Pool)' are estimated based on current area-capacity curves and existing historical data. This can result in small errors if area-capacity curves were changed due to updated reservoir surveys. These numbers are provided as a tool for trends and comparisons, and not for detailed analysis.

8-03 RECREATION. The Corps does not have any specific responsibilities related to recreation at Canyon Ferry. A reservoir level at or above 3782 feet allows for full use of all of the marina facilities and boat ramps. When conditions allow, the level of Canyon Ferry Reservoir should be maintained at or above this level during the prime recreation season of Memorial Day through Labor Day.

8-04 WATER QUALITY. The Corps does not have specific responsibilities related to water quality at Canyon Ferry. Reclamation will continue its water quality monitoring program for the reservoir.

8-05 FISH AND WILDLIFE. The Corps does not have any specific responsibilities related to fish and wildlife at Canyon Ferry. Minimum stream flows for the Missouri River Fishery were outlined in Section 7-08. The Canyon Ferry discharges may be modified from the desired fishery levels if it is determined to be necessary for flood control purposes.

Since initial filling of Canyon Ferry Reservoir in 1955, windblown, fine-grained material from exposed flats at the upper end of the reservoir have been a major contributor to air pollution in the area near the reservoir. The flats were exposed when the reservoir was drawn down to provide storage space for spring inflows or when water levels were low because of low precipitation and runoff. These conditions caused a deterioration of the living environment for farmers and stockmen in the general area and especially for the town of Townsend. These conditions also have an adverse effect on crops and livestock.

In June 1968, the Governor of Montana suggested that the best long range solution would be attained through a cooperative program between Reclamation and the Montana Fish and Game Department. A dike system at the upper end of the reservoir

that would include waterfowl development features had been planned by the Fish and Game Department, but was beyond the financial capabilities of that agency. Therefore, federal assistance was requested.

The Conservation and Wildlife Enhancement Program at Canyon Ferry Reservoir was initiated in 1972 to alleviate a serious dust problem at the upper end of the reservoir near Townsend, Montana. A series of dust abatement dikes were constructed from 1972 to 1978. The dikes created 1,900 acres of marshland and a valuable waterfowl habitat forming the Canyon Ferry Wildlife Management Area (CFWMA). The waterfowl facilities provide habitat for nesting and breeding, supplemental resting and feeding sites for migratory birds, and public hunting and observation of waterfowl and upland game birds.

8-06 WATER SUPPLY. The Corps does not have any specific responsibilities related to water supply at Canyon Ferry, but as stated in the Field Working Agreement, this document “will not prohibit the Regional Director from meeting irrigation, power generation and other downstream conservation requirements.”

a. **Water Rights.** There are a number of large water rights below the dam that are senior to the water rights claimed for Canyon Ferry Reservoir. Normal operation of the reservoir results in Reclamation releasing enough water to satisfy these senior water rights. If adequate water is not being provided for the senior rights, additional releases may be requested based on reservoir inflow conditions. NWE owns six hydropower dams downstream and one hydropower dam upstream of Canyon Ferry Reservoir with water rights senior to Canyon Ferry Reservoir. The prior rights with MPC are satisfied through compliance with the terms in the Coordination Agreement between NWE and Reclamation found in Exhibit VI.

b. **Irrigation.** Through storage and regulation of river flows by Canyon Ferry, additional irrigation of 155,600 acres of new land and 82,000 acres requiring supplemental water was made possible in the area above Fort Benton. Most of the new irrigation developments made possible through construction of the Canyon Ferry Unit are provided water under physically separate units. The East Bench Unit near Dillon, Montana and the Crow Creek Unit just upstream of Canyon Ferry Reservoir receive water from Canyon Ferry by exchange. The Helena Valley Unit irrigates approximately 17,000 acres and provides water for municipal use. Except for Helena Valley, the irrigation benefit of the Canyon Ferry Unit arises from its basic function of providing replacement storage for increased irrigation diversions in the upper Missouri River Basin that would otherwise interfere with established downstream water rights.

The Crow Creek Unit irrigates 6,250 acres and the East Bench Unit fully irrigates 28,055 acres while 33,706 acres receive a supplemental water supply. The 1998 development of the Helena Valley Unit is about 13,867 full-service acres, including 5,200 acres previously irrigated by pumping from Lake Helena or from other streams. A small amount of water is also furnished to the City of Helena, Montana

through facilities of the Helena Valley Unit.

8-07 HYDROELECTRIC POWER. The Corps does not have any specific responsibilities related to hydroelectric power generation at Canyon Ferry. Canyon Ferry Reservoir must stay within the elevation limits outlined in Section 7-10 in order to maintain capability at the Canyon Ferry Power Plant.

8-08 NAVIGATION. Canyon Ferry is not regulated for navigation.

8-09 DROUGHT CONTINGENCY PLAN. Reclamation is responsible for the coordination of the drought contingency plan.

8-10 FLOOD EMERGENCY ACTION PLAN. Follow the procedures referenced in Section 7-13.

8-11 FREQUENCIES.

a. **Peak Inflow Probability.** Peak discharge frequency curves for Missouri River at Toston, Montana, Dearborn River near Craig, Montana, Smith River near Eden, Montana, and Sun River near Vaughn, Montana, are presented on Plates 8-15 through 8-18, respectively. Table 8-3 shows annual peak releases for Canyon Ferry Reservoir.

b. **Pool Elevation Duration and Frequency.** A pool elevation frequency curve is shown on Plate 8-19. Historic pool elevations and releases are shown in Plate 8-5 and Plate 8-6, respectively.

8-12 OTHER STUDIES.

a. **Regulation of Joint Use Zone.** Exhibit VIII gives a detailed example of the joint use storage evacuation calculations as occurs through the winter and into the runoff season.

b. **Regulation Using Regulation Schedule.** The regulation schedule on Plate 7-2 should be used during large floods. The curves indicate the minimum releases necessary to assure effective use of the flood control space as described in Section 7-05. An example using these curves is shown on Plate 8-3. The following assumptions were made:

- 1) Project Design Flood inflows were used, and
- 2) Initial releases of 15,000 cfs were made.

A peak pool level of 3798.2 feet resulted. The schedule did not call for releases greater than the initial releases. See Plate 8-3 for results.

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IX - WATER CONTROL MANAGEMENT

9-01 RESPONSIBILITIES AND ORGANIZATION.

a. **General.** The organization for regulation of Canyon Ferry 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 regulatory functions are the responsibility of Reclamation.

b. **Corps of Engineers.** ER 1110-2-1400, September 1993, 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 Canyon Ferry Reservoir, according to plans agreed on in advance, has been delegated to the Omaha District Engineer. The WCWQS of the Omaha District has been assigned this District responsibility. In those years when replacement storage in Canyon Ferry Reservoir is required to assist in flood control regulation of the Mainstem System, the NWD Engineer will provide written authority to the Omaha District regarding the replacement storage needs. In addition, the NWD Engineer, through NWD's MRBWMD, 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 exclusive flood control zone, between elevations 3797 and 3800 feet, the Corps is solely responsible for the regulation of the reservoir. When the reservoir level is in the joint use zone, between elevations 3770 and 3797 feet, releases for flood control will be the responsibility of the Corps and releases for all other purposes will be the responsibility of Reclamation. See the Release Responsibility Diagram on Plate 7-6 for further detail on joint use zone responsibility.

c. **Bureau of Reclamation.** Reclamation is the construction agency for Canyon Ferry Dam and Reservoir and is responsible for coordinating all matters pertaining to the operation and regulation of the project. Reclamation is solely responsible for regulation of the reservoir when the pool elevation is below 3770 feet or above 3800 feet. Between elevations 3770 feet and 3797 feet, the joint use storage zone, releases for flood control will be the responsibility of the Corps and releases for all other purposes will be the responsibility of Reclamation.

Reclamation's Reservoir and River Operations Branch, MTAO in Billings, Montana is responsible for water regulation at Canyon Ferry Dam and Reservoir for all purposes except flood control. Within limits for the use of water and storage set by the Reservoir and River Operations Branch, power generation is scheduled by the MTAO in Billings, Montana. Operation and maintenance of the project are under the

immediate supervision of the Canyon Ferry Facility Manager who resides at the project. The Facility Manager's duties for flood control operation are given in Exhibit III, Standing Instructions to Dam Tender. The Facility Manager will operate the outlet facilities and collect and report reservoir and hydrologic data. Exhibit III also lists Reclamation's Reservoir and River Operations Branch personnel. An organization chart for Reclamation is shown on Plate 9-2.

d. **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.

e. **US Geological Survey.** USGS reports data from several stations related to Canyon Ferry and is involved in a cooperative streamgaging agreement as described in Section 5-01.

f. **Montana Fish, Wildlife, and Parks.** Reclamation has an agreement with this agency for management of the dust abatement and dike system at the CFWMA, located at the south end of Canyon Ferry Reservoir. The overall objective of this agreement is to produce a habitat suitable for a diversity of wildlife species. Management of the Canyon Ferry Reservoir area for wildlife purposes was established under Contract No. 14-06-600-2233 dated 29 January 1956.

g. **Northwestern Energy.** NWE operates Hebgen and Ennis Reservoirs on the Madison River upstream of Canyon Ferry and Hauser, Holter, Black Eagle, Rainbow, Ryan, Cochrane, and Morony Dams and Reservoirs on the Missouri River, downstream from Canyon Ferry. Contract No. 14-06-600-476A, found in Exhibit VI, sets criteria for coordinating reservoir operations to achieve optimum power production from Reclamation and NWE systems, and for computing headwater benefits. Headwater benefit payments are made by NWE to Reclamation and reflect increased power generation by NWE due to Canyon Ferry operation. This agreement remains in effect unless terminated by either party.

9-02 INTERAGENCY COORDINATION. The organization for regulation of the Canyon Ferry 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.

9-03 INTERAGENCY AGREEMENTS. An energy coordination agreement between Reclamation and NWE can be found in Exhibit VI. The Field Working Agreement between Reclamation and the Corps is located in Exhibit II.

9-04 REPORTS. The WCWQS publishes an Annual Operating Report that describes operation and flood regulation for each project in the Omaha District. Reclamation's Reservoir and River Operations Branch of the MTAO also publishes an Annual Ops. Report each year that describes the operation and flood regulation for Canyon Ferry.

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. Note that all elevation references for Canyon Ferry Dam in this document are based upon the National Geodetic Vertical Datum of 1929 (NGVD29). See paragraph 1-03 of Water Control Manual for additional information on elevation datum for Canyon Ferry Dam. 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 16960	22170 19560 16960	19560 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

¹Cr—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

²F—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

³FCA—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

⁴Appl 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

CANYON FERRY DAM AND RESERVOIR

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

SUBJECT: Memorandum of Field Working Agreement for Canyon Ferry Dam and Reservoir

1. Flood control regulations governing the operation of Canyon Ferry Dam and Reservoir, Missouri River, Lewis and Clark County, MT, were completed and published in the Federal Register, at Page 53638, Volume 41, issue of May 18, 1976. 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. A copy of these regulations is enclosed hereto as Exhibit I. It is agreed that Canyon Ferry Dam and Reservoir will be regulated in the interest of flood control in accordance with the regulations set forth in Part 208 - Flood Control Regulations as published in the Federal Register; the Flood Control Storage Reservation Diagram, included as a part of this agreement; the Standing Instructions to the Dam Operator; and the following criteria and procedures. This updated field working agreement for the regulation of Canyon Ferry Dam and Reservoir supersedes the previously signed Field Working Agreement dated May 23, 1977. Note the elevation references in this document are based upon the National Geodetic Vertical Datum of 1929 (NGVD29). See paragraph 1-03 of the Water Control Manual for additional information on elevation datum.

a. Flood Control Regulation Objectives. Canyon Ferry releases will be adjusted as necessary to achieve the following objectives, insofar as practicable:

(1) Local Flood Control. Project releases will be restricted to the amount which, in conjunction with incremental inflows below the dam, will minimize damaging discharges on the Missouri River from the dam downstream to Fort Peck Reservoir. The damage stages and discharges at downstream control points in the Missouri River are estimated as follows:

Cascade	12.0 feet	20,000 cubic feet per second (cfs)
Ulm 6E	13.8 feet	25,000 cfs
Fort Benton	13.4 feet	77,000 cfs

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(2) Replacement Flood Control. In years when utilization of a major portion of the flood control and multiple-use storage space within the downstream Fort Peck Reservoir is anticipated, Canyon Ferry will assist in flood control along the Missouri River below Fort Peck by storing inflows to withhold or delay flood water from reaching Fort Peck Reservoir.

(3) Integrated Regulation of All Flood Control Reservoirs in Missouri River Basin. Releases from Canyon Ferry Reservoir eventually flow into Fort Peck Reservoir, the uppermost of the six Missouri River mainstem reservoirs. In the quotes below, The USACE Northwestern Division's Reservoir Control Center (RCC) has since been renamed the Missouri River Basin Water Management Division (MRBWMD). As per the Missouri River Mainstem Reservoir System Master Water Control Manual (Master Manual), March, 2006, paragraph 7-04.23, "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 RCC. During such periods, the RCC 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 Canyon Ferry Reservoir may be adjusted in order to meet basin-wide flood control goals of the Missouri River system. In the case of Canyon Ferry Reservoir, requests for modification will be made to the Montana Area Office Facility Operations and Maintenance Division, Bureau of Reclamation in Billings, MT, which is part of the Great Plains Region. Requests should be made via conference call or email, and confirmed via an official reservoir regulation order the same day.

b. Storage Capacity Allocation. To achieve the objectives specified in paragraph 1.a, storage space between elevations 3770.0 feet and 3800.0 feet (currently amounting to 895,378 acre-feet) is utilized for flood control purposes. Of this amount, the space between elevations 3797.0 feet and 3800.0 feet (currently amounting to 101,089 acre-feet) is for exclusive flood control. Joint use space for replacement flood control, local flood control and conservation purposes is between elevations 3783.0 feet and 3797.0 feet (currently amounting to 445,564 acre-feet). Joint use space for local flood control and conservation purposes is between elevations 3770.0 feet and 3783.0 feet (currently amounting to 348,725 acre-feet). The joint use space will be made available for flood control purposes during the January through July period on the basis of anticipated April through July inflows and conservation releases in accordance with the attached

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Flood Control Storage Reservation Diagram dated December 15, 2016.

c. Flood Control Regulation Criteria and Procedures. The Montana Area Office, Bureau of Reclamation, will regulate the reservoir in the interest of flood control in accordance with the following procedures:

(1) Regulation of the reservoir when the pool level is in the exclusive flood control zone or in that portion of the joint use zone when required for flood control shall be construed as flood control regulation and releases or flood control regulation criteria shall be determined by the District Commander, Omaha District, Corps of Engineers. At all other pool levels, the District Commander may make recommendations to the Montana Area Office for operating in the interest of flood risk mitigation, but such recommendations shall not be considered mandatory.

(2) On or about August 1 each year the Montana Area Office will begin evacuation of the joint use storage space. Between this time and January 10, releases up to power plant capacity will be scheduled to target evacuation of the replacement flood control storage portion of the joint use space by March 1, if subsequent forecasts and storage conditions on January 1 and February 1 warrant.

(3) Forecasts of inflow to the reservoir for the April through July period will be made as of January 1 and monthly thereafter during the January through July period and will be exchanged between the District Commander and Regional Director as soon after the first of each month as practicable. Estimates of Canyon Ferry release requirements for power generation and other conservation purposes will be developed monthly by the Bureau of Reclamation commencing on January 1 and extending from the current date through July 31. These will be furnished to the District Commander.

(4) The District Commander will notify the Montana Area Office prior to January 10 if continued evacuation of the replacement storage space is required. This is to be determined by the MRBWMD based on the anticipated storage conditions in the Missouri River Mainstem Reservoir System. On or prior to January 10 and February 10 the District Commander will notify the Montana Area Office of the actual amount of space required for replacement purposes. This is to be determined from forecasts of assured inflow (85-90% exceedance probability) and estimates of conservation release requirements for the April through July period. Upon receipt of such notice, the Montana Area Office will modify releases (including spills in excess of power requirements, if necessary) to provide the required space by March 1. Evacuation of storage for replacement purposes will be limited to elevation 3783.0 feet.

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(5) The District Commander will also utilize the assured inflow forecasts as the basis for advising the Montana Area Office on or prior to January 10 and monthly thereafter of the amount of joint use storage space required for local flood control purposes on May 1, June 1, or July 1 as appropriate. Upon receipt of such notice the Montana Area Office will schedule releases from the joint use storage zone (including spills in excess of power requirements, if necessary) to provide the required joint use space as indicated. Evacuation rates shall be selected so as not to result in damaging stages or to minimize damaging stages below the dam.

(6) Whenever the reservoir level rises to elevation 3797.0 feet or into the portion of the joint use storage zone reserved for flood control, or whenever damaging downstream discharges appear imminent, the Montana Area Office shall report as soon as practicable to the District Commander and as requested thereafter until the reservoir level falls below elevation 3797.0 feet, or falls below the joint use storage space reserved for flood control and damaging downstream discharges cease.

d. Special Provisions.

(1) The flood control regulation criteria and procedures given above are subject to temporary modification by the District Commander if found necessary in time of emergency.

(2) Nothing in this agreement shall prohibit the Montana Area Office from making the releases as are required to meet irrigation, power, or other project purpose requirements.

(3) Oral instructions issued by the District Commander to the Montana Area Office shall be confirmed in writing as soon as possible.

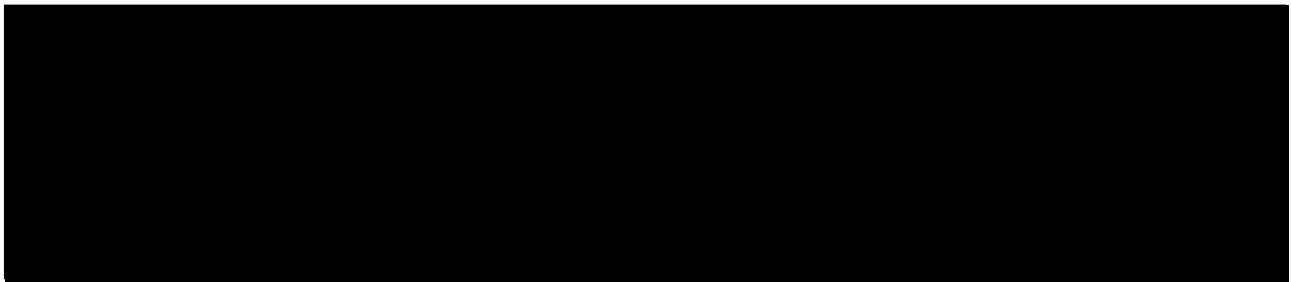
(4) Proposed schedules of conservation releases and storage changes, if available, and current operating data shall be provided to the District Commander by the Montana Area Office. Operating data shall be tabulated daily, furnished periodically as required, and shall include such items as: reservoir elevation, reservoir storage, inflow, discharge and other pertinent available hydrologic data.

(5) The discharge characteristics of the river outlet works and the spillway (having a combined capacity of 141,200 cfs with reservoir level at elevation 3797.0 feet shall be maintained in accordance with the as-constructed drawings Bureau of Reclamation Drawing No. 296-D-927 dated February 18, 1953, and No. 296-D-1058 dated July 1, 1953).

SUBJECT: Memorandum of Field Working Agreement for Canyon Ferry Dam and Reservoir

(6) Nothing in these regulations shall be construed to require that releases shall be made at rates or in a manner inconsistent with requirements for protecting the dam and reservoir from major damage, inconsistent with the safe routing of the spillway design flood, or to require dangerously rapid changes in releases.

2. The signed original Flood Control Storage Reservation Diagram is on file in the Office, Chief of Engineers, Washington, D.C. Copies of the Diagram currently in force shall also be kept on file in and may be obtained from the Office of the Commissioner of Reclamation, Washington D.C., the District Commander, Omaha District, Corps of Engineers, the Regional Director and the Montana Area Office, Great Plains Region, Bureau of Reclamation. Revisions of the above criteria, procedures, and the attached Flood Control Storage Reservation Diagram may be made from time to time as jointly considered necessary by the Corps of Engineers and the Bureau of Reclamation.

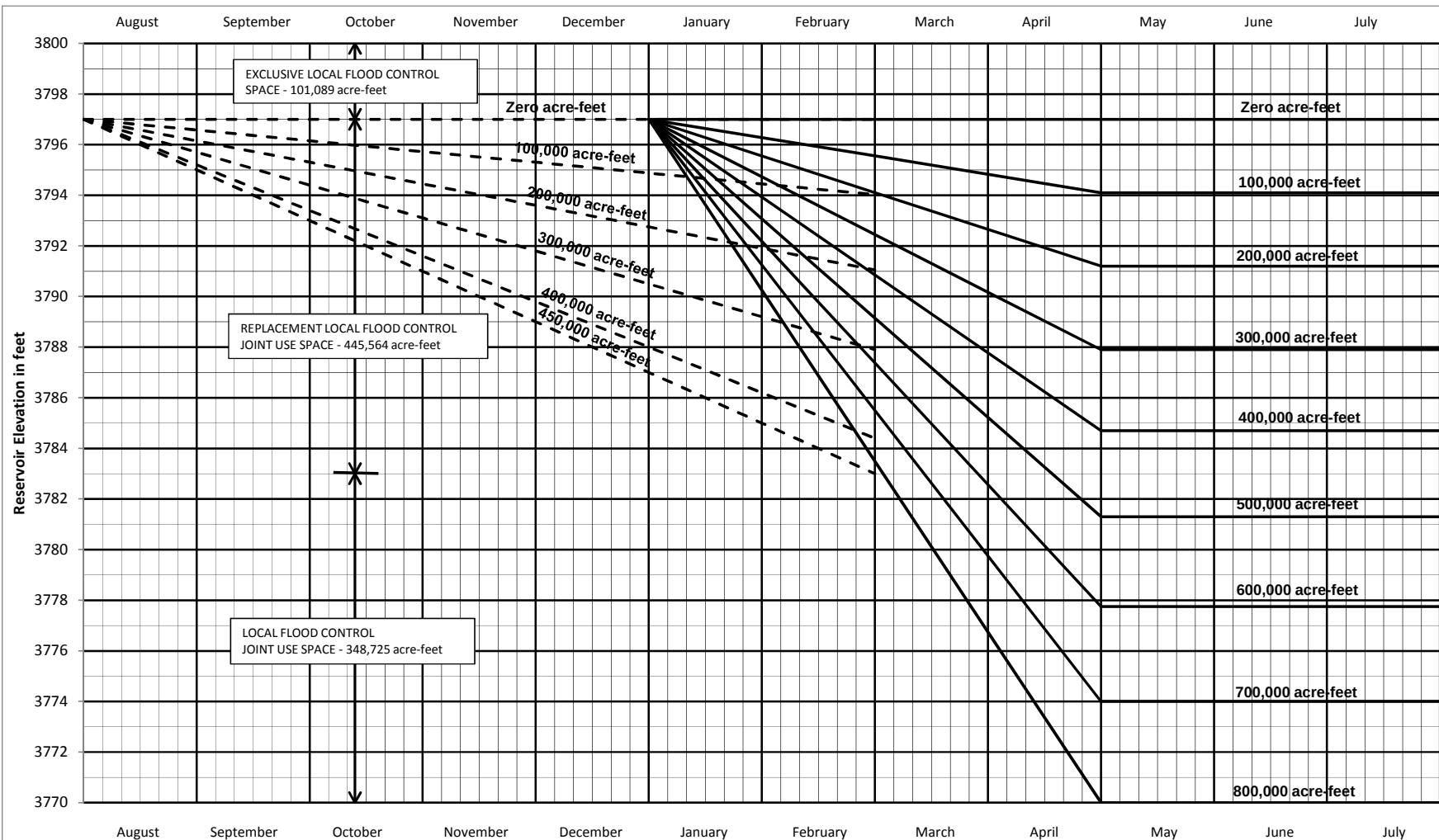


13 FEBRUARY 2017

(Date)

FEBRUARY 27, 2017

(Date)



Notes:

1. Dashed lines define the seasonal flood control space reservations when replacement flood control regulation is required while solid lines define the reservation if replacement flood control regulation is not required. Parameters are forecast assured remaining April-July inflows in excess of anticipated conservation releases.
2. The lowermost dashed line indicates the normal power operation and maximum drawdown for replacement flood control purposes. While releases in excess of conservation requirements will not be required during the August-December period to maintain the reservoir at or below elevations indicated by the dashed lines, recognition should be given to their appropriateness for orderly evacuation of replacement flood control storage space.
3. During the January-July period pool elevations above that defined by the appropriate parameter lines represents an encroachment into the flood control storage space. If this occurs, releases will be scheduled to evacuate flood control storage space as rapidly as practical while not contributing to downstream damages including stages and discharges in excess of 12.0 feet - 20,000 cfs. at Cascade, 13.8 feet - 25,000 cfs at Ulm 6E.

4. This diagram is replicated based on the diagram approved by USACE and Reclamation in 1977.

Water Control Manual
Canyon Ferry Reservoir and Dam, Montana

Flood Control Storage Reservation Diagram

15 December 2016

EXHIBIT III

**STANDING INSTRUCTIONS TO DAM TENDER FOR
FLOOD CONTROL OPERATIONS**

CANYON FERRY DAM AND RESERVOIR

EXHIBIT III

POST IN A CONSPICUOUS PLACE

STANDING INSTRUCTIONS TO DAM TENDER FOR FLOOD CONTROL OPERATIONS AT CANYON FERRY DAM AND RESERVOIR

1. Routine Reports. The Water Control & Water Quality Section of the Office of the District Engineer, U. S. Army Corps of Engineers (Corps), Omaha, Nebraska, is the unit of the Corps designated to prepare and issue regulation orders concerning the flood control operation of Canyon Ferry Dam and Reservoir. Regulation orders are prepared by the Corps and normally telephoned or emailed to Reclamation's Montana Area Office, Facility and Operations and Maintenance Division in Billings, Montana (MTAO). Normally hydrologic data is obtained from Reclamation's HydroMet database. Should this data be unavailable, the Dam Tender will furnish to the Corps through MTAO by 8 a.m. daily, reports of pertinent reservoir data (e.g., pool and tailwater elevations, storage, outflow, inflow, precipitation).

2. Elevation Datum. In this document, elevations for reservoir levels and project drawings are based on 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 NAVD88 datum are needed, at Canyon Ferry Dam to convert from NGVD29 datum to NAVD88, add 3.2 feet. See Paragraph 1-03 of Water Control Manual for additional details.

3. Special Reports. The Dam Tender will notify the Corps through the MTAO, immediately whenever the following conditions occur between 7:45 a.m. and 4:30 p.m., and will report by 8:00 a.m. the following day whenever they occur between 4:30 p.m. and 7:45 a.m., weekends and holidays included. In the event the MTAO cannot be reached, the Dam Tender will telephone the Special Reports to the Corps' Project Engineer at Fort Peck, Montana, for further transmittal to Corps' Water Control and Water Quality Section.

a. Rainfall at the dam exceeds 1 inch in 6 hours and/or the Dam Tender has knowledge of heavy runoff or flooding downstream.

b. The pool has risen 0.5 foot or more in 8 hours. Exception: A rise in pool which, in the opinion of the Dam Tender, reaches this limit only as a result of wind effects, need not be reported.

c. Anytime the pool rises above elevation 3797.0 feet and during the May-July period whenever the pool rises into the joint use zone evacuated for flood control. Note: The amount of joint use storage evacuated for flood control changes from year to year and month to month. The Dam Tender will periodically be advised by the MTAO of the amount of joint use space reserved for flood control.

d. The pool is above elevation 3770.0 feet and the average daily inflow is more than 5000 cfs greater than the previous report furnished.

4. Emergency Regulation. If there is a communications failure and the Dam Tender cannot transmit the Special Reports required in paragraph 3, the Dam Tender, while remaining at his post, will

continue every possible effort to re-establish communication with the Corps personnel or the MTAO (shown in Table A) including use of any available federal, commercial, or private means of communication or transportation media. In the meantime, the Dam Tender will regulate releases for flood control as shown in the attached Emergency Release Schedule.

5. Safety of Dam. The foregoing regulation procedures are not intended to restrict the Dam Tender from taking such additional measures as are necessary to ensure safety of the dam.

6. Reports of Emergency Regulation. The Dam Tender shall report all details of emergency regulation to the Corps and/or MTAO personnel as promptly as practical when communications are restored. Any use of the term conservation requirement in this exhibit refers the release as determined by Reclamation needed to meet the project's authorized purpose of conservation at that time (water supply, irrigation, hydropower, fish and wildlife, etc).

Note: Times referred to are for the Mountain Time Zone.

EMERGENCY RELEASE SCHEDULE FOR FLOOD CONTROL
CANYON FERRY RESERVOIR

A. FOR A RISING POOL.

1. When rainfall at the dam exceeds 1 inch in 6 hours or there is heavy runoff downstream.

Reservoir Elevation (feet)	Release Schedule
3770-3790	Immediately reduce release to conservation requirement. Hold for 3 days, then follow last Regulation Order.
3790-3800	Release greater of: conservation requirement, last Regulation Order, or as shown on Plate 7-2 when it indicates a release of 10,000 cfs or more should be made.

2. When rainfall at dam is less than 1 inch in 6 hours and there is no heavy runoff downstream.

3770-3785	Follow last Regulation Order.
3785-3800	Release greater of: conservation requirement, last Regulation Order, or as shown on Plate 7-2 when it indicates a release of 10,000 cfs or more should be made.

Note: Plate 7-2 is included in this exhibit.

B. FOR A STATIONARY OR FALLING POOL.

1. When rainfall at dam exceeds 1 inch in 6 hours or there is heavy runoff downstream.

3770-3800	Follow above schedule for rising pool based on the current pool elevation.

2. When rainfall at dam is less than 1 inch in 6 hours and there is no heavy runoff downstream.

3770-3797	Release between the range of 15,000 cfs and conservation requirement to maintain the pool elevation below 3797.0.
3797-3800	Maintain maximum gate opening attained.

C. FURTHER INSTRUCTIONS.

1. Releases need not be reduced below conservation requirements for flood control purposes.
2. Flood control releases will normally not be adjusted more often than at 6-hour intervals.
3. Incremental 6-hour release changes shall not exceed 5,000 cfs when the river downstream is open or 1,000 cfs when river is frozen.

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EXHIBIT IV

AREA-CAPACITY TABLES IN ONE-FOOT INCREMENTS

CANYON FERRY DAM AND RESERVOIR

Table 1
Canyon Ferry Reservoir 1997 Capacity in Acre-Feet

Elevation (NGVD29)	Elevation Increment in Feet Above Column 1									
	0	1	2	3	4	5	6	7	8	9
3620						0	0	1	3	5
3630	8	13	19	28	38	51	66	85	108	135
3640	165	203	253	314	388	473	569	676	793	921
3650	1060	1212	1380	1565	1767	1986	2248	2581	2985	3460
3660	4005	4673	5513	6526	7710	9068	10577	12218	13992	15897
3670	17933	20089	22349	24715	27185	29761	32483	35395	38495	41784
3680	45262	48943	52840	56955	61287	65836	70566	75441	80461	85626
3690	90936	96368	101897	107525	113251	119074	125030	131153	137442	143897
3700	150519	157310	164271	171403	178705	186179	193817	201614	209570	217685
3710	225960	234359	242851	251434	260108	268874	277755	286773	295928	305220
3720	314650	324228	333965	343860	353914	364126	374533	385168	396031	407123
3730	418444	429989	441754	453739	465943	478368	491013	503880	516969	530279
3740	543812	557585	571616	585907	600456	615263	630351	645739	661429	677419
3750	693711	710331	727309	744643	762334	780381	798808	817634	836861	856488
3760	876516	896933	917729	938903	960456	982388	1004693	1027366	1050409	1073819
3770	1097599	1121772	1146366	1171380	1196814	1222668	1248972	1275754	1303015	1330754
3780	1358972	1387650	1416767	1446324	1476321	1506757	1537567	1568682	1600103	1631769
3790	1663620	1695656	1727879	1760288	1792884	1825667	1858660	1891888	1925350	1959046
3800	1992977	2027413	2062624	2098610	2135371	2172908	2210987	2249375	2288071	2327077
3810	2366390									

Table 2
Canyon Ferry Reservoir 1997 Area in Acres

Elevation (NGVD29)	Elevation Increment in Feet Above Column 1									
	0	1	2	3	4	5	6	7	8	9
3620						0	1	1	2	3
3630	3	5	7	10	12	14	17	21	25	28
3640	32	44	56	67	79	91	102	112	123	133
3650	144	160	177	193	210	227	298	369	439	510
3660	581	754	926	1099	1271	1444	1575	1707	1839	1971
3670	2103	2208	2313	2418	2523	2628	2817	3006	3195	3383
3680	3572	3789	4006	4223	4440	4657	4802	4947	5093	5238
3690	5383	5481	5579	5677	5775	5873	6039	6206	6372	6539
3700	6705	6876	7047	7217	7388	7559	7718	7877	8036	8195
3710	8354	8445	8537	8629	8720	8812	8949	9087	9224	9361
3720	9499	9657	9816	9975	10133	10292	10521	10749	10978	11206
3730	11435	11655	11875	12095	12314	12534	12756	12978	13200	13422
3740	13643	13902	14161	14420	14678	14937	15238	15539	15840	16141
3750	16442	16799	17156	17512	17869	18226	18626	19027	19427	19827
3760	20228	20606	20985	21364	21742	22121	22489	22858	23227	23595
3770	23964	24384	24804	25224	25644	26064	26543	27021	27500	27979
3780	28457	28897	29337	29777	30217	30657	30962	31268	31574	31758
3790	31943	32129	32316	32503	32689	32876	33111	33345	33579	33814
3800	34048	34823	35599	36374	37149	37925	38233	38542	38851	39159
3810	39468									

In these tables, elevations for reservoir levels are based upon the National Geodetic Vertical Datum of 1929 (NGVD29). See Paragraph 1-03 of Water Control Manual for additional details.

EXHIBIT V

AREA-CAPACITY TABLES IN 0.1 FOOT INCREMENTS CANYON FERRY DAM AND RESERVOIR

AUGUST 1997

The tables for Canyon Ferry Lake were generated by means of the area-capacity program ACAP, using the least squares method of curve fitting developed by the Bureau of Reclamation Technical Service Center. This program computes area at 1.0-, 0.1-, and 0.01-foot increments by linear interpolation between basic data contours. The respective capacities and capacity equations are then obtained by integration of the area equations. The initial capacity equation is tested over successive intervals to check whether it fits within an allowable error term. At the next interval beyond, a new capacity equation (integrated from the basic area equation over that interval) begins testing the fit until it too exceeds the error term. The capacity curve thus becomes a series of curves, each fitting a certain region of data. The final area equations are obtained by differentiation of the capacity equations. Capacity equations are of the form $y = a_1 + a_2x + a_3x^2$ where y is capacity and x is the elevation above an elevation base. The capacity equation coefficients for the reservoir are shown below ($\epsilon = 0.000001$). In these tables, elevations for reservoir levels are based upon the National Geodetic Vertical Datum of 1929 (NGVD29). See Paragraph 1-03 of Water Control Manual for additional details.

CANYON FERRY LAKE - CANYON FERRY UNIT, MONTANA					
1997 AREA - CAPACITY TABLES					
EQUATION NUMBER	ELEVATION BASE	CAPACITY BASE	COEFFICIENT A1(INTERCEPT)	COEFFICIENT A2(1ST TERM)	COEFFICIENT A3(2ND TERM)
1	3625.00	0	.0000	.0000	.3300
2	3630.00	8	8.2500	3.3000	1.0400
3	3635.00	50	50.7500	13.7000	1.8300
4	3640.00	165	165.0000	32.0000	5.9100
5	3645.00	472	472.7500	91.1000	5.2600
6	3650.00	1059	1059.7500	143.7000	8.2900
7	3655.00	1985	1985.5000	226.6000	35.4800
8	3660.00	4005	4005.4998	581.4001	86.2100
9	3665.00	9067	9067.7501	1443.5000	65.9300
10	3670.00	17933	17933.4999	2102.8005	52.5299
11	3675.00	29760	29760.7497	2628.1001	94.4200
12	3680.00	45261	45261.7504	3572.2998	108.5100
13	3685.00	65836	65836.0017	4657.3991	72.5202
14	3690.00	90936	90936.0007	5382.5996	49.0101
15	3695.00	119074	119074.2491	5872.7011	83.2498
16	3700.00	150519	150519.0015	6705.1982	85.3402
17	3705.00	186178	186178.5019	7558.5985	79.5302
18	3710.00	225959	225959.7507	8353.8997	45.8001
19	3715.00	268874	268874.2487	8811.8997	68.6603
20	3720.00	314650	314650.2536	9498.5003	79.3497
21	3725.00	364126	364126.4937	10292.0051	114.3092
22	3730.00	418444	418444.2498	11435.1020	109.9197
23	3735.00	478367	478367.7482	12534.3058	110.9080
24	3740.00	543812	543812.0057	13643.3937	129.3710
25	3745.00	615263	615263.2462	14937.1056	150.4891
26	3750.00	693711	693711.0234	16441.9810	178.4132
27	3755.00	780381	780381.2570	18226.0941	200.1709
28	3760.00	876516	876516.0058	20227.7896	189.3024
29	3765.00	982387	982387.5063	22120.7914	184.2922
30	3770.00	1097598	1097598.7622	23963.6815	210.0525
31	3775.00	1222668	1222668.4920	26064.1964	239.3222
32	3780.00	1358972	1358972.4806	28457.4133	219.9080
33	3785.00	1506757	1506757.2447	30656.5228	152.9279
34	3788.00	1600103	1600103.1411	31574.0752	92.1367
35	3790.00	1663619	1663619.8849	31942.5948	93.3604
36	3795.00	1825666	1825666.8582	32876.2159	117.1669
37	3800.00	1992977	1992977.1175	34047.8970	387.6717
38	3805.00	2172908	2172908.4825	37924.6165	154.3471

The Canyon Ferry Lake survey in July and August of 1997 used the contour method to obtain the basic data for these tables. Close interval profiles of the underwater portion of the reservoir were collected by standard surveying techniques using a global positioning system and echo sounder. The above-water portion was measured from aerial photography obtained on October 7, 1996. The underwater survey was run by personnel from the Great Plains Region and the Technical Service Center. Reduction of the aerial and underwater field data was completed at the Technical Service Center in Denver, Colorado.

CANYON FERRY LAKE - CANYON FERRY UNIT, MONTANA

(ACAP92) COMPUTED

8/ 6/1998

1997 AREA - CAPACITY TABLES

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THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET (NGVD29)	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3625	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
3626	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
3627	1.	1.	1.	2.	2.	2.	2.	2.	2.	2.
3628	2.	2.	2.	2.	2.	2.	2.	2.	3.	3.
3629	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3630	3.	4.	4.	4.	4.	4.	5.	5.	5.	5.
3631	5.	6.	6.	6.	6.	6.	7.	7.	7.	7.
3632	7.	8.	8.	8.	8.	9.	9.	9.	9.	9.
3633	10.	10.	10.	10.	10.	11.	11.	11.	11.	11.
3634	12.	12.	12.	12.	12.	13.	13.	13.	13.	13.
3635	14.	14.	14.	15.	15.	16.	16.	16.	17.	17.
3636	17.	18.	18.	18.	19.	19.	20.	20.	20.	21.
3637	21.	21.	22.	22.	22.	23.	23.	24.	24.	24.
3638	25.	25.	25.	26.	26.	27.	27.	27.	28.	28.
3639	28.	29.	29.	29.	30.	30.	31.	31.	31.	32.
3640	32.	33.	34.	36.	37.	38.	39.	40.	41.	43.
3641	44.	45.	46.	47.	49.	50.	51.	52.	53.	54.
3642	56.	57.	58.	59.	60.	62.	63.	64.	65.	66.
3643	67.	69.	70.	71.	72.	73.	75.	76.	77.	78.
3644	79.	80.	82.	83.	84.	85.	86.	88.	89.	90.
3645	91.	92.	93.	94.	95.	96.	97.	98.	100.	101.
3646	102.	103.	104.	105.	106.	107.	108.	109.	110.	111.
3647	112.	113.	114.	115.	116.	117.	118.	120.	121.	122.
3648	123.	124.	125.	126.	127.	128.	129.	130.	131.	132.
3649	133.	134.	135.	136.	137.	138.	139.	141.	142.	143.
3650	144.	145.	147.	149.	150.	152.	154.	155.	157.	159.
3651	160.	162.	164.	165.	167.	169.	170.	172.	174.	175.
3652	177.	179.	180.	182.	183.	185.	187.	188.	190.	192.
3653	193.	195.	197.	198.	200.	202.	203.	205.	207.	208.
3654	210.	212.	213.	215.	217.	218.	220.	222.	223.	225.
3655	227.	234.	241.	248.	255.	262.	269.	276.	283.	290.
3656	298.	305.	312.	319.	326.	333.	340.	347.	354.	361.
3657	369.	376.	383.	390.	397.	404.	411.	418.	425.	432.
3658	439.	447.	454.	461.	468.	475.	482.	489.	496.	503.
3659	510.	518.	525.	532.	539.	546.	553.	560.	567.	574.
3660	581.	599.	616.	633.	650.	668.	685.	702.	719.	737.
3661	754.	771.	788.	806.	823.	840.	857.	875.	892.	909.
3662	926.	943.	961.	978.	995.	1012.	1030.	1047.	1064.	1081.
3663	1099.	1116.	1133.	1150.	1168.	1185.	1202.	1219.	1237.	1254.
3664	1271.	1288.	1306.	1323.	1340.	1357.	1375.	1392.	1409.	1426.

CANYON FERRY LAKE - CANYON FERRY UNIT, MONTANA

(ACAP92) COMPUTED

8/ 6/1998

1997 AREA - CAPACITY TABLES

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THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET (NGVD29)	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3665	1443.	1457.	1470.	1483.	1496.	1509.	1523.	1536.	1549.	1562.
3666	1575.	1589.	1602.	1615.	1628.	1641.	1654.	1668.	1681.	1694.
3667	1707.	1720.	1734.	1747.	1760.	1773.	1786.	1800.	1813.	1826.
3668	1839.	1852.	1865.	1879.	1892.	1905.	1918.	1931.	1945.	1958.
3669	1971.	1984.	1997.	2010.	2024.	2037.	2050.	2063.	2076.	2090.
3670	2103.	2113.	2124.	2134.	2145.	2155.	2166.	2176.	2187.	2197.
3671	2208.	2218.	2229.	2239.	2250.	2260.	2271.	2281.	2292.	2302.
3672	2313.	2323.	2334.	2344.	2355.	2365.	2376.	2386.	2397.	2407.
3673	2418.	2428.	2439.	2449.	2460.	2471.	2481.	2492.	2502.	2513.
3674	2523.	2534.	2544.	2555.	2565.	2576.	2586.	2597.	2607.	2618.
3675	2628.	2647.	2666.	2685.	2704.	2723.	2741.	2760.	2779.	2798.
3676	2817.	2836.	2855.	2874.	2892.	2911.	2930.	2949.	2968.	2987.
3677	3006.	3025.	3044.	3062.	3081.	3100.	3119.	3138.	3157.	3176.
3678	3195.	3214.	3232.	3251.	3270.	3289.	3308.	3327.	3346.	3365.
3679	3383.	3402.	3421.	3440.	3459.	3478.	3497.	3516.	3535.	3553.
3680	3572.	3594.	3616.	3637.	3659.	3681.	3703.	3724.	3746.	3768.
3681	3789.	3811.	3833.	3854.	3876.	3898.	3920.	3941.	3963.	3985.
3682	4006.	4028.	4050.	4071.	4093.	4115.	4137.	4158.	4180.	4202.
3683	4223.	4245.	4267.	4288.	4310.	4332.	4354.	4375.	4397.	4419.
3684	4440.	4462.	4484.	4505.	4527.	4549.	4571.	4592.	4614.	4636.
3685	4657.	4672.	4686.	4701.	4715.	4730.	4744.	4759.	4773.	4788.
3686	4802.	4817.	4831.	4846.	4860.	4875.	4889.	4904.	4918.	4933.
3687	4947.	4962.	4976.	4991.	5005.	5020.	5035.	5049.	5064.	5078.
3688	5093.	5107.	5122.	5136.	5151.	5165.	5180.	5194.	5209.	5223.
3689	5238.	5252.	5267.	5281.	5296.	5310.	5325.	5339.	5354.	5368.
3690	5383.	5392.	5402.	5412.	5422.	5432.	5441.	5451.	5461.	5471.
3691	5481.	5490.	5500.	5510.	5520.	5530.	5539.	5549.	5559.	5569.
3692	5579.	5588.	5598.	5608.	5618.	5628.	5637.	5647.	5657.	5667.
3693	5677.	5686.	5696.	5706.	5716.	5726.	5735.	5745.	5755.	5765.
3694	5775.	5784.	5794.	5804.	5814.	5824.	5833.	5843.	5853.	5863.
3695	5873.	5889.	5906.	5923.	5939.	5956.	5973.	5989.	6006.	6023.
3696	6039.	6056.	6073.	6089.	6106.	6122.	6139.	6156.	6172.	6189.
3697	6206.	6222.	6239.	6256.	6272.	6289.	6306.	6322.	6339.	6356.
3698	6372.	6389.	6406.	6422.	6439.	6455.	6472.	6489.	6505.	6522.
3699	6539.	6555.	6572.	6589.	6605.	6622.	6639.	6655.	6672.	6689.
3700	6705.	6722.	6739.	6756.	6773.	6791.	6808.	6825.	6842.	6859.
3701	6876.	6893.	6910.	6927.	6944.	6961.	6978.	6995.	7012.	7029.
3702	7047.	7064.	7081.	7098.	7115.	7132.	7149.	7166.	7183.	7200.
3703	7217.	7234.	7251.	7268.	7286.	7303.	7320.	7337.	7354.	7371.
3704	7388.	7405.	7422.	7439.	7456.	7473.	7490.	7507.	7524.	7542.

CANYON FERRY LAKE - CANYON FERRY UNIT, MONTANA

(ACAP92) COMPUTED

8/ 6/1998

1997 AREA - CAPACITY TABLES

17:54:21

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET (NGVD29)	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3705	7559.	7575.	7590.	7606.	7622.	7638.	7654.	7670.	7686.	7702.
3706	7718.	7734.	7749.	7765.	7781.	7797.	7813.	7829.	7845.	7861.
3707	7877.	7893.	7909.	7924.	7940.	7956.	7972.	7988.	8004.	8020.
3708	8036.	8052.	8068.	8083.	8099.	8115.	8131.	8147.	8163.	8179.
3709	8195.	8211.	8227.	8243.	8258.	8274.	8290.	8306.	8322.	8338.
3710	8354.	8363.	8372.	8381.	8391.	8400.	8409.	8418.	8427.	8436.
3711	8446.	8455.	8464.	8473.	8482.	8491.	8500.	8510.	8519.	8528.
3712	8537.	8546.	8555.	8565.	8574.	8583.	8592.	8601.	8610.	8620.
3713	8629.	8638.	8647.	8656.	8665.	8675.	8684.	8693.	8702.	8711.
3714	8720.	8729.	8739.	8748.	8757.	8766.	8775.	8784.	8794.	8803.
3715	8812.	8826.	8839.	8853.	8867.	8881.	8894.	8908.	8922.	8935.
3716	8949.	8963.	8977.	8990.	9004.	9018.	9032.	9045.	9059.	9073.
3717	9087.	9100.	9114.	9128.	9141.	9155.	9169.	9183.	9196.	9210.
3718	9224.	9238.	9251.	9265.	9279.	9293.	9306.	9320.	9334.	9347.
3719	9361.	9375.	9389.	9402.	9416.	9430.	9444.	9457.	9471.	9485.
3720	9499.	9514.	9530.	9546.	9562.	9578.	9594.	9610.	9625.	9641.
3721	9657.	9673.	9689.	9705.	9721.	9737.	9752.	9768.	9784.	9800.
3722	9816.	9832.	9848.	9864.	9879.	9895.	9911.	9927.	9943.	9959.
3723	9975.	9990.	10006.	10022.	10038.	10054.	10070.	10086.	10102.	10117.
3724	10133.	10149.	10165.	10181.	10197.	10213.	10229.	10244.	10260.	10276.
3725	10292.	10315.	10338.	10361.	10383.	10406.	10429.	10452.	10475.	10498.
3726	10521.	10543.	10566.	10589.	10612.	10635.	10658.	10681.	10704.	10726.
3727	10749.	10772.	10795.	10818.	10841.	10864.	10886.	10909.	10932.	10955.
3728	10978.	11001.	11024.	11046.	11069.	11092.	11115.	11138.	11161.	11184.
3729	11206.	11229.	11252.	11275.	11298.	11321.	11344.	11367.	11389.	11412.
3730	11435.	11457.	11479.	11501.	11523.	11545.	11567.	11589.	11611.	11633.
3731	11655.	11677.	11699.	11721.	11743.	11765.	11787.	11809.	11831.	11853.
3732	11875.	11897.	11919.	11941.	11963.	11985.	12007.	12029.	12051.	12073.
3733	12095.	12117.	12139.	12161.	12183.	12205.	12227.	12249.	12270.	12292.
3734	12314.	12336.	12358.	12380.	12402.	12424.	12446.	12468.	12490.	12512.
3735	12534.	12556.	12579.	12601.	12623.	12645.	12667.	12690.	12712.	12734.
3736	12756.	12778.	12800.	12823.	12845.	12867.	12889.	12911.	12934.	12956.
3737	12978.	13000.	13022.	13044.	13067.	13089.	13111.	13133.	13155.	13178.
3738	13200.	13222.	13244.	13266.	13288.	13311.	13333.	13355.	13377.	13399.
3739	13422.	13444.	13466.	13488.	13510.	13532.	13555.	13577.	13599.	13621.
3740	13643.	13669.	13695.	13721.	13747.	13773.	13799.	13825.	13850.	13876.
3741	13902.	13928.	13954.	13980.	14006.	14032.	14057.	14083.	14109.	14135.
3742	14161.	14187.	14213.	14239.	14264.	14290.	14316.	14342.	14368.	14394.
3743	14420.	14445.	14471.	14497.	14523.	14549.	14575.	14601.	14627.	14652.
3744	14678.	14704.	14730.	14756.	14782.	14808.	14834.	14859.	14885.	14911.

CANYON FERRY LAKE - CANYON FERRY UNIT, MONTANA

(ACAP92) COMPUTED

8/ 6/1998

1997 AREA - CAPACITY TABLES

17:54:21

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET (NGVD29)	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3745	14937.	14967.	14997.	15027.	15057.	15088.	15118.	15148.	15178.	15208.
3746	15238.	15268.	15298.	15328.	15358.	15389.	15419.	15449.	15479.	15509.
3747	15539.	15569.	15599.	15629.	15659.	15690.	15720.	15750.	15780.	15810.
3748	15840.	15870.	15900.	15930.	15960.	15991.	16021.	16051.	16081.	16111.
3749	16141.	16171.	16201.	16231.	16261.	16292.	16322.	16352.	16382.	16412.
3750	16442.	16478.	16513.	16549.	16585.	16620.	16656.	16692.	16727.	16763.
3751	16799.	16834.	16870.	16906.	16942.	16977.	17013.	17049.	17084.	17120.
3752	17156.	17191.	17227.	17263.	17298.	17334.	17370.	17405.	17441.	17477.
3753	17512.	17548.	17584.	17620.	17655.	17691.	17727.	17762.	17798.	17834.
3754	17869.	17905.	17941.	17976.	18012.	18048.	18083.	18119.	18155.	18190.
3755	18226.	18266.	18306.	18346.	18386.	18426.	18466.	18506.	18546.	18586.
3756	18626.	18666.	18707.	18747.	18787.	18827.	18867.	18907.	18947.	18987.
3757	19027.	19067.	19107.	19147.	19187.	19227.	19267.	19307.	19347.	19387.
3758	19427.	19467.	19507.	19547.	19587.	19627.	19667.	19707.	19747.	19787.
3759	19827.	19867.	19908.	19948.	19988.	20028.	20068.	20108.	20148.	20188.
3760	20228.	20266.	20304.	20341.	20379.	20417.	20455.	20493.	20531.	20569.
3761	20606.	20644.	20682.	20720.	20758.	20796.	20834.	20871.	20909.	20947.
3762	20985.	21023.	21061.	21099.	21136.	21174.	21212.	21250.	21288.	21326.
3763	21364.	21401.	21439.	21477.	21515.	21553.	21591.	21629.	21666.	21704.
3764	21742.	21780.	21818.	21856.	21894.	21932.	21969.	22007.	22045.	22083.
3765	22121.	22158.	22195.	22231.	22268.	22305.	22342.	22379.	22416.	22453.
3766	22489.	22526.	22563.	22600.	22637.	22674.	22711.	22747.	22784.	22821.
3767	22858.	22895.	22932.	22969.	23005.	23042.	23079.	23116.	23153.	23190.
3768	23227.	23263.	23300.	23337.	23374.	23411.	23448.	23485.	23521.	23558.
3769	23595.	23632.	23669.	23706.	23743.	23779.	23816.	23853.	23890.	23927.
3770	23964.	24006.	24048.	24090.	24132.	24174.	24216.	24258.	24300.	24342.
3771	24384.	24426.	24468.	24510.	24552.	24594.	24636.	24678.	24720.	24762.
3772	24804.	24846.	24888.	24930.	24972.	25014.	25056.	25098.	25140.	25182.
3773	25224.	25266.	25308.	25350.	25392.	25434.	25476.	25518.	25560.	25602.
3774	25644.	25686.	25728.	25770.	25812.	25854.	25896.	25938.	25980.	26022.
3775	26064.	26112.	26160.	26208.	26256.	26304.	26351.	26399.	26447.	26495.
3776	26543.	26591.	26639.	26686.	26734.	26782.	26830.	26878.	26926.	26974.
3777	27021.	27069.	27117.	27165.	27213.	27261.	27309.	27357.	27404.	27452.
3778	27500.	27548.	27596.	27644.	27692.	27739.	27787.	27835.	27883.	27931.
3779	27979.	28027.	28075.	28122.	28170.	28218.	28266.	28314.	28362.	28410.
3780	28457.	28501.	28545.	28589.	28633.	28677.	28721.	28765.	28809.	28853.
3781	28897.	28941.	28985.	29029.	29073.	29117.	29161.	29205.	29249.	29293.
3782	29337.	29381.	29425.	29469.	29513.	29557.	29601.	29645.	29689.	29733.
3783	29777.	29821.	29865.	29909.	29953.	29997.	30041.	30085.	30129.	30173.
3784	30217.	30261.	30305.	30349.	30393.	30437.	30481.	30525.	30569.	30613.

CANYON FERRY LAKE - CANYON FERRY UNIT, MONTANA

(ACAP92) COMPUTED

8/ 6/1998

1997 AREA - CAPACITY TABLES

17:54:21

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS IN ONE TENTH FOOT

ELEV. FEET (NGVD29)	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3785	30656.	30687.	30718.	30748.	30779.	30809.	30840.	30871.	30901.	30932.
3786	30962.	30993.	31024.	31054.	31085.	31115.	31146.	31176.	31207.	31238.
3787	31268.	31299.	31329.	31360.	31391.	31421.	31452.	31482.	31513.	31544.
3788	31574.	31593.	31611.	31629.	31648.	31666.	31685.	31703.	31721.	31740.
3789	31758.	31777.	31795.	31814.	31832.	31850.	31869.	31887.	31906.	31924.
3790	31943.	31961.	31980.	31999.	32017.	32036.	32055.	32073.	32092.	32111.
3791	32129.	32148.	32167.	32185.	32204.	32223.	32241.	32260.	32279.	32297.
3792	32316.	32335.	32353.	32372.	32391.	32409.	32428.	32447.	32465.	32484.
3793	32503.	32521.	32540.	32559.	32577.	32596.	32615.	32633.	32652.	32671.
3794	32689.	32708.	32727.	32745.	32764.	32783.	32802.	32820.	32839.	32858.
3795	32876.	32900.	32923.	32947.	32970.	32993.	33017.	33040.	33064.	33087.
3796	33111.	33134.	33157.	33181.	33204.	33228.	33251.	33275.	33298.	33321.
3797	33345.	33368.	33392.	33415.	33439.	33462.	33485.	33509.	33532.	33556.
3798	33579.	33603.	33626.	33650.	33673.	33696.	33720.	33743.	33767.	33790.
3799	33814.	33837.	33860.	33884.	33907.	33931.	33954.	33978.	34001.	34024.
3800	34048.	34125.	34203.	34281.	34358.	34436.	34513.	34591.	34668.	34746.
3801	34823.	34901.	34978.	35056.	35133.	35211.	35288.	35366.	35444.	35521.
3802	35599.	35676.	35754.	35831.	35909.	35986.	36064.	36141.	36219.	36296.
3803	36374.	36451.	36529.	36607.	36684.	36762.	36839.	36917.	36994.	37072.
3804	37149.	37227.	37304.	37382.	37459.	37537.	37614.	37692.	37770.	37847.
3805	37925.	37955.	37986.	38017.	38048.	38079.	38110.	38141.	38172.	38202.
3806	38233.	38264.	38295.	38326.	38357.	38388.	38419.	38449.	38480.	38511.
3807	38542.	38573.	38604.	38635.	38665.	38696.	38727.	38758.	38789.	38820.
3808	38851.	38882.	38912.	38943.	38974.	39005.	39036.	39067.	39098.	39129.
3809	39159.	39190.	39221.	39252.	39283.	39314.	39345.	39375.	39406.	39437.
3810	39468.									

CANYON FERRY LAKE - CANYON FERRY UNIT, MONTANA

(ACAP92) COMPUTED

8/ 6/1998

1997 AREA - CAPACITY TABLES

17:54:21

THE CAPACITY TABLE IS IN ACRE FEET

THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET (NGVD29)	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3625	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3626	0.	0.	0.	1.	1.	1.	1.	1.	1.	1.
3627	1.	1.	2.	2.	2.	2.	2.	2.	3.	3.
3628	3.	3.	3.	4.	4.	4.	4.	5.	5.	5.
3629	5.	6.	6.	6.	6.	7.	7.	7.	8.	8.
3630	8.	9.	9.	9.	10.	10.	11.	11.	12.	12.
3631	13.	13.	14.	14.	15.	16.	16.	17.	18.	18.
3632	19.	20.	21.	21.	22.	23.	24.	25.	26.	27.
3633	28.	28.	29.	30.	31.	33.	34.	35.	36.	37.
3634	38.	39.	40.	42.	43.	44.	45.	47.	48.	49.
3635	51.	52.	54.	55.	57.	58.	60.	61.	63.	65.
3636	66.	68.	70.	72.	74.	75.	77.	79.	81.	83.
3637	85.	88.	90.	92.	94.	96.	99.	101.	103.	106.
3638	108.	111.	113.	116.	118.	121.	124.	126.	129.	132.
3639	135.	138.	141.	143.	146.	149.	152.	156.	159.	162.
3640	165.	168.	172.	175.	179.	182.	186.	190.	194.	199.
3641	203.	207.	212.	217.	221.	226.	231.	236.	242.	247.
3642	253.	258.	264.	270.	276.	282.	288.	294.	301.	308.
3643	314.	321.	328.	335.	342.	349.	357.	364.	372.	380.
3644	388.	396.	404.	412.	420.	429.	437.	446.	455.	464.
3645	473.	482.	491.	501.	510.	520.	529.	539.	549.	559.
3646	569.	579.	590.	600.	611.	621.	632.	643.	654.	665.
3647	676.	687.	699.	710.	722.	733.	745.	757.	769.	781.
3648	793.	806.	818.	831.	843.	856.	869.	882.	895.	908.
3649	921.	935.	948.	962.	975.	989.	1003.	1017.	1031.	1045.
3650	1060.	1074.	1089.	1104.	1119.	1134.	1149.	1164.	1180.	1196.
3651	1212.	1228.	1244.	1261.	1277.	1294.	1311.	1328.	1345.	1363.
3652	1380.	1398.	1416.	1434.	1452.	1471.	1489.	1508.	1527.	1546.
3653	1565.	1585.	1604.	1624.	1644.	1664.	1685.	1705.	1726.	1746.
3654	1767.	1788.	1810.	1831.	1853.	1874.	1896.	1918.	1941.	1963.
3655	1986.	2009.	2032.	2057.	2082.	2108.	2134.	2162.	2189.	2218.
3656	2248.	2278.	2309.	2340.	2372.	2405.	2439.	2473.	2508.	2544.
3657	2581.	2618.	2656.	2694.	2734.	2774.	2815.	2856.	2898.	2941.
3658	2985.	3029.	3074.	3120.	3166.	3213.	3261.	3310.	3359.	3409.
3659	3460.	3511.	3563.	3616.	3669.	3724.	3779.	3834.	3891.	3948.
3660	4006.	4065.	4125.	4188.	4252.	4318.	4385.	4455.	4526.	4599.
3661	4673.	4749.	4827.	4907.	4988.	5072.	5156.	5243.	5331.	5421.
3662	5513.	5607.	5702.	5799.	5897.	5998.	6100.	6204.	6309.	6417.
3663	6526.	6636.	6749.	6863.	6979.	7096.	7216.	7337.	7460.	7584.
3664	7710.	7838.	7968.	8100.	8233.	8368.	8504.	8642.	8782.	8924.

CANYON FERRY LAKE - CANYON FERRY UNIT, MONTANA

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8/ 6/1998

1997 AREA - CAPACITY TABLES

17:54:21

THE CAPACITY TABLE IS IN ACRE FEET

THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET (NGVD29)	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3665	9068.	9213.	9359.	9507.	9656.	9806.	9958.	10111.	10265.	10420.
3666	10577.	10735.	10895.	11056.	11218.	11381.	11546.	11712.	11880.	12048.
3667	12218.	12390.	12563.	12737.	12912.	13089.	13267.	13446.	13626.	13808.
3668	13992.	14176.	14362.	14549.	14738.	14928.	15119.	15311.	15505.	15700.
3669	15897.	16094.	16293.	16494.	16696.	16899.	17103.	17309.	17516.	17724.
3670	17934.	18144.	18356.	18569.	18783.	18998.	19214.	19431.	19649.	19869.
3671	20089.	20310.	20533.	20756.	20980.	21206.	21432.	21660.	21889.	22118.
3672	22349.	22581.	22814.	23048.	23283.	23519.	23756.	23994.	24233.	24473.
3673	24715.	24957.	25200.	25445.	25690.	25937.	26184.	26433.	26683.	26933.
3674	27185.	27438.	27692.	27947.	28203.	28460.	28718.	28977.	29237.	29498.
3675	29761.	30025.	30290.	30558.	30827.	31098.	31372.	31647.	31924.	32203.
3676	32483.	32766.	33050.	33337.	33625.	33915.	34207.	34501.	34797.	35095.
3677	35395.	35696.	36000.	36305.	36612.	36921.	37232.	37545.	37860.	38176.
3678	38495.	38815.	39138.	39462.	39788.	40116.	40446.	40777.	41111.	41446.
3679	41784.	42123.	42464.	42807.	43152.	43499.	43848.	44199.	44551.	44905.
3680	45262.	45620.	45981.	46343.	46708.	47075.	47444.	47816.	48189.	48565.
3681	48943.	49323.	49705.	50089.	50476.	50864.	51255.	51648.	52043.	52441.
3682	52840.	53242.	53646.	54052.	54460.	54871.	55283.	55698.	56115.	56534.
3683	56955.	57379.	57804.	58232.	58662.	59094.	59528.	59965.	60403.	60844.
3684	61287.	61732.	62180.	62629.	63081.	63534.	63990.	64449.	64909.	65371.
3685	65836.	66302.	66770.	67240.	67711.	68183.	68657.	69132.	69608.	70086.
3686	70566.	71047.	71529.	72013.	72499.	72985.	73473.	73963.	74454.	74947.
3687	75441.	75936.	76433.	76932.	77431.	77933.	78435.	78940.	79445.	79952.
3688	80461.	80971.	81482.	81995.	82509.	83025.	83543.	84061.	84581.	85103.
3689	85626.	86150.	86676.	87204.	87733.	88263.	88795.	89328.	89862.	90398.
3690	90936.	91475.	92014.	92555.	93097.	93640.	94183.	94728.	95273.	95820.
3691	96368.	96916.	97466.	98016.	98568.	99120.	99674.	100228.	100783.	101340.
3692	101897.	102456.	103015.	103575.	104137.	104699.	105262.	105826.	106392.	106958.
3693	107525.	108093.	108662.	109232.	109803.	110375.	110949.	111523.	112098.	112674.
3694	113251.	113829.	114407.	114987.	115568.	116150.	116733.	117317.	117902.	118487.
3695	119074.	119662.	120252.	120844.	121437.	122031.	122628.	123226.	123826.	124427.
3696	125030.	125635.	126241.	126849.	127459.	128071.	128684.	129298.	129915.	130533.
3697	131153.	131774.	132397.	133022.	133648.	134276.	134906.	135537.	136170.	136805.
3698	137442.	138080.	138719.	139361.	140004.	140649.	141295.	141943.	142593.	143244.
3699	143897.	144552.	145208.	145866.	146526.	147187.	147850.	148515.	149181.	149849.
3700	150519.	151190.	151863.	152538.	153215.	153893.	154573.	155254.	155938.	156623.
3701	157310.	157998.	158688.	159380.	160074.	160769.	161466.	162164.	162865.	163567.
3702	164271.	164976.	165683.	166392.	167103.	167815.	168529.	169245.	169963.	170682.
3703	171403.	172125.	172850.	173576.	174303.	175033.	175764.	176497.	177231.	177967.
3704	178705.	179445.	180186.	180929.	181674.	182421.	183169.	183919.	184670.	185423.

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1997 AREA - CAPACITY TABLES

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THE CAPACITY TABLE IS IN ACRE FEET

THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET (NGVD29)	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3705	186179.	186935.	187693.	188453.	189215.	189978.	190742.	191508.	192276.	193046.
3706	193817.	194589.	195363.	196139.	196916.	197695.	198476.	199258.	200042.	200827.
3707	201614.	202402.	203192.	203984.	204777.	205572.	206368.	207167.	207966.	208767.
3708	209570.	210374.	211180.	211988.	212797.	213608.	214420.	215234.	216050.	216867.
3709	217685.	218506.	219328.	220151.	220976.	221803.	222631.	223461.	224292.	225125.
3710	225960.	226796.	227632.	228470.	229309.	230148.	230989.	231830.	232672.	233515.
3711	234359.	235204.	236050.	236897.	237745.	238594.	239443.	240294.	241145.	241998.
3712	242851.	243705.	244560.	245416.	246273.	247131.	247990.	248849.	249710.	250571.
3713	251434.	252297.	253161.	254026.	254892.	255759.	256627.	257496.	258366.	259237.
3714	260108.	260981.	261854.	262728.	263604.	264480.	265357.	266235.	267114.	267994.
3715	268874.	269756.	270639.	271524.	272410.	273297.	274186.	275076.	275968.	276861.
3716	277755.	278650.	279547.	280446.	281345.	282247.	283149.	284053.	284958.	285865.
3717	286773.	287682.	288593.	289505.	290418.	291333.	292249.	293167.	294086.	295006.
3718	295928.	296851.	297775.	298701.	299628.	300557.	301487.	302418.	303351.	304285.
3719	305220.	306157.	307095.	308035.	308976.	309918.	310862.	311807.	312753.	313701.
3720	314650.	315601.	316553.	317507.	318462.	319419.	320378.	321338.	322300.	323263.
3721	324228.	325195.	326163.	327132.	328104.	329077.	330051.	331027.	332005.	332984.
3722	333965.	334947.	335931.	336917.	337904.	338892.	339883.	340875.	341868.	342863.
3723	343860.	344858.	345858.	346859.	347862.	348867.	349873.	350881.	351890.	352901.
3724	353914.	354928.	355944.	356961.	357980.	359000.	360022.	361046.	362071.	363098.
3725	364126.	365157.	366189.	367224.	368262.	369301.	370343.	371387.	372433.	373482.
3726	374533.	375586.	376642.	377699.	378759.	379822.	380886.	381953.	383022.	384094.
3727	385168.	386244.	387322.	388403.	389486.	390571.	391658.	392748.	393840.	394935.
3728	396031.	397130.	398231.	399335.	400441.	401549.	402659.	403772.	404887.	406004.
3729	407123.	408245.	409369.	410496.	411624.	412755.	413888.	415024.	416162.	417302.
3730	418444.	419589.	420736.	421885.	423036.	424189.	425345.	426503.	427663.	428825.
3731	429989.	431156.	432325.	433496.	434669.	435844.	437022.	438202.	439384.	440568.
3732	441754.	442943.	444134.	445326.	446522.	447719.	448919.	450120.	451324.	452530.
3733	453739.	454949.	456162.	457377.	458594.	459814.	461035.	462259.	463485.	464713.
3734	465943.	467176.	468411.	469648.	470887.	472128.	473372.	474617.	475865.	477115.
3735	478368.	479622.	480879.	482138.	483399.	484663.	485928.	487196.	488466.	489738.
3736	491013.	492290.	493569.	494850.	496133.	497419.	498707.	499997.	501289.	502583.
3737	503880.	505179.	506480.	507783.	509089.	510397.	511707.	513019.	514333.	515650.
3738	516969.	518290.	519613.	520939.	522266.	523596.	524929.	526263.	527600.	528938.
3739	530280.	531623.	532968.	534316.	535666.	537018.	538372.	539729.	541088.	542449.
3740	543812.	545178.	546546.	547917.	549290.	550666.	552045.	553426.	554810.	556196.
3741	557585.	558976.	560370.	561767.	563166.	564568.	565973.	567380.	568789.	570202.
3742	571616.	573034.	574454.	575876.	577301.	578729.	580159.	581592.	583028.	584466.
3743	585907.	587350.	588796.	590244.	591695.	593149.	594605.	596064.	597525.	598989.
3744	600456.	601925.	603396.	604871.	606348.	607827.	609309.	610794.	612281.	613771.

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ELEV. FEET (NGVD29)	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
3745	615263.	616758.	618257.	619758.	621262.	622769.	624280.	625793.	627309.	628829.
3746	630351.	631876.	633405.	634936.	636470.	638008.	639548.	641091.	642638.	644187.
3747	645739.	647295.	648853.	650415.	651979.	653547.	655117.	656691.	658267.	659846.
3748	661429.	663015.	664603.	666195.	667789.	669387.	670987.	672591.	674197.	675807.
3749	677420.	679035.	680654.	682275.	683900.	685528.	687158.	688792.	690429.	692068.
3750	693711.	695357.	697007.	698660.	700316.	701977.	703640.	705308.	706979.	708653.
3751	710331.	712013.	713698.	715387.	717080.	718775.	720475.	722178.	723885.	725595.
3752	727309.	729026.	730747.	732471.	734199.	735931.	737666.	739405.	741147.	742893.
3753	744643.	746396.	748152.	749913.	751676.	753444.	755214.	756989.	758767.	760548.
3754	762334.	764122.	765915.	767710.	769510.	771313.	773119.	774930.	776743.	778560.
3755	780381.	782206.	784035.	785867.	787704.	789544.	791389.	793238.	795090.	796947.
3756	798808.	800672.	802541.	804413.	806290.	808171.	810055.	811944.	813837.	815733.
3757	817634.	819539.	821448.	823360.	825277.	827198.	829122.	831051.	832984.	834920.
3758	836861.	838806.	840755.	842707.	844664.	846625.	848589.	850558.	852531.	854508.
3759	856488.	858473.	860462.	862455.	864451.	866452.	868457.	870466.	872478.	874495.
3760	876516.	878541.	880569.	882601.	884637.	886677.	888721.	890768.	892819.	894874.
3761	896933.	898996.	901062.	903132.	905206.	907284.	909365.	911450.	913539.	915632.
3762	917729.	919829.	921933.	924041.	926153.	928269.	930388.	932511.	934638.	936769.
3763	938903.	941041.	943183.	945329.	947479.	949632.	951789.	953950.	956115.	958284.
3764	960456.	962632.	964812.	966996.	969183.	971374.	973570.	975768.	977971.	980177.
3765	982388.	984601.	986819.	989040.	991265.	993494.	995726.	997962.	1000202.	1002446.
3766	1004693.	1006943.	1009198.	1011456.	1013718.	1015983.	1018253.	1020525.	1022802.	1025082.
3767	1027366.	1029654.	1031945.	1034240.	1036539.	1038841.	1041147.	1043457.	1045771.	1048088.
3768	1050409.	1052733.	1055061.	1057393.	1059729.	1062068.	1064411.	1066757.	1069108.	1071462.
3769	1073819.	1076181.	1078546.	1080915.	1083287.	1085663.	1088043.	1090426.	1092813.	1095204.
3770	1097599.	1099997.	1102400.	1104807.	1107218.	1109633.	1112053.	1114476.	1116904.	1119336.
3771	1121773.	1124213.	1126658.	1129107.	1131560.	1134017.	1136478.	1138944.	1141414.	1143888.
3772	1146366.	1148849.	1151336.	1153826.	1156322.	1158821.	1161324.	1163832.	1166344.	1168860.
3773	1171380.	1173905.	1176434.	1178966.	1181504.	1184045.	1186590.	1189140.	1191694.	1194252.
3774	1196814.	1199381.	1201952.	1204527.	1207106.	1209689.	1212276.	1214868.	1217464.	1220064.
3775	1222669.	1225277.	1227891.	1230509.	1233133.	1235760.	1238393.	1241031.	1243673.	1246320.
3776	1248972.	1251629.	1254290.	1256956.	1259628.	1262303.	1264984.	1267669.	1270360.	1273054.
3777	1275754.	1278459.	1281168.	1283882.	1286601.	1289325.	1292053.	1294787.	1297525.	1300267.
3778	1303015.	1305767.	1308525.	1311287.	1314053.	1316825.	1319601.	1322382.	1325168.	1327959.
3779	1330754.	1333555.	1336360.	1339170.	1341984.	1344804.	1347628.	1350457.	1353291.	1356129.
3780	1358973.	1361820.	1364673.	1367530.	1370391.	1373256.	1376126.	1379000.	1381879.	1384762.
3781	1387650.	1390542.	1393438.	1396339.	1399244.	1402154.	1405067.	1407986.	1410908.	1413835.
3782	1416767.	1419703.	1422643.	1425588.	1428537.	1431491.	1434448.	1437411.	1440378.	1443348.
3783	1446324.	1449304.	1452288.	1455277.	1458270.	1461267.	1464269.	1467276.	1470286.	1473301.
3784	1476321.	1479345.	1482373.	1485406.	1488443.	1491484.	1494530.	1497580.	1500635.	1503694.

EXHIBIT VII

SEASONAL RUNOFF FORECAST PROCEDURE CANYON FERRY DAM AND RESERVOIR

EXHIBIT VII
SEASONAL RUNOFF FORECAST PROCEDURE
CANYON FERRY DAM AND RESERVOIR

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Plate E-VII-3. Tributary Reservoir Holdouts

EXHIBIT VII SEASONAL RUNOFF FORECAST PROCEDURE

1. General. The drainage area above Canyon Ferry Dam is almost entirely bounded by mountains. About one-half of its annual inflow normally occurs during the April-July period as a result of mountain snowmelt. In years when the snow accumulation is high it is necessary that reservoir storage space be made available in advance of the anticipated runoff. To determine the amount of space needed to store and control this runoff, a seasonal volume forecast has been developed.
2. Development of Forecast Procedure. The seasonal runoff forecast procedure is based on a study of multiple linear regressions between independent and dependent hydrologic variables.

The independent variables are:

- a. October and November natural runoff,
- b. Beginning of the month or annual peak mountain snow-water content, and
- c. January through June precipitation.

The dependent variable is:

- a. April through July natural runoff.

Reliable runoff and precipitation data is available since Canyon Ferry was in operation in 1953, but an adequate mountain snow-water content record did not become available until 1970. Therefore, development of the seasonal forecast procedure uses a 45-year record from 1970-2014. The October-November and April-July runoff volumes were determined from the daily inflow values, calculated by Reclamation. Mountain snow water equivalent (SWE) data is from the USDA-NRCS SNOw TELemtry (SNOTEL) automated measurements and manual snow survey measurements. Precipitation data is from the National Weather Service. See Plate E-VII-1 for a map of the Canyon Ferry Reservoir drainage basin that shows the location of the SNOTEL and precipitation stations used in developing the forecast.

a. April through July natural runoff. The dependent variable (April through July natural runoff) is the amount of runoff that would have been passed by the Canyon Ferry site with no upstream regulation. To determine the natural runoff, the actual (regulated) inflow from projects upstream of Canyon Ferry is adjusted for holdouts. This adjustment, often times referred to as “holdouts”, involves 1) converting the inflow and regulated releases from the upstream reservoirs - Lima, Clark Canyon and Hebgen – into natural river flows and 2) routing that river flow downstream to Canyon Ferry. Due to the lack of reliable information as well as the minimal effect on the determination of natural inflows, the effects of evaporation were not incorporated into calculation of historical Canyon Ferry

natural inflows. Plate E-VII-2 shows historic monthly Canyon Ferry natural inflows from 1954 to 2014. Determination of the Canyon Ferry April-July natural inflow reveals:

- a. Average Apr-Jul natural inflow = 1.95 Million Acre Feet (MAF) (1970-2014)
- b. Maximum Apr-Jul natural inflow = 3.60 MAF (1997)
- c. Minimum Apr-Jul natural inflow = 0.84 MAF (2004)

Note: Minimum Apr-Jul natural inflow from the 1954-2014 period of record is 0.72 MAF (1961), which was outside of the data set analyzed due to SNOTEL data becoming available in 1970.

b. October and November natural runoff. The October-November runoff during the preceding fall is often referred to as “antecedent runoff”. There is some correlation between the fall streamflow and soil moisture conditions (e.g. wetter than normal, drier than normal) and the following April-July runoff. The October and November natural runoff was calculated in the same manner as the April-July natural runoff. Determination of the Canyon Ferry October-November natural inflow reveals:

- a. Average Oct-Nov natural inflow = 0.54 MAF (1970-2014)
- b. Maximum Oct-Nov natural inflow = 0.87 MAF (1984)
- c. Minimum Oct-Nov natural inflow = 0.31 MAF (2004)

c. Mountain snow-water content. The USDA-NRCS has 36 SNOTEL sites upstream of Canyon Ferry that provide daily mountain SWE data. See Plate E-VII-1 for a graphical location of these stations. Plate 5-5 of the Canyon Ferry Water Control Manual lists the 36 SNOTEL sites and their average first of the month and mid-month SWE. Real-time and historical SNOTEL data can be found at <http://www.wcc.nrcs.usda.gov/snow/>.

d. Precipitation. Daily precipitation data is available from NWS at six reporting stations (see Table 1).

TABLE 1 – Precipitation Stations

Precipitation Station	Elevation (feet)	Station ID
Bozeman 6W Exp Farm	4780	BZMM8
Bozeman MSU	4856	BZEM8
Bozeman Gallatin Field	4475	BZN
Dillon Airport	8225	DLN
Butte Bert Mooney AP	5758	BTM
Helena Regional AP	3874	HLN

3. **Application of Basic Forecast Equation.** The multiple linear regression analysis provides a basic forecast equation that is further defined into monthly equations:

a. Mountain SWE. The January 1, February 1, March 1 and April 1 forecast equations use the corresponding average mountain SWE from the 36 SNOTEL sites (see Plate E-VII-1). For example, the February 1 and March 1 forecast equations use the February 1 and March 1 average SWE, respectively. The mountain snowpack normally peaks by April 15. If the peak has not occurred by May 1, the May 1 average SWE should be used in the May 1 forecast. If the peak has occurred before May 1, use the peak SWE in the May 1 and June 1 forecast equations. SWE is denoted throughout the equations below with a subscript denoting which month is used in the equation (e.g., SWE_{JAN} is the January 1 average SWE).

b. Antecedent Conditions. The October-November natural inflow, which includes October and November holdouts and is referred to as antecedent inflow ($ANTQ$), and the previous Jan-Dec precipitation, which is referred to as the antecedent precipitation ($ANTPREC$), are initially calculated for the January 1 forecast and then used in each of the subsequent monthly equations. Table 3 shows the historic October-November regulated inflow, October-November holdouts, and the natural October-November inflows.

c. Precipitation. Starting on February 1, the accumulated calendar year average precipitation is used. This accumulation averages the six precipitation sites for each month and then totals the monthly averages. For example, the February 1 forecast uses the average monthly January precipitation (P_J) and the March 1 forecast uses the average monthly January and February precipitation (P_{J+F}).

d. Coefficients. The forecast equations are determined by a multiple linear regression analysis. Each resultant equation has a coefficient for each independent variable (e.g. C_{swe} , C_{antQ} , $C_{antprec}$, C_p) as well as an intercept ($C_{intercept}$). The coefficients are specific to the monthly forecast (see Table 2). For example, C_{ja-swe} and C_{fe-swe} are the SWE coefficients for the January 1 and February 1 forecast equations, respectively. These coefficients should be updated as necessary to maximize the accuracy of inflow forecasting.

Note: Previous versions of this manual included a forecasting regression equation based on July 1 information. By July 1, rainfall accounts for most of the variability in the forecasted runoff. To best account for this forecast variability, July runoff should be forecasted using a recession inflow forecast or hydrologic modeling following a rainfall event. The recession inflow forecast is detailed in the Canyon Ferry WCM (2017) in Sections 6-02.c. and 7-05.f.1 and on Plate 6-1..

Natural April-July inflow volume (Q) forecast equations:

January 1 equation:

$$Q = C_{ja-swe}(SWE_{JAN}) + C_{ja-antQ}(ANTQ) + C_{ja-antprec}(ANTPREC) + C_{ja-intercept}$$

February 1 equation:

$$Q = C_{fe-swe}(SWE_{FEB}) + C_{fe-antQ}(ANTQ) + C_{fe-antprec}(ANTPREC) + C_{fe-p}(P_J) + C_{fe-intercept}$$

March 1 equations:

$$Q = C_{mr-swe}(SWE_{MAR}) + C_{mr-antQ}(ANTQ) + C_{mr-antprec}(ANTPREC) + C_{mr-p}(P_{J+F}) + C_{mr-intercept}$$

April 1 equation:

$$Q = C_{ap-swe}(SWE_{APR}) + C_{ap-antQ}(ANTQ) + C_{ap-antprec}(ANTPREC) + C_{ap-p}(P_{J+F+M}) + C_{ap-intercept}$$

May 1 equation:

$$Q = C_{my-swe}(SWE_{peak}) + C_{my-antQ}(ANTQ) + C_{my-antprec}(ANTPREC) + C_{my-p}(P_{J+F+M+A}) + C_{my-intercept}$$

June 1 equation:

$$Q = C_{je-swe}(SWE_{peak}) + C_{je-antQ}(ANTQ) + C_{je-antprec}(ANTPREC) + C_{je-p}(P_{J+F+M+A+M}) + C_{je-intercept}$$

NOTE: Coefficients (C) are specific to the month of the forecast and should be updated as necessary to maximize the accuracy of inflow forecasting.

The coefficients (e.g. C_{ja-swe} , C_{ja-p}) are shown in Table 2. These coefficients should be updated as necessary to maximize the accuracy of inflow forecasting. Updating the coefficients is accomplished by collecting the model data (inflow, SWE and precipitation) since the coefficients were last updated and including them in the multiple linear regression analysis.

Table 2 – Linear Regression Coefficients**

	January (ja)	February (fe)	March (mr)	April (ap)	May (my)	June (je)
C_{xx-swe}	0.1995	0.1439	0.1172	0.1183	0.1131	0.0844
$C_{xx-antQ}$	0.3309	0.5173	0.4305	-0.1010	-0.1694	0.1589
$C_{xx-antprec}$	0.09587	0.1066	0.1147	0.1252	0.1006	0.0573
C_{xx-p}	n/a	0.56986	0.42827	0.24743	0.08907	0.08599
$C_{xx-intercept}$	-1.0154	-1.6221	-1.8541	-2.1555	-1.9968	-1.8502

****Note:** These coefficients are as of WY 2015. These coefficients should be updated as necessary to maximize the accuracy of inflow forecasting.

4. Pertinent Data. Table 3 presents historical October-November natural inflow

(ANTQ) and SWE data. Table 4 presents historical Jan-May monthly precipitation totals (P). Table 5 presents historical observed April-July natural runoff. Table 6 presents historical forecasted April-July natural runoff (Q). Tables 7 and 8 present the residuals and squares of residuals of the historical forecasts.

5. Estimation of Tributary Holdouts. As explained in Section 2.a, the forecasted natural inflow for the April to July period is adjusted to account for upstream tributary holdouts at Lima, Clark Canyon and Hebgen reservoirs. The estimated April-July holdouts for the upstream projects are determined by either of two methods:

- a. Method 1 – Equation**.

$$\text{HOLD} = 70.35 (\text{IF}) - 0.80 (\text{HEB}) + 167.16$$

Where:

HOLD = total forecasted April-July holdout (in 1000 AF) for
Lima, Clark Canyon and Hebgen reservoirs.

IF = forecasted natural inflow volume to Canyon Ferry
Reservoir (in 1,000,000 AF).

HEB = Estimated 1 April Hebgen storage (in 1000 AF).

** Note: The equation originally included the holdout of Ruby Reservoir. Due to Ruby's relatively small holdout and lack of real-time data, Ruby was eliminated from this equation.

Plate E-VII-3 shows a graphic interpretation of this equation. It should be noted that this is a fairly weak relationship and should be used in estimating holdouts only if the forecaster lacks up-to-date storage information for each tributary reservoir.

- b. Method 2 – Estimate based on historical operation.

Upon review of historic holdout volumes, Omaha District and Reclamation collaboratively determined that a holdout volume estimate of 125,000 af is fairly accurate for most years. This estimate can be adjusted if conditions dictate.

	Previous yrs		Previous yrs	Average Snow Water Equivalent, inches						
	OCT-NOV	Holdouts	OCT-NOV							
Years	Inflow, maf	maf	Natural Inflow, maf	Jan	Feb	Mar	Apr	May	Jun	Year's Max
1970	0.66	0.00	0.66	7.64	15.34	18.16	23.37	29.0	19.0	29.0
1971	0.69	0.01	0.70	11.7	17.33	21.05	26.18	28.2	21.2	28.2
1972	0.72	0.02	0.73	11.42	17.74	21.72	25.18	26.0	14.5	26.0
1973	0.63	0.03	0.66	6.79	9.47	11.66	15.21	17.8	7.5	17.8
1974	0.56	0.02	0.58	10.42	15.16	18.45	26.31	26.0	20.7	26.3
1975	0.81	-0.01	0.80	5.96	11.16	15.41	20.04	25.4	21.1	25.4
1976	0.78	0.00	0.78	11.17	14.67	18.67	22.05	23.8	8.2	23.8
1977	0.56	0.02	0.58	2.97	5.16	6.32	10.06	4.6	1.9	10.1
1978	0.59	0.01	0.61	10.68	14.65	17.98	19.05	19.1	13.8	19.1
1979	0.45	0.02	0.46	7.15	9.78	14.37	16.78	17.3	6.5	17.3
1980	0.61	0.01	0.62	4.3	8.47	11.33	15.72	10.5	5.1	15.7
1981	0.58	0.02	0.60	6.03	7.34	10.54	13.46	11.0	7.2	13.5
1982	0.71	0.01	0.72	8.65	13.36	15.84	21.14	22.7	15.7	22.7
1983	0.84	0.03	0.87	8.61	10.76	13.72	17.82	17.4	9.9	17.8
1984	0.78	-0.01	0.78	7.94	9.76	11.79	16.27	18.4	9.8	18.4
1985	0.55	0.03	0.57	8.4	9.61	12.01	15.39	12.1	1.8	15.4
1986	0.63	0.02	0.65	6.67	9.33	14.72	16.37	17.0	8.4	17.0
1987	0.44	-0.03	0.41	5.38	7.65	9.42	11.64	5.8	0.2	11.6
1988	0.36	0.00	0.36	4.57	7.48	9.83	13.32	12.8	3.7	13.3
1989	0.49	-0.05	0.44	6.49	10.35	12.28	17.12	15.7	7.9	17.1
1990	0.45	-0.06	0.39	5.76	9.47	11.58	14.1	12.0	8.4	14.1
1991	0.49	-0.05	0.43	6.34	8.49	9.47	13.59	17.0	10.8	17.0
1992	0.48	-0.06	0.42	8.52	9.73	11.69	12.63	10.4	0.6	12.6
1993	0.61	-0.09	0.53	7.07	9.66	11.65	13.66	17.6	4.8	17.6
1994	0.44	-0.04	0.40	4.69	7.12	10.13	11.64	10.2	1.0	11.6
1995	0.69	-0.08	0.61	8.85	12.27	13.82	18.24	21.8	14.3	21.8
1996	0.55	-0.05	0.50	8.84	12.88	16.07	19.1	20.5	14.9	20.5
1997	0.74	-0.08	0.66	13.27	18.21	20.86	24.02	26.0	11.6	26.0
1998	0.61	-0.01	0.60	5.23	9.61	11.47	14.19	14.3	6.0	14.3
1999	0.50	0.01	0.51	7.94	12.03	16.42	18.06	18.2	10.8	18.2
2000	0.44	0.00	0.45	5.62	8.67	11.56	14.28	10.7	4.0	14.3
2001	0.36	0.00	0.36	5.86	7.01	8.77	11.01	11.6	0.5	11.6
2002	0.36	0.00	0.36	6.18	9.12	11.03	13.6	14.3	6.3	14.3
2003	0.31	0.00	0.31	4.72	8.35	11.61	15.31	16.7	6.8	16.7
2004	0.39	0.00	0.39	7.55	10.44	12.99	13.53	11.6	6.5	13.5
2005	0.43	0.02	0.45	5.95	7.75	8.77	12.01	12.7	3.8	12.7
2006	0.44	0.02	0.46	8.47	12.34	14.48	17.43	16.9	4.7	17.4
2007	0.37	0.03	0.40	5.83	7.53	11.29	11.97	11.0	2.5	12.0
2008	0.43	0.05	0.48	6.99	11.18	14.07	17.2	18.7	11.5	18.7
2009	0.50	0.01	0.51	7.56	10.38	12.23	17.56	19.5	7.8	19.5
2010	0.47	0.00	0.47	6.05	8.59	10.04	12.23	12.8	10.7	12.8
2011	0.55	-0.02	0.53	8.33	11.76	14.30	18.77	23.7	18.9	23.7
2012	0.42	0.02	0.43	5.71	8.53	11.85	15.59	12.8	5.9	15.6
2013	0.41	0.02	0.43	7.2	9.6	11.3	13.2	13.6	3.9	13.6
2014	0.46	0.02	0.48	8.08	11.05	15.61	20.73	21.01	8.80	21.01
Ave	0.54	0.00	0.54	7.32	10.59	13.30	16.58	16.80	8.67	17.70
Max	0.84	0.05	0.87	13.27	18.21	21.72	26.31	28.96	21.21	28.96
Min	0.31	-0.09	0.31	2.97	5.16	6.32	10.06	4.58	0.16	10.06
				Water Control Manual						
				Canyon Ferry Reservoir and Dam, Montana						
				Regression Analysis Independent Variables						
				U. S. Army Engineer District, Omaha						
				Corps of Engineers, Omaha, Nebraska						
				December 2016						
Table 3 - Page 6										

	Average Annual Precipitation	Average Cumulative Rainfall					
Years	inches	Jan	Jan-Feb	Jan-Mar	Jan-Apr	Jan-May	
1970	14.49	0.44	0.77	2.07	3.08	5.68	
1971	12.18	0.71	1.22	1.72	3.51	5.28	
1972	12.12	0.73	1.15	2.12	3.02	4.21	
1973	11.84	0.52	0.75	1.50	2.95	3.97	
1974	11.06	0.35	0.63	1.70	2.41	4.83	
1975	19.31	1.10	1.92	2.72	4.62	7.37	
1976	13.28	0.26	0.64	1.14	3.14	4.52	
1977	14.51	0.61	0.68	2.19	2.62	5.01	
1978	13.76	0.64	1.32	1.72	2.50	4.68	
1979	10.88	0.68	1.25	2.08	3.93	5.09	
1980	17.76	0.72	1.78	2.99	3.69	8.50	
1981	16.01	0.18	0.84	1.71	2.97	8.65	
1982	16.39	0.76	1.30	3.28	4.61	6.86	
1983	15.51	0.12	0.36	1.15	2.15	3.68	
1984	13.15	0.25	0.79	1.86	3.35	4.77	
1985	10.52	0.38	0.83	1.72	2.11	3.92	
1986	14.36	0.38	1.52	2.41	3.89	5.05	
1987	13.53	0.19	0.42	1.02	1.76	5.32	
1988	11.38	0.46	0.76	1.57	3.22	6.39	
1989	14.34	1.23	1.89	3.16	4.37	6.77	
1990	12.15	0.60	0.80	2.03	3.45	5.89	
1991	13.86	0.32	0.62	1.91	3.43	6.57	
1992	13.72	0.32	0.54	1.15	2.71	4.55	
1993	20.25	0.58	1.12	1.73	4.16	6.79	
1994	12.40	0.20	0.65	1.20	2.82	4.34	
1995	14.43	1.01	1.27	2.83	4.48	6.40	
1996	14.87	0.70	1.55	2.35	3.65	7.23	
1997	19.26	1.17	1.68	2.55	4.11	7.13	
1998	15.29	0.70	1.26	2.42	3.79	5.73	
1999	11.69	0.52	0.91	1.65	3.11	5.45	
2000	12.66	0.51	1.04	2.07	3.18	5.61	
2001	10.94	0.34	0.57	1.11	2.34	3.12	
2002	12.43	0.62	0.95	1.36	2.20	4.34	
2003	10.95	1.02	2.10	3.10	5.98	7.89	
2004	13.64	0.32	0.89	1.33	2.83	5.44	
2005	15.13	0.26	0.50	1.34	2.96	5.07	
2006	13.88	0.49	0.60	1.30	4.14	5.71	
2007	15.21	0.24	1.25	1.81	3.46	6.99	
2008	12.50	0.52	0.89	1.39	2.67	5.55	
2009	14.71	0.19	0.49	2.05	4.06	5.27	
2010	16.22	0.55	0.86	1.27	2.36	4.73	
2011	12.14	0.30	0.69	1.31	2.63	5.18	
2012	9.52	0.34	0.69	1.87	3.62	5.21	
2013	12.78	0.35	0.56	0.85	1.37	4.21	
2014	15.31	0.38	1.37	2.89	4.18	5.52	
Ave	13.83	0.52	0.99	1.88	3.28	5.57	
Max	20.25	1.23	2.10	3.28	5.98	8.65	
Min	9.52	0.12	0.36	0.85	1.37	3.12	
Note: Average Precipitations are comprised of the following stations: BZMM8-Bozeman_6_W_Exp_Farm BZN-Bozeman_Gallatin_Fld BZEM8-Bozeman_MT_State_U BTM-Butte_Bert_Mooney_AP DLN-Dillon HLN-Helena_Rgnl_Airport			Water Control Manual Canyon Ferry Reservoir and Dam, Montana Regression Analysis Independent Variables U. S. Army Engineer District, Omaha Corps of Engineers, Omaha, Nebraska December 2016				

	*Reported in maf		Natural	Arithmetic	Deviation from	Deviation		
Years	Actual Inflow	Holdouts	Inflow	Mean	Mean	Squared		
1970	2.65	0.022	2.68	1.95	0.73	0.53		
1971	2.80	0.036	2.84	1.95	0.89	0.79		
1972	2.28	-0.010	2.27	1.95	0.32	0.10		
1973	1.34	-0.050	1.29	1.95	-0.65	0.43		
1974	2.34	-0.060	2.28	1.95	0.33	0.11		
1975	3.03	0.105	3.14	1.95	1.19	1.41		
1976	3.00	0.034	3.03	1.95	1.09	1.18		
1977	0.94	-0.044	0.89	1.95	-1.06	1.11		
1978	2.21	-0.012	2.20	1.95	0.25	0.06		
1979	1.63	-0.042	1.59	1.95	-0.36	0.13		
1980	2.19	0.005	2.19	1.95	0.24	0.06		
1981	2.52	-0.011	2.51	1.95	0.56	0.31		
1982	2.90	0.025	2.93	1.95	0.98	0.96		
1983	2.24	0.003	2.24	1.95	0.29	0.08		
1984	2.99	0.054	3.04	1.95	1.09	1.20		
1985	1.25	-0.057	1.19	1.95	-0.76	0.58		
1986	1.90	-0.028	1.87	1.95	-0.08	0.01		
1987	0.86	0.058	0.92	1.95	-1.03	1.07		
1988	1.02	-0.021	1.00	1.95	-0.94	0.89		
1989	1.22	0.033	1.25	1.95	-0.70	0.49		
1990	1.20	0.054	1.25	1.95	-0.69	0.48		
1991	1.63	0.078	1.70	1.95	-0.24	0.06		
1992	0.90	0.045	0.94	1.95	-1.01	1.01		
1993	2.30	0.171	2.47	1.95	0.52	0.27		
1994	1.04	-0.010	1.03	1.95	-0.92	0.85		
1995	2.69	0.238	2.93	1.95	0.98	0.97		
1996	2.77	0.083	2.85	1.95	0.91	0.82		
1997	3.60	0.152	3.75	1.95	1.80	3.25		
1998	2.53	0.141	2.67	1.95	0.72	0.52		
1999	2.04	0.112	2.16	1.95	0.21	0.04		
2000	1.05	-0.039	1.01	1.95	-0.93	0.87		
2001	0.83	0.003	0.84	1.95	-1.11	1.24		
2002	1.14	-0.006	1.13	1.95	-0.82	0.66		
2003	1.36	-0.006	1.35	1.95	-0.60	0.36		
2004	0.84	0.098	0.94	1.95	-1.01	1.02		
2005	1.36	0.074	1.43	1.95	-0.51	0.26		
2006	1.68	0.078	1.76	1.95	-0.19	0.04		
2007	1.09	-0.054	1.03	1.95	-0.92	0.84		
2008	2.19	0.083	2.28	1.95	0.33	0.11		
2009	2.08	0.137	2.22	1.95	0.27	0.07		
2010	2.12	0.089	2.21	1.95	0.26	0.07		
2011	3.46	0.175	3.63	1.95	1.69	2.85		
2012	1.63	0.002	1.63	1.95	-0.32	0.10		
2013	1.01	-0.019	0.99	1.95	-0.96	0.92		
2014	2.06	0.032	2.09	1.95	0.15	0.02		
Ave	1.91	0.04	1.95		SST	29.20		
Max	3.60	0.24	3.75	SST = Sum of the squares due to				
Min	0.83	-0.06	0.84	total variability.				
Note: Average Precipitations are comprised of the following stations: BZMM8-Bozeman_6_W_Exp_Farm BZN-Bozeman_Gallatin_Fld BZEM8-Bozeman_MT_State_U BTM-Butte_Bert_Mooney_AP DLN-Dillon HLN-Helena_Rgnl_Airport			Water Control Manual Canyon Ferry Reservoir and Dam, Montana Regression Analysis Observed Inflows					
			U. S. Army Engineer District, Omaha Corps of Engineers, Omaha, Nebraska December 2016					
Table 5 - Page 8								

		Forecast Natural Apr-Jul Inflow					
	Natural	maf					
Years	Inflow	Jan	Feb	Mar	Apr	May	Jun
1970	2.68	2.360	2.993	2.841	3.190	3.580	3.635
1971	2.84	2.918	3.155	3.074	3.105	3.263	3.224
1972	2.27	2.653	2.994	2.872	2.795	2.712	2.586
1973	1.29	1.740	1.706	1.535	1.454	1.760	1.617
1974	2.28	2.409	2.355	2.214	2.783	2.640	2.678
1975	3.14	1.423	2.087	2.290	2.208	2.704	2.872
1976	3.03	3.316	3.099	3.157	3.061	3.237	3.125
1977	0.89	1.106	1.283	1.033	1.157	0.951	1.022
1978	2.20	2.690	2.692	2.725	2.275	2.087	2.045
1979	1.59	1.925	1.950	2.200	2.000	1.972	1.838
1980	2.19	1.036	1.404	1.680	1.756	1.445	1.871
1981	2.51	2.088	1.745	2.040	2.013	1.837	2.373
1982	2.93	2.436	2.744	2.647	3.093	2.919	2.973
1983	2.24	2.503	2.108	2.093	2.207	2.111	1.979
1984	3.04	2.336	2.021	2.015	2.077	2.253	2.210
1985	1.19	2.171	1.778	1.745	1.656	1.493	1.447
1986	1.87	1.509	1.354	1.973	1.632	1.592	1.471
1987	0.92	1.643	1.446	1.348	1.202	1.127	1.301
1988	1.00	1.325	1.364	1.350	1.457	1.383	1.484
1989	1.25	1.485	1.960	1.851	2.036	1.729	1.755
1990	1.25	1.649	1.833	1.677	1.760	1.590	1.586
1991	1.70	1.537	1.274	1.078	1.402	1.681	1.790
1992	0.94	2.149	1.656	1.519	1.310	1.279	1.147
1993	2.47	1.842	1.768	1.738	1.559	2.010	2.064
1994	1.03	2.027	1.941	2.155	1.993	1.858	1.661
1995	2.93	2.064	2.239	1.900	2.210	2.396	2.352
1996	2.85	2.327	2.479	2.605	2.423	2.385	2.631
1997	3.75	3.210	3.497	3.221	3.119	3.107	3.240
1998	2.67	2.085	2.547	2.516	2.459	2.198	2.160
1999	2.16	2.227	2.337	2.465	2.236	2.140	2.151
2000	1.01	1.391	1.421	1.502	1.455	1.307	1.333
2001	0.84	1.511	1.159	1.060	0.958	0.987	0.680
2002	1.13	1.381	1.389	1.253	1.119	1.097	0.991
2003	1.35	1.234	1.671	1.984	1.936	1.986	1.993
2004	0.94	1.639	1.385	1.437	1.109	1.078	1.060
2005	1.43	1.604	1.292	1.116	1.260	1.295	1.205
2006	1.76	2.264	2.270	2.022	2.070	2.141	2.020
2007	1.03	1.625	1.311	1.791	1.395	1.298	1.483
2008	2.28	1.963	2.106	2.086	2.078	2.113	2.128
2009	2.22	1.844	1.555	1.426	1.941	2.098	1.947
2010	2.21	1.765	1.754	1.595	1.391	1.353	1.313
2011	3.63	2.350	2.207	2.174	2.363	2.802	2.778
2012	1.63	1.457	1.361	1.447	1.614	1.562	1.472
2013	0.99	1.473	1.195	0.987	0.761	0.775	0.783
2014	2.09	1.956	1.760	2.206	2.561	2.311	2.167

Water Control Manual
 Canyon Ferry Reservoir and Dam, Montana
Regression Analysis
Forecast Results

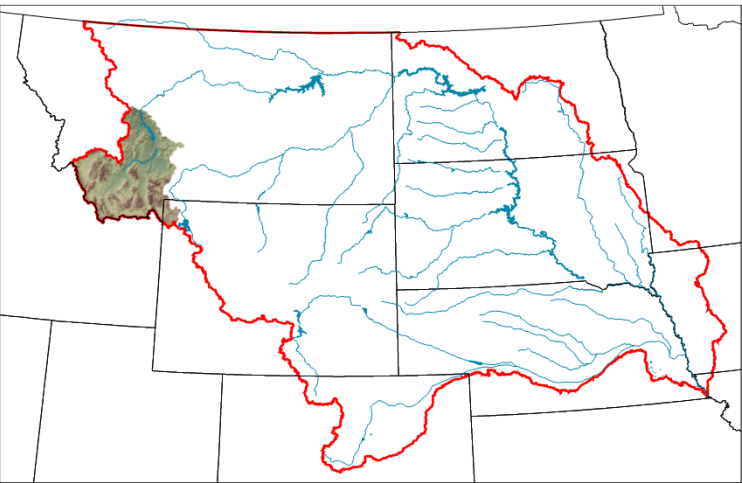
U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016

		Residuals (Natural Inflow - Forecasted)					
	Natural	maf					
Years	Inflow	Jan	Feb	Mar	Apr	May	Jun
1970	2.68	0.32	-0.32	-0.17	-0.51	-0.90	-0.96
1971	2.84	-0.08	-0.32	-0.24	-0.27	-0.43	-0.39
1972	2.27	-0.38	-0.72	-0.60	-0.52	-0.44	-0.32
1973	1.29	-0.45	-0.41	-0.24	-0.16	-0.47	-0.32
1974	2.28	-0.13	-0.08	0.06	-0.51	-0.36	-0.40
1975	3.14	1.71	1.05	0.85	0.93	0.43	0.26
1976	3.03	-0.28	-0.07	-0.12	-0.03	-0.20	-0.09
1977	0.89	-0.21	-0.39	-0.14	-0.27	-0.06	-0.13
1978	2.20	-0.49	-0.49	-0.52	-0.07	0.11	0.16
1979	1.59	-0.34	-0.36	-0.61	-0.41	-0.38	-0.25
1980	2.19	1.16	0.79	0.51	0.44	0.75	0.32
1981	2.51	0.42	0.76	0.47	0.49	0.67	0.13
1982	2.93	0.49	0.18	0.28	-0.17	0.01	-0.05
1983	2.24	-0.26	0.13	0.15	0.03	0.13	0.26
1984	3.04	0.71	1.02	1.03	0.96	0.79	0.83
1985	1.19	-0.98	-0.59	-0.56	-0.47	-0.30	-0.26
1986	1.87	0.36	0.52	-0.10	0.24	0.28	0.40
1987	0.92	-0.73	-0.53	-0.43	-0.29	-0.21	-0.39
1988	1.00	-0.32	-0.36	-0.35	-0.45	-0.38	-0.48
1989	1.25	-0.24	-0.71	-0.60	-0.79	-0.48	-0.51
1990	1.25	-0.40	-0.58	-0.42	-0.51	-0.34	-0.33
1991	1.70	0.17	0.43	0.63	0.30	0.02	-0.09
1992	0.94	-1.21	-0.71	-0.58	-0.37	-0.34	-0.20
1993	2.47	0.63	0.70	0.73	0.91	0.46	0.40
1994	1.03	-1.00	-0.91	-1.13	-0.97	-0.83	-0.63
1995	2.93	0.87	0.69	1.03	0.72	0.54	0.58
1996	2.85	0.53	0.37	0.25	0.43	0.47	0.22
1997	3.75	0.54	0.25	0.53	0.63	0.64	0.51
1998	2.67	0.58	0.12	0.15	0.21	0.47	0.51
1999	2.16	-0.07	-0.18	-0.31	-0.08	0.02	0.01
2000	1.01	-0.38	-0.41	-0.49	-0.44	-0.29	-0.32
2001	0.84	-0.67	-0.32	-0.22	-0.12	-0.15	0.16
2002	1.13	-0.25	-0.26	-0.12	0.01	0.04	0.14
2003	1.35	0.12	-0.32	-0.63	-0.59	-0.64	-0.64
2004	0.94	-0.70	-0.45	-0.50	-0.17	-0.14	-0.12
2005	1.43	-0.17	0.14	0.32	0.17	0.14	0.23
2006	1.76	-0.50	-0.51	-0.26	-0.31	-0.38	-0.26
2007	1.03	-0.59	-0.28	-0.76	-0.36	-0.27	-0.45
2008	2.28	0.31	0.17	0.19	0.20	0.16	0.15
2009	2.22	0.37	0.66	0.79	0.28	0.12	0.27
2010	2.21	0.45	0.46	0.62	0.82	0.86	0.90
2011	3.63	1.28	1.43	1.46	1.27	0.83	0.86
2012	1.63	0.17	0.27	0.18	0.02	0.07	0.16
2013	0.99	-0.48	-0.21	0.00	0.23	0.21	0.21
2014	2.09	0.14	0.33	-0.11	-0.47	-0.22	-0.07

Water Control Manual
 Canyon Ferry Reservoir and Dam, Montana
Regression Analysis
Forecast Residuals

U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016

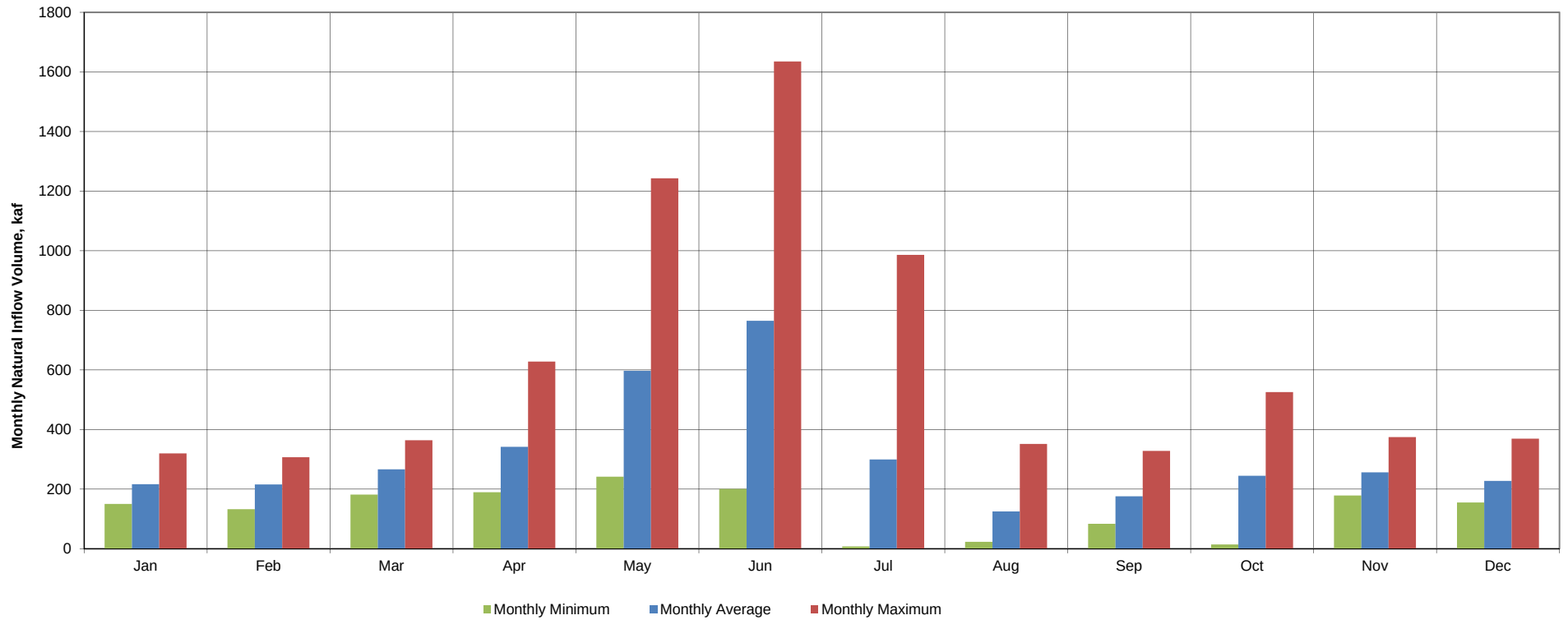
	Square of Residuals					
Years	Jan	Feb	Mar	Apr	May	Jun
1970	0.10	0.10	0.03	0.26	0.82	0.92
1971	0.01	0.10	0.06	0.07	0.18	0.15
1972	0.15	0.52	0.36	0.27	0.19	0.10
1973	0.20	0.17	0.06	0.03	0.22	0.10
1974	0.02	0.01	0.00	0.26	0.13	0.16
1975	2.93	1.10	0.72	0.86	0.19	0.07
1976	0.08	0.00	0.02	0.00	0.04	0.01
1977	0.05	0.15	0.02	0.07	0.00	0.02
1978	0.24	0.24	0.27	0.01	0.01	0.02
1979	0.11	0.13	0.37	0.17	0.15	0.06
1980	1.34	0.62	0.26	0.19	0.56	0.10
1981	0.18	0.58	0.22	0.24	0.45	0.02
1982	0.24	0.03	0.08	0.03	0.00	0.00
1983	0.07	0.02	0.02	0.00	0.02	0.07
1984	0.50	1.04	1.05	0.93	0.62	0.69
1985	0.97	0.35	0.31	0.22	0.09	0.07
1986	0.13	0.27	0.01	0.06	0.08	0.16
1987	0.53	0.28	0.19	0.08	0.04	0.15
1988	0.10	0.13	0.12	0.21	0.14	0.23
1989	0.06	0.51	0.36	0.62	0.23	0.26
1990	0.16	0.34	0.18	0.26	0.11	0.11
1991	0.03	0.18	0.39	0.09	0.00	0.01
1992	1.46	0.51	0.33	0.14	0.11	0.04
1993	0.39	0.49	0.53	0.83	0.21	0.16
1994	1.00	0.83	1.27	0.93	0.69	0.40
1995	0.75	0.48	1.06	0.52	0.29	0.34
1996	0.28	0.14	0.06	0.19	0.22	0.05
1997	0.29	0.06	0.28	0.40	0.41	0.26
1998	0.34	0.02	0.02	0.04	0.22	0.26
1999	0.00	0.03	0.09	0.01	0.00	0.00
2000	0.14	0.17	0.24	0.19	0.09	0.10
2001	0.46	0.10	0.05	0.01	0.02	0.02
2002	0.06	0.07	0.01	0.00	0.00	0.02
2003	0.01	0.10	0.40	0.34	0.40	0.41
2004	0.49	0.20	0.25	0.03	0.02	0.01
2005	0.03	0.02	0.10	0.03	0.02	0.05
2006	0.25	0.26	0.07	0.10	0.14	0.07
2007	0.35	0.08	0.58	0.13	0.07	0.20
2008	0.10	0.03	0.04	0.04	0.03	0.02
2009	0.14	0.44	0.63	0.08	0.01	0.07
2010	0.20	0.21	0.38	0.67	0.74	0.81
2011	1.65	2.04	2.13	1.62	0.69	0.73
2012	0.03	0.07	0.03	0.00	0.00	0.03
2013	0.23	0.04	0.00	0.05	0.05	0.04
2014	0.02	0.11	0.01	0.22	0.05	0.01
SSE	16.85	13.38	13.68	11.48	8.77	7.60
MSE	0.38	0.30	0.31	0.26	0.20	0.17
Std Err	0.62	0.55	0.56	0.51	0.45	0.42
R^2	0.42	0.54	0.53	0.61	0.70	0.74
Water Control Manual Canyon Ferry Reservoir and Dam, Montana Regression Analysis Squares of Residuals U. S. Army Engineer District, Omaha Corps of Engineers, Omaha, Nebraska December 2016						



U.S. Army Engineers District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

Plate E-VII-1

**Canyon Ferry Reservoir
Historic Monthly Natural Inflow 1954-2014**



Source: USBR Hydromet

Prepared By: AF
Reviewed By: JB

Water Control Manual
Canyon Ferry Reservoir and Dam, Montana
**Historic Monthly Minimum, Maximum
and Mean Natural Inflow Volume
1954-2014**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

EXHIBIT VIII

DETERMINATION OF SEASONAL FLOOD CONTROL STORAGE REQUIREMENTS

CANYON FERRY DAM AND RESERVOIR

EXHIBIT VIII
DETERMINATION OF SEASONAL
FLOOD CONTROL STORAGE REQUIREMENTS
CANYON FERRY DAM AND RESERVOIR

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DETERMINATION OF SEASONAL
FLOOD CONTROL STORAGE REQUIREMENTS
CANYON FERRY DAM AND RESERVOIR

1. General. Canyon Ferry Reservoir joint use storage space (a total of 794,289 acre-feet (af) between elevations 3770.0 and 3797.0 feet) will be vacated for flood control purposes to store runoff from the upcoming mountain snowmelt, provided it can be reasonably assured of refill prior to the end of the snowmelt period while conservation release requirements are satisfied.
2. Forecast Accuracy. Long-term runoff forecasting is not an exact science. The April-July inflow volume forecast uses the best data available. The April-July inflow volume forecast equations were developed based on historical data and contain some degree of uncertainty. Therefore, determining the amount of vacated space needed to control flooding in any given year also contains some uncertainty. The April-July inflow volume forecast, outlined in Exhibit VII, is initially made on January 1 and then updated monthly with the most up-to-date information. The uncertainty, sometimes referred to as error allowance, in making this inflow volume forecast will, in some years, result in the observed April-July inflow being much greater or much less than the forecast April-July inflow volume.
3. Reasonable Assurance of Refill. The evacuation of joint use storage for flood control purposes is designed such that there is a reasonable assurance that refill of the conservation/joint use zone will occur. To limit the impact of the April-July inflow volume forecast uncertainty to non-flood control purposes, an assured (85-90 percent exceedence) inflow volume forecast is made. Reclamation determines and provides a Canyon Ferry release volume estimate for the same 4-month period. How those two estimates compare with the available storage in Canyon Ferry determines the required joint use zone evacuation.
4. Assured Inflow. The established criteria for reasonable assurance of filling the joint use storage is satisfied by using an assured or dependable forecast that will be exceeded during 85-90 percent of the years. The forecast of April-July natural inflow is made using the seasonal runoff forecast procedure described in Exhibit VII. The April-July assured inflow forecast is determined by applying a volume deviation factor (or forecast error allowance) to April-July inflow volume calculated in Exhibit VII. The volume deviation factors, which are different for each month, are sometimes referred to as the assured inflow factors. They were determined by analyzing historical April-July forecasted and observed inflow volumes. The monthly assured inflow factors are outlined in Table 1 and were mutually agreed upon by the Corps and Reclamation. Plates

E-VIII-1 through E-VIII-6 outline how the assured inflow factors were determined for January 1 through June 1, respectively.

Table 1 - Assured Inflow Factors
(Volume Deviation Factors)

January 1	680,000 af
February 1	600,000 af
March 1	600,000 af
April 1	510,000 af
May 1	460,000 af
June 1	403,000 af

As the runoff season advances the assured inflow factor becomes progressively less. This is because more observed data has become available and the forecast has become more accurate. These factors represent the volume to be subtracted from the most probable actual April-July inflow volume, as determined in Exhibit VII, to obtain the assured forecast volume.

5. Estimated Outflow. On or about the first of each month, from January 1 through July 1, Reclamation will furnish the Corps an estimate for April-July conservation release requirements based on power generation and Helena Valley requirements. The release estimate is provided in Reclamation's monthly water supply outlook and projected operations plan for Canyon Ferry. An example of Reclamation's operations plan is shown on Plate E-VIII-9, which displays the March 1, 2014 operations plan. The operations plan release estimate should be used as the conservation release whenever available and relevant. In the absence of recent Reclamation estimates, Table 2 shows estimated maximum monthly conservation releases during the runoff period.

Table 2 - Maximum Monthly Conservation Releases
(Volume and Rate)

April	390,000 af	6,550 cfs/day
May	420,000 af	6,830 cfs/day
June	380,000 af	6,390 cfs/day
July	360,000 af	5,850 cfs/day

The monthly release estimates in Table 2 include water that is taken from the reservoir to supply the Helena Valley Unit (HVV). The amount of water diverted to supply the HVV will range from 0 cfs to 750 cfs, depending on the time of year and requirement. The releases in Table 2 are primarily for power requirements; the actual releases are based on pool levels anticipated during each month. Table 3 lists the maximum Canyon Ferry power plant releases. Power plant releases are presently expected to satisfy all downstream requirements from the river.

Table 3 - Maximum Power Plant Releases

Elevation (feet)	Discharge (cfs)
3800	5,100
3790	5,600
3780	6,000
3770	6,300

6. Determining Storage Requirements. An example is provided to demonstrate how the flood control storage requirement is determined. Refer to Exhibit VII for additional information about determining the April-July inflow volume forecast.

Table 4 lists the monthly distribution percentages, based on 1954-2014 observed inflows, which are used when preparing determining the joint use storage evacuation and utilized in Table 5.

Table 4 – Monthly Percentages of Observed April-July Inflow Volume

Period	Percentage of Inflow			
	April	May	June	July
April – July	17	30	38	15
May – July		36	46	18
June – July			72	28
July				100

After the water manager has determined the most probable April-July inflow volume, the water manager should then use Table 5 to determine the necessary evacuation of the joint use zone. Table 5 is available in the Corps and Reclamation's electronic file systems. For some, the logic and methods used in these tables is better understood in the electronic version. A detailed explanation of the volume forecast and a step-by-step look at Table 5 is detailed in an example.

The following example is provided to demonstrate the regulation of the joint use storage zone. The example scenario details the regulation of the spring 2014 runoff season. Plate E-VIII-7 and E-VIII-8 graphically illustrates the forecast regulation. Refer to Plate 7-6 in the Water Control Manual for a graphical representation of how the joint use zone is used for flood control.

Conditions on January 1:

Pool elevation = 3783.8 feet; 421,000 af of joint use space vacant (3783.8 feet to 3979 feet).

January 1 forecast: The April-July most probable natural runoff forecast is 1,849,000 af calculated using the method in Exhibit VII. After subtracting the

expected holdouts (125,000 af), the most probable actual runoff forecast is 1,724,000 af. After subtracting assured factor (680,000 af), the result is an April-July assured actual inflow forecast of 1,044,000 af. Estimated April inflows (177,000 af) subtracted from the assured actual April-July runoff produces the assured inflow May-July forecast of 867,000 af. Reclamation provided the Corps a forecast May-July total release of 1,150,000 af. Since May-July planned releases of 1,150,000 af are greater than the May-July assured actual inflow of 867,000 af, no evacuation of joint use zone was required. Regarding replacement storage, 421,000 of the 445,000 af of potential replacement storage was vacated as part of Reclamation's planned operation. No request for replacement storage was made by the Corps.

February 1 forecast: Pool elevation was 3784.3 feet. The most probable natural April-July inflow forecast is 1,581,000 af. After adjustment for holdouts (125,000 af), the assured factor (600,000 af) and the estimated April inflows (146,000), the May-July assured inflow forecast was 710,000 af. Reclamation's forecast May-July releases of 990,000 af are higher than the assured inflow, thus no evacuation of the joint use zone was required. No request for replacement storage was made by the Corps.

March 1 forecast: The pool elevation was 3783.3 feet. Large increases in mountain snowpack accumulation during February results in a most probable natural April-July inflow forecast of 2,053,000 af. After adjustment for holdouts (125,000 af), the assured factor (600,000 af) and the estimated April inflows (226,000), the May-July assured inflow forecast was 1,102,000 af. Reclamation's planned May-July maximum conservation and hydropower releases of 1,160,000 af are higher than the assured inflow, thus no evacuation of the joint use zone was required. Reclamation's March 1 forecasted release volume for May-July was actually 1,180,000 af, further decreasing risk of overwhelming the joint use storage zone. A plot of this planned regulation is shown in Plate E-VIII-7.

April 1 forecast: The pool elevation was 3781.9 feet. The mountain snowpack accumulation continued to increase during March at a higher-than-normal rate and resulted in a most probable natural April-July inflow forecast of 2,514,000 af. After adjustment for holdouts (125,000 af), the assured factor (510,000 af) and the estimated April inflow (319,000 af), the May-July assured inflow forecast was 1,560,000 af. This inflow volume exceeded the maximum May-July conservation and hydropower release (1,160,000 af) and required Reclamation to vacate at least 400,000 af in the joint use storage zone by May 1. At pool elevation 3781.9 feet, 488,000 af of joint use storage was available, so no additional evacuation was required. If 400,000 af of joint use storage was not vacated or was not planned to be vacated, planned releases would need to be increased above the maximum May-July conservation release to assure the joint use storage is available to mitigate flood risk.

May 1 forecast: The pool elevation was 3778.8 feet, 568,000 af of joint use storage available. Mountain snowpack peaked in early April, 132 percent of normal and resulted in a most probable natural April-July inflow forecast of 2,207,000 af. After adjustment for holdouts (125,000 af) and the assured factor (460,000 af), the May 1 April-July assured actual inflow forecast was 1,622,000 af, which included observed April runoff of 340,000 af. The observed April inflow of 340,000 af was subtracted from this volume to produce a May-July assured inflow of 1,282,000 af. This volume exceeded the maximum May-July conservation and hydropower release (1,160,000 af) and required Reclamation to evacuate 122,000 af in the joint use storage zone by May 1. As of May 1 568,000 af of storage in the joint use zone was evacuated, so no additional evacuation was necessary. Determination of the June 1 requirement involves subtracting the expected May runoff from the 1,282,000 af May-July forecast. Historically, 36 percent of the observed May-July runoff occurs during May and 64 percent of the observed May-July runoff occurs during June and July. The June-July assured forecasted inflow as of May 1 was 820,000 af, or 64 percent of the May-July forecast. This would require 80,000 af of joint use storage available on June 1, after subtracting the maximum June-July conservation and hydropower release of 740,000 af. As of May 1, Reclamations operation plans had more than the required 80,000 af of joint use zone evacuated and no increased releases were necessary.

June 1 forecast: The pool elevation was 3784.8 feet, 313,200 af of joint use storage available. The June 1 most probable natural April-July inflow was 2,067,000 af. After adjustment for holdouts (125,000 af) and the assured factor (400,000 af), the June 1 assured actual forecast was 1,542,000 af, which included observed April and May runoff of 340,000 af and 600,000 af, respectively. The observed April and May inflows of 940,000 af were subtracted from the assured actual forecast resulting in a June-July assured inflow forecast of 602,000 af. Reclamation's planned June-July maximum conservation and hydropower releases of 740,000 af was greater than assured inflow, thus there was no required joint use storage evacuation for 1 June. Historically, 72 percent of the June-July runoff occurs during June and 28 percent of the June-July runoff occurs during July. The July assured forecasted inflow as of June 1 was 170,000 af, or 28 percent of the June-July forecast. Since Reclamation's planned June release volume of 360,000 af is greater than the July assured forecast inflow of 170,000 af, no joint use storage evacuation was required by July 1.

July 1 forecast: Pool elevation was 3797.3 feet, 0.3 feet into the exclusive flood control zone. Canyon Ferry's joint use pool filled on June 30 and began storing water in the exclusive flood control zone after late June rainfall increased inflows to Canyon Ferry. At that time, releases were adjusted to evacuate water from the exclusive flood control zone as downstream

conditions permitted. The pool peaked on 6 July at elevation 3797.7 feet, 0.7 foot into the 3-foot exclusive flood control pool. Normally by July 1, 85% of the April-July runoff has occurred and the snowmelt runoff contribution has peaked in all years of the record. For these reasons a multiple linear regression analysis to predict the additional expected runoff in July would provide minimal foresight into the upcoming runoff. It is recommended July's runoff be forecasted by a recession of peak inflow forecast or hydrologic modeling. The recession inflow forecast procedures detailed in Sections 6-02.c, 7-05.f.1 and Plate 6-1 were used. The July 1 inflow at Canyon Ferry was approximately 9,500 cfs. Applying a recession constant of 0.93 to this flow for the remainder of the month produced a July inflow of 264,000 af. The July forecasted inflow was then added to the observed April-June inflow of 1,700,00 maf to produce a Most Probable Natural April-July forecast of 1,964,000 af. An assured factor of 0 is used for July under these forecasting conditions, since any opportunity to further draft in the joint use pool before July 1 have expired. The holdouts were also set to zero as the effects of holdouts exist in the measured inflow after March 31. The remaining July forecasted inflow was less than the maximum July conservation and hydropower release, so no additional release was required. When the pool level reached 3797 feet on July 17, Reclamation resumed regulation responsibility of Canyon Ferry.

August through December: Releases during this 5-month drier period were primarily made through the power plant to maximize hydroelectric power generation. Releases made to meet non-flood control purposes resulted in the pool level declining about 7 feet to elevation 3788.4 feet on December 31.

The following assumptions were made in the above example:

- 1) the actual 2014 monthly Canyon Ferry inflows were used;
- 2) monthly outflows during January, February and March and month end pool storage through March were as actually occurred;
- 3) the actual 2014 forecast of seasonal runoff was used;
- 4) to determine joint use storage requirements, conservation release estimates for the April-July period found in Exhibit VIII were used along with an assumed holdout from Lima, Hebgen and Clark Canyon of 125,000 af**;
- 5) drawdown of the replacement joint use storage zone started on August 1 with a following March 1 target date for total evacuation.

The evacuation release rate (power plant capacity release – 5,500-5,800 cfs) is maintained until a January 1 forecast is made to determine actual requirements. Reclamation will sometimes set the release rate below 5,500 cfs to assure the proper joint use level is achieved. Storage requirements are determined as the difference between assured inflow and conservation release for the remaining April-July period. Exhibit VIII presents the technique used to determine assured inflows. Table 8-4 illustrates how joint use storage space requirements were determined. Actual regulation during

the 2014 runoff season is shown in Plate E-VIII-8. The differences between the forecasted releases and observed releases stemmed primarily from the inability to predict the exact runoff pattern, not having all data readily available to make the forecast on the first day of the month, and not having the hindsight element afforded in the example.

** 125,000 af is an assumed holdout from Lima, Hebgen and Clark Canyon estimated by the Corps and Reclamation. These reservoir levels should be checked to verify expected holdouts.

7. Other Considerations.

- a. Some factors involved in assured storage refill are as follows. By using an assured inflow forecast there exists an 85-90 percent chance that inflow will be greater than the forecast, thereby resulting in an 85-90 percent chance that releases will have to be increased above conservation requirements in order to maintain evacuated flood control storage space in the joint use zone. However, releases necessary for conservation purposes are generally much less than those which can be tolerated without contributing to flood damages. For example conservation requirements may be satisfied with a release of 5000 cfs while releases up to 15,000 cfs may be made without contributing to downstream flooding. An increase of releases in the approximate range of 5000 cfs to 15,000 cfs will be required during 85-90 percent of the years when it becomes apparent that increasing releases are necessary to maintain evacuated joint use storage space. As an example, suppose a negative forecast error occurs resulting in the actual inflow being 600,000 af more than the forecasted assured inflow. Then this amount (600,000 af) will have to be released during the April-July period, in addition to conservation release requirements, in order to keep the pool level within the joint use zone. Maintaining joint use evacuation requirements throughout the May-July period will tend to spread this volume, and the resultant releases, over the entire period. However, in the event that non-damaging stages below the dam cannot be maintained and still keep the pool in the joint use zone, the exclusive flood control zone will have to be utilized. When the joint use flood control pool becomes filled, Plate 7-2 will be used as a guide to avoid overtopping the dam.
- b. Releases exceeding required conservation releases during the April-July period are considered flood control releases.
- c. Forecasts made prior to May 1 will determine joint use space requirements on May 1. Any evacuation of space needed to achieve this will be made by Reclamation's Regional Director in a gradual and orderly manner.

- d. On or after May 1, if pool levels encroach into the evacuated space required for flood control as determined from the techniques shown in Table 5, the Corps' District Engineer will determine flood control releases. In this event, the District Engineer will determine what releases above current conservation requirements are needed based on the latest Apr-July inflow forecast and storage levels. During May, the Corps shall schedule flood control releases, which may be sometimes described as excess conservation spill necessary to target the June 1 requirement, to occur uniformly throughout the month. After June 1, the Corps shall schedule flood control releases necessary to meet the July 1 requirement as rapidly as downstream conditions permit. The previously described scenario from prior to May 1 through July 1 assumes the flood targets outlined in this manual are not exceeded during that period.
- e. Once the peak inflow has occurred, refer to Section 7-05.f. for release and elevation schedules that may be utilized for refill of the joint use zone.
- f. In the event that replacement regulation is required (see Section 7-05.d.4), storage space assured of fill during the forecast period will be vacated by March 1.

Table 5
Canyon Ferry Joint Use Requirements Example
(Using 2014 Data and Forecasts)

Be sure to work down each column. Following the 1st of each month, data can be filled in for that month.

Canyon Ferry April-July Forecast:		Date of Forecast						
		1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul
Most Probable Natural:		1.849	1.581	2.053	2.514	2.207	2.067	1.964
Less Holdouts:		0.125	0.125	0.125	0.125	0.125	0.125	0
Most Probable Actual:		1.724	1.456	1.928	2.389	2.082	1.942	1.964
Assured Factor		0.68	0.6	0.6	0.51	0.46	0.4	0
Assured Actual		1.044	0.856	1.328	1.879	1.622	1.542	1.964
Measured Inflow After 31 March						0.34	0.94	1.70
Remaining April-July Assured		1.044	0.856	1.328	1.879	1.28	0.60	0.26
Estimated Apr Most Probable Actual Inflow (17% of Apr-Jul)		0.18	0.15	0.23	0.319			
Assured Inflow May-July		0.87	0.71	1.10	1.56	1.28		
Conservation Requirements May-July		1.15	0.99	1.16	1.16	1.16		
1 May Joint use Requirement		0.00	0.00	0.00	0.40	0.12		
1 May Elevation Requirement		3797.0	3797.0	3797.0	3784.5	3793.2		
Assured Inflow June-July						0.82	0.60	
Conservation Requirements June-July						0.74	0.74	
1 June Joint Use Requirement						0.08	0	
1 June Elevation Requirement						3794.5	3797.0	
Assured Inflow July							0.17	0.26
Conservation Requirements July							0.36	0.36
1 July Joint Use Requirement							0.00	0.00
1 July Elevation Requirement							3797.0	3797.0

Notes:

July forecast not produced in 2014. Inflows peaked on May 30th. Therefore, June forecast was used as the 1 July forecast.
Holdouts of 125,000 af are assumed. Calculate expected reservoir holdout from Clark Canyon, Lima and Hebgen.

*64% of May-Jul Assured Flow (64% x 1.28)

**28% of Jun-Jul Assured Flow (28% x 0.60)

***In event the runoff pattern occurs significantly different than anticipated, additional (middle of the month) forecast of remaining runoff should be made to determine new space requirements to protect both the flood control and conservation (assurance of joint use fill) usage of the joint use zone.

Note: Requirements between values are estimated by the District Engineer, normally by straight line interpolation.

Table 5 is generated from a Microsoft Excel spreadsheet and is used to calculate the drawdown requirement. This spreadsheet is maintained by the Omaha District and is available upon request.

Color Codes

	User Entered
	Static Data from WCM
	Calculated Value
	Leave Blank

	Col 1 - Observed	Col 2- Forecast	Col 3	Col 4	Col 5	
	CAFÉ	CAFÉ	Forecast -	Obs - Forecast	Exceedance	
	Apr-Jul Inflow	Apr-Jul Inflow	Assured	- Assured	Occurrences	
Years	Natural (maf)	Natural (maf)	(maf)	(maf)		
1970	2.68	2.36	1.68	1.00	Exceeded	
1971	2.84	2.92	2.24	0.60	Exceeded	
1972	2.27	2.65	1.97	0.30	Exceeded	
1973	1.29	1.74	1.06	0.23	Exceeded	
1974	2.28	2.41	1.73	0.55	Exceeded	
1975	3.14	1.42	0.74	2.39	Exceeded	
1976	3.03	3.32	2.64	0.40	Exceeded	
1977	0.89	1.11	0.43	0.47	Exceeded	
1978	2.20	2.69	2.01	0.19	Exceeded	
1979	1.59	1.93	1.25	0.34	Exceeded	
1980	2.19	1.04	0.36	1.84	Exceeded	
1981	2.51	2.09	1.41	1.10	Exceeded	
1982	2.93	2.44	1.76	1.17	Exceeded	
1983	2.24	2.50	1.82	0.42	Exceeded	
1984	3.04	2.34	1.66	1.39	Exceeded	
1985	1.19	2.17	1.49	-0.30	Not Exceeded	
1986	1.87	1.51	0.83	1.04	Exceeded	
1987	0.92	1.64	0.96	-0.05	Not Exceeded	
1988	1.00	1.32	0.64	0.36	Exceeded	
1989	1.25	1.48	0.80	0.44	Exceeded	
1990	1.25	1.65	0.97	0.28	Exceeded	
1991	1.70	1.54	0.86	0.85	Exceeded	
1992	0.94	2.15	1.47	-0.53	Not Exceeded	
1993	2.47	1.84	1.16	1.31	Exceeded	
1994	1.03	2.03	1.35	-0.32	Not Exceeded	
1995	2.93	2.06	1.38	1.55	Exceeded	
1996	2.85	2.33	1.65	1.21	Exceeded	
1997	3.75	3.21	2.53	1.22	Exceeded	
1998	2.67	2.09	1.41	1.26	Exceeded	
1999	2.16	2.23	1.55	0.61	Exceeded	
2000	1.01	1.39	0.71	0.30	Exceeded	
2001	0.84	1.51	0.83	0.01	Exceeded	
2002	1.13	1.38	0.70	0.43	Exceeded	
2003	1.35	1.23	0.55	0.80	Exceeded	
2004	0.94	1.64	0.96	-0.02	Not Exceeded	
2005	1.43	1.60	0.92	0.51	Exceeded	
2006	1.76	2.26	1.58	0.18	Exceeded	
2007	1.03	1.63	0.95	0.09	Exceeded	
2008	2.28	1.96	1.28	0.99	Exceeded	
2009	2.22	1.84	1.16	1.05	Exceeded	
2010	2.21	1.77	1.09	1.13	Exceeded	
2011	3.63	2.35	1.67	1.96	Exceeded	
2012	1.63	1.46	0.78	0.85	Exceeded	
2013	0.99	1.47	0.79	0.20	Exceeded	
2014	2.09	1.96	1.28	0.82	Exceeded	
Note: A negative Forecast - Assured - Obs (Column 4) value indicates the observed runoff did not exceed the Forecasted Assured (factored) inflow (Column 3).						
			Water Control Manual			
	STATS		Canyon Ferry Reservoir and Dam, Montana			
	Exceedance (assured)		April-July Inflow Forecast Assured Fill Analysis (Jan 1 Forecast)			
	Factor:	0.68 maf				
	Years in Record:	45	U. S. Army Engineer District, Omaha			
	Years Forecast					
	Exceeded:	40	Corps of Engineers, Omaha, Nebraska			
	Exceedance					
	Probability:	89%	December 2016			
						Plate E-VIII-1

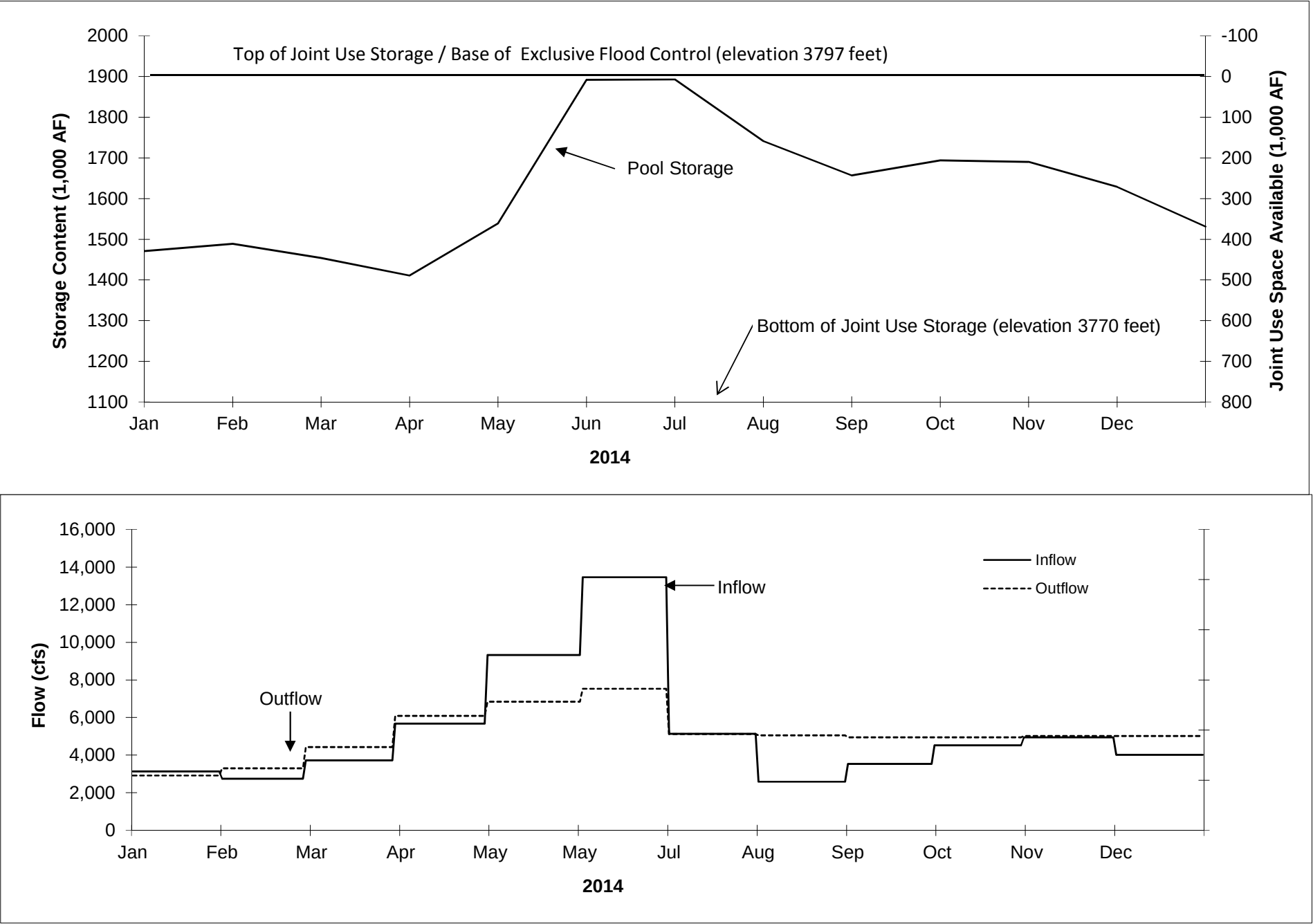
	Col 1 - Observed	Col 2- Forecast	Col 3	Col 4	Col 5	
	CAFÉ	CAFÉ	Forecast -	Obs - Forecast	Exeedance	
	Apr-Jul Inflow	Apr-Jul Inflow	Assured	- Assured	Occurrences	
Years	Natural (maf)	Natural (maf)	(maf)	(maf)		
1970	2.68	2.99	2.39	0.28	Exceeded	
1971	2.84	3.16	2.56	0.28	Exceeded	
1972	2.27	2.99	2.39	-0.12	Not Exceeded	
1973	1.29	1.71	1.11	0.19	Exceeded	
1974	2.28	2.36	1.76	0.52	Exceeded	
1975	3.14	2.09	1.49	1.65	Exceeded	
1976	3.03	3.10	2.50	0.53	Exceeded	
1977	0.89	1.28	0.68	0.21	Exceeded	
1978	2.20	2.69	2.09	0.11	Exceeded	
1979	1.59	1.95	1.35	0.24	Exceeded	
1980	2.19	1.40	0.80	1.39	Exceeded	
1981	2.51	1.74	1.14	1.36	Exceeded	
1982	2.93	2.74	2.14	0.78	Exceeded	
1983	2.24	2.11	1.51	0.73	Exceeded	
1984	3.04	2.02	1.42	1.62	Exceeded	
1985	1.19	1.78	1.18	0.01	Exceeded	
1986	1.87	1.35	0.75	1.12	Exceeded	
1987	0.92	1.45	0.85	0.07	Exceeded	
1988	1.00	1.36	0.76	0.24	Exceeded	
1989	1.25	1.96	1.36	-0.11	Not Exceeded	
1990	1.25	1.83	1.23	0.02	Exceeded	
1991	1.70	1.27	0.67	1.03	Exceeded	
1992	0.94	1.66	1.06	-0.11	Not Exceeded	
1993	2.47	1.77	1.17	1.30	Exceeded	
1994	1.03	1.94	1.34	-0.31	Not Exceeded	
1995	2.93	2.24	1.64	1.29	Exceeded	
1996	2.85	2.48	1.88	0.97	Exceeded	
1997	3.75	3.50	2.90	0.85	Exceeded	
1998	2.67	2.55	1.95	0.72	Exceeded	
1999	2.16	2.34	1.74	0.42	Exceeded	
2000	1.01	1.42	0.82	0.19	Exceeded	
2001	0.84	1.16	0.56	0.28	Exceeded	
2002	1.13	1.39	0.79	0.34	Exceeded	
2003	1.35	1.67	1.07	0.28	Exceeded	
2004	0.94	1.38	0.78	0.15	Exceeded	
2005	1.43	1.29	0.69	0.74	Exceeded	
2006	1.76	2.27	1.67	0.09	Exceeded	
2007	1.03	1.31	0.71	0.32	Exceeded	
2008	2.28	2.11	1.51	0.77	Exceeded	
2009	2.22	1.56	0.96	1.26	Exceeded	
2010	2.21	1.75	1.15	1.06	Exceeded	
2011	3.63	2.21	1.61	2.03	Exceeded	
2012	1.63	1.36	0.76	0.87	Exceeded	
2013	0.99	1.19	0.59	0.39	Exceeded	
2014	2.09	1.76	1.16	0.93	Exceeded	
	Note: A negative Forecast - Assured - Obs (Column 4) value indicates the observed runoff did not exceed the Forecasted Assured (factored) inflow (Column 3).					
			Water Control Manual Canyon Ferry Reservoir and Dam, Montana April-July Inflow Forecast Assured Fill Analysis (Feb 1 Forecast) U. S. Army Engineer District, Omaha Corps of Engineers, Omaha, Nebraska December 2016			
	STATS					
	Exeedance (assured)					
	Factor:	0.6 maf				
	Years in Record:	45				
	Years Forecast					
	Exceeded:	41				
	Exeedance					
	Probability:	91%				
						Plate E-VIII-2

	Col 1 - Observed	Col 2- Forecast	Col 3	Col 4	Col 5	
	CAFÉ	CAFÉ	Forecast -	Obs -Forecast	Exeedance	
	Apr-Jul Inflow	Apr-Jul Inflow	Assured	- Assured	Occurrences	
Years	Natural (maf)	Natural (maf)	(maf)	(maf)		
1970	2.68	2.84	2.24	0.43	Exceeded	
1971	2.84	3.07	2.47	0.36	Exceeded	
1972	2.27	2.87	2.27	0.00	Not Exceeded	
1973	1.29	1.53	0.93	0.36	Exceeded	
1974	2.28	2.21	1.61	0.66	Exceeded	
1975	3.14	2.29	1.69	1.45	Exceeded	
1976	3.03	3.16	2.56	0.48	Exceeded	
1977	0.89	1.03	0.43	0.46	Exceeded	
1978	2.20	2.73	2.13	0.08	Exceeded	
1979	1.59	2.20	1.60	-0.01	Not Exceeded	
1980	2.19	1.68	1.08	1.11	Exceeded	
1981	2.51	2.04	1.44	1.07	Exceeded	
1982	2.93	2.65	2.05	0.88	Exceeded	
1983	2.24	2.09	1.49	0.75	Exceeded	
1984	3.04	2.01	1.41	1.63	Exceeded	
1985	1.19	1.75	1.15	0.04	Exceeded	
1986	1.87	1.97	1.37	0.50	Exceeded	
1987	0.92	1.35	0.75	0.17	Exceeded	
1988	1.00	1.35	0.75	0.25	Exceeded	
1989	1.25	1.85	1.25	0.00	Not Exceeded	
1990	1.25	1.68	1.08	0.18	Exceeded	
1991	1.70	1.08	0.48	1.23	Exceeded	
1992	0.94	1.52	0.92	0.02	Exceeded	
1993	2.47	1.74	1.14	1.33	Exceeded	
1994	1.03	2.15	1.55	-0.53	Not Exceeded	
1995	2.93	1.90	1.30	1.63	Exceeded	
1996	2.85	2.61	2.01	0.85	Exceeded	
1997	3.75	3.22	2.62	1.13	Exceeded	
1998	2.67	2.52	1.92	0.75	Exceeded	
1999	2.16	2.47	1.87	0.29	Exceeded	
2000	1.01	1.50	0.90	0.11	Exceeded	
2001	0.84	1.06	0.46	0.38	Exceeded	
2002	1.13	1.25	0.65	0.48	Exceeded	
2003	1.35	1.98	1.38	-0.03	Not Exceeded	
2004	0.94	1.44	0.84	0.10	Exceeded	
2005	1.43	1.12	0.52	0.92	Exceeded	
2006	1.76	2.02	1.42	0.34	Exceeded	
2007	1.03	1.79	1.19	-0.16	Not Exceeded	
2008	2.28	2.09	1.49	0.79	Exceeded	
2009	2.22	1.43	0.83	1.39	Exceeded	
2010	2.21	1.59	0.99	1.22	Exceeded	
2011	3.63	2.17	1.57	2.06	Exceeded	
2012	1.63	1.45	0.85	0.78	Exceeded	
2013	0.99	0.99	0.39	0.60	Exceeded	
2014	2.09	2.21	1.61	0.49	Exceeded	
Note: A negative Forecast - Assured - Obs (Column 4) value indicates the observed runoff did not exceed the Forecasted Assured (factored) inflow (Column 3).						
			Water Control Manual			
	STATS		Canyon Ferry Reservoir and Dam, Montana			
	Exeedance (assured)		April-July Inflow Forecast Assured Fill Analysis (March 1 Forecast)			
	Factor:	0.6 maf				
	Years in Record:	45				
	Years Forecast		U. S. Army Engineer District, Omaha Corps of Engineers, Omaha, Nebraska December 2016			
	Exceeded:	39				
	Exeedance					
	Probability:	87%				
						Plate E-VIII-3

	Col 1 - Observed	Col 2- Forecast	Col 3	Col 4	Col 5	
	CAFÉ	CAFÉ	Forecast -	Obs - Forecast	Exeedance	
	Apr-Jul Inflow	Apr-Jul Inflow	Assured	- Assured	Occurrences	
Years	Natural (maf)	Natural (maf)	(maf)	(maf)		
1970	2.68	3.19	2.68	0.00	Not Exceeded	
1971	2.84	3.10	2.59	0.24	Exceeded	
1972	2.27	2.79	2.28	-0.01	Not Exceeded	
1973	1.29	1.45	0.94	0.35	Exceeded	
1974	2.28	2.78	2.27	0.00	Exceeded	
1975	3.14	2.21	1.70	1.44	Exceeded	
1976	3.03	3.06	2.55	0.48	Exceeded	
1977	0.89	1.16	0.65	0.24	Exceeded	
1978	2.20	2.27	1.76	0.44	Exceeded	
1979	1.59	2.00	1.49	0.10	Exceeded	
1980	2.19	1.76	1.25	0.95	Exceeded	
1981	2.51	2.01	1.50	1.00	Exceeded	
1982	2.93	3.09	2.58	0.34	Exceeded	
1983	2.24	2.21	1.70	0.54	Exceeded	
1984	3.04	2.08	1.57	1.47	Exceeded	
1985	1.19	1.66	1.15	0.04	Exceeded	
1986	1.87	1.63	1.12	0.75	Exceeded	
1987	0.92	1.20	0.69	0.22	Exceeded	
1988	1.00	1.46	0.95	0.06	Exceeded	
1989	1.25	2.04	1.53	-0.28	Not Exceeded	
1990	1.25	1.76	1.25	0.00	Exceeded	
1991	1.70	1.40	0.89	0.81	Exceeded	
1992	0.94	1.31	0.80	0.14	Exceeded	
1993	2.47	1.56	1.05	1.42	Exceeded	
1994	1.03	1.99	1.48	-0.46	Not Exceeded	
1995	2.93	2.21	1.70	1.23	Exceeded	
1996	2.85	2.42	1.91	0.94	Exceeded	
1997	3.75	3.12	2.61	1.14	Exceeded	
1998	2.67	2.46	1.95	0.72	Exceeded	
1999	2.16	2.24	1.73	0.43	Exceeded	
2000	1.01	1.46	0.95	0.07	Exceeded	
2001	0.84	0.96	0.45	0.39	Exceeded	
2002	1.13	1.12	0.61	0.52	Exceeded	
2003	1.35	1.94	1.43	-0.08	Not Exceeded	
2004	0.94	1.11	0.60	0.34	Exceeded	
2005	1.43	1.26	0.75	0.68	Exceeded	
2006	1.76	2.07	1.56	0.20	Exceeded	
2007	1.03	1.40	0.89	0.15	Exceeded	
2008	2.28	2.08	1.57	0.71	Exceeded	
2009	2.22	1.94	1.43	0.79	Exceeded	
2010	2.21	1.39	0.88	1.33	Exceeded	
2011	3.63	2.36	1.85	1.78	Exceeded	
2012	1.63	1.61	1.10	0.53	Exceeded	
2013	0.99	0.76	0.25	0.74	Exceeded	
2014	2.09	2.56	2.05	0.04	Exceeded	
	Note: A negative Forecast - Assured - Obs (Column 4) value indicates the observed runoff did not exceed the Forecasted Assured (factored) inflow (Column 3).					
			Water Control Manual Canyon Ferry Reservoir and Dam, Montana April-July Inflow Forecast Assured Fill Analysis (April 1 Forecast) U. S. Army Engineer District, Omaha Corps of Engineers, Omaha, Nebraska December 2016			
	STATS					
	Exeedance (assured)					
	Factor:	0.51 maf				
	Years in Record:	45				
	Years Forecast					
	Exceeded:	40				
	Exeedance					
	Probability:	89%				
						Plate E-VIII-4

	Col 1 - Observed	Col 2- Forecast	Col 3	Col 4	Col 5	
	CAFÉ	CAFÉ	Forecast -	Obs - Forecast	Exeedance	
	Apr-Jul Inflow	Apr-Jul Inflow	Assured	- Assured	Occurrences	
Years	Natural (maf)	Natural (maf)	(maf)	(maf)		
1970	2.68	3.58	3.12	-0.44	Not Exceeded	
1971	2.84	3.26	2.80	0.03	Exceeded	
1972	2.27	2.71	2.25	0.02	Exceeded	
1973	1.29	1.76	1.30	-0.01	Not Exceeded	
1974	2.28	2.64	2.18	0.10	Exceeded	
1975	3.14	2.70	2.24	0.89	Exceeded	
1976	3.03	3.24	2.78	0.26	Exceeded	
1977	0.89	0.95	0.49	0.40	Exceeded	
1978	2.20	2.09	1.63	0.57	Exceeded	
1979	1.59	1.97	1.51	0.08	Exceeded	
1980	2.19	1.45	0.99	1.21	Exceeded	
1981	2.51	1.84	1.38	1.13	Exceeded	
1982	2.93	2.92	2.46	0.47	Exceeded	
1983	2.24	2.11	1.65	0.59	Exceeded	
1984	3.04	2.25	1.79	1.25	Exceeded	
1985	1.19	1.49	1.03	0.16	Exceeded	
1986	1.87	1.59	1.13	0.74	Exceeded	
1987	0.92	1.13	0.67	0.25	Exceeded	
1988	1.00	1.38	0.92	0.08	Exceeded	
1989	1.25	1.73	1.27	-0.02	Not Exceeded	
1990	1.25	1.59	1.13	0.12	Exceeded	
1991	1.70	1.68	1.22	0.48	Exceeded	
1992	0.94	1.28	0.82	0.12	Exceeded	
1993	2.47	2.01	1.55	0.92	Exceeded	
1994	1.03	1.86	1.40	-0.37	Not Exceeded	
1995	2.93	2.40	1.94	1.00	Exceeded	
1996	2.85	2.39	1.93	0.93	Exceeded	
1997	3.75	3.11	2.65	1.10	Exceeded	
1998	2.67	2.20	1.74	0.93	Exceeded	
1999	2.16	2.14	1.68	0.48	Exceeded	
2000	1.01	1.31	0.85	0.17	Exceeded	
2001	0.84	0.99	0.53	0.31	Exceeded	
2002	1.13	1.10	0.64	0.50	Exceeded	
2003	1.35	1.99	1.53	-0.18	Not Exceeded	
2004	0.94	1.08	0.62	0.32	Exceeded	
2005	1.43	1.29	0.83	0.60	Exceeded	
2006	1.76	2.14	1.68	0.08	Exceeded	
2007	1.03	1.30	0.84	0.19	Exceeded	
2008	2.28	2.11	1.65	0.62	Exceeded	
2009	2.22	2.10	1.64	0.58	Exceeded	
2010	2.21	1.35	0.89	1.32	Exceeded	
2011	3.63	2.80	2.34	1.29	Exceeded	
2012	1.63	1.56	1.10	0.53	Exceeded	
2013	0.99	0.78	0.32	0.67	Exceeded	
2014	2.09	2.31	1.85	0.24	Exceeded	
	Note: A negative Forecast - Assured - Obs (Column 4) value indicates the observed runoff did not exceed the Forecasted Assured (factored) inflow (Column 3).					
			Water Control Manual			
	STATS		Canyon Ferry Reservoir and Dam, Montana			
	Exeedance (assured)		April-July Inflow Forecast Assured Fill			
	Factor:	0.46 maf	Analysis (May 1 Forecast)			
	Years in Record:	45	U. S. Army Engineer District, Omaha			
	Years Forecast		Corps of Engineers, Omaha, Nebraska			
	Exceeded:	40	December 2016			
	Exeedance					
	Probability:	89%				
						Plate E-VIII-5

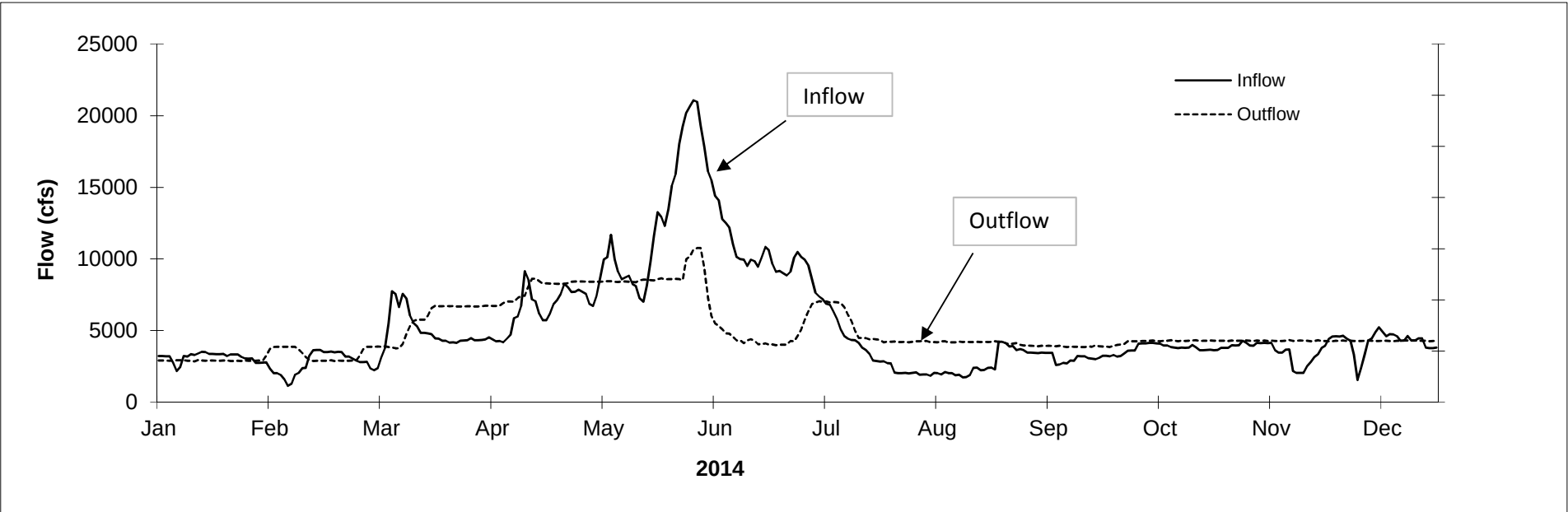
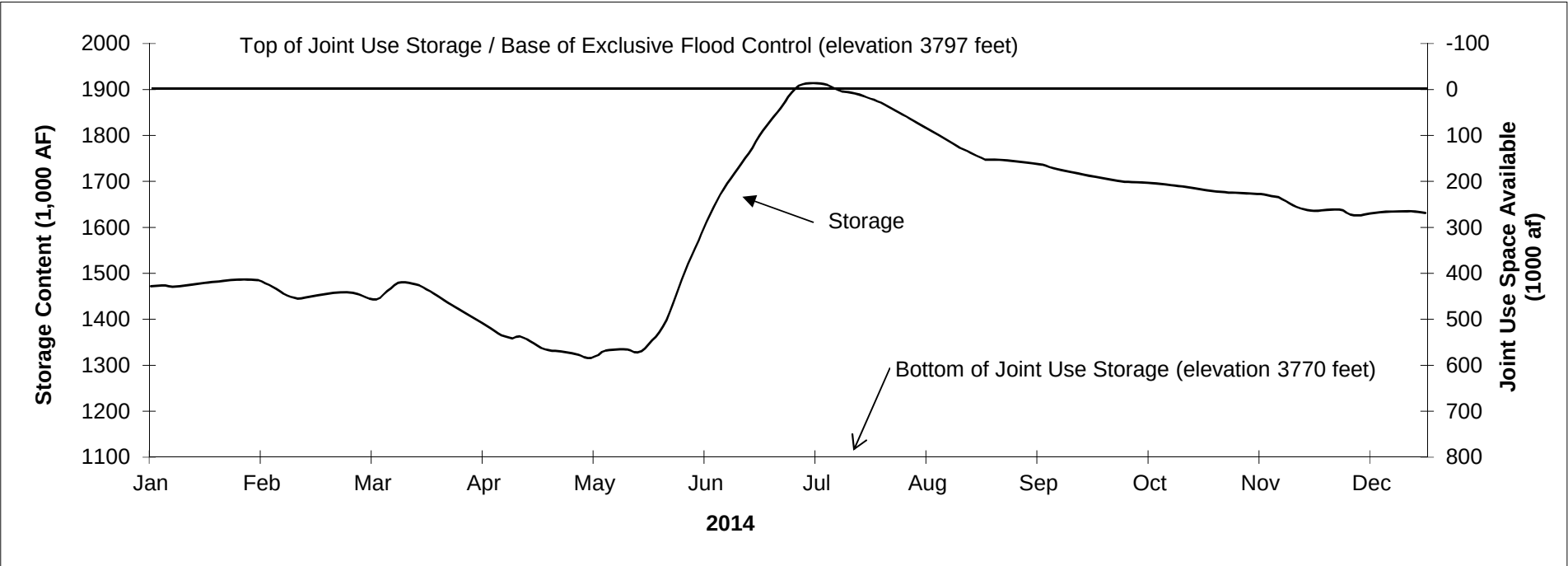
	Col 1 - Observed	Col 2- Forecast	Col 3	Col 4	Col 5	
	CAFÉ	CAFÉ	Forecast -	Obs - Forecast	Exeedance	
	Apr-Jul Inflow	Apr-Jul Inflow	Assured	- Assured	Occurrences	
Years	Natural (maf)	Natural (maf)	(maf)	(maf)		
1970	2.68	3.64	3.23	-0.56	Not Exceeded	
1971	2.84	3.22	2.82	0.02	Exceeded	
1972	2.27	2.59	2.18	0.09	Exceeded	
1973	1.29	1.62	1.21	0.08	Exceeded	
1974	2.28	2.68	2.28	0.00	Exceeded	
1975	3.14	2.87	2.47	0.67	Exceeded	
1976	3.03	3.13	2.72	0.31	Exceeded	
1977	0.89	1.02	0.62	0.27	Exceeded	
1978	2.20	2.05	1.64	0.56	Exceeded	
1979	1.59	1.84	1.44	0.15	Exceeded	
1980	2.19	1.87	1.47	0.72	Exceeded	
1981	2.51	2.37	1.97	0.54	Exceeded	
1982	2.93	2.97	2.57	0.36	Exceeded	
1983	2.24	1.98	1.58	0.66	Exceeded	
1984	3.04	2.21	1.81	1.23	Exceeded	
1985	1.19	1.45	1.04	0.14	Exceeded	
1986	1.87	1.47	1.07	0.80	Exceeded	
1987	0.92	1.30	0.90	0.02	Exceeded	
1988	1.00	1.48	1.08	-0.08	Not Exceeded	
1989	1.25	1.76	1.35	-0.10	Not Exceeded	
1990	1.25	1.59	1.18	0.07	Exceeded	
1991	1.70	1.79	1.39	0.32	Exceeded	
1992	0.94	1.15	0.74	0.20	Exceeded	
1993	2.47	2.06	1.66	0.81	Exceeded	
1994	1.03	1.66	1.26	-0.23	Not Exceeded	
1995	2.93	2.35	1.95	0.98	Exceeded	
1996	2.85	2.63	2.23	0.63	Exceeded	
1997	3.75	3.24	2.84	0.91	Exceeded	
1998	2.67	2.16	1.76	0.91	Exceeded	
1999	2.16	2.15	1.75	0.41	Exceeded	
2000	1.01	1.33	0.93	0.08	Exceeded	
2001	0.84	0.68	0.28	0.56	Exceeded	
2002	1.13	0.99	0.59	0.54	Exceeded	
2003	1.35	1.99	1.59	-0.24	Not Exceeded	
2004	0.94	1.06	0.66	0.28	Exceeded	
2005	1.43	1.21	0.80	0.63	Exceeded	
2006	1.76	2.02	1.62	0.14	Exceeded	
2007	1.03	1.48	1.08	-0.05	Not Exceeded	
2008	2.28	2.13	1.72	0.55	Exceeded	
2009	2.22	1.95	1.54	0.67	Exceeded	
2010	2.21	1.31	0.91	1.30	Exceeded	
2011	3.63	2.78	2.38	1.26	Exceeded	
2012	1.63	1.47	1.07	0.56	Exceeded	
2013	0.99	0.78	0.38	0.61	Exceeded	
2014	2.09	2.17	1.76	0.33	Exceeded	
Note: A negative Forecast - Assured - Obs (Column 4) value indicates the observed runoff did not exceed the Forecasted Assured (factored) inflow (Column 3).						
			Water Control Manual			
	STATS		Canyon Ferry Reservoir and Dam, Montana			
	Exeedance		April-July Inflow Forecast Assured Fill Analysis (Jun 1 Forecast)			
	Factor:	0.403 maf				
	Years in Record:	45				
	Years Forecast					
	Exceeded:	39	U. S. Army Engineer District, Omaha			
	Exeedance		Corps of Engineers, Omaha, Nebraska			
	Probability:	87%	December 2016			
						Plate E-VIII-6



Source: Example of Joint use regulation produced on March 5, 2014 by Reclamation.
This plate uses observed data for January and February, then shows forecasted inflows and releases for the remainder of the year. This forecasted operation met the joint use drawdown requirements determined by Omaha District on March 1 and shown in Table 8-4.

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Example of Joint Use Regulation -
March 2014 Forecast**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Source: USBR Hydromet Data

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Example of Joint Use Regulation - Actual
Data from 2014**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

CANYON FERRY LAKE MONTHLY OPERATIONS

Canyon Ferry Reservoir		Initial Cont		1454.1 kaf		Maximum Cont		1993.0 kaf		Minimum Cont		445.5 kaf		Total
		Elev		3783.26 ft		Elev		3800.00 ft		Elev		3732.31 ft		
	2014	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
Reservoir Inflow	kaf	229.2	337.6	573.1	801.2	315.9	158.9	210.4	278.0	294.5	247.2	211.7	216.3	3874.0
Evaporation Loss	kaf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HV Canal Diversions	kaf	0.0	11.0	18.4	17.0	18.4	18.4	12.0	0.0	0.0	0.0	0.0	0.0	95.2
HV Pump Turbines	kaf	0.0	15.0	23.9	18.6	18.3	19.0	13.3	0.0	0.0	0.0	0.0	0.0	108.1
Turbine Release	kaf	272.1	336.5	346.4	311.6	278.2	273.0	269.3	240.9	298.7	308.7	308.7	278.8	3522.9
Turbine Release	cfs	4425	5655	5634	5237	4524	4440	4526	3918	5020	5021	5021	5020	
Spill/Waste	kaf	0.0	0.0	32.0	100.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	132.8
River Release	kaf	272.1	351.5	402.3	431.0	296.5	292.0	282.6	240.9	298.7	308.7	308.7	278.8	3763.8
River Release	cfs	4425	5907	6543	7243	4822	4749	4749	3918	5020	5021	5021	5020	
Min Release	cfs	3880	3911	3959	3707	3981	3975	3944	3918	3936	3939	3928	3893	
Total Dam Release	kaf	272.1	362.5	420.7	448.0	314.9	310.4	294.6	240.9	298.7	308.7	308.7	278.8	3859.0
Total Dam Release	cfs	4425	6092	6842	7529	5121	5048	4951	3918	5020	5021	5021	5020	
End-Month Content	kaf	1411.2	1386.3	1538.7	1891.9	1892.9	1741.4	1657.2	1694.3	1690.1	1628.6	1531.6	1469.1	
End-Month Elevation	ft	3781.8	3781.0	3786.0	3797.0	3797.0	3792.4	3789.8	3791.0	3790.8	3788.9	3785.8	3783.8	
Net Change	kaf	-42.9	-24.9	152.4	353.2	1.0	-151.5	-84.2	37.1	-4.2	-61.5	-97.0	-62.5	15.0
Canyon Ferry Power	2014	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
Turbine Release	cfs	4425	5655	5634	5237	4524	4440	4526	3918	5020	5021	5021	5020	
Tailwater Elev	ft	3650.9	3651.1	3651.1	3651.2	3650.9	3650.9	3650.9	3650.8	3651.0	3651.0	3651.0	3651.0	
Average Head	ft	131.6	130.3	132.4	140.4	146.1	143.8	140.2	139.6	139.9	138.9	136.4	133.8	
Average Power	mw	45.3	55.8	56.7	56.7	50.8	49.2	49.1	41.7	54.4	54.0	53.1	52.1	
Average Kwh/Af		124	119	122	131	136	134	131	129	131	130	128	126	128
Generation	gwh	33.703	40.176	42.185	40.824	37.795	36.605	35.352	31.025	39.168	40.176	39.506	35.011	451.526
End-Month Power Cap	mw	56	56	57	57	57	57	57	57	57	57	57	57	
Hauser	2014	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
Missouri Gain	kaf	10.2	9.0	5.4	13.1	1.3	3.3	5.2	9.1	8.4	8.8	9.0	9.3	92.1
End-Month Content	kaf	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	
Release	kaf	282.3	360.5	407.7	444.1	297.8	295.3	287.8	250.0	307.1	317.5	317.7	288.1	3855.9
Release	cfs	4591	6058	6631	7463	4843	4803	4837	4066	5161	5164	5167	5188	
Turbine Release	cfs	4591	4740	4740	4740	4740	4740	4740	4066	4740	4740	4740	4740	
Turbine Bypass	cfs	0	1318	1891	2723	103	63	97	0	421	424	427	448	
Generation	gwh	11.887	11.877	12.272	11.877	12.272	12.272	11.877	10.527	11.877	12.272	12.272	11.085	142.367
Holter	2014	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Water Control Manual Canyon Ferry Reservoir and Dam Reclamation Forecast, March 5 U. S. Army Engineer District, C Corps of Engineers, Omaha, Ne September 2015				
Missouri Gain	kaf	3.3	2.3	3.3	10.3	6.0	4.4	4.1	2.1					
End-Month Content	kaf	81.9	81.9	81.9	81.9	81.9	81.9	81.9	81.9					
Release	kaf	285.6	362.8	411.0	454.4	303.8	299.7	291.9	252.1					
Release	cfs	4645	6097	6684	7636	4941	4874	4906	4100					
Min Release	cfs	4100	4100	4100	4100	4100	4100	4100	4100					
Turbine Release	cfs	4645	6097	6684	7100	4941	4874	4906	4100					
Turbine Bypass	cfs	0	0	0	536	0	0	0	0					
Generation	gwh	24.329	30.904	35.009	35.988	25.880	25.529	24.868	21.475					

Water Control Manual
Canyon Ferry Reservoir and Dam, Montana
Reclamation Forecast, March 5, 2014
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
September 2015

EXHIBIT IX

Agreement Concerning Unscheduled Power Plant Outages

CANYON FERRY DAM AND RESERVOIR

Montana Department of Fish, Wildlife & Parks

1420 E 6th Ave
PO Box 200701
Helena MT 59620-0701
January 22, 1996



FILE COPY

JAN 23 '96

Tim Felchle
Bureau of Reclamation
P.O. Box 30137
Billings, MT 59107

Dear Tim:

The purpose of this letter is to summarize discussions held at Canyon Ferry Visitor Center on December 18 regarding plant trips and flow restoration at the Canyon Ferry project. I have also summarized the agreement reached regarding actions taken subsequent to plant trips.

Representatives of the Bureau of Reclamation (BOR), Montana Power Company (MPC) and Montana Fish, Wildlife and Parks (FWP) met to discuss the October 18, 1995 plant trip at Canyon Ferry and actions that can be taken to restore flow and ensure that MPC is able to meet the conditions of their FERC license regarding flows downstream of Hauser and Holter. BOR representatives explained the events that occurred on October 18, as well as the change from local operation of Canyon Ferry plant to remote control from Casper. This change will result in a reduction of time that staff will be on-site at the Canyon Ferry plant.

BOR indicated that when they lose power at the plant they are still capable of opening the river outlets and releasing up to 2000 cfs. However, to open the spill gates requires staff to be on-site which can take upwards of an hour depending upon the time of day and other factors.

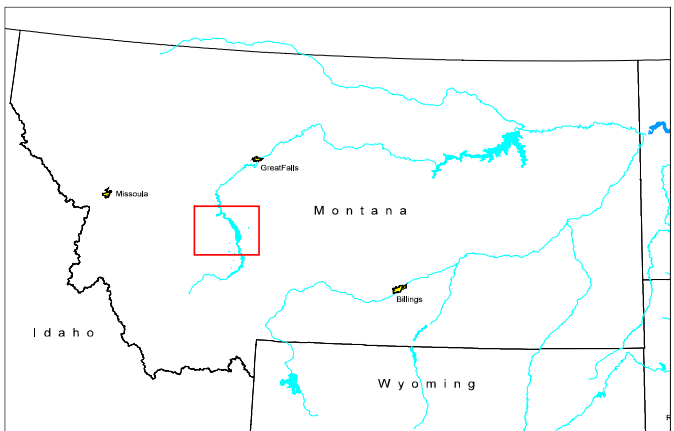
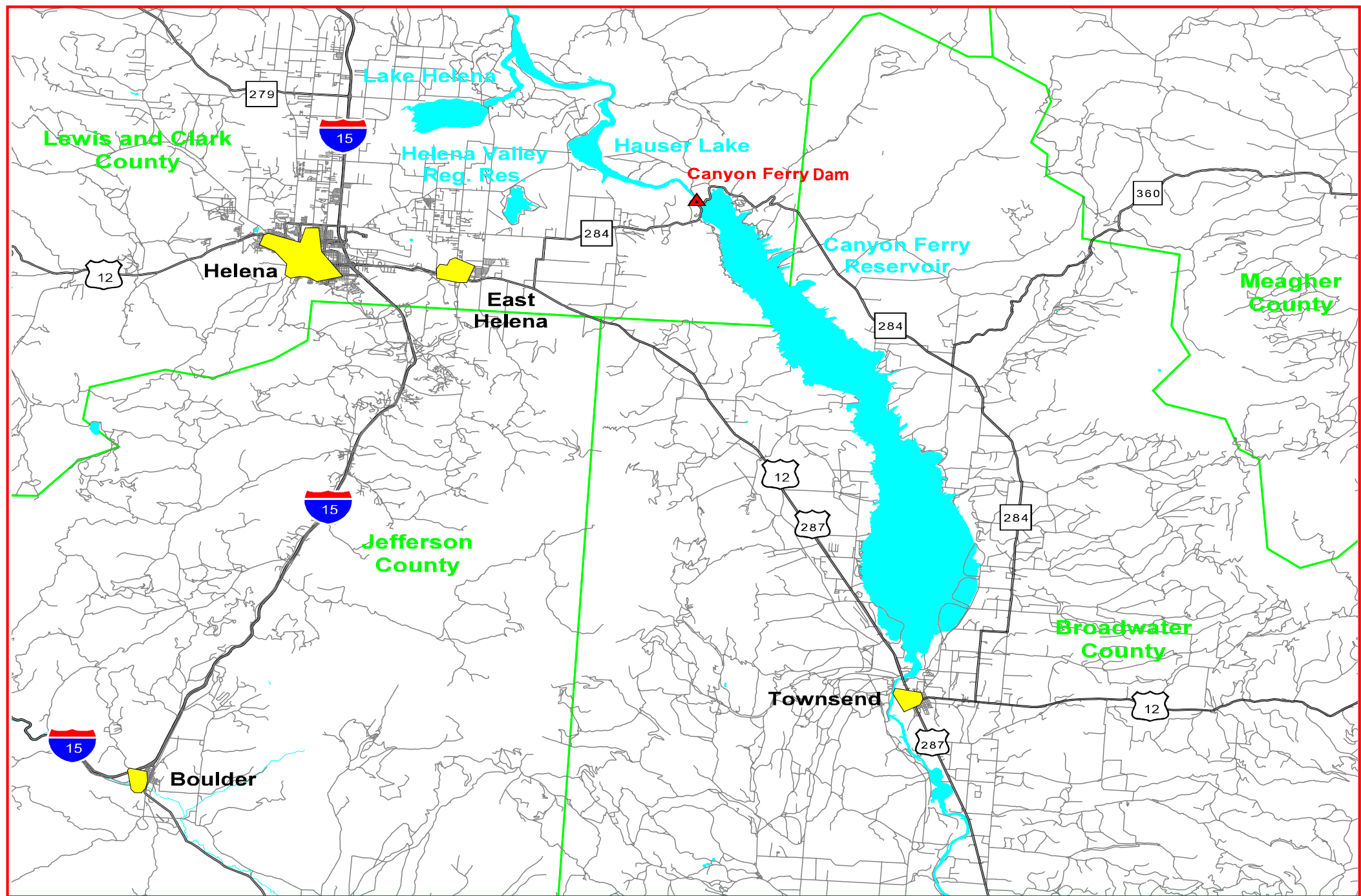
Ed Seimers of MPC Hauser plant indicated that when flow from Canyon Ferry ceases, the Hauser elevation begins to drop .116 ft per hour. During the October 18 plant trip, flow from Canyon Ferry was lost for about two hours. The Hauser plant had to begin to make adjustments in their discharge in order to meet their FERC license conditions. Although the lake elevation change was small, Ed received calls for two weeks from angry lakeshore landowners.

Lance Elias (MPC), suggested that if flow is not restored within one hour of a Canyon Ferry plant trip, BOR should begin releasing 2000 cfs from the river outlets. If it looks as though Canyon Ferry will be off line for a longer term (hours) they will restore flow using the spill gates. This solution was agreed to by all present.

Thanks for arranging the meeting Tim. I think it was useful and a reasonable solution was reached. I hope you have a great holiday season and abundant water in the new year.

NO REPLY NEEDED		INITIALS	DATE
REPLY OR OTHER ACTION TAKEN		CODE NO	
INFO. COPY TO:			
ROUTE TO	INITIALS		
450	Jim	1/23/96	
400			

ief



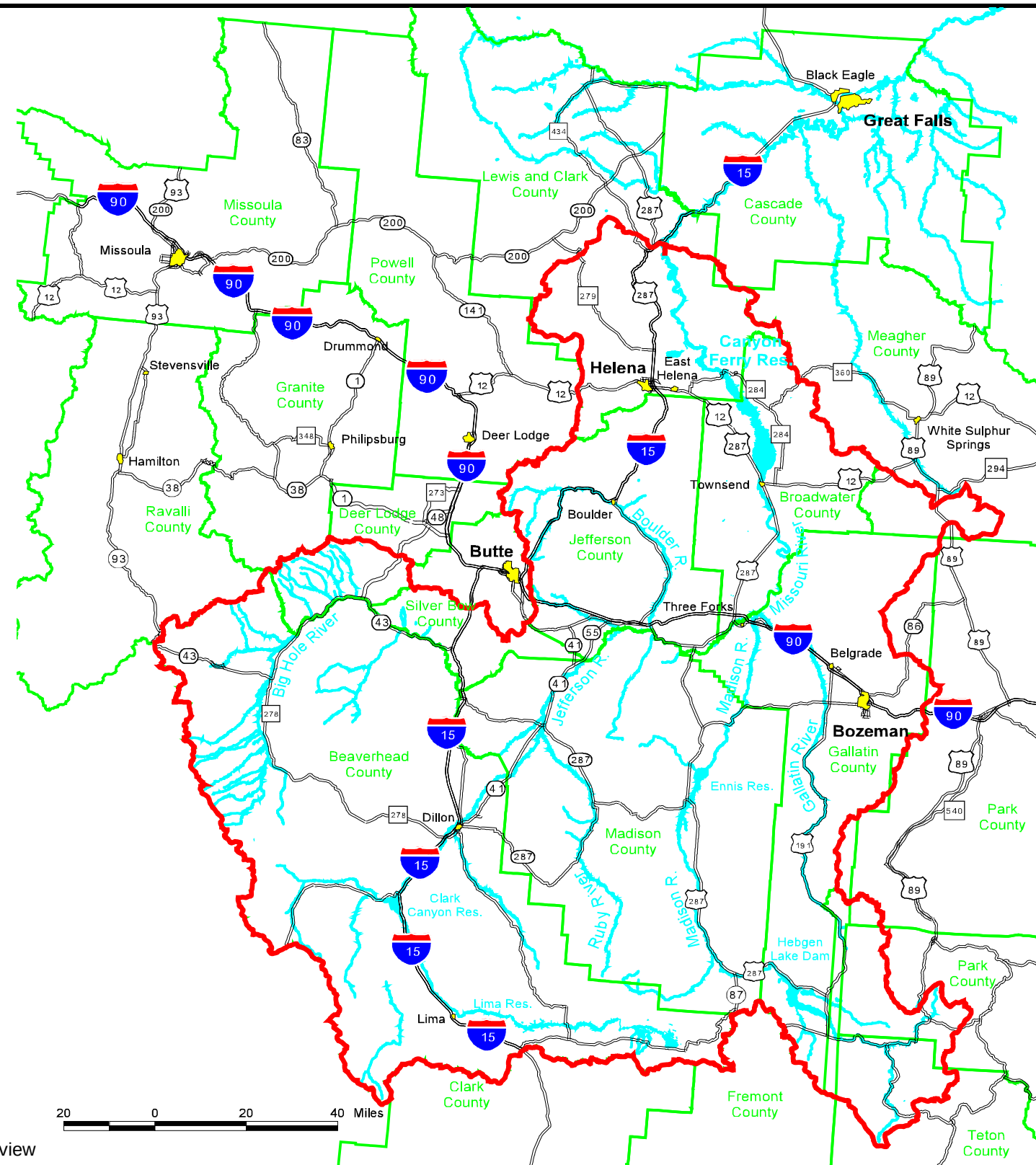
Map created in Arcview

Prepared By: KS
 Reviewed By: JL

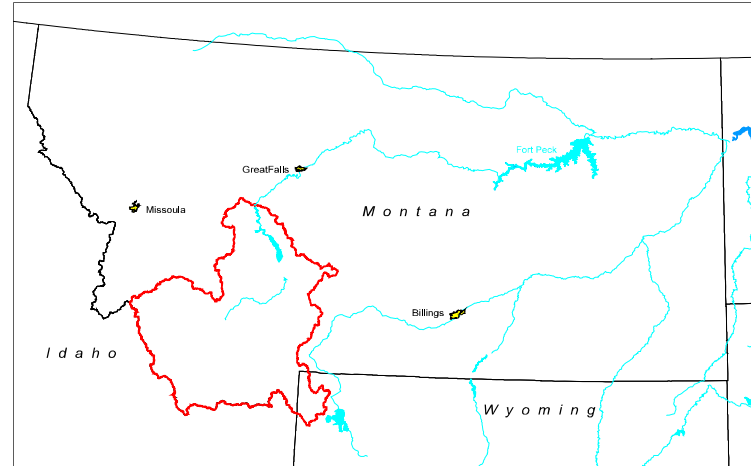
Water Control Manual
 Canyon Ferry Reservoir and Dam, Montana

**Location Map
 Canyon Ferry Dam and Reservoir**

U.S. Army Engineers District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



Map created in Arcview

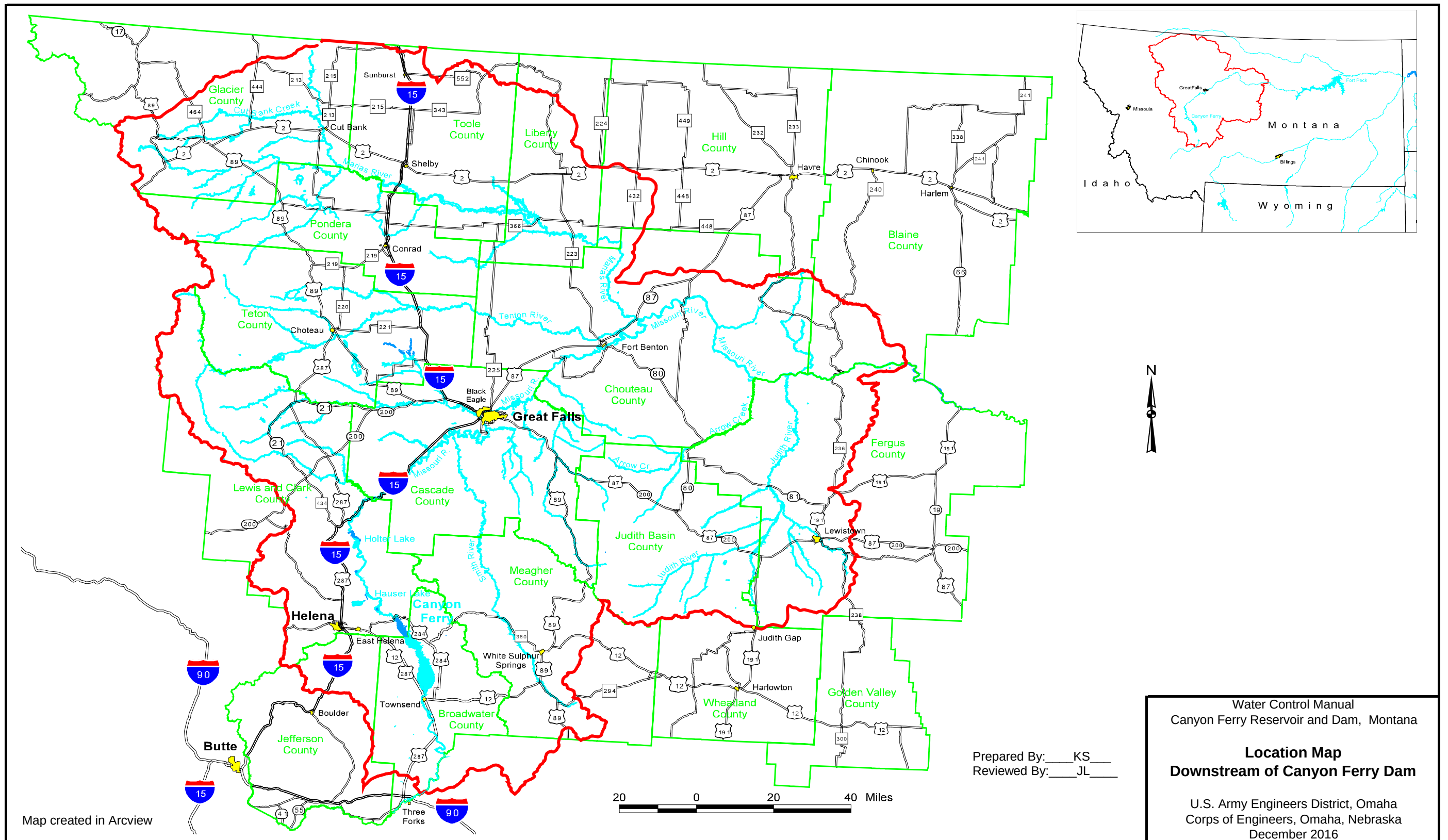


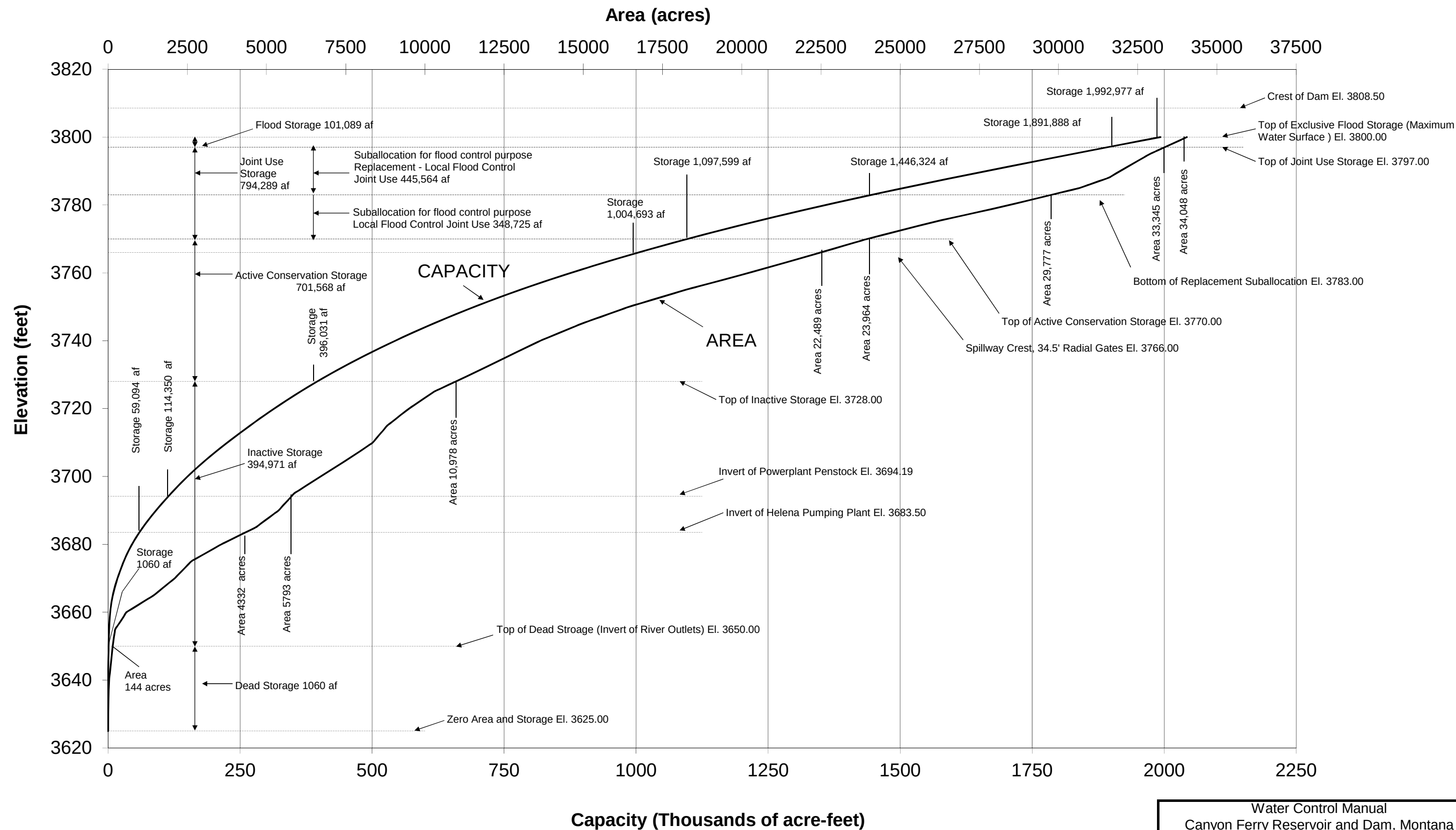
Prepared By: ____KS____
Reviewed By: ____JL____

Water Control Manual
Canyon Ferry Reservoir and Dam, Montana

Location Map
Upstream of Canyon Ferry Dam

U.S. Army Engineers District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016





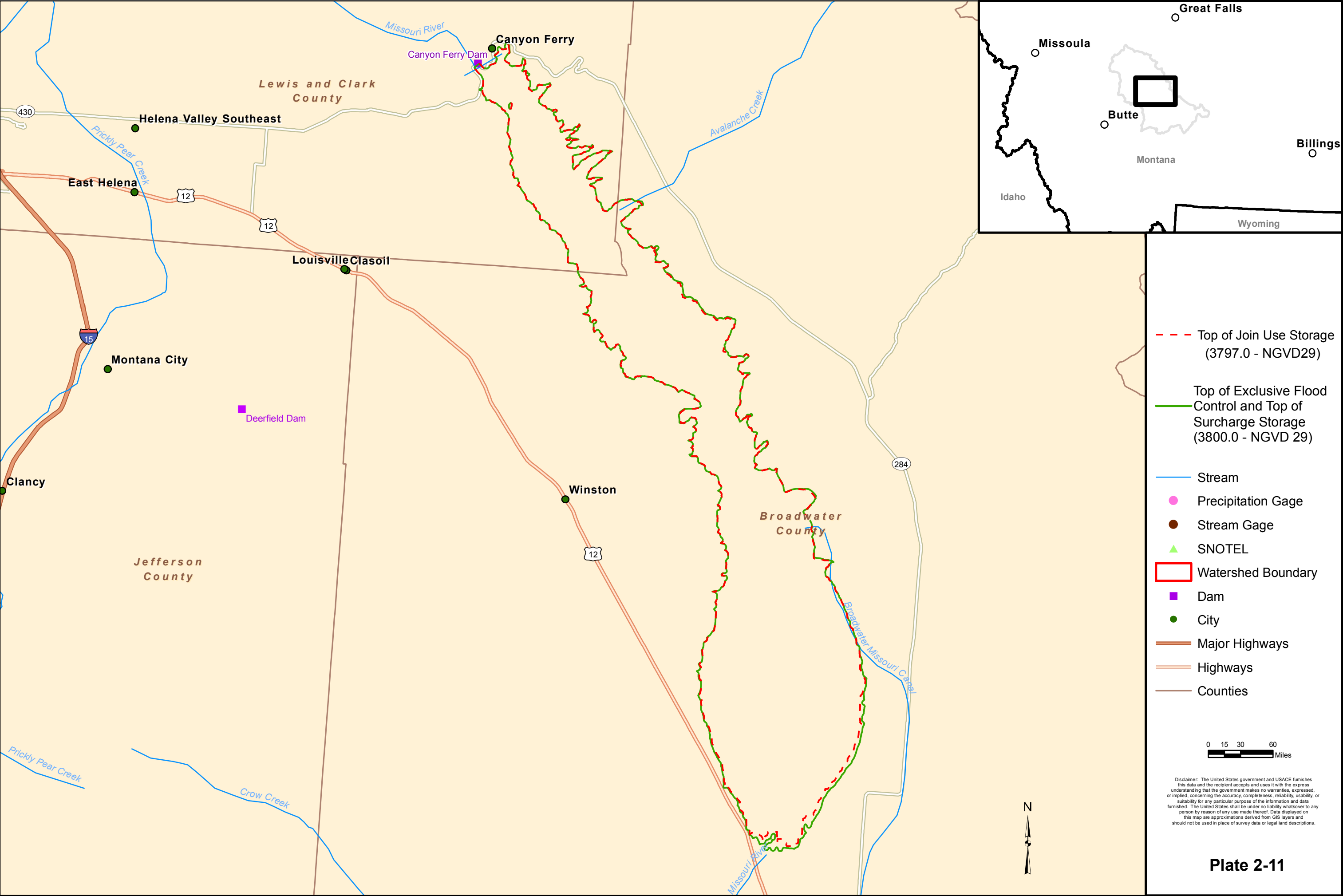
Source: Re-created from Drawing 296-600-3064 in Exhibit IV-3, Bureau of Reclamation Standing Operating Procedures, November 1999

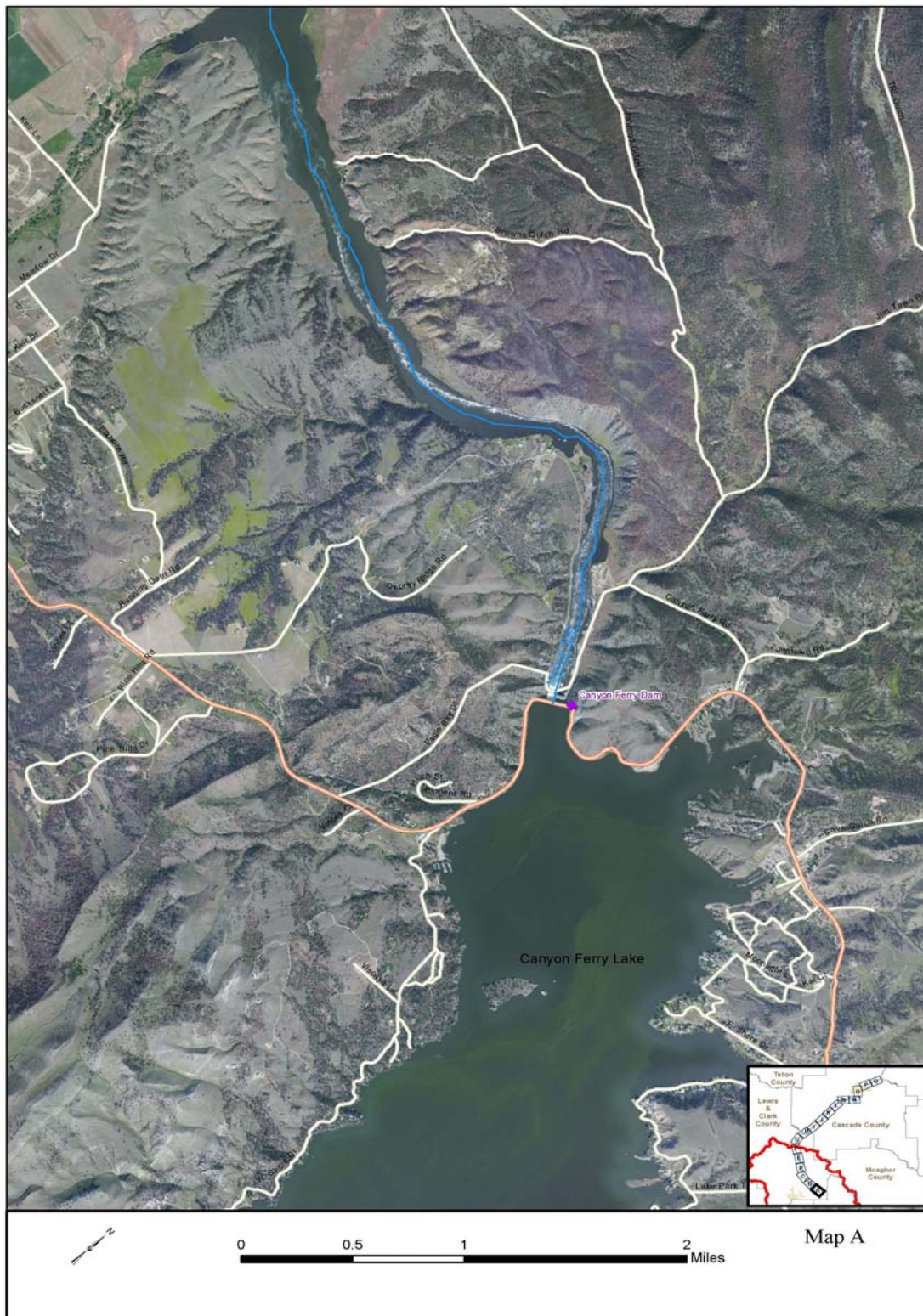
Prepared By: __ KB __
 Reviewed By: __ JL __

Water Control Manual
 Canyon Ferry Reservoir and Dam, Montana

**Area-Capacity Curve
 1997 Update**

U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016





Map A

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map A

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET

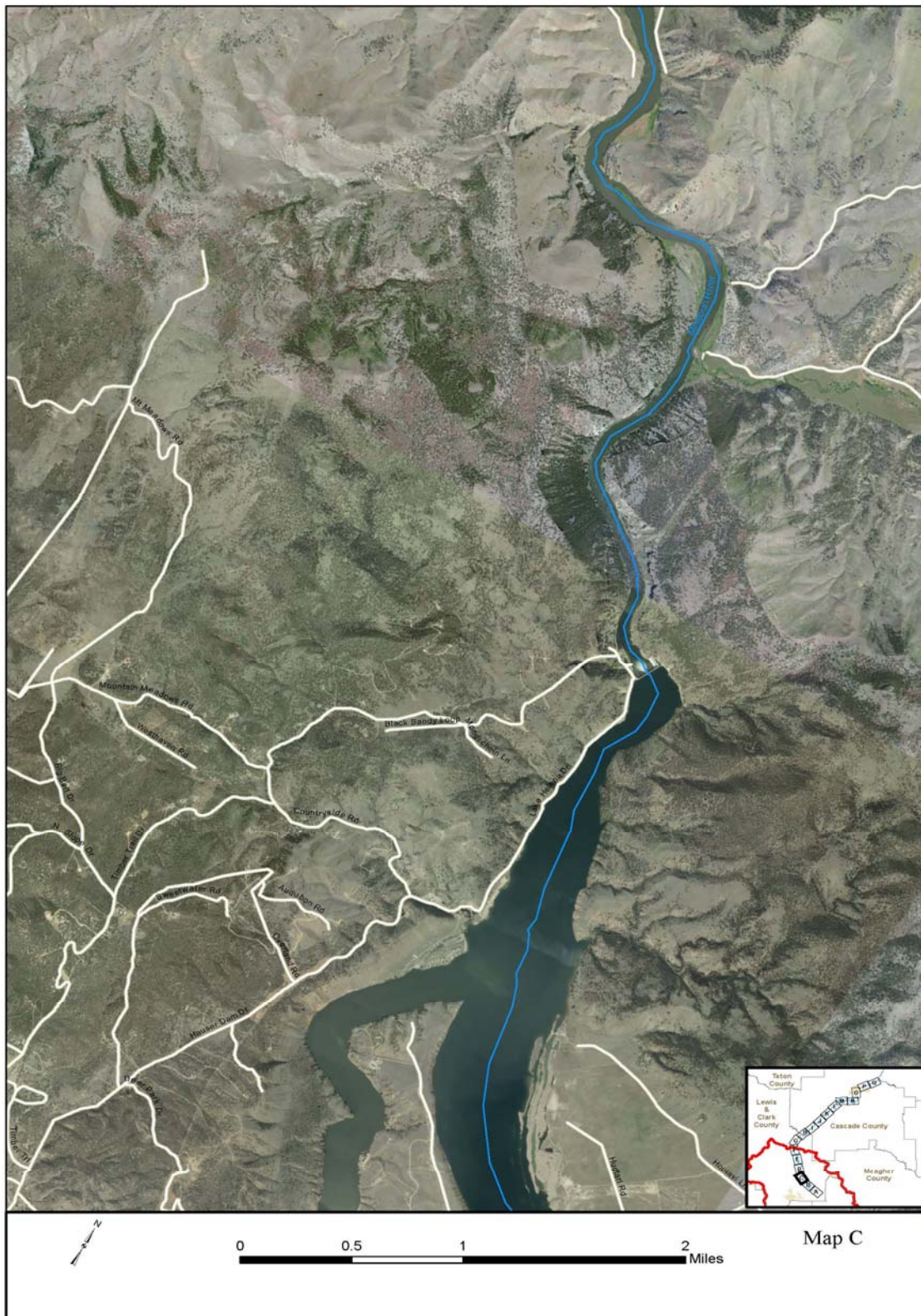


Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map B

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET

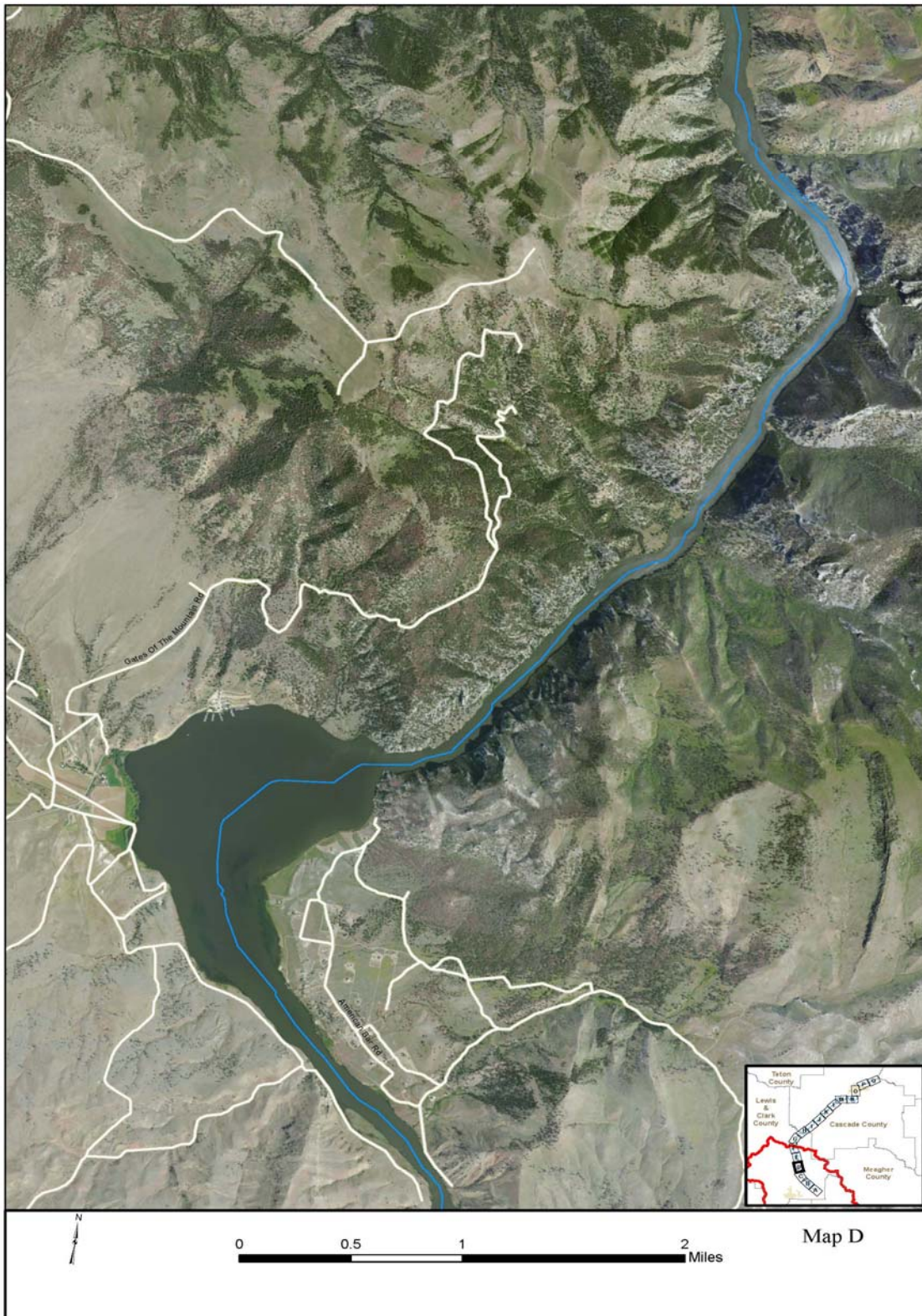


Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map C

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET



Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map D

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET



0 0.5 1 2 Miles

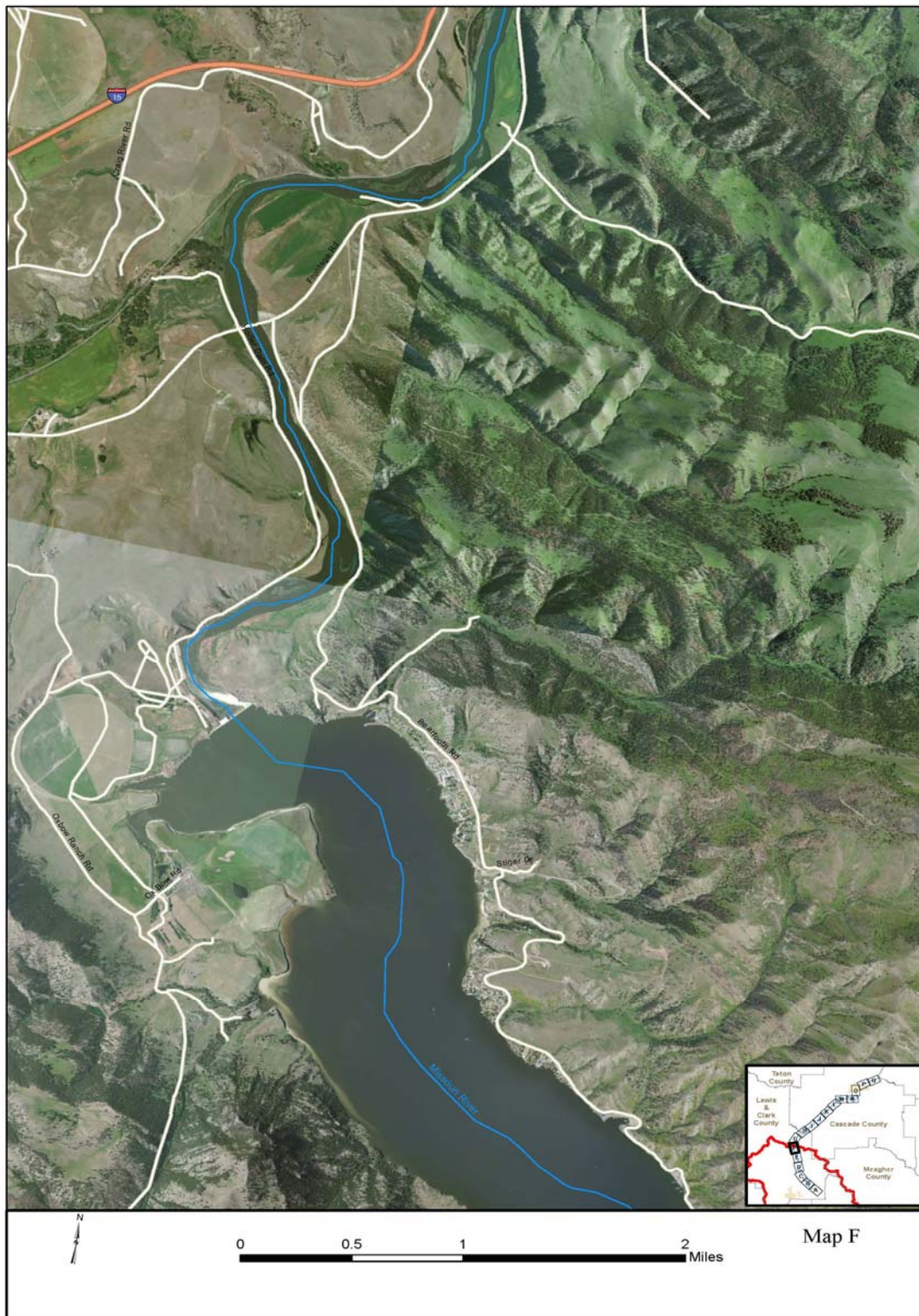
Map E

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map E

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET

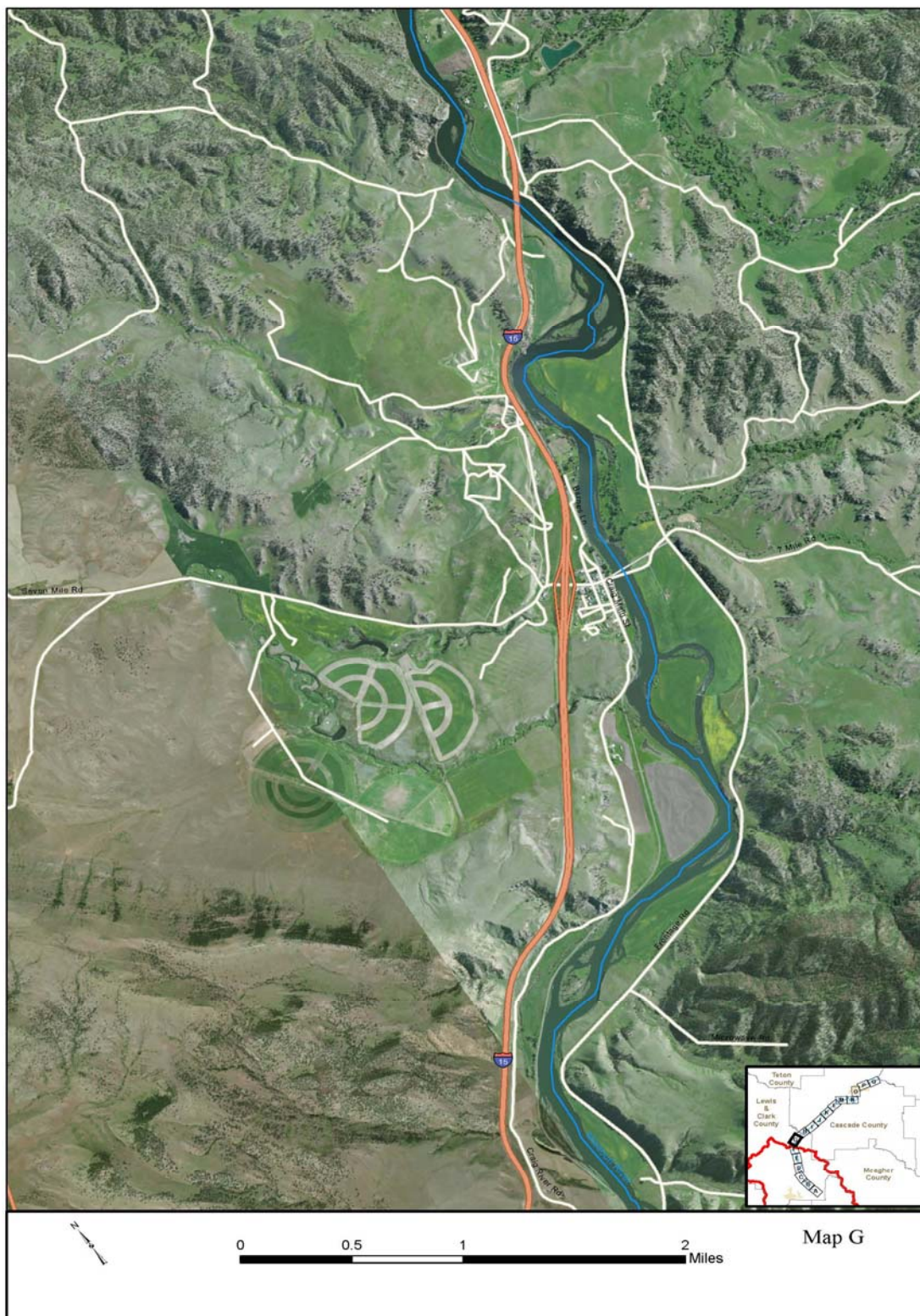


Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map F

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET

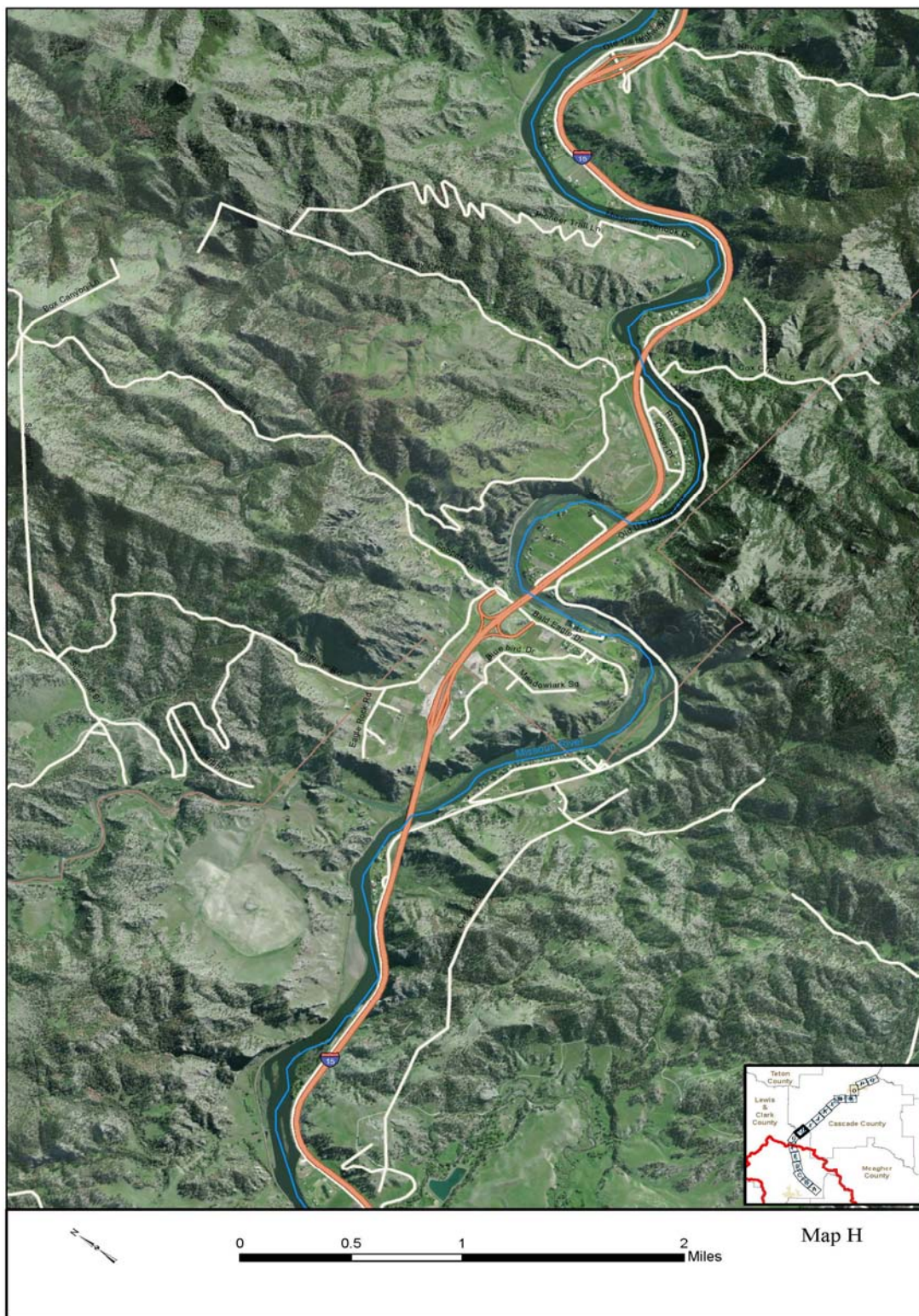


Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map G

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET

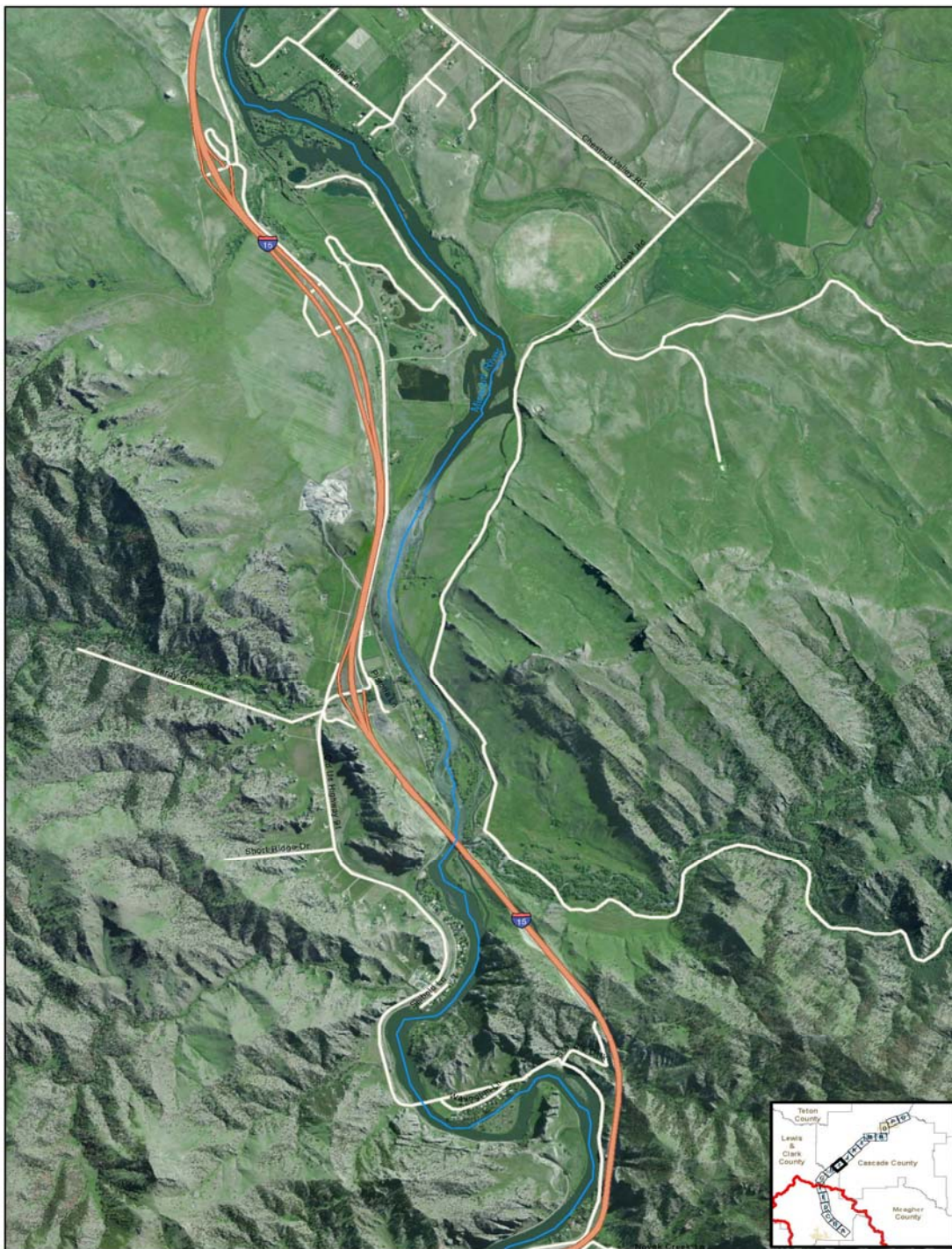


Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map H

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET



0 0.5 1 2 Miles

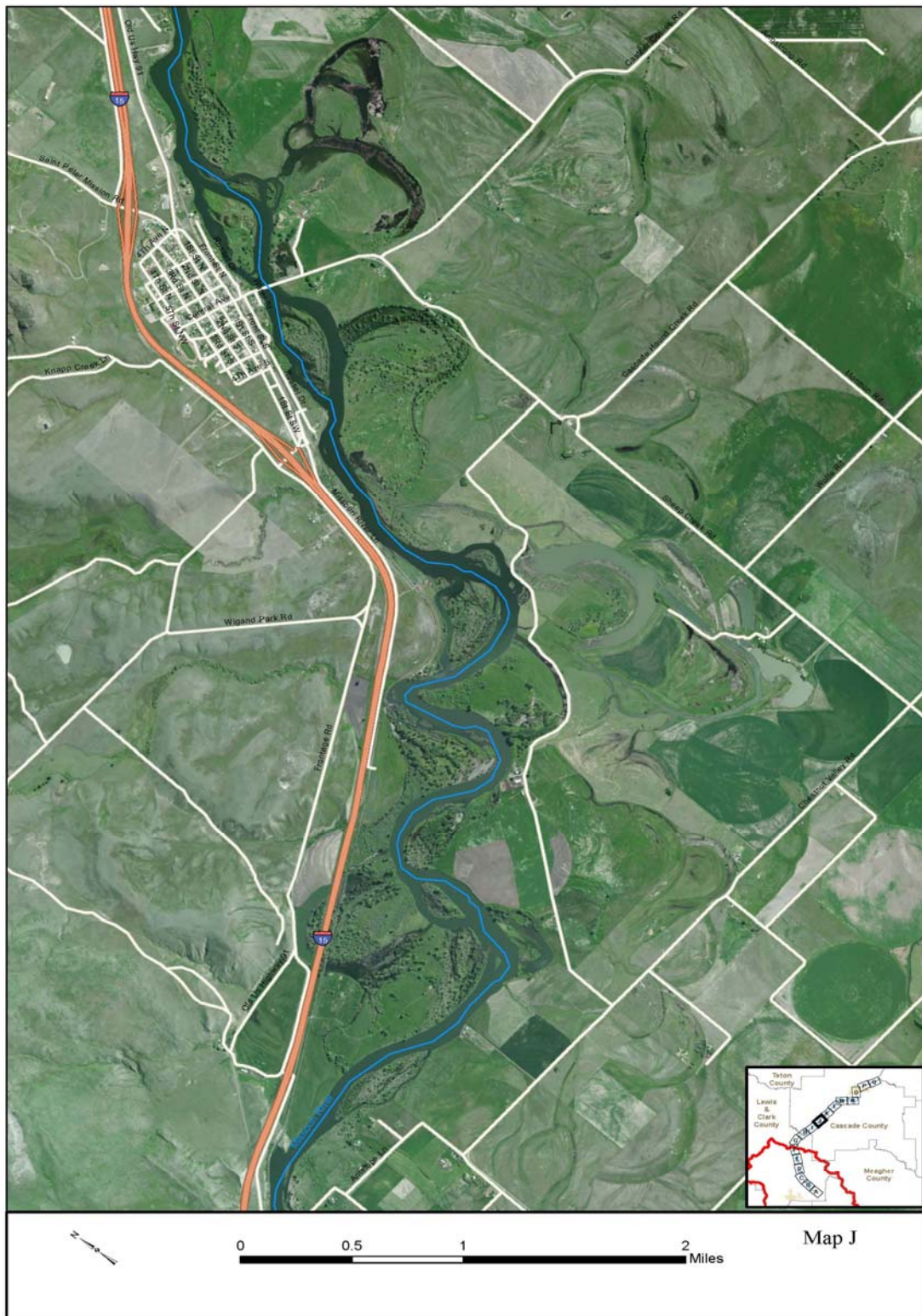
Map I

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map I

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET



Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map J

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET



Map K

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map K

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET



Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map L

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET

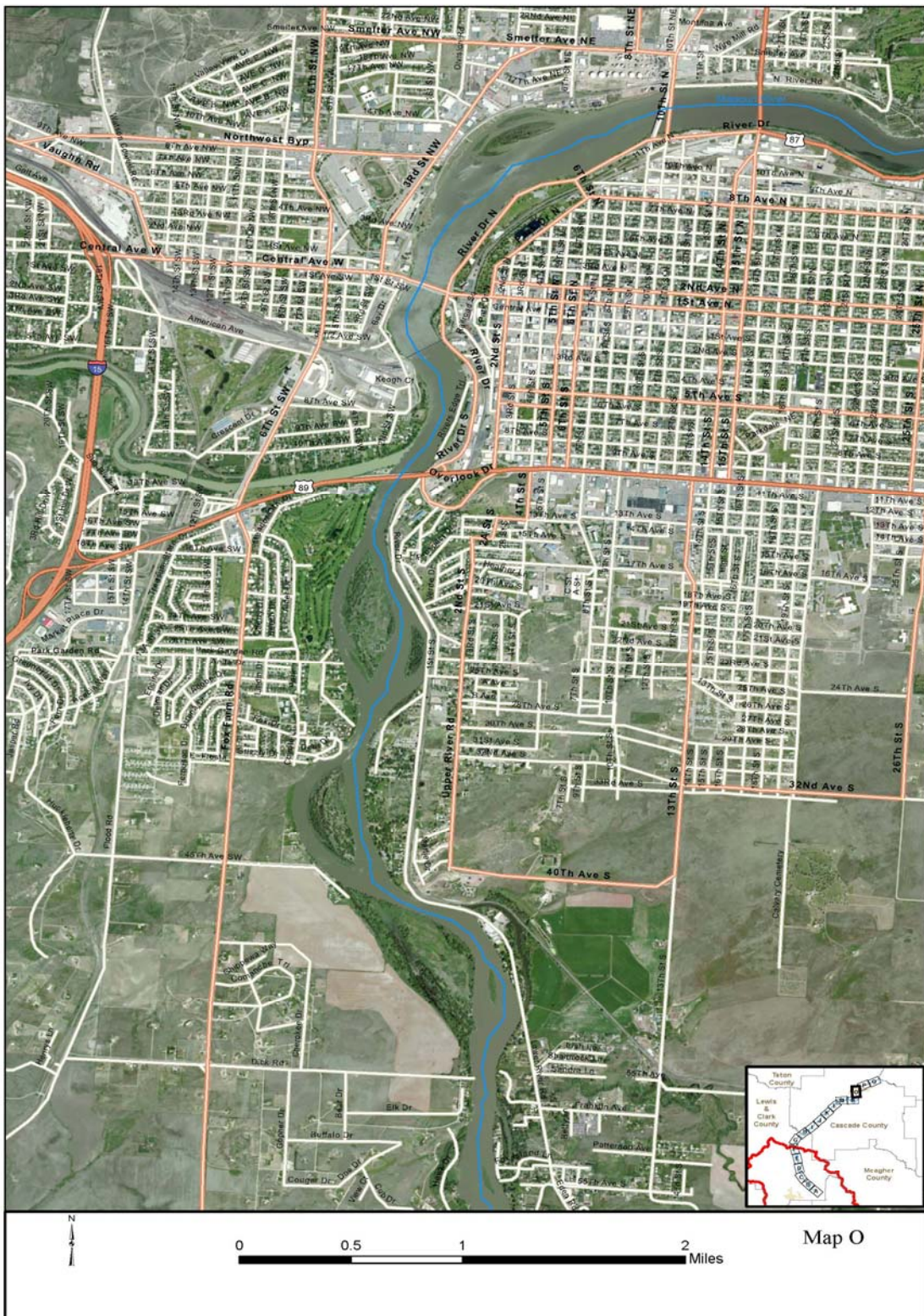


Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map N

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET



Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map O

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET



Map P

Prepared By: MAS
 Reviewed By: TET

Water Control Manual
 Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map P

U.S. Army Engineer District
 Corps of Engineers, Omaha, Nebraska
 December 2016

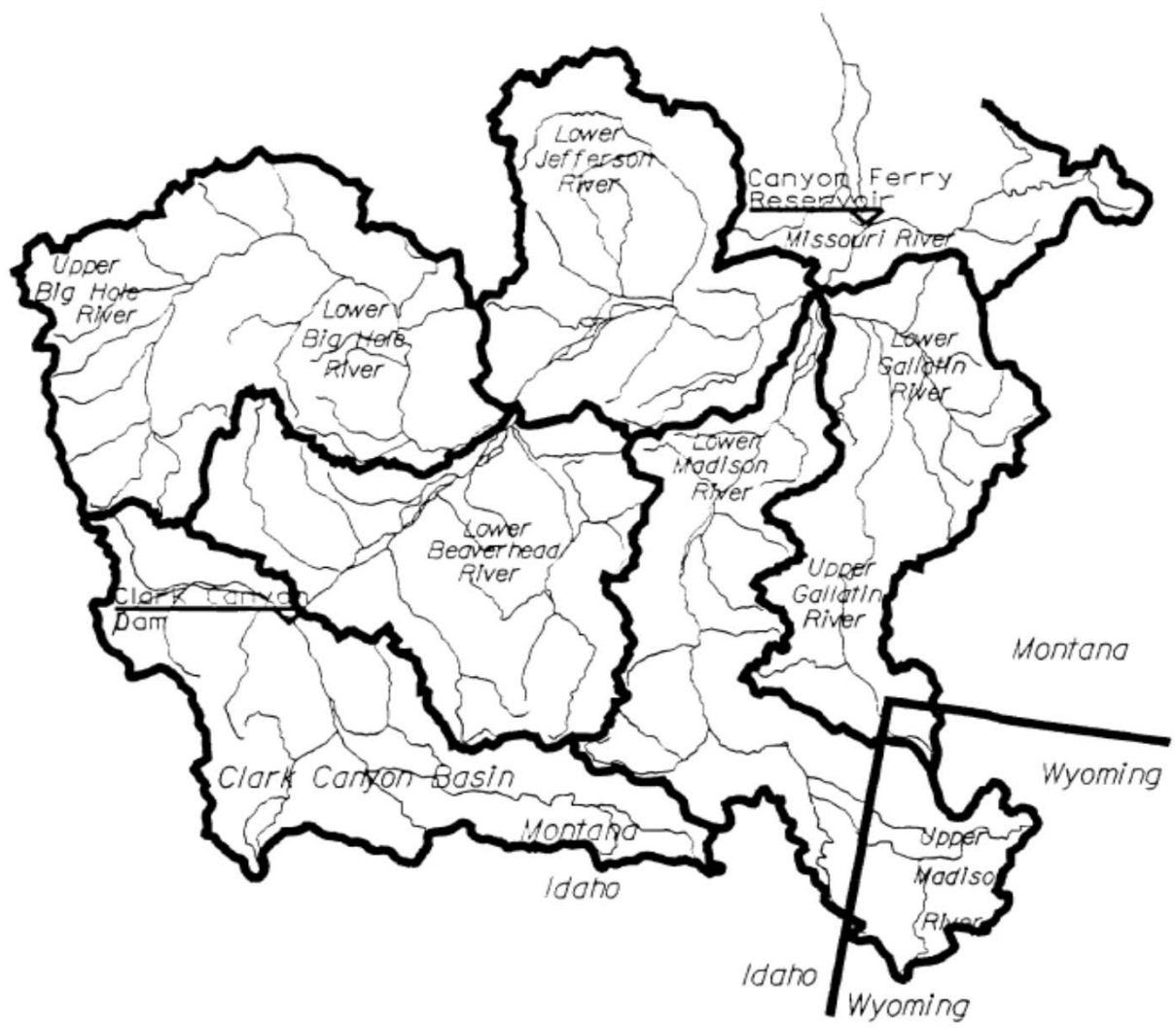


Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Location Map
Canyon Ferry Dam to Great Falls, MT
Map Q

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: MAS
Reviewed By: TET



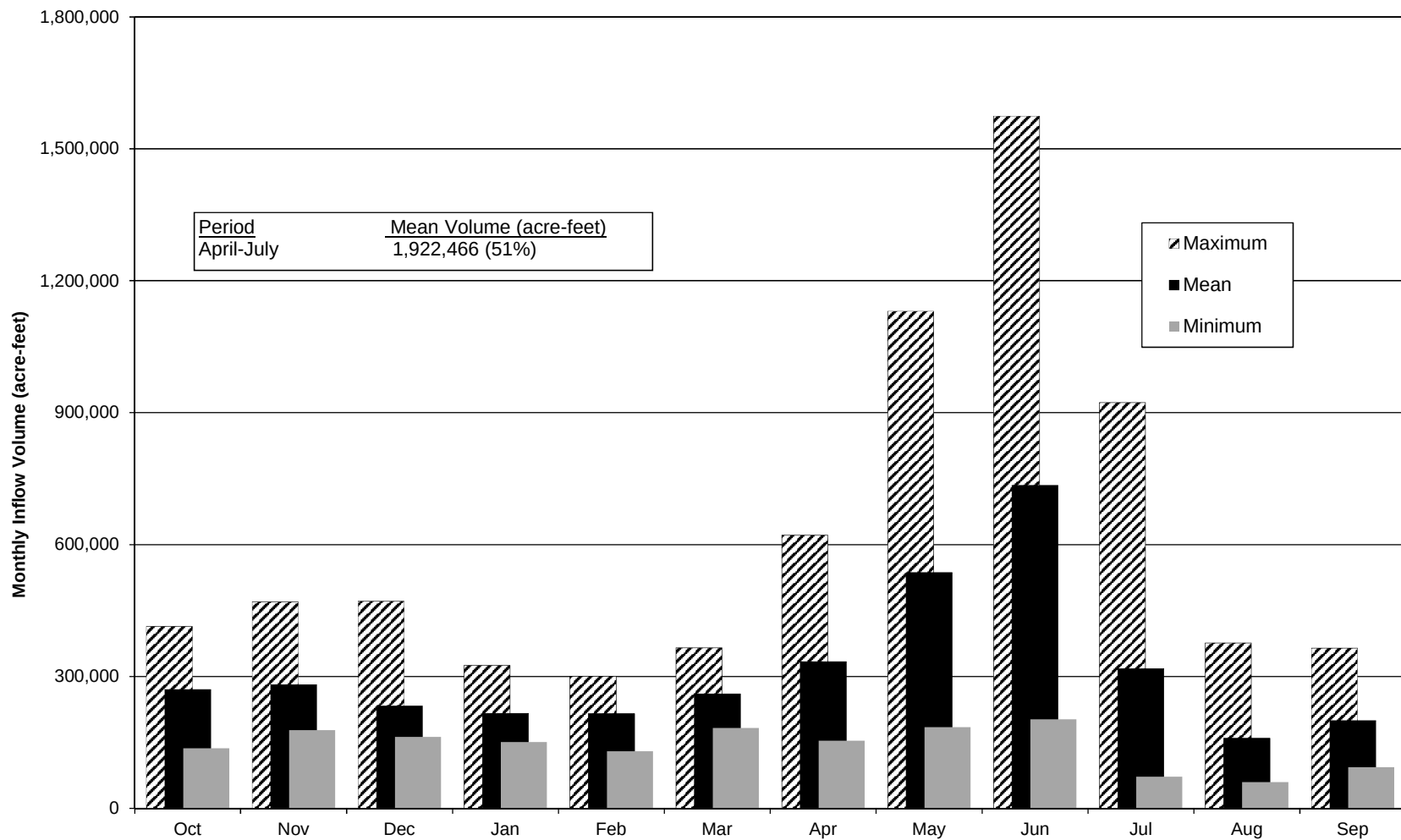
Scanned from Preliminary Information Report on Reservoir Regulations for Canyon Ferry Dam and Lake, Corps of Engineers, 1972

Prepared By: KB
Reviewed By: JL

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Sub-Basin Drainage Areas

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Period Analyzed: 1954-2014
 Total Average Annual Inflow Volume = 3,730,179 ac-ft
 Source of Data: USBR HydroMet-Hydrological Database

Prepared By: TET
 Reviewed By: JAB

Water Control Manual
 Canyon Ferry Dam and Reservoir, MT
Historical Max, Min and Mean Monthly Inflow Volume
at Canyon Ferry Reservoir
 U.S. Army Engineer District
 Corps of Engineers, Omaha, Nebraska
 December 2016

Canyon Ferry Reservoir
Historical Monthly Inflow Volumes (acre-feet)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1953	-----	-----	-----	-----	-----	38,565	275,942	299,694	921,751	301,083	166,928	207,855
1954	268,748	297,907	226,100	220,637	249,455	242,331	253,251	313,614	379,627	247,041	140,258	172,865
1955	244,797	270,012	198,582	184,658	158,823	193,644	242,000	351,891	509,351	344,478	115,132	148,289
1956	209,154	247,463	243,023	228,335	176,607	323,996	428,325	802,475	678,848	183,866	130,448	169,209
1957	232,204	306,191	210,266	150,800	190,867	242,967	264,161	584,386	796,607	255,171	110,334	181,922
1958	286,036	307,578	243,807	207,012	217,817	238,241	296,847	585,521	527,158	254,873	134,673	160,934
1959	260,991	278,078	239,762	194,823	176,686	253,534	285,190	352,958	774,154	306,981	103,555	153,185
1960	413,614	470,079	471,106	230,758	239,428	365,220	441,877	481,984	436,344	105,178	105,755	144,810
1961	186,036	226,520	209,850	194,451	205,575	199,107	153,900	198,584	301,748	79,394	69,773	175,140
1962	310,185	330,473	192,565	169,456	213,082	244,475	386,227	490,971	689,265	276,240	174,026	215,920
1963	290,084	312,735	246,565	174,032	291,670	231,352	237,204	495,531	897,442	283,594	114,204	217,468
1964	258,069	300,218	211,297	206,894	205,171	221,454	251,505	541,710	1,152,641	468,110	163,869	226,937
1965	259,005	299,735	234,276	265,610	224,640	248,649	436,119	687,196	1,116,423	653,034	254,769	311,920
1966	405,906	413,583	267,266	240,334	229,347	263,088	282,801	273,207	253,349	125,889	75,581	127,043
1967	265,175	302,038	207,630	209,718	190,463	202,154	221,747	562,219	1,220,352	479,505	146,586	203,076
1968	309,831	311,533	227,937	228,338	272,684	319,120	308,383	450,324	1,014,141	352,488	236,644	310,587
1969	337,751	342,983	243,456	238,944	254,797	333,253	621,210	909,669	669,569	483,801	189,161	205,904
1970	331,733	308,972	251,328	236,699	232,868	255,335	290,409	725,391	1,155,067	490,147	183,221	287,477
1971	328,759	329,566	256,516	256,992	300,263	251,323	417,018	793,812	1,080,260	520,668	205,742	290,948
1972	346,350	342,851	238,451	252,133	262,819	355,628	423,370	603,837	962,116	302,185	186,582	237,828
1973	355,427	360,922	226,734	227,180	223,909	267,593	282,805	427,277	433,566	203,970	121,022	234,173
1974	298,755	329,849	249,309	231,324	229,621	274,882	406,473	558,054	1,042,721	336,645	192,211	206,502
1975	295,285	264,786	250,007	211,739	195,808	257,432	298,017	634,338	1,185,851	923,198	375,996	291,989
1976	407,575	399,782	371,844	304,970	265,050	329,133	542,929	1,130,311	926,576	409,867	250,674	322,614
1977	411,740	365,701	277,912	218,003	219,766	224,540	288,125	214,366	320,705	117,998	99,194	195,585
1978	292,481	267,420	237,040	222,300	223,299	358,982	445,918	618,812	717,003	446,115	169,443	289,569
1979	318,833	275,174	229,993	191,205	210,959	335,931	390,765	612,606	477,511	157,229	135,821	152,423
1980	197,537	250,287	217,581	171,350	221,262	246,825	348,028	702,208	829,457	312,333	137,782	269,655

Prepared By: TET
Reviewed By: JAB

Source of Data: USBR HydroMet-Hydrological Database

Water Control Manual
Canyon Ferry Dam and Reservoir
**Table of Historical Monthly
Inflow Volumes**
at Canyon Ferry Reservoir
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Canyon Ferry Reservoir
Historical Monthly Inflow Volumes (acre-feet)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1981	297,030	313,728	268,815	237,527	213,806	243,525	280,226	861,734	1,108,829	273,586	131,027	138,573
1982	288,467	287,986	249,186	196,392	259,831	289,629	364,227	746,759	1,143,836	657,090	201,642	290,385
1983	362,580	351,878	282,146	290,840	249,895	318,136	344,102	507,708	776,503	616,401	255,766	302,492
1984	410,254	427,329	280,441	324,940	283,266	314,369	396,249	799,404	1,195,359	608,677	364,278	364,546
1985	391,893	390,124	266,478	258,020	211,252	299,990	446,594	451,039	267,950	85,830	143,797	212,354
1986	327,516	218,739	229,898	230,407	239,232	301,187	368,342	502,640	786,998	248,516	150,073	285,589
1987	331,251	293,753	224,600	203,357	217,639	239,216	251,898	217,752	202,466	190,513	158,278	171,782
1988	213,786	228,094	187,486	172,234	197,159	208,781	278,660	407,224	270,659	71,710	59,963	103,551
1989	166,215	196,425	196,087	164,457	130,112	263,230	323,971	432,307	349,199	116,008	121,295	163,943
1990	216,970	273,951	196,578	197,584	163,679	215,247	295,838	283,503	480,460	146,006	139,687	140,357
1991	207,188	240,964	165,391	165,766	185,429	186,335	199,587	468,177	765,922	196,962	80,347	152,281
1992	214,173	271,543	221,667	184,227	185,794	212,524	219,064	224,329	217,148	241,348	91,183	140,801
1993	234,885	244,713	169,320	159,959	155,038	277,543	280,703	685,244	788,832	559,301	357,253	273,846
1994	327,224	286,965	242,650	238,533	170,040	251,460	322,889	370,964	241,589	107,309	81,727	94,903
1995	202,164	236,663	198,374	180,276	236,192	272,453	340,421	618,136	1,116,255	627,117	230,633	278,159
1996	336,141	353,859	284,999	239,023	285,637	325,529	475,308	802,204	1,218,383	281,481	138,995	187,002
1997	264,571	286,347	217,474	263,483	248,099	305,430	419,829	1,082,033	1,574,394	532,383	315,743	275,887
1998	368,541	371,191	279,666	269,294	252,605	312,617	401,096	611,215	868,772	657,382	236,893	210,094
1999	298,895	315,914	262,665	299,790	268,992	312,546	338,877	540,638	905,218	265,675	170,004	178,690
2000	237,803	264,790	249,426	241,140	228,614	246,581	263,890	333,283	345,342	116,440	82,375	122,091
2001	227,128	215,743	195,419	205,780	180,290	229,040	211,485	243,434	255,292	128,136	76,908	100,815
2002	163,805	195,454	167,623	183,619	154,883	185,798	218,488	218,521	547,984	157,941	91,108	121,788
2003	164,870	195,283	185,515	181,165	165,177	230,508	302,608	422,276	523,859	112,531	82,838	93,603
2004	136,467	177,767	179,845	155,381	180,770	214,904	192,248	184,395	301,815	167,522	103,519	136,915
2005	187,350	204,779	184,543	176,081	171,785	182,582	178,991	376,526	606,004	202,652	111,332	118,777
2006	207,681	219,684	193,800	226,028	170,171	223,714	382,554	598,755	548,888	157,095	90,151	118,080
2007	219,772	221,818	205,729	176,497	200,669	278,368	246,942	409,243	334,690	100,252	81,743	101,428
2008	188,811	179,074	172,909	152,454	181,975	197,198	220,505	581,045	967,057	430,589	111,154	244,688

Prepared By: TET
Reviewed By: JAB

Source of Data: USBR HydroMet-Hydrological Database

Water Control Manual
Canyon Ferry Dam and Reservoir
**Table of Historical Monthly
Inflow Volumes**
at Canyon Ferry Reservoir
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

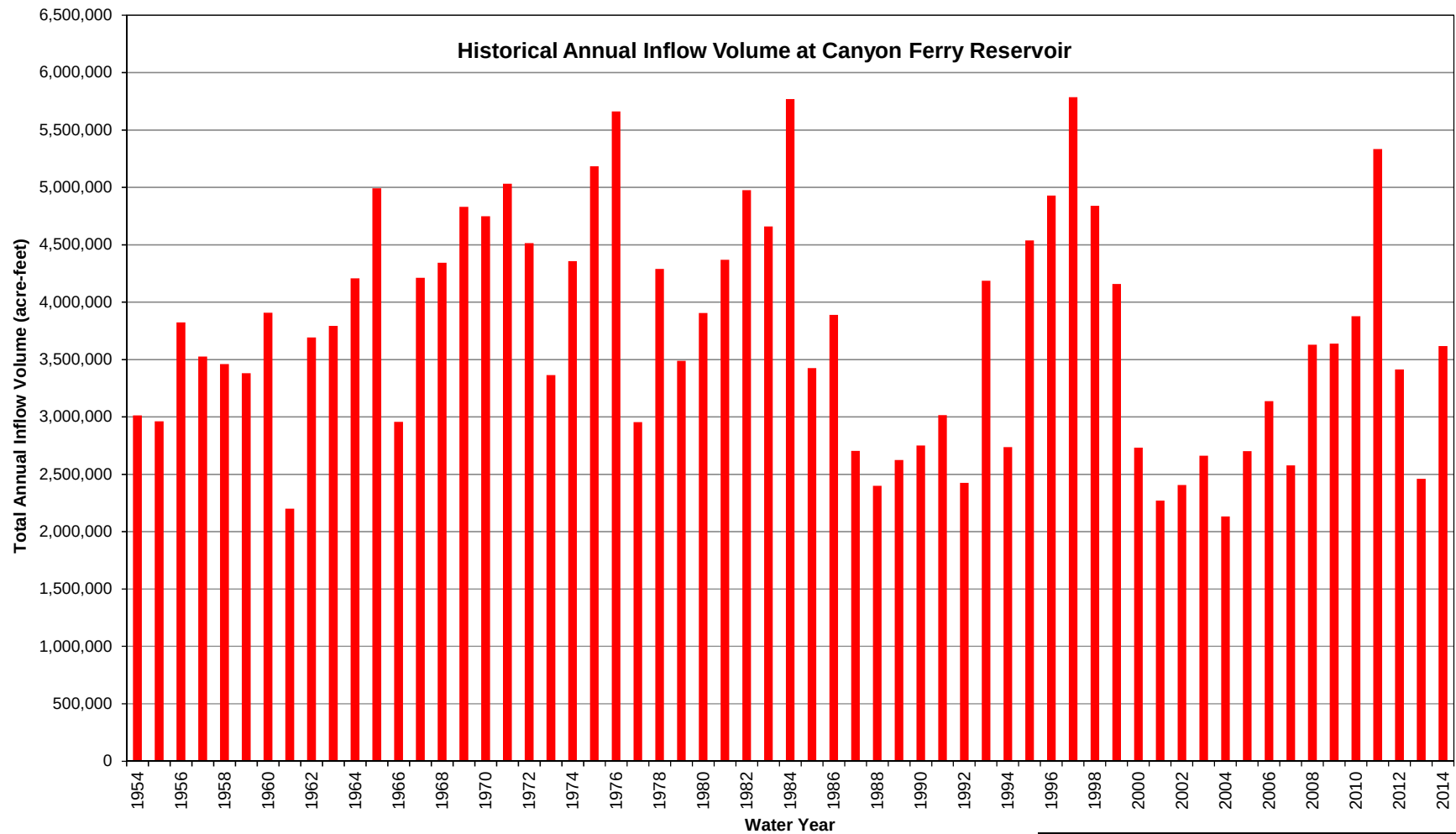
Canyon Ferry Reservoir
Historical Monthly Inflow Volumes (acre-feet)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2009	195,772	233,303	175,964	204,073	203,185	239,807	359,244	649,950	766,852	311,585	168,017	129,704
2010	250,796	253,743	184,065	227,857	210,567	215,655	258,771	317,569	1,102,008	449,586	179,020	227,774
2011	233,111	237,931	250,315	249,187	197,005	286,347	321,631	741,502	1,508,322	888,116	232,739	188,239
2012	272,495	275,407	246,704	252,442	241,805	291,656	434,623	506,896	502,550	172,979	104,555	111,335
2013	182,416	231,294	207,074	201,040	205,987	233,992	225,959	314,083	338,765	124,151	77,913	116,499
2014	209,502	200,447	162,515	192,656	152,698	293,844	377,076	733,871	677,914	267,790	158,933	190,445
2015	239,965	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Prepared By: TET
Reviewed By: JAB

Source of Data: USBR HydroMet-Hydrological Database

Water Control Manual
Canyon Ferry Dam and Reservoir
**Table of Historical Monthly
Inflow Volumes
at Canyon Ferry Reservoir**
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

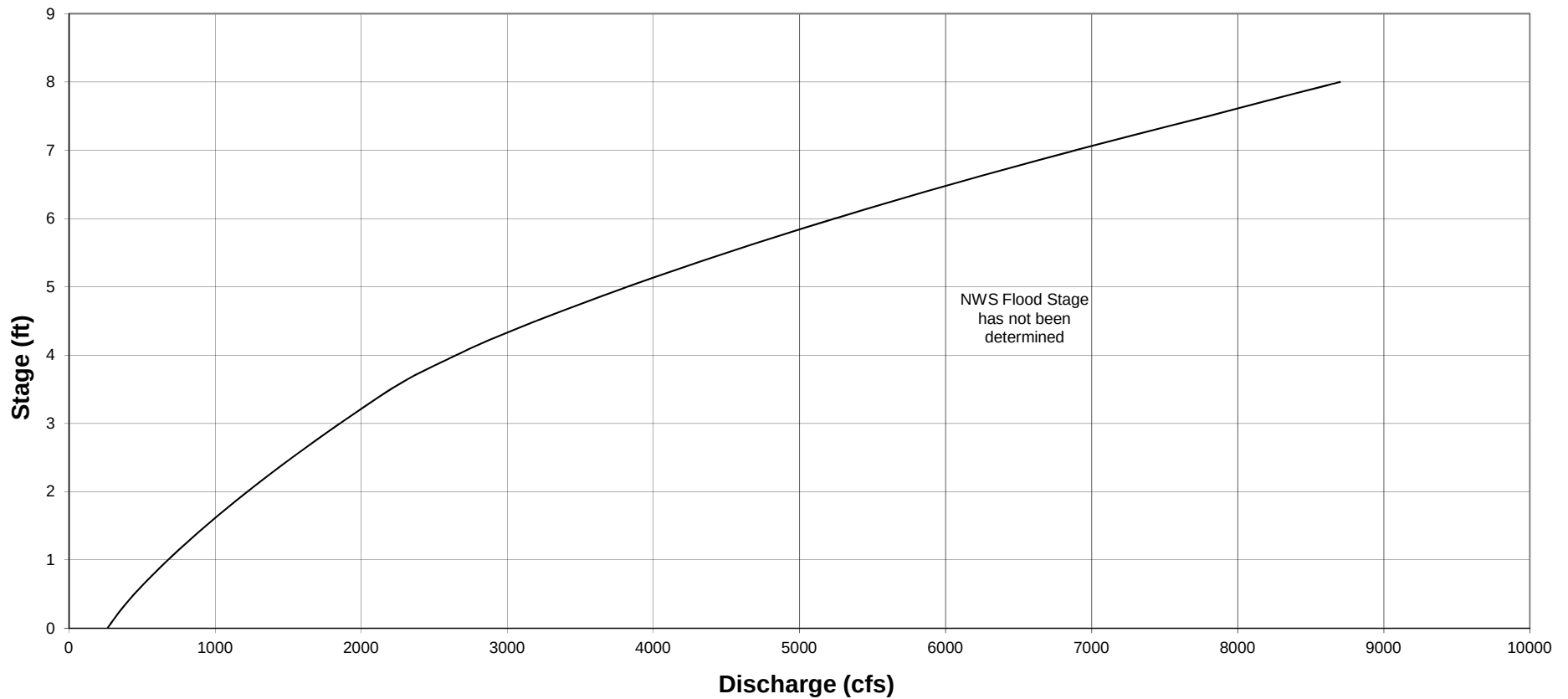


Annual Inflow Volume is an accumulation of average monthly inflows over a water year (Oct. - Sept.).

Source of Data: USBR HydroMet-Hydrological Database

Prepared By: TET
 Reviewed By: JAB

Water Control Manual
 Canyon Ferry Dam and Reservoir, MT
Historical Annual Inflow Volume
Canyon Ferry Dam, MT
 U.S. Army Engineer District
 Corps of Engineers, Omaha, Nebraska
 December 2016



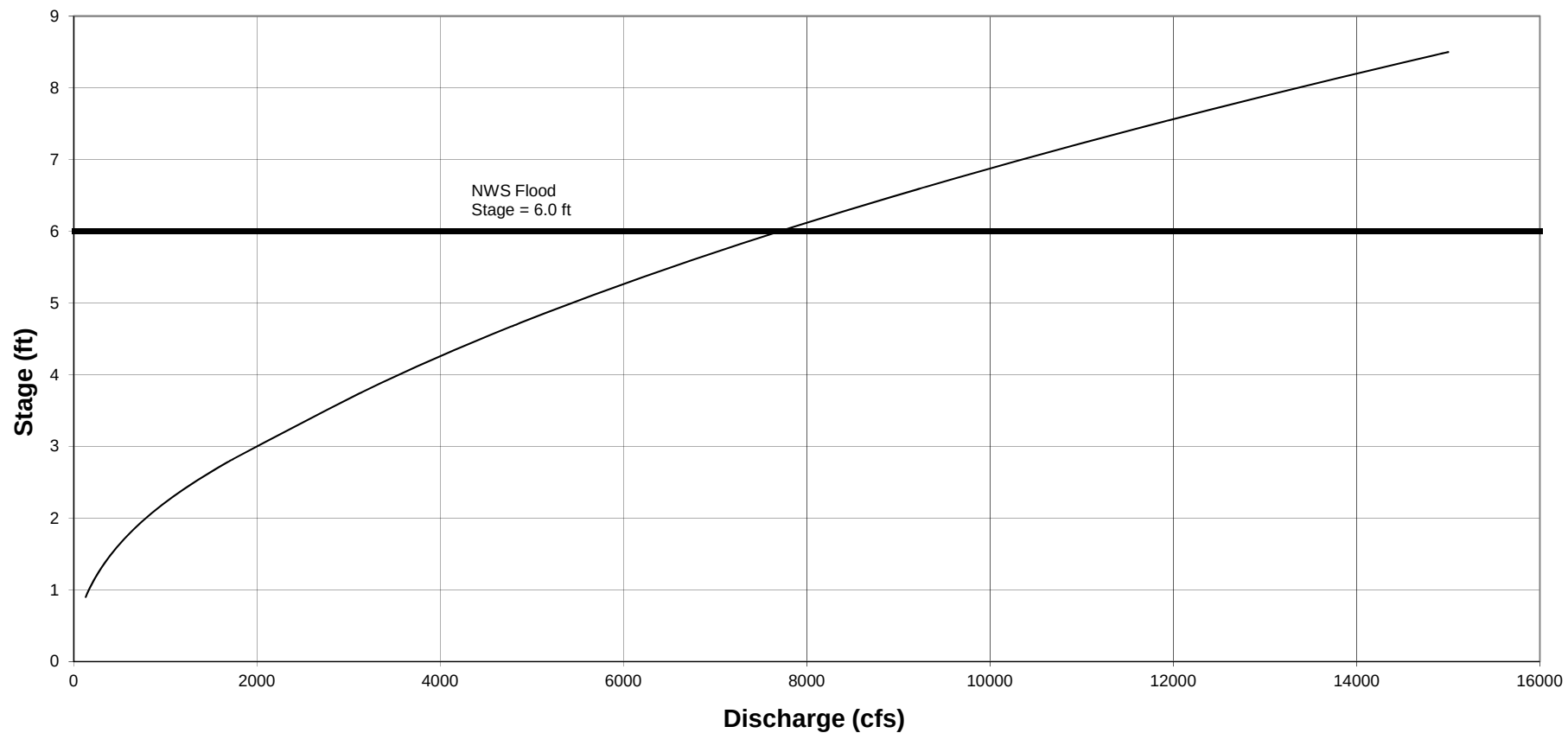
USGS Station No. 06041000 curve number 9

Datum is 4689.03 feet NGVD29.
Prior to May 7, 1941 at different datum.

Prepared By: JS
Reviewed By: AF

Water Control Manual
Canyon Ferry Reservoir and Dam
**Rating Curve Madison River below
Ennis Lake, MT**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



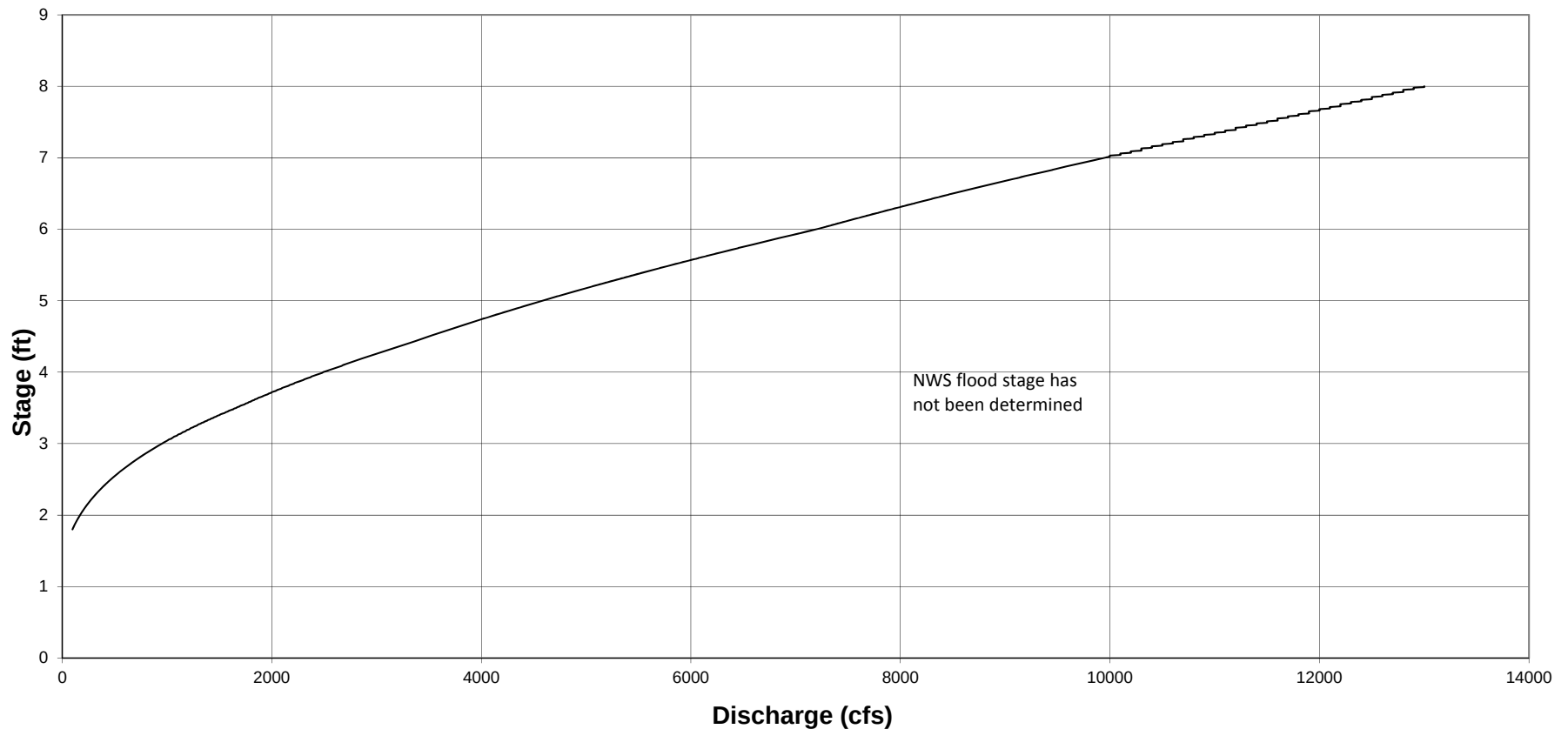
USGS Station No. 06025500 curve number 11

Datum is 5032.87 feet NGVD29.
Prior to September 30, 1931 at different datum.

Prepared By: JS
Reviewed By: AF

Water Control Manual
Canyon Ferry Dam and Reservoir
**Rating Curve Big Hole River near
Melrose, MT**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



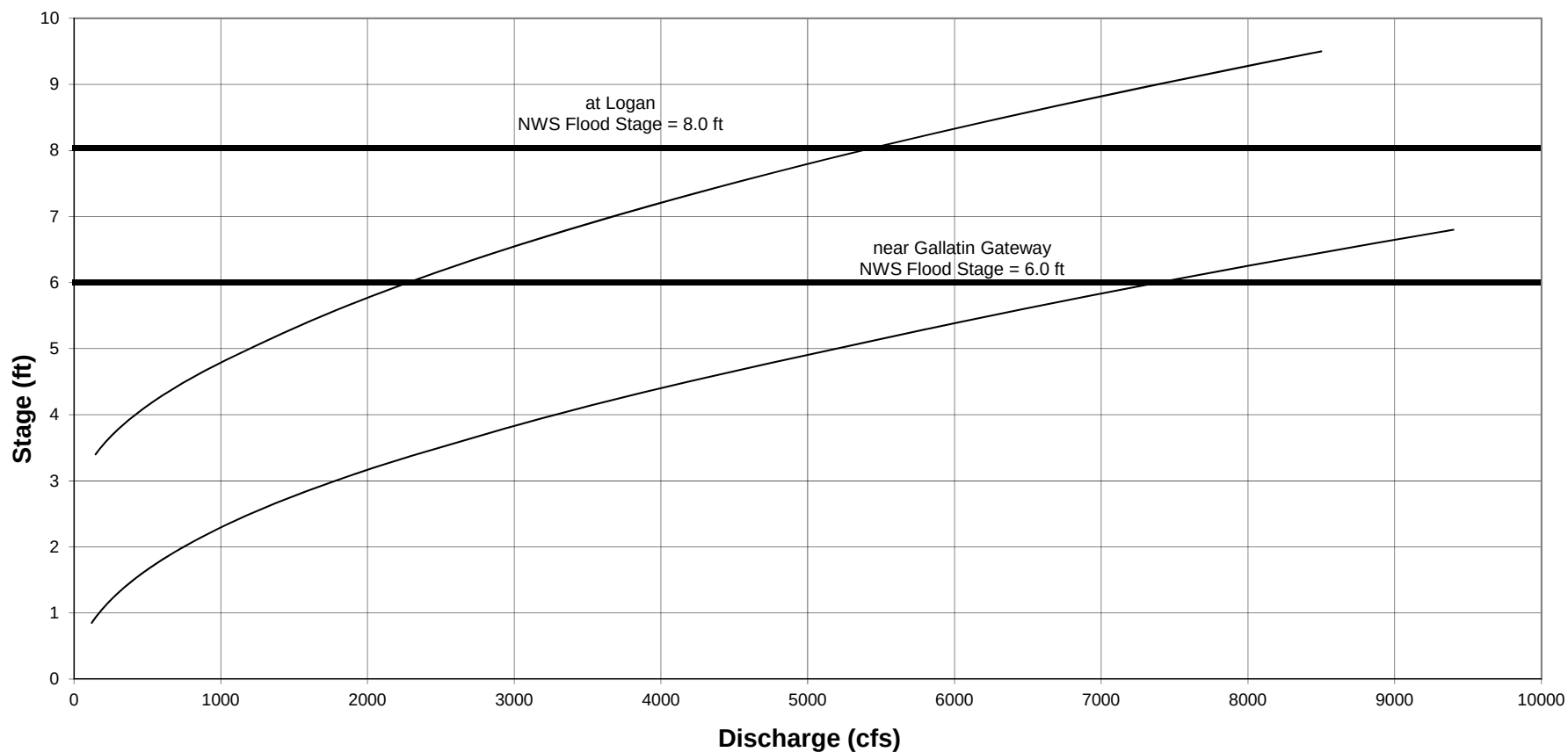
USGS Station No. 06026210 curve number 3.1

Datum is 4850.00 feet NAVD88.

Prepared By: JDM
Reviewed By: JAB

Water Control Manual
Canyon Ferry Dam and Reservoir
**Rating Curve Big Hole River near
Glen, MT**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Gallatin River at Logan, MT (USGS Station No. 06052500) curve number 14.

Datum is 4086.42 feet NGVD29.

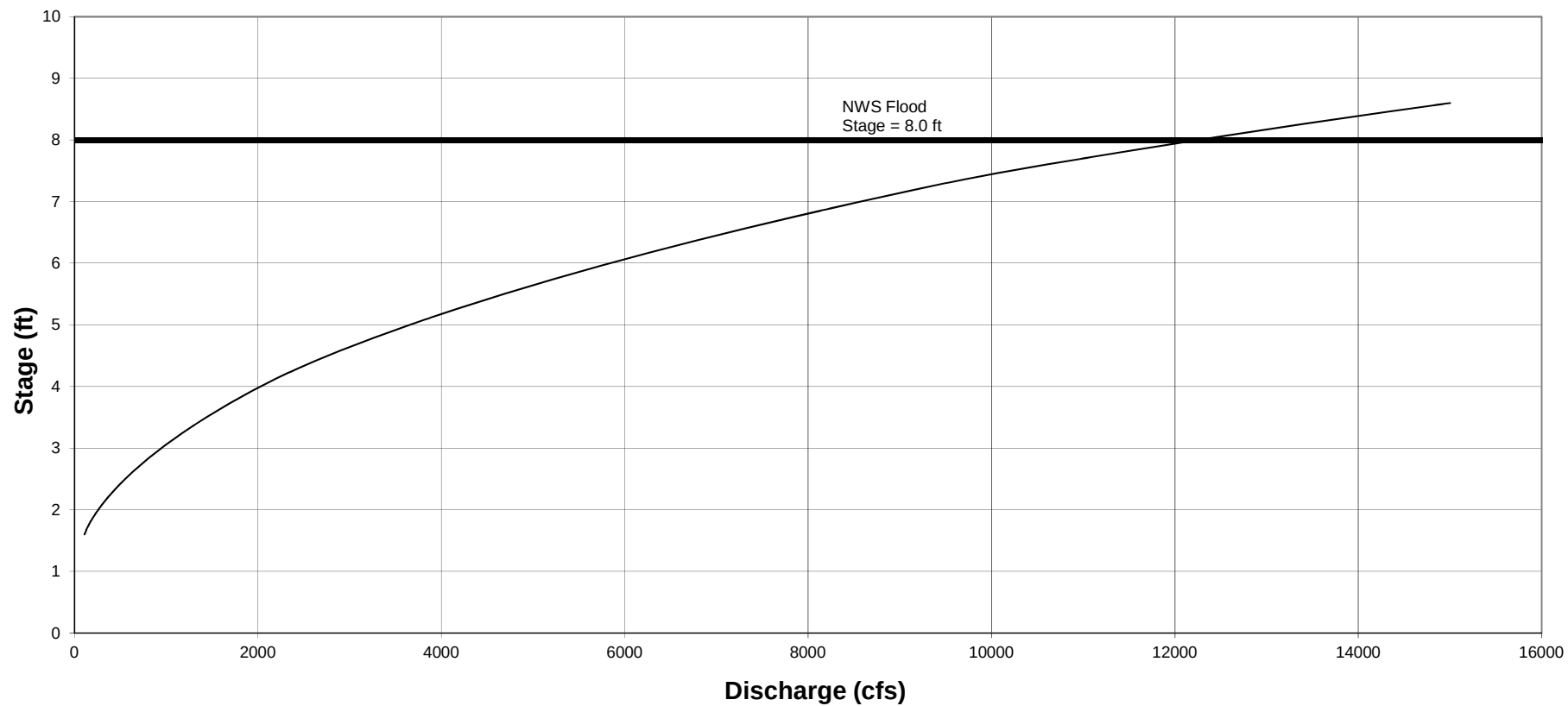
Gallatin River at Gallatin Gateway, MT (USGS Station No. 06043500)
curve number 9.

Datum is 5167.67 feet NGVD29.

Prepared By: JS
Reviewed By: AF

Water Control Manual
Canyon Ferry Dam and Reservoir
**Rating Curves - Gallatin River at Logan,
MT and near Gallatin Gateway, MT**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



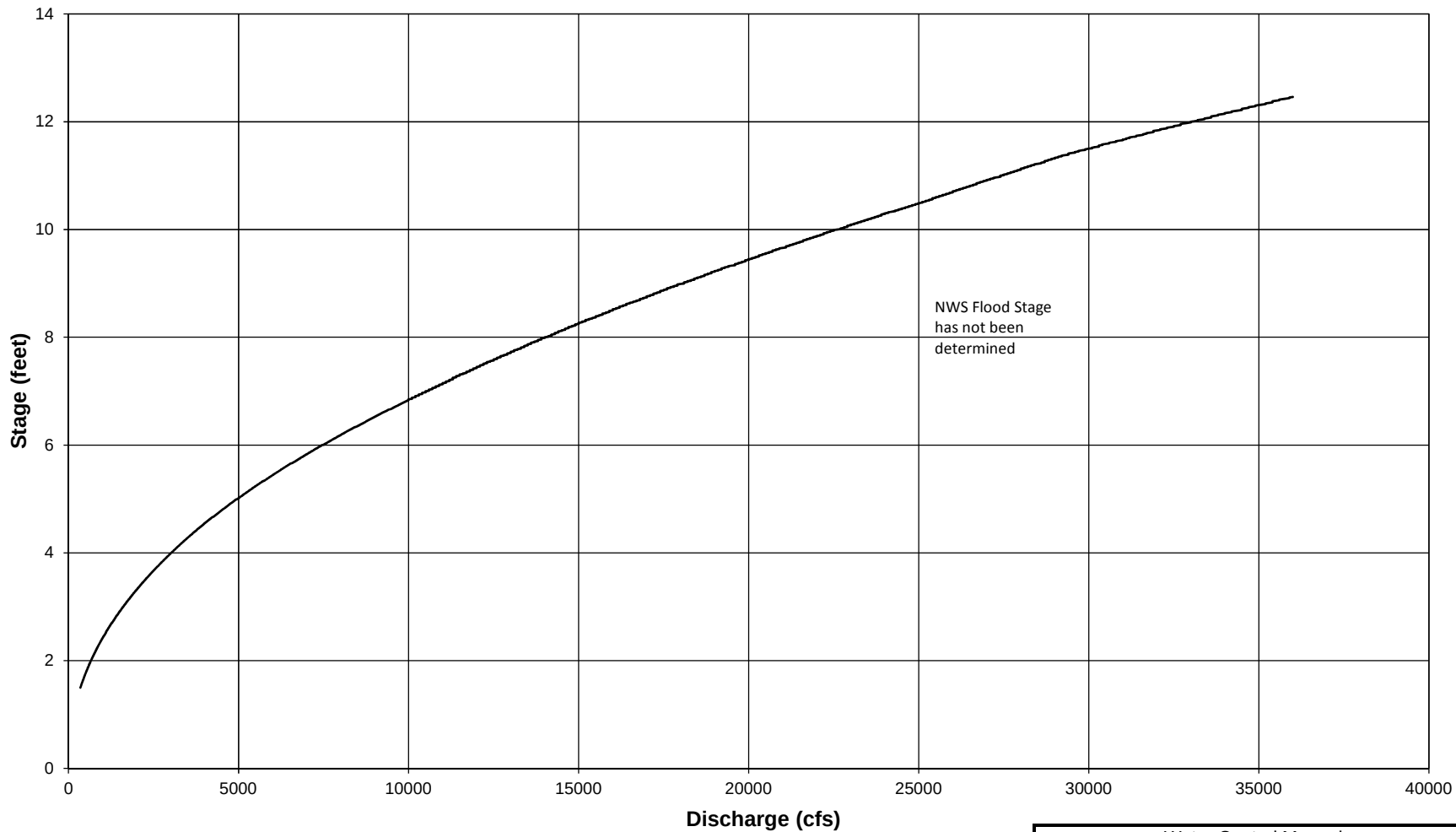
USGS Station No. 06036650 curve number 7.1

Datum is 4076.76 feet NGVD29.

Prepared By: JS
Reviewed By: AF

Water Control Manual
Canyon Ferry Dam and Reservoir
Rating Curve
Jefferson River
near Three Forks, MT

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



USGS Station No. 06054500 curve number 4.

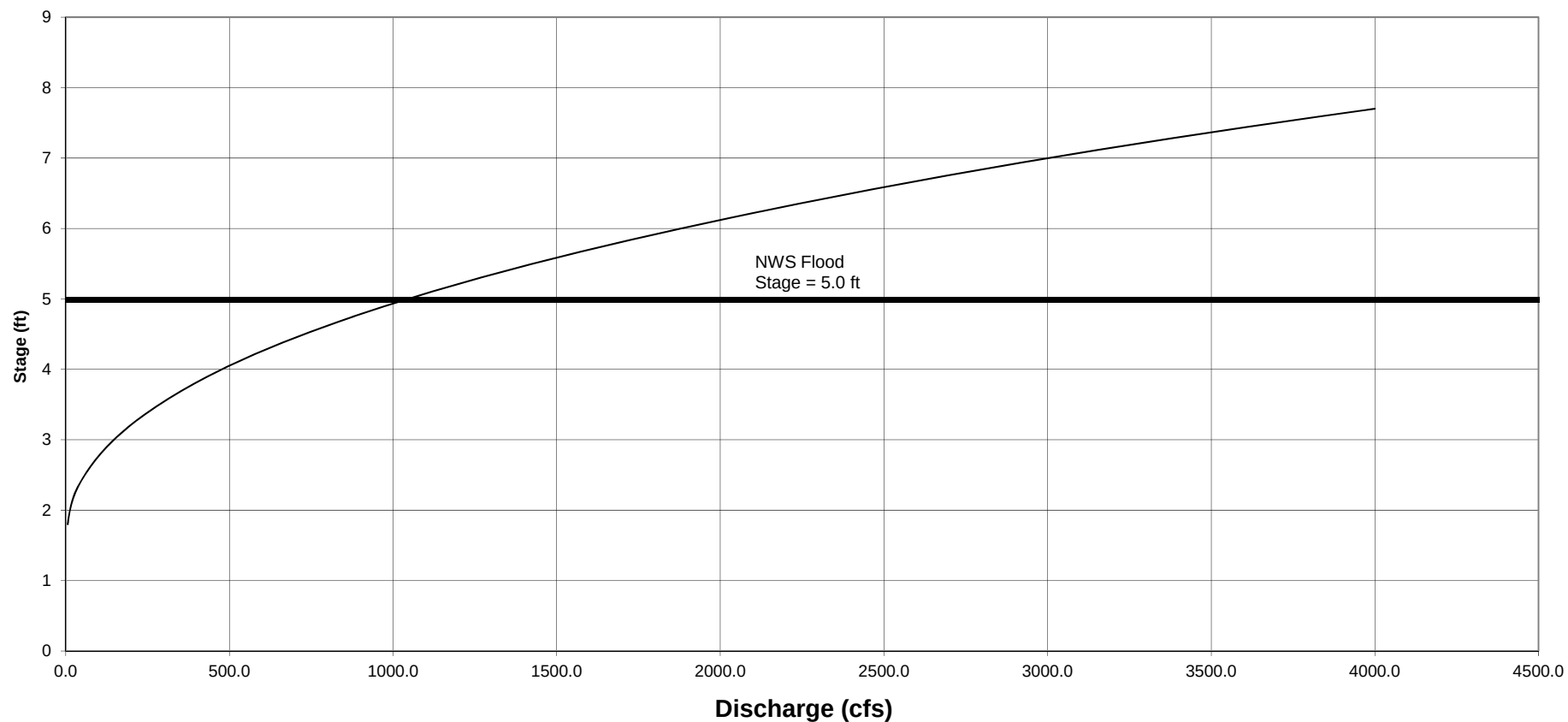
Gage Datum: 3,905.68 feet NGVD29

Prepared By: JS
 Reviewed By: AF

Water Control Manual
 Canyon Ferry Dam and Reservoir

Rating Curve Missouri River at Toston, MT

U.S. Army Engineer District
 Corps of Engineers, Omaha, Nebraska
 December 2016



USGS Station No. 06073500 curve number 15.

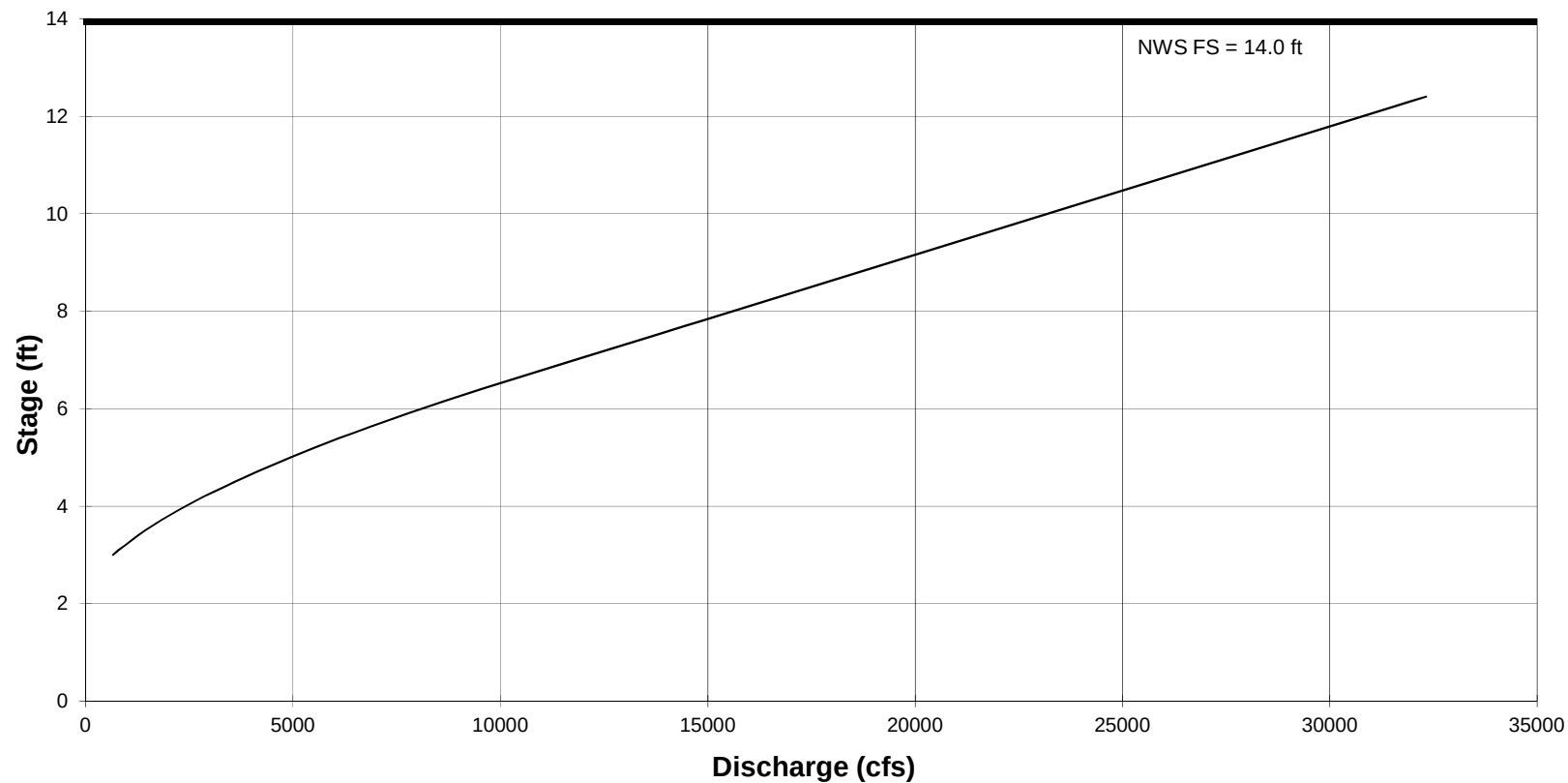
Datum is 3800 feet NAVD88.

Prepared By: JS
Reviewed By: AF

Water Control Manual
Canyon Ferry Dam and Reservoir

Rating Curve
Dearborn River near Craig, MT

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



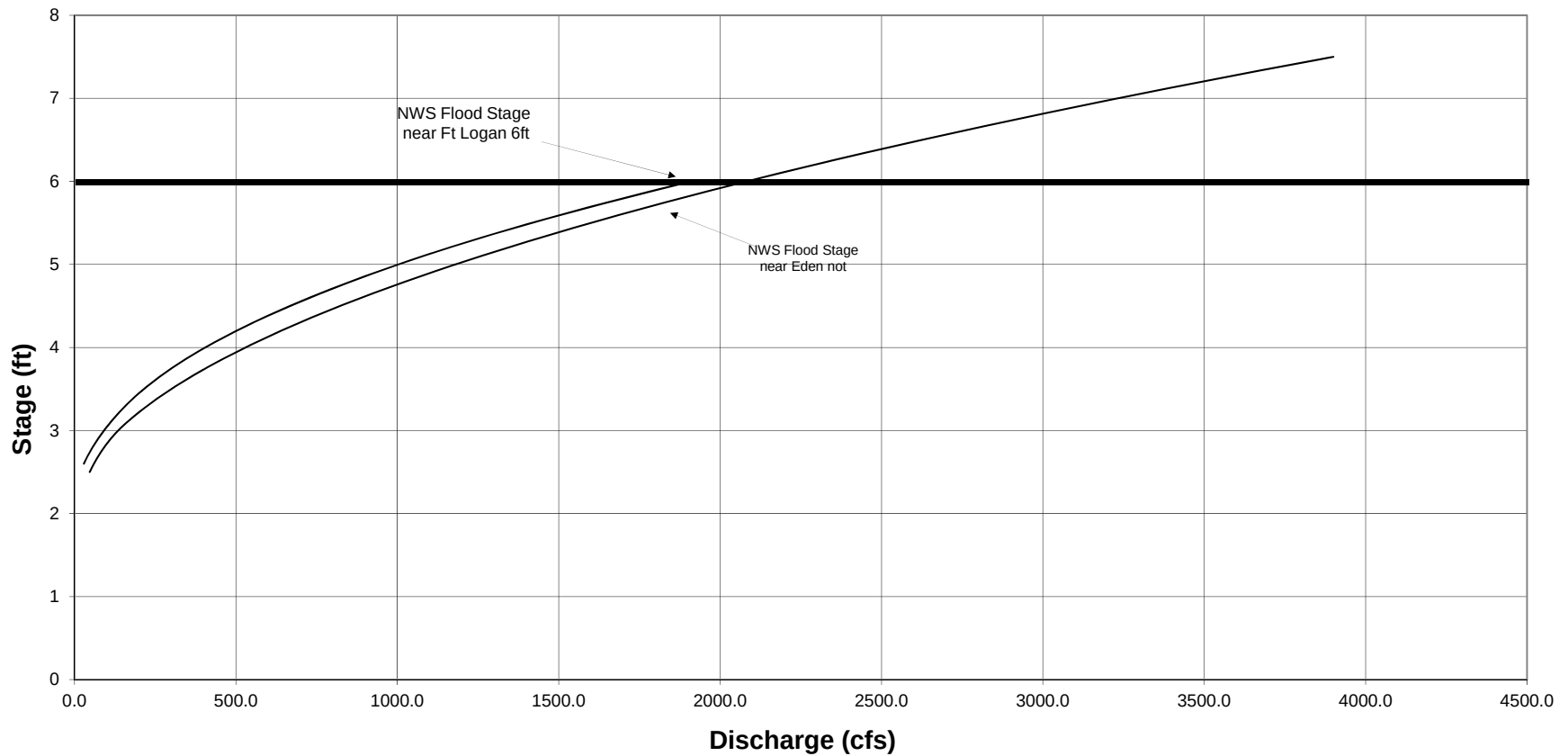
USGS Station No. 06074000 curve number 1.

Datum is 3,337.8 feet NGVD29.

Note: In May 2014 the USGS began collecting real-time data at

Prepared By: JS
 Reviewed By: AF

Water Control Manual
 Canyon Ferry Dam and Reservoir
Rating Curve
Missouri River at Cascade, MT
 U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



Smith River near Ft. Logan, MT (USGS Station No. 06076690) curve number 6.

Elevation is 4400 feet NGVD29.

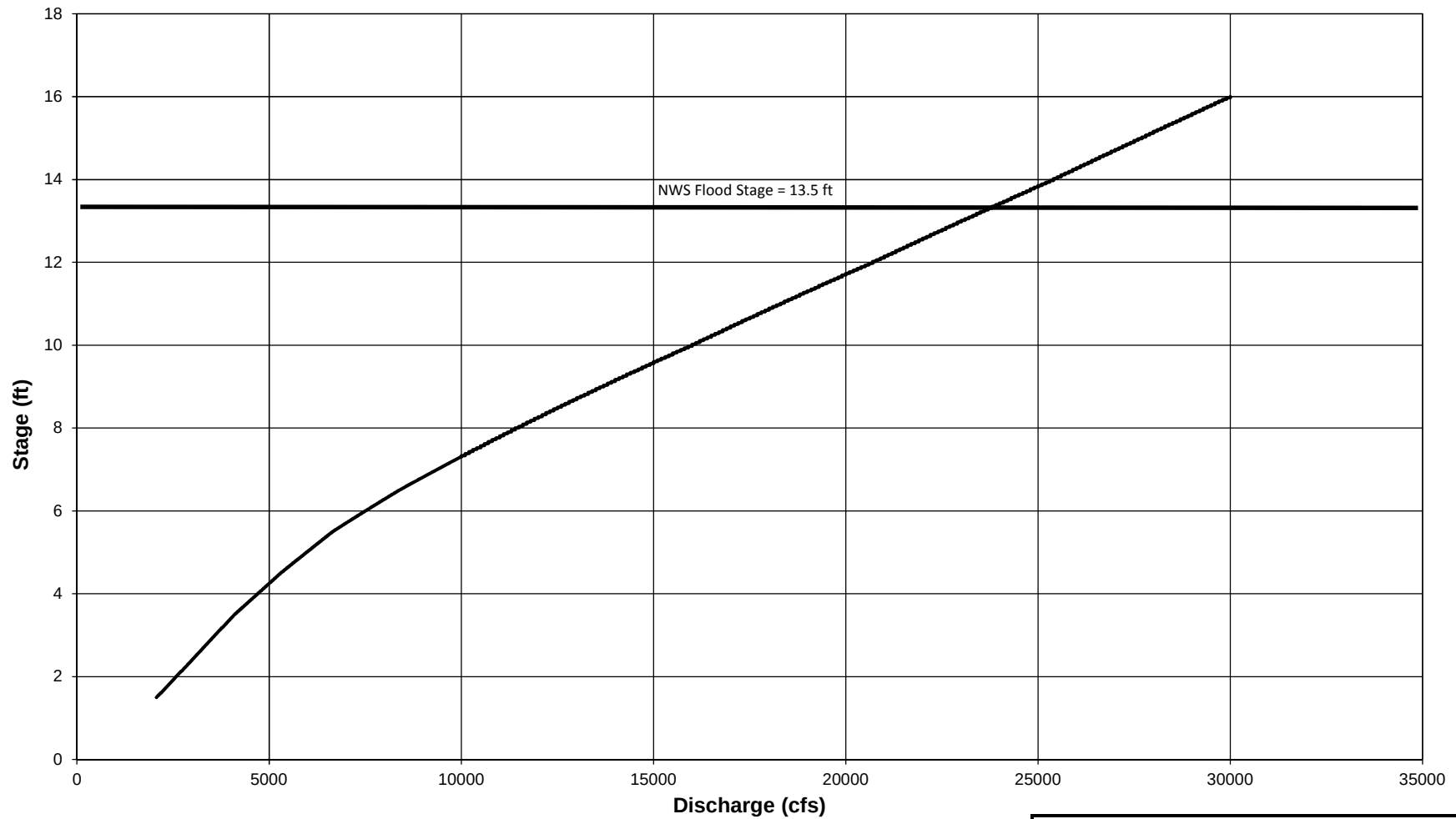
Smith River near Eden, MT (USGS Station No. 06077500) curve number 6.

Elevation is 3500 feet NAVD88.

Prepared By: JS
 Reviewed By: AF

Water Control Manual
 Canyon Ferry Dam and Reservoir
**Rating Curve Smith River near Ft. Logan
 and Eden, MT**

U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016

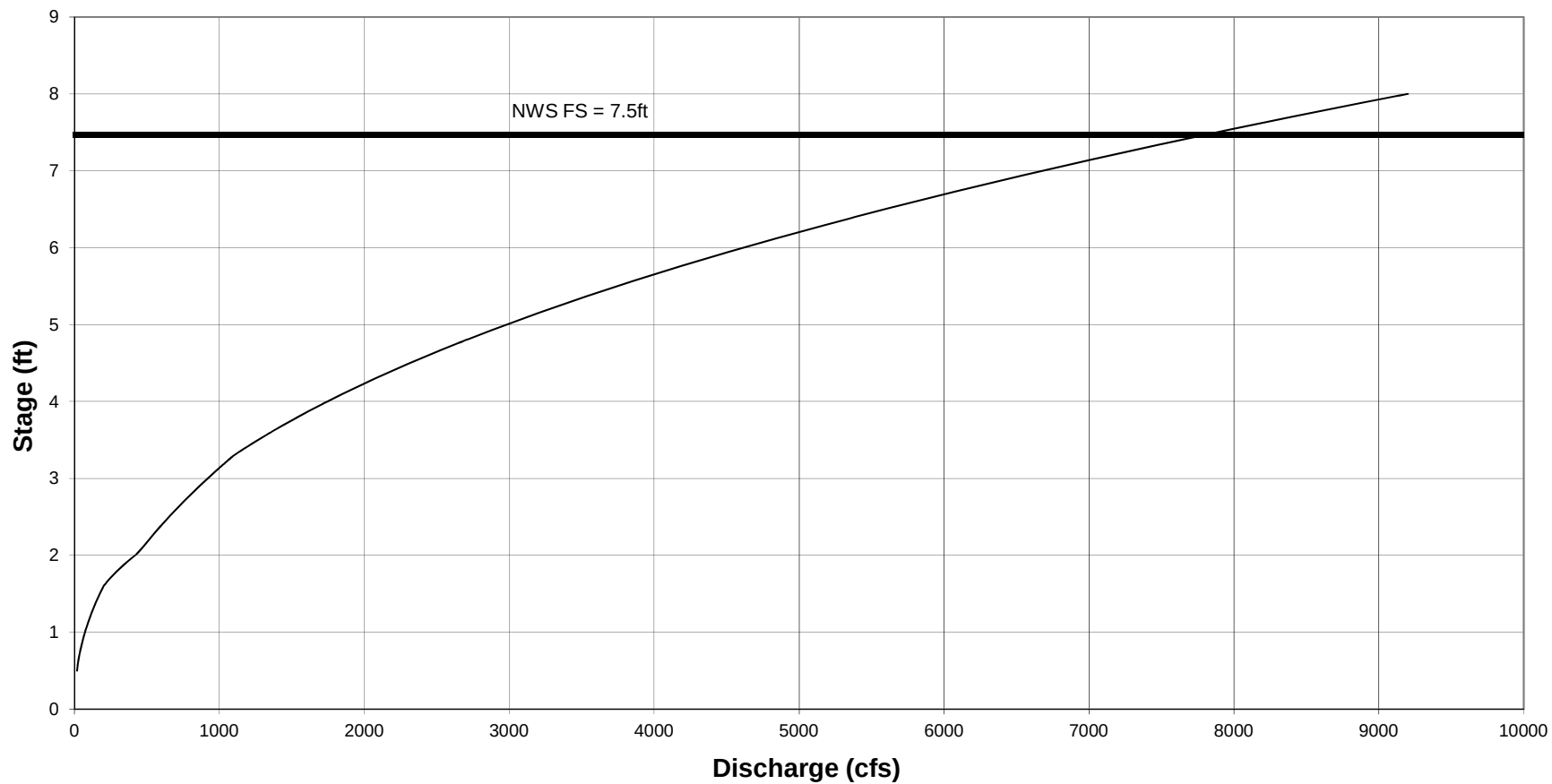


USGS Station No. 06078200 curve number 8.

Gage Datum: 3,313.27 feet NGVD29

Prepared By: JS
 Reviewed By: AF

Water Control Manual
 Canyon Ferry Dam and Reservoir
Rating Curve
Missouri River at Ulm, MT
 U.S. Army Engineer District
 Corps of Engineers, Omaha, Nebraska
 December 2016



USGS Station No. 06085800 curve number 12.

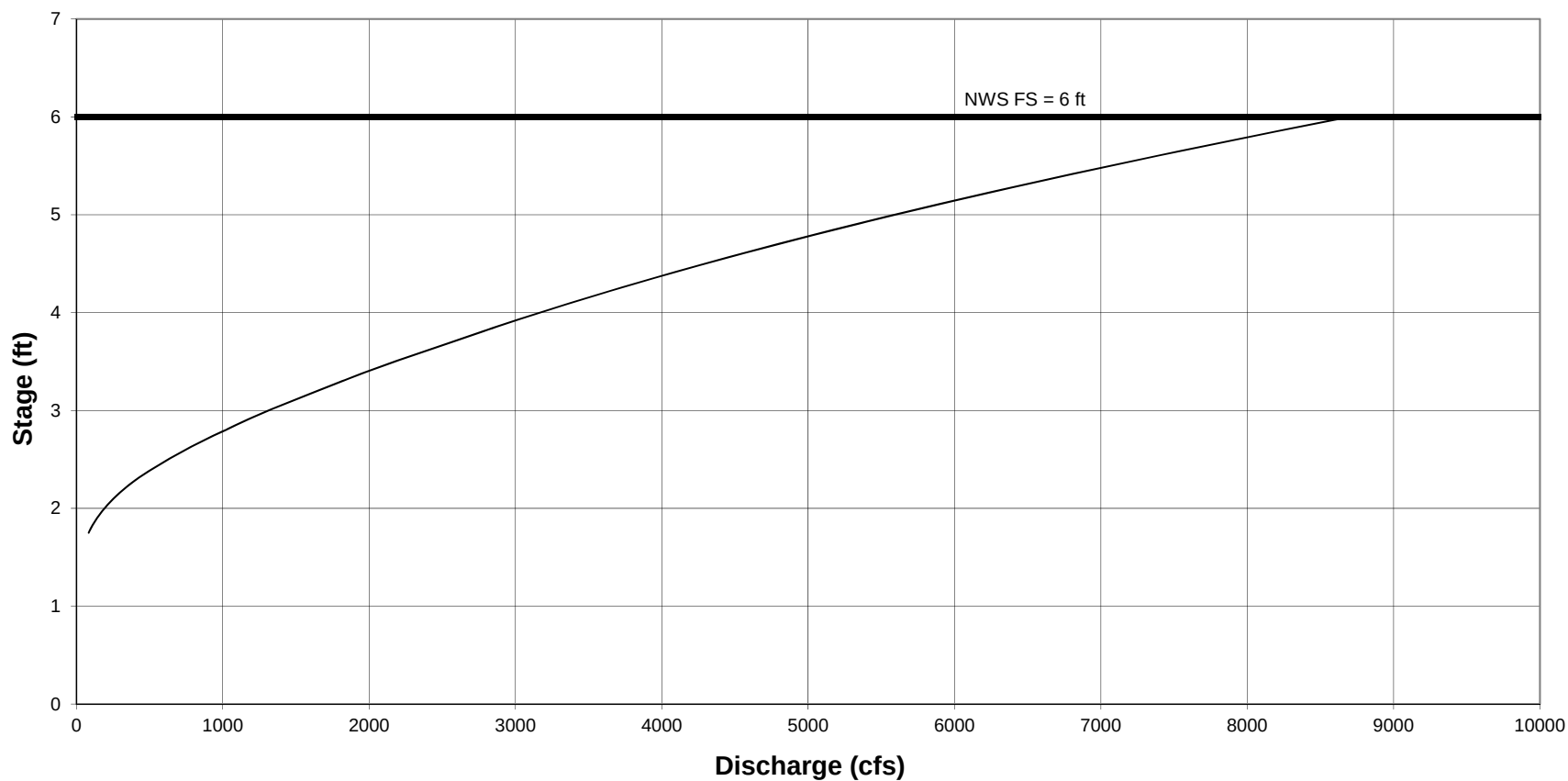
Datum is 3570 feet NAVD88.

Prepared By: JS
Reviewed By: AF

Water Control Manual
Canyon Ferry Dam and Reservoir

Rating Curve
Sun River at Simms, MT

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



USGS Station No. 06089000 curve number 16.

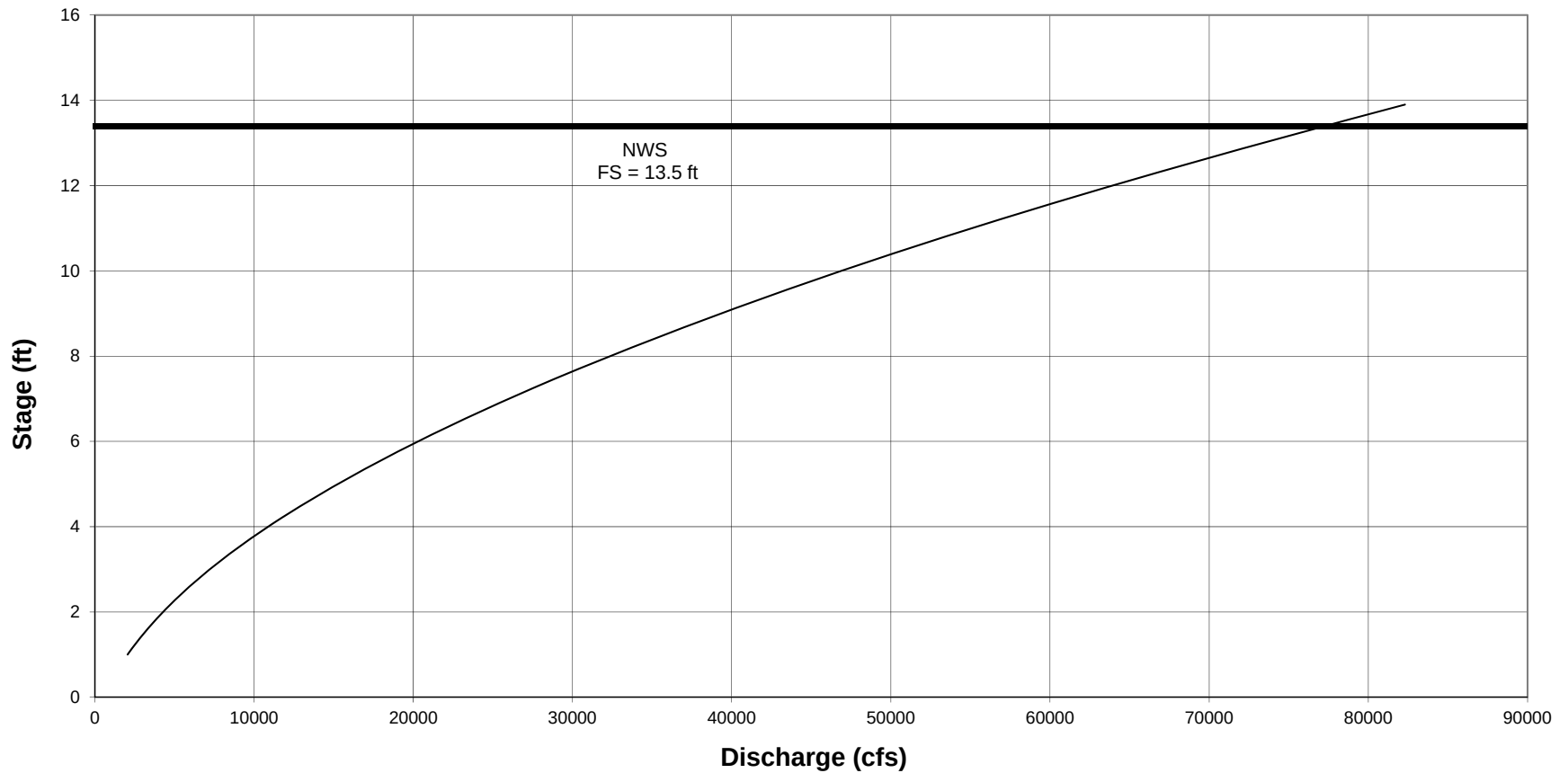
Datum is 3340.02 feet NGVD29.

Prepared By: JS
Reviewed By: AF

Water Control Manual
Canyon Ferry Dam and Reservoir

Rating Curve
Sun River at Vaughn, MT

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



USGS Station No. 06090800 curve number 7.

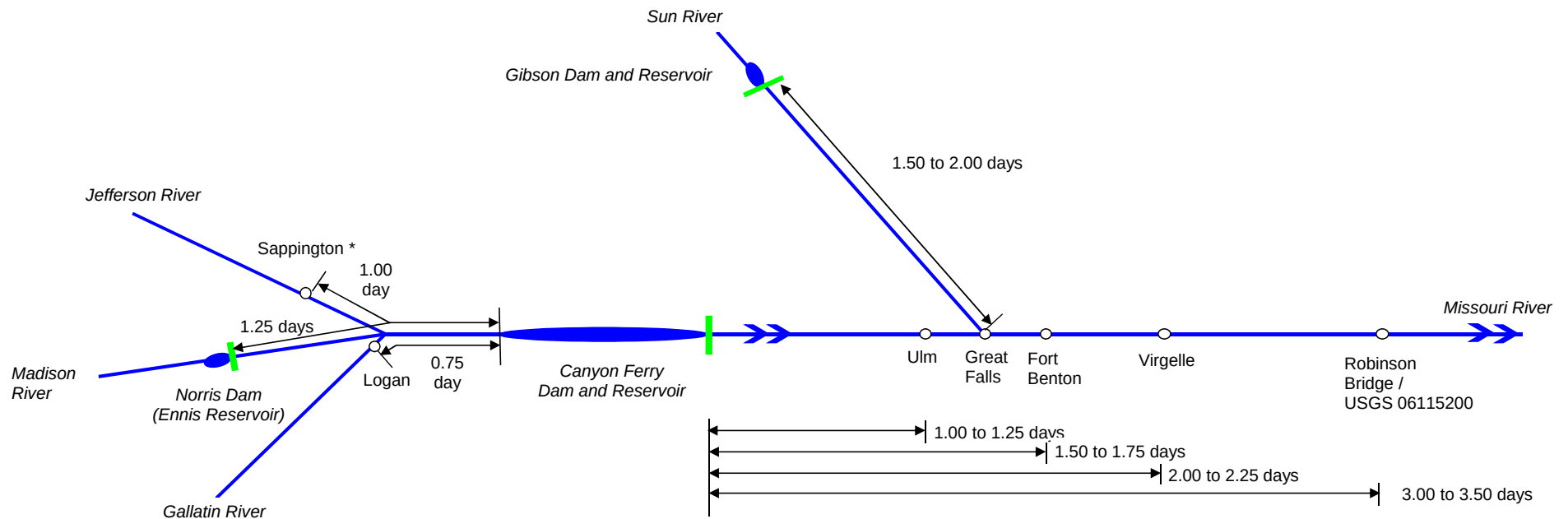
Datum is 2614.05 feet NGVD29.

Prepared By: JS
Reviewed By: AF

Water Control Manual
Canyon Ferry Dam and Reservoir
Rating Curve
Missouri River at Fort Benton, MT
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

APPROXIMATE TRAVEL TIMES

Bank full to less than bank full below Canyon Ferry Dam.
Bank full above Canyon Ferry Dam.



Water Control Manual
Canyon Ferry Reservoir and Dam, Montana

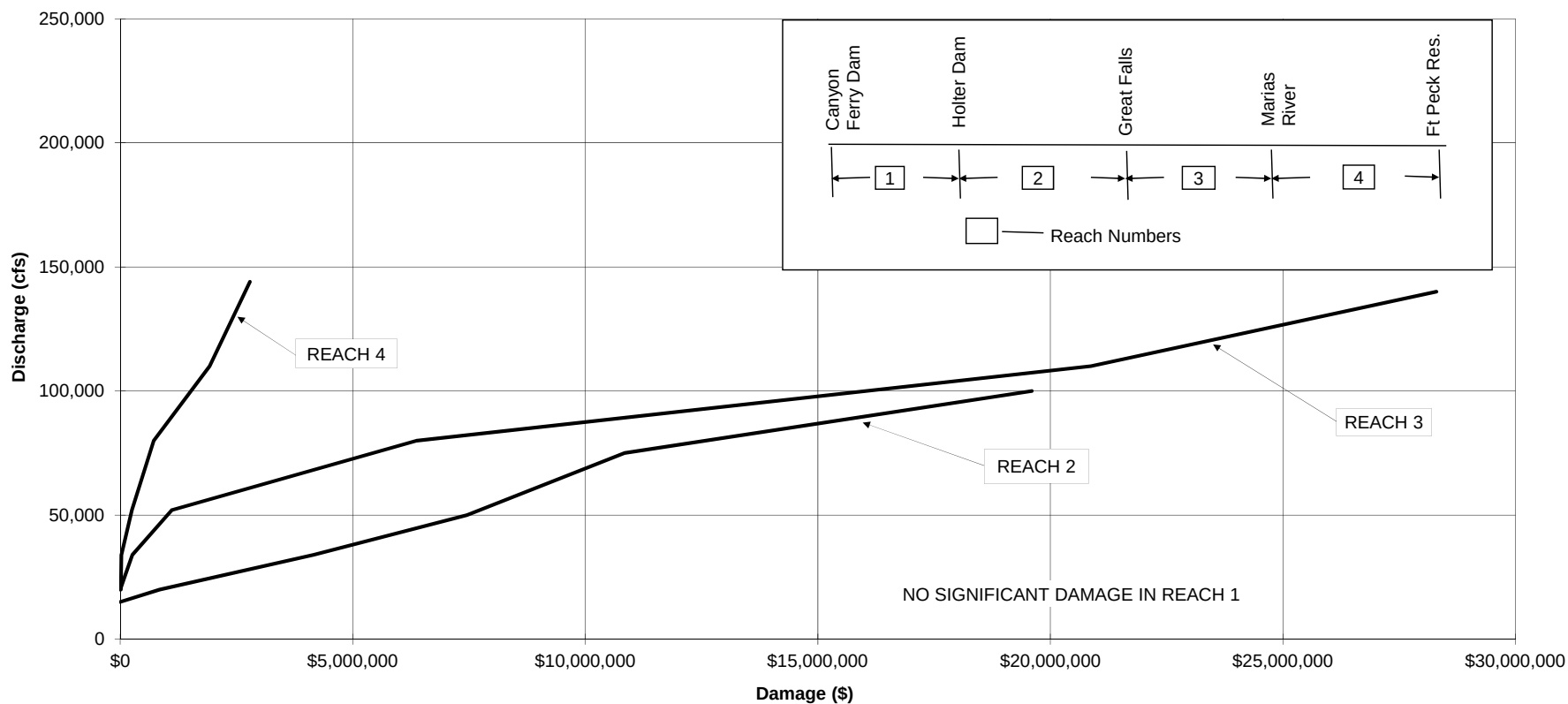
Average Travel Times Near Canyon Ferry Dam

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

Source: Preliminary Information Report on Reservoir Regulations for
Canyon Ferry Dam and Lake, Corps of Engineers, 1972
and letter from Bureau of Reclamation, January, 1994

* Sappington is approximately 15 river miles upstream of Three Forks, MT

Prepared By: JB
Reviewed By: TET

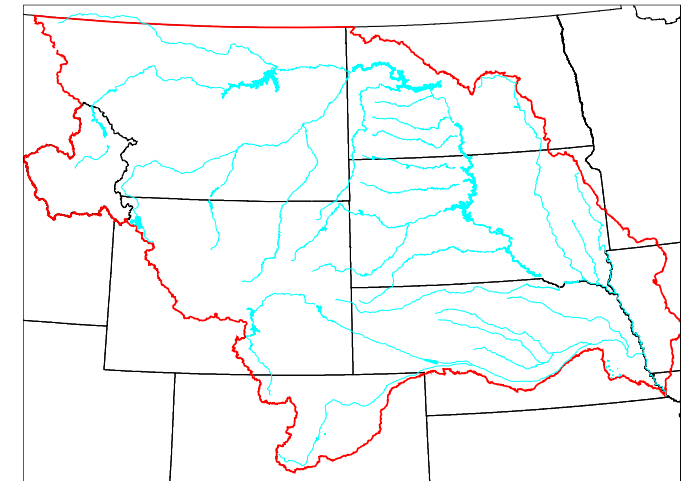
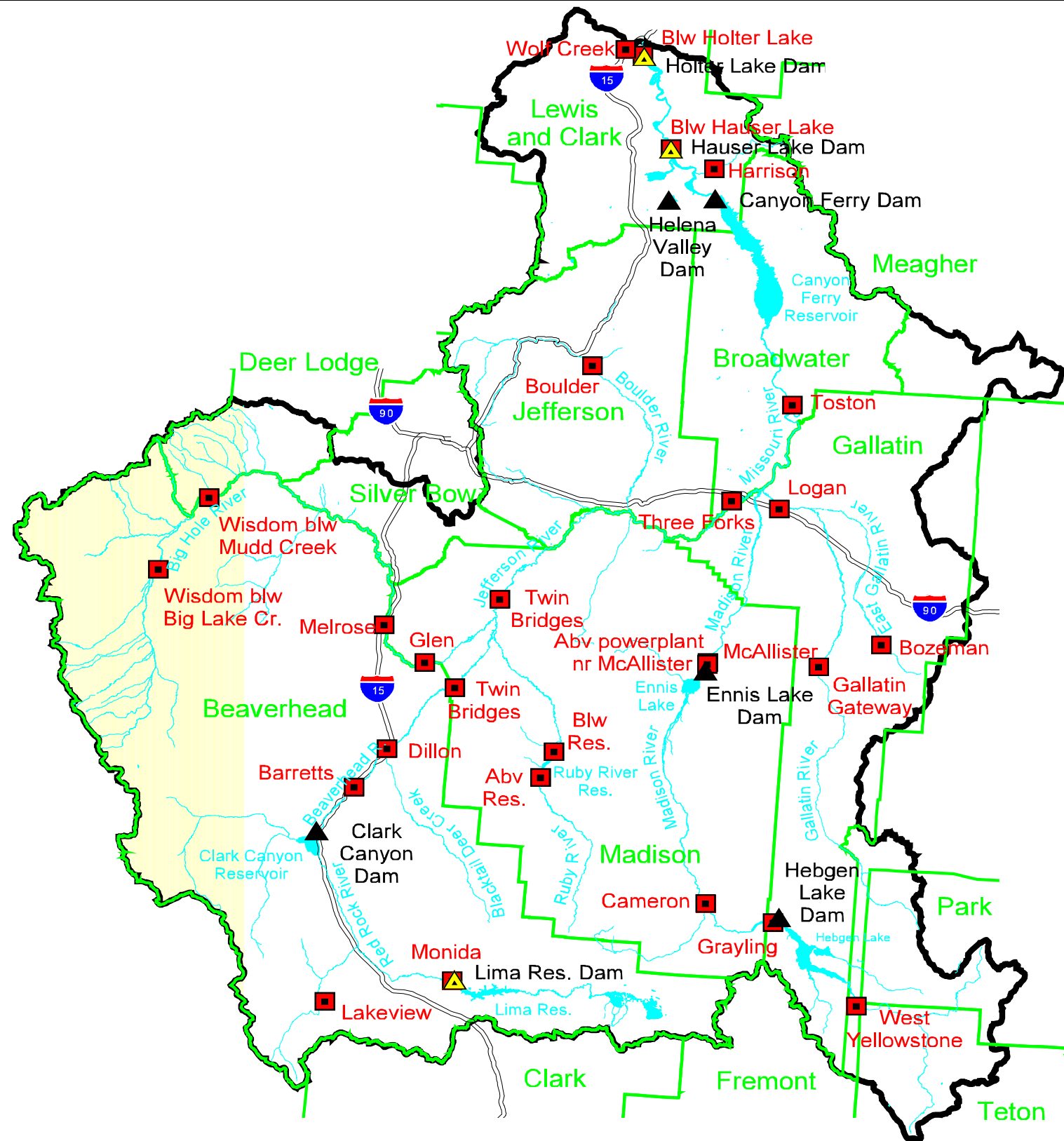


September 2013 Price Levels
 Data provided by Environmental, Economics and Cultural Resource Section,
 Project Management Branch, Corps of Engineers, Omaha District

Prepared By: TET
 Reviewed By: JAB

Water Control Manual
 Canyon Ferry Reservoir and Dam, Montana
**Missouri River Discharge Damage
 Curves (Sept 2013 Price Levels)**

U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



- Dams (Contains No Pool Gage)
- Dams (Includes a Pool Gage)
- Gage Stations
- Counties
- Canyon Ferry Upstream Basin

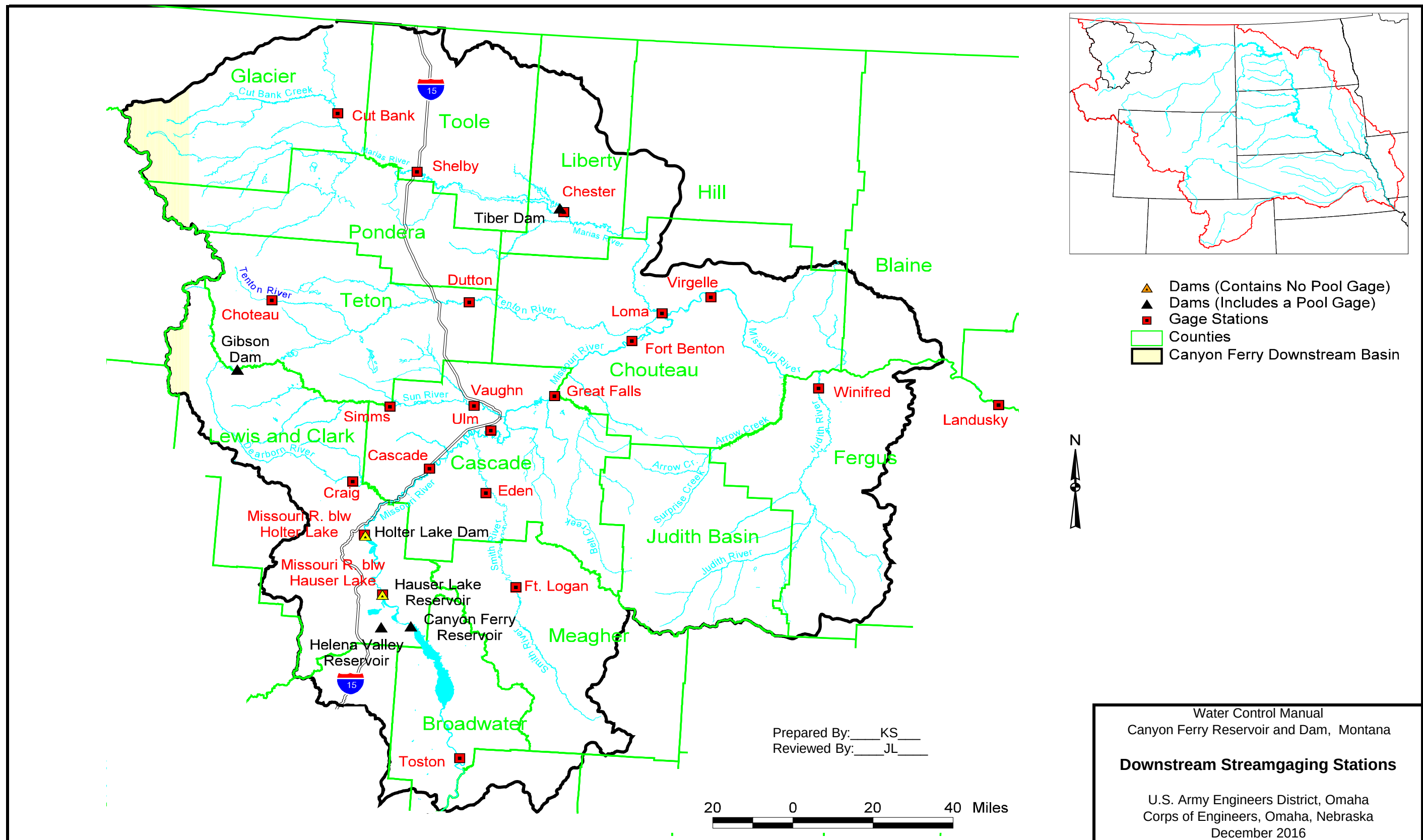


Prepared By: ____KS____
Reviewed By: ____JL____

Water Control Manual
Canyon Ferry Reservoir and Dam, Montana

Upstream Streamgaging Stations

U.S. Army Engineers District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



											Reservoir Contents				
Station Name	USGS	Corps Station ID CWMS	NWS NESS ID	USBR Hydromet ID	Drainage Area (sq. mi.)	Flood Stage (ft.)	Annual Mean (cfs)	Reservoir Completed	Records	Notes	Spillway Crest (ft, msl)	Maximum Elevation (ft, msl)	Usable Capacity (acre-ft)	Maximum Storage (acre-ft)	Year
Lima Res. Dam	06012000	LRMT	F23007B6	LIMR	570			1902	1940-		6582.7	6582.98	84,050	85,870	1984
Red Rock R blw Lima Reservoir nr Monida MT 1	06012500		34867130	LIMR	570	unknown	143		1911-	1,2					
Clark Canyon Dam	06015300	CLCA	F23014C0	CCR	2321			1964	1964-		5560.4	5564.7	253,400	283,000	1984
Beaverhead R at Barretts MT	06016000	BRMT	163F41A0	BVB	2737	unknown	441		1907-	1,2					
Beaverhead R at Dillon MT	06017000	DIMT	DD3094A2	BRDM	2895	unknown	366		1907-	1,2					
Beaverhead R. nr Twin Bridges MT	06018500	TBMT	162CEF1A	BVTB	3619	7.0	382		1935-						
Ruby R abv reservoir nr Alder MT	06019500		DD9C5676	RRAM	534	unknown	180		1938-						
Ruby River Reservoir	06020500	Real-Time Pool Elevations Unavailable											38,000		
Ruby R blw reservoir nr Alder MT	06020600		DE064692	RRBM	596	unknown	201		1962-						
Big Hole R blw Big Lake Cr at Wisdom MT	06024450		DE08F174	WISM	575	unknown	252		1988-	2					
Big Hole R blw Mudd Creek nr Wisdom MT	06024540		DD9662BE	BHWM	1267	unknown	696		1997-	2					
Big Hole R nr Melrose MT	06025500	MELM	1735112C	MELM	2476	6.0	1103		1923-						
Big Hole R nr Glen MT	06026210		DD9671C8	BHGM	2655	unknown	1266		1997-	2					
Jefferson R. nr Twin Bridges	06026500	JRMT	174AA19C	JRMT	7632	unknown	1831		1940-	1					
Boulder R nr Boulder MT	06033000		1718D6BA	BLDM	381	unknown	120		1929-	1					
Willow Cr nr Harrison MT	06035000		171C83FC	-	8308	unknown	41		1938-	1,2					
Jefferson R. nr Three Forks MT	06036650	TFMT	CE78B056	TFMT	9532	8.0	1910		1978-						
Madison R nr West Yellowstone MT	06037500		DD7F54F2	MWYM	420	unknown	495		1913-	1					
Hebgen Lake	06038000	HEBN	F23044BC	HEBR	904			1915	1936-		6534.87	6535	344,700	380,500	1987
Madison R blw Hebgen Lake nr Grayling MT	06038500		F0010078	MWYM	905	unknown	1038		1909-						
Madison R at Kirby Ranch nr Cameron MT	06038800	MRKR	D10F2284	MRCM	1065	unknown	1214		1959-	1					
Ennis Lake	06040500	Real-Time Pool Elevations Unavailable			2181			1900	1936-		4841.5	4841.45	41,020	40,830	1968
Madison R. ab powerplant nr McAllister MT	06040800		D10F827C	-	2186	unknown	432		2002-						
Madison R blw Ennis Lake nr McAllister MT	06041000	MCMT	D10F72F8	MAMT	2186	unknown	1751		1939-	1					
Gallatin R nr Gallatin Gateway MT	06043500		DE345660	GRGM	825	6.0	810		1889-	1					
East Gallatin R blw Bridger Cr nr Bozeman MT	06048700		16691550	-	226	unknown	67		2001-						
Gallatin R at Logan MT	06052500	LGMT	CE78ADF2	LGMT	1795	8.0	1059		1893-1905,1928-	1					
Missouri R at Toston MT	06054500	TOMT	CE788BE84	TOMT	14,669	10.5	5086		1890-	1					
Canyon Ferry Dam	06058500	CAFÉ	F23057CA	CFR	15,904			1953	1953-		3766	3800	1,993,000	2,043,000	1955, 1956, 1962, 1960
Lake Helena	06064500		F23300B8	-	610			1907			3635	3635.7	12,710	12,040	2003
Hauser Lake Dam	06065000	Real-Time Pool Elevations Unavailable			16,876			1907	1936-		3635	3635.4	61,870	66,040	2003
Missouri R blw Hauser Lake nr Helena MT	06065500		DE3470BC	HAUM	16,876	unknown	4539		1923-1942,1994-						
Holter Lake Dam	06066000	Real-Time Pool Elevations Unavailable						1918	1936-		3564	3564.7	81,920	85,250	1970
Missouri R. blw Holter Dam nr Wolf Cr MT	06066500	HOLM	DE067308	HOLM	17,149	unknown	5325		1946-						
Little Prickly Pear Cr at Wolf Creek MT	06071300		DE06607E	LPPWCM	381	unknown	88		1962-1967,1991-	2					
Dearborn R nr Craig MT	06073500	DRMT	DD1F702C	DRMT	325	6.5	193		1945, 1993-						
Missouri R at Cascade	06074000	CAMT	16E94294	CASM	18,493	unknown	6357		1902-1915, 2014-						
Smith R. blw Eagle Cr nr Fort Logan MT	06077200	FLMT	D104325A	FLMT	1088	unknown	241		1996-						
Smith R. nr Eden MT	06077500		DE0690FA	-	1594	unknown	350		1951-1969						
Missouri R nr Ulm MT	06078200	UL6E	CE78C6C6	ULGE	20,941	13.5	6183		1957-						
Gibson Reservoir	06079500		F2306250	GIBR	575			1929	1929-		4724	4732.23	96,480	116,399	1964
Sun R. at Simms MT	06085800		DD3CD634	SRSM	1320	7.5	451		1953-	1					
Muddy Creek nr Vaughn MT	06088300		171C05E8	-	282	unknown			1968-1987, 1996-						
Muddy Creek at Vaughn MT	06088500		17C057F2	MCVM	314	unknown	125		1925-						
Sun R. nr Vaughn MT	06089000	VAMT	CE78E02A	VAMT	1849	6.0	669		1897, 1934-						
Missouri R nr Great Falls MT	06090300		D10EF616	MGFM	23,292	unknown	7333		1953-						
Missouri R at Fort Benton MT	06090800		DD7F721E	MFBM	24,749	13.5	7579		1890-	1					
Marias River nr Shelby MT	06099500	MARM	3486C2BE	MARM	3242	9.0	882		1902-	1					
Tiber Dam	06101300	TIBR	F23092D4	LER	4923										
Marias River nr Chester MT	06101500	MARI	3473A28C	MARI	4927	9.0	800		1921-	1					
Missouri R at Virgelle MT	06109500	VIMT	CE512286	VIMT	34,379	17.0	8274		1935-						
Missouri R nr Landusky MT	06115200	RBMT	CE5DC0E8	RMBT	40,987	25.0	8947		1934-						

Sources -

<http://amazon.nws.noaa.gov/hads/charts/MT.html>

<http://pubs.usgs.gov/wdr/2005/wdr-mt-05/>

1. Records are intermittent
2. Seasonal

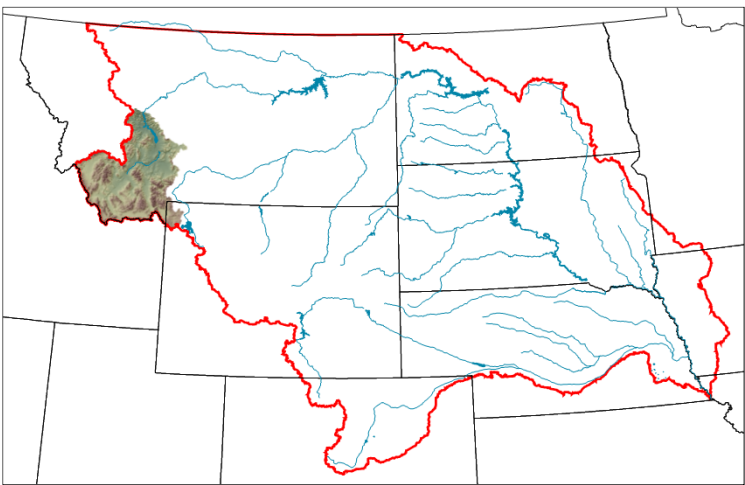
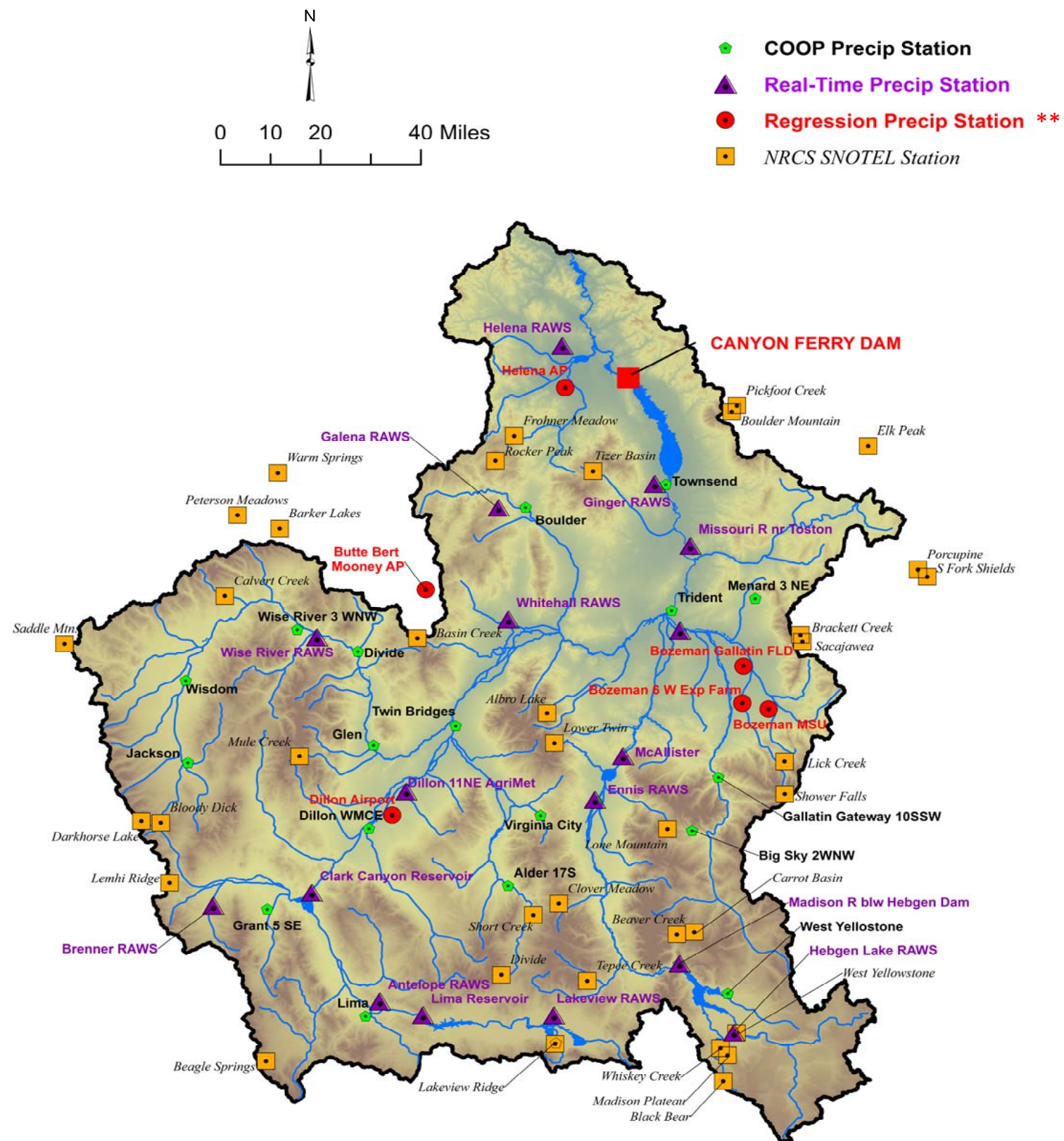
Prepared By: ____JS____

Reviewed By: ____AF____

Water Control Manual
Canyon Ferry Reservoir and Dam, Montana

Table of Relevant Hydrologic Stations

US Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



** Note: Regression Precipitation Stations are the sites used in the Apr-Jul seasonal runoff forecast.

Water Control Manual
Canyon Ferry Reservoir and Dam, Montana

SNOTEL and Precipitation Gaging Stations

U.S. Army Engineers District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared By: ____MS____
Reviewed By: ____AF____

Snotel Site Name	NRCS SITE ID	Elevation (feet)	Basin Name	Average Snow Water Equivalent in Inches (1980-2010)																									
				1-Oct	15-Oct	1-Nov	15-Nov	1-Dec	15-Dec	1-Jan	15-Jan	1-Feb	15-Feb	1-Mar	15-Mar	1-Apr	15-Apr	1-May	15-May	1-Jun	15-Jun	1-Jul	15-Jul	1-Aug	15-Aug	1-Sep	15-Sep	Peak	Date
Albro Lake	11D28S	8300	Jefferson	0.1	1.6	2.8	3.8	5.5	6.6	8.7	10.1	11.4	12.6	14.1	15.5	18.0	19.9	20.1	18.6	10.4	5.0	0.0	0.0	0.0	0.0	0.0	0.0	20.4	26-Apr
Barker Lakes	13C44S	8250		0.3	1.3	2.2	3.2	4.6	5.5	6.7	7.6	8.6	9.5	10.6	11.9	14.0	15.3	15.8	14.5	9.1	4.1	0.2	0.0	0.0	0.0	0.0	0.2	15.9	30-Apr
Basin Creek	12D09S	7180	Jefferson	0.1	0.6	1.0	1.5	2.3	2.9	3.6	4.1	4.7	5.2	5.9	6.6	8.0	9.1	9.3	7.8	2.7	0.7	0.0	0.0	0.0	0.0	0.0	0.1	9.3	1-May
Beagle Springs	12E08S	8850	Red Rock	0.1	0.4	0.9	1.5	2.4	3.1	4.0	4.7	5.4	6.1	6.9	7.7	9.0	9.2	8.1	5.7	1.0	0.2	0.0	0.0	0.0	0.0	0.0	9.3	13-Apr	
Beaver Creek	11E38S	7850	Madison	0.2	0.6	1.5	2.9	4.6	6.3	8.2	9.8	11.4	12.8	14.2	15.5	17.3	18.1	17.8	14.6	6.4	1.1	0.0	0.0	0.0	0.0	0.0	0.1	18.3	21-Apr
Black Bear	11E35S	8170	Madison	0.2	1.1	3.2	6.2	10.3	13.9	18.4	21.9	25.9	29.2	32.7	35.4	38.5	39.5	38.9	35.2	23.6	12.8	2.2	0.0	0.0	0.0	0.0	0.1	39.6	18-Apr
Bloody Dick	13D10S	7600	Red Rock	0.1	0.3	0.7	1.7	3.1	4.1	5.5	6.6	7.8	8.7	9.7	10.5	11.5	11.4	9.0	4.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	11.7	11-Apr	
Boulder Mountain		7950		0.2	0.8	1.8	3.2	5.4	7.2	9.3	11.1	12.9	14.3	15.7	17.0	19.3	20.5	20.0	16.6	7.5	1.9	0.0	0.0	0.0	0.0	0.0	0.1	20.6	22-Apr
Brackett Creek	10D35S	7320	Gallatin	0.1	0.7	1.4	2.3	4.6	6.1	8.3	10.4	12.6	14.3	16.0	17.5	20.4	21.7	20.6	15.9	5.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	21.8	19-Apr
Calvert Creek	13D26S	6430	Big Hole	0.0	0.1	0.2	0.7	1.8	2.7	3.9	4.8	5.8	6.6	7.3	7.7	7.7	5.7	2.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	31-Mar	
Carrot Basin	11E29S	9000	Gallatin	0.3	1.4	3.2	5.2	7.9	10.2	13.0	15.1	17.4	19.4	21.6	23.5	26.3	27.9	28.9	27.3	20.1	20.3	2.3	0.0	0.0	0.0	0.0	0.1	28.9	1-May
Clover Meadow	11D08S	8600	Madison	0.2	1.2	2.4	3.6	5.2	6.5	8.0	9.2	10.6	11.7	13.2	14.4	16.3	17.5	17.7	16.1	9.9	4.4	0.1	0.0	0.0	0.0	0.0	0.1	17.9	29-Apr
Darkhorse Lake	13D19S	8600	Big Hole	0.2	1.1	2.8	5.3	8.5	10.9	14.0	16.9	19.6	21.6	23.9	25.7	28.6	30.5	31.9	31.0	24.6	15.8	3.6	0.1	0.0	0.0	0.0	0.1	32.0	4-May
Divide	12E07S	7800	Beaverhead	0.1	0.4	1.0	1.8	2.8	3.7	4.7	5.5	6.4	7.1	8.1	9.0	10.5	11.3	11.2	8.1	1.4	0.0	0.0	0.0	0.0	0.0	0.0	11.6	25-Apr	
Elk Peak		7600		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Frohner Meadow	12C13S	6480	Up Missouri	0.1	0.4	0.5	0.9	1.7	2.3	3.2	3.9	4.6	5.2	5.9	6.5	7.5	7.5	5.6	3.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	7.7	11-Apr
Lakeview Ridge	11E30S	7400	Red Rock	0.1	0.3	0.6	1.4	2.6	3.6	4.9	5.8	6.8	7.7	8.8	9.7	10.8	10.4	7.9	4.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	10.9	9-Apr	
Lemhi Ridge	13E23S	8100	Red Rock	0.1	0.4	0.9	1.7	2.9	3.8	4.8	5.8	6.7	7.4	8.4	9.3	10.6	11.1	10.1	6.8	1.1	0.2	0.0	0.0	0.0	0.0	0.0	11.1	17-Apr	
Lick Creek	10D13S	6860	Gallatin	0.1	0.4	0.8	1.5	2.8	3.6	4.7	5.5	6.5	7.3	8.3	9.4	11.2	11.2	8.7	4.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	11.5	12-Apr	
Lone Mountain	11D16S	8880	Gallatin	0.1	0.7	1.9	3.2	4.9	6.2	8.1	9.7	11.3	12.6	14.0	15.2	17.1	18.4	18.9	16.2	8.3	2.7	0.0	0.0	0.0	0.0	0.0	19.0	30-Apr	
Lower Twin	11D11S	7900	Madison	0.2	1.0	2.1	3.5	5.3	6.7	8.4	9.7	11.1	12.2	13.5	14.7	16.7	18.2	19.0	17.8	11.3	5.4	0.3	0.0	0.0	0.0	0.0	19.1	30-Apr	
Madison Plateau	11E31S	7750	Madison	0.1	0.5	1.6	3.3	6.1	8.3	11.1	13.1	15.5	17.6	19.7	21.5	23.5	24.1	22.4	17.5	7.2	1.3	0.0	0.0	0.0	0.0	0.0	24.1	16-Apr	
Mule Creek	12D11S	8300	Big Hole	0.1	0.6	1.3	2.4	4.1	5.3	6.9	8.3	9.6	10.8	12.0	13.1	14.7	15.7	16.2	14.6	8.2	3.2	0.1	0.0	0.0	0.0	0.0	16.2	2-May	
Peterson Meadow		7200		0.1	0.4	0.7	1.4	2.4	3.2	4.2	4.8	5.6	6.3	7.2	8.2	9.8	10.7	10.6	8.6	2.6	0.3	0.0	0.0	0.0	0.0	0.0	11.0	23-Apr	
Pickfoot Creek		6650		0.1	0.2	0.5	1.3	2.6	3.7	5.1	6.0	7.3	8.0	8.9	9.5	10.2	8.7	4.7	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2	23-Apr	
Porcupine		6500		0.0	0.1	0.2	0.6	1.3	1.9	2.7	3.3	4.2	4.8	5.5	5.9	6.0	5.0	2.5	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	3-Apr	
Rocker Peak	12C11S	8000	Boulder	0.3	0.9	1.6	2.5	3.8	4.9	6.2	7.2	8.4	9.4	10.4	11.4	13.3	14.5	15.3	14.4	9.5	4.1	0.0	0.0	0.0	0.0	0.0	0.2	15.3	6-May
S Fork Shields		8100		0.2	0.8	1.6	2.6	4.2	5.4	7.0	8.4	9.9	11.3	12.7	14.2	16.5	18.2	18.3	16.5	9.7	3.9	0.0	0.0	0.0	0.0	0.0	18.6	26-Apr	
Sacajawea		6550		0.0	0.5	0.6	1.1	2.9	4.1	5.8	7.2	8.8	10.6	11.9	12.8	14.2	13.3	9.2	5.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	14.5	7-Apr	
Saddle Mountain		7940		0.1	0.5	1.5	3.4	6.0	8.2	11.2	13.6	16.1	18.3	20.2	21.8	23.7	24.5	23.8	20.9	12.2	4.4	0.0	0.0	0.0	0.0	0.0	24.5	19-Apr	
Short Creek	11E39S	7000	Ruby	0.0	0.1	0.6	0.9	1.6	2.1	2.6	3.1	3.6	4.0	4.5	4.9	5.5	5.4	3.8	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	10-Apr	
Shower Falls	10D16S	8100	Gallatin	0.2	1.2	2.8	4.4	6.3	7.8	9.6	11.4	13.1	14.7	16.4	18.2	21.2	23.4	25.0	24.3	17.3	10.0	1.3	0.0	0.0	0.0	0.0	25.0	10-May	
Tepee Creek	11E24S	8000	Madison	0.1	0.3	1.0	2.1	3.6	4.8	6.3	7.4	8.5	9.5	10.7	11.7	13.2	13.7	13.1	10.4	3.4	0.4	0.0	0.0	0.0	0.0	0.0	13.7	21-Apr	
Tizer Basin	11C04S	6880	Up Missouri	0.1	0.4	1.1	1.9	3.0	3.8	4.8	5.4	6.2	6.8	7.6	8.4	9.6	9.9	7.7	3.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	10.0	14-Apr	
Warm Springs		7800		0.1	0.8	2.0	3.6	5.7	7.3	9.2	11.0	12.9	14.4	16.0	17.6	19.9	21.7	22.5	21.5	15.9	9.9	1.4	0.0	0.0	0.0	0.0	22.5	4-May	
West Yellowstone	11E07S	6700	Madison	0.0	0.1	0.4	1.2	2.6	3.8	5.4	6.6	7.9	9.0	10.1	10.7	11.0	8.5	3.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	1-Apr	
Whiskey Creek	11E30S	6800	Madison	0.0	0.2	0.8	1.9	3.8	5.4	7.4	8.8	10.6	12.0	13.5	14.6	15.5	16.0	13.7	8.5	0.9	0.0	0.0	0.0	0.0	0.0	0.0	16.0	15-Apr	
AVERAGE OF ALL STATIONS				0.1	0.6	1.4	2.5	4.1	5.4	7.1	8.5	9.9	11.1	12.4	13.5	15.2	15.8	14.8	12.2	6.4	3.1	0.3	0.0	0.0	0.0	0.0	0.0	16.4	20-Apr

Source - Natural Resources Conservation Service (NRCS) National Water and Climate Center

Prepared By: ____JS____
Reviewed By: ____AF____

Water Control Manual
Canyon Ferry Reservoir and Dam, Montana

Average Snow Water Equivalent Values for
SNOTEL Stations in Upstream Basin

US Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

Station Name	Elevation ft	Shef ID	Coop Number	Period of Record	Average Precipitation (Inches)												
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Alder 17S	5850	ALSM8	240110	1956-2015	0.39	0.35	0.73	1.29	2.33	2.61	1.42	1.45	1.19	1.05	0.54	0.46	13.81
Big Sky 2WNW	6590	BGSM8	240775	1984-2015	1.45	0.95	1.29	1.64	2.74	2.74	1.47	1.56	1.59	1.78	1.40	1.58	20.19
Boulder	4904	BOUM8	241008	1948-2015	0.31	0.26	0.47	0.75	1.99	2.16	1.65	1.33	0.99	0.64	0.49	0.33	11.37
Bozeman 6 W EXP FARM	4775	BZMM8	241047	1966-2015	0.55	0.54	1.03	1.78	2.81	2.78	1.41	1.21	1.26	1.38	0.90	0.54	16.19
Bozeman Gallatin FLD	4427	BZN	240622	1941-2015	0.48	0.43	0.94	1.60	2.45	2.40	1.12	1.08	1.11	1.10	0.76	0.52	13.99
Bozeman MSU	4913	BZEM8	241044	1892-2015	0.83	0.78	1.38	2.30	3.18	3.11	1.46	1.43	1.40	1.72	1.19	0.93	19.71
Dillon Airport	5200	DLN	242404	1948-2015	0.28	0.24	0.56	1.04	1.95	1.97	1.21	1.05	0.87	0.76	0.37	0.27	10.57
Dillon WMCE	5228	DLLM8	242409	1895-2015	0.29	0.30	0.66	1.39	2.19	1.93	1.12	1.16	0.91	0.91	0.45	0.36	11.67
Divide	5350	DVDM8	242421	1915-2015	0.34	0.32	0.73	0.90	1.93	2.09	1.19	1.24	1.01	0.71	0.59	0.52	11.57
Ennis	4953	ENSM8	242793	1948-2015	0.45	0.46	0.81	1.41	2.16	2.39	1.25	1.23	0.97	1.04	0.69	0.50	13.36
Gallatin Gateway 10SSW	5480	GTNM8	243366	1950-2015	1.19	0.93	1.75	2.47	3.37	3.25	1.59	1.78	1.56	1.81	1.27	1.24	22.21
Glen	4960	GLEM8	243570	1958-2015	0.23	0.19	0.44	0.77	1.64	1.77	1.04	1.07	0.76	0.50	0.39	0.24	9.04
Grant 5 SE	5780	GRNM8	243707	1949-2015	0.35	0.29	0.65	1.02	1.77	1.78	1.05	0.98	0.80	0.85	0.51	0.38	10.43
Hebgen Dam	6489	HBGM8	244038	1948-2015	2.82	2.35	2.23	2.03	2.98	3.09	1.95	1.49	1.50	1.97	2.55	3.07	28.03
Helena AP ASOS	3828	HLN	244055	1893-2015	0.36	0.30	0.59	0.98	1.87	2.06	1.19	1.20	1.10	0.68	0.49	0.40	11.22
Jackson	6480	JACM8	244447	1949-2015	0.64	0.44	0.74	1.06	1.58	1.90	1.06	1.09	0.89	0.91	0.92	0.56	11.79
Lakeview	6710	LKVM8	244820	1948-2015	0.99	0.86	1.26	2.05	2.40	2.40	1.59	1.15	1.33	1.61	1.30	1.09	18.03
Lima	6273	LMAM8	245030	1898-2015	0.30	0.29	0.57	1.11	1.83	2.08	1.24	1.17	0.88	0.96	0.45	0.38	11.26
Menard 3 NE	5053	MENM8	245608	1952-2015	0.58	0.51	0.92	1.36	2.32	2.39	1.35	1.05	1.10	1.00	0.76	0.70	14.04
Norris Madison PH	4745	MADM8	246157	1907-2015	0.51	0.49	1.00	1.86	2.91	3.05	1.49	1.53	1.29	1.50	0.72	0.60	16.95
Townsend	3840	TOWM8	248324	1948-2015	0.24	0.21	0.48	0.81	1.77	2.25	1.37	1.20	0.85	0.58	0.34	0.30	10.40
Trident	4036	TRIM8	248363	1922-2015	0.45	0.24	0.70	1.54	2.47	2.27	1.68	1.04	1.16	0.99	0.58	0.58	13.70
Twin Bridges	4625	TNBM8	248430	1950-2015	0.23	0.19	0.46	0.92	1.77	2.02	1.21	1.03	0.90	0.69	0.39	0.28	10.09
Virginia City	5773	VACM8	248597	1948-2015	0.69	0.53	0.98	1.49	2.36	2.55	1.47	1.40	1.03	1.18	0.84	0.78	15.30
West Yellowstone	6572	WEYM8	248859	1939-2015	2.16	1.74	1.78	1.77	2.45	2.31	1.77	1.16	1.37	1.56	2.10	2.67	22.84
Wisdom	6060	WISM8	249067	1948-2015	0.63	0.50	0.72	1.01	1.83	2.07	1.22	1.07	1.00	0.74	0.83	0.68	12.30
Wise River 3 WNW	5730	WRVM8	249082	1951-2015	0.49	0.39	0.57	0.84	1.65	1.84	1.38	1.18	1.10	0.90	0.91	0.67	11.92

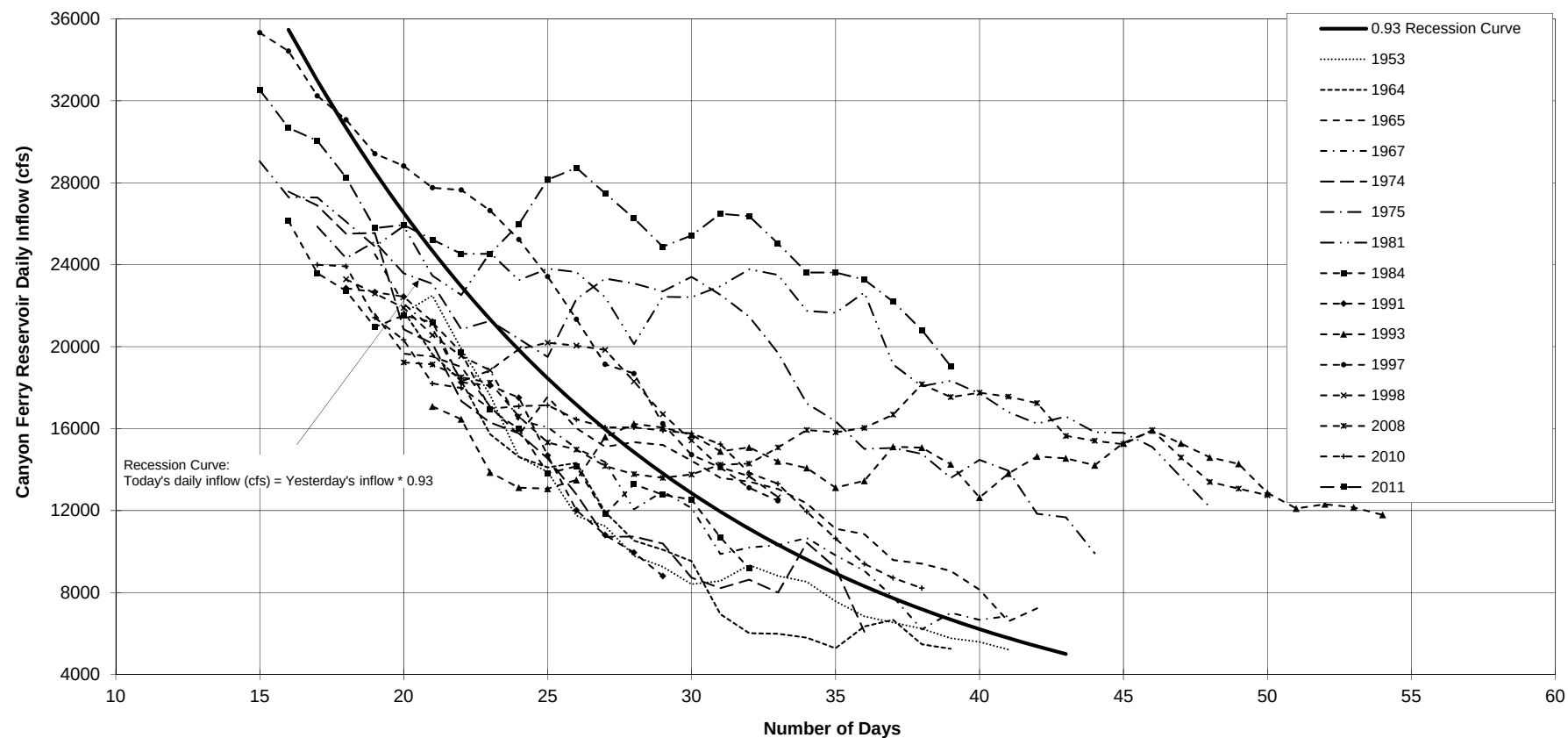
Source - NOAA NCDC-
<http://www.ncdc.noaa.gov>

Prepared By: _____AF____
Reviewed By: _____KS____

Water Control Manual
Canyon Ferry Reservoir and Dam, Montana

**Average Monthly Precipitation for
NWS Coop Stations in Upstream
Basin**

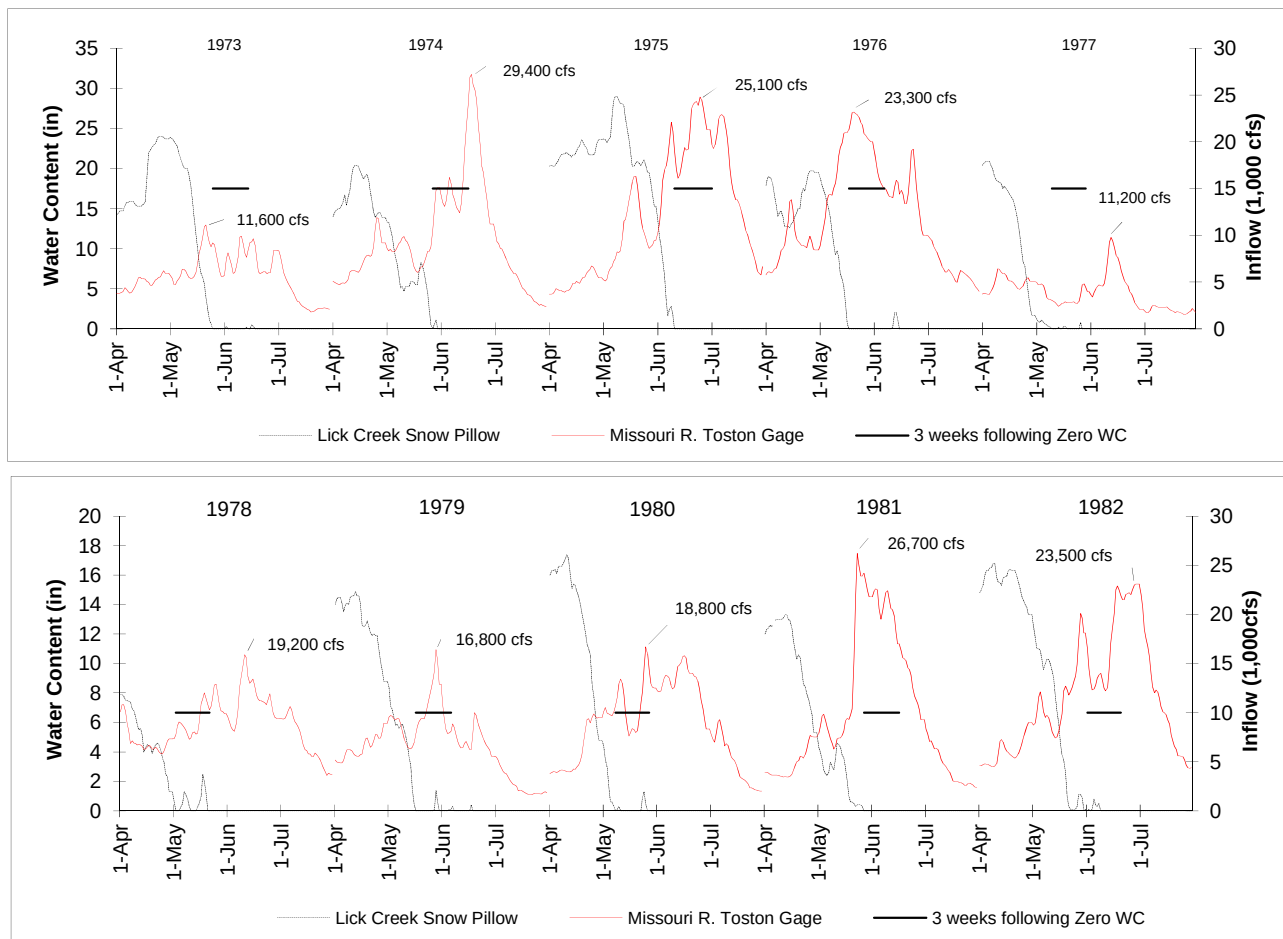
US Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Source of Data: USBS HydroMet-Hydrological Database

Prepared By: JAB
Reviewed By: TET

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Comparison of Actual Inflow Recessions
to Recession Constant 0.93**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



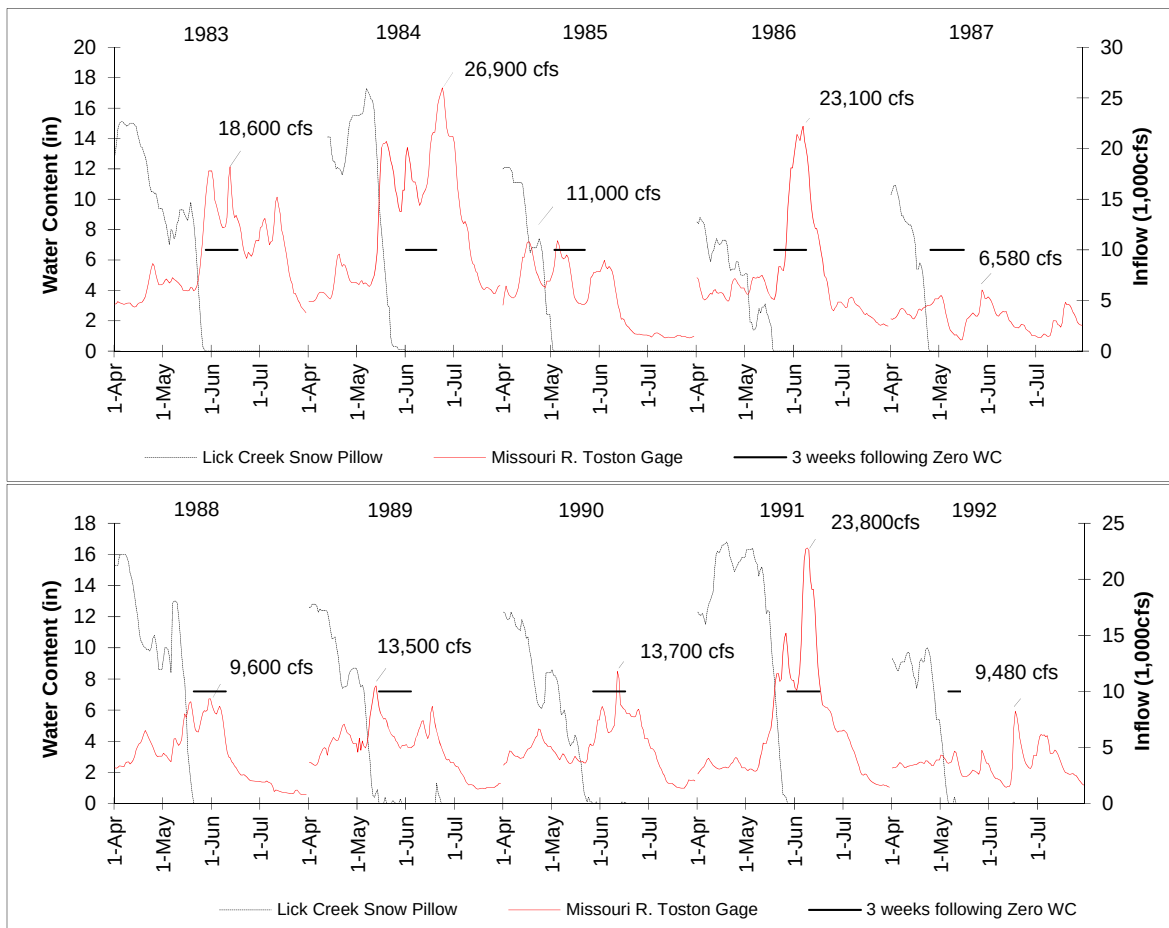
Source: Lick Creek SNOTEL information via NRCS.
Missouri River at Toston, MT discharge information via USGS

Note: The solid black lines indicate the 3-week period following the full melt of the snowpack at the Lick Creek SNOTEL gage.
The numbers denoted in plot are the peak year discharges for the Missouri River at Toston, MT.

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**3-Week Time Lag Between Snowmelt at
Lick Creek and Peak Discharge at Toston,
1973-1982**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Source: Lick Creek SNOTEL information via NRCS
Missouri River at Toston, MT discharge information via USGS

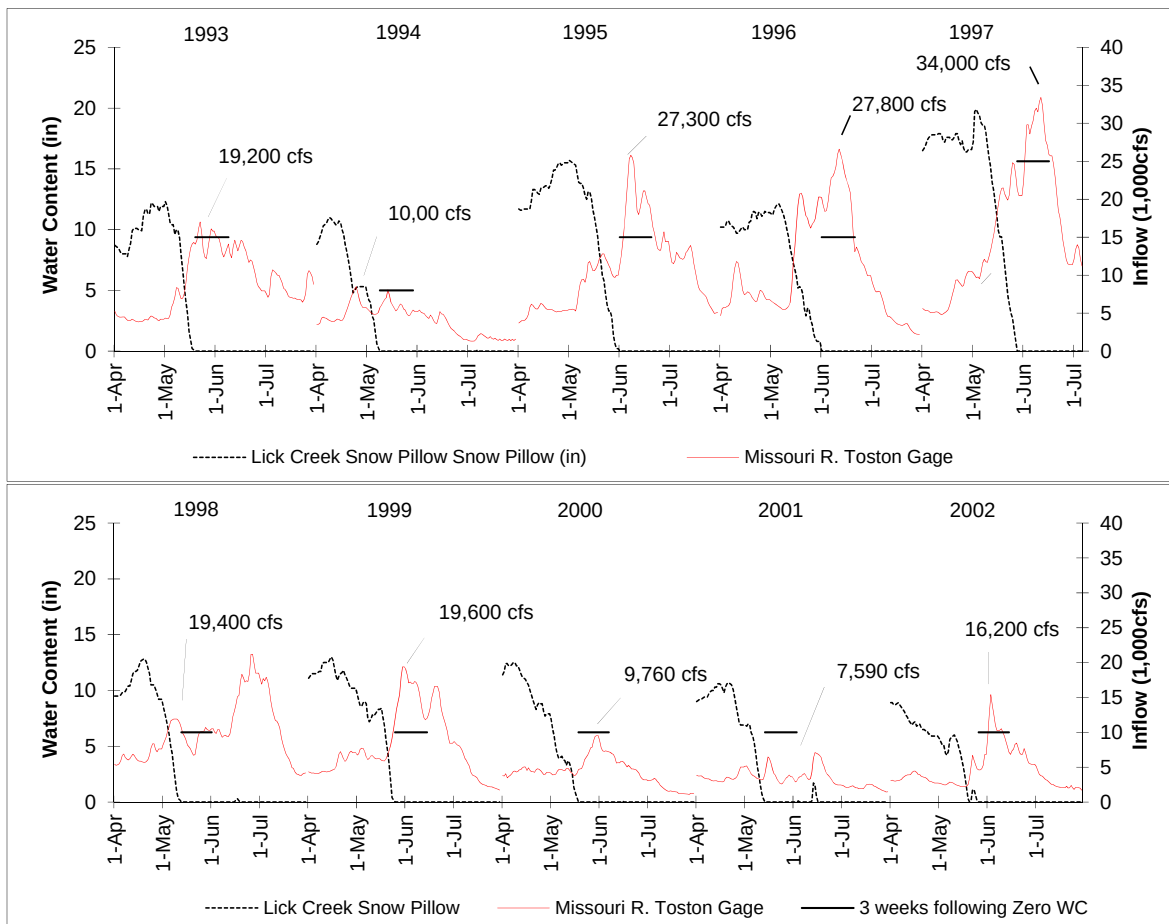
Note: The solid black lines indicate the 3-week period following the full melt of the snowpack at the Lick Creek SNOTEL gage.

The numbers denoted in plot are the peak year discharges for the Missouri River at Toston, MT.

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**3-Week Time Lag Between Snowmelt
at Lick Creek and Peak Discharge at
Toston, 1983-1992**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

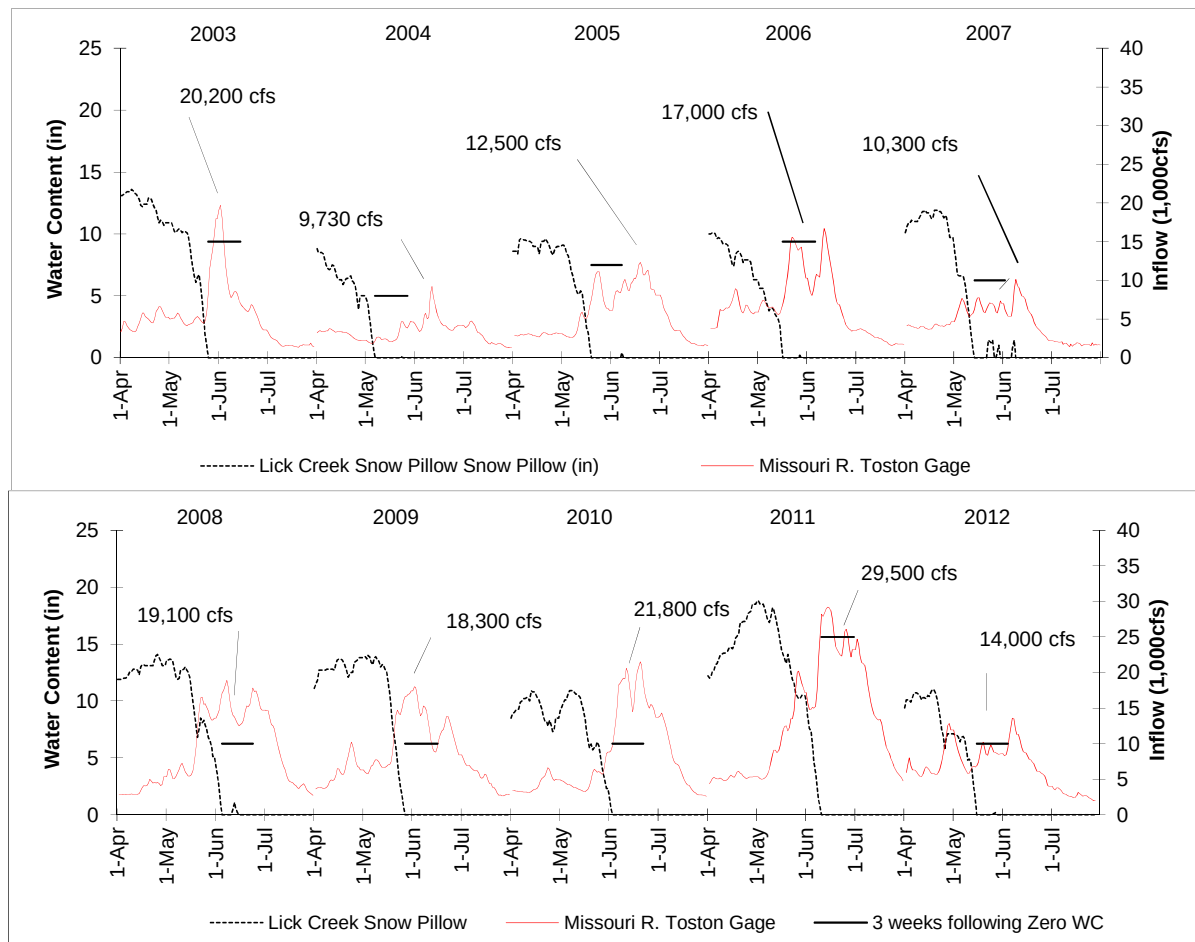


Source: Lick Creek SNOTEL information via NRCS.
Missouri River at Toston, MT discharge information via USGS

Note: The solid black lines indicate the 3-week period following the full melt of the snowpack at the Lick Creek SNOTEL gage.
The numbers denoted in plot are the peak year discharges for the Missouri River at Toston, MT.

Prepared By: AF
Reviewed By: KS

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**3-Week Time Lag Between Snowmelt
at Lick Creek and Peak Discharge at
Toston, 1993-2002**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Source: Lick Creek SNOTEL information via NRCS.
Missouri River at Toston, MT discharge information via USGS

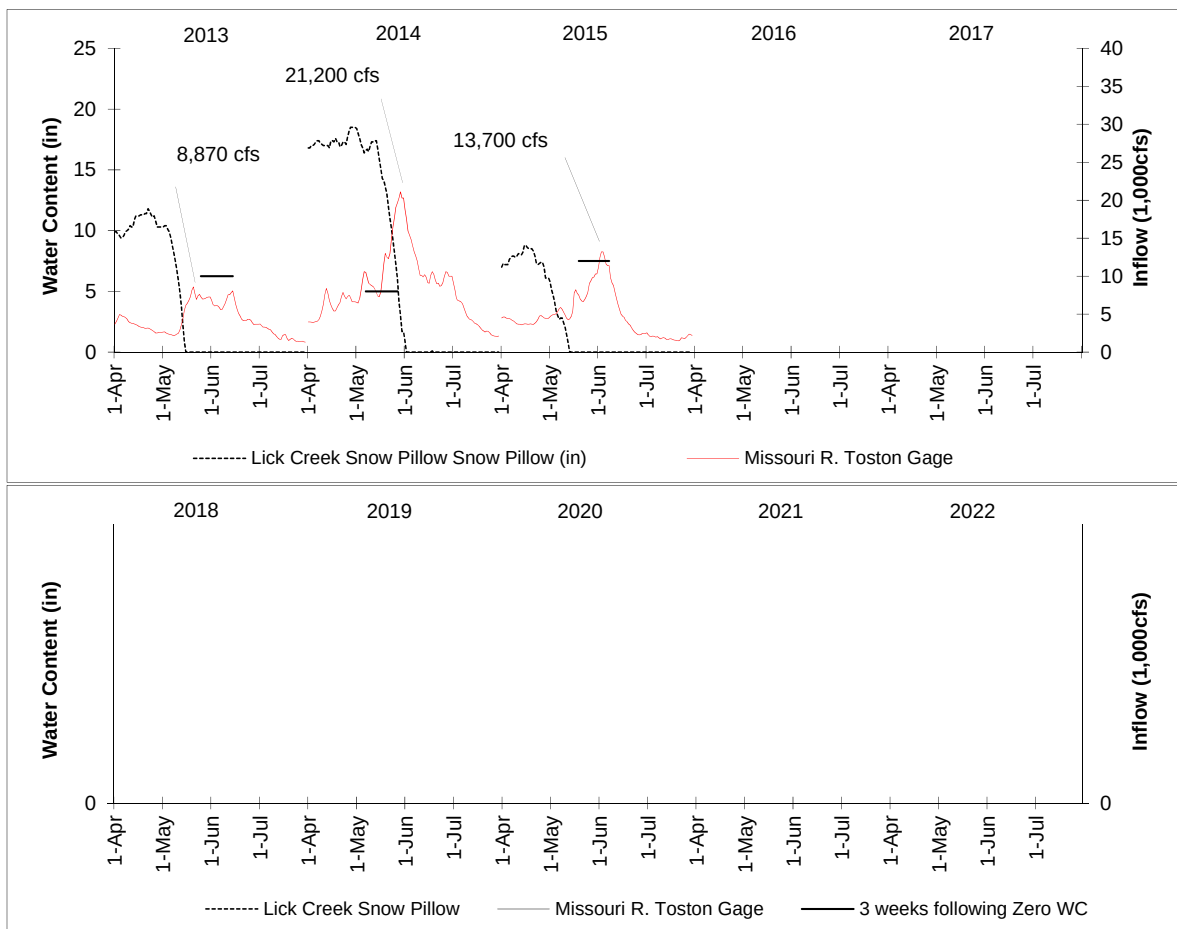
Note: The solid black lines indicate the 3-week period following the full melt of the snowpack at the Lick Creek SNOTEL gage.

The numbers denoted in plot are the peak year discharges for the Missouri River at Toston, MT.

Prepared By: AF
Reviewed By: KS

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**3-Week Time Lag Between Snowmelt
at Lick Creek and Peak Discharge at
Toston, 2003-2012**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

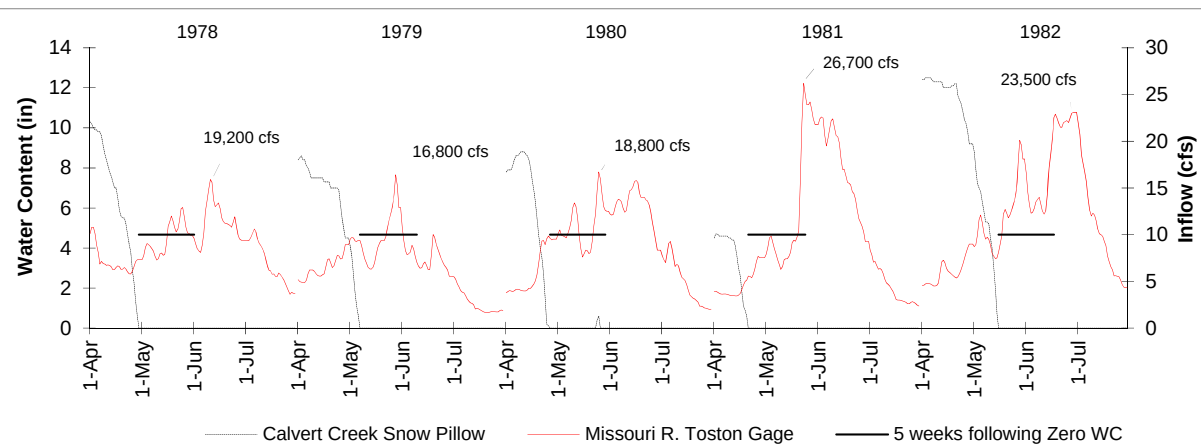
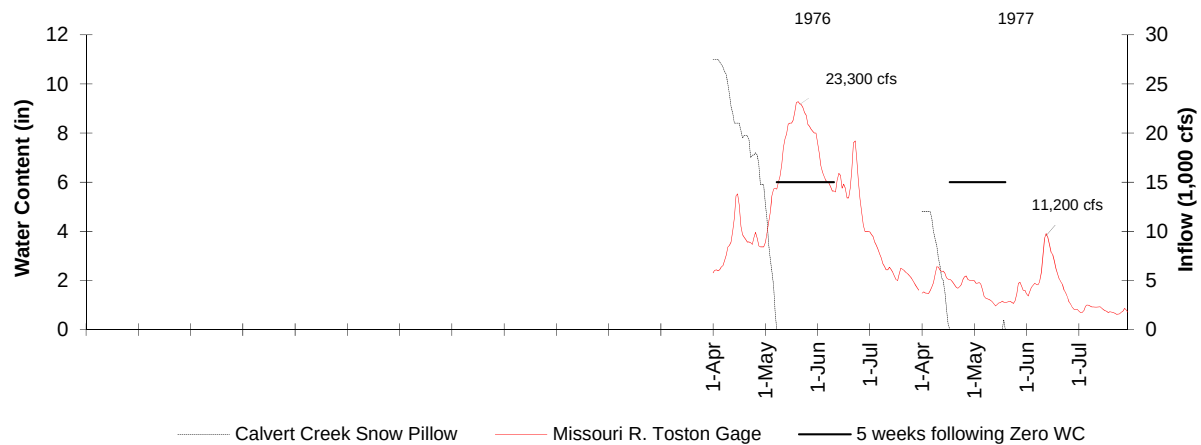


Source: Lick Creek SNOTEL information via NRCS.
Missouri River at Toston, MT discharge information via USGS

Note: The solid black lines indicate the 3-week period following the full melt of the snowpack at the Lick Creek SNOTEL gage.
The numbers denoted in plot are the peak year discharges for the Missouri River at Toston, MT.
2015 data is provisional

Prepared By: AF
Reviewed By: KS

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**3-Week Time Lag Between Snowmelt
at Lick Creek and Peak Discharge at
Toston, 2013-2015**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

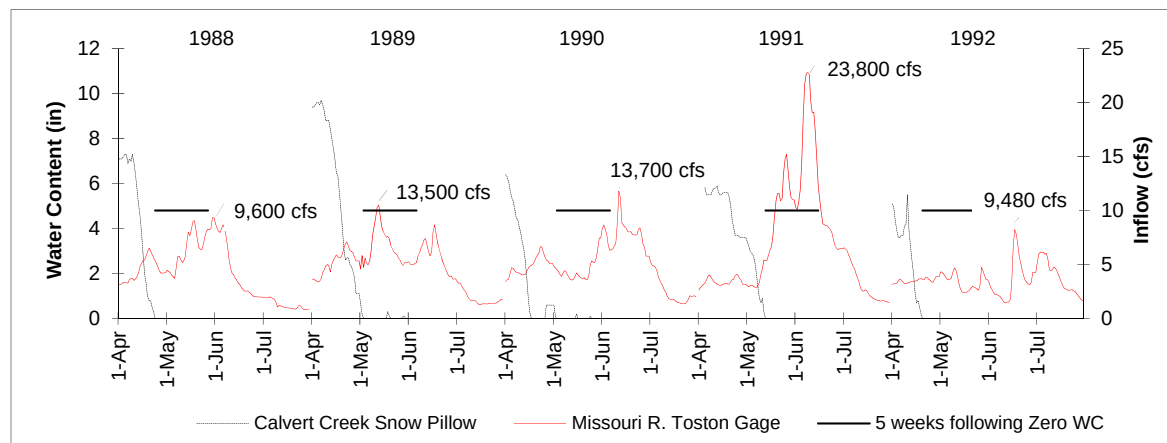
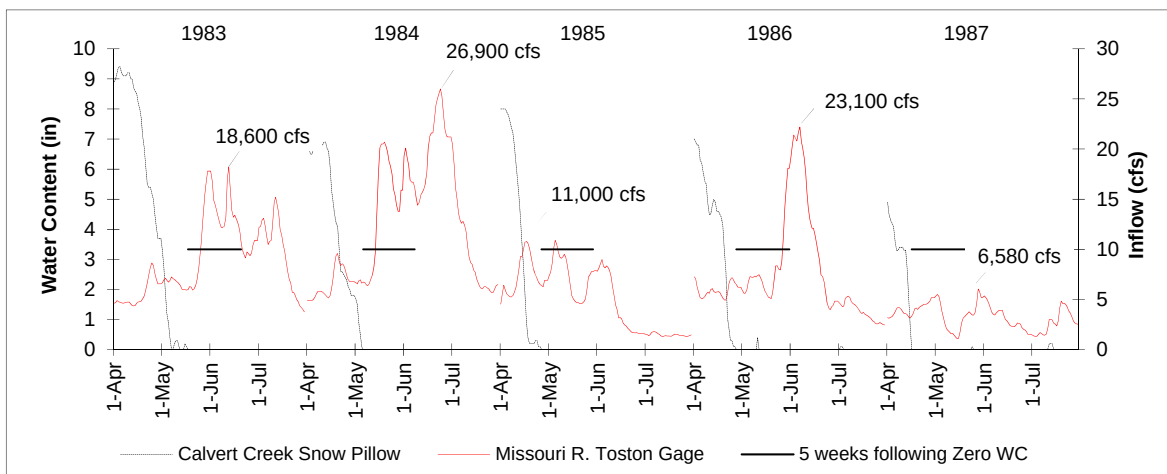


Source: Calvert Creek SNOTEL information via NRCS.
Missouri River at Toston, MT discharge information via USGS

Note: The solid black lines indicate the 5-week period following the full melt of the snowpack at the Calvert Creek SNOTEL gage.
The numbers denoted in plot are the peak year discharges for the Missouri River at Toston, MT.

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**5-Week Time Lag Between Snowmelt at
Calvert Creek and Peak Discharge at
Toston, 1976-1982**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



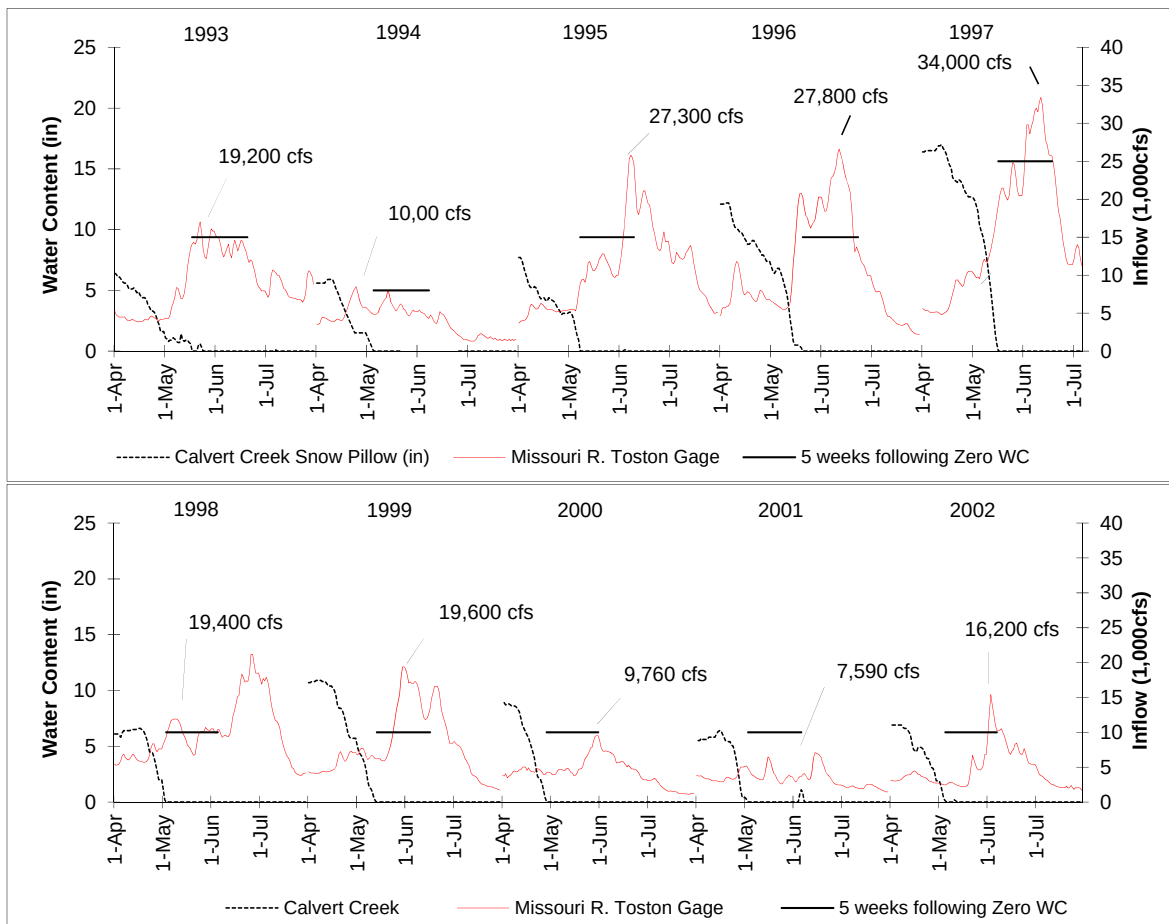
Source: Calvert Creek SNOTEL information via NRCS.
Missouri River at Toston, MT discharge information via USGS

Note: The solid black lines indicate the 5-week period following the full melt of the snowpack at the Calvert Creek SNOTEL gage.
The numbers denoted in plot are the peak year discharges for the Missouri River at Toston, MT.

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**5-Week Time Lag Between Snowmelt at
Calvert Creek and Peak Discharge at
Toston, 1983-1992**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

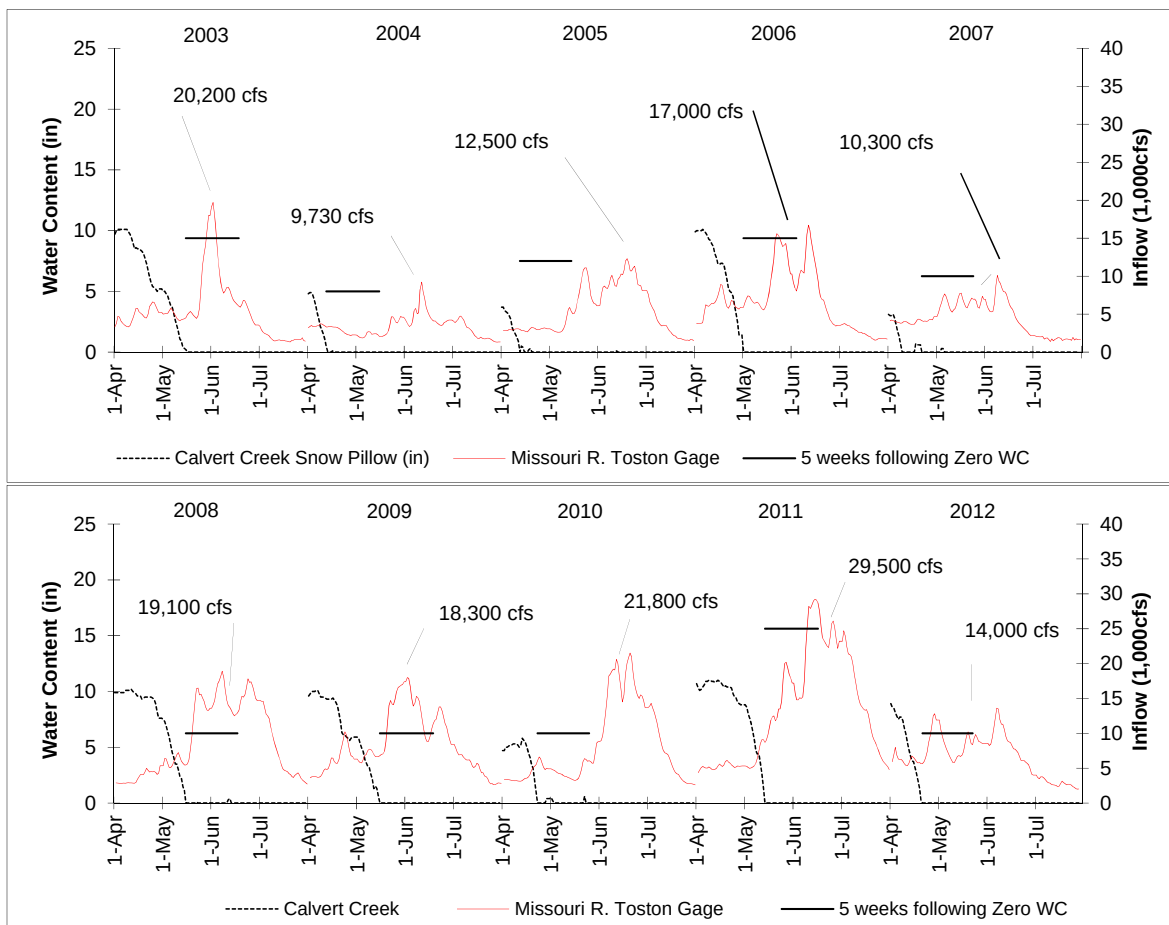


Source: Calvert Creek SNOTEL information via NRCS.
Missouri River at Toston, MT discharge information via USGS

Note: The solid black lines indicate the 5-week period following the full melt of the snowpack at the Calvert Creek SNOTEL gage.
The numbers denoted in plot are the peak year discharges for the Missouri River at Toston, MT.

Prepared By: AF
Reviewed By: KS

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**5-Week Time Lag Between Snowmelt
at Calvert Cr and Peak Discharge at
Toston, 1993-2002**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

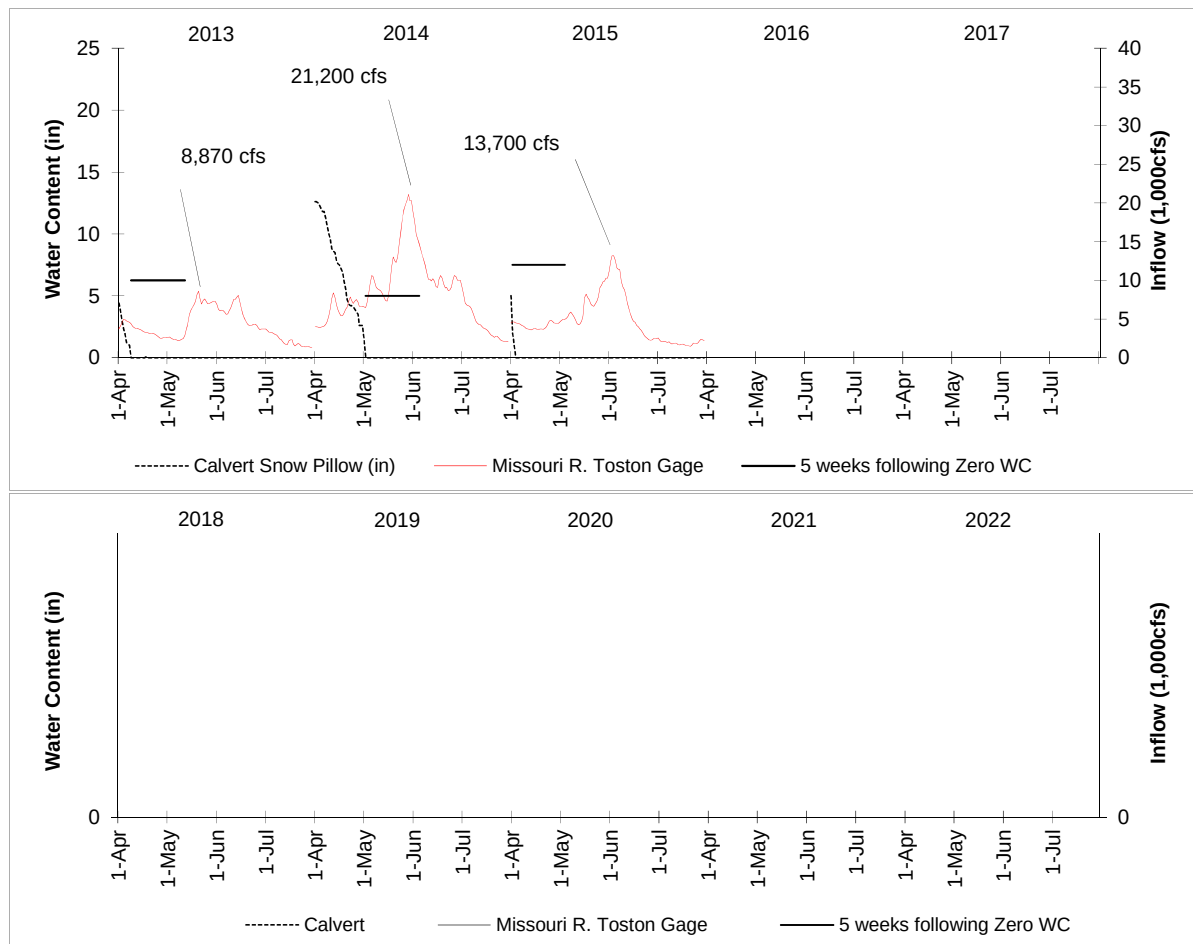


Source: Calvert Creek SNOTEL information via NRCS.
Missouri River at Toston, MT discharge information via USGS

Note: The solid black lines indicate the 5-week period following the full melt of the snowpack at the Calvert Creek SNOTEL gage.
The numbers denoted in plot are the peak year discharges for the Missouri River at Toston, MT.

Prepared By: AF
Reviewed By: KS

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**5-Week Time Lag Between Snowmelt
at Calvert Cr and Peak Discharge at
Toston, 2003-2012**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

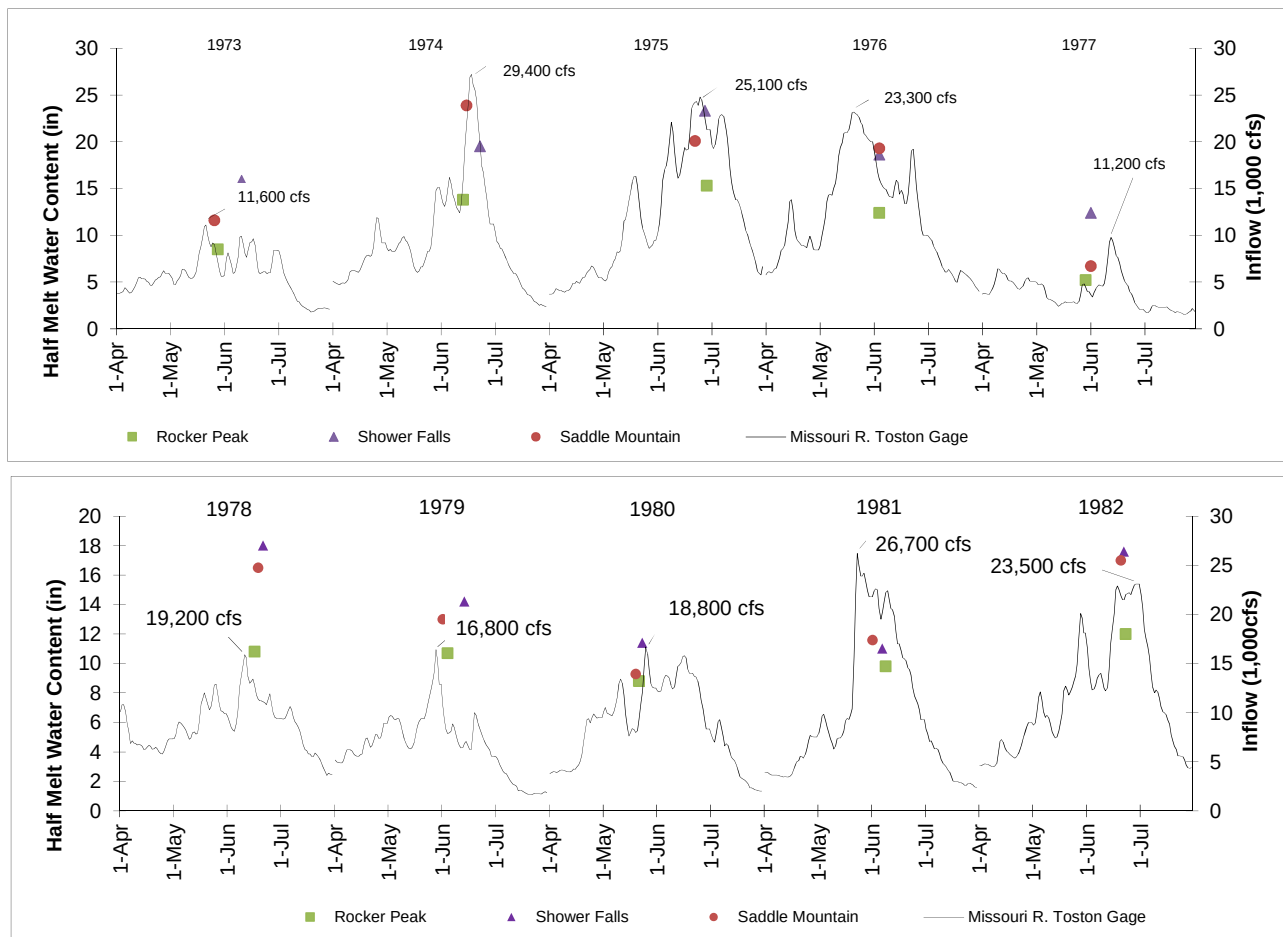


Source: Calvert Creek SNOTEL information via NRCS.
Missouri River at Toston, MT discharge information via USGS

Note: The solid black lines indicate the 5-week period following the full melt of the snowpack at the Calvert Creek SNOTEL gage.
The numbers denoted in plot are the peak year discharges for the Missouri River at Toston, MT.

Prepared By: AF
Reviewed By: KS

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**5-Week Time Lag Between Snowmelt
at Calvert Cr and Peak Discharge at
Toston, 2013-2015**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



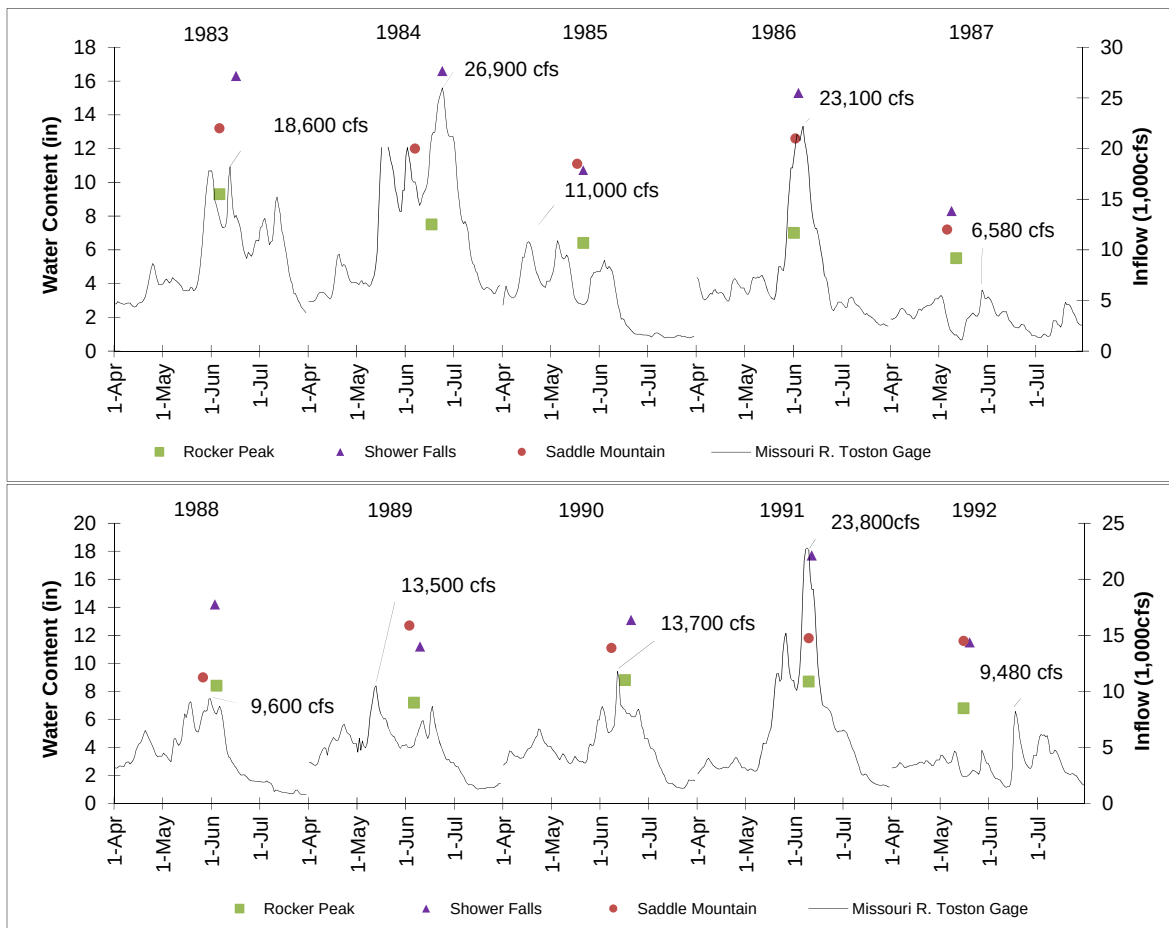
Source: Rocker Peak SNOTEL information via NRCS.
Missouri River at Toston, MT discharge information via USGS

Note: Analysis of observed inflow tendencies based on historic melt rates vs. peak inflows.
-Peak inflows to Canyon Ferry can be expected on or around the day when Saddle Mountain and Rocker Peak reach half melt.
-Peak inflows to Canyon Ferry can be expected 2 days before Shower Falls reaches half melt.

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Half Melt at Rocker Peak, Shower Falls
and Saddle Mountain and Peak Discharge
at Toston, 1973-1982**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Source: Rocker Peak SNOTEL information via NRCS

Missouri River at Toston, MT discharge information via USGS

Note: Analysis of observed inflow tendencies based on historic melt rates vs. peak inflows.

-Peak inflows to Canyon Ferry can be expected on or around the day when Saddle Mountain and Rocker Peak reach half melt.

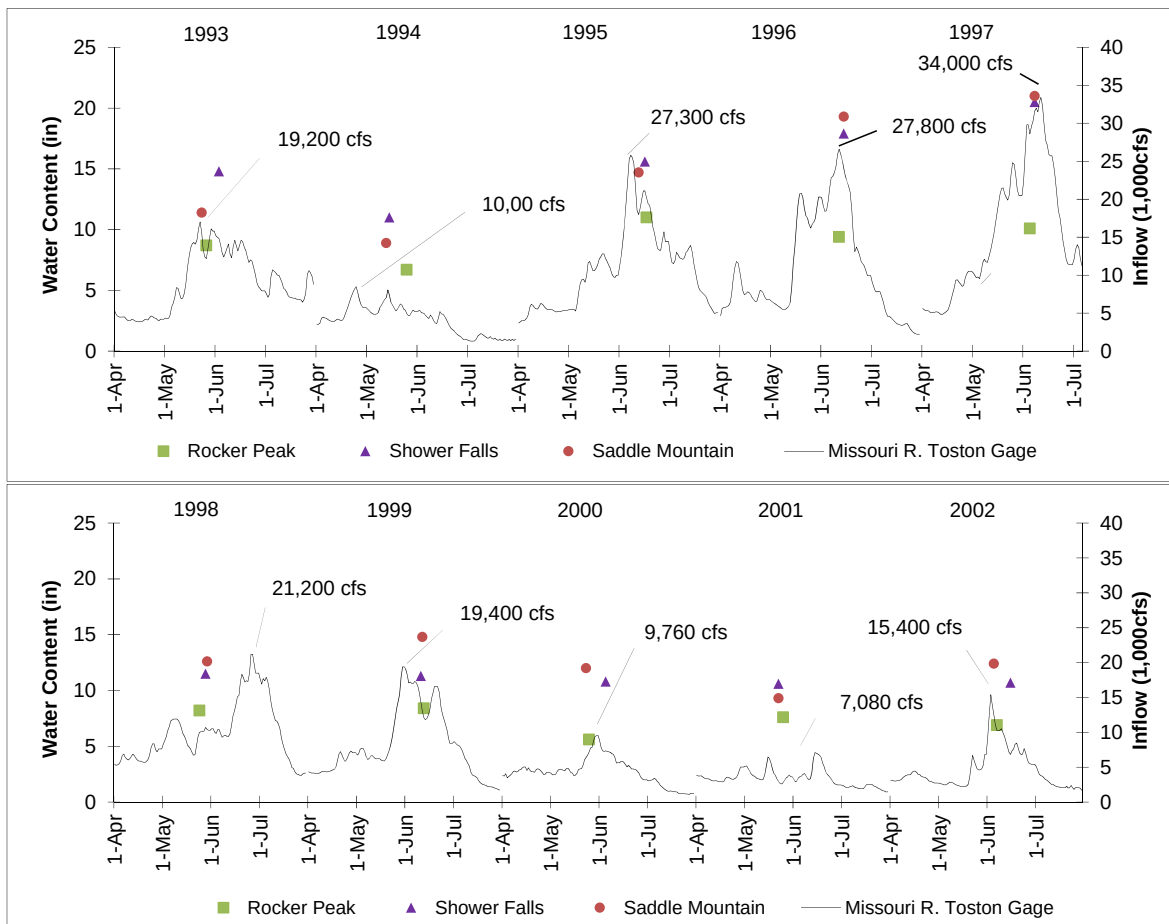
-Peak inflows to Canyon Ferry can be expected 2 days before Shower Falls reaches half melt.

Prepared By: AF

Reviewed By: KS

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Half Melt at Rocker Peak, Shower Falls
and Saddle Mountain and Peak Discharge
at Toston, 1983-1992**

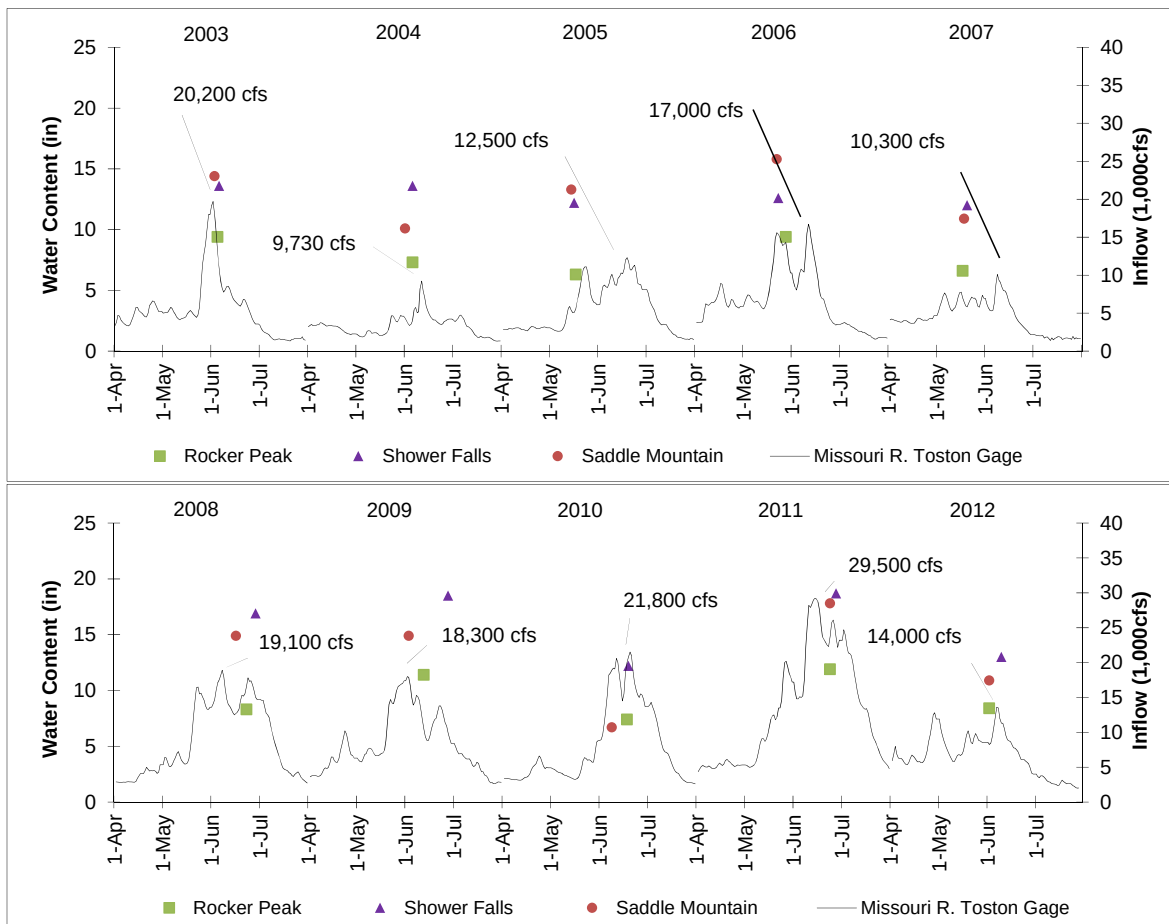
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Source: Rocker Peak SNOTEL information via NRCS
Missouri River at Toston, MT discharge information via USGS
Note: Analysis of observed inflow tendencies based on historic melt rates vs. peak inflows.
-Peak inflows to Canyon Ferry can be expected on or around the day when Saddle Mountain and Rocker Peak reach half melt.
-Peak inflows to Canyon Ferry can be expected 2 days before Shower Falls reaches half melt.

Prepared By: AF
Reviewed By: KS

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Half Melt at Rocker Peak, Shower Falls
and Saddle Mountain and Peak Discharge
at Toston, 1993-2002**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

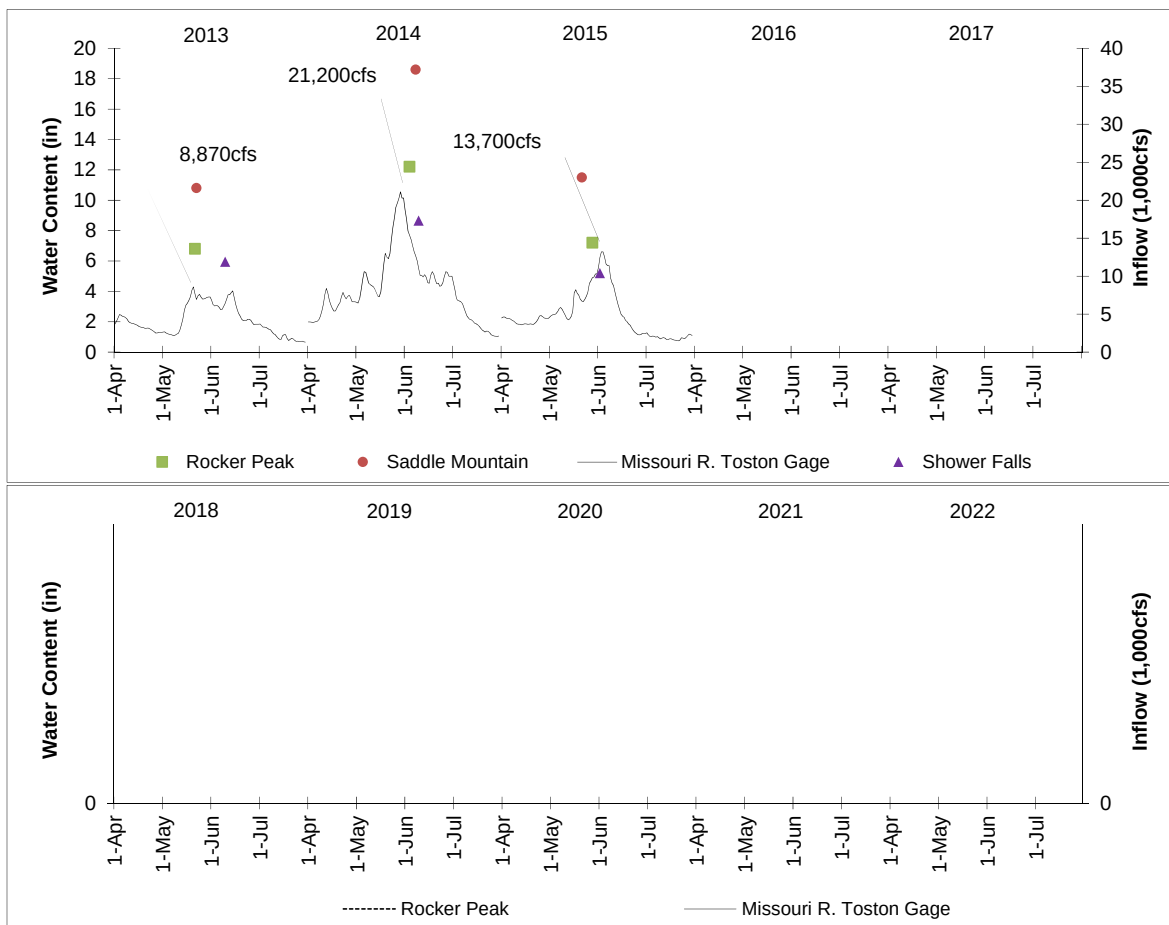


Source: Rocker Peak SNOTEL information via NRCS
Missouri River at Toston, MT discharge information via USGS

Note: Analysis of observed inflow tendencies based on historic melt rates vs. peak inflows.
-Peak inflows to Canyon Ferry can be expected on or around the day when Saddle Mountain and Rocker Peak reach half melt.
-Peak inflows to Canyon Ferry can be expected 2 days before Shower Falls reaches half melt.

Prepared By: AF
Reviewed By: KS

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Half Melt at Rocker Peak, Shower Falls
and Saddle Mountain and Peak Discharge
at Toston, 2003-2012**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



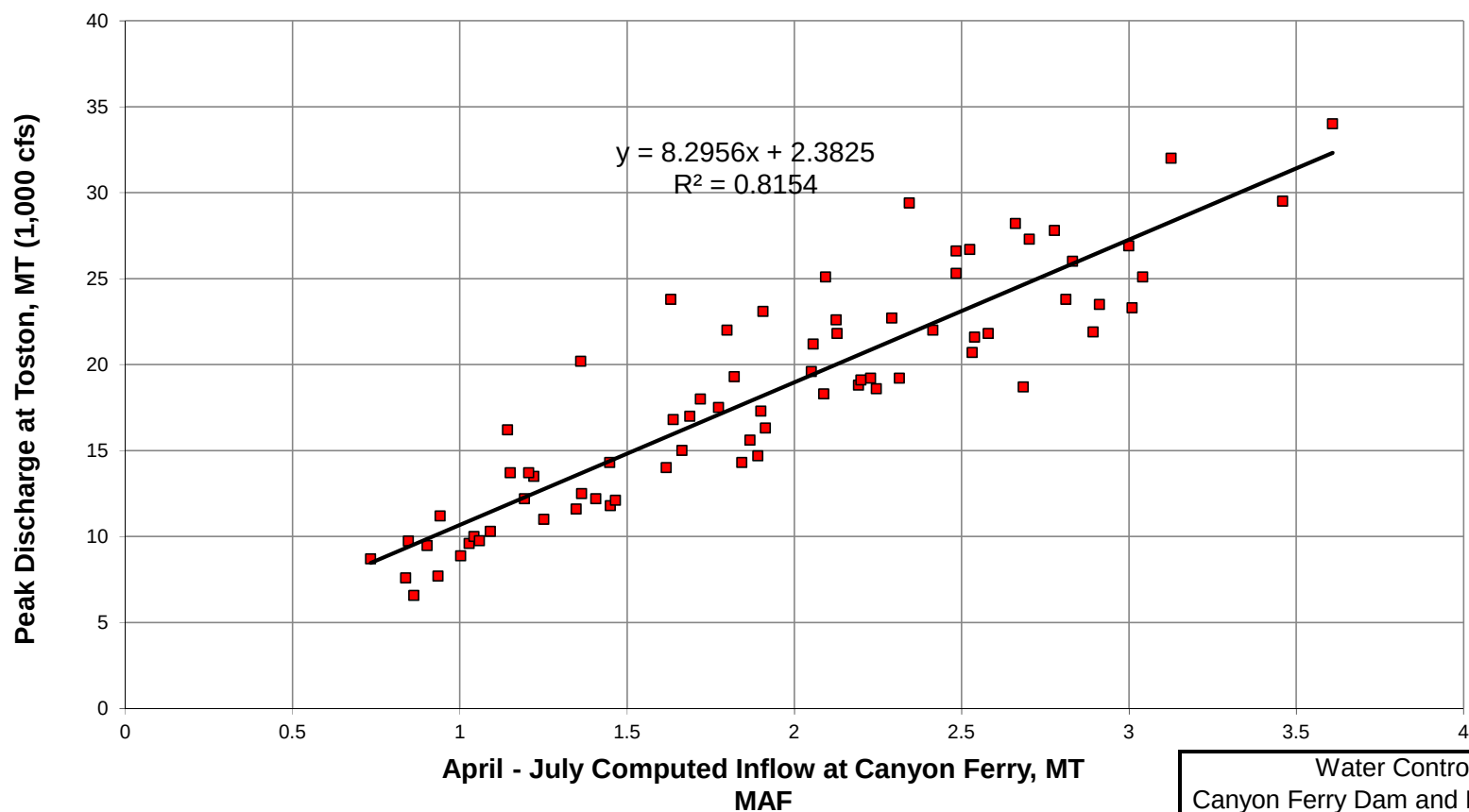
Source: Rocker Peak SNOTEL information via NRCS
Missouri River at Toston, MT discharge information via USGS

Note: Analysis of observed inflow tendencies based on historic melt rates vs. peak inflows.
-Peak inflows to Canyon Ferry can be expected on or around the day when Saddle Mountain and Rocker Peak reach half melt.
-Peak inflows to Canyon Ferry can be expected 2 days before Shower Falls reaches half melt.
-2015 Data is provisional.

Prepared By: AF
Reviewed By: KS

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Half Melt at Rocker Peak, Shower Falls
and Saddle Mountain and Peak Discharge
at Toston, 2013-2015**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

Toston Peak Flow vs. April-July inflow Volume



Sources of data:

- (1) Canyon Ferry inflow volumes from USBR Hydromet website (<http://www.usbr.gov/gp/hydromet>)
 - (2) Peak flow at Toston from USGS website (<http://nwis.waterdata.usgs.gov>)
- Period Analyzed: 1942-2015. 2015 data is provisional

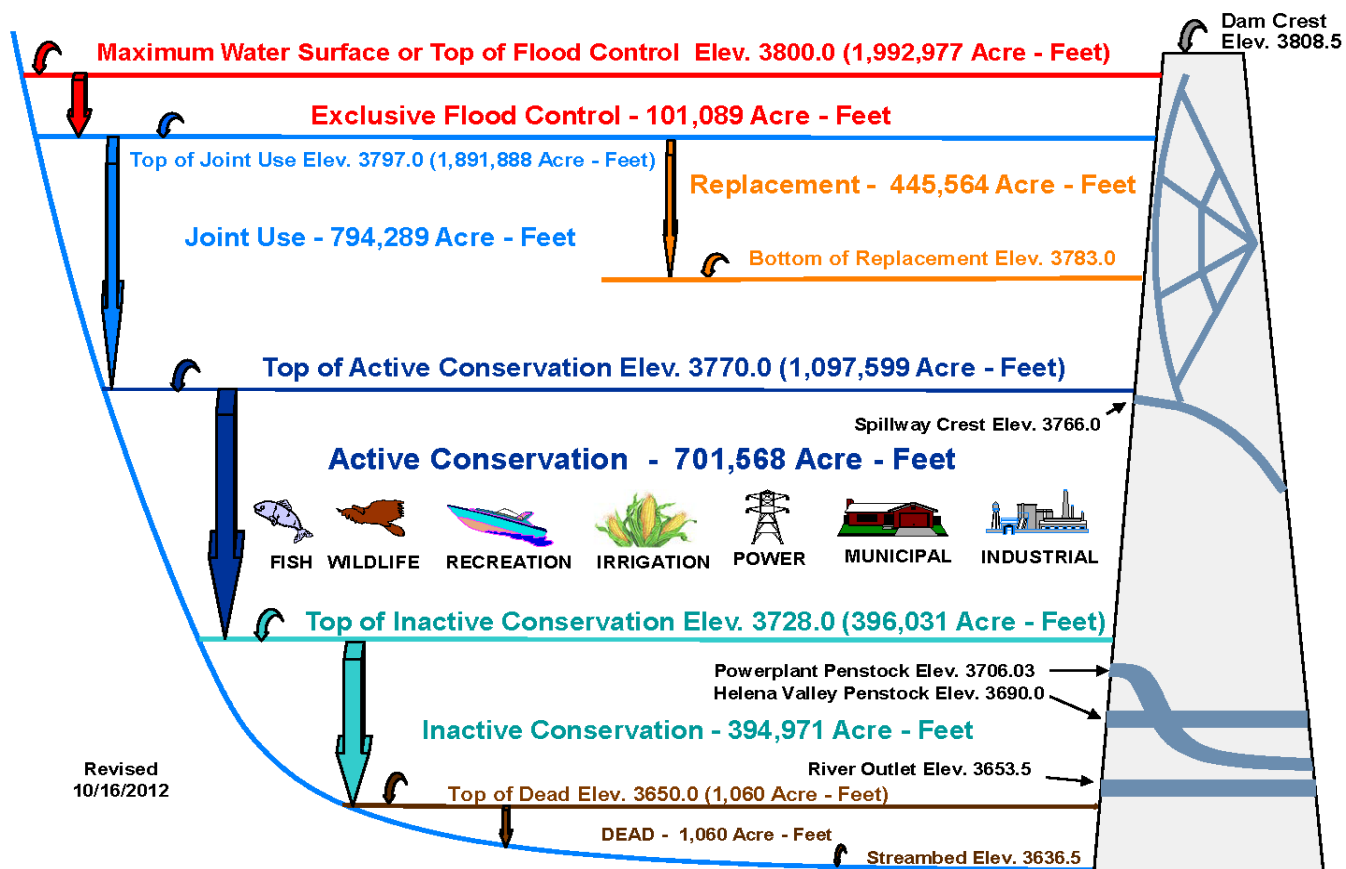
Prepared By: AF
 Reviewed By: JB

Water Control Manual
 Canyon Ferry Dam and Reservoir, Montana

**Missouri River Flow Comparison
 Toston, MT Peak Discharge vs. Canyon
 Ferry Apr-Jul Inflow Volume**

U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016

CANYON FERRY RESERVOIR ALLOCATIONS



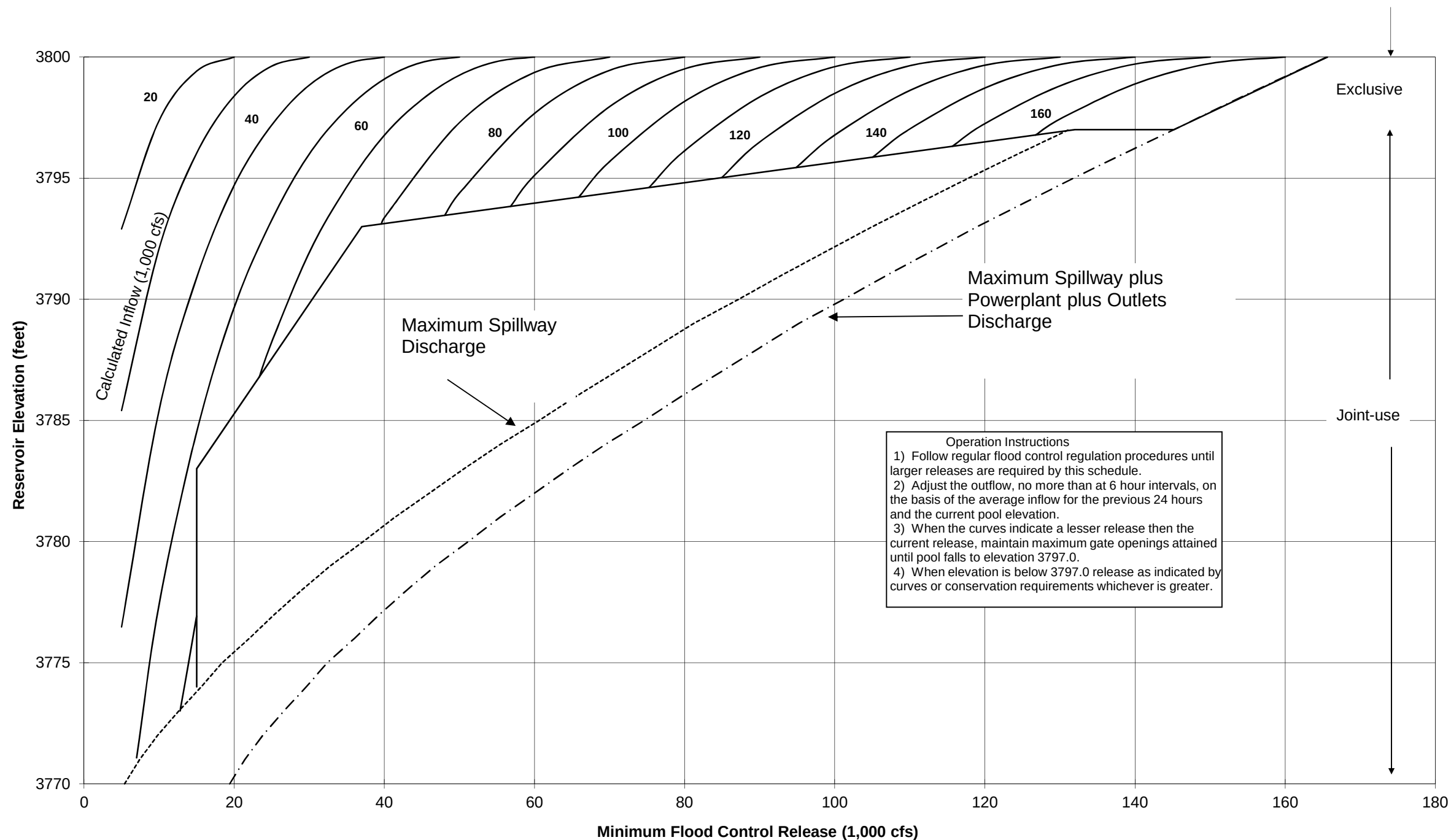
Revised
10/16/2012

Source of Data: US Bureau of Reclamation

Prepared By: JAB
Reviewed By: TET

Water Control Manual
Canyon Ferry Dam and Reservoir, MT
**Reservoir Storage Allocations
for Canyon Ferry Reservoir**

U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016



Note: Use only during large snowmelt floods or under emergency conditions. Based on mountain snowmelt hydrograph with 15-day inflow recession and provides for fill to top of dam. To use these curves refer to paragraph 7-05-g. Only use prior to peak event inflow if the "Emergency Release Schedule for Flood Control Canyon Ferry" from the Standing Instructions to Dam Tender are in effect.

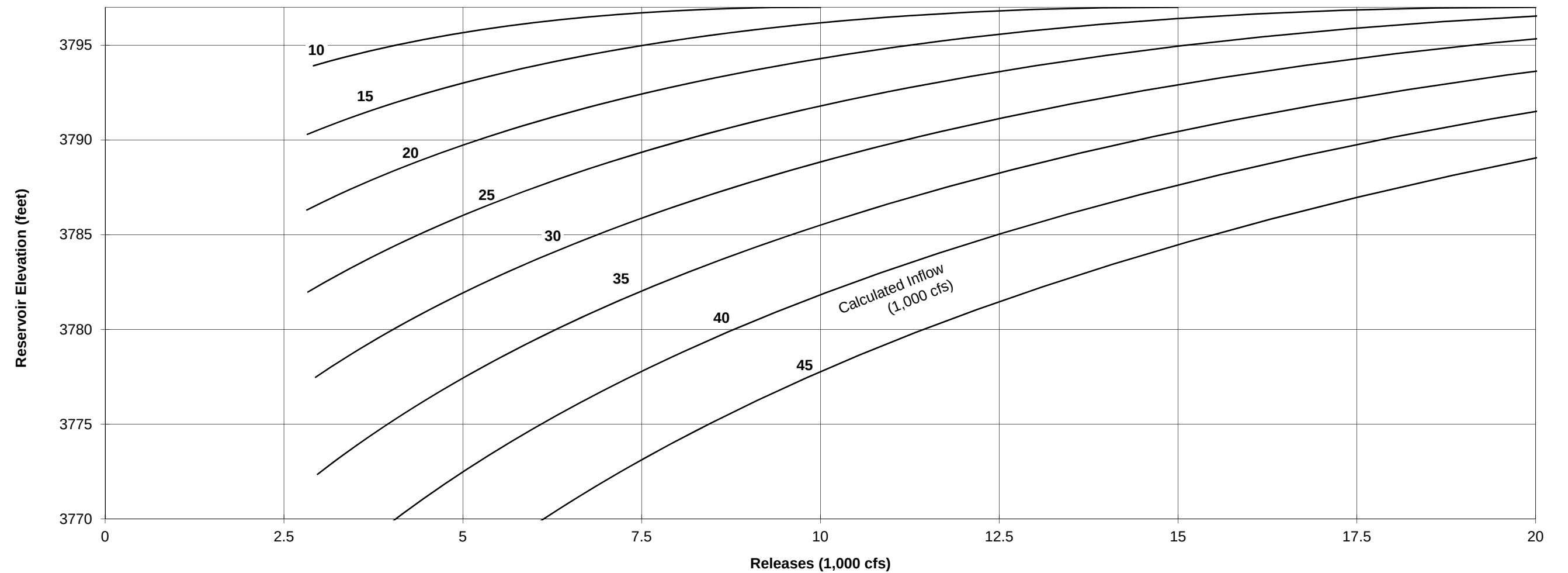
Source: Preliminary Information Report on Reservoir Regulations for Canyon Ferry Dam and Lake, Corps of Engineers, 1972

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Emergency Flood Control Regulation Schedule

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

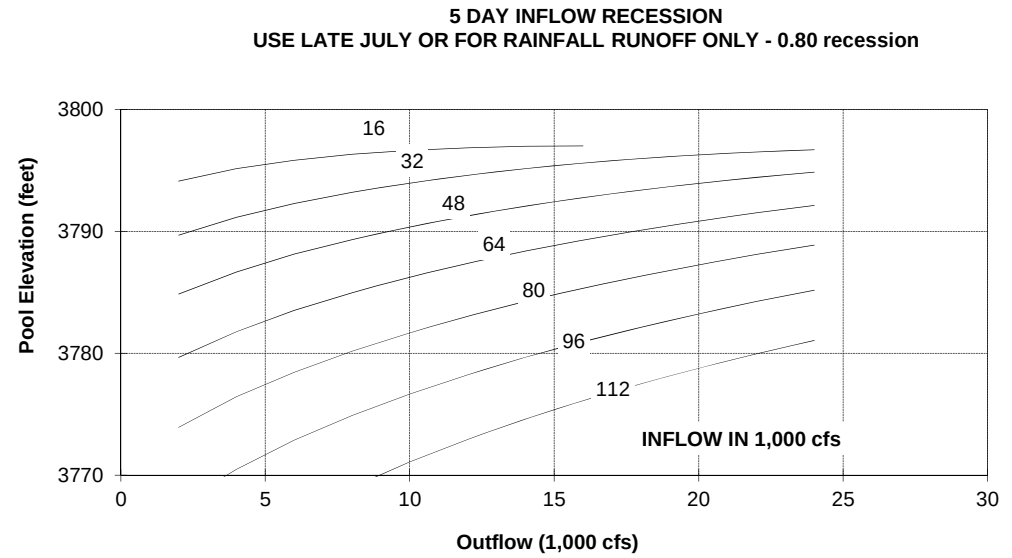
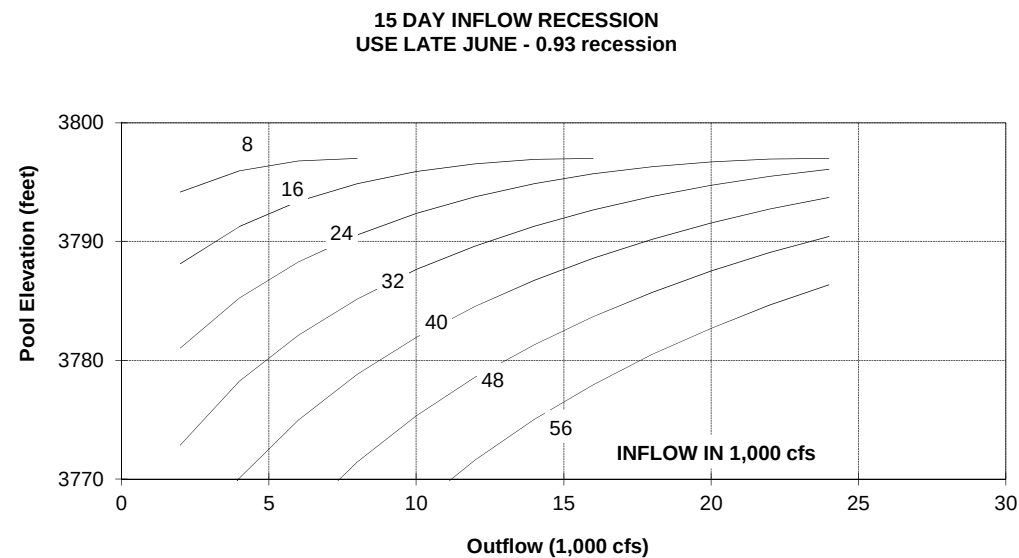
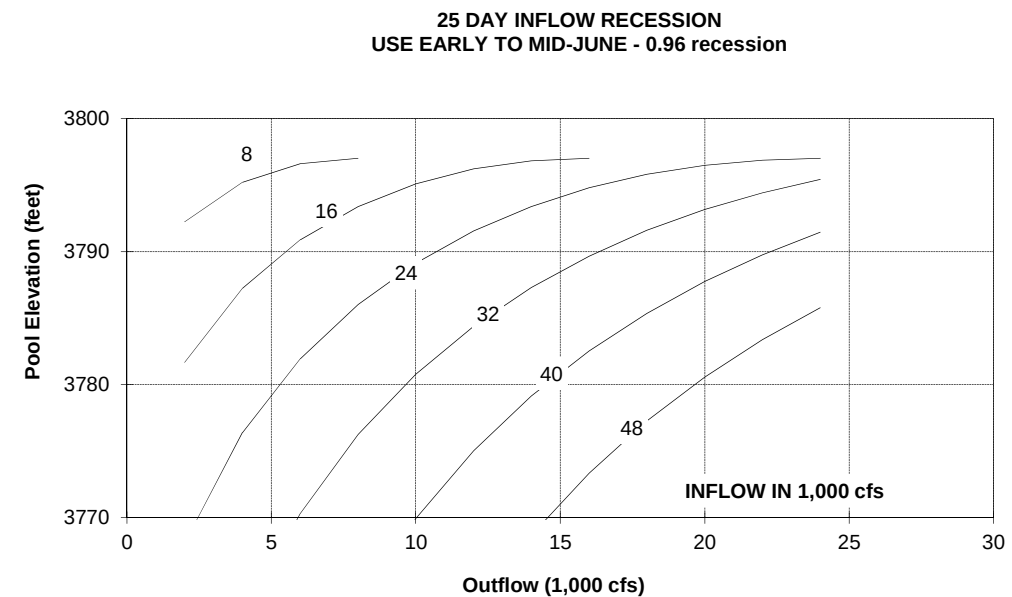
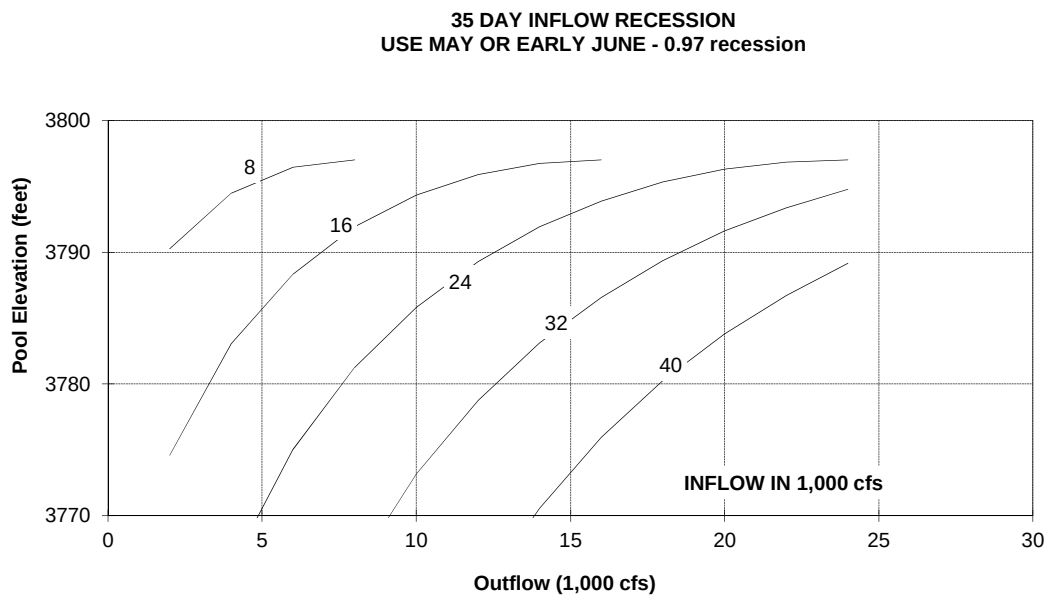


Note: To use these curves refer to paragraph 7-05-f(1).

Source: Preliminary Information Report on Reservoir Regulations for
Canyon Ferry Dam and Lake, Corps of Engineers, 1972

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
Release Schedule for Joint Use
Storage Refill with Recession Constant
of 0.93
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

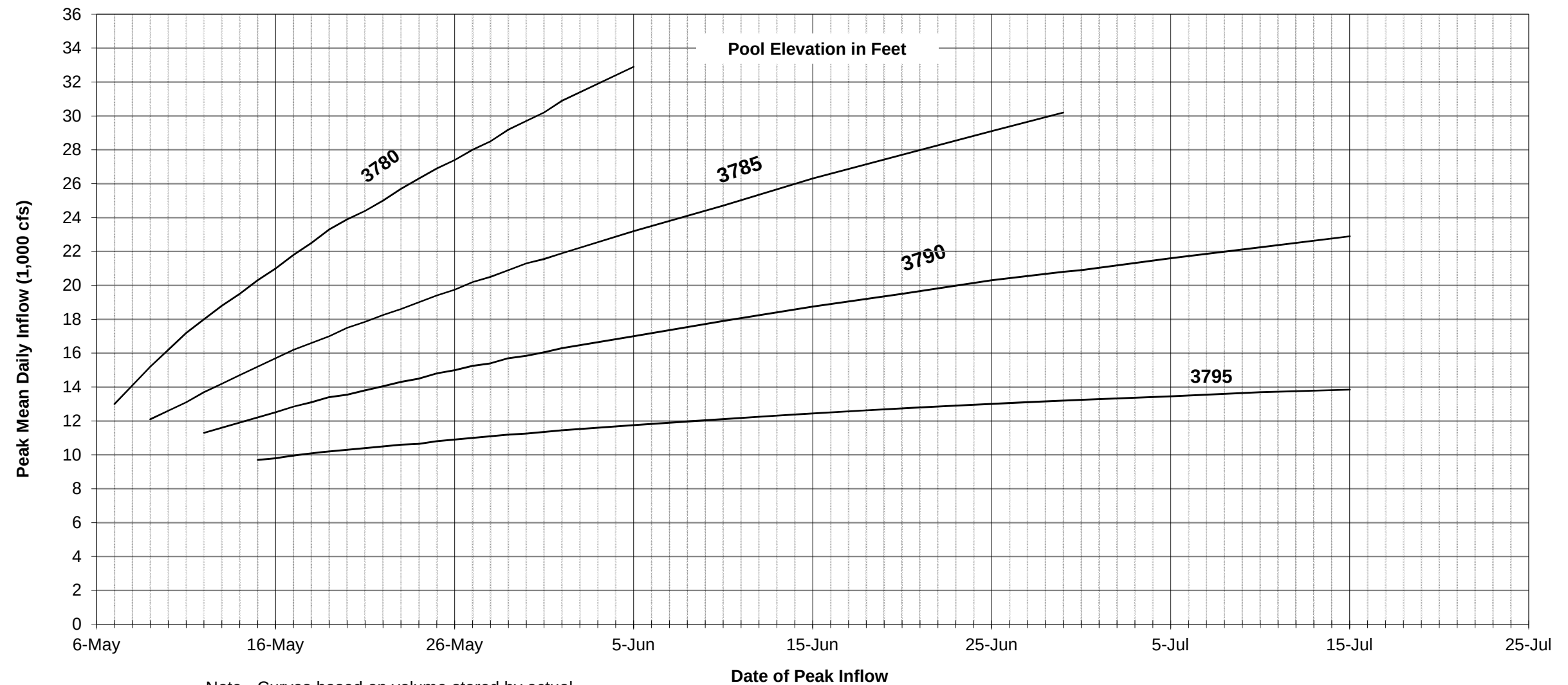


Note: To use these curves refer to paragraph 7-05-f(2) on page 7-8.

Source: Preliminary Information Report on Reservoir Regulations for
Canyon Ferry Dam and Lake, Corps of Engineers, 1972

Prepared By: KB
Reviewed By: JL

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Release Schedule for Joint Use
Storage Refill for 5, 15, 25, and
35-day Recession Curves**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Note - Curves based on volume stored by actual flow recessions over a release of 6000cfs. They indicate the pool level from which the Joint-use storage can assuredly be filled with a release of 6000cfs. To use these curves refer to paragraph 7-05-f(3) on page 7-9.

Source: Preliminary Information Report on Reservoir Regulations for Canyon Ferry Dam and Lake, Corps of Engineers, 1972

Prepared By: KB
Reviewed By: JL

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Reservoir Elevation Schedule for
Joint Use Storage Refill Based
on 6000 cfs Release**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

Canyon Ferry Release Responsibility Diagram

Note: Figure below denotes who is responsible for release decisions based on the time of year and pool elevation. All elevations are NGVD29 Datum.

The diagram illustrates the release responsibility zones for Canyon Ferry Dam and Reservoir, categorized by pool elevation and time of year. The zones are defined by the following elevations and responsibilities:

- Above 3800 feet:** Reclamation's release responsibility. Releases will be made to avoid overtopping the spillway gates and for dam safety operations.
- 3800 ft to 3797 ft:** **Exclusive Flood Control Zone** – Corps release responsibility year round.
- 3797 ft to 3770 ft:** **Joint Use Zone** – Filled for conservation, Reclamation's release responsibility year round when Local Flood Targets are NOT exceeded. Pool elevation of responsibility moves up and down based on Apr-Jul runoff forecast from Jan 1 - Jul 1. If the pool elevation is expected to exceed the pool elevation of responsibility, the Corps will notify Reclamation, who schedules releases to evacuate storage to the pool elevation of responsibility by the seasonal date. Releases for this purpose should stay below damaging levels.
 Joint Use Zone – The Corps has year round release responsibility when the Water Control Manual's Local Flood Targets are exceeded.
- 3770 ft to 3650 ft:** **Joint Use Zone** – Filled for conservation, Reclamation's responsibility year round when Local Flood targets are NOT exceeded.
- Below 3650 ft:** **Conservation Zone** – Reclamation's release responsibility year round.

A vertical double-headed arrow on the left indicates the 3770-3797 ft Pool elevation of responsibility varies based on Apr-Jul runoff volume forecast.

Note: Drawing not to scale

Water Control Manual
Canyon Ferry Dam and Reservoir
Canyon Ferry Release Responsibility Diagram
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016

Canyon Ferry Release Responsibility Diagram

Note: Figure below denotes who is responsible for release decisions based on the time of year and pool elevation. All elevations are NGVD29 Datum.

The diagram illustrates the release responsibility zones for Canyon Ferry Dam and Reservoir, categorized by pool elevation and time of year. The zones are defined by the following elevations and responsibilities:

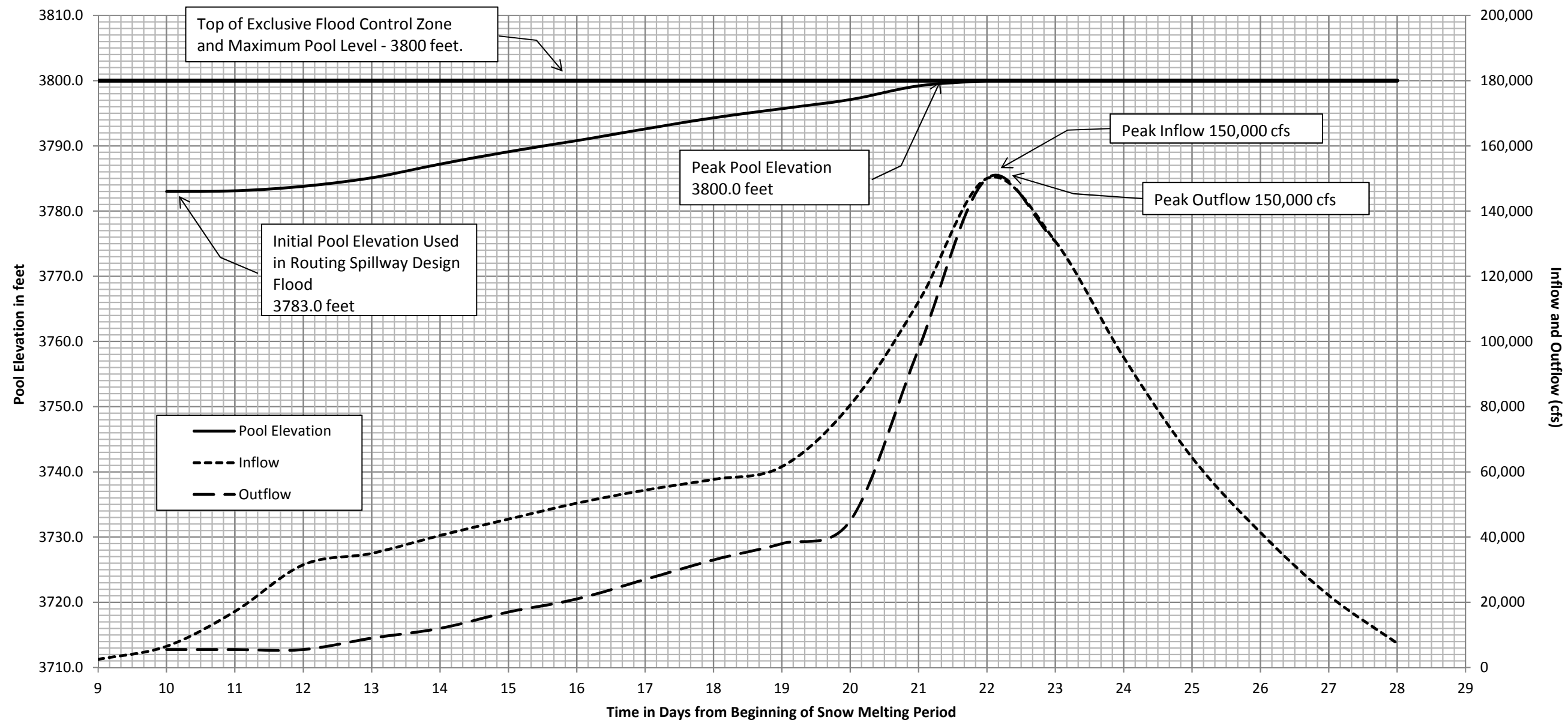
- Above 3800 feet:** Reclamation's release responsibility. Releases will be made to avoid overtopping the spillway gates and for dam safety operations.
- 3800 ft to 3797 ft:** **Exclusive Flood Control Zone** – Corps release responsibility year round.
- 3797 ft to 3770 ft:** **Joint Use Zone** – Filled for conservation, Reclamation's release responsibility year round when Local Flood Targets are NOT exceeded. Pool elevation of responsibility moves up and down based on Apr-Jul runoff forecast from Jan 1 - Jul 1. If the pool elevation is expected to exceed the pool elevation of responsibility, the Corps will notify Reclamation, who schedules releases to evacuate storage to the pool elevation of responsibility by the seasonal date. Releases for this purpose should stay below damaging levels.
 Joint Use Zone – The Corps has year round release responsibility when the Water Control Manual's Local Flood Targets are exceeded.
- 3770 ft to 3650 ft:** **Joint Use Zone** – Filled for conservation, Reclamation's responsibility year round when Local Flood targets are NOT exceeded.
- 3650 ft to 3500 ft:** **Conservation Zone** – Reclamation's release responsibility year round.

A vertical double-headed arrow on the left indicates the 3770-3797 ft Pool elevation of responsibility varies based on Apr-Jul runoff volume forecast.

Note: Drawing not to scale

Prepared By: JDC
Reviewed By: AJF

Water Control Manual
Canyon Ferry Dam and Reservoir
Canyon Ferry Release Responsibility Diagram
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016



NOTE: The x-axis values are labeled at the middle of each day.

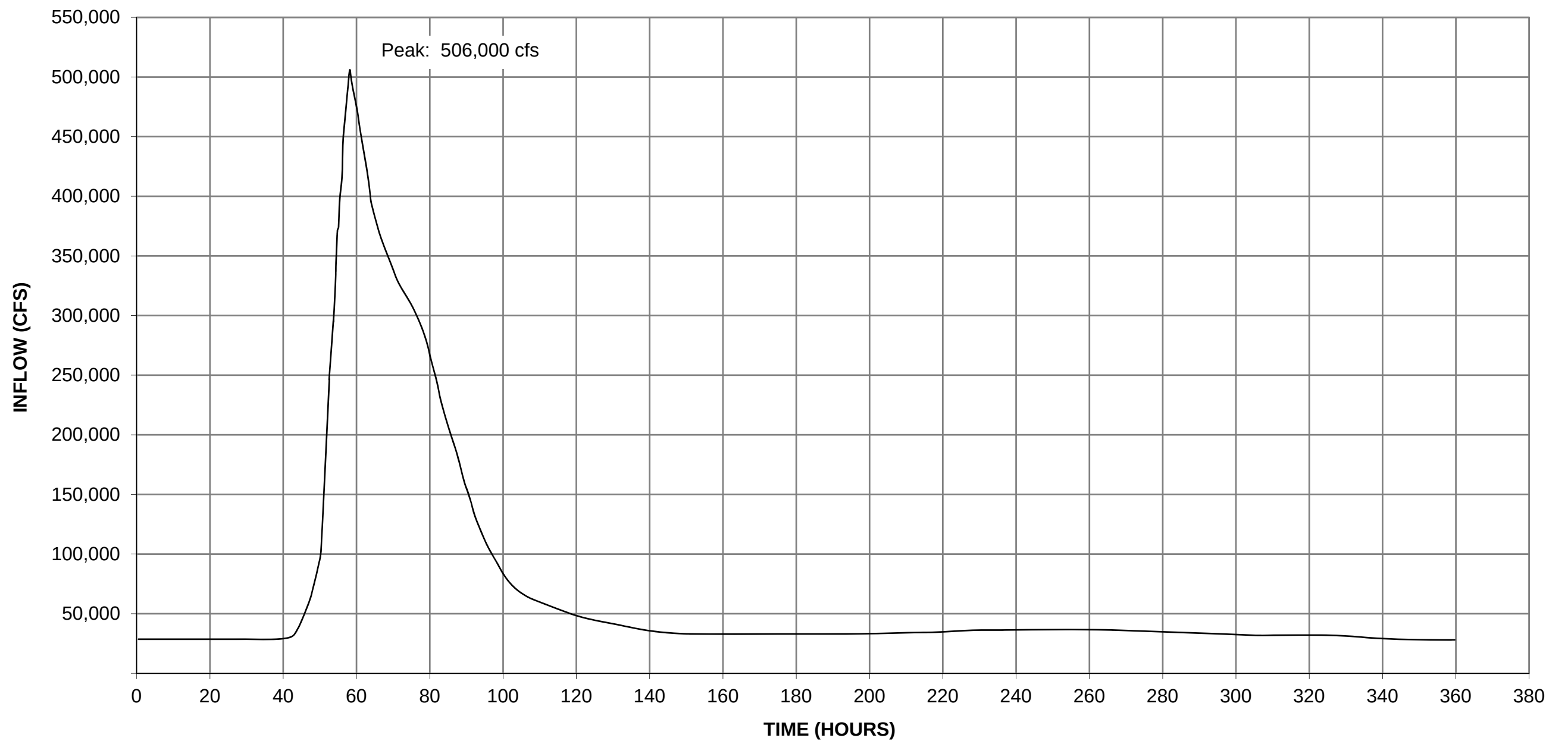
Source: Design Flood Routings, Canyon Ferry Dam and Reservoir, Omaha District, Corps of Engineers, 1972

Prepared By: TET
Reviewed By: JAB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Original Spillway Design Flood

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Note: Reservoir releases essentially the same as inflows (see paragraph 8-02)

Source: Exhibit IV-5, USBR Standing Operating Procedures,
November 1999

Prepared By: KB
Reviewed By: JL

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana
**Updated Spillway Design Flood
(1985)**
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

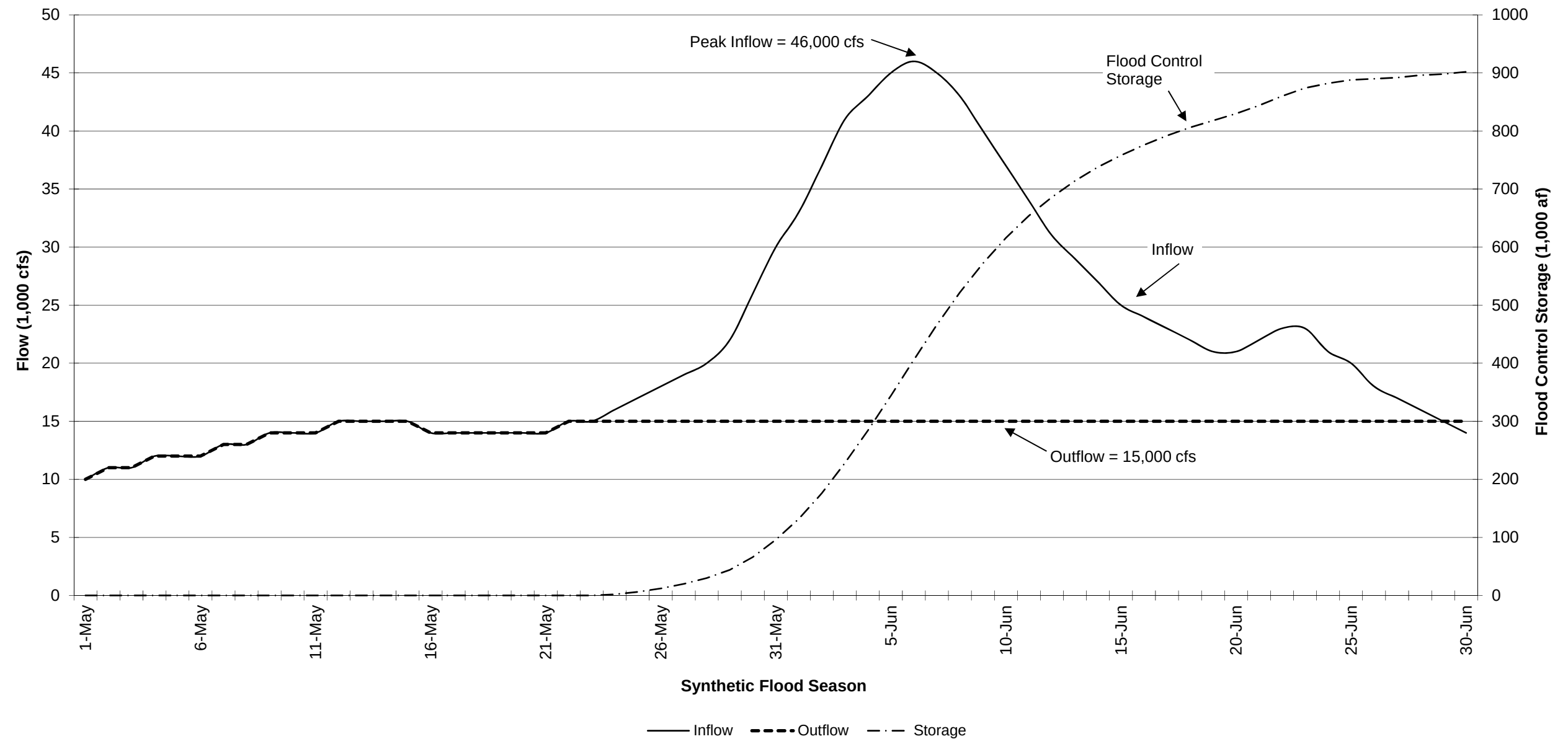


Illustration of flood control storage space required to route design flood with constant 15,000 cfs release (see Section 8-02.b).

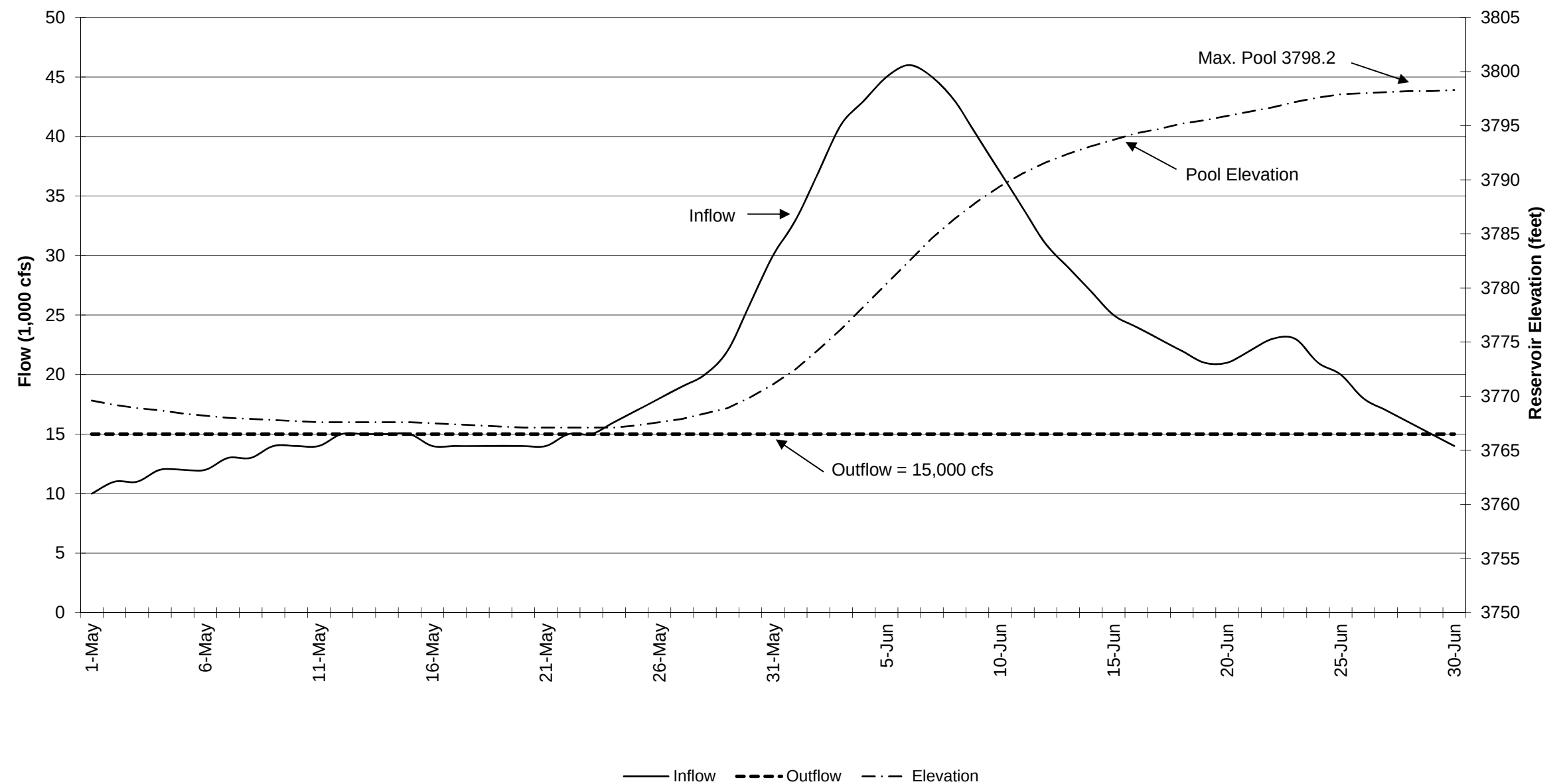
Source: Preliminary Information Report on Reservoir Regulations for Canyon Ferry Dam and Reservoir, Corps of Engineers, 1972

Prepared By: KB
Reviewed By: JL

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Reservoir Design Flood Routing vs. Storage

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Note: Regulation based on Plate 7-2 with an initial release of 15,000 cfs (see Section 8-02.b).

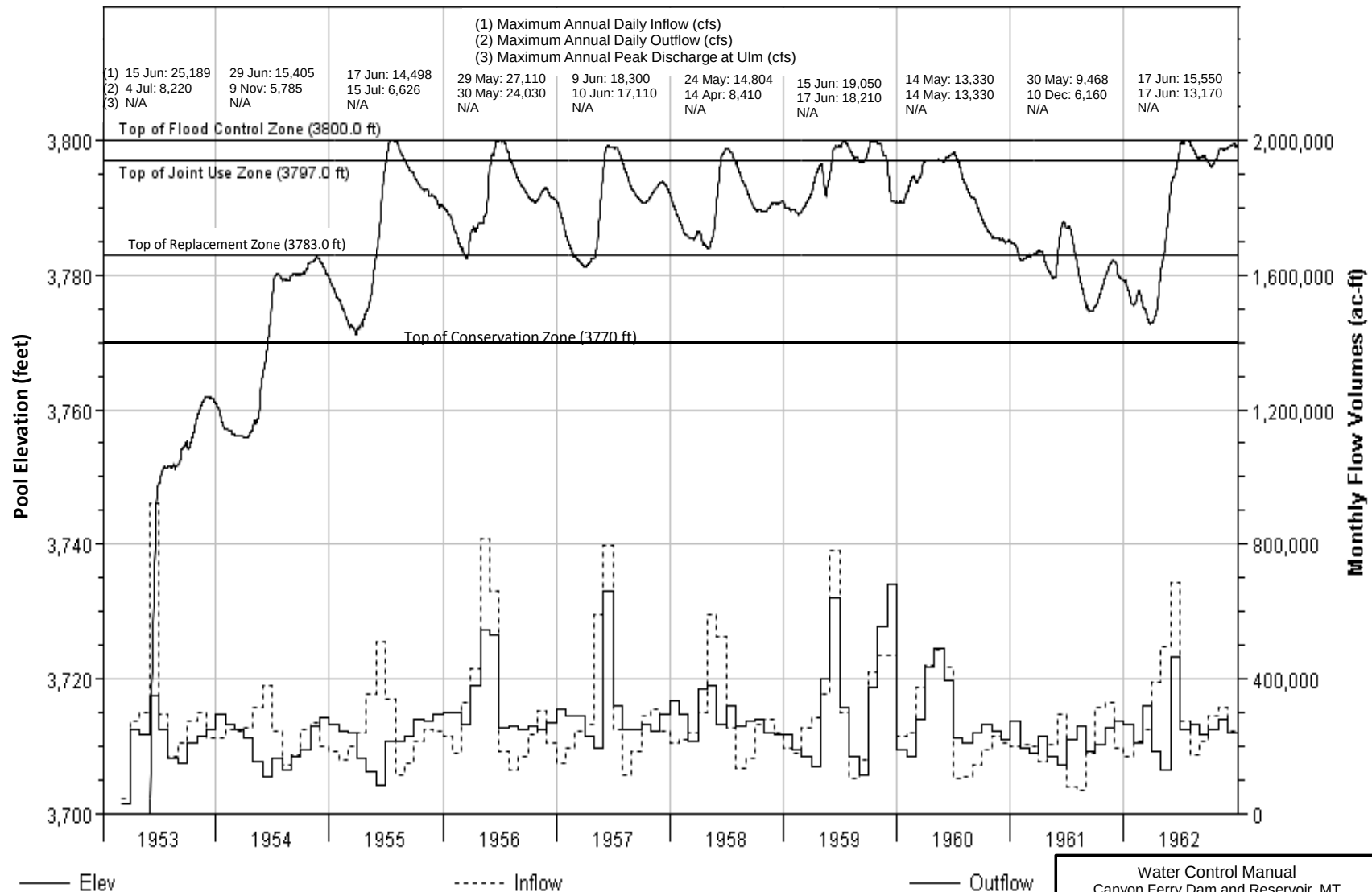
Source: Preliminary Information Report on Reservoir Regulations for
Canyon Ferry Dam and Reservoir, Corps of Engineers, 1972

Prepared By: KB
Reviewed By: JL

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

Reservoir Design Flood Routing vs. Elevation

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



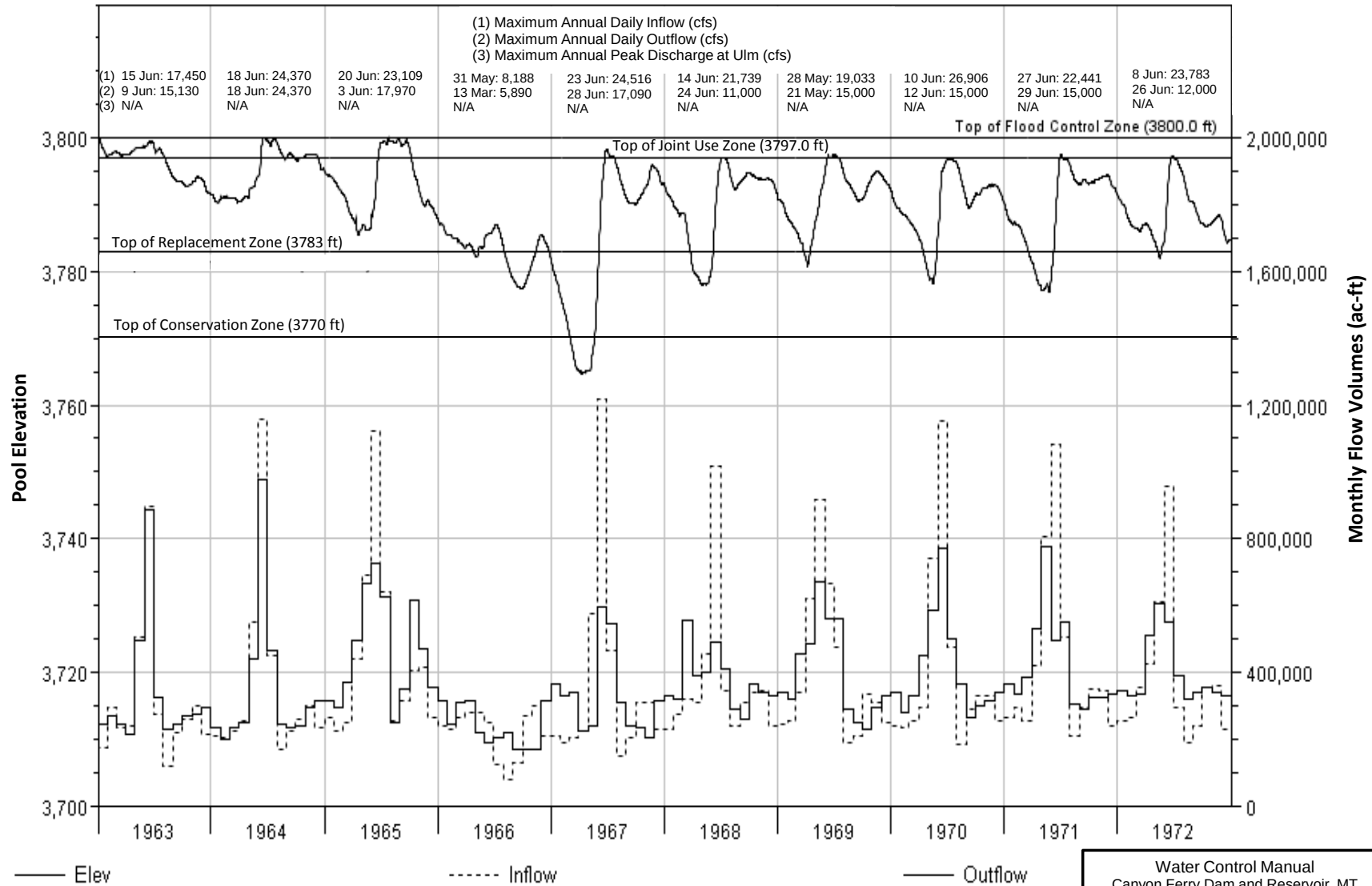
Pool Elevations are reported in feet
 Flow Volumes are an accumulation of daily average flows in ac-ft.

Source of Data: USACE 0168 records

Prepared by: JAB

Reviewed by: TET

Water Control Manual
 Canyon Ferry Dam and Reservoir, MT
Operating Hydrographs
1953-1962
 U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016

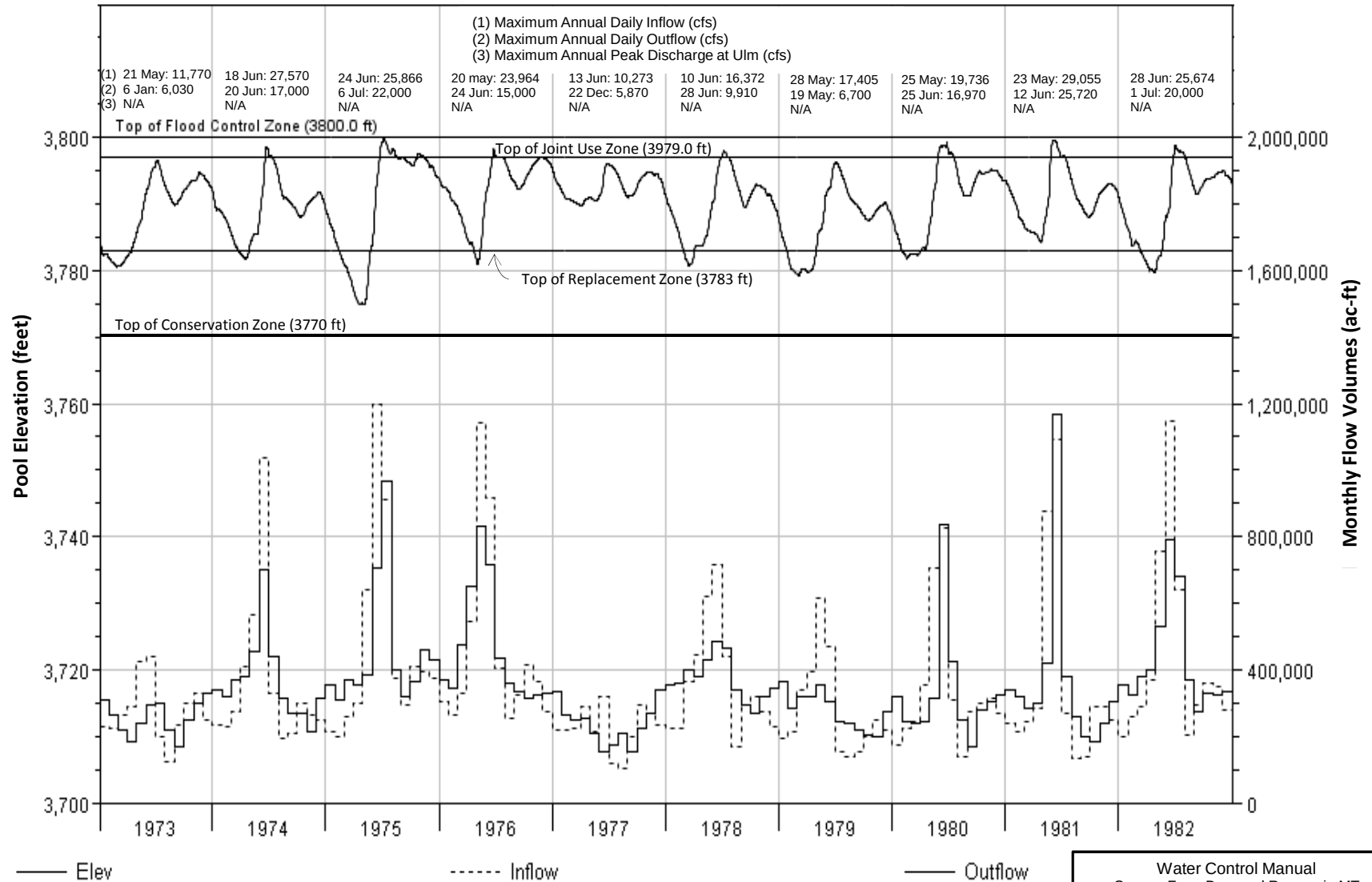


Pool elevations are reported in feet
flow Volumes are an accumulation of daily average flows in ac-ft.

Source of Data; USACE 0168 record

Prepared by JAB
Reviewed by TET

Water Control Manual
Canyon Ferry Dam and Reservoir, MT
Operating Hydrographs
1963-1972
U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

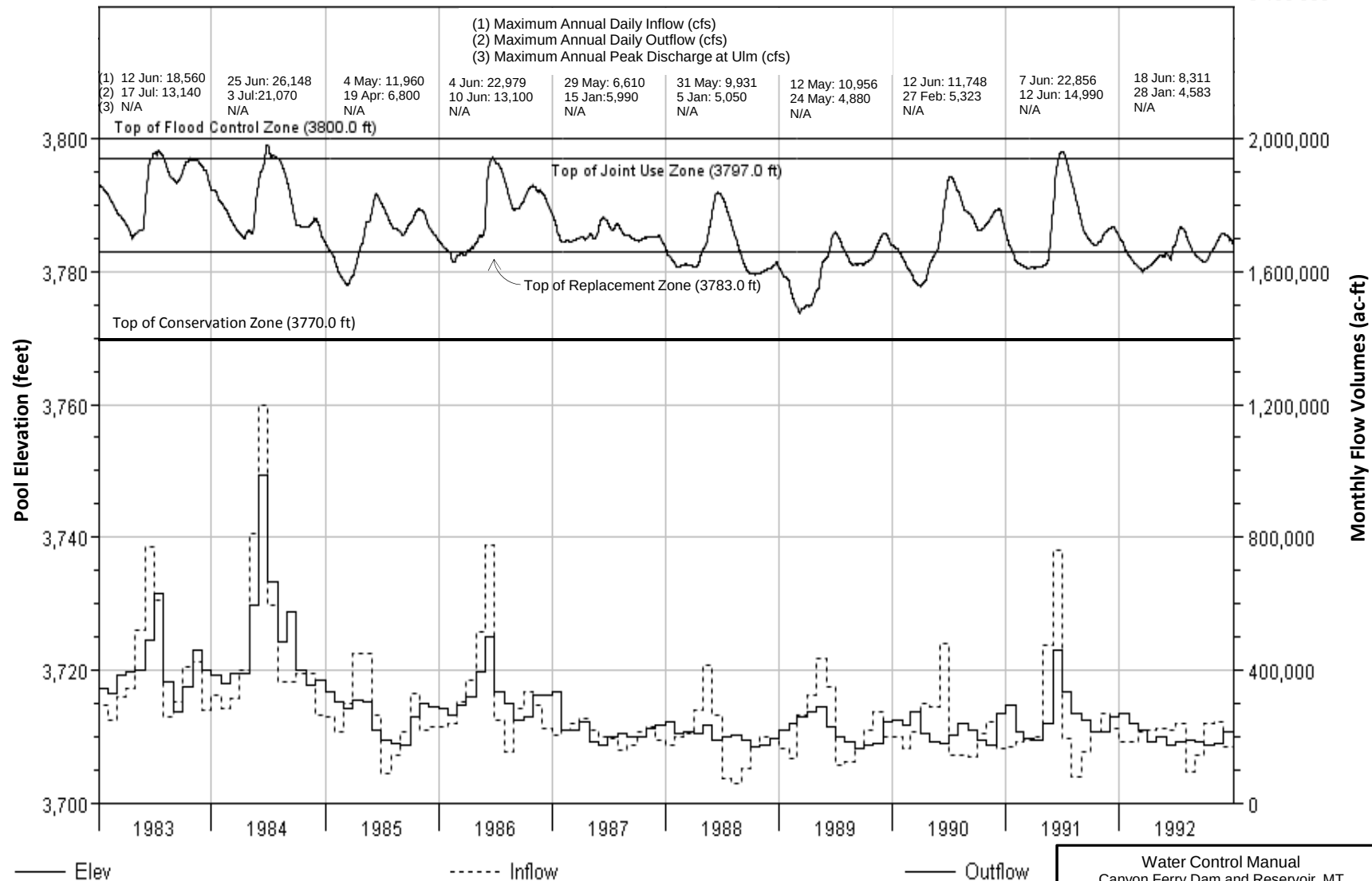


Pool Elevations are reported in feet
 Flow Volumes are an accumulation of daily average flows in ac-ft.

Source of Data: USACE 0168 record

Prepared by JAB
 Reviewed by TET

Water Control Manual
 Canyon Ferry Dam and Reservoir, MT
Operating Hydrographs
1973-1982
 U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



Pool Elevations are reported in feet
Flow Volumes are an accumulation of daily average flows in ac-ft

Source of Data: USACE 0168 record

Prepared by JAB
Reviewed by TET

Water Control Manual
Canyon Ferry Dam and Reservoir, MT
Operating Hydrographs
1973-1992
U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

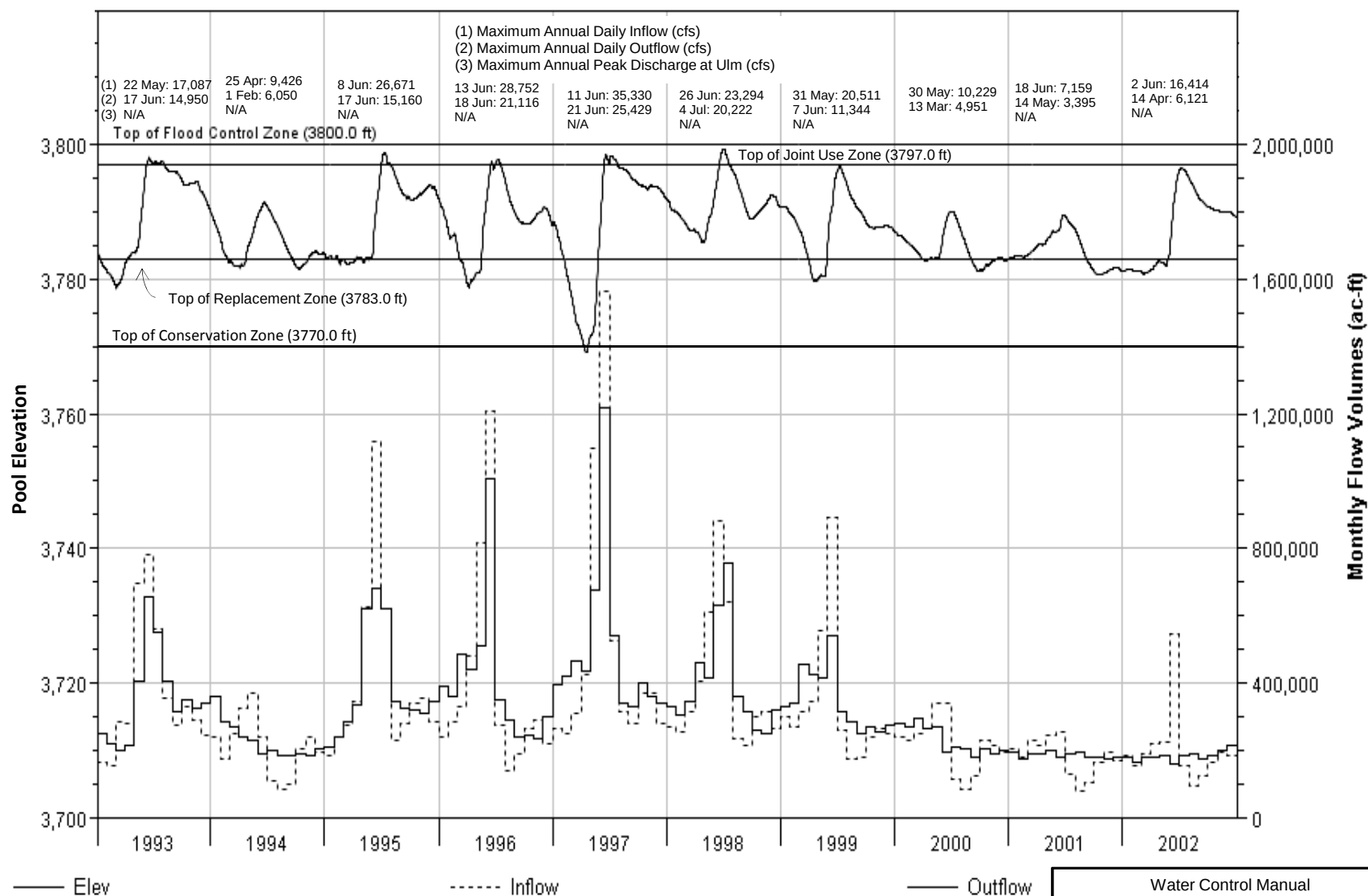


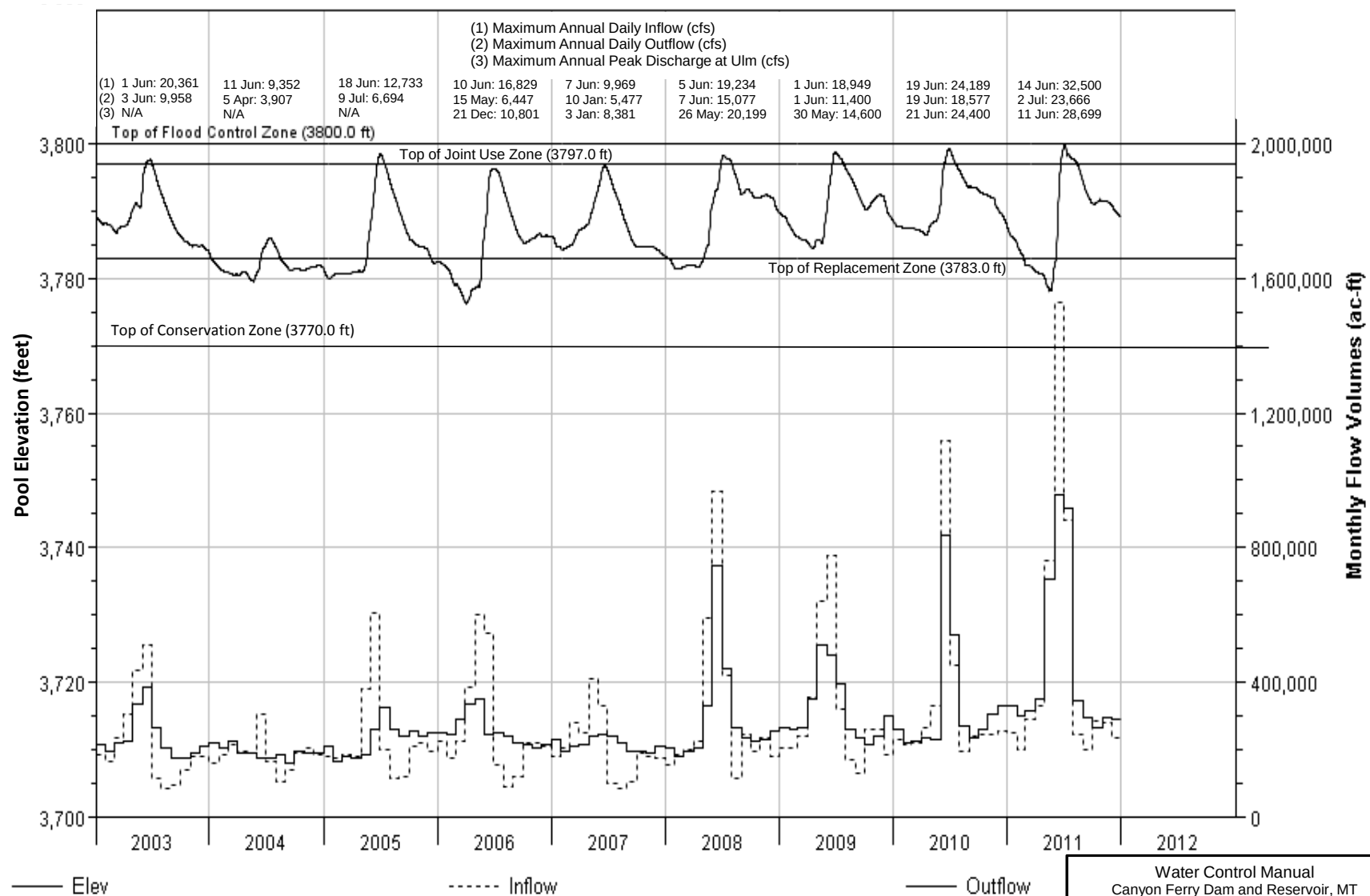
Plate 8-5d

Pool Elevations are reported in feet
Flow Volumes are an accumulation of daily average flows in ac-ft

Source of Data: USACE 0168 record

Prepared by JAB
Reviewed by TET

Water Control Manual
Canyon Ferry Dam and Reservoir, MT
Operating Hydrographs
1973-1992
U.S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Pool Elevations are reported in feet
 flow Volumes are an accumulation of daily average flows in ac-ft

Source of Data: USACE 0168 record

Prepared by JAB
 Reviewed by TET

Water Control Manual
 Canyon Ferry Dam and Reservoir, MT
Operating Hydrographs
1973-1922
 U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016

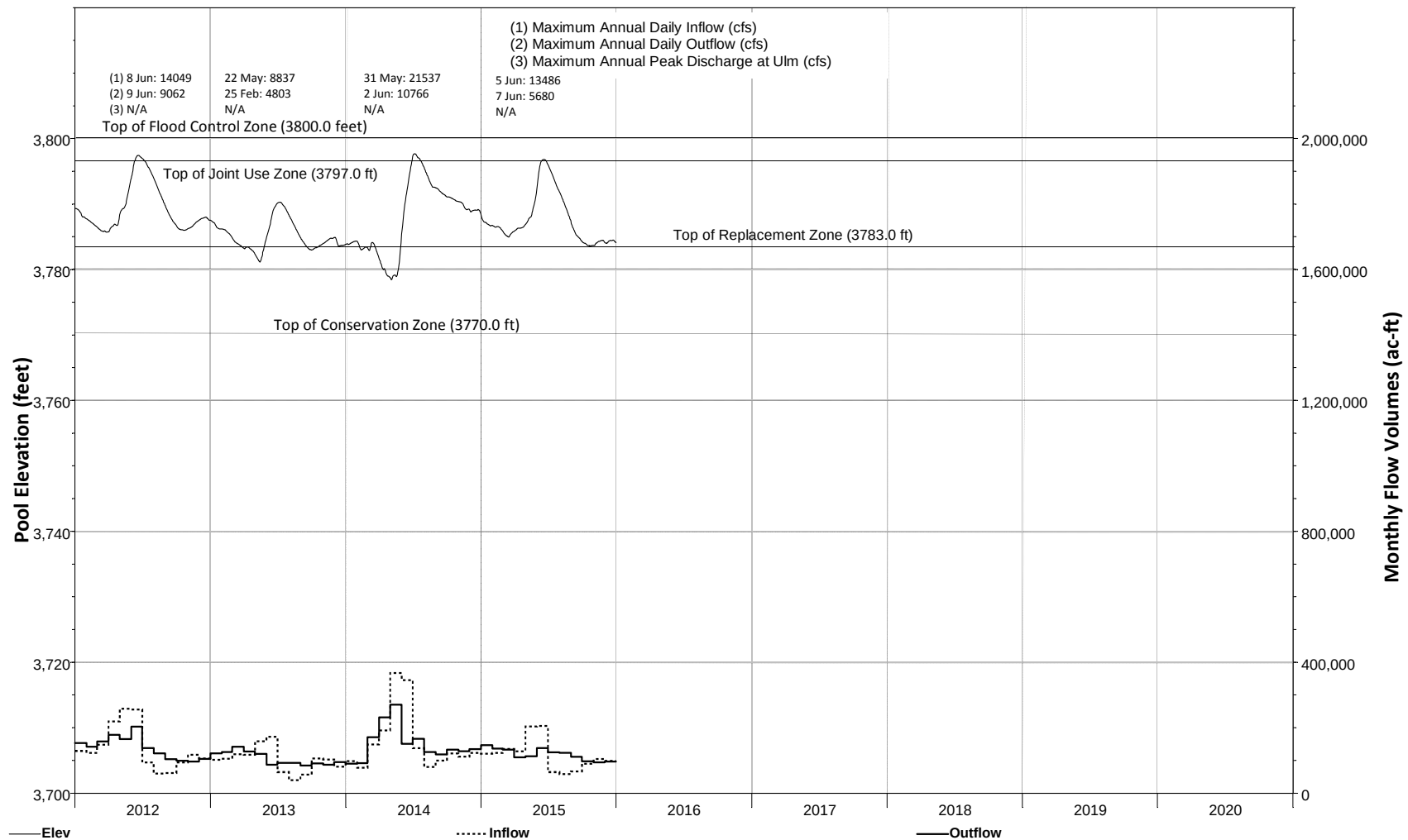


Plate 8-5f

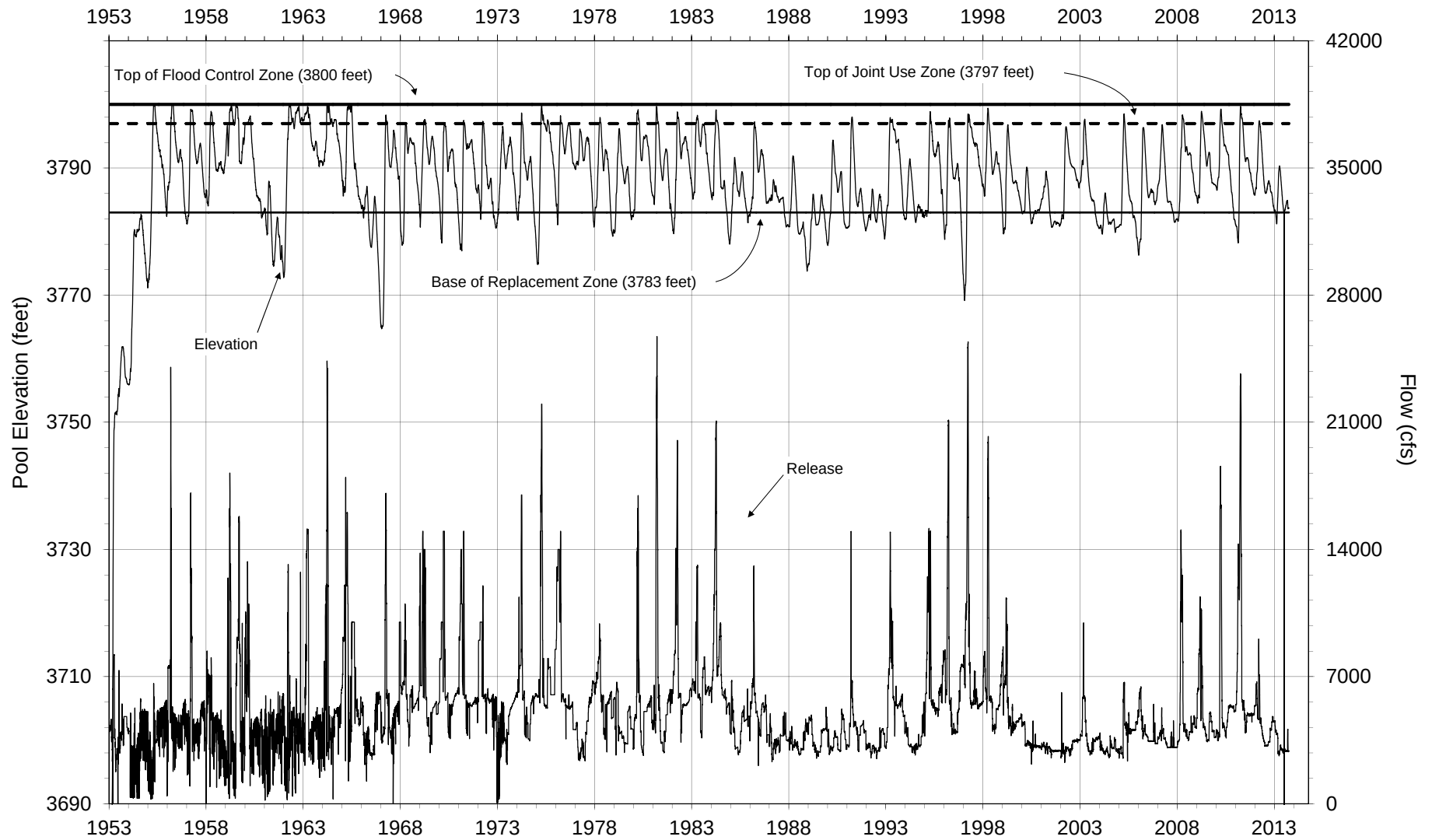
Pool Elevations are reported in feet
flow Volumes are an accumulation of daily average flows in ac-ft

Source of Data: USACE 0168 record

Prepared by: ___SDS___

Reviewed by: ___AJF___

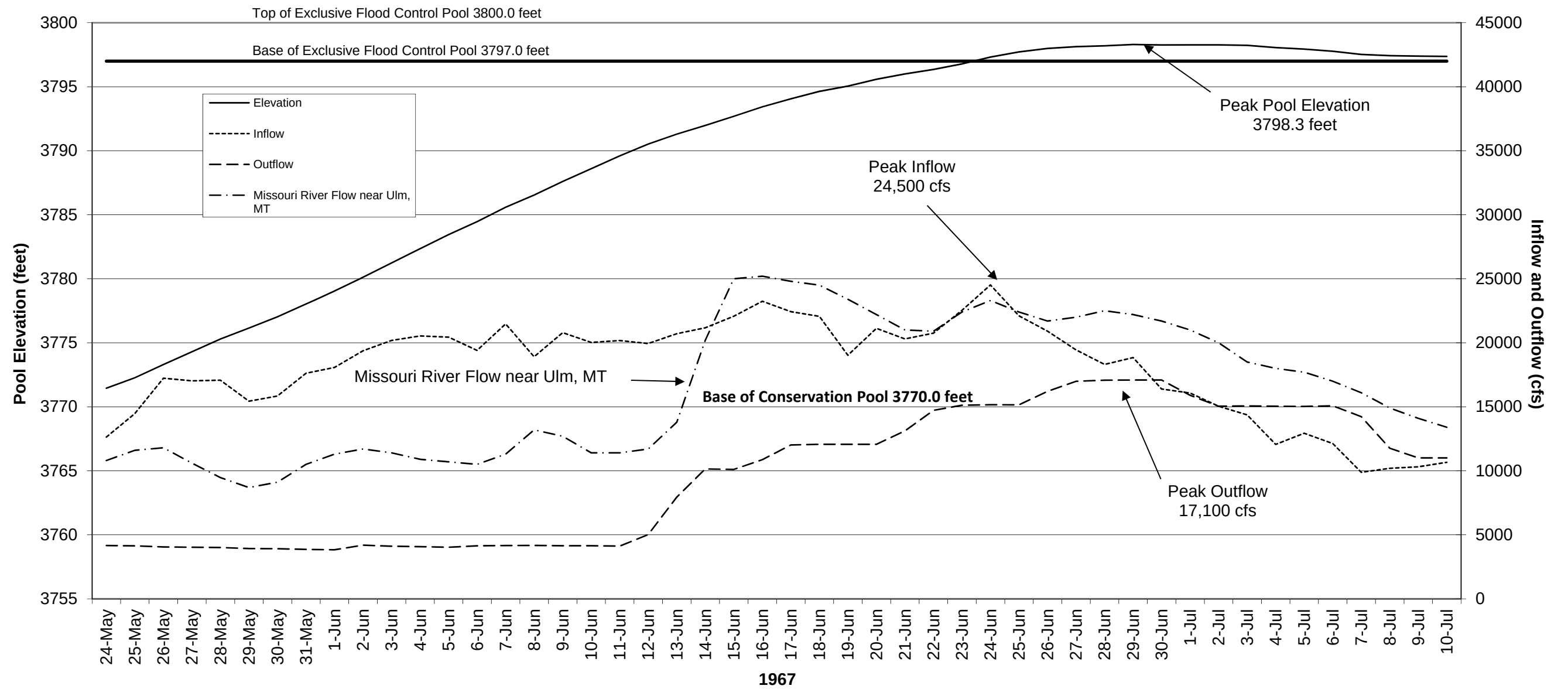
Water Control Manual
 Canyon Ferry Dam and Reservoir, MT
Operating Hydrographs
1973-1922
 U.S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



Source of data: USBR Hydromet-Hydrological database

Prepared By: JDM
Reviewed By: TET

Water Control Manual
Canyon Ferry Dam and Reservoir
Historical Pool Elevation and Releases
Period of Record
U.S. Army Engineer District
Corps of Engineers, Omaha, Nebraska
December 2016



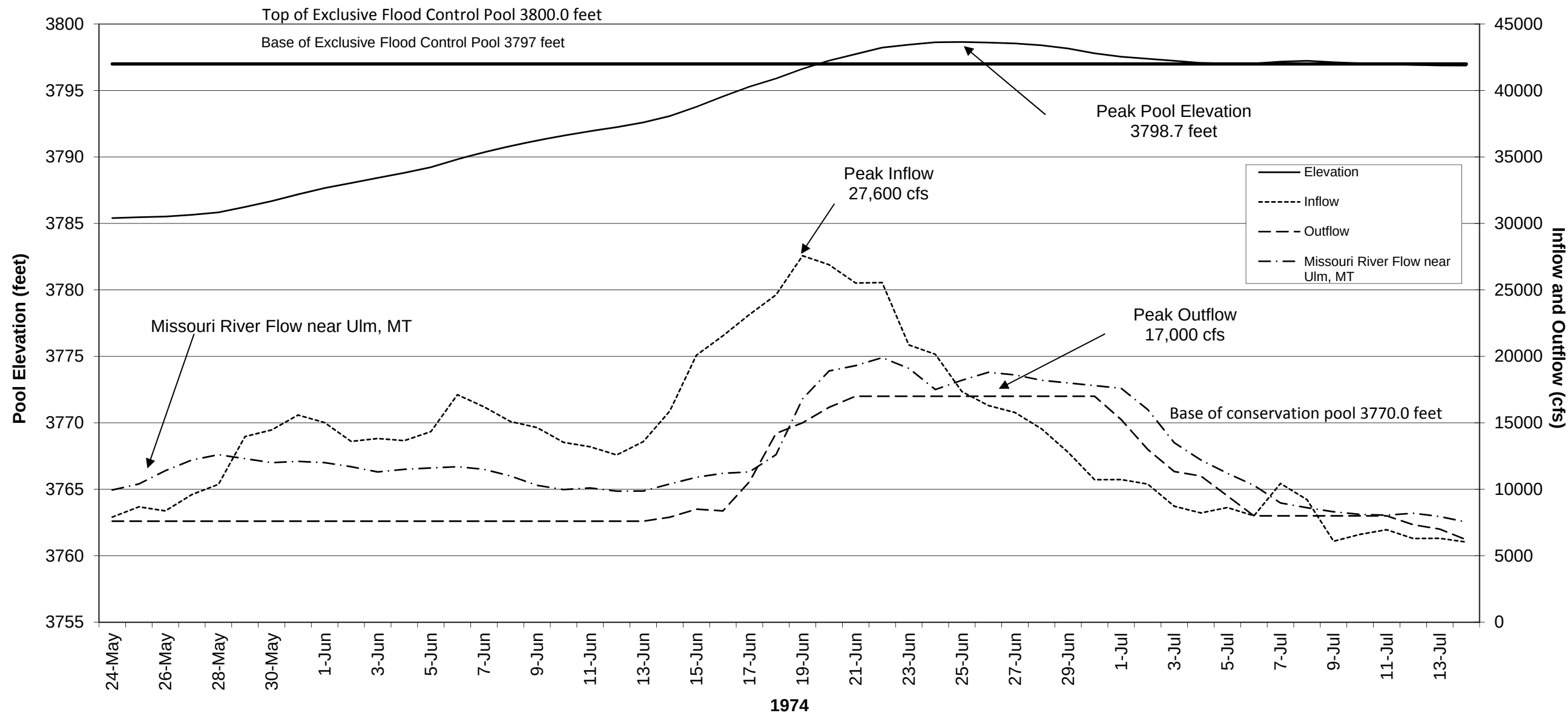
Source: USBR Hydromet Data, USGS gage data

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

1967 Flood Routing

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



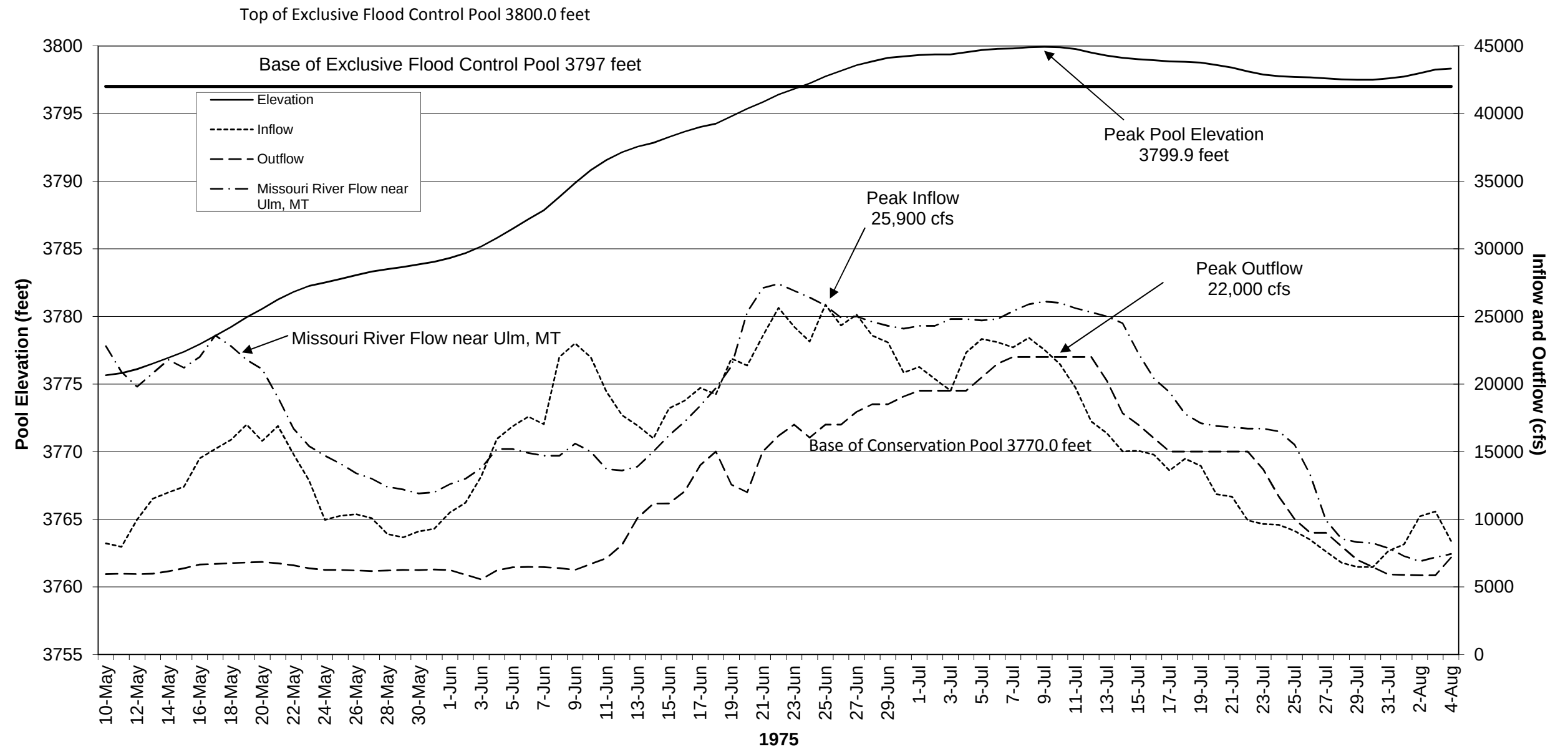
Source: USBR Hydromet Data, USGS gage data

Prepared By: AF
 Reviewed By: KB

Water Control Manual
 Canyon Ferry Dam and Reservoir, Montana

1974 Flood Routing

U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



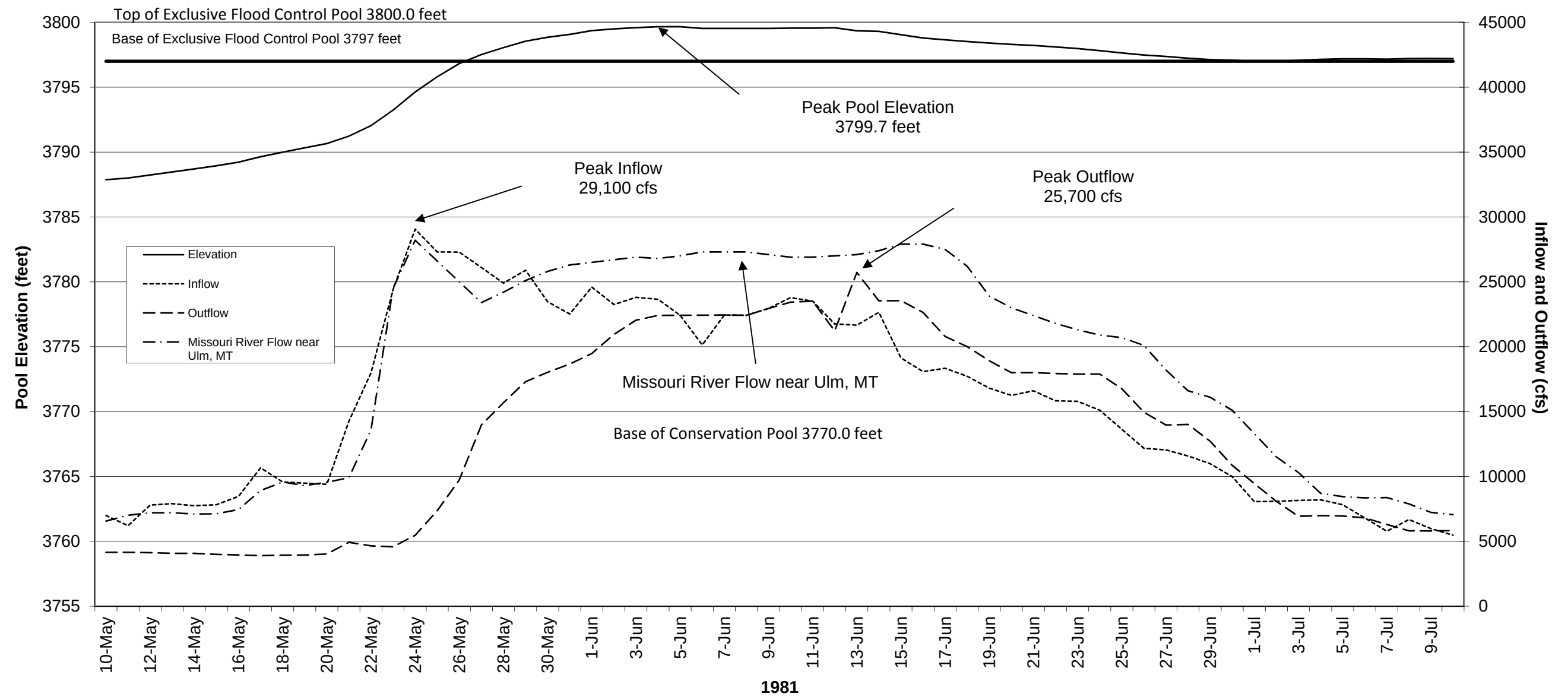
Source: USBR Hydromet, USGS gage data

Prepared By: KB
Reviewed By: JL

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

1975 Flood Routing

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



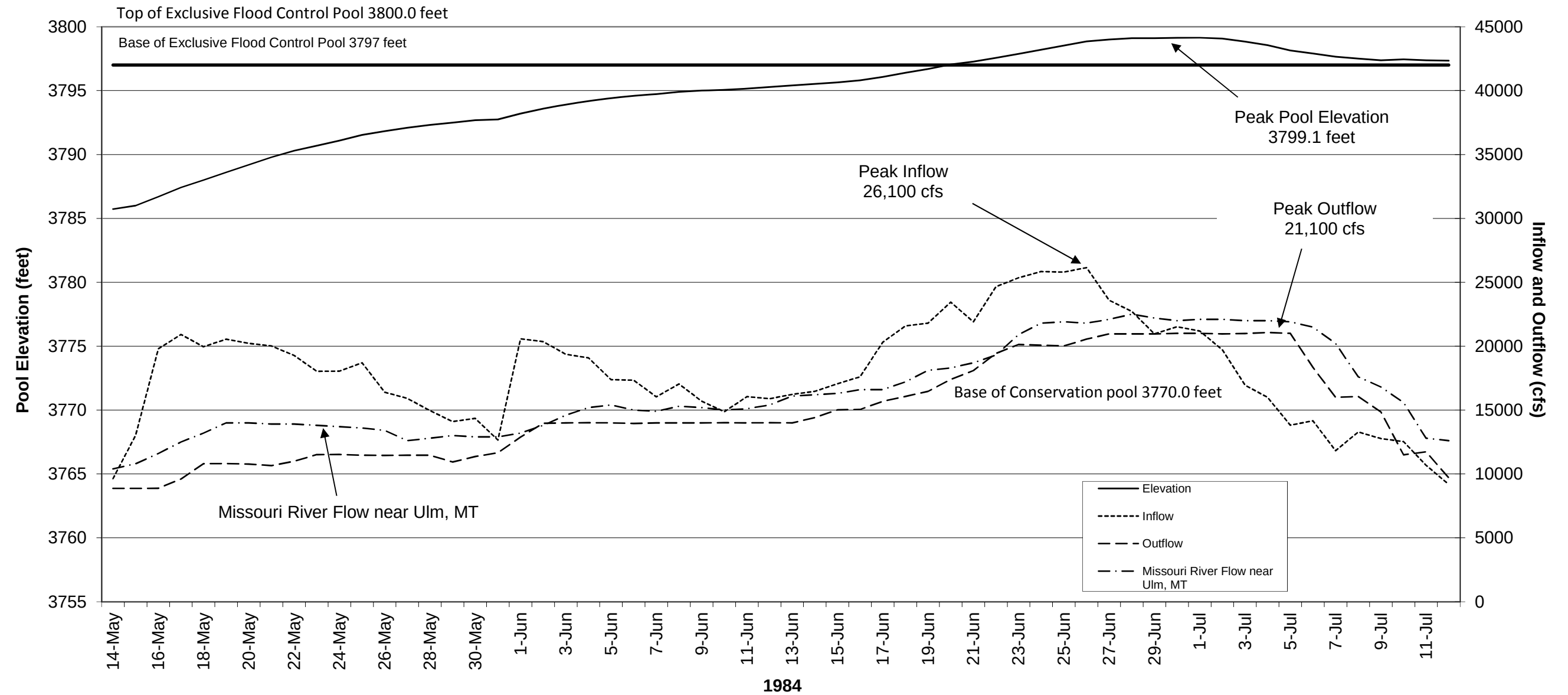
Source: USBR Hydromet Data, USGS gage data

Prepared By: ____AF____
 Reviewed By: ____KB____

Water Control Manual
 Canyon Ferry Dam and Reservoir, Montana

1981 Flood Routing

U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



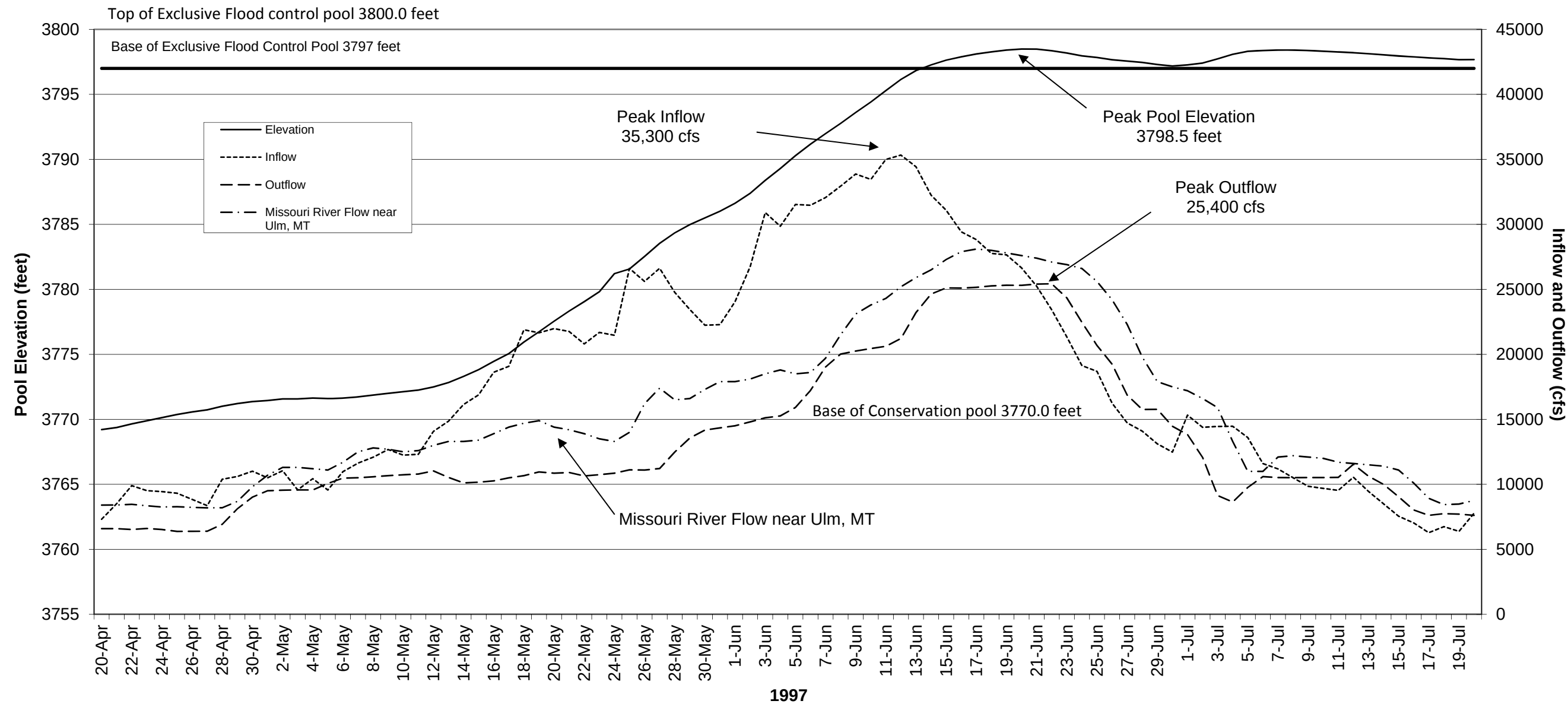
Source: USBR Hydromet Data, USGS gage data

Prepared By: AF
 Reviewed By: KB

Water Control Manual
 Canyon Ferry Dam and Reservoir, Montana

1984 Flood Routing

U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
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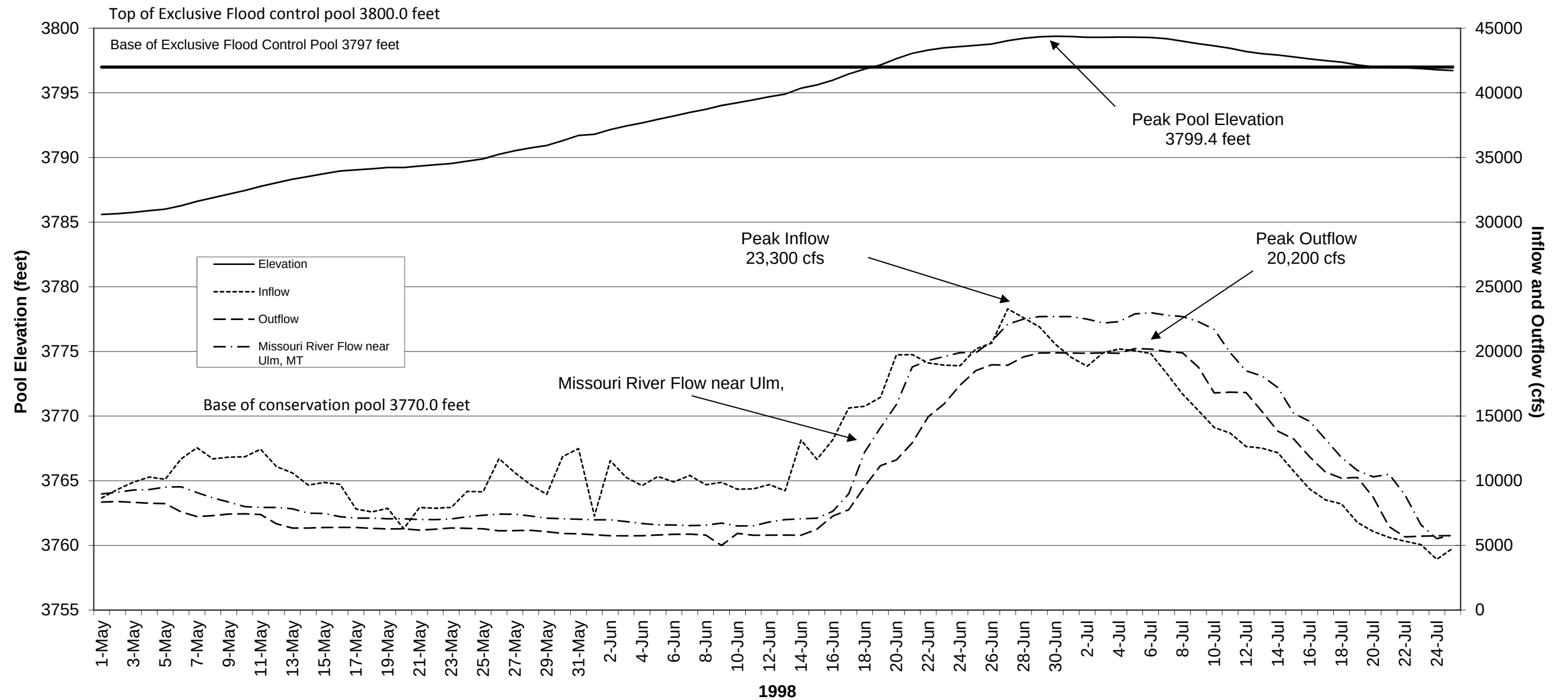
Source: USBR Hydromet Data, USGS gage data

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

1997 Flood Routing

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



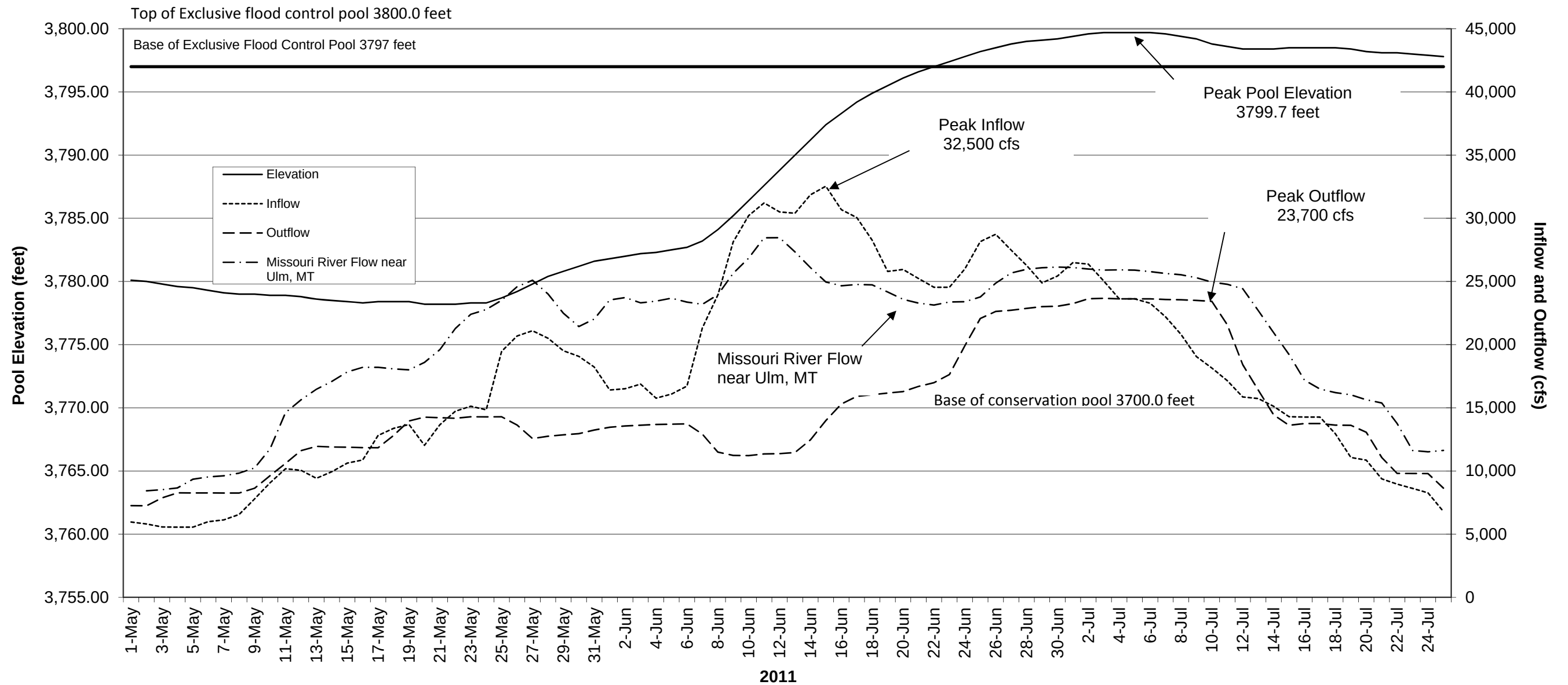
Source: USBR Hydromet Data, USGS gage data

Prepared By: AF
Reviewed By: KB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

1998 Flood Routing

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



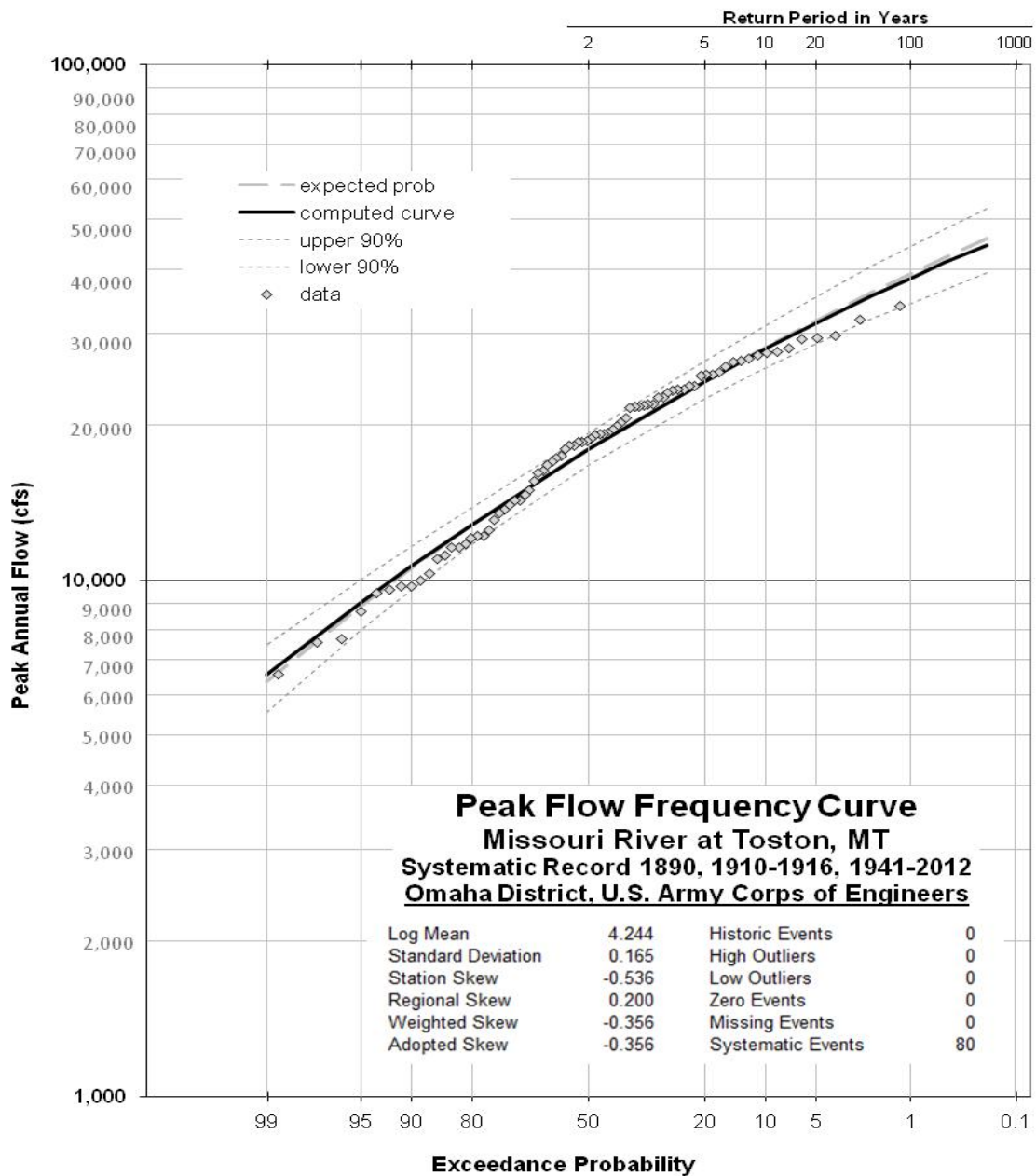
Source: USBR Hydromet Data, USGS gage data

Prepared By: AF
 Reviewed By: KB

Water Control Manual
 Canyon Ferry Dam and Reservoir, Montana

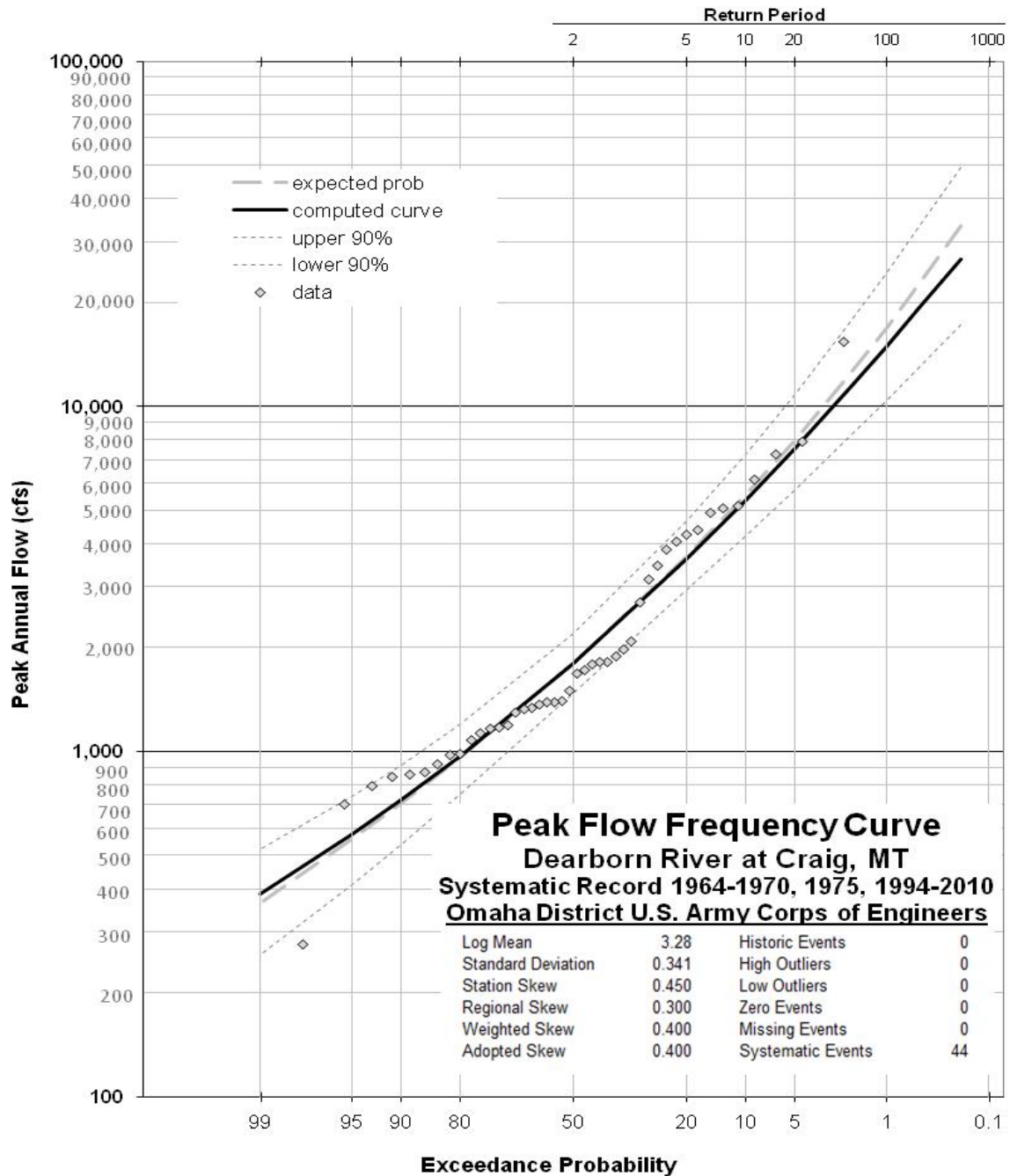
2011 Flood Routing

U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



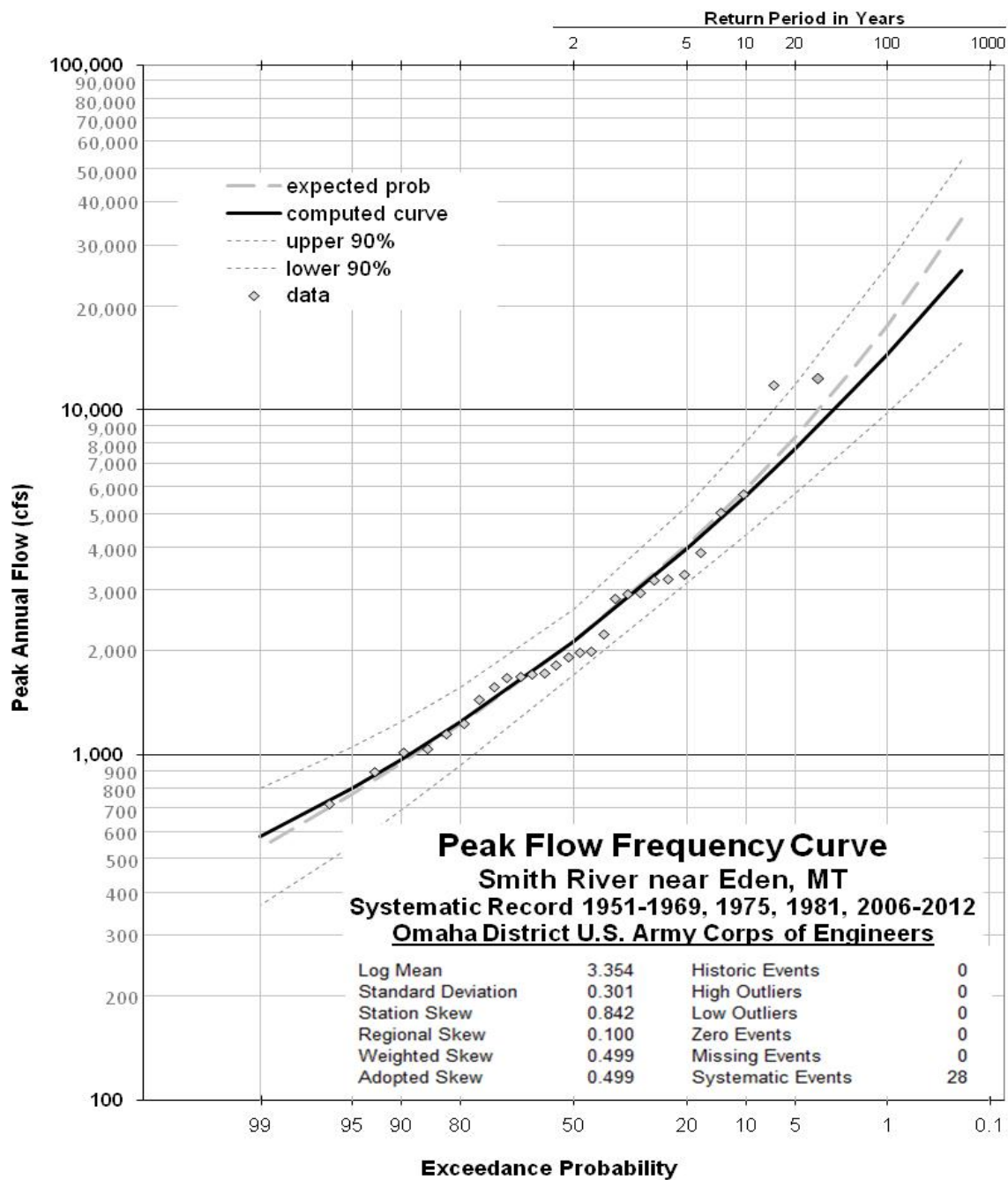
Source: 2014 Annual Peak Flow Frequencies for Four Gages near Canyon Ferry Dam, Montana. U.S. Army Corps of Engineers, Omaha District, February 2014

Water Control Manual
 Canyon Ferry Dam and Reservoir, Montana
Peak Discharge Frequency Curve
Missouri River at Toston, MT
 U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



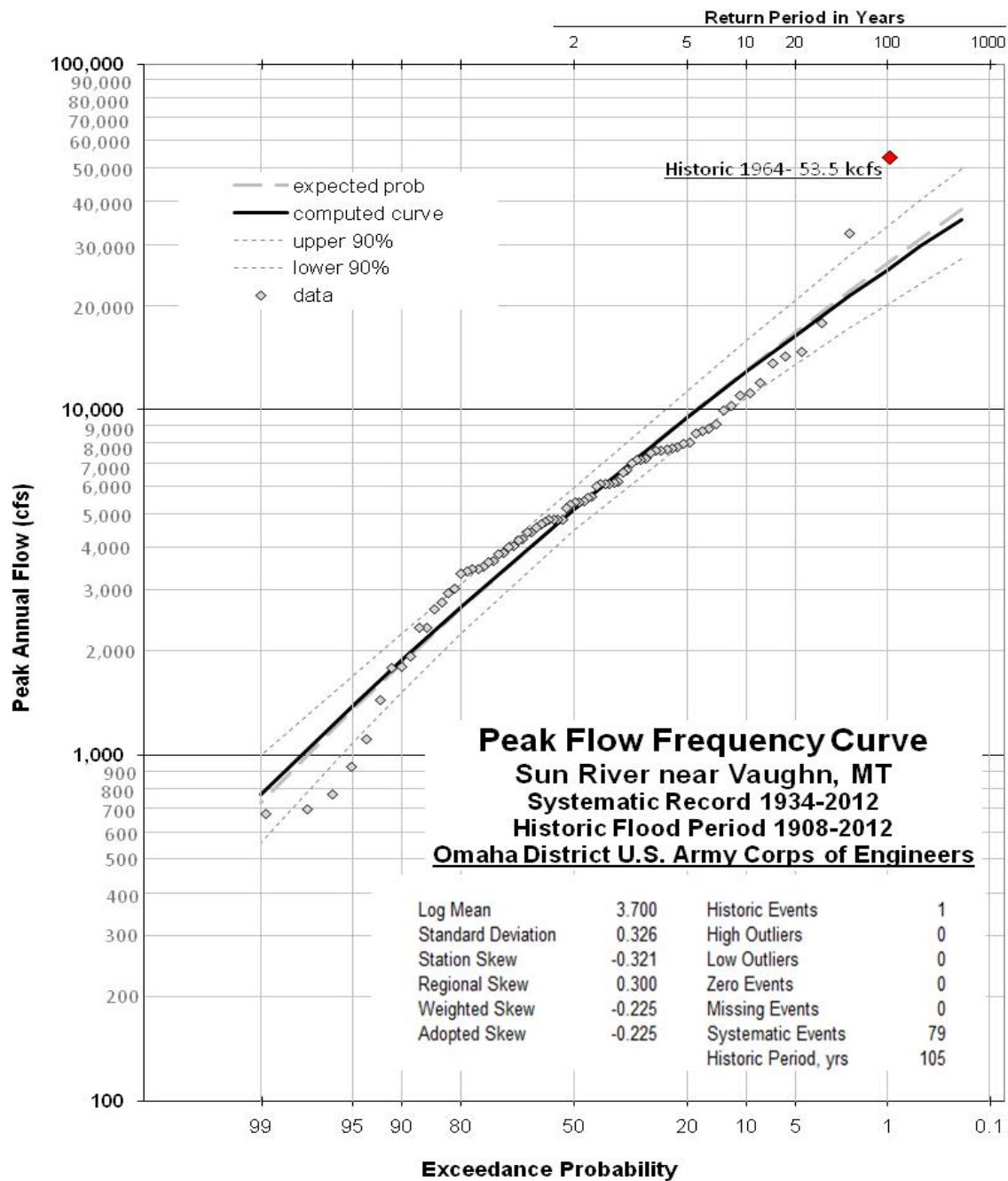
Source: Annual Peak Flow Frequencies for Four Gages near Canyon Ferry Dam, Montana. U.S. Army Corps of Engineers, Omaha District, February 2014

Water Control Manual
 Canyon Ferry Dam and Reservoir, Montana
Peak Discharge Frequency Curve
Dearborn River near Craig, MT
 U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



Source: Annual Peak Flow
 Frequencies for Four Gages near
 Canyon Ferry Dam, Montana. U.S.
 Army Corps of Engineers, Omaha

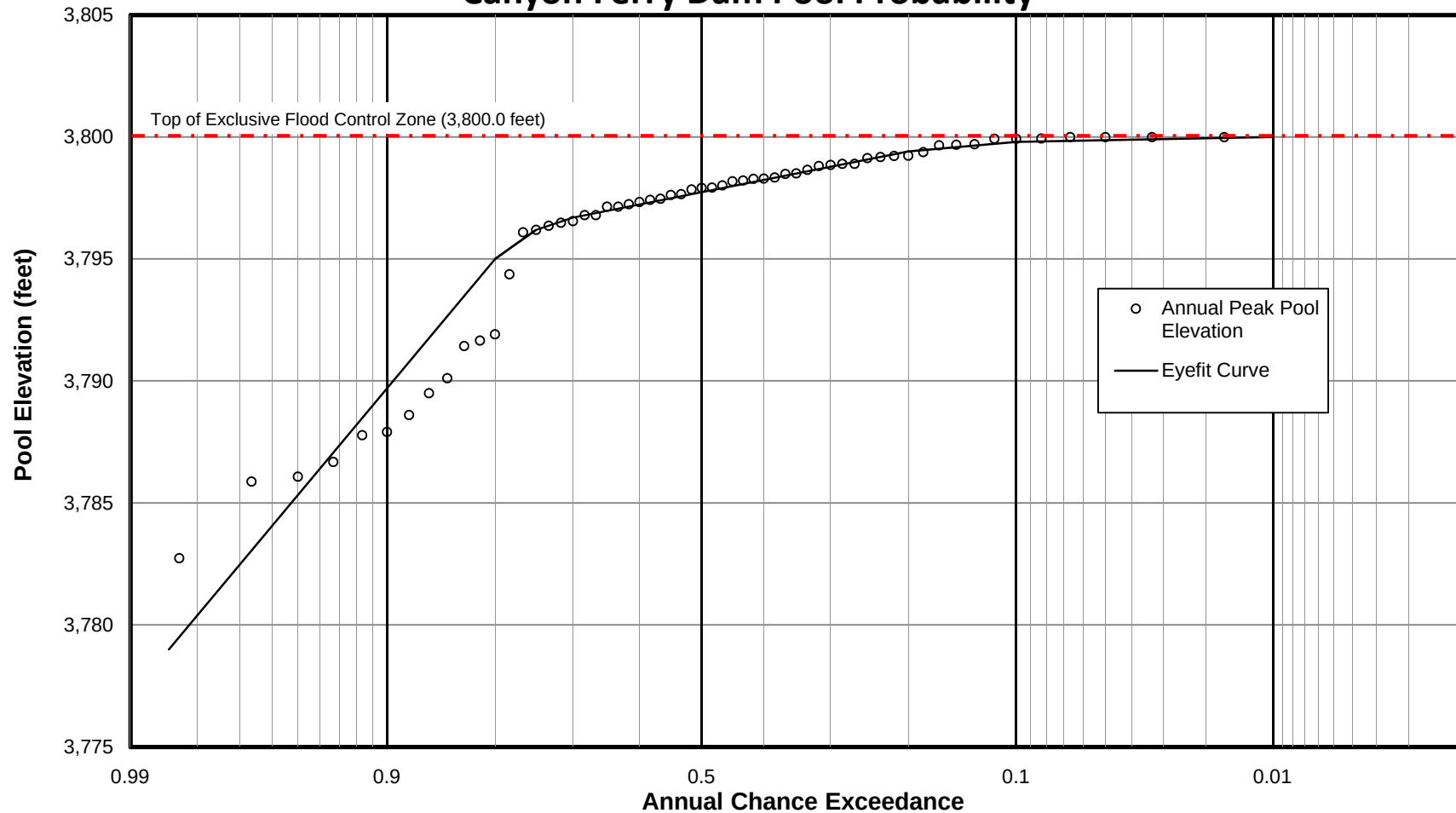
Water Control Manual
 Canyon Ferry Dam and Reservoir, Montana
Peak Discharge Frequency Curve
Smith River near Eden, MT
 U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016



Source: Annual Peak Flow
 Frequencies for Four Gages near
 Canyon Ferry Dam, Montana. U.S.
 Army Corps of Engineers, Omaha

Water Control Manual
 Canyon Ferry Dam and Reservoir, Montana
Peak Discharge Frequency Curve
Sun River near Vaughn, MT
 U. S. Army Engineer District, Omaha
 Corps of Engineers, Omaha, Nebraska
 December 2016

Canyon Ferry Dam Pool Probability



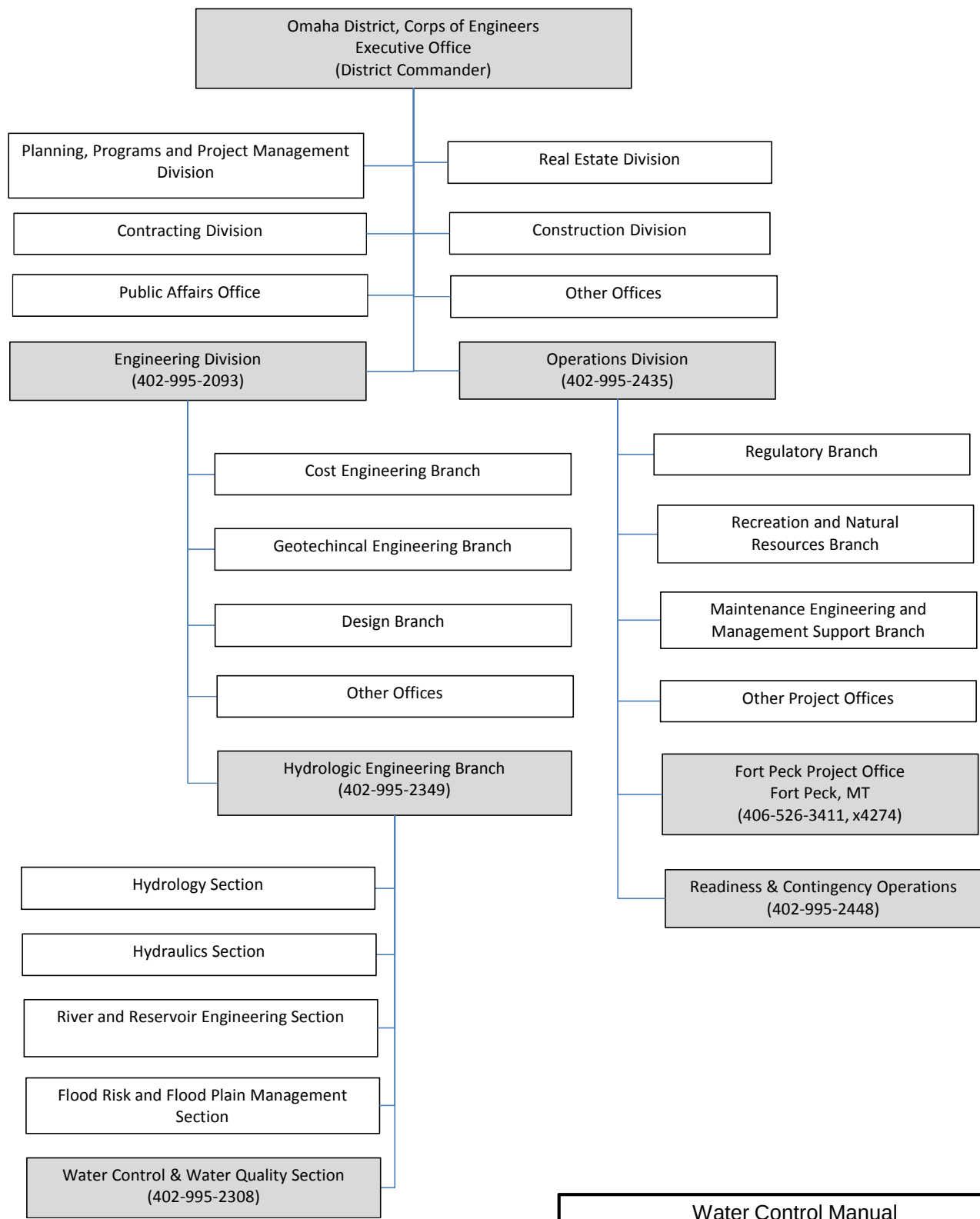
NOTE: The plot was created based only on historical peak pool levels 1954-2012. no modeling or routing was used to compute data points. The curve was plotted using the eyefit method.

Top of Dam: 3808.5 feet

Spillway Crest: 3766.0 feet

Prepared By: JAB
 Reviewed By: DJC

Water Control Manual
 Canyon Ferry Dam and Reservoir
**Pool Probability
 for Canyon Ferry Reservoir**
 U.S. Army Engineer District
 Corps of Engineers, Omaha, Nebraska
 December 2016

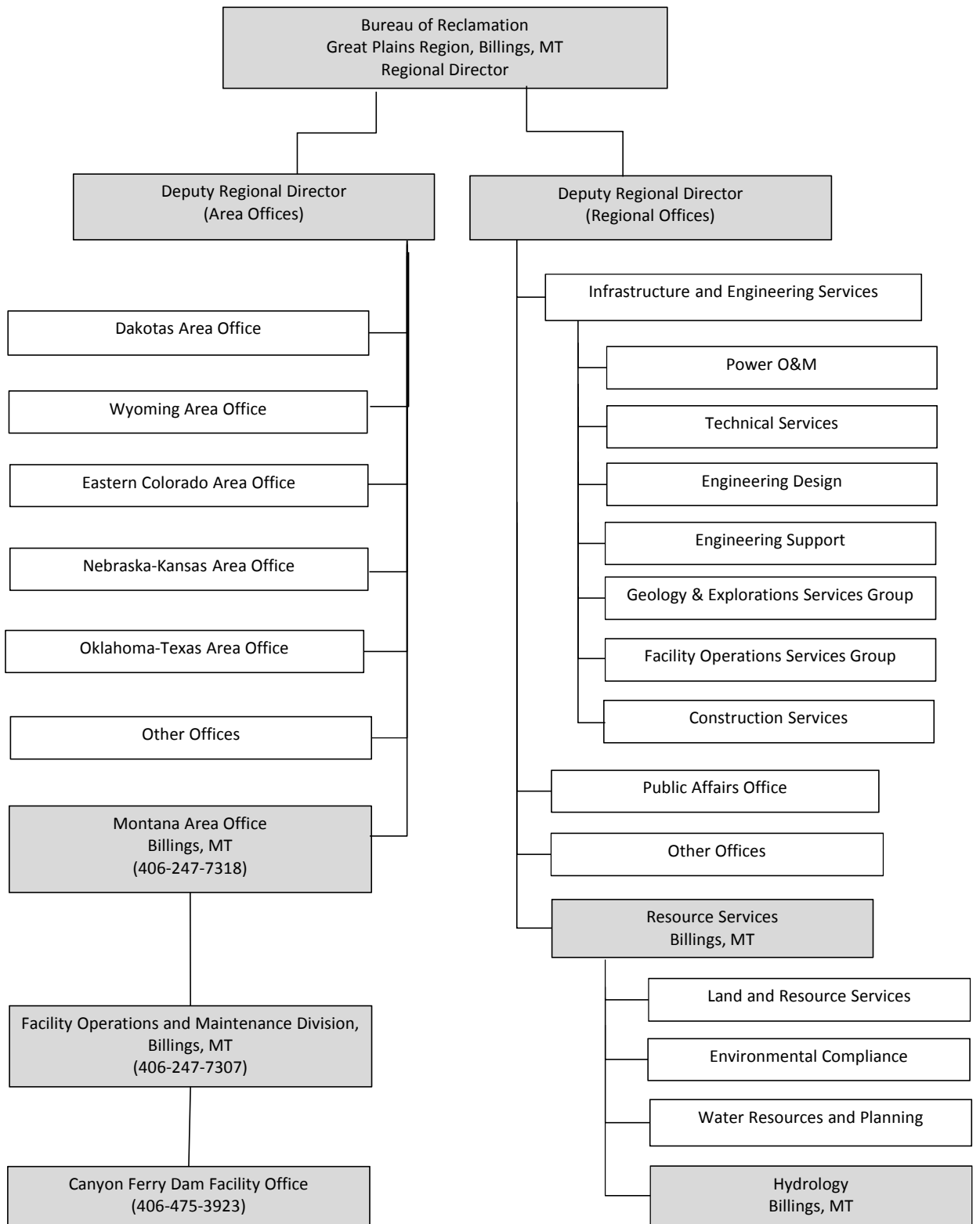


Prepared by: TET
Reviewed by: JAB

Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

**Omaha District
Corps of Engineers
Organization Chart**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016



Water Control Manual
Canyon Ferry Dam and Reservoir, Montana

**Great Plains Region
Bureau of Reclamation
Organization Chart**

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
December 2016

Prepared by: TET
Reviewed by: JAB

