US Army Corps
of Engineers

Northwestern Division
Missouri River Region
Reservoir Control Center

Missouri River Region
RCC
Since 1953
Reservoir Control Center

Missouri River Main Stem Reservoirs

Summary of Actual 1997 - 1998 Operations

January 1999

MISSOURI RIVER MAIN STEM RESERVOIRS

Summary of Actual 1997-1998 Operations

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LIST OF ABBREVIATIONS

AOP -	annual operating plan
ac.ft. -	acre-feet
AF -	acre-feet
B -	Billion
cfs -	cubic feet per second
COE -	Corps of Engineers
CY -	calendar year (January 1 to December 31)
EA -	Environmental Assessment
EIS -	Environmental Impact Statement
elev -	elevation
ESA -	Endangered Species Act of 1978
FONSI -	Finding of No Significant Impact
ft -	feet
FWS -	U.S. Fish and Wildlife Service
FY -	fiscal year (October 1 to September 30)
GIS -	Geographic Information System
GWh -	gigawatt hour
KAF -	1,000 acre-feet
Kcfs -	1,000 cubic feet per second
kW -	kilowatt
kWh -	kilowatt hour
M -	million
MAF -	million acre-feet
MRBA -	Missouri River Basin Association
MRNRC -	Missouri River Natural Resources Committee
msl -	mean sea level
MW -	megawatt
MWh -	megawatt hour
NEPA -	National Environmental Policy Act
plover -	piping plover
pp -	powerplant
RCC -	Reservoir Control Center
RM -	river mile
tern -	interior least tern
tw -	tailwater
USGS -	United States Geological Survey
yr -	year

DEFINITION OF TERMS

Acre-foot (AF, ac-ft) is the quantity of water required to cover 1 acre to a depth of 1 foot and is equivalent to 43,560 cubic feet or 325,850 gallons.

Cubic foot per second (cfs) is the rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second and is equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute. The volume of water represented by a flow of 1 cubic foot per second for 24 hours is equivalent to 86,400 cubic feet, approximately 1.983 acre-feet, or 646,272 gallons.

Discharge is the volume of water (or more broadly, volume of fluid plus suspended sediment) that passes a given point within a given period of time.

Drainage area of a stream at a specific location is that area, measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into the river above the specified point. Figures of drainage area given herein include all closed basins, or noncontributing areas, within the area unless otherwise noted.

Drainage basin is a part of the surface of the earth that is occupied by drainage system, which consists of a surface stream or body of impounded surface water together with all tributary surface streams and bodies of impounded water.

Gaging station is a particular site on a stream, canal, lake, or reservoir where systematic observations of hydrologic data are obtained.

Runoff in inches shows the depth to which the drainage area would be covered if all the runoff for a given time period were uniformly distributed on it.

Streamflow is the discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

MISSOURI RIVER MAIN STEM RESERVOIRS

Summary of Actual 1997 – 1998 Operations

I. FOREWORD

This document contains a summary of the actual operation of the Missouri River main stem reservoirs for the 12-month period ending July 31, 1998. In previous years, a comprehensive Annual Operating Plan document was prepared that contained three sections. The first section, the blue pages, contained a system description and a discussion of the typical operation to meet authorized purposes. The second section, which this document replaces, reviewed the actual operation for the previous 12 months, through July of the current year. The third section, the yellow pages, presented the tentative plan for operating the reservoirs for the remainder of the current year through December of the following year. This year, in an attempt to reduce reproduction and mailing costs, the AOP has been divided into three separate documents based on the descriptions above. All three reports, "System Description and Operation," "Summary of Actual 1997-1998 Operation," and "Annual Operating Plan, 1998-1999," can be obtained from the Reservoir Control Center's website at **http://www.nwd-mr.usace.army.mil/rcc** or by contacting the Reservoir Control Center at 12565 West Center Road, Omaha, Nebraska 68144-3869, phone (402) 697-2676.

A basin map is presented on ***Plate 1*** and the pertinent data table for the Missouri River Main Stem System (System) is shown on ***Plate 2***.

II. REVIEW OF REGULATION FROM AUGUST 1997 THROUGH JULY 1998

A. General. During this period, the Missouri River main stem reservoirs were regulated in accordance with the applicable provisions of the 1997-1998 Annual Operating Plan (AOP), which was discussed and reviewed by representatives of state and Federal agencies as well as the general public and specific interest groups. A summary of the significant events during this past year is given in the following paragraphs.

B. Precipitation and Water Supply Available in 1997.

1. January - July 1997. Runoff during the first 7 months of 1997, as shown on ***Table I***, came in record amounts as a result of tremendous plains and mountain snowpack which peaked at over 135 percent of the normal peak accumulation. Runoff into the System was so high, in fact, that by the end of July year-to-date runoff had already exceeded the previous record annual runoff. By late summer, soil was moist in South Dakota, but areas of drought were developing in the western and southern portions of the basin. For a detailed description of

Table I
Upper Missouri River Basin Runoff
For Calendar Year 1997

Reach Above	Fort Peck	Garrison	Oahe	Fort Randall	Gavins Point	Sioux City	Summation above Gavins Point	Summation above Sioux City	Accumulated Summation above Sioux City
				Values in 1000 Acre-Feet					
	(Historic)								
JAN 97	512	267	168	114	258	166	1,319	1,485	1,485
NORMAL	315	265	10	20	95	25	705	730	730
DEPARTURE	197	2	158	94	163	141	614	755	755
% OF NOR	163%	101%	1680%	570%	272%	664%	187%	203%	203%
FEB 97	582	646	516	589	436	134	2,769	2,903	4,388
NORMAL	360	350	70	40	120	80	940	1,020	1,750
DEPARTURE	222	296	446	549	316	54	1,829	1,883	2,638
% OF NORM	162%	185%	737%	1473%	363%	168%	295%	285%	251%
MAR 97	717	1,890	2,604	845	405	783	6,461	7,244	11,632
NORMAL	600	990	545	215	200	290	2,550	2,840	4,590
DEPARTURE	117	900	2,059	630	205	493	3,911	4,404	7,042
% OF NORM	120%	191%	478%	393%	203%	270%	253%	255%	253%
APR 97	631	1,974	2,828	451	356	2,376	6,240	8,616	20,248
NORMAL	670	1,120	480	140	170	300	2,580	2,880	7,470
DEPARTURE	-39	854	2,348	311	186	2,076	3,660	5,736	12,778
% OF NORM	94%	176%	589%	322%	209%	792%	242%	299%	271%
MAY 97	1,500	1,609	841	415	375	1,235	4,740	5,975	26,223
NORMAL	1,120	1,280	300	135	170	235	3,005	3,240	10,710
DEPARTURE	380	329	541	280	205	1,000	1,735	2,735	15,513
% OF NORM	134%	126%	280%	307%	221%	526%	158%	184%	245%
JUN 97	3,023	4,652	336	583	337	649	8,931	9,580	35,803
NORMAL	1,645	2,710	435	150	170	240	5,110	5,350	16,060
DEPARTURE	1,378	1,942	-99	433	167	409	3,821	4,230	19,743
% OF NORM	184%	172%	77%	389%	198%	270%	175%	179%	223%
JUL 97	1,231	2,917	263	105	274	360	4,790	5,150	40,953
NORMAL	820	1,790	165	60	125	180	2,960	3,140	19,200
DEPARTURE	411	1,127	98	45	149	180	1,830	2,010	21,753
% OF NORM	150%	163%	159%	175%	219%	200%	162%	164%	213%
AUG 97	586	1,271	4	154	287	324	2,302	2,626	43,579
NORMAL	350	615	60	45	110	110	1,180	1,290	20,490
DEPARTURE	236	656	-56	109	177	214	1,122	1,336	23,089
% OF NORM	167%	207%	7%	342%	261%	295%	195%	204%	213%
SEP 97	472	608	-8	17	244	165	1,333	1,498	45,077
NORMAL	340	480	115	45	105	85	1,085	1,170	21,660
DEPARTURE	132	128	-123	-28	139	80	248	328	23,417
% OF NORM	139%	127%	-7%	38%	232%	194%	123%	128%	208%
OCT 97	458	525	-140	16	193	184	1,052	1,236	46,313
NORMAL	395	525	70	10	115	65	1,115	1,180	22,840
DEPARTURE	63	0	-210	6	78	119	-63	56	23,473
% OF NORM	116%	100%	-200%	160%	168%	283%	94%	105%	203%
NOV 97	491	551	-39	-48	178	155	1,133	1,288	47,601
NORMAL	390	410	65	10	115	60	990	1,050	23,890
DEPARTURE	101	141	-104	-58	63	95	143	238	23,711
% OF NORM	126%	134%	-60%	-480%	155%	258%	114%	123%	199%
DEC 97	394	491	14	191	230	116	1,320	1,436	49,037
NORMAL	330	250	-5	5	90	40	670	710	24,600
DEPARTURE	64	241	19	186	140	76	650	726	24,437
% OF NORM	119%	196%	280%	3820%	256%	290%	197%	202%	199%
				Calendar Year Totals					
1997	10,597	17,401	7,387	3,432	3,573	6,647	42,390	49,037	
NORMAL	7,335	10,785	2,310	875	1,585	1,710	22,890	24,600	
DEPARTURE	3,262	6,616	5,077	2,557	1,988	4,937	19,500	24,437	
% OF NORM	144%	161%	320%	392%	225%	389%	185%	199%	

precipitation, snowpack, and runoff patterns for the period January through July 1997, see last year's AOP.

2. <u>August - December 1997</u>. With the exception of the southeastern corner of the basin, summer precipitation was above normal as shown in ***Figure 1***. August rainfall was generally above normal except in eastern Nebraska and western Iowa where precipitation averaged less than half of normal. Northern Montana and northern North Dakota were also drier than normal. Despite a brief period of very hot weather in early August and another near month's end, the average temperature for August was near normal throughout the basin.

The sporadic weather patterns of summer continued into September with isolated areas of heavy rain and wildly fluctuating temperatures. Precipitation was well above normal from eastern South Dakota through Kansas and also from north-central Wyoming through central Colorado. However, much of Montana and western North Dakota received less than half the normal rainfall. Missouri was also considerably drier than normal. Temperatures averaged well above normal during September, except for a brief cold blast that dropped temperatures below freezing in the upper basin near mid-month.

October began hot and dry but turned wetter and colder as the month progressed. One to 2 inches of rain fell across the southeastern half of the basin prior to mid-month while the northwest half of the basin remained very dry. Late in the month, winter made its grand entrance when a powerful blizzard dumped up to 2 feet of snow from Colorado through Iowa on October 24-26, knocking out power lines, stranding travelers, and causing tremendous tree damage. Denver and Omaha were particularly hard hit. Numerous snowfall records were broken in Colorado, Kansas, Wyoming, Nebraska, and Iowa. Monthly precipitation was more than double normal in a wide swath from North Dakota to eastern Colorado and western Kansas. Eastern Nebraska and western Iowa also received more than twice their normal amounts. Late summer and early fall precipitation virtually wiped out drought conditions that had developed in the basin during the summer months, as shown on the last Palmer Drought Severity map for the 1997 growing season, dated October 25, 1997, ***Figure*** 2.

The first 3 weeks of November were dry and very cold east of the Rockies. Temperatures dipped into the subzero range the second week of November from Montana to Colorado. Precipitation was limited to scattered light snow. Much warmer and wetter weather moved into the basin during the last week of November. One to 3 inches of rain fell along the Missouri River downstream of Omaha, with localized areas of over 4 inches. Temperatures averaged 6 to 12 degrees above normal. Monthly precipitation was less than half of normal for most of the upper basin.

Figure 1 shows the autumn precipitation distribution as a percent of normal.

The northern branch of the split jet stream remained mostly north of the U.S. in December, keeping the northern plains warm and dry. Temperatures averaged as much as 10 to 15 degrees above normal in eastern Montana and North Dakota. Temperatures along the Continental Divide, however, averaged below normal and precipitation ranged from less than half of normal in the

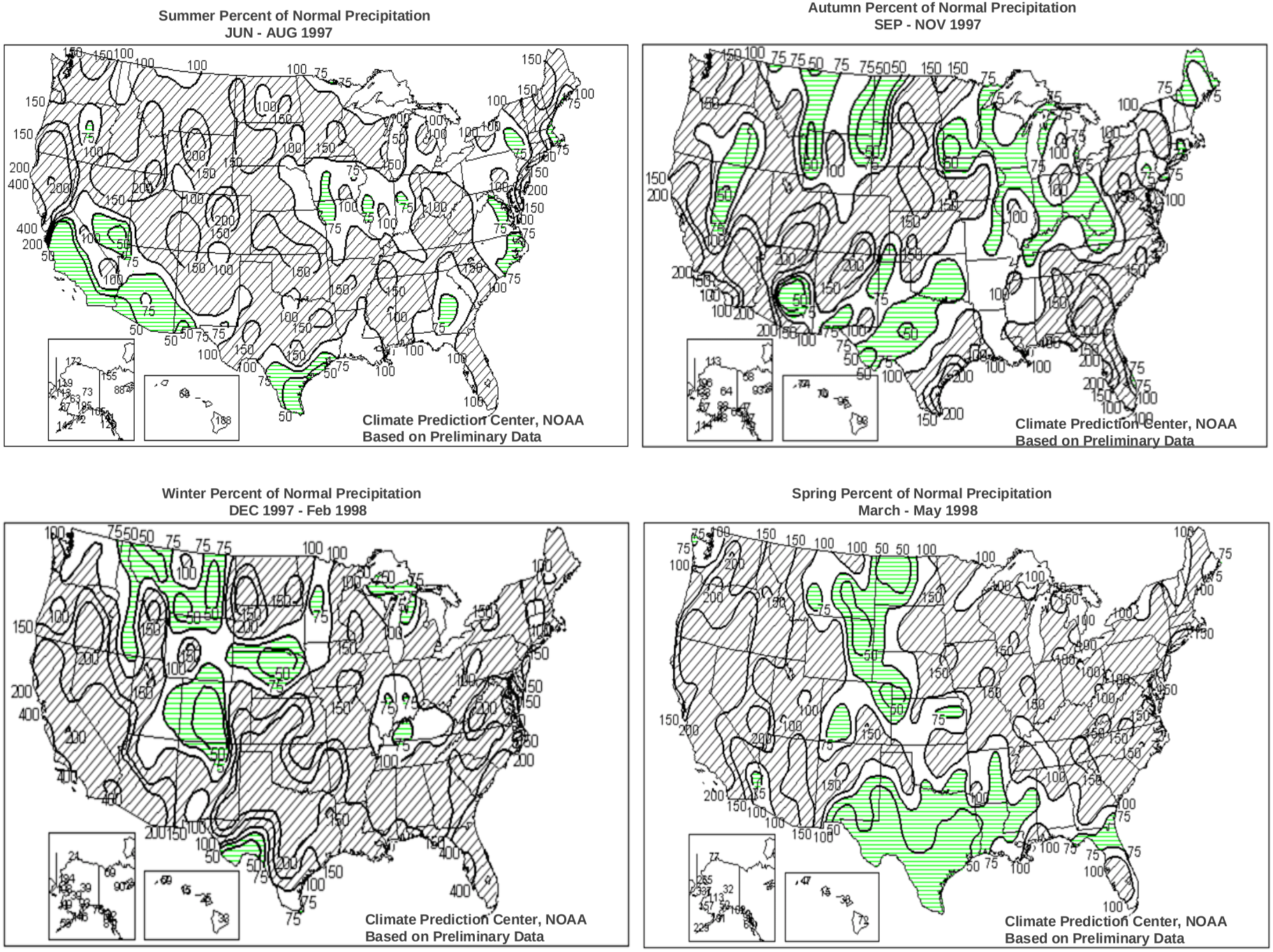
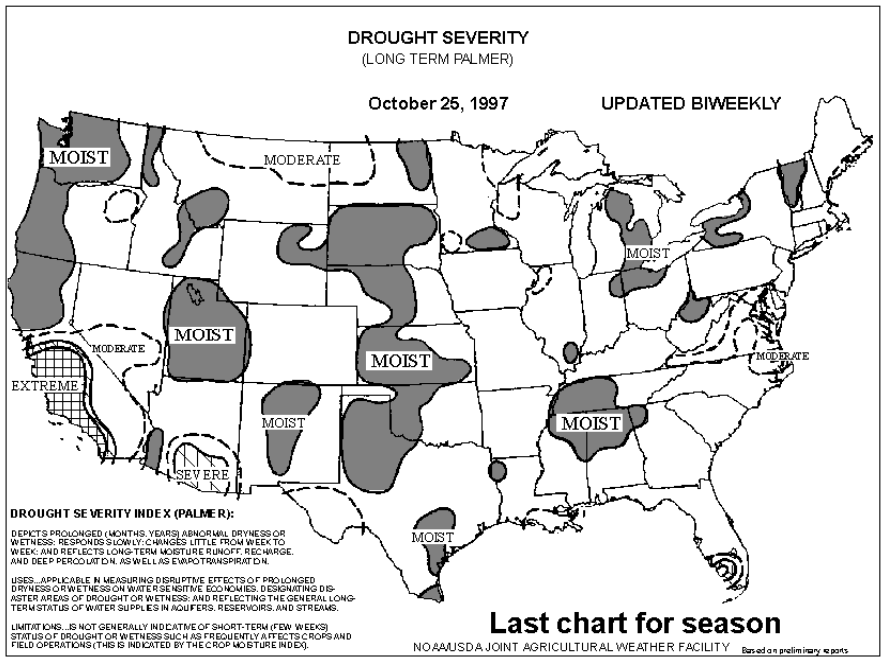
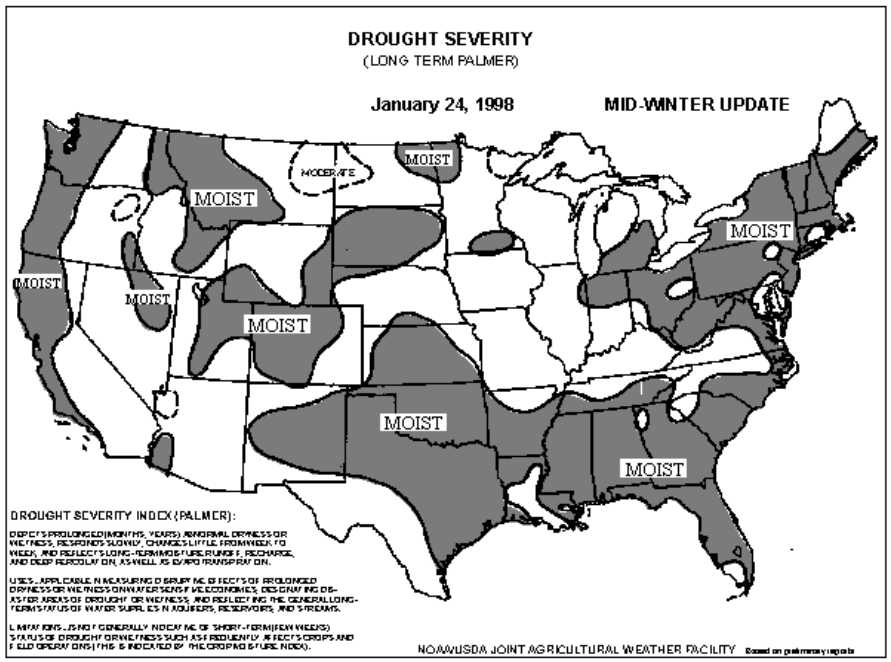
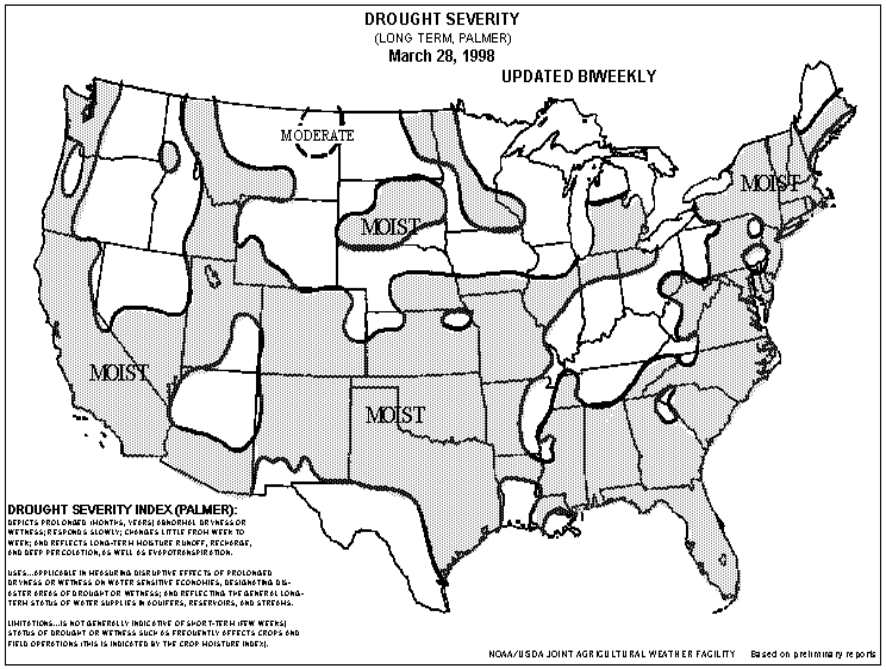

Summer Percent of Normal Precipitation
JUN - AUG 1997
Climate Prediction Center, NOAA
Based on Preliminary Data
Autumn Percent of Normal Precipitation
SEP - NOV 1997
Climate Prediction Center, NOAA
Based on Preliminary Data
Winter Percent of Normal Precipitation
DEC 1997 - Feb 1998
Climate Prediction Center, NOAA
Based on Preliminary Data
Spring Percent of Normal Precipitation
March - May 1998
Climate Prediction Center, NOAA
Based on Preliminary Data

Figure 14


DROUGHT SEVERITY
(LONG TERM PALMER)
October 25, 1997
UPDATED BIWEEKLY
MOIST
MODERATE
MOIST
MOIST
MODERATE
EXTREME
MOIST
MOIST
SEVERE
MOIST
MOIST
MODERATE
DROUGHT SEVERITY INDEX (PALMER):
DEPICTS PROLONGED (MONTHS, YEARS) ABNORMAL DRYNESS OR WETNESS; RESPONDS SLOWLY; CHANGES LITTLE FROM WEEK TO WEEK; AND REFLECTS LONG-TERM MOISTURE RUNOFF, RECHARGE, AND DEEP PERCOLATION, AS WELL AS EVAPOTRANSPIRATION.
USES...APPLICABLE IN MEASURING DISRUPTIVE EFFECTS OF PROLONGED DRYNESS OR WETNESS ON WATER SENSITIVE ECONOMIES, DESIGNATING DISASTER AREAS OF DROUGHT OR WETNESS; AND REFLECTING THE GENERAL LONG-TERM STATUS OF WATER SUPPLIES IN AQUIFERS, RESERVOIRS, AND STREAMS.
LIMITATIONS...IS NOT GENERALLY INDICATIVE OF SHORT-TERM (FEW WEEKS) STATUS OF DROUGHT OR WETNESS SUCH AS FREQUENTLY AFFECTS CROPS AND FIELD OPERATIONS (THIS IS INDICATED BY THE CROP MOISTURE INDEX).
Last chart for season
NOAA/USDA JOINT AGRICULTURAL WEATHER FACILITY
Based on preliminary reports


DROUGHT SEVERITY
(LONG TERM PALMER)
January 24, 1998
MID-WINTER UPDATE
MOIST
MODERATE
MOIST
MOIST
MOIST
MOIST
MOIST
MOIST
MOIST
MOIST
DROUGHT SEVERITY INDEX (PALMER):
NOAA/USDA JOINT AGRICULTURAL WEATHER FACILITY
Based on preliminary reports


DROUGHT SEVERITY
(LONG TERM, PALMER)
March 28, 1998
UPDATED BIWEEKLY
MODERATE
MOIST
MOIST
MOIST
MOIST
MOIST
DROUGHT SEVERITY INDEX (PALMER):
DEPICTS PROLONGED (MONTHS, YEARS) ABNORMAL DRYNESS OR WETNESS; RESPONDS SLOWLY; CHANGES LITTLE FROM WEEK TO WEEK; AND REFLECTS LONG-TERM MOISTURE RUNOFF, RECHARGE, AND DEEP PERCOLATION, AS WELL AS EVAPOTRANSPIRATION.
USES...APPLICABLE IN MEASURING DISRUPTIVE EFFECTS OF PROLONGED DRYNESS OR WETNESS ON WATER SENSITIVE ECONOMIES, DESIGNATING DISASTER AREAS OF DROUGHT OR WETNESS; AND REFLECTING THE GENERAL LONG-TERM STATUS OF WATER SUPPLIES IN AQUIFERS, RESERVOIRS, AND STREAMS.
LIMITATIONS...IS NOT GENERALLY INDICATIVE OF SHORT-TERM (FEW WEEKS) STATUS OF DROUGHT OR WETNESS SUCH AS FREQUENTLY AFFECTS CROPS AND FIELD OPERATIONS (THIS IS INDICATED BY THE CROP MOISTURE INDEX).
NOAA/USDA JOINT AGRICULTURAL WEATHER FACILITY
Based on preliminary reports

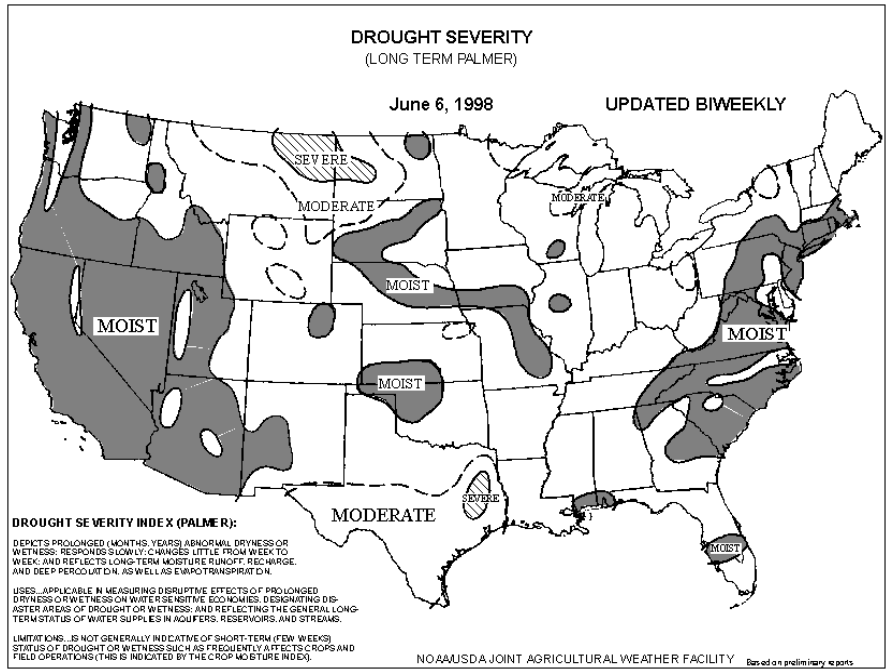

DROUGHT SEVERITY
(LONG TERM PALMER)
June 6, 1998
UPDATED BIWEEKLY
SEVERE
MODERATE
MODERATE
MOIST
MOIST
MOIST
MOIST
SEVERE
MODERATE
MOIST
DROUGHT SEVERITY INDEX (PALMER):
DEPICTS PROLONGED (MONTHS, YEARS) ABNORMAL DRYNESS OR WETNESS: RESPONDS SLOWLY; CHANGES LITTLE FROM WEEK TO WEEK; AND REFLECTS LONG-TERM MOISTURE RUNOFF, RECHARGE, AND DEEP PERCOLATION, AS WELL AS EVAPOTRANSPIRATION.
USES...APPLICABLE IN MEASURING DISRUPTIVE EFFECTS OF PROLONGED DRYNESS OR WETNESS ON WATER SENSITIVE ECONOMIES, DESIGNATING DISASTER AREAS OF DROUGHT OR WETNESS; AND REFLECTING THE GENERAL LONG-TERM STATUS OF WATER SUPPLIES IN AQUIFERS, RESERVOIRS, AND STREAMS.
LIMITATIONS...IS NOT GENERALLY INDICATIVE OF SHORT-TERM (FEW WEEKS) STATUS OF DROUGHT OR WETNESS SUCH AS FREQUENTLY AFFECTS CROPS AND FIELD OPERATIONS (THIS IS INDICATED BY THE CROP MOISTURE INDEX).
NOAA/USDA JOINT AGRICULTURAL WEATHER FACILITY
Based on preliminary reports

Figure 25

Colorado Rockies to more than twice normal in western Wyoming. Very dry conditions persisted on the northern plains where virtually no precipitation had fallen since October. In Glasgow, Montana, temperatures failed to fall below 0 degrees Fahrenheit during December for the first time on record and only 0.01 inch of precipitation was recorded.

3. 1997 Calendar Year Runoff. Despite the dry conditions that developed in the upper basin during the last half of 1997, runoff above Sioux City remained well above normal due to abnormally high base flows. Runoff ranged from more than twice normal in August and December to a mere 105 percent of normal in October. The last month with below normal runoff above Sioux City was November 1994 (although individual reaches have experienced months with below normal runoff.)

The runoff upstream of Sioux City adjusted to the 1949 level of depletion for calendar year 1997 was a record setting 49.0 million acre-feet (MAF), nearly twice the normal annual runoff. The previous record was 40.6 MAF set in 1978. In addition, 1997 was the fourth year out of the past 5 years with greater than Upper Decile level runoff. The 1997 annual runoff at Sioux City is shown in historical perspective on ***Figure 3***.

Although the total runoff above Sioux City was nearly twice normal, distribution in the six reaches varied from 144 and 161 percent of normal in the Fort Peck and Garrison reaches, respectively, to nearly 400 percent of normal in the Fort Randall and Sioux City reaches. The 1997 annual reach runoff is presented in ***Table II***. The monthly reach runoff is shown on ***Table I.*** This table is prepared on the first of each month to indicate the historic and forecast runoff for the year. ***Figure 4A*** displays the monthly distribution of runoff for 1997 and compares it with the long-term average.

C. Precipitation and Water Supply Available in 1998.

1. Plains Snowpack 1997-1998. Unlike the previous winter, when snow began building on the plains in October and continued to accumulate throughout the winter, plains snowpack during the 1997-1998 season consisted of a series of winter storms and intermittent melt periods. Strong El Nino conditions which had developed earlier in 1997 kept the majority of the winter storms out of the upper plains. The lower basin, however, received more than its share of wintry weather as the split jet stream forced many of the storms further south than usual.

The winter season got off to an early start in the lower basin with a tremendous blizzard, October 24-26, which moved across the southern plains from Colorado and Wyoming, through Nebraska, Kansas, and Iowa. Snowfall amounts ranged from nearly 22 inches in Denver and 19.5 inches in Goodland, Kansas, to 17 inches in Hastings, Nebraska, 9 inches in Omaha, Nebraska, and 7 inches in Des Moines, Iowa. Numerous snowfall records were set with the passage of the storm and the wet, heavy snow downed thousands of trees and power lines. Fortunately, warm temperatures the following week melted much of the snow.

Missouri River Main Stem
Annual Runoff at Sioux City, Iowa

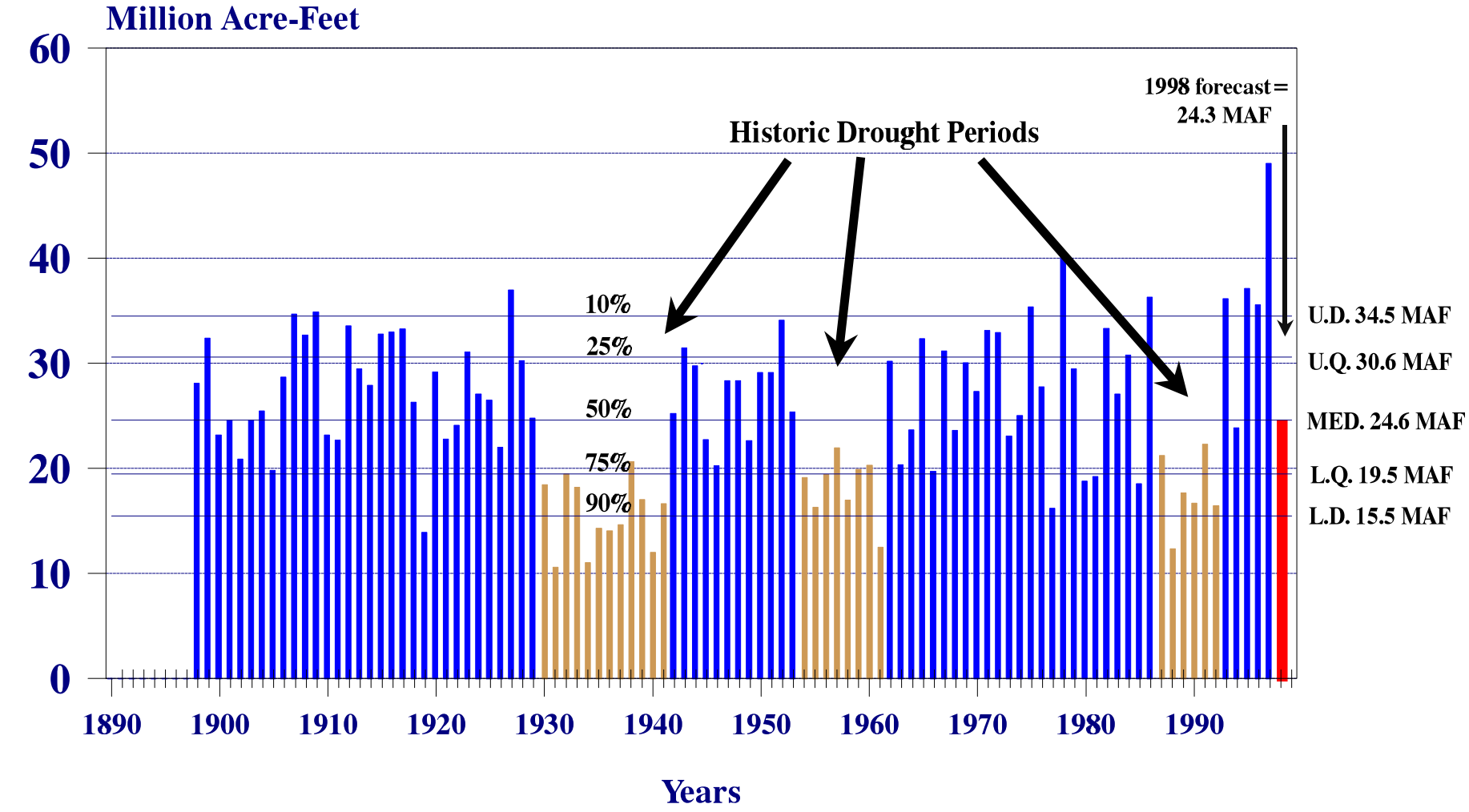


Figure 3

TABLE II
1997 CALENDAR YEAR RUNOFF FOR SELECTED REACHES
(In 1,000 Acre-Feet)

Reach	1898-1992 Normal Runoff-Volume	Calendar Year 1997 Runoff-Volume	Percent of Normal Runoff
Above Fort Peck	7,335	10,597	144
Fort Peck to Garrison	10,785	17,401	161
Garrison to Oahe	2,310	7,387	320
Oahe to Fort Randall	875	3,432	392
Fort Randall to Gavins Point	1,585	3,573	225
Gavins Point to Sioux City	1,710	6,647	389
TOTAL ABOVE SIOUX CITY	24,600	49,037	199
Sioux City to Nebr. City	7,690	7,573	98
Nebr. City to Kansas City	11,490	10,119	88
Kansas City to Hermann	23,990	24,733	103
TOTAL BELOW SIOUX CITY*	43,170	42,425	98

* Reaches from Sioux City to Hermann are not adjusted to 1949 depletions. Averages are taken from USGS Water-Data Reports for the period 1967-1997.

The first 3 weeks of November were cold and relatively dry across the upper plains although several weak storms dropped 3 to 6 inches of snow in the Dakotas. Temperatures during the last week of November rebounded to well above normal, melting the accumulated snow and leaving the plains snow-free by December 1.

Snowfall in December was limited to 3 to 6 inches from eastern Colorado through Nebraska, Kansas, Iowa, and Missouri. Warm temperatures throughout the basin prevented any significant accumulation. Likewise, the northern plains remained almost completely devoid of snow with depths generally under 3 inches, a stark contrast from the previous winter when snowpack was measured in feet rather than inches.

The first 2 weeks of January were very cold and dry. Mid-month temperatures made a dramatic turnaround and the basin enjoyed a pleasant January thaw. The eastern Dakotas received up to a foot of new snow in mid-January, but snowpack in eastern Montana and the western Dakotas remained dismal with depths generally in the 2- to 4-inch range.

1997 Missouri River Runoff
Above Sioux City, Iowa

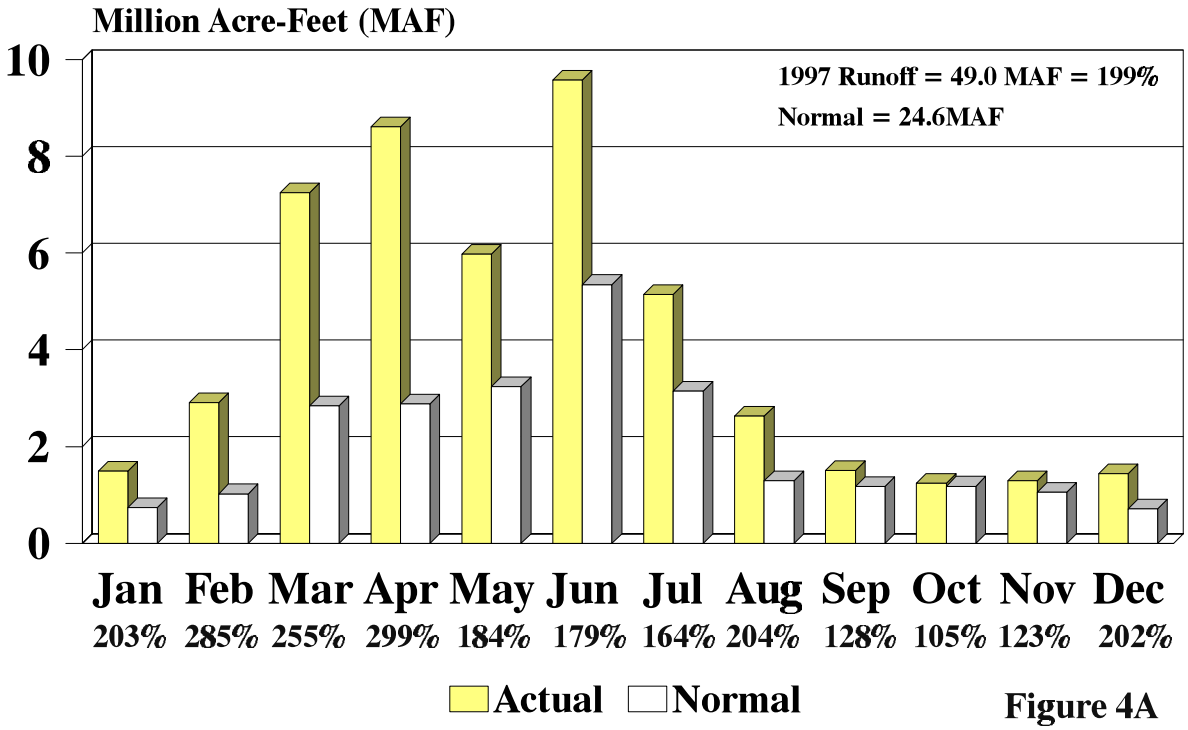


Figure 4A

1998 Missouri River Runoff
Above Sioux City, Iowa

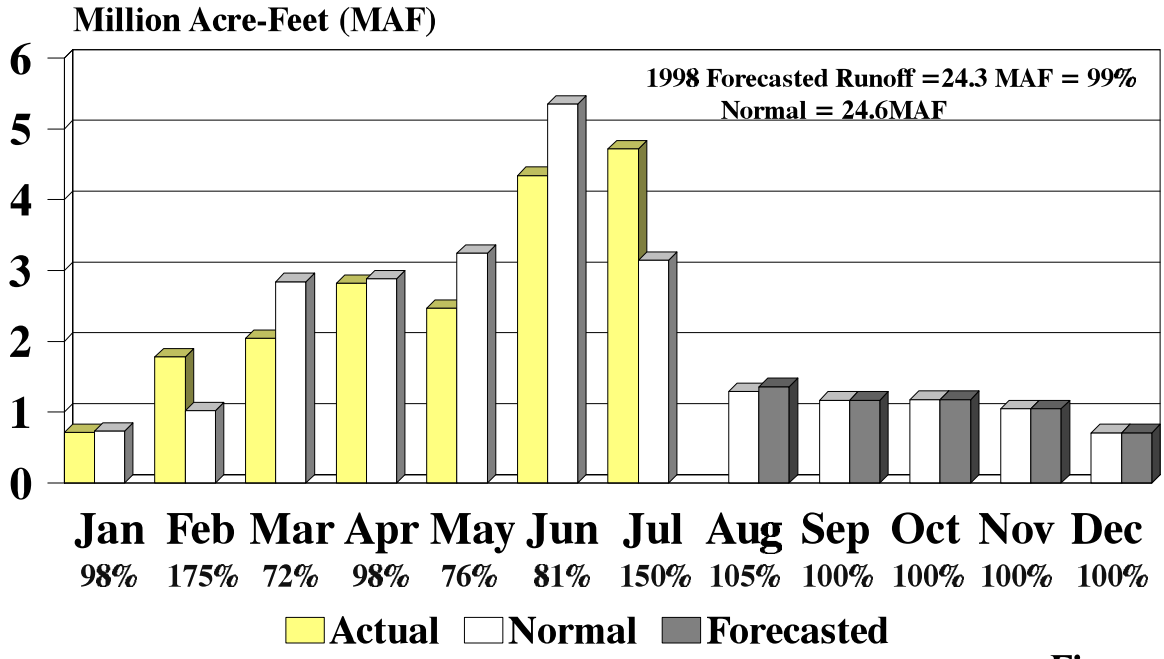


Figure 4B

The dry, mild weather continued in the upper basin through the first 3 weeks of February. Late in the month the biggest blizzard of the season roared into the upper basin bringing ferocious winds and heavy snow. Blizzard conditions engulfed eastern Montana, eastern Wyoming, western Nebraska, and the western Dakotas beginning on February 25. The storm lingered into early March, dropping a total of 103 inches of snow on Lead, South Dakota, and more than 2 feet of snow over a wide area. High winds, with gusts of over 70 mph, produced drifts estimated at 12 feet in some areas.

After nearly 2 months of unseasonably warm temperatures, bitter cold returned to the basin in early March and remained in place for 3 weeks. A series of winter storms also crossed the lower basin. The heaviest snows were in eastern Nebraska, northeastern Kansas, western Iowa, and northwestern Missouri where depths ranged from 8 to 15 inches. Summer-like weather late in the month quickly melted much of the plains snowpack. However, a final blast of winter weather on March 31 added another foot of snow to the seasonal total in Sioux Falls, South Dakota.

2. <u>Mountain Snowpack 1997-1998</u>. The mountain snowpack was also rather dismal during the winter of 1997-1998, especially compared to the near-record snowpack of the previous winter. El Nino-induced dryness limited the accumulation of mountain snowpack as well as that on the northern plains. As winter storms continued to skirt across the southern edge of the basin, the mountain snowpack remained well below normal. On December 1, the snowpack was 91 percent of normal in both reaches, above Fort Peck Dam and between Fort Peck and Garrison Dams.

Warm, dry weather during December dropped the mountain snowpack to its lowest level of the season on January 1, 1998, averaging just 72 percent of normal in the Fort Peck reach and 84 percent of normal in the reach between Fort Peck and Garrison. Snows during the month of January boosted the snowpack to 85 percent of normal on February 1 in the Fort Peck reach and 94 percent of normal in the Fort Peck to Garrison reach.

The snowpack made only minor gains throughout the remainder of the accumulation season and peaked on April 18 at 92 percent of normal in the reach above Fort Peck and at 101 percent of the normal peak in the reach between Fort Peck and Garrison.

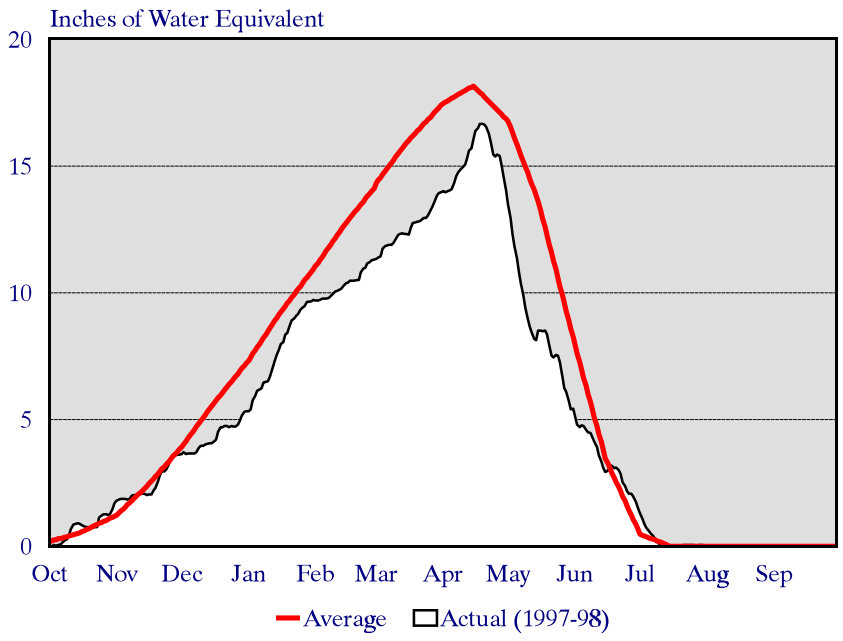
Following the uneventful season, the snowpack melted in an orderly fashion and was essentially complete by mid-June. The 1997-1998 snow accumulation and melt are illustrated in ***Figure 5***.

3. <u>January - July 1998</u>. Runoff during the first 7 months of 1998 returned to more normal levels following the record setting inflows of 1997. As previously discussed, much of the winter precipitation was pushed into the southern portion of the basin and the mountain snowpack was slightly below normal. The late February blizzard in eastern Montana and the western Dakotas boosted the seasonal precipitation above normal over a portion of the northern plains, but elsewhere in the upper basin conditions were very dry. ***Figure 1*** shows the winter precipitation as a percent of normal.

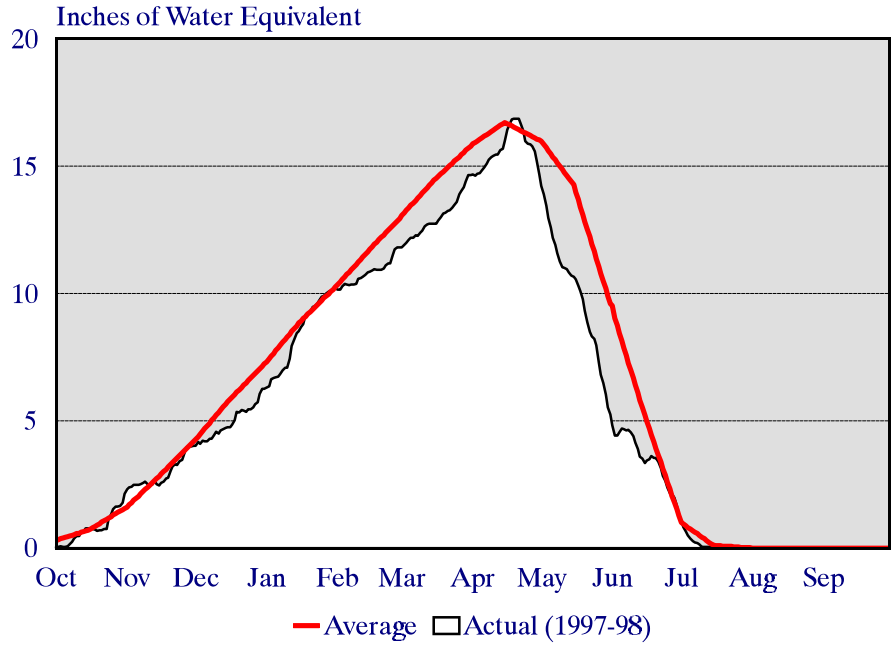
Mountain Snowpack Water Content
Missouri River Basin, Winter 1997 - 1998

Figure 5
11

Total Above Fort Peck



Total Fort Peck to Garrison



Snowpack peaked on April 18, 1998 at 92% of the normal peak accumulation in the reach above Fort Peck,
and 101% of the normal peak in the reach between Fort Peck and Garrison.

March precipitation varied greatly across the basin. Less than half the normal precipitation fell in North Dakota and the Nebraska panhandle, but precipitation in the remainder of the basin was generally much above normal. The snowstorm the last day of the month boosted Sioux Falls, South Dakota's monthly precipitation to a new March record (4.08 inches.) Soil was moist in South Dakota and most of the lower basin, as indicated by the Palmer Drought Severity map, dated March 28, 1998, shown on ***Figure 2***. Northeast Montana had moderate drought conditions, and the remainder of the basin was near normal.

April weather consisted of hit-and-miss rains and widely fluctuating temperatures, not uncommon for the Midwest during spring. The heaviest rains fell from north-central Kansas, through eastern Nebraska, to northwestern Iowa. Sioux City reported over 6 inches during the month, more than twice normal. Northeast Montana also received more than twice its normal April rainfall but not enough to ease the drought conditions that had developed since late 1997. Warm, dry conditions returned to the remainder of the upper basin and less than half of normal rain fell from the western Dakotas to the Nebraska panhandle.

Drought conditions continued to expand in the upper basin through early June as indicated on the Palmer Drought Severity map, dated June 6, 1998, shown in ***Figure 2***. May precipitation was well below normal except along the northeastern edge of the basin and in western Montana. Dry conditions were also beginning to develop in northeast Kansas and northwest Missouri where spring rains failed to materialize. ***Figure 1*** shows the spring precipitation as a percent of normal.

June's precipitation was above normal for all but the southwest corner of the basin but did little to relieve drought conditions in the upper basin. More than 8 inches of rain fell over eastern Nebraska, eastern Kansas, western Iowa, and northern Missouri during June. The most significant weather-related event of the summer was the tremendous rain that fell over the Nishnabotna basin in early June. Atlantic, Iowa, was inundated with an all-time state-record 13.18 inches of rain on June 14. A few days later, on June 17, the Nishnabotna River at Hamburg, Iowa, crested at a record 15.18 feet above flood stage. Temperatures averaged well below normal the first 3 weeks of June, only rebounding to seasonal levels the last week of the month.

The heat intensified during the first 3 weeks of July with temperatures reaching into the 100's across the lower basin. Late in July, the heat finally broke and temperatures returned to normal levels. Summertime thunderstorms favored the lower basin again in July helping to alleviate drought conditions that had developed during the spring. The heaviest rains of the month fell in eastern Kansas and central Missouri with numerous monthly totals surpassing 8 inches. Meanwhile, drought conditions continued to intensify in the upper basin. The Palmer Drought Severity map, dated August 1, 1998, is shown in ***Figure 2***. As indicated, moderate to extreme drought existed in eastern Montana, eastern Wyoming, and western North Dakota. Moist conditions were common in the lower basin.

4. <u>1998 Calendar Year Runoff</u>. Runoff for the period January through July 1998 totaled 18.9 MAF, 98 percent of normal. Although the 7-month total was nearly normal, monthly runoff above Sioux City varied from a low of 72 percent of normal in March to 175 percent of

normal in February. The August 1 forecast for CY 1998 runoff is 24.3 MAF, 99 percent of normal and just 0.3 MAF below the long-term average, as shown in ***Figure 4B***.

The historic and forecasted monthly runoff for CY1998 from Fort Peck downstream to Sioux City by major reach are presented in ***Table III***. The table describes the annual runoff by month and is the basic compilation of the month-by-month runoff in the upper basin by reach. This forecast forms a basis for intrasystem balancing of storage accumulated in the projects and is used by the RCC on the first of each month to forecast the runoff for the remainder of the year. The monthly accumulation of actual runoff through July and the forecasts through December are shown under the "Summation above Sioux City" column. As the season progresses and the actual runoff accumulates, the forecast becomes more reliable. The majority of the annual runoff has normally occurred by the end of July and the remainder of the year can be estimated with a fair degree of accuracy.

D. System Operations.

1. System Operational Objectives - August 1997 to July 1998. The 1997 peak System storage, 71.7 MAF on July 13, was 3.2 MAF higher than the July 7, 1996, peak storage and just under the record 72.1 MAF set in 1975. Runoff during the first 7 months of 1997 surpassed the previous annual runoff and was forecast to continue above average for the remainder of the year. Additionally, record releases had been made from the System every month of 1997 except January. Therefore, the 1997 navigation season was extended and the service level was set to evacuate the largest runoff ever into the System. Releases from Gavins Point Dam reached a new record of 70,100 cfs in October and November of 1997, greatly surpassing the previous record, 61,100 cfs, set back in 1975.

System storage declined to 69.1 MAF on September 1, 1997, still 11.1 MAF over the amount needed to provide full service support to the power function during the winter season. According to the guidelines in the Missouri River Main Stem Master Water Control Manual (Master Manual), above average winter releases from Fort Randall were required to continue the evacuation of flood control storage and to provide support for the extended navigation season. Gavins Point winter releases were scheduled to evacuate the maximum amount of storage possible while preventing downstream flooding. System storage was reduced from 62.9 MAF on November 1, 1997, to 58.1 MAF on January 31, 1998. With February runoff at 175 percent of normal, storage increased to 58.3 MAF on March 1, 1998, 1.2 MAF above the desired 57.1 MAF level, the top of the carryover multiple use zone.

Support for the 1998 navigation season was in accordance with the plan presented in the 1997-1998 AOP. The plan included a normal season opening date with full service flows for the fifth consecutive year and a season length based on July 1 System storage. Flow support for the 1998 navigation season began on March 23 at Sioux City, March 25 at Omaha, March 26 at Nebraska City, March 28 at Kansas City, and April 1 at the mouth of the Missouri River near St. Louis.

Table III
Upper Missouri River Basin Runoff
For Calendar Year 1998
Historic and Forecasted

Reach Above	Fort Peck	Garrison	Oahe	Fort Randall	Gavins Point	Sioux City	Summation above Gavins Point	Summation above Sioux City	Accumulated Summation above Sioux City
				Values in 1000 Acre Feet					
	(Historic)								
JAN 98	281	161	-235	123	186	198	516	714	714
NORMAL	315	265	10	20	95	25	705	730	730
DEPARTURE	-34	-104	-245	103	91	173	-189	-16	-16
% OF NOR	89%	61%	-2350%	615%	196%	792%	73%	98%	98%
FEB 98	463	643	113	133	309	121	1,661	1,782	2,496
NORMAL	360	350	70	40	120	80	940	1,020	1,750
DEPARTURE	103	293	43	93	189	41	721	762	746
% OF NORM	129%	184%	161%	333%	258%	151%	177%	175%	143%
MAR 98	468	700	212	162	314	186	1,856	2,042	4,538
NORMAL	600	990	545	215	200	290	2,550	2,840	4,590
DEPARTURE	-132	-290	-333	-53	114	-104	-694	-798	-52
% OF NORM	78%	71%	39%	75%	157%	64%	73%	72%	99%
APR 98	528	902	247	175	381	584	2,233	2,817	7,355
NORMAL	670	1,120	480	140	170	300	2,580	2,880	7,470
DEPARTURE	-142	-218	-233	35	211	284	-347	-63	-115
% OF NORM	79%	81%	51%	125%	224%	195%	87%	98%	98%
MAY 98	787	867	16	122	327	347	2,119	2,466	9,821
NORMAL	1,120	1,280	300	135	170	235	3,005	3,240	10,710
DEPARTURE	-333	-413	-284	-13	157	112	-886	-774	-889
% OF NORM	70%	68%	5%	90%	192%	148%	71%	76%	92%
JUN 98	1,315	1,727	271	294	383	349	3,990	4,339	14,160
NORMAL	1,645	2,710	435	150	170	240	5,110	5,350	16,060
DEPARTURE	-330	-983	-164	144	213	109	-1,120	-1,011	-1,900
% OF NORM	80%	64%	62%	196%	225%	145%	78%	81%	88%
JUL 98	1,433	2,399	222	108	342	208	4,504	4,712	18,872
NORMAL	820	1,790	165	60	125	180	2,960	3,140	19,200
DEPARTURE	613	609	57	48	217	28	1,544	1,572	-328
% OF NORM	175%	134%	135%	180%	274%	116%	152%	150%	98%
	(Forecast)								
AUG 98	350	615	60	45	170	120	1,240	1,360	20,232
NORMAL	350	615	60	45	110	110	1,180	1,290	20,490
DEPARTURE	0	0	0	0	60	10	60	70	-258
% OF NORM	100%	100%	100%	100%	155%	109%	105%	105%	99%
SEP 98	340	480	115	45	105	85	1,085	1,170	21,402
NORMAL	340	480	115	45	105	85	1,085	1,170	21,660
DEPARTURE	0	0	0	0	0	0	0	0	-258
% OF NORM	100%	100%	100%	100%	100%	100%	100%	100%	99%
OCT 98	395	525	70	10	115	65	1,115	1,180	22,582
NORMAL	395	525	70	10	115	65	1,115	1,180	22,840
DEPARTURE	0	0	0	0	0	0	0	0	-258
% OF NORM	100%	100%	100%	100%	100%	100%	100%	100%	99%
NOV 98	390	410	65	10	115	60	990	1,050	23,632
NORMAL	390	410	65	10	115	60	990	1,050	23,890
DEPARTURE	0	0	0	0	0	0	0	0	-258
% OF NORM	100%	100%	100%	100%	100%	100%	100%	100%	99%
DEC 98	330	250	-5	5	90	40	670	710	24,342
NORMAL	330	250	-5	5	90	40	670	710	24,600
DEPARTURE	0	0	0	0	0	0	0	0	-258
% OF NORM	100%	100%	100%	100%	100%	100%	100%	100%	99%
				Calendar Year Totals					
1998	7,080	9,679	1,151	1,232	2,837	2,363	21,979	24,342	
NORMAL	7,335	10,785	2,310	875	1,585	1,710	22,890	24,600	
DEPARTURE	-255	-1,106	-1,159	357	1,252	653	-911	-258	
% OF NORM	97%	90%	50%	141%	179%	138%	96%	99%	

On April 1, System storage stood at 59.2 MAF, 5.6 MAF lower than the previous year. It made moderate gains during two runoff periods in 1998. The plains snowmelt produced a March-April runoff of 4.9 MAF, lower than the normal 5.7 MAF inflow. Runoff from May, June, and July was 2.5 MAF, 4.3 MAF, and 4.7 MAF, respectively. Normal for that same time period is 3.2 MAF, 5.4 MAF, and 3.1 MAF, respectively. End-of-month System storage was 59.2 MAF for May, 60.9 MAF for June, and 62.3 MAF for July. System storage peaked at 62.5 MAF on July 23, 1998, 9.2 MAF lower than the 1997 peak. The 62.3 MAF storage ending in July was 0.5 MAF above average.

In accordance with the 1997-1998 AOP and based on the actual 60.9 MAF July 1 System storage, a full 8-month navigation season with a 10-day extension and full service flows was scheduled for the remainder of the 1998 navigation season.

Energy generation at the six main stem powerplants totaled 12.5 billion kilowatt hours (kWh) for the period August 1, 1997, to July 31, 1998, 2.5 billion kWh above the average since the System first filled in 1967. The above normal generation was due to the evacuation of excess flood storage.

2. <u>Fort Peck Operation - August 1997 to July 1998</u>. Fort Peck Reservoir, the third largest Corps of Engineers storage reservoir, serves all authorized purposes. Fort Peck's primary functions are: (1) to capture the mountain and plains snow and localized rainfall runoffs from the large drainage area above Fort Peck Dam. Captured floodwaters are metered out at controlled release rates to meet the main stem authorized purposes while reducing flood damages in the Fort Peck to Garrison reach; (2) to serve as a secondary storage location for water accumulated in the System from reduced System releases due to major downstream flood control operations, thus helping to alleviate large pool increases in Garrison, Oahe, and Fort Randall projects; and (3) to provide the extra water needed to meet all main stem authorized purposes which draft storage during low water years.

Late Summer and Fall 1997. Record runoff in the basin during 1997 made floodwater evacuation the primary objective during the latter half of the year. Fort Peck releases were well above normal levels during the period, averaging 18,000 cfs in August, 20,100 cfs in September, 21,600 in October, and 21,100 cfs in November. September, October, and November releases were at record levels for those months. The releases for August through November were 7,200, 10,200, 12,300, and 11,500 cfs above average, respectively. Fort Peck pool elevation started the period near the top of the exclusive flood control pool at 2250 feet msl, over 5 feet higher than a year earlier. The pool declined to near elevation 2237 by the end of November, 3 feet into the annual flood control and multiple use zone and the same elevation as the previous year.

Winter 1997-1998. Fort Peck releases averaged 10,700 cfs for both December and January, and 11,000 cfs for February. Releases were held near the 10,000 cfs level through January 12, 1998, to prevent ice jam flooding during the winter freeze-in period on the Missouri River downstream from Fort Peck Dam. Due to the mild weather, the freeze-in period was about a month later than normal. On January 13, 1998, releases were increased to 11,000 cfs and held there until the end of February. Beginning on March 1, 1998, the releases were reduced from 11,000 cfs to

5,000 cfs by March 4, 1998. Fort Peck's daily average releases ranged between 4,800 and 5,300 cfs through the remainder of March. This below average daily discharge was made for intrasystem storage balance and downstream flood control. December's average daily release was 500 cfs above average, while releases for January through March were 900, 1,200, and 3,500 cfs below average, respectively.

The Fort Peck Lake level began the winter season at elevation 2237.3 feet msl, 3.3 feet into the annual flood control zone and 0.3 foot above the previous year. The lake fell to the season low of 2234.3 feet msl on March 2, 1998. By the end of March the lake rose about 0.9 foot, to an elevation of 2235.2 feet msl. This was 1.2 feet above the base of the annual flood control zone.

Winter River and Ice Conditions Below Fort Peck Dam. Ice formation on the Missouri River below Fort Peck Dam was delayed until early January due to unseasonably warm temperatures in December. On January 5 and 6, 1998, the stage rose over 2 feet in the Wolf Point, Montana, area and 3 feet in the Culbertson area. The Fort Peck releases were held at the 10,000 cfs level until the ice conditions and stages on the Missouri River stabilized. The releases were then increased to 11,000 cfs by January 13, 1998. No reports of ice-affected flooding on the Missouri River below Fort Peck Dam were recorded during this winter season.

Spring and Summer 1998. Releases from Fort Peck averaged 5,500 cfs in March and 6,200 cfs in April, near the 6,000 cfs recommended to support fish spawning below the dam. Summer releases from Fort Peck were adequate to meet irrigation demands. In May, releases from Fort Peck averaged near normal at 9,700 cfs. June and July's release averages were slightly below normal at 10,100 and 9,200 cfs, respectively.

The elevation of Fort Peck Lake was at 2235.2 feet msl at the beginning of the 1998 navigation season, 3.3 feet less than at the beginning of the 1997 navigation season. The pool rose moderately through the period, peaking on July 25 at 2240.46 feet msl, 9.91 feet lower than the 1997 peak. Fort Peck Lake in 1998 occupied 6.46 feet of the annual flood control storage zone, which extends from 2234 to 2250 feet msl.

3. <u>Garrison Operation - August 1997 to July 1998</u>. Garrison, as the largest Corps of Engineers storage reservoir, is another key player in the operation of the main stem system. Its primary functions are (1) to capture the snowmelt runoff and localized rainfall runoffs from the large drainage area between Fort Peck and Garrison Dam. Captured floodwaters are metered out at controlled release rates to meet the main stem authorized purposes while reducing flood damages in the Garrison to Oahe reach, particularly the urban Bismarck area; (2) to serve as a secondary storage location for water accumulated in the System from reduced System releases due to major downstream flood control operations, thus helping to alleviate large pool increases in Oahe and Fort Randall projects; and (3) to provide the extra water needed to meet all main stem authorized purposes which draft storage during low water years.

Late Summer and Fall 1997. Continuing the floodwater evacuation, daily releases from Garrison varied between 21,000 cfs and 51,500 cfs with monthly average releases of 49,900, 46,500, 49,400, and 42,300 cfs for August through November, record releases every month save August. The releases were 24,300, 24,500, 28,500, and 20,600 cfs above average from August through November, respectively. Lake Sakakawea began the period at elevation 1852.20 feet msl, 2.20 feet into the exclusive flood control pool and 3.38 feet higher than at the same time a year earlier. By the end of November it was at 1841.35, 1.5 feet higher than 1 year earlier.

Winter 1997-1998. Releases from Garrison were near normal in December and slightly below normal in January and February. The release on December 1, 1997, was 22,400 cfs and by December 31, 1997, the daily average was 19,900 cfs as a precaution against ice-affected flooding in the Bismarck area. Releases varied from 19,500 to 25,100 cfs through January with a monthly average of 22,000 cfs. Beginning in early February, the Garrison release was gradually increased from 22,900 to 25,000 cfs by February 8, 1998, and held there through March 1, 1998, to help the intrasystem storage balance. Then on March 2, 1998, the releases were reduced to 20,000 cfs preventing ice-affected flooding in the Bismarck area as colder temperatures returned to the Missouri River basin. As ice developed in the Missouri River below Garrison, the Bismarck stage rose from 7.91 to 11.01 feet over the 24-hour period ending on March 2, 1998. For the remainder of March the release fluctuated between 17,200 cfs and the 20,100 cfs to prevent downstream ice-affected flooding in the Bismarck area and meet both power demands and intrasystem storage balance.

Lake Sakakawea began the season near elevation 1841.5 feet msl, 4 feet into the annual flood control zone. The lake declined throughout the winter season to an elevation of 1839.1 feet msl by February 21, 1998, 1.6 feet above the top of the carryover multiple use zone. By the end of March, Lake Sakakawea pool was at an elevation of 1839.4 feet msl, 5 feet lower than March 1997.

Winter River and Ice Conditions Below Garrison Dam. As a precaution, Garrison releases were reduced in late December from 22,000 cfs to 20,000 to prevent the Missouri River at Bismarck, North Dakota, from exceeding the critical 14.0-foot stage during freeze-in. Due to mild temperatures during December, the freeze-in at Bismarck began about a month later than usual. On January 4, 1998, the river rose over 3 feet in less than 24 hours. Over the following 3 days the Missouri River continued to rise and the stage at Bismarck crested at 13.0 feet on January 7, 1998. Flood stage is 16 feet on the Missouri River at Bismarck. With the threat of ice–affected flooding in the Bismarck area and the stage holding just under the 13 feet, the Garrison release was maintained near 20,000 cfs until January 8, 1998. Once the river conditions stabilized and river flows could pass safely under the established ice cover, Garrison releases were gradually increased to 25,000 cfs by January 23, 1998.

Starting on January 26, 1998, Garrison releases were reduced to 23,000 cfs and held there until February 3. This brief reduction was made as a precaution to prevent any flooding from the premature melting of snow and ice during an unexpected late January - early February warm spell. The Missouri River stage in the Bismarck area dropped below 12 feet on January 30, 1998, and continued to decline slowly through February ending the month just under 8 feet.

Following the unseasonably warm February, the first half of March was much colder and stages on the Missouri River in the Bismarck area rose significantly on two separate occasions as ice developed. The first noted rise was on March 1-2, 1998, when the stage rose from 7.81 to 11.97 feet. The second, on March 10-11, saw the stage rise from 7.6 feet to 11.6 feet. Garrison releases were reduced on both occasions: from 25,000 to 20,000 cfs on March 1, and from 20,000 to 18,000 cfs on March 10. The releases remained near the 18,000 cfs level until March 22 when they were increased 1,000 cfs a day to 20,000 cfs by March 24, 1998, where they were held through mid-April for intrasystem storage balance.

Spring and Summer 1997. Releases from Garrison during the spring and summer were near normal. Releases in April were 19,400 cfs, down 500 cfs from the mean of 19,900. In April, 19,000 acre-feet of water were transferred to Lake Audobon. An additional 1,000 and 3,000 acre-feet were transferred in June and July, respectively. Releases during May averaged 24,200 cfs, June averaged 25,700, and July averaged 24,000 cfs. Pool elevations for Lake Sakakawea were 1839.34 feet msl on both April 1 and May 1, 1839.16 on June 1, 1840.90 on July 1, and 1843.00 at the end of July. Lake Sakakawea peaked at an elevation of 1843.45 on July 27, 1998, down 10.9 feet from last year's peak. Pumping costs associated with the Buford-Trenton project for the period August 1, 1997, through July 31, 1998, were $16,950; the total pumping costs to date are $138,507.

4. <u>Oahe and Big Bend Operation - August 1997 to July 1998</u>. Oahe Reservoir, the second largest Corps of Engineers storage reservoir, serves all authorized purposes. The Oahe project's primary functions are: (1) to capture plains snow and localized rainfall runoffs from the large drainage area between Garrison and Oahe Dams. Captured floodwaters are metered out at controlled release rates to meet the main stem authorized purposes while reducing flood damages in the Oahe to Big Bend reach, especially in the urban Pierre and Fort Pierre areas; (2) to serve as a primary storage location for water accumulated in the System from reduced System releases due to major downstream flood control operations, thus helping to alleviate large pool increases in Big Bend, Fort Randall, and Gavins Point projects; and (3) to provide the extra water needed to meet all main stem authorized purposes which draft storage during low water years, particularly downstream water supply and navigation. In addition, hourly and daily releases from Big Bend and Oahe fluctuate widely to meet varying power loads. Over the long term, their release rates are geared to back up navigation releases from Fort Randall and Gavins Point in addition to providing storage space to permit a smooth transition in the scheduled annual fall drawdown of Lake Francis Case. Big Bend, with less than 2 MAF of storage, is primarily used for hydropower production, so releases from Oahe are generally passed directly through Big Bend.

Late Summer and Fall 1997. Monthly releases at Oahe and Big Bend were much above normal between August and November for floodwater evacuation. Releases ranged from 30 percent above normal in August to almost double normal in November. The Big Bend pool generally fluctuated between elevations 1419 and 1420 feet. Lake Oahe crested at an elevation of 1618.67 feet msl on June 23, 1997, 1.67 feet into the exclusive flood control pool and nearly identical to the 1618.71 feet msl maximum of record experienced on June 25, 1995. Lake Oahe dropped out

of the exclusive flood control zone near mid-August and by the end of November was at an elevation of 1612.39 feet msl.

Winter 1997-1998. Oahe Lake began the winter season at elevation 1612.5 feet msl, 3.4 feet higher than the previous year's elevation. The pool declined through the winter to 1608.4 feet msl by the end of February, 1.5 feet lower than the previous year. The average release for the winter period was 29,500 cfs, 5,500 cfs higher than the previous winter and 4,000 cfs greater than the release rate from the downstream Fort Randall project. The additional volume released from the Oahe and Big Bend projects was stored in Lake Francis Case. Oahe's daily average releases varied from 11,300 to 56,700 cfs. The December 1, 1997, Oahe release of 56,700 cfs was a record high daily average for the month of December.

Flooding in the Pierre-Fort Pierre area, especially at street intersections in the Stoeser Addition, has been a recurring problem since 1979. High Oahe releases, coupled with the formation of river ice in the LaFramboise Island area, cause water to back up into a storm sewer outlet flooding street intersections. Release restrictions have been implemented in previous years but were not required during the 1997-1998 winter due to the mild weather.

Big Bend was operated to follow power peaking requirements with hourly releases varying widely. The daily average flow varied between 1,900 and 58,500 cfs. The level of Lake Sharpe varied in a narrow range from elevation 1418.9 to 1420.1 feet msl.

Spring and Summer 1998. Like the other main stem projects, releases from Oahe were at or below normal levels from April through July due to the near normal runoff. Although the March release was slightly above normal, the daily average release for April was 14,100 cfs, almost half the 22,800 cfs normal. May’s releases averaged 22,500 cfs; June and July average releases were 21,600 cfs and 19,100 cfs, respectively. Big Bend’s releases generally mimic releases from Oahe.

Releases from Oahe usually are considerably lower during weekends than on weekdays. The normal plan is to maintain Oahe's releases above 3,000 cfs during weekend daylight hours beginning in early April. This minimum release criteria is scheduled to enhance downstream fishing and boating use for the recreation season. There have also been complaints relating to zero releases from Big Bend on the weekends. However, during the recreation season, Lake Francis Case extends into the Big Bend tailwater area and establishment of minimum release rates for Big Bend would be of little value to boating or fishing in the tailwaters.

Lake Oahe began the spring period on March 1, 1998, near elevation 1608 feet msl and crested at an elevation of 1612.87 feet msl on July 26, 5.84 feet below the 1618.71 feet msl maximum of record experienced on June 25, 1995. The normal 1-foot weekly fluctuation of Lake Sharpe was resumed in the summer of 1998 and the lake fluctuated between elevations 1419.8 and 1421.2 feet msl during the period.

5. Fort Randall Operation - August 1997 to July 1998. Fort Randall Dam, the fourth largest Corps of Engineers storage reservoir, serves all authorized purposes. Fort Randall's primary functions are: (1) to capture plains snow and localized rainfall runoffs in the drainage

area from Big Bend Dam to Fort Randall Dam. Captured floodwaters are metered out at controlled release rates to meet the main stem authorized purposes while reducing flood damages in the Fort Randall reach where several areas have homes and cabins in close proximity to the river; (2) to serve as a primary storage location along with the Oahe project for water accumulated in the System from reduced System releases due to major downstream flood control operations, thus helping to alleviate large pool increases in the very small Gavins Point project; (3) to provide a location to store the water necessary to provide increased winter energy to the basin by allowing an annual fall drawdown of the lake to occur with a winter refilling operation which is unique to this project; and (4) to provide the extra water needed to meet all main stem authorized purposes, particularly navigation and downstream water supply, which draft storage during low water years.

Late Summer and Fall 1997. As was the case at Gavins Point, record releases were made from August through November for floodwater evacuation. Releases averaged 60,700, 61,700, 65,400, and 66,700 cfs during the August through November period; 24,800, 25,800, 30,100, and 35,000 cfs greater than normal, respectively. Lake Francis Case was near elevation 1368.8 feet msl, 3.8 feet into the exclusive flood control pool at the beginning of August, down from the 1372.2 feet msl yearly maximum pool that occurred on May 7, 1997. The annual fall drawdown caused the lake to decline over 35.3 feet to 1337.2 feet msl by December 1, 1997. This drawdown is accomplished each year near the end of the navigation season to provide space for storing winter power releases from the upstream projects.

Winter 1997-1998. Fort Randall releases were reduced from the autumn floodwater evacuation rate to the winter release rate during the month of December. Fort Randall releases ranged from 63,000 to 22,300 cfs in December. The 63,000 cfs was a December record for the maximum daily release from Fort Randall. Throughout December and early January the ice conditions below Fort Randall remained stable. Beginning on January 6, 1998, releases from Fort Randall were reduced from 24,000 to 19,000 cfs following the reductions made at Gavins Point Project. The reductions at Gavins were necessary to avoid ice-jam flooding on the Missouri River downstream from Gavins Point. On January 12, 1998, ice bridging upstream from Verdel, Nebraska, delayed the Fort Randall releases from reaching Gavins Point Reservoir and caused a drop of 2.6 feet to 1204.6 feet msl by January 15, 1998. The Gavins Point pool did not recover until January 23, 1998, when the midnight pool elevation reached 1207.0 feet msl. During this critical period the Fort Randall releases were gradually increased from 18,500 to 21,000 cfs. Through the remainder of the winter season, Fort Randall releases ranged between 19,000 and 25,000 cfs as needed to maintain the Lewis and Clark pool elevation at 1207 feet msl.

Fort Randall releases averaged 32,400, 21,700, and 22,000 cfs during December, January, and February, respectively, well above the normal winter release rate of 15,000 cfs, to continue the floodwater evacuation. The releases varied from 177 percent of normal in December to 139 percent in January and 159 percent of normal in February. The December average monthly release was the highest December since the main stem system first filled in 1967. February 1998 release was the second highest February average monthly release, and January was the third highest January average monthly release. Lake Francis Case rose from 1337.2 feet msl on the first of December to 1354.1 feet msl by the end of February.

Spring and Summer 1998. Releases from Fort Randall generally paralleled those from Gavins Point and averaged 22,700 cfs in March, 17,100 in April, 24,200 cfs in May, 22,200 in June, and 24,800 cfs in July. Daily average releases varied between 12,600 and 28,100 cfs during this period. By April 7, Lake Francis Case rose to an elevation of 1357.05 msl, more than 15 feet lower than the maximum pool of 1372.2 feet msl experienced on May 7, 1997, the highest since closure of the dam in 1952. Lake Francis Case slowly fell during July, reaching 1355 feet msl by the end of the month.

6. Gavins Point Operation - August 1997 to July 1998. Gavins Point Dam, the most downstream of the main stem dams, is primarily used as a reregulating dam to level out the release fluctuations of the upper dams to serve downstream purposes. With a total storage of only 500,000 acre-feet, it provides very little flood control and is generally maintained in a narrow band between 1205 and 1207 feet msl. Due to the limited storage, releases from Gavins Point must be backed up with releases out of the upper reservoirs. Gavins Point is the key location in the initiation of release reductions for downstream flood control. Even though it has only a small amount of storage space for flood control, by coordinating Gavins release reductions with Fort Randall reductions, this volume is usually adequate to perform significant downstream flood control. Releases greater than the powerplant capacity, near 35,000 cfs, are passed through the spillway.

Late Summer and Fall 1997. The primary operational objective of Gavins Point in the late summer and fall of 1997 was the evacuation of floodwater from the upper reservoirs. The August 1, 1997, forecast indicated that a Gavins Point release rate of 65,000 cfs was required for the remainder of the navigation season. Releases were at 62,000 cfs on August 1 and increased to a record high of 70,000 by October. This increase above the August 1 forecast was the result of continued above normal runoff during the fall months. Releases were held at 70,000 cfs throughout November. On December 1, releases were reduced by 3,000 cfs per day until a release rate of 28,000 cfs was reached on December 14. The official closing of the 1997 navigation season at the mouth of the Missouri occurred on December 11, 1997.

Average monthly releases were 64,400 cfs for August, 27,200 cfs greater that average; 65,400 cfs for September, 27,700 greater than average; 68,200 cfs for October, 30,800 cfs greater than average; and 70,000 cfs for November, 35,900 cfs greater than average. The release rates from Gavins Point, August through November, were new record releases.

Lewis and Clark Lake was operated to maintain a pool elevation near 1207 feet msl throughout the period varying between 1206.4 feet msl and 1207.8 feet msl.

Winter 1997-1998. The plan for Gavins Point during the winter 1997-1998 was to evacuate the remaining 2.7 MAF of floodwater stored in the System by March 1. The winter release rate for Gavins Point Dam was set at 28,000 cfs, 8,000 cfs above the normal maximum winter release. The 28,000 cfs release was maintained through February requiring careful monitoring of downstream stages and weather conditions to prevent flooding and ice jams. Like last year, ice bridging on the Missouri River downstream from Gavins Point was not a major problem;

however, on January 6, 1998, Gavins Point was reduced from 28,000 cfs to 25,000. Over the following 3 days reductions continued, with releases reaching 22,000 cfs by January 9, 1998. These reductions were made in anticipation of possible ice bridges forming in the Missouri River downstream from Gavins Point as the coldest weather of the winter season approached. These reductions also helped slow the decline of the Gavins Point pool which dropped 2.6 feet over a 6-day period due to bridging on the Missouri River upstream from the dam.

The Gavins Point average daily release was well above the normal winter release rates. Monthly averages were 37,100 cfs, a record high for December; 24,800 cfs in January; and 28,000 cfs in February. This was the third highest January and the second highest February on record. The winter of 1997-1998 was also the third consecutive year that above normal winter releases were made.

The recurring challenge of assuring operational spillway gates at Gavins Point continued during the winter of 1997-1998. One of the three Gavins Point generating units is usually out of service for maintenance during the winter months. A second unit failure or a transmission system failure during very cold conditions would necessitate opening the spillway gates to prevent releases being reduced to that permitted by one generating unit. Municipal and powerplant intakes could experience inadequate river stages if ice jams occurred with only one unit generating. A second concern for operable spillway gates would be the ability to release floodwaters in excess of two-unit capacity if sudden changes in winter conditions produced high reservoir inflows.

Supplemental sidewall heaters were installed on the downstream walls of tainter gates 2, 4, and 6 to prevent the ice bridging which normally occurs between the spillway gate and the sidewalls. Additionally, the existing side seal heaters on tainter gates 2, 4, and 6 were replaced. The winter of 1997-1998 was the first time the sidewall heaters were available for continuous usage. Water pressure from spillway flows caused the lower aluminum sheets of the sidewall heaters to curl away from the concrete wall. The aluminum sheets have been refastened to the concrete sidewall, the sidewall heating elements have been tested and will be available for use during the winter of 1998-1999.

During the winter period, Lewis and Clark Lake was near 1207 feet msl, the same target as the previous six winter seasons. The target elevation was then lowered to 1206 feet msl by the end of February for flood control. The maximum pool level reached during the winter period was 1207.7 feet msl on February 2, 1998. The minimum pool level of the season occurred as a result of the ice bridge upstream from Verdel, Nebraska, discussed previously. The ice bridge blocked inflows to Gavins Point and the Lewis and Clark Lake dropped from 1207.2 feet msl on January 9, 1998, to 1204.6 feet msl on January 15. The Gavins pool recovered to the 1207 feet msl level by January 28 and remained at that level through February 13, 1998.

Winter River and Ice Conditions Below Gavins Point Dam. The Gavins Point winter release rate of 28,000 cfs was reached on December 14, 1997. Bitterly cold weather moved into the basin in early January. On January 6, 1998, the Gavins Point release was reduced to 25,000 cfs when ice reports indicated 5 to 10 percent floating ice with 5-foot pads on the Missouri River

from Sioux City, Iowa, downstream to Nebraska City, Nebraska. The ice was gone the following day. As noted in earlier paragraphs, the releases continued to be reduced to 22,000 cfs by January 9, 1998, and were held at this level until January 19, 1998. Over the January 12-14, 1998, period, the highest percentages and sizes of floating ice occurred for the winter season. Floating ice ranged from 30 to 90 percent with 4- to 20-foot pads on the Missouri River between Sioux City, Iowa, and Nebraska City, Nebraska. Releases from Gavins Point were gradually increased from 22,000 cfs to 28,000 and remained at that level until March 11, 1998. This was an unusual winter season on the Missouri River below Gavins Point; no ice cover developed and no ice-jam flooding was reported. The moderate winter temperatures and diligent regulation of releases from the Gavins Point Dam during the periods of ice formation allowed the 28,000 cfs release on all but 23 days of the winter season.

Spring and Summer 1998. Gavins Point releases were in the 28,000 cfs range in early March, about 7,000 cfs above normal. The high winter releases made navigation on the lower river possible throughout most of the winter and flows at all downstream target locations were exceeding navigation requirements by April 1, the first day of flow support for the 1998 navigation season. The first tow of 1998, the "Vicksburg," entered the river on January 6, 1998. Only three tows were operating on the Missouri River on April 1, but as many as seven tows were on the river by late that month.

By spring, with most of the 1997 floodwater evacuated and a lack of significant plains or mountain snowpack, Gavins Point releases were near normal. Releases were set to meet a Sioux City navigation target from late March through the first half of May. They were increased in mid-May to the summer release rate of 32,000 cfs prior to the start of the endangered species nesting season. There was one reduction in system releases during the summer of 1998 to provide downstream flood control. In June, as record stages were reached on the Nishnabotna River in southwest Iowa, Gavins Point releases were reduced to as low as 22,000 cfs, thus providing only minimum service navigation flows at Sioux City. As floodwaters receded, releases were returned to 30,000 cfs, 2,000 cfs lower than the previous rate due to wet lower basin conditions, indicating the navigation target was unlikely to shift downstream from Sioux City.

Average daily outflows ranged from 23,300 cfs in April to 29,600 cfs in July, slightly below the historic averages.

Lewis and Clark Lake was targeted for elevation 1206 feet msl throughout the spring and summer of 1998. The lake elevation ranged from 1205.5 on April 14 to 1207.3 on June 18.

E. <u>Non-Routine Operations and Other Items Pertaining to Main Stem Regulation</u>. Numerous operations are performed each year that, although at one time may have been considered special, are now considered almost routine. These include the release restrictions from a particular project for a period of time to permit soundings or to facilitate limited construction within or adjacent to the downstream channel, and to pattern releases to facilitate measurements of downstream discharges and water surface profiles. Events which occurred in connection with operations during the past year that may be considered unusual, or recently have come to the attention of the Reservoir Control Center, are discussed in the following paragraphs.

1. Lawsuit. The State of Missouri v. Craig lawsuit, filed on March 12, 1996, in the U.S. District Court for the Western District of Missouri, Central Division, is similar in many respects to a lawsuit filed by the State of Missouri on May 11, 1992. Both lawsuits involve a challenge to a Missouri River AOP and alleged noncompliance with NEPA. Plaintiffs, State of Missouri and MO-ARK, allege that the 1995-96 AOP implemented a deviation from the current Master Manual that is a major change in the operation of the Missouri River Main Stem System and thus required NEPA compliance. The U.S. Department of Justice filed an Answer to the Complaint on May 7, 1996. Cross Motions for Summary Judgment were filed in December 1996. On August 29, 1997, the Court granted the Corps' Motion for Summary Judgment, ruling that changing the trigger point from 39 MAF to 52 MAF does not require the preparation of an EA, FONSI, or an EIS. The Court found that the Corps decision that NEPA is inapplicable was reasonable. The State of Missouri filed an appeal with the Eighth Circuit Court of Appeals. On December 16, 1998, the circuit court held that the case is moot, because the 1995-96 and 1996-97 navigation seasons are over. The court vacated the district court's decision and remanded the case for dismissal.

2. Repair of 1997 Flood Damages. The high pool levels at the main stem dams and the resulting high releases during 1997 caused extensive lake shoreline and river bank erosion and damages to the recreation and dam facilities. Emergency flood repair funds were provided to repair the damages. Contract repair work continues and additional contracts are expected to be awarded in FY 99. Protection and stabilization of cultural resource sites impacted by erosion is also planned. The following is a summary of funds programmed to date.

Project	Total $	Work Items
Fort Peck	$260,000	Recreation area erosion repairs
Garrison	$412,000	Tainter gate repairs, recreation area road repairs
Oahe	$1,323,000	Shoreline erosion protection of several recreation areas, cultural resource site protection, stilling basin repairs
Big Bend	$1,706,000	Shoreline erosion protection of environmental and recreation areas, road repairs, sewage lagoon repairs
Fort Randall	$1,332,000	Repairs to recreation area facilities and roads, shoreline erosion protection
Gavins Point	$349,000	Downstream river bank erosion repairs
Missouri River	$200,000	River bank erosion repairs

3. Fort Peck. Releases from Fort Peck during the fall of 1997 were held at a slightly higher rate than forecasted to speed the drawdown of the lake to elevation 2237 and thus facilitate construction work on a breakwater project in Fort Peck Lake.

Requests were received for a month-long warm water spill from Fort Peck in the spring of 1998 in combination with powerplant releases. This operation was not scheduled in 1998 because of potential impacts to flood control, hydropower, and downstream erosion. The lost power revenue estimates for these requests vary from $1.5 to $4.3 million.

4. Garrison. There were numerous complaints of streambank erosion with the high summer and fall Garrison releases during 1995, 1996, and 1997. Bank erosion from the high river flows is a primary concern of many citizens in the Garrison reach. Several local initiatives are being pursued in an attempt to resolve the erosion problem at the most significant areas.

5. Oahe. The Omaha District is investigating solutions to the sediment and flooding problems downstream of Oahe Dam. They propose to address the Oahe operational constraints on three levels: (1) continued support of the Natural Resource Conservation Service's efforts to reduce tributary sediment inflows; (2) evaluation of potential ice management alternatives on the Missouri River, such as a winter drawdown; and (3) changes in the Pierre and Fort Pierre floodplain management by establishing a Memorandum of Understanding (MOU) between the Corps, Western Area Power Administration, and the Federal Emergency Management Agency (FEMA) and by updating the 1988 flood hazard analysis and developing new FEMA maps.

During the months of March through August 1998, several special release patterns were made at Oahe to enable construction of the Mni Wiconi water intake near channel block 6. Most of the requests were for varying lengths of zero release or one-unit releases, to assist divers working in the area. Flows were also restricted to approximately 27,000 cfs on some days to restrict downstream stages from rising significantly during construction activities. Several hours of higher releases were also needed periodically to float barges associated with the construction into place.

In addition to the water intake contractor mentioned above, a dredge contractor working near LaFramboise Island requested low Oahe releases on several occasions during 1998. When possible, these were arranged to coincide with the work being done by the water intake contractor, otherwise they were scheduled during weekends when releases are normally lower.

During the spring of 1998, low releases were also required for several days to facilitate a diving contractor surveying mussels in the Pierre area. Minimal adjustments to Oahe releases were made during the survey. The contractor asked to have releases restricted to one unit from noon to 5 p.m. on May 18-20. However, the diver was able to complete most of his work on the weekend and completed the rest without restrictions to Oahe releases on Monday and Tuesday. The survey was being conducted for the EA for the proposed fall drawdown of Lake Sharpe.

6. Fort Randall and Gavins Point. The sustained high releases from these projects during 1997 caused a notable, although as of yet unquantified, increase in the channel capacity below the dams. An analysis of the current channel conditions will be completed in 1999.

7. Downstream Reach. A general lowering trend of the river level and the accumulation of sediment in downstream marinas continues to be a concern for marina operators and recreational boaters. Dredging was necessary in 1990, 1991, and in 1992 because of sediment deposits resulting from high short duration flows. The Great Flood of 1993 deposited large amounts of sediment in many marinas making that the fourth consecutive year that sediment removal was necessary by the marina operators. From 1995 through 1997 most marina owners between Sioux City and Omaha did not have to deepen their entrances and dredge basins to provide access because of higher main stem flows. Such was not the case in 1998. The return to normal service flows along with the river channel degradation above Omaha (as much as 2 feet in the Sioux City area) presented major problems to marina operators. Early in the season, higher tributary flows helped alleviate the situation, but as the summer progressed and tributary flows receded the problem became more severe. There were times during 1998 when the marinas could not operate, especially during June when main stem flows were reduced for downstream flood control.

F. Reservoir Releases and Storage Pool elevations and storage contents of the main stem reservoirs at the end of July 1998 , are presented in ***Table IV***.

TABLE IV
PROJECT POOL LEVELS AND STORAGES

	Pool Elevation feet msl		Water in Storage - 1,000 AF July 31, 1998		
	July 31, 1997	12-Month Change	Total	Above Min. Pool*	12-Month Change
Fort Peck	2240.1	- 10.0	16,353	12,142	- 2,362
Garrison	1843.0	- 12.2	19,921	14,941	- 3,207
Oahe	1612.2	- 6.1	20,443	15,070	- 2,061
Big Bend	1419.9	+ 0.1	1,683	1	+ 3
Fort Randall	1355.2	- 13.5	3,544	2,027	- 1,223
Gavins Point	1206.3	+ 0.1	364	43	0
			62,308	44,224	- 8,850

*Net usable storage above minimum pool levels established for power, recreation, irrigation diversions, and other purposes.

G. Summary of Results.

1. Flood Control. Since 1987 the Missouri River basin and Main Stem System have experienced a wide range of climatological events. The near record inflow and reduced releases for The Great Flood of 1993 essentially refilled the system during 1993, a quick turn-around from the low levels resulting from the 1987-1992 drought. The 1995-1997 timeframe was a period of major flood control action performed by the System. August 1997 through July 1998 was marked by a shift from record high releases, required to evacuate floodwaters captured during the greatest runoff year in the 100 years of record keeping, to a rather benign year of near normal runoff and releases.

System storage in the main stem reservoirs on August 1, 1997, was 71.2 million acre-feet (MAF), much greater than the 31-year average of 61.9 MAF and 3.5 MAF higher than in 1996. After peaking at 71.7 MAF, System storage was down only 0.5 MAF, so releases during the late summer, fall, and winter were directed at evacuating flood storage.

Below normal mountain snowpack and spotty plains snowpack kept runoff in 1998 near normal levels and System storage peaked at 62.5 MAF on July 23. The estimated total flood damages prevented by the main stem reservoirs during Fiscal Year (FY) 1998 is $63.9 million. The $63.9 million total damages prevented in the Missouri River basin includes $6.2 million in the Kansas City District and $57.6 million in the Omaha District. The damages prevented by the Missouri River main stem reservoirs along the Mississippi River totaled $0.1 million for FY 1998. The flood damages prevented by the Main Stem System since construction now totals $15.9 billion, the bulk of which was prevented between 1993 and 1997 (see ***Figure 6A***). Although the reservoirs prevent enormous amounts of damage, they are not capable of totally eliminating flooding along the Missouri River. The estimated actual flood damages incurred in the Omaha District along the Missouri River from above Fort Peck Dam to Rulo, Nebraska, for 1998 were $16.5 million. The estimated flood damages incurred along the Missouri River in the Kansas City District have not yet been provided for FY 1998. ***Figure 6B*** indicates the $1.2 billion cost to construct the main stem dams. High stages on the Missouri River from spring and summer rains prevented planting, destroyed crops, or forced late planting thereby reducing yields of 61,000 acres of farmland in the reach between Sioux City and St. Joseph.

The Kansas City District tributary reservoirs also prevented a significant amount of flood damages because of large rainfall events captured by the Kansas projects during this past year. The total Kansas City District damages prevented, exclusive of the Missouri River main stem, was $29.7 million.

Figure 7 shows the Actual Regulated Flows that were experienced at Sioux City, Iowa, Nebraska City, Nebraska, and St. Joseph, Missouri, and the Unregulated Flows that would have been experienced if the main stem and tributary reservoirs had not been in operation.

Missouri River Main Stem

Cumulative Flood Damages Prevented

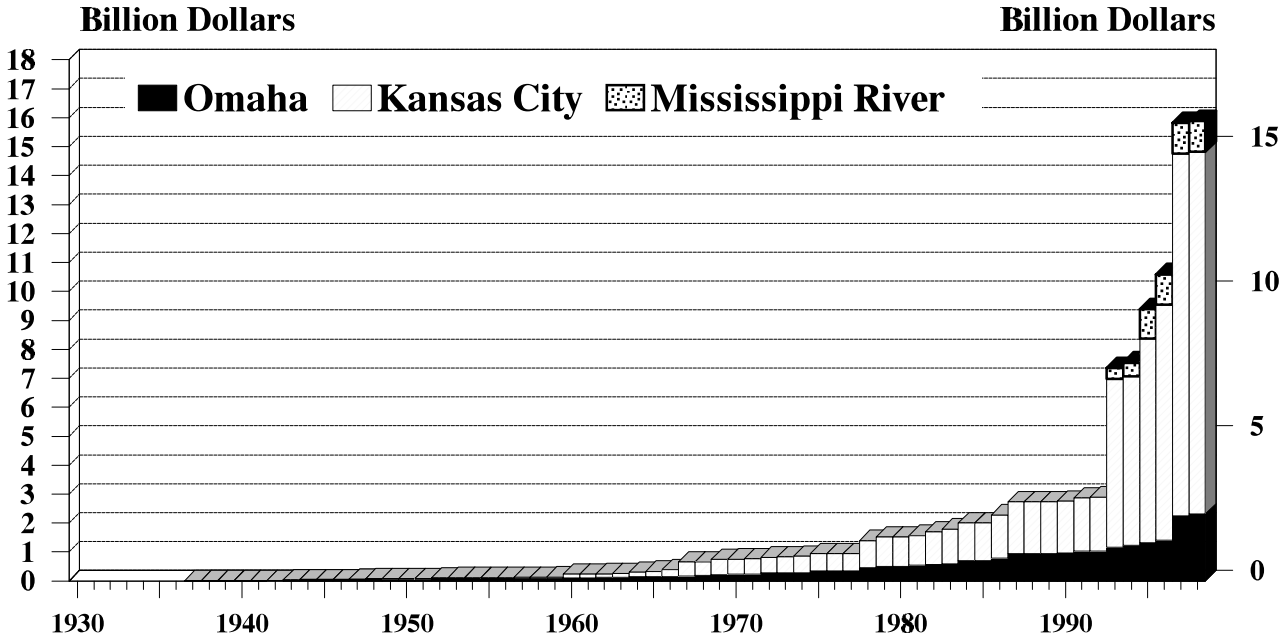


Figure 6A

Annual Flood Damages Prevented

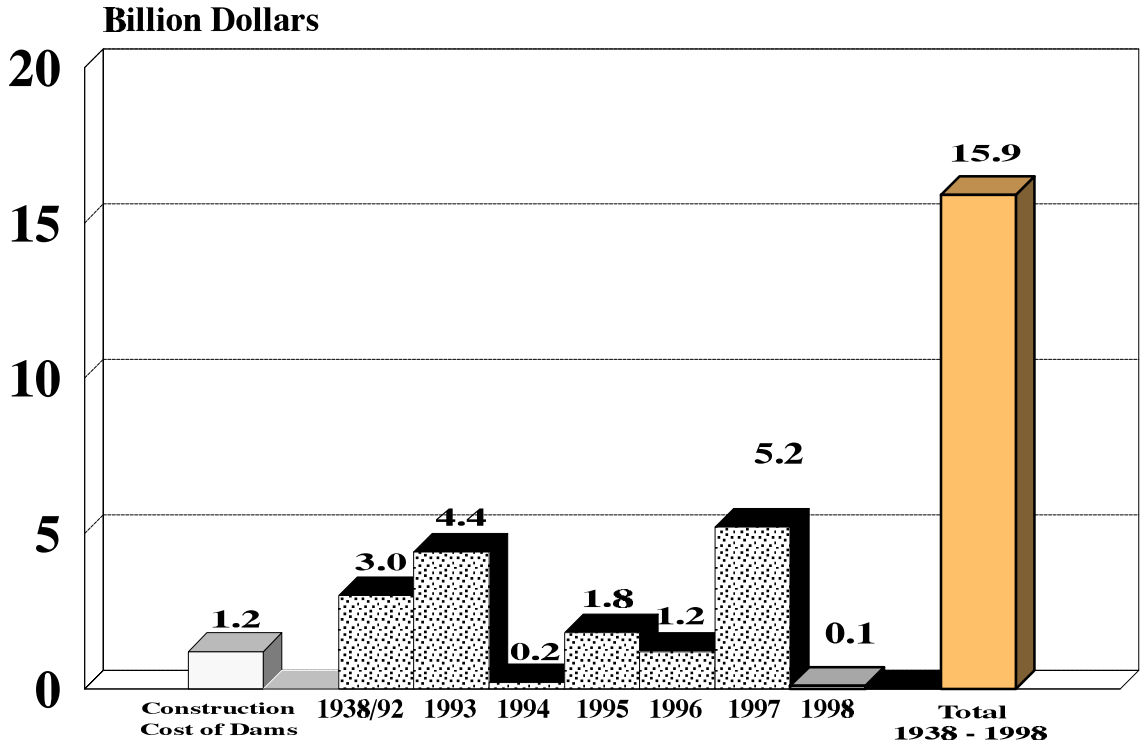
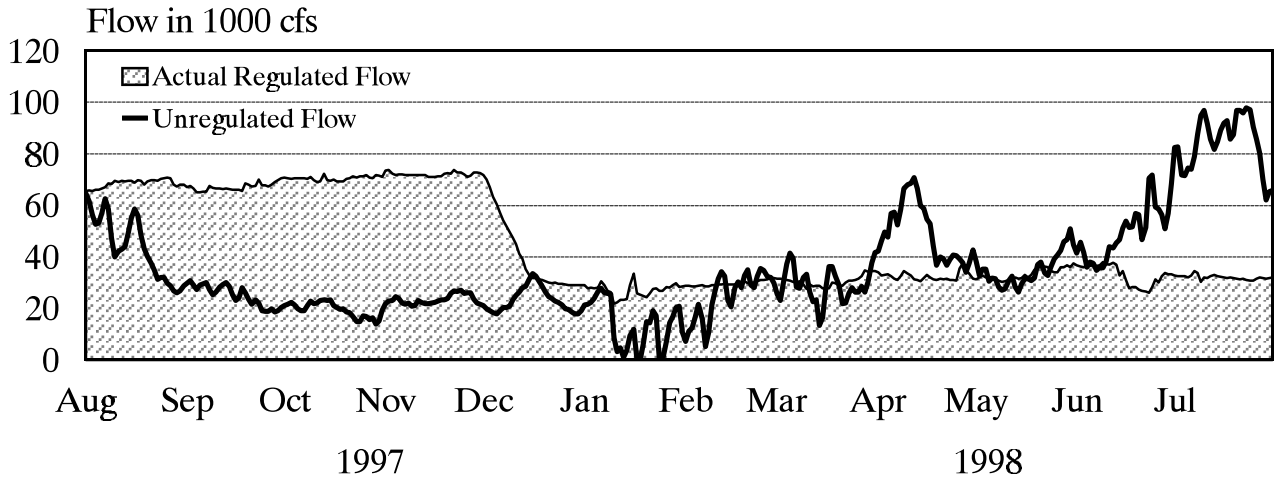
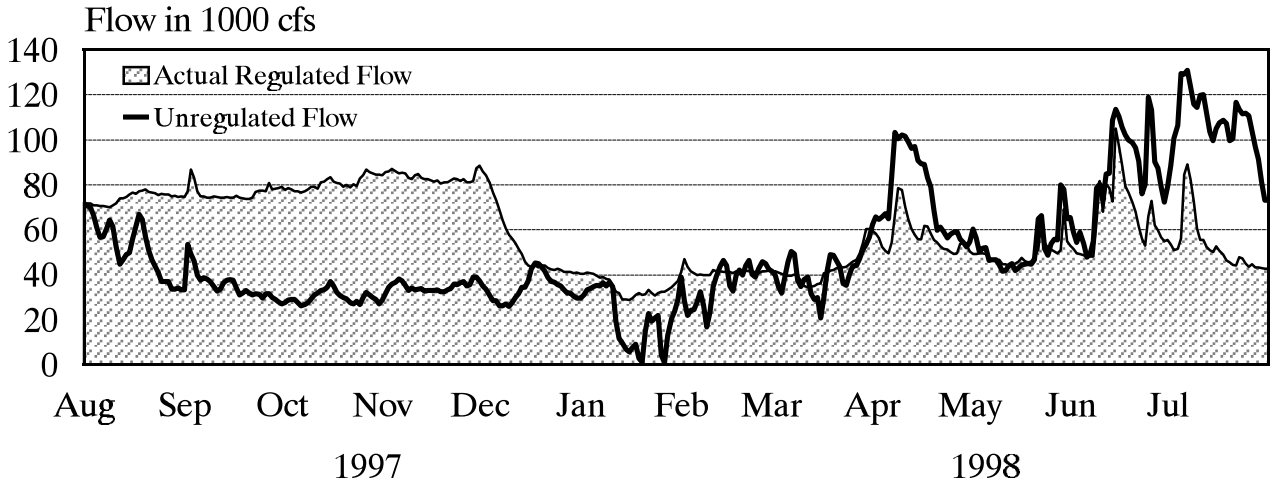


Figure 6B

Sioux City
Regulated and Unregulated Flows



Nebraska City
Regulated and Unregulated Flows



St. Joseph
Regulated and Unregulated Flows

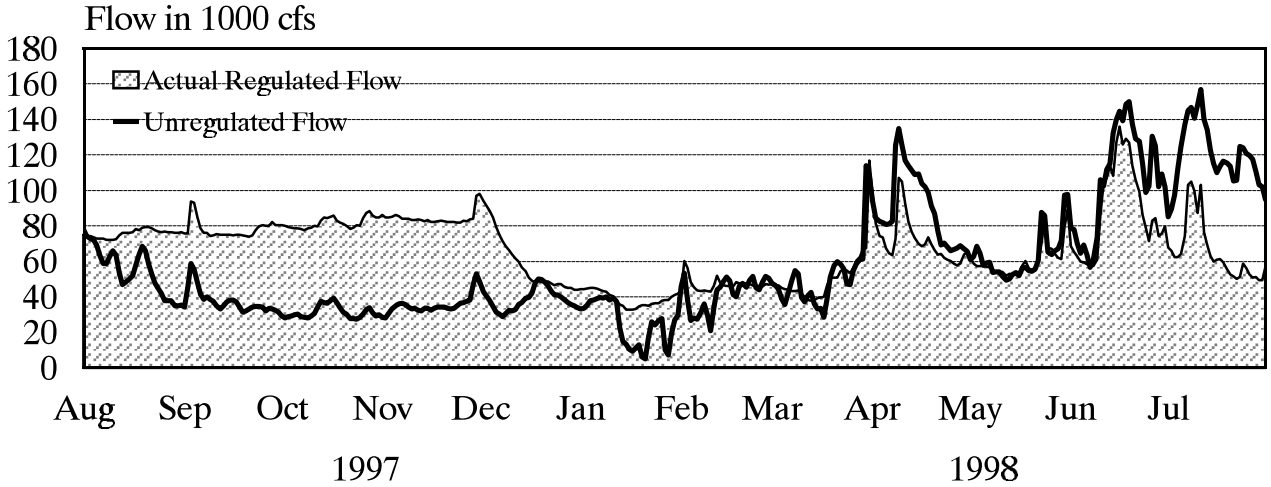


Figure 7

2. Irrigation. Federally developed irrigation projects are not being served directly from main stem reservoirs. However, releases from the reservoirs are being utilized by numerous private irrigators as well as Federally financed projects that take water from the river. Over 400 private irrigators have been granted permits to pump directly from the reservoirs. Releases from the reservoirs during 1997 and 1998 generally met the needs of irrigators.

3. Water Supply and Water Quality Control. Daily flows exceeded minimum requirements for water supply and water quality control purposes throughout the system for the entire 1997-1998 period. With higher than average winter release rates, there were very few water supply problems. Intake owners today are also better prepared to handle periods of low water due to adjustments made to intakes or operating procedures as a result of the drought. Some of these adjustments involved using warm water to keep ice formation from building up on intake screens, installing new pumps, lowering intakes and installing sediment redirection veins, installing ice deflectors, obtaining or arranging to obtain alternate sources of water, and cleaning screens more thoroughly and frequently. These remedial actions were expensive but have significantly improved the ability of the intakes to tolerate low river stages.

Figure 8 shows the end-of-July pool elevation for Fort Peck, Garrison, and Oahe plus total Main Stem System end-of-July storage for 1997 and 1998. An individual table with the maximum, average, and minimum end-of-July pool elevations for each major reservoir is also shown on this figure. The end-of-July 1998 pool elevations were considerably lower than last year at all three big storage projects. Fort Peck (2240.1 feet msl) was 6.1 feet into the annual flood control zone and 10.0 feet lower than the 1997 end-of-July level. Garrison (1843.0 feet msl) was 5.5 feet into the annual flood control zone, 9.2 feet lower than 1997. Oahe (1612.2 feet msl) was 4.7 feet into the annual flood control zone and 6.1 feet lower than in 1997. Also shown are the minimum, maximum, and average pool elevations for the periods since the system closed in 1967.

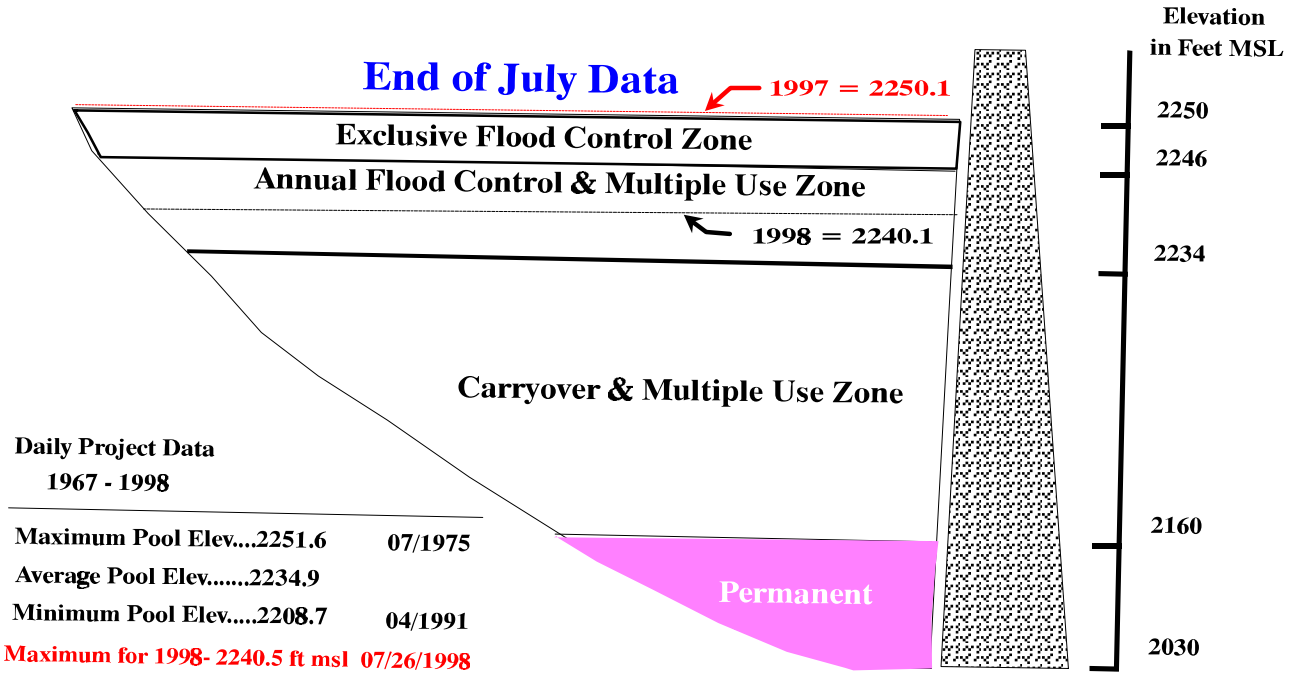
Specific water quality problems detected in the Missouri River main stem projects in 1997 were the exceedence of state standards for several parameters. ***Table V*** lists the issues and problems identified at each of the main stem projects during 1997.

Parameters exceeding state standards at one or more main stem reservoir projects are arsenic, iron, phosphorus, sulfate, dissolved oxygen, pH, and lead. The majority of these parameter exceedences arise from sources outside project boundaries. This is particularly true for metals and organics. Agricultural practices, both past and present, included the application of pesticides throughout much of the Missouri River basin. While state ambient water quality standards do not exist for most pesticides, the following pesticides and herbicides have been detected in minute concentrations in the main stem reservoirs during the past 5 years: atrazine, alachlor, diacamba, diazinon, dacthal, benzene hexachloride, dieldrin, DDT, metolachlor, simazine, metribuzin, trifluralin, and propachlor. Pesticide levels will continue to be closely monitored.

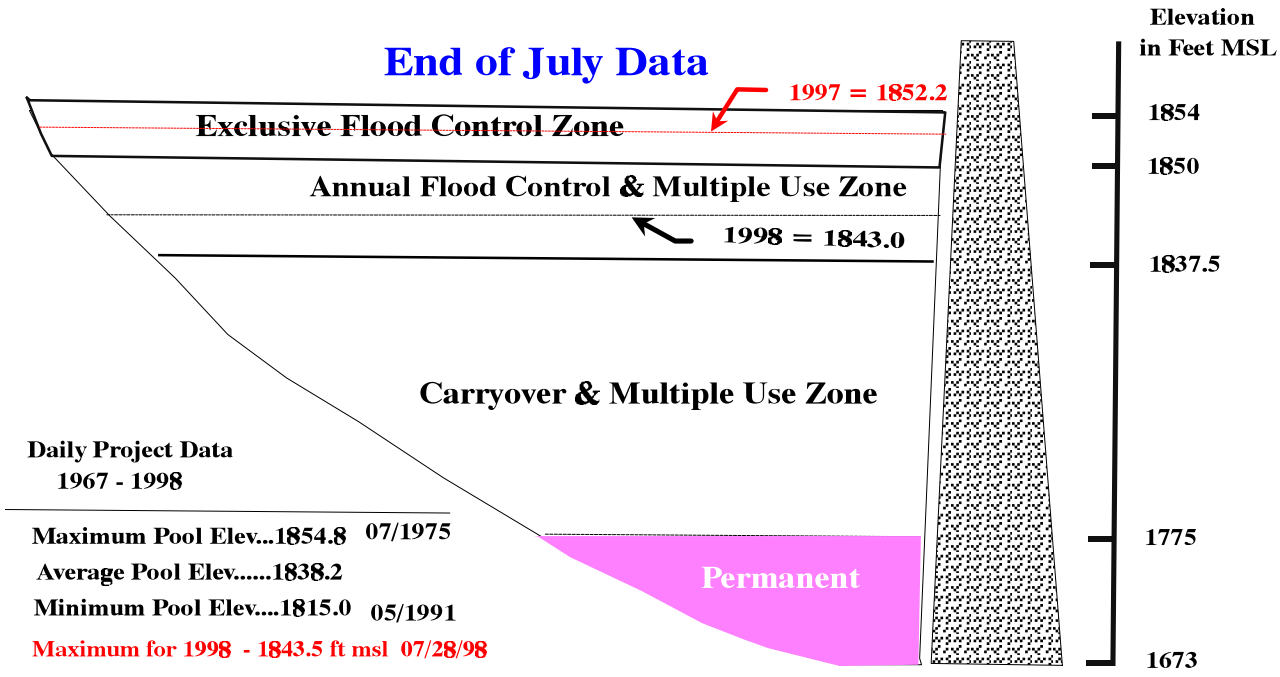
TABLE V
WATER QUALITY ISSUES AND PROBLEMS
IN MAIN STEM LAKES - 1997

Project	Algal Blooms	Fish Kills	Potential Problem Areas	State Standard or EPA Ambient Water Quality Criteria; Exceedences
Fort Peck	No	No	Coal & oil development, algal blooms, and shoreline erosion	*Inflow:* none identified *Reservoir*: dissolved oxygen *Releases*: none identified
Lake Sakakawea	No	No	Oil drilling, strip mining, algal blooms, low dissolved oxygen	*Inflow*: none identified *Reservoir:* dissolved oxygen, phosphorus, and pH *Releases:* none identified
Lake Oahe	No	No	Agricultural runoff, bioaccumulation of mercury	*Inflow*: sulfate *Reservoir*: dissolved oxygen and pH *Releases:* dissolved oxygen and pH
Lake Sharpe	No	No	Agricultural runoff and winter kills	*Inflow*: none identified *Reservoir:* dissolved oxygen and pH *Releases*: arsenic, dissolved oxygen, and pH
Lake Francis Case	No	No	Intrusion of the White River delta	*Inflow*: arsenic, dissolved oxygen, and pH *Reservoir*: dissolved oxygen, pH, arsenic, and lead *Releases*: dissolved oxygen and pH
Lewis and Clark Lake	No	No	Emergent aquatic vegetation, atrazine, banvel, and metribuzin	*Inflow*: none identified *Reservoir*: dissolved oxygen, pH, arsenic, and iron *Releases:* arsenic, dissolved oxygen, and pH

Missouri River Main
Recent Lake Elevations and



Fort Peck Lake

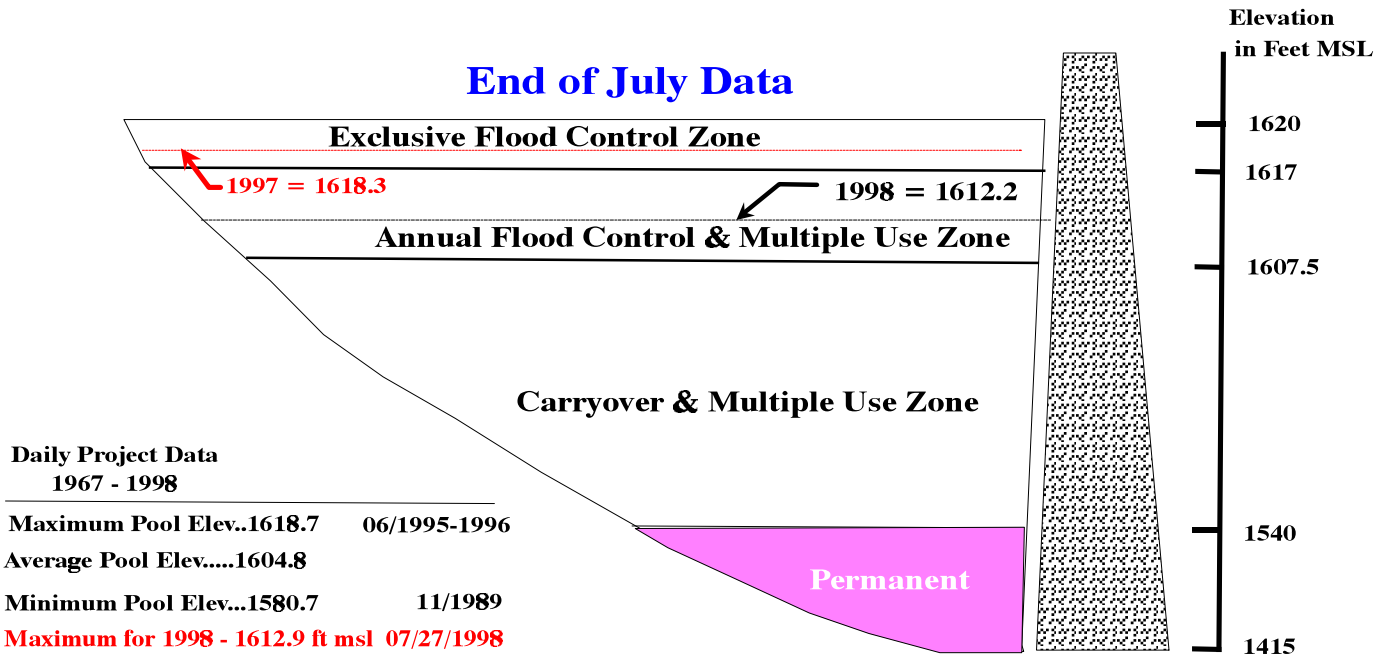


Garrison Dam - Lake Sakakawea

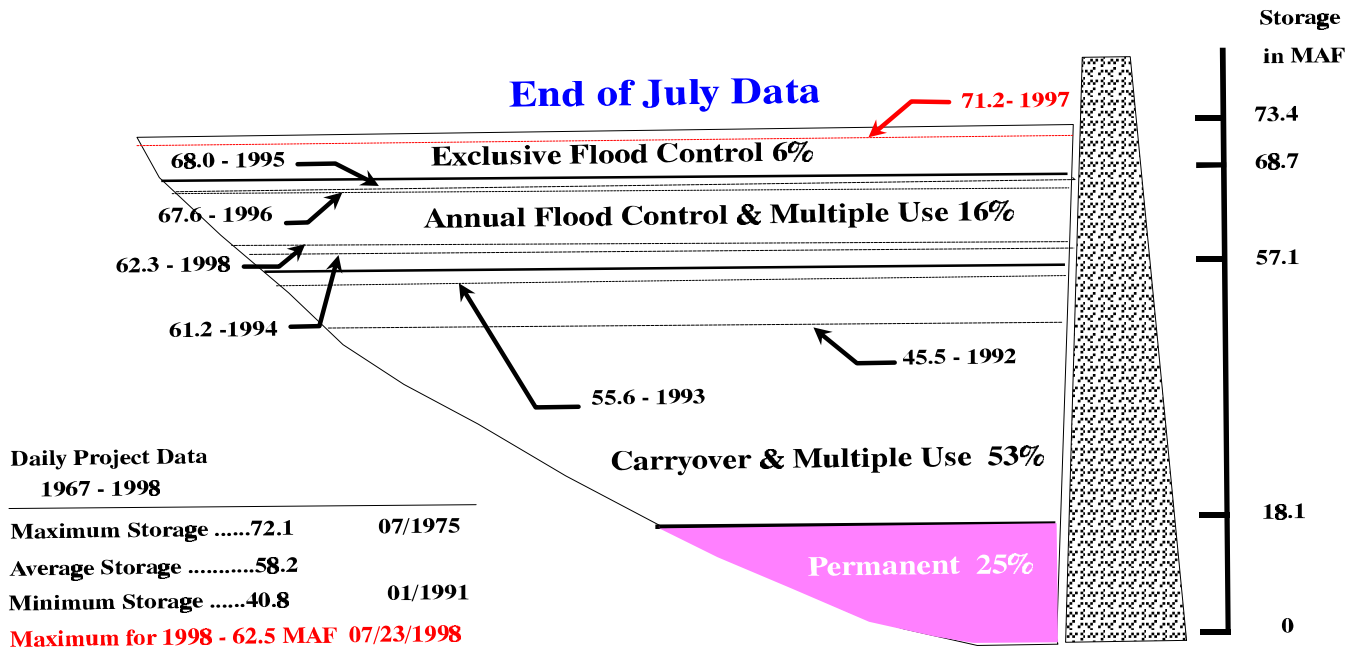
Figure 8 A

Stem Reservoirs

Total System Storages



Oahe Dam - Lake Oahe



Total System Storage

Figure 8 B

Low dissolved oxygen concentrations may result from the impoundment of water in lakes and reservoirs. Low dissolved oxygen concentrations may result in an influx of metals such as iron and manganese from the sediments into the water in concentrations that may exceed state standards.

In certain years, a potential exists for low dissolved oxygen levels in Garrison Reservoir. Garrison has had problems in the past with low dissolved oxygen during low water supply years when hypolimnetic volume is small. The oxygen demand exerted by the bottom sediments and within-lake organic matter reduces the hypolimnetic oxygen levels. The hypolimnetic dissolved oxygen levels may remain below state standards until the fall turnover. The dissolved oxygen levels in the releases from Garrison Reservoir have never been below state standards. Low dissolved oxygen levels were detected in the hypolimnion by the U.S. Geological Survey (USGS) in their 1993 studies; however, levels returned to above state standards at the next sampling period. The project will continue to be sampled for this problem. If a problem is detected, increased sampling will be initiated to determine the severity and extent of the low dissolved oxygen. The higher pool and increased volume since 1993 has diminished considerably the chance of a problem occurring. Lake Oahe has experienced problems similar to those at Garrison during low volume years but the higher lake levels have alleviated the problem since 1993.

The North Dakota Department of Health and Consolidated Laboratories (NDDHCL) in Bismarck has annually issued since 1993 an advisory on consumption of fish caught in some streams and lakes in North Dakota. Lake Sakakawea was included in this advisory. The advisory was not intended to discourage anglers from eating fish but offers advice on how fish caught in these impoundments could be eaten safely. The NDDHCL analyzed fish fillets in 1996 and collected tissue samples again in 1997. The fish eating advisory remains in effect.

4. <u>Navigation</u>. A discussion of the first half of the 1997 navigation season is included in last year's AOP. The latter half of the 1997 navigation season included a 10-day extension and record high releases from Gavins Point Dam (70,000 cfs in October and November) in order to evacuate the highest runoff in 100 years. Fortunately, there were no major runoff events below the System so river levels, though very high, were relatively stable. Obviously, flow support was not needed in 1997 from the Corps' Kansas River tributary reservoirs to help meet Missouri River navigation flows at or below Kansas City.

Gavins Point releases were held at 70,000 cfs through November. On December 1, releases were reduced by 3,000 cfs per day until a release rate of 28,000 cfs was reached on December 14. Support flows for the 1997 extended navigation season ended on December 11 at the mouth of the Missouri. The last tow to leave the river, not involved with sand and gravel operations or the movement of cement, was the "Evelyn Rushing" on December 19, 1997. The "Jamie Leigh" of Jefferson City River Terminal ceased cement movement operations on December 23, 1997.

One grounding was reported during the 1997 navigation season. It occurred on December 11, 1997.

Final navigation commodity tonnage for 1997 has been provided by the Waterborne Commerce Statistics Center (WCSC). The WCSC final data for the Missouri River are not normally available until nearly a year after the end of the season. The WCSC estimate of commercial navigation tonnage on the Missouri River for 1997 is 1.7 million tons. This number does not include sand, gravel, and waterway materials. The WCSC estimate of total tonnage indicates approximately 8.2 million tons were transported, the same as in 1996. A record 8.5 million tons were transported in 1994, including 6.1 million tons of sand and gravel. The largest commercial tonnage season, excluding sand, gravel, and waterway material used to maintain the navigation and bank stabilization structures, occurred in 1977 when 3.3 million tons were moved on the Missouri River. Principal commodities transported downstream were corn, wheat, sorghum, soybeans, fertilizer, and animal feeds. Major commodities moved upstream were fertilizer, cement, salt, molasses, petroleum products, iron, and steel. The amounts of each commodity shipped during 1996 and 1997 are shown in ***Table VI***. Several companies mine sand and gravel from the Missouri River. Movement of the sand and gravel is usually within a few miles of the mining to the nearest loading facility.

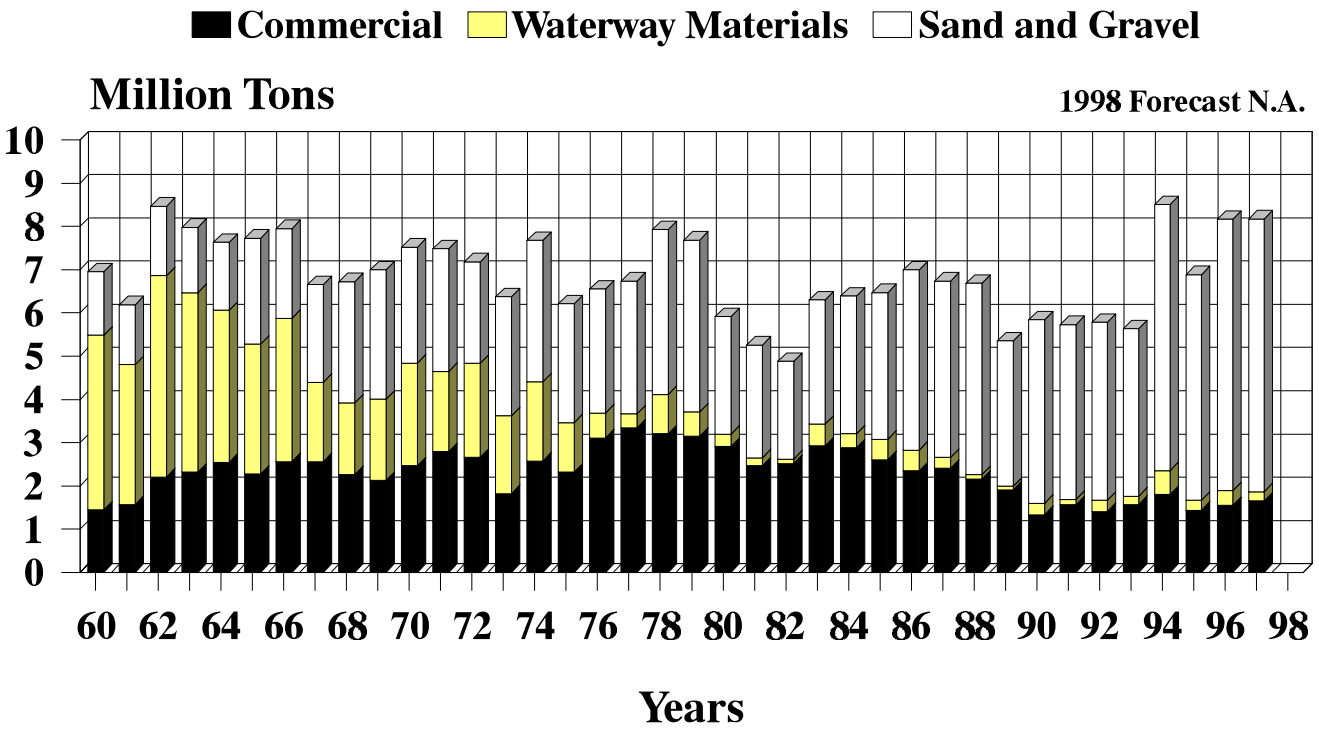
TABLE VI
TONNAGE BY COMMODITIES
MISSOURI RIVER

COMMODITY CLASSIFICATION GROUP	TOTAL (Thousand Tons)	
	1996	1997
Grain (Wheat, Corn, Sorghum)	55	311
Other Food and Farm Products (incl soybeans)	447	277
Fertilizers and Other Chemicals	551	549
Petroleum Products	236	289
Primary Manufactured Goods	224	185
Other	34	39
Subtotals	1,547	1,651
Sand and Gravel	6,278	6,303
Waterway Material	340	218
Totals	**8,165**	**8,172**

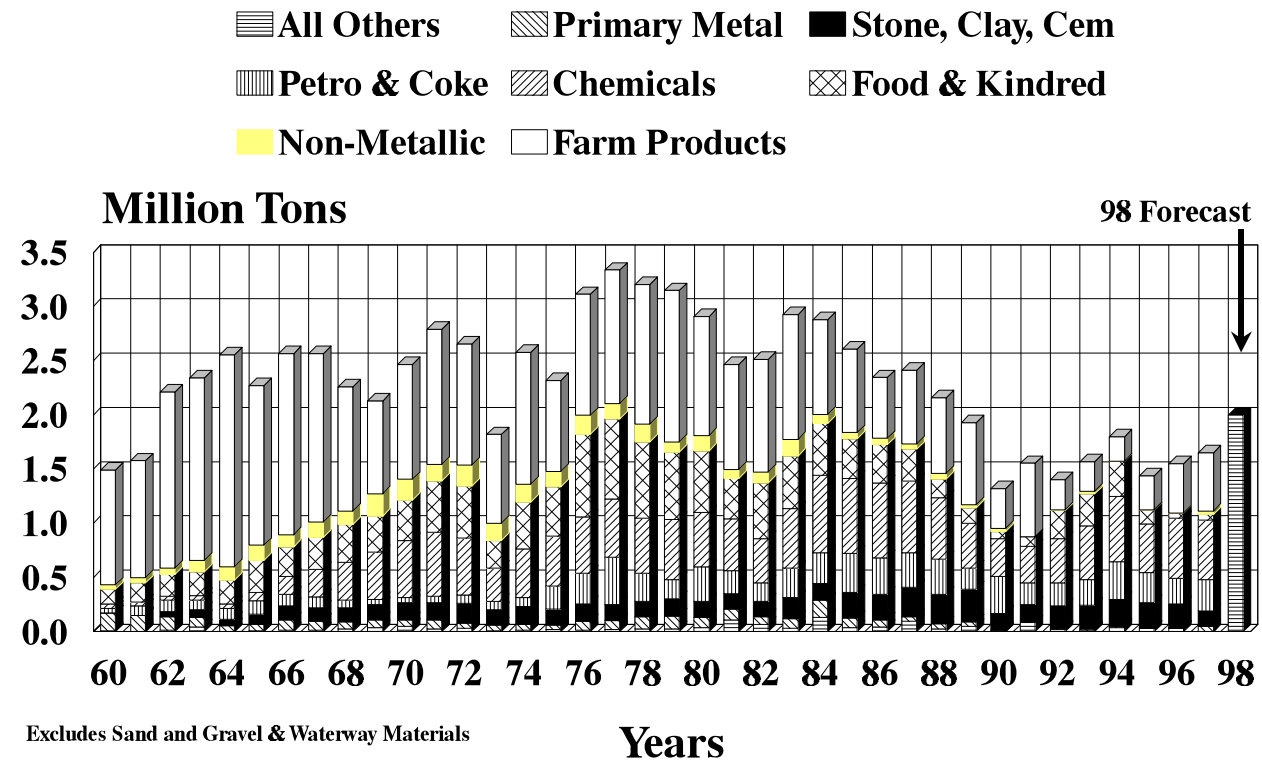
A summary of tonnage by major commodities for 1960 through 1997 is displayed on the bar graphs shown on ***Figure 9***. The bottom graph shows the commodity tonnage, excluding sand and gravel and waterway materials, while the top graph shows the total Missouri River tonnage. This includes sand and gravel moved on the river plus waterway materials for navigation project construction and maintenance. As the navigation project has been completed, waterway materials moved have diminished but the sand and gravel moved has increased greatly over the past years.

Missouri River

Total Navigation Tonnage



Commercial Navigation Tonnage



Excludes Sand and Gravel & Waterway Materials

Figure 9

The official 1998 flow support for navigation began on the normal scheduled opening dates of March 23 at Sioux City, March 25 at Omaha, March 28 at Kansas City, and April 1 at the mouth near St. Louis. However, high releases scheduled during the winter to evacuate flood storage were sufficient to allow boats to operate on the lower river throughout the winter.

The first towboat on the river in 1998 was the "Vicksburg," which entered on January 6, 1998. On April 1, the first official day of flow support for the 1998 navigation season at St. Louis, there were four tows operating on the river, the same number as the previous year. The first tow arrived at Sioux City on April 1, 1998. The number of tows to date during 1998 is slightly ahead of 1997. The Coast Guard issued a no-wake advisory on June 16, 1998, from River Mile (RM) 98 to RM 396 as the record flood on the Nishnabotna River poured into the Missouri River. The no-wake restriction was lifted on June 19. There was one reported grounding prior to the official start of the 1998 navigation season; the “Vicksburg” hit a dike on February 12.

Navigation season target flows for past years are given in ***Table VII***. The System storage peaked on July 23, 1998, at 62.5 MAF, 9.2 MAF lower than the July 13, 1997, peak storage. Full service flows were provided at all target locations during the 1998 navigation season except for a brief period in June when releases were reduced for downstream flooding from the record flood on the Nishnabotna River. During the cutback, minimum service flows were provided at Sioux City.

Table VIII shows the scheduled lengths of past navigation seasons with total tonnage and ton-miles for the past year. The 1998 season is the fourth in a row that the navigation season will be extended by 10 days due to the ample water supply. The commercial tonnage figure for 1998 is a preliminary estimate and will change once WCSC tabulations are available. Missouri River commercial tonnage may reach 2 million tons in 1998 based on estimates from daily reports of towboat activity.

Figure 10 presents discharge data at Sioux City, Nebraska City, and Kansas City for the August 1997 through July 1998 period. The three graphs demonstrate that actual flows at these locations are influenced considerably by main stem releases. During the summer of 1997, flows were much above full service from Sioux City to Kansas City due to the need to evacuate water accumulated from above normal runoff into the System. In 1998, flows at Sioux City were near full service level while those at Nebraska City and Kansas City fluctuated considerably due to flood inflows below the System.

TABLE VII
NAVIGATION SEASON TARGET FLOWS
Target Flows, 1,000 cfs

Year	Months	Sioux City	Omaha	Nebraska City	Kansas City
1967	Apr-Jun	28.0	28.0	34.0	38.0
	Jul-Nov	31.0	31.0	37.0	41.0
1968	Apr-Nov	31.0	31.0	37.0	41.0
1969	Apr-Jun (1)	35.0-40.0	35.0-40.0	41.0-46.0	45.0-50.0
	Jul (1)	36.0	36.0	42.0	46.0
	Aug-Sep (1)	50.0-55.0	50.0-55.0	55.0-60.0	55.0-60.0
	Oct-Nov (1)	40.0-45.0	40.0-45.0	45.0-50.0	50.0-55.0
1970	Apr-May	31.0	31.0	37.0	41.0
	May-Sep (1)	36.0	36.0	42.0	46.0
	Oct-Nov (1)	40.0	40.0	46.0	50.0
1971	Apr-May (1)	36.0	36.0	42.0	46.0
	May-Nov (1)	45.0-50.0	45.0-50.0	50.0-55.0	55.0-60.0
1972	Apr-Nov (1)	40.0-50.0	40.0-50.0	45.0-55.0	50.0-60.0
1973-74	Apr-Nov	31.0	31.0	37.0	41.0
1975	Apr	31.0	31.0	37.0	41.0
	May-Nov (1)	35.0-60.0	35.0-60.0	41.0-66.0	45.0-70.0
1976	Apr-Jul (1)	34.0-38.0	34.0-38.0	40.0-44.0	44.0-48.0
	Aug-Dec (1)	31.0-34.0	31.0-34.0	37.0-40.0	41.0-44.0
1977	Apr-Nov	31.0	31.0	37.0	41.0
1978	Apr	31.0	31.0	37.0	41.0
	May-Jul (1)	35.0-46.0	35.0-46.0	41.0-52.0	45.0-56.0
	Aug-Nov (1)	46.0-51.0	46.0-51.0	52.0-57.0	56.0-61.0
1979	Apr-Jul (1)	36.0-42.0	36.0-42.0	42.0-48.0	46.0-52.0
	Aug-Nov (1)	31.0-36.0	31.0-36.0	37.0-42.0	41.0-46.0
1980	Apr-Nov	31.0	31.0	37.0	41.0
1981	Apr-Nov (2)	31.0	31.0	37.0	41.0
1982	Apr-Sep	31.0	31.0	37.0	41.0
	Oct	31.0-36.0	31.0-36.0	37.0-42.0	41.0-46.0
	Nov-Dec (1)	36.0-46.0	36.0-46.0	42.0-52.0	46.0-56.0
1983	Apr-Jun	31.0	31.0	37.0	41.0
	Jul	31.0-36.0	31.0-36.0	37.0-42.0	41.0-46.0
	Aug-Nov (1)	36.0	36.0	42.0	46.0
1984	Apr-Jun	31.0	31.0	37.0	41.0
	Jul-Dec (1)	31.0-44.0	31.0-44.0	37.0-50.0	41.0-54.0
1985	Apr-Dec	31.0	31.0	37.0	41.0
1986	Apr (1)	36.0-41.0	36.0-41.0	42.0-47.0	46.0-51.0
	May-Dec (1)	41.0-46.0	41.0-46.0	47.0-52.0	51.0-56.0
1987	Apr-Nov	31.0	31.0	37.0	41.0
1988	Apr-Nov (2)	31.0	31.0	37.0	41.0
1989	Apr-Aug (3)	28.0	28.0	34.0	38.0
	Sep-Oct (3)	28.0	28.0	34.0	35.0
1990-93	Apr-Oct (4)	25.0	25.0	31.0	35.0
1994	Apr-Dec	31.0	31.0	37.0	41.0
1995	Apr-May	31.0	31.0	37.0	41.0
	Jun-Dec (1)	46.0-56.0	46.0-56.0	52.0-62.0	56.0-66.0
1996	Apr (1)	41.0	41.0	47.0	51.0
	May (1)	41.0-51.0	41.0-51.0	47.0-57.0	51.0-61.0
	Jun-Dec (1)	56.0	56.0	62.0	66.0
1997	Apr - Dec (5)	*	*	*	*
1998	Apr - Jul	31	31	37	41

(1) Downstream flow targets above full-service navigation level as a flood control storage evacuation measure.
(2) Full service flows provided for shortened season.
(3) Navigation targets below full service as a water conservation measure.
(4) Navigation targets at minimum service as a water conservation measure.
(5) Releases determined by flood control storage evacuation criteria and not adjusted to meet specific navigation targets.

TABLE VIII
MISSOURI RIVER NAVIGATION
TONNAGE AND SEASON LENGTH

Year (1)	Scheduled Length of Season (Months)	Commercial (Tons) (1)	Total Traffic (Tons) (2)	Total Traffic (1000 Ton-Miles)
1967 (3)	8	2,562,657	6,659,219	1,179,235
1968	8 (4)	2,254,489	6,724,562	1,047,935
1969	8 (4)	2,123,152	7,001,107	1,053,856
1970	8 (5)	2,462,935	7,519,251	1,190,232
1971	8 (4)	2,791,929	7,483,708	1,329,899
1972	8 (4)	2,665,579	7,182,841	1,280,385
1973	8	1,817,471	6,370,838	844,406
1974	8	2,576,018	7,673,084	1,227,525
1975	8 (4)	2,317,321	6,208,426	1,105,811
1976	8 (4)	3,111,376	6,552,949	1,535,912
1977	8	3,335,780	6,734,850	1,596,284
1978	8 (4)	3,202,822	7,929,184	1,528,614
1979	8 (4)	3,145,902	7,684,738	1,518,549
1980	8	2,909,279	5,914,775	1,335,309
1981	7-1/4 (6)	2,466,619	5,251,952	1,130,787
1982	8 (4)	2,513,166	4,880,527	1,131,249
1983	8 (4)	2,925,384	6,301,465	1,300,000
1984	8 (4)	2,878,720	6,386,205	1,338,939
1985	8 (4) (7)	2,606,461	6,471,418	1,201,854
1986	8 (4) (7)	2,343,899	6,990,778	1,044,299
1987	8	2,405,212	6,735,968	1,057,526
1988	7-1/2	2,156,387	6,680,878	949,356
1989	6-3/4	1,906,508	5,352,282	796,799
1990	6-3/4	1,329,000	5,841,000	552,509
1991	6-3/4	1,563,000	5,729,000	
1992	6-3/4	1,403,000	5,783,000	
1993	8 (8)	1,570,000	5,631,000	615,541
1994	8	1,800,000	8,501,000	774,491
1995	8 (4) (8)	1,439,000	6,884,000	604,171
1996	8 (4) (8)	1,547,000	8,165,000	680,872
1997	8 (4)	1,646,000 (9)	8,167,000 (9)	
1998	8 (4)	2,000,000 (9)		

(1) Includes commercial tonnage except for sand and gravel or waterway materials. Tonnage compiled by Waterborne Commerce Statistics Center (WCSC)
(2) Includes commodities; sand, gravel and crushed rock; and waterway improvement materials. Tonnage by WCSC.
(3) Main stem reservoir system reached normal operating storage level in 1967.
(4) 10-day extension of season provided.
(5) 10-day extension and 10-day early opening provided.
(6) Full service flows for shortened season in preference to reduced service.
(7) 10-day extension provided for 1985 season in trade for 10-day delayed support of 1986 season.
(8) Lower Missouri River closed: 57 days in 1993, 20 days in 1995, and 2 days in 1996.
(9) Preliminary estimate.

Missouri River Flows at Sioux City, Nebraska City and Kansas City

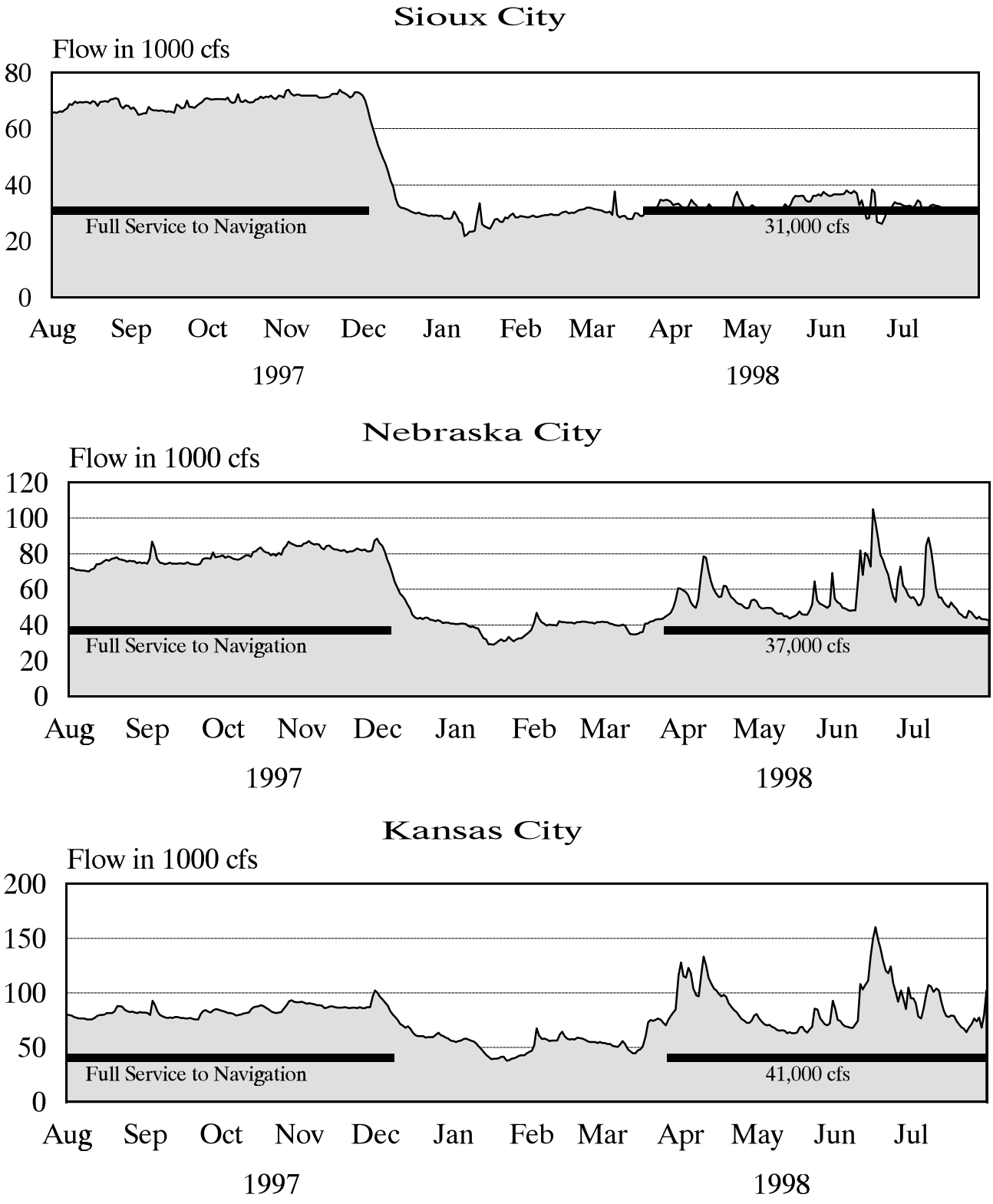


Figure 10

5. Power - Eastern Division, Pick-Sloan Missouri Basin Program (P-S MBP). The CY 1997 generated energy was transmitted over a Federal transmission system traversing 7,745 circuit miles. This past year, service was provided to 319 customers in a six-state area. Those receiving direct service include 186 municipalities, 5 Federal agencies, 36 state agencies, 26 U.S. Bureau of Reclamation projects, 3 irrigation districts, 24 rural electric cooperatives, 8 public utility districts, and 31 private utilities. Additional benefits were provided by the interconnections to the Southwestern and Bonneville Power Administrations and other areas of the Western Area Power Administration (Western). Statistics from the Omaha Public Power District (OPPD) show that the average customer uses approximately 11,000 kilowatt hours (kWh) of energy annually. Based upon these numbers, the energy generated in CY 1997 by the Federal power system could have supplied all of the yearly needs of 1.3 million residential OPPD customers for a retail value of over $1 billion.

In addition to the clean, renewable power and energy transmitted to the Midwest area, the hydropower system provided an added measure of stability to the regional power system with the ability to meet full load in 5 seconds or less. These units can be reinforced by idle hydro units, typically in 30 seconds. Outside utilities can have access to the hydropower capability within several minutes of a known problem. The reliability of the hydropower system is indicated by having to maintain 10 percent reserve while thermal power must maintain 15 percent reserve. Although the Federal hydropower system accounts for only 9 percent of the region's power, it is large enough to fill gaps and provide a positive benefit to the integrated system.

CY 1997 generation was 146 percent of the average since the reservoir system first filled in 1967, a record high. Much above normal releases at all six powerplants resulted in the above normal generation. CY main stem generation with individual project distribution since 1954 is shown on ***Figure 11***.

Generation was 2.74 billion kWh for the December-through-February (1997-1998) winter energy period, 125 percent of the past 31-year average. Generation was above normal due to above normal releases at the lower four projects. Western purchased about 0.2 billion kWh between December 1, 1997, and February 28, 1998, at a cost of $3.0 million to supplement main stem hydropower production.

Energy production was at record levels in October, November, and December as excess flood control storage continued to be evacuated from the system. The return to more normal releases in CY 1998 permitted the projects to perform much needed spring and fall unit maintenance that had been shortened or cancelled during the recent high runoff years. Western sold 4.6 billion kWh over and above firm energy for the August 1997-July 1998 period valued at $75.4 million.

Main Stem Power Generation
1954 - 1998

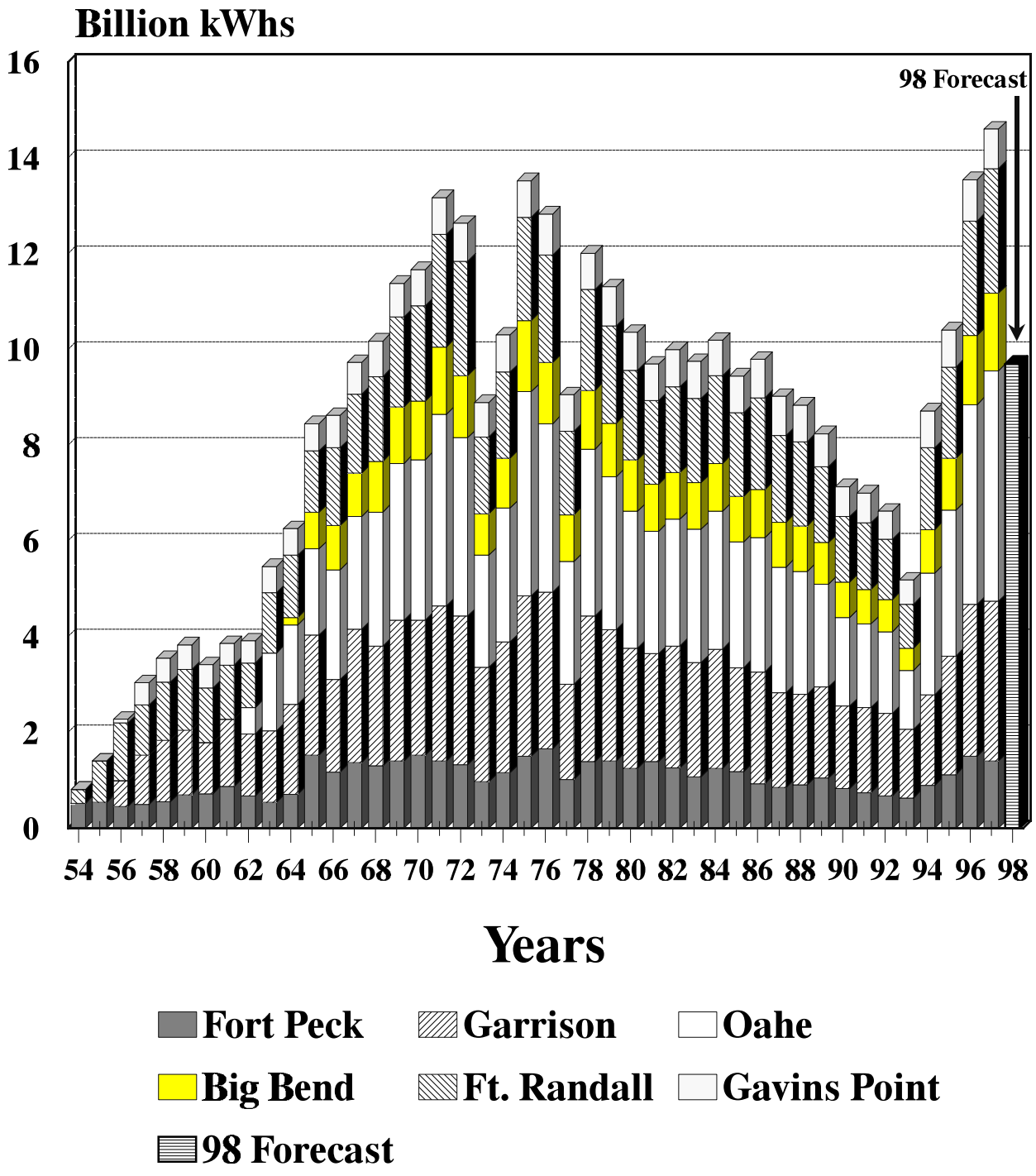


Figure 11

Total generation for the 1997-1998 AOP year was 12.5 billion kWh, 123 percent of the 31-year average dating back to 1967. The gross generation from the Federal system (peak capacity and energy sales) for the August 1997 through July 1998 operating period is shown in ***Table IX***.

Western markets firm main stem hydropower to customers based on the capacity that would have been available in 1961 if the system had been operational at that time and based on long term average energy. The year 1961 was the last and most severe year of an 8-year drought.

TABLE IX
GROSS POWER SYSTEM GENERATION
(August 1997 through July 1998)

	Energy Generation 1,000 kWh	**Peak Hour kW**	**Generation Date**
Corps Powerplants - Main Stem			
Fort Peck	1,362,686	215,000	8/97
Garrison	2,993,162	510,000	8/97
Oahe	3,804,459	752,000	8/1/97
Big Bend	1,357,287	483,000	12/2/97
Fort Randall	2,147,529	359,000	09/97
Gavins Point	825,217	113,000	12/12/97
Subtotal	12,490,340	2,323,000	10/9/97
USBR Powerplants			
Canyon Ferry	472,964	58,000	11/97 & 4/97
Yellowtail*	574,155	130,000	8/97
USBR Subtotal	1,047,119		
FEDERAL SYSTEM TOTAL	13,537,459		

*Includes one half of total Yellowtail generation which is marketed by Eastern Division.

The tabulations in ***Tables X*** and ***XI*** summarize the total gross generation and power operations for the Eastern Division, P-S MBP, marketing area system for the past operating year. Actual settlement figures at the end of the billing periods differ somewhat from the calendar month figures shown.

TABLE X

HISTORICAL GENERATION AND LOAD DATA
EASTERN DIVISION, PICK-SLOAN MISSOURI BASIN PROGRAM*
Data at plant - 1,000 kW
August 1, 1997 through July 31, 1998

Period	Corps of Engineers Peak Hour Generation (Gross)	(plus)	USBR Hourly Generation (Gross)	(equals)	Federal Peak Hour Generation (Gross)	(plus)	Interchange and Purchases Received**	(equals)	Total System Load**
1997									
August	2,295		55		2,350		518		2,868
September	2,305		54		2,359		559		2,918
October	2,321		56		2,377		548		2,925
November	2,305		54		2,359		417		2,776
December	2,226		54		2,280		370		2,650
1998									
January	2,134		56		2,190		385		2,575
February	2,044		56		2,100		707		2,807
March	2,010		57		2,067		444		2,511
April	1,570		56		1,626		480		2,106
May	2,009		56		2,065		632		2,697
June	2,033		37		2,070		845		2,915
July	2,120		54		2,174		643		2,817

* This tabulation summarizes the total gross generation and power operations for the Eastern Division marketing area system shown on Table XV.
** During hour of Federal peak hour generation.

TABLE XI

HISTORICAL GENERATION AND LOAD DATA
EASTERN DIVISION, PICK-SLOAN MISSOURI BASIN PROGRAM*
Data at plant - 1,000 kWh
August 1, 1997 through July 31, 1998

Period	Corps of Engineers Generation (Gross)	(plus)	USBR Generation (Gross)	(equals)	Federal Generation (Gross)	(plus)	Scheduled Interchange and Purchases Received	(equals)	Total System Load
1997									
August	1,509,521		121,000		1,630,521		53,000		1,683,521
September	1,410,474		87,000		1,497,474		2,000		1,499,474
October	1,491,533		90,000		1,581,533		-36,000		1,545,533
November	1,425,283		74,000		1,499,283		-32,000		1,467,283
December	1,034,842		72,000		1,106,842		121,000		1,227,842
1998									
January	904,404		76,000		980,404		145,000		1,125,404
February	796,944		76,000		872,944		167,000		1,039,944
March	779,396		85,000		864,396		136,000		1,000,396
April	603,894		93,000		696,894		162,000		858,894
May	866,431		83,000		949,431		92,000		1,041,431
June	835,057		76,000		911,057		228,000		1,139,057
July	832,561		114,000		946,561		22,000		968,561

*Powerplants from Table XV

Annual energy production for 1998 will be about 97 percent of normal due to slightly below normal releases at all projects.

6. Fish Management. The Missouri River Natural Resources Committee (MRNRC), comprised of representatives from the Game and Fish agencies of the seven states bordering the Missouri River, was formed in the spring of 1987. The group and the Corps at the spring MRNRC meeting in Nebraska City, Nebraska, on March 20, 1998, discussed coordinated recommendations for 1998.

The Corps March forecast was for a 24.0 million acre-foot (MAF) runoff year compared to the long term average of 24.6 MAF. The years 1995 through 1997 were very large runoff years with high resulting pool elevations and, in general, very good fish reproduction. As a result there was no MRNRC recommended special spring manipulation of the upper three reservoirs for 1998 as the forecasted lake rises would be substantially less than the three preceding years. The MRNRC requested a minimum of no less than 6,000 cfs daily release through July for trout and salmon rearing below Fort Peck Dam and an hourly release of no less than 5,000 cfs if possible. This request was honored from April 20 through early September 1998. An hourly minimum of at least 17,000 cfs was desired below Fort Randall Dam for species spawning between mid-April and the end of July. This request was honored from mid-April through mid-June at which time the reservoir system release was cut back for flood control and the minimum release had to be reset at about 11,000 cfs. Every third-day spiking at Gavins Point was not considered ideal for fish or bird reproduction below that project and was not recommended nor attempted. Releases were cut back from 32,000 cfs beginning on June 13 for flood control. They were as low as 22,000 cfs for 8 days but spiking was not needed as endangered birds continued initiating nests at high elevations.

The Fort Peck Lake elevation stayed in the 2235 to 2236 msl range January through May. The lake rose slowly in June and more quickly in July peaking out at elevation 2240.5 on July 25. This peak was about 10 feet lower than the previous year's peak. Releases were increased slowly from 5,500 cfs in mid-April to 10,000 cfs by mid-May then held there through June. The second week in July releases were reduced to 7,500 cfs for about 6 days as high tributary inflows from the Milk River were occurring and adding to the Missouri River flow. The release rate was returned to 9,500 cfs by July 14 and held there through mid-August. An operation requested by the MRNRC, the U.S. Fish and Wildlife Service (FWS), and the American Fisheries Society involving mixing warmer spillway water with powerplant discharges to benefit native fish species for a month in the spring was not scheduled. There were several reasons the request was denied: major effects on flood control, hydropower, and erosion; lack of coordination by people collecting the data; lack of consensus in the State of Montana; and this operation was simulated, to some extent, in some of the alternatives presented in the upcoming Revised Draft Environmental Impact Statement (RDEIS) for the Master Manual.

The Garrison pool elevation stayed near 1839.5 msl from mid-January through the end of June. The lake then peaked out at 1843.4 on July 27 receding to 1843.0 by the end of July. The peak was about 11 feet below the previous year's peak. Releases averaged near 19,500 cfs in March and April and were slowly increased to 26,000 cfs by mid-May for endangered bird nesting

and held there through late June. Releases were reduced to average 24,000 cfs in July. Angler success on the lake was reported to be good during the spring and summer but success on the river was good only in the spring.

Lake Oahe elevation rose slowly through April from 1608.2 to 1609.7 feet msl by month's end. The lake held steady in May and then increased to peak near 1612.9 on July 26. This was nearly 6 feet below the previous year's peak. Oahe's average release rate in 1998 for the April-through-July period was only 40 percent of 1997's average release rate for the same time period. Several sources stated that large numbers of smelt may have been flushed from Oahe with 1997's high flows and this was a limiting factor in 1998 sport fish growth in Lake Oahe and possibly upstream also. Nevertheless, angler success on the lower lake was good early in the year while success below the project was good throughout 1998.

7. <u>Endangered and Threatened Species</u>. This is the 13th year of operation since the interior least terns and piping plovers were Federally listed as endangered and threatened species, respectively, and the first year that fledge ratios have exceeded the goal for both species. Stream gages have been installed on the Missouri River to monitor stream flows during the nesting season. These gages provide a check, as well as a stage history, throughout the season to help relate the effects of regulation and natural events at intervals along the river. The gaging data must be supplemented with observations of nesting activities and conditions to provide the information that is needed for regulation. A dynamic flow routing model has been developed to closely predict maximum river stages along the river for different combinations of daily discharge and hourly power peaking characteristics. In recent years creation of additional habitat has allowed flexibility in the release levels at the lower two main stem projects. Although the Corps has prevented inundation of nests where possible and accomplished habitat creation, fledging has continued to be lower than predicted by the FWS 1990 Biological Opinion until 1998, when fledge ratios exceeded the goal for both species. The previous disappointingly low fledging was caused by predation, severe weather, nest inundation, recent record water runoff, and other factors. The record fledging that occurred for both species in 1998 was due to the large increase in viable sandbar habitat caused by the high flows of 1997.

Both the least tern and piping plover nest on sparsely vegetated sandbars, islands, and shoreline on the Missouri River. Productivity estimates for these birds on the Missouri River in 1998 were broken down into natural nesting and captive rearing as collection of three dozen plovers was accomplished for study purposes.

For 1998, most of the birds on the Missouri River System were found below Garrison, on Lake Oahe, between the mouth of the Niobrara River and the headwaters of Lewis and Clark Lake, and below Gavins Point.

Table XII shows the population distribution and productivity for terns and plovers for 1989 through 1998. Adult birds in this table are considered breeders even though they may not have had nesting success. The term "fledglings/pair" means the number of young birds produced per breeding pair. This ratio is an estimate as the fate of every single fledgling is impossible to obtain.

Table XII
Missouri River Main Stem
Least Tern and Piping Plover Survey Data

	Interior Least Tern											Piping Plover										
	1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Fort Peck Lake																						
Adults	3	4	6	10	0	7	9	2	0	0	4	10	12	22	25	26	30	16	9	0	0	4
Fledglings/Pair	-	-	-	0.5	{}	0	0.44	0	0	0	0	-	1.50	-	1.90	1.30	0.60	0.50	0.30	0	0	0
Fort Peck to Lake Sakakawea																						
Adults	18	51	92	66	110	30	60	95	126	162	26	5	11	17	13	0	2	9	20	24	23	4
Fledglings/Pair	1.66+	1.62+	0.20+	0.70+	0.62+	0.46+	0.67+	1.58	0.34	0.53	1.73	-	-	0	0	{}	0+	0	2.33	1	0.89	1
Lake Sakakawea																						
Adults	7	15	6*	8	29+	14	35	7	27	2	22	143	57	132	150	108	5	47	24	66	3	112
Fledglings/Pair	-	-	-	-	0.50+	0.22+	0	0	0.15	0	1.27	-	-	-	-	1.50	22.7	1.19	0	0.61	0.67	1.50
Garrison to Lake Oahe																						
Adults	142	122	174	195	198	138	208	348	105	41	123	113	86	71	121	77	125	118	287	41	6	68
Fledglings/Pair	0.93+	0.42	0.44+	0.65	0.48	0.39	0.57	0.74	0.08	0.39	1.35	1.0+	0.26+	1.05+	1.06+	1.06+	0.73+	1.19	0.85	0.1	0	1.79
Lake Oahe																						
Adults	82	97	100	143	124	147+	160	93	74	101	90	55	140	88	87	143	77+	73	36	20	31	91
Fledglings/Pair	-	-	-	-	0.42	0	0.06	0	0.24	0.16	1.49	0.90	-	-	-	0.96+	0.24	0.05	0.77	0.3	1.28	1.10
Ft. Randall to Niobrara																						
Adults	45	4	67	62	20	36	43	10	2	0	64	31	0	31	45	12	12	17	0	3	0	31
Fledglings/Pair	0.14	0	0.34+	0.23	0.30	0	0	0	0	0	0.94	0.07	0	0.69+	0.21	0.50	0	0	0	0	0	1.29
Lake Lewis and Clark																						
Adults	0	29	21	25	22	76	44	16	28	60	120	0	18	11	12	1	32	12	4	6	32	84
Fledglings/Pair	-	0.64	0.34+	0	2.09	0.97	0	0	0	1.57	2.50	-	0.56	0.69+	0	0	0.06	0.33	0	0	1.25	2.45
Gavins Point to Ponca																						
Adults	252	210	166	193	186	272	204	93	80	115	144	212	122	144	165	111	109	62	63	22	22	49
Fledglings/Pair	0.49	0.55	0.46+	0.26	0.22	0.83	0.40	0.49	0.00	0.9	2.33	0.62	0.21	0.41+	0.35	0.35	1.06	0.61	0.16	0	0	2.12
Total Adults	549	532	632	702	689	720	763	664	442	481	593	569	446	516	618	478	392	354	443	182	117	443
Fledglings/Pair	0.64	0.70	0.40	0.44	0.47	0.49	0.35	0.68	0.16	0.66	1.80	0.82	0.35	0.62	0.64	0.96	0.91	0.71	0.75	0.41	0.87	1.68

Ten Year Interior Least Tern Fledge Ratio Goal = 0.70

Fifteen Year Piping Plover Fledge Ratio Goal = 1.44

- \- Data not collected
- * Partial Survey Results
- {} No Birds Found
- \+ Subsamplng of Selected Nesting Areas

The data does not include least terns and piping plovers raised in captivity. The data represents only wild fledged birds.

The following summarizes main stem regulation activities for the 1998 tern and plover season.

On April 1, 1998, System storage was above normal and the CY 1998 total runoff forecast was for a near normal year. By mid-May plovers were observed from Lake Oahe to below Gavins Point, and Gavins Point releases were increased from 28,000 cfs to a nesting season rate of 32,000 cfs. There were reductions in releases for flood control in different reaches as mentioned below. The final adult census on the Missouri River main stem was 443 adult plovers and 593 adult terns. The total number of adult birds was the highest since 1995. Due to optimal habitat conditions provided by the high flows of 1997, reproduction was at the highest levels recorded since the System operations for the birds began in 1986. The fledge ratio for naturally raised terns was 1.8 fledglings per pair and for plovers 1.68. These fledge ratios exceeded the goals suggested by the FWS. A total 24 eggs were collected during the 1998 nesting season and reared at the Gavins Point hatching and rearing facility in conjunction with a University of Wisconsin study on survivability of captive reared fledglings. Twenty-one piping plovers were later released during July and August at selected locations along and near the Missouri River.

Activity by river reach is summarized below.

Reach below Gavins Point . The Gavins Point summer release for nesting birds was initiated mid-May but nesting got off to a slow start. By June 1, 1998, there were only five nests in this reach. At 32,000 cfs, less than half of the previous year's high release, viable habitat was at its greatest extent in decades. By June 13 there were 9 plover nests and 19 new tern nests. Gavins Point releases were cut back for flood control June 12-25 to as low as 22,000 cfs. Most of the birds were nesting high and nesting remained at least one and a half feet above the water surface at this time. When releases were returned to 30,000 cfs near the end of June, there were 11 plover nests, 42 tern nests, and many chicks. The adult census in this reach was 49 plovers and 144 terns. Releases fluctuated in July between 25,000 and 31,000 cfs for flood control. A total of 52 plovers and 168 terns were fledged in the wild when the season ended by August 22.

Lewis and Clark Lake. By May 23 birds had begun to nest on this reach which extends from the mouth of the Niobrara River to below Springfield, South Dakota. By June 13 releases from Fort Randall were beginning to be reduced from the 27,000 cfs level toward 16,000 cfs by mid-month for flood control. By this time hourly power peaking releases had been set near 38,000 cfs maximum. At mid-month there were 13 plover nests and over 40 tern nests. Many of the nests were less than 18 inches above the water surface. Releases were increased from 15,000 cfs on June 21 to 25,000 cfs by month's end. Nesting sites from RM 852 to RM 835 were monitored during the July 4 weekend by Corps and FWS personnel and the South Dakota Game & Fish Department. Some eggs from this reach were collected for the captive rearing facility. The adult census for the Lewis and Clark Lake reach was a record for both species; 84 plovers and 120 terns. A new record total of 103 plovers and 150 terns were fledged for this reach.

Fort Randall to Niobrara Reach. Birds began scraping nests in this reach the week of May 17. Approaching mid-June, releases were cut back from the 27,000 cfs level to 16,000 cfs by June 15 for flood control. Some nests were moved higher when releases were returned to 25,000 cfs near month's end. Restricting hourly power peaking releases also helped to prevent nest

inundation in this reach. By July 4 there were 9 plover nests, 25 tern nests, and birds were hatching. The adult census for this reach was 31 plovers and a record 64 terns. There were 6 plover nests and 21 tern nests at this time. Some eggs from this reach were collected for captive rearing. By the week of August 16 all the young birds had fledged and surveys were completed. A total of 20 plovers and 30 terns were fledged for this reach.

Lake Oahe. Plovers arrived in the Pierre section of this reach in mid-May but not until later in the month in the Mobridge or Bismarck sections. By June 27 there were birds in all sections with a total of 8 plover nests and 26 tern nests. Habitat was reported as very good with the lake elevation being 7 feet lower than the previous year. Some chicks began fledging by July 4 while new nests were being initiated. The adult census for this reach was 91 plovers and 90 terns. The lake peaked out at elevation 1612.9 feet msl on July 26 but no birds were lost to flooding. The last survey was the week of August 31. Total fledged for this reach were 50 plovers and a record 67 terns.

Below Garrison to Lake Oahe Reach. Garrison releases were increased to 26,000 cfs on May 16 as plovers began showing up in this reach. Hourly power release maximums were set at 33,000 cfs. By mid-June there were 2 plover nests and 15 tern nests. By July 4 there were 17 plover nests and 26 tern nests, from RM 1377 near Stanton, North Dakota, to RM 1302 below Bismarck. Releases were reduced to 25,000 cfs near the end of June and to 24,000 cfs in early July for intrasystem storage balance. This added to the already excellent habitat in this reach. The adult census was 68 plovers and 123 terns. The last of the fledged birds flew off near the end of August. Total fledged for this reach were 61 plovers and 83 terns.

Lake Sakakawea. Plovers began nesting in the reservoir area in late May on excellent habitat. By mid-June the lake elevation was 15 feet lower than the previous year's high. There were 12 plover nests and 1 tern nest. Near the end of June nesting peaked out with 14 plover nests and 9 tern nests. The adult census was 112 plovers and 22 terns. The lake peaked out at elevation 1843.4 feet msl on July 27 with no nests destroyed by flooding. Surveys were completed the week ending August 22. Total fledged for the reach were 84 plovers and 14 terns, a record number of fledged plovers.

Below Fort Peck. In mid-May Fort Peck daily average releases were increased from 9,000 cfs to 10,000 cfs and hourly power peaking releases were restricted to 14,400 cfs as plovers had already shown up on Fort Peck Lake. By July 4 there was only 1 plover nest and 8 tern nests on the river. The adult census was 3 plovers and 26 terns. Fort Peck releases were reduced to near 7,500 cfs July 8-12 as the Milk River was adding increased tributary flow to the river. Nesting remained light and surveys were completed for this reach the week ending August 22. Total fledged for the reach were 2 plovers and 22 terns.

Fort Peck Lake. Fort Peck Lake elevation peaked out about 10 feet lower than the previous year and habitat was more than adequate. By mid-June there were two adult plovers with four chicks and two tern nests which later hatched. By July 4 one plover nest had been destroyed by flooding and no plover adults or chicks were observed. Two dead tern chicks were also found.

The adult census was four plovers and four terns. No birds of either species were observed after July 4. Fledging was zero for both species.

Summary of Habitat Activities for period August 1997 - July 1998

Habitat development, enhancement, and maintenance activities for least terns and piping plovers was limited during the past year due to high water in 1997 and the great abundance in viable habitat created in 1997 for the 1998 nesting season. Evidence of beneficial impacts of the past 3 years of high water was observed in the emergence of vast expanses of sandbar habitats, especially on the Gavins Point and Garrison river reaches. We remain optimistic, foregoing a very large runoff, that habitat conditions along the Missouri River for least terns and piping plovers will be very good in 1999.

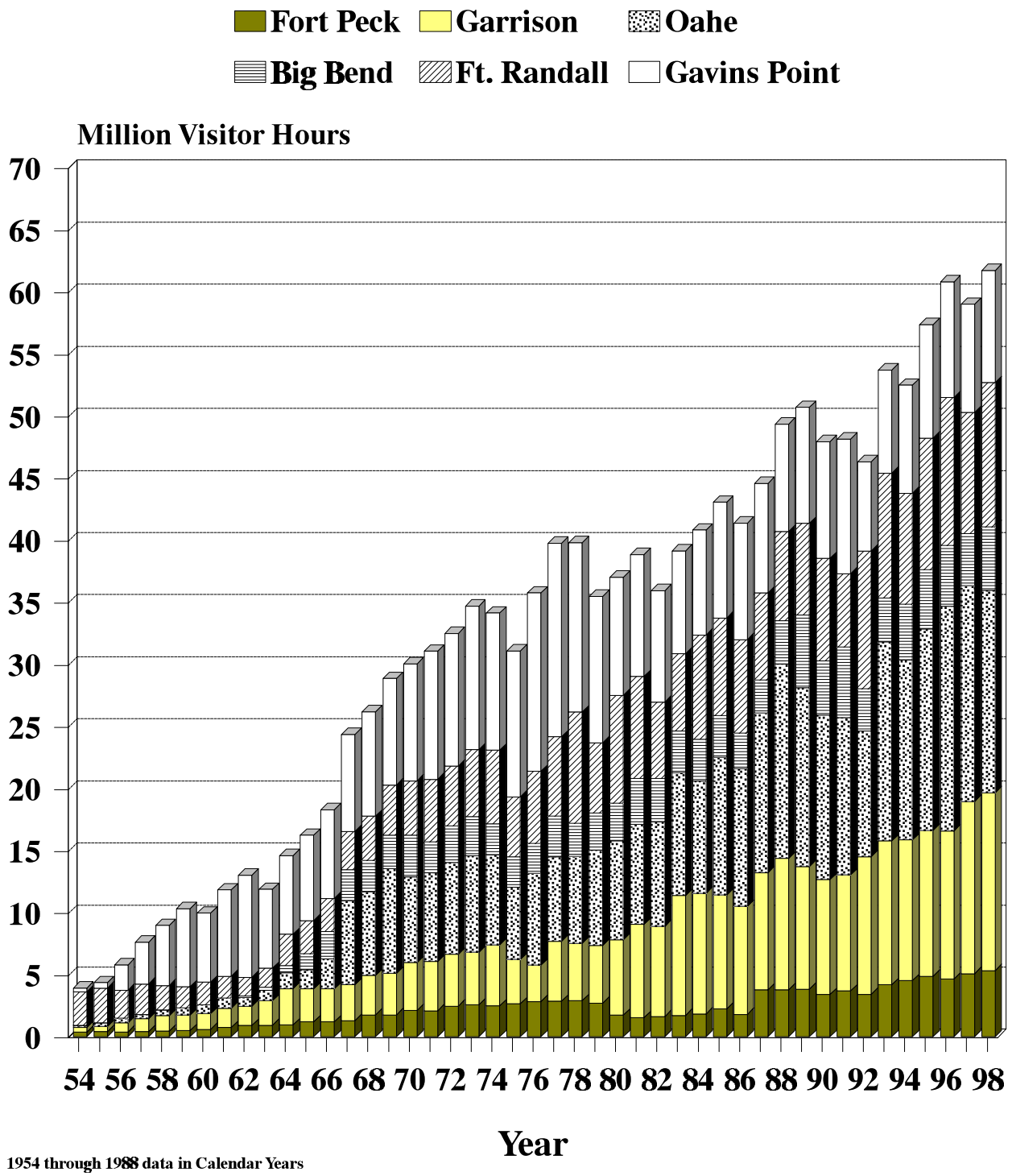
8. Recreation and Resource Management. The Missouri River main stem reservoirs provide outstanding opportunities for boating, fishing, swimming, camping, and other outdoor recreation pursuits. Tourism related to the lakes is a major economic fact in all the states adjoining the main stem. During 1998, public use at these lakes was 61,718,500 visitor hours, an increase of 4.6 percent from 1997. Pool levels have returned to normal and although all recreation areas were open to the public in 1998, some facilities remained closed. Visitor attendance at the lake projects for 1996, 1997, and 1998 is shown in ***Table XIII.*** ***Figure 12*** displays recreation-related visitor hours at each of the six projects for the years 1954 through 1998. The reporting method was changed from recreation days to visitor hours in 1987, and the reporting period was changed from calendar year to fiscal year in 1989 for all Corps of Engineers projects. All Corps projects, including the main stems, are now reporting visitation using the Visitation Estimation Reporting System (VERS).

TABLE XIII
VISITATION IN VISITOR HOURS

MAIN STEM PROJECT	YEAR			PERCENT INCREASE OR DECREASE
	1996	1997	1998	
Fort Peck	4,650,000	5,070,900	5,342,700	+ 5.4
Garrison	11,943,100	13,887,700	14,314,300	+ 3.1
Oahe	18,075,900	17,381,600	16,324,300	- 6.1
Big Bend	4,886,700	4,196,400	5,107,500	+ 21.7
Fort Randall	11,919,500	9,734,600	11,593,600	+ 19.1
Gavins Point	9,339,500	8,722,700	9,036,100	+ 3.6
SYSTEM TOTAL	60,814,700	58,993,900	61,718,500	+ 4.6

Figures computed using the Visitation Estimating Reporting System

Missouri River Main Stem
Project Visits
1954 to 1998



1954 through 1988 data in Calendar Years
1989 to 1991 in Fiscal Years
1992 to present in VERS System.

Figure 12

Project resource management staff have the difficult task of balancing the multiple uses of project lands and water. The following Mission Statement for the Corps' natural resources management program supports the goals of the Corps' Strategic Vision: to revolutionize effectiveness, seek growth opportunities, and invest in people.

Natural Resources Management Mission Statement

> The Army Corps of Engineers is the steward of the lands and waters at Corps water resources projects. Its Natural Resource Management mission is to manage and conserve those natural resources, providing quality public outdoor recreation experiences to serve the needs of the present and future generations.
>
> In all aspects of natural and cultural resources management, the Corps promotes awareness of environmental values and adheres to sound environmental stewardship, protection, compliance, and restoration practices.
>
> The Corps integrates the management of diverse natural resources components such as fish, wildlife, forests, wetlands, grasslands, soil, air, and water with the provision of public recreation opportunities. The Corps conserves natural resources and provides public recreation opportunities that contribute to the quality of American life.

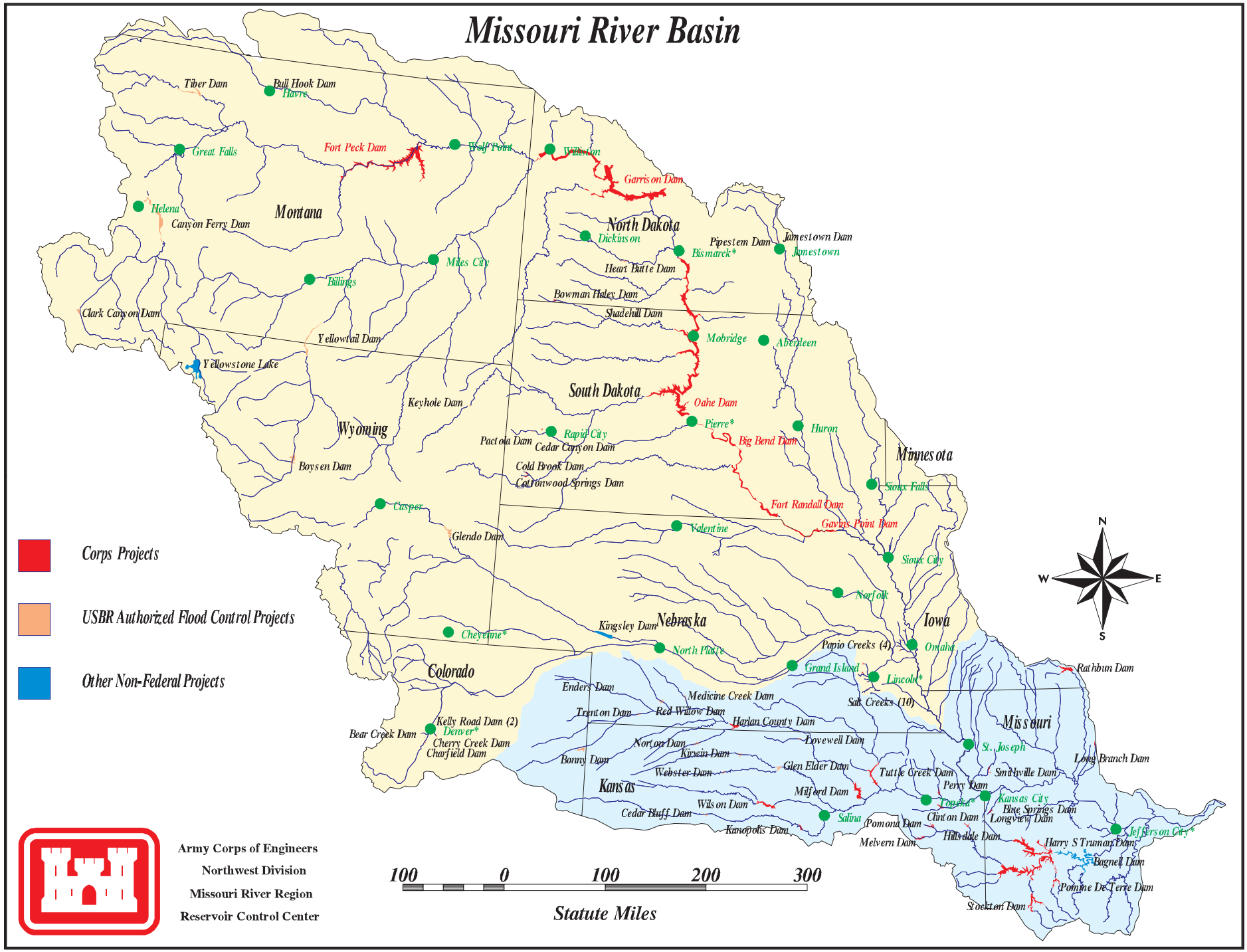

Missouri River Basin
Tiber Dam
Bull Hook Dam
Havre
Great Falls
Fort Peck Dam
Wolf Point
Williston
Garrison Dam
Helena
Canyon Ferry Dam
Montana
North Dakota
Dickinson
Pipestem Dam
Jamestown Dam
Bismarck*
Jamestown
Heart Butte Dam
Miles City
Billings
Bowman Haley Dam
Shadehill Dam
Clark Canyon Dam
Yellowtail Dam
Mobridge
Aberdeen
Yellowstone Lake
South Dakota
Keyhole Dam
Oahe Dam
Pierre*
Huron
Wyoming
Rapid City
Pactola Dam
Cedar Canyon Dam
Big Bend Dam
Minnesota
Boysen Dam
Cold Brook Dam
Cathedral Springs Dam
Sioux Falls
Fort Randall Dam
Casper
Gavins Point Dam
Valentine
Glendo Dam
Sioux City
Norfolk
Kingsley Dam
Nebraska
Iowa
Cheyenne*
North Platte
Papio Creeks (4)
Omaha
Grand Island
Rathbun Dam
Colorado
Lincoln*
Enders Dam
Medicine Creek Dam
Salt Creeks (10)
Trenton Dam
Red Willow Dam
Harlan County Dam
Missouri
Kelly Road Dam (2)
Bear Creek Dam
Denver*
Cherry Creek Dam
Chatfield Dam
Norton Dam
Lovewell Dam
St. Joseph
Long Branch Dam
Kirwin Dam
Bonny Dam
Webster Dam
Glen Elder Dam
Tuttle Creek Dam
Smithville Dam
Perry Dam
Kansas
Milford Dam
Topeka*
Kansas City
Blue Springs Dam
Wilson Dam
Longview Dam
Cedar Bluff Dam
Salina
Pomona Dam
Clinton Dam
Jefferson City*
Kanopolis Dam
Melvern Dam
Hillsdale Dam
Harry S Truman Dam
Bagnell Dam
Pomme De Terre Dam
Stockton Dam
Corps Projects
USBR Authorized Flood Control Projects
Other Non-Federal Projects
N
W
E
S
100 0 100 200 300
Statute Miles
Army Corps of Engineers
Northwest Division
Missouri River Region
Reservoir Control Center

Plate 1

Summary of Engineering Data -- Missouri River Main Stem Reservoirs

Item No.	Subject	Fort Peck Lake	Garrison Dam - Lake Sakakawea	Oahe Dam - Lake Oahe
1	Location of Dam	Near Glasgow, Montana	Near Garrison, ND	Near Pierre, SD
2	River Mile - 1960 Mileage	Mile 1771.5	Mile 1389.9	Mile 1072.3
3	Total & incremental drainage areas in square miles	57,500	181,400 (2) 123,900	243,490 (1) 62,090
4	Approximate length of full reservoir (in valley miles)	134, ending near Zortman, MT	178, ending near Trenton, ND	231, ending near Bismarck, ND
5	Shoreline in miles (3)	1520 (elevation 2234)	1340 (elevation 1837.5)	2250 (elevation 1607.5)
6	Average total & incremental inflow in cfs	10,200	25,600 15,400	28,900 3,300
7	Max. discharge of record near damsite in cfs	137,000 (June 1953)	348,000 (April 1952)	440,000 (April 1952)
8	Construction started - calendar yr.	1933	1946	1948
9	In operation (4) calendar yr.	1940	1955	1962
	Dam and Embankment			
10	Top of dam, elevation in feet msl	2280.5	1875	1660
11	Length of dam in feet	21,026 (excluding spillway)	11,300 (including spillway)	9,300 (excluding spillway)
12	Damming height in feet (5)	220	180	200
13	Maximum height in feet (5)	250.5	210	245
14	Max. base width, total & w/o berms in feet	3500, 2700	3400, 2050	3500, 1500
15	Abutment formations (under dam & embankment)	Bearpaw shale and glacial fill	Fort Union clay shale	Pierre shale
16	Type of fill	Hydraulic & rolled earth fill	Rolled earth filled	Rolled earth fill & shale berms
17	Fill quantity, cubic yards	125,628,000	66,500,000	55,000,000 & 37,000,000
18	Volume of concrete, cubic yards	1,200,000	1,500,000	1,045,000
19	Date of closure	24 June 1937	15 April 1953	3 August 1958
	Spillway Data			
20	Location	Right bank - remote	Left bank - adjacent	Right bank - remote
21	Crest elevation in feet msl	2225	1825	1596.5
22	Width (including piers) in feet	820 gated	1336 gated	456 gated
23	No., size and type of gates	16 - 40' x 25' vertical lift gates	28 - 40' x 29' Tainter	8 - 50' x 23.5' Tainter
24	Design discharge capacity, cfs	275,000 at elev 2253.3	827,000 at elev 1858.5	304,000 at elev 1644.4
25	Discharge capacity at maximum operating pool in cfs	230,000	660,000	80,000
	Reservoir Data (6)			
26	Max. operating pool elev. & area	2250 msl 246,000 acres	1854 msl 380,000 acres	1620 msl 374,000 acres
27	Max. normal op. pool elev. & area	2246 msl 240,000 acres	1850 msl 364,000 acres	1617 msl 360,000 acres
28	Base flood control elev & area	2234 msl 212,000 acres	1837.5 msl 307,000 acres	1607.5 msl 312,000 acres
29	Min. operating pool elev. & area	2160 msl 90,000 acres	1775 msl 128,000 acres	1540 msl 117,000 acres
	Storage allocation & capacity			
30	Exclusive flood control	2250-2246 975,000 a.f.	1854-1850 1,489,000 a.f.	1620-1617 1,102,000 a.f.
31	Flood control & multiple use	2246-2234 2,717,000 a.f.	1850-1837.5 4,222,000 a.f.	1617-1607.5 3,201,000 a.f.
32	Carryover multiple use	2234-2160 10,785,000 a.f.	1837.5-1775 13,130,000 a.f.	1607.5-1540 13,461,000 a.f.
33	Permanent	2160-2030 4,211,000 a.f.	1775-1673 4,980,000 a.f.	1540-1415 5,373,000 a.f.
34	Gross	2250-2030 18,688,000 a.f.	1854-1673 23,821,000 a.f.	1620-1415 23,137,000 a.f.
35	Reservoir filling initiated	November 1937	December 1953	August 1958
36	Initially reached min. operating pool	27 May 1942	7 August 1955	3 April 1962
37	Estimated annual sediment inflow	18,100 a.f. 1030 yrs.	25,900 a.f. 920 yrs.	19,800 a.f. 1170 yrs.
	Outlet Works Data			
38	Location	Right bank	Right Bank	Right Bank
39	Number and size of conduits	2 - 24' 8" diameter (nos. 3 & 4)	1 - 26' dia. and 2 - 22' dia.	6 - 19.75' dia. upstream, 18.25' dia. downstream
40	Length of conduits in feet (8)	No. 3 - 6,615, No. 4 - 7,240	1529	3496 to 3659
41	No., size, and type of service gates	1 - 28' dia. cylindrical gate 6 ports, 7.6' x 8.5' high (net opening) in each control shaft	1 - 18' x 24.5' Tainter gate per conduit for fine regulation	1 - 13' x 22' per conduit, vertical lift, 4 cable suspension and 2 hydraulic suspension (fine regulation)
42	Entrance invert elevation (msl)	2095	1672	1425
43	Avg. discharge capacity per conduit & total	Elev. 2250 22,500 cfs - 45,000 cfs	Elev. 1854 30,400 cfs - 98,000 cfs	Elev. 1620 18,500 cfs - 111,000 cfs
44	Present tailwater elevation (ft msl)	2032-2036 5,000 - 35,000 cfs	1670-1680 15,000- 60,000 cfs	1423-1428 20,000-55,000 cfs
	Power Facilities and Data			
45	Avg. gross head available in feet (15)	194	161	174
46	Number and size of conduits	No. 1-24'8" dia., No. 2-22'4" dia.	5 - 29' dia., 25' penstocks	7 - 24' dia., imbedded penstocks
47	Length of conduits in feet (8)	No. 1 - 5,653, No. 2 - 6,355	1829	From 3,280 to 4,005
48	Surge tanks	PH#1: 3-40' dia., PH#2: 2-65' dia.	65' dia. - 2 per penstock	70' dia., 2 per penstock
49	No., type and speed of turbines	5 Francis, PH#1-2: 128.5 rpm, 1-164 rpm , PH#2-2: 128.6 rpm	5 Francis, 90 rpm	7 Francis, 100 rpm
50	Discharge cap. at rated head in cfs	PH#1, units 1&3 170', 2-140' 8,800 cfs, PH#2-4&5 170'-7,200 cfs	150' 38,000 cfs	185' 54,000 cfs
51	Generator nameplate rating in kW	1&3: 43,500; 2: 18,250; 4&5: 40,000	3 - 109,250, 2 - 95,000	112,290
52	Plant capacity in kW	185,250	517,750	786,030
53	Dependable capacity in kW (9)	181,000	388,000	534,000
54	Avg. annual energy, million kWh (13)	1,170	2,472	2,898
55	Initial generation, first and last unit	July 1943 - June 1961	January 1956 - October 1960	April 1962 - June 1963
56	Estimated cost September 1996 completed project (14)	$158,428,000	$299,938,000	$346,521,000

Summary of Engineering Data -- Missouri River Main Stem Reservoirs

Big Bend Dam - Lake Sharpe	Fort Randall Dam - Lake Francis Case	Gavins Point Dam - Lewis & Clark Lake	Total	Item No.	Remarks
21 miles upstream Chamberlain, SD	Near Lake Andes, SD	Near Yankton, SD		1	(1) Includes 4,280 square miles of non-contributing areas.
Mile 987.4	Mile 880.0	Mile 811.1		2	
249,330 (1) 5,840	263,480 (1) 14,150	279,480 (1) 16,000		3	
80, ending near Pierre, SD	107, ending at Big Bend Dam	25, ending near Niobrara, NE	755 miles	4	(2) Includes 1,350 square miles of non-contributing areas.
200 (elevation 1420)	540 (elevation 1350)	90 (elevation 1204.5)	5,940 miles	5	(3) With pool at base of flood control.
28,900	30,000 1,100	32,000 2,000		6	
440,000 (April 1952)	447,000 (April 1952)	480,000 (April 1952)		7	(4) Storage first available for regulation of flows.
1959	1946	1952		8	(5) Damming height is height from low water to maximum operating pool. Maximum height is from average streambed to top of dam.
1964	1953	1955		9	
1440	1395	1234		10	
10,570 (including spillway)	10,700 (including spillway)	8,700 (including spillway)	71,596	11	(6) Based on latest available storage data.
78	140	45	863 feet	12	
95	165	74		13	(7) River regulation is attained by flows over low-crested spillway and through turbines.
1200, 700	4300, 1250	850, 450		14	
Pierre shale & Niobrara chalk	Niobrara chalk	Niobrara chalk & Carlile shale		15	(8) Length from upstream face of outlet or to spiral case.
Rolled earth, shale, chalk fill	Rolled earth fill & chalk berms	Rolled earth & chalk fill		16	
17,000,000	28,000,000 & 22,000,000	7,000,000	358,128,000 cu. yds	17	(9) Based on 8th year (1961) of drought drawdown (From study 8-83-1985).
540,000	961,000	308,000	5,554,000 cu. yds.	18	
24 July 1963	20 July 1952	31 July 1955		19	
Left bank - adjacent	Left bank - adjacent	Right bank - adjacent		20	(10) Storage volumes are exclusive of Snake Creek arm.
1385	1346	1180		21	
376 gated	1000 gated	664 gated		22	(11) Affected by level of Lake Francis case. Applicable to pool at elevation 1350.
8 - 40' x 38' Tainter	21 - 40' x 29' Tainter	14 - 40' x 30' Tainter		23	
390,000 at elev 1433.6	620,000 at elev 1379.3	584,000 at elev 1221.4		24	
270,000	508,000	345,000		25	(12) Spillway crest.
					(13) 1967-1997 Average
1423 msl 61,000 acres	1375 msl 102,000 acres	1210 msl 31,000 acres	1,194,000 acres	26	(14) Source: Annual Report on Civil Works Activities of the Corps of Engineers. Extract Report Fiscal Year 1996.
1422 msl 60,000 acres	1365 msl 95,000 acres	1208 msl 28,000 acres	1,147,000 acres	27	
1420 msl 57,000 acres	1350 msl 77,000 acres	1204.5 msl 24,000 acres	989,000 acres	28	
1415 msl 51,000 acres	1320 msl 38,000 acres	1204.5 msl 24,000 acres	450,000 acres	29	(15) Based on Study 8-83-1985
1423-1422 60,000 a.f.	1375-1365 985,000 a.f.	1210-1208 59,000 a.f.	4,670,000 a.f.	30	
1422-1420 117,000 a.f.	1365-1350 1,309,000 a.f.	1208-1204.5 90,000 a.f.	11,656,000 a.f.	31	
	1350-1320 1,607,000 a.f.		38,983,000 a.f.	32	
1420-1345 1,682,000 a.f.	1320-1240 1,517,000 a.f.	1204.5-1160 321,000 a.f.	18,084,000 a.f.	33	
1423-1345 1,859,000 a.f.	1375-1240 5,418,000 a.f.	1210-1160 470,000 a.f.	73,393,000 a.f.	34	
November 1963	January 1953	August 1955		35	
25 March 1964	24 November 1953	22 December 1955		36	
4,300 a.f. 430 yrs.	18,300 a.f. 250 yrs.	2,600 a.f. 180 yrs.	92,500 a.f.	37	
	Left Bank			38	
None (7)	4 - 22' diameter	None (7)		39	
	1013			40	
	2 - 11' x 23' per conduit, vertical lift, cable suspension			41	
1385 (12)	1229	1180 (12)		42	
	Elev 1375			43	
	32,000 cfs - 128,000 cfs				
1351-1355(11) 25,000-100,000 cfs	1228-1239 5,000-60,000 cfs	1155-1163 15,000-60,000 cfs		44	
70	117	48	764 feet	45	
None: direct intake	8 - 28' dia., 22' penstocks	None: direct intake		46	
	1,074		55,083	47	
None	59' dia, 2 per alternate penstock	None		48	
8 Fixed blade, 81.8 rpm	8 Francis, 85.7 rpm	3 Kaplan, 75 rpm	36 units	49	
67' 103,000 cfs	112' 44,500 cfs	48' 36,000 cfs		50	
3 - 67,276, 5 - 58,500	40,000	44,100		51	
494,320	320,000	132,300	2,435,650 kw	52	
497,000	293,000	74,000	1,967,000 kw	53	
1,052	1,846	749	10,187 million kWh	54	Corps of Engineers, U.S. Army
October 1964 - July 1966	March 1954 - January 1956	September 1956 - January 1957	July 1943 - July 1966	55	Compiled by
$107,498,000	$199,066,000	$49,617,000	$1,161,068,000	56	Missouri River Division May 1998