Master Water Control Manual – Revised March 2006

Remove the pages or plate specified in column 1 in the March 2004 manual and replace with the pages or plate in column 2 in the table below to make your manual current with the March 2006 Master Manual.

Remove Old Pages or Plates	**Insert New Pages or Plates**	**Description of Change**
Cover	Cover	Revised March 2006
Index pages iii-xi	Index pages iii-xi	Updated
Chapter 7 pages: VII-11&VII-12, VII-53&VII-54	VII-11 & V11-12 VII-53 & VII-54	Text correction line12 pageVII-11,Text Correction Line 10 page VII-12 Sentenced added last paragph. Pge 53
Appendix A: pages A1-A2	Revised Appendix Pages A1-A2, A35-A44	Drought History Added
Appendix I: pages I1-I6	Revised Appendix I Pages I1- I12	Spring Pulse description and criteria included
Plate II-13	Revised Plate II-13	Updated to reflect final study
Plate II-17	Revised Plate II-17	Updated to reflect final study
Plate II-23	Revised Plate II-23	Change on title block
Plate II-27	Revised Plate II-27	Updated to reflect final study
Plate II-31	Revised Plate II-31	Updated to reflect final study
Plate II-40	Revised Plate II-40	Updated to reflect final study
Plate II-44	Revised Plate II-44	Updated to reflect final study
Plate II-52	Revised Plate II-52	Updated to reflect final study
Plate II-56	Revised Plate II-56	Updated to reflect final study
Plate II-65	Revised Plate II-65	Updated to reflect final study
Plate II-69	Revised Plate II-69	Updated to reflect final study
Plate II-77	Revised Plate II-77	Updated to reflect final study
Plate II-81	Revised Plate II-81	Updated to reflect final study
Plate III-25	Revised Plate III-25	Fixed x-y axis labels
Plate III-26	Revised Plate III-26	Fixed x-y axis labels
Plate III-27	Revised Plate III-27	Fixed x-y axis labels
Plate V-4	Revised Plate V-4	Change on title block
Plate VI-1	Revised Plate VI-1	Lower gridlines repositioned
	New Plate A-3	Additional Plate
Plate B-1	Revised Plate B-1	Updated to 2004 Data

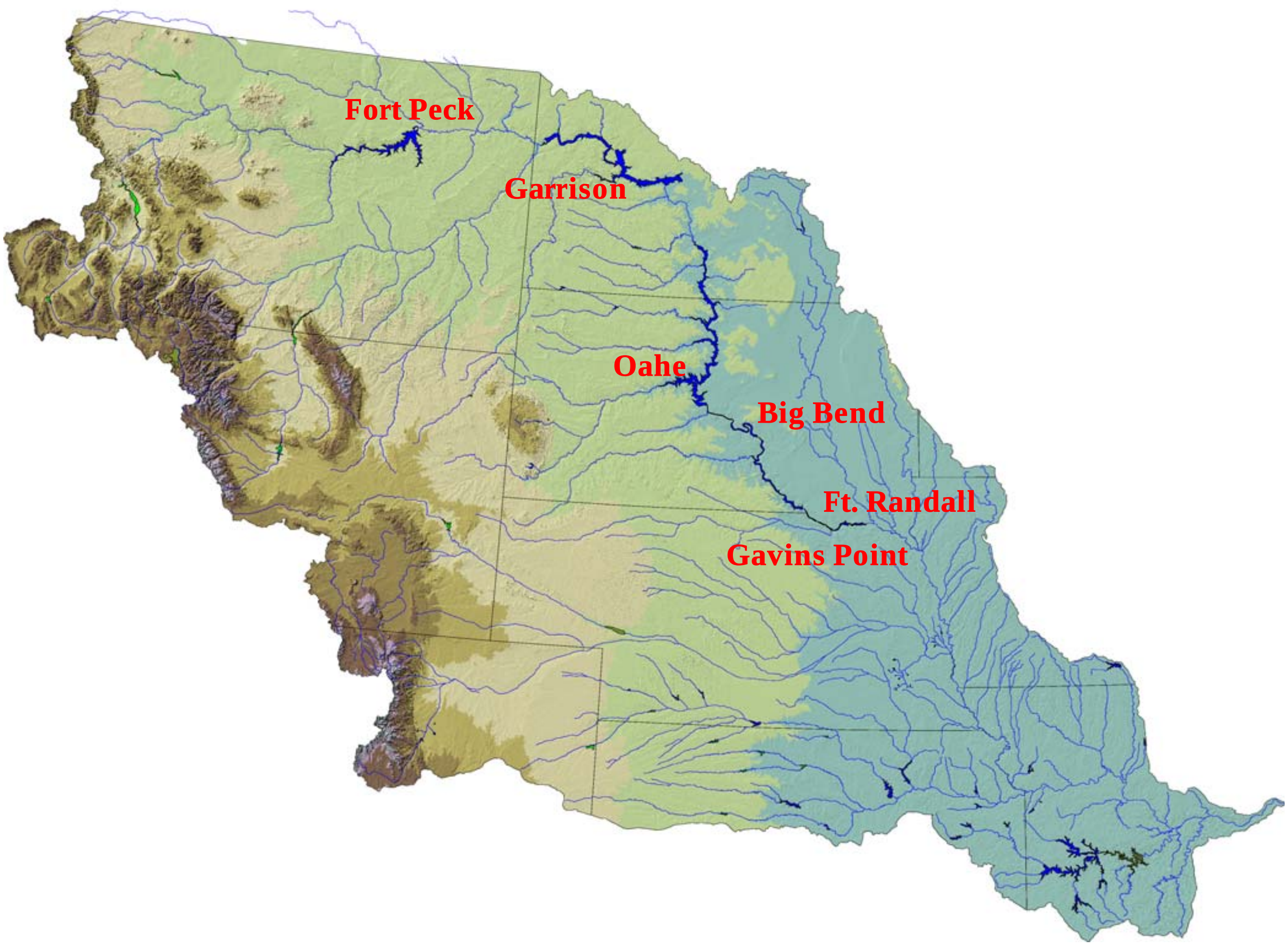
US Army Corps
of Engineers

Northwestern Division

Missouri River Mainstem Reservoir System

Master Water Control Manual

Missouri River Basin



Reservoir Control Center
U. S. Army Corps of Engineers
Northwestern Division - Missouri River Basin
Omaha, Nebraska

Revised March 2006

APPENDICES

TABLES

PLATES

ABBREVIATIONS

AOP	-	annual operating plan
ARPA	-	Archaeological Resources Protection Act
ac.ft.	-	acre-feet
AF	-	acre-feet
B	-	Billion
BIA	-	Bureau of Indian Affairs
BiOp	-	November 2000 U.S. Fish and Wildlife Service Biological Opinion
BSNP	-	Missouri River Bank Stabilization and Navigation Project
cfs	-	cubic feet per second
COOP	-	Continuity of Operations Plan
CO-OP)	-	cooperative stream-gaging program
Corps	-	Corps of Engineers
COE	-	Corps of Engineers
con't	-	continued
CRREL	-	Corps' Cold Regions Research and Engineering Laboratory
CSU/DSU	-	Channel Service Unit/Data Service Unit
CY	-	calendar year (January 1 to December 31)
CWCP	-	current water control plan
CWMS	-	Corps' Water Management System
DCP	-	Data Collection Platform
DOMSAT	-	DOMestic SATellite
DRGS	-	Direct Readout Ground Station
DRM	-	Daily Routing Model
DSS	-	HEC-Data Storage System
EIS	-	Environmental Impact Statement
elev	-	elevation
EPA	-	Environmental Protection Agency
EMWIN	-	Emergency Managers Weather Information Network
ERDC	-	Corps' Engineering Research and Development Center
EOC	-	Emergency Operations Center
ESA	-	Endangered Species Act
F	-	Fahrenheit
FEIS	-	Missouri River Master Water Control Manual Final Environmental Impact Statement
FEMA	-	Federal Emergency Management Agency
FIS	-	Flood Insurance Study
FPC	-	Federal Power Commission
ft	-	feet
FUI	-	Forecasted Ungaged Inflow
GIS	-	Geographic Information System
GOES	-	Geostationary Orbiting Environmental Satellite
GSA	-	General Service Administration
GWh	-	gigawatt hour
HEC	-	Corps' Hydrologic Engineering Center

in the System to extend availability of water-in-storage in the case of an extended drought. The specific technical criteria for season length are shown in Table VII-3. Straight-line interpolation between 51.5 and 46.8 MAF of water-in-storage on July 1 provides the closure date for a season length between 8 and 7 months. If System water-in-storage on July 1 is between 46.8 and 41.0 MAF, a 7-month navigation season is provided. A straight-line interpolation is again used between 41.0 and 36.5 MAF, providing season lengths between 7 and 6 months. For System water-in-storage on July 1 below 36.5 MAF, a 6-month season is provided.

Table VII-3
Relation of System Storage to Season Length

Date	System Storage (MAF)	Season Closure Date at Mouth of the Missouri River
March 15	31.0 or less	no season
July 1	51.5 or more	December 1 – 8-month season
July 1	46.8 through 41.0	November 1 – 7-month season
July 1	36.5 or less	October 1 – 6-month season

7-03.4.1. **Season Opening and Closing Dates**. Navigation on the Missouri River is limited to the normal ice-free season, with a full-length flow support season of 8 months. Successful commercial navigation on the Missouri River from Sioux City to the mouth is dependent upon low-flow supplementation from the System, with occasional assistance from tributary reservoirs authorized to support Missouri River navigation. Navigation is limited to the ice-free season and, based on historical records of ice formation on the Missouri River together with experience gained in System regulation to date, the opening and closing dates of a normal 8-month navigation season have been scheduled as follows:

	Opening Date	Closing Date
Sioux City	March 23	November 22
Omaha	March 25	November 24
Kansas City	March 28	November 27
Mouth	April 1	December 1

In some years, ice conditions will undoubtedly delay the opening of the season and in others may force an early end to the season.

7-03.4.2. Fall extensions of the season beyond the normal 8-month length will normally be scheduled (ice conditions permitting) in years with above-normal water supply and when such extensions will not result in a drawdown into the System’s Carryover Multiple Use Zone. Based on experience to date, these season extensions will normally be limited to 10 days beyond the normal closure date, resulting in a season closing on December 11 at the mouth of the Missouri River. In addition to enhancing navigation and water supply, the 10-day extension of the navigation season also enhances hydropower production by transferring an additional block of power from the normal navigation season to the more critical (for power purposes) winter season.

7-03.5. **System Seasonal Considerations.** For a portion of some years, deviations may be made from the above stated specific technical criteria to achieve the operational objectives of the CWCP or to comply with other statutory or regulatory obligations such as the ESA. In such circumstances, the AOP will explain the deviation from the specific technical criteria and the rationale for that deviation related to the operational objectives of the CWCP or applicable statutory and regulatory requirements. Other seasonal considerations and the corresponding reservoir regulation are further discussed elsewhere, as appropriate, in this Master Manual.

7-03.5.1. **System Winter Release Determination.** Another seasonal consideration is regulation in the wintertime period, which extends from December through February, to support the Congressionally authorized project purposes of hydropower production and downstream water supply and water quality. The specific technical criteria for Gavins Point Dam winter release rate is shown in Table VII-4. The System water-in-storage check for System winter release is taken on September 1 of each year.

Table VII-4
Relation of System Winter Release Level to System Storage

September 1 System Storage in MAF	Average Winter Release from Gavins Point in cfs
58.0 or more	17,000 cfs
55.0 or less	12,000 cfs

7-03.5.2. A modification to the winter release rate from Gavins Point Dam generally occurs when the evacuation of System flood control storage cannot be accomplished by providing a full-service navigation season with a 10-day extension of the navigation season. With an excess annual water supply, the winter season Gavins Point release will be scheduled at a rate of up to 25,000 cfs to continue to evacuate the remaining excess water in System flood control storage. When extremely high runoff has not been previously evacuated due to downstream flood control regulation, consideration will be given to scheduling winter releases in the 25,000 to 30,000 cfs range to accomplish the flood control objective of evacuating the Annual Carryover and Multiple Use Zone prior to the beginning of the next flood season.

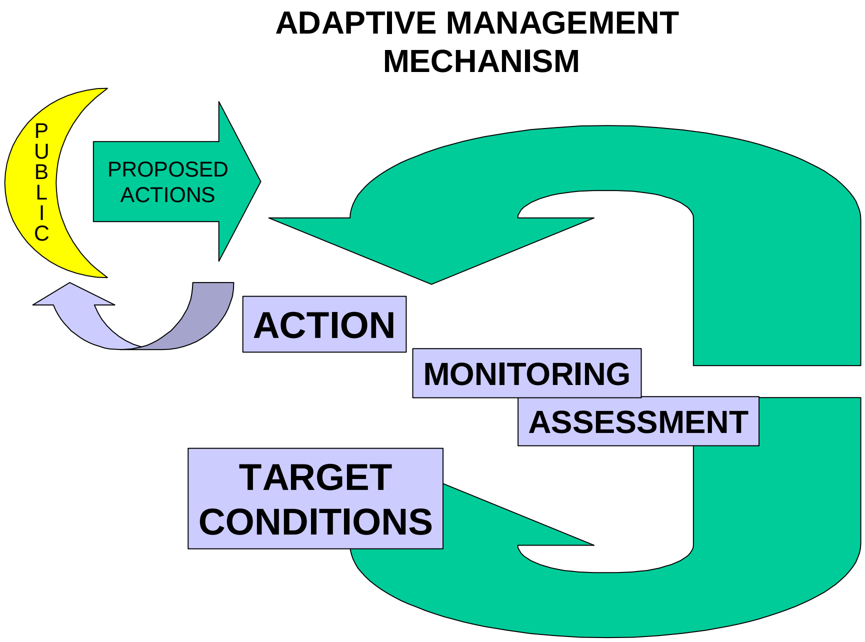
7-03.6. **Integration of Downstream Requirements.** Gavins Point Dam releases are regulated to provide service to all multiple-use purposes, while at the same time recognizing the important flood control function of the System. In years of excess water supply, Gavins Point Dam releases in excess of full-service requirements may be necessary to evacuate flood control storage space. In recognition that these higher-than-normal releases can have an adverse effect on downstream floods, should unexpected rainfall occur, the higher releases should be made, to the extent possible, when floods from downstream tributaries are less likely. Also, the magnitude of these releases during the open-water season can be reduced somewhat by scheduling winter releases at a higher rate than would be the case with a normal water supply. While this may have the effect of slightly increasing the flood risk during the winter months, it reduces the flood risk during the open-water season when the flood potential is greatest. In addition, it may also increase the service provided to the power and navigation purposes by

Guard coordinate this closing and reopening so that significant impacts can be minimized both to the levee system and to the navigation industry. During both the 1987-93 drought and the current drought, navigators experienced hardships and lost revenues due to both reduced Gavins Point Dam releases and shortened navigation seasons, including disruptions caused by court-ordered actions and threatened and endangered species operations. Table G-3 provides the season lengths and tonnage on the Missouri River since the System filled in 1967.

7-14. **Adaptive Management.** The Corps has implemented some System regulation changes via an Adaptive Management process for many years. The Corps, in implementing the CWCP described in this manual, will continue the use of the Adaptive Management process. Adaptive Management is not a new concept; but rather, commonly used throughout the world to help shape resource management decisions, policies, and approaches. The process involves recognition that all is not known about the impacts, both positive and negative, of changes in System regulation. It also recognizes the likelihood that physical conditions may change in the future, and allows flexibility to meet the challenges of those changed conditions. For example, the database of information on the complete life cycles and behaviors of the threatened and endangered species or their requisite habitat needs throughout their life cycles grows constantly. Adaptive Management is an overall strategy for dealing with change and scientific uncertainty. It promotes an environment that allows testing of hypotheses and pursuit of promising change based on sound scientific data and analyses followed by critical monitoring and evaluation.

7-14.1. 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 threatened and endangered 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, Endangered Species Act and the Flood Control Act of 1944. Adaptive management measures implemented as part of the water control plan are described and explained in Appendix I.

7-14.2. **Adaptive Management Process Diagram.** A conceptual diagram of an Adaptive Management strategy is provided below.



7-15. **Drought Contingency Plan.** Regulation of the System during drought was a significant consideration in the development of this CWCP. The System is the largest reservoir system in the United States serving all authorized project purposes during an extended drought like the 1930's was part of the original objectives of the System. This resulted in the construction of the System with an enormous amount of water normally retained in System storage in anticipation of the onset of extended drought. For this reason, the three upper reservoirs are extremely large compared to other Corps reservoirs, which makes the System so unique. The System was designed to use this stored water during extended drought periods to meet a diminished level of service to all Congressionally authorized purposes except flood control. As such, no separate Drought Contingency Plan is needed or required for the System, as it is included as part of the CWCP presented in this Master Manual.

7-16. **Flood Emergency Action Plans.** The Omaha District is responsible for the development of Flood Emergency Action Plans for the System. The Omaha District has developed a Contingency Plan for Emergencies for each of the System dams, and these plans are presented as Appendix E of the Operations and Maintenance Manuals for each System project. The action plans were all developed for individual projects and were last updated in 1984. These action plans are available to the RCC and project staff for use should a catastrophic failure be imminent or occur. These action plans are contained in large documents and, as such, are not provided as part of this Master Manual. In addition, the Omaha District has conducted full Emergency Dam Safety Exercises involving all of the larger System dams with expected emergency management partners. The RCC was a participant in these exercises and provided modeling support for System regulation during the exercises. The Fort Peck Dam Safety Exercise was conducted in July 1985, and it simulated an earthquake-related event that involved Federal, State, and local participation. The Garrison Dam Safety Exercise was conducted in August 1987, and it was a

Appendix A – Extreme Events – Historic Floods and Droughts with Regulation Examples

A-01. **Introduction.** This appendix contains information related to the major historic floods and droughts in the Missouri River basin. These examples include historic floods and droughts that occurred prior to the construction of the System and since the System was first filled in 1967. Examples of actual historic System regulation for flood control are provided along with a discussion of anticipated flood control regulation for a hypothetical event. A summary of the historic sizing of the System storage zones is also presented. A discussion of regulation during past droughts including those that have occurred since 1967, are included in this appendix.

A-02. **Historic Major Basin Floods Prior to System Regulation.** This section of this appendix summarizes information on the major floods that occurred on the Missouri River prior to System construction. The earliest major flood with information for water management analysis is the flood of 1844. Flood data on this flood and major floods up to the flood of 1960 are discussed in this section.

A-02.1. **Flood of 1844.** This flood, of near legendary proportions, is generally considered to be the greatest known flood in the lower Missouri River basin. From stage records at Kansas City and St. Louis, Missouri, high water marks at Manhattan and Topeka, Kansas and Boonville and Hermann, Missouri, and the precipitation records at Ft. Leavenworth and Ft. Scott in Kansas and Jefferson Barracks in St. Louis, the flood has been traced, and the events leading up to it, have been reconstructed. These events do not differ from those that are recognized today as being conducive to major lower Missouri River basin flooding and include prolonged periods of antecedent rainfall saturating the basin followed by sequential bursts of intense storm rainfall. From May 10 to June 6, 1844, Ft. Leavenworth had 5.77 inches of rainfall and Ft. Scott had 14.34 inches. The normal precipitation for that time period and location is 4.5 inches. This antecedent rainfall apparently saturated the Kansas River basin sufficiently that most of the 4 to 8 inches of additional rainfall that fell in numerous bursts from June 7 through 14 likely became direct runoff. Actual river stages and discharge measurements are not available for this historical event, but the maximum stages and discharges, shown on Table A-1, are believed to be reasonable estimates and have been accepted by most hydrologic investigators. Some evidence exists to indicate that the basin above the System reservoirs probably contributed only a relatively small amount to the 1844 crest flow at St. Joseph, Missouri. A Missouri River down-bound French steamboat captain reported grounding difficulties in the Dakotas with no report of high water until he saw the evidences of a great flood below the mouth of the Platte River. Further mention of a large contribution from the Platte River that year was provided by a wagon train heading west on the Oregon Trail, which reported in its journals a delay while awaiting the passage of a great flood before fording the Platte River.

A-02.2. **Floods of 1881.** The floods of March through April 1881 include the second greatest flood of record on the Missouri River in the Dakotas, and the “June rise” in 1881 was one of the largest of the late spring rises. The flood year of 1881 had the greatest total cumulative runoff volume of record on the Missouri River between Bismarck, North Dakota, and St. Joseph, Missouri. Following a wet year in 1880, the winter of 1880-81 experienced much-below-normal temperatures accompanied by very heavy snows. This resulted in the heaviest known snow blanket on the plains area by the spring of 1881. Spring thaws and ice breakup began in the

Table A-1
Crest Stage and Discharge Data for Major Floods

Station	Miles Above Mouth	Flood Stage (feet)	1952 Floods			1951 Floods			1943 Floods			1903 Flood			1881 Flood			1844 Flood			Highest of Record		
			Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge (cfs)
Williston	1650.2	20	Apr 1	17.8	170,000	Apr 8	16.8	110,000	Mar 28	19.8											Mar 28, 1943	19.8	
									Mar 30	-	204,000										Apr 4, 1930	-	231,000
Elbowoods (a)	1504.0	17	Apr 5	25.2	360,000	Apr 6	16.0		Mar 31	21.1	241,000										Apr 5, 1952	25.2	360,000
						Apr 11	-	94,000															
Garrison (b)	1455.0	1690	Apr 5	1701.6	348,000	Apr 7	1693.6	130,000	Apr	1696.3											Mar 27, 1947	1704.0	
																					Apr 15, 1952		348,000
Bismarck	1377.8	19	Apr 6	27.9	500,000	Apr 4	16.3		Apr 1	22.7					Mar 30	31.6					Mar 30, 1881	31.6	
						Apr 5		130,000	Apr 3	-	282,000										Apr 6, 1952		500,000
Mobridge	1250.6	16	Apr 9	25.1	435,000	Apr 4	14.8	195,000	Mar 28	19.6											Apr 9, 1952	25.1	435,000
									Apr 5	-	282,000												
Pierre	1117.6	15	Apr 10	25.4	440,000	Apr 8	12.3	127,000	Apr 6	19.6	281,000	Jun 25	9.8		Apr	23.0	259,000 (f)				Apr 10, 1952	25.4	440,000
Chamberlain	1012.9	18	Apr 11	25.6	440,000	Apr 8	11.5	113,000	Apr 7	19.3	(e)										Apr 11, 1952	25.6	440,000
Ft Randall (b)	922.0	1250	Apr 12	1258.9	447,000	Apr 8	1246.3	134,000	Apr 8	1252.6											Apr 12, 1952	1258.9	447,000
Yankton	840.4	12	Apr 13,14	15.5	480,000	Mar 28	11.9	134,000	Apr 9	13.6					Apr 5	30.5					Apr 5, 1881	30.5	
									Apr 8	-	282,000										Apr 13,14 1952		480,000
Sioux City	760.0	16	Apr 14	24.3	441,000	Apr 8	13.0	152,000	Apr 10	18.7	212,000	Jul 10,11	12.3		Apr 23	22.5	362,000 (f)				Apr 14, 1952	24.3	441,000
Decatur (b)	715.7		Apr 15	23.3	(e)	Apr 9	16.6	(e)	Apr 11	20.5	(e)										Apr 15, 1952	23.3	
Blair	670.4	19	Apr 17	23.5	(e)	Apr 12	19.0	(e)	Apr 12	21.4	(e)				Apr 24	19.7					Apr 17, 1952	23.5	
Omaha	632.0	19	Apr 18	30.2	396,000	Apr 11	18.2	152,000	Apr 13	22.4	-	Jun 1	14.4		Apr 25	24.6	370,000(f)				Apr 18, 1952	30.2	396,000
									Apr 12	-	200,000												
Plattsmouth (b)	607.5	952.5	Apr 18	961.4	(e)	Apr 11,12	954.5	(e)	Apr 14	957.6	(e)	Jun 1	11.2		Apr 25	957.9					Apr 18, 1952	961.4	
Nebraska City	579.3	18	Apr 18	27.7	414,000	Jun 2	18.5		Apr 14	19.9	181,000				Apr 27	18.1	380,000(f)				Apr 18, 1952	27.7	414,000
						Mar 29		163,000															
Brownville (b)	552.0	15	Apr 17	29.8	(e)	Jun 3	21.5	(e)	Apr 16	19.9	(e)										Apr 17, 1952	29.8	
Rulo	514.4	17	Apr 22	25.6	358,000	Jun 3	21.0	175,000	Apr 17	20.2	(e)										Apr 22, 1952	25.6	358,000
St. Joseph	460.3	17	Apr 22	26.8	397,000	May 3	19.9	198,000	Jun 18	18.5		Jun 2	20.5	252,000(c)	Apr 29	27.2	370,000	Jun	24.5	350,000(e)	Apr 29, 1881	27.2	
									Apr 18	-	154,000										Apr 22, 1952		397,000
Leavenworth (b)	408.2	19	Apr 23	27.6	(e)	Jul 8	20.8	(e)	Jun 19	23.1	(e)				Apr 30	23.1					Apr 23, 1952	27.6	
Kansas City	377.5	22	Apr 24	30.6	400,000	Jul 14	36.2	573,000	Jun 19	29.1		Jun 2	35.0	548,000(c)	Apr 30	27.8	373,000	Jun 16	38.0	625,000(e)	Jun 16, 1844	38.0	625,000 (c)
									Jun 18		336,000												
Napoleon (b)	332.4	17	Apr 24	24.6	(e)	Jul 14	26.8	(e)	Jun 19	22.4	(e)										Jul 14, 1951	26.8	
Waverly	297.2	18	Apr 24	28.1	369,000	Jul 14	28.2		Jun 18	24.4											Jul 14, 1951	28.2	
						Jul 16		549,000	Jun 19	-	310,000										Jul 16, 1951		549,000
Glasgow (b)	226.8	25	Apr 27	32.1	358,000	Jul 17	36.7	550,000	Jun 21	33.3	(e)	Jun 5	32.7(c)		May 3	28.2(c)					Jul 17, 1951	36.7	550,000
Boonville	196.7	21	Apr 27	27.7	360,000	Jul 17	32.8	550,000	Jun 22	28.8	366,000	Jun 6	30.9	612,000(c)	May 3	23.3		Jun 21	32.7	710,000 (c)	Jul 17, 1951	32.8	
																					Jun 21, 1844		710,000 (c)
Jefferson City (b)	143.0	23	Apr 27	26.1	(e)	Jul 18	34.2	(e)	Jun 23	30.1	(e)	Jun 6	33.5		May 4	26.3(c)					Jul 18, 1951	34.2	
Gasconade (b)	103.9	22	Apr 27,28	29.2	(e)	Jul 19	35.4	(e)	May 21	34.2	(e)										Jul 19, 1951	35.4	
Hermann	96.9	21	Apr 28	27.1	368,000	Jul 19	33.3	618,000	May 21	31.1	550,000	Jun 6,7	29.5	676,000(d)	May 4	23.7		Jun	35.6	892,000(d)	Jun 1844	35.6	892,000(d)
Washington (b)	66.8	20	Apr 28	24.4	(e)	Jul 19	31.0	(e)	May 22	28.6	(e)										Jul 19, 1951	31.0	
St. Charles	28.1	25	Apr 29	31.8	(e)	Jul 20	37.3	(e)	May 22	36.6	(e)	Jun 8	36.8	730,000 (c)	May 5	31.6		Jun 27	40.1	900,000 (c)	Jun 27, 1844	40.1	900,000 (c)

Note: Stages are from gage readings reported by the U.S.W.B unless otherwise noted. Discharge values are those reported or published by the U.S.G.S. unless otherwise noted. Discharge values are given for the flood of 1903, 1881 and 1844 where such estimates are available.

(a) U.S.G.S. gage (b) Corps gage (c) Data from 308 Report (d) Estimated by Kansas City District (e) Stage only station (f) Estimated by Omaha District

A-07. **Historic Missouri River Basin Droughts.** A drought, for the purposes of this discussion, is defined as those years when less than median runoff occurs for 3 or more consecutive calendar years. There is no question that the System regulation associated with drought is the most challenging. All Congressionally authorized project purposes except flood control are negatively affected during significant drought, and the negative impacts are generally less localized. Also the drought and the resultant water conservation that comes with it persists for years at a time, unlike the annual evacuation of flood, which compounds and amplifies negative impacts. An examination of the period of record from 1898 to present of annual runoff above Sioux City, Iowa (approximates inflow to the System), indicates significant drought is somewhat rare, as shown on Plate A-3. Plate A-3 displays the annual runoff in million acre feet (MAF) with a vertical bar for each year. These data are adjusted to a consistent depletion level that occurred in 1949 before most of the major water resources were developed in the Missouri River basin. The drought periods, per the definition discussed above, are represented in Plate A-3 as yellow bars. The System was constructed during the 1950's and early 1960's and first filled in 1967, but, as is shown in Plate A-3, three out of the four droughts in the historic record have directly impacted the storage in the System.

A-07.1.1. **Mega-drought.** The fact that the Missouri River basin experiences significant drought has been chronicled many times in its historic descriptions. Terms like the Great Desert, have been used historically to describe the diverse aspect of this semi-arid region. The term mega-drought is used in describing periods of drought that last for more than 20 years to centuries. Only in recent years has the full scope of mega-drought in this region been evaluated by climate researchers using scientific methods to verify the temporal and spatial extent of historic droughts.

A-07.1.1.1 Recently climate researchers have been examining the impacts of weather phenomena such as El Niño and La Niña on the United States climate, but these effects may pale in comparison to mega-droughts of the past. A drought in the 16th Century, according to the latest research, could have lasted over 40 years and been the worst in the last 800 years according to tree ring studies. Some drought researchers currently conclude that these types of extensive droughts are linked to ocean currents like those discussed above but on a much larger scale. Drought is currently the most severe type of natural disaster because of its large aerial extent and prolonged duration. Another research effort is ongoing to examine drought in the Sand Hills area of Nebraska, where past droughts have been so severe as to cause all vegetation to disappear and the area to turn to dust. Such a drought occurred in this area 800 to 900 years ago. An examination of this data leads to the conclusion that drought has been a part of the fabric of the Missouri River basin for hundreds of years.

A-07.1. **Historic Major Droughts Prior to System Regulation in 1967.** This section of this appendix discusses drought prior to the System being filled in 1967. An examination of Plate A-3 reveals there have been two documented droughts between 1898, when detailed basin runoff record keeping began, and 1967, when the System filled to normal levels. The first was the 12-year drought that extended from 1930 through 1941. The other significant drought is the 8-year drought that began in 1954 and ended in 1961. These two droughts are discussed below. Various indicators have identified the potential for droughts much greater than those that have been experienced since 1898.

A-07.1.2. **Drought of 1930-1941.** Since detailed record keeping began in 1898, the first major basin drought was the 12-year drought that extended from 1930 through 1941 (30's drought). It occurred during what is often labeled the Great Depression era of our country and caused the central plains to turn into what was termed the "dust bowl" Fort Peck, one of the three largest System reservoirs, was constructed during this period. The Great Depression and the drought of the 30's forced many farmers and businessmen to leave the Missouri River basin, never to return. During the decade spanning 1930-1939 Federal and State agencies poured more that $1,250,000,000 into the Missouri River basin for agricultural relief. Avoidance of the tremendous negative impacts of drought and floods was a primary consideration of Congress in the authorization of the construction of the System. System regulation during drought was an integral part of the original water control plan. The System as constructed has a great capacity to serve project purposes during droughts. The 30's drought was the most significant event in the basin hydrologic record at the time that the original water control plan was developed. The Corps designed the System and its storage zones discussed above in paragraphs A-06. through A-06.14 with the 30's drought in mind. The substantial Carry Over Multipurpose Zone was sized to provide continued support to project purposes during a drought similar to the 30's drought.

A-07.1.3. **Drought of 1954 - 1961.** Fort Peck filled to its normal operating pool level just after the 30's drought in May 1942. Construction of the remaining five dams began in 1946. The time to construct each project varied from 5 to 14 years, with the two large upstream projects requiring the longer time for construction. When completed, Garrison and Oahe Dams became the 4^{th} and 10^{th} largest earth-fill dams in the world. The second most significant drought in the past century in the Missouri River basin occurred during and immediately following the construction of the System when these projects were being filled to their normal operating pools levels. The drought began in 1954 just after Fort Randall and Garrison were closed and extended for 8 years, which was 2 years before the last System project, Big Bend, was closed in 1963. This drought delayed the filling of the System considerably and prompted a great amount of discussion and yearly System regulation plan changes to promote the filling of the System. Seventy-five million acre-feet of storage was available for multipurpose use when this System was completed, the largest such reservoir system in the United States. The System has the capacity to hold 3 years of the annual flow of the Missouri River at Sioux City, Iowa, which is just downstream of the System. It was not until the summer of 1967 that the carryover storage zone was fully filled.

A-07. 2. **Major Droughts since the System Filled in 1967.** This section of this appendix provides information on System regulation during the droughts that have occurred since the System filled in 1967. An examination of Plate A-3 reveals there have been two droughts since the System filled. The first was the drought from 1987 through 1992. This drought prompted a review of the System water control plan that ultimately resulted in a revision to the Master Water Control Manual in March 2004 to include more stringent water conservation measures. The other significant drought began in 2000 and is currently still occurring. These two droughts are discussed in detail below. System criteria that involve water conservation regulation are discussed first, however, in the following paragraphs.

A-07.2.1. **Water Conservation Measures**. The System is driven by basin runoff and the level to which Congressionally authorized project purposes can be served is very dependent on the amount and seasonal distribution of this of runoff. Because of this, water conservation measures are instituted during dry or drought periods to provide for saving, or conserving, of existing water in storage to allow service to project purposes during extended droughts. Generally, only near-normal or higher runoff can restore the System to its normal state after storage level are reduced due to drought. The results of System regulation during post 1967 drought periods are discussed below.

A-07.2.3. **Drought Period from 1987-1992.** The 1987-1992 drought was the first significant drought that occurred in the Missouri River basin since the System was filled in 1967. The runoffs for this 6-year drought period are shown in Table-A-14 . The second year of this drought (1988) was significant because of the very low runoff, only 12.4 MAF, the 4th lowest runoff year in 107 years of record keeping. This low runoff caused a significant reduction in System storage to occur and the upper three reservoir pool levels fell dramatically. The calendar year runoffs during the drought period are shown on Plate A-3 and in Table A-14.

A-07.2.3.1. The water conservation criteria presented in the previous Master Manual were in place during this drought but, some adjustments were made to that plan for changed circumstances that had occurred since that Manual was published. Generally, the System water conservation criteria of the previous Master Manual delayed implementation of conservation measures early in a drought as compared to the criteria presented in the current Master Manual. An important feature of both the previous and current water conservation criteria is that they are based on actual System storage checks, not forecast data.

A-07.2.4. **Detailed Regulation during the 1987-1992 drought period.** Regulation of the System during this drought is described below. Regulation for protected species began in 1986 and regulation for this purpose is therefore, also covered in the discussion.

A-07.2.4.1**. Drought year 1987**. Flow support started at full service on normal opening dates. Releases were cycled during a cut back period for downstream flood control in late May through early June to prevent T&E birds from nesting too low. The navigation season was of normal length, and full service flows were provided based on Master Manual criteria and storage checks. Gavins Point winter release was scheduled at 18,000 cfs, which was considered a normal winter release rate. Since this was the first year of a drought no water conservation measures occurred.

A-07.2.4.2. **Drought Year 1988**. Downstream flow support was provided on normal navigation season opening dates. The endangered species nesting occurred with a System release rate of 32,000 cfs (the highest release possible during the T&E nesting season without inundating nests). During late June and early July of 1988 this release combined with downstream tributary flows did not meet downstream flow targets. This continued because of the inability to increase System releases without inundating T&E species nests. Flows on the Missouri River were approximately 3,500 cfs lower than needed to meet targets. Based on the July 1 System storage check of 54.3 MAF the service level for the second half of the navigation season should have been reduced by 3,000 cfs. Following a series of coordination meetings with basin interests, a decision was made to provide full service navigation flow support during the remainder of the 1988 season in exchange for a one-week delay in the opening of the 1989 navigation season. Dredging on the Missouri river was required during July, September and October 1988. The navigation season was shortened 3 weeks in the fall of 1988. Winter System releases were lowered to 12,500 cfs when the navigation season closed in mid-November as a water conservation measure. Calendar year 1988 runoff was only 12.4 MAF the fourth lowest since record keeping began in 1898.

A-07.2.4.3**. Drought Year 1989**. Downstream flow support began 1 week later than normal to compensate for the higher service level provided in 1988. The 1989 navigation service level was established at 3,000 cfs below full service based on the March 15 System water in storage check. There were many groundings, double-trippings and bottom bumpings that occurred on the lower Missouri River at these flows. A decision was made in May that 32,000 cfs was the System release rate that would be required to meet downstream flow targets later that summer. Based on Master Manual criteria at that time, a July 1 System storage less than the 50.5 MAF would result in minimum service flow support for the remainder of the season. After several coordination meetings with the basin stakeholders, a rate of 3,000 cfs rather than 6,000 cfs less than full service was provided in exchange for an increased reduction in navigation season length. The navigation season was closed 4 weeks early to balance the higher service level flows provided during the last half of the navigation season. As downstream tributary flows dropped much lower than expected, the downstream flow targets were missed by an average of 1,000 cfs during August and a maximum of 3,400 cfs, to protect T&E species. Many groundings occurred during this period even with the extra 3,000 cfs releases. In this third year of the drought, $3 million dollars in Federal funding was spent by the Corps extend boat ramps on the upper System reservoirs. The average System winter release rate was set at 10,500 cfs based on the September 1 System storage check. Fall releases were reduced to as low as 10,000 cfs, the minimum level to prevent downstream intake problems. Releases during December were reduced from 17,000 cfs during ice formation to 12,000 cfs once a stable ice cover was formed. Four hundred miles of ice cover on the Missouri River existed during the coldest period during that winter.

A-07.2.4.4. **Drought Year 1990**. By mid-January, System releases were lowered to 10,500 cfs. In March, System releases were reduced to 9,500 cfs after coordinating with the users along the river that had earlier experienced intake problems. Flow support again began 1 week later than normal as an added conservation measure from the 1989 season and based on March 15 storage check, the service level was reduced to minimum service(6,000 below full service) and the season length was shortened another 4 weeks in the fall. A lot of interests provided input to System release rates and downstream target values during the draft 1989-1990 AOP period during the fall of 1989. The decision was made to open the season 1 week later than normal to compensate for the extra service provided the year before and to close the season 4 weeks early. Navigators loaded tows to 7.5-foot drafts. A 30,000 cfs Gavins Point release rate was forecasted as adequate to meet downstream flow targets during August and System releases were increased to this rate in May. Also once every third day, releases were cycled as a water conservation measure. This was the first year for this type of cycling except during the flood control regulation period in 1987. System storage crested at 45.4 MAF. Downstream flow targets were missed by about 500 cfs on a couple of occasions. Missouri River navigation support from Kansas River reservoirs was utilized beginning in September. Up to 2,300 cfs above water quality requirement flows were requested during October from several projects in the Kansas River system. The Missouri river navigation season closed on November 1. System release was reduced to 9,000 cfs by November 14th. Releases were increased to 16,000 cfs in mid-December because of river ice formation. A set of ice jams formed and river levels dropped considerably, causing many intakes to lose access to water for over a day, as the stage reduction moved downstream.

A-07.2.4.5. **Drought Year 1991**. Winter releases were as low as 9,000 cfs after the ice cover stabilized in February. One hundred seventy-six miles of ice cover formed on the Missouri river during the winter of 1990-1991. Following several meetings during the fall of 1990 the decision was made to shorten the 1991 navigation season by 5 weeks and provide minimum service. In May, a release rate of 29,000 cfs was determined adequate to meet later summer flow targets. Cycling was implemented with 29,000 cfs released every third day. High flows on the James River required reduced System releases for several days, during which the T&E protected birds took advantage of by nesting on the clean sand at a low elevation. As a result of the low nesting, the cycle peak was temporarily reduced to 27,500 cfs to prevent nest inundation. Following a reconnaissance by Service staff, the peak of the cycle was increased slightly to 28,000 cfs but could not return to the 29,000 cfs rate established earlier. Tows were again loaded to 7.5-foot drafts. The tow Tara Ann sunk in the Missouri River on July 26, 1991. Supplemental navigation flow support from the Kansas Reservoirs was utilized and drew the tributary reservoirs with authorized Missouri River navigation support down 6 feet as provided for in the water control manuals for those projects. The navigation season closed on November 1. Following the close of the navigation season, System releases were reduced to 9,000 cfs until extremely cold temperatures entered the basin. Releases were increased to 15,000 cfs in late November. Once ice cover formed, releases varied between 12,000 and 14,000 cfs.

A-07.2.4.6. **Drought Year 1992**. During February, releases were first reduced to 9,000 cfs and then were further reduced to 6,000 cfs. Releases were at 7,000 cfs prior to the come-up for the 1992 navigation season. There were several meetings held during the winter of 1991-1992 to again discuss the 1992 navigation flow support. The outcome was that the season opening date was set at the normal date of April 1 at the mouth, navigation flow support was set at the minimum service level and it was determined the closing date would be based on the July 1 System storage check. In early May, the 29,000-cfs rate was again determined as the support level needed to meet downstream flow targets during late summer. Cycling was again implemented as a water conservation measure. This System release rate was later reduced to 27,000 cfs and then to a flat release of 23,000 cfs as high downstream tributary flows on the Big Sioux helped to meet navigation support flows. System storage peaked at 46.1 MAF on March 18. High downstream tributary flows kept the navigation target location at Sioux City and resulted in lower System releases. Also supplemental navigation support was not required from the Kansas Reservoir system as downstream tributary flows in the Nebraska City to Kansas City reach were greater than 4,000 cfs. The navigation season was closed 1 month early as a water conservation measure.

A-07.2.4.7. **End of drought Year 1993**. There were again meetings to discuss the 1993 navigation season support. The season started at minimum service flows and on the normal opening date of April 1. Because of high downstream flows and significant runoff, System storage recovered to normal levels during 1993. The Missouri River was closed to navigation for over 7 weeks (53 days) during the extremely high downstream flows as a safety precaution and to reduce wave action on the many levees that were nearly overtopped due to the Great Flood of 1993.

Table A-14
Drought of late 1980's and early 1990's System Significant Criteria

Year	Calendar Year Runoff-MAF	March 15 Storage MAF	Level of Service kcfs	July 1 Storage MAF	Level of Service kcfs	Sep 1 Storage MAF	Winter Release kcfs	Actual Winter Release kcfs	Season Shortening In Days
1987	23.1	59.4	full	62.9	full	60.9	17.0	18.0	0
1988	12.4	55.8	full	54.3	full	50.5	12.3	13.6	14
1989	17.7	45.3	-3.0	47.8	-3.0	45.3	10.0	13.0	37*
1990	16.7	44.3	min	45.2	min	43.9	10.0	12.4	37*
1991	22.3	41.7	min	47.7	min	46.8	10.0	12.1	37*
1992	16.4	45.4	min	45.1	min	44.7	10.0	13.1	37*

* Season shortened 1 week at beginning of season in March

A-07.2.5**. System Regulation During Droughts Under the Previous and Current Master Manual.** The drought of the late 1980's and early 1990's spawned a heated controversy to arise over the previous Master Manual and the relative service provided to project purposes, especially recreation versus navigation. This resulted in the Master Manual Review and Update Study, which investigated numerous water control plan alternatives. The change to the current Master Manual occurred in March 2004, in the middle of the current drought, and included more stringent water conservation criteria compared to the previous Master Manual.

A-07.2.5.1. **Drought Year 2000.** The 2000 navigation season began on the normal opening dates at full service flow support. The July 1 System storage check of 57.0 MAF resulted in a reduction in service level of 1,500 cfs for the second half of the season. The 2000 navigation season ended on the normal closing date of December 1 at the mouth. The previous Master Manual criteria called for water conservation to begin when System storage falls below 59 MAF on July 1.

A-07.2.5.2. **Drought Year 2001.** The 2001 navigation season began on normal opening dates. The service level was reduced to 3,000 cfs less than full service based on the March 15 storage check. Unfortunately, not all the volume contained in the plains snowpack could be utilized effectively as it came off at rates greater than that required to meet downstream target flows. The runoff during this year was influenced primarily by a large plains snow pack in the eastern Dakotas which resulted in low System releases through May. The July 1 storage check resulted in a continuation of service at a rate of 3,000 cfs less than full service (based on the previous Master Manual criteria which began water conservation at 59.0 MAF on July 1). No increased steady release was implemented in May for T&E bird nesting since it was determined that adequate T&E habitat was in place at the time. This habitat was created by high releases (60,000 to 70,000 cfs) in 1997 to evacuate System flood storage filled during the major runoff event in that year. Because the base tributary flows were expected to remain high and adequate T&E nesting habitat was in place, a "follow target" System release plan was implemented during the 2001 nesting season. This conserved a large amount of water, and System storage peaked at 54.7 MAF on August 1, 2001. The season ended on the normal closing dates. Fort Peck reservoir fell 10 feet as Montana was experiencing its third year of drought. Noxious weeds quickly became a serious issue since the exposed shoreline with no vegetation opened up great opportunity for weeds to encroach. Also, a new invasive species, the salt cedar, made this a more serious issue, because of its characteristic to take-up tremendous amounts of water. Weed control during this drought tied up significant resources that could have been used elsewhere to help alleviate other negative drought impacts. The Corps' Omaha District has an ongoing program to control noxious weeds on Corps property with a special focus on salt cedar.

A-07.2.5.3. **Drought Year 2002.** The 2002 navigation season began with service level at 4,000 cfs less than full service based on March 15 storage check of 48.6 MAF. The season was impacted beginning in May by a series of lawsuits beginning with one by the State of South Dakota to maintain a level or rising Oahe pool during the rainbow smelt spawn. The downstream service level was maintained, however, over the course of a 4-week period all five reservoirs other than Oahe fell from their normal levels, which spawned other court actions. Upstream fish spawn and reservoir access at all five reservoirs were negatively impacted. The July 1 storage check resulted in a System release change to minimum service, 6,000 cfs less than full service. A follow target regulation plan was implemented in the 2002 T&E bird nesting season. A reduction in downstream tributary inflow resulted in an increase in System releases, even though the service level was reduced by 2,000 cfs based on the July 1 storage check. The Corps planned to captively rear T&E eggs and chicks that were in danger of inundation by the follow target regulation. The collection of eggs was started, but was ceased when the Corps was informed by the Service that this operation would be considered an illegal "take". Therefore, from July 1 through August 15 releases were held at 25,500 cfs. This resulted in serious problems downstream. There were groundings, a tow was broken open, the navigation channel essentially closed and all tows had to leave the Missouri River. Later dredging was required at a cost of $465,000, to open two areas of the channel that experienced serious shoaling due to the below minimum service flows. Releases were as much as 7,000 cfs below target during this time period and Missouri River channel depths in some locations were less than 7 feet. After August 15, when the T&E bird species left the river for their fall migration, releases were increased back to the follow target levels. The estimated loss to the navigation industry was $3.5 million dollars. A river excursion boat estimated its losses alone at $1.1 million dollars. The navigation season ended on the normal closing dates.

A-07.2.5.4**. Drought Year 2003.** The season started on the normal opening dates at a service level of minimum service. From August 11 to September 1 flow support was not provided because of a court order restricting flows. The season length was shortened 6-days because of extra water used for winter 2002-2003 flow support. The season would have been shortened additional 10 days based on winter flows but there was an offset taken due to the inability to provide adequate flows during the six week period discussed above in the 2002 navigation season. This water was credited to the 2003 season since it could not be effectively provided in 2002 because of the T&E bird species nesting. Navigation support flows were required from the Kansas Reservoir system during 2003. Fort Peck fell approximately 7 feet, Garrison 5 feet and Oahe 4 feet. The Ft. Yates intake failed in November 2003 and Corps worked with the USBR to restore the intake as quickly as possible. The Corps spent $1,200,000 extending boat ramps in the Mainstem System.

A-07.2.5.5. **Drought Year 2004.** The Master Manual was updated in March, therefore the additional water conservation measures instituted with the update of the Manual were applied. The season started on the normal opening dates at a minimum service. Navigation targets were not met at Sioux City and Omaha in early April, in accordance with the current Master Manual, since there was no commercial barge traffic scheduled in those reaches during that period. Navigation support flows were required from the Kansas Reservoir system during 2004. The 2004 navigation season ended on October 13, 2004 at the mouth near St. Louis. The July 1 System storage check resulted in a 47-day shortening of the navigation season, 30 days shorter than under the previous Master Manual criteria. Reservoir cold water fishery issues at Garrison were a concern as the pool elevations reached record low levels. The Corps spent $600,000 in extending boat ramps in the Mainstem reservoirs in 2004. In addition, following the end of the navigation season, releases were very gradually reduced to 9,000 cfs, the non-navigation season downstream flow support rate. This was accomplished over an extended period of time to assure that downstream intakes would function. During the winter period releases averaged only 12,000 cfs. The October and December System releases were at record low levels, conserving a considerable amount of additional storage.

A-07.2.5.6. Drought Year 2005. The average daily release for the month of February from Gavins Point was a record low of 9,900 cfs. The navigation season started on the normal opening dates at minimum service flow support. The July 1 System storage check resulted in a record season reduction of 48 days. Missouri River navigation flow support was required from the Kansas River system in 2005. Downstream flow support for the 2005 navigation season ended on October 14, 2005 at the mouth near St. Louis. Unlike the season closing in 2004, releases were reduced quickly to conserve more storage. They were reduced to the 10,000 cfs level at a rate of 3,000 cfs per day by October 10 and then to the non-navigation flow support rate of 9,000 cfs on October 15.

Unlike the previous year, downstream tributary flows in the fall dropped below lower quartile levels. Therefore, System releases were increased to 12,000 cfs, 3,000 cfs over the minimum level of 9,000 cfs, to compensate for this low downstream tributary runoff. The winter release rate of 12,000 cfs was scheduled once downstream tributary flows improved.

Table A-15
Drought of 2000 to Present System Significant Criteria

Year	Calendar Year Runoff-MAF	March 15 Storage MAF	Level of Service MAF	July 1 Storage MAF	Level of Service kcfs	Sep 1 Storage MAF	Winter Release kcfs	Actual Winter Release kcfs	Season Shortening In Days
2000	16.5	57.7	full	57.0	-1.5	54.3	14.4	14.0	0
2001	22.5	50.3	-3.0	54.7	-3.0	53.2	13.6	13.4	0
2002	16.1	48.6	-4.0	48.8	min	46.9	10.0	13.3	0
2003	19.2	42.6	min	45.1	min	42.8	10.0	14.5	6
2004	16.2	39.0	min	38.6	min	36.5	12.0	12.0	47
2005	20.4	35.7	min	38.4	min	37.3	12.0		48
2006	20.0*		min*		min*				

* Estimate based on current forecast

Appendix I – Adaptive Management

I-01. **Introduction.** This appendix presents and discusses historic and proposed adaptive management as it relates to regulation of the System. The Corps has been functioning in an adaptive management mode for many years; however, this water control plan provides for a formalization of this process. This process is continuing to evolve and when necessary, will be updated in this Appendix.

I-02. **Previous Proposed Actions.** As discussed previously, adaptive management has been incorporated into the regulation of the System. There is a long history of the Corps working with various State and Federal wildlife and fisheries interests to provide significant fish and wildlife enhancement in and downstream of the System. The following is a discussion of recent adaptive management actions that are currently included in System regulation considerations. These regulation adjustments are intended to be implemented when hydrologic conditions allow to the extent appropriate after consideration of the impacts on all authorized purposes.

I-02.1. **Reservoir Unbalancing.** Unbalancing of the water stored within the System among the reservoirs has been implemented for many years to accomplish the authorized System project purpose of fish and wildlife. The use of storage in one or more reservoirs to enhance fish spawning and habitat creation is as old as when the System first filled. Early attempts to provide rising pools for the spawning of northern pike and other game fish were requested as the reservoirs reached the top of their Carryover Multiple Use Zones. The Corps has implemented these requests when it was advantageous for the System after evaluating the impacts on all authorized purposes. Reservoir unbalancing has matured over time into the formal process shown in the Table I -1. This planned regulation of the System involves unbalancing the three large upper reservoirs to benefit reservoir fishery and the Federally listed threatened and endangered (T&E) species protected under the ESA. Reservoir unbalancing is computed based on the percentage of the carryover multiple purpose pool that remains in Fort Peck, Garrison and Oahe reservoirs. The unbalancing would alternate at each project; high one year, float (normal regulation) the next year, and low the third year. Table I-2 shows the reservoir elevations proposed by the MRNRC at which the unbalancing would not be implemented. The ability to provide steady to rising pool levels at all of the System reservoirs during low water years is very dependent on the volume, timing, and distribution of runoff. Therefore, one or more reservoirs may be selected each year for emphasis in the enhancement of fishery resource management to the extent reasonably possible.

Table I-1
Reservoir Unbalancing Schedule

	Fort Peck		**Garrison**		**Oahe**	
Year	**March 1**	**Rest of Year**	**March 1**	**Rest of Year**	**March 1**	**Rest of year**
1	High	Float	Low	Hold Peak	Raise & hold during spawn	Float
2	Raise & hold during spawn	Float	High	Float	Low	Hold peak
3	Low	Hold peak	Raise & hold during spawn	Float	High	Float

Float year: Normal regulation, then unbalance 1 foot during low pool years or 3 feet when System storage is near 57.1 MAF on March 1.
Low year: Begin low, then hold peak the remainder of the year.
High year: Begin high, raise and hold pool during spawn, then float.

Table I-2

Reservoir Elevation Guidelines for Unbalancing

	Fort Peck	**Garrison**	**Oahe**
Implement unbalancing if March 1 reservoir elevation is above this level.	2234 feet msl	1837.5 feet msl	1607.5 feet msl
Implement unbalancing if March 1 reservoir elevation is in this range and the pool is expected to raise more than 3 feet after March 1.	2227-2234 feet msl	1827-1837.5 feet msl	1600-1607.5 feet msl
Scheduling Criteria	Avoid reservoir level decline during spawn period which ranges from April 15 to May 30	Schedule after spawn period of April 20 to May 20	Schedule after spawn period of April 8 to May 15

I-02.2. **Fort Peck T&E Species Tests.** These tests involve the use of a combination of spillway and powerplant releases to evaluate and test the ability of the Fort Peck project to provide warmer and significantly higher flows for T&E species and native river fishery enhancement.

I-02.2.1. **Fort Peck Mini-Test.** The Fort Peck mini-test is a regulation plan that involves flow modifications for the endangered pallid sturgeon. When Fort Peck has adequate water above the spillway crest by mid- to late May, a flow modification mini-test will be conducted in early June to monitor the effects of higher releases and warmer water released from the spillway. The purposes of the mini-test are to allow for an evaluation of the integrity of the Fort Peck spillway structure, to test data collection methodology, and to gather information on river temperatures with various combinations of flow from the spillway and powerhouse. Stream-bank erosion and fishery impacts will also be monitored. Stop protocol for the mini-test are identified in the Fort Peck Flow Modification Mini-Test Environmental Assessment, dated March 2004. Before this test and a subsequent full test are run, the Corps will fully coordinate with the Tribes of the Fort Peck Reservation, the State of Montana, and any other potentially affected stakeholders.

I-02.2.1.1. During the Fort Peck mini-test, which will last about 4 weeks, flows will vary from 8,000 to 15,000 cfs as various combinations of spillway and powerplant releases are monitored. The maximum spillway release of 11,000 cfs will combine with a minimum powerplant release of 4,000 cfs for 6 days. This operation will be timed to avoid lowering the reservoir during the forage fish spawn. The mini-test will not be conducted if sufficient flows will not pass over the spillway crest (elevation 2225 feet msl). A minimum reservoir elevation of about 2229 feet msl is needed during the test to avoid unstable flows over the spillway.

I-02.2.2. **Fort Peck Full Test.** A more extensive test, referred to as the "full test," with a combined 20,000- to 25,000-cfs release from Fort Peck is scheduled to be conducted beginning in early June in the year following the mini-test. This test would allow further tests of the integrity of the spillway and to determine if warm water releases will benefit the native river fishery. Peak outflows during the full test would be maintained for 2 weeks within the 4-week test period.

I-02.3. **Modified System Regulation for T&E Species.** Releases from all projects except Oahe and Big Bend have been modified to accommodate endangered interior least tern and threatened piping plover nesting since 1986. Daily hydropower peaking patterns are developed prior to nest initiation in early to mid-May and are provided to Western. Fort Peck and Garrison hydropower peaking has been limited in the past to four of five units for no more than 6 hours each day during T&E bird species nesting.

Fort Randall hydropower peaking has been limited in the past to seven of eight units for no more than 6 hours per day during T&E bird species nesting.

I-02.3.1. **Gavins Point Cycling.** During the early years of System regulation for endangered species, a technique of increasing project releases every third day by as much as 8,000 to 10,000 cfs was used to encourage terns and plovers to build their nests on higher habitat so that these nests would not be inundated later when increases were required to meet the regulation objectives of the System. This pattern of increasing releases every third day was referred to as "cycling." Cycling may not be used during years when System storage is high but has been used during extended drought when water conservation is of primary importance. It is not used in some years because of the potential harm to native fish and the risk of stranding T&E bird species chicks. Even in drought years, it is suspended when T&E chicks hatch to minimize the stranding of chicks. Cycling of Gavins Point releases when releases are reduced for downstream flood control during the T&E bird species nesting season has been used to keep birds nesting at sufficiently high elevations to maintain room for release increases when downstream flooding has subsided. The variation in releases is normally limited to 8,000 cfs to minimize adverse affects on downstream river users and fish.

I-02.3.2. **Gavins Point Steady Release.** Another modified regulation plan, called steady release, has been utilized to avoid loss of T&E bird species nests. This involves increasing the Gavins Point release by early to mid-May when the terns and plovers begin to initiate nesting activities. Releases are scheduled in the amount expected to be needed for downstream flow support in August when downstream tributary flows are typically lower. The release selected is then maintained through the nesting season, hence the designation steady release. This regulation results in releases that exceed the amount necessary to meet downstream flow targets during the early portion of the nesting season when downstream tributary flows are normally higher. A steady release plan uses an additional amount of water from that stored in the System. Also if the release level chosen is not high enough, downstream flows may not be sufficient to meet objectives. This situation generally occurs during the summer period because of drier-than-expected lower basin conditions.

I-02.3.3. **Gavins Point Steady Release – Flow to Target.** During the 2003 T&E bird species nesting season, a new regulation plan, called "steady release – flow to target" was used to set the Gavins Point release. This plan combined features of the original "flow-to-target" plan with the "steady release" plan. It called for an initial steady release high enough to inundate low-lying nesting habitat that would likely be subject to inundation later in the season. As downstream tributary streamflows declined through the summer, releases could be increased or decreased as needed, within the limits of the Incidental Take Statement provided by the Service in its 2003 Amended BiOp, to meet downstream flow support for navigation and other authorized purposes. Depending on the release level selected as the initial steady release, this regulation normally makes a larger amount of habitat available early in the nesting season and saves additional water in the upper three reservoirs when compared to the steady release regulation plan. This plan also reduces the potential for flooding nests when compared to the flow-to-target release plan and also provides a higher level of certainty for downstream users that Gavins Point releases could be increased if needed to meet Missouri River flow targets.

I-03. **New Proposed Actions**. Several other actions have been discussed and will be considered in future adaptive management implementations. These include numerous proposals for the adjustment of river flows to enhance native river fish in all reaches of the Missouri River. There have also been discussions of short-term higher releases to condition T&E bird species habitat. As actions are developed into System regulation plans, they will be described in this section.

I-03.1. **U.S. Fish and Wildlife Service 2000 Biological Opinion.** The Corps entered into formal ESA consultation with the Service that culminated in the Service's Missouri River Biological Opinion (BiOp) issued in November 2000 (2000 BiOp). The 2000 BiOp concluded that the Corps' proposed action jeopardized the continued existence of the listed pallid sturgeon, piping plover and interior least tern. The 2000 BiOp also recommended a Reasonable and Prudent Alternative (RPA) to avoid jeopardy.

I-03.1.1. On November 3, 2003, the Corps requested reinitiation of formal ESA consultation. The request for reinitiation was based on the existence of new information regarding the effects of System regulation on the Federally listed species as well as a new critical habitat designation for one of the listed species. The Corps' description of this information and of the proposed action was set forth in a detailed biological assessment accompanying the request to reinitiate consultation. Several possible actions were presented in the Corps' biological assessment that will not be restated here.

I-03.2. **Service's 2003 Amended BiOp.** On December 16, 2003, in response to the Corps' request for the reinitiation of consultation, the Service issued an amendment to its 2000 BiOp. The 2003 Amended BiOp includes an RPA for the Corps' proposed operations that the Service believes, if implemented, would avoid the likelihood of jeopardizing the continued existence of the endangered pallid sturgeon or result in the destruction or adverse modification of its critical habitat. The RPA flow components for pallid sturgeon replaced the Corps' proposed 3-year re-evaluation with a "feasibility, flow development, and adaptive management" element to determine how flows can be provided that, in the Service's opinion, are essential for the survival of the pallid sturgeon by March 2006.

I-03.2.1. The 2003 Amended BiOp recommended the implementation of a long-term Gavins Point spring pulse plan by 2006. It presented an "initial starting point" (ISP) spring pulse for the 2006 water year if an alternate plan that would meet the life-cycle needs of the pallid sturgeon could not be identified. The ISP presented in the 2003 Amended BiOp called for a bimodal spring pulse in March and May. The March pulse was assumed to follow a winter release of 16,000 cfs or less and was to be at least 31,000 cfs for no less than 7 days. Each of the ascending and descending limbs of the March spring pulse was to be 7 days in duration. The May pulse was to be no less than 16,000 cfs above existing releases for at least 14 days. The ascending limb of the pulse was to be no less than 7 days and no more than 10 days. The descending limb was to be no less than 7 days but could extend longer as required by other project purposes. The ISP spring pulse was to be implemented assuming near median hydroclimatic conditions and allowed adjustments if conditions were not near "median". The 2003 Amended BiOp states:

> "If the Corps, with the review and approval of the Service, is unable to determine a suitable flow management plan that incorporates the life history needs of the pallid sturgeon over all relevant flow frequencies within 2 years the Corps shall operate in the following manner in the operating year that begins on March 1, 2006. This initial starting point shall be subject to annual review and modification based on data collected and evaluated under the adaptive management program. This assumes a median hydroclimatic condition in the basin based on System storage, past precipitation, and projections of future precipitation based on historical probabilities."

I-03.2.2. Another RPA element states that when 1,200 acres of new shallow water habitat for pallid sturgeon have been made available, the Corps, in consultation with the Service, may modify the summer flows to take advantage of that habitat and more fully meet the Congressionally authorized System project purposes. In letters to the Service dated February 13, 2004 and March 2, 2004, the Corps identified a plan and biological rationale to support development of shallow water habitat in an expanded reach from Ponca State Park to the mouth of the Osage River by July 1, 2004. By a letter dated March 5, 2004, the Service concurred that there is sufficient biological information to support the expanded reach and also supported the Corps' decision to develop 1,200 new acres of shallow water habitat as a means to address an immediate need for survival and recovery of the pallid sturgeon. By a letter dated June 24, 2004 the Service accepted the Corps' determination that 1,200 acres of new shallow water habitat would be available by July 1, 2004 and concluded that the proposed regulation met the requirements presented in RPA element VII.1.b. The Corps could, therefore, modify summer flows, as discussed above, to more fully meet the Congressionally authorized System project purposes. Therefore, the requirement to reduce summer flows below minimum service levels to provide shallow water habitat was instead accomplished by the construction of new suitable shallow water habitat. The Corps continues to monitor this habitat for suitability and has committed to developing additional habitat per the schedule discussed in the 2003 Amended BiOp.

I-03.2.3. **The Adaptive Management Process for the Bimodal Spring Pulse**. In an attempt to develop a bimodal spring pulse plan as required by the 2003 Amended BiOp, the Corps enlisted the assistance of the U.S. Institute for Environmental Conflict Resolution (Institute), a Federal agency with a great amount of experience in similar endeavors. The Institute then invited Tribal representatives and Tribal members, State representatives, and a wide range of stakeholders to participate in the collaborative spring pulse plan identification process. However, these meetings did not constitute consultation under 36 CFR Part 800, the PA, or Executive Order 13175 with the 28 affected Tribes. A first step in the collaborative process was to select a contractor to facilitate the discussions and lead the participants to develop a recommendation for the Corps to use in the establishment of a spring pulse plan. The Institute invited a representative number of participants to help select the facilitators for the process. They unanimously recommended selection of CDR Associates to fill that role.

I-03.2.4. **The Plenary Group.** CDR subsequently established a "Plenary Group" that was comprised of more than 50 Tribal representatives and Tribal members, State representatives, and stakeholders. The Plenary Group chose to establish four technical working groups to provide technical assistance in support of its efforts: Socio-Economic; Historical/Cultural/Burial Site; Hydrology/Water Quality; Pallid Sturgeon/Fish and Wildlife. The Plenary Group met four times over a 3-month period in June through August 2005. Meetings of the technical working groups were also held periodically during this period. Issues considered by the plenary and technical working groups included, but were not limited to the following: water intakes and water quality; human health; the biological needs of the species; impacts of a spring pulse on historic and cultural resources, interior drainage, groundwater, flood risk, and erosion; and the need for monitoring historic and cultural resources, biological response, and socio-economic impacts of the spring pulse. Even though the Plenary Group was unable to reach consensus on a total spring pulse plan, it and the technical working groups provided valuable input through CDR and the Institute to the Corps and Service related to many of the factors that comprise a total spring pulse plan.

I-03.2.5. **Spring Pulses below Gavins Point.** This bimodal Gavins Point spring pulse plan was developed based on the following: the provisions of the 2003 Amended BiOp including the ISP, input from the 2005 spring pulse Plenary Group and its technical working groups discussed below, and Tribal consultations/meetings and public comments received on the draft spring pulse plan presented in the fall of 2005. The detailed features of the plan are described below.

I-03.2.6. **Gavins Point Spring Pulse Downstream Flows Limits.** The magnitude of both the March and May Gavins Point spring pulses will be constrained by the Gavins

Point spring pulse downstream flow limits (downstream flow limits). These downstream flow limits are established at the same locations as the current flood control constraints flow targets discussed in Chapter 7, paragraph 7-04.16 of this Master Manual and shown in Table VII-7 and below in Table I-3. The downstream flow limits shown in Table I-3 are the same values as the most conservative flood control constraint flow targets and therefore, will provide similar downstream flood control during the spring pulse periods. As an additional precaution, radar detected precipitation and NWS quantitative precipitation forecasted (QPF) precipitation will be used in forecasting the resultant downstream flows. Gavins Point releases will be adjusted as required during the spring pulse periods based on this forecast.

Table I-3
Downstream Flow Limits
during the Spring Pulse

Location	Flow Limit in CFS
Omaha	41,000
Nebraska City	47,000
Kansas City	71,000

I-03.2.7. **March Spring Pulse from Gavins Point.** The plan for the March spring pulse (March pulse) below Gavins Point includes a preclude based on System storage (March pulse preclude). If the actual System storage as computed on March 1 is at or below 36.5 MAF, a March pulse would not be implemented. After the first occurrence of a March pulse, the preclude will change to 40.0 MAF. The magnitude of the March pulse is defined as the combination of the Gavins Point release increase and the contribution of the James River. Assuming that System storage is above the March pulse preclude, the magnitude of the March pulse will be 5,000-cfs and will be implemented the day after System releases reach the level necessary to provide downstream flow support for the beginning of the navigation season. More specifically, the magnitude of the Gavins Point release at the peak of the March pulse will be 5,000 cfs minus the contribution of the James River measured at the Scotland, SD stream gage. Actual releases from Gavins Point dam will be set to the nearest 500 cfs increment. Also, the total Gavins Point release during the March pulse will not be set any higher than the Gavins Point powerplant capacity (35,000 cfs). The duration of the peak of the March pulse will be 2 days. Following the 2-day peak, the March pulse flows will be reduced each day over the next 5 days until non-spring pulse downstream flow support rates are achieved.

I-03.2.8. **May Spring Pulse from Gavins Point**. The plan for the May spring pulse (May pulse) from Gavins Point will also have a preclude based on an actual System storage as computed on May 1 (May pulse preclude). If the actual System storage as computed on May 1 is at or below 36.5 MAF, a May pulse would not be implemented. The May pulse preclude will also initially be 36.5 MAF until the first time the May spring pulse is implemented. As with the March pulse, once the first May spring pulse has been implemented the May spring pulse preclude will change to 40.0 MAF.

I-03.2.8.1. The magnitude of the May pulse, as is the case for the March pulse, is defined as the combination of Gavins Point release increase and the contribution of the James River. Therefore, the magnitude of the Gavins Point release at the peak of the May pulse will be the result of the two-step proration computation described below minus the contribution of the James River measured at the Scotland, SD stream gage. The total Gavins Point release during the May pulse will not be constrained to the Gavins Point powerplant capacity, as is case for the March pulse. The two-step proration computation to determine the magnitude of the May pulse is as follows:

First Step. The May pulse magnitude is first computed based on May 1 System storage. The May pulse magnitude is prorated in a straight-line interpolation between 16,000 cfs and 12,000 cfs based on a System storage range between 54.5 and 40 MAF. The May pulse magnitude in this step is limited to 16,000 cfs if System storage is greater than 54.5 MAF. For the initial occurrence of the May pulse, if System storage is between 36.5 and 40 MAF, the resultant magnitude from this step is 12,000 cfs.

Second Step. The resultant May pulse magnitude from the first step is then further prorated based on the Corps' May 1, Mainstem Calendar Year (CY) Runoff Forecast for the Missouri River basin above Sioux City, Iowa. The May pulse magnitude computed in the first step could be decreased or increased by as much as 25 percent in this step. The May pulse magnitude resulting from the first step is increased in a straight line interpolation from 0 to 25 percent for a CY runoff forecast that ranges from median to upper quartile. The May pulse magnitude from the first step is decreased in a straight line interpolation from 0 to 25 percent for a May 1 CY runoff forecast that ranges from median to lower quartile runoff. Use of both steps in this computational process produces a potential range of May pulse magnitudes from 9,000 cfs to 20,000 cfs. Actual releases from Gavins Point Dam will be set to the nearest 500 cfs increment.

I-03.2.8.2. The initiation of the May pulse will be between May 1 and May 19, depending on Missouri River water temperature measured immediately below Gavins Point Dam. The May pulse will be initiated after the second daily occurrence of a 16 degree Celsius or higher Missouri River water temperature. However, the final decision on the date of the initiation of the May pulse will take into account the potential for "take" of T&E bird species during the pulse period and downstream flow conditions.

I-03.2.8.3. Gavins Point releases will be increased at a rate of approximately 6,000 cfs per day from normal downstream flow support releases until the full May pulse magnitude, as calculated above, is achieved. The May pulse magnitude will be maintained for 2 days, after which releases will be decreased by 30 percent over the following 2 days. The remaining release reductions will be prorated over an additional 8 days until non-spring pulse downstream flow support rates are achieved. This will result in a recession length of 10 days from the peak of the May pulse. The length and magnitude of the recession may also be constrained by the downstream flow limits shown on Table I-3.

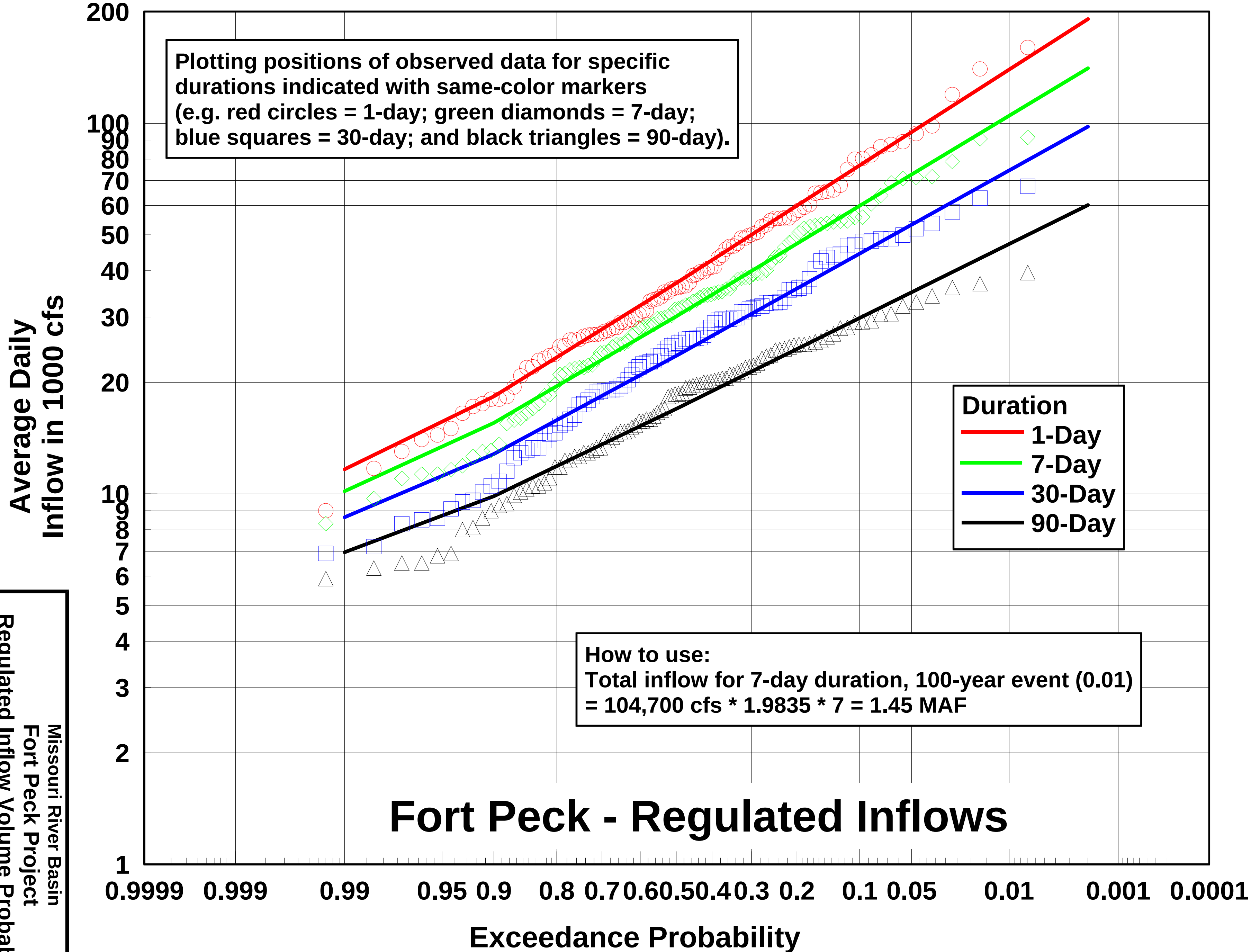
I-03.2.8.4. The spring pulse elements of this plan comply with the provisions of the 2003 Amended BiOp. The potential volume of System storage used for spring pulses is less than the ISP presented in the 2003 Amended BiOp, because of a reduction in the duration of peak releases. For example the ISP, which was to be implemented under median hydroclimatic conditions, would use approximately 800,000 acre-feet of storage from the System. With the shorter peak durations included in the bimodal spring plan presented in this Master Manual, both spring pulses would use 260,000 acre-feet of System storage at median hydroclimatic conditions. The 2003 Amended BiOp also included a provision that allows for a proration of the magnitude of the May pulse based on hydroclimatic conditions, but did not include any specific proration criteria. This allows a reduction in the magnitude of the May pulse during drought periods to reduce potential negative impacts to authorized System project purposes. Utilizing the proration criteria presented in this Master Manual, and assuming median runoff and 40 MAF of water in storage on May 1, both pulses would only use 160,000 AF of System storage. This would result in a 0.1-foot to 0.3-foot pool elevation decrease in each of the upper three reservoirs, or a 2-foot pool elevation decrease in Fort Randall reservoir if all of the water were taken from that reservoir to implement the spring pulses. The lower System storage volume required during drought reduces the adverse impacts associated with low reservoir storage levels such as reservoir water intake access and the exposure of historic and cultural resource sites. The shorter peak durations and reduced magnitudes of the May pulse during drought also reduces the risk of interior drainage and high groundwater problems in the reaches downstream from Gavins Point Dam. The bimodal spring pulse plan presented in this Master Manual utilized information gained from discussions with the Plenary Group at meeting held in the summer of 2005. It was also informed by detailed and comprehensive discussions with the Service.

I-03.2.8.5. The volume of water drafted from any of the System reservoirs to support the spring pulses will be based on the hydrologic conditions at that time and will take into account any potential impacts to authorized System project purposes. Any disproportionate change in pool levels at any of the System reservoirs would be adjusted back to normal levels as soon as hydrologic conditions permit. As with any intra-System regulation, System pool level adjustments associated with the bimodal spring pulse implementation will be fully coordinated with all the affected interests prior to implementation.

I-03.3. **Flexibility for the Gavins Point Bimodal Spring Pulse Plan.** The Draft Spring pulse Master Manual Water Control Plan Technical Criteria that was published with the Draft 2005-2006 AOP proposed to include flexibility related to several of the plan criteria. This proposed flexibility was discussed at the fall of 2005 public AOP meetings and at Tribal consultations/meetings in early 2006. One of the criteria under discussion was the downstream flow limits. Data analyzed as part of the Plenary Group discussions showed that the frequency of spring pulses as constrained by the downstream flow limits presented in this Master Manual is lower than anticipated in the 2003 Amended BiOp. This low frequency is associated with the implementation of spring pulses during non-drought periods, when System releases are set to provide full service. System storage in early 2006 is very low; the likelihood of providing full service flow support appears to lie several years in the future, therefore, none of the proposed flexibility is included in this plan. While the Service has indicated that the spring pulse frequency is not an issue during the current extended drought, they have indicated that the frequency question must be addressed within the next year, in the event the current drought ends. The Corps has initiated monitoring programs to address impacts on Missouri River uses and resources including interior and groundwater drainage, water intakes and Tribal and Cultural religious and cultural sites. Information gained through the planned monitoring studies, research, and other future identified studies/information will reduce the uncertainty relating to the flexibility and frequency issues. The information gained from the monitoring data and associated studies will be reviewed annually to determine if revisions to the technical criteria are necessary. This process of analysis and assessment will begin after the completion of the 2006 pulses and be conducted annually thereafter. This process conforms to the adaptive management approach presented in the biological opinion and adopted by the Corps to address potential changes to the technical criteria. Information resulting from all studies, the analysis of this information, and any proposed changes to the spring pulse Master Manual technical criteria, if required, will be fully coordinated with basin Tribes, states, stakeholders, and the public. All comments will be fully considered prior to a change in the Master Manual. This will include Consultation with the potentially affected Tribes.

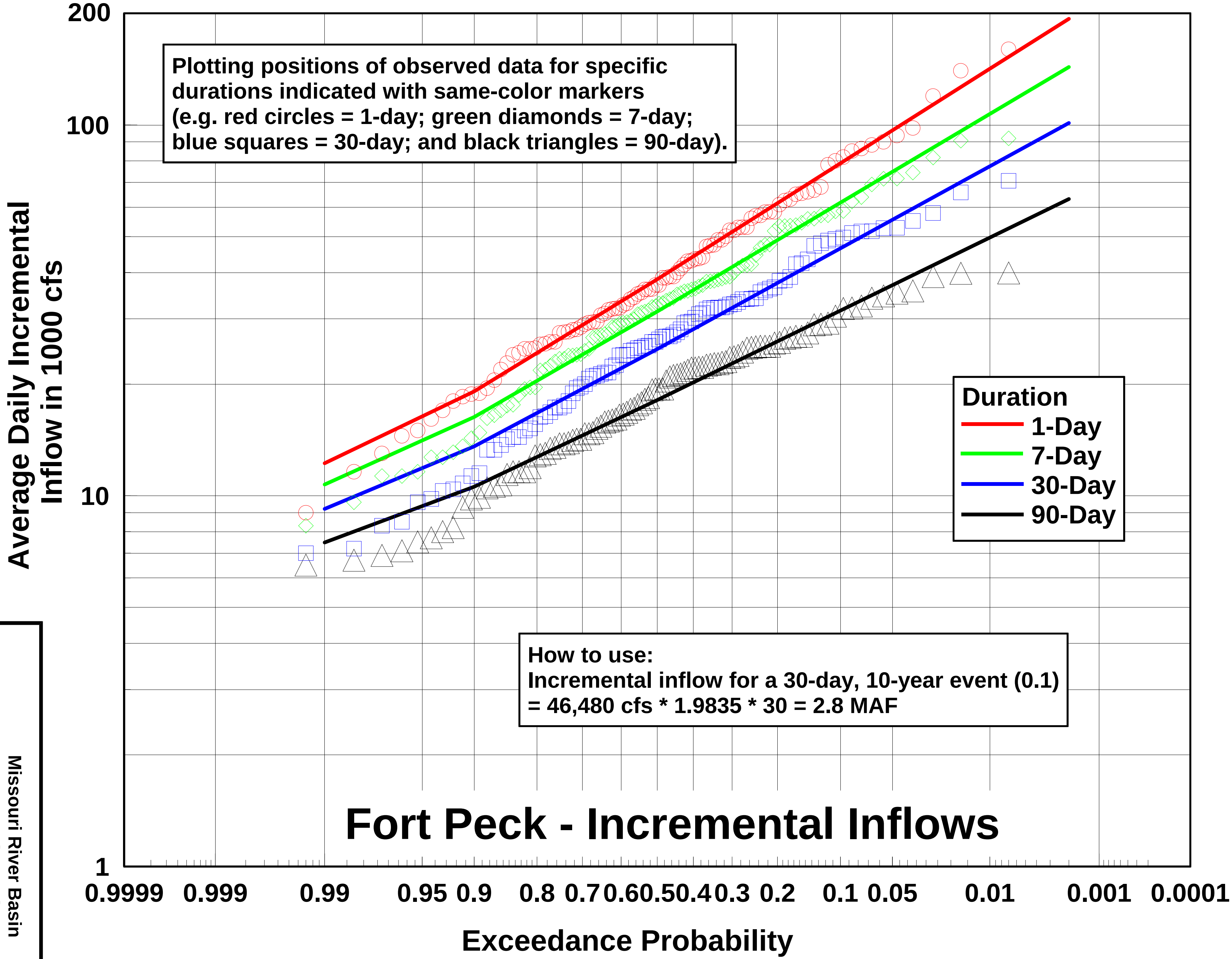
I-04. **The Missouri River Recovery Implementation Committee (MRRIC).** The Corps and the Service have proposed that a Missouri River Recovery Implementation Committee (MRRIC) be established, to include the full range of basin Tribes, states and stakeholders to advise the Corps and other Federal agencies on actions to recover Missouri River T&E species and the ecosystem on which they depend. The Corps is committed to the establishment of MRRIC and the adaptive management process as indicated in this Master Manual and is working the Service, the U.S. Environmental Institute for Environmental Conflict Resolution and their support contractor, CDR Associates, and other federal agencies to establish the framework for this committee.

I-04.1. The Institute and CDR Associates have prepared a "situational assessment" of the potential for a MRRIC. This includes an assessment of the feasibility of a recovery committee approach in the Missouri River basin. The assessment also includes a recommendation related to the participation, structure, and function of the MRRIC. Numerous basin Tribal members and representatives, state representatives and stakeholders were interviewed to get input for the "situational assessment". The Corps and the Service will review the findings of the Institute and CDR Associates prior to their decision on the establishment of MRRIC.



Missouri River Basin
Fort Peck Project
Regulated Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

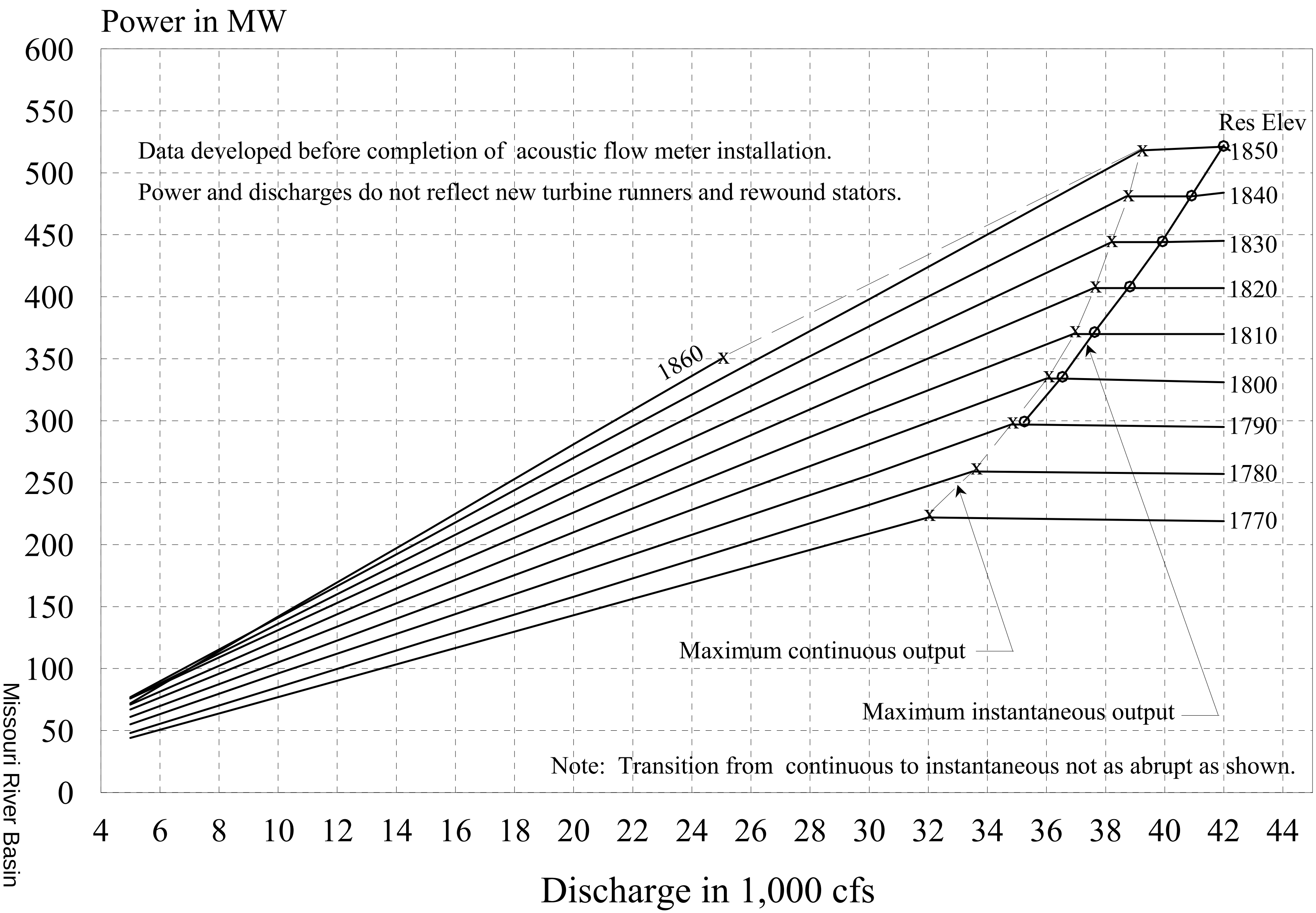
Revised Plate II-13



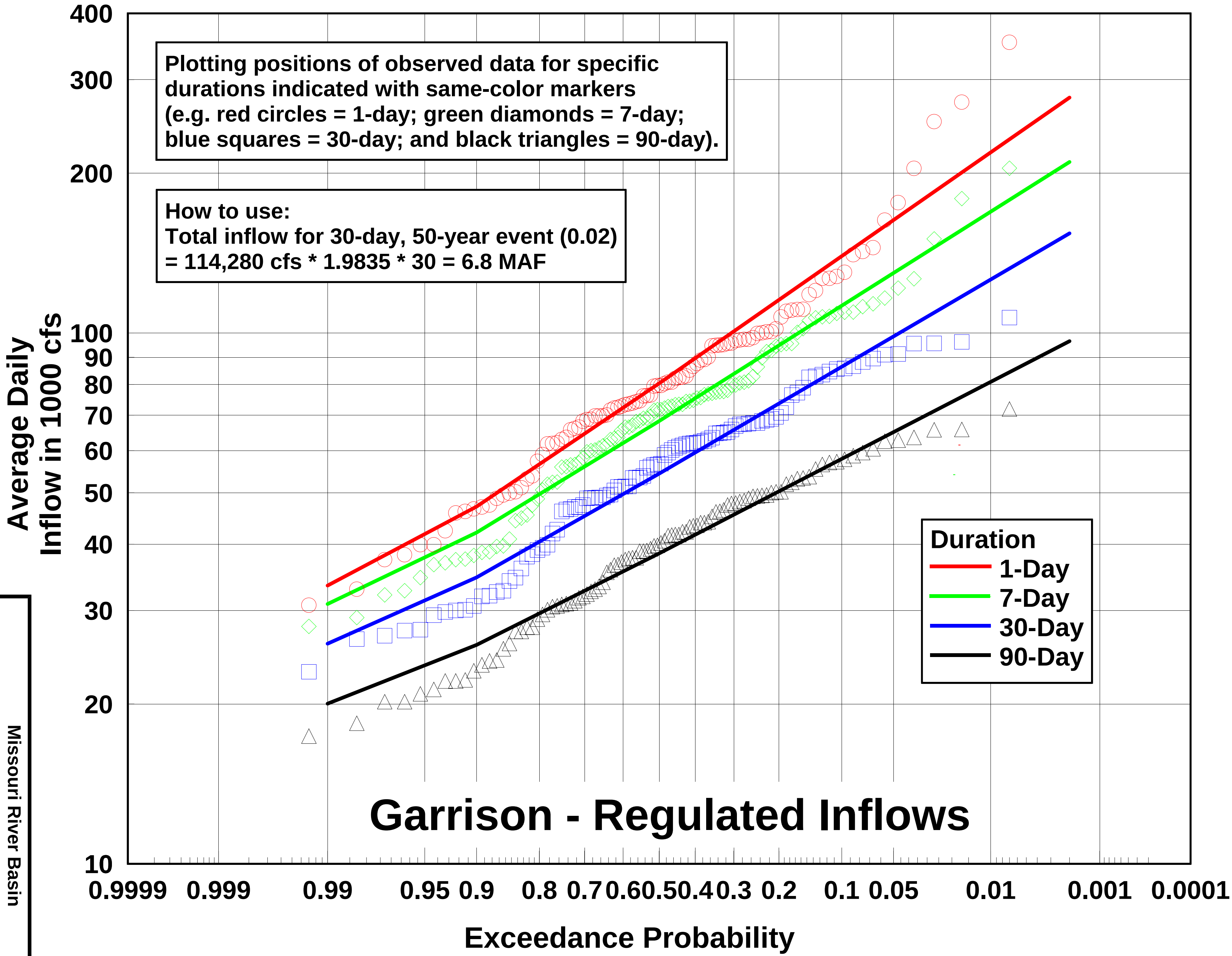
Missouri River Basin
Fort Peck Project
Incremental Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-17

Garrison Powerplant

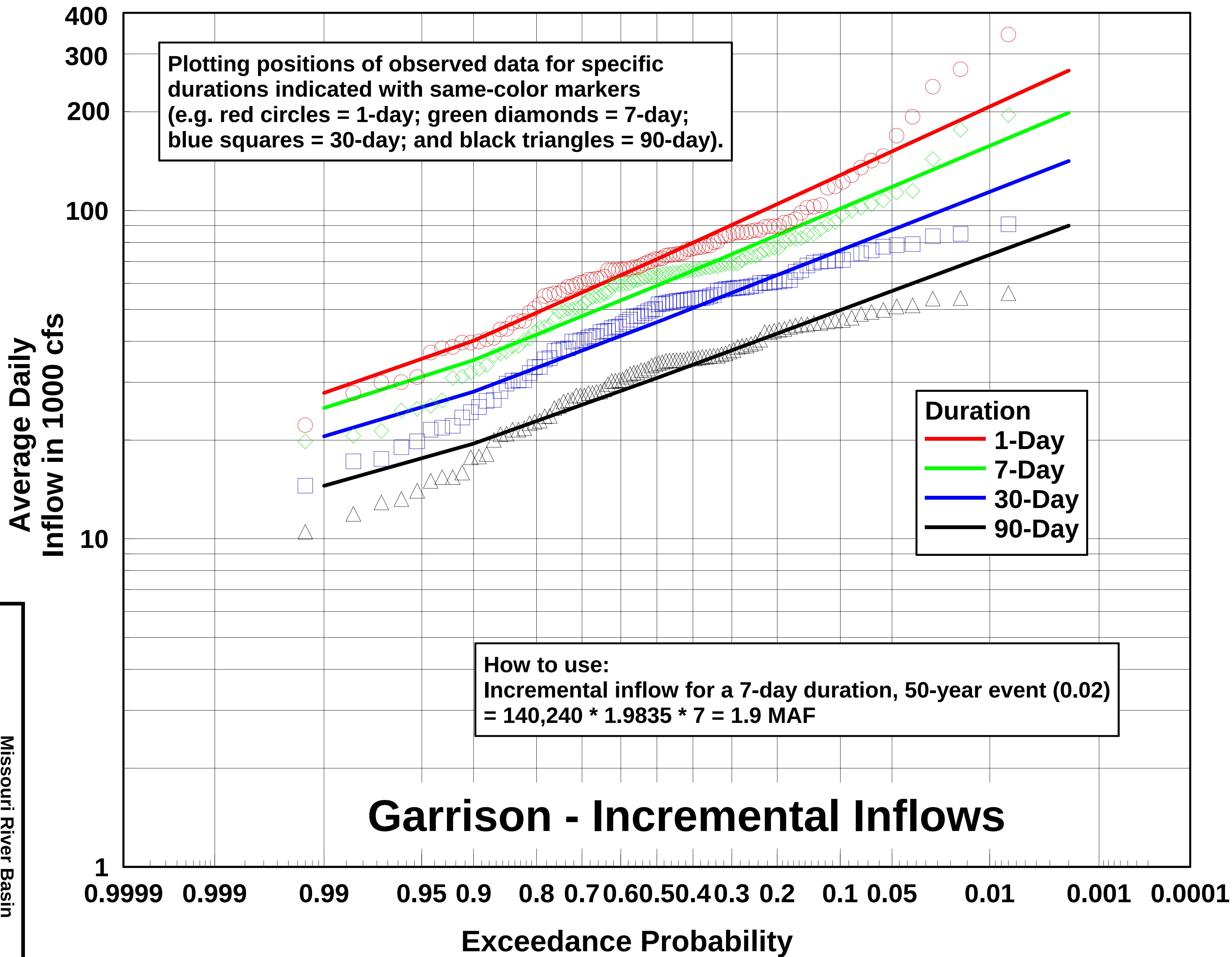


Missouri River Basin
Garrison Powerplant Characteristics
U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
March 2006
Revised Plate II-23



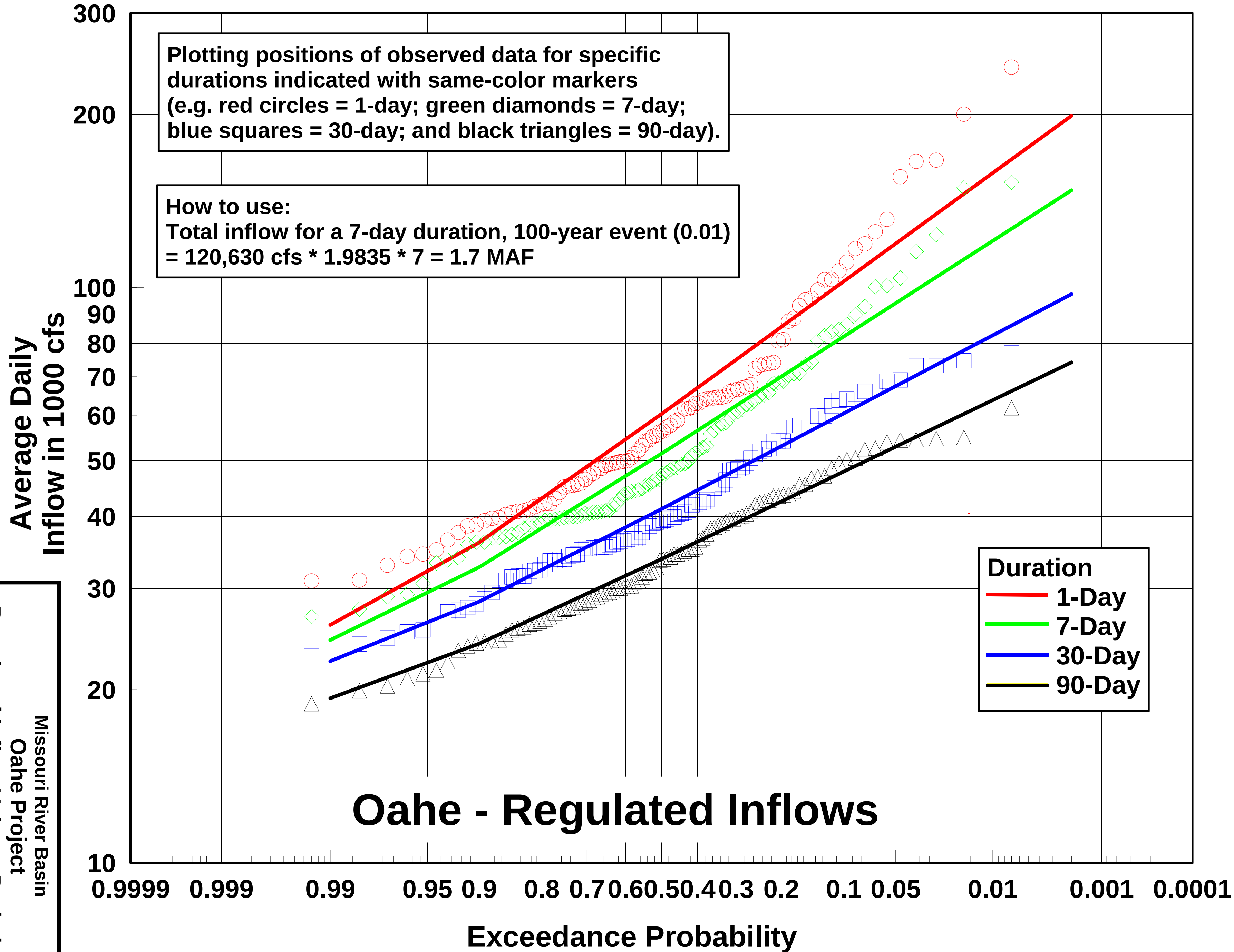
Missouri River Basin
Garrison Project
Regulated Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-27



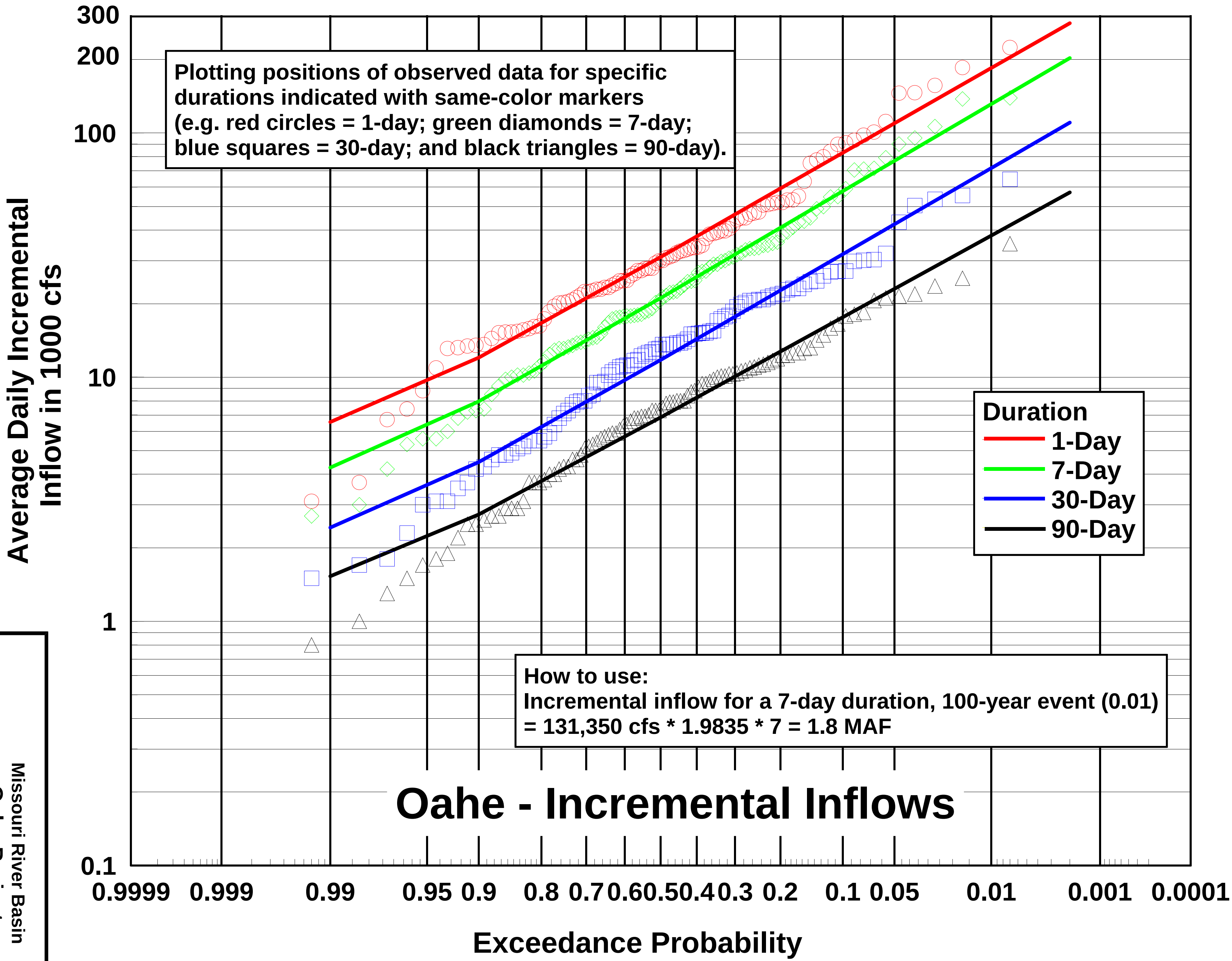
Missouri River Basin
Garrison Project
Incremental Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-31



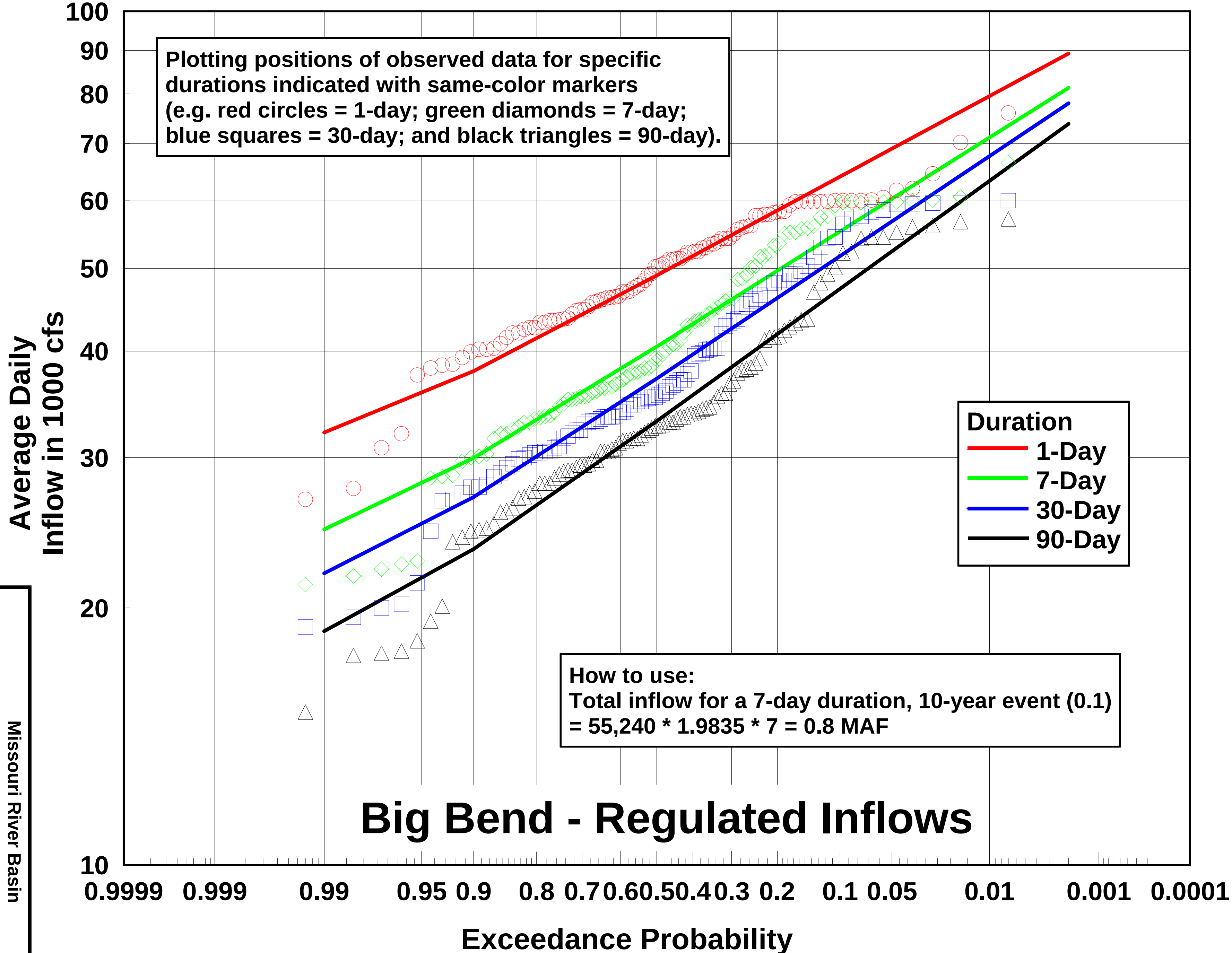
Missouri River Basin
Oahe Project
Regulated Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-40



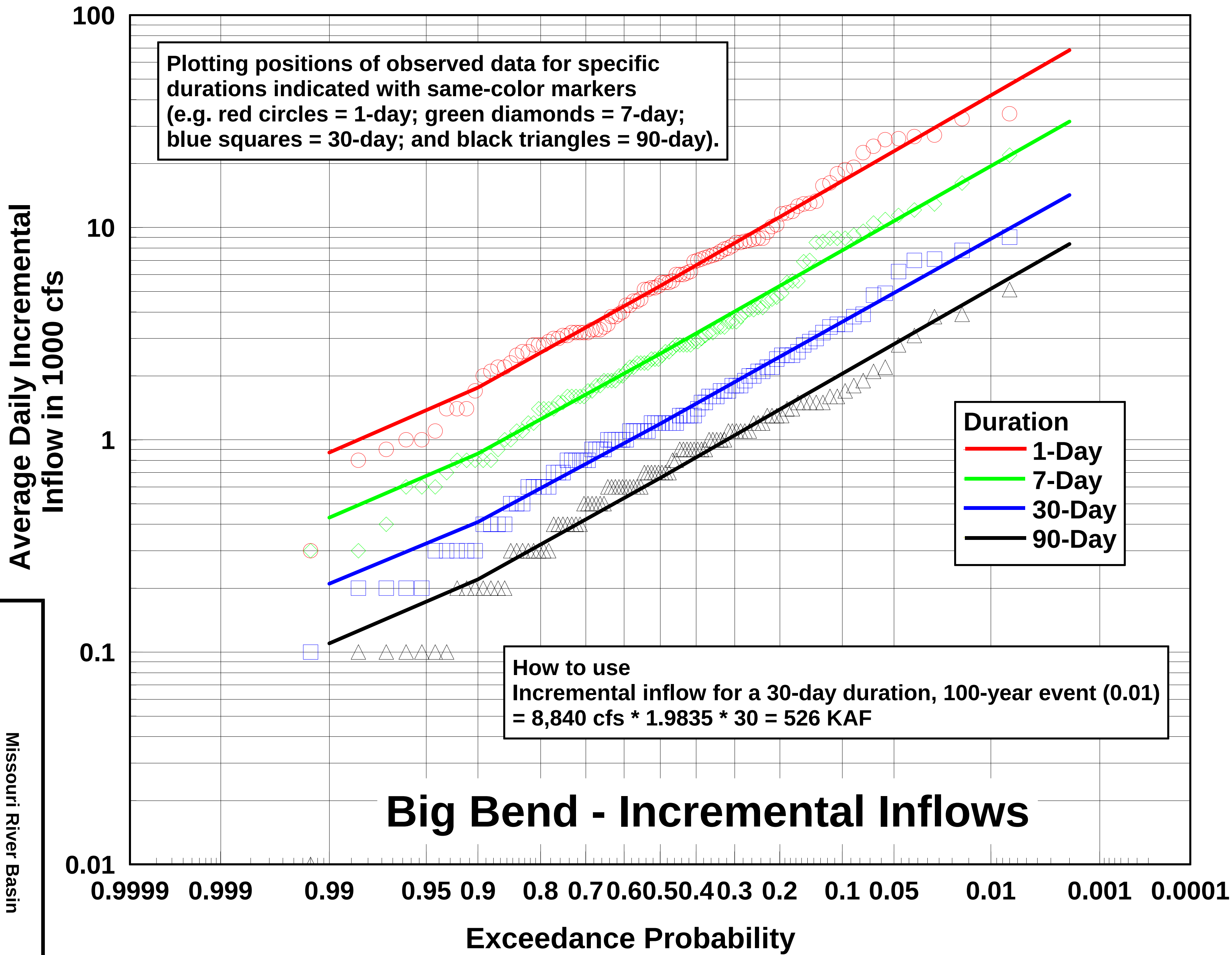
Missouri River Basin
Oahe Project
Incremental Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-44



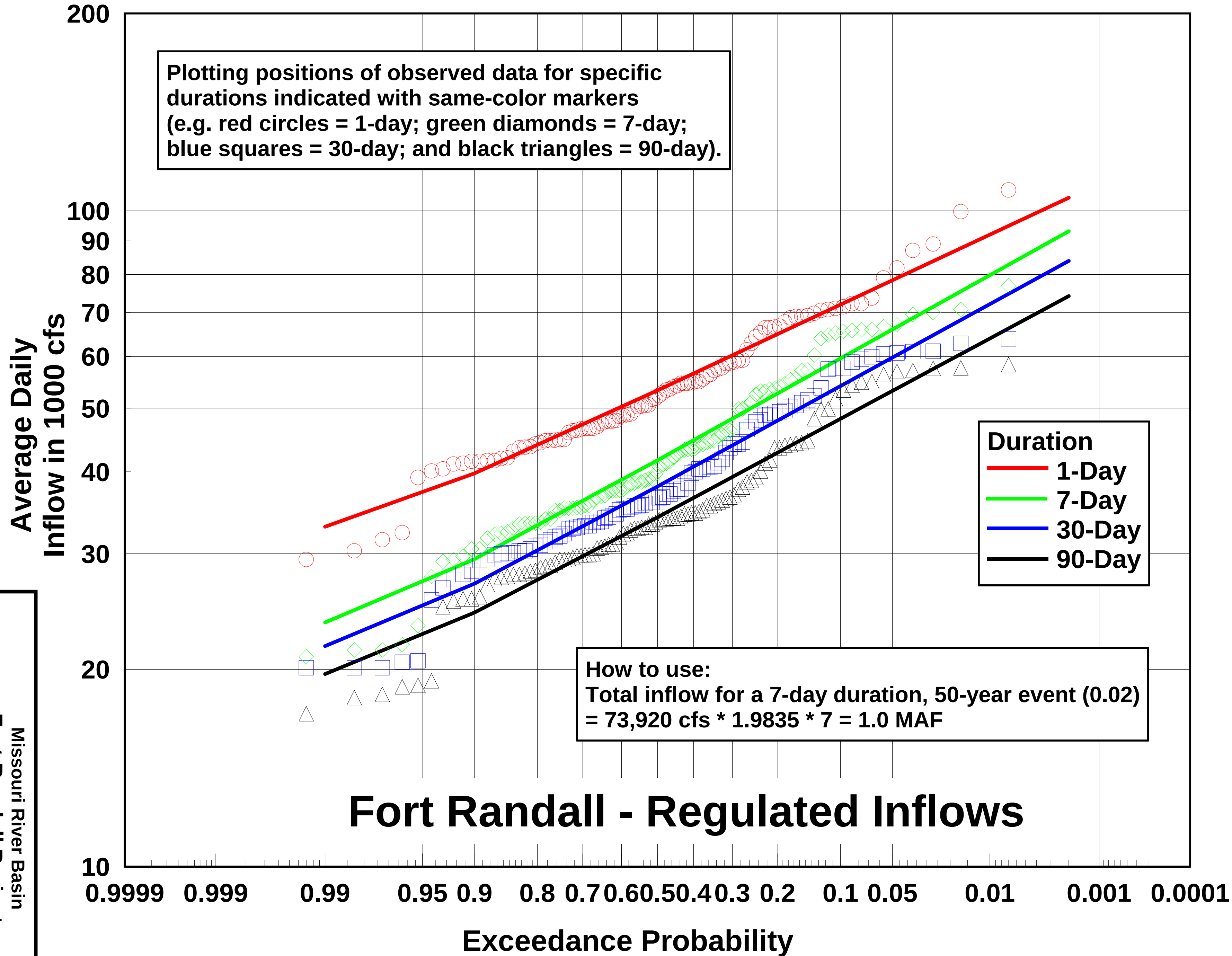
Missouri River Basin
Big Bend Project
Regulated Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-52



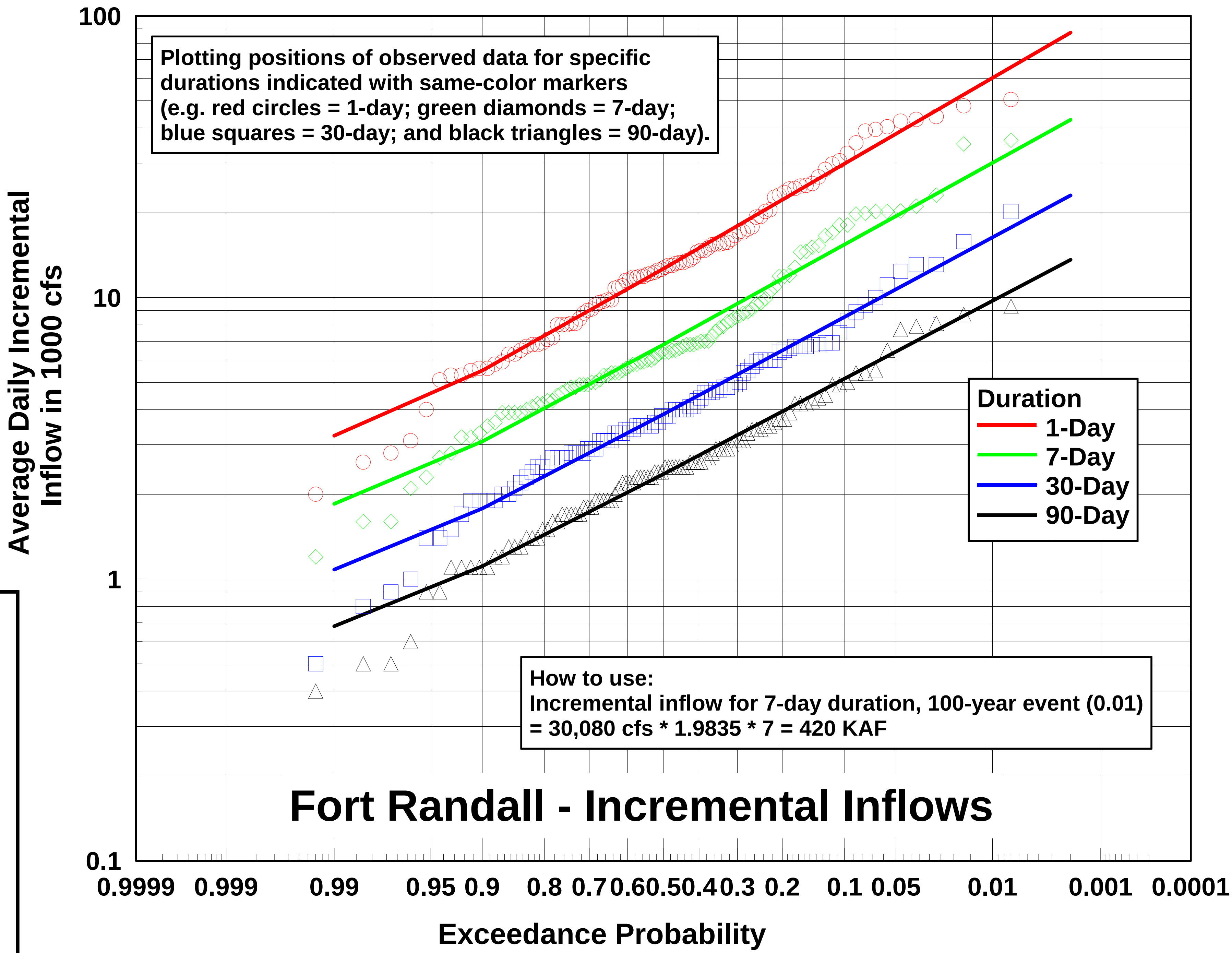
Missouri River Basin
Big Bend Project
Incremental Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-56



Missouri River Basin
Fort Randall Project
Regulated Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-65

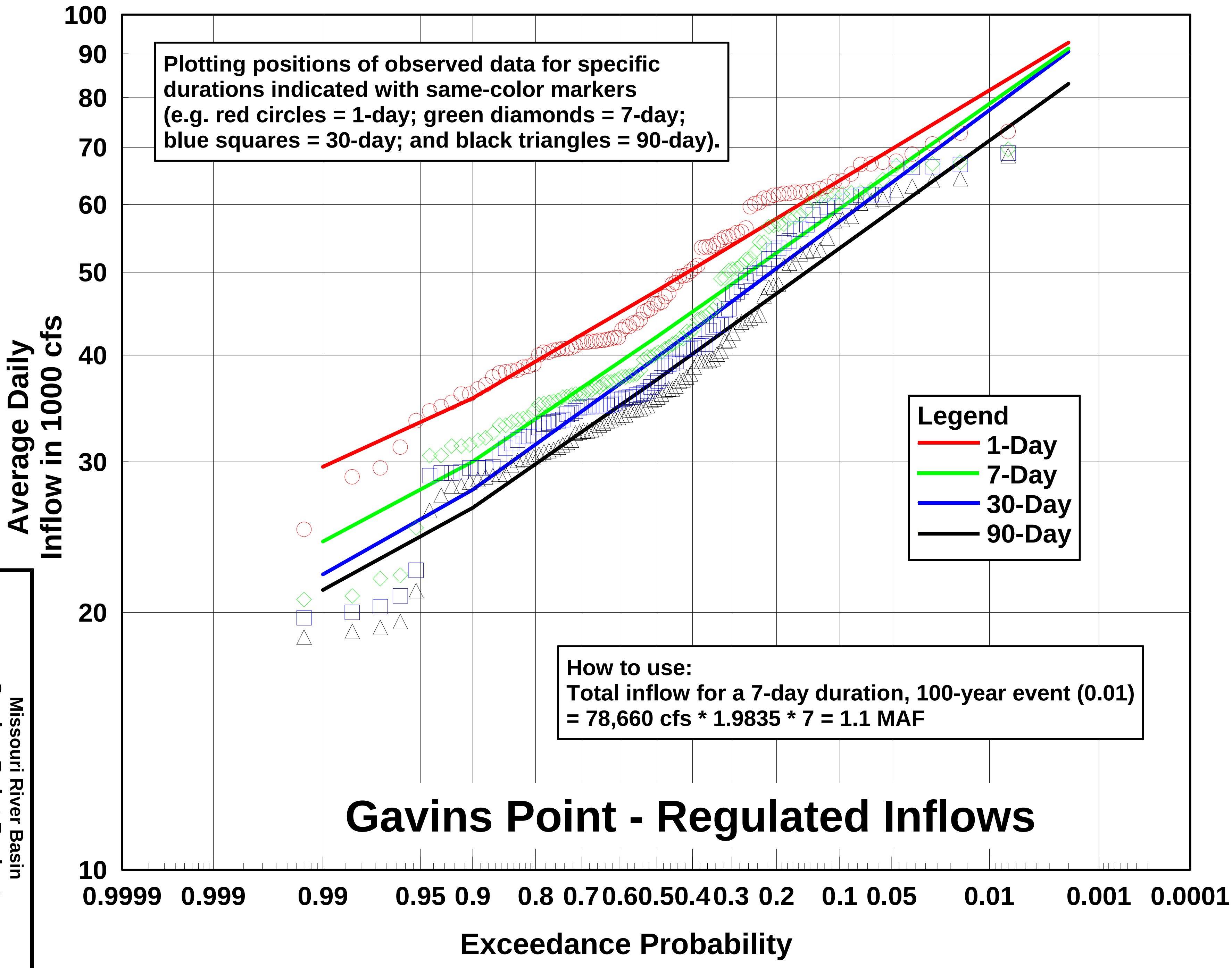


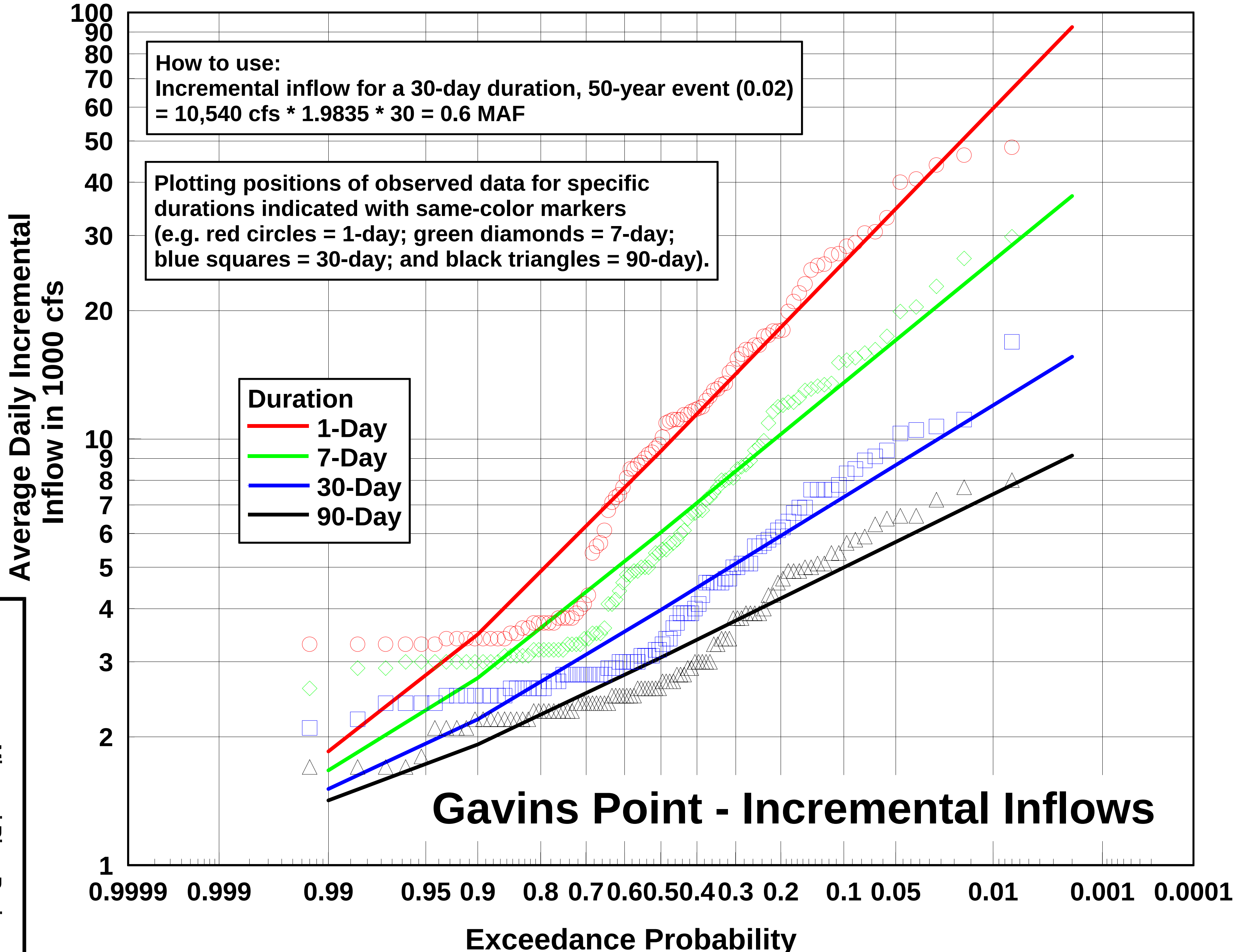
Missouri River Basin
Fort Randall Project
Incremental Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-69

Missouri River Basin
Gavins Point Project
Regulated Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-77





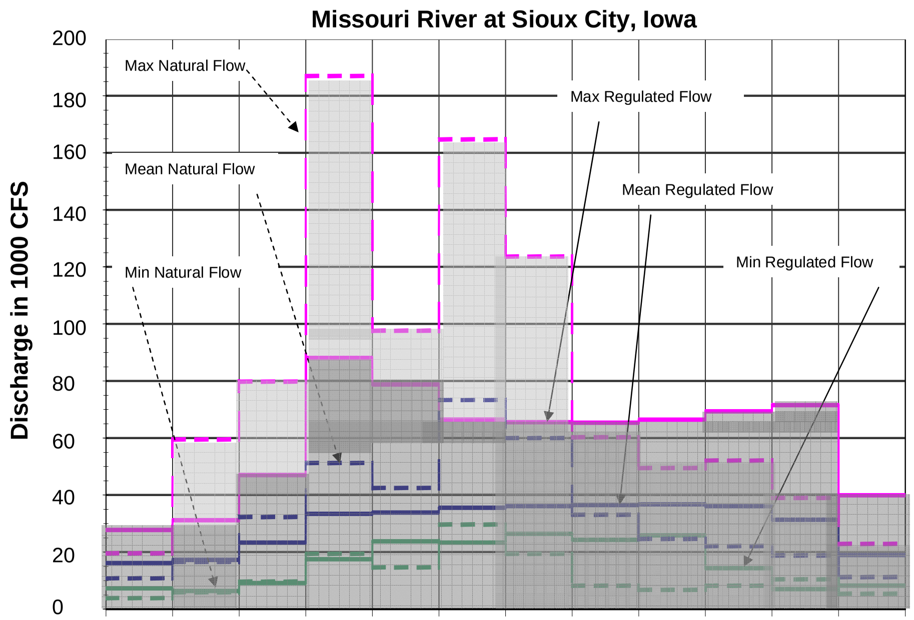
Missouri River Basin
Gavins Point Project
Incremental Inflow Volume Probabilities
U.S. Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraska
March 2006

Revised Plate II-81

Notes:

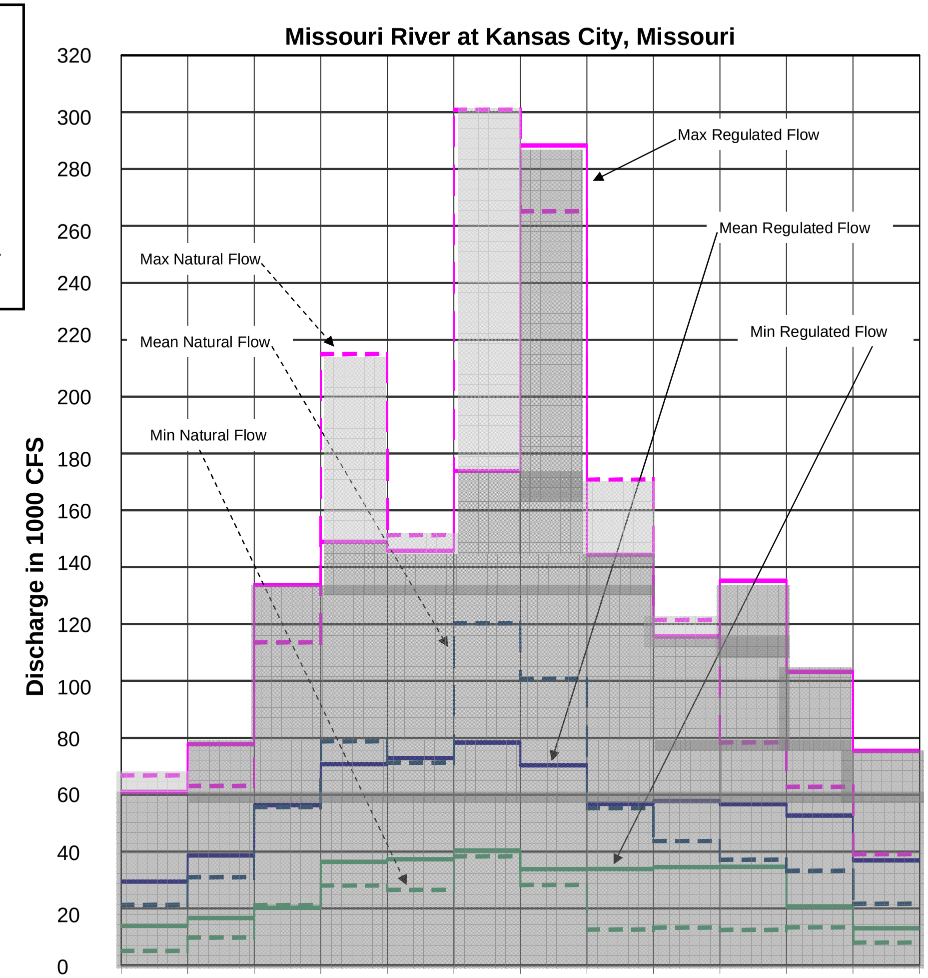
1. Natural flows refer to Missouri River flows prior to 1953.
2. Regulated flows refer to Missouri River flows from 1953 to present.
3. Natural flows are from historical data presented in Missouri River Inter-Agency Committee Report - 1959 Adequacy of Flows in the Missouri River for 1898-1952.
4. Regulated flows are from USGS measured flows as reported in the 2002 Water Supply Reports (Iowa and Missouri).

Missouri River at Sioux City, Iowa



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max Natural	1919	1928	1910	1952	1927	1927	1909	1923	1951	1923	1951	1923
Max Regulated	1987	1997	1997	1997	1997	1997	1997	1997	1997	1997	1997	1997
Min Natural	1940	1940	1940	1931	1931	1940	1934	1919	1919	1921	1935	1937
Min Regulated	1964	1963	1957	1957	1962	1960	2002	1993	1962	1961	1961	1961

Missouri River at Kansas City, Missouri



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max Natural	1910	1916	1949	1952	1920	1908	1915	1915	1951	1941	1951	1909
Max Regulated	1973	1973	1979	1984	1995	1984	1993	1993	1993	1973	1998	1986
Min Natural	1940	1940	1940	1934	1934	1934	1934	1934	1934	1939	1936	1937
Min Regulated	1963	1964	1964	1990	1989	1989	2002	1991	1991	1991	1990	1963

Missouri River Basin

Monthly Streamflow Distribution

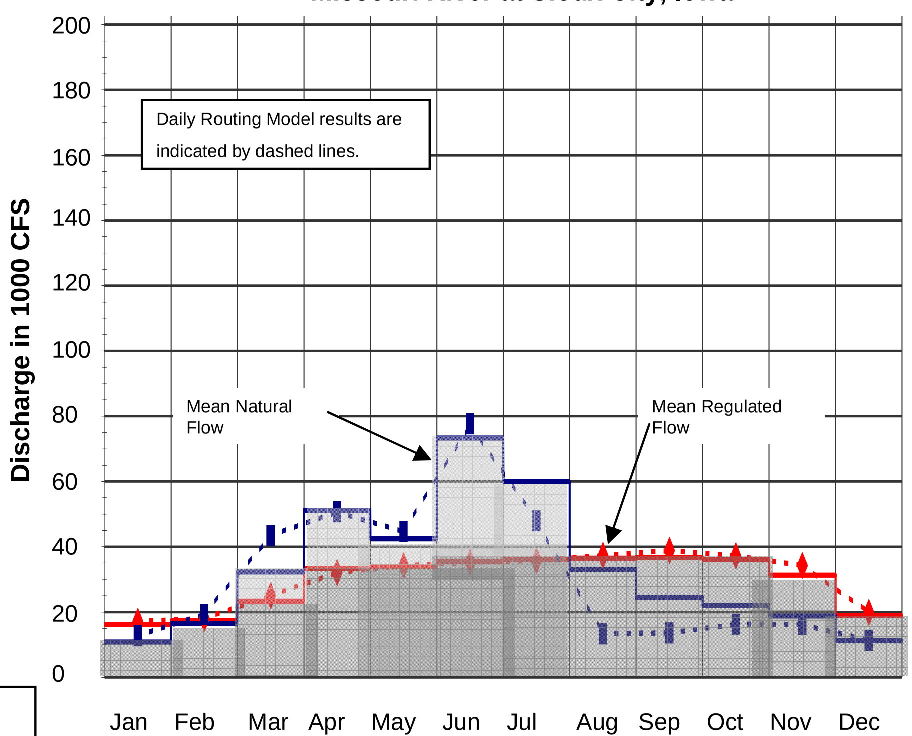
U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
March 2006

Revised Plate III-25

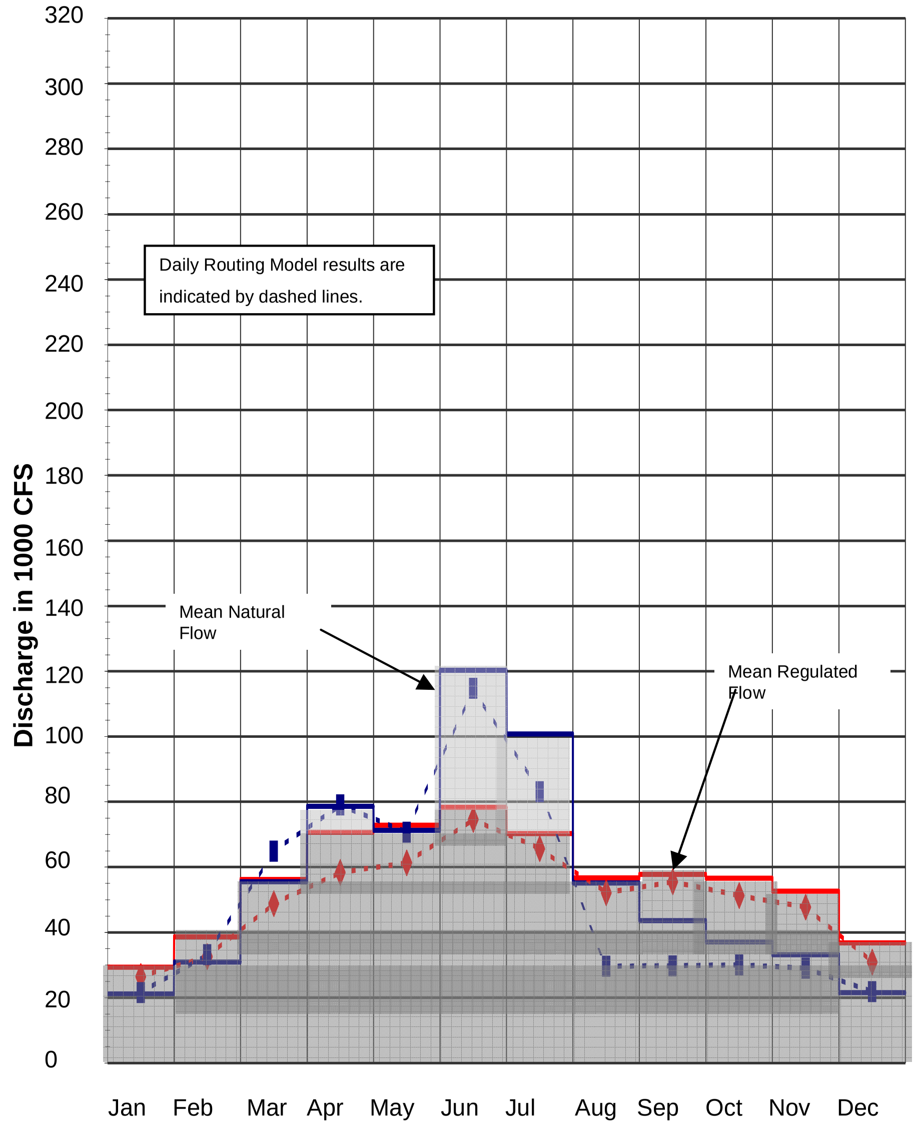
Notes:

1. Natural flows refer to Missouri River flows prior to 1953.
2. Regulated flows refer to Missouri River flows from 1953 to present.
3. Natural flows are from historical data presented in Missouri River Inter-Agency Committee Report - 1959 Adequacy of Flows in the Missouri River for 1898-1952.
4. Regulated flows are from USGS measured flows as reported in the 2002 Water Supply Reports (Iowa and Missouri).
5. Daily Routing Model flows encompass a 100-year period from 1898-1997.

Missouri River at Sioux City, Iowa



Missouri River at Kansas City, Missouri



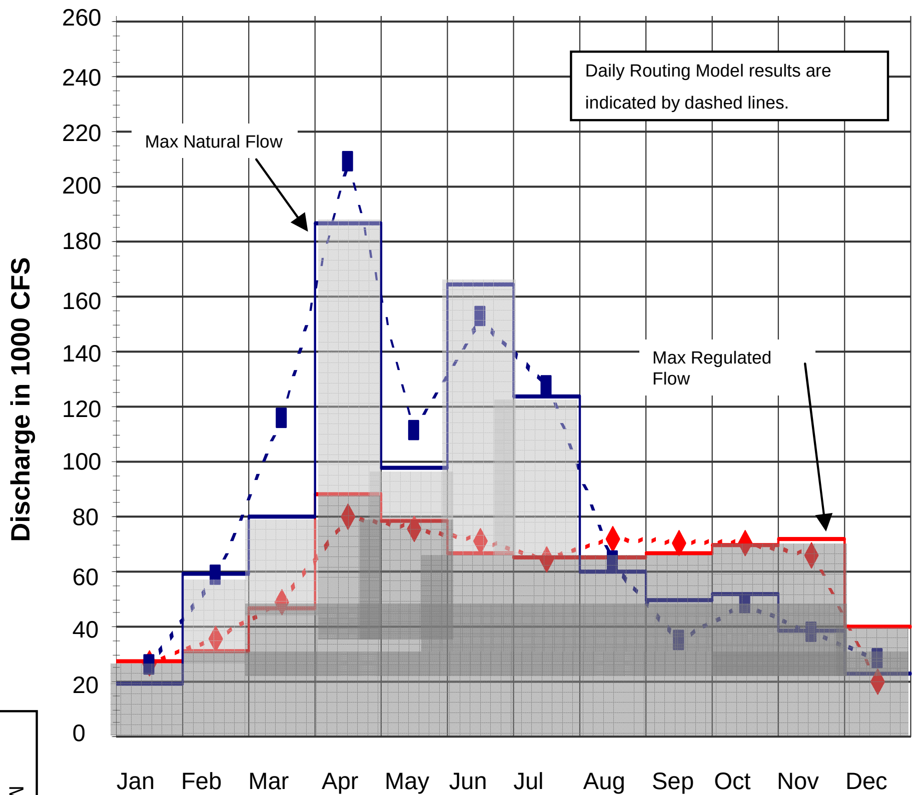
Missouri River Basin
Mean Monthly Streamflow
Distribution Comparison to DRM
Results

U.S.ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
November 2003

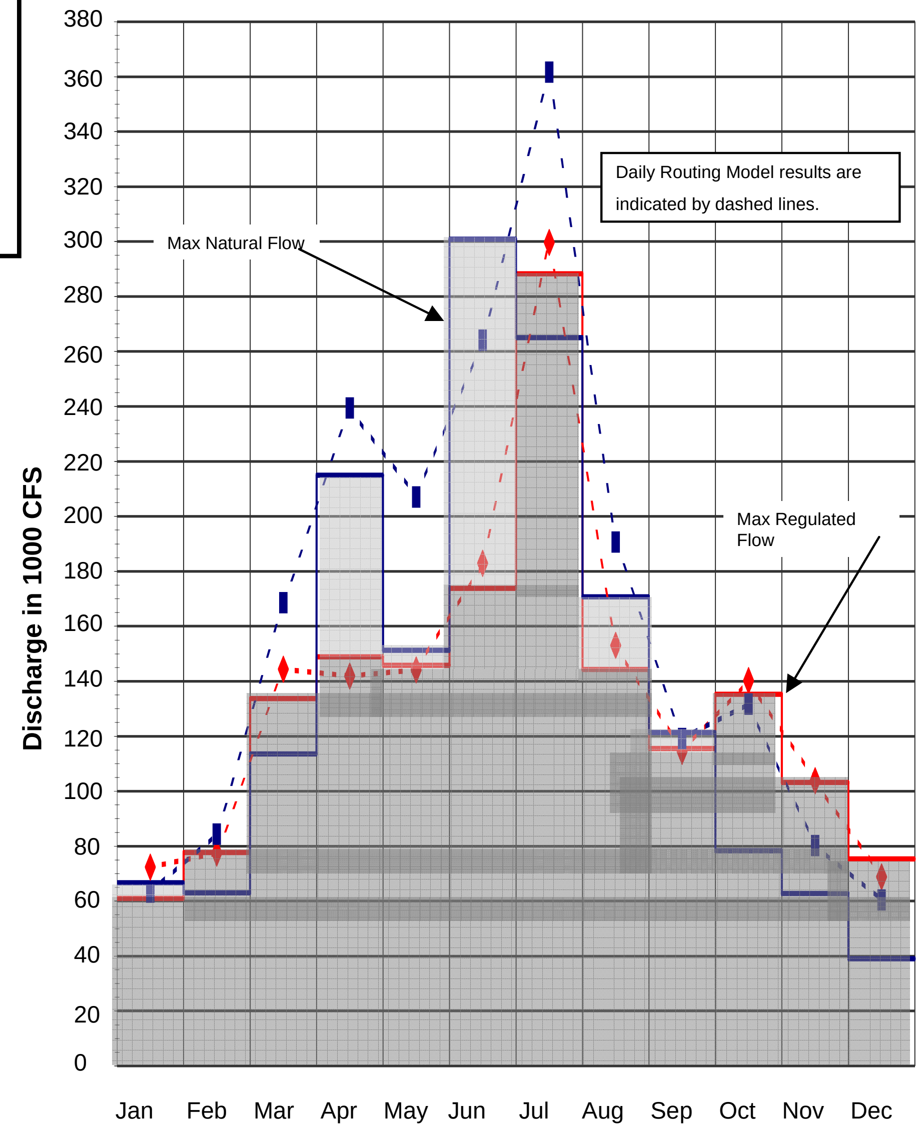
Notes:

1. Natural flows refer to Missouri River flows prior to 1953.
2. Regulated flows refer to Missouri River flows from 1953 to present.
3. Natural flows are from historical data presented in Missouri River Inter-Agency Committee Report - 1959 Adequacy of Flows in the Missouri River for 1898-1952.
4. Regulated flows are from USGS measured flows as reported in the 2002 Water Supply Reports (Iowa and Missouri).
5. Daily Routing Model flows encompass a 100-year period from 1898-1997.

Missouri River at Sioux City, Iowa



Missouri River at Kansas City, Missouri



Missouri River Basin
Max Monthly Streamflow
Distribution Comparison to DRM
Results

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
November 2003

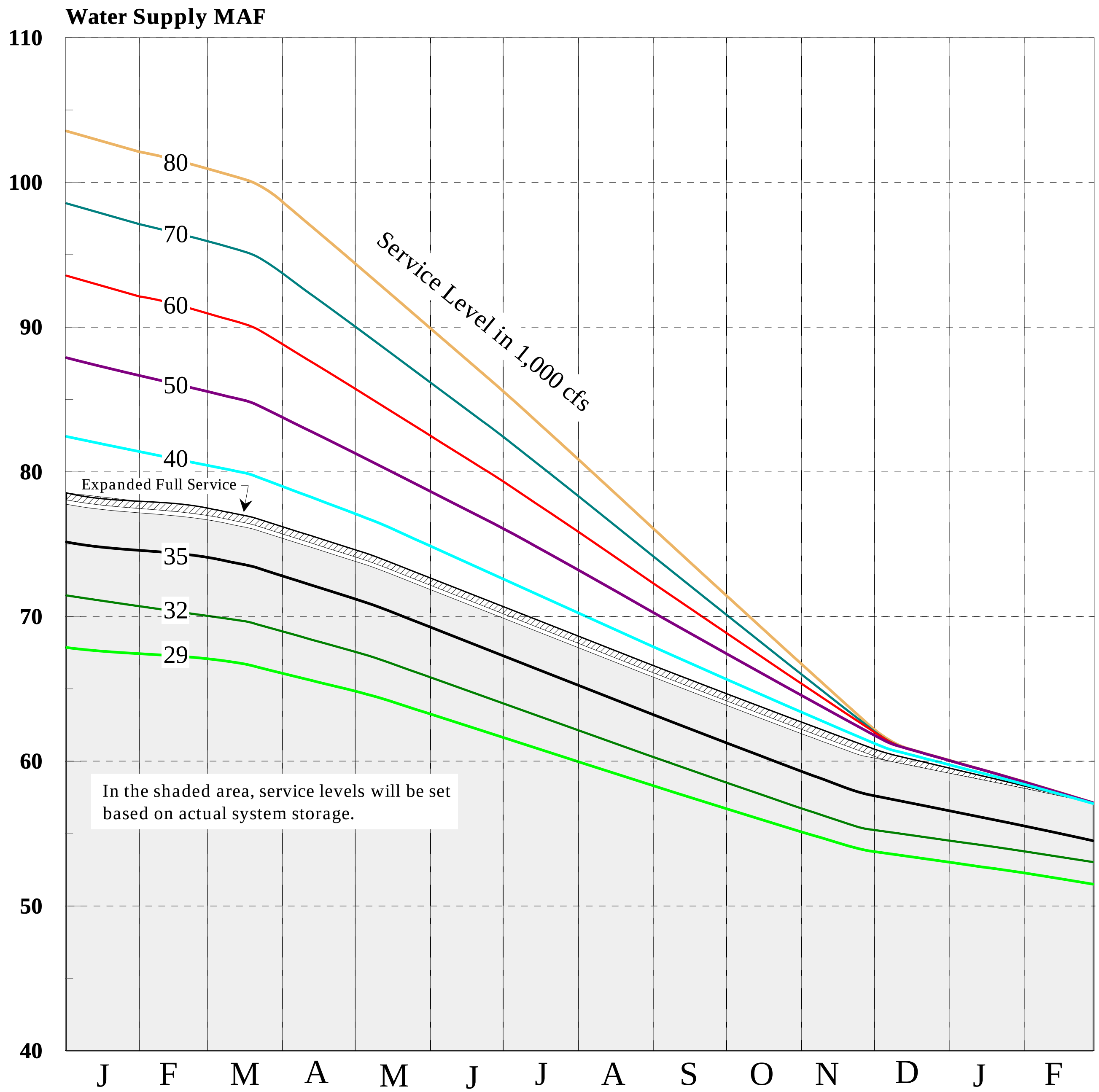
Revised Plate III-27

```
----------------------------------------------------------------------
*                      MONTHLY RESERVOIR OPERATION                   *
----------------------------------------------------------------------
*        RESERVOIR              RIVER              DISTRICT          *
*        FORT PECK         MISSOURI RIVER           OMAHA            *
----------------------------------------------------------------------
* MISSOURI RIVER REGION                  U.S. ARMY CORPS OF ENGINEERS *
----------------------------------------------------------------------
*     *        *             *          MEAN DISCHARGE IN CFS        *
* JAN.* ELEV.  *  PAN  EVAP. *        OUTFLOW        *     INFLOW    *
* 2004*  MSL   *  INCH  CFS  *    POWER  SPILL       *               *
----------------------------------------------------------------------
*   1 *2206.80+*         200-*    9,000      0+      *    5,000      *
*   2 *2206.72 *         200 *    9,000      0       *    5,000      *
*   3 *2206.63 *         200 *    8,800      0       *    3,000      *
*   4 *2206.54 *         200 *    8,800      0       *    2,000-     *
*   5 *2206.54 *         200 *    8,700      0       *    3,000      *
----------------------------------------------------------------------
*   6 *2206.54 *         200 *    8,500-     0       *    3,000      *
*   7 *2206.54 *         200 *    8,600      0       *    3,000      *
*   8 *2206.19 *         200 *    8,800      0       *    3,000      *
*   9 *2206.05 *         200 *    8,900      0       *    2,000      *
*  10 *2206.02 *         200 *    8,800      0       *    2,000      *
----------------------------------------------------------------------
*  11 *2205.97 *         200 *    8,800      0       *    3,000      *
*  12 *2205.92 *         200 *    9,000      0       *    5,000      *
*  13 *2205.85 *         200 *    9,000      0       *    5,000      *
*  14 *2205.80 *         200 *    8,600      0       *    5,000      *
*  15 *2205.79 *         200 *    8,800      0       *    5,000      *
----------------------------------------------------------------------
*  16 *2205.79 *         200 *    9,000      0       *    6,000      *
*  17 *2205.70 *         200 *    9,200      0       *    6,000      *
*  18 *2205.66 *         200 *    9,400+     0       *    6,000      *
*  19 *2205.61 *         200 *    9,100      0       *    6,000      *
*  20 *2205.61 *         300+*    9,100      0       *    7,000+     *
----------------------------------------------------------------------
*  21 *2205.56 *         300 *    9,100      0       *    7,000      *
*  22 *2205.55 *         300 *    8,900      0       *    7,000      *
*  23 *2205.49 *         300 *    9,000      0       *    7,000      *
*  24 *2205.50 *         300 *    8,800      0       *    7,000      *
*  25 *2205.47 *         300 *    9,000      0       *    7,000      *
----------------------------------------------------------------------
*  26 *2205.41 *         300 *    9,100      0       *    7,000      *
*  27 *2205.43 *         300 *    8,900      0       *    7,000      *
*  28 *2205.40 *         300 *    8,900      0       *    7,000      *
*  29 *2205.32 *         300 *    8,900      0       *    6,000      *
*  30 *2205.29-*         300 *    8,800      0       *    7,000      *
*  31 *2205.29 *         300 *    8,800      0       *    7,000      *
----------------------------------------------------------------------
*TOTAL*  (DSF) * 0.00   7400 *  276,100      0     0 *  161,000     0 *
*TOTAL* (AC-FT)*       15000 *  548,000      0     0 *  319,000     0 *
----------------------------------------------------------------------
* MEAN*2205.87 * 0.00    200 *    8,900      0     0 *    5,200     0 *
----------------------------------------------------------------------
* REMARKS - RESERVOIR STORAGE  EOM =  9806000     CHNG =  -243000    *
*  + MAX.             MONTHLY  MAX = 10040000 ( 1) MIN =  9806000 (31)*
*  - MIN.   MONTHLY PRECIP. =  0.68 INCHES                           *
*  NOTE: Lake Frozen Over 8 Jan 04                        JAN. 2004  *
----------------------------------------------------------------------
                                                               PROVISIONAL RECORD
STORAGE DIFFERENCE IN THE REMARKS IS -243000.
STORAGE ACCUMULATION IN THE TOTALS IS -242975.
```

Missouri River
Mainstem Reservoir System
0168 Report

U.S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
MARCH 2006

Revised Plate V-4



Notes:

1. Water supply consists of the accumulation of the following:
   a. Actual system storage
   b. Forecast remaining calendar year runoff volume (1949 basin development level) above Gavins Point Dam.
   c. Departure of total tributary storage from base level. (See text.)

2. Expanded full service consists of the following:
   a. Maintenance of 35,000 cfs service level through the navigation season.
   b. Extension of the navigation season for up to 10 days beyond the normal closing date of 1 December at the mouth of the Missouri River.
   c. Winter releases averaging 20,000 cfs from Gavins Point.

3. The relationship between the service level and target flow is as given in the table below:

Target Flows - 1,000 cfs

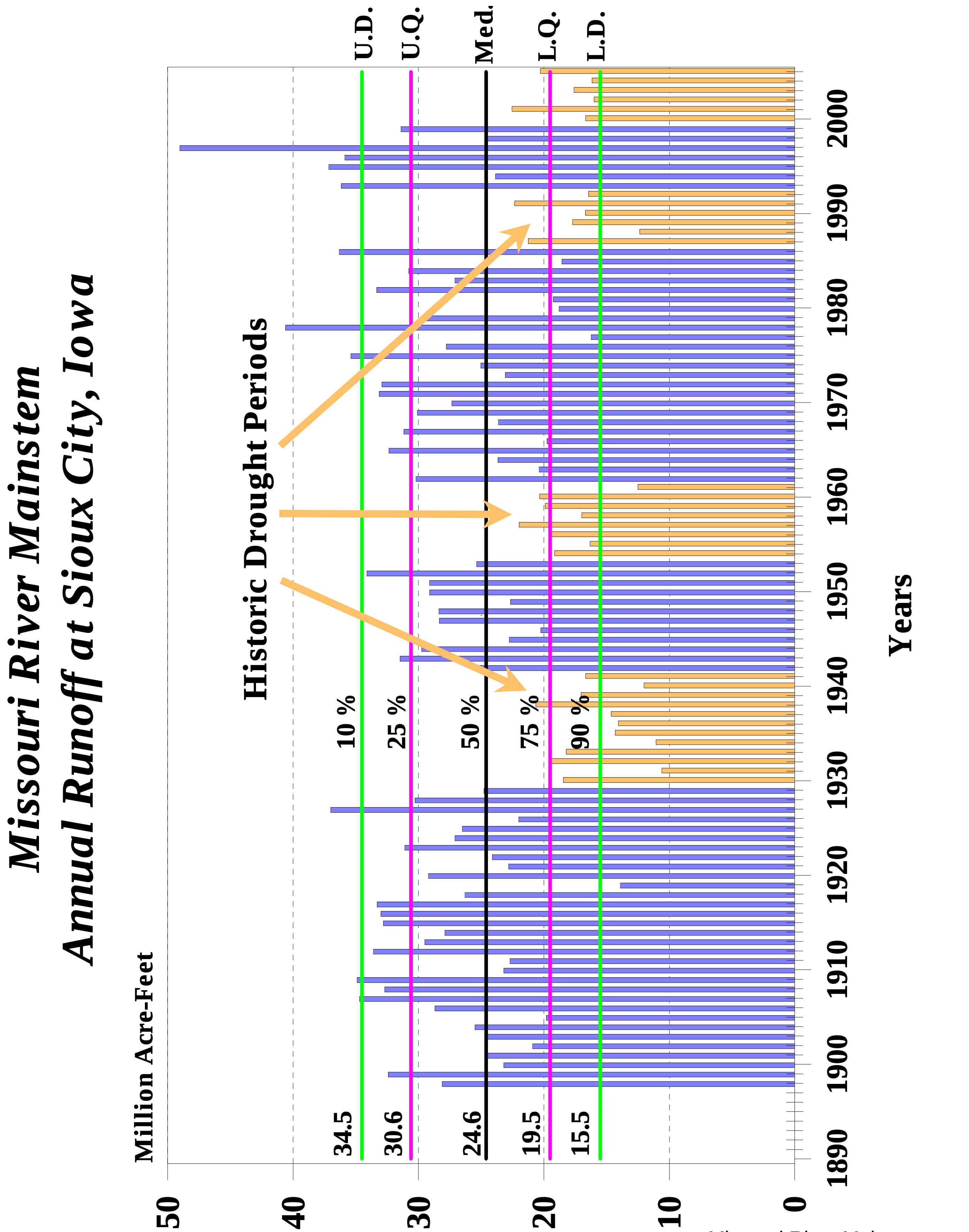
Service Level	Sioux City & Omaha	Nebraska City	Kansas City
29.0 1/	25.0	31.0	35.0
35.0 2/	31.0	37.0	41.0
40.0 3/	36.0	42.0	46.0
50.0 3/	46.0	52.0	56.0

1/ Minimum service level
2/ Full service level
3/ Storage evacuation service level

Misssouri River
Mainstem Reservoir System
Service Level

U. S. ARMY ENGINEER DIVISION, NORTHWESTERN
CORPS OF ENGINEERS, OMAHA, NEBRASKA
MARCH 2006

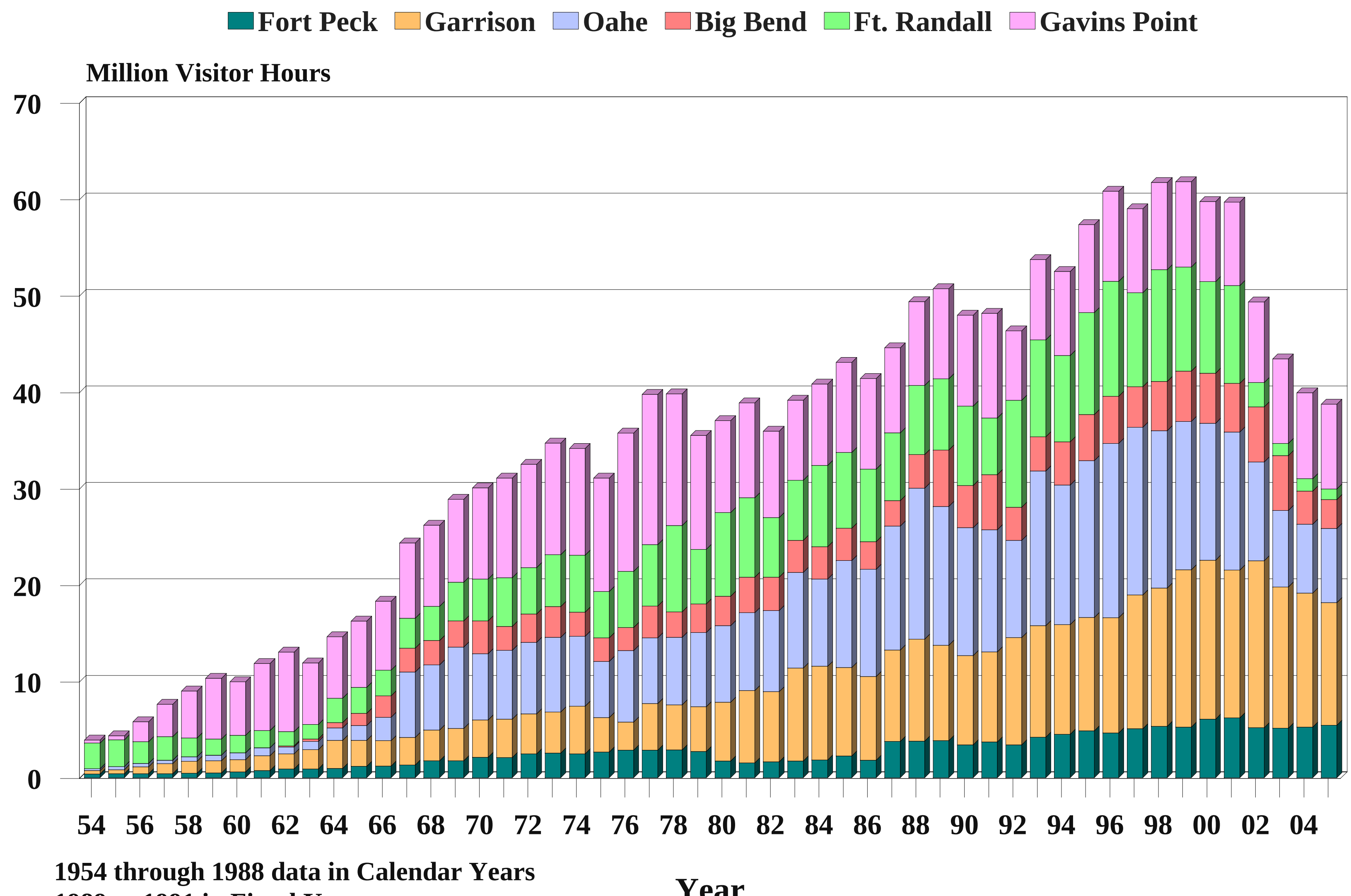
Revised Plate VI-1



Missouri River Mainstem
Annual Runoff at Sioux City, Iowa
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraksa
March 2006
Revised Plate A-3

Mainstem Project Visits

1954 to 2005



1954 through 1988 data in Calendar Years
1989 to 1991 in Fiscal Years
1992 to present in VERS System
2002 to present reflect changed accounting due to Title VI land transfer to state of SD

Missouri River Basin
Mainstem Project Visits
U.S. Army Engineer Division, Northwestern
Corps of Engineers, Omaha, Nebraksa
March 2006
Revised Plate B-1