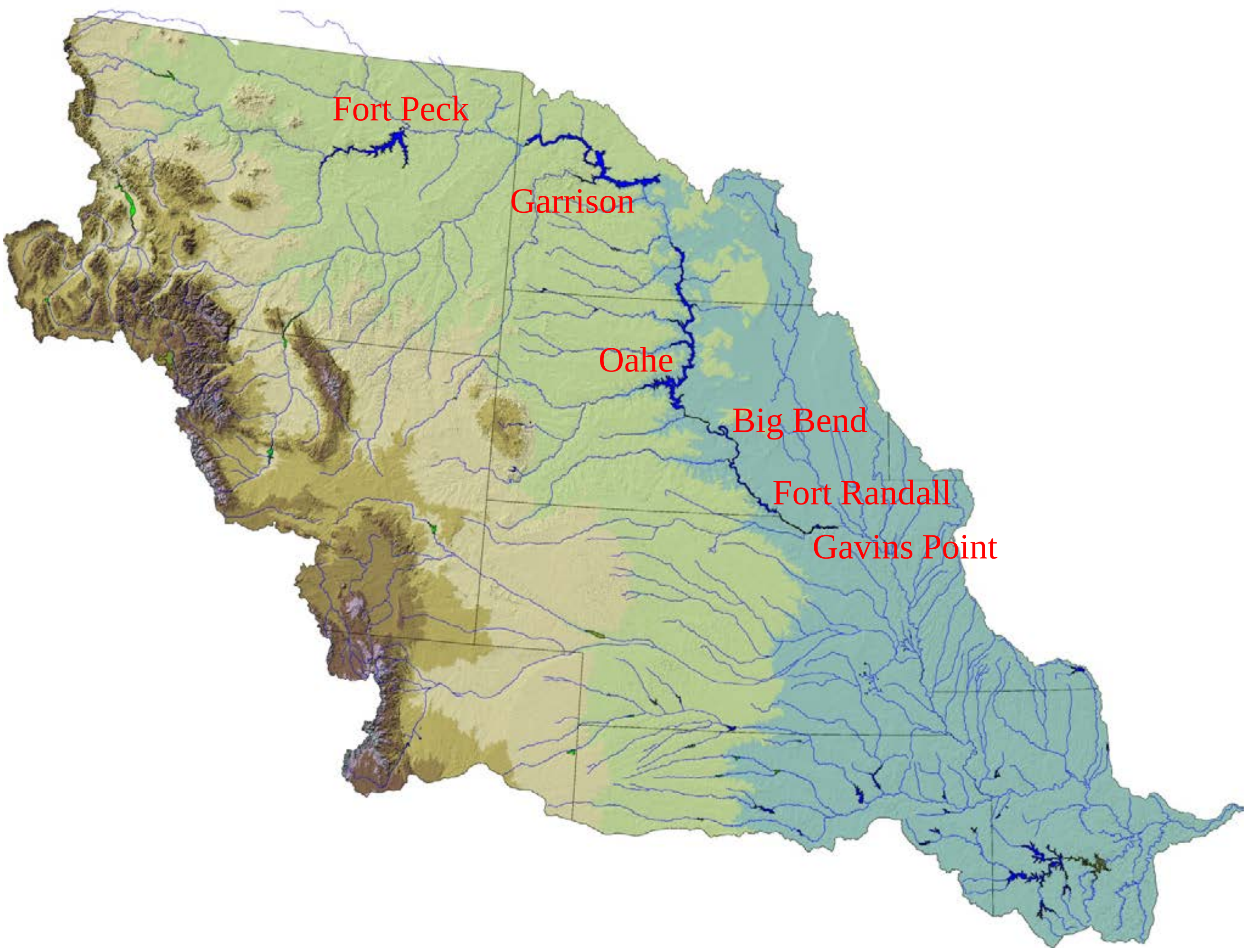
US Army Corps of Engineers ®
Northwestern Division

Missouri River Mainstem Reservoir System

Water Control Manual

Fort Peck Dam – Fort Peck Lake



Missouri River Basin Water Management Division
U.S. Army Corps of Engineers
Northwestern Division – Missouri River Basin
Omaha, Nebraska

December 2018

Missouri River Basin
Mainstem Reservoir System
Water Control Manual

In 7 Volumes   Volume 2

FORT PECK PROJECT

Volume 1	Master Manual
Volume 2	Fort Peck (Fort Peck Lake)
Volume 3	Garrison (Lake Sakakawea)
Volume 4	Oahe (Lake Oahe)
Volume 5	Big Bend (Lake Sharpe)
Volume 6	Fort Randall (Lake Francis Case)
Volume 7	Gavins Point (Lewis and Clark Lake)

Prepared by
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Corps of Engineers
Omaha, Nebraska

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FORT PECK PROJECT

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ACRONYMS AND ABBREVIATIONS

AF	-	acre-feet
AOP	-	Annual Operating Plan
BIA	-	Bureau of Indian Affairs
BLM	-	Bureau of Land Management
°C	-	degrees Celsius
cfs	-	cubic feet per second
CMR NWR	-	Charles M. Russell National Wildlife Refuge
CO-OP	-	Cooperative Streamgaging Program
Corps	-	U.S. Army Corps of Engineers
CWA	-	Clean Water Act
DCP	-	Data Collection Platform
DNRC	-	Department of Natural Resources and Conservation
DRM	-	Daily Routing Model
EM	-	Corps' Engineering Manual
ER	-	Corps' Engineering Regulation
ESA	-	Endangered Species Act
°F	-	degrees Fahrenheit
hp	-	horsepower
kAF	-	1,000 acre-feet
kcfs	-	1,000 cubic feet per second
kV	-	kilovolt
kVA	-	kilovolt-amp
kW	-	kilowatt
least tern	-	interior least tern
M&I	-	Municipal and Industrial
MAF	-	million acre-feet
Master Manual	-	Master Water Control Manual
MBRFC	-	Missouri Basin River Forecast Center
MFWP	-	State of Montana Department of Fish Wildlife and Parks
MPF	-	Maximum Probable Flood
MRBIR	-	Missouri River Basin Interagency Roundtable
MRBWM	-	Missouri River Basin Water Management
MRD	-	Missouri River Division
MRNRC	-	Missouri River Natural Resources Committee
MRR	-	Missouri River Region
MRRIC	-	Missouri River Recovery Implementation Committee
MW	-	megawatt
MWh	-	megawatt hour
NAVD88	-	National American Vertical Datum of 1988
NGVD29	-	National Geodetic Vertical Datum of 1929
NorthWestern	-	NorthWestern Energy
NPS	-	National Park Service
NRCS	-	Natural Resources Conservation Service
NWCC	-	NRCS National Water and Climate Center
NWD	-	Northwestern Division

NWDR	-	Northwestern Division Regulation
NWS	-	National Weather Service
PPCS	-	Powerplant Control System
QPE	-	Quantitative Precipitation Estimate
RCC	-	Reservoir Control Center
RM	-	River Mile (1960 mileage)
rpm	-	revolutions per minute
SDF	-	Spillway Design Flood
SNOTEL	-	SNOwpack TELemetry
Southwestern	-	Southwestern Power Administration
SPF	-	Standard Project Flood
SPP	-	Southwest Power Pool
SWE	-	snow water equivalent
System	-	Missouri River Mainstem Reservoir System
T&E	-	threatened and endangered
TMDL	-	total maximum daily load
TSI		trophic status index
USBR	-	U.S. Bureau of Reclamation
USDA	-	U.S. Department of Agriculture
USFWS	-	U.S. Fish and Wildlife Service
USGS	-	U.S. Geological Survey
WCM	-	water control manual
Western	-	Western Area Power Administration
WMS	-	Water Management System

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I - Introduction

1-01. Authorization. This manual has been prepared as directed in the U.S. Army Corps of Engineers' (Corps) Engineering Regulation, ER 1110-2-240, which prescribes the policies and procedures to be followed by the Corps in carrying out water management activities, including establishment and the updating of water control plans for Corps and non-Corps projects, as required by federal laws and directives. This manual is prepared as the water control manual (WCM) for Fort Peck, as discussed in that regulation. This WCM is also prepared in accordance with pertinent sections of the Corps' Engineering Manual, EM 1110-2-3600, and titled Management of Water Control Systems. This WCM is prepared under the general format and recommendations described in ER 1110-2-8156, dated August 31, 1995 and titled Preparation of Water Control Manuals. This Fort Peck WCM, like the Mainstem Master Water Control Manual (Master Manual) and its selected water control plan, establish guidelines intended to be used by the Corps in regulating Fort Peck. However, changed conditions or unforeseen conditions may necessitate changes or deviations from these guidelines. This is consistent with Corps' regulations that allow for both updates for changes in normal regulation as well as for deviations to the approved WCM. Revisions to this WCM are processed in accordance with ER 1110-2-240. Deviations from this WCM are processed in accordance with ER 1110-2-1400 and the Northwestern Division Regulation, NWDR 1110-2-6 titled Deviation Requests for Approved Water Control Manuals, dated November 9, 2005.

1-02. Purpose and Scope. This manual is one of the seven volumes prepared for the Missouri River Mainstem Reservoir System (System). Six of the volumes are for each of the six System projects (project name is the same as the name of the dam) and one is for total System regulation (Master Manual):

Volume	Project
1	Master Manual
2	Fort Peck – Fort Peck Dam / Fort Peck Lake
3	Garrison – Garrison Dam / Lake Sakakawea
4	Oahe – Oahe Dam / Lake Oahe
5	Big Bend – Big Bend Dam / Lake Sharpe
6	Fort Randall – Fort Randall Dam / Lake Francis Case
7	Gavins Point – Gavins Point Dam / Lewis and Clark Lake

1-02.1. This individual project WCM serves as a supplement to the Master Manual (Volume 1) and presents aspects of project regulation not common to the System as a whole. This includes detail on the incremental drainage areas regarding hydrology, hydrologic networks, forecasting, streamflow and runoff. This WCM also includes site-specific maps and regulation considerations. This individual project WCM, like the Master Manual, serves as a guide to the Missouri River Basin Water Management (MRBWM) Division in meeting the operational objectives of the System when regulating the six System reservoirs. Since Fort Peck is part of the System, any discussions regarding the regulation of Fort Peck that conflict with statements presented in the Master Manual will be secondary and conducted to the extent possible only after regulation of the System as a whole is accomplished.

1-03. Related Manuals and Reports. The System projects were constructed by the Corps for the purpose of flood control, navigation, recreation, water supply, water quality control, fish and wildlife, hydropower and irrigation. To achieve the multi-purpose benefits for which the System was authorized and constructed, it must be regulated as a hydraulically and electrically integrated system. Therefore, the Master Manual presents the basic System operational objectives and the plans for their optimum fulfillment, with supporting basic data. The Fort Peck WCM supplements the Master Manual by discussing the factors pertinent to the regulation of Fort Peck. The regulation of major tributary reservoirs located within the Missouri River basin affecting the regulation of Fort Peck is detailed in separate WCMs prepared for the individual tributary projects.

1-03.1. In an effort to reduce redundancy, frequent reference will be made in this WCM to information contained in the Master Manual. This is particularly true with respect to details concerning organization, coordination with other projects and agencies, and other factors that are pertinent to regulation of the System as a whole. This WCM presents further information and expands or emphasizes details that are of particular importance to Fort Peck and serves as a supplement to the Master Manual.

1-04. Project Owner. Fort Peck was constructed and is owned by the Corps of Engineers, Department of the Army.

1-05. Operating Agency. The Corps operates the System, which includes Fort Peck. The Corps' Northwestern Division's (NWD) MRBWM office, formerly known as the Reservoir Control Center (RCC), located in Omaha, NE, oversees the day-to-day implementation of the System Water Control Plan. The Omaha District of the NWD has staff located at Fort Peck, as well as the other System projects, to carry out the day-to-day operation (based on the reservoir regulation/power production orders received from the MRBWM office in Omaha) and maintenance of each project. All System dams have hydropower as an authorized purpose and are automated into a system called the Powerplant Control System (PPCS) for regulation of hydropower production and project releases. The Western Area Power Administration (Western) uses the System projects as an integral part of the Midwest power grid. Reservoir regulation/power production orders, reflecting the daily and hourly hydropower limits imposed on project regulation, are generated by the MRBWM office and sent to each mainstem project on a daily basis, or more frequently, as required. Also during critical periods, coordination between project personnel and the MRBWM staff is conducted on an as-needed basis to ensure that expected release rates are achieved.

1-06. Regulating Agencies. As the Fort Peck owner, the Corps has the direct responsibility of regulating the project, as well as the other five System projects, to meet the authorized project purposes. This is accomplished in coordination with many others, including federal, state, and Tribal agencies and a myriad of stakeholders. As these other entities provide input to the Corps regarding the System regulation through the Annual Operating Plan (AOP) process, the Corps must determine if the proposal is within the Corps' authority and has met all applicable laws and regulations regarding System regulation prior to incorporating any of this input into the AOP or day-to-day regulation. As part of its regulation of the System, the MRBWM office conducts day-to-day coordination with Western, which markets the power produced at each project, and frequent coordination with the U.S. Fish and Wildlife Service (USFWS), which advises the Corps on the effects of System regulation related to fish and wildlife, including threatened and endangered (T&E) species. Coordination with the other previously mentioned specific interest groups is conducted on an as-needed basis, following initiation by either the Corps or the stakeholder.

1-07. Vertical Datum. The System projects were designed and constructed to a local project datum while recent hydrologic updates such as elevation-area and elevation-capacity curves and rating curve datums are in National Geodetic Vertical Datum of 1929 (NGVD29).

1-07.1. Corps regulation, ER 1110-2-8160, dated March 1, 2009 and titled Policies for Referencing Project Elevation Grades to Nationwide Vertical Datums, specifies that a long-term effort should be programmed to transition from a legacy reference datum to the National Spatial Reference System (NSRS) which is currently the National American Vertical Datum of 1988 (NAVD88). However, conversion from local datum/NGVD29 to NAVD88 has not been conducted on the System projects at this time. See Table I-1 for adjustments for the three datums for Fort Peck. These are provided for reference only and should not be used for construction or other purposes.

Table I-1
Fort Peck Datums (in feet)

Local project datum	NGVD29	NAVD88
0.0	-0.25	+1.82
(ex.) 2234.0	2233.75	2235.82

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II - Legislative and Project Construction History

2-01. Project Authorization. The need for flood control projects along the Missouri River and its tributaries was long recognized. Comprehensive development was proposed by the Corps in House Document No. 238 (73rd Congress, 2nd Session, 1934). The report proposed construction of reservoirs on both the main stem of the Missouri River and on tributary streams in the Missouri River basin together with levees along the lower Missouri River as a flood control measure. The beneficial influence of the reservoirs on Missouri and Mississippi River navigation was also recognized. House Document No. 238 recommended the construction of Fort Peck primarily for navigation and future power generation.

2-01.1. In an Executive Order dated October 14, 1933, the President of the United States approved the construction of Fort Peck as part of the public works program to provide employment and to stimulate economic recovery from the depression of the 1930s. Fort Peck was authorized by the River and Harbor Act, approved August 30, 1935 (Public Law 409, 74th Congress) for navigation with secondary purposes of flood control, hydroelectric power and irrigation.

2-01.2. Construction of the hydroelectric powerplant was authorized by the River and Harbor Act approved May 18, 1938 (Public Law 527, 75th Congress, 3rd Session). Under the provisions of this Act the Corps was authorized to construct and operate the powerplant and the U.S. Bureau of Reclamation (USBR) was authorized to distribute and sell electrical power not required for the operation of the project.

2-01.3. The 1944 Flood Control Act (Public Law 534, 78th Congress, 2nd Session) modified the original authorizations to provide for the operation of the project as a multiple-purpose reservoir, and as an integral unit of the mainstem System, for flood control, navigation, irrigation, power, water supply, water quality control, recreation and fish and wildlife. The 1944 Flood Control Act also authorized construction, maintenance and operation of recreational facilities for public use in the reservoir area.

2-02. Project Development. The preliminary investigations, studies and design of Fort Peck were accomplished by the Kansas City District under the supervision of the Missouri River Division (MRD) and the Chief of Engineers. The major portion of the construction of Fort Peck was supervised by the Fort Peck District, which was organized at the inception of construction of the project. On July 1, 1956 the Fort Peck District was abolished and the office became an Area Office under the Garrison District. On April 1, l960, the Garrison District was reduced to an Area Office under the Omaha District and the Fort Peck District became a project office under the Garrison Area Office. The Fort Peck Project Office was established under the Omaha District on July 1, 1961 and maintains this status at the present time. Construction of the project was initiated in 1933, closure of the dam was made in 1937, and the project was placed in operation for navigation and flood control in 1938. In 1943, the first unit of the power installation was placed on line. With the completion of the second powerplant in 1961, the project had five units with a total capacity of 165,000 kilowatts (kW). Since 1954 Fort Peck has been operating as an integral unit of the System.

2-03. Construction History. Principal construction features of Fort Peck consisted of preliminary construction, the diversion tunnels and outlet works, the spillway, the earthfill dams, the first powerplant and switchyard, and the second powerplant and switchyard. Plate II-1 presents a summary of the significant dates of the System dams' construction, diversion, closure, filling of the minimum operating pool, and initial generation of the first and last units.

2-03.1. Embankment Construction. Construction of Fort Peck was started on October 23, 1933 when initial clearing operations began just nine days after the Executive Order was signed by the President. Excavation for construction of the base of the dam occurred during the summer and fall of 1934. In December 1935, construction of a cutoff wall of steel sheet piling within the limits of the core of the dam was completed. Topping out by rolled-fill methods and completing the upstream slope protection was accomplished in 1940. By 1946 settlement of the dam had decreased to such a rate that the final topping out to a new design elevation of 2280.5 feet was accomplished and a paved road constructed across the dam. The paved roadway and lighting across the top of the dam was completed in 1948.

2-03.2. Spillway Construction. Initial spillway channel excavation was started on October 20, 1934. By December 5, 1935 all excavation was complete except for the protective cover of shale, which could not be removed until just prior to placing concrete. Initial concrete was placed on the spillway approach slab in July 1935. Work also started on the pile holes and cutoff trench under the gate structure in late 1935. During 1936 the spillway approach slab and the training walls were completed; the approach channel sidewall lining and the channel floor slab were essentially completed; and concrete placement commenced on all gate piers. Excavation for the cutoff structure at the downstream end of the paved discharge channel was started and one concrete monolith was placed during 1936. Spillway channel sidewall lining was started late in the 1936 construction season. During 1937 the spillway gate structures, including completion of gate piers, highway bridge, service bridge, bridge abutments, roadway retaining walls, installation of spillway gates and machinery, spillway sidewall channel lining to the cutoff structure, and cutoff structure trench excavation, were completed and concrete was placed in the trenches and floor slab of the cutoff structure and the first lift of the channel sidewalls above the cutoff structure. The channel sidewalls at the cutoff structure were completed, roads paved, structural steel painted, construction buildings removed, area cleaned up and the spillway gate structure accepted as complete on September 7, 1938 and the spillway channel accepted as complete on September 1, 1938.

2-03.3. Diversion Tunnels, Main Control Gates and Shafts and Emergency Control Gates and Shafts Construction. Work commenced under contract for the completion of the diversion tunnels, the excavation of the emergency gate shafts and the excavation of the main control shafts in May 1934. That work was completed in March 1941.

2-03.4. Powerplant Construction. For Powerplant No. 1, work began in May 1942. The Unit No. 1 generator was placed in service in July 1943. The remaining work was delayed, then resumed in 1946. For Unit Nos. 1 and 2 in Powerplant No. 1, work was completed in 1949. For the third unit, Unit No. 3, construction began in March 1950 and was completed in late 1951.

Construction on Powerplant No. 2, which houses Unit Nos. 4 and 5, began in 1957 and was completed in June 1961.

2-04. Relocations. No major relocations of roadways or structures were needed during the construction of Fort Peck.

2-05. Real Estate Acquisition. The land acquired for the construction of Fort Peck includes a total of 590,084.29 acres, which was acquired prior to January 1, 1943. The total land acquired is summarized in Table II-1. Land within the reservoir was acquired to elevation 2250.0 feet from Fort Peck Dam to River Mile (RM) 1863 which is approximately 3 miles below the mouth of the Musselshell River. Land was acquired to elevation 2270.0 feet above RM 1863 due to the flatness of the terrain within the area and the effect of high backwater from flooding which may be caused by ice jams on the Musselshell and Missouri Rivers where these streams flow into the reservoir.

Table II-1
Real Estate Acquisition for the Construction of Fort Peck

Acres	Type of Real Estate Acquisition
167,704.62	Fee
422,068.97	Transferred from U.S. Department of Interior (public domain)
310.70	Easement
590,084.29	**Total**

2-06. Regulation History, 1937-1951. Impoundment of water in the Fort Peck reservoir began late in 1937 and the reservoir was regulated primarily for navigation during the initial years of the project operation. By the summer of 1947, filling of the reservoir's large Carryover Multiple Use Zone was accomplished. During this early period when Fort Peck was the only mainstem reservoir, floods and excess flows during each year's high water season were stored and the impounded water later released for navigation on the lower reaches of the Missouri River, for generation of hydroelectric power and for other incidental purposes. A drawdown to elevation 2225.0 feet by early November of each year was required to ensure adequate storage capacity for the control of floods, which might occur during the ensuing year. Release requirements were for a minimum flow of 30,000 cubic feet per second (cfs) at Sioux City, IA for navigation during the open water season and an average minimum release of about 3,000 cfs at the dam subsequent to the installation of the second hydroelectric power unit in June 1948.

2-07. Regulation History, 1952 to Present. Since 1952 regulation of the mainstem reservoirs on the Missouri River has broadened from a single reservoir to a six-reservoir System. Initial filling of Fort Randall, the second mainstem project constructed, was started during 1953 in coordinated operation with Fort Peck.

2-07.1. Record-keeping of pool elevation of the Fort Peck reservoir began with closure in June 1937. The pool elevation has risen into the Exclusive Flood Control Zone, elevation 2246.0 to 2250.0 feet, in 1969, 1970, 1975, 1976, 1978, 1979, 1996, 1997, 2011 and 2018. In 2011, the pool reached a record elevation of 2252.3 feet, surcharging 2.3 feet above the top of the

Exclusive Flood Control Zone. The previous record elevation was 2251.6 feet, set in 1975. Further information concerning historical regulation is contained in Appendix A of this WCM. Detailed descriptions of each year's project regulation are detailed in the AOPs and yearly Summary of Actual Regulation Reports published by the MRBWM office each year. Historical observed inflows, releases and elevations are illustrated in Plates A-1 through A-8. Description of the major floods occurring in the drainage area above Fort Peck during this period are contained in Appendix A of this WCM.

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III - Basin Description and Characteristics

3-01. General Characteristics. The portion of the Missouri River basin discussed in this WCM is primarily the drainage basin above Fort Peck. There is some discussion regarding the Milk River basin, since the Milk River enters the Missouri River about ten miles downstream of Fort Peck. There is also some discussion regarding the incremental drainage area between Fort Peck and the mouth of the Yellowstone River. The Yellowstone River and Milk River basins are major contributors of inflow to the Garrison reservoir and thus are described in detail in the Garrison WCM. The Missouri River drainage area above the mouth of the Yellowstone River totals 92,520 square miles of which 82,750 square miles lie within the United States and 9,770 square miles lie within Canada. The western boundary is fanned by the Continental Divide; the southern and eastern boundaries are formed by the northerly divide of the Yellowstone River basin; and the northern boundary by the Hudson Bay divide in Canada. Over half of the state of Montana and a very small portion of the states of Wyoming and North Dakota lie within this area. An area of 57,500 square miles, extending from Fort Peck Dam west to the Continental Divide, is controlled by Fort Peck. The Fort Peck drainage is bounded on the north by the Milk River and on the south by the Yellowstone River. Plates III-1 and III-2 are maps of the entire Missouri River basin and the drainage area above Fort Peck Dam, respectively.

3-02. Topography. The terrain of the upper Missouri River basin ranges from mountainous in the upper reaches on the eastern slope of the Rocky Mountains to the relatively flat or rolling Great Plains, which commence as broad Piedmont slopes and extend across the eastern two-thirds of the State of Montana. The Great Plains are broken by isolated areas of mountainous uplift such as the Bears Paw, Little Rocky, Highwood, Judith and Big Snowy Mountains. The relative levelness of the plains is further modified by streams flowing through broad valleys paralleled by terraces and high bluffs. The area to the south of the Missouri River ranges from local badlands to moderately sloping land. Elevations range from the 1847-foot streambed elevation of the Missouri River near the mouth of the Yellowstone River to mountain peaks of over 10,000 feet in the western part of the basin. Mountain drainage areas above elevation 6,000 feet in the Missouri River basin above Fort Peck total approximately 13,200 square miles.

3-02.1. Geology. The Missouri River headwaters are in an area underlain by Miocene rocks. Beneath the Miocene rocks, and exposed at higher elevations in the adjacent mountains, are rocks of various Paleozoic systems. Downstream at a point southeast of Helena, the Missouri River enters a broad area of pre-Cambrian granites and other igneous rocks. The valley has cut into these rocks to the bend of the river near Craig, MT in Lewis and Clark County. From this point eastward to the Fort Peck reservoir the Missouri River flows in a valley cut in Cretaceous rocks. These Cretaceous rocks are represented by the Colorado shale, Eagle, Claggett, Judith River and Bearpaw formations and consist of marine deposits of shale and sandstones, and some lignite and coal. Tertiary intrusions of igneous dikes and sills occur in the general area south of the Bears Paw Mountains. The Bears Paw Mountains lie approximately 20 to 25 miles north of the Missouri River valley and were formed during the Tertiary period. Deposits of Pleistocene glacial drift cover most of the upland plains area, with the exception of the area south of the Bears Paw Mountains and adjacent Little Rockies. These mountains formed a barrier which blocked the advancing ice sheets, diverting the flow of ice to the east and west sides of the mountains. Prior to glaciation in this area, the Missouri River flowed in a general northeasterly direction from Fort Benton, MT around the north side of the Bears Paw Mountains and east in the valley now occupied by the Milk River. This pre-glacial drainage of the Missouri River was blocked by the advancing ice sheet, ultimately diverting the river in an easterly direction south of the Bears Paw Mountains to its present course.

3-02.2. Soils. Due to variance of precipitation, temperature, vegetation and topography, the major soil groups change with decreasing elevation from the Podzol, Brown Podzolic and Gray Wooded soils developed under forest cover, to the Chernozem, Chestnut and Brown soils developed under grasses in the lower valleys. In the mountainous regions of the western and southwestern portions of the basin, the soil cover consists mainly of partially decomposed rock which may be residual at the site of decomposition, may be slowly moving down the slope under the influence of erosion and gravity, or may have accumulated in the valley bottoms. Many of the mountain soils are thin and poorly developed since the soil material often is eroded from the slopes and deposited in the valleys. In most of the eastern portion of the basin the soil cover has matured under the climatic regime of cold winters, warm summers and low precipitation, and vegetation consisting of grasses. Low topographic relief reduces the possibility of soil movement. This relative stability of the soil has permitted accumulation of humus from the natural grass cover of the plains, being quite similar over large areas regardless of the kind of rock from which they have developed. These soils have dark surface layers and are underlain by deposits of lime. Extensive areas of alluvial soils occur along the Missouri River and its tributaries in the upper Missouri River basin. Soils in the Milk River basin have been derived from alluvial deposits, from glacial drift and from disintegration of geological formations. Most of the arable soils of the upper Missouri River basin are inherently fertile and are suitable for continued profitable cultivation when supplied with adequate and properly distributed moisture. Soils in the stream valleys and bottoms and on the first terraces or benches are, in general, the most productive. Most of these soils are of medium texture and have good natural drainage. Areas of the Missouri River are in glacial tills, while south and east of the river many of the soils have their origin in shales and sandstones.

3-03. Land Use. Natural vegetative cover includes the dense growths of coniferous trees on the high mountain slopes of western and southwestern Montana, the thin stands and isolated patches of trees along the streams in eastern Montana, and the grazing land in the mountain and plains areas. The margin of the forests lies above elevation 6,000 feet. Natural vegetation in the low areas and prairies consists principally of grass and sagebrush except for the thin stands of timber along the streams. Irrigation is practiced where water supplies can be easily obtained from the lowest altitude to the high mountain valleys. Irrigated lands are present along the Missouri River and its other principal tributaries throughout the basin. Dryland farming is practiced in the prairies in eastern Montana. Refer to Plate III-3 for a graphical representation of land use in the Fort Peck drainage area.

3-03.1. The upper Missouri River basin is sparsely populated. The majority of the urban and rural population is located in areas bordering the major streams. The larger cities include Helena and Great Falls on the Missouri River, Bozeman on the Gallatin River and Havre on the Milk River. The upland areas and mountain regions of the basin are sparsely populated with most of the population living in small towns and villages. Agriculture is the principal industry of the basin and the majority of the population is supported directly, or indirectly, by farming or ranching. Other industries important to the basin include oil and gas production and refining, railroad and highway transportation, mining and manufacturing.

3-04. Drainage Pattern. The Missouri River is formed by the confluence of the Gallatin, Madison, and Jefferson Rivers near the town of Three Forks in southwestern Montana. Above Three Forks, the Gallatin, Madison and Jefferson Rivers spread in a fan-like manner to their sources in the principal and secondary ranges of the Rocky Mountains. From Three Forks, the Missouri River flows northerly to the vicinity of the town of Wolf Creek and then northeasterly through the city of Great Falls, MT to the town of Virgelle, MT. From Virgelle, the Missouri River flows in an easterly direction through Fort Peck Reservoir and Dam to its confluence with the Yellowstone River near Williston, ND. Most of the tributaries originate in the mountain areas. Principal tributaries above Fort Peck are shown on Plate III-2 and details are listed in Table III-1. Minor tributaries include the Dearborn River, Arrow Creek, and Belt Creek above Fort Peck, the Little Porcupine Creek and Wolf Creek between Fort Peck and the mouth of the Yellowstone River, and numerous smaller streams.

Table III-1
Principal Missouri River Tributaries above the Mouth of the Yellowstone River

Stream	Bank of Missouri River	1960 Missouri River Mileage at Mouth	Drainage Area (sq. miles)	Total Fall (feet)	Length (miles)	Average Slope (feet/mile)
Jefferson River	--	2316.40	9,710	4,400	245	18.0
Madison River	--	2316.40	2,570	4,400	164	27.0
Gallatin River	--	2315.14	1,820	4,800	100	48.0
Smith River	Right	2146.40	2,020	4,200	126	33.3
Sun River	Left	2120.79	2,000	3,900	123	31.7
Marias River	Left	2051.18	9,180[1]	4,150	261	15.9
Teton River	--	(2)	1,960	4,650	204	22.8
Judith River	Right	1984.25	2,780	4,600	130	35.4
Musselshell River	Right	1867.34	9,570	5,250	281	18.7
Milk River[3]	Left	1761.50	23,159	4,780	705	6.8
Redwater Creek[3]	Right	1681.31	2,140	740	115	6.4
Poplar River[3]	Left	1878.56	3,340	940	126	7.5
Big Muddy Creek[3]	Left	1630.36	2,590	860	106	8.1
(1) Includes drainage area of the Teton River.						
(2) Teton River is a major tributary to the Marias River.						
(3) Enter below Fort Peck.						

3-04.1. The Milk River, with a drainage area of about 23,200 square miles, is the only major tributary that materially affects the flow of the Missouri River between Fort Peck and the mouth of the Yellowstone River. The headwaters of the Milk River rise in Glacier County, Montana on the eastern slope of the Rocky Mountains at an elevation of about 7,000 feet. The Milk River enters the Missouri River about 10 miles below Fort Peck Dam. Numerous small lakes, both natural and artificial, which tend to decrease the runoff from storms, are found in the basin.

3-05. Stream Slopes. The total fall of the Missouri River from its headwaters at the confluence of the Jefferson, Madison and Gallatin Rivers to Fort Peck Dam is approximately 2,000 feet and averages 3.7 feet per mile. Slopes range from 4.8 feet per mile for the reach from Three Forks (head of the river) to Cascade, MT, 0.5 foot per mile for the reach from Cascade to above the falls at Great Falls, 40 feet per mile from above the falls through five reservoirs to below the falls at Morony Dam, 5.7 feet per mile from Morony Dam to Fort Benton, to 2.2 feet per mile from Fort Benton to the headwaters of the Fort Peck reservoir. The total fall of the Missouri River between Fort Peck Dam and the mouth of the Yellowstone River is approximately 183 feet and averages 0.9 foot per mile. The length of the Milk River from the confluence of the North Fork and South Fork and its mouth is approximately 625 miles, and it has an average slope of about 2.6 feet per mile. The North Fork and South Fork of the Milk River have an average slope of about 21 feet per mile and 26 feet per mile, respectively. The total fall and average slope of the principal tributaries of the Missouri River in the Fort Peck drainage basin are shown in Table III-1. Profiles of the Missouri River and its principal tributaries in the upper Missouri River basin are included in the previous Fort Peck WCM and were not updated or included in this WCM.

3-06. Climate. The climate of the upper Missouri River drainage basin varies from semi-arid in the eastern portion and the lower elevations in the central portion to sub-humid in the mountainous areas along the Continental Divide. The climate of the upper basin is influenced by the barrier effect of the mountain range in the west and southwest, the differences in elevations, the interior location on the North American continent, the latitude, and the movement of air masses and storms. These factors result in large variations in annual and daily temperatures and relatively low amounts of precipitation within the upper basin.

3-06.1. Annual Precipitation. Principal moisture-bearing air masses approach the upper Missouri River drainage basin from the Pacific Coast; however, a large portion of their moisture is lost as precipitation in crossing the more western mountain ranges of the continent. As the air masses cross the main range of the Northern Rockies, it results in further uplift of the air masses and precipitation over the western part of Montana. These losses, together with the warming and drying of the air during its descent over the eastern slope of the mountains, largely account for the small amount of precipitation in the lower elevation areas of the upper basin. In the mountainous regions of the basin the amount of precipitation tends to increase with elevation. Average annual precipitation varies widely throughout the upper basin, from less than 12 inches in northeastern Montana and other areas of lower elevations to over 30 inches along the Continental Divide. The average precipitation over the entire drainage area above Fort Peck is about 14 inches. Total average annual precipitation for the Missouri River basin is shown on Plate III-4. Monthly precipitation patterns are presented in the Master Manual (Plates III-4 through III-15).

3-06.2. Seasonal Precipitation. In the drainage area above Fort Peck approximately 70 percent of the yearly total precipitation occurs during the months of April through September. Most spring and summer rainfall occurs in the form of showers or thundershowers; however, steady rains may occasionally occur. Excessive rainfall is unusual. May and June are normally the wettest months of the year. Winter precipitation generally is very light and almost invariably falls as snow. Measurable precipitation normally occurs on about 90 days per year over the drainage area above Fort Peck.

3-06.3. Snow. The snow season in the upper basin generally extends from late October through April; however, snowfall may be expected during any month of the year in the higher elevations of the mountainous regions of the upper basin. The average annual snowfall over the upper basin varies from 20 inches in the plains area of eastern Montana to an excess of 100 inches at some high elevation stations. Nearly all stations have recorded heavy snowstorms with a foot or more of snowfall in one day. Blizzard conditions occur less frequently in the western sheltered valleys than over the exposed plains to the east. With the exception of the eastern portion of the drainage area, snow cover over the plains area and lower valleys is rarely continuous through the winter due to drifting caused by high winds and melting caused by the warming effect of downslope "Chinook" winds. Mean annual snowfall and maximum annual snowfall for the Missouri River basin are shown on Plates III-5 and III-6, respectively.

3-06.4. Temperature. Extreme seasonal temperatures are experienced in the upper basin with long, cold winters and relatively short, hot summers. Maximum temperatures in excess of 100 degrees Fahrenheit (°F) have been reported at most of the meteorological stations in the drainage area above Fort Peck while winter temperatures as low as -20°F are quite common. The warmest months of the year are July and August with average temperatures generally in the upper 60s (°F). The coldest month in the year is January with the average temperature usually in the upper teens (°F). The mountains give the western portion of the upper basin some protection from cold waves which sweep out of the interior of Canada on an average of six to twelve times a winter resulting in snow and periods of subzero temperatures. A few of the cold waves, at times, cover the entire upper basin. Often, the cold waves are modified by the downslope Chinook winds resulting in the adiabatic heating of the east flow of air as it descends to lower elevations in crossing the mountains. This results in an abrupt ending of the intense cold followed by extended periods of mild weather. The so-called “Chinook Belt” extends from the Browning-Shelby area to the Yellowstone River Valley above Billings, MT. The transition from winter to summer is usually fairly mild; however, cold weather may extend into May. During the summer the days are normally warm with cool nights and low humidity. The autumns are normally mild with occasional short periods of cold temperatures. Average annual minimum temperatures and average annual maximum temperatures for the Missouri River basin are shown on Plates III-7 and III-8, respectively. Temperature extremes are shown in the Master Manual on Plates III-22 and III-23.

3-06.5. Evaporation. The Fort Peck reservoir is located in a region characterized by moderate-to-strong winds, low humidity, light precipitation and hot summers. For these reasons substantial evaporation occurs from the Fort Peck reservoir, particularly during the summer months. Low temperatures and higher humidity during the cold winter months, along with ice cover on the reservoirs, result in greatly reduced evaporation during this season.

3-06.5.1. Annual evaporation from the surface of the Fort Peck reservoir is normally slightly more than 3 feet (38.5 inches per the MRD-RCC Technical Report JE-73, *Missouri River Mainstem System Reservoir Evaporation Estimates*). This evaporation loss equates to approximately 666,000 acre-feet (AF) of volume, depending on reservoir elevation (see Plates III-9 through III-12). Due to seasonal precipitation patterns, seasonal patterns of gross evaporation depths and the lag in normal reservoir surface temperatures from corresponding air temperatures, essentially all of the annual net evaporation from the Fort Peck reservoir can be expected to occur during the 6-month period from July through December.

3-06.6. Frost Penetration. Frost penetration in the upper Missouri River basin normally begins in November with the incidence of below-freezing mean temperature. The ground remains frozen until March or April. Depth of maximum frost penetration varies from 6 to 8 feet throughout most of the drainage basin above the mouth of the Yellowstone River except in the extreme northwest portion near the Canadian border where depths of 10 feet have been experienced. The major factors which influence the depths of the frost layer are snow cover, vegetation and temperature.

3-06.7. Storm Potentialities. Major storms throughout the basin result almost exclusively from conditions accompanying frontal systems. Winter storms in the upper part of the basin often result in sufficient accumulation of snow to cause the greatest flows of the year at the time the accumulation of snow melts and appears as streamflow. Since frontal passages are more numerous in May and June, major storms occur more frequently in the spring and early summer than in late summer. A sequence of minor storms that exceed infiltration capacity in the basin may also result in severe flooding due to the additional moisture from the later storms and contribute much larger volumes to the streamflow than if the soil was relatively dry prior to the later storms.

3-07. Streamflow Records. Records of runoff at streamgaging stations on the Missouri River and its tributaries in the drainage basin above Fort Peck are recent in origin with the exception of a few stations. The longest continuous period of record in the basin is at Fort Benton where reliable records date back to October 1890. A few of the tributary stations have records starting around 1890 but there are long periods of time when no records are available. The streamgaging stations that are pertinent to the regulation of Fort Peck are Ulm, Virgelle and Landusky on the Missouri River above the reservoir and Wolf Point and Culbertson on the Missouri River below the dam; Saco and Nashua on the Milk River below the dam; and Roundup and Mosby on the Musselshell River above the reservoir. Daily discharges at these locations are published in appropriate U.S. Geological Survey (USGS) streamflow records. As discussed in the Master Manual, planning of the System made it desirable to extend Missouri River streamflow records to the extent practicable. Daily records are available for the majority of streamgaging stations for the six System dams since their respective dates of closure, and daily flow data is available for the majority of streamgaging stations since 1930. Prior to 1930, there is a general lack of daily records in the basin. Representative daily data was constructed to cover the period from 1898 to 1929 because of the significance and statistical importance of the drought of the 1930s in System regulation. Inasmuch as water use for all purposes has expanded significantly since settlement of the region began, it is necessary to adjust System incremental inflow records to a common level of water resource development in order that flow data are directly comparable from year to year. The total flows originating above Fort Peck have been adjusted to the 1949 level of water resource development, with such adjustment being a continuing process as further data are accumulated. While any development level would have been satisfactory, the 1949 level, prior to recent accelerated resource development, was selected. As part of the 2004/2006 Master Manual revision, a continuous record of daily data was developed for the entire Missouri River basin for the time period of 1898-1997. A detailed explanation of the daily flow record and the modeling efforts is found in Section 6-04.1.6 of the 2004/2006 Master Manual. As part of ongoing studies, this continuous record of daily data is expanded as additional years become available. More information on this expanded dataset is found in Section 6-13 of the Master Manual.

3-08. Runoff Characteristics. The mountainous area in the western portion of the basin will normally contribute the greatest share of the total water year runoff into Fort Peck with the largest volume occurring during the "late spring" or "June rise" period. The plains area of the basin is occasionally a major source of runoff with large contributions occurring during the "early spring" or "March rise" period. High intensity rainstorms throughout the basin during the spring and summer months often cause localized high runoff volumes of short duration. Average annual runoff for the Missouri River and its tributaries above the mouth of the Yellowstone River are shown in Table III-2.

3-08.1. Seasonal Runoff Pattern. Since very little mountainous area drains into the Milk River, runoff appearing as streamflow in its lower reaches results largely from the melt of the winter accumulation of plains snowpack and rains during the spring and early summer period. Runoff from the Missouri River drainage basin above Fort Peck follows a characteristic seasonal hydrologic pattern:

1. Winter is characterized by frozen streams, progressive accumulation of snow in the mountain areas, and intermittent snowfall and thaws in the plains area. The season usually ends with a "spotty" snowpack of relatively low water content and a considerable amount of water in ice storage in the stream channels. Runoff during this period, which usually extends from late November into March, is very low.
2. In the plains area, early spring is marked by a rapid melting of plains snow and ice on frozen ground, usually in March or April, as temperatures rise rapidly, accompanied by very little rainfall. This causes a characteristic early spring ice break-up and increases in tributary streamflow. Ice jams are frequently experienced on tributary streams during this period. The rapid release of water from melting snow and ice jams results in a flashy "March" rise in flow. Annual maximum peak stages and flows usually occur at this time along tributary streams. Snowmelt in the mountains also usually begins in mid-April but contributes little to runoff until late spring.
3. Late spring, consisting generally of the months of May, June and early July, is characterized by the melting of snow in the mountains and sometimes accompanied by severe local rainstorms and occasional extensive general rains. The peak runoff from these conditions usually occurs in late May, June or the early part of July. This results in a characteristic "June rise" over an extended period. The largest volume of runoff into Fort Peck occurs during this period. A short interlude of moderately low discharges usually is experienced between the early spring and late spring rises.
4. Summer and autumn are generally characterized by a lack of general rainfall and frequent, widely scattered local rainstorms, and occasional severe storms. Flow in the

rivers usually decreases rapidly from the June flows, and thereafter decreases generally, with infrequent interruptions, to the low flows which prevail in winter.

3-08.2. Total unregulated Missouri River runoff originating above Fort Peck usually follows a definite and characteristic annual pattern. Plate III-13 lists the Missouri River basin monthly runoff above Fort Peck for the period from 1898 to 2014. Total monthly runoff above Fort Peck (maximum, minimum and average) for each month is shown on Plate III-14.

3-08.3. The MRBWM Technical Report *Hydrologic Statistics on Inflows*, July 2015, details the development of inflow volume probability relationships for various durations for both regulated and unregulated flows into Fort Peck. Volume probabilities are discussed in detail in Section 6-15 of this WCM. See Plates VI-19 through VI-24 of this WCM for regulated and incremental inflow volume probability relationships for various durations.

3-09. Effects on Basin-Wide Floods. Regulation provided by Fort Peck, augmented by upstream tributary reservoir storage, has greatly reduced but not eliminated flooding along the portion of the Missouri River extending from Fort Peck Dam to the mouth of the Yellowstone River. Many instances of above-bankfull flows were experienced through this reach prior to construction of the System projects and would be continuing if the projects were not in operation. All but one flood experienced in this portion of the Missouri River have occurred in the March-July season with snowmelt as an important flood component. The one exception occurred in September 1923 when a large rainstorm over portions of southern Montana and northern Wyoming resulted in an October flood on the Missouri River. Basin-wide floods are described in Appendix A of the Master Manual.

3-10. Effects of Fort Peck on Flood Inflows. Studies conducted by the MRBWM office indicate that operation of Fort Peck in conjunction with other upstream tributary projects would greatly reduce, but not eliminate, flood damages in the reach extending from Fort Peck to the mouth of the Yellowstone River if any past floods of record were to recur. Further discussion of regulation effects on flood inflows is detailed in Appendix A of this WCM.

3-11. Water Travel Time to the Fort Peck Reservoir. Travel time for the Missouri River and its tributaries in the drainage basin above Fort Peck is shown on Plate III-15. The travel time shown on Plate III-15 indicates average travel time of moderate rises at or near bankfull levels. See Plate IV-3 of the Master Manual for travel times for the entire Missouri River basin.

3-12. Water Quality. The Omaha District Water Control and Water Quality Section is responsible for the water quality monitoring of the System projects and Missouri River, including the Fort Peck reservoir and the Missouri River downstream of Fort Peck. The Omaha District conducts long-term fixed-station ambient water quality monitoring at the System reservoirs and on the lower Missouri River. Water quality conditions of the water discharged through each of the six System dams is continuously monitored. Water quality stations and sampling is detailed further in Appendix C of this WCM and Section 5-11 and Appendix C of the Master Manual. Current and detailed water quality monitoring information is available in the water quality reports on the Omaha District website.

Table III-2
Missouri River Basin – Normal Annual Runoff
above Yellowstone River

Contributing Area	Drainage Area (sq mi)	Average Annual Runoff[1]	
		1000 AF	Inches
Jefferson River			
Twin Bridges	7,616	1,298	3.2
Madison River			
McAllister	2,150	1,262	11.0
Gallatin River			
Logan	1,789	759	8.0
Missouri River			
Toston	14,641	3,652	4.7
Ulm	20,605	4,443	4.0
Sun River			
Vaughn	1,774	486	5.1
Missouri River			
Great Falls	23,881	5,286	4.2
Marias River			
Shelby	2,716	646	4.5
Missouri River			
Virgelle	34,000	5,942	3.3
Judith River			
Winifred	2,727	376	2.6
Missouri River			
Landusky	40,649	6,444	3.0
Musselshell River			
Mosby	7,784	198	0.5
Milk River			
Nashua	22,332	480	0.4
Poplar River			
Poplar	3,140	119	0.5
Missouri River[2]			
Above Fort Peck Dam	57,500	7,231	2.36

[1]Based on available record at each location.
[2]Missouri River runoff at the 1949 depletion level of water resource development.

3-13. Sediment. The sediment contributing to the delta formations within the Fort Peck reservoir are derived from two general sources: 1) the alluvial material forming the banks and bed of the Missouri River and its tributaries within their entrenched valleys, and 2) sheet erosion of the weathered surface of the uplands terrain. In general, the sediment flow is limited to the drainage area downstream from Cascade, MT since several small powerplant reservoirs located upstream of Cascade entrap most of the headwater contribution. In the vicinity of Virgelle, where the Missouri River assumes the traits of an alluvial stream, channel meanderings develop as bed shifting, sandbar formations and bank erosion become more pronounced. Upstream from this alluvial transition point, the streambed and banks are essentially stable due to the abundance of rock and gravel. The channel erosion below Virgelle can be severe during periods of high flows and particularly where the channel has cut into the Bearpaw shale formation. Sheet erosion of the weathered uplands surface is accomplished by runoff from either rainstorms or snowmelt. Although the amount of precipitation occurring over this plains area is relatively low, the gross erosion potential is increased by wind erosion during dry periods, which causes surface soils to accumulate in drainage courses, or coulees, where it is available for transport by surface runoff into tributary streams. The Bearpaw shale formation is particularly susceptible to surface erosion. Sediment carried in suspension at the Powerplant Ferry sampling station above Fort Peck generally consists of 35 percent sand, 25 percent silt and 40 percent clay. Prior to the closure of Fort Peck, it is estimated that the Missouri River transported an average of 15 to 20 million tons of sediment past the damsite each year. See Section 4-11 of this WCM for additional information on aggradation. Sediment rangelines for the Fort Peck reservoir are shown in Plates III-16 and III-17.

3-13.1. Downstream from Fort Peck, the bed of the Missouri River is composed essentially of medium-to-fine sand with occasional segments of gravel and cobbles and outcrops of clay and shale. The channel width varies between 800 and 1,200 feet depending on sandbar or island configurations. The channel bank heights are up to 15 feet high. The bank materials consist predominately of a mixture of fine sand and silts interspersed with lenses or pockets of dense, resistant clay formations. The Omaha District monitors degradation within the Missouri River downstream of Fort Peck through periodic surveys and analysis. The most recent summary of this effort is reported in the Omaha District report *Missouri River, Fort Peck Project Downstream Channel and Sediment Trends Study, M.R.B. Sediment Memoranda 28,* April 2013. Sediment rangelines for the Missouri River downstream of Fort Peck are shown in Plate III-18. See Section 4-12 of this WCM for additional information on degradation.

3-14. Missouri River Channel below Fort Peck Dam. In the reach between Fort Peck and the mouth of the Yellowstone River, the Missouri River has the characteristics of a typical, alluvial stream flowing in a meandering pattern within a valley varying from one to three miles in width. The alluvial nature of the river results in caving banks and shifting sandbars becoming more pronounced in this reach. The maximum flow that can be conveyed without damage will vary and is dependent on channel characteristics, the degree of encroachment on the floodplain and on local improvements, such as levees and channel modifications. Conveyance capacities will vary from season to season with a decrease in capacity during the winter and early spring when an ice cover is formed. See Section 3-15 of this WCM for a detailed discussion on the effect of ice.

3-14.1. Damages begin with open water flows of approximately 35,000 cfs in the reach from Fort Peck to the mouth of the Yellowstone River. In the upper portion of this reach (dam to Wolf Point), damages are relatively minor when flows are less than 50,000 cfs. In the lower portion of this reach (Wolf Point to mouth of Yellowstone River), damages are relatively minor when flows are less than 50,000 cfs. For both the upper and lower portions of this reach, the damages are limited largely to pasture and low-lying areas.

3-15. River Ice. From late November to late March the upper Missouri River and its tributaries are fully, or at least partially, ice covered. Ice thickness on streams in the basin will range up to 2 to 3 feet with the greatest thickness of ice on the slower flowing streams. The MRBWM office keeps records of the Fort Peck reservoir ice cover. The Fort Peck reservoir ice cover has formed as early as November 29 (1955) with ice break-up occurring as late as May 9 (1950). The reservoir ice cover will normally lag that on the streams by about one month. It should also be noted that the reservoir did not completely freeze over in the winters of 1986-87 and 1991-92.

3-15.1. Effect on Streamflow. During the freeze-up of the Missouri River and its tributaries above Fort Peck, a very noticeable drop in reservoir inflow occurs due to a large volume of water going into ice storage. There is a corresponding marked increase in reservoir inflow during the ice break-up in the spring.

3-15.2. Effects on Channel Capacities. Formation of ice cover greatly decreases the channel capacities. This reduction varies considerably from location to location and season to season. Observation of flows and stages in the reach between Fort Peck and the mouth of the Yellowstone River indicates that, with minor tributary inflows, Fort Peck releases of 10,000 cfs or less at the time an ice cover initially forms, and ranging up to 15,000 cfs after the downstream ice cover has stabilized, are unlikely to result in damages in this reach.

3-15.3. Ice Blocks and Jams. The break-up of the ice cover often causes ice jams, which have a marked effect on streamflow and stages during such periods. Downstream flow and accompanying stages may be reduced at the beginning of the ice jam while stages just upstream may rise at restricted points and cause some overbank flooding. The volume of ice in any particular reach of the river which may contribute to jamming is a function of the thickness of the ice, the width of the river and the length of the reach. With low stages, the river width, and consequently the ice volume within the reach, is reduced from that of higher stages. The Fort Peck reservoir traps the flowing ice from the upstream portion of the river and thereby reduces the probability of severe ice jams in the reach of the Missouri River from Fort Peck to the mouth of the Yellowstone River.

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Missouri River Basin
Fort Peck Dam – Fort Peck Lake
Water Control Manual

IV - Project Description and History

4-01. Location. Fort Peck is the most upstream of the six System dams. Fort Peck Dam is located at Missouri RM 1771.9 on the Missouri River in the counties of Valley and McCone in Montana about 10 miles above the mouth of the Milk River. The Fort Peck reservoir (Fort Peck Lake) extends 134 valley miles upstream. A project photo is shown as Plate IV-1.

4-02. Embankment. The dam consists of an earthfill embankment with an impervious core approximately 4 miles in length including the 2-mile dike section. The embankment has a maximum height of 250.5 feet and a maximum width of 4,900 feet. The crest elevation of the dam is at elevation 2280.5 feet with crest widths of 50 feet on the main dam section and on the dike section. The dam is a hydraulic fill type except for the final topping out and a section at the end of the dike, which are rolled fill. The upstream face of the dam is protected from wave action by riprap placed above elevation 2162.0 feet. Gravel was placed in the downstream toe of the dam to stabilize the slopes and facilitate drainage at the downstream toe. Seepage control is provided by a continuous sheet steel piling cutoff well, which is located 37.5 feet upstream from the axis of the dam. A system of relief wells were installed along the downstream toe to facilitate drainage of seepage water and reduce hydrostatic pressures in the foundation material downstream from the cutoff wall. Detailed description of the embankment is contained in the Operation and Maintenance Manual (O&M) for the Fort Peck Dam Embankment. Refer to Plate IV-1 for an aerial photo that shows the Fort Peck embankment, reservoir and powerhouses. Plan and cross sections of the embankment are shown on Plate IV-2. Refer to Plate II-1 for other pertinent System dam and reservoir information.

4-02.1. Seismic Evaluation. A Fort Peck dam seismic evaluation and analysis was completed in March 1976 by the U.S. Army Engineer Waterway Experiment Station (WES). The results of this investigation are presented in the WES Technical Report S-76-1, *Dynamic Analysis of Fort Peck Dam*, March 1976. A summary of the conclusions, obtained from Technical Report S-76-1, states:

> "The Fort Peck Dam is not expected to experience 5 percent strain if an earthquake of magnitude 5.5 occurs at a distance of 10 miles. This finding is based on the failure criteria of 5 percent strain and 5 cycles of stress. It is concluded, based on this analysis and sound engineering judgment, that the dam is safe for earthquakes considered possible at the site."

4-02.2. In support of ER 1110-2-1806, dated July 31, 1995, a limited seismic safety review was initiated in August 2004. The 2005 report indicated that the findings of the 1976 seismic evaluation are likely still valid.

4-03. Spillway. The spillway, located in a natural saddle of the reservoir rim about 3 miles east of the dam, consists of a partially lined approach channel, a gate control structure including a training wall section, a lined discharge channel and an unlined earth discharge channel, which enters the Missouri River approximately 9 miles below the dam. The concrete gate structure is surmounted by a highway bridge, a service bridge, an equipment platform and service walkways. Plan, profile and section of the spillway are shown on Plate IV-2. See Plate IV-3 for a photo of the spillway and embankment. Spillway discharge rating curves are shown on Plates IV-4 and IV-5.

4-03.1. Approach Channel. See Plates IV-2 and IV-5 for cross sections of the spillway profile. See Plate IV-6 for photos of the spillway approach channel.

a. Base Slab and Riprap. The concrete base slab and riprap extend upstream of the gate structure to protect the structures from erosion and to provide a constant cross section immediately upstream of the gate control structure. The concrete base slab extends 220 feet upstream from the gate control structure and a 2-foot layer of riprap is provided for another 100 feet upstream of the concrete base slab. The approach channel consists of concrete monoliths measuring 20 feet by 40 feet, except where irregular shapes are necessary to fit the structure. The slabs are 3 feet thick with 4-foot by 4-foot collars extending entirely across the channel underneath each transverse construction joint.
b. Concrete Walls. The approach channel side slopes are concrete lined for a distance of about 360 feet. The walls vary from a slope of 1 vertical (V) on 2 horizontal (H) to a vertical wall adjacent to the gate structure. The upstream 196 feet of side wall was constructed against sloping shale cut and the slope transitions from 1V on 1H to a vertical wall at a point approximately 70 feet upstream from the point where it joins the gate structure abutment. A cutoff trench, 10 feet deep by 8 feet wide, is located at the upstream end of the wall and intermediate cutoff walls, 3 feet deep by 4 feet wide, were provided at 20-foot centers beneath each construction joint.
c. Unlined Approach Channel. From the upstream end of the lined channel the approach channel is excavated in glacial till and shale. The channel is trapezoidal in section and has a bottom width of 820 feet. The slope of the side walls is 1V on 1H for shale and 1V on 3H for glacial till. The unlined approach channel is about 1,600 feet in length.

4-03.2. Spillway Gate Structure. See Plates IV-2 and IV-6 for cross sections and photos of the spillway gates, respectively.

a. Foundation Piling. A total of 467 concrete piles, each 5 feet in diameter and from 30 to 40 feet deep, provide stability and sliding resistance for the structure. The reinforced concrete piles are spaced on 18.33-foot centers longitudinally and on 13-foot centers transversely with intermediate piles located at the center of each group of four piles.
b. Cutoff Wall. A reinforced concrete cutoff wall, 10 feet wide by 30 feet deep, was installed beneath the upstream edge of the gate pier foundation. This wall extends across the channel under the slab and up the side slopes to elevation 2260.0 feet in the form of a 4-foot by 12-foot reinforced concrete collar.
c. Foundation Slab and Gate Pier. Tile pier foundation slab monoliths are approximately 75 feet long, 57 feet wide, and 12 feet thick and were placed on a foundation of Bearpaw shale, the concrete foundation piling and the concrete cutoff wall. The 17 gate piers are set in a curved line and uniformly spaced at 52-foot

centers on the crest line of the gate structure. Piers No. 1 and No. 17 are considered to be part of the abutment structures. Each of the other piers has a maximum height of 77 feet, a width of 12 feet and a length of 75 feet. The piers serve to support and provide mountings for the 16 vertical lift spillway gates and support the steel service bridge, the reinforced concrete highway bridge and piers, the machinery platforms and service walkways.

d. Training Walls. The training walls downstream of the gate structure are 187-foot extensions of the gate piers and were provided to eliminate turbulence during high spillway discharge. The training walls vary in thickness from about 11 feet at the gate pier to 18 inches at the downstream end. The height varies from 22 to 24.5 feet. The base slabs beneath the training walls are 4 feet thick and 20 feet wide. The intermediate slabs between the training walls are 3 feet thick and vary from 25 to 30 feet in width. A system of transverse collars was provided beneath each construction joint.

e. Gate Structure Abutments. The abutments on the right and left ends of the gate structure are about 123 feet long by 75 feet wide and consist of a thick base slab supported by 46 concrete piles, a relatively thick back slope slab, a number of 4-foot thick crosswalls, two piers, and a section of channel wall, which in effect is a modified pier with a curved nose section on the channel side containing the gate slots and castings. A cutoff collar, 4 feet wide by 12 feet deep, was constructed along the upstream edge of the abutment structure up to elevation 2262.0 feet.

f. Bridge Abutments. The bridge abutments retain the highway approach fill and support the highway bridge, service bridge and control house. The abutments consist of a group of independent but adjoining counter-forted retaining wall structures on slab footings at different elevations and form a continuous wall around three sides of the approach fill for the highway bridge. Each abutment is about 171 feet long, 75 feet wide and 45 feet high except for the left abutment which has the control structure built into it. The base of each abutment adjoins the upper portion of the gate substructure abutment at elevation 2262.0 feet, which is about 8 feet below the top of the access road.

g. Spillway Gates. The 16 vertical lift spillway gates are each 25 feet high by 40 feet wide. The gates are electrically operated and can be individually controlled from the service bridge. Selective operation of all gates is accomplished from the control house at the west end of the gate structure. Spillway rating curves are shown on Plates IV-4 and IV-5.

4-03.3. Lined Discharge Channel. See Plate VI-2 for a cross section of the spillway profile. See Plate IV-6 for photos of the spillway discharge channel.

a. Channel Slab. The concrete-lined channel is about 4,800 feet long varying in width from about 700 feet at the end of the training wall section to 120 feet at the downstream end of the cutoff structure. The floor slab of the concrete lined discharge channel varies from 2.33 to 4.0 feet thick. The floor slab monoliths are 20 feet wide in the longitudinal direction of the channel and generally 30 or 40 feet wide in the transverse direction. Collars with a bottom width of 4 feet and 1V on 1H side slopes varying in depth from 5.33 to 7.33 feet from the top of the channel floor slab are provided at each joint. Drain tile was provided below the collars under transverse joints connecting to the main longitudinal drain installed in a trench along the center line at a depth of 10 feet below the top of the floor slab.

b. Lined Channel Walls. The slab channel walls are about 4,700 feet long and extend from the channel wall at the gate structure to the cutoff structure at the downstream end. The walls consist of a cantilever base, a sloping slab wall and an 8-foot vertical section. A parapet wall, 4 feet high by 2 feet thick, surmounts the walls. The cantilever slab varies from 2.33 to 7 feet in thickness. The sloping slab walls are on a 1V on 1H slope and vary from 3 to 6 feet in thickness with cutoff collars varying in depth from 2 to 3.5 feet below the slab and spaced every 20 feet. The vertical section of wall is about 8 feet high and 7 feet wide at the top.
c. Cutoff Structure. A cellular-reinforced concrete cutoff structure is provided at the downstream end of the lined discharge channel. The cutoff structure extends approximately 70 feet below the channel floor and has wide wing walls to prevent scour on the sides of the channel. The reinforced concrete walls of the structure are 8 feet thick and the natural shale left in place between the walls. The main part of the cutoff structure, which spans the channel, is 95 feet in width parallel to the channel and 229 feet normal to the channel. Each wing wall branches off at a 45 degree angle and is 260 feet long by 71 feet wide.

4-03.4. Stilling Basin, pre-2011. Information on the post-2011 flood repairs can be found in Section 4-03.11 of this WCM. Immediately downstream of the cutoff structure the channel has been enlarged and deepened by erosion. This area served as a natural stilling basin to dissipate the energy created by the high velocity spillway discharges. The initial deepening of the channel appears to have stabilized at a depth of about 25 feet below the end of the lined channel. This deep scour area slopes upward and intersects the original excavation line about 450 feet downstream from the end of the lined discharge channel. The sections immediately downstream of the lined channel indicate the deepest scour is in the center of the channel and it slopes upward to each side at a slope of about 1V on 6H or flatter.

4-03.5. Unlined Discharge Channel.

a. Excavated Portion. Downstream of the cutoff structure the spillway channel was excavated through the shale bluffs to the river floodplain. The unlined channel was trapezoidal in cross section with 1V on 2H side slopes, a bottom width of 130 feet and a flat grade at elevation 2010.0 feet. Operation of the spillway during major floods, through erosion and deposition, has altered the original shape and grade of this unlined portion of the spillway.
b. Unexcavated Portion. The unlined channel originally terminated at the floodplain. Just prior to the operation of the Fort Peck spillway a pilot channel about 10 feet in width was excavated to the river. The initial controlled releases from the spillway quickly enlarged the channel until it could accommodate the maximum required releases.

4-03.6. Spillway Movement – Historical Observations. Movement observations indicate that the entire gate structure of the spillway had risen about 0.2 foot prior to 1944 with some additional rebound since that date; appreciable differential movement has occurred in the gate structure area; consolidation of the fill in the spillway bridge abutments has caused the intermediate wall at both abutments to settle and shift laterally; movement of the spillway channel paving and sidewalls and roadway retaining wall has occurred; and there has been considerable erosion at the downstream end of the lined discharge channel. Detailed description of the results of movement observations are included in reports titled *Report on Fort Peck Spillway Movement Survey* dated July 1, 1947 and *Report on Spillway Movement Observations, Fort Peck Dam* dated September 1962.

4-03.7. Repairs to the Fort Peck spillway include the replacement of the intermediate walls of the spillway bridge abutments in 1949 and 1950 with walls supported by piling, provision of an expansion joint to allow independent movement of the approach slab and the gate pier structure, and repair of the construction joint between gate structure and training wall slabs.

4-03.8. The movements, which are of concern in the Fort Peck spillway, are differential movements taking place in localized areas. The record of movement indicates the differential movement in localized areas will continue in the future. This type of movement has caused only slight apparent structural damage to date; however, continued movement will eventually result in structural damage and possibly complete destruction of sections of the spillway. Studies and investigations to determine factors causing the differential movement include geological and foundation surveys, laboratory analysis of shale samples, time movement studies, significant crack surveys, plastic flow analysis, slab replacement study, drainage system study and experimental grading plans. Detailed descriptions of these studies and investigations are contained in Design Memorandum No. MFP-109 titled *Spillway Rehabilitation* dated June 1965.

4-03.9. A reconnaissance study was completed in August 1997 titled *Fort Peck Dam Spillway Engineering Reconnaissance Study*. The then-record high 1997 runoff season, described in Appendix A of this report, illuminated the increased likelihood that the emergency spillway would have to be utilized in case of high water or emergency drawdown conditions. The study focused on cavitation and uplift induced forces on the spillway chute, scour potential downstream of the cutoff structure, and the structural integrity and slope stability analyses of the chute cutoff structure.

4-03.10. Spillway Movement – Recent Observations. In 2011, a team of experts from the Omaha District was dispatched to Fort Peck to observe the spillway while record spillway flows were being made. The team's observations are documented in the March 2012 Omaha District report titled *2011 High Water and Post Assessment Report, Fort Peck Dam and Lake.* Regarding the movement of the spillway, the team noted the following:

a. Movement, primarily rebound, of the chute spillway structure (downstream of gate structure) has been a concern at Fort Peck Dam since shortly after construction. Rebound has been observed as a result of unloading (excavation) the shale material for construction of the channel/chute. Numerous movement surveys and other movement devices have been employed to monitor the chute structure over the years. Considerable effort has been expended over the years to monitor the movement.
b. The 2008 and 2011 surveys revealed the same rebound phenomena as have been observed over the life of the project. The rate of rebound appears to be slowing. The current rate of rebound varies from 0.01 to 0.02 foot/year at the various stations along the chute.

c. The data indicates an overall rebound with a maximum value of 0.2 foot. The majority of the rebound has occurred on the west side of the chute.
d. No apparent movement (settlement) of the chute structure can definitely be attributed to the discharge loading during the 2011 high water event.

4-03.11. Post-2011 Spillway Construction. Since completion of the emergency spillway, the spillway has been operated approximately a dozen times, never passing discharges greater than 25,000 cfs until 2011. During the 2011 flood, spillway releases were made from May 6-22 and June 2-September 30. Peak spillway releases were 52,200 cfs for several days in June. Scour in the downstream channel reached a maximum depth of more than 40 feet, leaving less than 30 feet of embedment of the spillway cutoff wall structure. As a result, the downstream face of the cutoff structure was determined to be potentially unstable with concerns that the erosion would flank the cutoff structure and ultimately lead to progressive failure of the spillway chute. AECOM Technical Services, Inc. was contracted in 2012 to perform various analyses and develop repair alternatives to return the emergency spillway back to a pre-flood level of service.

4-03.11.1. In September 2012, a contract was awarded to ASI Constructors, Inc. to construct the plunge pool repairs which included the following:

a. Structural tie-back anchors to connect the front and back faces of the existing cutoff structure and tie them to the chute foundation;
b. A roller-compacted concrete apron to improve the stability and increase scour resistance immediately downstream of the existing cutoff structure;
c. A 20-foot deep cutoff wall at the downstream end of the new roller-compacted concrete apron;
d. A reinforced concrete cap with vertical foundation anchors to provide increased durability of the apron slab;
e. Gravity-type roller-compacted concrete training walls designed to contain a hydraulic jump that forms under discharges up to approximately 85,000 cfs; and
f. Structural backfill behind the roller-compacted concrete training walls to improve the stability of the existing cutoff structure.

Construction of the repair was considered substantially complete in November 2016. Additional guidance regarding best practices and/or special considerations and restrictions for use of the spillway at Fort Peck can be found in Exhibit A of this WCM.

4-04. Outlet Works and Powerplants.

4-04.1. Tunnels. The Fort Peck outlet release system consists of four tunnels, the intake structure, the emergency control shafts, the main control shafts and the outlet structure. The tunnels are spaced 125 feet center to center at the intake and the control shafts fan out to 195 feet center to center at the outlet. The tunnels vary in length. The length of Tunnel Nos. 1, 2, 3 and 4 are 5,653 feet, 6,355 feet, 6,615 feet and 7,240 feet, respectively, and bypass the dam through the right abutment. Tunnel Nos. 1 and 2 are used to supply water to the power units and Tunnel Nos. 3 and 4 are used for flood control purposes and to supplement downstream flows. The four tunnels are reinforced concrete lined, with steel liners installed downstream from the control shafts in Tunnel Nos. 1 and 2. The finished inside diameter of Tunnel Nos. 1, 3 and 4 is 24 feet

8 inches. Tunnel No. 2 has a finished inside diameter of 24 feet 8 inches upstream from the control shafts and 22 feet 4 inches inside diameter downstream from the main control shaft. Approximate discharge capacities of Tunnels No. 1, 2, 3 and 4 are 8,800 cfs, 7,200 cfs, 22,500 cfs and 22,500 cfs, respectively. The plan and sections of the tunnel system are shown on Plate IV-7. The discharge and tailwater rating curves for the outlet tunnels are shown on Plate IV-8.

4-04.1.1. Two unsafe conditions were identified and documented in 1988 regarding Powerplant No. 1: 1) the potential for surge tank overtopping and 2) an inadequate factor of safety for the penstocks. A March 1988 report titled Replacement of the Penstock System, Fort Peck Powerplant No. 1 recommended extensive modification to Tunnel No. 1. Multiple trifurcation and double bifurcation design alternatives were studied. Ultimately the Escher Wyss trifurcation design, Alternative 6T, was selected as noted in the July 1989 document Trifurcation Alternatives Fort Peck Powerplant No. 1 (see Plate IV-9). Powerplant No. 1 was removed from service from April 14, 1990 to November 30, 1992 for penstock replacement.

4-04.2. Outlet Structure. The tunnels discharge into a stilling pool located downstream from the dam embankment and adjacent to the downstream riverbed. The stilling pool is protected by reinforced concrete retaining walls, training walls, outlet portals, a base slab and baffle piers. The retaining walls extend along the right and left sides of the outlet channel and between the outlet portals. The right retaining wall is approximately 900 feet long, the left retaining wall is 660 feet long, and the retaining wall between portals is 305 feet long. The retaining walls vary in height from 33 to 43 feet. The outlet portals connect Tunnel Nos. 3 and 4 to the outlet channel and consist of a barrel section, portal transition, portal wall and stop log guide slots. Powerplant Nos. 1 and 2 are located downstream from the portals of Tunnel Nos. 1 and 2, respectively. The penstocks for the powerplants are connected to Tunnel Nos. 1 and 2 at the portals. Training walls extend out about 100 feet into the outlet channel from the south side of each portal (except No. 1). The discharge channel is about 1,200 feet in length with a maximum width of 550 feet. Pavement in the discharge channel consists of a 3-foot thick reinforced concrete slab with a 10-foot wide and 37-foot deep cutoff wall at the downstream end of the pavement. Downstream from the cutoff wall, cast concrete blocks, approximately 6 feet by 6 feet 3 inches, have been placed for a distance of about 25 feet in lieu of paving. The discharge channel slab is at elevation 2026.8 feet, which is approximately 6 feet below the low range of tailwater elevations. Forty baffle piers have been placed at the downstream end of the lined discharge channel to reduce kinetic energy and to direct the outflow toward the left bank. The baffle piers are made of reinforced concrete and are 12 feet long with the widths varying from 7.1 to 9.4 feet and the heights varying from 10 to 12 feet. Detailed descriptions of the various features of the outlet works are contained in the Operation and Maintenance Manual for the Fort Peck Outlet Works. The plan, profile and section of the outlet works are shown on Plate IV-2.

4-04.3. Use of Flood Tunnels. Per Section 4-04.1.4 of the Master Manual, since 1975, supplemental releases above powerplant capacity have been made over the spillway. Additional guidance regarding best practices and/or special considerations and restrictions for use of the outlet works can be found in Exhibit A of this WCM. Per Section 1.6.3 of Exhibit A, it is recommended that the ring gates (flood tunnels Nos. 3 and 4) should not be used except in case of a dam safety emergency in coordination with Omaha District Engineering Division.

4-05. Powerplant No. 1. Powerplant No. 1 is on the left bank of the discharge channel with the center line of units approximately 263 feet downstream from the portal of Tunnel No. 1. Principal features of Powerplant No. 1 include three penstocks extending from a wye branch at the outlet end of Tunnel No. 1 to the surge tanks; an enclosed surge tank section that houses three interconnected surge tanks; a generator section that houses the generators, turbines, a control room and related equipment; the three draft tubes that carry turbine outflows to the tailrace; and the outdoor substation and switchyard. The generating facilities include one 18,250 kW (Unit No. 2) and two 43,500 kW turbine-driven generators (Unit Nos. 1 and 3) and associated control and switching equipment. Detailed description of Powerplant No.1 is contained in the O&M Manual for Fort Peck Powerplant No. 1. Plan and sections of Powerplant No. 1 are shown on Plate IV-7. Powerplant tailwater rating curves and powerplant characteristic curves are shown on Plates IV-10 and IV-11, respectively.

4-05.1. Penstocks and Surge Tanks. Water is supplied to Powerplant No. 1 by a 24-foot 8-inch inside diameter steel penstock connected to the steel liner in Tunnel No. 1 at the portal. Approximately 50 feet downstream from the portal of Tunnel No. 1, a wye branch divides the flow into two 14-foot inside diameter penstocks supplying Unit Nos. 1 and 3 and an 11-foot inside diameter penstock supplying Unit No. 2. Each penstock is provided with a butterfly valve and surge tank. The three surge tanks are enclosed in a structure that is 94.5 feet wide, 144 feet long and 271 feet high. The surge tank for each unit is approximately 40 feet in diameter with the low point of the hemispherical bottom at elevation 2120.0 feet and the top at elevation 2288.0 feet. Penstocks for Unit Nos. 1 and 3 have risers approximately 11 feet in diameter and Unit No. 2 has an approximate 8-foot diameter riser connecting to the surge tanks. The three surge tanks are interconnected by a total of six 5-foot inside diameter equalizing pipes at elevation 2162.0 and 2180.0 feet, respectively.

4-05.2. Powerhouse. The powerhouse consists of three generator bays and an erection bay. The powerhouse also contains office space, a control room, a public reception lobby, an observation balcony, a machine shop, and all necessary water treatment, sewage treatment, heating and ventilating facilities. The substructure has an overall length of 186 feet 6 inches and the transverse width, exclusive of the surge tank base, is 76 feet. The substructure of the powerhouse and surge tank structure is constructed as a single monolith to eliminate the possibility of differential settlement. The height of the substructure is 42 feet above the low point of the draft tubes. The control room, cubicles, offices, machine shop and station service facilities are located in the surge tank base immediately adjacent to the upstream side of the powerhouse. The powerhouse superstructure is constructed of reinforced concrete and structural steel construction and has a length of 186 feet 6 inches and a transverse width of 61 feet. The height of the superstructure is approximately 62 feet above the turbine room floor.

4-05.3. Turbines. Three hydraulic turbines of the vertical shaft, single-runner, Francis-type, with plate-steel scroll cases, are installed in the powerhouse. Unit Nos. 1 and 3 turbines are rated 50,000 horsepower (hp) at 170 feet net head and operate at 128.5 revolutions per minute (rpm). Unit No. 2 turbine is rated 20,000 hp at 140 feet net head and operates at 164 rpm. Governors are of the isochronous, oil-hydraulic conventional-type capable of full-opening or full-closing time of six seconds.

4-05.4. Generators. The original installation in Powerplant No. 1 included one 15,000 kW and two 35,000 kW generators. The generators were rewound in 1978 and were uprated to one 18,250 kW and two 43,500 kW, 3-phase, 60-cycle, 13.8 kilovolts (kV), wye-connected, class B insulation for normal temperature rise of 60 degrees Celsius (°C) and rated at 0.90 power factor. Speeds of Unit Nos. 1 and 3 are 128.5 rpm and the speed of Unit No. 2 is 164 rpm. The generating units are enclosed, forced-air cooled, with waste heat used to heat the generator room and surge tank enclosures. Each generator has a direct-connected exciter permanently connected to the generator field, a pilot exciter, and a high speed voltage regulator. Main generator protective system includes a neutral reactor and circuit breaker, surge protective equipment, differential relays, a ground detector, a resistance temperature detector and overspeed protection for each unit.

4-05.5. Tailrace. The tailrace for Powerplant No. 1 is paved reinforced concrete for a distance of 100 feet downstream from the powerhouse, and slopes upward to join the concrete paving of the discharge channel for the outlet works. The surface of the tailrace paving is level at elevation 2010.6 feet at the ends of the draft tubes and slopes upward to elevation 2026.8 feet where it joins the discharge channel paving. The width of the tailrace floor slab varies from 130 feet at the upstream edge of the ends of the draft tubes to 146 feet at the downstream edge with the width increasing on the left side. Slope paving connects the tailrace floor slab to the retaining walls on the sides of the tailrace at elevation 2026.8 feet.

4-05.6. Switchyard No. 1. The switchyard for Powerplant No. 1 is an outdoor-type and is located southwest of the first powerhouse and to the left of the tailrace. Installations located in Switchyard No. 1 include the 13.8 kV bus structure, a 50,000 kilovolt-amp (kVA) 161 kV substation; a 25,000 kVA 69 kV substation and switchyard; a 15,000 kVA 115 kV substation, a 50,000 kVA 115 kV substation and a 115 kV switchyard; a 1,500 kVA 33 kV substation and a 4,160 volt project substation. Power transformers are 13.8 kV delta connected on the low side and grounded-wye connected on the high side.

4-06. Powerplant No. 2. Powerplant No. 2 is located to the right of the tailrace from Powerplant No. 1, with the center line of units approximately 350 feet downstream from the portal of Tunnel No. 2. Principal features of the Powerplant No. 2 include two penstocks extending from a wye branch at the outlet end of Tunnel No. 2 to the surge tanks; an enclosed surge tank structure that houses two interconnected surge tanks; a generator section that houses the generators; turbines; an erection bay; switchgear, oil storage and purification facilities and other equipment; two draft tubes that carry turbine discharge to the tailrace; and the outdoor substation and switchyard. The generating facilities include two 40,000 kW turbine-driven generators and associated control and switching equipment. Detailed description of Powerplant No. 2 is contained in the O&M Manual for Fort Peck's Powerplant No. 2. Plan and sections of Powerplant No. 2 are shown on Plate IV-7. Powerplant tailwater rating curves and powerplant characteristic curves are shown on Plates IV-10 and IV-11, respectively.

4-06.1. Penstocks and Surge Tanks. Water is supplied to Powerplant No. 2 by a 22-foot 4-inch inside diameter steel penstock connected to the steel liner in Tunnel No. 2. Approximately 95 feet downstream from the portal of Tunnel No. 2, a wye branch divides the flow into two 15-foot 11-5/8 inch inside diameter penstocks supplying Unit Nos. 4 and 5. Each of the penstocks is provided with a butterfly valve and a surge tank. The two surge tanks are enclosed in a structure with base dimensions of 73 feet 3 inches by 155 feet 4 inches and 190 feet high. The surge tank for each unit is approximately 65 feet in diameter, with the low point of the hemispherical bottom at elevation 2107.5 feet and with the top at elevation 2237.0 feet. Each penstock has a 13-foot inside diameter riser connection to its surge tank. The two surge tanks are interconnected by two 8-foot inside diameter equalizing pipes with center lines at elevations 2158.0 and 2230.0 feet.

4-06.2. Powerhouse. The powerhouse consists of two generator bays and an erection bay. The generating units are on 56-foot centers and the erection bay is 52.3 feet wide. The overall length of the substructure is 186.5 feet and the transverse width, excluding the base of the surge tank structure, is 83.0 feet. The substructure of the powerhouse and surge tank base is constructed as a single monolith to eliminate the possibility of differential settlement. Equipment rooms, the carbon dioxide fire protection system, and the heating and ventilating systems are located in the base of the surge tank structure. The height of the substructure above the low point of the draft tubes is approximately 48 feet. The superstructure is made of reinforced concrete and structural steel construction and has a length of 185.5 feet and a transverse width of 68.7 feet. The height of the superstructure is approximately 62.5 feet above the turbine room floor.

4-06.3. Turbines. Two hydraulic turbines of the vertical shaft, single-runner, Francis-type, with plate steel scroll case are installed in Powerplant No. 2. The turbines are rated 55,000 hp (at best gate) at 170 feet net head and operate at 128.6 rpm. Governors are of the isochronous, oil-hydraulic conventional-type capable of full-opening or full-closing time of five seconds.

4-06.4. Generators. The generators are 40,000 kW, 3-phase, 60 cycles, 13.8 kV, wye-connected 128.6 rpm, class B insulation for normal temperature rise of 60°C and rated at 0.95 power factor. Provision is made for alternative control of the two generating units from the control room in Powerplant No. 1 or from the turbine room in Powerplant No. 2. The generating units are enclosed, forced-air cooled, with waste heat used to heat the generator room and the surge tank enclosures. Each generator has a direct-connected exciter permanently connected to the generator field, a pilot exciter, and a high speed voltage regulator. The main generator protective system includes a neutral reactor and circuit breaker, differential relays, ground detector, resistance temperature detectors and overspeed protection for each unit.

4-06.5. Tailrace. The tailrace for Powerplant No. 2 is 120 feet wide and is paved reinforced concrete for a distance of 120 feet downstream from the powerhouse. The surface of the tailrace paving is level at the ends of the draft tubes and slopes upward to where it joins the concrete paving of the discharge channel for the outlet works. A training wall is located on the left side of the tailrace in order to maintain minimum tailwater at elevation 2032.0 feet with one unit operating. The right training wall is an extension of the training wall located on the left side of the portal of Tunnel No. 3. Slope paving connects the tailrace floor slab to the training wall on the right side of the tailrace.

4-06.6. Switchyard No. 2. The switchyard for Powerplant No. 2 is an outdoor-type and is located to the right and adjacent to the second powerhouse. Equipment in Switchyard No. 2 includes the main power transformers for Unit Nos. 4 and 5, a system interconnecting autotransformer, high voltage busses, circuit breakers, disconnects, coupling capacitor, lightning arresters and instrument transformers. The generating voltage of Powerplant No. 2 is stepped up to 230 kV by two 3-phase 36/48 Mega Volt Amp (MVA) main power transformers located in Switchyard No. 2. The switchyard provides for one initial 230 kV overhead line (Fort Peck-Dawson County Transmission Line), a future 230 kV overhead line, and also, a 3-phase 230/115 13.8 kV system interconnecting auto transformer, rated 40/53.3/66.7 kVA with a tie line to Switchyard No. 1 to provide means for interchanging power between Powerplant No. 2 and Powerplant No. 1. Power transformers and autotransformers are 13.8 kV delta connected on the low side and grounded-wye connected on the high side.

4-07. Intake Structure. The intake is a submerged-type reinforced concrete structure located at the upstream end of the flood control and power tunnels. The intake structure has a length of 517.5 feet, a width of 57 feet and a height of 65 feet. The structure is divided into four individual water intake chambers by three cross walls each 15 feet thick. Each chamber is equipped with removable steel trash racks. The inlet of the intake and the base of the trash racks are at elevation 2095.0 feet. The intake floor at the tunnel portals is at elevation 2030.0 feet. Slots and guides are provided for installing stop logs to permit dewatering the tunnels.

4-07.1. Emergency and Main Control Shafts. The control gates for the tunnels are located near the axis of the dam and are housed in reinforced concrete shafts which extend upward to ground level where a reinforced concrete structure houses the gate operating machinery. Each tunnel has an emergency shaft and a main control shaft. The emergency control shafts are 71.8 feet upstream from the main control shafts and consist of a reinforced concrete shaft and building, emergency gates, and hoisting equipment. The emergency control shafts are rectangular, approximately 34 feet by 17 feet in outside dimensions, and are divided into two gate passages with inside dimensions of 7 feet by 12.1 feet. Each tunnel has two 48-ton vertical lift tractor-type emergency gates measuring 11.5 feet wide and 22 feet high. The main control shafts are located just upstream from the axis of the dam and consist of a transition section, a reinforced concrete shaft, a control building, control gates and gate hoist machinery installed in Tunnel Nos. 3 and 4, an overhead crane and miscellaneous operator facilities. The main control shaft consists of a circular waterway 50 feet in diameter with an inner tower having an inside diameter of 28.1 feet and an orifice with an inside diameter of 24.3 feet. Tunnel Nos. 3 and 4 have two cylindrical main control gates installed in each of the main control shafts. The upper main control gates are installed at elevation 2165.0 feet and the lower main control gates at elevation 2085.0 feet. Each of the main control gates has a diameter of approximately 28 feet and height of 12 feet. Tunnel Nos. 1 and 2, which are used as power tunnels, are controlled at the powerhouse. The main control shafts in these tunnels serve as auxiliary surge tanks.

4-08. Reservoir. The reservoir formed by Fort Peck Dam, Fort Peck Lake, lies in northeastern Montana. At elevation 2250.0 feet, the top of the Exclusive Flood Control Zone, the Fort Peck reservoir has an approximate length of 134 miles, a maximum width of 16 miles, a shoreline of 1,600 miles, a surface area of 245,000 acres and a maximum depth of 220 feet. Based on the latest survey completed in 2007, the reservoir provides a maximum storage of 18,463,000 AF at elevation 2250.0 feet and a normal operating maximum storage of 17,492,000 AF at elevation 2246.0 feet, the top of the Annual Flood Control and Multiple Use Zone. A map of the reservoir area is shown in Plate IV-12.

4-08.1. Allocation of storage space in Fort Peck was based on mainstem requirements as described in Section 7-03 of the Master Manual. Types of storage space, with associated elevations and storage quantities for each type, are presented in Table IV-1. Area and capacity tables for the Fort Peck reservoir are shown on Plate IV-13.

Table IV-1
Fort Peck Reservoir Storage Space Allocations

Storage Designation (Zone)	Elevation in feet		Storage Space in AF
	From	To	
Exclusive Flood Control	2246.0	2250.0	971,000
Annual Flood Control and Multiple Use	2234.0	2246.0	2,704,000
Carryover Multiple Use	2160.0	2234.0	10,700,000
Permanent	2030.0	2160.0	4,088,000
Total Storage			18,463,000

Note: Storage volumes are based on January 2009 elevation-area capacity tables (2007 Surveys)

4-09. Recreation Facilities. Fluctuating reservoir levels can have a major effect on recreational use of the reservoir. Numerous public-use areas have been established around the shoreline of the project with a common development of most of these areas being a boat ramp providing access to the reservoir. Recreation at System projects consists of both water-based and land-based activities. Water-based recreation includes boating, fishing, water skiing, jet skiing and swimming. Land-based recreation includes hunting, camping, picnicking, sightseeing, hiking and wildlife photography. Visitors participate in these activities at recreation areas that range from undeveloped reservoir access points to highly developed and extensively used campground areas. The six System projects have a total of 188 public recreation areas. Plates IV-14 and IV-15 present the 27 recreational facilities at Fort Peck. Boat ramps have also been constructed for access to the reservoir as well as to the Missouri River below the dam. While some are considered to be a portion of the Fort Peck project, others have been constructed by private interests or as a part of other federal, state and private recreational developments. These downstream ramps generally continue to be operable through the normal range of Fort Peck releases.

4-10. Leasing of Project Lands. As indicated in Section 2-05 of this WCM, land surrounding the Fort Peck reservoir below elevation 2250.0 feet (from the dam to RM 1863, 1960 mileage), and below 2270.0 feet (from RM 1863 to 1931.8) was acquired by the Government for project purposes. Unless inflows to the reservoir are decidedly above average, inundation of lands above these elevations will usually not occur. Consequently, on an annual basis, the Corps makes tracts of land available for leasing, generally for agricultural purposes, as a part of their land management program. The extent of leased lands is based on an analysis of expected reservoir levels, as well as land management considerations. A major portion of the revenue from this leasing program is returned to the counties within which the leased land lies. All such leases are subject to possible flooding of land, if needed for operational purposes, and do not serve as constraints on regulation of the reservoir for authorized purposes.

4-11. Reservoir Aggradation. Accumulation of sediment within the Fort Peck reservoir is evidenced by progressive delta growths at the confluence of the prevailing reservoir pool levels and each contributing stream. The growth of individual delta formations is variable depending on the pool elevation and the sediment production from each contributing stream. The original capacity of the Fort Peck reservoir, determined in 1937, was 19,557,492 AF at the maximum operating pool elevation of 2250.0 feet. The latest survey in 2007 showed the new capacity to be 18,463,000 AF. This loss of 1,094,492 AF in capacity represents a 5.6 percent reduction in the original storage capacity and a sediment depletion rate of 15,600 AF per year, averaged over 70 years of regulation. The current estimated annual sediment depletion rate is 17,200 AF per year. At this rate the estimated sediment life of the reservoir is 1,073 years. Although sediment accumulation occurs throughout the reservoir the largest accumulations exist in the headwater reaches; the Musselshell River tributary arm vicinity, immediately upstream and downstream of the Hell Creek tributary arm, and within the Big Dry Creek tributary arm. While the total depletion of the reservoir since 1937 is 5.6 percent, the headwater area's depletion is 46.5 percent. A limited redistribution of the deposited material may occur in each delta area due to local channel slope adjustment and scour whenever the reservoir reaches lower operating levels for significant periods of time. The location of the aggradation ranges are shown on Plates III-17 and III-18.

4-12. Tailwater Degradation. The Fort Peck degradation reach extends about 175 river miles downstream of the dam to about 10 miles upstream of the Yellowstone River confluence. The valley width is relatively uniform and is well entrenched in the terrain of the Montana prairies. As noted in Section 3-13.1 of this WCM, the channel width varies between 800 and 1,200 feet depending on sandbar or island configurations. Since Fort Peck Dam traps all upstream contributed sediment, the downstream river remains relatively free of suspended sediment until the Milk River, which enters the Missouri River about 10 miles downstream of the dam, and other tributaries introduce their individual load contributions into the Missouri River. As the finer sand particles in the streambed are gradually entrained into suspension from between the larger sand or gravel particles and transported downstream, a gradual lowering or degradation of the channel occurs. This degradation will continue at a diminishing rate until the bed surface becomes sufficiently covered, or armored, with particles whose size, shape and position resist further movement by prevailing maximum flow conditions. After this time the degradation trend will remain relatively static until higher flow conditions sufficiently rearrange or disturb the armored bed surface to induce further particle losses or such a disturbance is artificially introduced to accelerate degradation. At the present time, several natural clay and shale outcrops cause local controls which augment this armoring process to further curtail the rate of degradation. A study completed in 2013 titled *Fort Peck Downstream Sediment Trends Study* analyzed water surface profiles for three discharges: 10,000 cfs, 20,000 cfs and 30,000 cfs. Overall, the water surface profiles have decreased between 1950 and 2012. However, the decrease has not been steady over the entire period or for the entire 175-mile reach. Decreases occurred from 1950 to 1966 and 1975 to 1984, while increases occurred from 1966 to 1975 and 1984 to 1995. The largest decreases occurred from 1995 to 2012, as a result of the high releases made in 1996 and 1997 and the record releases made in 2011. The report showed that from 1950 to 2012 at the 10,000 cfs flow level, the reach's average decrease was 2.4 feet, of which 1.3 feet (54 percent) occurred in the 1995 to 2012 period. The location of the degradation ranges are shown on Plate III-19.

4-13. History of Water Resources Development. Due to the generally arid climate, as well as the lack of transportation facilities, development of water resources in the portion of the Missouri

River basin extending from Fort Peck Dam downstream to the headwaters of the Garrison reservoir began soon after westward expansion in the early 1800s. Initial development was concerned with navigation, as a means of transportation in the region, and irrigation. In later years as the population increased, the development of hydroelectric power facilities, generally in connection with irrigation projects, received emphasis. Control of floods became a major concern in the 1940s and in recent years municipal and industrial (M&I) water supply, recreation, water quality enhancement as well as fish and wildlife enhancement and other matters related to the environment have been of increasing importance.

4-13.1. Federal legislation pertinent to water resource development throughout the Missouri River basin is summarized in Chapter II of the Master Manual. As indicated in the Master Manual, construction of the Fort Peck project commenced under Executive Order in October 1933 with funds provided by Congress for the relief of unemployment. The Flood Control Act of 1944 is of primary importance through this portion of the basin. This act authorized the construction of the other five System projects (Fort Peck Dam was already constructed by then and was authorized by this Act to become part of the System) and many tributary projects, and emphasized the multiple-purpose aspects of water resource development for the region.

4-13.2. The most important water resource development in this section of the Missouri River basin has been construction of dams and the development of associated reservoirs. In addition to Fort Peck, a number of projects have been constructed in the Missouri River basin by federal, state and private agencies in the basin above Fort Peck and above the mouth of the Yellowstone River. Several were constructed by the Montana Power Company for hydroelectric power productions. Those facilities are now owned by NorthWestern Energy (NorthWestern). The Montana Water Projects Bureau, formerly known as the Montana State Water Conservation Board, owns and operates various private irrigation districts and the Bureau of Indian Affairs (BIA) has numerous projects in the basin that were constructed for irrigation purposes. There are also a number of projects in the basin constructed by private organizations for irrigation purposes. Reservoirs in the drainage area above Fort Peck with a usable storage capacity of 5,000 AF or more are shown in Table IV-2. In addition, many reservoirs with a storage capacity of less than 5,000 AF used for irrigation and other conservation purposes, and numerous small stock ponds, have been constructed in the arid regions of the basin.

4-13.3. The upstream and tributary reservoirs can affect the regulation of Fort Peck by usually reducing the natural peak flows provided significant runoff contributing to the peak flows originates above these reservoirs. In certain instances a reservoir may increase the size of the peak below the project over that which would be observed naturally either by the increase of travel time through the length of the reservoir or by delaying a portion of the runoff from a sub-area and thereby contributing to a major peak on the main stream. However, with the storage space provided and the large number of reservoirs tributary to the mainstem, the possibility of their aggregate effect increasing the main stem flows is remote.

4-14. Miscellaneous Resource Development. The land and water areas at Fort Peck are administered and managed to obtain sustained public benefits from conservation and use of their natural resources. Other federal, state and local agencies have and will continue to be encouraged to assume responsibility for administration and development for public uses and wildlife management lands where feasible and it is determined that they have the resources to properly develop and utilize the area for the use intended. The Corps reviews plans and recommendations of the state and federal agencies in order to interpret and translate their effects and their relationship to the aspects of the project and assure compliance with the requirements of the overall operational plan.

4-14.1. The USFWS manages the Charles M. Russell National Wildlife Refuge (CMR NWR). The CMR NWR encompasses the entire Fort Peck project and covers approximately 1.1 million acres. The CMR NWR includes land acquired by the USFWS, land acquired by the Corps and used by the USFWS through interagency cooperative agreements, lands withdrawn for both the Fort Peck project and CMR NWR, and lands withdrawn specifically and exclusively for CMR NWR purposes. A cooperative agreement between the Corps and the USFWS grants authority for wildlife management and issuing grazing leases on CMR NWR lands to the USFWS. The Corps is responsible for the management of these same project lands for the benefit of recreation, flood control, navigation, hydropower, irrigation, and domestic water supply. The USFWS has developed and maintains three low density recreation sites on the upper end of the reservoir. In addition, the USFWS administers the UL Bend National Wildlife Refuge, the UL Bend Wilderness Area, 15 proposed wilderness areas, and a self-guided auto tour.

4-14.2. The Montana State Fish and Game Commission maintains game ranges, wildlife development areas, game preserves, game bird farms, fish hatcheries and spawning stations. These are widely distributed throughout the Missouri River basin above the mouth of the Yellowstone River.

Table IV-2
Reservoirs in the Missouri River Basin above the Mouth of the Yellowstone River

Reservoir	River Basin	Useable Storage[1] in AF	Year Completed	Operated By
Lima	Jefferson	84,050	1934	Private
Clark Canyon	Jefferson	253,440	1964	USBR
Ruby	Jefferson	37,640	1938	MT DNRC
Delmoe Lake	Jefferson	6,600	1913	Private
Willow Creek	Jefferson	18,000	1938	MT DNRC
Hebgen Lake	Madison	386,200	1915	NorthWestern
Earthquake Lake	Madison	35,000	see Note	n/a
Ennis Lake	Madison	42,060	1900	NorthWestern
Middle Creek	Gallatin	10,180	1950	MT DNRC
Canyon Ferry	Missouri	1,992,980	1954	USBR
Hauser Lake	Missouri	111,060	1911	NorthWestern
Helena Valley	Missouri	10,450	1945	USBR
Holter Lake	Missouri	240,400	1918	NorthWestern
Smith River	Smith	11,500	1936	MT DNRC
Gibson	Sun	98,690	1940	USBR
Pishkun	Sun	46,690	1940	USBR
Willow Creek	Sun	31,850	1941	USBR
Nilan	Sun	10,090	1951	MT DNRC
Morony	Missouri	13,600	1930	NorthWestern
Bynum	Teton	75,000	1926	Private
Lower Two Medicine Lake	Marias	11,880	1967	BIA
Four Horns	Marias	19,250	1932	BIA
Swift	Marias	30,000	1967	Private
Lake Frances	Marias	116,900	1913	Private
Tiber	Marias	1,328,720	1956	USBR
Ackley Lake	Judith	6,720	1938	MT DNRC
Martinsdale	Musselshell	23,350	1939	MT DNRC
Deadman’s Basin	Musselshell	72,220	1941	MT DNRC
Fort Peck	Missouri	18,460,000	1940	Corps
Sherburne	Milk	66,150	1921	USBR
Fresno	Milk	91,750	1939	USBR
Nelson	Milk	78,950	1915	USBR

[1]Total Storage
Note: Formed by 1959 earthquake

4-14.3. Bureau of Land Management. The 149-mile Upper Missouri National Wild and Scenic River flows between Fort Benton, MT and the James Kipp Recreation Area. The lower 9.5 miles of the designated river flows inside the boundaries of the Fort Peck project and the CMR NWR. This segment is classified as “scenic”. The National Park Service (NPS) is the overseeing agency for the National Wild and Scenic Rivers System. Under NPS oversight, the Bureau of Land Management (BLM) is the managing agency for the Upper Missouri National Wild and

Scenic River. Within the Fort Peck project and CMR NWR boundaries, BLM's area of responsibility of the designated river is confined to the area between the average high water marks. This would include islands, but the BLM has deferred management of the islands to the USFWS. The BLM also manages the Upper Missouri River Breaks National Monument that surrounds the Wild and Scenic River. The Corps has out-granted the James Kipp Recreation Area at Highway 191 to the BLM for management. The James Kipp Recreation Area services as a take-out point for river trips on the upper Missouri River.

4-14.4. National Park Service. A portion of the Lewis and Clark National Historic Trails follows the Missouri River from Fort Peck Dam to the Fred Robinson Bridge (U.S. Highway 191). The NPS administers the trail and oversees any state, local, and private interests that express a desire to develop and manage facilities along the trail.

4-14.5. Water Rights. In 1973 Montana passed the Water Use Act, which reformed the historical water rights process. This act adopted a central records system, a new permitting process to acquire water rights, and a process to resolve disputes about claims to water. In 1979, the law was amended to create a Water Court to adjudicate or finalize claims for water use in the state. For administrative purposes, the state has been divided into 85 "basins," which reflect the boundaries of the watersheds involved. The Montana Department of Natural Resources and Conservation (MT DNRC) has managed the records system and all filings for water rights since 1973.

4-14.6. U.S. Coast Guard. The U.S. Coast Guard has jurisdiction on the Fort Peck reservoir for placement of the navigational aids and coordinates with the Corps on bridge construction.

4-15. Flood Control. Fort Peck is a multi-purpose reservoir. In addition to the other seven authorized purposes, Fort Peck is regulated to prevent or reduce flooding in the reach from Fort Peck to the headwaters of the Garrison reservoir and as a component of the System to provide flood risk reduction measures in the lower Missouri River valley. Many of the tributary projects discussed in Section 4-13 of this WCM may have incidental effects on flood flows. However, with the exception of Fort Peck, only three projects in the drainage area above Fort Peck are actively regulated for flood control as a stated purpose: Tiber on the Marias River, Clark Canyon on the Beaverhead River, and Canyon Ferry on the headwaters of the Missouri River. These three projects were constructed by the USBR. The USBR operates these projects under non-flood control circumstances. Under Section 7 of the 1944 Flood Control Act, the Corps has exclusive authority over the three projects for flood control purposes. The Corps Omaha District's Water Control and Water Quality Section is responsible for directing the USBR in the operation of the dams for flood control purposes.

4-15.1. Replacement Storage. As described in greater detail in Sections 7-04.4 and 7-04.4.1 of the Master Manual, three Missouri River basin USBR tributary reservoirs above Fort Peck have replacement System flood control storage: Clark Canyon, Canyon Ferry and Tiber. The Corps' NWD Commander is responsible for the flood control regulation of these projects under Section 7 of the 1944 Flood Control Act. The NWD Commander has delegated the flood control regulation of these USBR projects to the Corps' Omaha District Commander. The three USBR projects have the use of replacement System flood control storage outlined in their respective tributary WCMs. Each WCM details the procedures for the Corps to follow in computing the amount of replacement storage available for each runoff season.

4-15.2. Tiber Reservoir is located on the Marias River in north-central Montana. As shown on Plate IV-16, Tiber reservoir's flood control zone, which contains the Exclusive Flood Control and Replacement Storage Zones, extends from elevation 2993.0 to 3012.5 feet, a total of 403,074 AF. The Exclusive Flood Control Zone extends from elevation 3008.1 to 3012.5 feet, a total of 99,350 AF. The Replacement Storage Zone extends from elevation 2993.0 to 3008.1 feet, a total of 303,724 AF. At all levels below elevation 2993.0 feet or above 3012.5 feet the Corps may make recommendations to the USBR for operating in the interest of flood control. However, such recommendations shall not be considered mandatory inasmuch as regulation of such storage is the responsibility of the USBR. The Joint Use Zone, which extends from elevation 2976.0 to 2993.0 feet, a total of 258,436 AF, will normally be used for conservation purposes, except when required for flood control and/or replacement purposes. That portion of the Joint Use Zone that is required is determined by the Corps and the USBR based on their respective monthly inflow runoff forecasts.

4-15.3. Clark Canyon Dam is located on the Beaverhead River in southwestern Montana. As shown on Plate IV-16, Clark Canyon reservoir's Exclusive Flood Control Zone, which contains the Replacement Storage Zone, extends from elevation 5546.1 to 5560.4 feet, a total of 79,075 AF. The Replacement Storage Zone extends from elevation 5546.1 to 5556.6 feet, a total of 56,455 AF. At all levels below elevation 5546.1 feet or above 5560.4 feet the Corps may make recommendations to the USBR for operating in the interest of flood control. However, such recommendations shall not be considered mandatory inasmuch as regulation of such storage is the responsibility of the USBR. The Joint Use Zone, which extends from elevation 5535.7 to 5546.1 feet, a total of 50,207 AF, will normally be used for conservation purposes, except when required for flood control and/or replacement purposes. That portion of the Joint Use Zone that is required is determined by the Corps and the USBR based on their respective monthly inflow runoff forecasts.

4-15.4. Canyon Ferry Dam is located on the Missouri River in central-western Montana about 50 miles downstream from where the Gallatin, Madison, and Jefferson Rivers join to form the Missouri River. As shown on Plate IV-16, Canyon Ferry reservoir's Exclusive Flood Control Zone extends from elevation 3797.0 to 3800.0 feet, a total of 101,089 AF. The Replacement Storage Zone is located in the upper portion of the Joint Use Zone. The Joint Use Zone extends from elevation 3770.0 to 3797.0 feet, a total of 794,289 AF. The Replacement Storage Zone extends from elevation 3783.0 to 3797.0 feet, a total of 445,564 AF. At all levels below elevation 3783.0 feet or above 3800.0 feet the Corps may make recommendations to the USBR for operating in the interest of flood control. However, such recommendations shall not be considered mandatory inasmuch as regulation of such storage is the responsibility of the USBR. The lower portion of the Joint Use Zone from elevation 3770.0 to 3783.0 feet, which totals 348,725 AF, shall normally be available for conservation usage but may be used for seasonal flood control between May 1 and July 31.

4-15.5. Local Flood Protection. Levee projects have been constructed at Havre, Saco and Glasgow on the Milk River, Musselshell on the Musselshell River, and on the Missouri River at Great Falls. These projects have essentially no effect on the regulation of Fort Peck. No projects have been constructed through the reach of the Missouri River below Fort Peck to the mouth of the Yellowstone River. Therefore, the operation and maintenance of local protection projects is not a factor in the regulation of Fort Peck.

4-16. Irrigation. Existing irrigation above Fort Peck and irrigation development in the Fort Peck drainage basin consists of numerous community- or privately-owned developments; the Lower Marias, the Sun River, Helena Valley, and Crow Creek projects developed by the USBR, the Broadwater-Missouri, Middle Creek, Willow Creek and Ruby River projects developed by the Montana State Water Conservation Board and the irrigation system constructed by the BIA on the Blackfoot Indian Reservation. As of 2007, 941,800 acres were under irrigation upstream of Fort Peck Dam. Of this total, 67,000 acres were in the Musselshell River basin and 186,000 acres were in the Marias River basin.

4-16.1. There are a number of small irrigators along the Missouri River between Morony Dam, which is about 10 miles downstream of Great Falls, MT, and on the Fort Peck reservoir. Irrigation from the Fort Peck reservoir is limited to a few isolated pumping units. Development of the utilization of water from the Fort Peck reservoir in this area in general is impracticable due to the high pumping heads required to reach the surrounding tablelands upstream from the dam.

4-16.2. There is significant irrigation in the Missouri River in the reach from Fort Peck Dam to the Garrison reservoir. As noted in Section E-01.1.1.2 in the Master Manual, there are 450 water supply intakes and intake facilities on the Missouri River in the Missouri River reach from Wolf Point, MT to Williston, ND. These include 4 municipal water supply facilities, 283 irrigation intakes, 162 domestic intakes and 1 public intake.

4-17. Navigation. There is currently no commercial navigation through this reach of the Missouri River. Storage has been provided in the Fort Peck reservoir to serve multiple purposes, including Missouri River navigation; however, storage and releases from Fort Peck serve navigation only indirectly. A description of the Missouri River navigation project is contained in Chapter VII and Appendix G of the Master Manual.

4-18. Hydroelectric Power. At the present time there are eleven hydroelectric powerplants in operation in the upper Missouri River basin having a total installed capacity of 575,250 kW. These include the two powerplants at Fort Peck constructed by the Corps, Canyon Ferry on the Missouri River, which was constructed and is operated by the USBR, and nine plants operated by NorthWestern. The installed capacity of Fort Peck is 185,000 kW. All power generated by federal facilities in the Missouri River basin is marketed by Western. Fort Peck power generation is integrated with the generation provided from other System projects and other federal and private facilities throughout Western's power marketing area. Further details concerning Western's power marketing and transmission facilities are provided in Section 7-12 and Appendix F of the Master Manual and Appendix F of this WCM.

4-19. Municipal and Industrial Water Supply. A number of towns and cities obtain their water supply from the streams and reservoirs in the basin above Fort Peck and from the Missouri River below Fort Peck. Above Fort Peck, Great Falls and Helena have the only large municipal water systems that utilize Missouri River water. Other municipal requirements above the Fort Peck reservoir are supplied by smaller tributaries or wells. The city of Butte obtains its municipal water supply from the Bighole River. Downstream of Fort Peck, the towns of Nashua, Culbertson and Williston obtain their municipal water supply from the Missouri River. Culbertson also has an industrial use permit and there are several other small industrial users below Fort Peck. The present usage of the water supply for municipal purposes is far below the available supply and it is not anticipated that demands in the near future will exceed the supply.

4-20. Land Treatment. In response to the program administered by the U.S. Department of Agriculture (USDA), land treatment measures designed to reduce erosion and local floods and to increase the local surface water supply are in operation throughout the incremental drainage area discussed in this WCM. Associated with this program are many stock ponds or farm ponds that have been developed. While these ponds and other land treatment measures have a depleting effect on the overall water supply to the Missouri River and provide a degree of local flood protection, their effect on Missouri River flows is minimal.

4-21. Fish, Wildlife and Recreation. The effects of water resource development on fish and wildlife are a consideration throughout the Missouri River basin in the planning and reservoir regulation processes. Recreation opportunities have generally been increased as a result of water resource developments. To the degree practicable, fish and wildlife interests are considered prior to operation of projects. Recreational use of the Fort Peck reservoir continues to increase through the years. Appendix B of this WCM presents additional information regarding recreation.

4-22. Streamflow Depletions. Water resource developments in the incremental drainage above Fort Peck has two major effects on the regulation of the Fort Peck reservoir, a depletion in the available water supply and a partial redistribution of inflows. As resource development continues, a growth in depletions can be expected. While increasing depletions can benefit the flood control function, it is evident that they would generally have adverse effects on other functions dependent on the availability of a continuing water supply.

4-22.1. Prior to 1865, streamflow throughout the Missouri River basin was largely unused, except for transportation. Settlers and homesteaders in the late 1800s and soon after the turn of the century started substantial irrigation and mining ventures in several regions of the upper Missouri River basin. As these uses increased, they began to have a significant effect on streamflow. Table IV-3 lists results of the 2005 USBR analysis of the historical and estimated future depletions above Fort Peck. Depletions are based on irrigation and as well as M&I uses. Future depletions are primarily based on projected population changes.

Table IV-3
Depletions above Fort Peck

Time Period	Average Annual Depletion (kAF)
1929-1940	2,356
1941-1950	2,233
1951-1960	2,576
1961-1970	2,505
1971-1980	2,572
1981-1990	2,586
1991-2002	2,331
Future (Estimated)	
2002-2010	2,506
2010-2015	2,513
2015-2020	2,528
2020-2025	2,543
2025-2030	2,558
2030-2050	2,595
2050-2070	2,628
2070-2090	2,635
2090-2110	2,642

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Missouri River Basin
Fort Peck Dam – Fort Peck Lake
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V - Data Collection and Communications Networks

5-01. General. Refer to Chapter V of the Master Manual for an outline of the basic hydrologic data required for regulation of the System. This chapter outlines agency responsibilities, communications methods and other details relevant to the data collection process.

5-02. Fort Peck Project Data. Hourly data are automatically transmitted from the Fort Peck PPCS via satellite telemetry from a data collection platform (DCP) to the MRBWM office and also to the Corps' Kansas City District for redundancy. The data include hourly releases, generation, pool elevations, tailwater elevations, water temperature and wind conditions. The daily data files include daily maximum and minimum air temperatures, precipitation, manually-entered pan evaporation and tailwater temperatures. Tailwater temperatures are obtained from a thermometer located in a turbine unit. Precipitation, air temperature and wind data are obtained from a weather station located on the intake structure. In the event the automatic data collection and transfer is not working, Fort Peck personnel fax or email hourly and daily project powerplant data to the MRBWM office and the MRBWM staff manually input the information into the Missouri River Region's (MRR) Corps Water Management System Oracle database. The Fort Peck monthly summary is faxed or emailed to the MRBWM office and is used to verify daily data.

5-02.1. When there is a significant snow accumulation during the winter season, weekly reports of the depth and water content of the existing snow cover in the vicinity of the damsite may be furnished. Reservoir ice-in and ice-free conditions and dates are reported to the MRBWM office. Reports of ice conditions downstream of the project may also be provided to the MRBWM office.

5-02.2. Throughout the year Fort Peck project personnel investigate requests and complaints that occur as a result of Fort Peck regulation and report their recommendations and findings to the MRBWM office. The MRBWM office keeps the Fort Peck project personnel advised concerning anticipated changes in releases and reservoir levels. Based on this information, project personnel assist in informing affected interests of any major change in release rates or reservoir elevations that may be scheduled, and also informing affected interests of unusual reservoir elevations that may be anticipated. System coordination is discussed further in Chapter VIII of this WCM and also in the Master Manual.

5-03. Precipitation and Temperature. Sections 5-03 and 5-04 of the Master Manual contains detailed descriptions of data collection procedures throughout the Missouri River basin. Precipitation data is available through automated precipitation gages at real-time DCP stations and observer precipitation stations, some described in greater detail later in this chapter. Spatially-distributed observed precipitation data is provided by the National Weather Service (NWS) through its quantitative precipitation estimates (QPE). Plate V-1 in the Master Manual presents NWS QPE site locations in the Missouri River basin. Forecasted precipitation grids 7 days in the future are also available for NWS quantitative precipitation forecasts (QPF) products.

The hourly QPE and 6-hour QPF files are automatically retrieved from the NWS Missouri Basin River Forecast Center (MBRFC) on a near real-time basis and stored in gridded format on the MRR Water Management System (WMS).

5-03.1. Air Temperature. Air temperature data is available via real-time DCP stations as well as through a comprehensive NWS-supported network of automated and observer stations. Spatially-distributed observed and forecasted temperature data derived by the NWS for the entire basin is provided to the MRBWM through a data exchange method developed and supported by the Corps' Cold Regions Research and Engineering Laboratory (CRREL) and HEC. The observed air temperature data is converted into a gridded format at 1-hour time steps, both for observed data and for 16 days in the future. Additionally, forecasted temperature data at 6-hour time steps is available for 5-7 days in the future. The gridded temperature files are automatically created on a near real-time basis at the Corps' Central Processing Center in Vicksburg, MS and retrieved and stored in the MRR WMS.

5-04. Snow. During the winter season, reports of snowfall and accumulated snowpack are received from numerous stations located throughout the Missouri River basin. The USDA's Natural Resource Conservation Service (NRCS) installs, operates and maintains an extensive, automated system to collect mountain snowpack and related climatic data in the Western United States called SNOTEL (SNOwpack TELemetry). SNOTEL uses meteor-burst communication technology to collect and communicate data in near real-time. The sites are generally located in remote high-mountain watersheds where access is often difficult or restricted. Basic SNOTEL sites have a pressure sensing snow pillow, storage precipitation gage and air temperature sensor. Data for the Missouri River basin are transmitted and stored in the Snow Survey and Water Supply Forecasting Program database in Kansas City, MO. The MRBWM office accesses the data via the National Water and Climate Center (NWCC) website and internet. The SNOTEL stations used by the MRBWM office are shown on Plates V-1 and V-2. Refer to Chapter V of the Master Manual and Sections 6-06 and 6-07 of this WCM for detailed discussion regarding plains and mountain snow data.

5-05. Stages and Discharges. River stage information reported to the MRBWM office as indicated by the basic network in Chapter V of the Master Manual are supplemented by reports from many tributary locations, particularly during the March-July flood season or at other times of the year if unusual stages are occurring. See Plate V-3 and Table V-1 for key locations within the incremental drainage area and directly below Fort Peck, where streamgaging stations (DCPs) are located. Additional DCP information and DCP locations can be found at the USGS Water Resources website. Daily reports of elevations and releases are furnished to the MRBWM office from the Canyon Ferry, Clark Canyon, Hebgen, Gibson, Lima and Tiber reservoirs, which are located upstream of Fort Peck, and the Fresno reservoir, which is located on the Milk River. The Milk River enters the Missouri River about 10 miles downstream of Fort Peck.

5-06. Communication during Normal Regulation. Fort Peck is regulated as a component of the System. As such, regulation must be fully coordinated with regulation of the other five projects; therefore, regulation of all System projects is directed by the MRBWM office. Full details relating to organizational responsibilities, coordination and communications pertinent to the System's regulation process are contained in Sections 5-21 through 5-23 of the Master

Manual. Consequently, only a brief summary is presented in this WCM and reference must be made to the Master Manual for a complete understanding of these factors.

5-06.1. Reservoir regulation/power production orders to mainstem project personnel and Western are the basis of the regulation process. These are issued by the MRBWM office and are based on detailed analysis of current and expected hydrologic conditions throughout the Missouri River basin and releases needed to meet the Congressionally authorized purposes of Fort Peck and the System. The MRBWM office is responsible for coordinating project regulation as described in the Master Manual and also in Chapter VIII of this WCM.

Table V-1
Key Data Collection Platforms

Corps ID	Location	USGS ID	DCP ID	ALT. ID
CLMT	Missouri River at Culbertson, MT	06185500	CE51171C	CLBM8[2]
DRMT	Dearborn River near Craig, MT	06073500	16930560	DBRM8[2]
HOLM	Missouri River below Holter Dam, MT	06066500	166BC6CC	HTRM8[2]
JDRM8	Judith River near Winifred, MT	06114700		
JRMT	Jefferson River near Twin Bridges, MT	06026500	1711701E	TWIM8[2]
LGMT	Gallatin River at Logan, MT	06052500	CE78ADF2	LOGM8[2]
MARM	Marias River near Shelby, MT	06099500	1635108E	SHLM8[2]
MCMT	Madison River at McAllister, MT	06041000	CE78FD8E	MAMT[1]
MOMT	Musselshell River at Mosby, MT	06130500	D10F618E	MSBM8[2]
NAMT	Milk River at Nashua, MT	06174500	CE512C54	NSHM8[2]
RBMT	Missouri River at Landusky, MT	06115200	CE5DC0E8	LDKM8[2]
RUMT	Musselshell River at Roundup, MT	06126500	CE78C814	RUPM8[2]
SACO	Milk River at Saco, MT	06164510	CE78D5B0	SACM8[2]
TFMT	Jefferson River at Three Forks, MT	06036650	CE78B056	TFKM8[2]
TOMT	Missouri River at Toston, MT	06054500	CE78BE84	TOSM8[2]
UL6E	Missouri River at Ulm, MT	06078200	CE78C6C6	ULMM8[2]
VAMT	Sun River at Vaughn, MT	06089000	CE78E02A	VAUM8[2]
VIMT	Missouri River at Virgelle, MT	06109500	CE512286	VRGM8[2]
VNMT	Big Dry Creek at Van Norman, MT	06131000	CE78F35C	VNRM8[2]
WPMT	Missouri River at Wolf Point, MT	06177000	CE5119CE	WPTM8[2]

[1] Denotes USBR ID if different from Corps ID
[2] Denotes NWS Handbook5 ID

5-06.2. Fort Peck personnel are expected to furnish the MRBWM office all information they may receive that is pertinent to the regulation process. This includes observations made by project personnel as well as complaints or suggestions from those affected by project regulation. In addition, project personnel assist in informing the public in the local area of current and probable near-future regulation activities. It is the responsibility of the MRBWM office to keep project personnel informed of such activities. Any requests for information that are complex and/or of a long-term nature, or that involve policy, are to be referred to the MRBWM office.

5-06.3. The Corps' Omaha District is responsible for project O&M, including maintenance of those facilities required to support the regulation process. District staff collect snow survey data pertinent to Fort Peck regulation on request by the MRBWM office. The District is also responsible for flood fighting activities in the incremental drainage area. Information that is considered pertinent to the regulation of Fort Peck, or other System projects, is to be furnished to the MRBWM office.

5-07. Emergency Regulation. If emergency conditions develop at Fort Peck, project personnel are expected to take appropriate action, which varies depending on the nature of the emergency. When there is an immediate threat of serious injury or loss of life at the project, or the probability that serious damage may occur or has occurred to project facilities project personnel are expected to take the actions deemed necessary and notify the Omaha District and the MRBWM office of the circumstances and actions initiated as soon as conditions permit. Subsequent modification or continuance of regulation of project facilities will be based on an evaluation of current conditions and potential effects by all appropriate offices. The MRBWM office will direct this evaluation to ensure complete coordination in regulation of the project and the System.

5-07.1. During critical reservoir regulation periods and to ensure timely response, significant coordination is often conducted by telephone between Fort Peck and the MRBWM office. This direct contact ensures that issues are completely coordinated and concerns by both offices are presented and considered before final release decisions are made by the MRBWM office. The MRBWM's Reservoir Regulation and Power Production team leaders, as well as the MRBWM chief, are generally available by cell phone as are the mainstem Operations Project Managers. The MRBWM weekend worker also carries a cell phone and has the responsibility of notifying the appropriate MRBWM staff so that proper coordination can occur before significant changes are made to project releases. More information on emergency regulation procedures can be found in Chapter VII of this WCM.

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VI - Hydrologic Forecasts

6-01. General. Regulation of Fort Peck as a component of the System requires continuing analysis of available hydrologic information and, to the degree practicable, forecasts of future events. These are considered in conjunction with the anticipated demands imposed in serving the various project purposes. These considerations may be of a long-term nature or may be based on anticipated inflows and demands for a relatively short period in the future. AOP studies are discussed in Section 6-12.3 of the Master Manual. Also discussed in Chapter VI of the Master Manual are analyses, forecasts and studies, while important for the regulation of Fort Peck, have essentially the same degree of importance for all of the other mainstem projects. Analyses considered to be unique or particularly important to Fort Peck regulation are presented in the following sections.

6-02. Precipitation and Temperature Forecasts. As discussed in Section 6-04 of the Master Manual, NWS precipitation and temperature forecasts are monitored by the MRBWM office. The NWS's short-term precipitation forecasts, often referred to as Quantitative Precipitation Forecasts (QPF), are not integrated into the short-range runoff forecasts for day-to-day actual regulation, but may add value for short-term planning purposes. Particularly pertinent to regulation of Fort Peck are temperature and precipitation forecasts prepared for the portions of Montana and Canada east of the Continental Divide as well as temperature forecasts during periods where an ice cover may form on the Missouri River below the project.

6-03. Runoff Forecasts. Short-range runoff forecasts are determined with water on the ground, per ER 1110-2-240, which consists of existing snowpack and recently observed rainfall. The short-range runoff forecasts, which are discussed in greater detail in Section 6-09 of this WCM, are integral to the day-to-day regulation of Fort Peck.

6-04. Precipitation-Runoff Relationships. As seen on Plate III-4, average annual precipitation in the drainage area above Fort Peck varies from 6 inches to greater than 60 inches. The majority of the drainage area receives an annual precipitation in the range of 12 to 20 inches per year. Infiltration losses in the Missouri River basin above the mouth of the Yellowstone River are estimated to be 0.75 inch for the initial loss and 0.15 inch per hour for the constant infiltration loss. These values are based on relatively few rainfall events because of the rarity of heavy rainfall centers in the area. Snowmelt infiltration ranges from zero for frozen ground, or ice under snow, to approximately the values shown for rainfall. In actual practice, estimating the rainfall or snowmelt runoff is very imprecise. This is due to the lack of a dense network of precipitation reporting stations, errors in estimating the snowpack and snow water equivalent (SWE) available for melt, errors in estimating the snowmelt rate, as well as marked departures from the previously stated average infiltration or loss rates. Use of NWS-provided QPE data has improved knowledge of rainfall events.

6-05. Unit Hydrograph Analyses. A conventional means of forecasting flows from a particular drainage area is by the use of unit hydrographs. However, unit hydrograph development and subsequent use of the developed hydrographs as a forecasting tool has been found to be largely impractical for the drainage area under consideration in this WCM. Reasons for this include the large size of the drainage area, requiring the division of the area into many sub-areas, the lack of sufficient past rainfall and subsequent runoff events for unit hydrograph definition; the scarcity of rainfall reporting stations needed for both analysis and forecasting purposes; and the fact that by far the greatest amount of runoff that occurs from this drainage area does not result from particular rainfall events but results from progressive plains and mountain snowmelt, making runoff definition during a selected time period very imprecise. Further, with the large amount of storage space available in the Fort Peck reservoir compared to the volume of runoff from individual rainfall events, and the very nature of the regulation process, the effort necessary for a valid and complete analysis by means of unit hydrograph procedures is not believed to be warranted. However, runoff forecasting procedures will continue to receive consideration as a means of possibly improving the regulation process. As discussed in the Master Manual, future runoff modeling efforts include the use of QPE within the Corps' Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS), which should improve development of reliable real-time forecasting models. Refer to the 1976 Fort Peck WCM for detailed descriptions of historical unit hydrograph analysis for the drainage area above Fort Peck.

6-06. Plains Snow. A portion of the annual runoff from the plains contributing area above Fort Peck is a result of melting the plains snowpack accumulated during the winter months. This melt usually occurs during late March or April and often results in the annual peak flow above Fort Peck. While the plains snow is a major incremental flow contributor to the lower five System projects, plains snowmelt, in comparison to mountain snowmelt, is only a minor contributor to overall runoff into Fort Peck. Basic data pertinent to plains area snowmelt volume analyses are: 1) precipitation during the late fall and winter months, 2) winter season temperatures, 3) water content of the accumulated snowpack prior to the melt period, and 4) soil conditions. However, even with these data, forecasts of the plains snowmelt runoff volume are usually quite imprecise. The MRBWM office continues to investigate new and improved techniques including soil condition instrumentation and continuous soil moisture accounting modeling to more accurately predict runoff from plains snow. Section 5-06 of the Master Manual contains additional information on snow.

6-06.1. Plains area snow surveys, requested by the MRBWM office and conducted by the Omaha District, are made during any year that a substantial snow accumulation exists over the drainage area. Results from the snow surveys are compared to the interactive snow map for modeled SWE from the NWS's National Operational Hydrologic Remote Sensing Center to help in the verification process. Snow surveys are one method of obtaining quantitative estimates of runoff volume by comparing water content of the current survey with surveys made in preceding years. This comparison will indicate which of the past years is most analogous to the current year for the total drainage basin above Fort Peck. Forecasts are developed by assuming that the volume of snowmelt runoff from this portion of the Missouri River basin should be similar to that observed in the most analogous year. These estimates are tempered by available ground condition data (e.g., frost depth, soil moisture), which could either increase or decrease the infiltration losses at the time of runoff. If analogous data are not available for a particular portion of the basin, it is necessary to estimate the runoff volume by noting runoff volumes during previous years from other areas where snowpack conditions appear similar to the current year's snowpack over the plains drainage area above Fort Peck. For the entire Missouri River basin five years in particular, 1952, 1969, 1997, 2010 and 2011, experienced floods that were largely affected by melting of heavy snowpack on the northern plains. Table VI-1 contains information related to a plains snow comparison of the five years.

6-06.2. Improvement in the techniques of forecasting the runoff resulting from plains snowmelt is an ongoing process of the MRBWM office. As technology continues to improve, more precise and objective forecasting methods are being developed. In addition, the NWS has initiated forecasts of plains snowmelt runoff volumes that are made just prior to the melt season. As experience is gained with new methods, it appears probable that better estimates of the runoff volume from plains snowmelt will be available than in the past. See Section 5-06.1.3 in the Master Manual for details regarding the Corps' Missouri Basin Snow Tool.

Table VI-1
Plains Snow in Major Floods

Late Winter Snow Moisture in Major Flood Years (SWE in Inches)						
Stream	**Location**	**17-Mar-1952***	**31-Mar-1969***	**18-Mar-1997***	**4-Mar-2010****	**11-Feb-2011****
Milk River	Nashua, MT	3.0	2.0	<1	1.5	3.2
Knife River	Hazen, ND	2.8	2.3	1.8	4.7	5.0
Heart River	Mandan, ND	3.5	3.0	1.8	4.4	4.7
Apple Creek	Bismarck, ND	3.0	3.0	3.0	4.7	5.1
Beaver Creek	Linton, ND	3.5	2.5	4.3	5.2	4.8
Cannonball R	Breien, ND	3.5	3.0	3.4	4.4	3.8
Grand River	Little Eagle, SD	3.6	2.3	2.6	3.8	2.7
Moreau River	Whitehorse, SD	4.0	2.3	1.7	3.0	1.9
Cheyenne River	Eagle Butte, SD	5.0	1.0	<1	1.2	1.0
Bad River	Fort Pierre, SD	3.0	1.5	<1	3.4	1.3
Elm River	Westport, SD	5.0	5.0	3.2	5.0	4.2
James River	Scotland, SD	3.6	4.0	3.9	4.6	4.0
Vermillion R	Wakonda, SD	0.5	4.5	3.4	3.5	3.2
Big Sioux River	Watertown, SD	3.8	4.2	4.2	6.7	5.3
Floyd River	Sioux City, IA	0.5	3.3	0	4.3	3.2
Little Sioux R	Turin, IA	0	3.2	<1	5.1	2.4

*From the 1997 Midwest Floods Post Flood and After Action Report, Volume 1
**From working files of Hydrology and Meteorology Section, Hydrologic Engineering Branch, Omaha District.

6-07. Mountain Snow. A large portion of the annual runoff entering the Fort Peck reservoir occurs during the May-July period of which snowmelt runoff from the mountainous portions of the basin is an important component. Fort Peck and Garrison are the only two mainstem projects that directly capture runoff from mountain snowmelt. Based on the 1898-2014 historical record, 37 percent of the total runoff in the upper basin occurs in Fort Peck and Garrison during this 3-month period. As discussed in Section 5-04 of this WCM, numerous NRCS SNOTEL stations are in operation that collect and transmit snowpack and related climatic data in near real-time.

From October 1 to July 1 the MRBWM office regularly determines the amount of snowpack, in terms of percent of normal, for the drainage basin above Fort Peck. The MRBWM office tracks the amount of SWE in the snowpack throughout this 9-month period. Table VI-2 and Plates V-1 and V-2 present the NRCS SNOTEL stations and corresponding drainage basins used in the mountain snowpack analysis.

6-07.1. The May-July runoff forecasts for Fort Peck are developed using simple and multiple linear regression equations. The equations predict historical May-July runoff from:

a. average SWE,
b. average accumulated May-July precipitation,
c. average maximum April-June air temperature,
d. observed May runoff, and
e. observed June runoff.

The methodology for the runoff forecasts are documented in an MRBWM Technical Report, *Long-Term Runoff Forecasting,* dated February 2017. The mountain snowpack peak generally occurs in mid-April. The NRCS daily-reporting SNOTEL stations used in this runoff forecast analysis are listed in Table VI-2. The May-July runoff forecasts are generated on a monthly basis beginning on January 1. Similar runoff forecasts are generated by the NWS and NRCS. The three agencies readily share their forecasts and communicate when conditions warrant.

Table VI-2
Mountain Snowpack above Fort Peck Dam - SNOTEL Stations

Drainage Basin	SNOTEL Stations
Gallatin River	Brackett Creek, Lick Creek, Sacajawea, Shower Falls
Jefferson River	Albro Lake, Barker Lakes, Beagle Springs, Bloody Dick, Calvert Creek, Clover Meadow, Darkhorse Lake, Divide, Frohner Meadow, Lakeview Ridge, Lemhi Ridge, Lower Twin, Moose Creek, Mule Creek, Rocker Peak, Saddle Mountain, Short Creek, White Elephant
Madison River	Beaver Creek, Black Bear, Carrot Basin, Lone Mountain, Madison Plateau, Tepee Creek, West Yellowstone, Whiskey Creek
Smith, Judith and Musselshell Rivers	Boulder Mountain, Crystal Lake, Daisy Peak, Deadman Creek, Elk Peak, Nevada Ridge, Pickfoot Peak, Porcupine, Spur Park, Tizer Basin
Sun, Teton and Marias Rivers	Badger Pass, Dupuyer Creek, Mount Lockhart, Pike Creek, Waldron, Wood Creek
Saint Mary and Milk Rivers	Flattop Mountain, Many Glacier, Rocky Boy

6-08. Monthly Reach Inflow (Runoff) Forecasts. Soon after the first of each month throughout the year a forecast of incremental monthly inflows to the System reservoirs, including those originating above Fort Peck, is prepared by the MRBWM office. The drainage area above Fort Peck reach normally generates the second-most annual runoff (Fort Peck to Garrison is first) of the five incremental areas defined by the individual mainstem projects. Forecasts of monthly reach inflow or runoff extend from the current date through the remainder of the calendar year to March 1 of the succeeding year. These forecasts are utilized to develop System regulation studies, as described in Section 6-12 of the Master Manual.

6-08.1. Monthly reach inflow or runoff forecasts are based on, but are not limited to, monthly average reach runoff, antecedent reach runoff, antecedent soil moisture conditions, accumulated station and/or reach precipitation during March-April and May-July, observed reach temperature, accumulated snow over the incremental drainage area and accumulated mountain SWE. In the Fort Peck reach, snow contributions include mountain and plains snowmelt. Estimation of this snowmelt runoff is important during the early spring (March-April), the period of plains snowmelt runoff, as well as during the late spring and early summer (May-July), the period of mountain snowmelt runoff. There have been years when warmer-than-normal January and February temperatures have resulted in some or all of the plains snow melting during these months. Consequently, long-range reach inflow forecasts for periods other than the spring and early summer periods consist primarily of modifying the long-term normal runoff volume by observed antecedent basin conditions. These forecasts are utilized to develop System regulation studies, as described in Section 6-12 of the Master Manual. Details and techniques currently applicable for forecast development are contained in the MRBWM technical report on long-term runoff forecasting, described in Section 6-07.1 of this WCM.

6-09. Short-Range Forecasts of Daily Inflow. The MRBWM office develops forecasts of future daily inflows to the Fort Peck reservoir and the other associated System reservoirs at frequent intervals. Each week daily inflow forecasts extending three weeks or more into the future are developed. Experience has indicated that the most satisfactory method of anticipating the Fort Peck reservoir inflows for periods of up to a week or two beyond the current data is a combination of routing observed flow from upstream and tributary locations and extrapolating incremental inflows above or between observation points. With the large amount of storage space available in Fort Peck, forecast emphasis is not toward exact definition of the incremental inflow hydrograph, but rather toward a definition of incremental inflow volumes over a relatively longer period of time (a week or more) so that release adjustments from upstream projects, and on occasion from Fort Peck, can be scheduled to meet regulation objectives. As discussed in the Master Manual, future runoff modeling efforts include the use of observed gridded precipitation in the Corps' HEC-HMS models.

6-10. Stage-Discharge Relationships. Stage-discharge relationships, sometimes referred to as rating curves, are maintained by the MRBWM office for key tributary streamflow stations in the Fort Peck incremental drainage area. These are kept current on the basis of discharge measurements made by the USGS. Plates VI-1 through VI-4 show the present stage-discharge relationships at key locations, in table format, that are used to develop short-range inflow forecasts pertinent to Fort Peck regulation. The stage-discharge relationships for key locations, in curve format, are shown in Plates VI-5 through VI-17.

6-11. Forecasts of Downstream Locations. Fort Peck releases flow 204 miles downstream to the Garrison reservoir. The Poplar River is the only major unregulated tributary in the 204-mile reach from Fort Peck Dam to the Garrison reservoir. The Milk River, which is provided some regulation by Fresno Dam, a non-flood control USBR project located 14 miles west of Havre, MT, enters the Missouri River about 10 miles downstream of Fort Peck. The majority of flow in the reach downstream of Fort Peck is directly attributable to Fort Peck releases and flows from the Milk River. Historical regulation has shown that stages at Wolf Point and Culbertson up to 21 feet and 13 feet, respectively, do not cause significant flood damages. During the winter season, the ice-covered channel capacity through this Missouri River reach is limited to 10,000 cfs at the time of ice formation, increasing to over 15,000 cfs after the ice cover has stabilized. Refer to Section 4-05.2 of the Master Manual and Section 3-14.1 of this WCM for further description of the Missouri River reach from Fort Peck Dam to the Garrison reservoir.

6-12. Routing Procedures. A simple translation of observed or anticipated upstream flows by the approximate travel time from the upstream location is an adequate routing procedure for the purpose of forecasting inflow into Fort Peck. The large storage capacity of the Fort Peck reservoir and associated regulation procedures do not require precise definition of anticipated inflows. The lack of information from a considerable portion of the Fort Peck incremental drainage area also precludes such precision.

6-12.1. Routing procedures are also utilized to translate the effects of upstream reservoirs to Fort Peck in order that the total reservoir effects at this location may be determined. These procedures are based on travel time to Fort Peck which would be appropriate prior to the development of either tributary or mainstem reservoirs. A simple lag-average routing method is used with coefficients as presented in Table VI-3.

Table VI-3
Lag Average Routing Coefficients
Upstream Dams to Fort Peck Reservoir Headwaters

Dam	Average Days	Lag Days
Clark Canyon	5	8
Canyon Ferry	4	7
Gibson	3	6
Hebgen	3	6
Tiber	2	4
Fort Peck reservoir headwaters to dam	1	3

Note: 1. Data averaged is at the average daily rate.
2. Lag given is the number of days from the last day of average daily values averaged.

6-13. Evaporation. Due to the large surface area, evaporation is an important component of the overall water budget of the Fort Peck reservoir. An estimate of the daily evaporation volume is required for developing daily inflow estimates and for more precisely estimating the effects of reservoir development on the available water supply. Observed pan measurements are taken daily at Fort Peck and then factored by an average monthly pan coefficient to determine the lake evaporation. During those portions of the year when pan data were not available, normal evaporation depths for each month was considered the most practical means of developing evaporation estimates for day-to-day regulation activities. Pan coefficients and monthly evaporation rates were taken from the June 1973 MRD-RCC Technical Report JE-73 titled, *Missouri River Main Stem Reservoir System, Reservoir Evaporation Estimates*. Plates III-9 through III-12 show pertinent evaporation information for the System reservoirs.

6-13.1. The MRBWM office and Omaha District partnered with the Corps' Cold Regions Research and Engineering Laboratory (CRREL) to develop a more accurate real-time model, known as the Omaha District Evaporation Technique, to determine reservoir evaporation. This real-time model uses local meteorological hourly parameters of air temperature, dew point, wind speed, relative humidity, air pressure and cloud cover to calculate solar radiation in addition to water temperature profiles. The MRBWM office plans to implement this new technique in 2019.

6-13.2. In addition to evaporation, development of the effects of the Fort Peck reservoir on streamflow must consider the offsetting effects of precipitation on the reservoir surface and must also make allowances for the channel area in existence prior to the impoundment of water in the reservoir. Also, allowance must be made for that portion of the rainfall now falling on the reservoir surface that prior to the formation of the reservoir would have contributed to direct runoff from the area now inundated. Precise calculations of these factors are impractical. As stated in MRD-RCC Technical Report JE-73, it is estimated that 75 percent of the precipitation that falls on the reservoir today historically would not have flowed into the Missouri River. This assumes that 10 percent of the precipitation would have fallen on original channel area and that 15 percent would have appeared as direct runoff from the former ground surface now inundated by the reservoir.

6-14. Wind Effects on Water Surface Elevations. The general orientation of the Fort Peck reservoir is from west-southwest to east-northeast although the major Dry Creek arm of the reservoir has a south-to-north orientation. The pool level recorder, which forms the basis for estimates of storage, storage change and inflows, is located at the damsite. Due to the orientation of the reservoir, winds from a direction having a southwesterly component result in pool level set-up at the dam while a wind from the northeast would results in a pool level set-down. See Plate VI-18 for wind correction tables for the pool level recorder at the dam at various elevations. An anemometer is located near the dam; however, it should be recognized that only approximations of the wind effect on the reported pool level can be obtained with data from this instrument. The time required for set-up to be fully established, variations in wind velocity and direction over the entire reservoir surface, and the difficulty of having one location represent the entire length of the reservoir, will result in deviations from calculated values. Synoptic surface weather maps may also be used for qualitative wind estimates or to determine the probable representativeness of the anemometer.

6-15. Daily Inflow Estimates. Estimates of inflow to the Fort Peck reservoir are made each day by the MRBWM office for regulation purposes. The steps involved consist of:

a. plotting hourly pool elevations as reported by the Corps' PPCS at Fort Peck;
b. utilizing reported wind reports to estimate the set-up or set-down effects on the reservoir to select an estimated midnight pool elevation;
c. calculating the reservoir storage change equivalent to the estimated 24-hour reservoir elevation change; and

d. using all this information, in conjunction with reported releases and estimated evaporation, to compute the daily reservoir inflow.

6-15.1. At times it will be necessary to adjust data for previous days on the basis of continuing trends in the reservoir level that were not evident during those days. See Plates VI-19 through VI-24 for regulated and incremental inflow volume probability relationships for various durations. Since there are no System reservoirs upstream of Fort Peck, there is little difference between the regulated and incremental inflow volume probabilities for Fort Peck. More information on the inflow volume probability for the mainstem projects can be found in the MRBWM Technical Report, *Hydrologic Statistics on Inflows*, July 2015.

6-16. Unregulated Flows. Construction of the Fort Peck project, together with the other mainstem and tributary projects in the basin, has materially altered flows downstream from the dam. Flood peaks have been reduced and low flows augmented by reservoir regulation. A quantitative estimate of the effects of regulation upon flows at the damsite and important locations immediately downstream is frequently required. This represents a continuing effort by the MRBWM office, and involves such factors as reservoir evaporation, precipitation on the Fort Peck reservoir, variations in travel time resulting from reservoir development, channel area inundated by the reservoir, runoff that could have been expected from previous overbank areas now inundated by the reservoir, inflows, releases and storage changes. Refer to the MRD-RCC Technical Study S-73, *Upper Missouri River, Unregulated Flow Development*, dated September 1973, for additional details of the analysis.

6-16.1. In addition to unregulated flows, determination of flows at the 1949 level of basin development prior to construction of the other five mainstem dams and other water resource development in the Missouri River basin represents a continuing effort of the MRBWM office. Fort Peck represents a location where such determinations are made. Reference is made to Section 6-15 of the Master Manual for further details of these analyses.

6-16.2. Refer to Plates VI-25 through VI-37 and Table VI-4 for flow probability relationships for tributary and Missouri River locations in the Fort Peck incremental area. The flow probability relationships were developed for five tributary streams flowing into the Missouri River above Fort Peck (Jefferson, Madison, Gallatin and Musselshell Rivers and Big Dry Creek); four locations on the Missouri River upstream of Fort Peck (Toston, Ulm, Virgelle and Landusky); two locations on the Milk River tributary that enters the Missouri River just downstream of Fort Peck Dam (Saco and Nashua); and two locations on the Missouri River downstream of Fort Peck (Wolf Point and Culbertson).

6-17. Evaluation of Regulation Effects. In evaluation of the effects of regulation on downstream flows, and consequent flood damage reduction estimates, Fort Peck is considered to be a component of the total System. Damage reductions attributable to regulation of this individual project are not differentiated from those resulting from the six-project System as a whole. Details of the evaluation process are presented in Sections 6-15 and 6-16 of the Master Manual.

Table VI-4
Tributary Flow Probability Relationships

Tributary	Drainage Area (sq. mi.)	Peak Discharge (in cfs) for Given Return Period (in years)			
		10	50	100	500
Jefferson River near Three Forks, MT	9,558	15,200	21,900	24,800	31,600
Madison R bl Ennis Lk near McAllister, MT	2,150	7,200	9,100	9,900	11,600
Gallatin River at Logan, MT	1,789	7,700	9,600	10,400	12,000
Missouri River at Toston, MT	14,641	27,800	34,700	37,300	42,700
Missouri River near Ulm, MT	20,605	27,100	37,800	42,300	52,600
Missouri River at Virgelle, MT	34,000	48,800	83,600	103,000	161,800
Missouri River near Landusky, MT	40,649	59,900	104,000	129,000	202,000
Milk River at Juneberg Br near Saco, MT	17,691	9,100	18,300	23,100	36,400
Milk River at Nashua, MT	22,452	15,300	26,800	32,500	47,800
Musselshell River at Mosby, MT	7,784	12,300	25,400	32,900	55,200
Big Dry Creek near Van Norman, MT	2,551	10,900	24,200	31,000	49,300
Missouri River near Wolf Point, MT	80,650	35,200	56,000	67,100	99,800
Missouri River near Culbertson, MT	89,858	38,100	64,300	79,100	125,000

6-18. Ice Formation below Fort Peck Dam. Refer to Section 7-19 of this WCM for details on optimum regulation of Fort Peck during the winter months.

6-19. Long-Term Studies. Simulated regulation of Fort Peck as a component of the System, through the entire period of available hydrologic record, is a technique utilized by the MRBWM office for the development and improvement of regulation criteria. Current regulation criteria are the result of many involved and detailed studies, augmented by actual regulation experience. Accomplishment of the long-term studies is described in Chapter VI and Appendix H of the Master Manual and in the detailed reports that have been published describing specific studies. From the long-term studies that incorporate current regulation criteria and water use, as well as studies that assume various potential future levels of water resource development in the Missouri River basin, long-term examples of Fort Peck regulation are available. From the examples incorporating the present level of water resource development, conclusions relative to regulation of Fort Peck can be established, as described in succeeding sections.

6-20. Long-Range Streamflow Forecasts. As noted in previous sections in this chapter, forecasts are prepared by the MRBWM office as a guide for making estimates of annual and seasonal water yields and for scheduling of releases for the regulation of Fort Peck. Forecasts of water supply and extended period runoff for the upper Missouri River basin above Fort Peck issued by other agencies are described in Sections 6-20.1 through 6-20.3.

6-20.1. NRCS Water Supply Forecasts. Data are collected and a report titled *Snow Survey and Water Supply Forecasts* is published by the NRCS's NWCC and are available via the internet: http://www.wcc.nrcs.usda.gov/wsf. These publications contain forecasts of water supply and data pertaining to mountain snow accumulation.

6-20.2. NWS Water Supply Forecasts. These forecasts are published on the first of the month, January through May, and cover the period of a water year (October through September) and the residual portion of the water year remaining after the forecast date. These forecasts are available via the internet: http://www.crh.noaa.gov/mbrfc/?n=water.

6-20.3. USBR Water Supply Forecasts. These forecasts are long-range volume forecasts largely for the operation of their tributary reservoirs located in the upper Missouri River basin. The forecasts are published on the first of each month, February through October. These forecasts are available via the internet: http://www.usbr.gov/gp/lakes_reservoirs/.

6-21. Frequency Estimates. Frequency of occurrence estimates of reservoir elevations and releases at each of the System reservoirs were developed as described in MRBWM Technical Report *Hydrologic Statistics*, dated September 2013. Per Table 4 of that report, the 1 percent chance of exceedance pool elevation for Fort Peck is estimated to be 2252.5 feet. The historic maximum level experienced was 2252.3 feet in June 2011. Per Table 5 of that report, the 1 percent chance of exceedance maximum release from Fort Peck is estimated to be 60,000 cfs. The historic maximum release experienced was 65,900 cfs in June 2011.

6-22. Fort Peck Elevations. Reservoir records, since when the System closed in 1967, indicate the levels of the Fort Peck reservoir have fluctuated from a minimum pool of 2196.2 feet (2007) to 2252.3 feet (2011). The minimum pool level was 37.6 feet below (2234.0 feet) and 36.2 feet above (2160.0 feet) the top and bottom of the Carryover Multiple Use Zone, respectively. The maximum pool was 2.3 feet above the top of Exclusive Flood Control Pool Zone (2250.0 feet). Since the System closed, utilization of the Exclusive Flood Control Zone, elevation 2246.0 to 2250.0 feet, was required in 1969, 1970, 1975, 1976, 1978, 1979, 1996, 1997, 2011 and 2018. Average levels of the Fort Peck reservoir range from a low of 2227.0 feet in February to a high of 2233.0 feet in July with an average elevation of 2229.7 feet, 4.3 feet below the base of the Annual Flood Control and Multiple Use Zone. Extreme low elevations, below elevation 2210.0 feet, occurred during the last two extended droughts in 1990, 1991, 1993 and 2003-2009.

6-22.1. The Fort Peck reservoir elevation-duration curve, shown on Plate VI-38, indicates that a reservoir level at or above elevation 2234.0 feet, the base of the Annual Flood Control and Multiple Use Zone, can be expected just over 55 percent of the time while the reservoir level at or above an extreme low elevation of 2210.0 feet can be expected between 80 and 90 percent of the time. A pool-probability relationship of annual maximum Fort Peck elevations is shown on Plate VI-39. The relationship was developed from the long-range study analysis using the Daily Routing Model (DRM) simulation, as tempered by actual regulation experience of Fort Peck to date. The curve indicates that a maximum annual reservoir level at or above the base of the Annual Flood Control and Multiple Use Zone of 2234.0 feet can be expected in seven years out of every ten. An elevation of 2246.0 feet, the base of the Exclusive Flood Control Zone, is expected to be equaled in one year out of every five. Further particulars regarding development of these pool-duration and pool-probability curves are given in MRBWM Technical Report, *Hydrologic Statistics*, dated September 2013.

6-22.2. Average Fort Peck reservoir levels and normal seasonal variations since 1967 are shown on Plate VI-40. This plot of average monthly data shows the characteristic elevation rise during the March-July period. During these five months, runoff into the Fort Peck reservoir increases due to plains snowmelt (March-April), mountain snowmelt (May-July) and spring rainfall events (March-July), followed by a corresponding gradual decrease in levels through the remaining eight months of the year.

6-23. Fort Peck Releases. The Fort Peck flow duration curve, shown on Plate VI-41, indicates that releases in excess of the powerplant capacity of about 16,000 cfs will be rare, occurring only about 2 percent of the time. The median release from Fort Peck is about 9,200 cfs. The frequency curve of annual maximum releases shown on Plate VI-42 was developed from long-term regulation study (DRM) results augmented by data experienced during actual regulation. Further particulars regarding development of these frequency curves are given in the *Hydrologic Statistics* report referenced in Section 6-22.1.

6-23.1. Average monthly and daily inflows and releases based on System regulation (since 1967) are shown on Plate VI-40 and illustrate the seasonal release pattern. Releases are generally shaped to provide higher releases in the summer and winter periods. Higher releases from Fort Peck in the winter partially compensate for the reduction of generation at the projects downstream of Garrison.

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Missouri River Basin
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VII - Current Water Control Plan

7-01. Multiple Purpose Regulation. Aspects of multi-purpose regulation that are pertinent to the System as a whole are discussed in Chapter VII of the Master Manual. Since continuing development of System regulation plans requires coordination of plans for all mainstem projects, this subject has been explored thoroughly in the Master Manual and will not be repeated in this, the Fort Peck WCM. Rather, the following sections will be concerned with amplifying the regulation objectives and requirements given in the Master Manual that are pertinent to regulation of Fort Peck for the authorized purposes of flood control, hydropower, navigation, water supply, water quality control, irrigation, recreation and fish and wildlife, which includes T&E species. Regulation of Fort Peck for flood control is discussed later in this chapter.

7-02. Basis for Service. As an introduction to regulation of Fort Peck, the need to conform to certain storage provisions and basic regulation criteria should be recognized. The bottommost zone, the Permanent Zone, is the portion of the reservoir lying below elevation 2160.0 feet and is to remain permanently filled with water. This ensures maintenance of minimum power heads, a minimum level for the design of irrigation diversion and other water supply facilities, and a minimum pool for recreation and fish and wildlife purposes. The Carryover Multiple Use Zone extends from 2160.0 to 2234.0 feet. This zone is to be used to provide service to authorized purposes during droughts. The Annual Flood Control and Multiple Use Zone extends from 2234.0 to 2246.0 feet, and is the preferred operating zone. Ideally, the runoff year begins with all 12 feet available to capture runoff during the wetter late winter, spring and early summer periods. The stored waters are then evacuated during the drier late summer, fall and winter periods to meet all authorized purposes. The Exclusive Flood Control Zone extends from elevation 2246.0 to 2250.0 feet. This zone is reserved exclusively for flood control regulation of major floods. The next zone is the Surcharge Zone, which is from elevation 2250.0 feet, the elevation of the gates when closed, to elevation 2256.1 feet, the maximum flood pool elevation from the routing of the Spillway Design Flood (SDF). This zone, which does provide some downstream flood risk reduction, is used during extreme flooding events. When the pool elevation is in this zone, release decisions are primarily made to ensure the safety of the project. Embankment freeboard is provided above the Surcharge Zone from elevation 2256.1 feet to the top of the dam embankment (2280.5 feet).

7-03. General Approach to Regulation. The following general approach is observed during regulation of Fort Peck:

a. Regulation of Fort Peck as an individual project must be subordinate to regulation of the entire System as a whole.
b. Flood control will be provided for by evacuating storage space in the reservoir above elevation 2234.0 feet, to the degree practicable, prior to the start of the runoff season, approximately March of each year.

c. At all times when an adequate reserve of vacant flood control storage space is available, releases will be made in a manner to not contribute to significant flooding along the Missouri River between Fort Peck and Garrison reservoir.
d. All irrigation and water requirements for beneficial consumptive purposes will be served to the extent reasonably possible.
e. Releases will be sufficient to serve irrigation, water supply and water quality demands in the reach extending from Fort Peck Dam to the Garrison reservoir. In this context, the Corps' responsibility is to maintain an adequate flow quantity, with downstream users responsible for providing satisfactory intake facilities to divert the needed water supply.
f. Within the limits designated above, Fort Peck will participate in the intra-system adjustment of releases to achieve optimum power generation to the degree consistent with other multiple-purpose uses.
g. Releases from the System to support Missouri River navigation will be backed up by releases from Fort Peck as appropriate to maintain storage reserves in the System at a generally balanced level.
h. Insofar as possible without serious interference with the aforementioned, Fort Peck will be regulated for maximum benefit to recreation and fish and wildlife, including T&E species.

7-04. Irrigation. The effects of depletions on streamflow due to irrigation are considered in the regulation planning for the System as described in the Master Manual. Maintenance of adequate downstream flows is the only active regulation required of Fort Peck for this Congressionally authorized purpose since there are no significant acreages irrigated by pumping from the reservoir. Releases of sufficient quantity to meet irrigation diversion requirements along the Missouri River below the dam are made at all times, but supplemental releases to provide desirable river levels for satisfactory intake operation are made only to the degree that available water supply and equitable regulation for other project purposes will permit. As stated in Section 7-11.3.1 in the Master Manual, irrigation demands below Fort Peck Dam during the irrigation season currently call for a flow of 6,000 cfs as a minimum; however, the formation of sandbars has at times restricted flows to some intakes in this reach. Recent regulation experience has indicated that, when possible, adjusting Fort Peck releases through the late spring and summer to target a minimum flow of 8,000 cfs at the Missouri River at Culbertson streamgaging station provides adequate flows for irrigation intakes located in the Missouri River reach downstream of Fort Peck. Per Section 7-10.2.1 of the Master Manual, a year-round instantaneous minimum release of 3,000 cfs was established at Fort Peck in 1992 for the trout fishery located in the Dredge Cuts immediately below Fort Peck Dam.

7-04.1. Table E-3 in Appendix E of the Master Manual lists the Missouri River water supply intakes throughout the System. Current estimates show that there are approximately five irrigation intakes from the Missouri River in the Fort Peck reservoir and 283 irrigation intakes from the Missouri River between Fort Peck Dam and the Garrison reservoir. If other irrigation withdrawals directly from the Fort Peck reservoir or the Missouri River downstream of the dam should develop, similar regulation responsibilities are anticipated. Access to the available water supply from each System reservoir and the Missouri River is the responsibility of the intake owner.

7-05. Water Supply and Water Quality Control. Fort Peck is regulated to provide sufficient streamflow in the reach between Fort Peck and the headwaters of the Garrison reservoir for municipal water supply and water quality purposes. The town of Fort Peck maintains the only municipal intake at Fort Peck. The intake is fed from the penstocks and the tap is located downstream of the dam. There is a cross connection so the intake can be fed from either powerplant. The Corps owns the taps, valves and line from the penstock to the point exterior to Powerplant No. 1, located just south of the Switchyard No. 1 boundary fence.

7-06. Navigation. All Fort Peck releases are re-regulated by downstream System reservoirs prior to serving the System's navigation function. Consequently, the regulation of Fort Peck for this function consists primarily of backing up the downstream System projects' navigation releases. This is not a day-by-day regulation consideration, but a long-term operation, approaching an annual water scheduling matter.

7-07. Power Production. Hydroelectric power generated by Fort Peck is integrated with the power generated by the other System projects and many other public and private generation facilities in the Missouri River basin and surrounding areas. To the extent practical all releases are made through the powerplants. Since 1967 when the System filled, releases greater than the combined powerplant capacity of about 15,000 to 16,000 cfs have occurred in 1971, 1976, 1979, 1997, 2011 and 2018.

7-07.1. The Western system power dispatcher in Watertown, SD schedules hourly loading of the Fort Peck powerplants. These loadings must be within limits prescribed by the MRBWM office. These limits are developed on the basis of daily, as well as hourly releases, required to serve functions other than hydropower generation. Due to changing power load during the day, releases may fluctuate between 3,000 cfs, the minimum water supply release, and approaching 16,000 cfs, the maximum powerplant release. Further discussion on power scheduling is presented in Section 7-12 of the Master Manual.

7-07.2. During years of normal or below normal water supply there will also be a seasonal variation in Fort Peck power releases, reflecting concurrent service being provided to other functions as well as the seasonal nature of power demand. During the navigation season relatively large releases are required from the lowermost System project (Gavins Point) to provide flow support for navigation, especially during the drier August-November portion of the navigation season. The Gavins Point releases are normally backed up by correspondingly large releases from the Fort Randall, Big Bend and Oahe projects, since the lower three projects contain a relatively small amount of the total storage in the System. These releases generate substantial amounts of power, leaving a lesser portion of the firm power loads to be served by Garrison and Fort Peck. To avoid generating more power than can be marketed advantageously under these circumstances and to provide more winter hydropower, the usual practice during this time of year is to hold releases and generation at Fort Peck and Garrison at lower levels unless the evacuation of flood control storage space or the desire to balance reservoir storages between projects becomes an overriding consideration. During the winter months when navigation is not supported, releases from the downstream reservoirs are usually restricted to less than half their navigation season level due to the reduced capacity of the ice-covered Missouri River channel. Winter is also a season of peak firm power demands over a large portion of the System's marketing area. Consequently, Fort Peck releases during the winter season are often at a higher rate consistent with the ice-covered channel capacity from the dam downstream to the Garrison reservoir. These winter higher releases are also used to refill the vacated space in the Fort Randall reservoir, as detailed in the Fort Randall WCM.

7-08. Fish and Wildlife. Regulation of the Fort Peck reservoir for fishery purposes largely involves pool level manipulations, which will provide a suitable environment for the spawning and initial growth of game and forage fish. Steady or rising reservoir levels through the late-March to early-July period are desirable for this purpose. However, the ability to provide steady-to-rising pool levels in the upper three reservoirs in low runoff years is very dependent on the volume, timing and distribution of runoff. As part of the overall plan, an effort is made to rotate emphasis among the upper three reservoirs during the low runoff years when it may not be possible to keep all three reservoirs rising. Typically, Fort Peck and Oahe are scheduled to be favored in the same year while Garrison is favored in the following year if runoff conditions require it. Additionally, some species such as the northern pike require the inundation of terrestrial vegetation during late March and April for a suitable spawning habitat. Providing such conditions becomes rather complex and difficult considering typical runoff and regulation requirements for other purposes. Since prolonged inundation destroys terrestrial vegetation, it can only be re-established by lowering and maintaining the Fort Peck reservoir level below the vegetative zone for an extended length of time during the growing season. The growing season coincides with the March-July flood season; therefore, maintenance of lowered pool levels to establish vegetation becomes practical only when inflows during this period are well below average. After terrestrial vegetation is established, successful spawning requires that it be inundated during the late-March through April pike spawning period. In view of the typical Fort Peck regulation pattern, with pool levels lowered through the fall and winter months after the end of the growing season, inundation of terrestrial vegetation established during the preceding year prior to the end of April is not practical unless well-above-average runoff from plains snowmelt occurs at the time. Due to the difficulties involved, pool level manipulations of the Fort Peck reservoir specifically designed to enhance spawning of northern pike have not been possible up to this time. However, the possibility of this type of regulation during future years when runoff conditions are appropriate, should be recognized. Refer to Appendix D of the Master Manual and Appendix D of this manual for further discussion of fish and wildlife.

7-09. Threatened and Endangered Species. Since 1986, releases from Garrison, Fort Randall and Gavins Point have been modified to accommodate endangered interior least tern (least tern) and threatened piping plover (plover) nesting. Releases from Fort Peck were also modified for several years, but no longer are due to the nesting patterns below that project. Planned operations to address Endangered Species Act (ESA) requirements will normally be provided in the AOP. Daily hydropower peaking patterns are developed prior to nest initiation in early to mid-May and are provided to Western. Peaking may be restricted in both magnitude and duration at Garrison and Fort Randall. Refer to Appendix D of this WCM for further discussion of fish and wildlife.

7-10. Recreation. Water-based recreation at Fort Peck is dependent on the constructed access facilities. Boat ramps at the reservoir public use areas as described in Section 4-09 of this WCM have top elevations varying from 2255.0 to 2246.0 feet and bottom elevations from 2229.0 to 2179.0 feet. Recreational use of Fort Peck is enhanced by near full pool levels and will be adversely affected during those periods of low inflows when a loss of storage becomes necessary to sustain downstream multi-purpose demands. In addition to reducing the water surface area available for recreation, continued drawdown results in the exposure of increasing areas of mud flats which are unpleasant in appearance. As a consequence, when a loss of System storage below the essentially full condition occurs during extended dry (i.e., drought) periods, the storage loss is distributed, insofar as practicable, amongst the upper three reservoirs in the System, which includes Fort Peck. This distribution is made so that no one project bears the brunt of these adverse circumstances. Additionally, with a loss in System storage, the service to downstream project purposes is reduced. With this reduction in service the effects of drought periods on recreation and related functions are ameliorated to some extent.

7-11. Release Scheduling. As discussed in the Master Manual, scheduling of releases from Fort Peck and the other System projects is normally based on continuing studies by the MRBWM office in which all authorized purposes, including flood control, are considered. These studies are made at maximum intervals of one month and incorporate current conditions with the most recent estimates of future runoff, as expressed in terms of forecasted inflow, to the individual System projects. Service to all authorized purposes receives consideration including current projections of power demands and navigation requirements. The frequency of these studies, perhaps resulting in modifications of the Fort Peck reservoir levels, is increased when previously unanticipated inflows occur that may have a substantial effect on System regulation. An example of these studies is included in the AOP, published each year as described in Section 6-12.3 of the Master Manual.

7-11.1. On a short-term basis there are often modifications to the general long-term scheduling of Fort Peck releases. As discussed in the Master Manual, a short-range forecast is prepared in addition to the long-term monthly forecasts. The Three-Week forecast is developed using a short-range System regulation model of the same name. The forecast presents forecasted inflows, releases, reservoir elevations and hydropower generation for a 3- to 5-week period for each of the System projects. The forecast serves as a guide for short-term System modifications and is used to make regulation adjustments within the range normally determined by the long-term monthly studies.

7-11.2. Reservoir regulation/power production orders, furnished by the MRBWM office to operating personnel at Fort Peck and Western, are the basis for scheduling average daily releases from Fort Peck. Since exact daily power demands cannot be anticipated, reservoir regulation/power production orders usually allow a specified variation from the scheduled average daily release rate. Hourly patterning of the Fort Peck average daily release rate within limits prescribed by the MRBWM office is accomplished by Western's scheduling of daily power production.

7-12. Objectives of Flood Control Regulation. The flood control regulation objectives of Fort Peck are: 1) to coordinate regulation of Fort Peck with the regulation of the other System projects to prevent runoff from the drainage basin above Fort Peck from contributing to damaging flows through the lower reaches of the Missouri River and 2) to utilize available storage space in the best possible manner to prevent or reduce flooding in the reach from Fort Peck to the Garrison. The first objective given is the primary flood control objective for the mainstem System as a whole. As a consequence, it is discussed in Section 7-04 of the Master Manual. The concerns of this WCM are to amplify System regulation procedures as they apply particularly to Fort Peck and to discuss regulation pertaining to the reduction in flooding along the Missouri River immediately below Fort Peck.

7-13. Method of Flood Control Regulation. In general, the developed method of regulation of Fort Peck may be classified as Method C, as defined in EM 1110-2-3600. This represents a combination of the maximum beneficial use of the available storage space in the Fort Peck reservoir during each flood event with regulation procedures based on the control of floods of approximate project design magnitude.

7-14. Storage Space Available for Flood Control Regulation. During any specific flood event all available space in Fort Peck will be utilized to the maximum extent practicable for flood control purposes. The control of floods will be combined with regulation for other beneficial water uses. Storage space allocated for flood control in the Fort Peck reservoir totals 3.7 million acre-feet (MAF). Of this total, 1.0 MAF is in the Exclusive Flood Control Zone, to be utilized only during unusually large flood season inflow periods. The remainder of the storage space is in the Annual Flood Control and Multiple Use Zone that will be filled seasonally to the extent required by the available water supply, and subsequently evacuated in the interest of flood control and other beneficial uses. Surcharge storage space has also been provided in Fort Peck to ensure the safety of the project during extreme floods. However, utilization of this storage will usually provide some downstream flood reductions during these extreme flood events. Storage space in the Carryover Multiple Use Zone, when evacuated, will also serve the flood control function although deliberate evacuation of this space to serve flood control will not be scheduled.

7-15. Replacement Flood Control Space. As described in Section 4-15 of this WCM and Section 7-04.4 of the Master Manual, three Missouri River basin USBR tributary reservoirs above Fort Peck – Tiber, Clark Canyon and Canyon Ferry – have a portion of their available storage space allocated to flood control use on a “replacement” basis. Replacement storage is defined as tributary reservoir storage space that is regulated in close coordination with the System and, as a consequence, can replace a portion of the System’s Annual Flood Control and Multiple Use Zone. Since Fort Peck is the immediate downstream mainstem project below these tributary reservoirs, replaced mainstem flood control storage space equivalent to that provided in Tiber, Clark Canyon and Canyon Ferry would normally be in the Fort Peck reservoir. This would allow Fort Peck to be maintained at a higher elevation at the start of the runoff season than indicated by storage allocations previously prescribed. Regulation of the tributary reservoirs with a replacement flood control function is described in the Clark Canyon, Canyon Ferry and Tiber WCMs. Replacement System flood control storage was last utilized in the mid-1980s and is not anticipated to be requested in the near future.

7-16. Flow Regulation Devices. In theory, releases from Fort Peck may be made through the two powerplants, the outlet tunnels and the spillway. Normally, releases through the powerplants will be used to the fullest extent possible in order to achieve the maximum economic return from the project. When releases in excess of that required for power generation or larger than the powerplant capacity demand are necessary, the outlet tunnels and/or the spillway will be used. As described in Section 4-04.3 and Exhibit A of this WCM, the outlet flood tunnels should not be used except in the case of a dam safety emergency.

7-17. General Plan of Flood Control Regulation. Flood control regulation of Fort Peck to meet the stated objectives is based on consideration of the following factors:

a. coordination of flood control regulation of Fort Peck with the regulation of the other System reservoirs and upstream tributary reservoirs as described in Chapter VII of the Master Manual;
b. channel capacity through the reach of the Missouri River between Fort Peck and the mouth of the Yellowstone River;
c. observed and anticipated inflows in the incremental drainage area between Fort Peck and the mouth of the Yellowstone River;
d. observed and anticipated inflows to Fort Peck;
e. space currently available within the Fort Peck reservoir for storage of future runoff;
f. release requirements from Fort Peck for purposes other than flood control; and
g. flood storage space available in USBR's Clark Canyon, Canyon Ferry and Tiber tributary reservoirs upstream from Fort Peck.

7-17.1. The general plan of regulation applicable to most of the System reservoirs including Fort Peck is based on having the flood control storage space evacuated prior to the beginning of the March-July flood season. Flood season inflows that are in excess of the current multiple-use requirements are deliberately stored in the Annual Flood Control and Multiple Use Zone until such time there is reasonable assurance that adequate reserves are stored to satisfy multiple-use requirements to the beginning of the next flood season without drawdown into the Carryover Multiple Use Zone. This deliberate storage for future multiple use also serves the flood control function. Following the time that an adequate supply of multiple-use storage is reasonably assured, releases in excess of current multiple-use requirements are made as a storage evacuation measure when they are not anticipated to contribute to significant downstream flooding.

7-18. Local Flood Control Constraints. Procedures described in the preceding sections are designed for regulation of Fort Peck as a significant part of the System. This project is also designed to provide flood protection through the reach extending from Fort Peck to the headwaters of the Garrison reservoir. The Milk and Yellowstone Rivers are major tributaries entering this reach. Other minor tributaries can also contribute large inflows for short periods of time. At times, Fort Peck regulation is based on conditions in this reach. Immediately below the mouth of the Milk River, which enters the Missouri River about 10 miles downstream of Fort Peck, the Missouri River has an open water channel capacity of about 35,000 cfs. Therefore, Milk River flows are monitored accordingly. When Milk River discharges exceed this rate Fort Peck releases may be reduced to minimum average daily rates of 3,000 cfs or less. With an ice cover, the channel capacity below the mouth of the Milk River is reduced and regulation is based on maintaining the Missouri River stages at the Wolf Point streamgaging site at 21 feet or less, which is 2 feet below the flood stage, to the extent possible. The Milk River is a slow-peaking stream and flows at Nashua, the most downstream streamgaging station on the Milk River, are approximately coincidental (with respect to downstream travel time) with Fort Peck releases to the Wolf Point streamgaging site.

7-18.1. Due to the rapid peaking time of minor tributaries below Fort Peck and the lack of streamflow data from these tributaries, regulation of Fort Peck to coincide with peak flows on those tributaries is not possible. Sharp tributary rainfall peaks will enter the Missouri River prior to the time that Fort Peck release reductions based on rainfall reports can be effective. However, unless high flows are also occurring from the Milk River as a result of runoff which occurred sometime previously, adequate channel capacity is usually available with Fort Peck releases at or below the powerplant capacity. Peak flows from these tributaries attenuate rapidly when entering the Missouri River. At times when a significant plains snowmelt runoff appears imminent from these minor tributary streams, it is practical to reduce Fort Peck releases. During the winter ice cover period, Fort Peck releases are based on maintaining a stage of 13 feet or less at the Missouri River at Culbertson streamgaging station, to the extent possible. This requires consideration of possible snowmelt runoff from the tributary area.

7-18.2. The Williston Levee runs along the left bank of the Missouri River from Highway 85 (RM 1552.7) downstream to the Little Muddy River confluence (RM 1547.5). Results from the Missouri River hydraulic modeling indicate that the 50-, 100- and 500-year flood events will overtop the entire length of the Williston Levee for the future conditions when the 50-year maximum aggradation scenario is applied. Modeling results show that for the mean aggradation scenario, the 100- and 500-year flood events will overtop the levee and for the minimum aggradation scenario, only the 500-year flood event will overtop the levee. This overtopping would result in the flooding of the city of Williston as outlined in the Omaha District report *Garrison Dam – Lake Sakakawea Headwaters Aggradation Evaluation of the Missouri River and Tributaries*, dated January 2014.

7-19. Regulation during Missouri River Ice Formation. Winter ice cover forms each year on the reach of the Missouri River extending from Fort Peck to the headwaters of the Garrison reservoir. Usually this occurs in late November and December with the initial cover forming near the headwaters of the Garrison reservoir. The head of the ice cover then progresses upstream toward Fort Peck with the rate of progress and total extent of cover dependent largely on temperature. As the ice cover forms at a particular point, a sudden sharp increase in stage is experienced due to the associated friction effects. After the ice cover forms, stabilization of the ice cover, a smoothing of its undersurface and an increase in channel capacity occurs.

7-19.1. On the basis of actual experience, Fort Peck releases are typically limited to 10,000 cfs during the period of initial active ice formation in the reach extending from the headwaters of the Garrison reservoir up to Wolf Point, MT. If this initial freeze continues rapidly upstream from Wolf Point, maximum releases continue to be limited to 10,000 cfs. After the Missouri River has frozen above Wolf Point, and the ice cover in the reach downstream of Wolf Point has stabilized, Fort Peck releases can be increased up to 12,000 cfs during further periods of active ice formation in the reach immediately below the dam. After a stabilized ice cover has formed from the mouth of the Milk River downstream, releases can be increased to the full powerplant capacity (about 15,000 cfs) provided significant inflows are not occurring from the incremental drainage area extending from Fort Peck to the mouth of the Yellowstone River. The head of the ice cover will move downstream during warm periods, which often occur during the winter months. Continued powerplant capacity releases during the time the ice cover is diminishing generally create no problems. However, if a substantial amount of ice cover is lost as a result of warm temperatures, it may be necessary to reduce releases to those described for initial freeze-up when cold temperatures recur (10,000 cfs maximum).

7-19.2. Qualitative conclusions from previous studies examining the relationships between release temperature, release volume, air temperature and downstream ice formation indicate that minimum temperatures well below 0°F and an average daily temperature of near 0°F are required for the initial ice cover to form rapidly through this reach when releases are in the 10,000 to 15,000 cfs range. While release temperatures apparently have little effect on river ice formation through the lower portion of the reach, high release temperatures do reduce river ice formation closer to the dam. Regulation during the winter ice season must consider these factors as occurring or forecast. Additional studies would be required to provide a more detailed relationship.

7-20. Coordinated System Flood Control Regulation. The System, of which Fort Peck is an integral component, is regulated to reduce flooding to the maximum degree practical along the Missouri River. Release scheduling from Fort Peck to accomplish this objective is based on studies performed by the MRBWM office. The long-range studies of current operations extend from the current date through the succeeding months up the subsequent March 1, when the start of the runoff year generally occurs. All factors listed in Section 7-17 of this WCM are considered to the extent possible in these studies. Such studies are made at a maximum interval of one month as new estimates of future inflows are developed. If conditions change materially from those anticipated in previous monthly studies, additional within-month studies are made. Details of flood control regulation procedures applicable to the System are described in Section 7-04 of the Master Manual.

7-21. Exclusive Flood Control Regulation Techniques. Fort Peck will usually be operated at an elevation of 2246.0 feet or lower. Occasionally flood inflows will be of such magnitude that encroachment into the Exclusive Flood Control Zone, which extends from elevation 2246.0 to 2250.0 feet, will occur. Consequential actions will be dependent on existing or anticipated conditions in the other System reservoirs. If a portion of the Annual Flood Control and Multiple Use Zone is vacant in downstream Garrison and Oahe reservoirs, and is expected to remain vacant, one option is to increase Fort Peck releases and move water downstream to those reservoirs. If the Exclusive Flood Control Zone is being utilized in all reservoirs, action will be on the basis of the studies described in preceding sections, with System releases and the balance of exclusive storage scheduled in each reservoir of the System defined in procedures discussed in the Master Manual. Generally these procedures recognize the desirability of maintaining somewhat more vacant storage space in the lower reservoirs than in Fort Peck and Garrison, since this storage distribution provides more and better opportunities for controlling downstream floods at the major damage centers.

7-21.1. At times, encroachment into the Fort Peck Exclusive Flood Control Zone will occur or will be anticipated when ample annual flood control storage space remains vacant in the downstream Garrison, Oahe and Fort Randall projects. Normally when this occurs Fort Peck releases will be maintained at full powerplant capacity in an effort to transfer the storage water downstream to Garrison and Oahe, while at the same time obtaining the maximum practical power revenue. Flood control storage space within the System projects downstream from Oahe is relatively limited. Unless unprecedented inflows from the drainage area upstream of Fort Peck occurs, Fort Peck releases in excess of the powerplant capacity will not be scheduled, except during a deliberate coordinated process of storage evacuation from the System as a whole.

7-21.2. Encroachment into the Surcharge Zone of the Fort Peck reservoir, above elevation 2250.0 feet, should be avoided by increasing releases to the extent possible without contributing to substantial downstream flood damages. If releases in excess of the powerplant capacity appear necessary, the releases should be made through the spillway. See Section 4-04.3 and 7-16 of this WCM for details regarding the use of the outlet flood tunnels. Additional guidance regarding any operational restrictions and best practices for the outlet works and spillway facilities can be found in Exhibit A of this WCM.

7-21.3. If unusually large amounts of runoff should originate upstream of Fort Peck, the emergency regulation curves on Plate VII-1 will serve as a guide for Fort Peck regulation as part of the development of the monthly and short-range daily inflow forecasts described in Sections 6-08 and 6-09 of this WCM, respectively. Due to marked differences in characteristics between the early spring and late spring floods originating in the upper part of the Missouri River basin, separate curves have been developed for Fort Peck for each flood type. Reservoir release rates are dependent on pool elevations and rate of inflow and are shown on Plate VII-1. The schedules have been developed in accordance with the method described in EM 1110-2-3600. The adopted recession constant values are 3.5 days for the early spring regulation curve and are variable from 6 to 10 days for the late spring and summer regulation curve.

7-21.4. As discussed in Section 7-21.3, curves shown on Plate VII-1 serve only as a guide for possible regulation, since they are based on typical recession hydrographs for the particular types of floods indicated. Final release selection could be greater or less than indicated by the curves and would be based on anticipated inflows, the effects of release through downstream reaches, and the anticipated maximum pool level of the Fort Peck reservoir as reflected in additional System regulation studies performed at that time.

7-22. Surcharge and Emergency Flood Regulation Techniques. During exceptionally large flood inflows, all available flood control storage space may be utilized and Fort Peck may rise into the Surcharge Zone above elevation 2250.0 feet. Since the primary reason for providing surcharge space is to ensure the safety of the Fort Peck project, significant Surcharge Zone encroachment should be allowed only when necessary to prevent extensive downstream damage or if unusually large flood inflows occur. The Fort Peck reservoir has entered its Surcharge Zone three times: in 1975, peaking at elevation 2251.6 feet; in 1997, peaking at elevation at 2250.3 feet; and in 2011, when the record pool level of 2252.3 feet was reached. See Appendix A of this WCM and Appendix A of the Master Manual for more details on Fort Peck regulation during these floods.

7-23. Responsibility for Application of Flood Control Regulation Techniques. As described in Section 7-04.23 of the Master Manual, the MRBWM office is responsible for and directs all regulation, including flood control regulation, of Fort Peck and the other System projects. Instructions to ensure continuation of Fort Peck regulation during periods of communication failure between the project and the MRBWM office are presented in succeeding sections and in Exhibit B of this WCM.

7-24. Emergency Regulation. Reliable and rapid communication is usually available between the MRBWM office and Fort Peck personnel. When communications are interrupted for any extended period of time, project personnel will be required to continue regulation, as discussed in

Section 5-07 of this WCM. Exhibit B of this WCM outlines the emergency procedures to be followed. In general, these procedures are written such that service will be continued to multiple-use functions through the period of communications failure at the approximate level prevailing prior to the communications outage if Fort Peck inflows continue in the range of those previously anticipated. The emergency procedures also allow for increased inflows, up to those occurring during maximum possible floods as developed for spillway design purposes. Emergency regulation curves are shown on Plates VII-2 and VII-3.

7-25. Emergency Regulation of the Spillway Design Flood. Plate VII-4 illustrates the regulation of Fort Peck during the SDF by use of the Emergency Regulation Curves – Late Spring Flood Season shown on Plate VII-2. The maximum runoff for 16 days during the SDF totaled about 7,000,000 AF with peak inflow of 360,000 cfs. In the illustration the reservoir was assumed to be at the base of the Exclusive Flood Control Zone, elevation 2246.0 feet, at the beginning of the flood. Regulation by this method resulted in the reservoir reaching a maximum elevation of 2256.1 feet, surcharging 6.1 feet above the top of the Exclusive Flood Control Zone, with a maximum daily release of 263,700 cfs.

7-26. Emergency Regulation of an Early Spring Flood of Spillway Design Magnitude. An early spring flood corresponding to the present day concept of a SDF was routed post-construction. The example used in illustrating the emergency regulation of an early spring flood of design magnitude was the maximum probable (or spillway design) early spring flood shown in the Master Manual. This flood was developed by increasing the observed 1947 March rise by a magnitude of five. Regulation of this flood by means of the Emergency Regulation Curve - Early Spring Flood Season found on Plate VII-2, is shown on Plate VII-5 and is based on the assumption that the reservoir elevation was at 2234.0 feet, the base of the Annual Flood Control and Multiple Use Zone. Peak inflow to Fort Peck during this flood was 469,000 cfs. The 15-day total volume of inflow to Fort Peck was approximately 4,641,000 AF. The maximum release was 78,100 cfs with a peak reservoir pool of 2250.2 feet, 0.2 foot above the top of the Exclusive Flood Control Zone.

7-27. Emergency Regulation of the Standard Project Flood. The Standard Project Flood (SPF) based on the latest criteria was developed for Fort Peck by the Omaha District using procedures outlined in EM 1110-2-1411, *Standard Project Flood Determinations*. The standard project storm used in developing the SPF was centered over the lower portion of the Missouri River drainage basin between the mouth of the Marias River and Fort Peck Dam using a typical isohyetal pattern. This storm pattern resulted in an average of 2.43 inches of rainfall in a 24-hour period over the 23,677 square mile contributing drainage area. Runoff from this rainfall was applied to unit hydrographs determined for pertinent sub-area basins lying above Fort Peck. The resulting flood hydrographs from the sub-areas were then lagged to Fort Peck to obtain the SPF hydrograph shown on Plate VII-6. The initial loss and constant loss used in the computation of runoff for the SPF was 0.4 inch and 0.1 inch per hour, respectively. The baseflow of 60,000 cfs used for this flood was estimated from the baseflow experienced in the 1953 flood. The SPF hydrograph as developed has a 10-day volume of 2,261,300 AF, a 30-day volume of 4,540,000 AF and a peak flow of 224,000 cfs. Plate VII-6 illustrates the regulation of Fort Peck during the SPF as developed by use of the Late Spring Flood Season Emergency Regulation Curve shown on Plate VII-3. The reservoir was assumed to be at elevation 2246.0 feet, the base of the Exclusive Flood Control Zone, at the beginning of the flood. Regulation by this method resulted in the reservoir reaching a maximum elevation of 2252.1 feet, surcharging 2.1 feet above the top of the Exclusive Flood Control Zone, and a peak release of 132,000 cfs.

7-28. Emergency Regulation of the Maximum Probable Flood. The maximum probable flood (MPF) for Fort Peck determined by the Omaha District resulted from a maximum probable mid-June rainfall event centered over the lower portion of the drainage basin between the mouth of the Marias River and Fort Peck preceded by a maximum snowmelt event over the upper portion of the basin centered over the area above Canyon Ferry Dam. In developing the MPF all available maximum probable rainfall data applicable to the area was examined, including extrapolation of values from the NWS's *Technical Paper 38*. After examination of these data, the rainfall criteria used for computing the MPF for Fort Peck was based on data prepared by the NWS Hydrometeorological Section for the area above Garrison Dam, as presented in a report titled *An Estimate of Maximum Possible Flood-Producing Meteorological Conditions in the Missouri River Basin above Garrison Damsite*, dated November 1, 1945. This study contains the only data available on maximum rainfall criteria over large areas in this region. Although it is recognized that this study was made for an area immediately east of the area above the Fort Peck reservoir, an approximate storm transposition study indicated little change in precipitation values would be involved in transposing the storm to the area above Fort Peck and it was considered that the use of precipitation data from the Hydromet Report (without modification) in the area farther west represented a conservative extrapolation of the data. Copies of the two plates from the Hydromet Report which were utilized in these studies are shown on Plate 46 in the 1976 Fort Peck WCM. The maximum probable precipitation based on these curves for the months of June and July for the area above Fort Peck is also shown on Plate 46 of the 1976 Fort Peck WCM. These curves were used in computing the rainfall-runoff component of the maximum probable inflow hydrograph for Fort Peck.

7-28.1. The maximum probable storm pattern as determined from a typical isohyetal pattern resulted in an average rainfall of 4.48 inches in a 24-hour period over the 23,677 square mile contributing drainage area. Principles utilized in determining the maximum probable snow accumulation are also those presented in the Garrison Hydromet Report. From examination of the region's topography it was estimated that the contributing mountain area would amount to about 8,000 square miles above Canyon Ferry Reservoir, 550 square miles above Tiber Reservoir and 1,450 square miles between these reservoirs and Fort Peck, totaling about 10,000 square miles. The normal annual precipitation of these mountain areas was estimated to be 23 inches and it was assumed that snowfall would accumulate to about May 1. From figures contained in the Garrison Hydromet Report, the mountain SWE would amount to 16.1 inches over the 10,000 square mile contributing area. From this accumulation, estimated evaporation and irrigation losses were subtracted. Accumulated losses in the amount of 6.1 inches were subtracted leaving 10.0 inches of SWE available for snowmelt runoff. This represents a snowmelt runoff volume of about 5,350,000 AF above Fort Peck. This runoff was distributed through an assumed 60-day melt period and on the basis of observed occurrence of this type of runoff from the drainage area involved. The MPF hydrograph for Fort Peck shown on Plate VII-7 was determined by adding the hydrograph resulting from the maximum probable mid-June rainfall event over the lower basin (between the mouth of the Marias River and Fort Peck) to the hydrograph of the maximum snowmelt event centered over the area above Canyon Ferry. The rainfall portion of the MPF hydrograph was obtained by applying runoff from the maximum probable storm to unit hydrographs for the sub-area basins lying above Fort Peck. The sub-area flood hydrographs were then lagged to Fort Peck to obtain the rainfall portion of the MPF hydrograph shown on Plate VII-7. The initial loss and constant loss used in computation of the runoff for the MPF was 0.4 inch and 0.1 inch per hour, respectively. The MPF hydrograph as developed has a 10-day volume of 4,058,000 AF, a 30-day volume of 6,597,000 AF, and a peak flow of 486,000 cfs. Plate VII-7 illustrates the regulation of Fort Peck during the MPF as developed by use of the Emergency Regulation Curves - Late Spring Flood Season shown in Exhibit B, Enclosure 2. The reservoir was assumed to be at elevation 2246.0 feet, the base of the Exclusive Flood Control Zone, at the beginning of the flood. Regulation by this method resulted in the reservoir reaching a maximum elevation of 2255.0 feet, surcharging 5.0 feet above the top of the Exclusive Flood Control Zone, and a peak release of 265,900 cfs.

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Fort Peck Dam – Fort Peck Lake
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VIII - Water Management Organization

8-01. Responsibilities and Organization. This chapter describes the personnel and coordination necessary to regulate Fort Peck. Fort Peck is regulated as part of the System, which is comprised of six projects on the main stem of the Missouri River. The Corps has the long- and short-term direct responsibility for regulating Fort Peck as a hydraulically and electrically integrated project. This has been the case since November 1937, when Fort Peck was closed to begin storing water.

8-01.1. NWD's MRBWM Division of the Programs Directorate, located in Omaha, NE, is comprised of a 12-person staff of engineers, biologists, information management specialists and support staff. The MRBWM office is comprised of two teams: Reservoir Regulation and Power Production. The Corps' Guidance Memorandum titled, *Reservoir Control Center*, dated March 1972, serves as the document that details the role and responsibilities of the MRBWM office in managing and regulating the System. The RCC, now known as MRBWM, was founded in 1954 and was the first RCC established in the Corps. The organization chart for the MRBWM office is provided on Plate VIII-1.

8-01.1.1. The Corps started construction of Fort Peck in 1933. Fort Peck is one of the six System projects that were constructed during the period from 1933 to 1966. The Corps is the sole owner and regulator of the six dams that comprise the System. The Chief of Engineers for the Corps has delegated the regulation of this System to the NWD Commander, who has in turn delegated the day-to-day regulation of the System to the MRBWM office. The MRBWM office has the direct responsibility of regulating the System and issuing reservoir regulation/power production orders to accomplish this mission. The O&M of the System dams and associated structures are the responsibility of the Omaha District of NWD. The Omaha District has staff physically located at the System projects to make the regulation changes stated on the reservoir regulation/power production orders developed and sent by the MRBWM office. The System is the largest reservoir system in the United States, based on storage capacity. The MRBWM office prepares long- and short-term runoff and streamflow forecasts that are integrated into model simulations to effectively regulate the System, as described in Chapter VI of this WCM. Refer to Exhibit B of this WCM for instructions to the Fort Peck operations manager in case of loss of communication for an extended period of time during a significant or catastrophic event. The MRBWM staff maintains communication with Corps staff at the System projects via cell phones and computers that are available from work, their homes, and while they are on travel status. Maintaining these communication devices ensures that staff can be reached at any hour of any day of the year. Also, there is at least one staff person that physically reports to the MRBWM office, for at least part of each day. Detailed calling lists are provided to the System projects and Omaha District Emergency Operations staff in case there is a need to contact MRBWM staff during off-duty hours.

8-01.1.2. The two teams within the MRBWM office have the responsibility for regulating the System. The Reservoir Regulation Team in MRBWM has the responsibility of running the daily Missouri River streamflow forecast to determine releases (often called the System release) from the lowermost System dam (Gavins Point). This team forecasts runoff volumes for long-range monthly model simulations, and for some short-range simulations. The Reservoir Regulation Team reviews the deviation requests from the Omaha and Kansas City Districts for Corps tributary reservoirs and USBR tributary reservoirs that have Corps-regulated flood control zones. The Reservoir Regulation Team also coordinates tributary reservoir releases during significant basin-wide flood regulation to provide System flood control for the Missouri River basin. The Power Production Team has the responsibility of intrasystem regulation and forecasts runoff volumes for short-range model simulations. This team has the responsibility of T&E species coordination relating to System regulation. Intra-System regulation oversight by this team is conducted to respond to widely varying Missouri River basin runoff to meet the operational objectives stated in the Master Manual. It also performs all hydropower-related activities.

8-01.1.3. A third team, the Missouri River Master Manual Team, was formed in 1989 to oversee the studies and documentation required for the review and update of the 2004/2006 Master Manual. This team also provided program management and oversight of the non-flow related actions for the Missouri River and tributaries necessary to comply with the ESA. This team also had the responsibility to ensure that the overall adaptive management process for both the flow and non-flow ESA-related actions was established and proceeded in an effective and efficient manner. A reorganization of the MRBWM office dissolved this team in 2008 with functions transferred to the Power Production Team, the Omaha District and the Programs Directorate at NWD.

8-01.1.4. Adaptive Management. The Corps has implemented some System regulation changes via an adaptive management process for many years. The Corps, in implementing the current water control plan described in the Master Manual, will continue the use of the adaptive management process. The Corps recognizes that changes in the operation of the System may impact many river uses and is committed to ensuring that the public is actively involved and well informed of potential changes in System regulation and has the opportunity to comment on those proposed changes prior to any decision on implementation. The adaptive management process will be used to implement changes designed to improve the benefits provided by the System, including benefits to the T&E species. Decisions regarding actions proposed through the adaptive management process will meet the Corps' treaty and trust responsibilities to the Tribes and conform to all of the applicable requirements of federal laws including the National Environmental Policy Act (NEPA), ESA and the Flood Control Act of 1944. Additional details regarding adaptive management are presented in Section 7-10 of the Master Manual.

8-02. System Coordination. The MRBWM office strives to keep those interested in the short- and long-term regulation of the System informed as to the amount of water stored in the System, the outlook for future runoff, and the short- and long-term plans for System water management. As the largest storage reservoir system in the United States with the potential for a wide array of positive and negative impacts, the regulation of this System generates a high level of interest within and outside of the basin. The AOP process, developed by the MRBWM office, provides an important tool for the Corps to interact with, inform and coordinate with the public on a semi-annual basis. Other interests have a need to keep informed of changes and project status of the

System on an almost continual basis. Successful regulation of the System to meet the regulation objectives stated in the Master Manual is dependent on a group of well-informed stakeholders and partners providing dialog on the effects of actual and proposed System regulation. The following sections detail how this coordination is accomplished.

8-02.1. News Releases. The MRBWM office provides monthly and other special news releases concerning the regulation of the System. The NWD Public Affairs Office is responsible for issuing the official MRBWM news releases.

8-02.2. MRBWM Website. The MRBWM office maintains a public website at the following address: www.nwd-mr.usace.army.mil/rcc. This site contains information concerning System regulation. It includes forecasted reservoir levels and dam releases as well as historic data in both tabular and graphic formats. The website contains user-friendly, clickable maps to observe graphical streamflow and System project data. While the NWS has the responsibility for issuing streamflow forecasts, the MRBWM office performs streamflow forecasting at select locations needed to regulate the System. These results are provided for information only. The NWS forecasts are available as a link from the MRBWM website. The website contains both normal monthly news releases and special news releases concerning other significant items that occur on an unscheduled basis. In addition, the Corps produces numerous reports on a daily basis that provide updates of the System's status and regulation changes.

8-02.3. AOP Public Meetings. The Corps follows a public process as part of the AOP preparation and implementation process for regulating the System. This process involves the development and publishing of a draft AOP in the fall of each year. The draft AOP simulates the regulation of the System for five runoff scenarios for the remainder of the current year, plus the following calendar year. The draft AOP is generally provided to all interested stakeholders in late September via hardcopy of the MRBWM website. Public meetings are held at three to six sites within the basin, normally in October, to accept verbal comments from the public and provide a forum for discussion on the draft AOP. Written comments on the draft AOP are also accepted generally through mid-November. After considering the comments from the public meetings and any written comments provided during the comment period, appropriate changes are made to the draft AOP to produce a final AOP, which is normally made available in December. In the spring, the Corps again conducts public meetings to provide information on the current hydrologic conditions in the basin and the expected results of System regulation for the remainder of the year given the most-likely forecast and other possible runoff scenarios. Once again, comments are obtained for fine-tuning the System regulation for the spring and summer. Actual real-time regulation of the System is accomplished using the best information and tools available and is adjusted to respond to changing conditions on the ground. The process begins again in August for the next AOP. It should be stated that not all circumstances are covered in the AOP. Actual real-time regulation plans may indicate runoff volumes, reservoir levels and releases outside those described in the AOP. Flexibility in these situations allows the Corps to regulate the System for maximum benefit in an area of the continent where extreme climatic conditions can and frequently do occur.

8-02.4. National Weather Service Coordination. The NWS is the official federal agency responsible for issuing streamflow forecasts to the public. The Corps considers these forecasts in its regulation of the System. The NWS office interface for the MRBWM office is the NWS

MBRFC, located in Pleasant Hill, MO. The MBRFC has the forecasting responsibility for the entire Missouri River basin. The Corps and NWS share real-time data, USGS measurements and flood information, and forecasts for streamflow and runoff. The MRBWM office provides the MBRFC with System regulation data on a daily basis. The MBRFC integrates the Corps' forecasted System project releases with its short- and long-range streamflow forecasts for the Missouri River. The normal method of data and file exchange is through email and other file exchange methods or by direct telephone contact, when required. The Corps receives MBRFC forecasts and QPE rainfall radar imagery, as described in Section 5-03 of this WCM for integration into the MRBWM real-time forecasting models. During years of significant plains snowpack, additional coordination between the Corps and MBRFC is necessary to ensure proper data exchange between the two agencies for the forecasting of plains snowmelt. In addition, whenever the Corps conducts special reconnaissance surveys of ice conditions on the Missouri River, the obtained information is readily shared with the MBRFC.

8-02.5. U.S. Geological Survey Coordination. The USGS is the primary source of data and hydrologic support to the Corps. The USGS obtains streamflow measurement data that it supplies to the MRBWM office in a real-time mode. This prompt delivery of data allows the MRBWM office to meet its mission of managing the basin's water resources. This effort is conducted through a cooperative streamgaging program (Co-op), as described in Section 5-07.2 of the Master Manual. The Co-op program covers the 1) maintenance of DCP stations, 2) measurement of streamflow at select locations, and 3) sediment and water quality sampling at select locations. The MRBWM office has review responsibility for this program but has delegated the implementation of the program to the Corps' Omaha and Kansas City District Water Management staffs. The Districts negotiate separate programs with each state and manage these programs throughout the year.

8-02.6. Western Area Power Administration Coordination. Reservoir regulation/power production orders, reflecting the daily and hourly hydropower limits imposed on project regulation are generated by the MRBWM office and are sent to the mainstem projects on a daily basis. This information is also shared with Western via a daily phone call. Long-term (monthly) and short-term (weekly) regulation forecasts of energy generation and capability are coordinated with Western. These forecasts serve an important role in determining when surplus energy is available during high-water years, otherwise referred to as surplus sales, and when firm energy commitments cannot be met during low-water years, otherwise referred to as energy purchases. These "short-term" forecasts are also used to reflect unanticipated adjustments in project releases such as flood control regulation that can dramatically alter energy generation schedules. Scheduled and forced outages of the generating units are closely coordinated with Western. Coordination with Western is required during the planning and execution of major rehabilitation of the System powerplants.

8-02.7. U.S. Fish and Wildlife Service Coordination. The USFWS is the primary federal agency in charge of administering the ESA as it relates to protected species in the Missouri River basin. The MRBWM and the USFWS coordinate extensively on regulation of the System during the T&E nesting season and on other issues relating to the implementation of the USFWS's 2018 Final Biological Opinion on the *Operation of the Missouri River Mainstem Reservoir System, the Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, the Operation of the Kansas River Reservoir System, and the Implementation of the Missouri*

River Recovery Management Plan, dated April 13, 2018. Additional interagency coordination will continue and expand as the adaptive management process evolves.

8-03. Interagency Agreements. No permanent interagency agreements are in effect with regard to the regulation of the System. A considerable amount of coordination has been conducted between the MRBWM office and the federal agencies that have missions that are affected by the System. In 2003, the MRBWM office participated in a Memorandum of Understanding with the Southwestern Power Administration (Southwestern) with regard to hydropower generation on the Corps' tributary projects in the Kansas City District.

8-03.1. Replacement Storage. The MRBWM office has an existing agreement with the Great Plains Region of the USBR for the use of replacement System flood control storage. The agreement concerns the USBR Clark Canyon, Canyon Ferry and Tiber projects. These three USBR tributary projects contain authorized Flood Control Storage Zones that are regulated by the Omaha District when water is stored in this zone. The flood control storage space provided in the System was developed on the basis that no upstream storage space existed although it was recognized that, as upstream space became operational, a re-evaluation of the mainstem System 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. Effective operation requires a coordinated regulation of the upstream tributary storage space with the space in the mainstem System, which results in the most efficient overall utilization of the basin water resources. Such space provided in upstream reservoirs has been designated as "replacement System flood control storage space." Refer to Sections 4-15.1 and 7-15 of this WCM for more information on replacement storage.

8-04. Commissions, River Authorities, Compacts and Committees. Refer to Section 8-04 of the Master Manual for a detailed history of the various commissions, river authorities, compacts and committees in the Missouri River basin. The Missouri River Recovery and Implementation Committee (MRRIC), the Missouri River Basin Interagency Roundtable (MRBIR) and the Missouri River Natural Resources Committee (MRNRC), and are three such groups discussed in the following sections.

8-04.1. Missouri River Recovery Implementation Committee. This group is a 70-member committee made up of federal, state, Tribal, and stakeholder representatives throughout the Missouri River basin. MRRIC serves as a collaborative forum developing a shared vision and comprehensive plan for the restoration of the Missouri River ecosystem. The committee provides guidance and recommendations to the Corps and USFWS on the current Missouri River Recovery Program for the river's T&E species and on the Missouri River Ecosystem Restoration Plan (currently not funded). MRRIC was established by Section 5018 of the Water Resources Development Act of 2007 under the authority of the Secretary of the Army.

8-04.2. Missouri River Basin Interagency Roundtable. This group was re-activated in 2001 to promote interagency cooperation among the federal agencies within the Missouri River basin. The mission is to foster effective communication and coordination among federal agencies, and, when possible and where appropriate, to communicate to other basin interests with a single federal voice. The cooperating agencies include, but are not limited to the Corps, NPS, USGS, USFWS, USBR, BIA, Environmental Protection Agency (EPA), Western, U.S. Forest Service and the USDA's NRCS. Members are composed of executives of federal agencies with activities in the basin.

8-04.3. Missouri River Natural Resources Committee. The MRNRC is a non-profit corporation formed in 1988 by the Missouri River basin states to promote and facilitate the preservation, conservation and enhancement of the natural resources of the Missouri River. Its official members are the fish and wildlife conservation agencies of the states of Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas and Missouri. The MRNRC's ex-officio members are the Corps, the USFWS and Western.

8-05. Non-Federal Hydropower. All hydropower facilities located either at or in association with the System are federally owned and operated. This includes all hydropower facilities at Fort Peck. No non-federal hydropower facilities are currently located either at the System projects or on System project lands.

8-06. Reports. The MRBWM office prepares several reports to serve as summaries of activities and to communicate to others the current status and proposed regulation of the System. Most reports are available on the MRBWM website: www.nwd-mr.usace.army.mil/rcc. This website is used for public dissemination of water resource information related to regulation of the System. In addition to the reports shown in Table VIII-1, the MRBWM office prepares technical reports and flood reports on an as-required basis to provide information and additional guidance in regulation of the System.

Table VIII-1
Missouri River Basin Water Management Reports

Frequency	Type of Report	Reporting Requirement[1]
Hourly	15-day plots of hourly data of stream and reservoirs with DCP transmissions in basin.	
Daily	Daily Bulletin	
	Weekly Bulletin	
	Monthly Bulletin	
	Yearly Bulletin	
	Reservoir Summary Bulletins	
	Flood Report (as needed)	
	Power Production Orders	
	Missouri River Streamflow Forecast – 14 days	
	Ice Report (Seasonal Dec-Apr)	
	Mainstem Release and Energy Schedule	
Monthly	Basin Calendar – Year Runoff	
	Monthly Mountain Snow Report (Seasonal)	
	Runoff Outlook	ER Requirement
	Long-Range Monthly Model Simulation	
	Project Monthly Summary (MRD 0168)	ER Requirement
	Monthly News Release	
	Monthly Project and System Energy Summary	
Yearly	Draft Annual Operating Plan (AOP)	
	Final Annual Operating Plan (AOP)	
	Annual Summary of Actual Regulation	
	Division Annual Report	ER Requirement, includes District Reservoirs
	Flood Damages Prevented Report	ER Requirement – MRBWM provides holdouts[2] and districts provide estimated damages prevented
	Stage Trends Report	
	Annual Sediment Report	
	Annual Water Quality Report	ER Requirement
	Cooperative Stream Gage Program (Co-op)	ER Requirement

[1] Report required per Corps Engineering Regulation (ER).
[2] Unregulated flows.

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Appendix A - Historic Floods and Droughts with Regulation Examples

A-01. Floods. Regulation provided by the Fort Peck and Garrison projects, augmented by upstream tributary reservoir storage, has greatly reduced flooding along the portion of the Missouri River extending from Fort Peck Dam to the mouth of the Yellowstone River and the portion extending from Garrison Dam to the headwaters of the Oahe reservoir below Bismarck, ND. Many instances of above-bankfull flows were experienced through these reaches prior to construction of the System and would be continuing if the projects were not in operation. All floods experienced in this portion of the Missouri River except one have occurred in the March-July period with snowmelt as an important flood component. The one exception occurred in September 1923 when a large rainstorm over portions of southern Montana and northern Wyoming resulted in an October flood on the Missouri River.

A-01.1. Appendix A of the Master Manual contains relatively detailed descriptions of several of the experienced Missouri River floods, including data that is pertinent to the incremental reach described in this WCM. Since there is little additional data beyond that given in the Master Manual for several of these floods, they will not be discussed further in this WCM. Sections that follow present a more detailed description of large flows that have originated in the drainage area above Fort Peck as illustrative of events that could utilize storage space allocated for flood control in the Fort Peck reservoir. The descriptions are limited to events for which streamflow data are available.

A-02. Flood of 1881. The flood of March-April 1881 was one of the greater early spring floods occurring on the Missouri River above Fort Peck for which information is available. Following a wet year in 1880, the winter of 1880-81 was marked by below-normal temperatures and heavy snow, resulting in heavy snowfall in the mountainous headwaters region and one of the heaviest known snow blankets on the plains area by spring. Unusually warm weather in Montana resulted in spring thaws and ice break-up. This was accompanied by spring rains in the upper part of the basin beginning in late February and early March while the lower part of the river was still frozen. As a result, heavy flooding occurred in March in the drainage basin above Fort Peck as well as downstream from Fort Peck. Hydrographic comparisons with Missouri River gage heights at Bismarck, ND, adjusted to agree with available precipitation records, indicates that the flow at the Fort Peck damsite reached a peak of about 85,000 cfs on March 26 during the 1881 flood. The 1881 early spring flood was followed by a late spring and summer flood with an appreciable volume of flow characterized by moderate-sized peaks.

A-03. Flood of 1908. This flood was caused by heavy rainfall in the latter part of May and early June followed by the occurrence of a severe rainstorm from June 3-6. The runoff from this rain, accompanied by the mountain snowmelt, caused basin-wide flooding and considerable damage. It was estimated that the peak flow in the reach from Fort Peck to the mouth of the Yellowstone River was 154,000 cfs. Unregulated flow records (1938-2014) at Fort Peck (see Plates A-1 through A-8) as well as unregulated Missouri River flow records at Wolf Point and Culbertson (1993 to present) indicate that the estimated 1908 flow exceeds all existing records for Fort Peck, Wolf Point and Culbertson. As shown on Plate V-3, the streamgaging station at Culbertson would be the closest Missouri River streamgaging station upstream of the mouth of the Yellowstone River. Available gage and discharge information in the Fort Peck basin for this flood is shown in Table A-1.

A-04. Flood of 1948. During 1948 damaging floods occurred in the basin above Fort Peck from May 20 to June 13. A sudden rise in temperature in May caused an above-average mountain snowpack to rapidly melt. The mountain snowpack runoff, coupled with runoff from heavy rainfall, resulted in flooding on the Missouri River as well as many tributaries in the drainage area above Fort Peck. Precipitation recorded for May 30 to June 15 was 2.97 inches at Belgrade, MT; 2.36 inches at Helena, MT; and 3.04 inches at Great Falls, MT. Approximately 51,220 acres were flooded in the drainage area above from Fort Peck during this period. As shown on Plate A-10, peak unregulated flow at Fort Peck was in excess of 80,000 cfs. The runoff was captured and stored in the Fort Peck reservoir and releases were reduced to minimum releases during the time of the event. After the tributary flows downstream of the dam declined, Fort Peck releases were increased to evacuate the stored flood waters. Pertinent stages and discharges in the Missouri River basin above Fort Peck for this flood are shown in Table A-1.

A-05. Flood of 1953. As shown on Plate A-12, the unregulated flow into the Fort Peck reservoir peaked at over 120,000 cfs. This was the highest unregulated flow since the 1908 flood. Mountain snow surveys on April 1 and May 1 indicated average snowpack totals. While mountain snowmelt normally starts around mid-April, below-normal spring temperatures resulted in a later-than-normal melt. That snowmelt runoff, combined with rainfall runoff from three storms occurring from May 21 through June 3, resulted in above-average flows on the Missouri River and its tributaries in the drainage area above Fort Peck. Three distinct storms moved through the region during this period: 1) the first storm occurred May 24-25 and deposited significant amounts on snow in the uplands and rain in the lowlands; 2) the second storm occurred on May 29; and 3) the third storm occurred June 2-3. Each storm was more severe than the preceding one. The first storm saturated the soil, the second storm produced flood runoff, and third storm exacerbated the flooding. The flooded areas included the main stem of the Missouri River and extended to tributaries from the eastern slopes of the Continental Divide in central Montana to Fort Peck. Precipitation amounts recorded for the period from May 23 – June 4 were 8.69 inches at Choteau, MT; 9.43 inches at Great Falls, MT; 12.92 inches at Highwood, MT; and 19.90 inches at Shonkin, MT, with 6.52 inches at Shonkin occurring in a 24-hour period. While rain was falling in the lower elevation areas, mountain snowpack in the higher elevations was continuing to accumulate. Rural areas were flooded along the main stem of the Missouri River as well as along tributaries. Approximately 54,800 acres of land were inundated with flood waters. Municipal flooding occurred in the communities of Sun River and Great Falls, MT, on the Sun River; Belt and Highwood, MT, on the Belt and Highwood Creeks, respectively; and in Lewistown, MT on Big Spring Creek. Pertinent stages and discharges for this flood are shown in Table A-1.

A-06. Flood of 1964. The June 1964 flood in Montana was due to heavy rainfall creating a large volume of runoff into streams that were already carrying heavy runoff from mountain snowmelt. May 1 mountain snow surveys indicated that snowpack was 150 to 200 percent of average. May precipitation above Fort Peck was well above normal and basin conditions were conducive to high rainfall runoff at elevations below the snowline. During early June, tributary irrigation reservoirs in the area were filled or rapidly filling, mountain snowmelt was in progress, and streams were high, but not flooding. On June 7-8, a major rainstorm, one of the largest and most intense of record, occurred over the northwestern portion of Montana. The storm area extended from Lewistown, MT, northwestward into Canada and across the Continental Divide. It covered all of the mountain region west and northwest of Great Falls, MT and extended over the plains area northeast and southeast of Great Falls. The heaviest amounts of rainfall were reported along the eastern slope of the Continental Divide. Rainfall amounts reported for the 2-day period were 14.5 inches at Two Medicine Lake in Glacier National Park; 13.0 inches, 27 miles west and northwest of Choteau, MT; 12.8 inches, 13 miles southwest of Augusta, MT and 11.0 inches at Heart Butte, MT. The heavy rainfall, coupled with high snowmelt runoff, caused unprecedented flooding in the Sun and Marias River basins.

A-06.1. The area most seriously affected by this flood was the portion of the basin lying between Canyon Ferry Dam and the mouth of the Marias River. Severe flooding was experienced throughout the Sun River basin. Urban areas of Augusta, Sun River, Vaughn and Great Falls sustained extensive damage from Sun River stages that exceeded any experienced in the past. Flooding in the Marias River basin was equally widespread and severe. Flooding was experienced along the entire length of the Teton River, a major tributary of the Marias River. Floodwaters from the Teton River and a tributary, Spring Creek, combined to flood practically the entire town of Choteau. Flooding on the Marias River was limited to the basin above Tiber Dam. Pondera Coulee, which flows into the Marias River below Tiber Dam, and all of the headwater streams of the Marias River experienced flooding. Damages in the basin were compounded by failure of two irrigation dams, Swift Dam on Birch Creek and Lower Two Medicine Dam on Two Medicine Creek. Swift Dam released in excess of 30,000 AF of stored water and Lower Two Medicine Dam added over 20,000 AF of stored water to the flood when they failed. Other contiguous and outlying basin areas sustaining flood damage from the 1964 June floods include the Milk and St. Mary Rivers, which flow into Canada, the Judith River, Musselshell River, Dearborn River, Jefferson River, Belt Creek and Highwood Creek basins, the main stem of the Missouri River from Canyon Ferry Dam to Fort Benton, and other minor tributary drainage basins of the Missouri River from its headwaters to Fort Peck.

A-06.2. Urban flooding in Montana communities occurred at Great Falls on the Missouri and Sun Rivers; at Vaughn, Sun River and Augusta on the Sun River; at Choteau on the Teton River; at Shelby, Dupuyer, East Glacier Park and Browning in the Marias River basin; at St. Mary on Divide Creek, a small tributary of the St. Mary River; at Lewistown on the Judith River; at Raynesfor in the Belt Creek basin, and in the vicinity of Fort Benton on the Missouri River. The regulated peak inflow into Fort Peck was 90,000 cfs. As shown on Plate A-13 the unregulated inflow into Fort Peck during this flood period reached a peak of about 145,000 cfs. The maximum release from Fort Peck during the event was approximately 9,000 cfs. During this period Fort Peck was regulated to reduce flooding in the reach between Fort Peck Dam and the mouth of the Yellowstone River. Runoff was also being stored in the Garrison and Oahe reservoirs to reduce downstream flooding. Downstream Missouri River stage reductions ranged from 15.7 feet at Omaha, NE to 4.5 feet at Hermann, MO. Pertinent stages and discharges in the Fort Peck basin for this flood are shown in Table A-2.

Table A-2
Missouri River and Tributaries above Fort Peck
Peak Stages and Discharges for Major Floods in 1908, 1948 and 1953

Stream	Station	1908 Flood			1948 Flood			1953 Flood		
		Date	Peak Gage Height (in feet)	Discharge (in cfs)	Date	Peak Gage Height (in feet)	Discharge (in cfs)	Date	Peak Gage Height (in feet)	Discharge (in cfs)
Red Rock River	Lima	June 7		882						
Beaverhead River	Barretts	June 20	6.1	3,720	June 5	4.2	2,150	June 4	3.6	1,710
Jefferson River	Sappington				June 6	11.0	19,900	June 16	9.0	12,200
Madison River	bl Ennis Lake				June 4	6.0	5,420	June 13	6.0	5,380
Gallatin River	Logan				June 5	8.4	7,870	June 14	7.3	5,930
Missouri River	Toston				June 6	11.8	32,000	June 16	10.0	22,000
Missouri River	bl Holter Dam				June 8	11.7	34,800	June 19	6.1	13,500
Dearborn River	Clemons	June 2		4,000	June 4	6.0	3,420	June 4	6.2	3,200
Dearborn River	Craig				June 5	7.9	4,400	June 4	9.6	7,960
Missouri River	Cascade	June 5	16.7	54,250						
Smith River	Eden							June 4	10.5	12,300
Missouri River	Ulm									
N Fork Sun River	Augusta	June 7		20,000	June 3	7.0	4,320	June 3	6.4	3,990
Willow Creek	Augusta	June 5		900						
Smith Creek	Augusta	June 4	5.5	1,500	June 5	5.7	1,830			
Ford Creek	Augusta	June 4		1,030						
S Fork Sun River	Augusta	June 2	6.8	4,300						
Sun River	Sun River	June 7	13.4	27,200						
Muddy Creek	Vaughn	June	24.0		June 17	10.2	1,470	June 4	17.7	7,600
Sun River	Vaughn				June 6	13.5	14,300	June 4	16.4	17,900
Missouri River	Great Falls									
Missouri River	Fort Benton	June 6	18.5	140,000	June 7	10.9	52,800	June 5	13.6	78,700
Dupuyer Creek	Dupuyer	June 5	4.8	1,080						
Cutbank Creek	Cutbank	June 5	11.0	10,400				June 8	8.5	5,640
Marias River	Shelby				June 18	17.8	40,000	June 5	12.8	21,000
Marias River	Brinkman	June 19	24.0	70,000	June 19	21.0	50,700	June 5	16.3	28,100
Marias River	Loma									
Teton River	Strabone	June 10		2,300						
Teton River	Dutton									
Missouri River	Loma				June 20	17.6	92,000	June 5	21.0	121,000
Missouri River	nr Landusky				June 21	18.2	93,200	June 6	22.2	137,000

Table A-3
Missouri River and Tributaries above Fort Peck
Peak Stages and Discharges for Major Floods in 1964, 1975 and 1997

Stream	Station	1964 Flood			1975 Flood			1997 Flood		
		Date	Peak Gage Height (in feet)	Discharge (in cfs)	Date	Peak Gage Height (in feet)	Discharge (in cfs)	Date	Peak Gage Height (in feet)	Discharge (in cfs)
Red Rock River	Lima	May 28 to June 8	2.2	504						
Beaverhead River	Barretts	June 19	3.7	1,910	June 20	3.59	1,680			
Jefferson River	Sappington	June 12	10.2	16,000						
Madison River	bl Ennis Lake	June 28	6.2	5,660	June 26	6.14	5,250	June 6	7.42	7,650
Gallatin River	Logan	June 8	7.4	6,290	July 4	8.44	7,770	June 8	9.81	9,570
Missouri River	Toston	June 12	10.0	22,000	June 26	10.52	25,000	June 12	12.22	33,300
Missouri River	bl Holter Dam	June 19	10.0	27,100	June 23	8.10	19,300			
Dearborn River	Clemons									
Dearborn River	Craig	June 9	13.5	15,400						
Missouri River	Cascade									
Smith River	Eden	June 10	5.5	3,860						
Missouri River	Ulm	June 22	14.4	27,500	June 22	14.64	27,200	June 17	15.2	27,900
N Fork Sun River	Augusta	June 8	15.8	51,100						
Willow Creek	Augusta									
Smith Creek	Augusta									
Ford Creek	Augusta									
S Fork Sun River	Augusta									
Sun River	Sun River									
Muddy Creek	Vaughn	June 9	12.2	3,720						
Sun River	Vaughn	June 9	23.4	53,500	June 22	22.28	29,000	June 13	11.45	7,700
Missouri River	Great Falls	June 10		72,000	June 21		60,180			
Missouri River	Fort Benton	June 10	13.4	77,400	June 21	11.87	62,000			
Dupuyer Creek	Dupuyer									
Cutbank Creek	Cutbank	June 9	13.9	16,600						
Marias River	Shelby	June 9	23.6	241,000*	June 20	18.2	76,000	May 27	9.0	11,800
Marias River	Brinkman									
Marias River	Loma	June 16	8.7	10,800						
Teton River	Strabone									
Teton River	Dutton	June 9	18.9	71,300	June 20	14.8	15,500			
Missouri River	Loma									
Missouri River	nr Landusky	June 11	19.7	114,700	June 23	29.07	77,000			

* Largely due to failure of Swift Dam.

A-07. Flood of 1975. The 1975 March-July flood season runoff above Sioux City, IA of 26.9 MAF was the eighth highest runoff volume on record (1898-2014). Above Fort Peck, the 5-month flood season runoff volume of 9.9 MAF was the second highest recorded (1898-2014) (exceeded in 2011) and more than 2 times the long-term average of 4.8 MAF.

A-07.1. During the early part of 1975, mountain and plains snowpack conditions in the upper basin were normal. The January, February and March annual runoff volume forecasts for the upper basin were less than 24.6 MAF, the long-term average at that time (1898-1974). As the winter progressed, however, mountain snow accumulations increased at an above-average rate and a heavy snowfall occurred on the Dakota plains. The April annual runoff forecast increased to about the long-term average. April precipitation in Montana and western North Dakota was extremely heavy and, in some locations, monthly precipitation totals were four times normal. The ensuing May and June annual runoff forecasts progressively increased to more than the long-term average.

A-07.2. A major rainfall event occurred on June 18-19. The center of the storm was located east of the Continental Divide in Montana with a rainfall center of over 14 inches that included average depths of 10 inches covering 2,500 square miles, while a 10,000 square mile area had an average rainfall exceeding 6 inches. As a result of this storm many record stages and flows were recorded. Table A-3 lists of some of the stations recording maximum discharges for the 1975 flood. This storm resulted in serious flooding in Montana with most of the urban flooding occurring in Great Falls, MT.

A-07.3. Pertinent stages and discharges in the Fort Peck basin for this flood are shown in Tables A-2 and A-3.

Table A-4
Peak Discharges During June 1975 Flood

Stream/Location (Montana)	1975 Date and Discharge	Previous High
Musselshell River at Harlowton	June 20 - 7,300 cfs	4,500 cfs in 1938
So. Fork Musselshell River above Martinsdale	June 19 - 4,300 cfs	1,330 cfs in 1967
Boulder River near Boulder	June 19 - 3,500 cfs	3,490 cfs in 1964
Judith River near Ithaca	June 20 - 1,750 cfs	1,120 cfs in 1927
Boulder Creek near Maxwell	June 19 - 1,300 cfs	764 cfs in 1953
Prickly Pear Creek near Clancy	June 19 - 1,070 cfs	700 cfs in 1927
Tenmile Creek near Rimini	June 19 - 990 cfs	718 cfs in 1917

A-08. Flood of 1978. Drought conditions persisted over the entire Missouri River basin during the early part of 1977 but gave way to above-normal rainfall during the fall. Above-normal precipitation continued over much of the basin during the last few months of the 1977 calendar year and, at the end of the year, snow accumulations in the mountainous areas of the basin were 50 percent above average. By March 1, the mountain snow water content averaged 130 percent of average, while an unprecedented snow cover blanketed most of the plains areas of the basin. Much of the upper basin had at least 3 inches of SWE by late February and some areas had as much as 6 inches. April precipitation was 150 to 200 percent of normal over much of the basin. In May, the Yellowstone River basin received 3 to 6 times normal precipitation. The result of the high mountain snowpack, unprecedented plains snowpack and above-normal spring rainfall resulted in a then-record annual runoff of 40.6 MAF above Sioux City, IA. March-July runoff above Fort Peck was 8.4 MAF, which was about 4 MAF more than the long-term average of 4.8 MAF, and the third highest on record for the period 1898-2014, exceeded by the 5-month totals of 9.9 MAF in 1975, and 11.4 MAF in 2011. The 5-month inflow was somewhat evenly spread out over the 5-month flood season – 1.9 MAF (March), 1.5 MAF (April), 1.8 MAF (May), 1.7 MAF (June) and 1.5 MAF (July).

A-09. Flood of 1997. Flood season (March-July) runoff from the drainage controlled by the Missouri River System (above Gavins Point) during 1997 was 31.2 MAF. The March-July runoff above Sioux City, IA was 36.6 MAF. The 5-month runoff volume above Gavins Point was exceeded only by the 2011 record 5-month total of 40.9 MAF (1898-2014). The annual runoff in the upper basin (above Sioux City, IA) was 49.0 MAF, which was almost double the average annual runoff volume above Sioux City, and, until 2011, was the highest annual runoff on record. The high runoff was the result of an unprecedented heavy plains snowpack concurrent with a near-record mountain snowpack. The melt sequence was more rapid than normal due to much-above-normal temperatures during the melt period, sometimes in the 80°F range, which significantly increased the total volume of runoff. Mountain snowpack for both January and February above Fort Peck (181percent and 155 percent, respectively) and Garrison (169 percent and 159 percent, respectively) were significantly above average. In addition, plains snowpack depths ranged from 6 inches in eastern Montana to as much as 36 inches in eastern North and South Dakota. The 1997 runoff volume above Sioux City during March and April of 7.2 MAF and 8.6 MAF, respectively, nearly mirrored the previous maximum of 15 MAF that occurred in 1952 before the other five mainstem projects were constructed. Runoff in 1997 was primarily the result of mountain and plains snowmelt. Fortunately, heavy spring and summer rains did not materialize across the lower basin during the month of May. Dry conditions also continued to deepen in North Dakota and eastern Montana with less than half the normal May precipitation. During the summer dryness continued to dominate in eastern Montana and western North Dakota and the lower basin had normal to slightly below normal June rainfall. During July, the lack of intense thunderstorms in the lower basin eased the adverse impacts of evacuating the flood waters stored in the System reservoirs. Pertinent stages and discharges in the Fort Peck basin for the 1997 flood are shown in Table A-2.

A-10. Flood of 2011. The 2011 runoff year was the highest runoff year of record (1898-2014) in the upper Missouri River basin since record-keeping began, resulting in a total annual runoff of 61.0 MAF, almost 2.5 times average. It also marked the fourth consecutive year of above-average runoff in the upper Missouri River basin, immediately following the 2000-2007 drought. May (9.2 MAF), June (14.8 MAF) and July (10.2 MAF) had the highest inflows for their respective months in the 117-year period of record (1898-2014). The 34.3 MAF of runoff received during that 3-month period exceeded the total annual runoff in 102 of the previous 113 years (1898-2010). The winter of 2010-2011 marked the third consecutive year of significant plains snowpack, and mountain snowpack was much above average. During May, heavy rains fell across eastern Montana, western South Dakota and northern Wyoming. In some isolated areas, 10-15 inches of rain fell over the 3-day period. Because this runoff came in the form of rainfall runoff rather than snowmelt runoff, the volume of runoff over this very large area quickly made its way to the Fort Peck and Garrison reservoirs and dictated a need to increase releases from all six reservoirs. System storage peaked at 72.8 MAF on July 1, occupying 98 percent of the allocated flood control storage space (16.0 MAF of 16.3 MAF). As shown on Plates III-14 and III-15, runoff into Fort Peck in June was a record high.

A-11. Other Floods. Other floods of significance in the Fort Peck drainage basin include those of the years of 1886, 1887, 1892, 1894, 1916, 1917, 1927, 1943, 1947 and 1952.

A-11.1. The 1886 and 1887 floods were June rises and apparently had very similar characteristics of a fairly high peak in a relatively short period of time. The peak discharge at the Fort Peck damsite was estimated to have been about 70,000 cfs on June 18 during the 1886 flood and about 73,000 cfs on June 17 during the 1887 flood.

A-11.2. The 1892 and 1894 floods were also June rises, with the 1892 flood peaking with a flow of about 93,000 cfs on June 15 at the Fort Peck damsite and the 1894 flood peaking at about 78,000 cfs on June 9.

A-11.3. The 1916 flood was characterized by a relatively sharp discharge peak of about 73,000 cfs occurring at the Fort Peck damsite on June 27 followed by another sharp peak of approximately 95,000 cfs on July 2.

A-11.4. The 1917 and 1927 floods had very large volumes of runoffs. During the 1917 flood the flow at the Fort Peck damsite was estimated to have been above 50,000 cfs, from May 16 to July 4 with a peak discharge of approximately 75,000 cfs occurring on May 28. In 1927 the flow at the Fort Peck damsite was estimated to have been in excess of 50,000 cfs from May 28 to June 27 with peak discharges of 75,000 cfs and 78,000 cfs occurring at the Fort Peck damsite on June 3 and June 15, respectively.

A-11.5. The flood of 1943 was characterized by a high peak discharge of relatively short duration followed by a secondary peak after a short period of time. Missouri River peak flows recorded during this flood were 38,500 cfs on June 16 at Fort Benton, 55,800 cfs on June 17 at Loma, and 63,800 cfs on June 20 near Landusky.

A-11.6. The 1947 flood was an early spring flood resulting from snowmelt combined with the break-up of the river ice cover. This caused damaging floods upstream from Fort Peck and from Fort Peck downstream to the mouth of the Yellowstone River. During the 1947 flood, inflows to Fort Peck exceeded 15,000 cfs from March 17-28 and reached a peak of 93,000 cfs on March 22.

A-11.7. In 1952 extended periods of thawing temperatures in the lower reaches caused major flooding during late March and early April. Snowmelt runoff caused major flooding on minor tributaries on the Missouri River above Fort Peck. During this period there was also sporadic ice jam flooding on the Missouri River above Fort Peck. The 5-month March-July runoff above Fort Peck was 27.7 MAF, which was the highest 5-month runoff since record-keeping began (1898-1952). Since that time, the 1952 5-month inflow volume of 27.7 MAF has been exceeded in 1978, 1997 and 2011. The peak flow near Landusky due to ice jamming was 55,000 cfs on March 29 and inflow to Fort Peck on March 31 was 86,400 cfs.

A-12. Droughts. As outlined in Section 7-14 of the Master Manual, regulation of the System during drought was a significant consideration in the update of the 2004/2006 Master Manual. The System is the largest reservoir system in the United States serving all authorized purposes during an extended drought like the 1930s. As outlined in Section 7-03.2.1.1 of the Master Manual, the System water-in-storage checks, which occur on March 15, July 1 and September 1 of each year, allow the System to function to meet authorized purposes during significant multi-year drought periods. Refer to Tables VII-2, VII-3 and VII-5 in the Master Manual for the relation of System storage to service level, navigation season length and winter releases, respectively. With the original design consideration of the System and with the implementation of the aforementioned water-in-storage checks rules, no separate Drought Contingency Plan is needed or required for the System as outlined in Section 7-14 of the Master Manual.

A-12.1. Two multi-year droughts have occurred in the upper Missouri River basin since the system was first filled in 1967. The first drought was from 1987-1992. The Fort Peck reservoir level declined to a low of 2208.7 feet in April 1991. The second drought occurred from 2000-2007. The Fort Peck reservoir level declined to a record low (1967-2016) of 2196.2 feet in March 2007, 37.8 feet below the top of the Carryover Multiple Use Zone. During this drought the System storage set a new record low of 33.9 MAF in February 2007, 6.9 MAF below the record of 40.8 MAF set in the previous drought in January 1991. See Section A-07 (Appendix A) of the Master Manual for additional information regarding Missouri River basin droughts and regulation of the mainstem projects during droughts.

A-13. Historical Regulation and Effects. Closure of Fort Peck Dam was made in June 1937, beginning the accumulation of storage in the Fort Peck reservoir. As seen on Plate A-1, the pool level did not reach its minimum pool level of 2160.0 feet, the base of the Carryover Multiple Use Zone until March 1942 and the base of the Annual Flood Control and Multiple Use Zone, elevation 2234.0 feet, until April 1947. Between the time of closure and the time of fill to the "minimum" and "full" levels, runoff above Fort Peck was generally well below the long-term average. Plates A-1 through A-8 illustrate the levels of Fort Peck that have occurred since the closure of the dam in 1937. The base of the Exclusive Flood Control Zone, elevation 2246.0 feet, has been exceeded in nine years since the System closed in 1967: 2246.8 feet in 1969, 2247.3 feet in 1970, 2251.6 feet in 1975 (surcharge of 1.6 feet), 2249.0 feet in 1976, 2249.6 feet in 1978, 2247.3 feet in 1979, 2247.3 feet in 1996, 2250.3 feet (surcharge of 0.3 foot) in 1997, and 2252.3 feet (surcharge of 2.3 feet and historic maximum) in 2011.

A-13.1. Plates A-1 through A-8 illustrate the annual variation in the level of the Fort Peck reservoir since 1937. A minimum level usually occurs in late winter. Throughout most of the March-July flood season, storage accumulates in the reservoir provided upstream runoff is not extremely deficient. From late July extending through most of the winter season, storage is evacuated to serve multiple-purpose needs and to provide space for the control of runoff that can be expected during the succeeding flood season. Observed average daily releases from the Fort Peck project are also shown on Plates A-1 through A-8. Average daily releases since 1967 are 9,200 cfs, but vary throughout the year as detailed in Chapter VII of this WCM.

A-13.2. The historical effects of regulation provided by Fort Peck, combined with effects of regulation of upstream and downstream reservoir projects, are illustrated on Plates A-1 through A-8 for the 1937-2014 period. Average daily unregulated flows shown on these plates are the computed estimates of flow at the damsite if none of the upstream tributary projects, including Fort Peck, had been in operation. Regulation has resulted in substantial reductions to all annual peak flows that would have been experienced at Fort Peck. Further discussion of the regulation provided at Fort Peck during particular years is contained in succeeding sections and in the discussion of System regulation presented in the Master Manual. Sections A-13 through A-26 of this WCM discuss Fort Peck regulation during significant flooding and drought periods.

A-14. Regulation as a Sole System Project. During the years from late 1937 to 1952, Fort Peck was the sole System project. During this period, Fort Peck was regulated primarily for flood control and navigation. Releases were usually scheduled to support downstream navigation during the open water season, except that a minimum of 1,000 cfs was scheduled during the irrigation season. Flood control regulation consisted largely of storing water during the high runoff season to be released during late summer or fall. Releases were controlled to provide flood protection in the reach immediately below Fort Peck, with benefits further downstream only incidental to such regulation and to regulation for navigation. To the extent practical, releases were scheduled through the available power generating facilities. Initial filling of the reservoir was also in progress during the first half of this period. From 1938 to 1943, average monthly inflows to Fort Peck varied from 540 cfs in August 1941 to 24,520 cfs in June 1943; maximum daily inflows from 4,810 cfs in September 1940 to 98,070 cfs in June 1943 and average monthly inflows from 2,830 cfs in August 1940 to 48,540 cfs in June 1943. Mean monthly releases varied from 510 cfs in April 1943 to 19,270 cfs in September 1943.

A-14.1. In 1943, when hydroelectric power generation was commenced at Fort Peck, minimum releases were governed by power demands as well as flow requirements for downstream navigation, irrigation and other conservation purposes. By 1945, Fort Peck regulation followed the current process of storing inflow during the March-July period and then releasing it during the drier months. In 1945 and 1946, the Fort Peck pool peaked at elevation 2226.4 and 2232.2 feet, respectively, a few feet below the base of the Annual Flood Control and Multiple Use Zone (2234.0 feet). In 1947, the pool peaked at elevation 2232.2 feet, 1.8 feet below the base of the Annual Flood Control and Multiple Use Zone. In 1947, the pool elevation entered the Annual Flood Control and Multiple Use Zone in early April and exited in mid-September, emulating current regulation. Subsequent to the installation of generating Unit No. 2 in 1948, Fort Peck was regulated to provide a flow of 30,000 cfs at Sioux City for navigation flow support and a minimum of 3,000 cfs for other conservation purposes when the available water supply was adequate to support such releases. Regulation for flood control became an important consideration after the reservoir was filled to normal operating levels. During the period from 1944 to 1952, minimum daily inflows during each month varied from 490 cfs in November 1946 to 38,210 cfs in June 1948; maximum daily inflow from 3,840 cfs in August 1949 to 93,580 cfs in March 1947 and average monthly inflows from 2,847 cfs in August 1945 to 54,670 cfs in June 1948. Average monthly releases from 1944 to 1952 varied from 700 cfs in June 1944 to 28,170 cfs in October 1948. Observed floods of significance during the period from 1938 to 1952 include the floods of 1943, 1947, 1948 and 1952.

A-14.2. Since 1952 the regulation of Fort Peck has broadened from a single reservoir to integrated regulation as part of the System. The principal floods which have occurred above Fort Peck from 1952 to 1967, when the System was filled, and include 1953 and 1964. This period of record illustrates the actual regulation of Fort Peck in coordination with other System projects, during which the 1953-1967 period is unique in that System reservoirs downstream of Fort Peck were in the process of being filled to normal operating levels. Since 1967 the reservoirs have been regulated as the existing 6-project System.

A-15. 1947 Regulation. The 1947 flood was an early spring flood resulting from snowmelt combined with the break-up of the river ice cover, which resulted in significant ice jam flooding. Above Fort Peck, the abnormally thick ice cover, produced by a prolonged period of cold weather, broke up during the March 1947 thaw. Flood waters from melting snow carried block ice down the river where it gorged and spread over lowlands. Ice jams resulted in damages in the reach extending upstream from Fort Peck to Loma, MT as well as from Fort Peck downstream to the mouth of the Yellowstone River. During the flood period from March 17-28, inflows to Fort Peck exceeded 15,000 cfs and reached a peak of 93,600 cfs on March 22. The total volume of inflow to Fort Peck during this period was approximately 936,000 AF. During the March 17-28 flood period, Fort Peck releases were less than 2,000 cfs and the Fort Peck reservoir elevation rose 4.4 feet, from 2228.5 to 2232.9 feet. As shown on Plate A-9, the peak flow immediately below Fort Peck Dam was reduced by about 92,000 cfs. The regulation of Fort Peck during this period resulted in a stage reduction of about 13.5 feet and a maximum flow reduction of about 76,000 cfs at the Missouri River at Wolf Point streamgaging site.

A-16. 1948 Regulation. The 1948 flood was a late spring-summer flood resulting from the rapid melting of above-average mountain snowpack combined with heavy rainfall in the drainage basin above Fort Peck. See Section A-04 for a description of this flood. Inflows into Fort Peck during this flood varied from 20,000 cfs on May 20 to rainfall-runoff peaks of 70,000 cfs on June 4, 60,800 cfs on June 9 and 81,900 cfs on June 21. The total volume of inflow to the Fort Peck reservoir from May 20 to July 15 (about two months) was approximately 4.9 MAF. Long-term monthly average inflow volumes (1898-2014) into Fort Peck are 1.1, 1.6 and 0.8 MAF for May, June and July, respectively. The reservoir pool level rose 16 feet, from elevation 2228.8 to 2244.8 feet, from May 20 to July 15. After downstream stages receded, releases from Fort Peck were increased from 1,870 cfs to 10,470 cfs on June 17 and later increased to 23,950 cfs on July 6. As shown on Plate A-10, the peak Missouri River flow immediately downstream of Fort Peck Dam was reduced by about 67,000 cfs. The regulation of Fort Peck during this period resulted in a stage reduction of 8.0 feet and a maximum flow reduction of 58,000 cfs at the Missouri River at Wolf Point streamgaging site.

A-17. 1952 Regulation. The 1952 flood was an early spring flood resulting from low-elevation mountain and plains snowmelt. Ice-jam flooding occurred on the Missouri River above Fort Peck and record flows were observed on the Milk River, which enters the Missouri River about 10 miles downstream of Fort Peck. The low-elevation (below 8,000 feet) mountain snowmelt was from above-average snowpack in the mountainous regions in northern Montana east of the Continental Divide. In late March, the plains snow cover depth in northern Montana east of the Continental Divide varied from 5 to 13 inches with a SWE ranging from 1 to 3 inches. The ground was frozen to a depth of 1 foot or more and covered with a layer of 1-inch thick ice. Prolonged low winter temperatures resulted in tributary flows being locked up in ice. In late March and early April thawing temperatures occurred throughout the drainage basin above Fort Peck and in the incremental drainage area between the dam and the mouth of the Yellowstone River. The runoff from snowmelt and ice break-up resulted in overbank flooding on the Milk River, the Poplar River, and Big Muddy Creek and ice-jam flooding on the Missouri River above the Fort Peck reservoir. Specifically, ice-jam induced flooding occurred on the Missouri River in Fergus County on March 31. The coincident timing and accumulation of high flows from mountain snowmelt on the many tributaries in the Milk River basin resulted in the flood of record in the Milk River basin. The peak flow of the Milk River at Nashua reached 44,200 cfs on April 18 with high flows occurring from early April to early May. During the flood period, Fort Peck inflows peaked at 86,400 cfs on March 31. The total inflow volume during the March 27 to April 30 flood period was approximately 2.0 MAF, more than three times the long-term monthly inflow volume (April). The reservoir pool level rose almost 9 feet, from elevation 2218.0 to 2226.7 feet, from March 27 to April 30. The regulation of Fort Peck resulted in a stage reduction of about 10.5 feet and a maximum flow reduction of about 74,000 cfs at the Missouri River at Wolf Point streamgaging site. Plate A-11 presents the Fort Peck regulation of the 1952 flood.

A-18. 1953 Regulation. The 1953 flood was a late spring-summer flood resulting from snowmelt from a normal winter's accumulation of snow combined with runoff from three distinct storms with accompanying precipitation in the drainage basin above Fort Peck. Description of this flood is contained in Section A-05 of this manual. Fort Peck inflows were above 20,000 cfs from May 21 to June 24, with a peak unregulated inflow of 119,700 cfs on June 7. The total volume of inflow into the Fort Peck reservoir from May 24 to June 25 was approximately 3.6 MAF, more than two times the long-term June inflow of 1.6 MAF (1898-2014). Regulation of Fort Peck significantly reduced flooding in the area downstream from the dam. As shown on Plate A-12, releases from Fort Peck averaged about 3,000 cfs during the peak unregulated flows. Missouri River stage reductions downstream of Fort Peck ranged from about 14 feet at Wolf Point, MT, 7 feet at Bismarck, ND and Omaha, NE, to about 3.5 feet at Waverly, MO. While Fort Randall and Garrison were closed in July 1952 and April 1953, respectively, those two projects provided minimal downstream stage reductions during 1953. The reservoir level increased about 16 feet from elevation 2221.7 to 2238.0 feet from May 20 to June 26. The flood control operations of Fort Peck provided the vast majority of flood damages prevented through the entire reach of the Missouri River.

A-19. 1964 Regulation. As detailed in Section A-06, the 1964 flood was a late spring-summer rainfall flood that resulted in a large volume of runoff into streams that were already carrying heavy runoff from mountain snowmelt. Inflows into Fort Peck averaged 21,000 cfs in May. Peak inflows of about 90,000 cfs occurred on June 12 and 18. Average inflows for June were about 47,000 cfs and gradually decreased to less than 10,000 cfs by July 18. The total volume of inflows to Fort Peck from May 3 to July 18 (about 2.5 months) was approximately 4.9 MAF, 1.4 MAF more than the long-term May-July average inflow (3.5 MAF). Releases averaged about 6,000 cfs during May and about 4,400 cfs in June and July. The reservoir level increased about 20 feet from elevation 2214.4 to 2234.5 feet from May 1 to July 18. As seen on Plate A-13, the unregulated flow at the Fort Peck site peaked around 145,000 cfs in mid-June.

A-20. 1975 Regulation. As detailed in Section A-07, above Fort Peck, the 5-month flood season runoff volume of 9.9 MAF was the second highest recorded (1898-2014) and more than 2.7 MAF higher than the long-term average. The monthly precipitation amounts during the March-May period were above normal. In addition, an intense rainstorm on June 18-19 resulted in heavy runoff that, in combination with mountain snowmelt, resulted in severe flooding in Montana. Several maximum discharges of record occurred and are indicated in Section A-07.

Average monthly inflows into Fort Peck during April, May, June and July were 18,500 cfs, 36,800 cfs, 43,600 cfs and 36,600 cfs, respectively, with a peak regulated inflow of 80,000 cfs occurring on June 23. The releases from Fort Peck varied from a low of 4,300 cfs on April 24 to a maximum of 35,400 cfs on July 7. This is the second highest Fort Peck release (1937-2014), exceeded only in 2011 (65,900 cfs). The unregulated peak flow at the damsite was approximately 116,000 cfs. The Fort Peck reservoir elevation rose more than 15 feet from 2236.1 feet (2.1 feet into the Annual Flood Control and Multiple Use Zone) on March 15 to 2251.6 feet (surcharging 1.6 feet above the top of the Exclusive Flood Control Zone) on July 16. The 1975 peak pool of 2251.6 feet was the second highest of record (1937-2014). Regulation of Fort Peck resulted in Missouri River peak stages being reduced 8.3 and 8.6 feet at the Wolf Point and Culbertson streamgaging sites, respectively. Plate A-14 presents the Fort Peck regulation of the 1975 Flood. Further information describing the 1975 flood and accompanying System regulation is given in the Master Manual and in the special MRD-RCC Summary Report, *Regulation of the Missouri River Main Stem Reservoir System to Control the 1975 Inflows.*

A-21. 1978 Regulation. As detailed in Section A-08, the high flood season runoff above Fort Peck was spread out somewhat evenly over the 5-month period. This long period allowed for Fort Peck releases to be kept at lower levels than previous floods to effectively manage reservoir levels. The maximum release from Fort Peck during the 1978 runoff period was 15,300 cfs. The maximum Fort Peck elevation of 2249.6 feet, 0.4 foot below the top of the Exclusive Flood Control Zone, was reached on July 20. System releases during the early part of the 1978 navigation season were at a full service level, but System releases were increased to above full service on May 24, due to the near-record March-May runoff above the System. The 1978 March-May runoff for the upper basin (above Sioux City, IA) was 20.0 MAF, the third highest on record (1898-2014). System releases were gradually increased throughout the June and July period as downstream flow conditions permitted and as flood storage evacuation requirements increased due to continued high inflows. Flood damages along the main stem of the Missouri River during 1978 would have been the greatest since the flood of 1952 had the System not been in place. Plate A-15 presents the Fort Peck regulation of the 1978 flood. Further information describing the 1978 flood and accompanying System regulation is given in the Master Manual and in the special MRD-RCC Summary Report, *Regulation of the Missouri River Main Stem Reservoir System to Control the 1978 Flood.*

A-22. 1987-1992 Regulation. The upper three System reservoirs – Fort Peck, Garrison and Oahe – bear the brunt of impacts during extended droughts. The projects were designed with large Carryover Multiple Use Zones to provide flow, albeit at reduced levels as the drought worsens, for the seven authorized purposes that require water to be released from the projects: hydropower generation, navigation, water supply, irrigation, water quality control, recreation and fish and wildlife, including T&E species. In-reservoir purposes such as recreation, fish and wildlife, water supply and irrigation can also be impacted during extended droughts as the reservoir level declines to below-normal levels. As seen on Plates A-5 and A-6, the Fort Peck pool level steadily declined to then-record low levels since the System closed in 1967. Because the drought was affecting the entire basin, higher-than-minimum Fort Peck releases were needed to meet reduced System navigation and water supply requirements. During the 6-year drought, Fort Peck's average inflows were about 7,400 cfs, 2,700 cfs less than the long-term average; the average releases were about 7,700 cfs, 1,500 cfs less than the long-term average. The Fort Peck reservoir level reached its then-record low elevation of 2208.7 feet in April 1991 (record low is 2196.2 feet, March 2007).

A-23. 1993 Regulation. At the start of 1993, the basin was enduring its sixth consecutive year of drought. The Fort Peck reservoir elevation in February was 2208.8 feet, just 0.1 foot above the then-record low set in April 1991. The first three months of 1993 were drier than normal across most of the upper basin. April 1 mountain snowpack was 81 percent of average above Fort Peck and 75 percent of average between Garrison and Fort Peck. During this period Fort Peck releases averaged 6,000 cfs during April and were then increased to 7,000 cfs during May and June. While there was some flooding in portions of the basin due to plains snowmelt, the upper basin was still in "extreme" to "severe" drought conditions. That all changed in a matter of weeks. The summer of 1993 went into the record books as the wettest summer in 99 years of record (1895-1993) in five of the ten Missouri River basin states: Montana, North Dakota, South Dakota, Minnesota and Iowa. June precipitation was 150 to 200 percent of normal throughout the basin. In July, weekly to twice-weekly rounds of severe thunderstorms turned into almost daily events. The wet pattern continued through the remainder of July as severe thunderstorms dumped torrential rains from the northern plains to Kansas and Missouri. In July, Fort Peck releases were lowered to as low as 4,000 cfs to safeguard T&E birds. In September and October, Fort Peck releases were lowered to as low as 3,000 cfs to balance storage in the downstream reservoirs while minimizing flooding downstream of the System. The Fort Peck pool rose 21 feet, from 2211.2 to 2232.2 feet from April 1 to December 31. Total damages prevented for the 1993 flood by the System was $13.5 billion (indexed to 2015). Plate A-16 presents the Fort Peck regulation of the 1993 flood.

A-24. 1997 Regulation. The Fort Peck pool was at 2236.0 feet at the beginning of 1997, 2.0 feet above the base of the Annual Flood Control and Multiple Use Zone. In January, the runoff forecast for 1997 was 29.2 MAF, 119 percent of average. This runoff forecast steadily increased each month as plains and mountain snow continued to fall on the upper basin. The actual annual runoff above Sioux City, IA was 49.0 MAF, nearly twice average, making it the largest runoff in the last 100 years. The February 1 mountain snowpack in the upper Missouri River basin measured 155 percent of average above Fort Peck and 159 percent of average in the reach from Fort Peck to Garrison Dam and plains snowpack continued to accumulate at record levels throughout the upper basin. In February the MRBWM office began to aggressively make releases from the System reservoirs to prepare to capture the large volume of expected runoff. The March 1 mountain snowpack was a near-record 139 percent of average above Fort Peck and 147 percent of average in the reach from Fort Peck to Garrison Dam. In addition, a major plains snowpack remained. The March 1 runoff forecast for 1997 was raised to 35.5 MAF, which is comparable to the largest upper basin runoffs in the 100-year record (1898-1997). As warmer weather entered the basin during the March-April period, the plains snowmelt resulted in large amounts of inflow into the reservoirs. As the flows in the James and Big Sioux Rivers in eastern South Dakota, both of which empty into the Missouri River downstream of the System, began to rise, System releases were lowered to lessen flooding downstream of the System. The effect of the lowering of the System releases during this 2-month period affected all the System reservoirs. Releases from Fort Peck averaged a record low 3,200 cfs in April to retain as much vacant flood control storage space as possible in the downstream Oahe and Fort Randall reservoirs. The May 1 mountain snowpack measured 135 percent of average above Fort Peck and 136 percent of average between Fort Peck and Garrison. Knowing that the mountain snowmelt would be melting and result in very high inflows, MRBWM increased releases from both Fort Peck (3,000 to 12,000 cfs) and Garrison (20,000 to 40,000 cfs) in early May. In June, the remaining above-average mountain snowpack runoff, along with unseasonably warm temperatures and heavy rain, resulted in a June runoff that was 180 percent of average. Releases from Fort Peck were increased to 15,000 cfs, near full powerplant capacity, in early June. However, Fort Peck's releases were lowered to 7,000 cfs in mid-June because the downstream Garrison reservoir was quickly rising to the top of its Exclusive Flood Control Zone. With the reduced releases, the Fort Peck pool climbed to the top of its Exclusive Flood Control Zone, elevation 2250.0 feet, on July 15. It hovered near that elevation throughout the remainder of the month; the maximum pool elevation was 2250.3 feet, 0.3 foot into the Surcharge Zone. Because of downstream constraints, specifically those at the Garrison reservoir, Fort Peck releases were not increased significantly from the 7,000 cfs rate until late July, ending the month at 14,000 cfs. Releases were eventually increased above full powerplant capacity – 18,000 cfs (monthly average) in August, 20,100 cfs in September, 21,600 cfs in October, and 21,100 cfs in November – in the fall to complete the evacuation of the stored flood waters. Plate A-17 presents the Fort Peck regulation of the 1997 flood. The total estimate of flood damages prevented by the System during 1997 (indexed to 2015) was $8.6 billion. Further information describing the 1997 flood and accompanying System regulation is given in the Master Manual and in the special MRD-RCC Summary Report, *Regulation of the Missouri River Main Stem Reservoir System during the 1997 Flood.*

A-25. 2000-2007 Regulation. As noted in Section A-22, the upper three System reservoirs – Fort Peck, Garrison and Oahe – bear the brunt of impacts during extended droughts. During the 2000-2007 drought, the Fort Peck pool level steadily declined to record low levels since the System closed in 1967. Because the drought was affecting the entire basin, higher-than-minimum Fort Peck releases were needed to meet reduced System navigation and water supply requirements. During the 8-year drought, inflows averaged about 6,400 cfs, 3,700 cfs less than the long-term average; the average releases were about 6,800 cfs, 2,400 cfs less than the long-term average. The Fort Peck reservoir level reached its record lowest elevation of 2196.2 feet in March 2007. Plate A-7 presents the Fort Peck regulation of the 2000-2007 drought.

A-26. 2011 Regulation. As noted in Section A-10, total annual runoff above Sioux City, IA was 61.0 MAF, almost 2.5 times the long-term average. Annual runoff into Fort Peck totaled 14.4 MAF, twice the average. All stored flood waters from the 2010 flooding were fully evacuated by late January 2011. On January 28 the System storage was 56.8 MAF, the base of the System's Annual Flood Control and Multiple Use Zone. As shown on Plate A-18, the Fort Peck reservoir was at elevation 2235.5 feet, 1.5 feet above the base of the Annual Flood Control and Multiple Use Zone on March 1. As noted in Section A-10, during May, heavy rains fell across eastern Montana, western South Dakota and northern Wyoming. In some isolated areas, 10-15 inches of rain fell over the 3-day period. The record inflows required record releases from all the mainstem projects, including Fort Peck. The Fort Peck reservoir was in or above its Exclusive Flood Control Zone for 71 days, from May 26 through August 4, and was in the Surcharge Zone for 35 days, from June 3 through July 7. Peak daily flows into Fort Peck set records in June 2011. The peak daily June inflow of 101,000 cfs occurred on June 6. The inflow exceeded the previous June maximum daily inflow into Fort Peck of 80,000 cfs for total of ten days. The average daily release of 18,500 cfs was nearly twice average and was the highest average annual release since the System first filled in 1967. The new record maximum daily release from Fort

Peck was established on June 15, 2011 at 65,900 cfs (1937-2014). The previous record maximum was 35,400 cfs (July 1975), which was exceeded for 46 days in 2011. The record Fort Peck reservoir level of 2252.3 feet occurred on June 15, 0.7 foot above the previous reservoir level of 2251.6 feet set in July 1975. Spillway releases were made from May 6 to May 23, and June 2 to September 30, with a maximum spillway release of 52,200 cfs on June 15. The outlet tunnels were not used for regulation during 2011. The spillway gates, discharge channel and stilling basin (plunge pool) all required repairs following the record releases in 2011.

Appendix B - Recreation

B-01. General. The six reservoirs of the System and the Missouri River reaches between and downstream of these reservoirs provide recreation opportunities. Recreational activity is a source of income for businesses catering to boating, hunting, fishing, camping and other recreational pursuits. Service-related establishments located near the Missouri River also benefit from those recreating on the System reservoirs. A variety of recreational opportunities are available within the System and the lower Missouri River. Water-based recreation includes boating, fishing and swimming. Sport fishing is a primary component of recreation along the entire river. The wetlands along the river corridor provide waterfowl habitat, and waterfowl hunting is popular. Hunting for small and large game such as pheasant, grouse, rabbit and deer occurs on land along the System reservoirs and the river reaches. The aesthetically pleasing character of the reservoirs and river reaches attracts sightseers. Camping facilities vary from fully developed to primitive. Over 80,000 acres of recreational lands are located along nearly 6,000 miles of System reservoir shoreline. Of these 80,000 acres of recreational lands, 6,457 acres are designated as existing recreational areas located on Tribal Reservation lands along the main stem of the Missouri River with another 925 acres identified as future recreational areas. Recreation, an authorized System project purpose, has grown beyond original expectations. With time, recreational facilities became more developed and opportunities for recreation have increased. The introduction of additional fish species attracted greater numbers of fishermen to the reservoirs. Road improvements made the reservoirs and river reaches more accessible. Recently, the national trend towards outdoor recreation and the number of recreationists willing to travel longer distances have added to the recreational visitation all along the System. There is also a viable recreation industry below the System on the lower Missouri River; approximately 30 percent of the total recreation benefits attributed to the Missouri River occur below the System.

B-02. System Recreation Visitation. Visitation data is maintained by the Corps in the Natural Resource Management's Visitation Estimation and Reporting System (VERS) database. The methodology used for the Corps to determine visitation hours has been under revision since 2013. The new methodology will leverage metered data that is collected as vehicles enter and exit the recreation areas. Plate B-1 shows the annual visitation for the total System and the six individual System projects from 1954-2012. This plate shows that the trend is upward except during extended drought periods, when the trend levels off or is slightly reversed depending on the year. Other factors also affect the visitation numbers such as the overall United States economy. A survey completed in 1999 showed that, of the annual visits made to the six projects, approximately 37 percent are made by sightseers, 29 percent by fishermen, 24 percent by boaters, 10 percent by picnickers, 9 percent by swimmers, 2 percent by campers, 2 percent by water skiers, 2 percent by hunters, and 22 percent by visitors who participate in other activities. The visit percentages total more than 100 percent (137 percent) and indicate that some visits include multiple activities.

B-03. Fort Peck Recreation Visitation. Refer to Table B-1 for a history of Fort Peck recreation visitation. The reservoir levels of the lower three reservoirs (Big Bend, Fort Randall and Gavins Point) do not vary as much as the larger, upper three reservoirs. The lower reservoirs do not contain the flood or carryover multiple use storage volume that the upper three reservoirs (Fort Peck, Garrison and Oahe) do. Thus, recreation visitation in the lower three reservoirs is not affected as much during drought periods or flood periods because access issues do not normally occur.

Table B-1
Fort Peck Recreation Visitation of Corps' Recreation Areas

Year	Visitation in hours	Year	Visitation in hours
1954	378,510	1984	1,855,217
1955	406,630	1985	2,240,076
1956	402,560	1986	1,805,230
1957	404,780	1987	3,776,000
1958	458,800	1988	3,777,700
1959	502,460	1989	3,834,601
1960	597,920	1990	3,400,400
1961	748,140	1991	3,698,300
1962	913,530	1992	3,419,600
1963	921,300	1993	4,191,900
1964	949,050	1994	4,514,000
1965	1,194,730	1995	4,872,100
1966	1,202,500	1996	4,650,000
1967	1,308,690	1997	5,070,900
1968	1,756,020	1998	5,342,700
1969	1,758,240	1999	5,250,300
1970	2,111,220	2000	6,073,472
1971	2,083,470	2001	6,206,400
1972	2,475,670	2002	5,183,100
1973	2,564,840	2003	5,128,000
1974	2,484,920	2004	5,252,800
1975	2,652,900	2005	5,445,900
1976	2,849,433	2006	5,374,200
1977	2,862,024	2007	5,630,400
1978	2,898,562	2008	5,443,000
1979	2,726,530	2009	5,820,400
1980	1,734,560	2010	6,173,900
1981	1,534,390	2011	6,455,284
1982	1,635,030	2012*	6,666,900
1983	1,717,540		

* 2012 visitation data is only January through September.

Appendix C - Water Quality

C-01. Missouri River Basin Water Quality. Water quality characteristics that are of greatest concern in the basin are chemical constituents, which affect human health and plant and animal life; temperature, which affects fisheries and the aquatic environment; biological organisms, which affect human health; and taste, odor and floating materials, which affect the water's potability and the aesthetic quality of the environment. In general, the mainstem reservoirs function as pollutant "sinks" in that sediment and adsorbed pollutants settle out and are deposited on the bottom of the reservoirs. Water discharged through Fort Peck for power production is withdrawn from the Fort Peck reservoir at elevation 2095.0 feet, approximately 65 feet above the reservoir bottom. Although the Missouri River has historically contained high sediment loading and naturally occurring high concentrations of metals such as arsenic and selenium, the water quality characteristics of the Missouri River have changed within the past several decades. These water quality changes are a result of past and current changes in land use practices, increased urbanization, atmospheric deposition of pollutants, and dam construction and regulation within the Missouri River basin. Water quality impacts arising from the construction and regulation of the System can be broadly classified as direct impacts and indirect impacts.

C-02. Direct Water Quality Impacts of System Regulation. The System and its regulation have significantly improved water quality in the river reaches between the reservoirs and downstream of the System, compared to the water quality in the Missouri River before the System was constructed. The water quality has improved as seen through the Clean Water Act (CWA) because the river has become clearer and cooler and improved recreation and sport fishery. Conversely, the water quality has degraded as seen through the ESA because the natural turbid, warm river has become clearer and cooler which may affect native river fish. Downstream flow support from the System for the authorized purposes other than water quality more than meets the minimum flow requirements for Missouri River water quality.

C-02.1. The majority of the water quality impacts that are a direct result of System regulation occurs in the upper portion of the Missouri River basin. These direct water quality impacts include temperature changes in the reaches downstream from several of the dams, low concentrations of suspended solids in the releases, and temperature and dissolved oxygen problems when the upper three reservoirs are drawn down during droughts. These impacts are more physical in nature, involving the management of streamflow and water storage in the System. Water temperature is recognized as an important water quality condition affecting the fishery population in the Missouri River reaches downstream of the dams. Because releases from the System dams contain low concentrations of suspended solids, some native riverine fish species may be adversely affected. The drawdown of the three larger reservoirs during extended droughts diminishes the coldwater habitat (the temperature increases are a direct impact of System regulation and less dissolved oxygen being available in the reservoirs is an indirect impact, as discussed below). In turn, coldwater fish species in the reservoirs may be adversely affected.

C-03. Indirect Water Quality Impacts of System Regulation. Most water quality issues in the Missouri River basin are indirect impacts as they result from a combination of pollutant sources and hydrologic conditions throughout the watersheds. The Missouri River reservoirs and the tributaries receive pollutant loading from point and non-point sources within the watersheds.

The Corps reservoirs are not the source of the pollutants that enter the Missouri River; however, they directly affect the hydrologic regimes that store or transport pollutants downstream. Water quality impairments and problems may, therefore, arise when the Corps is regulating the System to meet the Congressionally authorized System project purposes. Brief descriptions of these indirect water quality issues and impacts are discussed below.

C-03.1. During extended droughts, low reservoir levels in the summer result in reduced volumes of deeper, cooler hypolimnetic water in the three larger System reservoirs. The low reservoir levels may cause an increase in the overall temperature of the water in the reservoir and may reduce the total amount of oxygen available in hypolimnetic waters to meet demands of sediment and decomposing organic material, such as decaying algae.

C-03.2. Dissolved oxygen concentrations, especially in hypolimnetic waters, can be lowered through the decomposition of accumulated organic matter and the oxygen demand of sediments and reduced substances. The absence of dissolved oxygen (i.e., anoxic conditions) during summer conditions may result in an influx of metals, such as iron and manganese, from the sediments into the water column. Anoxic conditions, through the oxidation-reduction process, can also liberate nutrients such as phosphorus from the sediments. This can lead to nutrient enrichment and possible nuisance growth of algae.

C-03.3. Elevated metal concentrations have been detected in the water column and fish tissue and within the sediments of the System. The major metals of concern in the System are arsenic and mercury. Fort Peck and Garrison reservoirs currently have fish consumption advisories issued for mercury. Natural background concentrations of arsenic, selenium and mercury in the System reservoirs are associated with the local geology, specifically the presence of Upper Cretaceous Age Pierre Shale. Elevated arsenic concentrations are a localized occurrence associated with large storm events that cause high sediment loading or wind action that results in re-suspension of the reservoir sediments. Arsenic is a naturally occurring metal within the watershed and readily adsorbs onto fine soil particles as they are transported downstream and deposited in the reservoirs. The majority of arsenic entering the System is adsorbed onto sediment particles. The sources of mercury are naturally occurring soils, point-source discharges (i.e., atmospheric deposition), and sediments generated from historical mining practices that have been transported downstream into the System reservoirs. Elemental mercury can be transformed to methyl mercury in rivers and reservoirs when organic matter and hypoxic conditions are present. Methyl mercury bioaccumulates in the aquatic food chain and accumulated levels in fish pose a threat to human health when the fish are consumed. Other metals that have been detected in the System reservoirs are copper, iron, manganese, nickel and zinc.

C-03.4. Agricultural practices, both past and present, include the application of pesticides throughout much of the Missouri River basin. The Omaha District Water Control and Water Quality Section scans for the following pesticides: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, metolachlor, metribuzin, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate and trifluralin.

C-03.5. Throughout the basin, tributary waters exhibit significant nutrient loadings because of effluent discharges, urban storm water and agricultural runoff, and other non-point sources of pollution. High nutrient levels in the Missouri River and its tributaries can deliver nutrients to the System reservoirs and lead to undesirable algal blooms.

C-04. Fort Peck Reservoir. The State of Montana has assigned Fort Peck Lake a B-3 classification in the state's water quality standards. As such, the reservoir is to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply. Fort Peck Lake is not assigned a coldwater fishery use by the state in their water quality standards; however, the reservoir supports a stocked salmon fishery and a naturally reproducing lake trout and lake cisco fishery – all are considered coldwater species. Since a coldwater fishery is currently supported in Fort Peck Lake it is seemingly an existing use and protected pursuant to the Federal CWA and antidegradation policy provisions found in the Code of Federal Regulations, *40 CFR 131.3*. Pursuant to Section 303(d) of the CWA, Montana has placed Fort Peck Lake on the state's list of impaired waters citing impairment to the use of drinking water. The impairment of drinking water is attributed to the pollutants of lead and mercury. The identified sources of these pollutants are agriculture, abandoned mining, atmospheric deposition, and historic bottom deposits. Montana's 305(b) assessment also identifies Fort Peck Lake's recreational use as impaired due to native aquatic plants (algal blooms), but does not consider this a 303(d) impairment for total maximum daily load (TMDL) development. The State of Montana has also issued a fish consumption advisory for Fort Peck Lake due to mercury concerns.

C-05. Fort Peck Tailwater. The Missouri River downstream of Fort Peck Dam has been designated a B-2 classification from the dam to the confluence of the Milk River, and a B-3 classification from the Milk River confluence to the Montana/North Dakota state line (Montana water quality standards). Both B-2 and B-3 waters are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; waterfowl and furbearers; and agricultural and industrial water supply. In addition, B-2 waters are to maintain growth and marginal propagation of salmonid fishes and associated aquatic life, and B-3 waters are to maintain growth and propagation of non-salmonid fishes and associated aquatic life. The river is used as a water supply by several towns along the reach. Pursuant to Section 303(d) of the Federal CWA, Montana has placed the Missouri River downstream of Fort Peck Dam on the state's list of impaired waters citing impairment to the uses of aquatic life support, coldwater fishery, and warmwater fishery due to the stressor of water temperature. Montana's 305(b) assessment also identifies the Missouri River's aquatic life as impaired due to degraded riparian vegetation and other flow regime alterations, but does not consider these 303(d) impairments for TMDL development. No fish consumption advisory has been issued for the Missouri River downstream of Fort Peck Dam by the State of Montana.

C-06. Water Quality Monitoring at the Project. The Corps has monitored water quality conditions at Fort Peck since the late 1970s. Water quality monitoring locations have included sites on the Fort Peck reservoir and on the Missouri River upstream and downstream from the Fort Peck Dam and are shown on Table C-1. The near-dam location has been continuously monitored since 1980. The Omaha District Water Control and Water Quality Section is the primary office responsible for water quality data collection, analysis and documentation. The section publishes an annual water quality report regarding the district tributary projects as well as the System projects.

Table C-1
Fort Peck Water Quality Monitoring Sites

Station Number	Station Alias	Name	Location	Station Type	Latitude	Longitude
FTPNFMORR1	NF1	Missouri River near Landusky, MT	At U.S. Highway 191 bridge crossing south of Landusky, MT	Boundary Conditions Tributary Inflow	-----	-----
FTPNFMSLR1	NF2	Musselshell River at Mosby, MT	At MT Highway 200 bridge crossing at Mosby, MT	Boundary Conditions Tributary Inflow	-----	-----
FTPNFBDCK1	NF3	Big Dry Creek near Jordan, MT	At County Rd 462 bridge crossing east of Jordan, MT	Boundary Conditions Tributary Inflow	-----	-----
FTPLK1772A	L1	Fort Peck Lake – Near Dam	In-Lake, Deepwater	In-Lake Conditions	47° 59' 02.971" (47.984167°)	106° 25' 09.224" (106.419233°)
FTPLK1778DW	L2	Fort Peck Lake – Skunk Coulee Bay	In-Lake, Deepwater	In-Lake Conditions	47° 53' 53.396" (47.898167°)	106° 31' 28.194" (106.524500°)
FTPLK1789DW	L3	Fort Peck Lake – The Pines Recreation Area	In-Lake, Deepwater	In-Lake Conditions	47° 47' 33.078" (47.792517°)	106° 38' 00.257" (106.63340°)
FTPLK1805DW	L4	Fort Peck Lake – Hell Creek Bay	In-Lake, Deepwater	In-Lake Conditions	47° 40' 48.675" (47.680183°)	106° 52' 45.436 (106.879283°)
FTPLKBDCA01	L6	Fort Peck Lake – Lower Big Dry Creek Arm	In-Lake, Deepwater	In-Lake Conditions	47° 54' 25.846" (47.907183°)	106° 24' 54.865" (106.415233°)
FTPLKBDCA02	L7	Fort Peck Lake – Rock Creek Bay	In-Lake, Deepwater	In-Lake Conditions	47° 44' 40.102" (47.744497°)	106° 17' 42.896" (106.295250°)
FTPPP1	OF1	Fort Peck Powerplant	Fort Peck Powerplant	Boundary Conditions Lake Outflow	-----	-----

C-07. Water Quality Trends - Reservoir. Water quality trends over the 35-year period of 1980-2014 were determined for the Fort Peck reservoir for Secchi depth, total phosphorus, chlorophyll *a* and trophic status index (TSI). The assessment was based on near-surface sampling of water quality conditions in the reservoir during the months of May through September at the near-dam, ambient monitoring site. For the assessment period, the Fort Peck reservoir exhibited significant trends for Secchi depth (decreasing), chlorophyll *a* (increasing), and TSI (increasing). No significant trend was detected for total phosphorus. Over the 35-year period, the reservoir has generally remained in a mesotrophic state. Table C-2 summarizes the water quality conditions that were monitored in the Fort Peck reservoir near the damsite during 2010-2014. Updated information and additional detail explaining the water quality trends can be found in the annual water quality report.

C-08. Water Quality Trends – Tailwater. Table C-3 summarizes the water quality conditions that were measured in samples collected from water discharged through Fort Peck during the 5-year period 2010-2014. Dissolved oxygen levels remained relatively high and stable during the winter, steadily declined through the spring and summer, and steadily increased during the fall. The lowest dissolved oxygen levels occurred during the late summer/early fall period. The higher winter, declining spring/summer, and increasing fall dissolved oxygen concentrations are attributed to decreasing dissolved oxygen solubility with warmer water temperatures. The decreasing dissolved oxygen in the July to September period is attributed to ongoing degradation of dissolved oxygen in the hypolimnion of the Fort Peck reservoir as the summer progresses. Water is withdrawn from the reservoir into the dam's power tunnels from below the thermocline at an elevation 65 feet above the reservoir bottom. There appeared to be little correlation between discharge rates and measured water temperature and dissolved oxygen concentrations.

Table C-2
2010-2014 Water Quality Conditions – Fort Peck Reservoir

	Monitoring Results[A]						Water Quality Standards Attainment		
Parameter	**Detection Limit**[B]	**No. of Obs.**	**Mean**[C]	**Median**	**Min.**	**Max.**	**State WQS Criteria**[D]	**No. of WQS Exceedances**	**Percent WQS Exceedance**
Pool Elevation (ft-NGVD29)	0.1	23	2233.3	2233.2	2222.4	2251.8	-----	-----	-----
Water Temperature (°C)	0.1	577	15.1	15.8	5.1	23.6	26.7[1,2]	0	0%
Dissolved Oxygen (mg/L)	0.1	577	9.0	8.9	3.4	11.8	5.0[1,3]	9	2%
Dissolved Oxygen (% Sat.)	0.1	577	92.1	93.4	33.5	111.5	-----	-----	-----
Specific Conductance (uS/cm)	1	577	682	734	536	794	-----	-----	-----
pH (S.U.)	0.1	577	8.3	8.3	7.5	9.0	6.5[1,3], 9.0[1,2]	0	0%
Turbidity (NTUs)	1	574	-----	n.d.	n.d.	49	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	577	309	326	113	494	-----	-----	-----
Secchi Depth (M)	0.2	23	3.25	3.35	0.66	6.10	-----	-----	-----
Alkalinity, Total (mg/L)	7	45	155	156	147	164	-----	-----	-----
Carbon, Total Organic (mg/L)	0.05	45	3.2	3.2	1.7	4.9	-----	-----	-----
Chloride (mg/L)	1	18	9	9	9	10	-----	-----	-----
Chlorophyll *a* (ug/L) – Field Measured	1	574	4	3	n.d.	17	-----	-----	-----
Chlorophyll *a* (ug/L) – Lab Determined	1	23	3	3	n.d.	6	-----	-----	-----
Colorized Dissolved Organic Matter (ug/L)	4	36	17	17	11	25	-----	-----	-----
Dissolved Solids, Total (mg/L)	5	45	511	520	268	746	-----	-----	-----
Nitrogen, Ammonia Total (mg/L)	0.02	45	-----	n.d.	n.d.	0.08	4.7 [1,2,4], 1.3[1,4,5]	0	0%
Nitrogen, Kjeldahl Total (mg/L)	0.1	45	-----	0.3	n.d.	0.7	-----	-----	-----
Nitrogen, Nitrate-Nitrite Total (mg/L)	0.02	45	-----	n.d.	n.d.	0.10	-----	-----	-----
Nitrogen, Total (mg/L)	0.1	37	0.2	0.3	n.d.	0.7	-----	-----	-----
Phosphorus, Dissolved (mg/L)	0.02	45	-----	n.d.	n.d.	0.04	-----	-----	-----
Phosphorus, Orthophosphate	0.02	45	-----	n.d.	n.d.	0.03	-----	-----	-----
Phosphorus, Total (mg/L)	0.02	45	-----	n.d.	n.d.	0.33	-----	-----	-----
Sulfate (mg/L)	1	45	198	218	122	249	-----	-----	-----
Suspended Solids, Total (mg/L)	4	45	-----	n.d.	n.d.	20	-----	-----	-----
Microcystin (ug/L)	0.1	23	-----	n.d.	n.d.	0.2	-----	-----	-----

n.d. = Not detected.

[A] Results for water temperature, dissolved oxygen, specific conductance, pH, turbidity, ORP, and chlorophyll *a* (field probe) are for water column depth-profile measurements. Results for chlorophyll *a* (lab determined) and microcystin are for "grab samples" collected at a near-surface depth. Results for other parameters are for "grab samples" collected at near-surface and near-bottom depths.

[B] Detection limits given for the parameters Pool Elevation, Water Temperature, Dissolved Oxygen (mg/L and % Sat.), Specific Conductance, pH, Oxidation-Reduction Potential, and Secchi Depth are resolution limits for field measured parameters.

[C] Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean (i.e. log conversion of logarithmic pH values was not done to calculate mean).

[D] Criteria given for reference – actual criteria should be verified in appropriate state water quality standards.

- [1] Criteria for B-3 classified waters.
- [2] Daily maximum criterion (monitoring results directly comparable to criterion).
- [3] Daily minimum criterion (monitoring results directly comparable to criterion).
- [4] Total ammonia criteria pH and temperature dependent. Criteria listed are for the median pH and temperature conditions.
- [5] 30-day average criterion (monitoring results not directly comparable to criterion).

Table C-3
2010-2014 Water Quality Conditions – Fort Peck Tailwater

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit(A)	No. of Obs.	Mean(B)	Median	Min.	Max.	State WQS Criteria(C)	No. of WQS Exceedances	Percent WQS Exceedance
Dam Discharge, Powerplant (cfs)	1	40	8,257	7,690	4,404	13,491	-----	-----	-----
Dam Discharge, Spillway (cfs)(D)	1	5	23,399	25,733	7,030	46,618	-----	-----	-----
Water Temperature (°C)	0.1	39	8.9	9.7	2.1	15.8	19.4(1,4)	0	0%
Dissolved Oxygen (mg/L)	0.1	39	9.7	9.9	4.1	12.9	8.0(1,2,4), 5.0(1,3,4)	9, 1	23%, 1%
Dissolved Oxygen (% Sat.)	0.1	39	85.7	88.5	39.6	107.0	-----	-----	-----
pH (S.U.)	0.1	38	8.1	8.1	7.6	8.7	6.5(1,5), 9.0(1,4)	0	0%
Specific Conductance (uS/cm)	1	39	684	734	537	786	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	38	346	344	167	568	-----	-----	-----
Turbidity (NTU)	0.1	38	-----	n.d.	n.d.	30	-----	-----	-----
Alkalinity, Total (mg/L)	7	40	156	157	147	164	-----	-----	-----
Carbon, Total Organic (mg/L)	0.05	40	3.3	3.2	1.6	7.2	-----	-----	-----
Chemical Oxygen Demand (mg/L)	2	10	8	9	3	12	-----	-----	-----
Chloride, Dissolved (mg/L)	1	15	9	9	8	11	-----	-----	-----
Colorized Dissolved Organic Matter (ug/L)	4	31	17	16	12	26	-----	-----	-----
Dissolved Solids, Total (mg/L)	5	40	494	524	278	690	-----	-----	-----
Nitrogen, Ammonia Total (mg/L)	0.02	40	-----	n.d.	n.d.	0.07	6.9(1,4,6), 2.0(1,4,7)	0	0%
Nitrogen, Kjeldahl Total (mg/L)	0.1	40	0.3	0.3	n.d.	0.6	-----	-----	-----
Nitrogen, Nitrate-Nitrite Total (mg/L)	0.02	40	-----	n.d.	n.d.	0.17	-----	-----	-----
Phosphorus, Dissolved (mg/L)	0.02	40	-----	n.d.	n.d.	0.17	-----	-----	-----
Phosphorus, Total (mg/L)	0.02	40	-----	0.02	n.d.	0.17	-----	-----	-----
Phosphorus-Orthophosphate (mg/L)	0.02	40	-----	n.d.	n.d.	0.04	-----	-----	-----
Sulfate (mg/L)	1	40	194	216	118	250	-----	-----	-----
Suspended Solids, Total (mg/L)	4	40	-----	n.d.	n.d.	59	-----	-----	-----

n.d. = Not detected. b.d. = Criterion below detection limit.

(A) Detection limits given for the parameters Streamflow, Water Temperature, Dissolved Oxygen (mg/L and % Sat.), pH, Specific Conductance, and Oxidation-Reduction Potential are resolution limits for field measured parameters.

(B) Nondetect values set to 0 to calculate mean. If 20% or more of observations were n.d., mean is not reported. The mean value reported for pH is an arithmetic mean (i.e. log conversion of logarithmic pH values was not done to calculate mean).

(C) Criteria given for reference – actual criteria should be verified in appropriate state water quality standards.
- (1) Criteria for B-3 classified waters.
- (2) Early life stages.
- (3) Non-early life stages.
- (4) Daily maximum criterion (monitoring results directly comparable to criterion).
- (5) Daily minimum criterion (monitoring results directly comparable to criterion).
- (6) Total ammonia criteria pH and temperature dependent. Criteria listed are for the median pH and temperature conditions.
- (7) 30-day average criterion (monitoring results not directly comparable to criterion).

(D) May through September 2011.

Appendix D - Fish and Wildlife

D-01. General. The USFWS has identified three protected species – the endangered least tern, the threatened piping plover and the endangered pallid sturgeon – that are affected by the regulation of the System. Development of the System has transformed a major portion of the Missouri River valley extending from eastern Montana through the Dakotas from an area typical of alluvial streams into a chain of long, relatively deep reservoirs. This development, in an area where such a quantity of surface water did not exist naturally and that is characterized as having a relatively dry climate, has had a great effect on the environment of the area. The purchase and subsequent management of lands associated with the individual System projects has changed use patterns of lands adjacent to the System projects from the use experienced prior to projects. Regulation of the reservoirs also has affected the regime of the Missouri River through those reaches below the System and in those reaches between the System reservoirs where the river is still more or less in its natural state. The full impact of each of the reservoirs and its regulation on the environment is constantly changing as they adapt to new conditions. The environmental emphasis has changed since the System was authorized. Current efforts are focused on increased stewardship of the Missouri River and surrounding affected lands by maintaining them in as natural a condition as possible through enhancing and supporting native plants and species. The two basic goals of the Corps stewardship are to manage lands and waters to ensure their availability for future generations and to help maintain healthy ecosystems and biodiversity. Balancing the needs of the people with those of nature is the basic challenge. Through observations and discussion with interested individuals and agencies, many suggestions for environmental enhancement of the System have been received and are being implemented by the Corps. The adaptive management process discussed in Chapter VII of the Master Manual provides additional focus on this effort, and, through implementation of the actions developed and tested through this process, Missouri River ecosystem restoration will occur.

D-01.1. Another major point of emphasis in environmental considerations has been the effect of the various System regulation practices on fish and wildlife, including T&E species. Improvement of fish spawning activities by appropriate management for habitat development and subsequent spawning is an important consideration in System regulation. Suggestions have been made and adopted to the degree practicable for improving migratory waterfowl habitat and hunter access along the river below the projects. Other suggestions, such as reduction of flows during the migration period so that more sandbars could be available, cannot always be implemented without serious effects on other authorized project purposes. As further suggestions are received, they will be evaluated through the adaptive management process. Another area of environmental concern is the management of project lands. Currently, the major emphasis on the development of these lands is for water-oriented recreation; however, large areas of project lands are now being managed almost exclusively for wildlife purposes.

D-02. Fish and Wildlife. Fish and wildlife enhancement has been discussed in other portions of the Master Manual. Section 4-06.6 of the Master Manual presents information on the activities of two existing federal fish hatcheries and the Fort Peck State Fish Hatchery. At all times of the year, but particularly during the fish spawning period and the T&E species nesting season, the MRBWM office recognizes and integrates fish and wildlife purpose considerations into System regulation decisions to the extent possible with consideration to other authorized purposes. The Corps coordinates closely with the USFWS and the state organizations to assure that the consideration of effects on fish and wildlife is provided. Appendix D of the Master Manual provides a detailed discussion of the existing Missouri River basin environment and historical System regulation related to this authorized purpose.

D-03. Regulation for Endangered and Threatened Species – Least Terns and Piping Plovers. Releases from Garrison, Fort Randall and Gavins Point have been modified to accommodate endangered least tern and threatened piping plover nesting since 1986. Regulation of Fort Peck for the T&E species ended after the 2004 nesting season due to its limited impact on the species. As a measure to minimize take while maintaining the flexibility to increase releases during the nesting season, hourly releases from Fort Randall and Garrison follow a repetitive daily pattern to limit peak stages below the project for nesting birds. Daily hydropower peaking patterns are developed prior to nest initiation in early to mid-May and are provided to Western. Average daily releases may be increased every third day to preserve the capability of increasing releases later in the summer with little or no incidental take if drier downstream conditions occur. If higher daily releases are required later in the nesting season, the daily peaking pattern may be adjusted, reduced or eliminated resulting in a steady release to avoid increased stages at downstream nesting sites. Additional System regulation criteria used for T&E species is discussed in Section 7-09 of this WCM and Section 7-10 and Appendix D of the Master Manual.

D-04. Fish and Wildlife Resources. The CMR NWR, which consists of approximately 1.1 million acres surrounding the reservoir, was created in 1936 by Executive Order. The game range lands are reserved for the development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources. The lands were withdrawn from settlement, sale or entry. However, they may be used subject to specific approval for mineral, oil and gas exploration, hunting and fishing. The federal and state fish and wildlife agencies, together with the BLM, recognized the need for public use developments due to the lack of such facilities in the vicinity, and have cooperated in the development program. The reservoir area supports abundant wildlife and various species of fish.

D-05. Montana Fish, Wildlife and Parks. The State of Montana Department of Fish Wildlife and Parks (MFWP) coordinates the management of fish and wildlife resources with the USFWS and manages the state parks and state fishing access sites located on land leased from the federal government. The MFWP, in cooperation with the USFWS, regulates hunting for game animals on project lands. The MFWP also manages fisheries on the Fort Peck reservoir and in the Missouri River within the Fort Peck project.

Appendix E - Water Supply and Irrigation

E-01. Introduction. System regulation has assured a relatively uniform supply of water for downstream municipalities and industrial uses. The Corps provides more than adequate flow in the river to meet the requirements of all who choose to utilize the Missouri River for their water supply. At times, releases from individual System projects have been adjusted to ensure continued satisfactory functioning of water intakes on a short-term basis. The Missouri River and its System reservoirs are a source of water for municipal water supply, irrigation, cooling water, and commercial, industrial and domestic uses. Approximately 1,600 water intakes of widely varying size are located within the System and the lower Missouri River. Access to water is a key concern because low water levels limit the ability of some intakes to access the water and increase the cost of getting water from both the reservoirs and Missouri River. Water supply is a purpose that has grown more than originally envisioned. The regulation of the System in such a predictable manner provides a dependable domestic and industrial water supply for many river communities for using the Missouri River as a source for domestic as well as industrial water supply. Releases have been of a uniformly good quality. There have been times when intake access becomes a problem, primarily during release reductions for flood control or because of reduced releases and low reservoir levels during an extended drought. It is the intake owner's responsibility to maintain adequate access to the water supply available in the Missouri River. Per the MRRMP-EIS, of the approximately 3.2 million persons served by water supply from the System, 89 percent are downstream of Gavins Point (see Table E-1 of the Master Manual). There are no thermal powerplants in the Fort Peck reservoir area or in the river reach below Fort Peck. More detailed discussion on water supply and irrigation can be found in Appendix E of the Master Manual.

E-02. The Fort Peck Reservoir. As shown in Table E-3 of the Master Manual, there are 109 water supply intakes and intake facilities located on the Fort Peck reservoir. These include 1 municipal water supply facility, 5 irrigation intakes, 101 domestic intakes and 2 public intakes. The municipal water supply facility serves a population of approximately 580 persons. Cabin owners own the majority of the domestic intakes, which are generally used in lawn watering, car washing, and fire protection. Domestic intakes along this reach are not generally used to provide drinking water, which is obtained in neighboring towns.

E-03. Fort Peck Dam to Garrison Reservoir. Per Table E-3 of the Master Manual, there are 450 water supply intakes and intake facilities located on the Missouri River in this reach from Wolf Point, MT to Williston, ND. These include 4 municipal water supply facilities, 283 irrigation intakes, 162 domestic intakes and 1 public intake. The municipal water supply facilities serve a population of approximately 114,277 persons, 80 percent of whom live in the Williston area. Of the 450 water supply intakes and intake facilities, there are 110 water supply intakes and intake facilities located on the Missouri River serving the Fort Peck Reservation. These include 2 municipal water supply facility, 94 irrigation intakes, and 14 domestic intakes. The municipal water supply facilities serve a population of approximately 200 persons.

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Appendix F - Hydropower

F-01. General. Hydropower generation by System powerplants represents one of the authorized project purposes. The hydropower production of the System continues to be of great importance and of direct interest because of the day-by-day direct benefits realized by a large segment of the Missouri River basin's population in the form of relatively low-cost power and the annual return of revenues to the U.S. Department of the Treasury. Hydropower plays an important role in meeting the electricity demands of our Nation. It is a renewable energy source that helps conserve the nonrenewable fossil and nuclear fuels. It helps meet the basin's needs at an affordable price in an environmentally safe way. Nearly $6 billion in cumulative hydropower benefits amortized to current dollars has occurred from the regulation of the System. At the six System dams, 36 hydropower units provide a combined capacity of 2,500 megawatts (MW), as shown in Table F-1. These units have provided an average of 9.3 million (1967-2015) megawatt hours (MWh) per year. Western, of the U.S. Department of Energy, markets power generated at the System dams within the Southwest Power Pool (SPP). Western joined the SPP market in October 2015. Western had previously marketed energy in the Mid-continent Area Power Pool region.

F-02. Hydropower Capacity. The aggregate installed capacity of all powerplants in the Missouri River basin exceeds 20,000 MW, with an annual generation of over 90 million MWh. The investor-owned systems have about 60 percent of the basin's generating capacity. The publicly-owned systems consist of about 40 percent federal hydroelectric capacity and 60 percent thermal capacity owned by non-federal public bodies. Hydropower installations in the basin total about 3,000 MW, of which about 82 percent is federal, 14 percent is investor owned, and 4 percent is publicly owned. The federal power system in the upper Missouri River basin includes the six Corps System powerplants as well as the Canyon Ferry and Yellowtail powerplants constructed by the USBR. Until October 1, 1977, power from all Missouri River basin federal powerplants was marketed by the USBR. At that time, the power marketing responsibility shifted to Western. The federal hydroelectric powerplants are connected with the extensive federal transmission system within Western's Eastern Division, Pick-Sloan Missouri Basin Program, power-marketing area, which includes Montana east of the Continental Divide, North Dakota, South Dakota, eastern Nebraska, western Minnesota and western Iowa. The transmission network is interconnected with numerous Rural Electric Association-financed cooperatives, municipal power systems, and investor-owned utilities. The Eastern Division transmission network is interconnected with Southwestern at Maryville, MO, and with the Western Division through a 100 MW direct current tie at Stegall, NE, owned by the Tri-States Cooperative. In addition, by a split-bus operation, a variable number of units can be operated on the Western System at the Fort Peck and Yellowtail (USBR reservoir project) powerplants.

F-03. Hydropower Facilities and Historic Regulation. The following sections describe the individual System project hydropower and generation. Chapter IV in the Master Manual contains a more detailed description of the hydropower and powerplant facilities. Table F-1 presents hydropower related information for the System projects. Refer to Appendix F of the Master Manual for additional hydropower information on System projects.

Figure F-1
System Project Hydropower Data

Dam	Generator Capacity (MW)	Energy (million MWh)	Average Annual Energy Plant Factor (%)	Units	Average Gross Head (feet)	Average Flow (kcfs)	Normal Powerhouse** Capacity (kcfs)	Average Annual Flow Plant Factor (%)	Type
Fort Peck	185	1.0	63	5	194	9.2	16	58	Semi-Peaking
Garrison	583	2.2	43	5	161	21.6	41	53	Semi-Peaking
Oahe	786	2.6	38	7	174	23.2	54	43	Peaking
Big Bend	517	1.0	22	8	70	23.7	103	22	Peaking
Fort Randall	320	1.7	61	8	118	25.1	44.5	56	Semi-Peaking
Gavins Point	132	0.7	62	3	48	27.6	36	77	Baseload
Total	**2,523**	**9.3**		**36**					

** Normal powerhouse capacity is based on average reservoir elevation.

Note: Flow plant factors are calculated based on average flows versus powerhouse flow capacities. These differ from energy-based plant factors to the extent that actual plant head is less than maximum gross head.

Source: Corps, 1967-2015 actual data.

F-04. Fort Peck Dam. There are five units operating at Fort Peck, with a generating capacity of 185 MW. The powerhouse discharge capacity is about 15,000 to 16,000 cfs, and the average release is 9,200 cfs (1967-2015). The average annual flow plant factor is 58 percent. The powerplant produces an average of approximately 1.0 million MWh of energy per year. The first hydropower unit went on line in 1943 and the first powerhouse was completed with the installation of the third unit in 1951. The second powerhouse with two units was completed in 1961. The Fort Peck powerplant is a semi-peaking plant.

F-05. Fort Peck Releases. Prior to 1956, Fort Peck was the only System project with a major amount of accumulated storage. As a consequence, releases as high as 28,000 cfs were made in the late summer and fall for flood storage evacuation as well as for downstream navigation flow support. After the second powerhouse went on line in 1961, nearly all the releases have been made through the power turbines except in years when releases were very high due to the evacuation of flood waters. Since 1967 when the System filled, releases greater than the combined powerplant capacity of about 16,000 cfs have occurred in 1971, 1976, 1979, 1997 and 2011. Minimum average daily releases since 1954 have usually been no less than 3,000 cfs; however, average daily releases as low as zero have occurred.

F-06. System Hydropower Generation Considerations. Power generation at the six System dams generally must follow the seasonal pattern of water movement through the System. Adjustments, however, have been made to the extent possible to provide maximum power production during the summer and winter months when demand is high. Oahe and Big Bend power generation is relatively high during the winter. Since System release in the winter is low, the winter Oahe and Big Bend powerplant releases must be stored in the Fort Randall reservoir. To allow for this, the Fort Randall reservoir is drawn down during the fall of each year, as discussed in Section F-06.2 of this WCM.

F-06.1. Hourly patterning of the average daily releases is also of major importance in realizing the full power potential of the System powerplants. Based on past experience with both open water and a downstream ice cover, in most cases no limits need be placed on daily peaking (with the exception of Gavins Point) up to the capacities of the individual powerplants, except during the T&E nesting seasons, provided the limiting average daily discharge is not exceeded. The minimum allowable hourly generation, and corresponding release, is dependent on the hydraulic characteristics of the river below each of the projects and the effect on water use in the downstream reaches. Downstream water supply intakes, fish spawning activities in the downstream channel, recreational usage, and other factors that may be seasonal in nature influence the selection of minimum limits. These constraints at particular projects are summarized in the Master Manual and additional detail for Fort Peck is found in this WCM.

F-06.2. Due to the flexibility inherent in such a large system of reservoirs, it is possible to pattern project releases (with the exception of Gavins Point) to cycles extending for periods longer than a day in duration for maximum power production while still providing full service to the authorized project purposes other than hydropower. During the navigation season when downstream flow requirements are high, large amounts of water are normally released from Gavins Point. This requires that large volumes of inflow to Gavins Point be supplied from Fort Randall. Fort Randall, in turn, requires similar support from Big Bend, and Big Bend from Oahe. Here the chain can be interrupted because Oahe is large enough to support high upstream releases for extended periods without correspondingly high inflows. High summer releases from Gavins Point, Fort Randall, Big Bend and Oahe result in high generation rates at these plants. To avoid generating more power than can be marketed advantageously under these circumstances and to provide more winter hydropower, the usual practice during this time of year is to hold releases and generation at Fort Peck and Garrison at lower levels unless the evacuation of flood control storage space or the desire to balance storages between projects becomes an overriding consideration. With the end of the navigation season, conditions are reversed. Releases from Gavins Point drop to about half of summer levels and the chain reaction proceeds upstream, curtailing releases from Fort Randall, Big Bend and Oahe. A means of partially compensating for the lesser amount of hydroelectric energy associated with lower winter release rates from Fort Randall and other mainstem reservoirs is the pre-winter drawdown of the Fort Randall reservoir. As part of this regulation, Oahe and Big Bend releases are reduced several weeks prior to the end of the navigation season. This leaves the Fort Randall reservoir in the position of supplying a majority of downstream releases requirements from accumulated storage, resulting in a lowering reservoir level. This vacated storage space is refilled during the winter months by releases from Oahe and Big Bend in excess of those that would have been possible if drawdown of the Fort Randall reservoir had not been made. At this time, Fort Peck and Garrison winter releases are usually maintained at relatively higher levels as permitted by the downstream ice cover to partially compensate for the reduction in generation downstream.

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Exhibit A

Missouri River Mainstem Dams

Operational Restrictions and Best

Practices for Spillway Gates and

Outlet Tunnels

CENWO-ED-DF 14 April 2017

MEMORANDUM FOR CENWD-PDR

SUBJECT: Missouri River Mainstem Dams, Operational Restrictions and Best Practices

1. In response to your 7 March 2017 request regarding current gate restrictions and/or operating guidelines, this memorandum contains all known operating restrictions that have been enacted by Engineering Division for the mainstem dams. Additional guidance regarding best practices and/or special considerations at the mainstem dams is also provided. The references listed in enclosure 1 provide the basis for these operational restrictions, best practices, and special considerations. More detailed information may be found within these documents.

a) General Operational Restrictions and Best Practices:

(1) Operation of Adjacent Tainter Gates - Operation of the tainter gates shall be sequenced such that differences in openings between adjacent gates shall not exceed 6 feet at any time in order to avoid excessive eccentricity of load on the trunnion beam and anchors. (ref. 1)

(2) Operation Adjacent to a Dewatered Tainter Gate - Do not operate a tainter gate that is subject to hydrostatic load if it is adjacent to a dewatered gate in order to avoid excessive eccentricity of load on the trunnion beam and anchors. (ref. 1)

(3) Ice on or Adjacent to Spillway Gates - Spillway tainter gates and spillway vertical lift gates shall not be operated if ice is present on the gate or if there is lake ice adjacent to the gate. Operation of a gate with ice either on or adjacent to the gate would risk overstressing of steel members, overload of the hoist mechanism, and damage to the seals. (ref. 1)

(4) Overtopping of Spillway Gates – Releases shall be managed to prevent the reservoir from rising above the top of the tainter gates and vertical lift gates. Overtopping would increase stresses in the steel framing beyond the design forces. (ref. 1 & 2)

(5) Operation of Gates with Wave Splash Over - There is no restriction against operating gates while waves are splashing over the top of the gate if the average pool elevation is not above the top of the gate. (ref. 1)

(6) Operation of Spillway Gates with Exceptionally Large Waves - If possible, operation of the spillway gates should be postponed until exceptionally large waves have subsided. (ref.1)

b) Project Specific Operational Restrictions and Best Practices:

(1) Oahe Dam Tainter Gate Deflector Plates - Releases shall be managed to prevent the Oahe Reservoir from rising above the top of the tainter gates and onto the wave splash deflector plates. The deflector plates were added in 1994 to the top of the tainter gates to prevent wave splash-over from impacting the top girder on the downstream side of the gate. The deflector plates were not intended to allow pool elevations higher than the original top of gate. (ref. 3)

(2) Fort Peck Spillway Vertical Lift Gates - Operation of spillway gates 11, 12, 13 and 16 shall be restricted as much as possible until the counterweight plates connected to the lifting

chain on those gates have been replaced. Ultrasound inspection of those connectors observed internal delamination. (ref. 4)

(3) Fort Peck Outlet Tunnels - Previous studies have reported damage to the ring gates, shaft, and tunnels during releases through the outlet works. The studies also questioned the ability to place the emergency gates during flow conditions. It is recommended that ring gates should not be used except in a case of a dam safety emergency. Engineering Division shall be notified in advance of any planned releases through the outlet works. (ref. 5)

(4) Garrison Dam Outlet Regulating Gates - The regulating gates shall not be operated at or below the 6 inch open position. The regulating gates in tunnels no. 7 and 8 shall not be operated at an opening greater than 19.0 feet, except in an emergency and then the gate must be fully opened. The regulating gate in tunnel no. 6 shall not be operated at an opening greater than 23.5 feet. Hydraulic model testing revealed unstable flow conditions at certain openings. The O&M manual states that the controls for these gates have been set to prevent operation of these gates at the openings identified above. (ref. 7)

c) Project Specific Special Considerations:

(1) Gavins Point Lake Yankton Embankment - The Lake Yankton Embankment includes the original training dike which starts at the left spillway wall and extends approximately 3,400 feet downstream to the hydraulic fill section. The Lake Yankton Embankment impounds water for recreational use, but Lake Yankton also provides a stabilizing effect on the under seepage performance of the Gavins Point Dam Embankment. The loss of Lake Yankton could initiate rapid development of high exit gradients immediately downstream of the relief wells and potentially threaten the integrity of Gavins Point Dam. While a formal operational restriction is not recommended, releases from the Gavins Point spillway should be coordinated with Omaha District Dam Safety staff so that release does not compromise the integrity of the Lake Yankton Embankment. Integrity concerns for Lake Yankton Embankment could include scour due to high spillway releases, overtopping of the embankment or sudden drawdown stability concerns caused by significant reduction in spillway releases in a short time period. (ref. 8)

2. Point of contact for this memo is Wayne Boeck, Chief, Structural Section, (402) 995-2151, email Wayne.R.Boeck@usace.army.mil.

[redacted]

JOHN J. BERTINO, JR., P.E.
Chief, Engineering Division

Encl:
1. References

CF:
CEWNO-OD-GP (Becker)
CENWO-OD-FR (Curran)
CENWO-OD-BB
CENWO-OD-OA (Stasch)
CENWO-OD-GA (Lindquist)
CENWO-OD-FP (McMurry)

REFERENCES

1. *Missouri River Mainstem Dams, Spillway Gate Plan of Action*, Memorandum from CENWO-ED for CENWO-OD (10 March 2015)

2. *Overtopping of the Fort Peck Spillway Gates*, Memorandum from CENWO-ED-DA for CENWO-ED-G (22 December 1997)

3. *Design Report on Overtopping Tainter Gates/Oahe Tainter Gate Renovation* Memorandum from CEMRO-ED-DI for Commander, Missouri River Division)18 March 1994)

4. *Fort Peck Dam, Spillway Gate Operational Restrictions*, Memorandum from CENWO-ED for CENWO-OD (21 June 2016)

5. *Outlet Works Modifications, Fort Peck Dam, Major Rehabilitation Evaluation Report* (March 1994)

6. *Oahe Outlet Works Bridge Scour Monitoring Plan* ,CEBIS Bridge File (03 March 2012)

7. *Operation and Maintenance Manual, Garrison Dam,* Paragraph 5-04L *Regulating Gates and Associated Equipment* (1982)

8. *2011 Flood Surveillance and Assessment, Gavins Point Dam Missouri River* (March 2012)

Exhibit B

Emergency Regulation Procedures

for

Fort Peck Project

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

REPLY TO
ATTENTION OF

CENWD-PDR (11-2-240a) 01 September 2017

MEMORANDUM FOR Fort Peck Operations Project Manager

SUBJECT: Reservoir Regulation Order, Emergency Regulation Procedure for Fort Peck

1. Procedures applicable to the regulation of Fort Peck during any period that communication with the Missouri River Basin Water Management (MRBWM) Division or the Omaha District Water Control and Water Quality Section is not possible are outlined in the following paragraphs. These instructions supersede all previously furnished emergency regulation criteria.

2. Normally, reservoir regulation orders specifying future project releases and power production are furnished by the MRBWM to Fort Peck. Fort Peck shall provide to the MRBWM project data such as observed reservoir elevations, releases, power generation and related hydrologic data.

3. The MRBWM office normally transmits the reservoir regulation orders via e-mail to Fort Peck on a daily basis. Regulation instructions for the weekend and holidays are contained in the previous normal working day's orders. Fort Peck utilizes the Power Plant Control System (PPCS) to transmit observed hourly and daily project data, via the Data Collection Platforms (DCPs) to the MRBWM office. If e-mail or network communication between the MRBWM and Fort Peck is not available, an alternate means of communication and/or data transfer shall be used. Alternate means of communication includes facsimile (fax), land-line telephone, cellular telephone, relay of data by other Missouri River Mainstem project offices and utilization of Western Area Power Administration (Western) facilities.

4. When communication, as outlined in paragraph 3 above, cannot be established, the following will apply:

a. Every reasonable effort will be made to re-establish communication between Fort Peck and the MRBWM office.

b. During this initial period of communication failure, project personnel should note the reservoir elevations and releases on the latest regulation forecasts (three-week and monthly) if available. As long as reservoir elevations do not vary significantly from these regulation forecasts, the provision of the latest regulation order will be extended. Hourly powerplant loading will follow the Western loading schedule, if available. If the hourly schedule has not been received from Western, powerplant releases will be made to provide the daily energy schedule specified in the latest regulation order and will be patterned similar to recent experience. If significant variations occur from the current forecasts, follow procedures as outlined in 4.c. and 4.d.

c. Following a communications failure, the provision of the latest regulation order will be extended. Hourly powerplant loading will be as described in 4.b. If requested by Western, and if power emergency conditions have been declared, energy generation may be increased to the maximum allowable limit shown on the latest regulation order. These procedures will continue to be utilized until communications are re-established as long as the Fort Peck reservoir level remains below elevation 2234.0 feet.

d. If the Fort Peck reservoir level is above elevation 2234.0 feet, procedures outlined in paragraph 4.c. will be applicable during the first day of communication failure, after which conditions will be reviewed to determine if the release level should be changed. Procedures are as follows:

(1) Minimum release will be the release specified in the most recent available regulation order.

(2) The mean inflow for the preceding 24 hours will be estimated by computing the storage change during the 24-hour period on the basis of pool elevations observed at the damsite. Normally, the pool elevation will follow a relatively smooth curve. Therefore, any sudden fluctuations in the pool level recorder trace from a smooth curve (probably due to wind effects on the reservoir gage) should be disregarded and the storage change based on an extrapolation of the smoothed pool level curve through the 24-hour period. The approximate mean inflow in cfs is equivalent to the mean outflow in cfs plus one-half the storage change in acre-feet during the 24-hour period. Twenty four-hour inflow may also be approximated by the equation:

Inflow = Outflow + (120,000 x elevation change in feet)

(3) Utilizing the inflow as developed above and the current pool elevation as indicated by the smoothed pool level curve developed in (2), determine the rule curve release by use of the emergency curves shown on Plate VII-2 or Plate VII-3 in the Fort Peck Water Control Manual (WCM) and as Enclosure 1 and Enclosure 2 of this document, as appropriate to the season.

(4) If the rule curve release developed by (3) is greater than the release given by (1), make releases specified by the rule curve. However, releases will not be

increased to a rate which is greater than twice the average rate for the preceding 24 hours.

(5) With a Fort Peck reservoir level below elevation 2246.0 feet, any release adjustments made necessary by use of the rule curve in accordance with (4) should be made once daily. With a pool elevation above 2246.0 feet, the analysis and necessary adjustments should be at intervals of 12 hours or less.

(6) If rule curve release is less than full powerplant capability, powerplant loading will be patterned similar to recent experience or as prescribed by Western, if communication with their office is possible.

(7) Releases from Fort Peck shall be made through the powerhouses to the degree feasible.

5. In the event of downstream flooding, as reported to or anticipated by the Fort Peck Operations Project Manager, releases will be reduced as deemed necessary to alleviate these conditions. However, with the Fort Peck reservoir above elevation 2234.0 feet, releases will not be reduced below those levels defined by the emergency curves, Enclosures 1 and 2.

6. The foregoing procedures are not intended to relieve the Fort Peck Operations Project Manager of taking such additional measures believed necessary to assure the safety of the project.

// signed copy on file

JODY S. FARHAT, P.E.
Chief, Missouri River Basin Water
Management Division

Encls
Emergency Regulation Curve (Early Spring)
Emergency Regulation Curve (Late Spring)

Fort Peck Dam – Fort Peck Lake

Water Control Manual

Plates

Summary of Engineering Data -- Missouri River Mainstem System

Item No.	Subject	Fort Peck Dam - Fort Peck Lake	Garrison Dam - Lake Sakakawea	Oahe Dam - Lake Oahe
1	Location of Dam	Near Glasgow, Montana	Near Garrison, ND	Near Pierre, SD
2	River Mile - 1960 Mileage	Mile 1771.5	Mile 1389.9	Mile 1072.3
3	Total & incremental drainage areas in square miles	57,500	181,400 (2) 123,900	243,490 (1) 62,090
4	Approximate length of full reservoir (in valley miles)	134, ending near Zortman, MT	178, ending near Trenton, ND	231, ending near Bismarck, ND
5	Shoreline in miles (3)	1520 (elevation 2234)	1340 (elevation 1837.5)	2250 (elevation 1607.5)
6	Average total & incremental inflow in cfs	10,200	25,600 15,400	28,900 3,300
7	Max. discharge of record near damsite in cfs	137,000 (June 1953)	348,000 (April 1952)	440,000 (April 1952)
8	Construction started - calendar yr.	1933	1946	1948
9	In operation (4) calendar yr.	1940	1955	1962
	Dam and Embankment			
10	Top of dam, elevation in feet msl	2280.5	1875	1660
11	Length of dam in feet	21,026 (excluding spillway)	11,300 (including spillway)	9,300 (excluding spillway)
12	Damming height in feet (5)	220	180	200
13	Maximum height in feet (5)	250.5	210	245
14	Max. base width, total & w/o berms in feet	3500, 2700	3400, 2050	3500, 1500
15	Abutment formations (under dam & embankment)	Bearpaw shale and glacial fill	Fort Union clay shale	Pierre shale
16	Type of fill	Hydraulic & rolled earth fill	Rolled earth filled	Rolled earth fill & shale berms
17	Fill quantity, cubic yards	125,628,000	66,500,000	55,000,000 & 37,000,000
18	Volume of concrete, cubic yards	1,200,000	1,500,000	1,045,000
19	Date of closure	24 June 1937	15 April 1953	3 August 1958
	Spillway Data			
20	Location	Right bank - remote	Left bank - adjacent	Right bank - remote
21	Crest elevation in feet msl	2225	1825	1596.5
22	Width (including piers) in feet	820 gated	1336 gated	456 gated
23	No., size and type of gates	16 - 40' x 25' vertical lift gates	28 - 40' x 29' Tainter	8 - 50' x 23.5' Tainter
24	Design discharge capacity, cfs	275,000 at elev 2253.3	827,000 at elev 1858.5	304,000 at elev 1644.4
25	Discharge capacity at maximum operating pool in cfs	230,000	660,000	80,000
	Reservoir Data (6)			
26	Max. operating pool elev. & area	2250 msl 245,000 acres	1854 msl 383,000 acres	1620 msl 386,000 acres
27	Max. normal op. pool elev. & area	2246 msl 240,000 acres	1850 msl 365,000 acres	1617 msl 362,000 acres
28	Base flood control elev & area	2234 msl 211,000 acres	1837.5 msl 308,000 acres	1607.5 msl 311,000 acres
29	Min. operating pool elev. & area	2160 msl 89,000 acres	1775 msl 125,000 acres	1540 msl 115,000 acres
	Storage allocation & capacity			
30	Exclusive flood control	2250-2246 971,000 a.f.	1854-1850 1,495,000 a.f.	1620-1617 1,107,000 a.f.
31	Flood control & multiple use	2246-2234 2,704,000 a.f.	1850-1837.5 4,211,000 a.f.	1617-1607.5 3,208,000 a.f.
32	Carryover multiple use	2234-2160 10,700,000 a.f.	1837.5-1775 12,951,000 a.f.	1607.5-1540 13,353,000 a.f.
33	Permanent	2160-2030 4,088,000 a.f.	1775-1673 4,794,000 a.f.	1540-1415 5,315,000 a.f.
34	Gross	2250-2030 18,463,000 a.f.	1854-1673 23,451,000 a.f.	1620-1415 22,983,000 a.f.
35	Reservoir filling initiated	November 1937	December 1953	August 1958
36	Initially reached min. operating pool	27 May 1942	7 August 1955	3 April 1962
37	Estimated annual sediment inflow	17,200 a.f./year 1073 yrs.	21,600 a.f./year 1,086 yrs.	14,800 a.f./year 1553 yrs.
	Outlet Works Data			
38	Location	Right bank	Right Bank	Right Bank
39	Number and size of conduits	2 - 24' 8" diameter (nos. 3 & 4)	1 - 26' dia. and 2 - 22' dia.	6 - 19.75' dia. upstream, 18.25' dia. downstream
40	Length of conduits in feet (8)	No. 3 - 6,615, No. 4 - 7,240	1529	3496 to 3659
41	No., size, and type of service gates	1 - 28' dia. cylindrical gate 6 ports, 7.6' x 8.5' high (net opening) in each control shaft	1 - 18' x 24.5' Tainter gate per conduit for fine regulation	1 - 13' x 22' per conduit, vertical lift, 4 cable suspension and 2 hydraulic suspension (fine regulation)
42	Entrance invert elevation (msl)	2095	1672	1425
43	Avg. discharge capacity per conduit & total	Elev. 2250 22,500 cfs - 45,000 cfs	Elev. 1854 30,400 cfs - 98,000 cfs	Elev. 1620 18,500 cfs - 111,000 cfs
44	Present tailwater elevation (ft msl)	2032-2036 5,000 - 35,000 cfs	1669-1677 15,000- 60,000 cfs	1422-1427 20,000-55,000 cfs
	Power Facilities and Data			
45	Avg. gross head available in feet (14)	194	161	174
46	Number and size of conduits	No. 1-24'8" dia., No. 2-22'4" dia.	5 - 29' dia., 24' penstocks	7 - 24' dia., imbedded penstocks
47	Length of conduits in feet (8)	No. 1 - 5,653, No. 2 - 6,355	1829	From 3,280 to 4,005
48	Surge tanks	PH#1: 3-40' dia., PH#2: 2-65' dia.	65' dia. - 2 per penstock	70' dia., 2 per penstock
49	No., type and speed of turbines	5 Francis, PH#1-2: 128.5 rpm, 1-164 rpm , PH#2-2: 128.6 rpm	5 Francis, 90 rpm	7 Francis, 100 rpm
50	Discharge cap. at rated head in cfs	PH#1, units 1&3 170', 2-140' 8,800 cfs, PH#2-4&5 170'-7,200 cfs	150' 41,000 cfs	185' 54,000 cfs
51	Generator nameplate rating in kW	1&3: 43,500; 2: 18,250; 4&5: 40,000	3 - 121,600, 2 - 109,250	112,290
52	Plant capacity in kW	185,250	583,300	786,030
53	Dependable capacity in kW (9)	181,000	388,000	534,000
54	Avg. annual energy, million kWh (12)	1,035	2,254	2,622
55	Initial generation, first and last unit	July 1943 - June 1961	January 1956 - October 1960	April 1962 - June 1963
56	Estimated cost September 1999 completed project (13)	$158,428,000	$305,274,000	$346,521,000

Summary of Engineering Data -- Missouri River Mainstem System

Big Bend Dam - Lake Sharpe	Fort Randall Dam - Lake Francis Case	Gavins Point Dam - Lewis & Clark Lake	Total	Item No.
21 miles upstream Chamberlain, SD	Near Lake Andes, SD	Near Yankton, SD		1
Mile 987.4	Mile 880.0	Mile 811.1		2
249,330 (1) 5,840	263,480 (1) 14,150	279,480 (1) 16,000		3
80, ending near Pierre, SD	107, ending at Big Bend Dam	25, ending near Niobrara, NE	755 miles	4
200 (elevation 1420)	540 (elevation 1350)	90 (elevation 1204.5)	5,940 miles	5
28,900	30,000 1,100	32,000 2,000		6
440,000 (April 1952)	447,000 (April 1952)	480,000 (April 1952)		7
1959	1946	1952		8
1964	1953	1955		9
1440	1395	1234		10
10,570 (including spillway)	10,700 (including spillway)	8,700 (including spillway)	71,596	11
78	140	45	863 feet	12
95	165	74		13
1200, 700	4300, 1250	850, 450		14
Pierre shale & Niobrara chalk	Niobrara chalk	Niobrara chalk & Carlile shale		15
Rolled earth, shale, chalk fill	Rolled earth fill & chalk berms	Rolled earth & chalk fill		16
17,000,000	28,000,000 & 22,000,000	7,000,000	358,128,000 cu. yds	17
540,000	961,000	308,000	5,554,000 cu. yds.	18
24 July 1963	20 July 1952	31 July 1955		19
Left bank - adjacent	Left bank - adjacent	Right bank - adjacent		20
1385	1346	1180		21
376 gated	1000 gated	664 gated		22
8 - 40' x 38' Tainter	21 - 40' x 29' Tainter	14 - 40' x 30' Tainter		23
390,000 at elev 1433.6	620,000 at elev 1379.3	584,000 at elev 1221.4		24
270,000	508,000	345,000		25
1423 msl 62,000 acres	1375 msl 102,000 acres	1210 msl 29,000 acres	1,206,000 acres	26
1422 msl 60,000 acres	1365 msl 94,000 acres	1208 msl 25,000 acres	1,146,000 acres	27
1420 msl 58,000 acres	1350 msl 76,000 acres	1204.5 msl 21,000 acres	984,000 acres	28
1415 msl 51,000 acres	1320 msl 36,000 acres	1204.5 msl 21,000 acres	437,000 acres	29
1423-1422 61,000 a.f.	1375-1365 986,000 a.f.	1210-1208 54,000 a.f.	4,674,000 a.f.	30
1422-1420 118,000 a.f.	1365-1350 1,306,000 a.f.	1208-1204.5 79,000 a.f.	11,626,000 a.f.	31
	1350-1320 1,532,000 a.f.		38,536,000 a.f.	32
1420-1345 1,631,000 a.f.	1320-1240 1,469,000 a.f.	1204.5-1160 295,000 a.f.	17,592,000 a.f.	33
1423-1345 1,810,000 a.f.	1375-1240 5,293,000 a.f.	1210-1160 428,000 a.f.	72,428,000 a.f.	34
November 1963	January 1953	August 1955		35
25 March 1964	24 November 1953	22 December 1955		36
3,445 a.f./year 525 yrs.	15,800 a.f./year 334 yrs.	2,700 a.f./year 159 yrs.	77,400	37
	Left Bank			38
None (7)	4 - 22' diameter	None (7)		39
	1013			40
	2 - 11' x 23' per conduit, vertical lift, cable suspension			41
1385 (11)	1229	1180 (11)		42
	Elev 1375			43
1351-1355(10) 25,000-100,000 cfs	32,000 cfs - 128,000 cfs 1228-1237 10,000-60,000 cfs	1153-1161 15,000-60,000 cfs		44
70	117	48	764 feet	45
None: direct intake	8 - 28' dia., 22' penstocks	None: direct intake		46
	1,074		55,083	47
None	59' dia, 2 per alternate penstock	None		48
8 Fixed blade, 81.8 rpm	8 Francis, 85.7 rpm	3 Kaplan, 75 rpm	36 units	49
67' 103,000 cfs	112' 44,500 cfs	48' 36,000 cfs		50
67,275	40,000	44,100		51
517,470	320,000	132,300	2,501,200 kw	52
497,000	293,000	74,000	1,967,000 kw	53
980	1,726	725	9,342 million kWh	54
October 1964 - July 1966	March 1954 - January 1956	September 1956 - January 1957	July 1943 - July 1966	55
$107,498,000	$199,066,000	$49,617,000	$1,166,404,000	56

Remarks

(1) Includes 4,280 square miles of non-contributing areas.
(2) Includes 1,350 square miles of non-contributing areas.
(3) With pool at base of flood control.
(4) Storage first available for regulation of flows.
(5) Damming height is height from low water to maximum operating pool. Maximum height is from average streambed to top of dam.
(6) Based on latest available storage data.
(7) River regulation is attained by flows over low-crested spillway and through turbines.
(8) Length from upstream face of outlet or to spiral case.
(9) Based on 8th year (1961) of drought drawdown (From study 8-83-1985).
(10) Affected by level of Lake Francis case. Applicable to pool at elevation 1350.
(11) Spillway crest.
(12) 1967-2015 Average
(13) Source: Annual Report on Civil Works Activities of the Corps of Engineers. Extract Report Fiscal Year 1999.
(14) Based on Study 8-83-1985

Corps of Engineers, U.S. Army
Compiled by
Northwestern Division
Missouri River Region
December 2016

Plate III-1

US Army Corps of Engineers®
Northwestern Division

Mainstem Dam
Cities
Rivers
Reservoirs/Lakes
Omaha/Kansas City District Boundaries
State Boundaries

0 50 100 200 300 Miles

Imagery Source:
U.S. Department of Agriculture, Farm Service Agency 2014

G:\2016_DivisionMaps\MO_BaseMap\mxd\General_Location_Map.mxd

Missouri River Basin
GENERAL LOCATION
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

River	Drainage Area (sq.mi.)
Musselshell River	**9570**
Madison River	**2570**
Smith River	**2020**
Marias River	**9180**
Gallatin River	**1820**
Big Dry Creek	**3800**
Sun River	**2000**
Jefferson River	**9710**
Other	**16830**
Total	**57500**

Plate III-2

US Army Corps of Engineers®
Northwestern Division

Mainstem Dam
Cities
Rivers
Reservoirs/Lakes
Fort Peck Drainage Area
Omaha/Kansas City District Boundaries
State Boundaries

0 25 50 100 150 Miles

N E S W

Data Source:
U.S. Department of Agriculture,
Farm Service Agency 2014

G:\2016_DivisionMaps\MO_Incremental_Drainage\mxd\Ft_Peck_Incremental_Drainage_Map.mxd

Missouri River Basin
FORT PECK DRAINAGE AREA
INCREMENTAL DRAINAGE
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

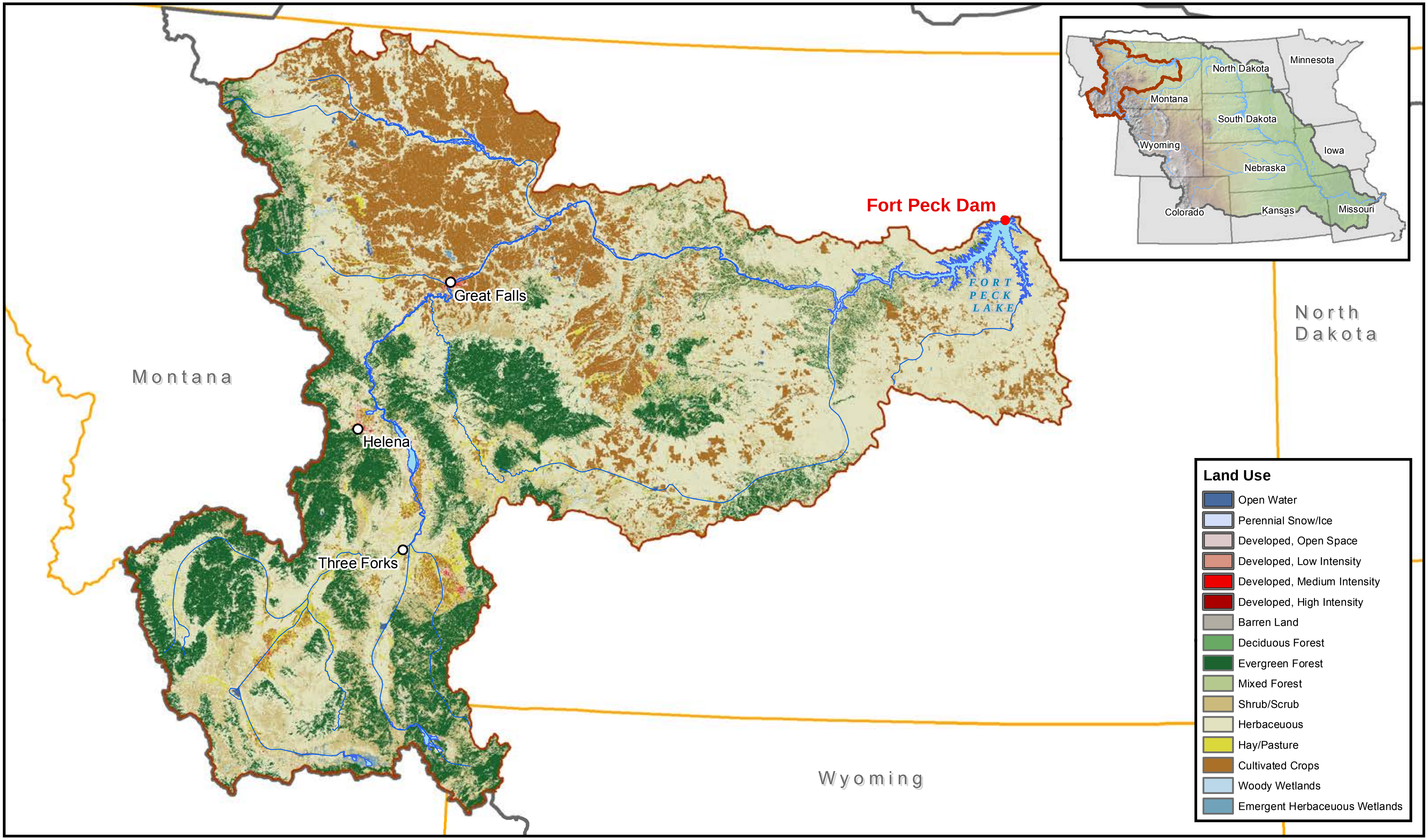


Plate III-3

US Army Corps of Engineers®
Northwestern Division

Mainstem Dam
Cities
Rivers
Reservoirs/Lakes
Fort Peck Drainage Area
Omaha/Kansas City District Boundaries
State Boundaries

0 25 50 100 150 Miles

N W E S

Data Source:
U.S. Department of Agriculture,
Farm Service Agency 2014

G:\2016_DivisionMaps\Land_Cover\mxd\Ft_Peck_Land_Use_Map.mxd

Missouri River Basin
FORT PECK DRAINAGE AREA
LAND USE
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Plate III-4

US Army Corps of Engineers®
Northwestern Division

Mainstem Dam
Cities
Rivers
Reservoirs/Lakes
Omaha/Kansas City District Boundaries
State Boundaries

Average Precipitation - Annual

< 8.0"
8.0" - 20.0"
20.0" - 40.0"
40.0" - 60.0"
> 60.0"

0 50 100 200 300 Miles

N W E S

Data Source:
U.S. Department of Agriculture,
Farm Service Agency 2014

G:\2016_DivisionMaps\MO_Precip\mxd\Precipitation_Annual_Map.mxd

Missouri River Basin
AVERAGE PRECIPITATION
ANNUAL
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

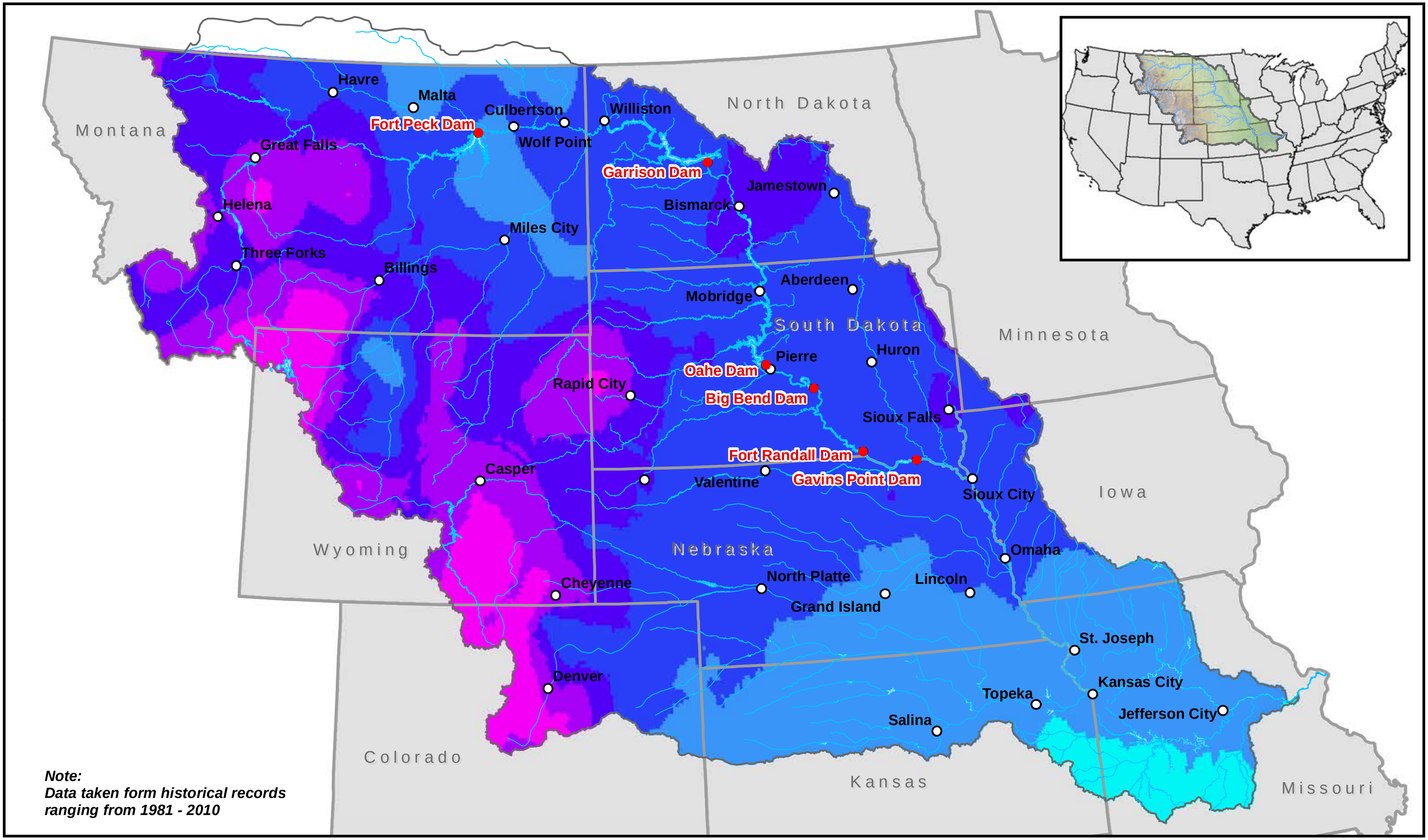


Plate III-5

US Army Corps of Engineers®
Northwestern Division

- Mainstem Dam
- Cities
- Rivers
- Reservoirs/Lakes
- Omaha/Kansas City District Boundaries
- State Boundaries

Annual Mean Snowfall

- < 12 Inches
- 12 - 24 Inches
- 24 - 36 Inches
- 36 - 48 Inches
- 48 - 72 Inches
- > 72 Inches

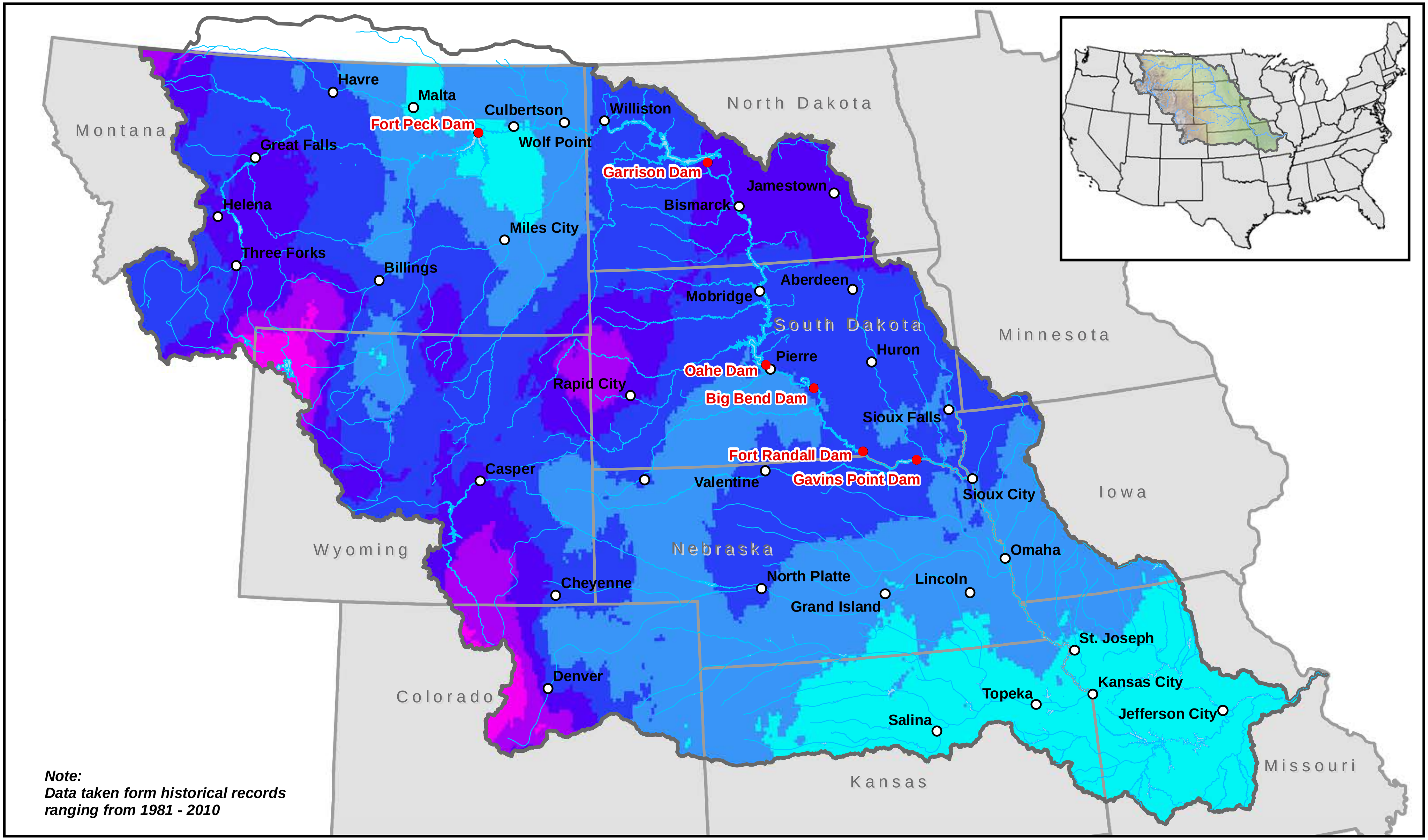
0 50 100 200 300 Miles

N E S W

Data Source:
http://scacis.rcc-acis.org

G:\2016_DivisionMaps\MO_Snow\mxd\Annual_Mean_Snowfall.mxd

Missouri River Basin
ANNUAL MEAN SNOWFALL
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



Note:
Data taken form historical records ranging from 1981 - 2010

Mainstem Dam
Cities
Rivers
Reservoirs/Lakes
Omaha/Kansas City District Boundaries
State Boundaries

Annual Maximum Snowfall
- < 40 Inches
- 40 - 60 Inches
- 60 - 80 Inches
- 80 - 110 Inches
- 110 - 150 Inches
- > 150 Inches

0 50 100 200 300 Miles

N W E S

Data Source:
http://scacis.rcc-acis.org

G:\2016_DivisionMaps\MO_Snow\mxd\Annual_Max_Snowfall.mxd

Missouri River Basin
ANNUAL MAXIMUM SNOWFALL
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

US Army Corps of Engineers®
Northwestern Division

Plate III-6

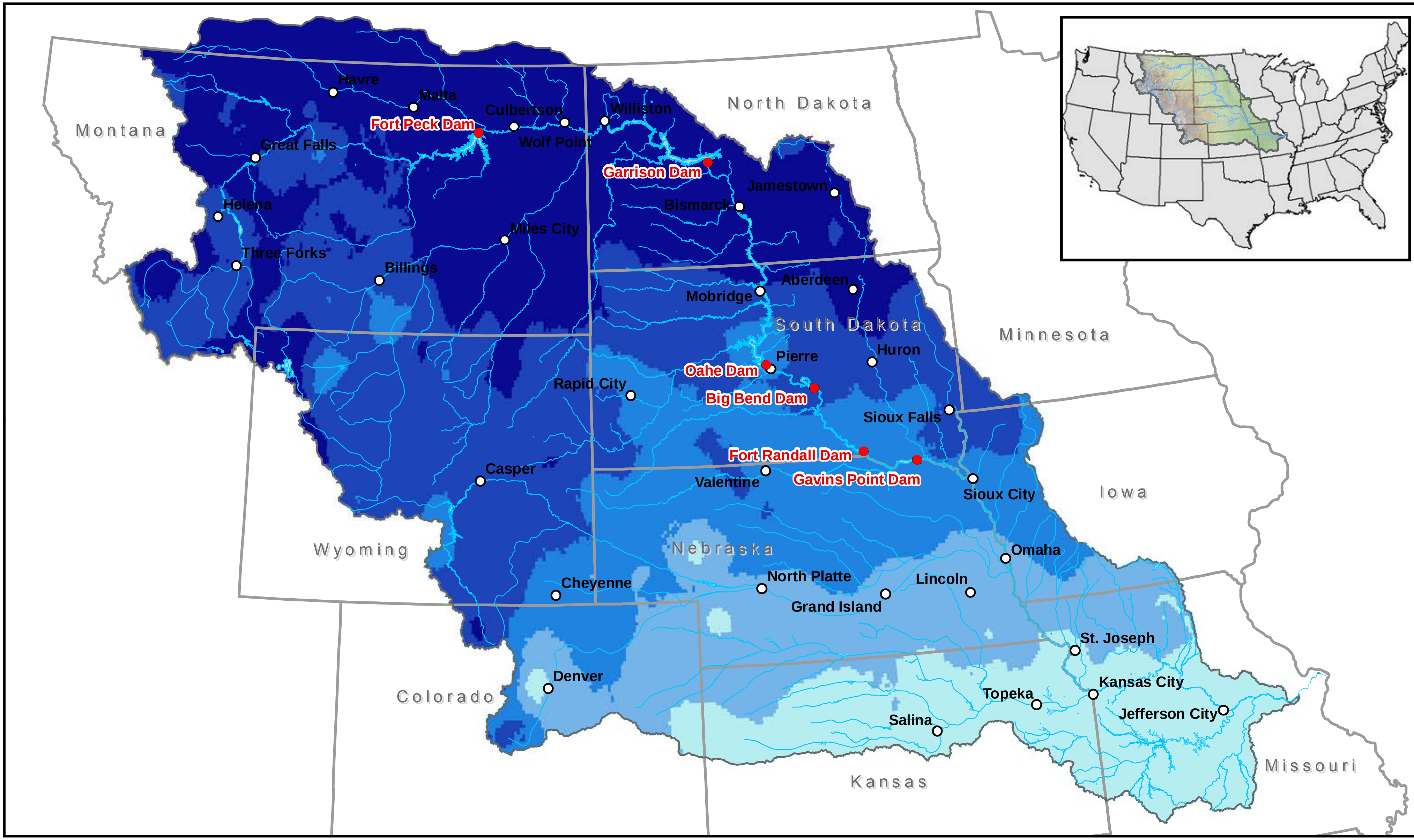


Plate III-7

US Army Corps of Engineers®
Northwestern Division

- Mainstem Dam
- Cities
- Rivers
- Reservoirs/Lakes
- Omaha/Kansas City District Boundaries
- State Boundaries

Average Minimum Temperature

- -36°F to -25°F
- -25°F to -20°F
- -20°F to -15°F
- -15°F to -10°F
- -10°F to 2.6°F

0 50 100 200 300 Miles

N E S W

Imagery Source:
U.S. Department of Agriculture,
Farm Service Agency 2014

G:\2016_DivisionMaps\MO_Temp\mxd\Annual_Average_Min_Temp.mxd

Missouri River Basin
AVERAGE MINIMUM TEMPERATURE
ANNUAL
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

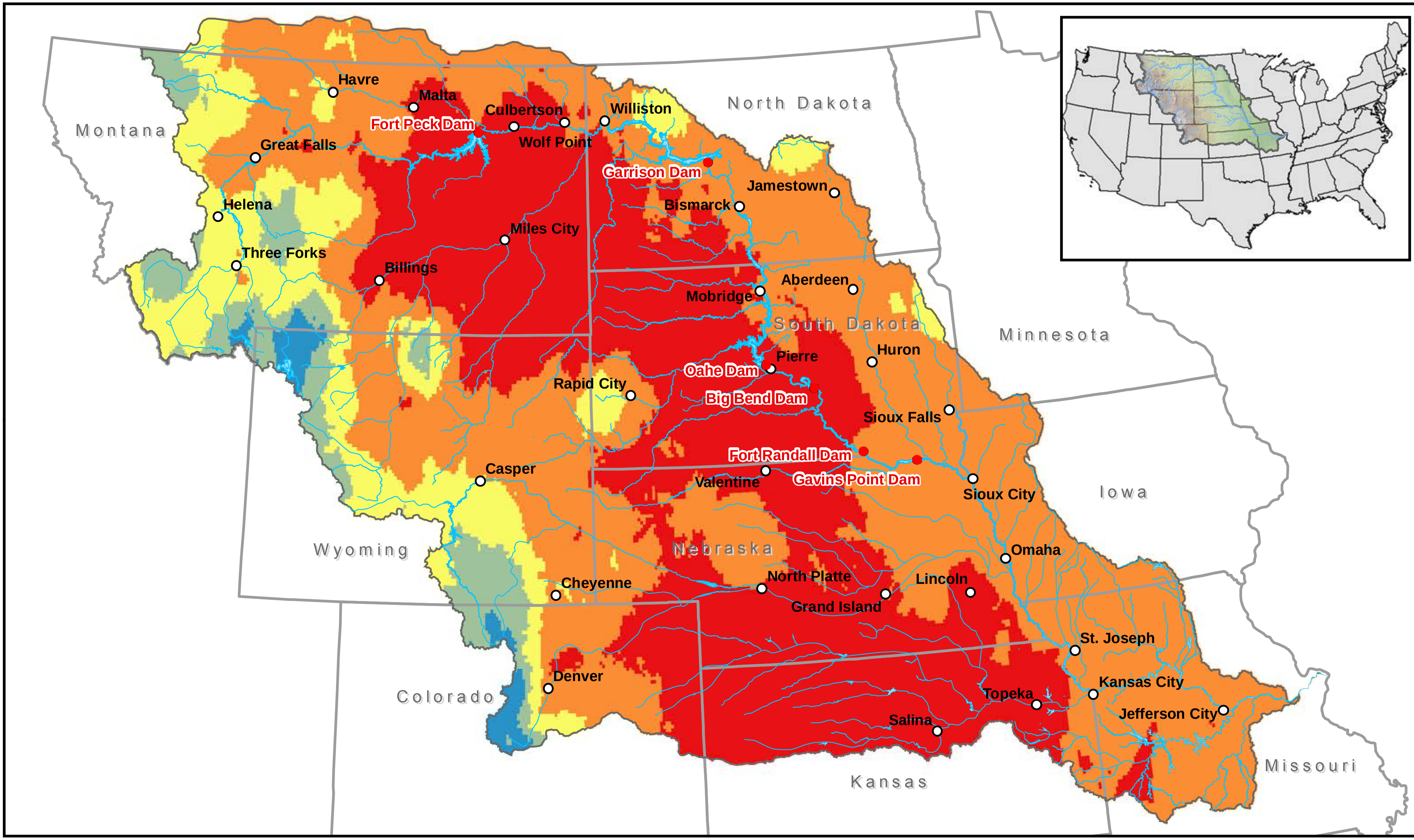


Plate III-8

US Army Corps of Engineers®
Northwestern Division

- Mainstem Dam
- Cities
- Rivers
- Reservoirs/Lakes
- Omaha/Kansas City District Boundaries
- State Boundaries

Average Maximum Temperature

- 78°F - 85°F
- 85°F - 90°F
- 90°F - 95°F
- 95°F - 100°F
- 100°F - 105.5°F

0 50 100 200 300 Miles

N W E S

Imagery Source:
U.S. Department of Agriculture,
Farm Service Agency 2014

G:\2016_DivisionMaps\MO_Temp\mxd\Annual_Average_Max_Temp.mxd

Missouri River Basin
AVERAGE MAXIMUM TEMPERATURE
ANNUAL
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Missouri River Mainstem Reservoir System

Normal Monthly Pan Evaporation
Inches of Depth

Month	Missouri River Mainstem Project					
	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavins Point
January	0.62	0.51	1.02	0.80	1.02	0.74
February	0.74	0.58	1.14	0.98	1.16	0.91
March	1.68	1.42	2.24	1.97	2.31	1.91
April	3.50	2.79	4.70	4.48	4.27	4.19
May	6.96	6.35	7.80	7.83	6.74	7.30
June	8.05	7.07	8.51	8.47	7.54	8.30
July	10.45	8.97	10.74	10.85	9.00	9.64
August	10.22	8.56	10.44	10.31	8.13	8.41
September	5.97	6.63	7.25	7.26	5.07	5.57
October	4.03	4.07	4.92	4.06	4.42	4.46
November	1.96	1.38	2.25	1.83	2.34	1.79
December	0.83	0.70	1.19	1.04	1.24	0.87
Annual	55.01	49.03	62.20	59.88	53.24	54.09

Source: Missouri River Mainstem Reservoir Evaporation Estimates, MRD-RCC Technical Report JE-73, June 1973, Figure 9.

Normal values in the above table were defined by all available pan data through the years 1963-1972. During months pan data were not available, pan depths were computed by a mass-transfer equation assuming pan water temperature to be equivalent to air temperature. Values given are for current pan installations and include depths for Oahe and Big Bend, which are believed to be unrepresentative. Adjustments for Oahe and Big Bend are accounted for in the lake evaporation coefficients table (Plate III-10).

Missouri River Mainstem Reservoir System

Normal Pan to Lake Evaporation Coefficients

Month	Missouri River Mainstem Project					
	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavins Point
January	1.28	0.70	0.73	0.63	0.70	0.70
February	0.70	0.70	0.56	0.63	0.70	0.70
March	0.60	0.70	0.49	0.54	0.63	0.62
April	0.11	0.14	0.13	0.47	0.19	0.53
May	0.22	0.20	0.16	0.35	0.32	0.53
June	0.32	0.21	0.18	0.39	0.37	0.53
July	0.39	0.26	0.22	0.53	0.42	0.56
August	0.64	0.64	0.50	0.70	0.78	0.70
September	1.21	1.13	0.89	0.82	1.31	0.93
October	1.32	1.44	1.19	1.05	1.42	0.97
November	2.57	3.74	2.22	1.52	1.62	1.59
December	4.22	5.04	3.42	1.36	1.39	1.57

Source: Missouri River Mainstem Reservoir Evaporation Estimates, MRD-RCC Technical Report JE-73, June 1973, Figure 11.

These coefficients are applicable to the pan installations currently in operation in conjunction with the projects. They make allowances for the fact that the Oahe and Big Bend installations are not considered to be representative installations. If pan evaporation is available, lake evaporation depths are estimated by application of the above coefficients.

For example: Garrison, May = 6.35 in (Plate III-9) x 0.20 (Plate III-10) = 1.27 in (Plate III-11).

Missouri River Basin

Fort Peck Water Control Manual
Pan to Lake Evaporation Coefficients

U.S. ARMY ENGINEER DIVISION,
NORTHWESTERN CORPS OF ENGINEERS,
OMAHA, NEBRASKA
September 2017

Missouri River Mainstem Reservoir System

Normal Monthly Lake Evaporation
Inches of Depth

Month	Missouri River Mainstem Project					
	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavins Point
January	0.79	0.36	0.74	0.50	0.71	0.52
February	0.52	0.41	0.64	0.62	0.81	0.64
March	1.01	0.99	1.10	1.06	1.46	1.18
April	0.38	0.39	0.61	2.11	0.81	2.22
May	1.53	1.27	1.25	2.74	2.16	3.87
June	2.58	1.48	1.53	3.30	2.79	4.40
July	4.08	2.33	2.36	5.75	3.78	5.41
August	6.54	5.48	5.22	7.22	6.34	5.89
September	7.22	7.49	6.45	5.95	6.64	5.18
October	5.32	5.86	5.85	4.26	6.28	4.33
November	5.04	5.16	5.00	2.78	3.79	2.85
December	3.50	3.53	4.07	1.41	1.72	1.37
Annual	38.51	34.75	34.82	37.70	37.29	37.85

Source: Missouri River Mainstem Reservoir Evaporation Estimates, MRD-RCC Technical Report JE-73, June 1973, Figure 12.

Normal depths for each project as shown above were developed by application of the normal pan to lake coefficients in Figure 11 (Plate III-10) to the normal monthly pan evaporation as shown on Figure 9 (Plate III-9).

Missouri River Basin
Fort Peck Water Control Manual
Normal Monthly Lake Evaporation

U.S. ARMY ENGINEER DIVISION,
NORTHWESTERN CORPS OF ENGINEERS,
OMAHA, NEBRASKA
September 2017

Missouri River Mainstem Reservoir System

Normal Monthly Lake Evaporation in 1000 Acre-Feet

Month	Missouri River Mainstem Project						System
	Fort Peck	Garriso n	Oahe	Big Bend	Fort Randall	Gavins Point	
January	14	9	19	2	5	1	50
February	9	11	17	3	5	1	46
March	18	26	29	5	10	3	91
April	7	10	16	10	5	5	53
May	27	33	33	13	14	8	128
June	46	39	40	16	19	10	170
July	73	61	62	27	25	12	260
August	117	144	136	34	42	13	486
Septembe	129	167	168	28	44	11	547
October	95	154	153	20	42	9	473
Novembe	90	135	130	13	25	6	399
December	63	93	106	7	11	3	283
Annual	688	882	909	178	247	82	2,986

Source: Missouri River Mainstem Reservoir Evaporation Estimates, MRD-RCC Technical Report JE-73, June 1973, Figure 13.

Volumes computed by assuming that each reservoir was at the base of its flood control pool.

Missouri River Basin
Fort Peck Water Control Manual
Normal Monthly Lake Evaporation in 1000 AF

U.S. ARMY ENGINEER DIVISION,
NORTHWESTERN CORPS OF ENGINEERS,
OMAHA, NEBRASKA
September 2017

Monthly Runoff - Missouri River Basin Upstream of Fort Peck Dam
For the Years 1898-2014 - Adjusted to 1949 Level of Depletion Development

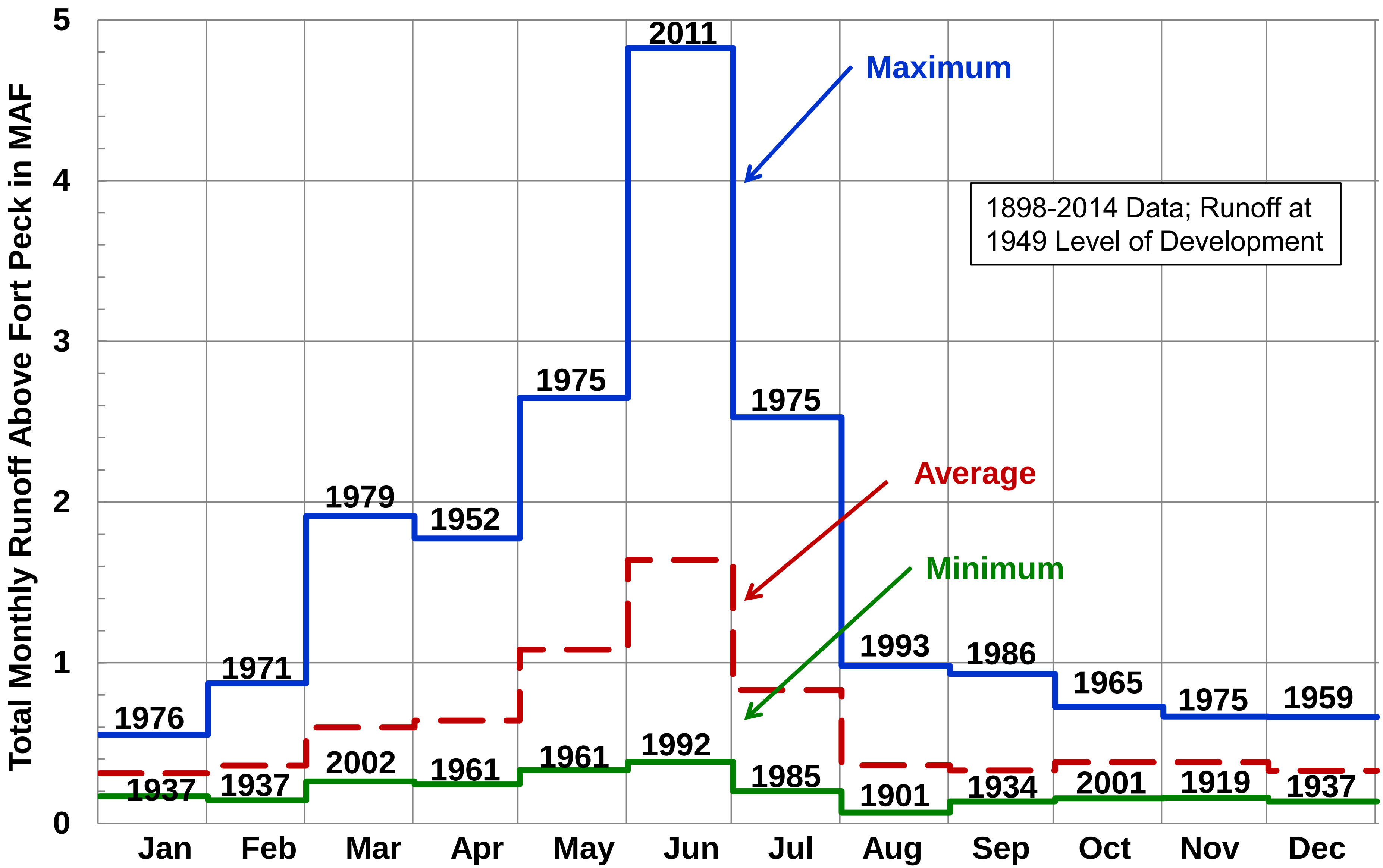
	Runoff in 1,000 acre-feet												Annual	Mar-Jul
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	**Total**
1898	313	278	419	776	1,436	2,668	1,176	216	244	353	339	313	8,531	6,475
1899	232	232	413	746	1,323	2,456	2,027	528	345	413	480	298	9,493	6,965
1900	309	315	504	730	1,732	1,379	335	79	194	333	294	349	6,553	4,680
1901	270	226	371	464	1,857	1,339	454	67	147	274	284	262	6,015	4,485
1902	240	220	264	331	1,182	1,644	873	171	179	288	311	268	5,971	4,294
1903	296	236	339	676	968	1,936	877	248	214	375	339	411	6,915	4,796
1904	355	329	672	768	1,325	1,765	825	248	196	286	309	353	7,431	5,355
1905	300	296	500	323	405	863	696	284	167	234	284	274	4,626	2,787
1906	272	290	381	668	728	1,386	605	216	248	288	260	260	5,602	3,768
1907	222	296	506	819	1,133	2,412	2,220	645	387	460	367	357	9,824	7,090
1908	335	298	456	895	1,176	4,140	1,722	563	468	575	587	440	11,655	8,389
1909	363	365	538	676	1,119	2,938	1,071	436	567	623	462	317	9,475	6,342
1910	327	301	910	1,351	1,847	1,384	470	311	365	341	377	379	8,363	5,962
1911	248	270	720	589	893	2,152	805	353	383	395	411	333	7,552	5,159
1912	296	311	282	704	1,396	2,249	893	492	379	545	526	379	8,452	5,524
1913	256	266	345	1,111	1,654	3,140	1,232	553	305	633	520	347	10,362	7,482
1914	337	347	680	867	1,597	2,003	591	240	315	494	407	339	8,217	5,738
1915	315	422	335	916	1,148	1,751	1,010	591	413	474	452	303	8,130	5,160
1916	315	488	799	712	1,307	2,612	1,847	545	474	409	381	347	10,236	7,277
1917	375	373	480	655	1,914	3,055	1,325	383	298	321	395	411	9,985	7,429
1918	395	347	492	607	1,085	1,503	551	371	270	377	337	351	6,686	4,238
1919	383	413	672	559	781	520	216	93	169	194	161	220	4,381	2,748
1920	228	385	553	551	1,549	1,819	776	325	280	319	393	325	7,503	5,248
1921	294	296	436	704	1,303	1,857	583	242	260	282	309	345	6,911	4,883
1922	282	238	415	666	1,321	2,249	454	307	309	278	317	321	7,157	5,105
1923	298	270	428	726	1,214	1,593	918	452	309	341	357	347	7,253	4,879
1924	305	399	391	647	1,440	996	399	260	252	282	305	319	5,995	3,873
1925	309	321	484	914	1,353	1,642	750	317	359	486	490	421	7,846	5,143
1926	343	456	452	851	1,279	589	438	325	337	393	339	351	6,153	3,609
1927	395	303	659	492	1,771	3,904	1,250	518	545	567	508	421	11,333	8,076
1928	333	502	966	724	1,924	1,436	1,396	432	377	369	357	298	9,114	6,446
1929	280	250	391	466	946	1,208	498	294	290	317	288	200	5,428	3,509
1930	300	444	407	863	867	555	300	218	236	301	298	303	5,092	2,992
1931	248	317	557	387	432	424	230	224	210	220	179	157	3,585	2,030
1932	196	157	303	532	825	1,406	516	422	240	260	218	194	5,269	3,582
1933	222	212	488	434	908	1,412	430	270	256	226	339	177	5,374	3,672
1934	315	450	516	722	781	811	290	141	137	204	256	210	4,833	3,120
1935	198	236	309	428	593	819	409	228	228	262	182	190	4,082	2,558
1936	179	167	613	430	823	569	264	230	220	246	244	196	4,181	2,699
1937	169	145	341	383	385	577	343	182	184	260	163	137	3,269	2,029

Monthly Runoff - Missouri River Basin Upstream of Fort Peck Dam
For the Years 1898-2014 - Adjusted to 1949 Level of Depletion Development

	Runoff in 1,000 acre-feet												Annual	Mar-Jul
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	**Total**
1938	186	204	599	327	756	1,682	1,349	298	317	272	327	272	6,589	4,713
1939	254	208	891	585	871	863	311	208	210	238	244	222	5,105	3,521
1940	198	246	399	415	619	619	236	192	212	246	186	262	3,830	2,288
1941	226	230	359	327	335	613	347	228	305	411	347	349	4,077	1,981
1942	282	298	629	825	1,131	2,061	599	329	282	331	357	301	7,425	5,245
1943	325	633	785	1,117	1,115	2,892	1,002	426	317	399	375	335	9,721	6,911
1944	301	290	678	456	565	1,740	914	375	309	339	327	270	6,564	4,353
1945	375	343	492	353	613	1,275	569	262	292	345	288	242	5,449	3,302
1946	351	413	450	514	710	855	540	258	359	385	303	399	5,537	3,069
1947	415	422	1,226	960	1,547	1,500	659	272	361	524	407	381	8,674	5,892
1948	367	351	504	879	1,654	3,255	1,309	541	405	422	417	256	10,360	7,601
1949	325	294	849	803	1,150	1,012	440	290	208	323	384	232	6,310	4,254
1950	236	347	554	804	739	1,711	1,092	556	440	483	409	436	7,807	4,900
1951	427	360	680	971	1,366	1,500	921	440	516	573	512	370	8,636	5,438
1952	340	484	606	1,773	1,587	1,148	598	394	355	326	304	297	8,212	5,712
1953	307	358	477	366	872	3,880	922	372	371	334	361	312	8,932	6,517
1954	186	414	411	510	776	1,142	791	409	288	381	406	247	5,961	3,630
1955	187	241	310	662	824	1,284	899	324	265	291	196	292	5,775	3,979
1956	296	263	541	628	1,075	1,591	481	354	308	336	407	316	6,596	4,316
1957	208	286	595	521	1,005	1,449	579	268	334	390	456	382	6,473	4,149
1958	299	284	525	516	854	1,330	711	349	319	386	420	395	6,388	3,936
1959	323	322	1,324	657	835	1,510	876	303	314	505	545	663	8,177	5,202
1960	337	516	877	714	1,010	888	363	264	295	280	331	313	6,188	3,852
1961	311	323	358	242	331	902	283	187	243	388	443	240	4,251	2,116
1962	285	446	423	577	1,178	1,720	801	381	336	414	391	315	7,267	4,699
1963	258	616	503	351	627	1,326	724	319	353	338	373	275	6,063	3,531
1964	304	370	364	387	1,327	3,233	1,234	375	392	418	420	354	9,178	6,545
1965	518	568	664	1,168	1,683	2,229	1,713	604	585	726	621	489	11,568	7,457
1966	389	401	828	638	806	762	586	254	288	324	438	381	6,095	3,620
1967	322	622	729	574	1,141	3,336	1,426	398	506	469	563	261	10,347	7,206
1968	448	486	752	543	880	1,928	1,016	474	589	574	557	374	8,621	5,119
1969	410	432	1,035	1,264	1,392	1,161	1,548	494	405	443	497	377	9,458	6,400
1970	278	451	608	531	1,902	2,479	1,147	469	451	535	477	400	9,728	6,667
1971	409	872	790	763	1,550	1,865	1,108	464	458	517	474	312	9,582	6,076
1972	392	476	1,169	682	1,088	1,988	771	570	426	492	566	342	8,962	5,698
1973	364	350	484	492	796	822	507	292	329	406	427	410	5,679	3,101
1974	410	435	489	567	1,121	2,015	977	525	462	393	448	396	8,238	5,169
1975	258	289	563	923	2,647	3,257	2,528	788	609	667	666	643	13,838	9,918
1976	553	603	688	816	2,147	1,919	1,076	562	566	587	557	452	10,526	6,646
1977	277	444	422	455	559	592	349	265	344	434	336	402	4,879	2,377

Monthly Runoff - Missouri River Basin Upstream of Fort Peck Dam
For the Years 1898-2014 - Adjusted to 1949 Level of Depletion Development

						Runoff in 1,000 acre-feet							Annual	Mar-Jul
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**	**Total**
1978	312	370	1,899	1,508	1,803	1,727	1,489	542	810	638	447	423	11,968	8,426
1979	373	408	1,913	1,222	1,430	1,292	564	273	329	311	415	352	8,882	6,421
1980	278	328	542	608	959	1,750	802	282	371	474	464	377	7,235	4,661
1981	445	392	522	473	1,659	2,404	775	323	251	492	471	370	8,577	5,833
1982	284	612	841	766	1,075	2,498	1,605	433	400	566	508	502	10,090	6,785
1983	441	468	550	471	858	1,215	1,079	419	426	579	560	321	7,387	4,173
1984	468	543	514	609	1,054	1,510	1,025	479	422	527	535	340	8,026	4,712
1985	397	320	609	703	771	645	201	288	340	668	476	431	5,849	2,929
1986	481	385	1,288	654	1,157	1,395	560	289	931	588	431	418	8,577	5,054
1987	271	378	481	503	516	511	405	403	345	287	346	273	4,719	2,416
1988	220	335	425	387	645	454	253	115	144	239	284	302	3,803	2,164
1989	241	214	840	713	1,094	869	438	315	386	388	491	344	6,333	3,954
1990	454	269	531	601	804	1,097	548	294	272	262	363	246	5,741	3,581
1991	285	345	393	418	1,128	1,991	931	291	238	326	372	343	7,061	4,861
1992	252	330	377	363	358	384	598	240	204	322	356	200	3,984	2,080
1993	201	270	721	530	1,017	1,328	1,557	981	690	550	533	535	8,913	5,153
1994	361	331	1,006	638	1,194	780	313	216	180	272	339	298	5,928	3,931
1995	257	330	467	505	1,256	2,155	1,443	537	412	504	578	502	8,946	5,826
1996	381	818	947	995	1,210	2,174	768	306	290	377	362	424	9,052	6,094
1997	512	582	717	631	1,500	3,023	1,231	586	472	458	491	394	10,597	7,102
1998	278	458	458	528	792	1,300	1,447	469	335	379	413	293	7,150	4,525
1999	441	418	504	416	764	1,472	766	312	292	269	353	373	6,380	3,922
2000	248	319	417	417	473	737	549	207	164	276	253	237	4,297	2,593
2001	313	234	395	313	432	574	460	256	150	156	243	213	3,739	2,174
2002	206	230	262	412	403	1,467	812	336	228	199	258	237	5,050	3,356
2003	200	290	596	481	689	1,029	435	266	146	166	204	252	4,754	3,230
2004	210	247	577	346	392	759	535	243	227	238	274	219	4,267	2,609
2005	209	310	319	295	637	1,357	750	327	228	228	326	202	5,188	3,358
2006	413	223	446	702	861	1,340	534	275	175	289	347	258	5,863	3,883
2007	256	362	627	498	826	1,114	460	265	171	218	232	208	5,237	3,525
2008	200	246	393	315	867	2,236	1,155	388	335	288	332	196	6,951	4,966
2009	359	339	514	514	1,130	1,411	849	397	350	385	360	300	6,908	4,418
2010	330	319	582	395	892	1,975	1,253	459	425	353	329	334	7,646	5,097
2011	398	577	1,010	891	2,408	4,825	2,228	635	279	380	416	430	14,477	11,362
2012	332	455	523	605	961	1,193	611	316	147	205	356	297	6,001	3,893
2013	278	335	416	386	567	1,726	610	371	188	251	286	261	5,675	3,705
2014	353	289	814	584	1,131	1,621	875	907	434	382	307	471	8,168	5,025



Missouri River Basin
Fort Peck Water Control Manual
Unregulated Monthly Runoff
Distribution above Fort Peck

U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

Missouri River Basin
FORT PECK DRAINAGE AREA
TRAVEL TIMES
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Legend:
- Travel Time - Days
- Mainstem Dam
- Cities
- Rivers
- Reservoirs/Lakes
- Fort Peck Drainage Area
- Omaha/Kansas City District Boundaries
- State Boundaries

0 25 50 100 150 Miles

N E S W

Data Source:
U.S. Department of Agriculture,
Farm Service Agency 2014

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US Army Corps of Engineers
Northwestern Division

Plate III-15

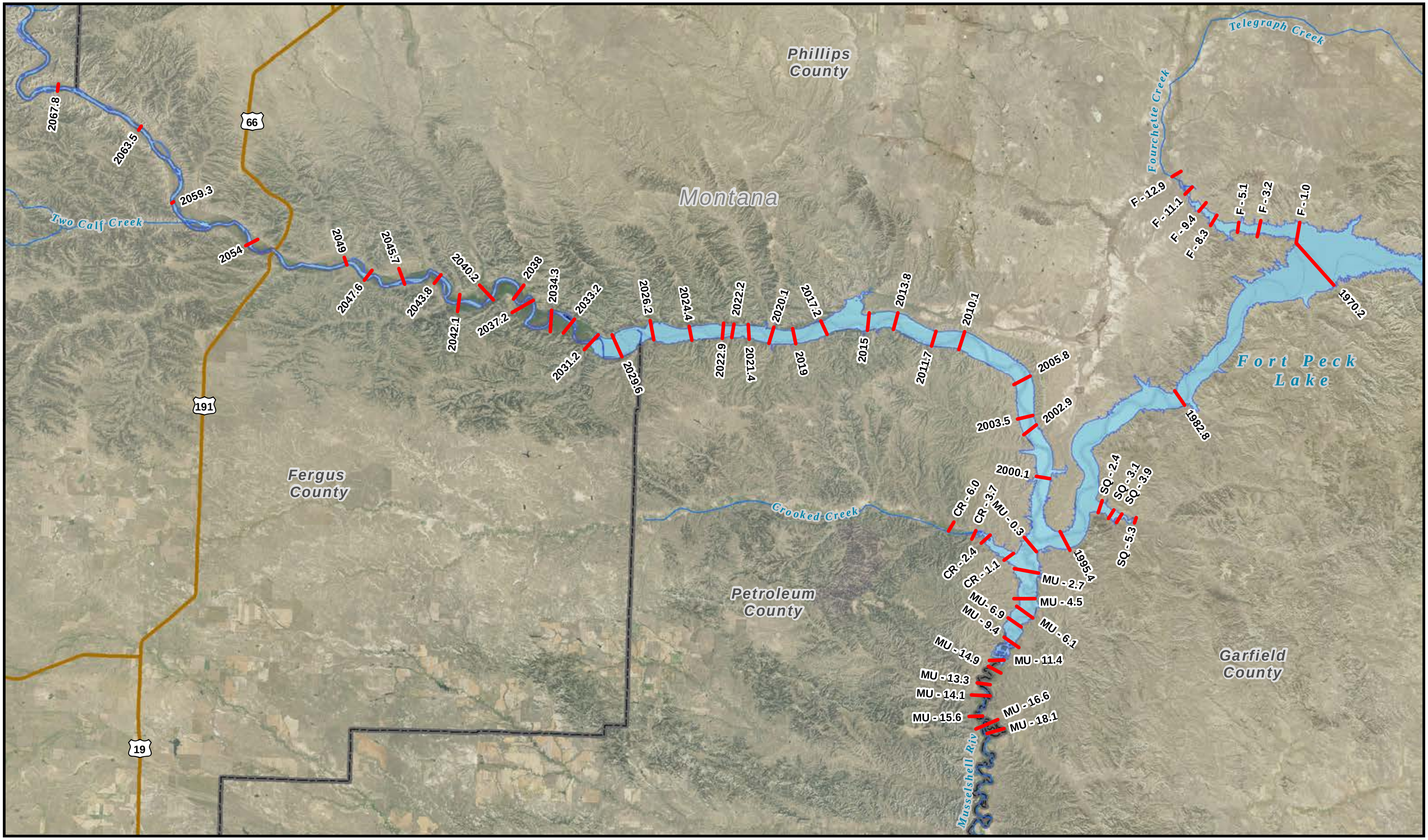

Plate III-16

US Army Corps of Engineers®
Northwestern Division

Cities
Aggregation Rangeline
Rivers
Roads
Reservations
Reservoirs/Lakes
State Boundaries
County Boundaries

0 2.5 5 10 15 Miles

N S E W

Imagery Source:
U.S. Department of Agriculture,
Farm Service Agency 2015

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Missouri River Basin
FORT PECK PROJECT
SEDIMENT RANGE UPPER RESERVOIR MAP
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

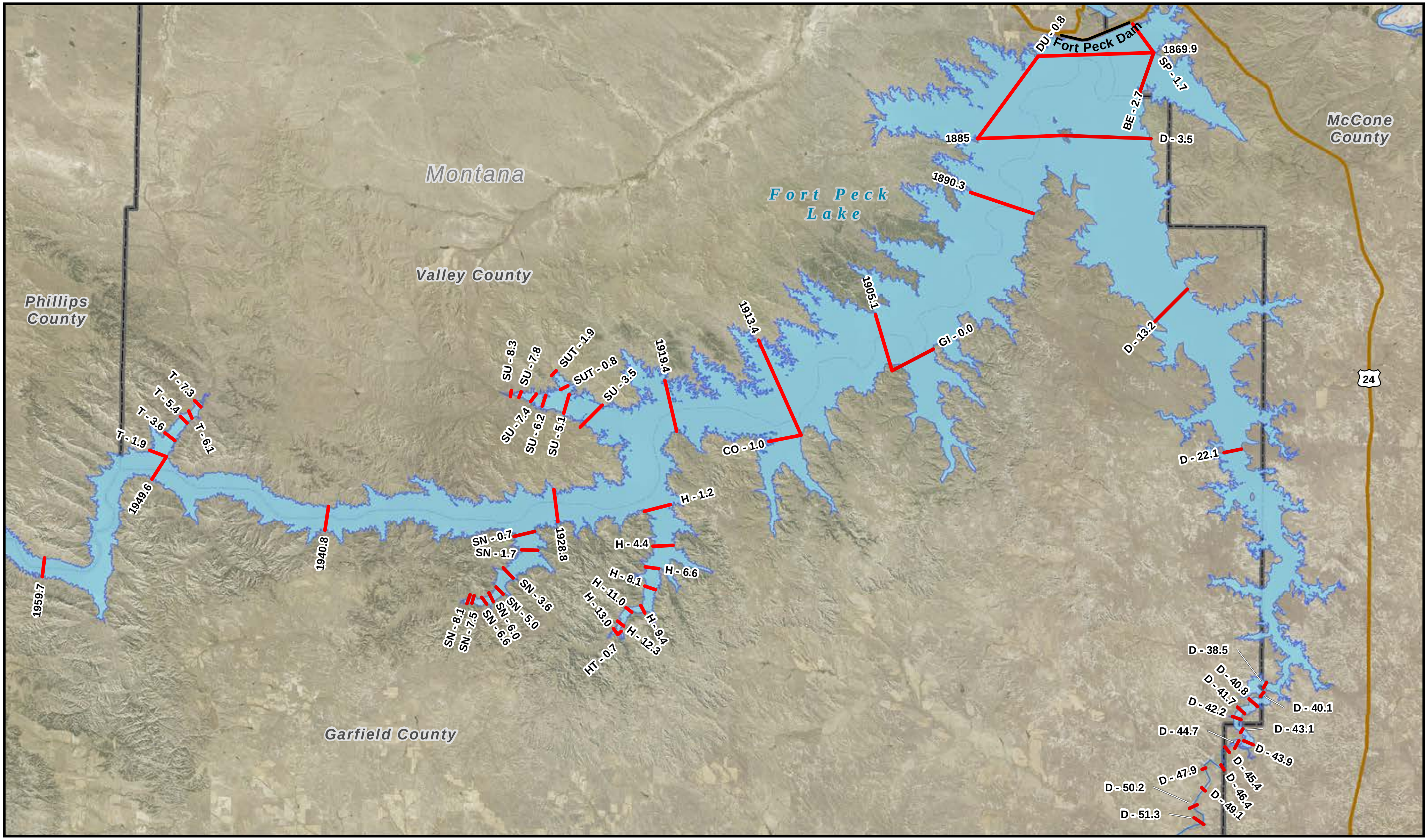


Plate III-17

US Army Corps of Engineers®
Northwestern Division

Cities
Aggregation Rangeline
Rivers
Roads
Reservations
Reservoirs/Lakes
State Boundaries
County Boundaries

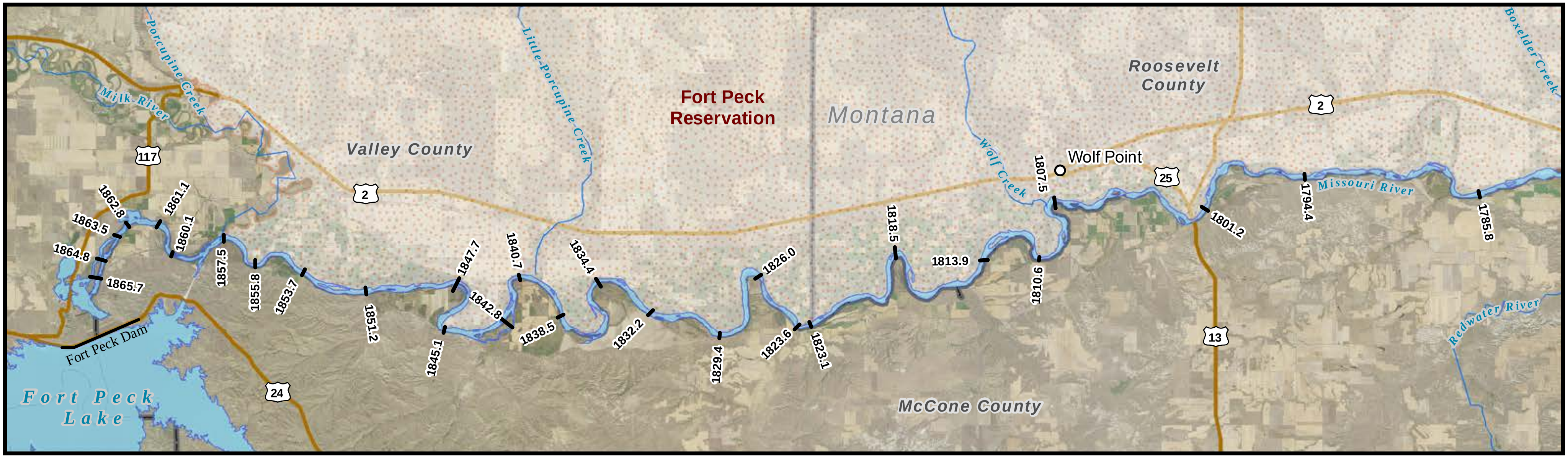
0 2.5 5 10 15 Miles

N W E S

Imagery Source:
U.S. Department of Agriculture,
Farm Service Agency 2015

G:\2016_DivisionMaps\Sediment_Rangeline\mxd\Ft_Peck_Sediment_Range_Down_Map.mxd

Missouri River Basin
FORT PECK PROJECT
SEDIMENT RANGE LOWER RESERVOIR MAP
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



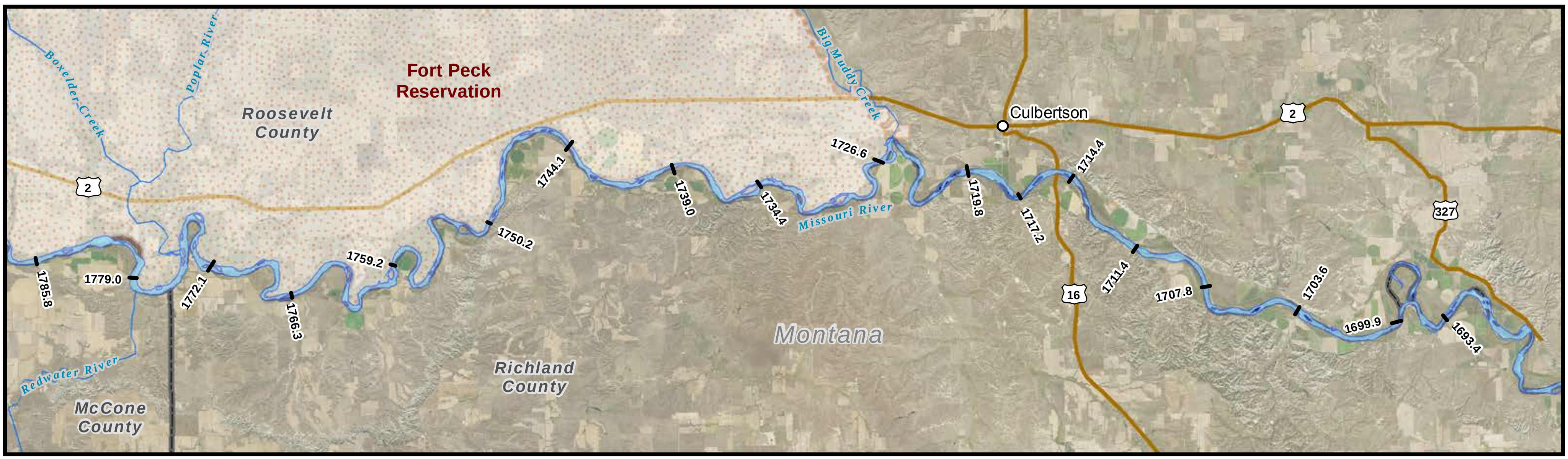


Plate III-18

US Army Corps of Engineers®
Northwestern Division

Cities
Degradation Reach
Rivers
Roads
Reservations
Reservoirs/Lakes
County Boundaries
State Boundaries

0 2.5 5 10 15 Miles

N S E W

Imagery Source:
U.S. Department of Agriculture,
Farm Service Agency 2015

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Missouri River Basin
FORT PECK PROJECT
SEDIMENT RANGE MAP
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Missouri River Basin

Fort Peck Water Control Manual

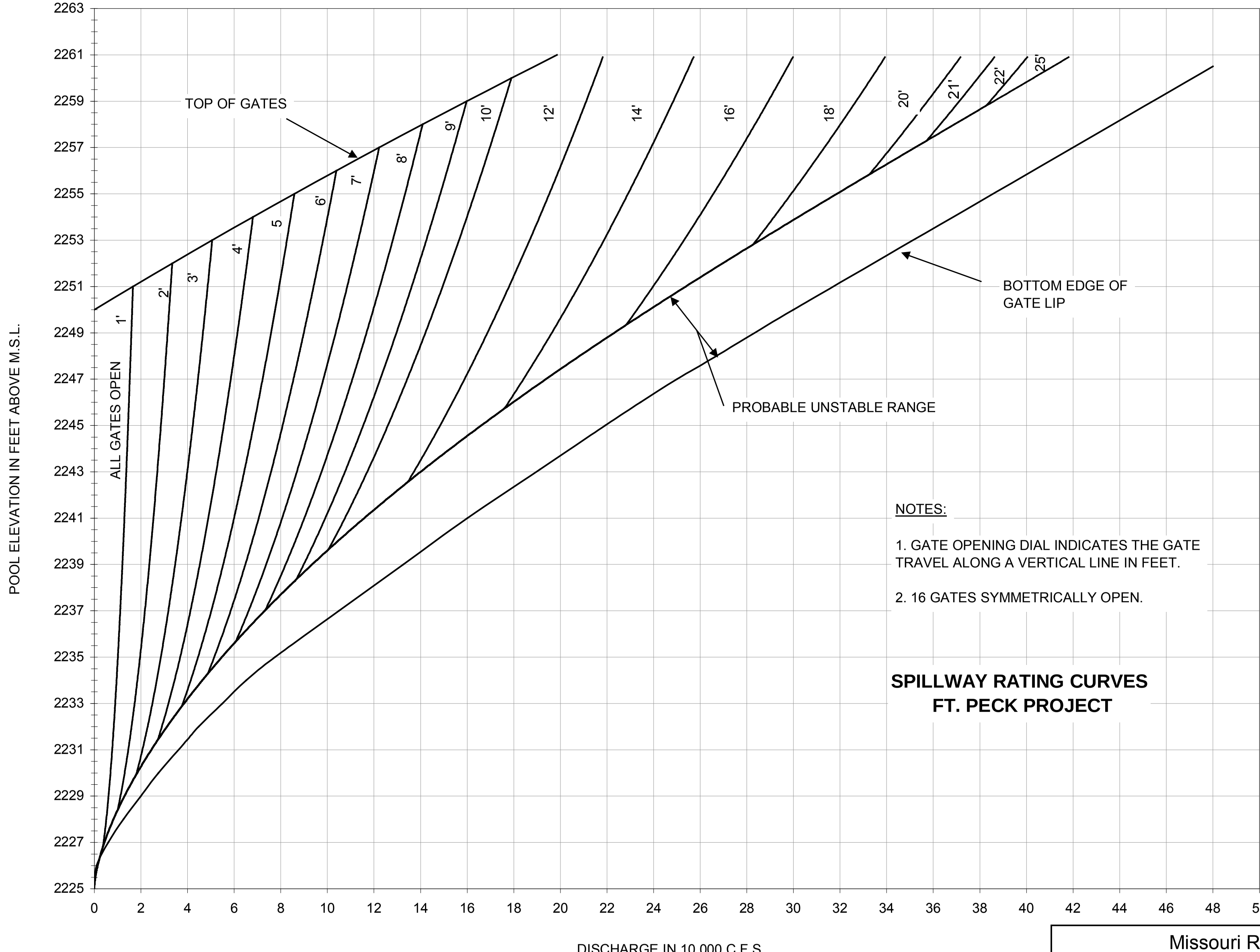
Fort Peck Project

Embankment, Reservoir and Powerhouses

U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Project
Spillway and Embankment,

U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

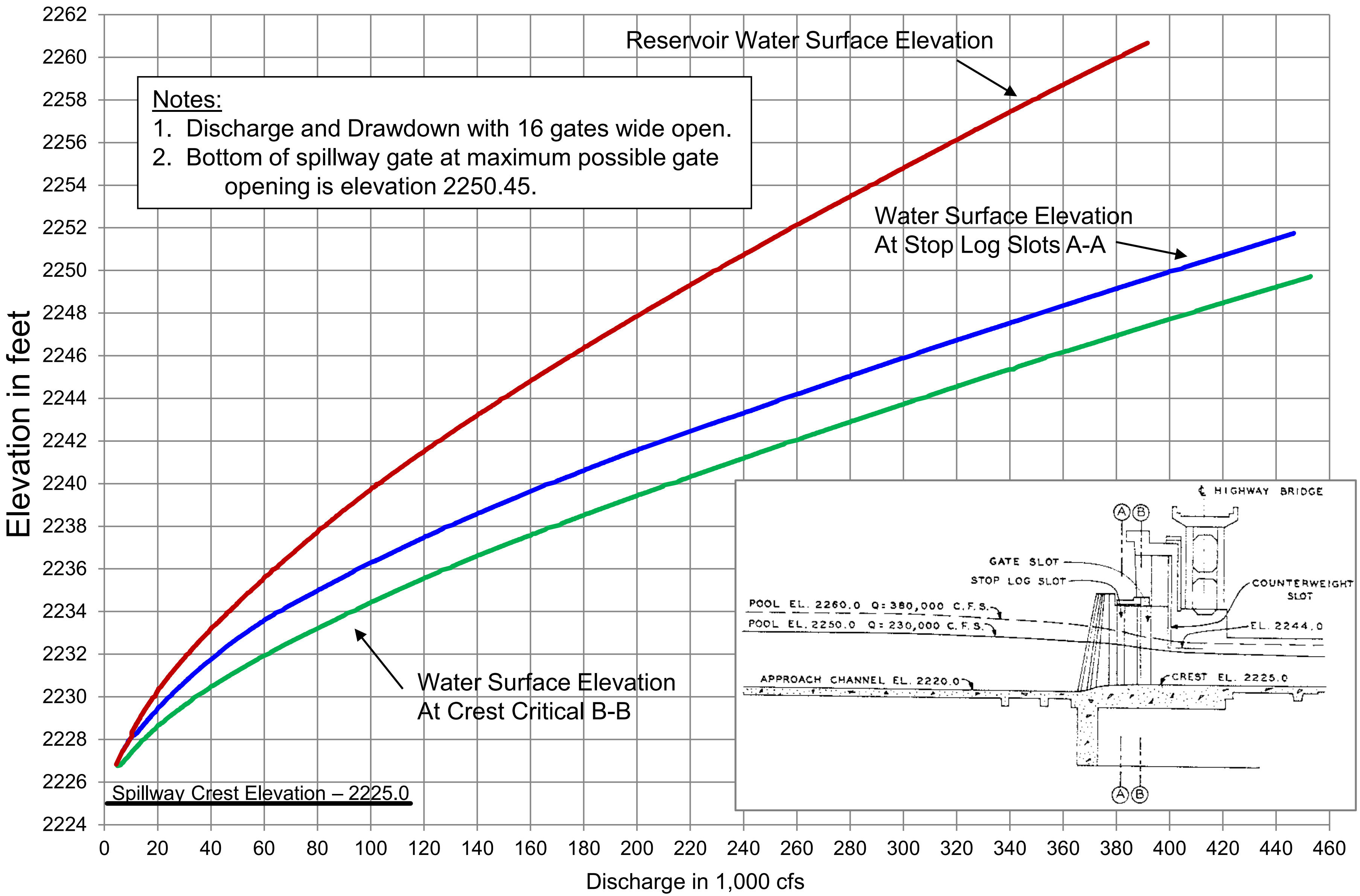


Missouri River Basin

Fort Peck Water Control Manual

Spillway Rating Curves

U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017



Missouri River Basin

Fort Peck Water Control Manual

Spillway Rating Curves and Drawdown

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

Spillway gates – viewed from approach channel

Spillway gate – viewed from discharge channel

Spillway discharge channel

Spillway gates – viewed from discharge channel

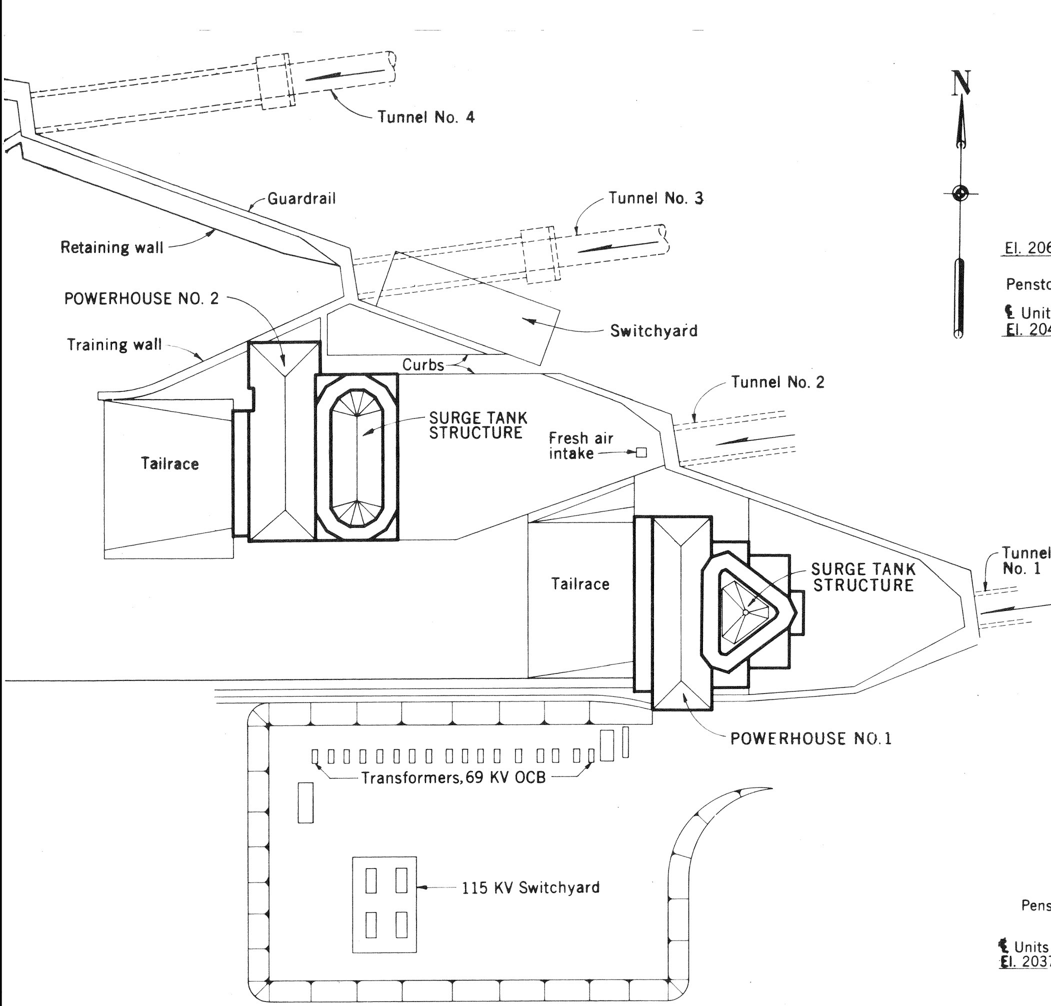
Missouri River Basin

Fort Peck Water Control Manual

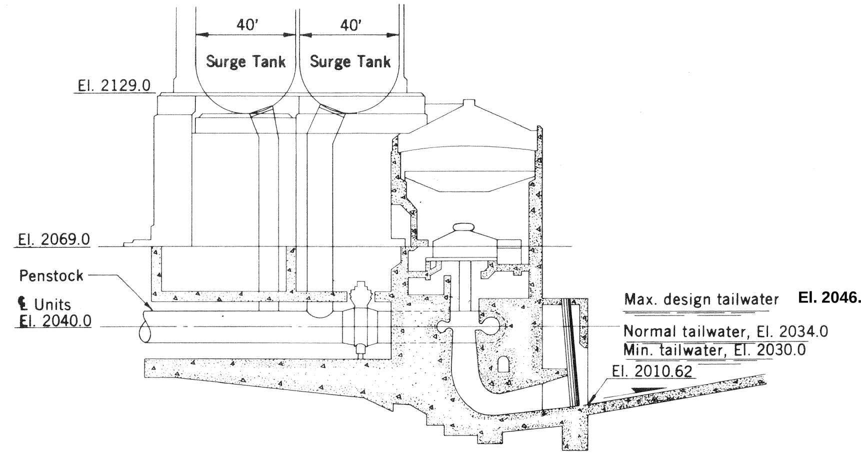
Fort Peck Project

Spillway Discharge Channel and Gates

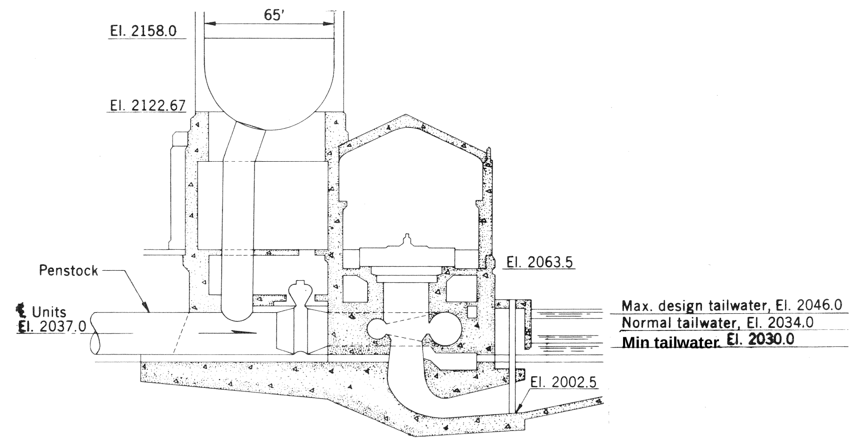
U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017



PLAN



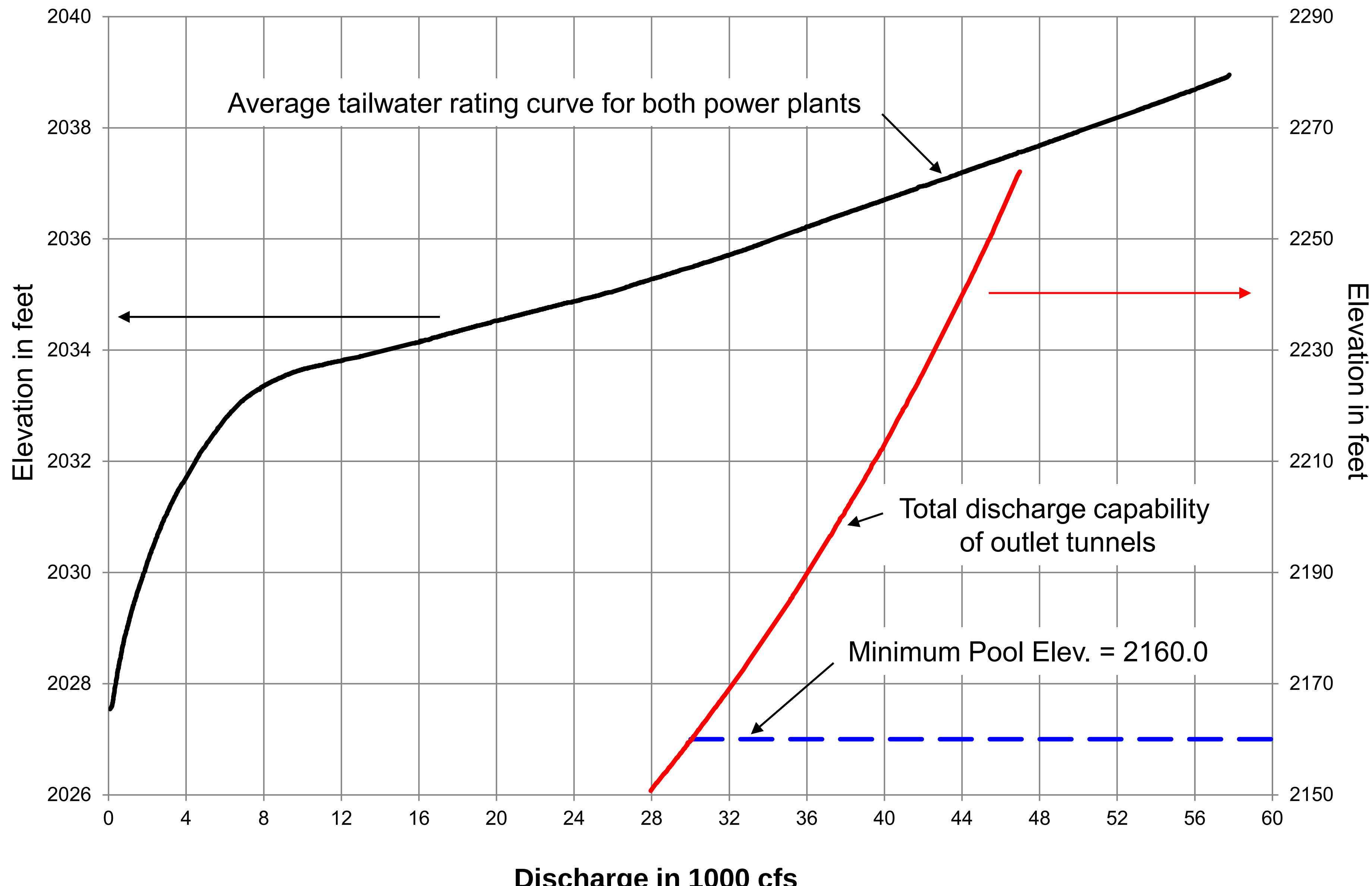
POWERHOUSE SECTION
POWERHOUSE NO. 1



POWERHOUSE SECTION
POWERHOUSE NO. 2

Missouri River Basin
Fort Peck Water Control Manual
Powerplant Plans and Sections

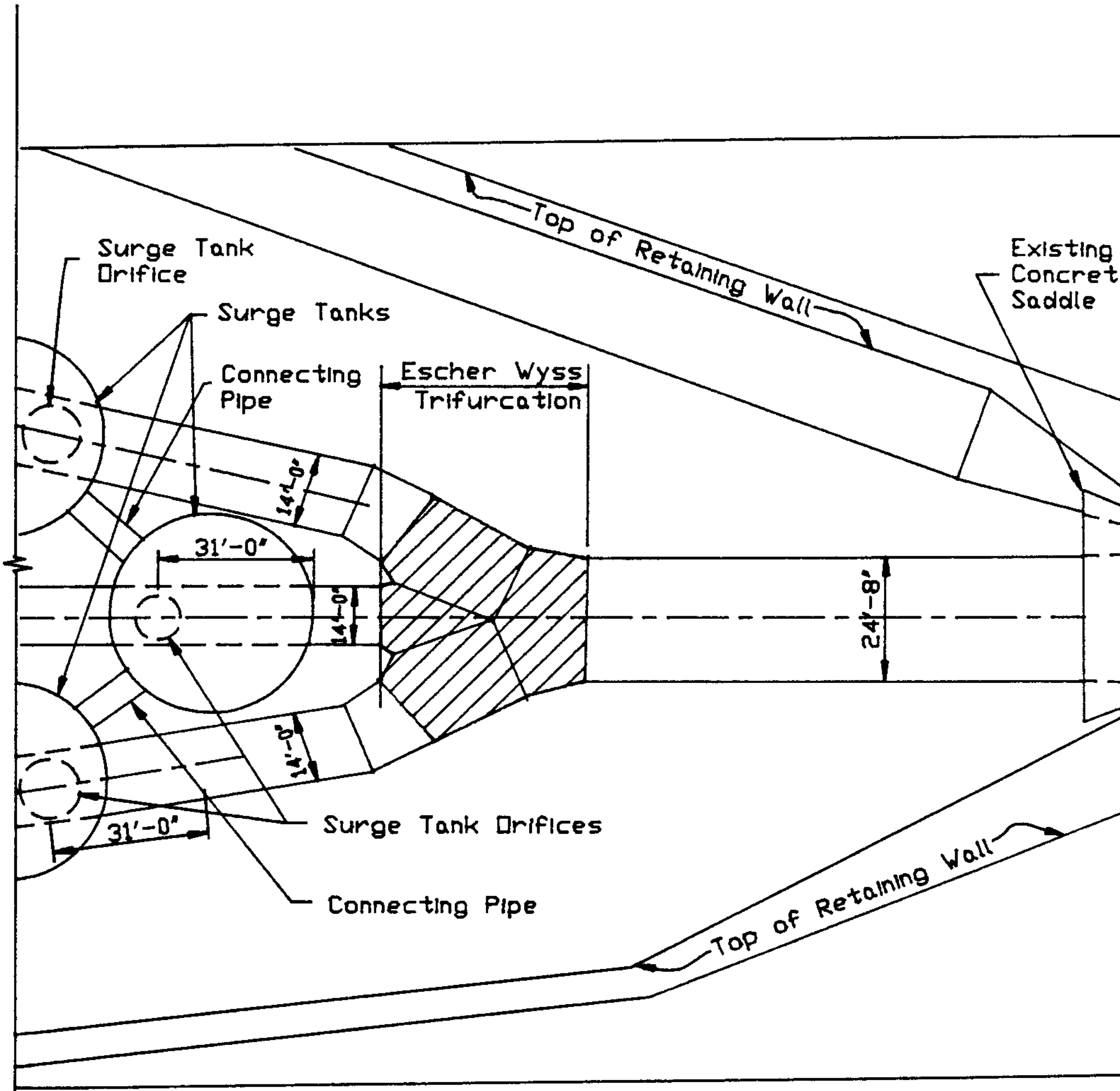
U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017



Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Powerplant, Tailwater Rating Curve
and Discharge Capability of Outlet Tunnels

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

Plate IV-8



PLAN

DRAWN BY: CHECKED BY:

PENSTOCK AREA AT POWERHOUSE

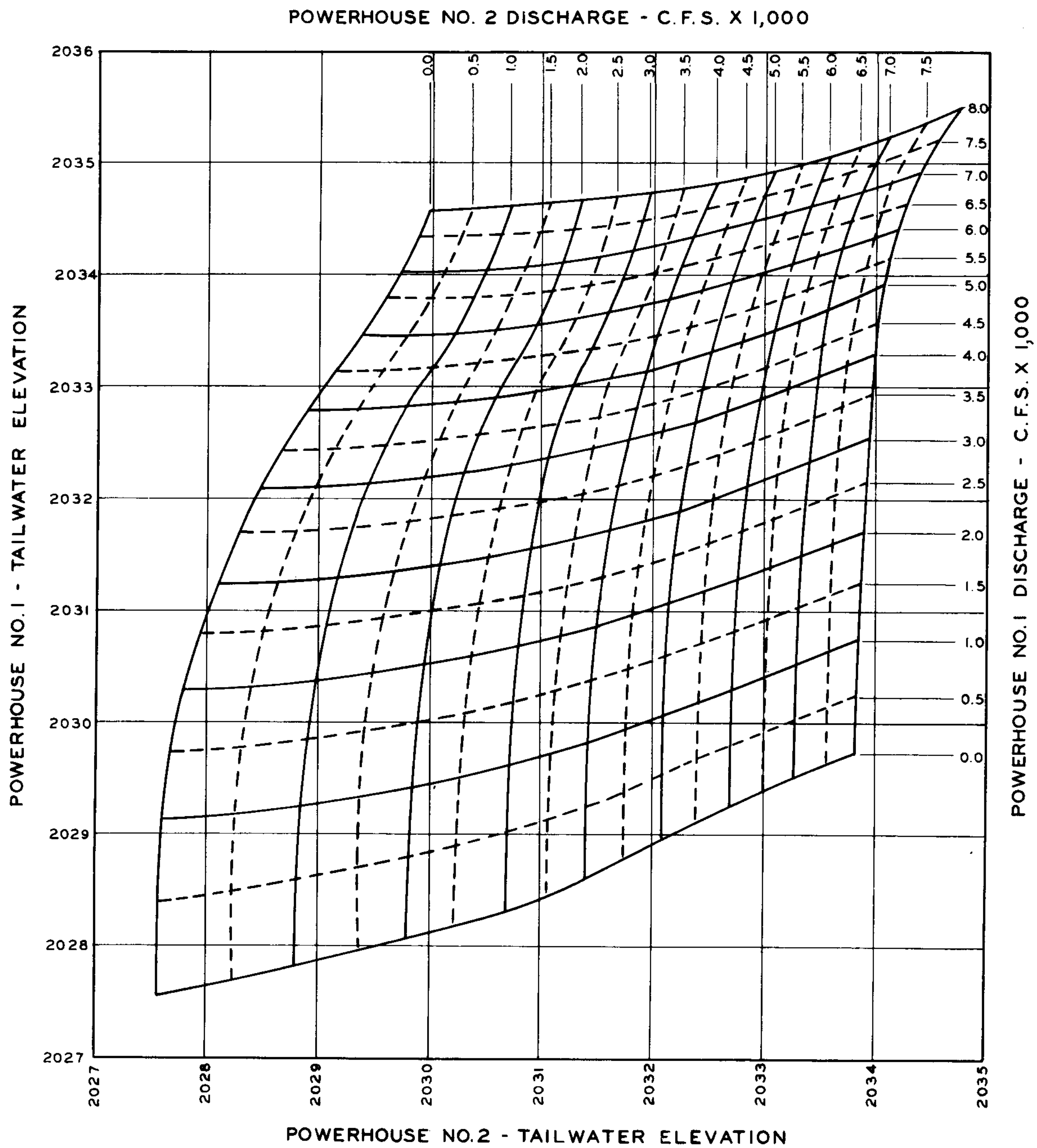
NO SCALE

Missouri River Basin

Fort Peck Water Control Manual

Fort Peck Powerplant No. 1 – Escher Wyss Trifurcation Alternative 6T

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017



Directions:

Tailwater elevation can be determined by following the Powerhouse No. 1 discharge curve to the left until the correct Powerhouse No. 2 discharge is reached. From this point read directly to the left for Powerhouse No. 1 tailwater elevation and straight down for Powerhouse No. 2 tailwater elevation.

Notes:

1. These curves are only good when steady state flow conditions exist at both powerhouses.
2. The curves are based on steady state flow period determined from the 1963 through 1965 stage recorder charts of both powerhouses. Discharges for these period were obtained from the hourly powerhouse releases.

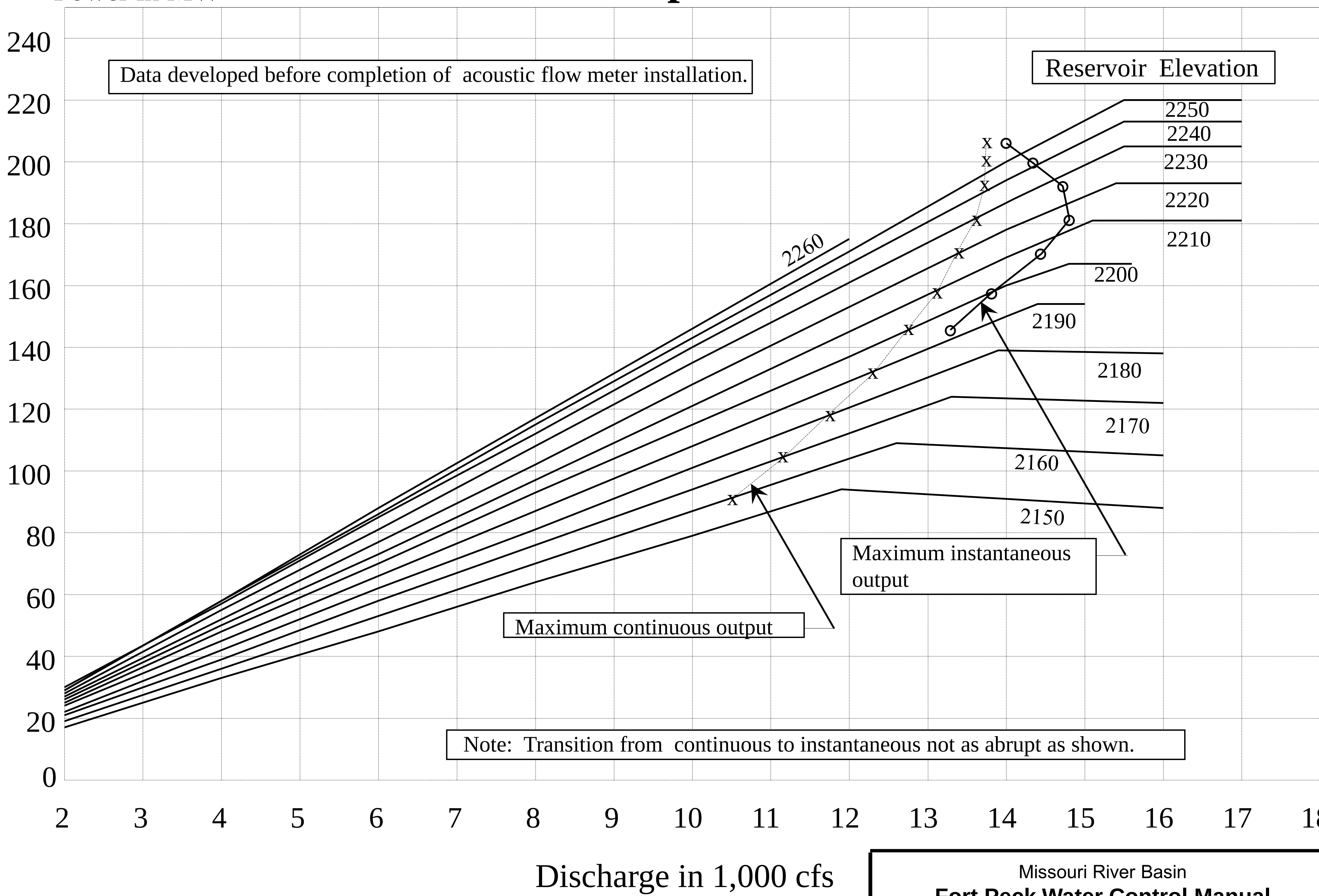
Missouri River Basin

Fort Peck Water Control Manual

Tailwater Rating Curves for Powerhouse No. 1 and No. 2

U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

Fort Peck Powerplant Characteristics



Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Powerplant Characteristics
U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

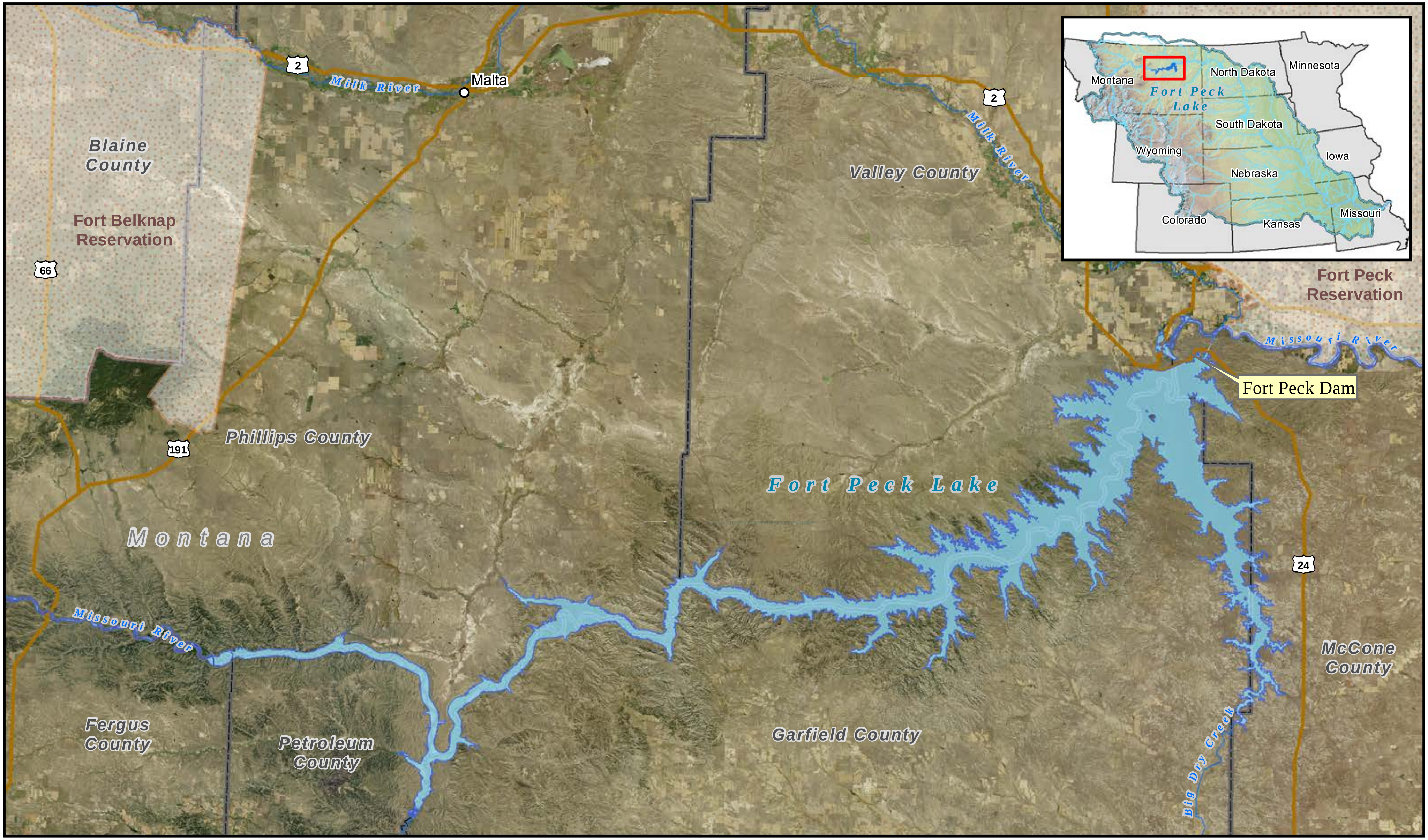


Plate IV-12

US Army Corps of Engineers®
Northwestern Division

Cities
Rivers
Roads
Reservations
Reservoirs/Lakes
State Boundaries
County Boundaries

0 5 10 20 30 Miles

Imagery Source:
U.S. Department of Agriculture,
Farm Service Agency 2015

N S E W

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Missouri River Basin
FORT PECK PROJECT
PROJECT MAP
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

FORT PECK PROJECT
(FORT PECK LAKE)

EFFECTIVE 01 January 2009
2007 Survey

AREA IN ACRES

ELEV	0	1	2	3	4	5	6	7	8	9
2030	0	0	0	0	0	50	87	108	129	151
2040	292	462	546	638	740	850	970	1,098	1,235	1,381
2050	1,479	1,489	1,498	1,573	1,714	1,921	2,193	2,530	2,934	3,404
2060	3,802	4,004	4,165	4,428	4,794	5,263	5,834	6,507	7,283	8,161
2070	9,100	10,002	10,820	11,569	12,248	12,857	13,397	13,866	14,265	14,596
2080	14,882	15,190	15,555	15,970	16,436	16,954	17,522	18,141	18,812	19,533
2090	20,221	20,791	21,328	21,915	22,550	23,236	23,972	24,757	25,591	26,476
2100	27,343	28,119	28,861	29,630	30,428	31,255	32,110	32,993	33,905	34,845
2110	35,709	36,418	37,115	37,917	38,822	39,831	40,946	42,164	43,486	44,913
2120	46,360	47,704	48,967	50,215	51,449	52,667	53,869	55,057	56,229	57,386
2130	58,579	59,849	61,126	62,353	63,530	64,656	65,731	66,757	67,733	68,658
3140	69,608	70,661	71,750	72,799	73,810	74,782	75,716	76,610	77,466	78,283
2150	79,022	79,691	80,396	81,201	82,106	83,110	84,214	85,418	86,721	88,124
2160	89,461	90,567	91,606	92,745	93,981	95,316	96,749	98,281	99,911	101,640
2170	103,394	105,061	106,652	108,219	109,763	111,285	112,782	114,256	115,708	117,136
2180	118,608	120,181	121,766	123,288	124,748	126,146	127,482	128,755	129,966	131,115
2190	132,175	133,178	134,237	135,407	136,688	138,081	139,585	141,201	142,928	144,765
2200	146,595	148,268	149,860	151,474	153,112	154,773	156,457	158,166	159,893	161,650
2210	163,400	165,100	166,790	168,495	170,210	171,930	173,670	175,420	177,175	178,950
2220	180,590	182,005	183,420	185,015	186,800	188,765	190,905	193,230	195,740	198,430
2230	201,130	203,610	205,955	208,310	210,665	213,025	215,395	217,765	220,145	222,530
2240	225,065	227,835	230,585	233,130	235,470	237,605	239,530	241,260	242,785	244,100
2250	245,405	246,945	248,635	250,330	252,025	253,715	255,410	257,105	258,795	260,485
2260	262,180									

FORT PECK PROJECT
(FORT PECK LAKE)

EFFECTIVE 01 January 2009
2007 Survey

CAPACITY IN ACRE-FEET

ELEV	0	1	2	3	4	5	6	7	8	9
2030	0	0	0	0	0	25	101	199	318	458
2040	620	1,042	1,544	2,134	2,821	3,614	4,522	5,554	6,719	8,025
2050	9,482	10,983	12,461	13,980	15,607	17,408	19,449	21,794	24,510	27,663
2060	31,318	35,267	39,326	43,597	48,182	53,185	58,708	64,853	71,723	79,420
2070	88,046	97,621	108,050	119,262	131,188	143,758	156,903	170,552	184,635	199,083
2080	213,827	228,847	244,207	259,957	276,147	292,830	310,055	327,874	346,338	365,498
2090	385,404	405,940	426,987	448,597	470,817	493,698	517,290	541,642	566,804	592,825
2100	619,756	647,512	675,995	705,234	735,256	766,091	797,766	830,311	863,753	898,121
2110	933,443	969,539	1,006,280	1,043,770	1,082,114	1,121,414	1,161,777	1,203,306	1,246,105	1,290,279
2120	1,335,932	1,383,000	1,431,340	1,480,935	1,531,771	1,583,833	1,637,105	1,691,572	1,747,219	1,804,030
2130	1,861,991	1,921,189	1,981,690	2,043,442	2,106,396	2,170,502	2,235,708	2,301,965	2,369,223	2,437,431
2140	2,506,539	2,576,647	2,647,862	2,720,147	2,793,461	2,867,767	2,943,026	3,019,199	3,096,246	3,174,131
2150	3,252,813	3,332,176	3,412,195	3,492,969	3,574,598	3,657,182	3,740,819	3,825,611	3,911,655	3,999,053
2160	4,087,903	4,177,975	4,269,037	4,361,188	4,454,527	4,549,151	4,645,159	4,742,650	4,841,722	4,942,473
2170	5,045,002	5,149,262	5,255,124	5,362,566	5,471,563	5,582,093	5,694,133	5,807,658	5,922,646	6,039,074
2180	6,156,918	6,276,291	6,397,280	6,519,823	6,643,856	6,769,319	6,896,149	7,024,283	7,153,659	7,284,215
2190	7,415,889	7,548,566	7,682,245	7,817,040	7,953,060	8,090,417	8,229,223	8,369,588	8,511,625	8,655,444
2200	8,801,156	8,948,634	9,097,693	9,248,354	9,400,641	9,554,578	9,710,187	9,867,493	10,026,520	10,187,280
2210	10,349,820	10,514,080	10,680,020	10,847,660	11,017,010	11,188,080	11,360,870	11,535,420	11,711,710	11,889,770
2220	12,069,610	12,250,950	12,433,620	12,617,790	12,803,650	12,991,390	13,181,180	13,373,200	13,567,640	13,764,680
2230	13,964,500	14,166,940	14,371,720	14,578,850	14,788,340	15,000,180	15,214,390	15,430,970	15,649,920	15,871,260
2240	16,094,980	16,321,390	16,550,650	16,782,560	17,016,910	17,253,500	17,492,120	17,732,560	17,974,640	18,218,130
2250	18,462,840	18,708,940	18,956,730	19,206,210	19,457,390	19,710,260	19,964,820	20,221,080	20,479,030	20,738,670
2260	21,000,000									

Missouri River Basin
Fort Peck Water Control Manual
Area and Capacity Tables

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

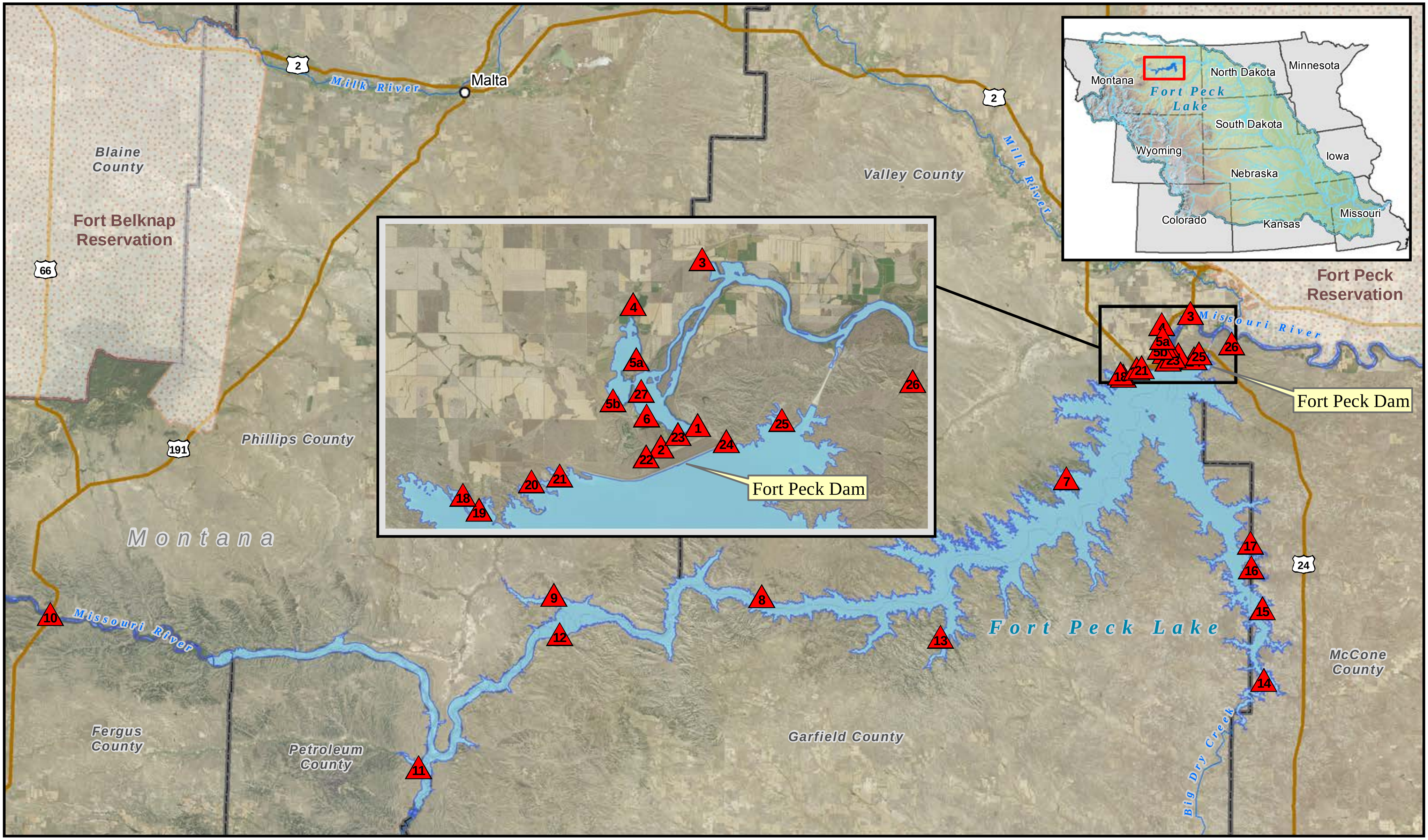

Plate IV-14

US Army Corps of Engineers®
Northwestern Division

Missouri River Basin
FORT PECK PROJECT
RECREATION AREAS
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

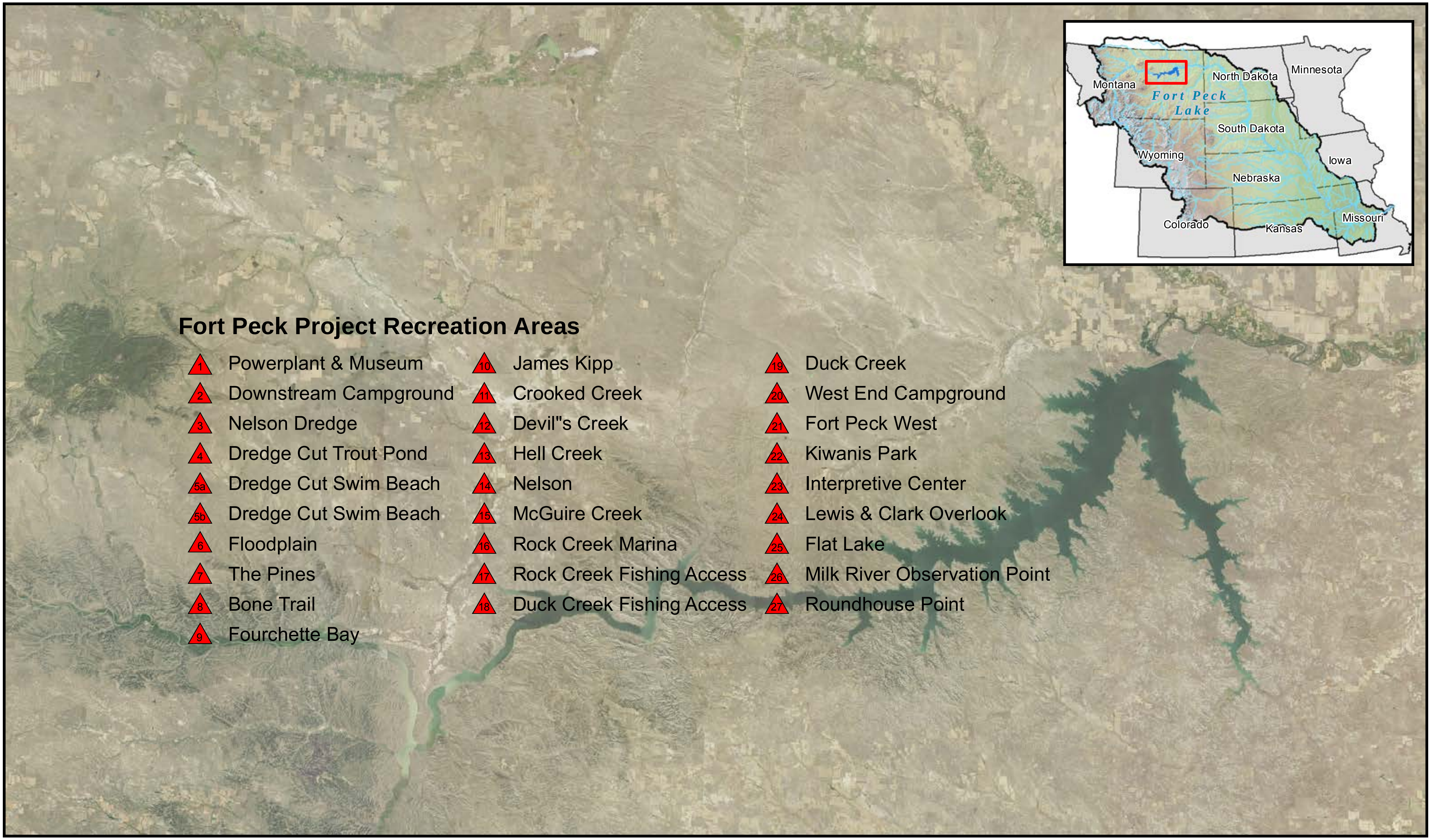

Plate IV-15

US Army Corps of Engineers ®
Northwestern Division

Imagery Source:
U.S. Department of Agriculture, Farm Service Agency 2015

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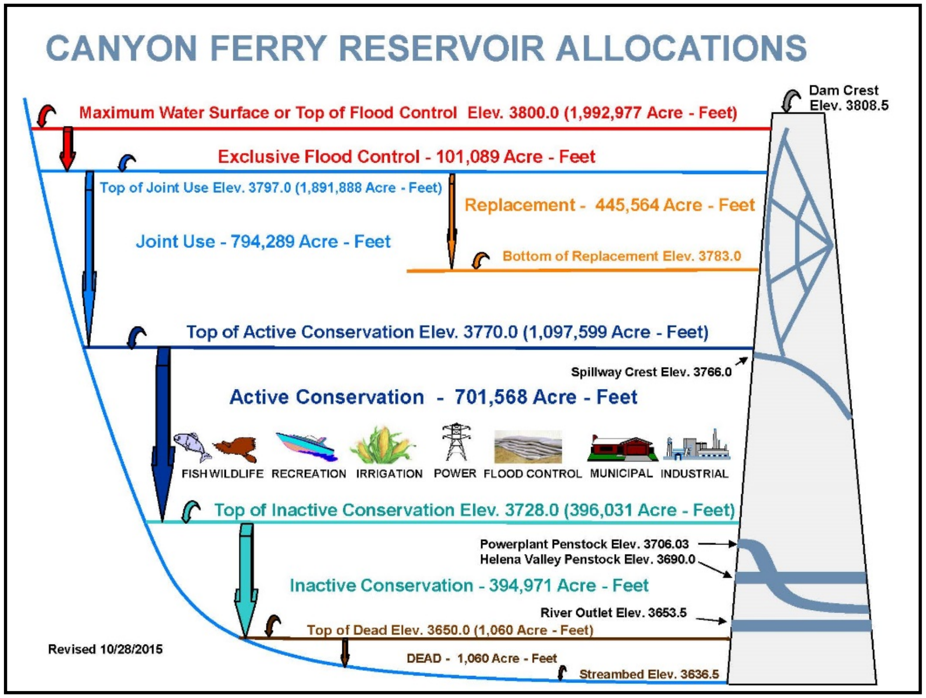
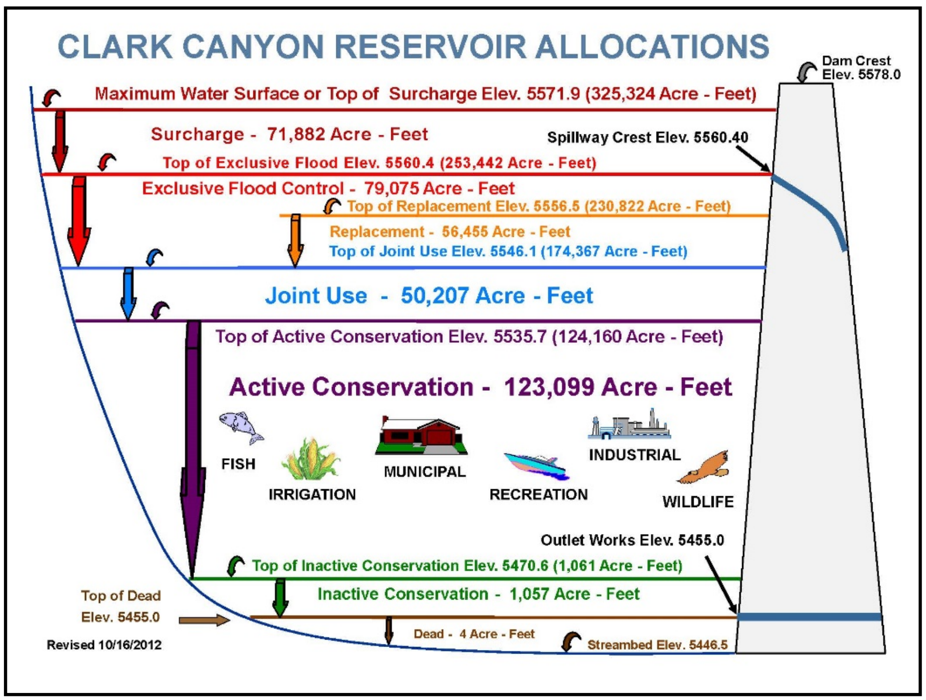
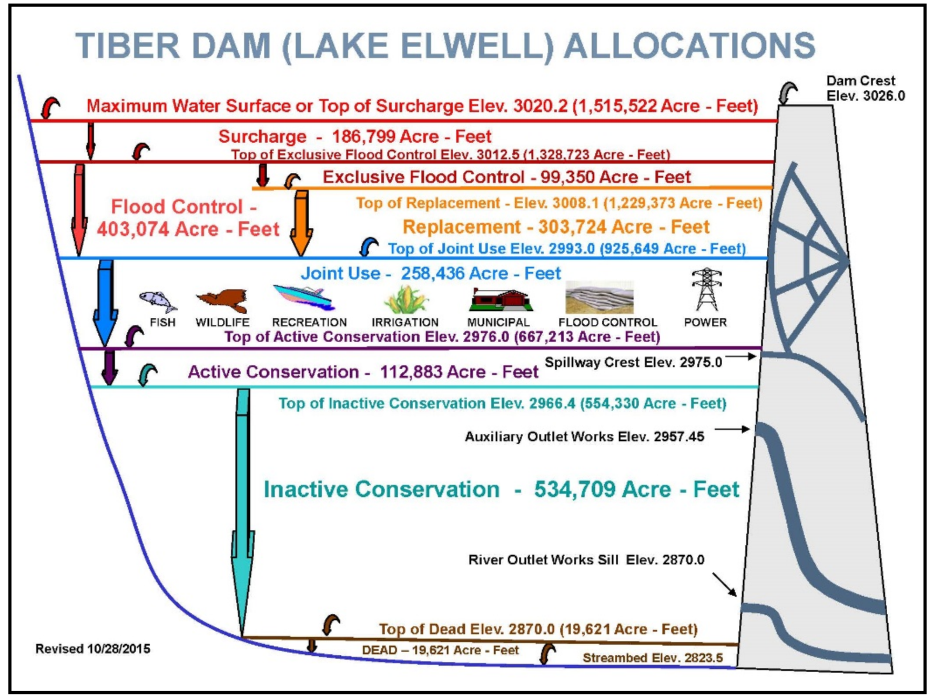
Missouri River Basin
FORT PECK PROJECT
RECREATION AREA INDEX
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017







Source: U.S. Bureau of Reclamation

Missouri River Basin
Fort Peck Water Control Manual
Storage Allocations - Section 7 Projects

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

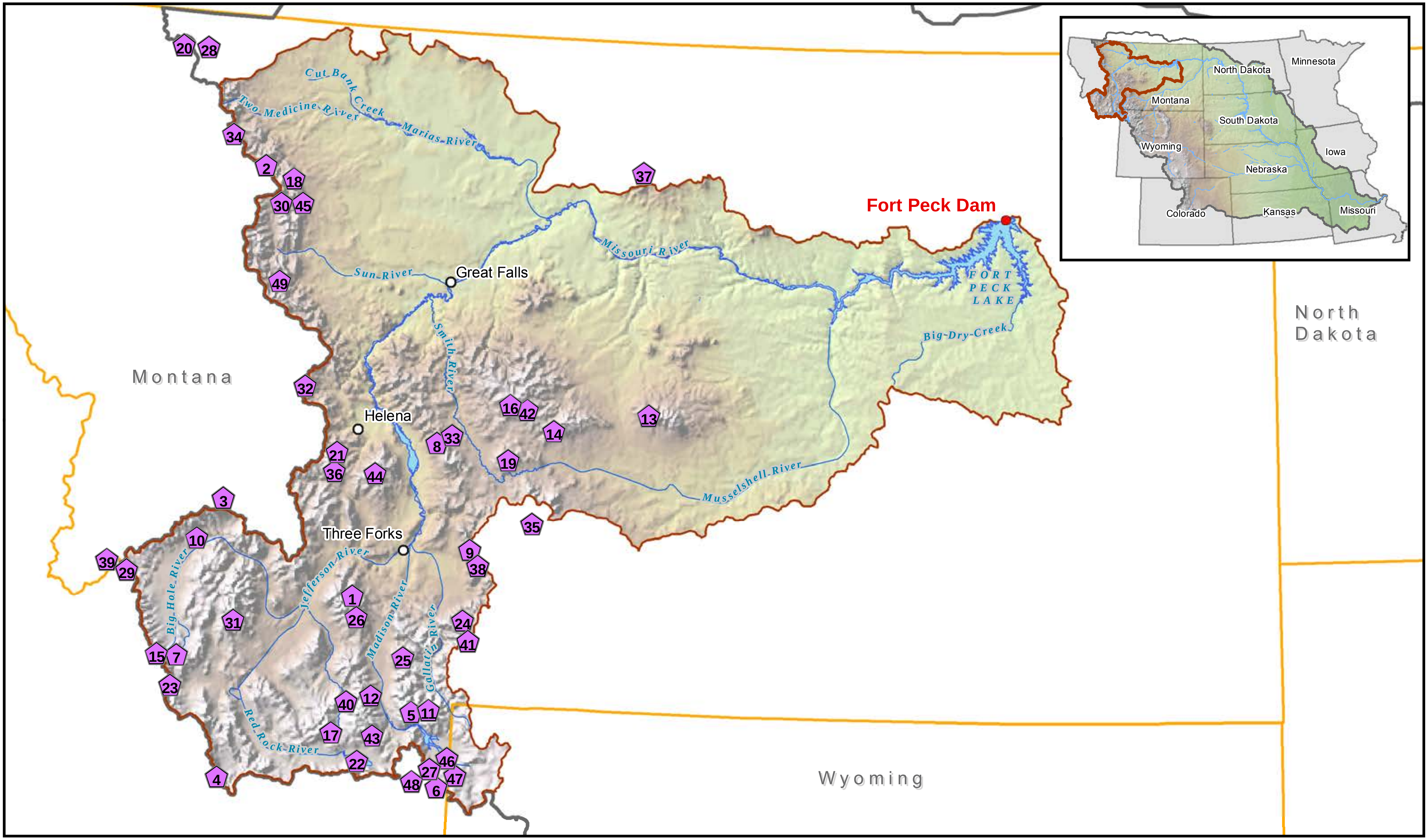


Plate V-1

US Army Corps of Engineers®
Northwestern Division

Snow Telemetry Stations
Mainstem Dam
Cities
Reservoirs/Lakes
Rivers
Fort Peck Drainage Area
Omaha/Kansas District Boundaries
State Boundaries

0 25 50 100 Miles

N E S W

Data Source:
U.S. Department of Agriculture,
Farm Service Agency 2014

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Missouri River Basin
FORT PECK DRAINAGE AREA
SNOTEL
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

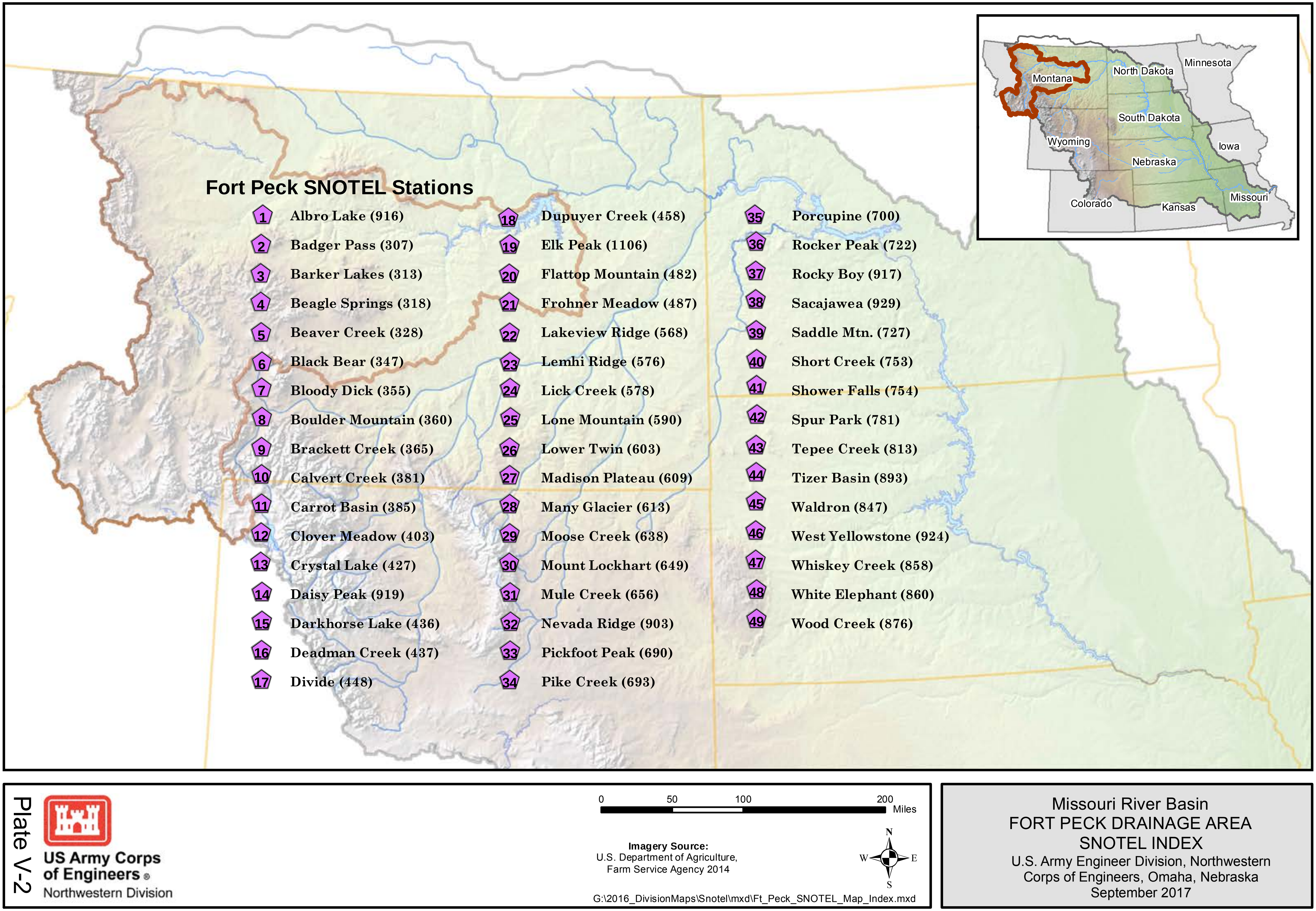

Plate V-2

US Army Corps of Engineers® Northwestern Division

Imagery Source:
U.S. Department of Agriculture, Farm Service Agency 2014

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Missouri River Basin
FORT PECK DRAINAGE AREA
SNOTEL INDEX
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Plate V-3

US Army Corps of Engineers®
Northwestern Division

- Streamgaging Station
- Mainstem Dam
- Cities
- Rivers
- Reservoirs/Lakes
- Fort Peck Drainage Area
- Omaha/Kansas City District Boundaries
- State Boundaries

0 25 50 100 Miles

N W E S

Data Source:
U.S. Department of Agriculture,
Farm Service Agency 2014

G:\2016_DivisionMaps\Stations\mxd\Ft_Peck_Stream_Gaging_Map.mxd

Missouri River Basin
FORT PECK DRAINAGE AREA
KEY STREAMGAGING STATIONS
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Stage	Flow in cfs							
	Beaverhead River at Barretts, MT	Beaverhead River at Dillon, MT	Beaverhead River near Twin Bridges, MT	Jefferson River near Twin Bridges, MT	Jefferson River near Three Forks, MT	Madison River bl Ennis Lake nr McAllister, MT	Gallatin River at Logan, MT	Missouri River at Toston, MT
	Rating # 8.0	Rating # 3.1	Rating # 7.0	Rating # 14.0	Rating # 8.0	Rating # 9.0	Rating # 14.0	Rating # 4.0
	No Flood Stage	No Flood Stage	Fld Stg = 7.0'	Fld Stg = 10.0'	Fld Stg = 8.0'	No Flood Stage	Fld Stg = 9.0'	Fld Stg = 10.5'
0.0								
0.5	80					429		
1.0	190					654		
1.5	381				167	910		350
2.0	743				347	1,210		660
2.5	1,150			245	610	1,550		1,080
3.0		29	18	487	966	1,910		1,610
3.5		88	77	815	1,430	2,330		2,250
4.0		185	165	1,230	2,020	2,790	323	3,020
4.5		479	278	1,740	2,720	3,290	593	3,910
5.0		700	418	2,400	3,530	3,860	944	4,920
5.5		966	580	3,200	4,520	4,570	1,380	6,070
6.0		1,280	756	4,090	5,680	5,330	1,890	7,350
6.5		1,630	978	5,100	6,990	6,160	2,480	8,750
7.0		1,790	1,320	6,110	8,470	7,050	3,150	10,300
7.5			1,840	7,230	10,100	8,000	3,910	11,900
8.0			1,970	8,440	12,000		4,780	13,600
8.5				9,750	14,000		5,810	15,500
9.0				11,200	16,200		6,970	17,500
9.5				12,400	18,700		8,230	19,600
10.0				13,600	21,300		9,000	21,800
10.5				14,900				24,200
11.0				16,000				26,700
11.5								29,300
12.0								32,500
12.5								36,000

Missouri River Basin
Fort Peck Water Control Manual
Rating Curves - above Fort Peck (1 of 3)
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Stage	Flow in cfs							
	Sun River at Vaughn, MT	Muddy Creek at Vaughn, MT	N F Milk River ab St. Mary Canal nr Browning, MT	Cut Bank Creek near Browning, MT	Two Medicine River bl South Fork nr Browning, MT	Badger Cr bl Four Horns Canal nr Browning, MT	Marias River near Shelby, MT	Milk River at Eastern Crossing of Int Bndry
	Rating # 15.0	Rating # 11.0	Rating # 6.0	Rating # 8.0	Rating # 9.0	Rating # 12.0	Rating # 14.0	Rating # 5.1
	Fld Stg = 6.0'	Fld Stg = 7.0'	No Flood Stage	No Flood Stage	No Flood Stage	Fld Stg = 7.0'	Fld Stg = 9.0'	Fld Stg = 9.5'
0.0								
0.5								
1.0								
1.5			7	13	41			4
2.0	210	10	29	43	118			27
2.5	664	30	66	106	244		99	87
3.0	1,340	64	110	327	431		252	212
3.5	2,190	112	159	632	679	24	490	435
4.0	3,170	177	197	989	1,000	63	820	734
4.5	4,290	263	219	1,380	1,400	122	1,250	1,150
5.0	5,590	370	236	1,810	1,880	259	1,750	1,710
5.5	6,770	489	250	2,080	2,440	471	2,280	2,330
6.0	8,030	630	260		3,100	745	2,890	3,030
6.5	9,370	807	273		3,840	1,070	3,580	3,830
7.0	10,800	1,010	293		4,670	1,430	4,410	4,730
7.5	12,300	1,260	342		5,610	1,810	5,320	5,710
8.0	13,900	1,530	501		6,640	2,230	6,330	6,770
8.5	15,500	1,850	742		7,810	2,680	7,430	7,950
9.0	17,200	2,200	1,070		9,080	3,160	8,630	9,200
9.5			1,520		10,500	3,470	9,920	10,500
10.0			2,100		12,000		11,400	12,000
10.5			2,860				13,000	13,500
11.0							14,800	15,100
12.0							18,700	
13.0							23,100	
14.0							28,000	

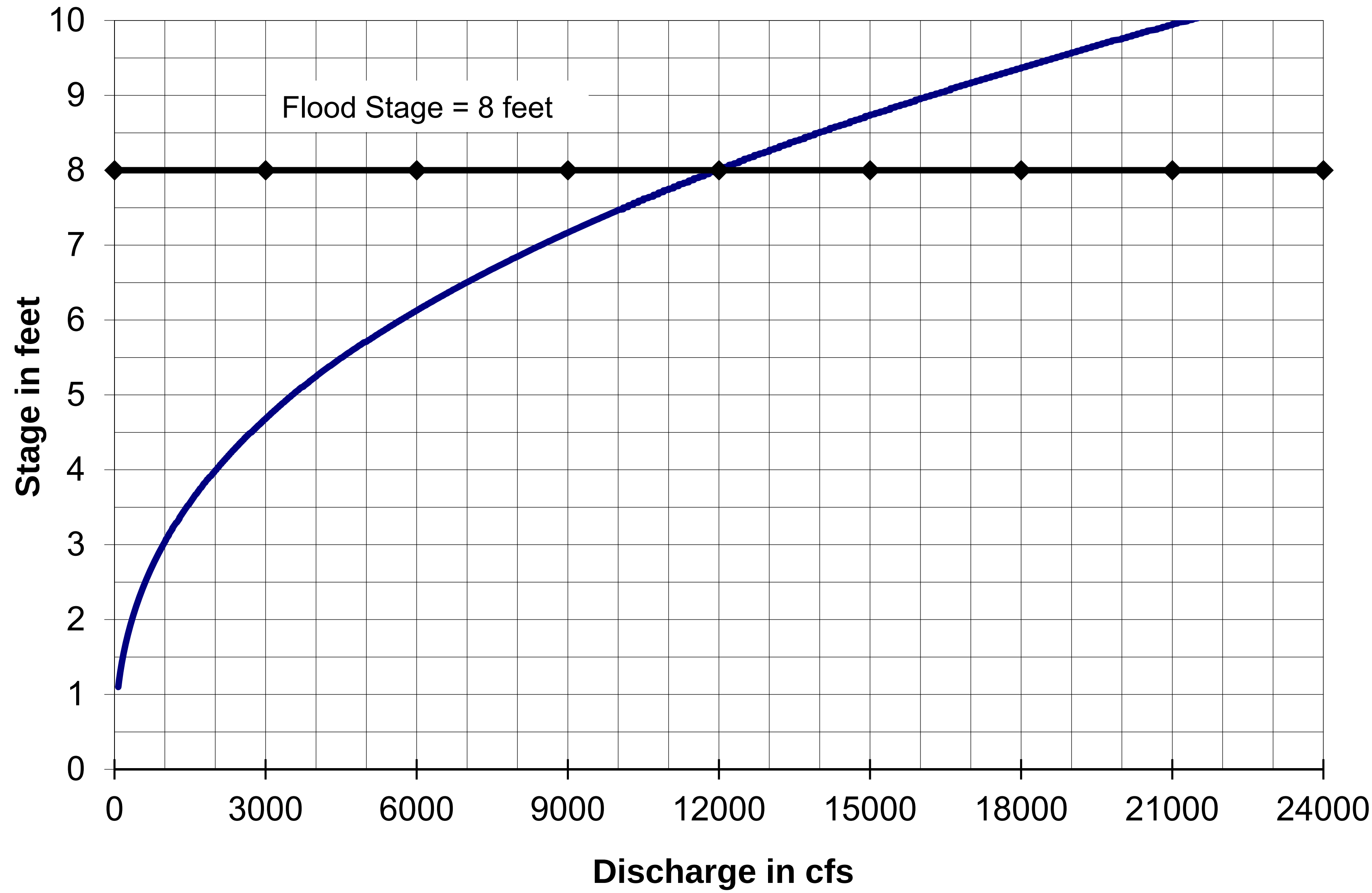
Missouri River Basin
Fort Peck Water Control Manual
Rating Curves - above Fort Peck (2 of 3)
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Stage	Flow in cfs					
	Missouri River at Virgelle, MT	Missouri River near Landusky, MT	Milk River near Harlem, MT	Milk River near Dodson, MT	Milk River at Juneberg Bridge nr Saco, MT	Milk River at Nashua, MT
	Rating # 5.0	Rating # 13.0	Rating # 19.0	Rating # 5.0	Rating # 4.0	Rating # 20.0
	Fld Stg = 17.0'	Fld Stg = 25.0'	Fld Stg = 21.0'	Fld Stg = 23.0'	Fld Stg = 20.0'	Fld Stg = 20.0'
0.0						
0.5			6			
1.0			18			
1.5	1,580		42			
2.0	2,480		70			100
2.5	3,520		103	0	10	328
3.0	4,690		139	5	83	626
3.5	5,970		180	29	232	864
4.0	7,360		232	68	413	1,100
4.5	8,850		290	115	644	1,330
5.0	10,400		354	175	911	1,560
6.0	13,900		495	329	1,420	2,020
7.0	17,700		656	491	1,830	2,470
8.0	21,800		835	648	2,250	2,920
9.0	26,200		1,030	808	2,680	3,360
10.0	30,900		1,240	976	3,120	3,800
11.0	35,900		1,470	1,150	3,560	4,230
12.0	41,200		1,720	1,390	4,070	4,750
13.0	47,000	4,300	1,980	1,670	4,590	5,300
14.0	53,200	6,040	2,250	1,970	5,140	5,920
15.0	59,700	7,980	2,540	2,290	5,690	6,560
16.0	66,400	10,100	2,840	2,670	6,250	7,230
17.0	73,300	12,400	3,160	3,070	6,830	7,920
18.0	80,400	14,800	3,490	3,500	7,430	8,620
19.0	87,700	17,400	3,840	3,980	8,070	9,350
20.0	95,200	20,100	4,200	4,490	8,710	10,100
21.0	103,000	23,000	4,570	5,040	9,370	10,800
22.0	111,000	26,000	5,240	5,610	10,300	11,700
23.0	119,000	29,100	6,000	6,220	11,300	12,500
24.0	122,000	32,300	6,940	6,960	12,500	13,400
25.0		35,600	8,200	7,750	12,800	14,500
26.0		39,000	13,900	8,590		15,600
27.0		42,600		9,520		17,000
28.0		46,400		10,500		18,700
29.0		50,800		11,800		21,900
30.0		56,700		13,500		28,000
31.0		63,000				35,000
32.0		71,000				
33.0		82,200				

Missouri River Basin
Fort Peck Water Control Manual
Rating Curves - above Fort Peck (3 of 3)
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

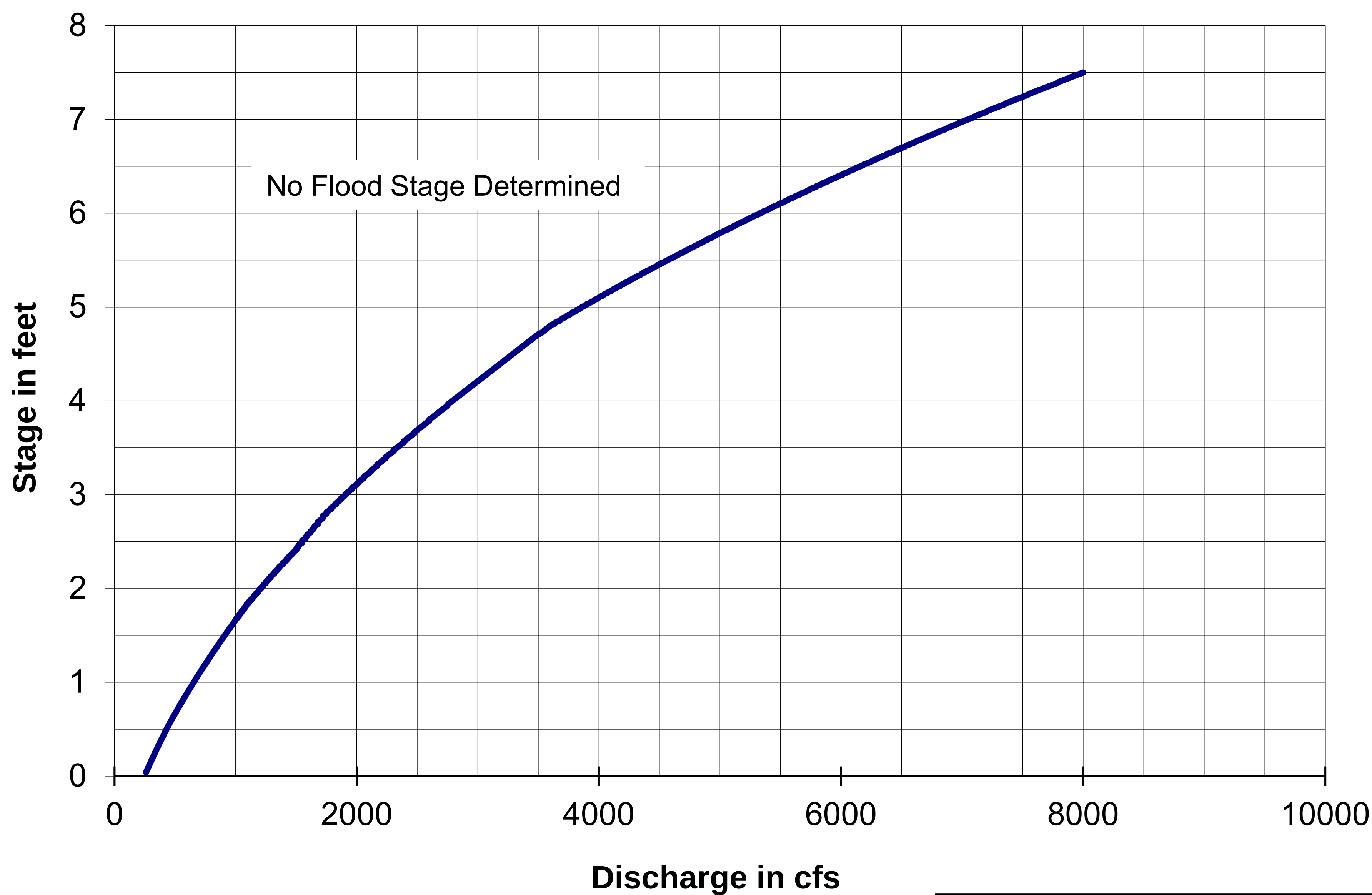
Stage	Flow in cfs							
	Smith River bl Eagle Cr nr Fort Logan, MT	Missouri river bl Holter Dam nr Wolf Cr, MT	Dearborn River near Craig, MT	Missouri River near Ulm, MT	Musselshell River near Roundup, MT	Musselshell River near Mosby, MT	Missouri River near Wolf Point, MT	Missouri River near Culbertson, MT
	Rating # 4.0	Rating # 6.0	Rating # 15.0	Rating # 8.0	Rating # 22.0	Rating # 28.0	Rating # 12.0	Rating # 10.0
	No Flood Stage	No Flood Stage	Fld Stg = 6.5'	Fld Stg = 13.5'	Fld Stg = 10.0'	Fld Stg = 10.0'	Fld Stg = 23.0'	Fld Stg = 19.0'
1.5		795		2,260	100	65		4,950
2.0		1,370		2,770	192	137		5,770
2.5		2,050	14	3,270	312	228		6,660
3.0	92	2,800	64	3,770	459	446		7,620
3.5	216	3,640	182	4,320	635	731		8,610
4.0	395	4,610	376	4,920	833	1,070		9,650
4.5	627	5,680	655	5,500	1,060	1,430		10,800
5.0	940	6,830	1,030	6,150	1,310	1,840		11,900
6.0	1,830	10,900	2,120	7,640	1,900	2,750		14,500
7.0	3,080	15,600	3,700	9,430	2,610	3,780		17,300
8.0	4,700	18,900	5,800	11,400	3,440	4,920		20,800
9.0	4,700	22,300	5,800	13,700	4,380	6,150	4,320	24,700
10.0	4,700	25,900	5,800	16,000	5,440	7,480	5,780	29,100
11.0		31,000		18,300	6,610	8,890	7,510	33,900
12.0		34,800		20,700	8,300	10,500	9,530	39,700
13.0		34,800		23,000	10,400	13,200	11,900	48,600
14.0				25,400	12,800	17,800	14,600	58,800
15.0				27,700	15,600	24,500	17,800	70,500
16.0				30,000	15,600	24,600	21,400	82,800
17.0				30,000			25,600	96,400
18.0							30,100	112,000
19.0							35,300	128,000
20.0							42,900	130,000
21.0							51,900	
22.0							62,400	
23.0							74,300	
24.0							87,900	
25.0							105,000	
26.0							130,000	

Missouri River Basin
Fort Peck Water Control Manual
Rating Curves - above and below Fort Peck
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



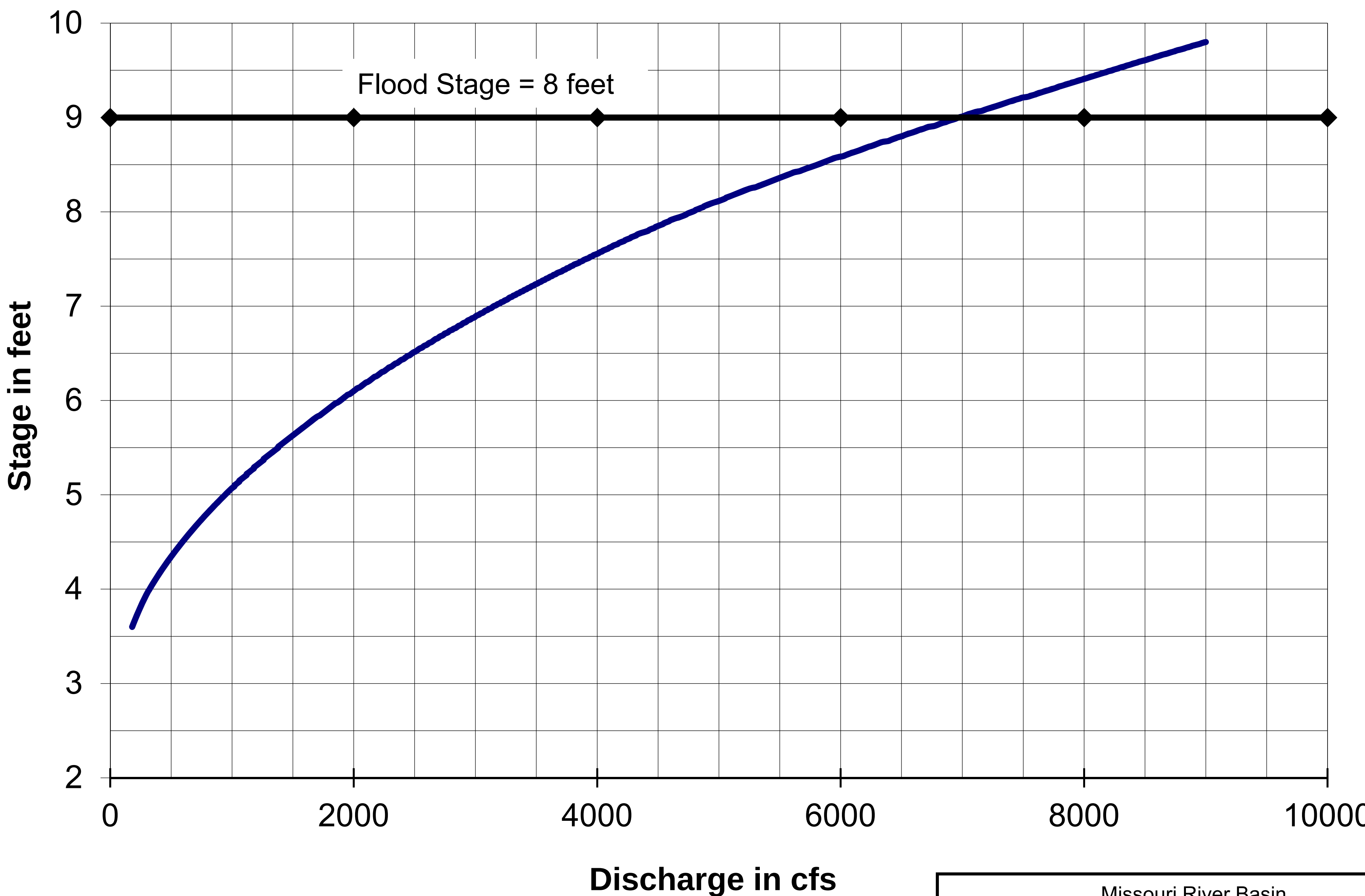
Datum of gage is 4,076.76 feet above sea level NGVD29.
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Jefferson River at Three Forks, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



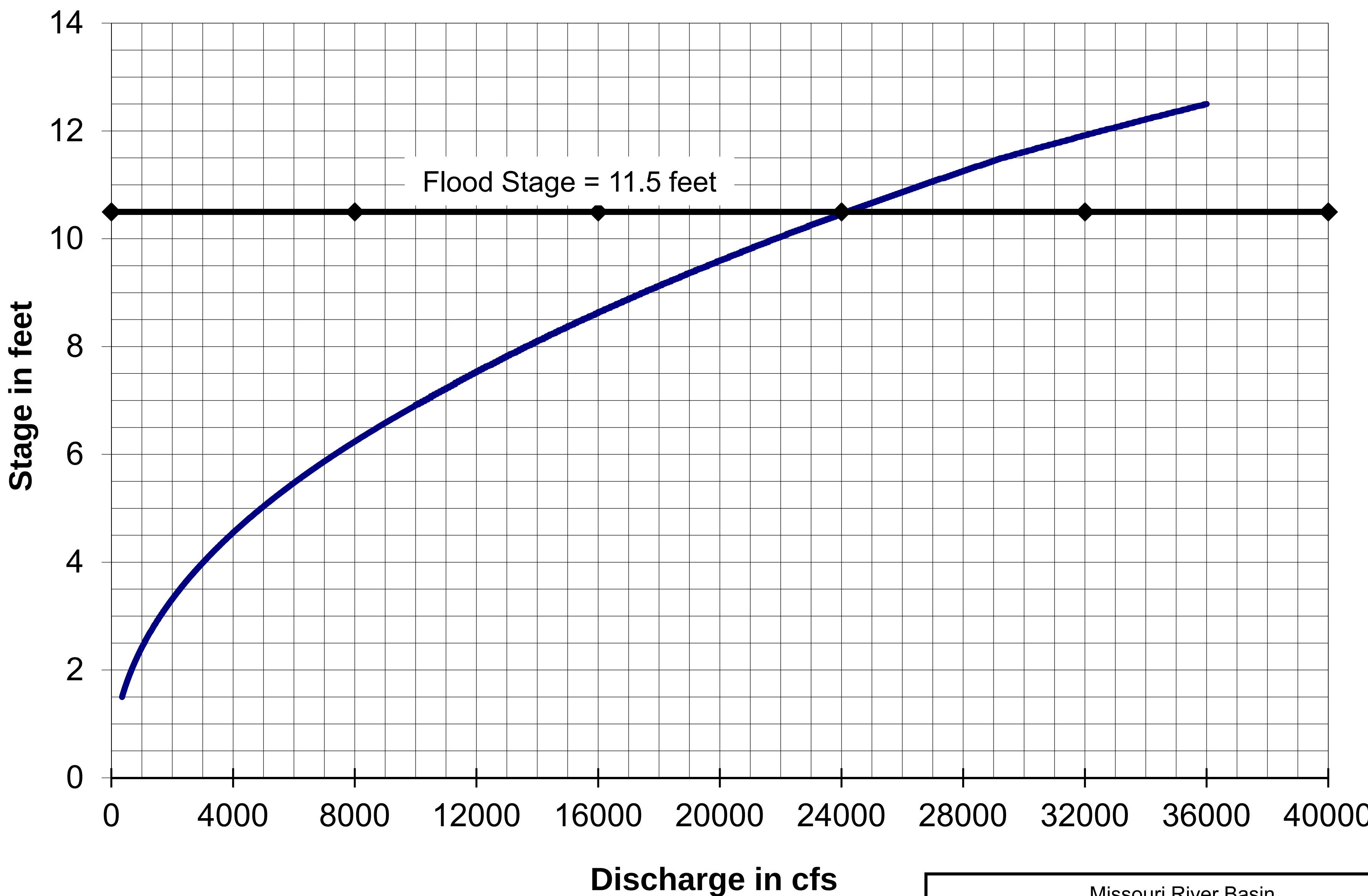
Datum of gage is 4,689.03 feet above sea level NGVD29.
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Madison River nr McAllister, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



Datum of gage is 4,086.42 feet above sea level NGVD29.
Source: USGS

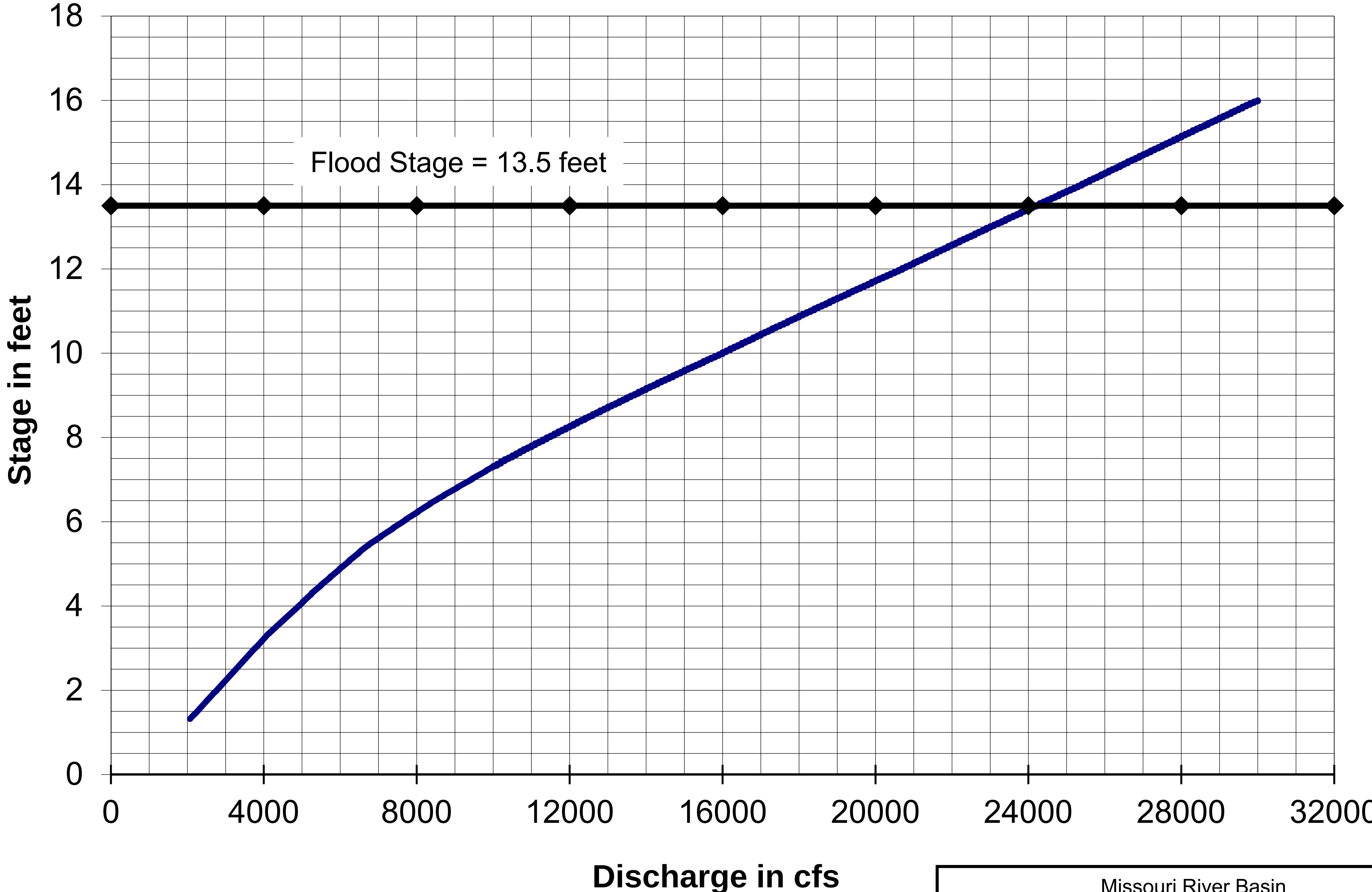
Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Gallatin River at Logan, MT
U.S. Army Engineer Division, Northwestern Corps of Engineers, Omaha, Nebraska
September 2017



Datum of gage is 3,905.68 feet above sea level NGVD29.

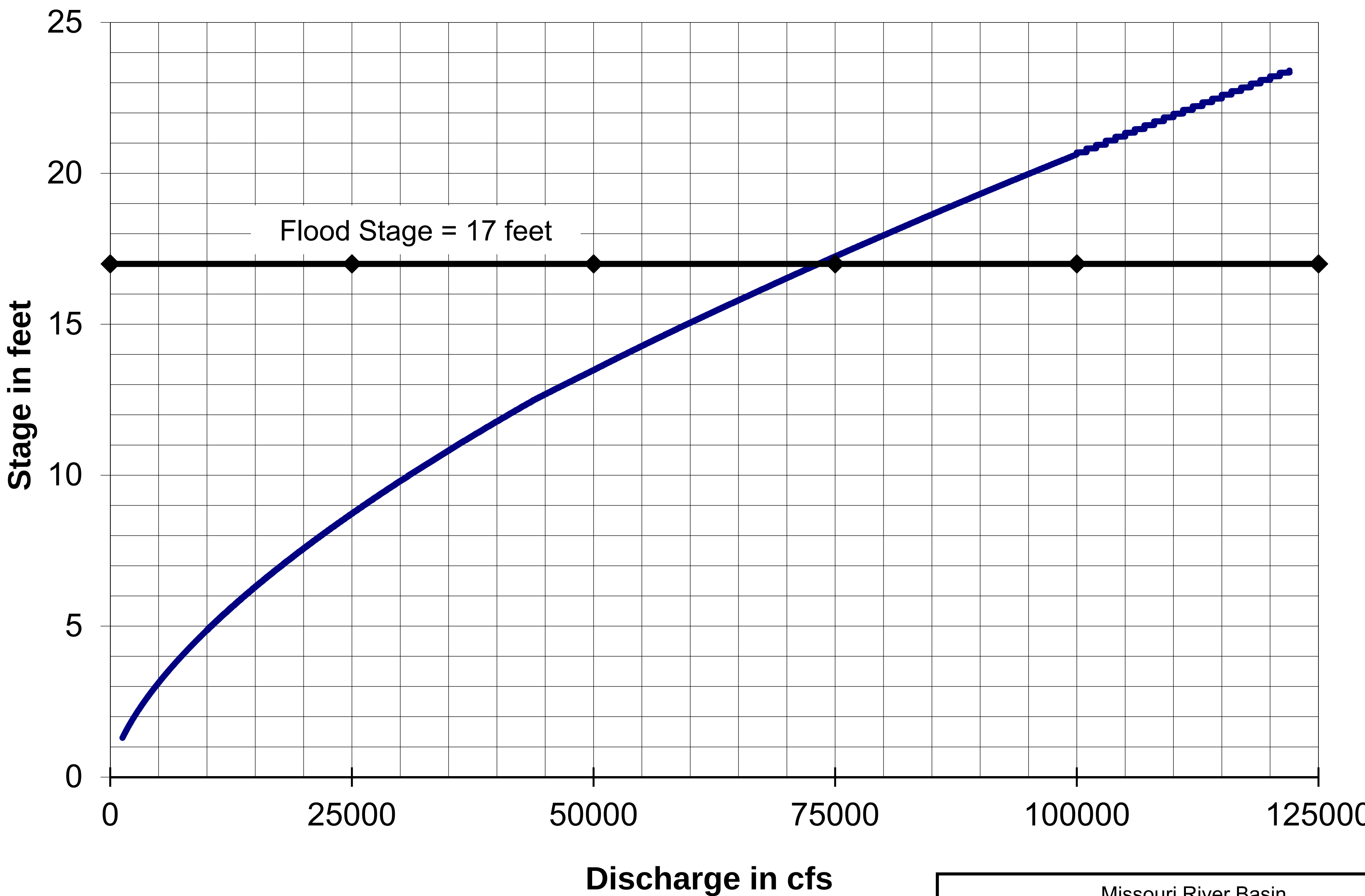
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Missouri River at Toston, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



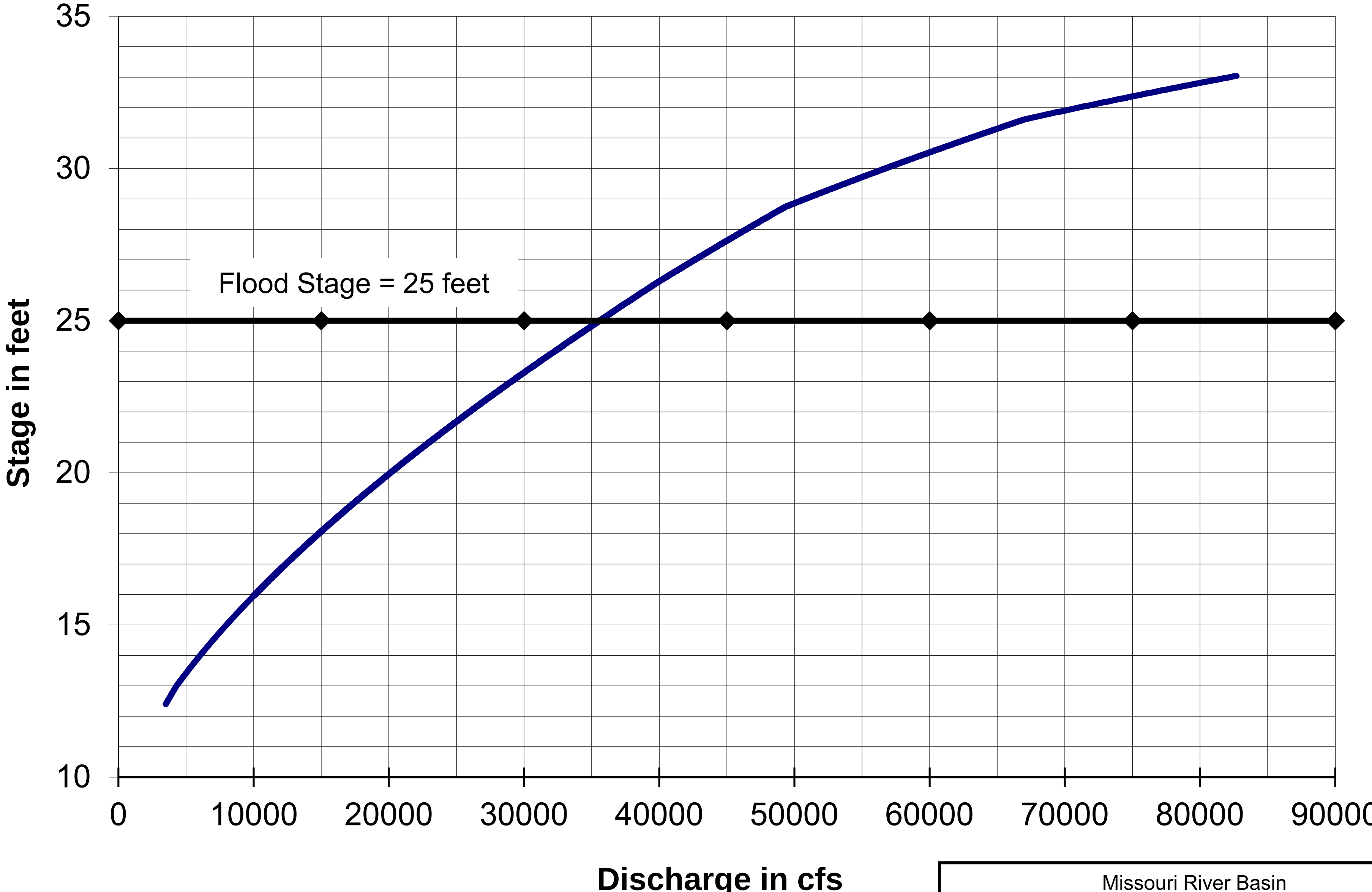
Datum of gage is 3,313.27 feet above sea level NGVD29.
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Missouri River near Ulm, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



Datum of gage is 2,507.5 feet above sea level NGVD29.
Source: USGS

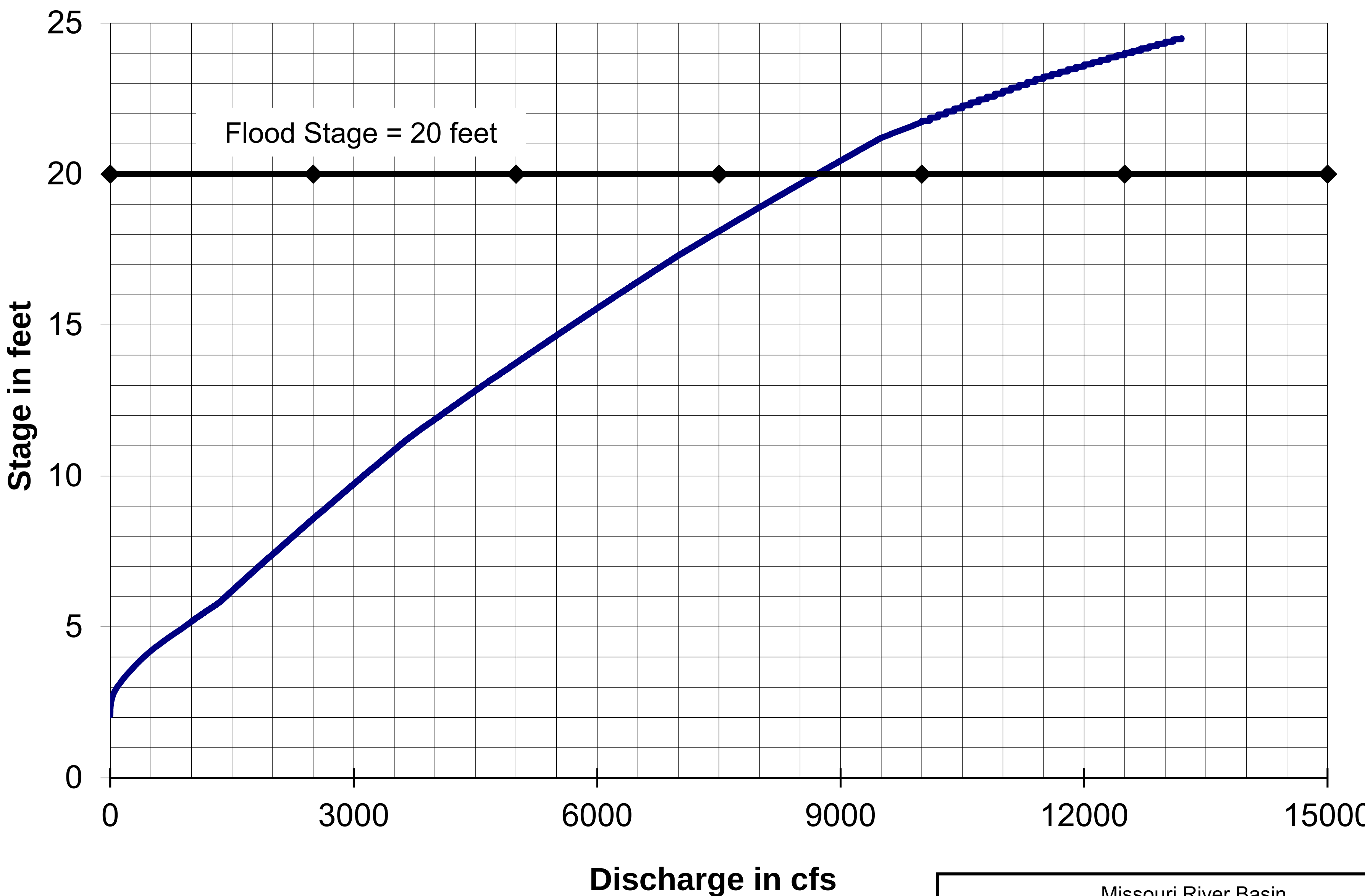
Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Missouri River at Virgelle, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



Datum of gage is 2,239.96 feet above sea level NGVD29.

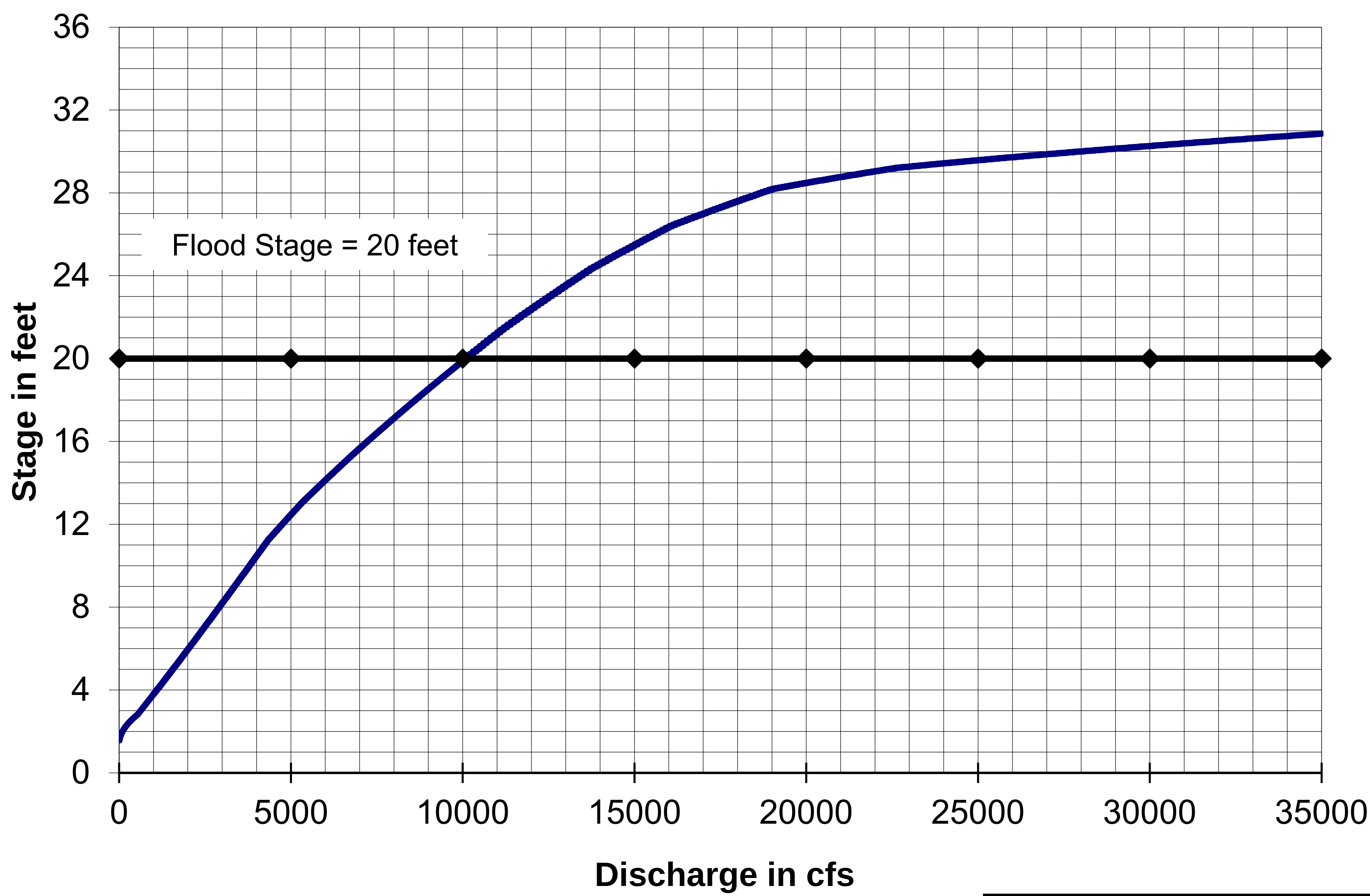
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Missouri River near Landusky, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



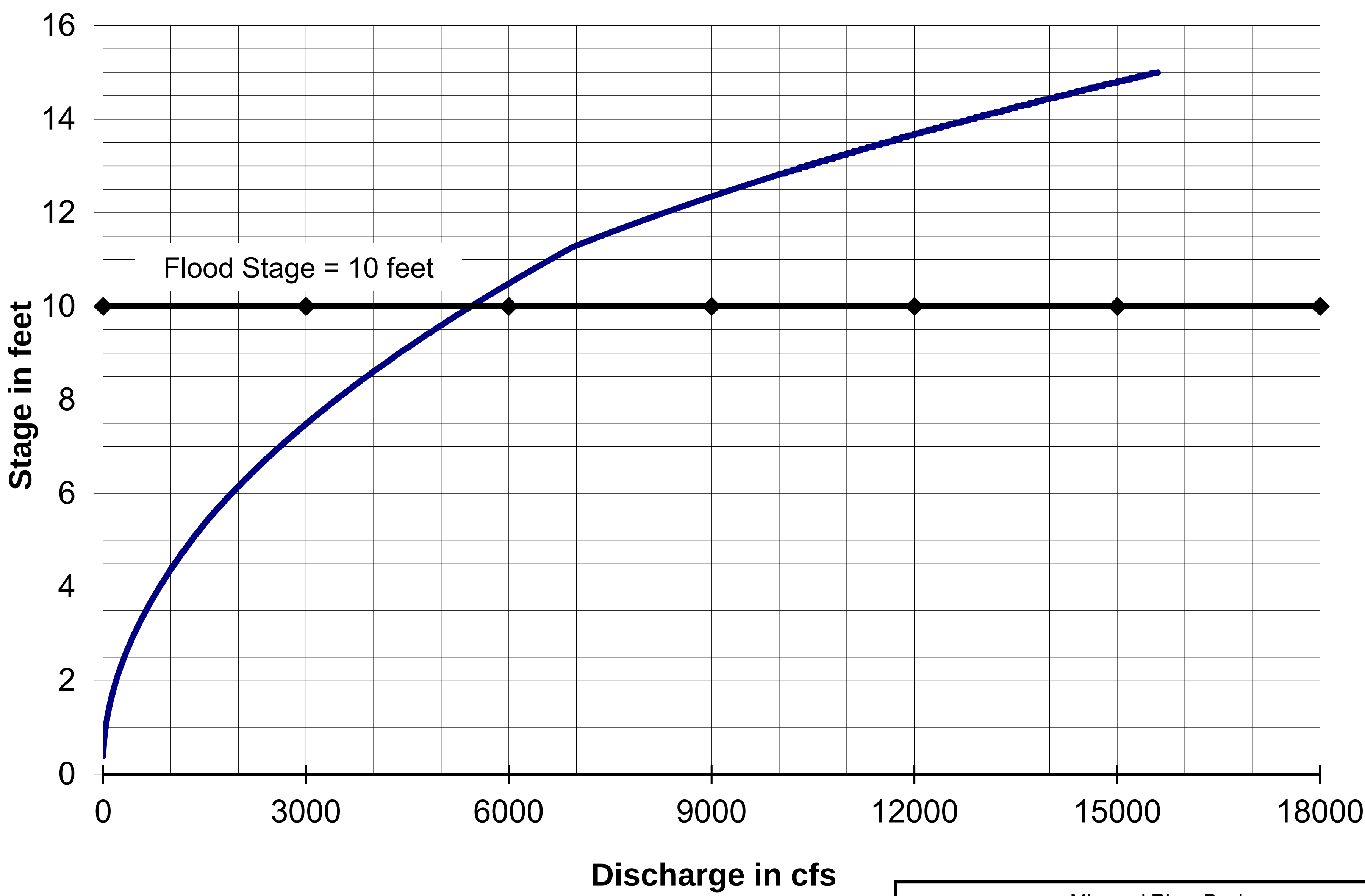
Datum of gage is 2,130 feet above sea level NGVD29.
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve - Milk River at Juneberg Bridge nr Saco, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



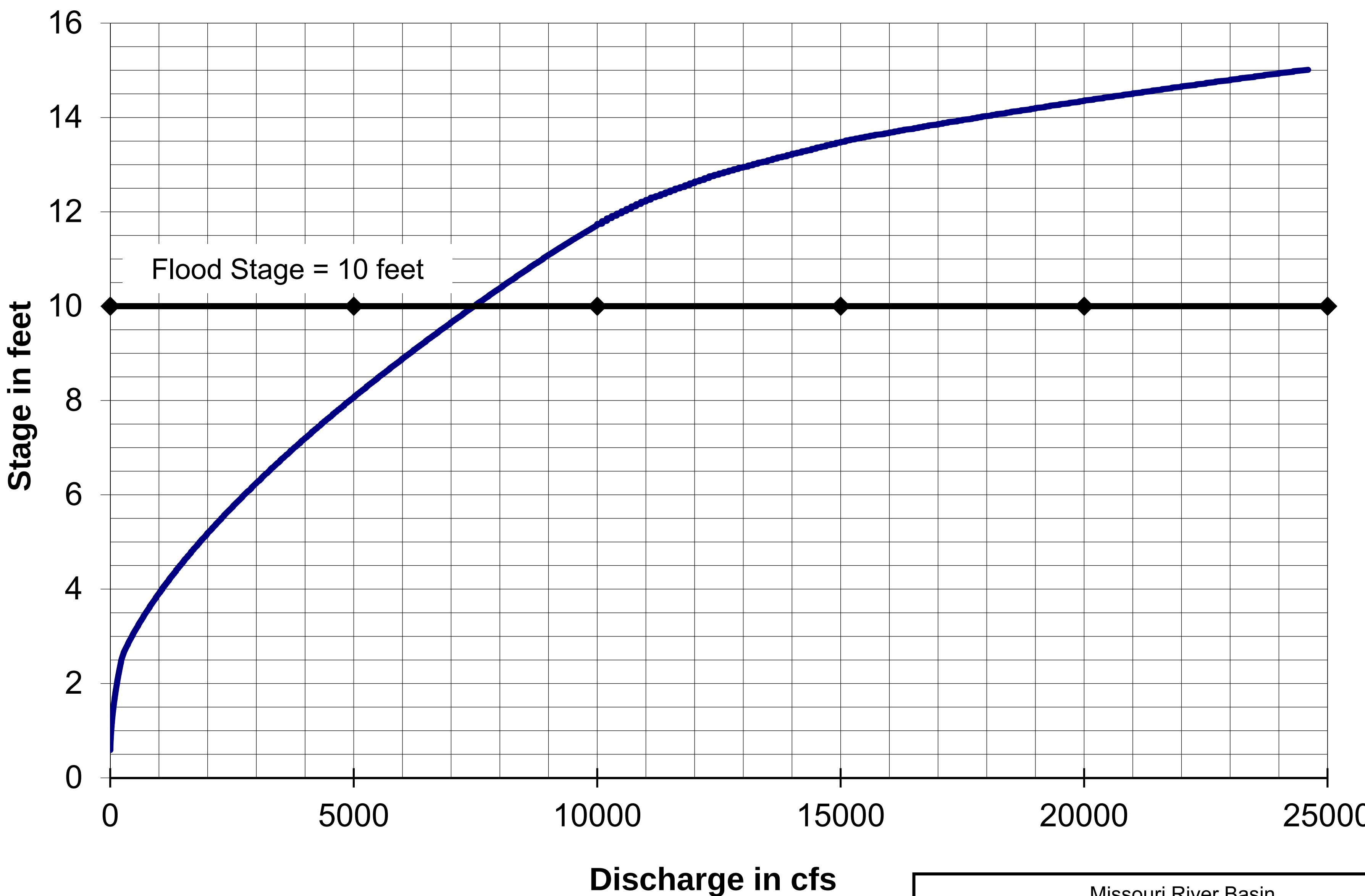
Datum of gage is 2,027.75 feet above sea level NGVD29.
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Milk River at Nashua, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



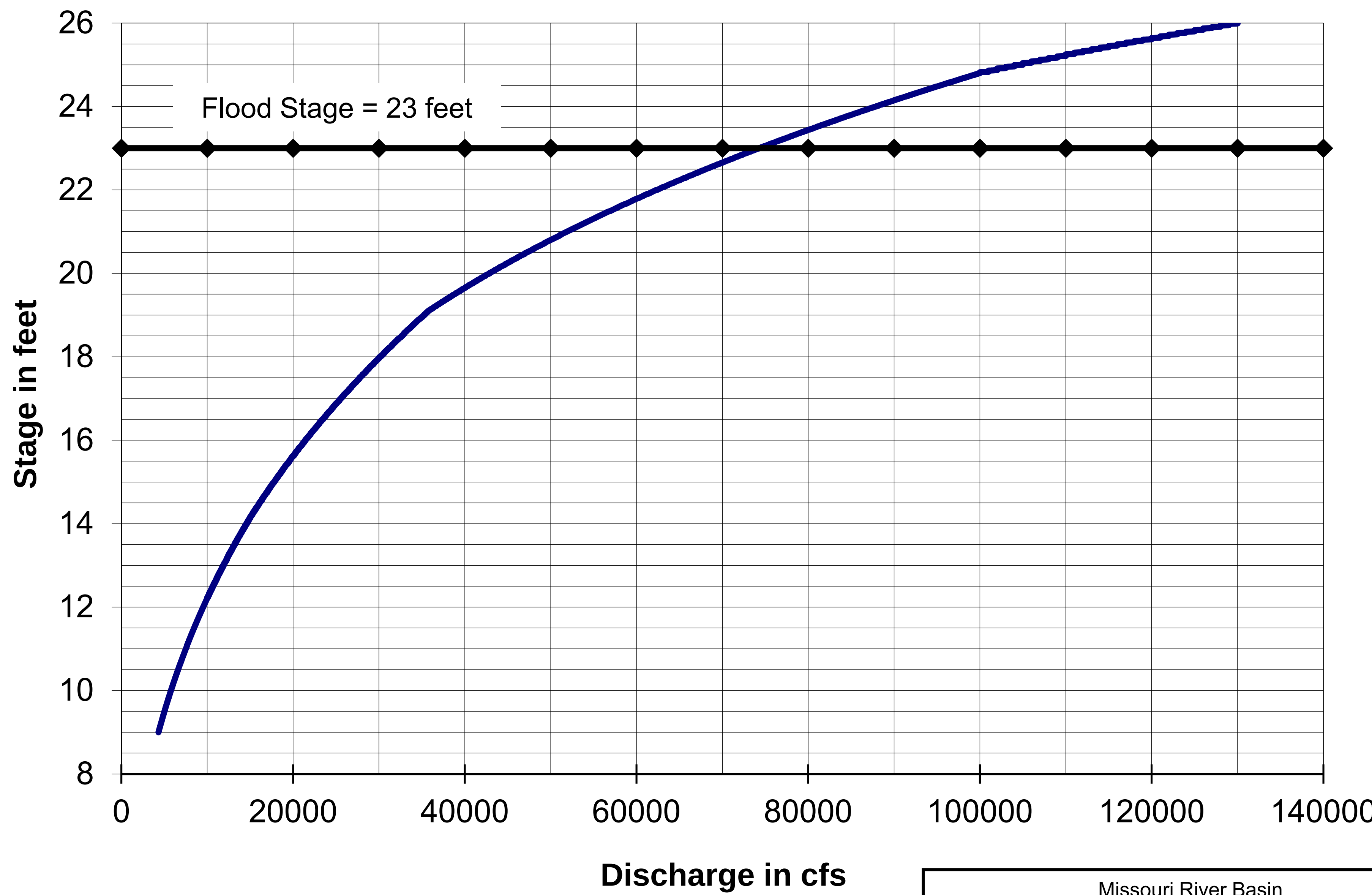
Datum of gage is 3,188.15 feet above sea level NGVD29.
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Musselshell River near Roundup, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



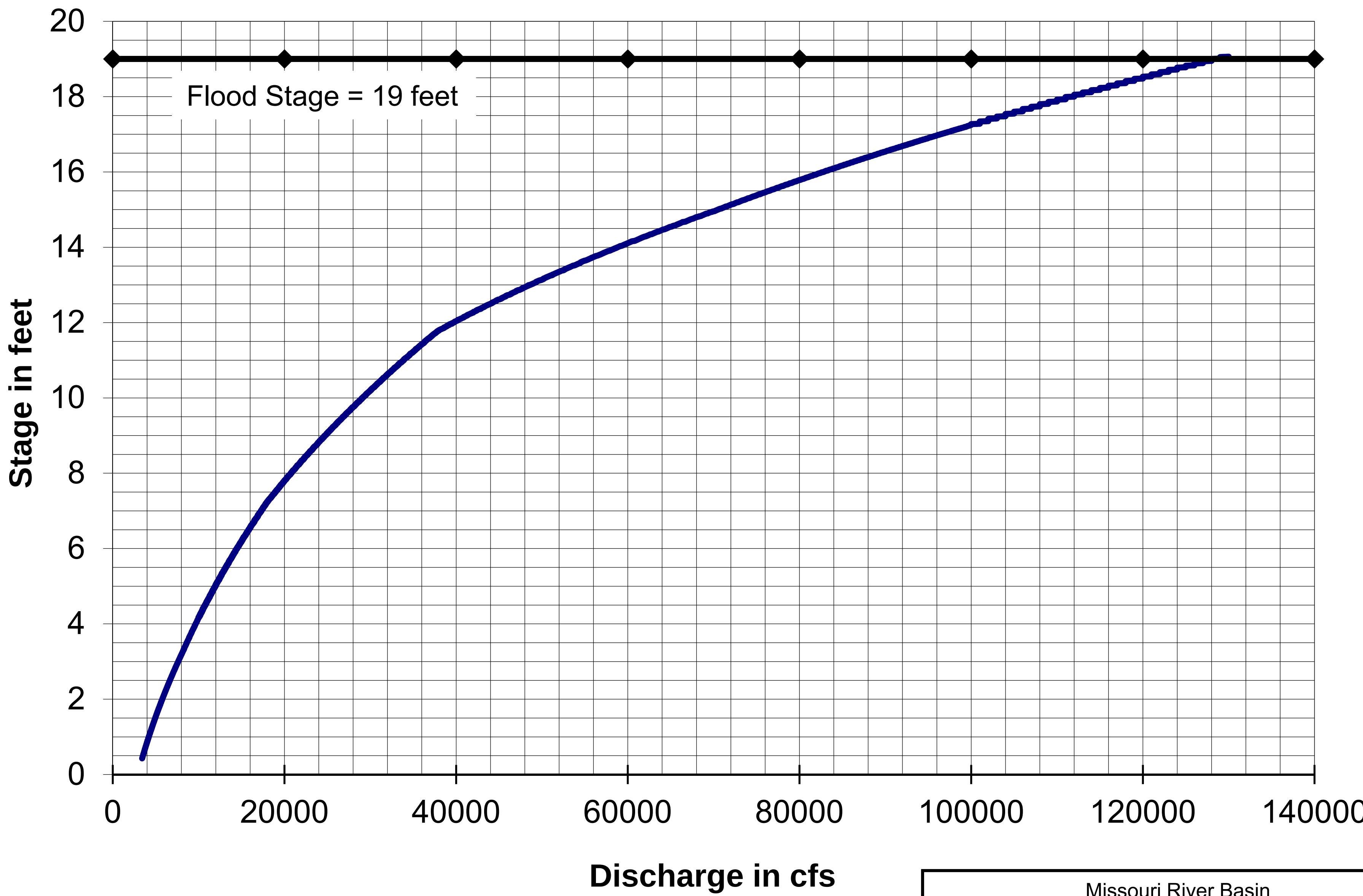
Datum of gage is 2,330 feet above sea level NGVD29.
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Musselshell River near Mosby, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



Datum of gage is 1,958.57 feet above sea level NGVD29.
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Missouri River near Wolf Point, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



Datum of gage is 1,883.4 feet above sea level NGVD29.
Source: USGS

Missouri River Basin
Fort Peck Water Control Manual
Rating Curve
Missouri River near Culbertson, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Reservoir Elevation Corrections at Fort Peck to Allow for Wind Effects

Reservoir Elevation at 2260 feet msl

(True Elevation = Reported Pool Elevation* + Correction)

Wind Speed in Miles Per Hour

Wind Direction	0	5	10	15	20	25	30	35	40	45	50	55	60	65
360	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.4	+0.6	+0.7	+1.0	+1.1	+1.4	+1.6
10	+0.0	+0.0	+0.0	+0.0	+0.2	+0.2	+0.4	+0.6	+0.7	+1.0	+1.2	+1.6	+1.8	+2.1
20	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+0.9	+1.2	+1.5	+1.8	+2.1	+2.5
30	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.6	+0.8	+1.1	+1.4	+1.7	+2.1	+2.5	+3.0
40	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.7	+0.9	+1.1	+1.5	+1.9	+2.2	+2.7	+3.2
50	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.7	+0.9	+1.2	+1.6	+2.0	+2.3	+2.8	+3.3
60	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.7	+0.9	+1.2	+1.6	+2.0	+2.4	+2.9	+3.4
70	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.7	+0.9	+1.2	+1.6	+2.0	+2.3	+2.8	+3.3
80	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.7	+0.9	+1.1	+1.5	+1.9	+2.2	+2.7	+3.2
90	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.6	+0.8	+1.1	+1.4	+1.7	+2.1	+2.5	+3.0
100	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+0.9	+1.2	+1.5	+1.8	+2.1	+2.5
110	+0.0	+0.0	+0.0	+0.0	+0.2	+0.2	+0.4	+0.6	+0.7	+1.0	+1.2	+1.6	+1.8	+2.1
120	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.4	+0.6	+0.7	+1.0	+1.1	+1.4	+1.6
130	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.2	+0.4	+0.5	+0.7	+0.7	+0.9	+1.1
140	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.2	+0.3	+0.4	+0.5
150	-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	-0.0
160	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2
170	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4
180	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7
190	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.9
200	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.5	-0.6	-0.7	-1.0	-1.3
210	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.6	-0.7	-0.8	-1.2	-1.6
220	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.6	-0.7	-1.1	-1.4	-1.9
230	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.7	-0.7	-1.1	-1.6	-2.0
240	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.7	-0.8	-1.1	-1.6	-2.1
250	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.7	-0.7	-1.1	-1.6	-2.0
260	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.6	-0.7	-1.1	-1.4	-1.9
270	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.6	-0.7	-0.8	-1.2	-1.6
280	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.5	-0.6	-0.7	-1.0	-1.3
290	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.9
300	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7
310	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4
320	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2
330	-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	-0.0
340	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.2	+0.3	+0.4	+0.5
350	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.2	+0.4	+0.5	+0.7	+0.7	+0.9	+1.1

Reservoir Elevation Wind Corrections in Feet

*** Pool elevation as measured at the dam.**

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation Wind Correction Table

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Reservoir Elevation Corrections at Fort Peck to Allow for Wind Effects

Reservoir Elevation at 2250 feet msl

(True Elevation = Reported Pool Elevation* + Correction)

Wind Direction	Wind Speed in Miles Per Hour														
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
360	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.4	+0.6	+0.7	+1.0	+1.2	+1.4	+1.7	+1.9
10	+0.0	+0.0	+0.0	+0.0	+0.2	+0.2	+0.4	+0.6	+0.8	+1.0	+1.3	+1.5	+1.8	+2.1	+2.5
20	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+1.0	+1.2	+1.5	+1.8	+2.1	+2.5	+2.9
30	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.8	+1.0	+1.3	+1.7	+2.1	+2.5	+2.9	+3.3
40	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.9	+1.1	+1.5	+1.8	+2.2	+2.6	+3.1	+3.6
50	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.9	+1.2	+1.6	+1.9	+2.3	+2.8	+3.2	+3.8
60	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+1.0	+1.3	+1.6	+1.9	+2.4	+2.9	+3.3	+3.9
70	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.9	+1.2	+1.6	+1.9	+2.3	+2.8	+3.2	+3.8
80	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.9	+1.1	+1.5	+1.8	+2.2	+2.6	+3.1	+3.6
90	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.8	+1.0	+1.3	+1.7	+2.1	+2.5	+2.9	+3.3
100	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+1.0	+1.2	+1.5	+1.8	+2.1	+2.5	+2.9
110	+0.0	+0.0	+0.0	+0.0	+0.2	+0.2	+0.4	+0.6	+0.8	+1.0	+1.3	+1.5	+1.8	+2.1	+2.5
120	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.4	+0.6	+0.7	+1.0	+1.2	+1.4	+1.7	+1.9
130	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.2	+0.4	+0.5	+0.6	+0.8	+1.0	+1.1	+1.3
140	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.3	+0.3	+0.4	+0.6	+0.6
150	-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	-0.0	-0.0
160	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2
170	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5
180	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.6	-0.8
190	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-1.0	-1.3
200	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.4	-0.5	-0.6	-0.7	-1.0	-1.3	-1.7
210	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.6	-0.6	-0.9	-1.3	-1.7	-2.1
220	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.6	-0.7	-1.0	-1.4	-1.8	-2.3
230	-0.0	-0.0	-0.0	+0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.6	-0.8	-1.1	-1.5	-2.0	-2.5
240	-0.0	-0.0	-0.0	+0.0	-0.1	-0.2	-0.2	-0.4	-0.5	-0.6	-0.8	-1.2	-1.6	-2.1	-2.5
250	-0.0	-0.0	-0.0	+0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.6	-0.8	-1.1	-1.5	-2.0	-2.5
260	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.6	-0.7	-1.0	-1.4	-1.8	-2.3
270	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.6	-0.6	-0.9	-1.3	-1.7	-2.1
280	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.4	-0.5	-0.6	-0.7	-1.0	-1.3	-1.7
290	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-1.0	-1.3
300	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.6	-0.8
310	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5
320	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2
330	-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	-0.0	-0.0
340	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.3	+0.3	+0.4	+0.6	+0.6
350	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.2	+0.4	+0.5	+0.6	+0.8	+1.0	+1.1	+1.3

Reservoir Elevation Wind Corrections in Feet

*** Pool elevation as measured at the dam.**

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation Wind Correction Table

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Reservoir Elevation Corrections at Fort Peck
to Allow for Wind Effects

Reservoir Elevation at 2240 feet msl
(True Elevation = Reported Pool Elevation* + Correction)

Wind Speed in Miles Per Hour

Wind Direction	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
360	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.6	+0.8	+0.9	+1.1	+1.4	+1.6	+1.9
10	+0.0	+0.0	+0.0	+0.1	+0.2	+0.2	+0.4	+0.5	+0.8	+1.0	+1.2	+1.5	+1.8	+2.1	+2.4
20	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+0.9	+1.2	+1.4	+1.8	+2.1	+2.5	+3.0
30	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.5	+0.8	+1.1	+1.4	+1.7	+2.0	+2.4	+2.9	+3.3
40	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.8	+1.1	+1.4	+1.8	+2.2	+2.7	+3.1	+3.6
50	+0.0	+0.0	+0.0	+0.1	+0.2	+0.5	+0.6	+0.9	+1.2	+1.5	+1.9	+2.3	+2.7	+3.3	+3.7
60	+0.0	+0.0	+0.0	+0.1	+0.2	+0.5	+0.7	+0.9	+1.2	+1.6	+1.9	+2.4	+2.8	+3.3	+3.8
70	+0.0	+0.0	+0.0	+0.1	+0.2	+0.5	+0.6	+0.9	+1.2	+1.5	+1.9	+2.3	+2.7	+3.3	+3.7
80	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.8	+1.1	+1.4	+1.8	+2.2	+2.7	+3.1	+3.6
90	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.5	+0.8	+1.1	+1.4	+1.7	+2.0	+2.4	+2.9	+3.3
100	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+0.9	+1.2	+1.4	+1.8	+2.1	+2.5	+3.0
110	+0.0	+0.0	+0.0	+0.1	+0.2	+0.2	+0.4	+0.5	+0.8	+1.0	+1.2	+1.5	+1.8	+2.1	+2.4
120	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.6	+0.8	+0.9	+1.1	+1.4	+1.6	+1.9
130	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.2	+0.4	+0.5	+0.6	+0.8	+0.9	+1.1	+1.3
140	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.3	+0.4	+0.5	+0.5	+0.6
150	-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	-0.0	-0.0
160	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2
170	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.4	-0.5	-0.5
180	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.5	-0.6	-0.8
190	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-1.0	-1.3
200	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-1.0	-1.3	-1.7
210	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.7	-0.9	-1.3	-1.7	-2.1
220	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.6	-0.8	-1.1	-1.4	-1.8	-2.4
230	-0.0	-0.0	-0.0	+0.0	-0.1	-0.2	-0.2	-0.4	-0.5	-0.6	-0.8	-1.1	-1.6	-2.0	-2.4
240	-0.0	-0.0	-0.0	+0.0	-0.1	-0.2	-0.2	-0.4	-0.5	-0.6	-0.8	-1.2	-1.6	-2.1	-2.5
250	-0.0	-0.0	-0.0	+0.0	-0.1	-0.2	-0.2	-0.4	-0.5	-0.6	-0.8	-1.1	-1.6	-2.0	-2.4
260	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.5	-0.6	-0.8	-1.1	-1.4	-1.8	-2.4
270	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.7	-0.9	-1.3	-1.7	-2.1
280	-0.0	-0.0	-0.0	-0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-1.0	-1.3	-1.7
290	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-1.0	-1.3
300	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.5	-0.6	-0.8
310	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.4	-0.5	-0.5
320	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2
330	-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	-0.0	-0.0
340	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.3	+0.4	+0.5	+0.5	+0.6
350	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.2	+0.4	+0.5	+0.6	+0.8	+0.9	+1.1	+1.3

Reservoir Elevation Wind Corrections in Feet

*** Pool elevation as measured at the dam.**

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation Wind Correction Table

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Reservoir Elevation Corrections at Fort Peck to Allow for Wind Effects

Reservoir Elevation at 2230 feet msl

(True Elevation = Reported Pool Elevation* + Correction)

Wind Speed in Miles Per Hour

Wind Direction	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
360	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.4	+0.6	+0.7	+0.9	+1.2	+1.4	+1.7	+1.9
10	+0.0	+0.0	+0.0	+0.1	+0.1	+0.3	+0.4	+0.6	+0.8	+1.0	+1.2	+1.5	+1.8	+2.1	+2.5
20	+0.0	+0.0	+0.0	+0.1	+0.1	+0.3	+0.5	+0.7	+0.9	+1.2	+1.5	+1.8	+2.2	+2.5	+3.0
30	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.8	+1.1	+1.4	+1.7	+2.0	+2.5	+2.9	+3.3
40	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.7	+0.9	+1.2	+1.5	+1.8	+2.3	+2.7	+3.1	+3.6
50	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.7	+0.9	+1.2	+1.6	+1.9	+2.3	+2.8	+3.3	+3.8
60	+0.0	+0.0	+0.0	+0.1	+0.3	+0.4	+0.7	+0.9	+1.2	+1.6	+2.0	+2.4	+2.8	+3.3	+3.9
70	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.7	+0.9	+1.2	+1.6	+1.9	+2.3	+2.8	+3.3	+3.8
80	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.7	+0.9	+1.2	+1.5	+1.8	+2.3	+2.7	+3.1	+3.6
90	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.8	+1.1	+1.4	+1.7	+2.0	+2.5	+2.9	+3.3
100	+0.0	+0.0	+0.0	+0.1	+0.1	+0.3	+0.5	+0.7	+0.9	+1.2	+1.5	+1.8	+2.2	+2.5	+3.0
110	+0.0	+0.0	+0.0	+0.1	+0.1	+0.3	+0.4	+0.6	+0.8	+1.0	+1.2	+1.5	+1.8	+2.1	+2.5
120	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.4	+0.6	+0.7	+0.9	+1.2	+1.4	+1.7	+1.9
130	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.1	+0.3	+0.4	+0.5	+0.7	+0.8	+0.9	+1.1	+1.3
140	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.1	+0.2	+0.3	+0.4	+0.4	+0.5	+0.7
150	-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	-0.0	-0.0
160	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2
170	-0.0	-0.0	-0.0	-0.0	-0.0	+0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5
180	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.4	-0.6	-0.7	-0.9
190	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-1.0	-1.3
200	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-1.1	-1.5	-1.7
210	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.7	-0.9	-1.3	-1.7	-2.1
220	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.4	-0.4	-0.6	-0.7	-1.2	-1.5	-2.0	-2.4
230	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.3	-0.4	-0.5	-0.7	-0.9	-1.2	-1.6	-2.0	-2.5
240	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.3	-0.4	-0.5	-0.7	-0.9	-1.2	-1.7	-2.1	-2.6
250	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.3	-0.4	-0.5	-0.7	-0.9	-1.2	-1.6	-2.0	-2.5
260	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.4	-0.4	-0.6	-0.7	-1.2	-1.5	-2.0	-2.4
270	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.7	-0.9	-1.3	-1.7	-2.1
280	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-1.1	-1.5	-1.7
290	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-1.0	-1.3
300	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.4	-0.6	-0.7	-0.9
310	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5
320	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2
330	-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	-0.0	-0.0
340	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.1	+0.2	+0.3	+0.4	+0.4	+0.5	+0.7
350	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.1	+0.3	+0.4	+0.5	+0.7	+0.8	+0.9	+1.1	+1.3

Reservoir Elevation Wind Corrections in Feet

*** Pool elevation as measured at the dam.**

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation Wind Correction Table

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Reservoir Elevation Corrections at Fort Peck
to Allow for Wind Effects

Reservoir Elevation at 2220 feet msl

(True Elevation = Reported Pool Elevation* + Correction)

Wind Direction	Wind Speed in Miles Per Hour														
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
360	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.4	+0.6	+0.8	+1.0	+1.2	+1.4	+1.7	+1.9
10	+0.0	+0.0	+0.0	+0.1	+0.1	+0.3	+0.4	+0.6	+0.8	+1.0	+1.2	+1.5	+1.8	+2.1	+2.5
20	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+1.0	+1.2	+1.5	+1.8	+2.1	+2.6	+3.0
30	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.6	+0.8	+1.0	+1.4	+1.7	+2.1	+2.5	+2.9	+3.4
40	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.9	+1.2	+1.5	+1.8	+2.2	+2.7	+3.2	+3.6
50	+0.0	+0.0	+0.0	+0.1	+0.3	+0.4	+0.7	+0.9	+1.2	+1.6	+1.9	+2.3	+2.8	+3.3	+3.7
60	+0.0	+0.0	+0.0	+0.1	+0.3	+0.4	+0.7	+1.0	+1.2	+1.6	+1.9	+2.3	+2.8	+3.4	+3.8
70	+0.0	+0.0	+0.0	+0.1	+0.3	+0.4	+0.7	+0.9	+1.2	+1.6	+1.9	+2.3	+2.8	+3.3	+3.7
80	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.9	+1.2	+1.5	+1.8	+2.2	+2.7	+3.2	+3.6
90	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.6	+0.8	+1.0	+1.4	+1.7	+2.1	+2.5	+2.9	+3.4
100	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+1.0	+1.2	+1.5	+1.8	+2.1	+2.6	+3.0
110	+0.0	+0.0	+0.0	+0.1	+0.1	+0.3	+0.4	+0.6	+0.8	+1.0	+1.2	+1.5	+1.8	+2.1	+2.5
120	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.4	+0.6	+0.8	+1.0	+1.2	+1.4	+1.7	+1.9
130	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.3	+0.4	+0.5	+0.6	+0.8	+1.0	+1.1	+1.3
140	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.1	+0.2	+0.3	+0.3	+0.4	+0.6	+0.6
150	-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	-0.0	-0.0
160	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	+0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3
170	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.3	-0.4	-0.5
180	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.5	-0.6	-0.7	-0.9
190	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.8	-1.1	-1.4
200	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.5	-0.6	-0.8	-1.1	-1.4	-1.9
210	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.6	-0.7	-1.0	-1.4	-1.7	-2.2
220	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.3	-0.3	-0.5	-0.6	-0.8	-1.2	-1.6	-2.0	-2.5
230	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.3	-0.3	-0.5	-0.6	-0.9	-1.2	-1.7	-2.1	-2.6
240	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.3	-0.3	-0.5	-0.6	-0.9	-1.3	-1.7	-2.2	-2.7
250	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.3	-0.3	-0.5	-0.6	-0.9	-1.2	-1.7	-2.1	-2.6
260	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.3	-0.3	-0.5	-0.6	-0.8	-1.2	-1.6	-2.0	-2.5
270	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.6	-0.7	-1.0	-1.4	-1.7	-2.2
280	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.5	-0.6	-0.8	-1.1	-1.4	-1.9
290	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.8	-1.1	-1.4
300	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.5	-0.6	-0.7	-0.9
310	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.3	-0.4	-0.5
320	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3
330	-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	-0.0	-0.0
340	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.1	+0.2	+0.3	+0.3	+0.4	+0.6	+0.6
350	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.3	+0.4	+0.5	+0.6	+0.8	+1.0	+1.1	+1.3

Reservoir Elevation Wind Corrections in Feet

*** Pool elevation as measured at the dam.**

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation Wind Correction Table

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Reservoir Elevation Corrections at Fort Peck to Allow for Wind Effects

Reservoir Elevation at 2210 feet msl

(True Elevation = Reported Pool Elevation* + Correction)

Wind Speed in Miles Per Hour

Wind Direction	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
360	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.6	+0.8	+1.0	+1.2	+1.4	+1.6	+1.9
10	+0.0	+0.0	+0.0	+0.1	+0.1	+0.3	+0.4	+0.6	+0.8	+1.0	+1.2	+1.6	+1.8	+2.1	+2.5
20	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+0.9	+1.2	+1.5	+1.8	+2.1	+2.5	+3.0
30	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.8	+1.0	+1.4	+1.7	+2.1	+2.5	+2.9	+3.3
40	+0.0	+0.0	+0.0	+0.1	+0.3	+0.4	+0.7	+0.9	+1.2	+1.5	+1.8	+2.2	+2.7	+3.2	+3.6
50	+0.0	+0.0	+0.0	+0.1	+0.3	+0.5	+0.7	+0.9	+1.2	+1.6	+2.0	+2.3	+2.8	+3.3	+3.7
60	+0.0	+0.0	+0.0	+0.1	+0.3	+0.5	+0.7	+0.9	+1.2	+1.6	+2.0	+2.4	+2.9	+3.3	+3.8
70	+0.0	+0.0	+0.0	+0.1	+0.3	+0.5	+0.7	+0.9	+1.2	+1.6	+2.0	+2.3	+2.8	+3.3	+3.7
80	+0.0	+0.0	+0.0	+0.1	+0.3	+0.4	+0.7	+0.9	+1.2	+1.5	+1.8	+2.2	+2.7	+3.2	+3.6
90	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.8	+1.0	+1.4	+1.7	+2.1	+2.5	+2.9	+3.3
100	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+0.9	+1.2	+1.5	+1.8	+2.1	+2.5	+3.0
110	+0.0	+0.0	+0.0	+0.1	+0.1	+0.3	+0.4	+0.6	+0.8	+1.0	+1.2	+1.6	+1.8	+2.1	+2.5
120	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.6	+0.8	+1.0	+1.2	+1.4	+1.6	+1.9
130	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.3	+0.4	+0.5	+0.7	+0.8	+1.0	+1.1	+1.3
140	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.3	+0.4	+0.5	+0.5	+0.7
150	-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	-0.0	-0.0
160	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3
170	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.5
180	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.6	-0.7	-0.9
190	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.8	-1.1	-1.4
200	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.8	-1.2	-1.5	-1.9
210	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.7	-1.1	-1.4	-1.8	-2.3
220	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.3	-0.3	-0.5	-0.6	-0.8	-1.2	-1.6	-2.1	-2.5
230	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.7	-1.0	-1.4	-1.8	-2.1	-2.7
240	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.7	-1.0	-1.4	-1.8	-2.2	-2.8
250	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.7	-1.0	-1.4	-1.8	-2.1	-2.7
260	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.3	-0.3	-0.5	-0.6	-0.8	-1.2	-1.6	-2.1	-2.5
270	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.7	-1.1	-1.4	-1.8	-2.3
280	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.8	-1.2	-1.5	-1.9
290	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.8	-1.1	-1.4
300	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.6	-0.7	-0.9
310	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.5
320	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3
330	-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	-0.0	-0.0
340	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.3	+0.4	+0.5	+0.5	+0.7
350	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.3	+0.4	+0.5	+0.7	+0.8	+1.0	+1.1	+1.3

Reservoir Elevation Wind Corrections in Feet

*** Pool elevation as measured at the dam.**

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation Wind Correction Table

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Reservoir Elevation Corrections at Fort Peck
to Allow for Wind Effects

Reservoir Elevation at 2200 feet msl
(True Elevation = Reported Pool Elevation* + Correction)

Wind Direction	Wind Speed in Miles Per Hour														
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
360	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.4	+0.5	+0.7	+0.9	+1.2	+1.3	+1.6	+1.8
10	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.4	+0.5	+0.7	+1.0	+1.2	+1.5	+1.8	+2.1	+2.4
20	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+0.9	+1.2	+1.5	+1.8	+2.1	+2.5	+2.9
30	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.5	+0.8	+1.0	+1.3	+1.6	+2.0	+2.4	+2.8	+3.2
40	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.9	+1.2	+1.5	+1.8	+2.1	+2.6	+3.1	+3.5
50	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.9	+1.1	+1.4	+1.7	+2.1	+2.6	+3.0	+3.4
60	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.7	+0.9	+1.2	+1.5	+1.9	+2.3	+2.7	+3.2	+3.7
70	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.9	+1.1	+1.4	+1.7	+2.1	+2.6	+3.0	+3.4
80	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.6	+0.9	+1.2	+1.5	+1.8	+2.1	+2.6	+3.1	+3.5
90	+0.0	+0.0	+0.0	+0.1	+0.2	+0.4	+0.5	+0.8	+1.0	+1.3	+1.6	+2.0	+2.4	+2.8	+3.2
100	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.5	+0.7	+0.9	+1.2	+1.5	+1.8	+2.1	+2.5	+2.9
110	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.4	+0.5	+0.7	+1.0	+1.2	+1.5	+1.8	+2.1	+2.4
120	+0.0	+0.0	+0.0	+0.0	+0.1	+0.2	+0.3	+0.4	+0.5	+0.7	+0.9	+1.2	+1.3	+1.6	+1.8
130	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.4	+0.5	+0.6	+0.7	+0.9	+1.1	+1.3
140	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.3	+0.4	+0.4	+0.5	+0.6
150	-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	-0.0	-0.0
160	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2
170	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5
180	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5	-0.7	-0.9
190	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.9	-1.1	-1.4
200	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.4	-0.5	-0.5	-0.9	-1.2	-1.5	-1.8
210	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.7	-1.0	-1.4	-1.8	-2.2
220	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.9	-1.2	-1.6	-2.0	-2.5
230	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.8	-1.2	-1.5	-2.0	-2.4
240	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.4	-0.5	-0.6	-1.0	-1.3	-1.7	-2.2	-2.7
250	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.8	-1.2	-1.5	-2.0	-2.4
260	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.9	-1.2	-1.6	-2.0	-2.5
270	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.7	-1.0	-1.4	-1.8	-2.2
280	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.4	-0.5	-0.5	-0.9	-1.2	-1.5	-1.8
290	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.9	-1.1	-1.4
300	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5	-0.7	-0.9
310	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5
320	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2
330	-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	-0.0	-0.0
340	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.3	+0.4	+0.4	+0.5	+0.6
350	+0.0	+0.0	+0.0	+0.0	+0.1	+0.1	+0.2	+0.2	+0.4	+0.5	+0.6	+0.7	+0.9	+1.1	+1.3

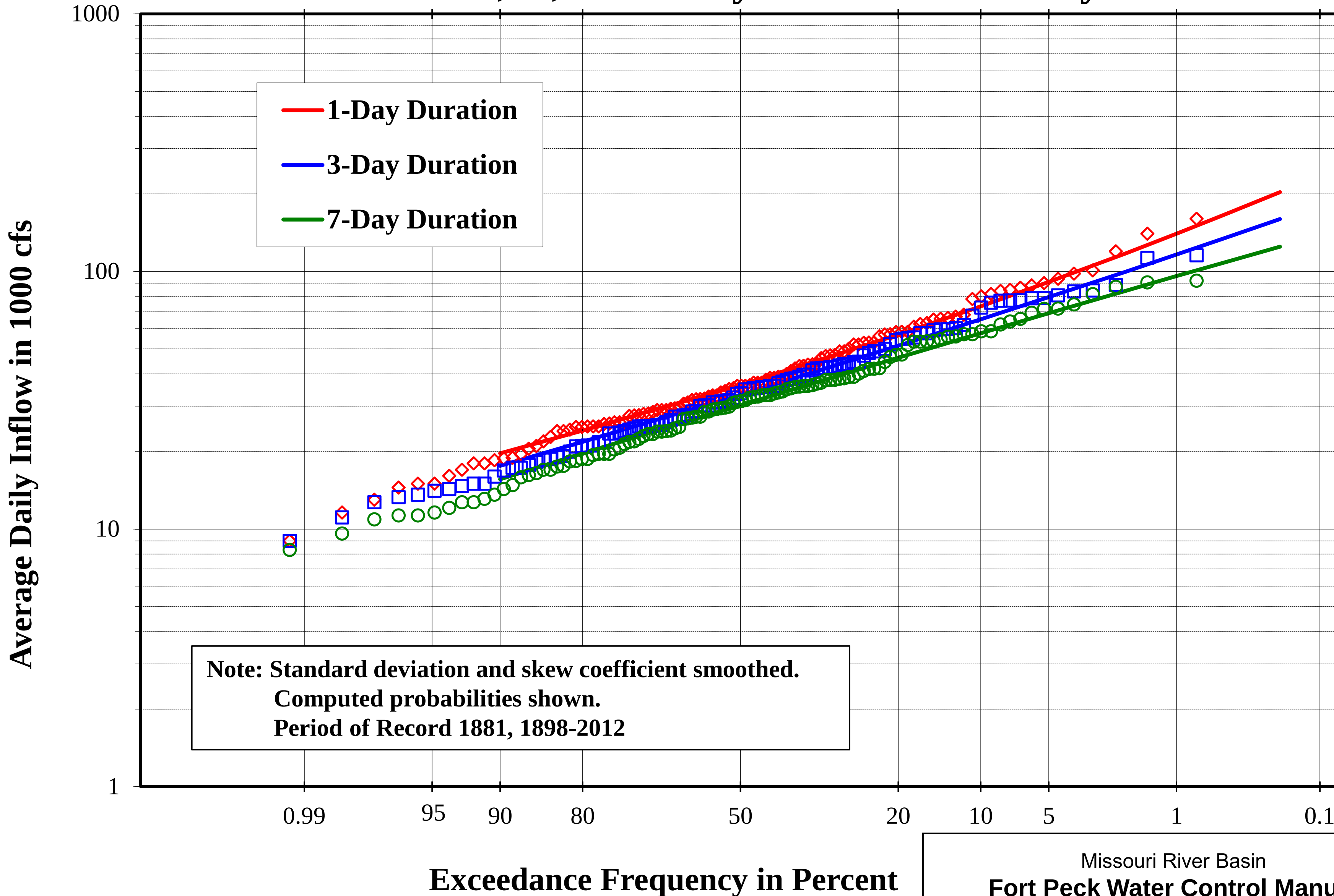
Reservoir Elevation Wind Corrections in Feet

*** Pool elevation as measured at the dam.**

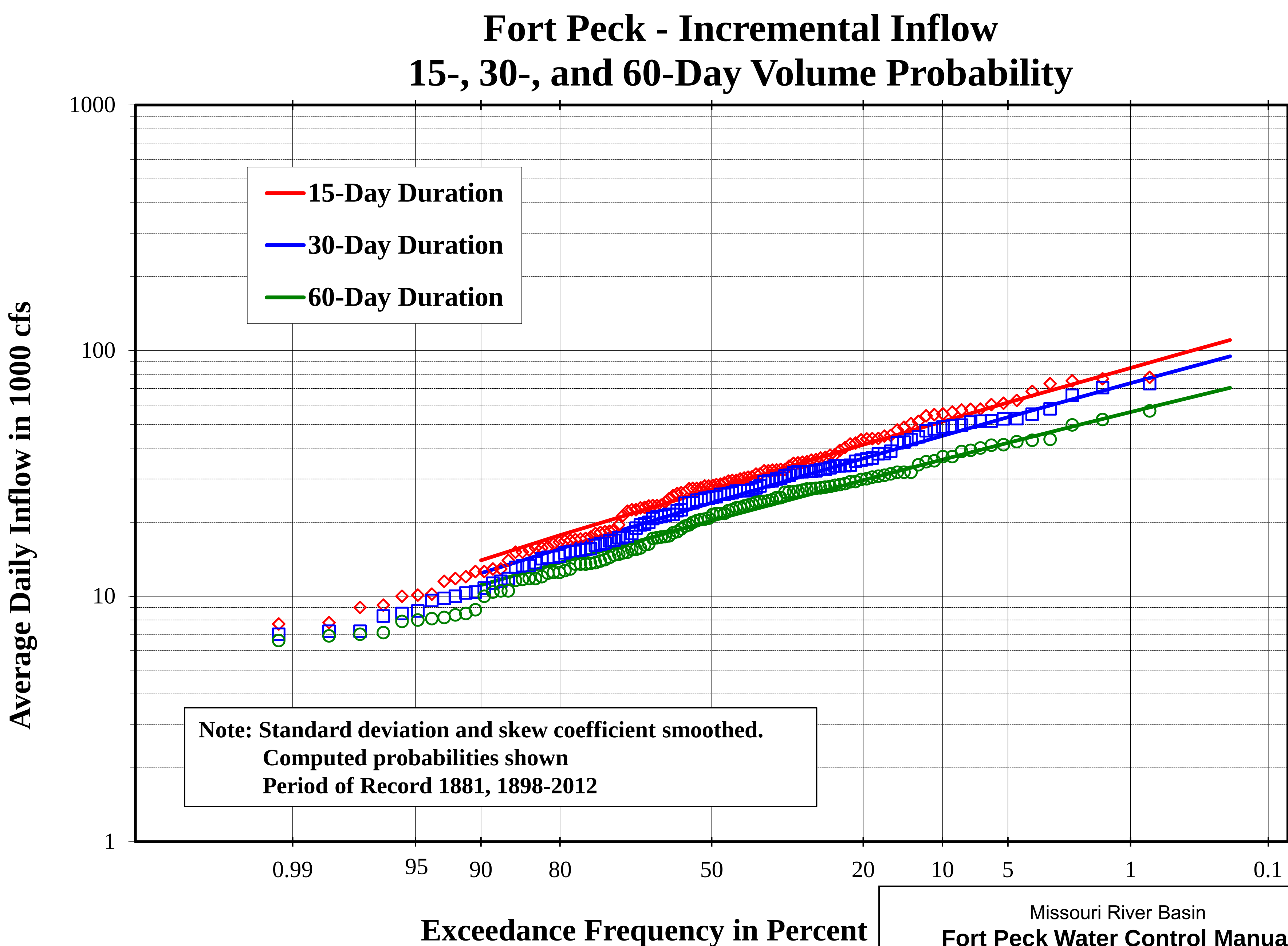
Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation Wind Correction Table

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Fort Peck - Incremental Inflow
1-, 3-, and 7-Day Volume Probability

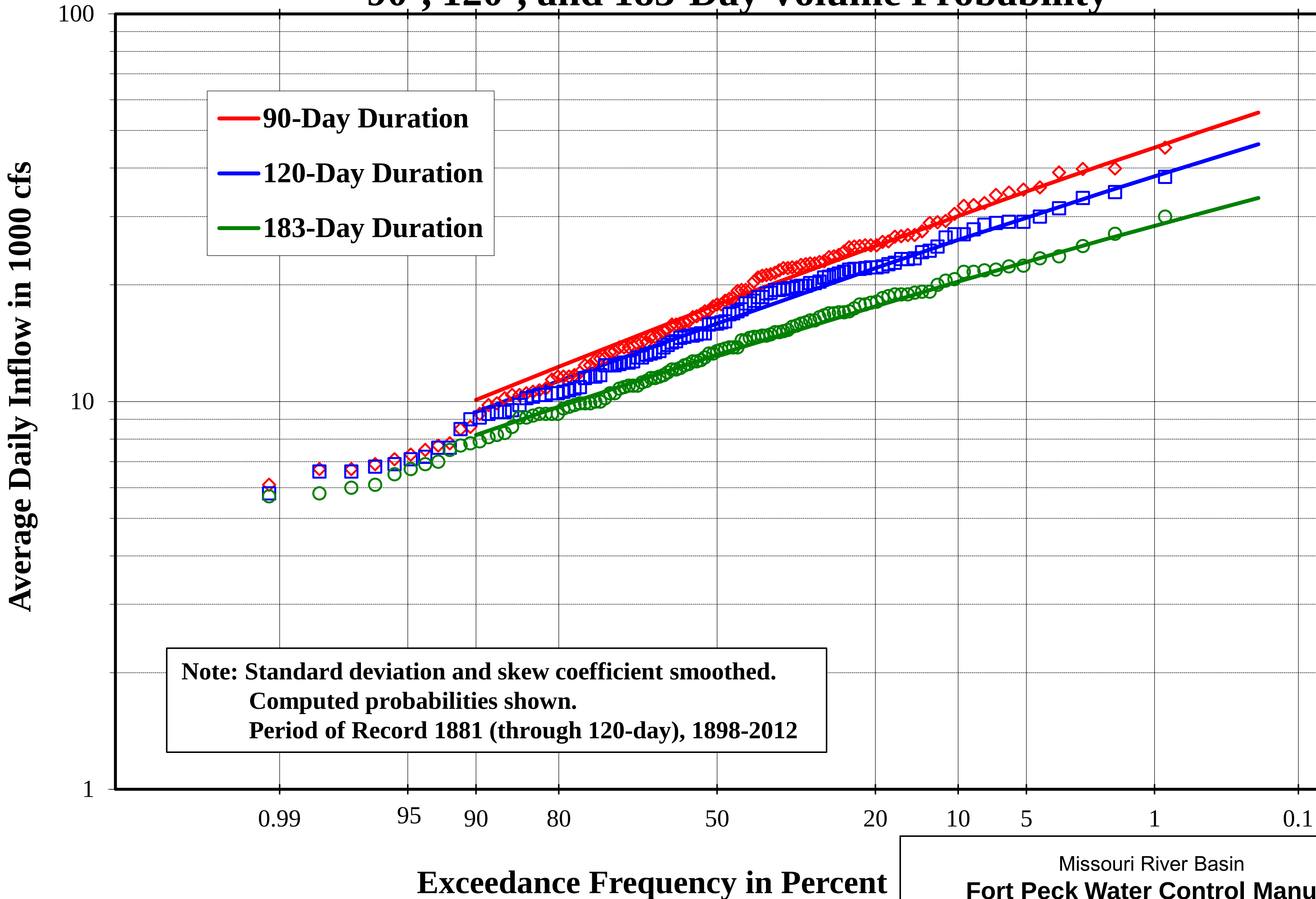


Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Incremental Inflow Probability
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



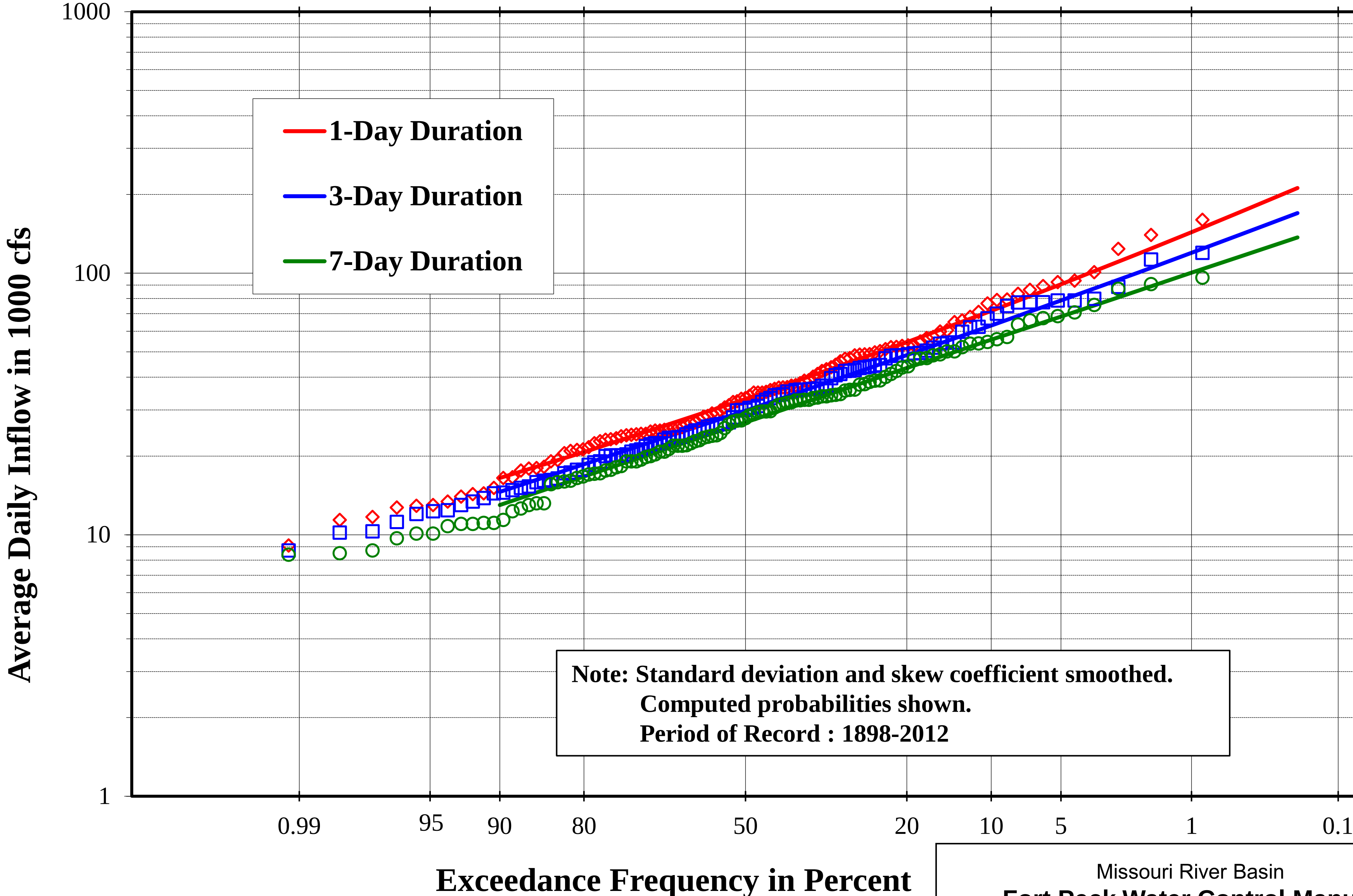
Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Incremental Inflow Probability
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Fort Peck - Incremental Inflow
90-, 120-, and 183-Day Volume Probability

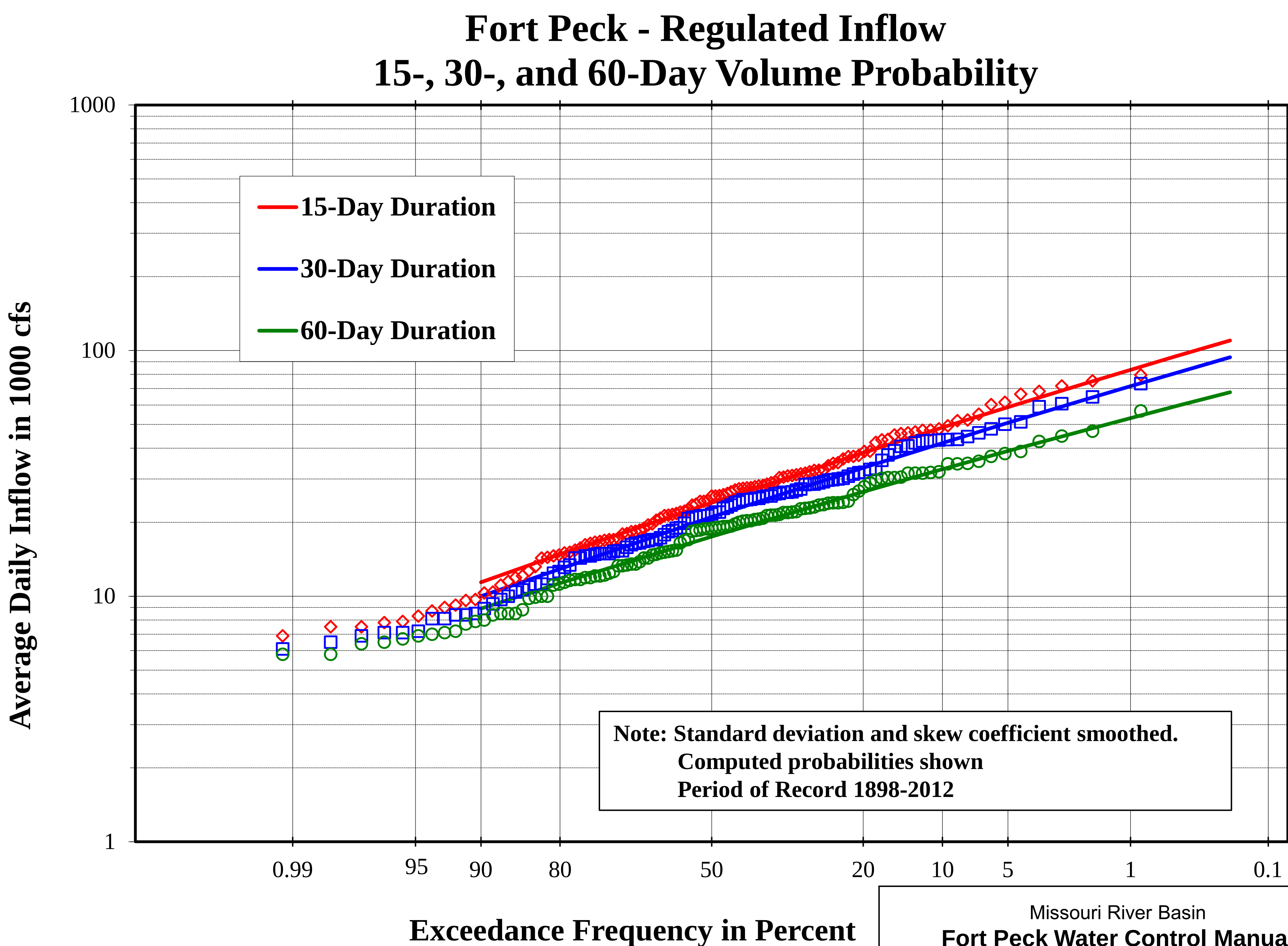


Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Incremental Inflow Probability
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Fort Peck - Regulated Inflow
1-, 3-, and 7-Day Volume Probability

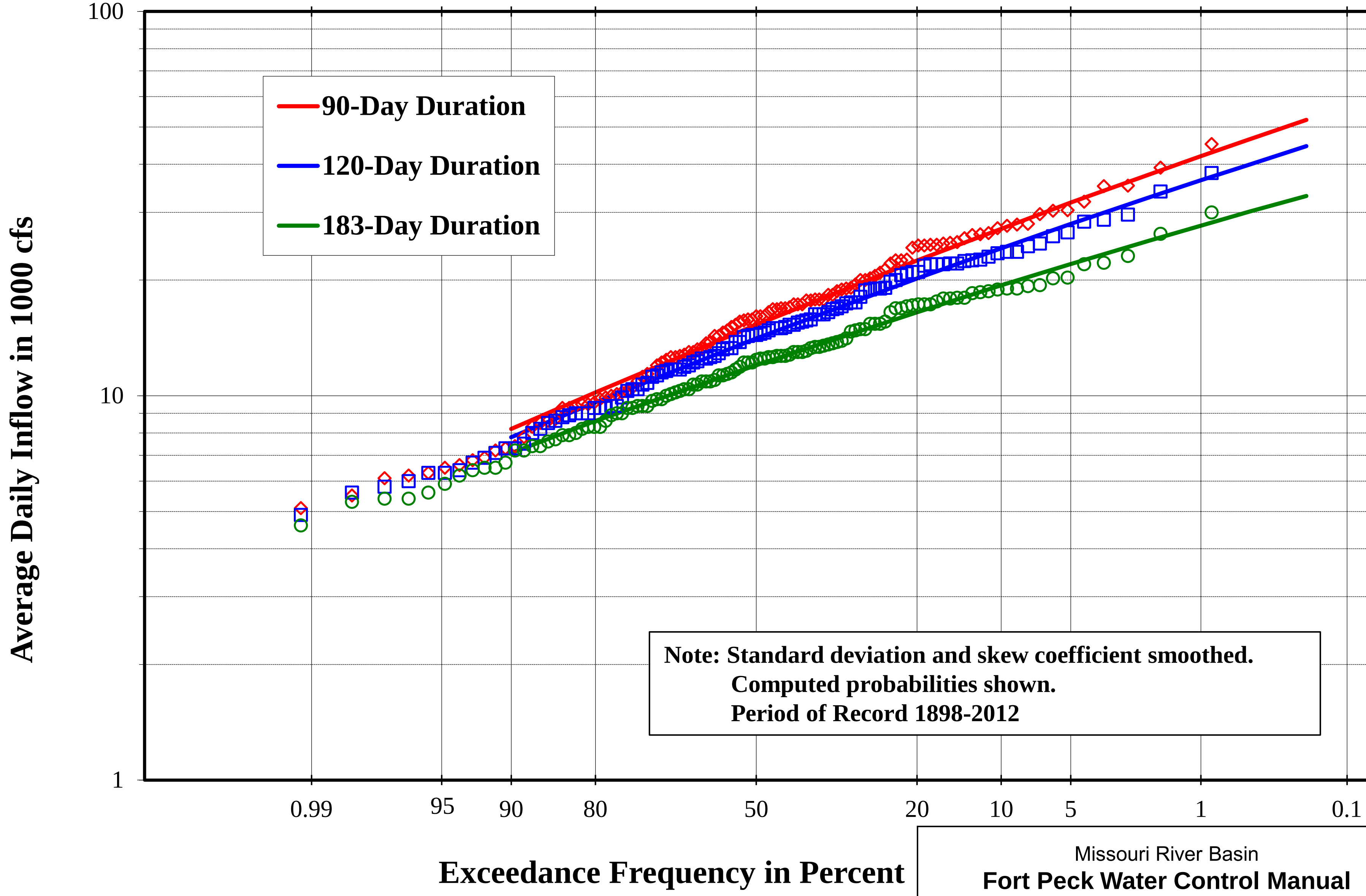


Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Regulated Inflow Probability
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



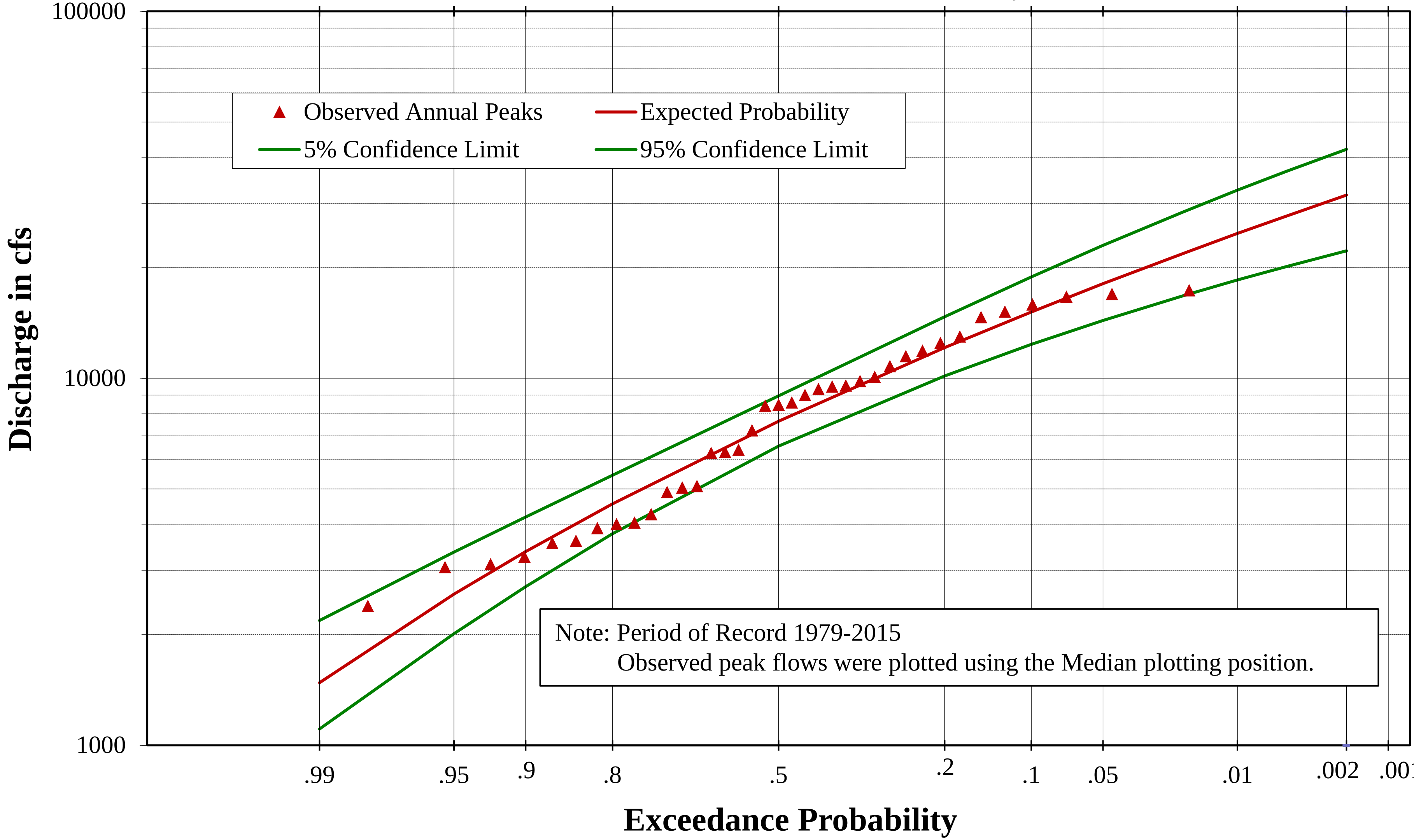
Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Regulated Inflow Probability
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Fort Peck - Regulated Inflow
90-, 120-, and 183-Day Volume Probability



Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Regulated Inflow Probability
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Jefferson River near Three Forks, MT



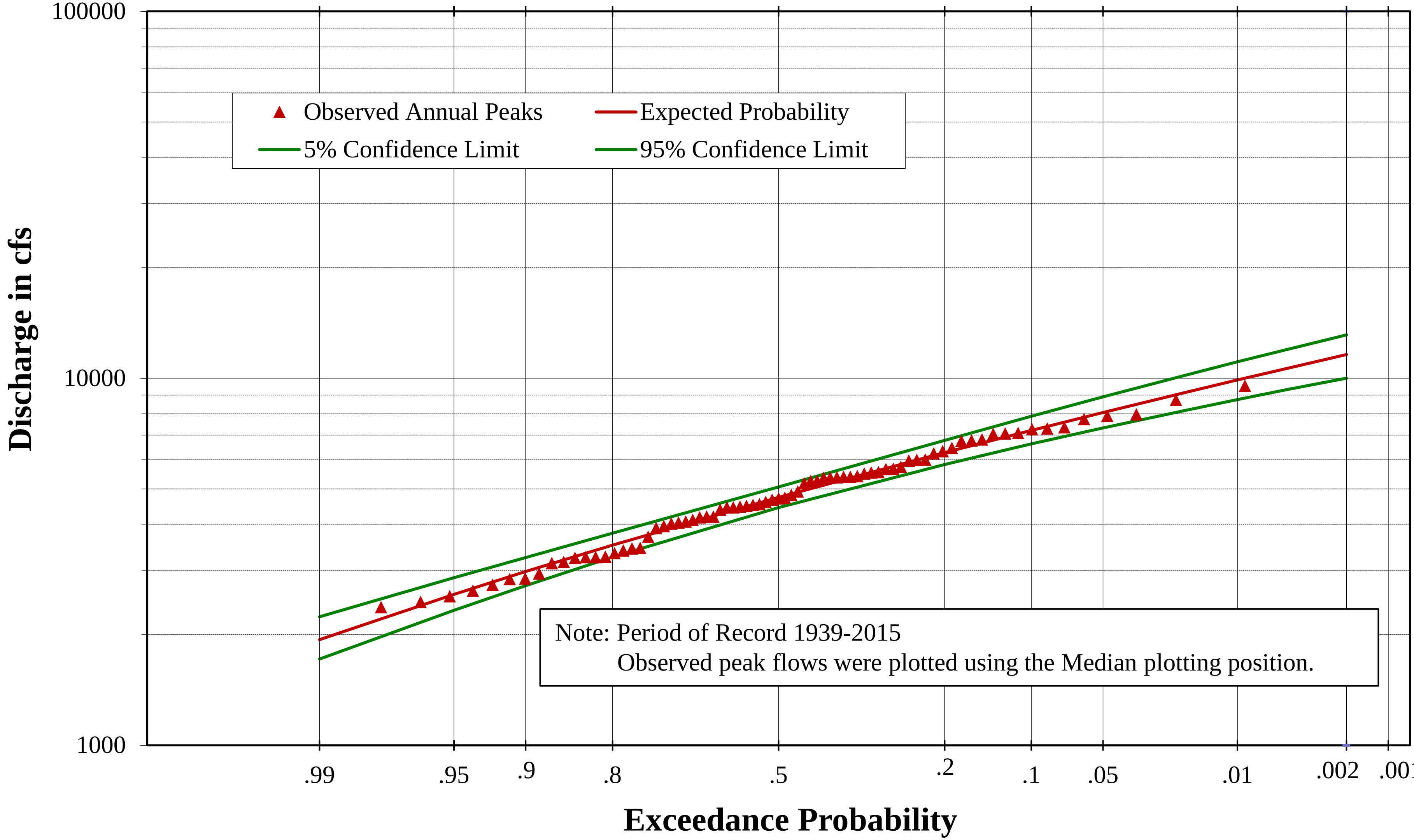
Missouri River Basin

Fort Peck Water Control Manual

Probability Curve – Jefferson River near Three Forks, MT

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Madison River bl Ennis Lake nr McAllister, MT

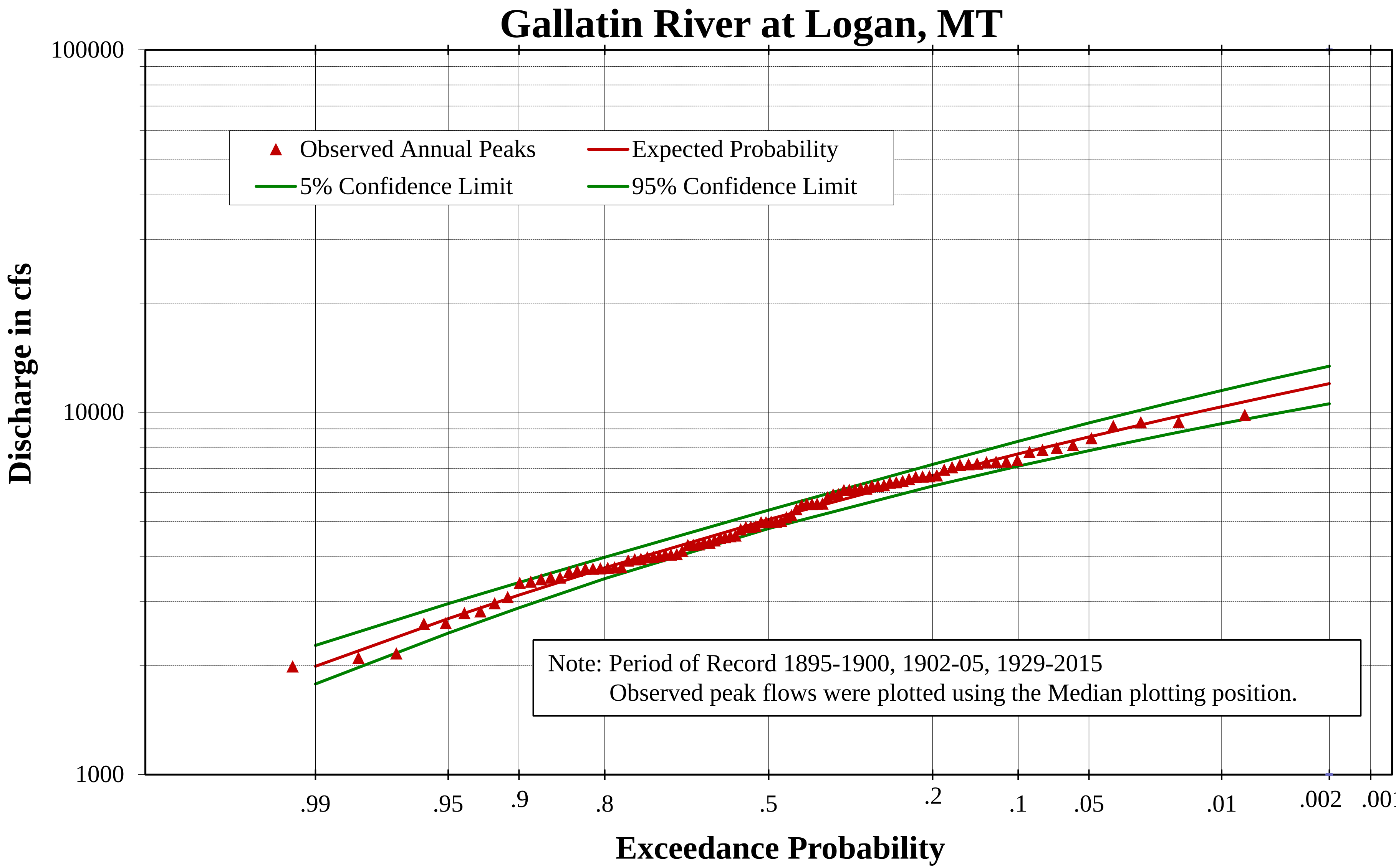


Missouri River Basin

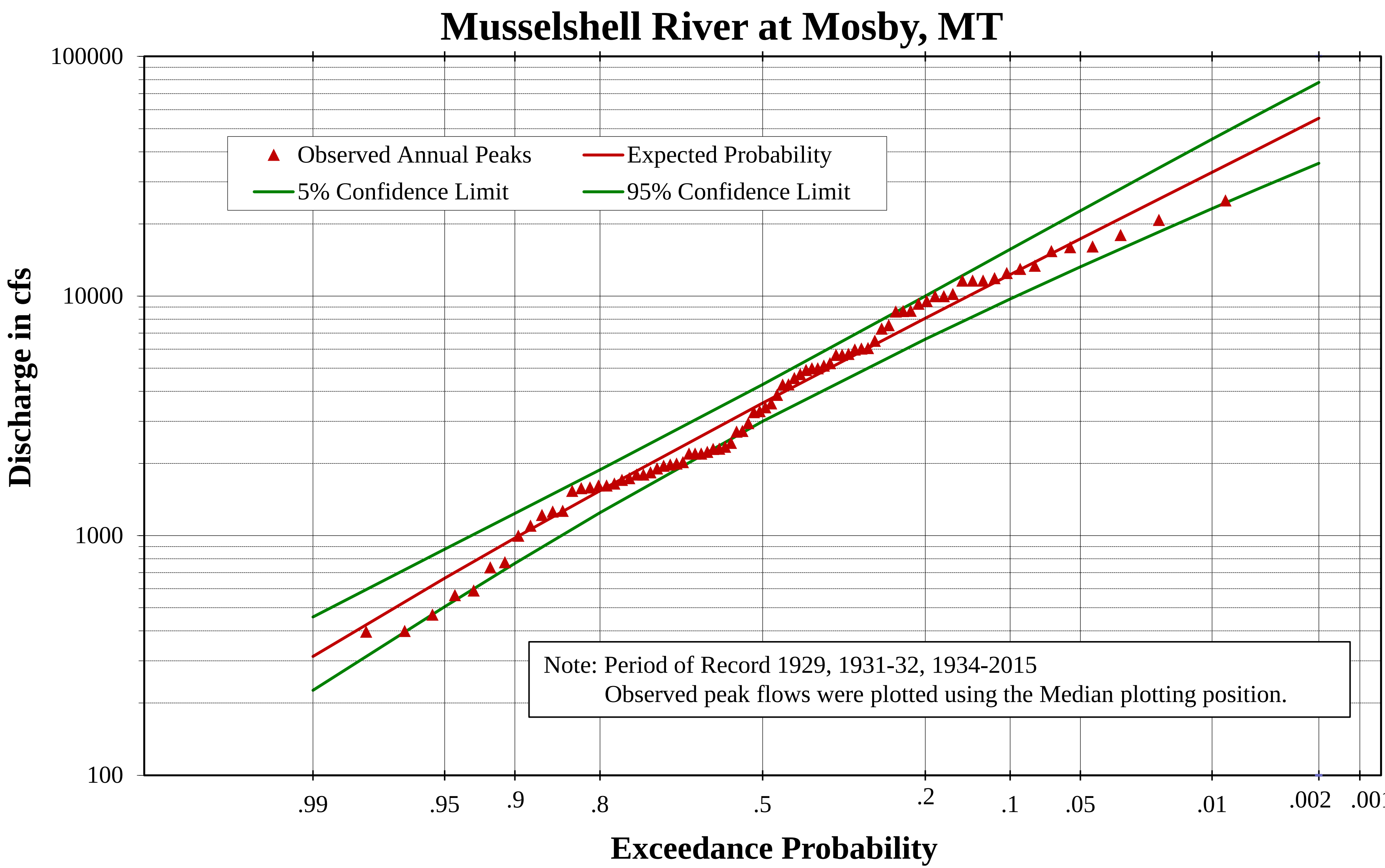
Fort Peck Water Control Manual

Probability Curve – Madison River bl Ennis Lake nr McAllister, MT

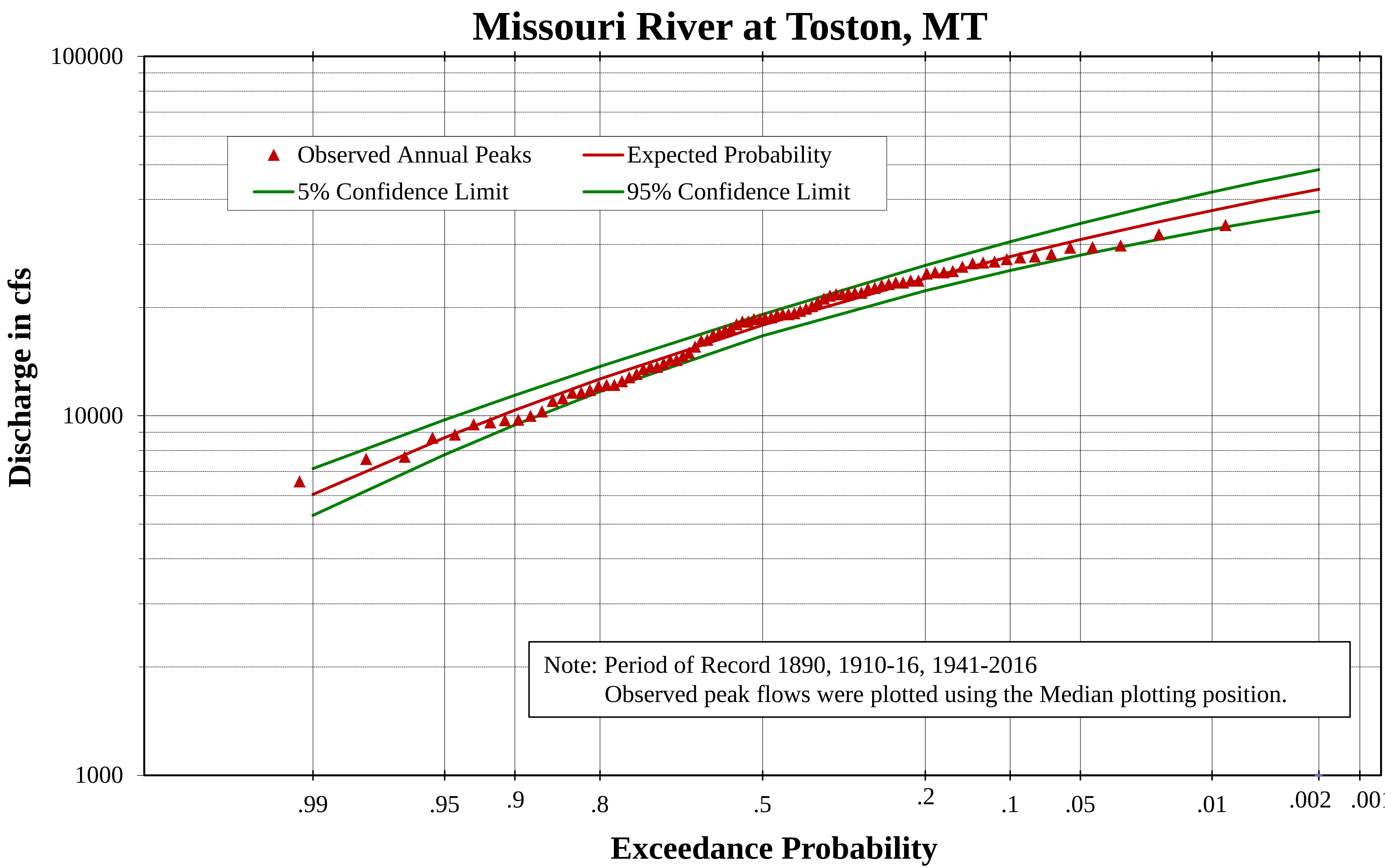
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



Missouri River Basin
Fort Peck Water Control Manual
Probability Curve – Gallatin River at Logan, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



Missouri River Basin
Fort Peck Water Control Manual
Probability Curve – Musselshell River at Mosby, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



Missouri River Basin

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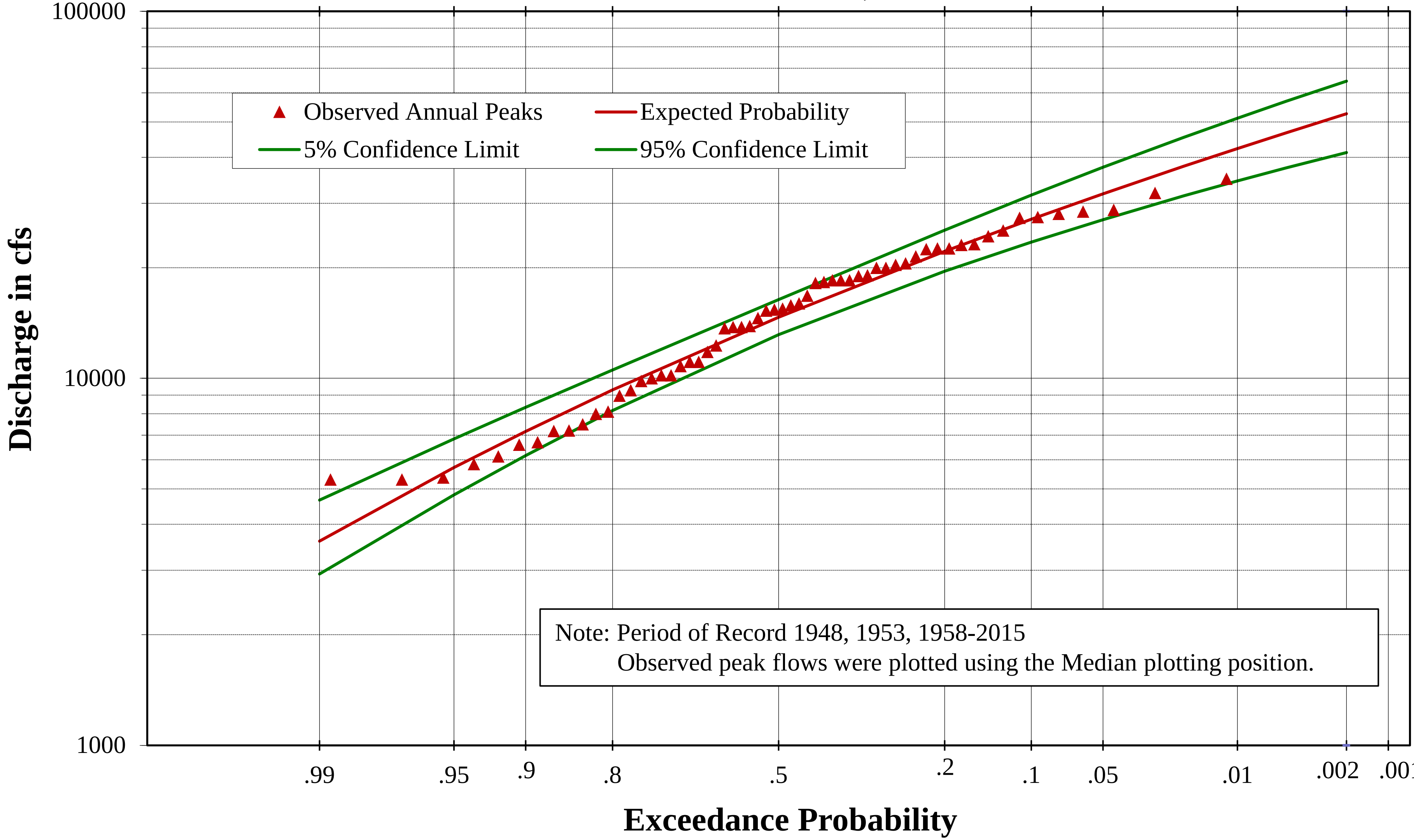
Probability Curve – Missouri River at Toston, MT

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Missouri River near Ulm, MT

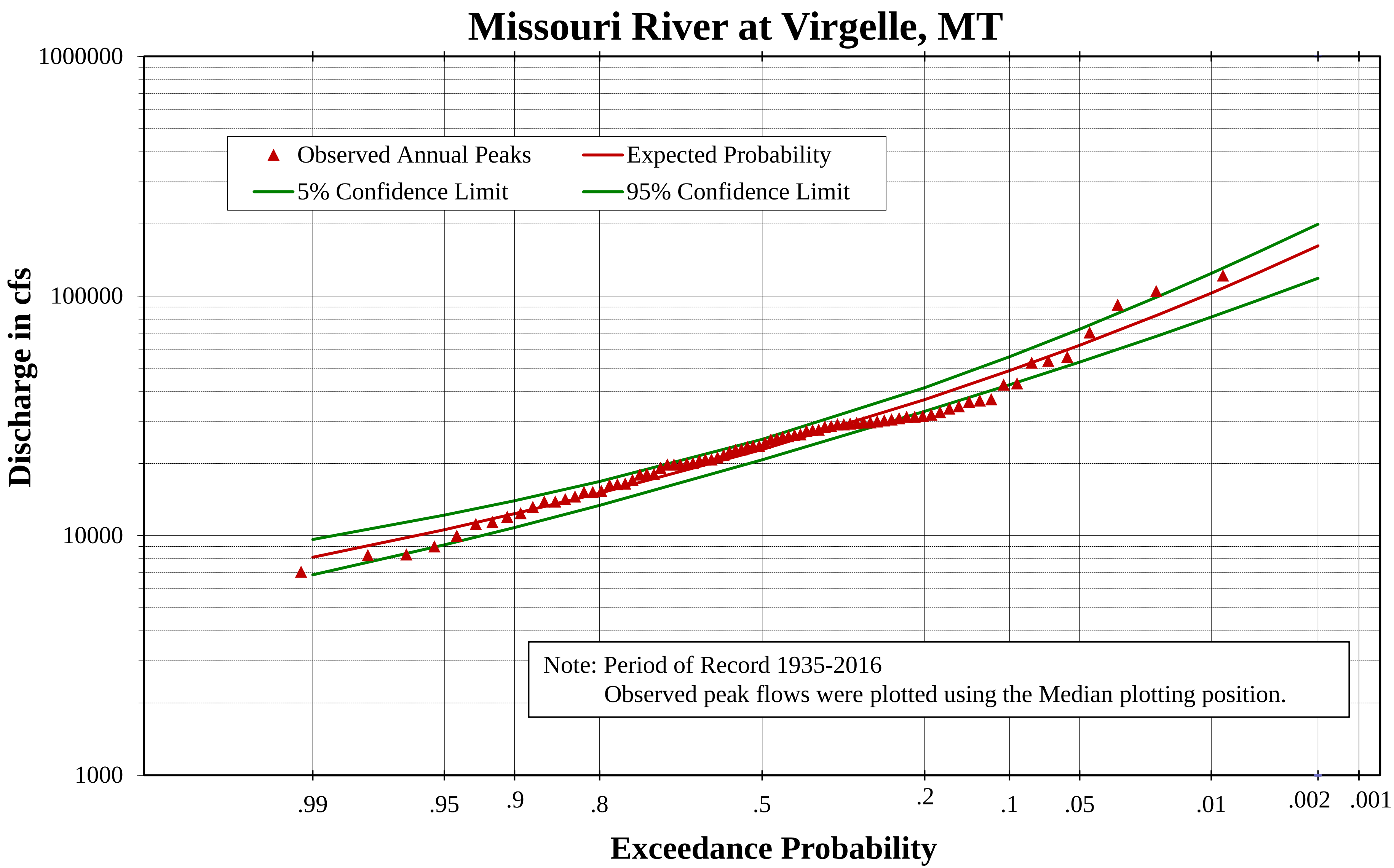


Missouri River Basin

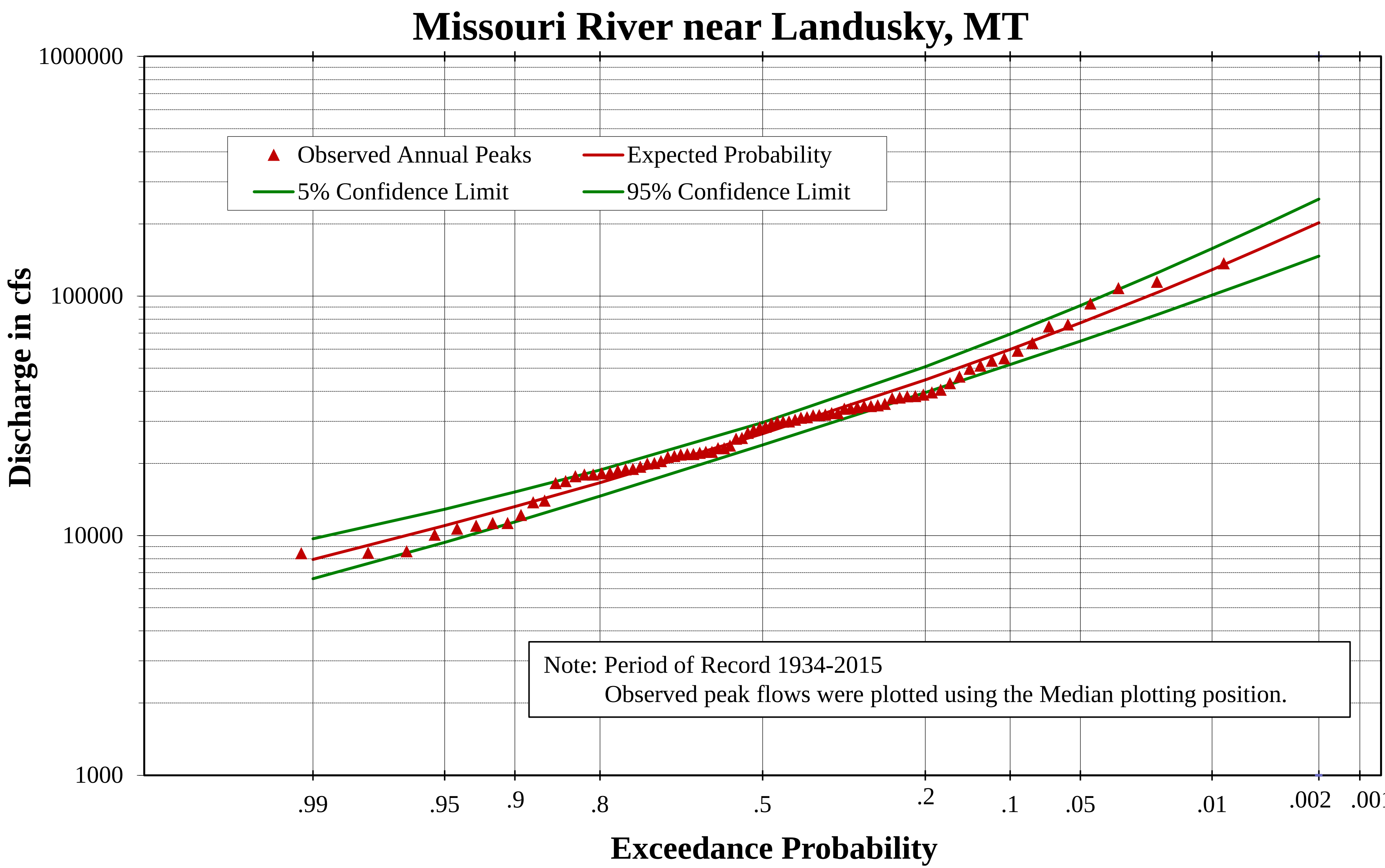
Fort Peck Water Control Manual

Probability Curve – Missouri River near Ulm, MT

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



Missouri River Basin
Fort Peck Water Control Manual
Probability Curve – Missouri River at Virgelle, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

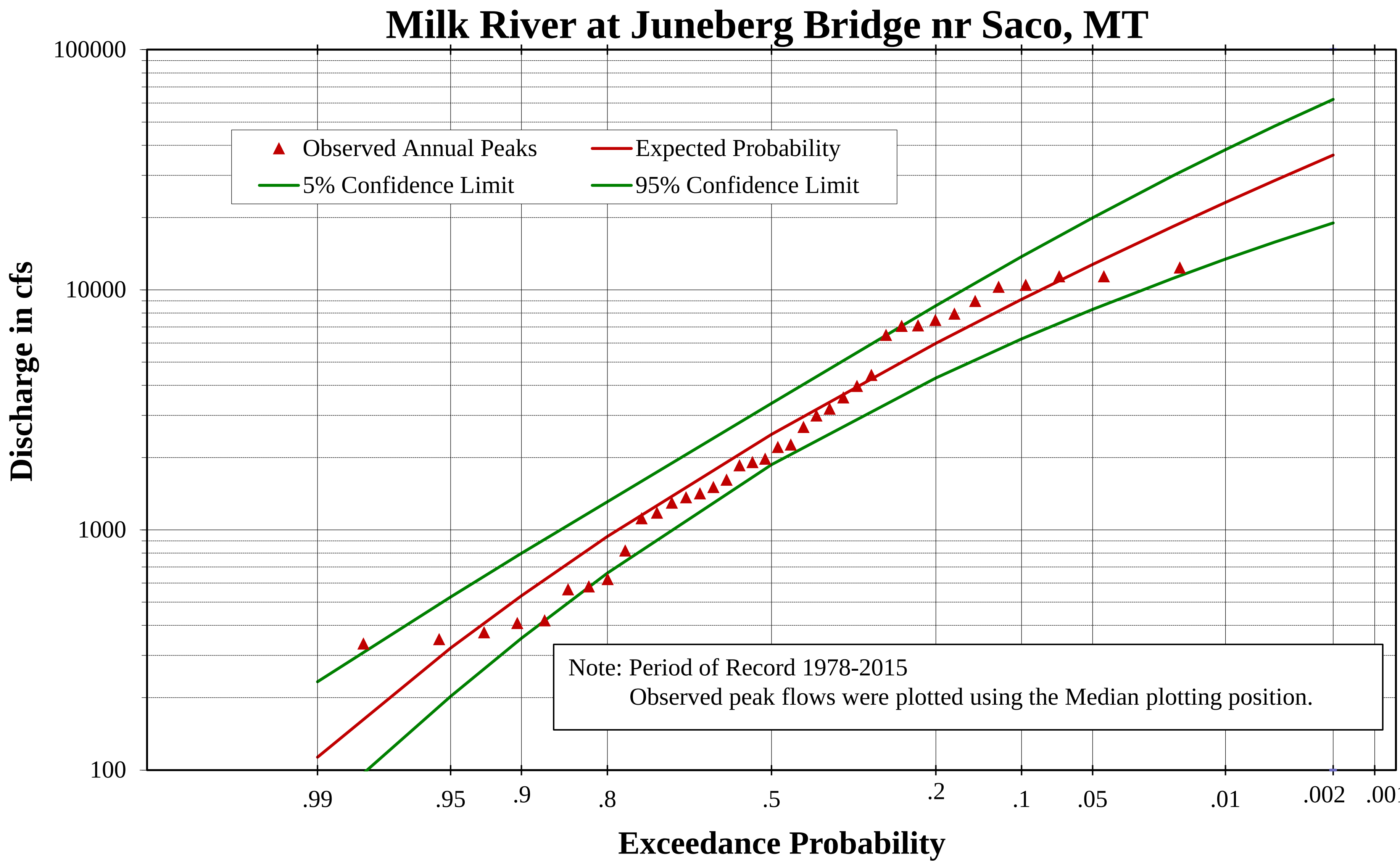


Missouri River Basin

Fort Peck Water Control Manual

Probability Curve – Missouri River near Landusky, MT

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



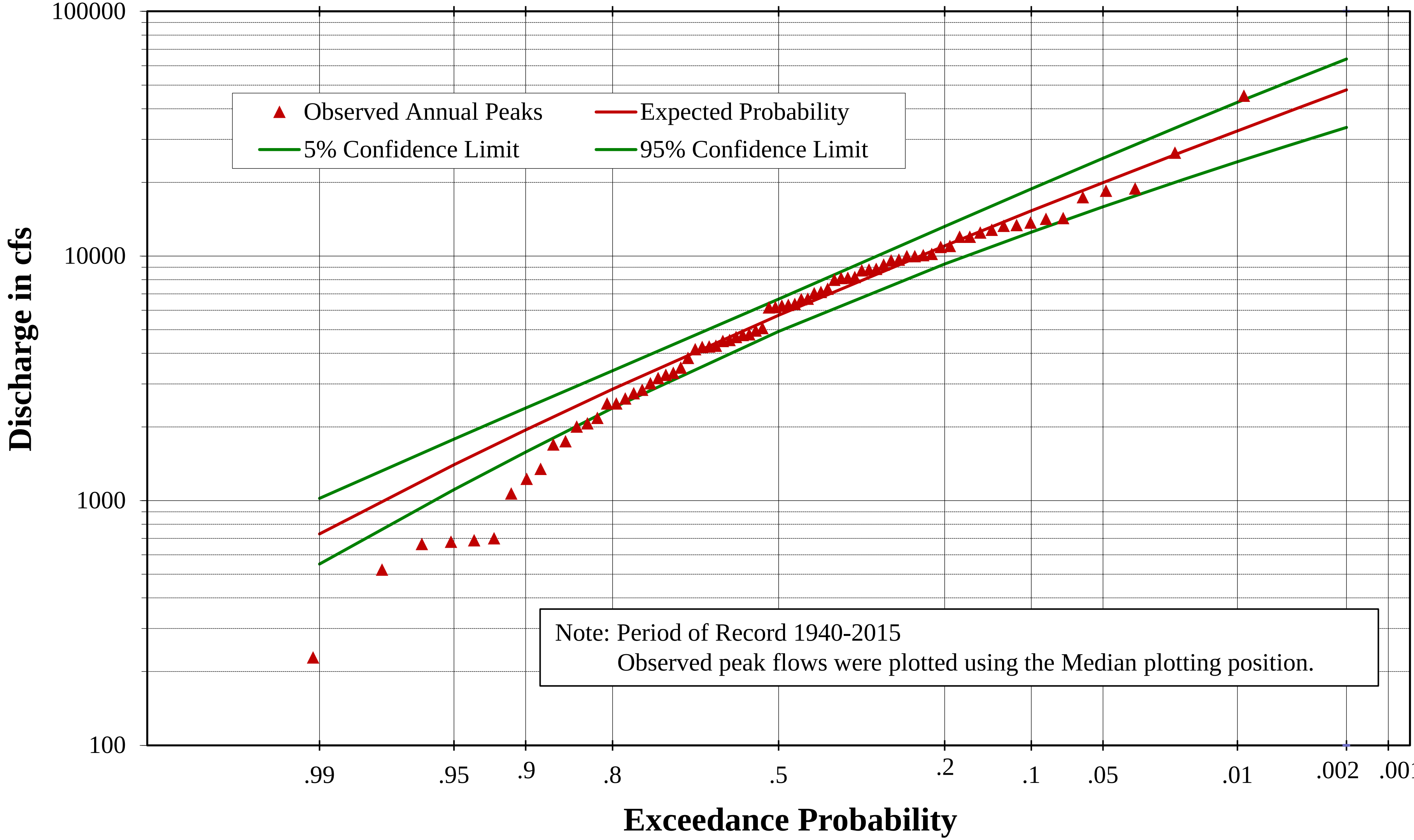
Missouri River Basin

Fort Peck Water Control Manual

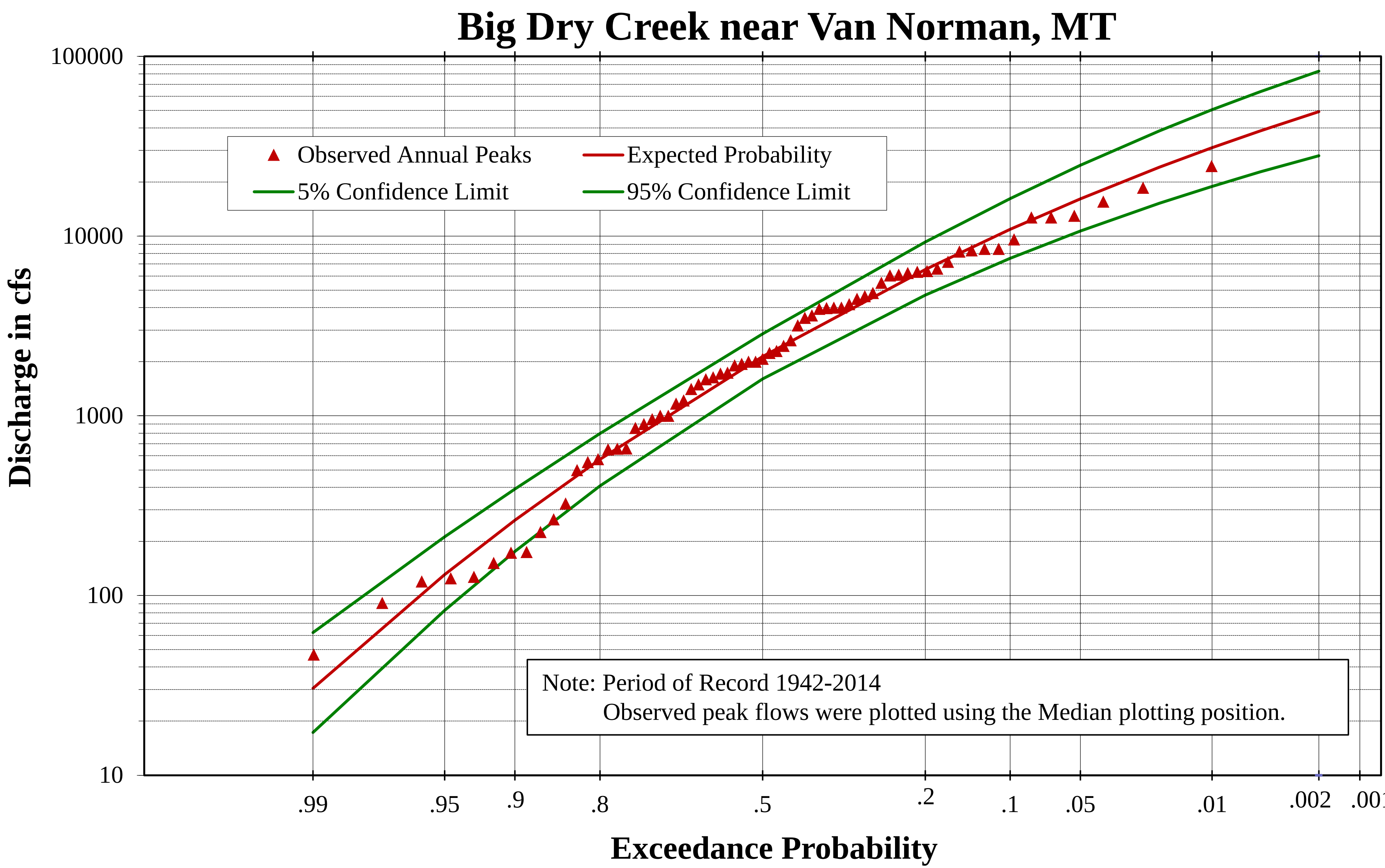
Probability Curve – Milk River at Juneberg Bridge nr Saco, MT

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Milk River at Nashua, MT



Missouri River Basin
Fort Peck Water Control Manual
Probability Curve – Milk River at Nashua, MT
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

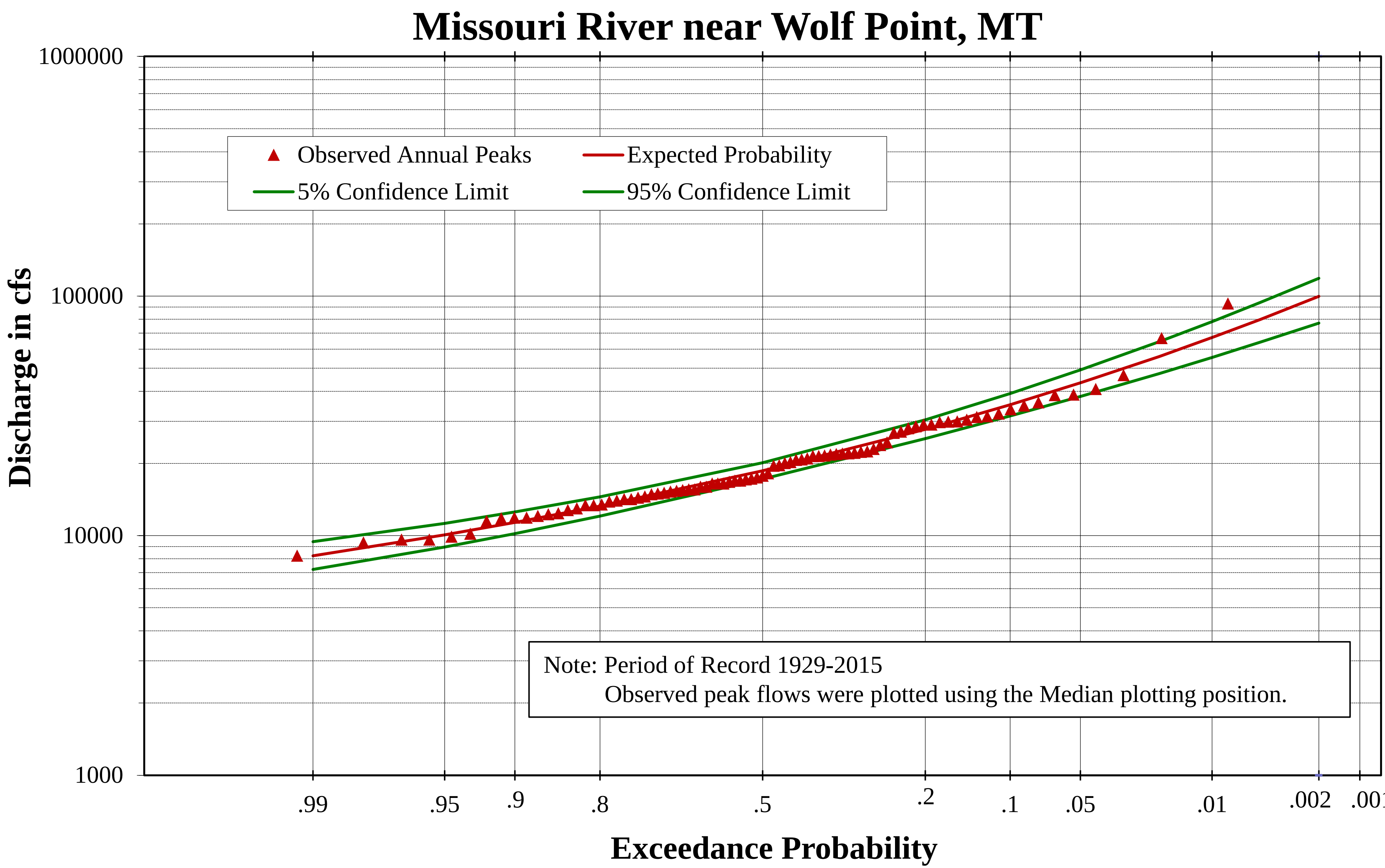


Missouri River Basin

Fort Peck Water Control Manual

Probability Curve – Big Dry Creek near Van Norman, MT

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

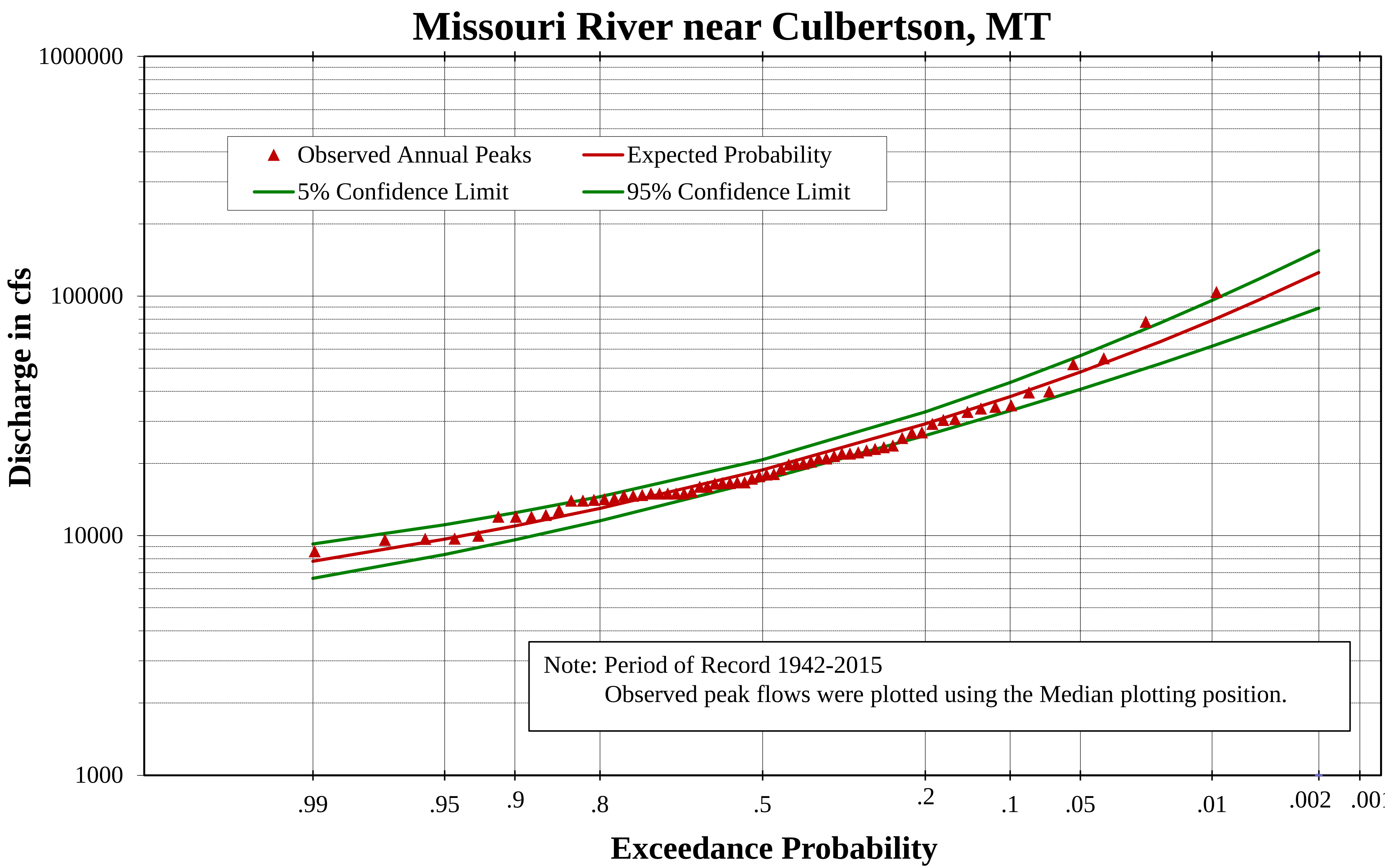


Missouri River Basin

Fort Peck Water Control Manual

Probability Curve – Missouri River near Wolf Point, MT

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

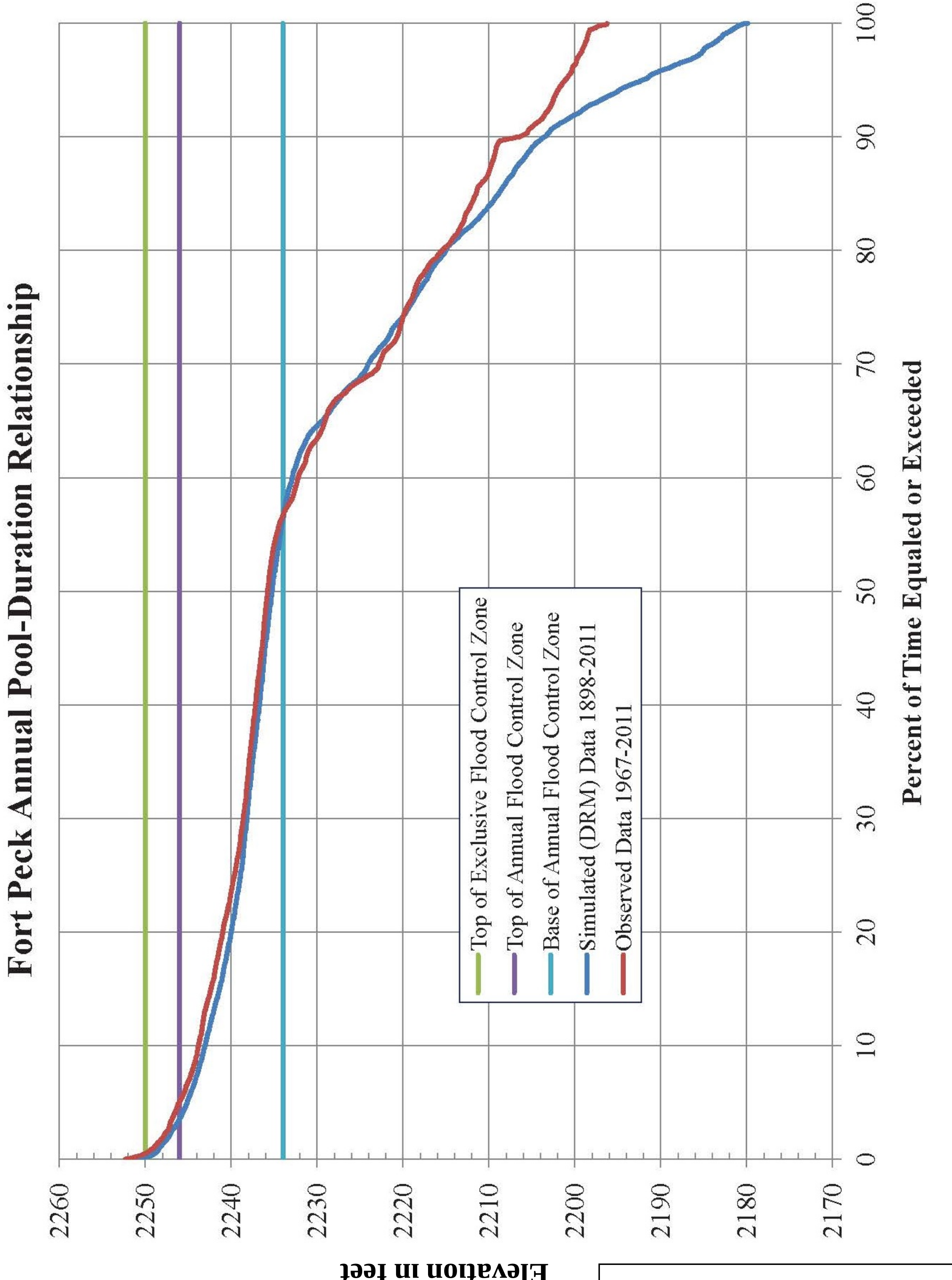


Missouri River Basin

Fort Peck Water Control Manual

Probability Curve – Missouri River near Culbertson, MT

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

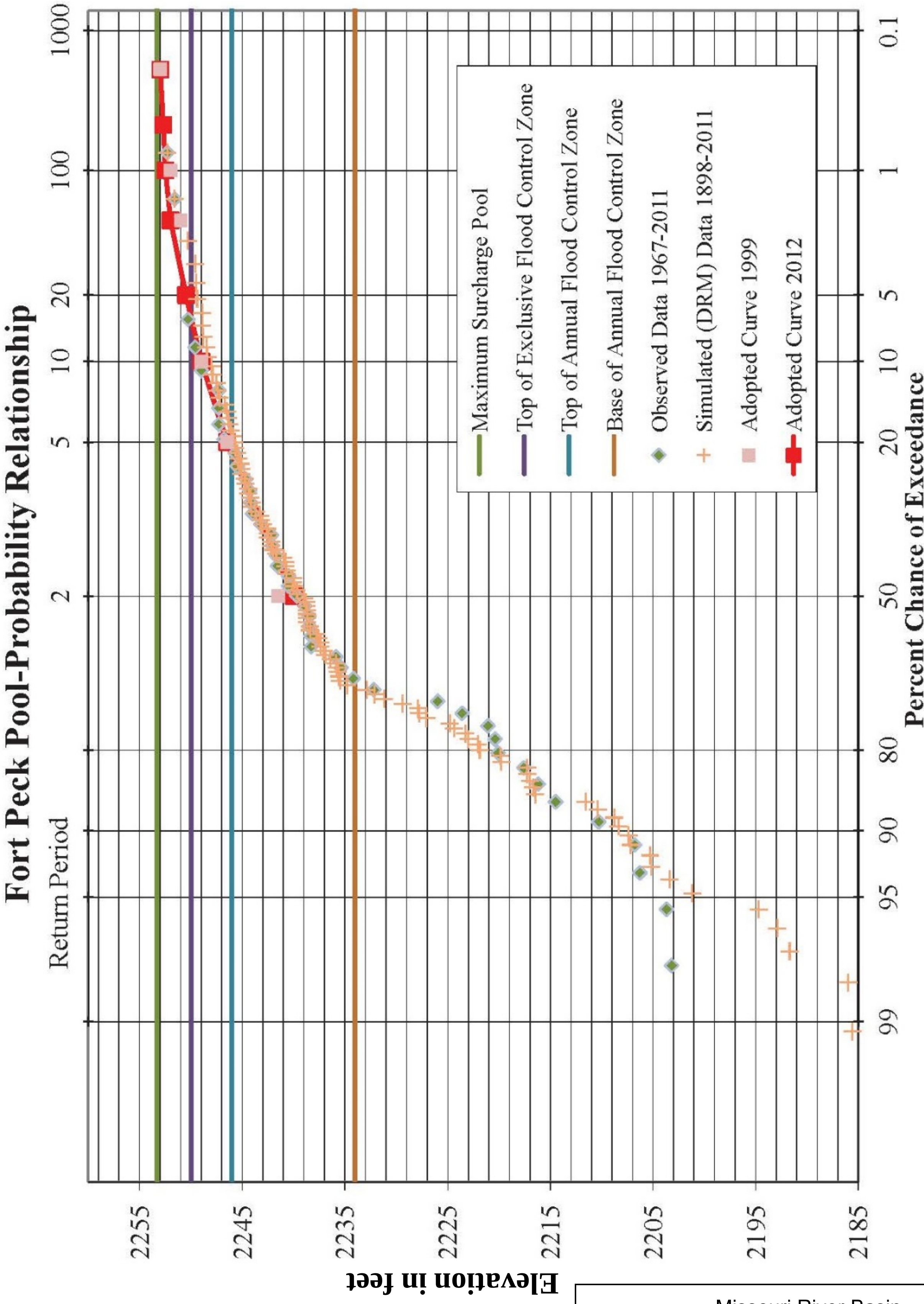


Missouri River Basin

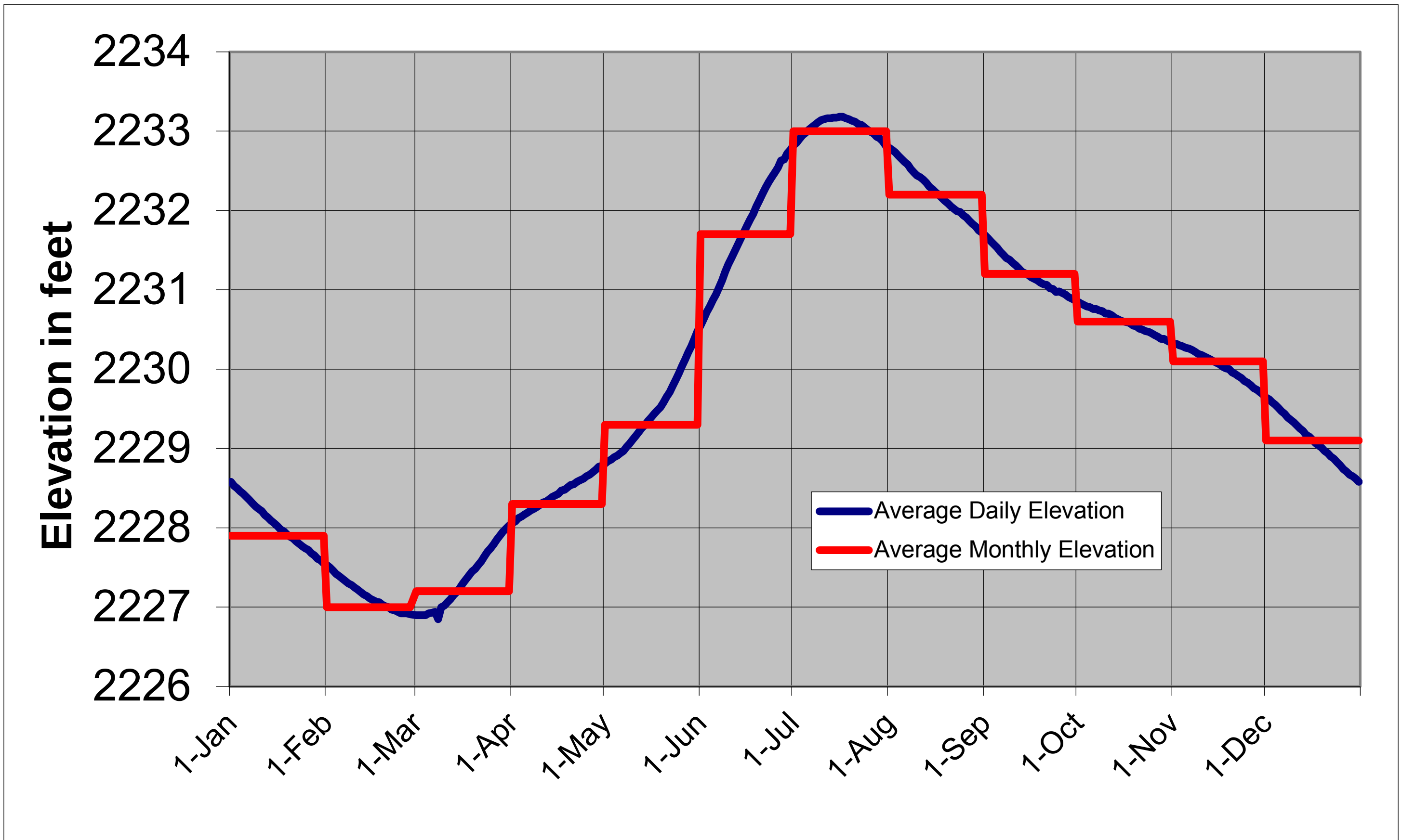
Fort Peck Water Control Manual

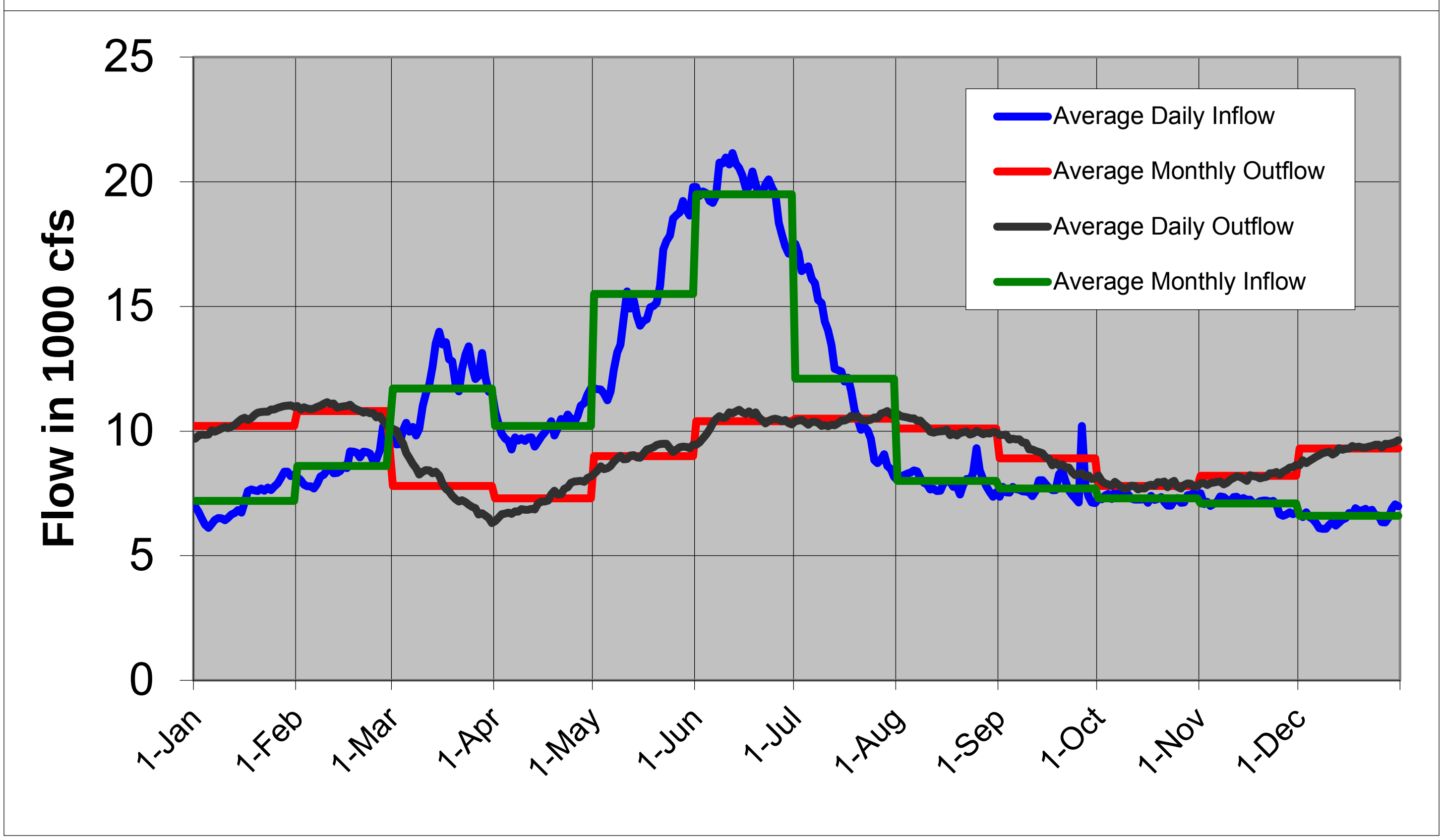
Fort Peck Pool-Duration Relationship

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017 Plate VI-38



Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Pool-Probability Relationship
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017





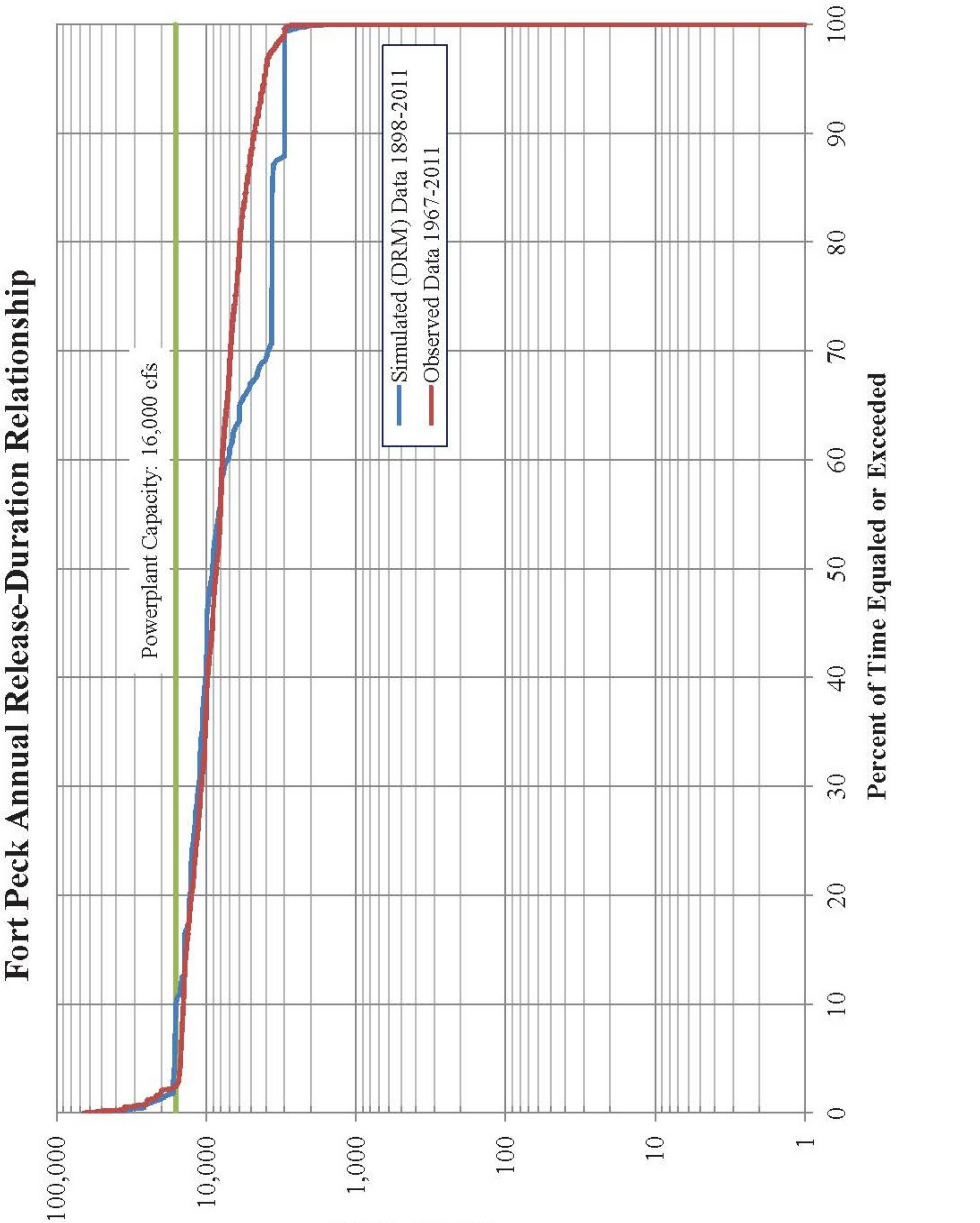
Period of Record: 1967 - 2015

Missouri River Basin

Fort Peck Water Control Manual

Average Daily and Monthly Elevations, Inflow and Outflow

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017



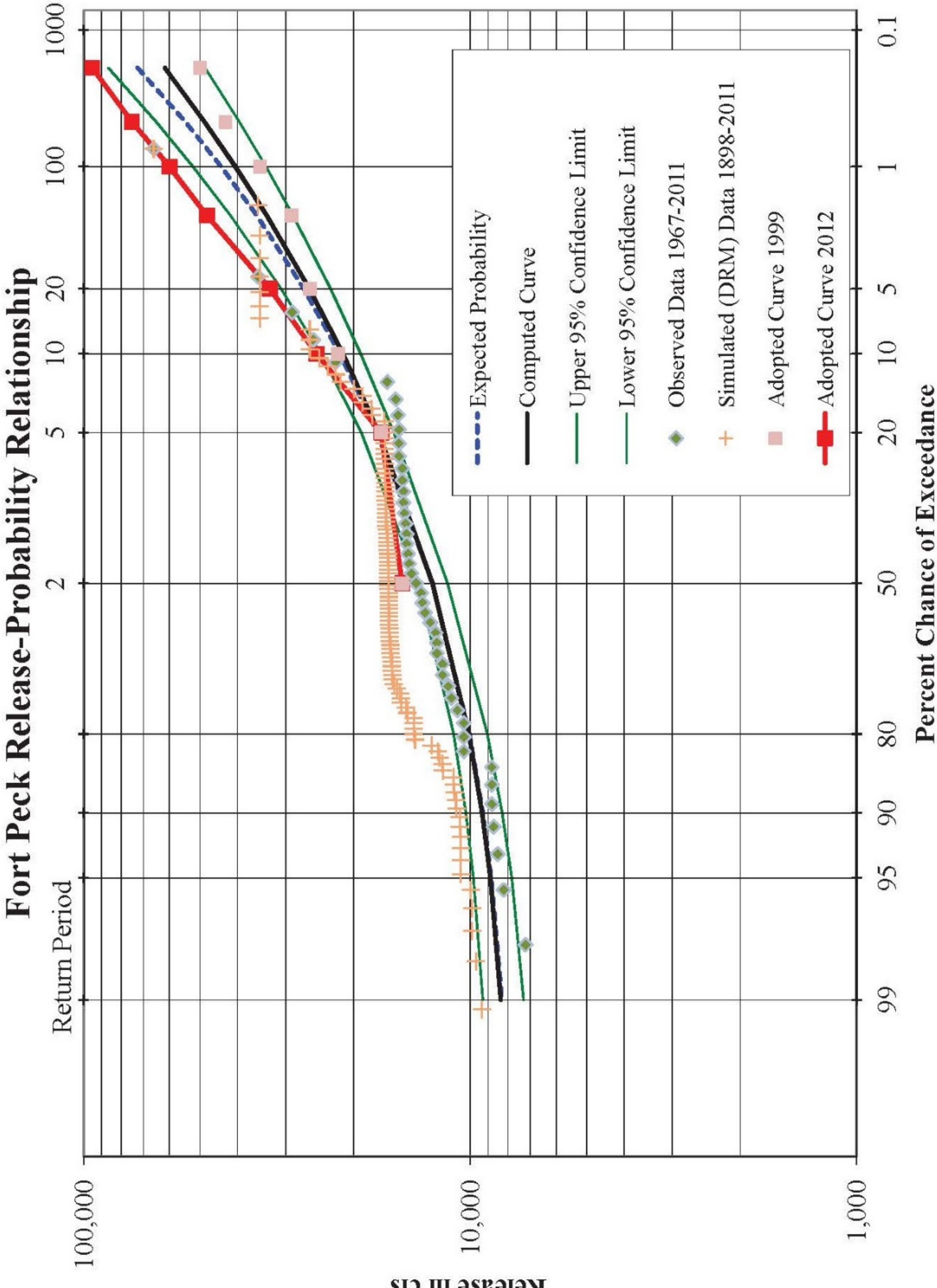
Missouri River Basin

Fort Peck Water Control Manual

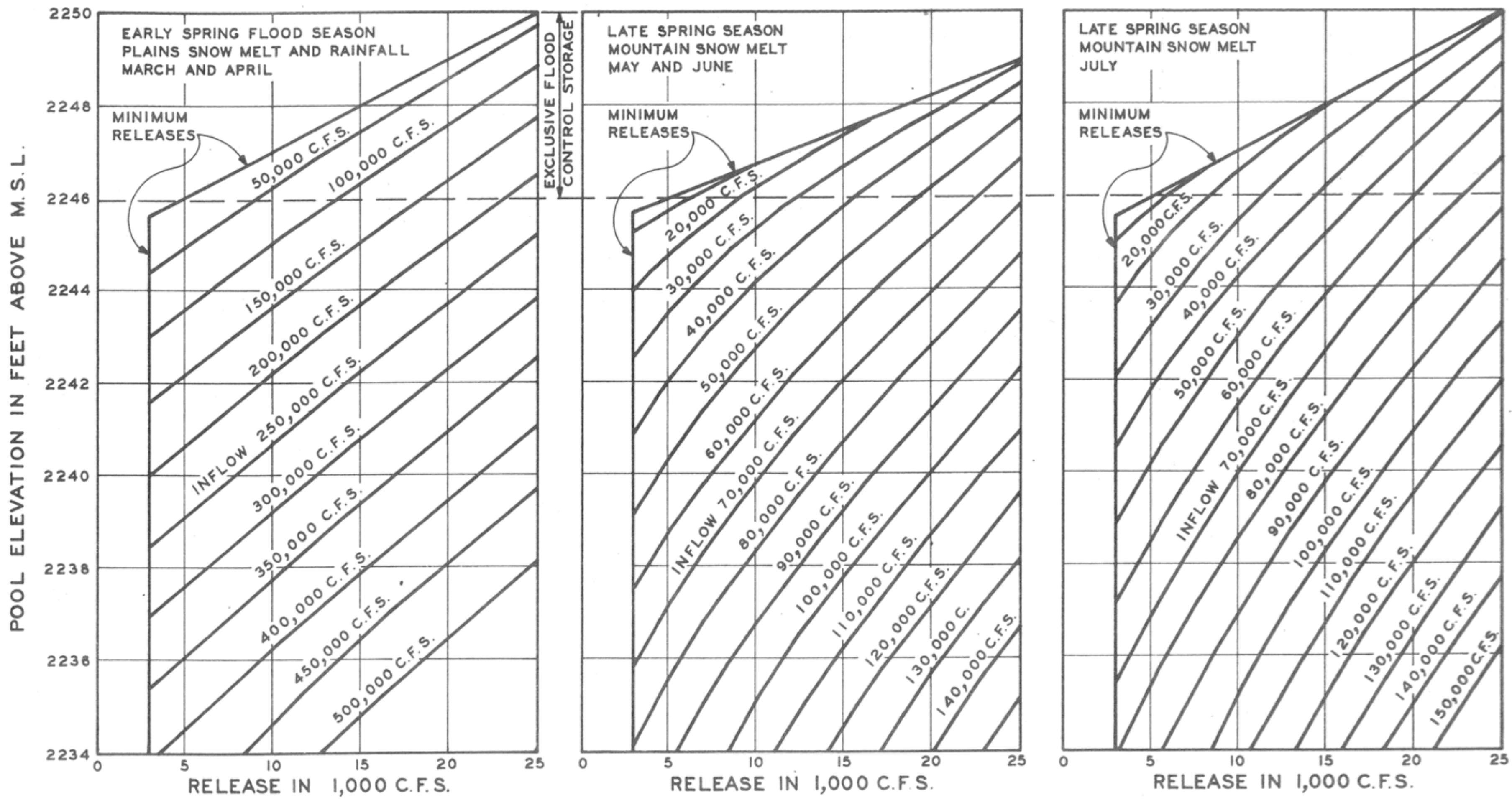
Fort Peck Release-Duration Relationship

U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017

Plate VI-41



Missouri River Basin
Fort Peck Water Control Manual
Fort Peck Release-Probability Relationship
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
September 2017



NOTES:

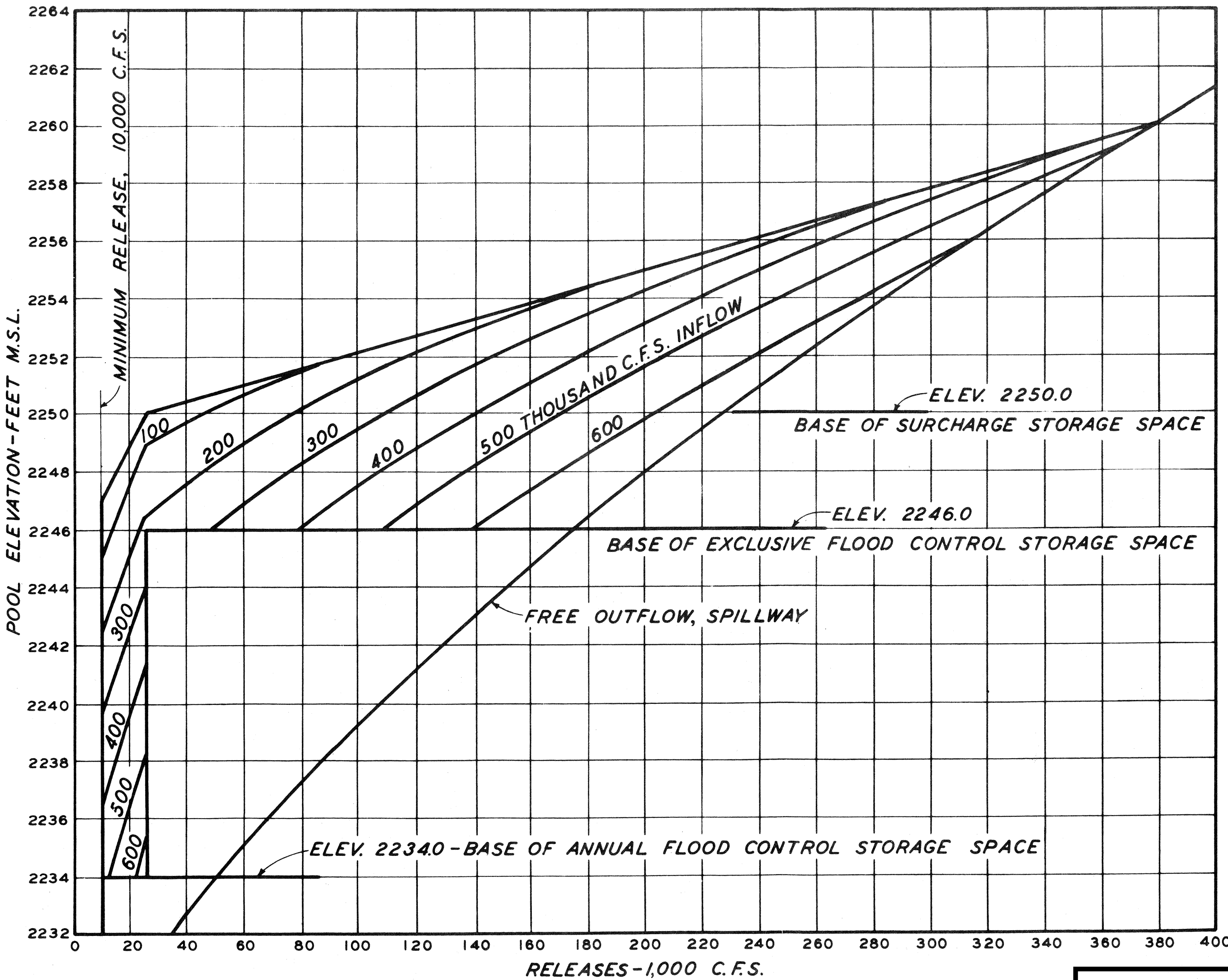
1. RELEASES ARE DETERMINED FROM CURRENT POOL ELEVATION AND MEAN INFLOW FOR THE PRECEDING 24 HOURS.
2. CURVES ARE APPLICABLE FOR THE REGULATION OF MODERATE FLOODS. FOR LARGE FLOODS, THE RULE CURVES INCLUDED IN THE EMERGENCY REGULATION PROCEDURES MAY BE USED AS REGULATION GUIDES.

Missouri River Basin

Fort Peck Water Control Manual

Regulation Curves for Moderate Floods

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017



Notes:

1. Curves are applicable for period 16 November to 30 April.

2. Numbered curves represent inflow in thousand cfs.

3. Emergency procedure will consist of:

   a. Enter curves with current pool elevation.
   b. Proceed to curve which equals inflow as determined for preceding 24 hours.
   c. Maintain release as indicated by point of intersection.
   d. No release shall exceed a rate greater than twice the average release rate for the preceding 24 hours.

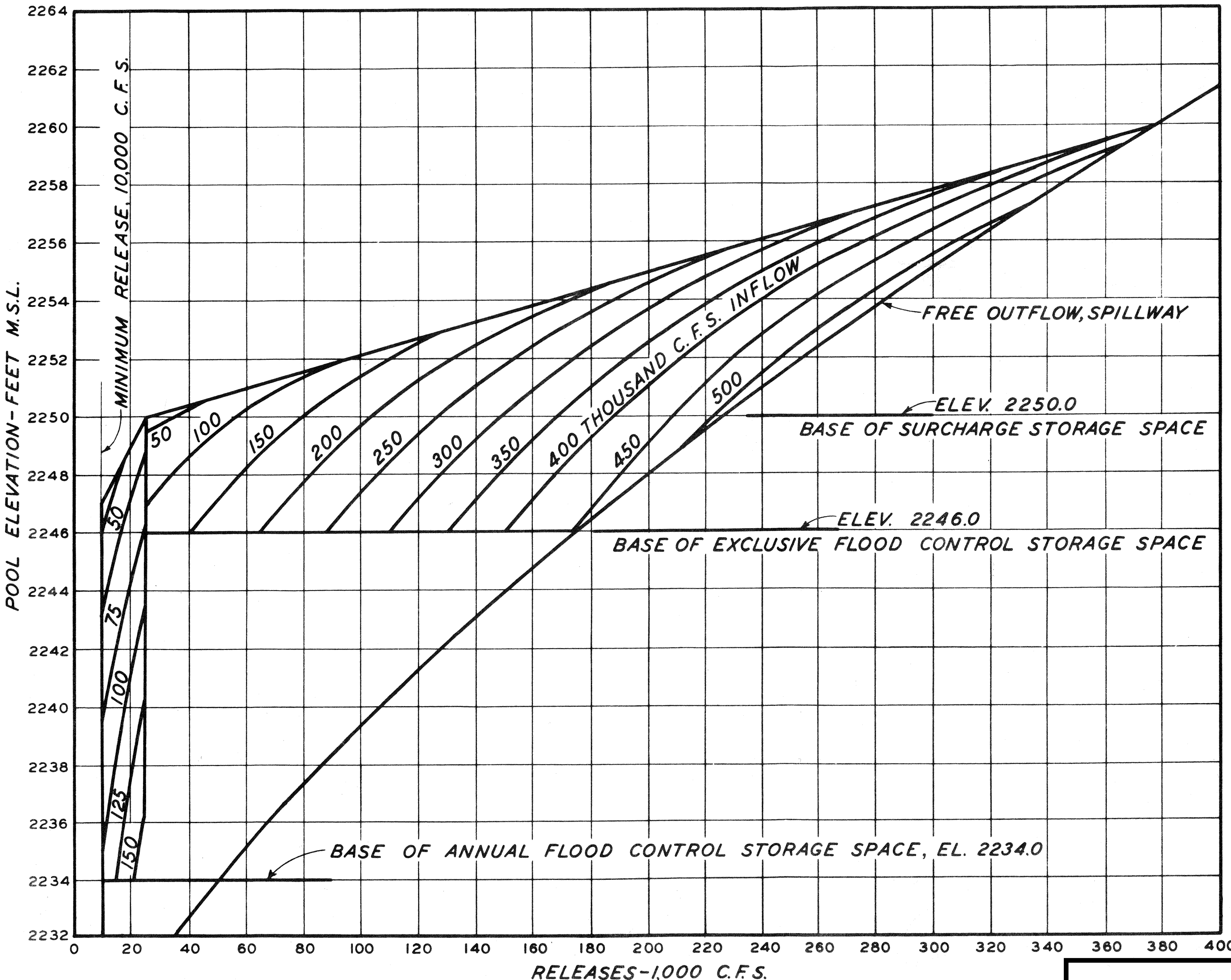
Missouri River Basin

Fort Peck Water Control Manual

Emergency Regulation Curves

Early Spring Flood Season

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
March 2017



Notes:

1. Curves are applicable for period 1 May to 15 November.

2. Numbered curves represent inflow in thousand cfs.

3. Emergency procedure will consist of:

   a. Enter curves with current pool elevation.
   b. Proceed to curve which equals inflow as determined for preceding 24 hours.
   c. Maintain release as indicated by point of intersection.
   d. No release shall exceed a rate greater than twice the average release rate for the preceding 24 hours.

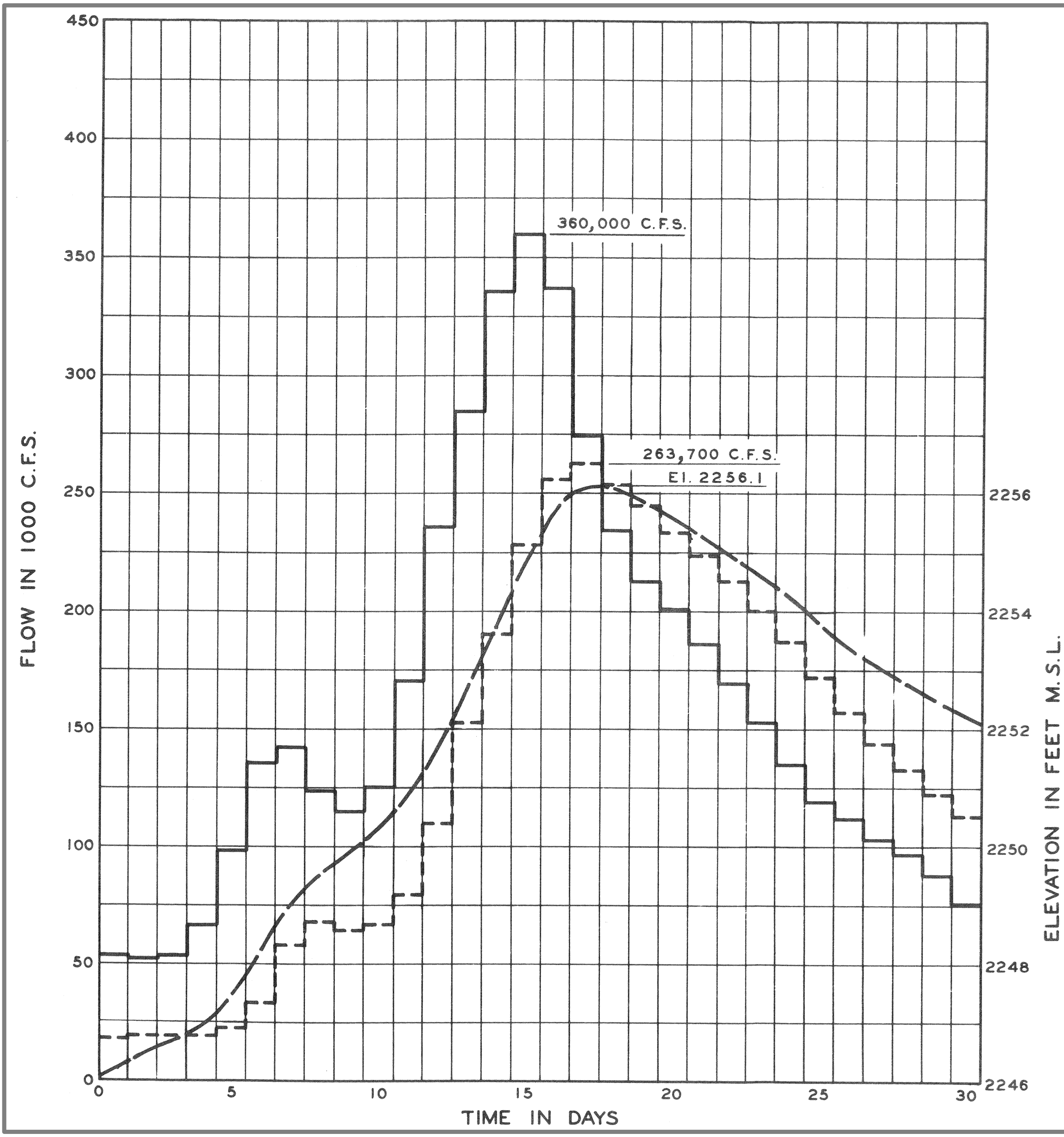
Missouri River Basin

Fort Peck Water Control Manual

Emergency Regulation Curves

Late Spring Flood Season

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
March 2017



Missouri River Basin

Fort Peck Water Control Manual

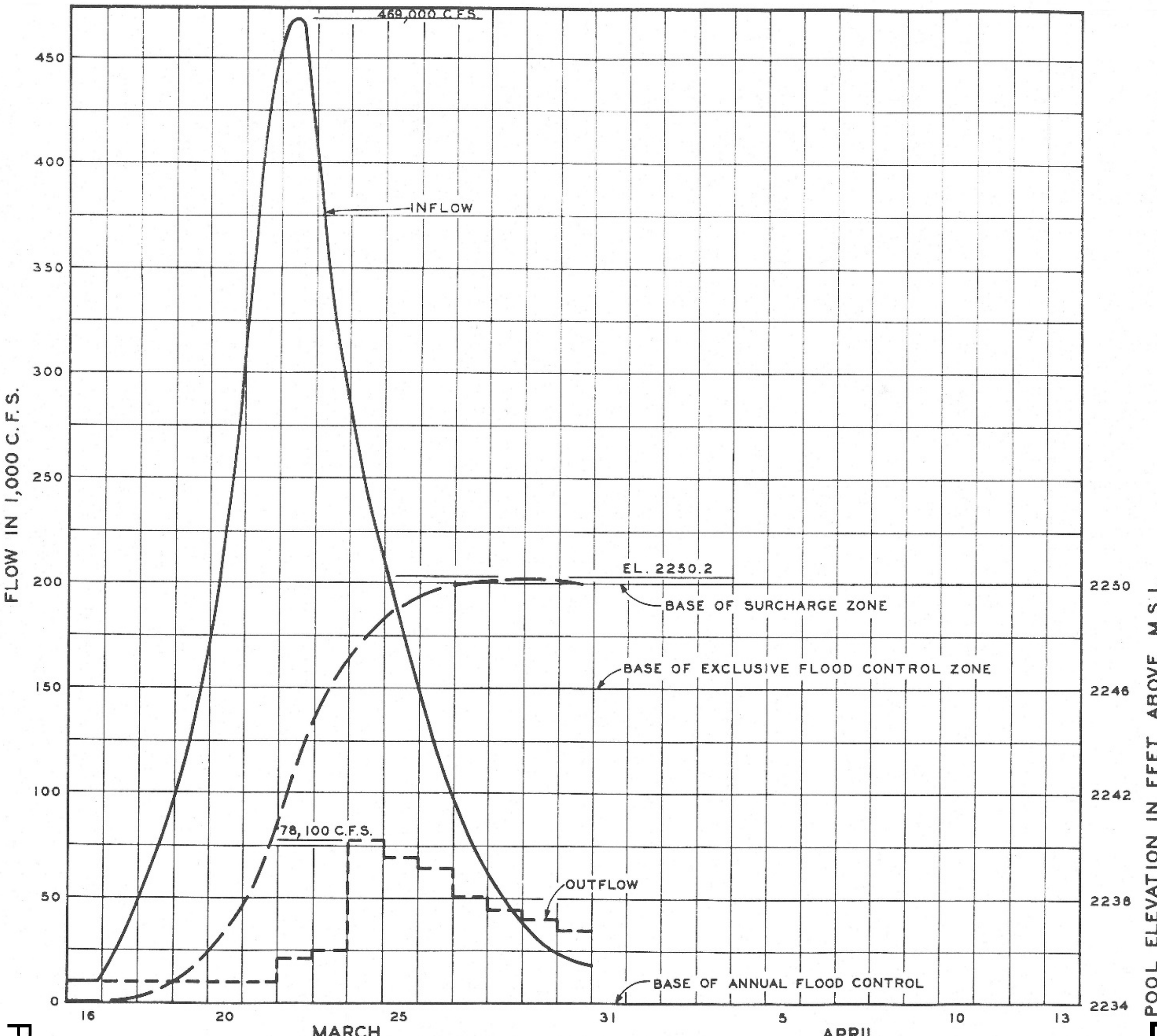
Example of Emergency Regulation

Late Spring Flood of SDF Magnitude

U.S. Army Engineer Division, Northwestern

Corps of Engineers, Omaha, Nebraska

September 2017

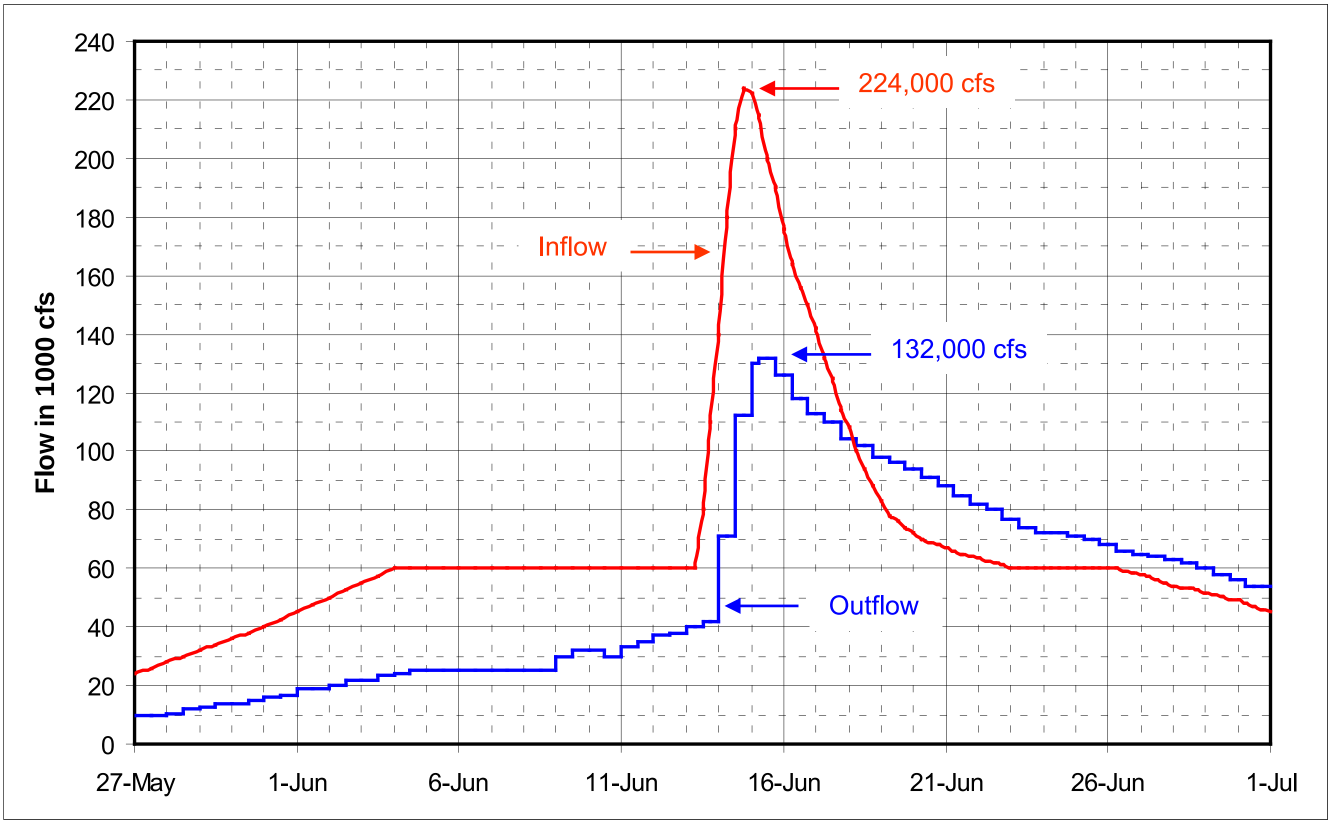


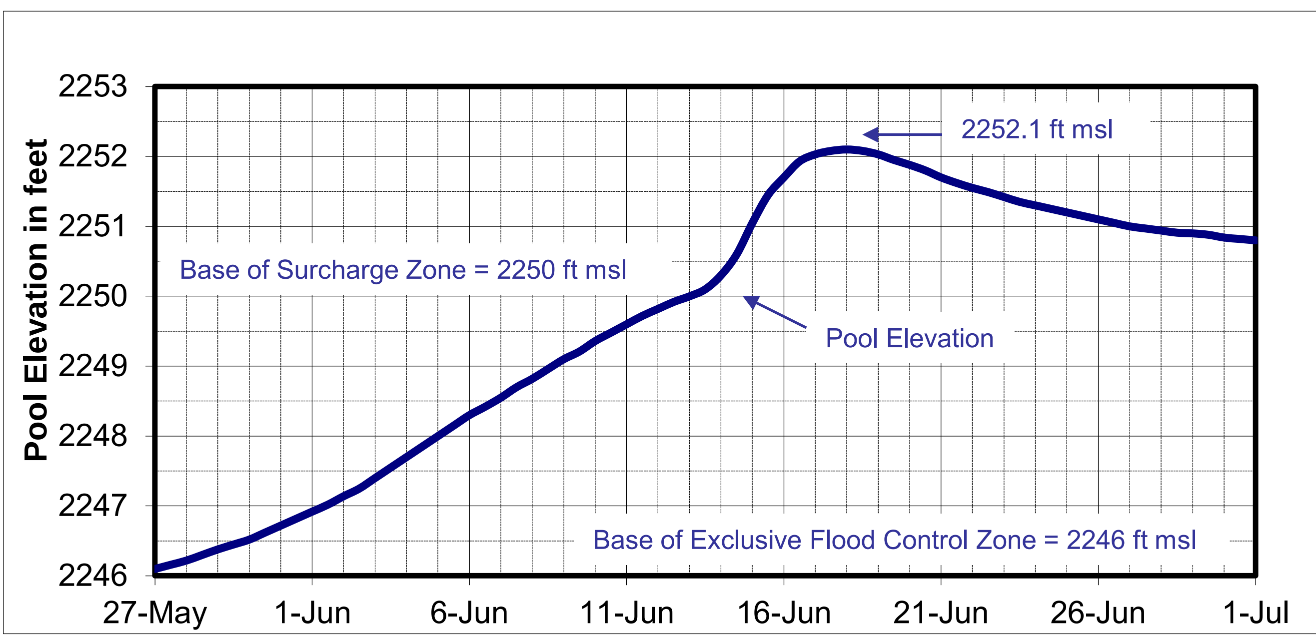
Missouri River Basin

Fort Peck Water Control Manual

Example of Emergency Regulation
Early Spring Flood of SDF Magnitude

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

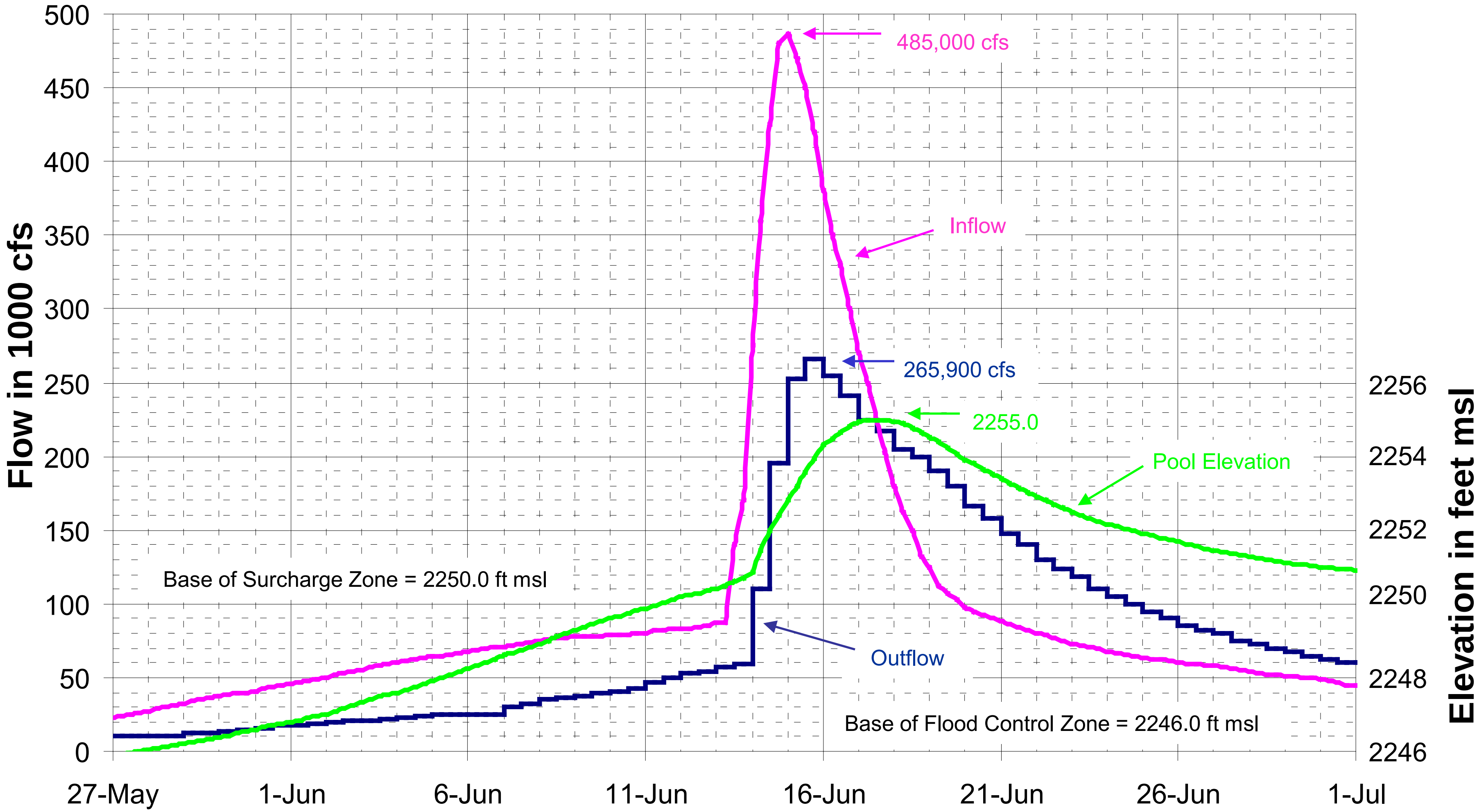




Note: For this example, Fort Peck regulation was conducted by using the Emergency Rule Curves.

Missouri River Basin
Fort Peck Water Control Manual
Example of Regulation
Late Spring Flood of SPF Magnitude
U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

Plate VII-6

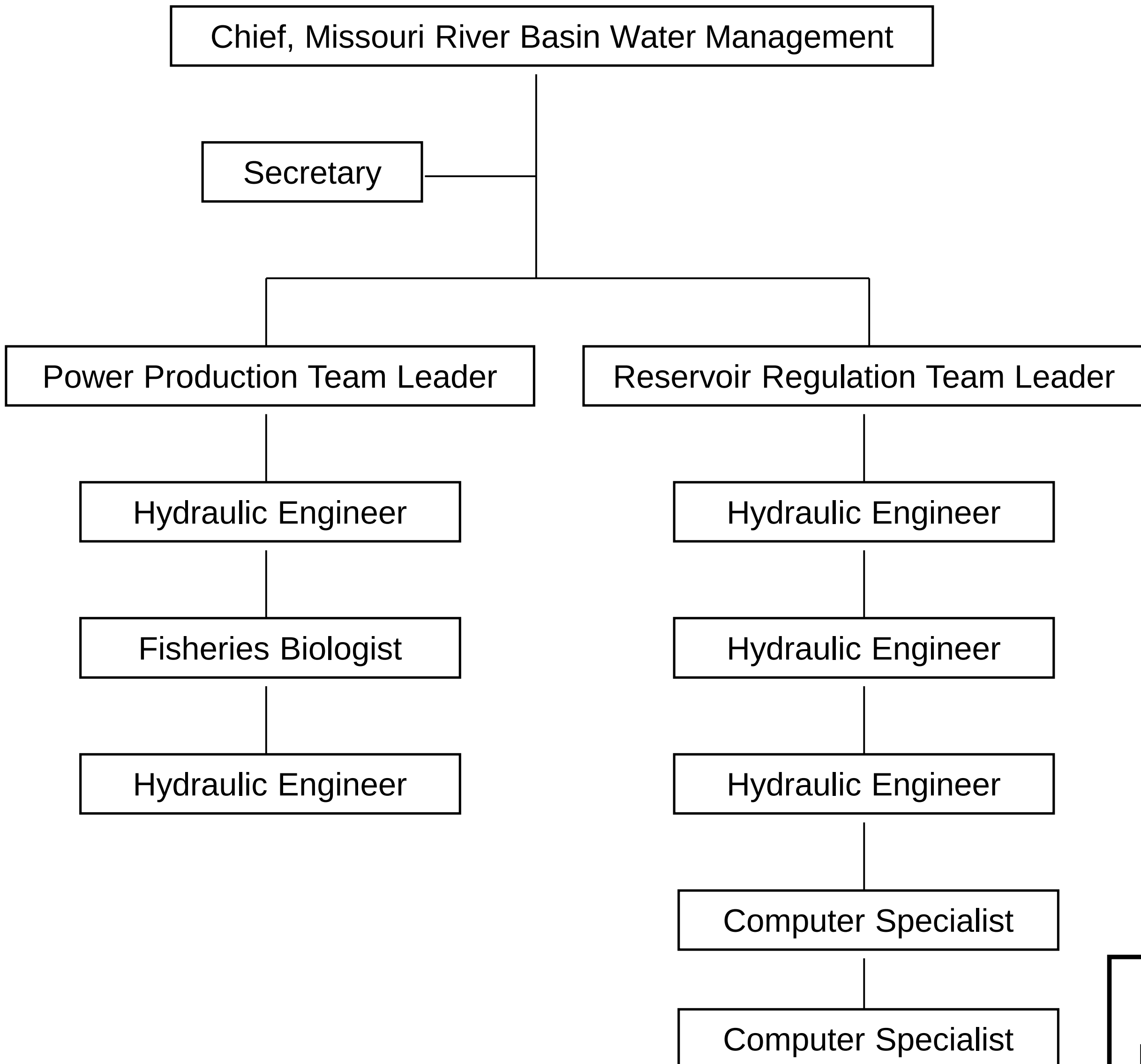


Note: Fort Peck Regulation by use of Emergency Rule Curves.

Missouri River Basin
Fort Peck Water Control Manual
Late Spring Flood of MPF Magnitude
Example of Regulation
U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

NWD-Omaha

Missouri River Basin Water Management Division

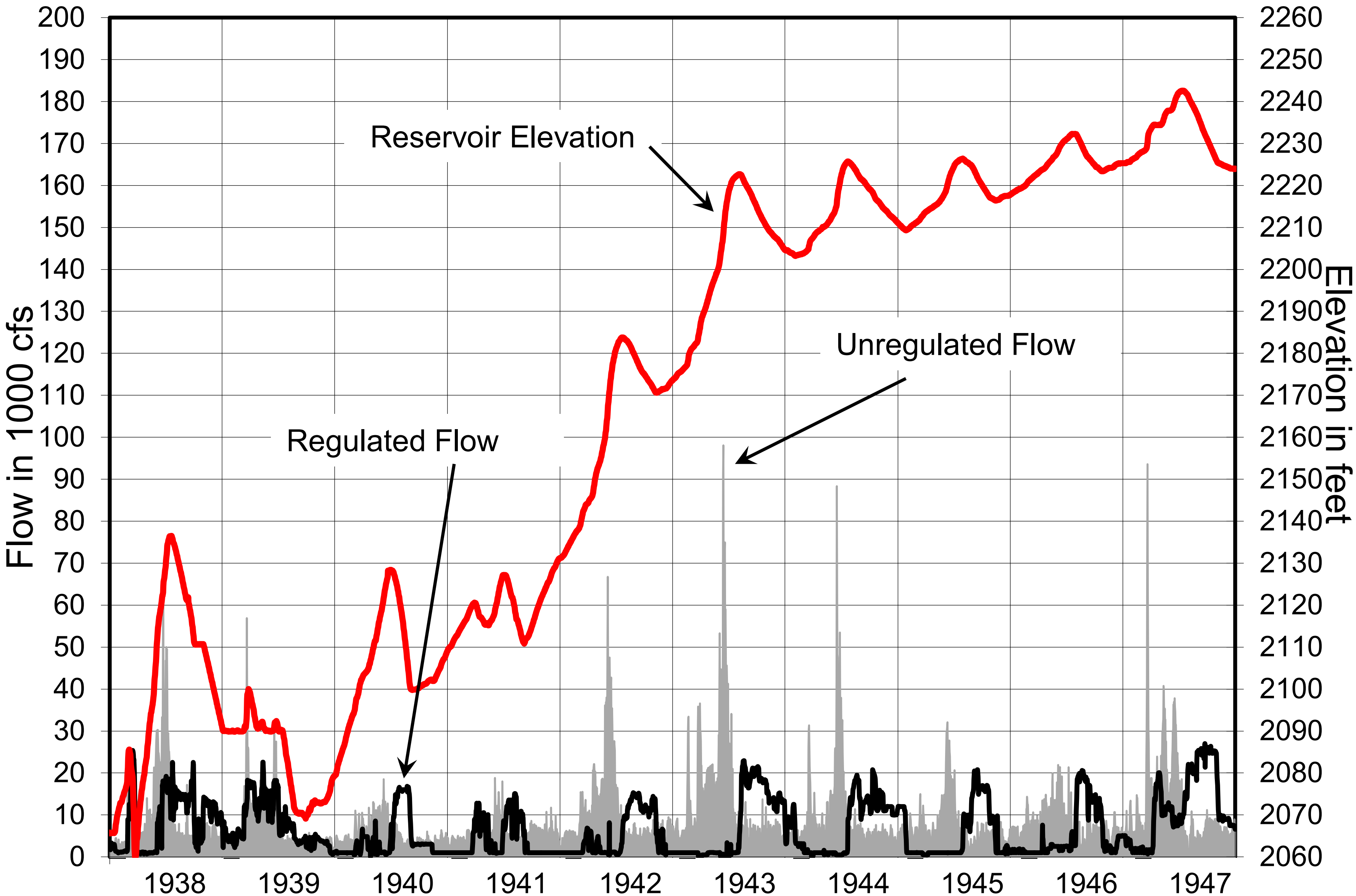


Budget Analyst is shared with Columbia River Basin Water Management

Missouri River Basin
Fort Peck Water Control Manual
MRBWM Division Organization Chart

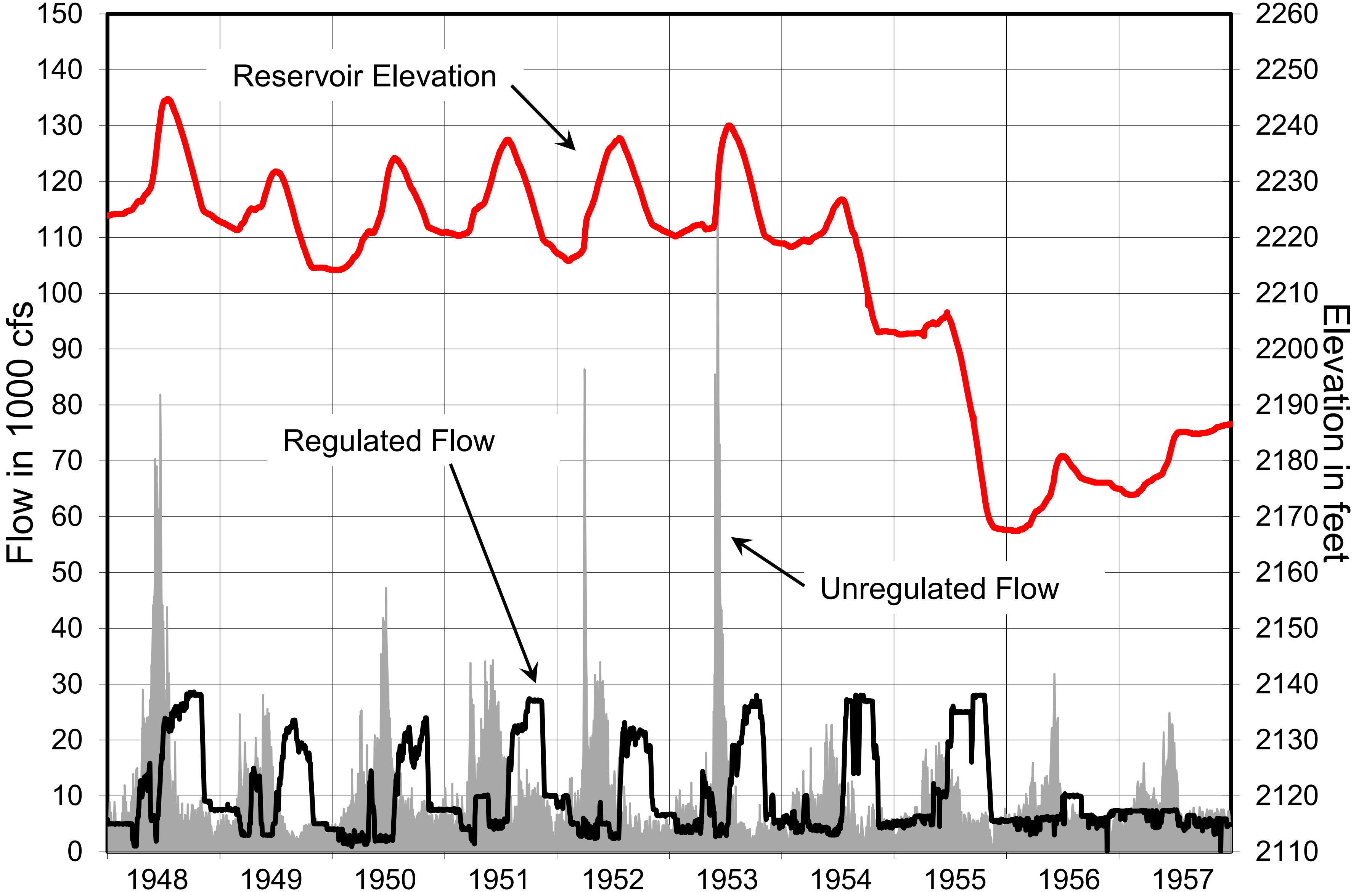
U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA

September 2017



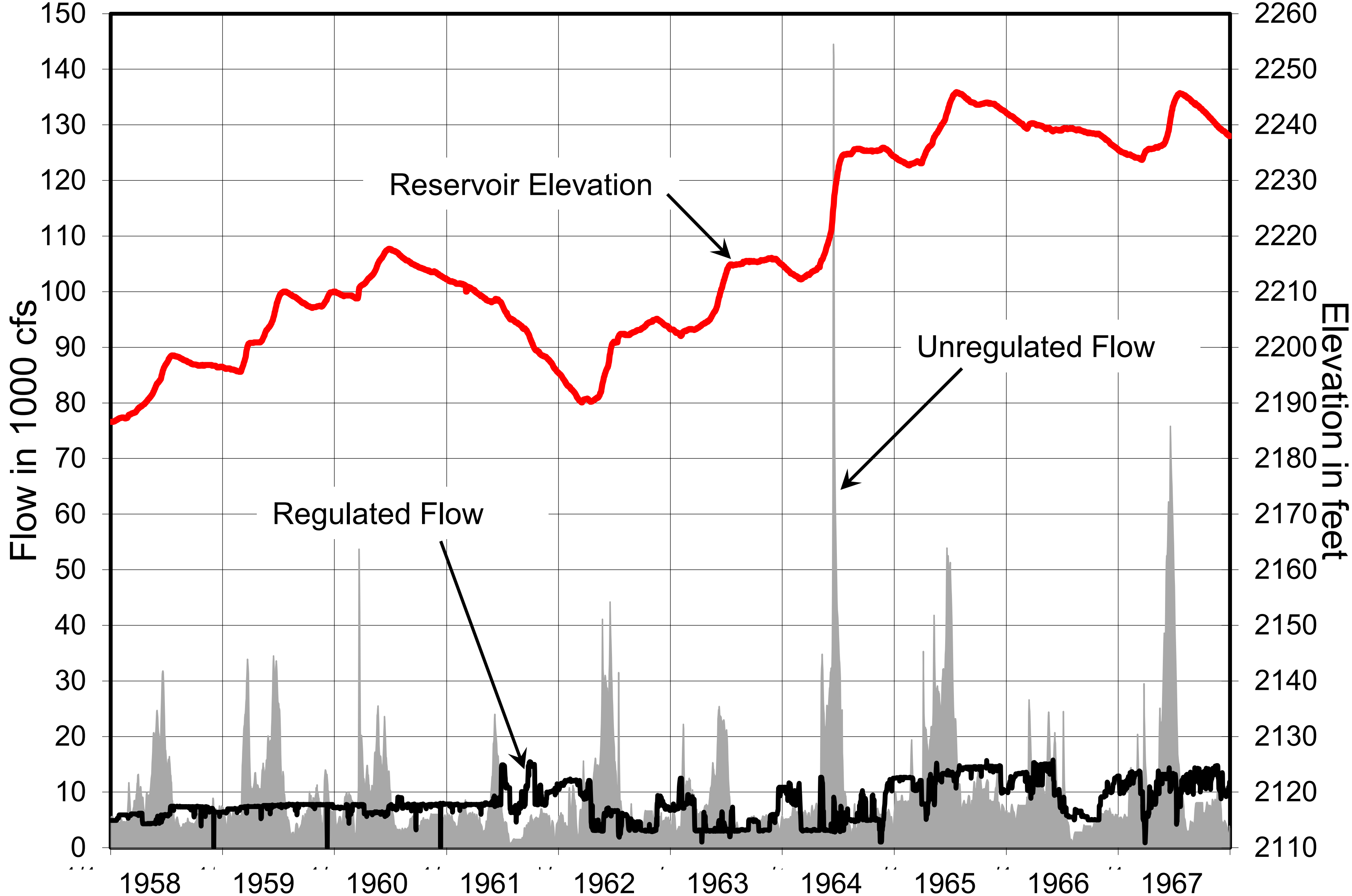
Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1938 - 1947

U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017



Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1948 - 1957

U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017



Missouri River Basin

Fort Peck Water Control Manual

Reservoir Elevation, Regulated and Unregulated Flows, 1958 - 1967

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CORPS OF ENGINEERS, OMAHA, NEBRASKA
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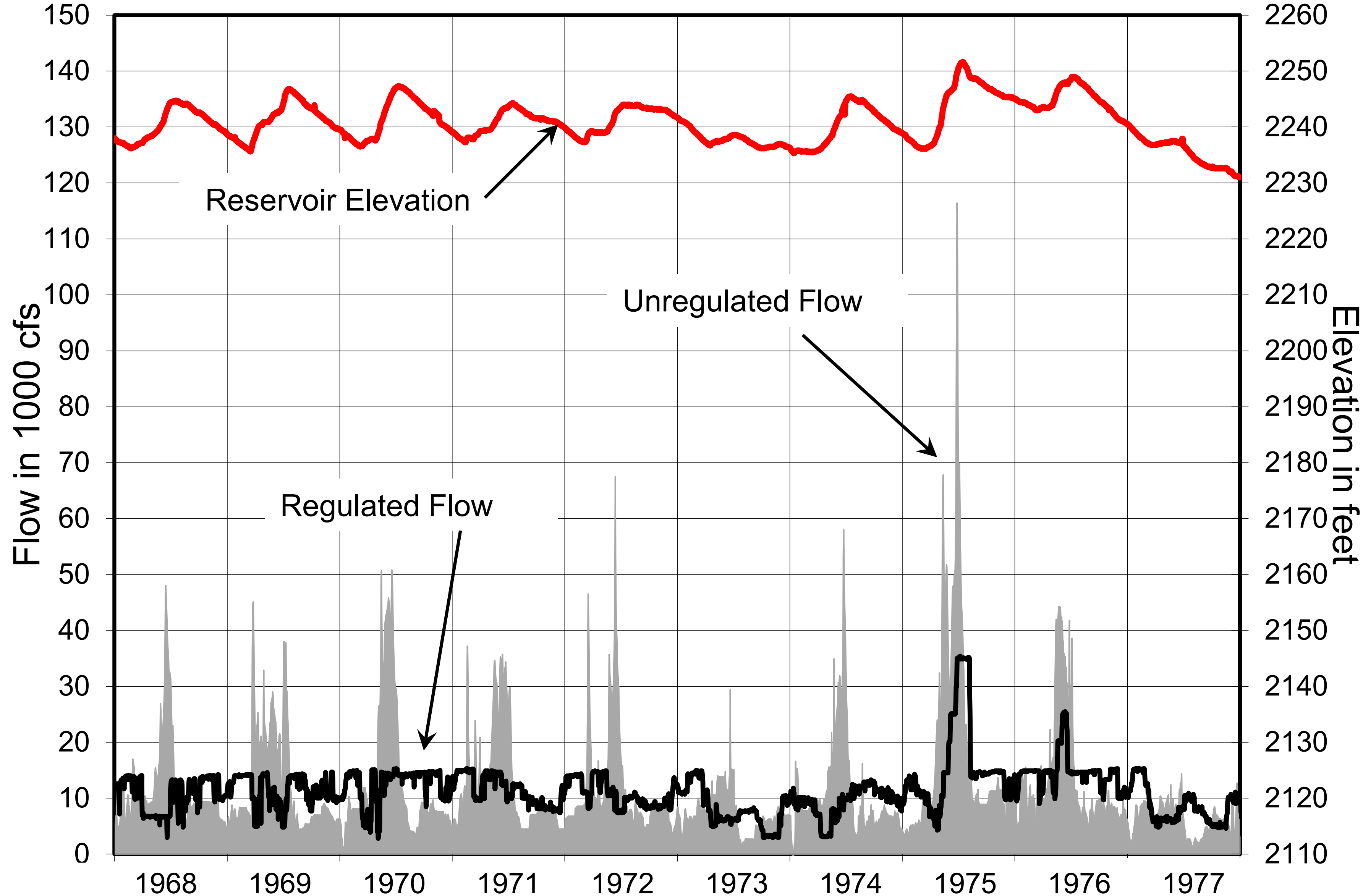

Missouri River Basin

Fort Peck Water Control Manual

Reservoir Elevation, Regulated and Unregulated Flows, 1968 - 1977

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CORPS OF ENGINEERS, OMAHA, NEBRASKA
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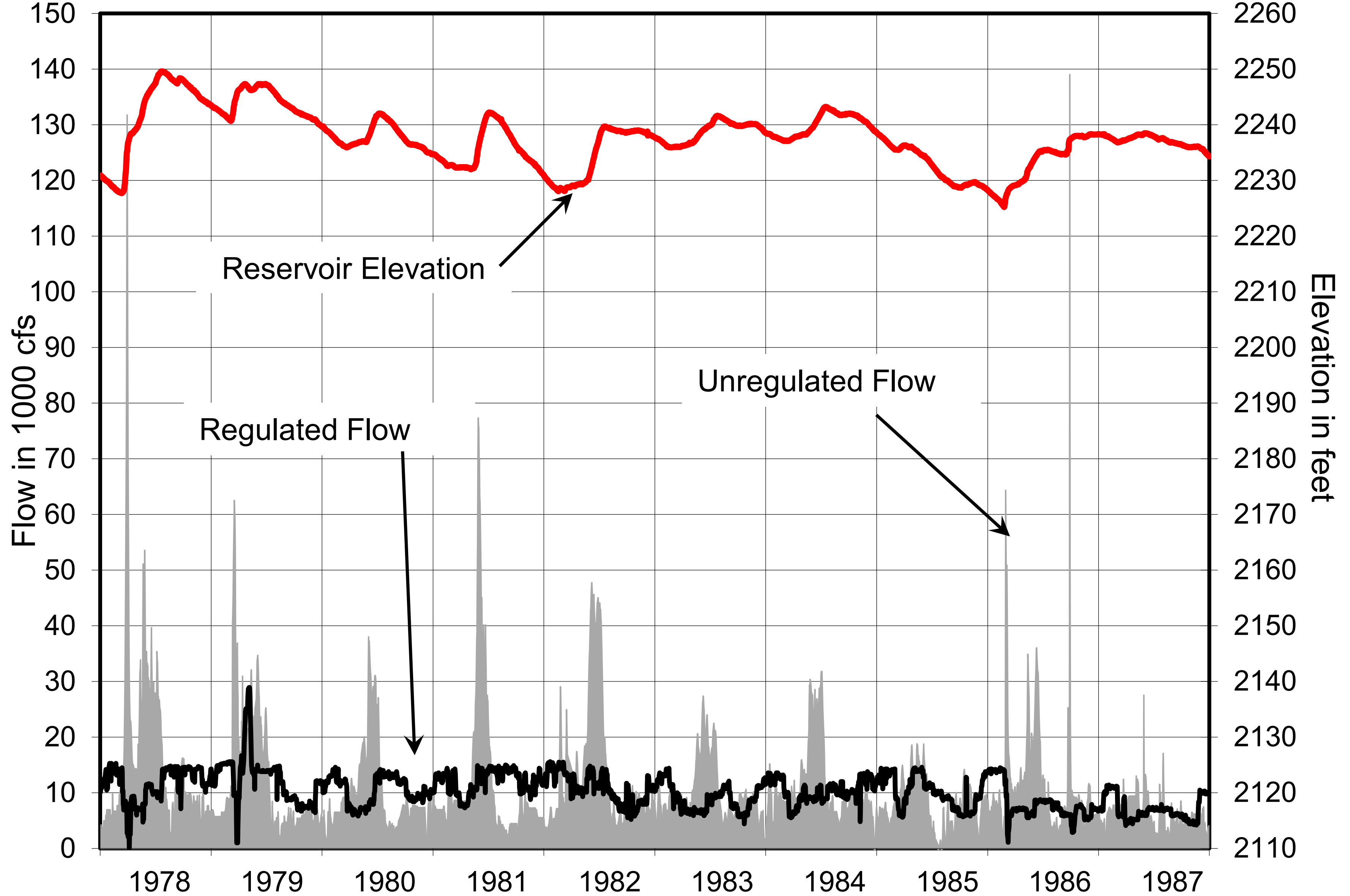

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1978 - 1987
U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
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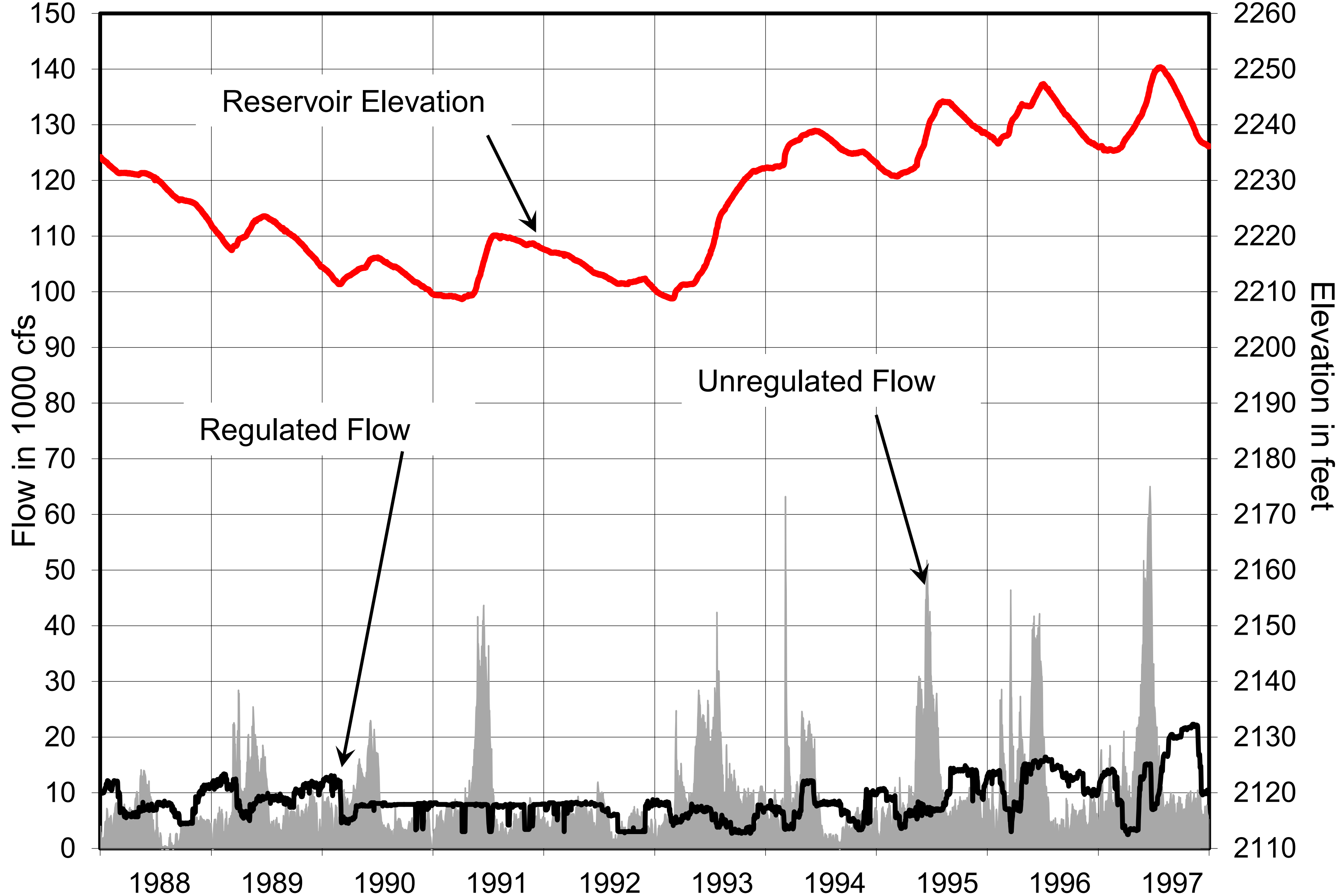
September 2017



Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1988 - 1997
U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
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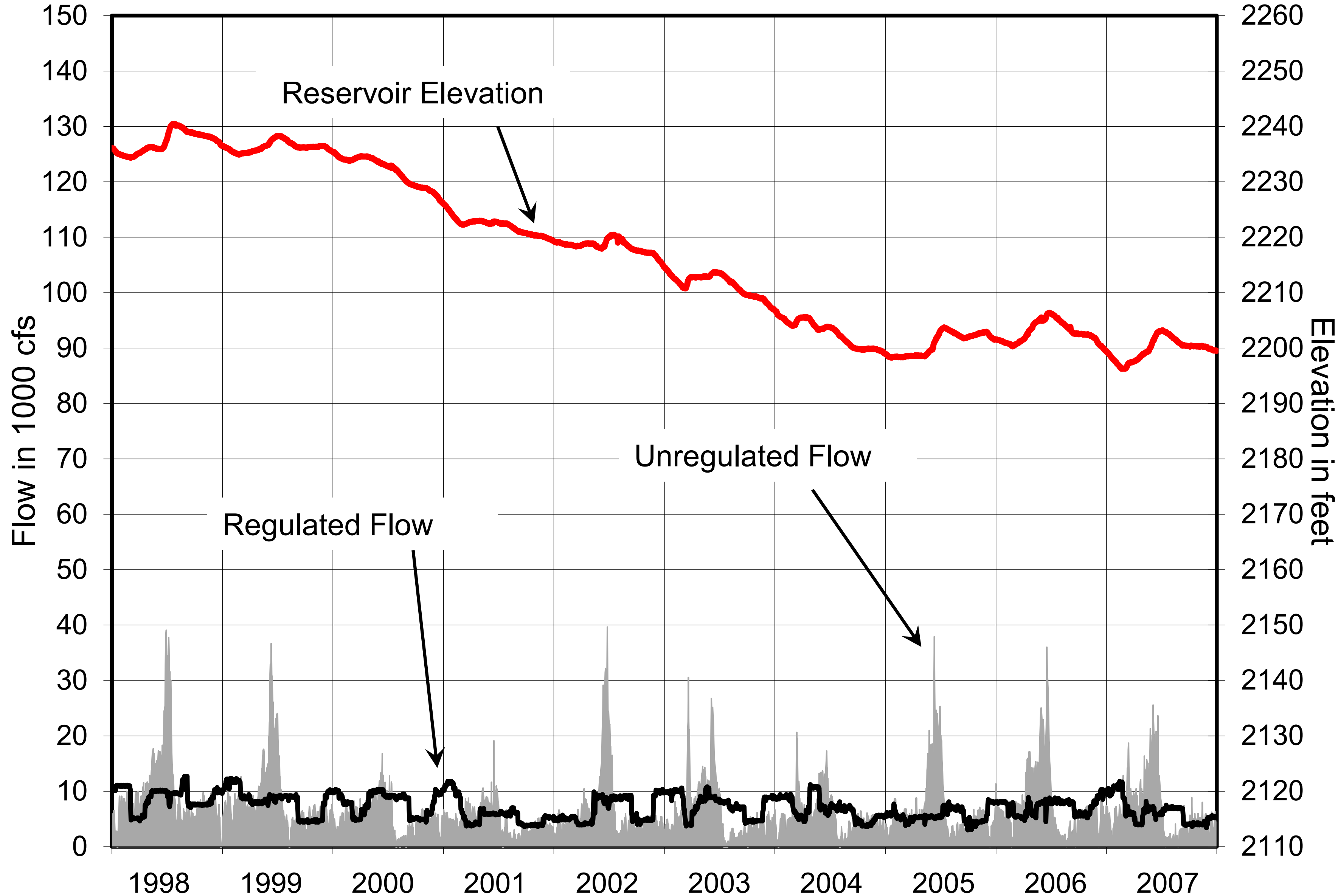

Missouri River Basin

Fort Peck Water Control Manual

Reservoir Elevation, Regulated and Unregulated Flows, 1998 - 2007

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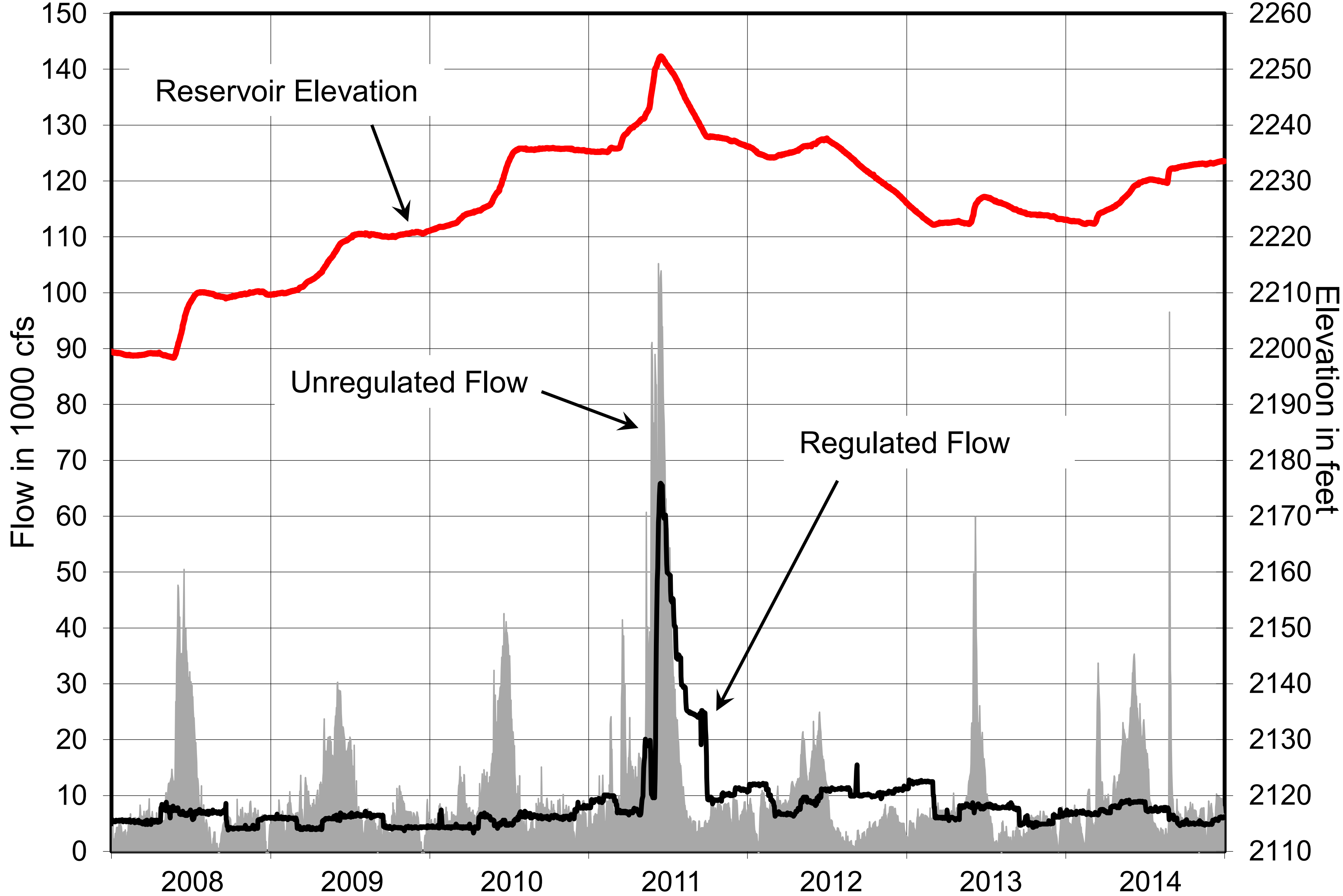
September 2017



Missouri River Basin

Fort Peck Water Control Manual

Reservoir Elevation, Regulated and Unregulated Flows, 2008- 2014

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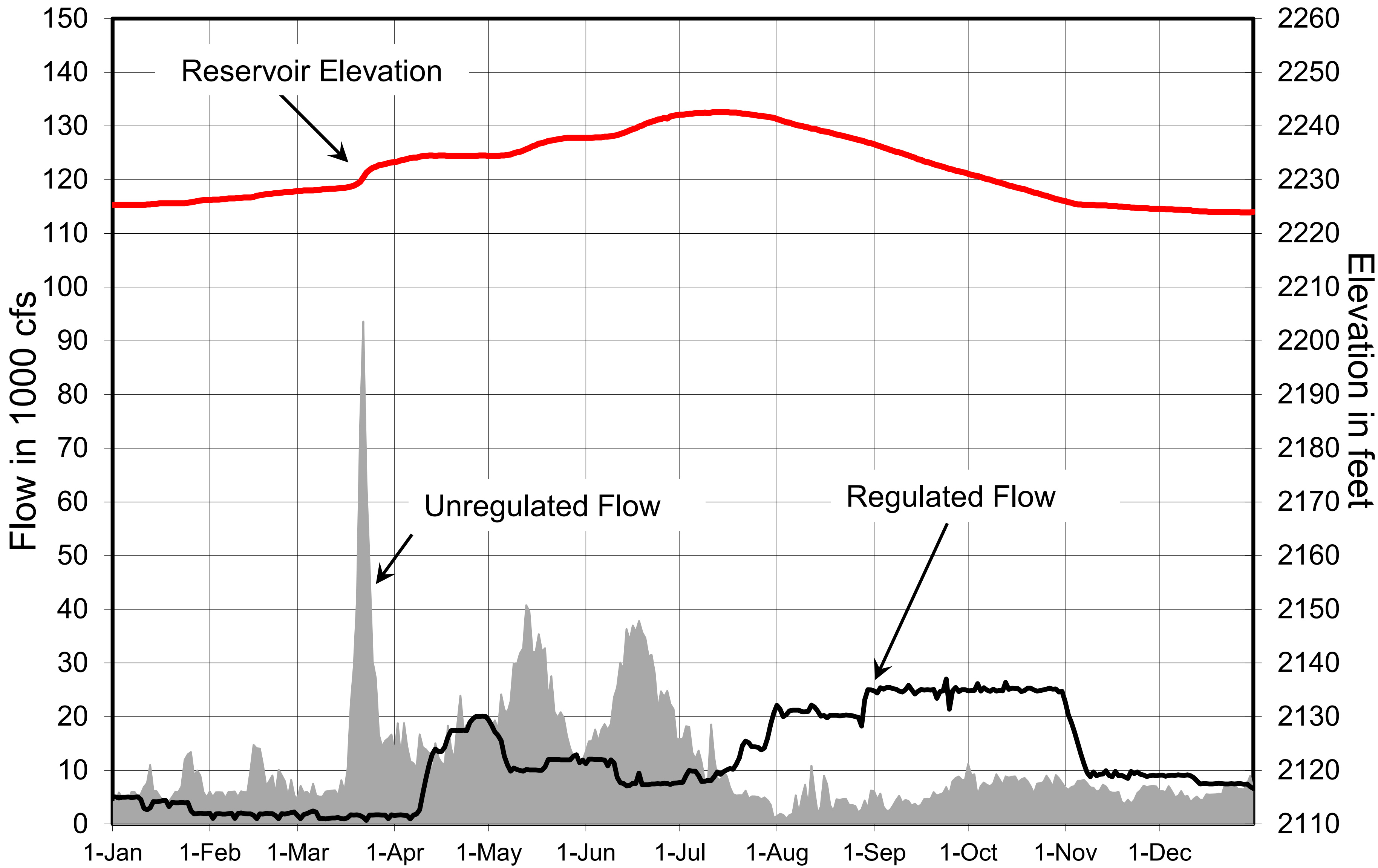
September 2017



Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1947

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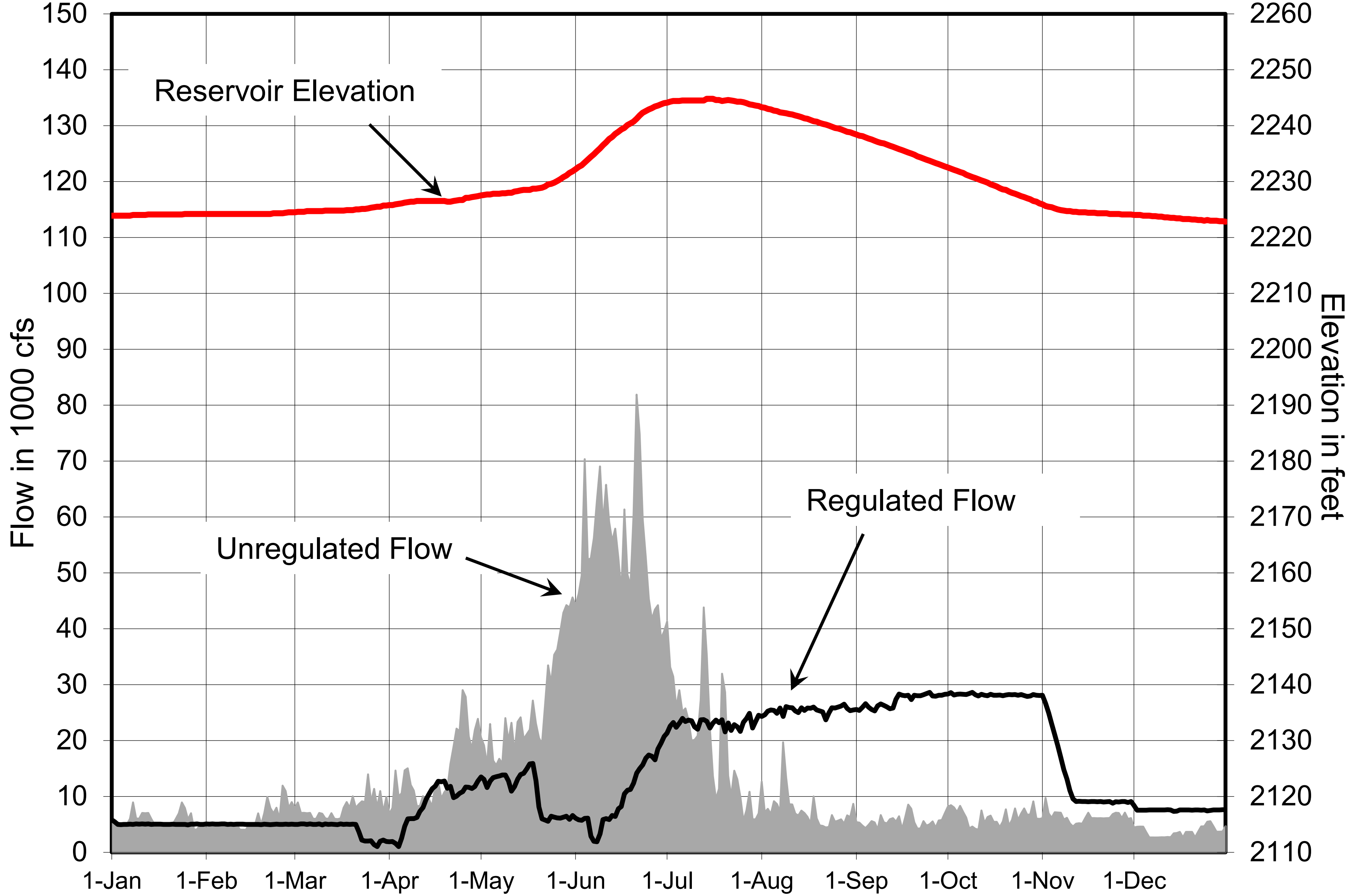

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1948

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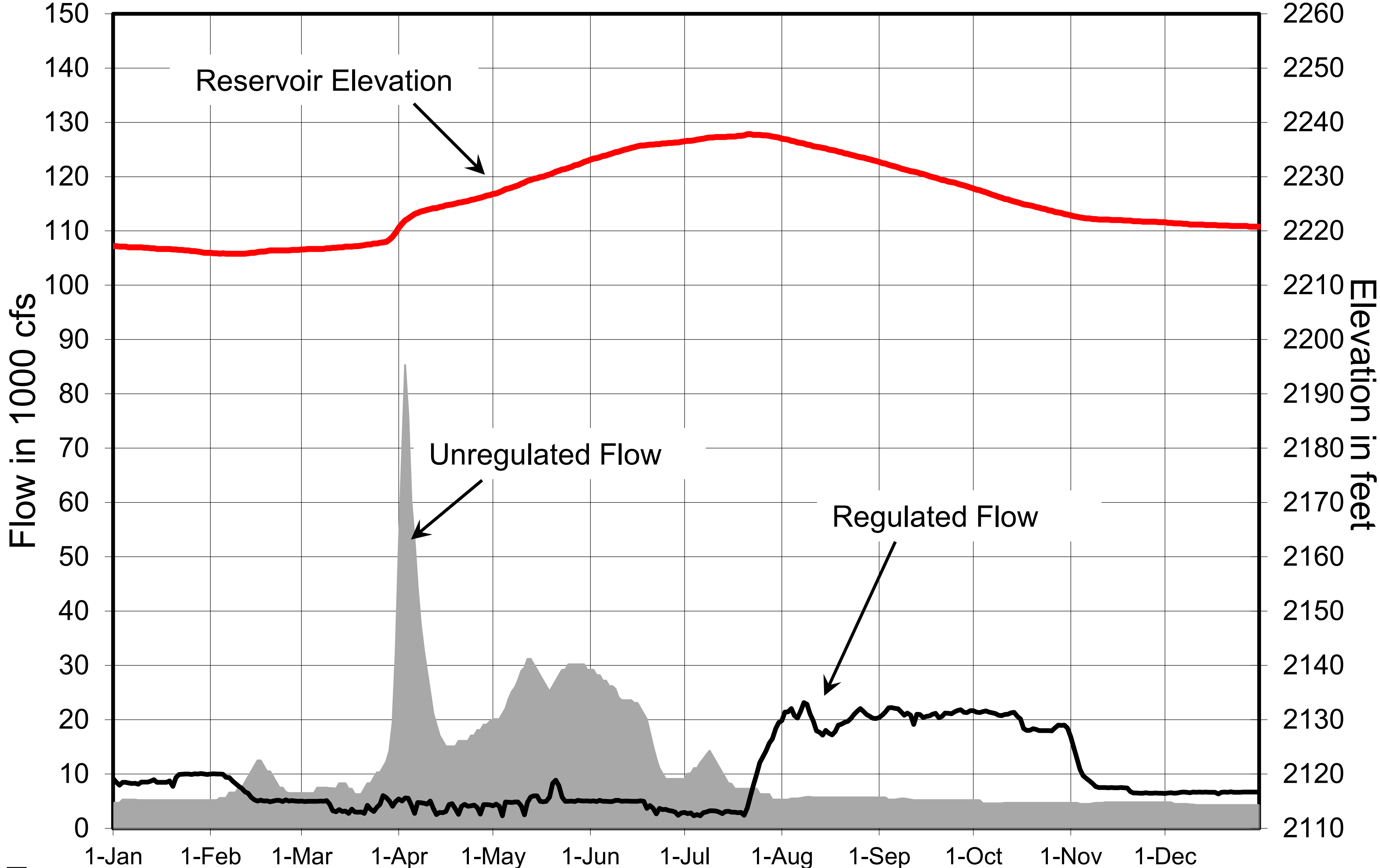

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1952
U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
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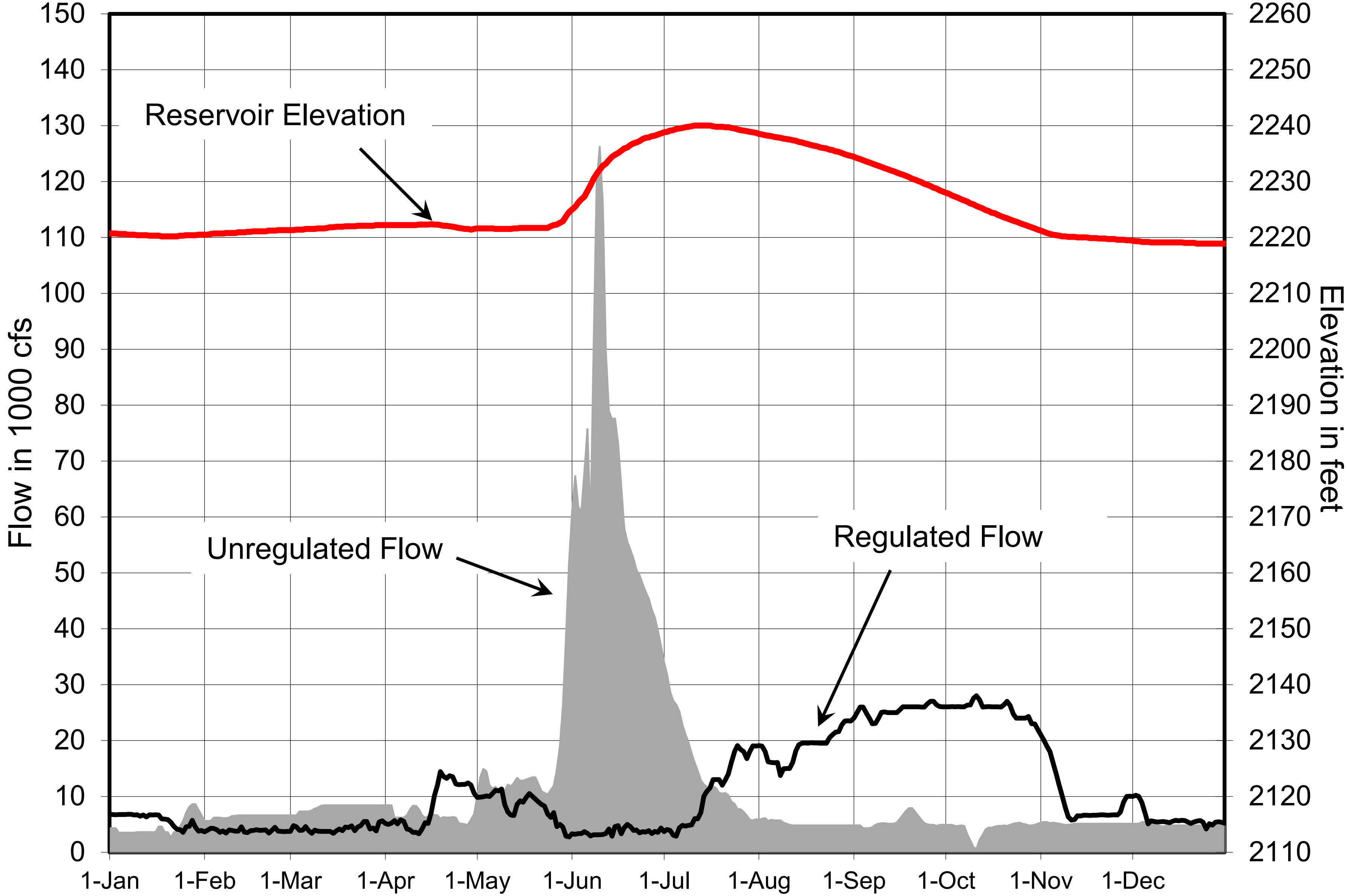

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1953

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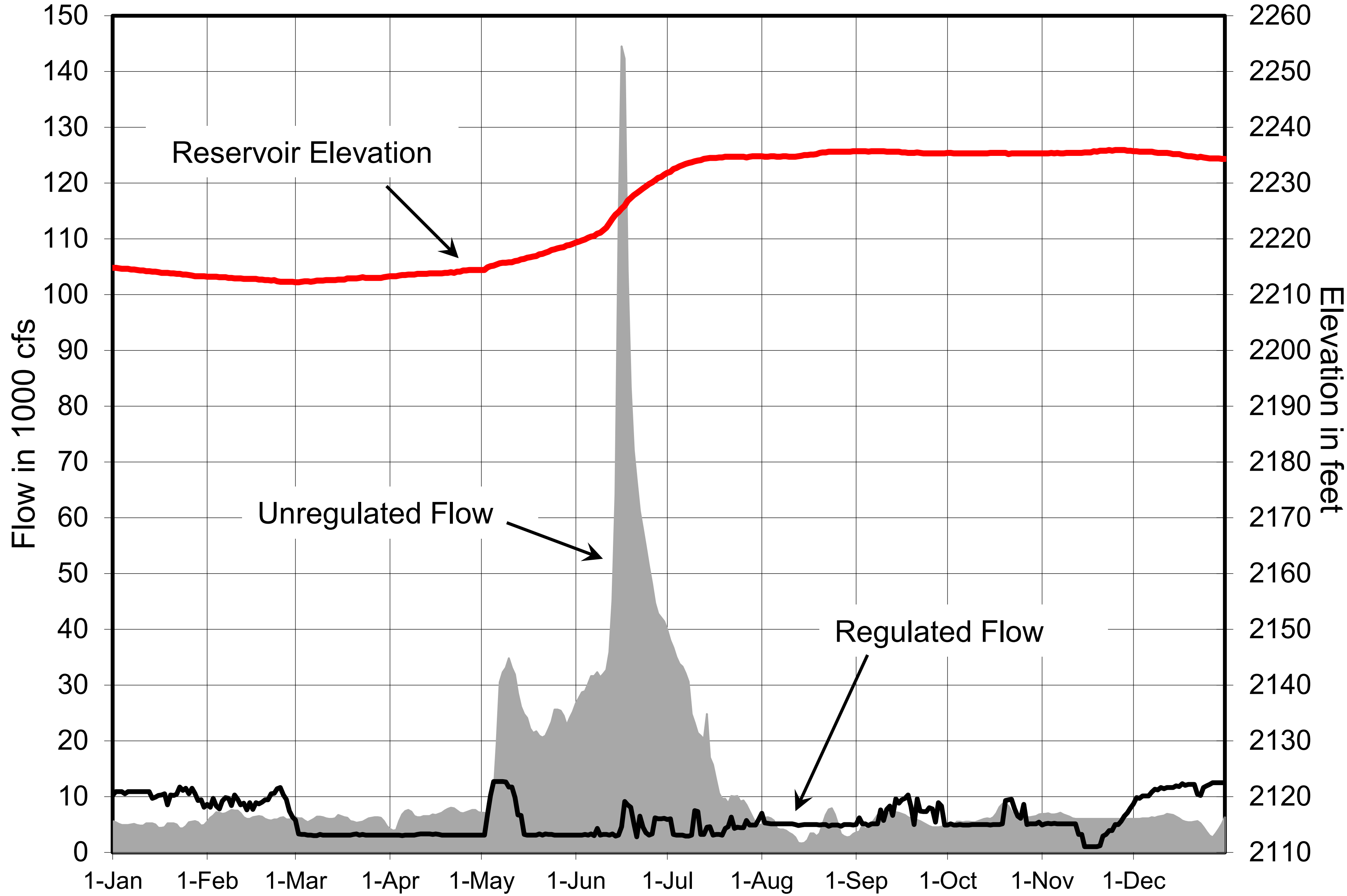

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1964

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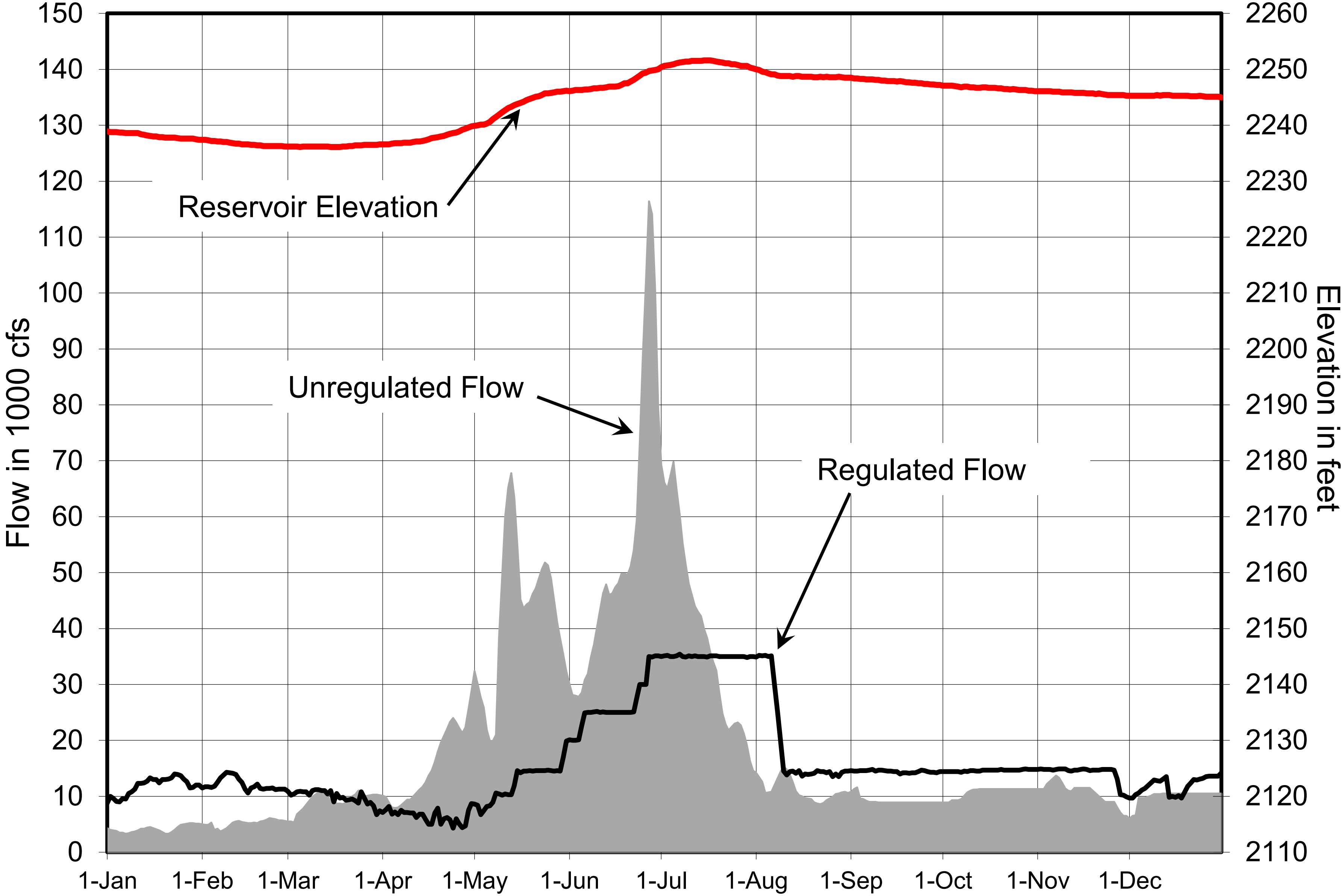

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1975

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CORPS OF ENGINEERS, OMAHA, NEBRASKA
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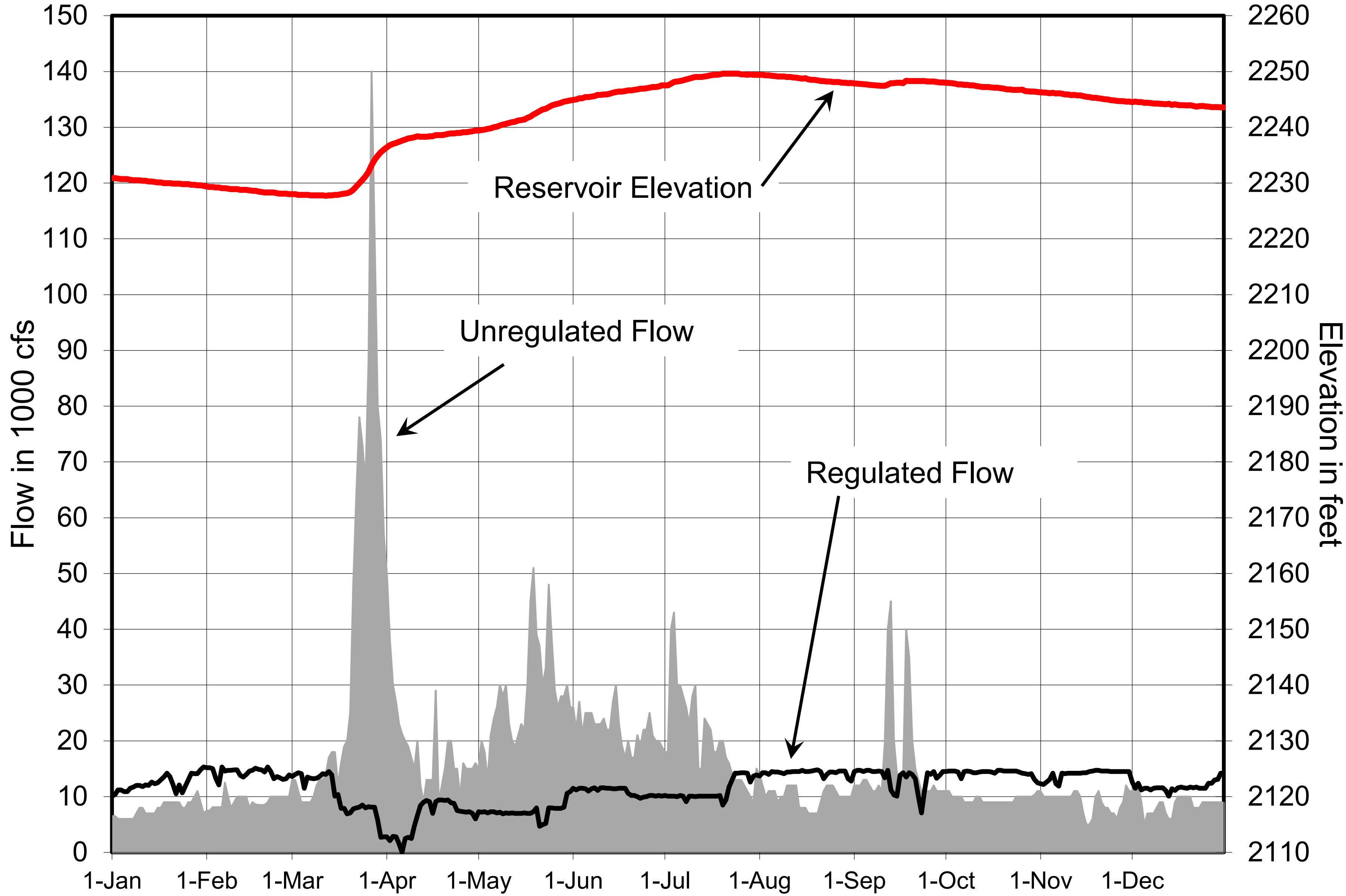

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1978
U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
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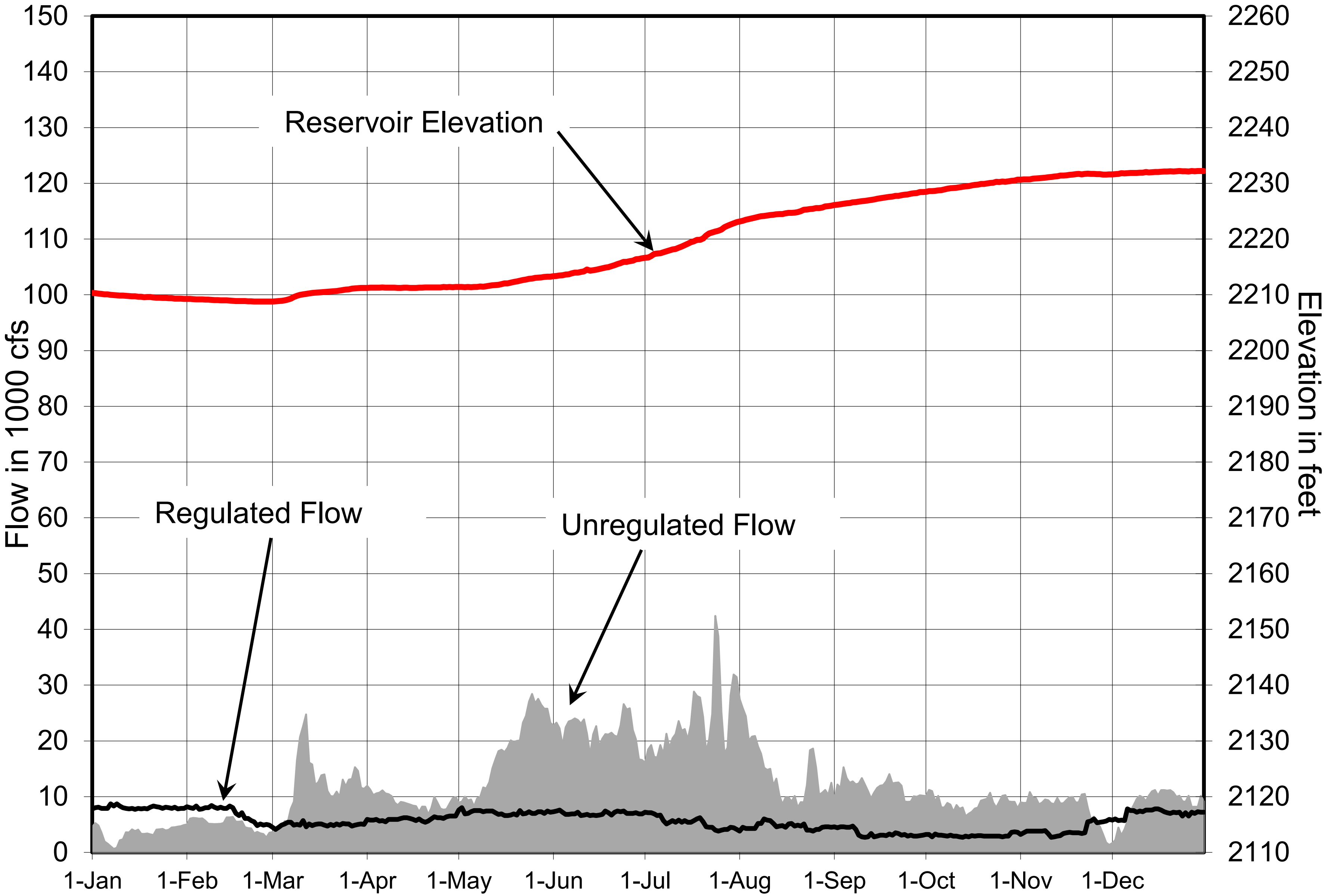

Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1993
U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
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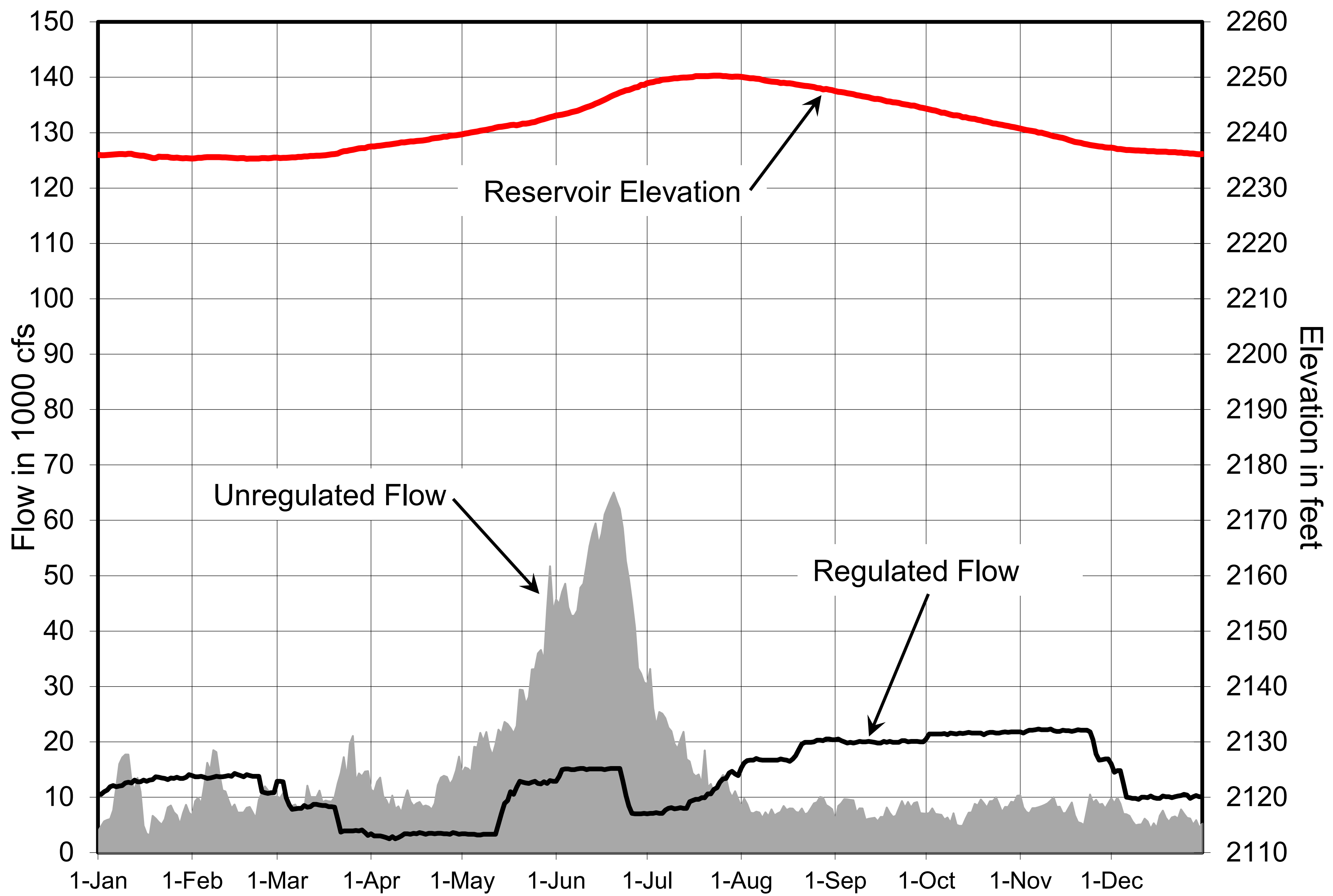
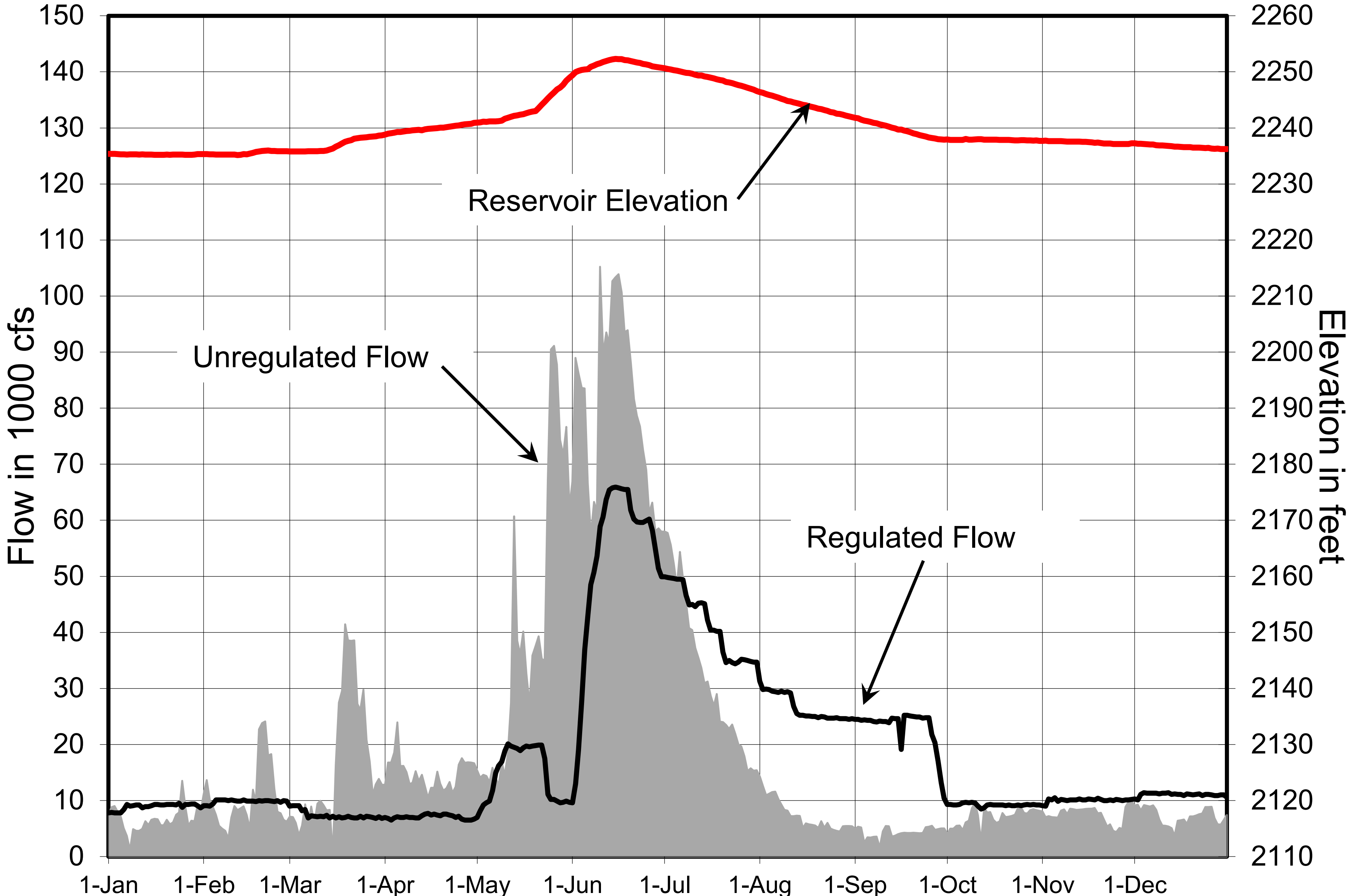
September 2017



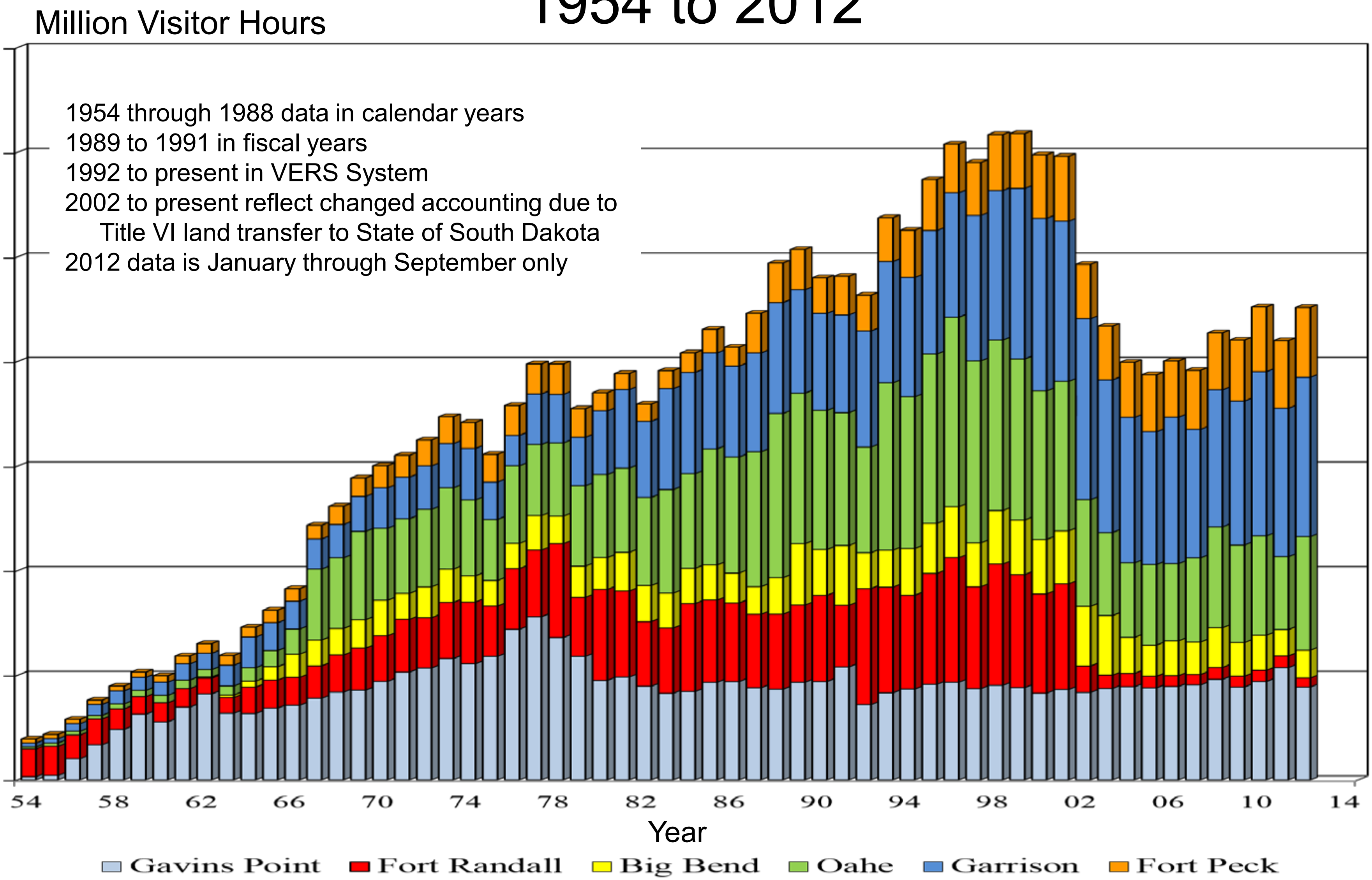
Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 1997

U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017



Missouri River Basin
Fort Peck Water Control Manual
Reservoir Elevation, Regulated and Unregulated Flows, 2011
U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017

Mainstem Project Visits
1954 to 2012



Missouri River Basin
Fort Peck Water Control Manual
Mainstem Project Visitor Hours

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
September 2017