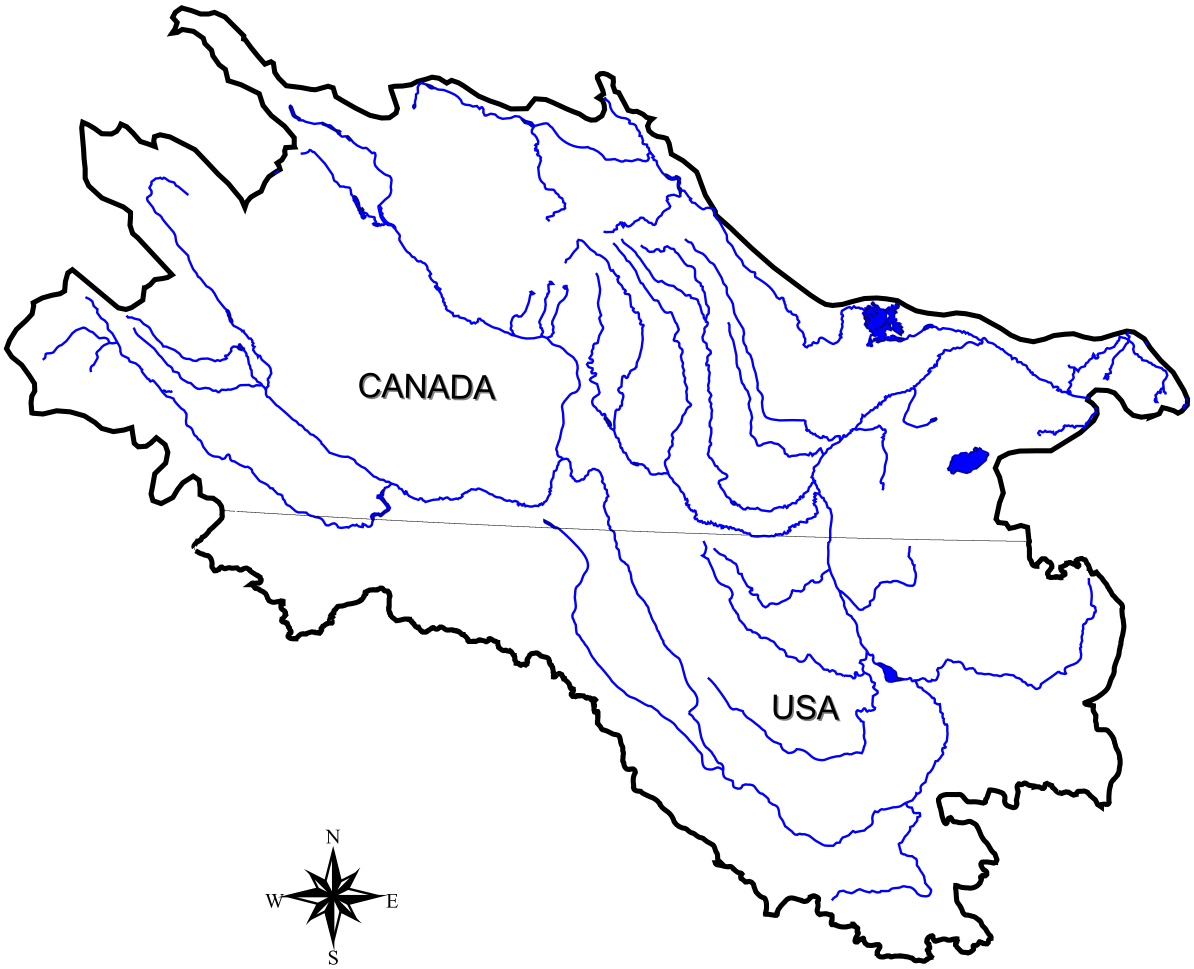
2001 POST- FLOOD REPORT
For The
SOURIS RIVER BASIN



St. Paul District
Hydrology Section
US Army Corps of Engineers®

February 21, 2007

2001 POST- FLOOD REPORT
For the
SOURIS RIVER BASIN

Submitted to
The International Souris River Board

And to
The United States Department of the Interior
Fish and Wildlife Service
Region 6

February 21, 2007

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CONVERSION FACTORS

The following table may be used to convert measurements in the English (United States) system of units to the SI or metric (Canadian) system of units.

Multiply English Units	By	To obtain SI Units
	Length	
inch (in)	25.4	millimetre (mm)
foot (ft)	0.3048	metre (m)
mile (mi)	1.609344	kilometre (km)
	Area	
square mile (mi^2)	2.590	square kilometre (km^2)
acre (ac)	4046.9	square metre (m^2)
acre (ac)	0.40469	Hectare (ha)
	Flow	
cubic ft/second (ft^3/s)	0.02831685	cubic metre/sec (m^3/s)
	Volume	
acre-foot (ac-ft)	1.23348	cubic decametre (dam^3)
	Velocity	
ft/second (ft/s)	0.3048	metre/second (m/s)
	Slope	
ft/mile (ft/mi)	0.1894	metre/kilometre (m/km)

1 hectare (ha) = 10,000 m^2 ==> ha x 2.4710 = acre

1 dam^3 = 1,000 m^3 ==> dam^3 x 0.81071 = ac-ft

1. INTRODUCTION

In 2001, runoff from an early snowmelt combined with moderate, but persistent spring rainfall, produced minor to moderate flooding conditions throughout most of the Souris River basin. Minor flooding occurred in Saskatchewan and the upper Souris River basin, extending to Towner, North Dakota. The worst flooding occurred along the lower reaches of the Souris River from Towner, North Dakota to Hartney, Manitoba. This was the second significant flood in the Souris basin since the 1999 flood event. However, river levels in the most affected areas of the lower Souris basin were generally 2 to 4 feet below the levels seen in 1999 and the duration of flooding was about a month less than in 1999. The 2001 flood event marked the second time that flood operations were triggered under the 1989 International Agreement between the Governments of Canada and the United States for water supply and flood control in the Souris basin.

This report documents the 2001 flood event in the Souris River basin and the second-ever flood operation of the Souris Basin Project. This report also serves to fulfill the requirement of Section 5.0 of Annex A of the 1989 International Agreement, which states that the U.S. Army Corps of Engineers will prepare a post-flood report in any year in which flood operations occur under the Agreement and that report will become a part of the U.S. Fish and Wildlife Service report to the International Souris River Board of Control, now the International Souris River Board (ISRB).

Section 2 of this report contains background information on the Souris River basin and the Souris Basin Project, operated for water supply and flood control objectives under the 1989 International Agreement. A discussion of the flood meteorology and hydrology is provided in Section 3 along with a detailed presentation of key flood parameters. Sections 4 through 6 of this report deal with the coordination of forecasts and reservoir operations, spring runoff forecasts and reservoir operations, respectively. Section 7 presents flood impacts observed during the 2001 flood, while Section 8 looks at the effectiveness of flood operations on reducing flood peaks. Section 9 of the report reviews the 1999 Souris Post-Flood Report Recommendations and actions taken to date, along with some lessons learned in the 2001 event. A brief summary is given in Section 10 and acknowledgements are provided in Section 11 to the agencies and groups and their staff who supported the preparation of this report.

2. BACKGROUND

2.1. Basin and Reservoir Information

The Souris River has its headwaters in the Province of Saskatchewan and flows generally in a southeasterly direction, crossing the United States Border into the State of North Dakota near Sherwood, North Dakota. The river continues its southeasterly flow to Velva, North Dakota, where it reverses course and flows northeasterly to Towner, North Dakota and then northwesterly to the Canadian Border and into the Province of Manitoba near Westhope, North Dakota. The Souris River eventually flows into the Assiniboine River, a tributary of the Red River of the North. The Souris River valley is flat and shallow, and its semi-arid prairie has been extensively cultivated. Major reservoirs have been constructed in both the U.S. and Canadian portions of the basin, including Boundary, Rafferty and Alameda reservoirs in Saskatchewan, and Lake Darling in North Dakota.

The basin also includes a number of wildlife refuges and small impoundments along the U.S. portion of the river. The U.S. Fish and Wildlife Service operates three national wildlife refuges located on the Souris River in North Dakota. Upper Souris National Wildlife Refuge is located near Foxholm, North Dakota, upstream of the City of Minot. J. Clark Salyer National Wildlife Refuge is located near Upham, North Dakota, downstream of the City of Towner. Des Lacs National Wildlife Refuge is located on the Des Lacs River (a tributary of the Souris River) near Kenmare, North Dakota.

All of the major storage impoundments in the Souris River basin in North Dakota are located on national wildlife refuges and are operated by the U.S. Fish and Wildlife Service under water rights permits issued by the State of North Dakota.

2.2. 1989 International Agreement for Water Supply and Flood Control

Pursuant to the 1989 International "Agreement Between The Government Of Canada And The Government Of The United States Of America For Water Supply And Flood Control In The Souris Basin," flood control within the Souris basin is afforded by several reservoirs in Canada and the United States, collectively known as the "Souris Basin Project". This term refers to the development and operation of the Saskatchewan works in Canada, the operation of the existing Boundary Reservoir in Saskatchewan and the operation of the existing Lake Darling Reservoir in North Dakota in the United States for flood control. The Saskatchewan works includes Rafferty Dam, Alameda Dam and the Boundary Diversion channel. Rafferty Reservoir, Boundary Reservoir, and Alameda Reservoir are known collectively as the "Canadian reservoirs." The project also includes a number of rural and levee improvements along the Souris River in North Dakota and improvements to other U.S. Fish and Wildlife refuge structures in North Dakota. **Figure 1** shows a map of the Souris River Basin Project.

As stated in Article X of the 1989 International Agreement, the entities responsible for flood control operation of the Souris Basin Project are the Government of Saskatchewan for the Canadian reservoirs and the U.S. Department of the Army for Lake Darling. Practically, the day-to-day flood control responsibilities rest with the Saskatchewan Water Corporation, a Crown corporation, in Canada and the U.S. Army Corps of Engineers in the United States. It is noted here that the flood control responsibilities of the Saskatchewan Water Corporation, also know as Sask Water, were transferred to the Saskatchewan Watershed Authority established by the Saskatchewan Watershed Authority Act of 2005. Inasmuch as the events described in this report center around the 2001 Souris basin flood, the agency names in effect at that time are used.

Under the terms of Article X, non-flood operation of Lake Darling is the responsibility of the U.S. Department of the Interior and has been delegated to the U.S. Fish and Wildlife Service. A June 2, 1989 Memorandum of Understanding (MOU) between the Fish and Wildlife Service and the Corps of Engineers formalized and established the procedures, administration, cooperation and coordination between the two agencies for operation of Lake Darling for flood control purposes under the 1989 International Agreement and for identification and remediation of adverse impacts of the Souris Basin Project to fish and wildlife resources, refuge facilities and operations on the Upper Souris River and J. Clark Salyer National Wildlife refuges.

In accordance with the operating plan for the Canadian reservoirs and Lake Darling, contained in "Annex A" of the 1989 International Agreement, flood control operation of the Souris Basin Project is triggered if a February 1st or subsequent spring runoff estimate shows a 50-percent chance of a 30-day unregulated runoff volume at the Sherwood Crossing equaling or exceeding 175,200 ac-ft (216 110 dam^3), a 10-percent (10-year) flood volume, and/or the local 30-day runoff volume at Sherwood Crossing equaling or exceeding 30,000 ac-ft (37 000 dam^3).

The objectives of the operating plan are: to provide 1-percent (100-year) flood protection at Minot, North Dakota; to provide flood protection to urban and rural areas downstream from Rafferty Dam, Alameda Dam and Lake Darling Dam; to ensure, to the extent possible, that the existing benefits from the supply of water in the Souris River basin and the supply of water to the Souris Basin Project are not compromised.

3. FLOOD METEOROLOGY AND HYDROLOGY

3.1. Antecedent Conditions

The 2000 fall precipitation was near normal throughout much of the basin in Saskatchewan. Fall stubble moisture conditions in this part of the basin varied from very good in the eastern tributaries along the Manitoba Boundary and the headwaters of the Moose Mountain Creek basin to dry throughout the Souris River and Long Creek basins in Saskatchewan. Fall moisture (Sep-Nov 2000) was above normal throughout the North Dakota portions of the basin based upon the data from the U.S. National Weather Service (NWS) cooperative weather observers. Three month precipitation totals varied from 2 to 7 inches (50 to 180 mm) or 100 percent to 200 percent of normal, with the heaviest amount falling in November. Early November NWS airborne gamma snow survey flights revealed significant soil moisture with the upper soils nearly saturated in parts of southeast Saskatchewan, southern Manitoba and the lower end of the basin in North Dakota. The upper end of the Souris basin in North Dakota was far drier.

Winter started strongly in November with 2 to 4 inches (50 to 100 mm) of precipitation falling over most of the basin during the month. Much of this precipitation fell during the first week of the month and was close to the total average amount received for the entire winter at some locations. Precipitation for the rest of the winter was well below average, but even so, precipitation totals for the winter were near or above normal, except for portions of Saskatchewan which were well above normal and the western portions of the basin in North Dakota which were well below normal. In late January a NWS airborne gamma snow survey (**Figure 2**) showed an above average snowpack water content of about 3 to 5 inches (75 to 125 mm) for the Souris River and Long Creek basins above Rafferty Reservoir and Moose Mountain Creek above Moose Mountain Lake in Saskatchewan. The gamma survey generally showed a snowpack water content of 1.5 to 2.8 inches (40 to 70 mm) in the North Dakota portions of the basin, except for the western portions of the basin which showed about 0.5 to 1.5 inches (13 to 40 mm). The Manitoba portions of the basin showed generally 2.3 to 2.8 inches (60 to 70 mm) of snowpack water content. March weather was favorable for the most part with a slow melt and significant sublimation losses. However, the slow sporadic melt did appear to prolong the runoff and the duration of flooding. A snowstorm at the end of March produced additional runoff. Ice-out occurred on the south end of Lake Darling on about April 15th and on the north end of the lake on April 20th, in response to the favorable early March and April weather.

Precipitation from the beginning of November 2000 through March 2001 generally ranged from about 100 to 150 percent of long-term seasonal averages in Saskatchewan and North Dakota to about 120 to 160 percent of long-term seasonal averages in Manitoba. This can be seen in **Tables 1, 2 and 3**, which show monthly precipitation totals and comparisons to long-term seasonal averages for several time periods for Saskatchewan, North Dakota and Manitoba, respectively. Snow depths in the basin were highly variable.

3.2. Spring Runoff Conditions

The recorded spring runoff was well above normal throughout the Long Creek, Souris River and Moose Mountain Creek basins in Saskatchewan, resulting in significant inflows into Boundary, Rafferty and Alameda reservoirs. The slow sporadic melt contributed to spring runoff that was somewhat unusual in the delay in time between the peak runoff dates of the various tributaries in the upper Souris River basin. The peak flow on Long Creek at Noonan occurred on March 22nd, whereas the peak flow on Moose Mountain Creek above Alameda Reservoir did not occur until May 2nd. In a high runoff year these peaks typically occur within a week or less of each other. The delayed melt in the upper Moose Mountain basin, combined with the well above normal snow pack, resulted in a record runoff in this area. The high flows caused extensive flooding of low lying agricultural lands and over-topped several roads. In a few locations roads were breached to protect upstream properties.

Due to early releases from Canadian reservoirs the monthly mean discharges for the Souris River near Sherwood, ND for February and March were the second highest for the 72 year period of record. The Sherwood flows during April and May, although in the upper quartile, were not especially remarkable. Early releases from Lake Darling resulted in monthly mean discharges for the Souris River near Foxholm being the fourth highest and second highest for February and March, respectively, for the 65 year period of record. Flow in the remaining main stem stations resulted in similar, but somewhat more dampened, flow statistics. Monthly mean discharge for Long Creek near Noonan was fourth highest for March, but steadily dropped to near the monthly mean for May. The Des Lacs River Basin was considerably drier with monthly mean discharges for February through May only slightly greater than the period of record mean monthly discharges for those months. The tributary streams in the eastern loop of the river in North Dakota were at or near upper quartile flow levels during periods of flow through May 2001. The Wintering River had the most significant amounts of flow, while the Deep River had the least.

Following a placid year in 2000, the Souris River in Manitoba produced an above average spring runoff in 2001. Including 2001 and the six previous years, five have produced significant flooding on the Souris River in Manitoba. However, peak stages in Manitoba were 2 to 4 feet lower than in 1999 and the duration of flooding was about one month less than in 1999. Flooding in the Manitoba portion of the basin from the U.S. boundary to Hartney began in late March and continued until mid-June. Flooding on Manitoba tributaries was avoided due to the gradual melt, except along Pipestone Creek where some flooding occurred during April.

3.2.1. Precipitation

Spring and early summer precipitation (April 1st to July 31st, 2001) in the Saskatchewan portion of the basin generally varied from below normal in the western areas of the basin to normal in remaining areas of the basin. In North Dakota and Manitoba spring and early summer precipitation, taken as a whole, varied from normal in April to somewhat above normal in June and July. May was a below normal month basin wide. Fall precipitation (August 1st to October 31, 2001) was well below normal throughout the entire basin with many areas recording record low precipitation values for this time period. See **fs 1, 2 and 3** for monthly and seasonal precipitation information.

Figure 3 shows the meteorological gage network for the U.S. National Weather Service and the Atmospheric Environment Service of Canada within the Souris basin. Additional information about these networks in Saskatchewan, North Dakota, and Manitoba, as of February 2002, may be found in **Appendix B** in **Tables B-1, B-2 and B-3,** respectively.

3.2.2. Streamflow

In 2001 favorable weather conditions resulted in an early runoff in some portions of the Souris River basin, but the slow sporadic melt prolonged the runoff and the duration of flooding and affected the normal timing of the runoff from the areas above Rafferty and Alameda reservoirs. There were two major runoff events. The first occurred in late March, as the snow melted over the area above Rafferty Reservoir. Late winter drawdowns of Boundary and Rafferty reservoirs were initiated in early March, in addition to an earlier drawdown of Alameda Reservoir initiated in early February. The drawdown releases resulted in abnormally high late February and early March flows at Sherwood in excess of 300 cfs. The second runoff event occurred from the delayed melting of the snowpack in the Moose Mountain Creek basin above Alameda Reservoir in late April and early May. During the 2001 runoff event, water level and flow data was collected using the existing stream gage network (**Figure 4**) within the Souris basin established by the U.S. Geological Survey, Water Survey of Canada, Saskatchewan Water Corporation and Manitoba Water Stewardship. Additional information about the active hydrometric stations in Saskatchewan, North Dakota, and Manitoba, as of February 2002, may be found in **Appendix B** in **Tables B-4, B-5 and B-6,** respectively.

Peak instantaneous flow data and annual flow volumes for 2001, along with their rankings, are shown in **Tables 4, 5 and 6** for Saskatchewan, North Dakota and Manitoba, respectively. **Table 7** shows the peak instantaneous elevations for the flood control reservoirs of the Souris Basin Project for 2001, along with their respective Full Supply Level (FSL). **Table 8** shows a comparison of the period-of-record mean annual flow to the 2001 annual mean flow for selected streamflow gauging stations in the Souris River basin in North Dakota and Manitoba, where flooding was more prolonged. This table also gives the annual mean flow of the highest or next highest year of record.

While flood peaks along the lower Souris River in North Dakota and Manitoba were well below those of 1999, they were modestly significant, ranging generally from the 10th to 27th highest of record with some exceptions. Higher ranked peaks were experienced in Saskatchewan, but many

Table 1 – Monthly Precipitation Totals in Millimeters (Nov 2000 – Oct 2001) And Percent of Period of Record Seasonal Averages Souris River Basin in Saskatchewan

Station	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov-Apr % of Average	May % of Average	Jun-Jul % of Average
ALIDA	M	M	M	M	M	M	M	M	M	M	M	1.0	M	M	M
AMULET EAST	51.6	27.4	12.6	10.0	21.8	15.8	15.9	66.2	60.2	0.0	12.4	14.8	94	27	97
BENSON	89.0	37.0	2.0	13.4	10.0	30.2	32.6	65.6	80.4	12.2	7.8	11.2	133	66	108
BROADVIEW (AUTO)	67.8	42.0	7.4	6.0	14.6	10.0	21.4	64.8	85.4	11.6	11.4	3.8	115	44	98
CARNDUFF	81.7	29.8	6.0	12.0	8.5	45.8	36.2	120.6	M	13.4	10.2	23.4	112	67	M
CEYLON	M	0.0	0.0	0.0	M	9.4	24.2	75.0	68.2	3.4	25.2	12.0	M	52	109
ESTEVAN A	97.4	26.5	5.2	3.0	5.6	32.0	37.4	82.2	69.4	6.8	9.4	6.7	140	72	108
FERTILE	100.4	47.0	2.0	11.0	4.0	51.6	40.7	107.6	84.2	5.6	8.8	13.8	148	67	130
HANDSWORTH	51.4	48.4	7.0	14.4	20.0	13.4	35.6	79.0	97.4	3.0	10.6	22.7	136	62	122
INDIAN HEAD CDA	32.9	48.1	4.9	11.5	25.6	7.8	21.1	28.0	42.0	12.2	21.4	8.5	102	44	50
KIPLING	70.2	47.0	2.0	14.0	25.0	17.2	27.0	183.6	81.0	4.0	11.6	8.0	132	53	185
LAKE ALMA	79.2	23.2	10.2	3.8	1.6	29.0	33.4	91.4	73.9	0.0	13.2	15.0	125	59	119
MACOUN	92.6	29.8	5.0	5.8	6.6	36.8	28.6	66.6	78.0	3.2	8.6	7.4	134	50	101
MANOR	68.0	27.2	3.0	8.0	15.4	34.5	60.4	110.8	125.2	8.8	6.4	14.2	119	110	142
MARYFIELD	87.0	82.0	4.0	21.5	20.0	19.6	42.4	107.5	92.1	22.2	6.8	4.8	173	78	135
MIDALE	126.2	29.5	5.2	10.0	11.9	38.6	30.6	73.2	67.6	7.8	4.8	17.8	150	52	98
MONTMARTRE	80.0	49.5	3.0	16.0	12.0	10.0	0.0	M	M	M	M	M	131	0	M
OXBOW	75.4	33.0	4.0	10.0	8.0	30.0	33.6	99.4	120.4	15.4	4.7	13.4	132	69	159
REDVERS	69.0	50.0	0.0	7.0	11.0	22.2	37.6	129.2	129.6	5.0	6.0	8.0	136	76	159
REGINA A	20.4	26.7	6.1	5.1	9.4	12.5	34.0	39.3	161.4	5.5	12.3	7.3	82	75	145
WEYBURN	101.0	26.4	5.6	8.4	13.0	21.8	22.4	62.9	81.5	2.0	7.8	16.5	150	43	106
WHITEWOOD	83.4	53.6	5.4	13.8	34.4	20.6	30.8	190.2	87.6	8.2	6.8	8.4	152	62	187
WILLMAR	69.0	36.0	1.0	7.0	8.0	31.4	36.4	74.0	65.2	13.2	6.2	13.4	125	72	92
YELLOW GRASS	48.4	33.0	10.0	9.6	19.0	18.6	28.5	102.4	91.8	0.0	8.0	16.2	117	61	144

NOTE: "M" indicates missing data; "0.0" indicates trace or less precipitation; incomplete or partial records for some years at some locations.
Data source – Atmospheric Environment Service, Environment Canada.

Table 2 – Monthly Precipitation Totals in Inches (Nov 2000 – Oct 2001)
And Percent of Period of Record Seasonal Averages
Souris River Basin in North Dakota

Station	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov-Apr % of Average	May % of Average	Jun-Jul % of Average
AMBROSE 3N	2.90	0.22	0.23	0.07	0.09	1.68	0.79	2.43	1.96	0.50	0.48	0.25	199	41	85
BELCOURT KEYA RADIO	2.08	0.24	0.12	0.08	0.70	1.00	2.35	2.29	4.49	1.15	0.19	0.42	127	100	112
BERTHOLD	2.71	0.51	0.28	0.28	0.10	1.14	0.66	3.54	2.56	0.51	0.35	0.43	114	29	103
BOTTINEAU	2.14	0.67	0.05	0.19	0.51	1.16	2.21	4.40	5.08	0.38	0.38	0.49	135	105	160
BUTTE 5SE	M	M	0.20	0.33	0.00	1.07	1.63	3.99	4.80	0.35	0.36	0.20	M	72	156
CROSBY	3.05	0.25	0.39	0.09	0.04	0.57	0.85	4.06	2.41	0.00	0.50	0.29	135	44	122
DRAKE 9NE	2.81	0.26	0.10	0.40	0.10	0.98	1.57	3.54	5.88	1.04	0.49	0.87	134	72	164
FORTUNA 1W	0.78	0.29	0.60	0.00	0.00	1.30	0.75	2.72	2.48	0.40	0.10	0.22	92	38	98
FOXHOLM 7N	1.95	0.27	0.11	0.07	0.01	1.22	1.33	2.89	3.70	1.23	0.19	1.43	97	67	123
GRANVILLE	0.61	0.54	0.17	0.42	0.00	0.66	1.42	2.47	1.59	0.78	0.47	0.06	66	60	70
KENMARE 1WSW	2.56	0.22	0.21	0.33	0.21	1.15	0.90	4.13	5.41	0.60	0.23	0.28	107	42	174
LAKE METIGOSHE ST PK	2.27	1.04	0.27	0.18	0.38	1.00	1.97	4.17	4.70	0.54	0.19	0.48	131	72	133
MAX	2.06	0.25	0.22	0.36	0.00	1.54	2.36	4.67	4.15	1.65	0.88	0.38	105	104	140
MCHENRY 3W	2.64	0.61	0.08	0.42	0.12	1.05	2.43	4.25	5.03	3.08	0.77	2.24	114	106	142
MINOT EXP STA	3.53	0.47	0.29	0.30	0.03	1.44	1.50	3.18	2.24	0.69	0.64	0.45	136	68	99
MINOT FAA AP	1.94	0.19	0.12	0.18	0.01	1.06	1.54	2.89	2.41	0.83	0.48	0.24	72	65	92
MOHALL	1.76	0.12	M	0.10	0.15	1.33	0.98	3.66	3.43	0.47	0.29	0.63	M	44	122
POWERS LAKE 1N	1.83	0.16	0.08	0.21	0.19	1.45	1.07	5.83	3.77	0.41	0.21	0.31	121	54	166
ROLETTE 2SE	M	0.60	0.20	0.39	0.32	1.20	1.33	3.22	5.19	0.20	0.69	0.50	M	37	126
ROLLA 3NW	3.13	0.52	0.06	0.32	0.15	0.51	2.53	3.57	7.09	0.64	0.35	0.63	121	109	165
RUGBY	2.22	0.29	0.06	0.13	0.14	0.99	2.53	3.11	7.30	1.13	0.25	1.05	95	108	169
SHERWOOD 3N	1.18	M	M	M	M	0.73	1.00	2.50	3.95	0.14	0.21	0.47	M	53	122
STANLEY 3NNW	1.56	0.39	0.34	0.27	0.14	1.83	1.98	4.69	5.49	1.29	0.46	0.40	108	80	155
TAGUS	2.13	0.25	0.44	0.23	0.02	1.25	1.22	2.97	7.94	0.40	0.34	0.26	99	60	190
TOWNER 2NE	1.66	0.36	M	0.29	0.19	0.95	2.80	5.64	4.50	0.75	0.10	0.75	M	137	185
UPHAM 3N	3.22	0.61	0.08	0.37	0.24	1.31	1.28	2.92	6.75	0.10	0.53	0.78	144	59	165
VELVA 3NE	4.32	0.46	0.30	0.46	0.00	1.05	2.21	4.43	3.02	0.23	0.60	0.90	147	96	122
WESTHOPE	2.70	0.53	0.08	0.16	0.51	1.71	1.73	2.07	3.50	0.12	0.36	0.63	153	84	97
WILLOW CITY	2.58	0.46	0.11	0.30	0.45	1.38	1.87	3.14	6.68	0.65	1.28	0.40	150	93	173

NOTE: “M” indicates missing data; “0.0” indicates trace or less precipitation; incomplete or partial records for some years at some locations.
Data source – U.S. National Climatic Data Center and National Weather Service cooperative observer data.

Table 3 – Monthly Precipitation Totals in Millimeters (Nov 2000 – Oct 2001) And Percent of Period of Record Seasonal Averages Souris River Basin in Manitoba

Station	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov-Apr % of Average	May % of Average	Jun-Jul % of Average
BALDUR	93.8	40.0	4.0	9.0	11.0	31.2	49.4	57.9	131.8	5.6	28.6	18.1	120	78	117
BELMONT	121.4	43.8	6.6	23.2	13.0	26.6	63.8	42.2	127.8	8.0	24.4	15.0	153	90	98
BRANDON A	70.6	39.8	3.0	7.2	11.4	17.4	69.4	117.4	31.8	36.8	20.0	12.0	118	137	105
BRANDON CDA	83.3	37.4	2.4	6.0	9.0	17.2	56.2	122.0	38.0	22.0	23.8	12.0	117	107	108
CAMERON	74.8	39.0	4.0	M	M	M	M	M	M	M	M	M	M	M	M
ELKHORN 2 EAST	94.2	43.6	5.4	13.2	26.4	26.2	49.7	169.8	83.0	13.8	5.2	4.6	140	89	155
MELITA	71.7	32.0	4.7	4.9	21.5	28.6	55.2	61.6	55.2	11.2	2.6	12.2	137	104	99
PEACE GARDENS	82.5	M	M	M	M	M	M	M	M	M	M	M	M	M	M
PIERSON	66.4	41.8	4.4	6.0	12.8	43.4	36.4	66.8	100.6	14.8	3.6	16.2	130	69	123
SOURIS	97.8	42.0	8.0	7.0	16.0	21.0	58.0	81.8	66.8	10.6	14.8	8.0	130	99	94
TURTLE MOUNTAIN 6	91.4	26.4	0.0	5.2	5.8	19.2	49.6	58.0	82.0	6.2	10.2	13.2	112	93	90
TURTLE MOUNTAIN 11	114.2	42.0	7.0	17.0	15.0	35.0	45.2	60.0	154.8	9.4	8.4	13.8	156	72	133
VIRDEN	104.4	58.0	2.0	13.0	15.0	25.1	44.0	181.4	68.7	18.6	6.2	5.4	158	94	177
WAPELLA-NEWFINLAND	89.4	44.2	1.4	11.4	35.8	19.6	36.4	165.0	86.8	5.0	13.6	13.8	163	76	170

NOTE: "M" indicates missing data; "0.0" indicates trace or less precipitation; incomplete or partial records for some years at some locations.
Data source – Atmospheric Environment Service, Environment Canada.

Table 4 - Streamflow Station Information with 2001 Peak Flow and Annual Flow Volume Data and Rankings
Souris River Basin in Saskatchewan

Station Number	Station Name	Years of Record (1)	Drainage (km^2)		2001 Peak Flow (2)				2001 Annual Flow Volume		
			Gross	Effective	Date	(ft^3/s)	(m^3/s)	Rank	(ac-ft)	(dam^3)	Rank
05NB001	Long Cr. nr Estevan d/s of Boundary Reservoir	1911 - Present	4 840	1 490	23-Mar	370	10.5	26 (4)	23,800	29 300	22 (5)
05NB014	Jewel Cr. nr Goodwater (tributary inflow to Rafferty)	1959 - Present (3)	211	192	01-Apr	286 (6)	8.1 (6)	16 (4)	7,390	9 120	10 (5)
05NB017	Souris River nr Halbrite (inflow to Rafferty)	1959 - Present	3 950	1 500	10-Apr	2,690	76.2	7 (4)	106,400	131 200	4 (5)
05NB021	Short Cr. nr Roche Percee	1960 - Present	1 210	325	19-Mar	430	12.2	16 (4)	6,940	8 560	18
05NB033	Moseley Cr. nr Halbrite (tributary inflow to Rafferty)	1992 - Present (3)	58.5	35.2	09-Apr	141	4.0	4 (4) (7)	3,040	3 750	4 (5) (7)
05NB034	Roughbark Cr. nr Goodwater (tributary inflow to Rafferty)	1992 - Present (3)	288	204	02-Apr	336 (6)	9.5 (6)	3 (4) (7)	8,510	10 500	3 (5) (7)
05NB035	Cooke Cr. nr Goodwater (tributary inflow to Rafferty)	1992 - Present (3)	129	65.8	04-Apr	115	3.3	3 (4) (7)	2,630	3 240	3 (5) (7)
05NB036	Souris River below Rafferty	1992 - Present	6 200	2 510	01-May	1,640	46.3	2 (4) (7)	131,300	162 000	2 (5) (7)
05NB038	Boundary Div. Canal nr Estevan	1993 - Present (3)	NA	NA	24-Mar	1,240	35.1	5 (8)	19,300	23 900	4 (5) (8)
05ND004	Moose Mountain Cr. nr Oxbow (d/s of Res.)	1913 - Present	6 050	2 170	09-May	742	21.0	22 (4)	61,600	76 100	8 (5)
05ND010	Moose Mountain Cr. abv Alameda Reservoir (inflow to Reservoir)	1992 - Present	4 710	1 940	02-May	1,270	36.1	5 (7)	62,800	77 500	2 (7)
05ND011	Shepherd Cr. nr Alameda	1992 - Present (3)	175	60.1	05-Apr	66	1.9	5 (7)	1,070	1 320	4 (5) (7)

(1) Partial or incomplete records in some years at some locations.
(2) Instantaneous peak flows.
(3) Seasonal records only; mostly Mar - Oct, but varies.
(4) Ranking estimated from maximum mean daily flow records, due to incomplete or non-existent instantaneous flow record.
(5) Ranking estimated from mean annual flows computed using available monthly mean flows; monthly flow records missing in some years.
(6) Maximum mean daily flow used; instantaneous flow record not available.
(7) These stations have a short period of record and higher flows and flow volumes have occurred in the past.
(8) This station has a short period of record and did not exist prior to construction of Rafferty Reservoir.

Table 5 - Streamflow Station Information with 2001 Peak Flow and Annual Flow Volume Data and Rankings Souris River Basin in North Dakota

Station Number	Station Name	Years of Record (1)	Drainage (mi^2)		2001 Peak Flow (2)				2001 Annual Flow Volume		
			Gross	Effective	Date	(ft^3/s)	(m^3/s)	Rank	(ac-ft)	(dam^3)	Rank
05113600	Long Creek nr Noonan	1959 - Present	1,790	630	22-Mar	2,350	66.5	9	59,080	72 870	10
05114000	Souris River nr Sherwood	1930 - Present	8,940	3,040	10-May	2,200	62.3	21	253,400	312 600	7
05116000	Souris River nr Foxholm	1936 - Present	9,470	3,270	06-May	2,210	62.6	12	247,600	305 400	8
05116500	Des Lacs River at Foxholm	1945 - Present	939	539	27-Mar	156	4.4	47	8,690	10 710	35
05117500	Souris River abv Minot	1903 - Present	10,600	3,900	07-May	2,070	58.6	27	251,200	309 900	12
05120000	Souris River nr Verendrye	1937 - Present	11,300	4,400	13-May	2,220	62.9	18	291,000	359 000	9
05120500	Wintering River nr Karlsruhe	1937 - Present	705	285	25-Mar	480	13.6	13	28,310	34 920	4
05122000	Souris River nr Bantry	1937 - Present	12,300	4,700	06-Apr	2,330	66.0	12	322,200	397 400	10
05123400	Willow Creek nr Willow City	1956 - Present	1,160	730	10-Apr	1,830	51.8	8	86,880	107 200	6
05123510	Deep River nr Upham	1957 – 1980 1985 – Present (3)	975	370	31-Jul	284	8.0	19	15,910	19 630	11
05124000	Souris River nr Westhope	1930 - Present	16,900	6,600	11-Apr	3,360	95.1	12	497,400	613 500	7

Table 6 - Streamflow Station Information with 2001 Peak Flow and Annual Flow Volume Data and Rankings Souris River Basin in Manitoba

Station Number	Station Name	Years of Record (1)	Drainage (km^2)		2001 Peak Flow (2)				2001 Annual Flow Volume		
			Gross	Effective	Date	(ft^3/s)	(m^3/s)	Rank (4)	(ac-ft)	(dam^3)	Rank (5)
05NF002	Antler River nr Melita	1935 - Present (3)	3 210	NA	18-Apr	452	12.8	27	20,700	25 500	23
05NF007	Gainsborough Cr nr Lyleton	1956 - Present (3)	1 150	NA	25-Apr	501	14.2	9	14,600	18 100	8
05NG001	Souris River at Wawanesa	1912 - Present	61 100	NA	11-Apr	8,050	228.0	11	669,300	825 500	10
05NG012	Elgin Cr nr Souris	1961 - Present (3)	1 170	NA	08-Apr	1,050	35.1	4	15,600	19 300	7
05NG020	Medora Cr nr Napinka	1966 - Present (3)	317	NA	07-Apr	788	22.3	4	7,940	9 790	5
05NG021	Souris River at Souris	1967 - Present (3)	58 700	NA	10-Apr	5,230	148.0	8	614,300	757 800	8

Notes for Tables 6 & 7:

(1) Partial, incomplete or monthly records in some years at some locations.
(2) Instantaneous peak flows.
(3) Seasonal records only; mostly Mar - Oct, but varies.
(4) Ranking estimated from maximum mean daily flow records, due to incomplete or non-existent instantaneous flow record.
(5) Ranking estimated from mean annual flows computed using available monthly mean flows; monthly flow records missing in some years.

Table 7 – Souris Basin Project Flood Control Reservoirs Drainage Area, FSL and 2001 Peak Elevation

Station Number	Station Name	Drainage (km^2)		Drainage (mi^2)		(FSL) Elevation		2001 Peak Elevation [1]		
		Gross	Effective	Gross	Effective	(ft)	(m)	Date	(ft)	(m)
05NB032	Rafferty Res. near Estevan	6 190	2 110	-	-	1,806.10	550.50	24-Apr	1807.99	551.076
05ND012	Alameda Res. near Alameda	6 040	2 260	-	-	1,843.83	562.00	09-Jun	1844.59	562.231
05NB012	Boundary Res. near Estevan	4 810	1 500	-	-	1,840.00	560.83	30-Apr	1839.93	560.810
05115500	Lake Darling Res. nr Foxholm	-	-	9,450	3,250	1,597.00	486.77	18-Jun	1597.00	486.765

Table 8 – Comparison of Period-of-Record Mean Annual Flow to 2001 Annual Mean Flow Selected Streamflow Gauging Stations - Souris River Basin in North Dakota and Manitoba

Station Name	Years of Continuous Record [2]	Mean Annual Flow (Period of Record)		2001 Annual Mean Flow		Rank of 2001	Highest or Next Highest Annual Mean Flow & Year		
		(ft^3/s)	(m^3/s)	(ft^3/s)	(m^3/s)		(ft^3/s)	(m^3/s)	Year
Long Creek nr Noonan	1959 - Present	43.4	1.23	81.6	2.31	10	200	5.66	1976
Souris River nr Sherwood	1930 - Present	130	3.68	350	9.91	7	878	24.86	1976
Souris River nr Foxholm	1936 - Present	133	3.77	342	9.68	8	948	26.84	1976
Des Lacs River at Foxholm	1945 - Present	28.3	0.80	12	0.34	35	148	4.19	1976
Souris River abv Minot	1903 - Present	160	4.53	347	9.83	12	1,105	31.29	1976
Souris River nr Verendrye	1937 - Present	203	5.75	402	11.38	9	1,185	33.56	1976
Wintering River nr Karlsruhe	1937 – Present	16.5	0.47	39.1	1.11	4	82.0	2.32	1999
Souris River nr Bantry	1937 – Present	228	6.46	445	12.60	10	1,226	34.72	1976
Willow Creek nr Willow City	1956 – Present	49.5	1.40	120	3.40	6	323	9.15	1999
Deep River nr Upham	1957 – 1980 1985 – Present [3]	20.5 [4]	0.58 [4]	22	0.62	11	140 [4]	3.96 [4]	1976
Souris River nr Westhope	1930 – Present	276	7.82	687	19.45	7	1,697	48.05	1976
Souris River at Wawanesa	1912 - Present	456 [4]	12.9 [5]	925	26.2	10	2,880	81.6	1976

Notes for Tables 8 & 9:

(1) Instantaneous peak flows, except mean daily peak only for Boundary Reservoir.
(2) Monthly records only for some periods at some stations.
(3) Seasonal records only; Feb - Sep.
(4) Based on complete water years only (1958-80).
(5) Based on 57 Years of available mean annual flow data.

of those streams have a relatively short record. Annual flood volumes show similar ranking trends. This is readily observed from the data contained in **Tables 5, 6 and 8**.

Souris River flows were above average throughout the summer and fall, despite very dry weather after July. This appeared to be largely due to a high base flow and storage releases from the U.S. portion of the watershed. Hydrographs of River flows at key gauging stations on Moose Mountain Creek at Oxbow, on the Souris River below Rafferty Reservoir and on the Souris mainstem at Sherwood, Foxholm, Minot, Verendrye, Bantry, Westhope, Souris and Wawanesa are shown in **Figures 5 through 14**, respectively.

4. COORDINATION OF FORECASTS AND RESERVOIR OPERATIONS

4.1. Operational and Liaison Responsibilities Under the 1989 International Agreement Between Canada and the United States

Under the provisions of Article X of the 1989 International Agreement for Water Supply and Flood Control in the Souris River Basin, the Governments of Canada and the United States have designated the Government of Saskatchewan and the U.S. Department of the Army, respectively, as the responsible entities for the management of the improvements covered by the Agreement during periods of flood. In Saskatchewan this authority rests with the Saskatchewan Water Corporation (Sask Water), a Provincial Crown Corporation. In the United States this authority rests with the U.S Army Corps of Engineers (USACE) through its St. Paul District. During non-flood periods, Sask Water is also the responsible entity for operations in Canada, while the U.S. Fish and Wildlife Service is the responsible entity in the United States. Section 6.0 of Annex A of the 1989 Agreement provides that these responsible entities will accomplish liaison with interested states, provinces and agencies from time-to-time as to the operation of the project. Additionally, Section 6.0 provides that representatives of the U.S Department of the Army, Saskatchewan Water Corporation, U.S. Fish and Wildlife Service and North Dakota State Engineer have responsibility to monitor reservoir operations under the Agreement.

Further responsibilities of the Governments of Canada and the United States are defined in Article V of the 1989 International Agreement. These responsibilities include consultation with interested states, provinces and agencies concerning preparation of reservoir regulation manuals and periodic review and revision of the operating plan contained in Annex A at 5-year intervals, or as mutually agreed, to maximize the provision of flood control and water supply benefits that can be provided consistent with the terms of the Agreement.

Article VII of the 1989 Agreement required that paragraph 1 of the 1959 Interim Measures for the apportionment of waters of the Souris River be modified as shown in Annex B of the Agreement. Pursuant to a February 28, 1992 request from the Governments of Canada and the United States, the International Joint Commission (IJC) directed the International Souris River Board of Control (ISRBC) to begin applying the "Interim Measurers as Modified." In response the ISRBC directed its "Natural Flow Methods Committee" to study implementation of the measures contained in Annex B and to report findings and recommendations back to the Board. As a result of the Committee's recommendations, Sask Water prepares forecasts each year of the maximum 30-day and 90-day runoff with assistance from the National Weather Service as appropriate. These runoff forecasts begin on February 1st and thereafter on the 15th and last day of the month until runoff occurs.

In December 2000, the International Joint Commission directed the Board to implement the "Interim Measures as Modified in 2000" for the 2001 calendar year and each year thereafter. The 2000 Interim Measures were developed to provide greater clarification of the conditions that must prevail for the determination of the share of natural flow between Saskatchewan and North Dakota at the Sherwood Crossing. All of the various "Interim Measures" for the apportionment of flows in the Souris River basin between Canada and the United States may be viewed on the web site of the ISRB under the "Boards" tab at www.ijc.org.

4.2. Forecasting and Flood Operations Coordination

During years of flood operation, the terms of Annex A of the 1989 Agreement established reservoir target drawdown levels for Rafferty, Alameda and Boundary reservoirs in Canada and Lake Darling Reservoir in North Dakota. It also provides for target flows in North Dakota for the Souris River at Sherwood and Minot in these years. A year of flood operation is triggered under the Agreement when a 50 percent chance exists of the estimated 30-day unregulated flow volume at Sherwood crossing equaling or exceeding a 10-percent (10-year) flood event volume of 175,200 ac-ft (216 110 dam^3) or when the local 30-day flow volume at Sherwood crossing is expected to equal or exceed 30,000 ac-ft (37 000 dam^3).

Forecasts issued by Sask Water in 2001 from February to April for the Souris River basin steadily indicated an expected flood event that was greater than a 10-year flood event based upon forecasted 30-day unregulated flow volumes at the Sherwood crossing. This triggered, flood operations for the second time since the 1989 Agreement was signed. The forecasted Sherwood local flow volume over this same period was slightly less than a 10-year event.

Inasmuch as 1999 was the first time that flood operations had been triggered, the Forecasting and Flood Operations Coordinating Group (FFOCG) established for the management of flood operations for that event was re-activated. The FFOCG was formally established by representatives of Sask Water and the U.S. Army Corps of Engineers on March 24, 1999 to co-ordinate activities for the flood operations. Representatives of agencies having responsibilities under the 1989 Agreement, other agencies directly involved in forecasting and reservoir operations and member agencies of the Souris River Flow Forecasting Liaison Committee (SRFFLC) of the former International Souris River Board of Control (now amalgamated as the International Souris River Board) were selected to participate. All of the people involved were already actively involved in the generation of forecasts and exchange of information between jurisdictions.

The FFOCG representatives were Alex Banga (Saskatchewan Water Corporation), Ed Eaton (U.S. Army Corps of Engineers), Bob White (North Dakota State Water Commission), Alf Warkentin (Water Resources Branch, Manitoba Natural Resources) and Dean Knauer (U.S. Fish and Wildlife Service).

The planning of flood operations became a highly coordinated effort. Agency representatives met by conference call on a regular basis from March through June to review reservoir operations based on updated forecasts and the latest flow information. Flow and water level information was exchanged between agencies by way of the Internet and other electronic formats on a daily basis. Members of the SRFFLC were kept informed of forecasts and planned reservoir operations through normal communication channels. At all material times between conference calls, members of the FFOCG and SRFFLC maintained contact by individual phone calls and various forms of electronic communications as conditions required. Whenever precipitation events occurred and a change in flow conditions warranted, reservoir operation plans were updated and a conference call was held to discuss reservoir operations, target flows and possible impacts to downstream interests. In all cases every effort was made to minimize impacts of high flows, while operating the system within the intent of the 1989 Agreement.

A coordination meeting was held on March 5th in Minot to discuss items of public interest, including the 2001 spring runoff potential. Attending were interested citizens, representatives from the city of Minot, Eaton Irrigation District, Souris River Joint Water Resources Board, North Dakota State Water Commission, Minot Park District, Corps of Engineers and the Fish and Wildlife Service. Officials presented the previous year's water management reports and proposed 2001 plans.

5. SPRING RUNOFF FORECASTS

Beginning on February 1st, Sask Water issued runoff forecasts (**Tables 9 through 18**) for the Souris River basin on the 1st and 15th of each month through the last forecast on April 1st. All of these forecasts indicated an expected flood event that was greater than a 10-year flood event based upon forecasted 30-day unregulated flow volumes at the Sherwood crossing that ranged from a high of 243,300 ac-ft (300 000 dam^3) on February 15th to a low of 178,400 ac-ft (220 000 dam^3) on April 1st, about two weeks after the beginning of the early stages of snowmelt runoff. With the forecasted 30-day unregulated flow volume at Sherwood Crossing being greater than a 10-year flood event, flood operations were triggered (the Sherwood local runoff flow volume forecast was less than a 10-year event).

In addition to the Sask Water forecasts, the NWS North Central River Forecast Center (NCRFC) in Chanhassen, Minnesota issued a spring 2001 flood outlook for the North Dakota portions of the Souris River basin on February 8th. This outlook forecast moderate flooding for the Sherwood to Foxholm reaches of the Souris River, primarily as a result of uncontrolled local runoff. Only minor flooding was forecast for the Des Lacs River at Foxholm and the Souris River from Minot to Velva, due to a limited snowpack in the Des Lacs basin. Moderate to major flooding was expected for the river reaches from Towner to Westhope due to a higher snowpack and the limited channel capacities of the lower reaches of the Souris River in North Dakota.

Another spring snowmelt outlook (**Figure 15**) was issued for the North Dakota portions of the basin on March 8th. This forecast provided a somewhat lessened flood potential, forecasting minor to moderate flooding, with the exception of the Des Lacs basin which no longer had a snowmelt flood potential.

Table 9 - February 1, 2001 Sask Water Runoff Forecast for the Souris River Basin

Forecast Location	Maximum 30-Day Volume (dam^3 x 10^3)	Maximum 90-Day Volume (dam^3 x 10^3)		Peak Flow (m^3/s)	Event Return Period
	Best Estimate	90 Percent Confidence	Best Estimate		
Long Creek near Noonan	75	45	90	80	1:10
Inflow into Rafferty Reservoir	120	70	140	80*	>1:10
Diversion to Rafferty	To be Determined				
Inflow into Alameda Reservoir	65	45	75	60	>1:10
Local Runoff	35	25	40		1:10
Sherwood Crossing Projected)**	155	40	205	90	
Sherwood Crossing (Natural)	245	150	290		
Sherwood Crossing (Unregulated)	295	185	345		>1:10

* Based on Halbrite (i.e. does not include local runoff).

** Assuming Reservoirs drawn down prior to spring runoff and then maintained at their FSL's after the 30 day time period.

Table 10 – 2001 Target Draw Down Levels for the Souris River Basin Reservoirs Based on the 90 Percent 90-Day Inflow Forecast

Forecast Location	Current Level (m)	Target Drawn Down Level (m)	Target Drawn Down Volume (dam^3)
Rafferty Reservoir	548.91	548.95	0
Boundary Reservoir	559.14	557.60	7 800
Alameda Reservoir	560.81	556.70	36 100

Notes to the Forecast:

1) The 90-percent 90-day inflow forecast to each of the Reservoirs is used in Plates A-1, A-2, and A-3 of the International Agreement to determine target drawdown levels at Rafferty, Boundary and Alameda, respectively (**Inflow into Rafferty Reservoir**, **Long Creek near Noonan**, and **Inflow into Alameda Reservoir** in the above table).
2) **Inflow into Rafferty Reservoir** does not include diversion from Boundary Reservoir.
3) **Local Runoff** is the volume of runoff that is expected at Sherwood Crossing from the basin below the Canadian reservoirs (Rafferty, Boundary and Alameda). If this 30-day volume exceeds 37 000 dam^3, the Flood operation, as per page A-26 of the International Agreement, is triggered.
4) **Sherwood Crossing (Projected)** = Expected Runoff - Planned reservoir storage at the Canadian reservoirs to the end of the forecast period.

   This is the volume (and associated peak flow) that is expected to occur at Sherwood Crossing based on local runoff and planned releases from the Canadian reservoirs.
5) **Sherwood Crossing (Natural)** = Expected Runoff – Yellow Grass and Tatagawa Marshes + Minor Project Diversions.

   This is an estimate of the natural flow volume at Sherwood Crossing and is provided for the information of the ISRB.
6) **Sherwood Crossing (Unregulated)** = Expected Runoff (including runoff from Yellow Grass and Tatagawa)

   If this best estimate 30-day volume exceeds 216 110 dam^3, the Flood Operation, as per page A-26 of the International Agreement, is triggered. The best estimate 30-day volume is used in Plates A-5 and A6 to determine target flows at Sherwood and Minot.

Table 11 - February 15, 2001 Sask Water Runoff Forecast for the Souris River Basin

Forecast Location	Maximum 30-Day Volume ($dam^3 \times 10^3$)	Maximum 90-Day Volume ($dam^3 \times 10^3$)		Peak Flow (m^3/s)	Event Return Period
	Best Estimate	90 Percent Confidence	Best Estimate		
Long Creek near Noonan	80	50	90	80	1:10
Inflow into Rafferty Reservoir	120	70	140	80*	>1:10
Diversion to Rafferty	To be Determined				
Inflow into Alameda Reservoir	65	50	75	60	>1:10
Local Runoff	35	25	40		1:10
Sherwood Crossing Projected)**	155	50	200	90	
Sherwood Crossing (Natural)	245	155	280		
Sherwood Crossing (Unregulated)	300	195	345		>1:10

* Based on Halbrite (i.e. does not include local runoff).

** Assuming reservoirs drawn down prior to spring runoff and then maintained at their FSL's after the 30 day time period.

Table 12 – 2001 Target Draw Down Levels for the Souris River Basin Reservoirs Based on the 90 Percent 90-Day Inflow Forecast

Forecast Location	Current Level (m)	Target Drawn Down Level (m)	Target Drawn Down Volume (dam^3)
Rafferty Reservoir	548.91	548.95	0
Boundary Reservoir	559.08	557.80	6 700
Alameda Reservoir	560.76	556.00	40 400

Notes to the Forecast:

7) The 90-percent 90-day inflow forecast to each of the reservoirs is used in Plates A-1, A-2, and A-3 of the International Agreement to determine target drawdown levels at Rafferty, Boundary and Alameda, respectively (**Inflow into Rafferty Reservoir**, **Long Creek near Noonan**, and **Inflow into Alameda Reservoir** in the above table).
8) **Inflow into Rafferty Reservoir** does not include diversion from Boundary Reservoir.
9) **Local Runoff** is the volume of runoff that is expected at Sherwood Crossing from the basin below the Canadian reservoirs (Rafferty, Boundary and Alameda). If this 30-day volume exceeds 37 000 dam^3, the Flood operation, as per page A-26 of the International Agreement, is triggered.
10) **Sherwood Crossing (Projected)** = Expected Runoff - Planned reservoir storage at the Canadian reservoirs to the end of the forecast period.

    This is the volume (and associated peak flow) that is expected to occur at Sherwood Crossing based on local runoff and planned releases from the Canadian reservoirs.
11) **Sherwood Crossing (Natural)** = Expected Runoff – Yellow Grass and Tatagawa Marshes + Minor Project Diversions.

    This is an estimate of the natural flow volume at Sherwood Crossing and is provided for the information of the ISRB.
12) **Sherwood Crossing (Unregulated)** = Expected Runoff (including runoff from Yellow Grass and Tatagawa)

    If this best estimate 30-day volume exceeds 216 110 dam^3, the Flood Operation, as per page A-26 of the International Agreement, is triggered. The best estimate 30-day volume is used in Plates A-5 and A6 to determine target flows at Sherwood and Minot.

Table 13 - March 1, 2001 Sask Water Runoff Forecast for the Souris River Basin

Forecast Location	Maximum 30-Day Volume ($dam^3 \times 10^3$)	Maximum 90-Day Volume ($dam^3 \times 10^3$)		Peak Flow (m^3/s)	Event Return Period
	Best Estimate	90 Percent Confidence	Best Estimate		
Long Creek near Noonan	80	50	90	80	1:10
Inflow into Rafferty Reservoir	110	70	135	80*	>1:10
Diversion to Rafferty	To be Determined				
Inflow into Alameda Reservoir	60	45	70	70	>1:10
Local Runoff	35	25	40		1:10
Sherwood Crossing Projected)**	130	35	180	90	
Sherwood Crossing (Natural)	235	165	275		
Sherwood Crossing (Unregulated)	285	190	335		>1:10

* Based on Halbrite (i.e. does not include local runoff).

** Assuming reservoirs drawn down prior to spring runoff and then maintained at their FSL's after the 30 day time period.

Table 14 – 2001 Target Draw Down Levels for the Souris River Basin Reservoirs Based on the 90 Percent 90-Day Inflow Forecast

Forecast Location	Current Level (m)	Target Drawn Down Level (m)	Target Drawn Down Volume (dam^3)
Rafferty Reservoir	548.90	548.95	0
Boundary Reservoir	559.06	557.80	6 600
Alameda Reservoir	559.74	556.75	24 300

Notes to the Forecast:

13) The 90-percent 90-day inflow forecast to each of the reservoirs is used in Plates A-1, A-2, and A-3 of the International Agreement to determine target drawdown levels at Rafferty, Boundary and Alameda, respectively (**Inflow into Rafferty Reservoir**, **Long Creek near Noonan**, and **Inflow into Alameda Reservoir** in the above table).
14) **Inflow into Rafferty Reservoir** does not include diversion from Boundary Reservoir.
15) **Local Runoff** is the volume of runoff that is expected at Sherwood Crossing from the basin below the Canadian reservoirs (Rafferty, Boundary and Alameda). If this 30-day volume exceeds 37 000 dam^3, the Flood operation, as per page A-26 of the International Agreement, is triggered.
16) **Sherwood Crossing (Projected)** = Expected Runoff - Planned reservoir storage at the Canadian reservoirs to the end of the forecast period.

    This is the volume (and associated peak flow) that is expected to occur at Sherwood Crossing based on local runoff and planned releases from the Canadian reservoirs.
17) **Sherwood Crossing (Natural)** = Expected Runoff – Yellow Grass and Tatagawa Marshes + Minor Project Diversions.

    This is an estimate of the natural flow volume at Sherwood Crossing and is provided for the information of the ISRB.
18) **Sherwood Crossing (Unregulated)** = Expected Runoff (including runoff from Yellow Grass and Tatagawa)

    If this best estimate 30-day volume exceeds 216 110 dam^3, the Flood Operation, as per page A-26 of the International Agreement, is triggered. The best estimate 30-day volume is used in Plates A-5 and A6 to determine target flows at Sherwood and Minot.

Table 15 - March 15, 2001 Sask Water Runoff Forecast for the Souris River Basin

Forecast Location	Maximum 30-Day Volume (dam^3 x 10^3)	Maximum 90-Day Volume (dam^3 x 10^3)		Peak Flow (m^3/s)	Event Return Period
	Best Estimate	90 Percent Confidence	Best Estimate		
Long Creek near Noonan	65	40	70	70	1:9
Inflow into Rafferty Reservoir	90	50	110	70*	1:9
Diversion to Rafferty	40	20	40	45	
Inflow into Alameda Reservoir	60	45	70	70	>1:10
Local Runoff	35	25	40		1:10
Sherwood Crossing Projected)**	105	25	145	70	
Sherwood Crossing (Natural)	220	135	255		
Sherwood Crossing (Unregulated)	250	160	290		>1:10

* Based on Halbrite (i.e. does not include local runoff).

** Assuming reservoirs drawn down prior to spring runoff and then maintained at their FSL's after the 30 day time period.

Table 16 – 2001 Target Draw down Levels for the Souris River Basin Reservoirs Based on the 90 Percent 90-Day Inflow Forecast

Forecast Location	Current Level (m)	Target Drawn Down Level (m)	Target Drawn Down Volume (dam^3)
Rafferty Reservoir	548.84	549.40	0
Boundary Reservoir	558.80	557.80	5 100
Alameda Reservoir	558.90	556.75	16 800

Notes to the Forecast:

19) The 90-percent 90-day inflow forecast to each of the reservoirs is used in Plates A-1, A-2, and A-3 of the International Agreement to determine target drawdown levels at Rafferty, Boundary and Alameda, respectively (**Inflow into Rafferty Reservoir**, **Long Creek near Noonan**, and **Inflow into Alameda Reservoir** in the above table).
20) **Inflow into Rafferty Reservoir** does not include diversion from Boundary Reservoir.
21) **Local Runoff** is the volume of runoff that is expected at Sherwood Crossing from the basin below the Canadian reservoirs (Rafferty, Boundary and Alameda). If this 30-day volume exceeds 37 000 dam^3, the Flood operation, as per page A-26 of the International Agreement, is triggered.
22) **Sherwood Crossing (Projected)** = Expected Runoff - Planned reservoir storage at the Canadian reservoirs to the end of the forecast period.

    This is the volume (and associated peak flow) that is expected to occur at Sherwood Crossing based on local runoff and planned releases from the Canadian reservoirs.
23) **Sherwood Crossing (Natural)** = Expected Runoff – Yellow Grass and Tatagawa Marshes + Minor Project Diversions.

    This is an estimate of the natural flow volume at Sherwood Crossing and is provided for the information of the ISRB.
24) **Sherwood Crossing (Unregulated)** = Expected Runoff (including runoff from Yellow Grass and Tatagawa)

    If this best estimate 30-day volume exceeds 216 110 dam^3, the Flood Operation, as per page A-26 of the International Agreement, is triggered. The best estimate 30-day volume is used in Plates A-5 and A6 to determine target flows at Sherwood and Minot.

Table 17 – April 1, 2001 Sask Water Runoff Forecast for the Souris River Basin

Forecast Location	Maximum 30-Day Volume (dam^3 x 10^3)	Maximum 90-Day Volume (dam^3 x 10^3)	Peak Flow (m^3/s)	Event Return Period
	Best Estimate	Best Estimate		
Long Creek near Noonan	65	70	65	~1:10
Inflow into Rafferty Reservoir	85	100	40*	~1:10
Diversion to Rafferty	20	20	40	
Inflow into Alameda Reservoir	50	60	35	~1:10
Local Runoff	20	25		<1:10
Sherwood Crossing Projected)**	95	150	55	
Sherwood Crossing (Natural)	185	215		
Sherwood Crossing (Unregulated)	220	255		1:10

* Based on Halbrite (i.e. does not include local runoff).

** Based on reservoir levels on March 20th (i.e. prior to any major runoff).

Table 18 – 2001 Souris River Reservoir Levels & Available Storage (April 3, 2001)

Forecast Location	Current Level (m)	Available Storage Volume (dam^3)
Rafferty Reservoir	549.61	41 900
Boundary Reservoir	560.71	800
Alameda Reservoir	558.28	37 800

Notes to the Forecast:

25) The 90-percent 90-day inflow forecast to each of the reservoirs is used in Plates A-1, A-2, and A-3 of the International Agreement to determine target drawdown levels at Rafferty, Boundary and Alameda, respectively (**Inflow into Rafferty Reservoir**, **Long Creek near Noonan**, and **Inflow into Alameda Reservoir** in the above table).
26) **Inflow into Rafferty Reservoir** does not include diversion from Boundary Reservoir.
27) **Local Runoff** is the volume of runoff that is expected at Sherwood Crossing from the basin below the Canadian reservoirs (Rafferty, Boundary and Alameda). If this 30-day volume exceeds 37 000 dam^3, the Flood operation, as per page A-26 of the International Agreement, is triggered.
28) **Sherwood Crossing (Projected)** = Expected Runoff - Planned reservoir storage at the Canadian reservoirs to the end of the forecast period.

    This is the volume (and associated peak flow) that is expected to occur at Sherwood Crossing based on local runoff and planned releases from the Canadian reservoirs.
29) **Sherwood Crossing (Natural)** = Expected Runoff – Yellow Grass and Tatagawa Marshes + Minor Project Diversions.

    This is an estimate of the natural flow volume at Sherwood Crossing and is provided for the information of the ISRB.
30) **Sherwood Crossing (Unregulated)** = Expected Runoff (including runoff from Yellow Grass and Tatagawa)

    If this best estimate 30-day volume exceeds 216 110 dam^3, the Flood Operation, as per page A-26 of the International Agreement, is triggered. The best estimate 30-day volume is used in Plates A-5 and A6 to determine target flows at Sherwood and Minot.

6. RESERVOIR OPERATIONS

6.1. Boundary Reservoir

A well above normal spring runoff (approximately 69 800 dam^3 (56,600 ac-ft) peak 90-day inflow volume) was recorded into Boundary Reservoir during the spring of 2001. A winter release was initiated for the first time ever on March 5th to draw down the reservoir to an elevation of 558.54 m (1,832.48 ft) by March 20th in preparation for the anticipated spring runoff volume. The peak downstream release from Boundary Reservoir was limited to 10 m^3/s (353 ft^3/s) compared to the peak mean daily inflow of 60 m^3/s (2,120 ft^3/s) on March 22nd. A volume of approximately 29 200 dam^3 (23,700 ac-ft) was released to Long Creek during the spring period. After the peak inflows receded, the riparian gates were closed. Reservoir levels were then controlled via releases through the diversion channel. Sask Water diverted approximately 23,900 dam^3 from Boundary Reservoir to Rafferty Reservoir via the diversion channel in 2001. The 2001 reservoir operations for Boundary Reservoir are shown in **Figure 16**.

Boundary Reservoir reached a peak elevation of 560.810 m (1,839.93 ft) on April 30th. The elevation of Boundary Reservoir was 559.53 m (1,835.73 ft) on December 31st, or 1.3 m (4.3 ft) below Full Supply Level (FSL).

6.2. Rafferty Reservoir

A well above normal runoff was recorded throughout the upper Souris River basin. The 90-day peak inflow volume was approximately 182 000 dam^3 (147,500 ac-ft) (an additional 23 900 dam^3 (19,400 ac-ft) via the diversion from Boundary Reservoir was also recorded into the reservoir). As was the case for Boundary Reservoir, a first time ever winter release was also initiated on March 5th for Rafferty Reservoir to draw down the reservoir to elevation of 548.81 m (1,800.56 ft) by March 16th in preparation for the spring runoff volume.

The reservoir was surcharged above its full supply level, to provide additional downstream flood protection, peaking at elevation 551.076 m (1,807.99 ft) on April 24th. The peak inflows of approximately 100 m^3/s (3,530 ft^3/s) into Rafferty Reservoir occurred on April 11th, but did not include flows from the Boundary Diversion Channel. Releases were slowly staged up in early April to help control the rate of rise of the reservoir water level. The total combined releases from both Rafferty and Boundary reservoirs were restricted to approximately 45 m^3/s (1,590 ft^3/s). Releases were staged down quickly to 5 m^3/s (177 ft^3/s) by the middle of May and then down to 2 m^3/s (70.6 ft^3/s) by the end of May. Releases were maintained between 1.6 m^3/s (56.5 ft^3/s) and 2.5 m^3/s (88.2 ft^3/s) until September 17th, at which time they were terminated.

Rafferty Reservoir was at elevation 549.31 m (1,802.20 ft) on December 31st, or 0.19 m (0.6 ft) below its February 1st draw down target elevation of 549.5 m (1,802.82 ft). **Figure 17** depicts the 2001 reservoir operations for Rafferty Reservoir.

6.3. Alameda Reservoir

The peak 90-day inflow volume into Alameda Reservoir in 2001 was approximately 78 000 dam^3 (63,200 ac-ft). In the Moose Mountain Creek basin, runoff from the lower portion of the basin (downstream of Kisbey) was only slightly above normal. As was the case for Boundary and Rafferty reservoirs, a first time ever winter release was also initiated for Alameda Reservoir to draw the reservoir down to elevation 558.17 m (1,831.27 ft) by the end of March in preparation for the spring runoff. The release was initiated on February 14th. Releases from Alameda Reservoir were restricted throughout the first three weeks of April until such time that the upper portion of the basin above the reservoir started to melt. In late April releases were staged up to 17 m^3/s (600 ft^3/s) and then to 20 m^3/s (706 ft^3/s) on May 3rd. This release was maintained until May 11th, at which time the release was staged back to 5 m^3/s (177 ft^3/s) and shortly thereafter to 3 m^3/s (106 ft^3/s). The reservoir peaked at an elevation of 562.231 m (1,844.59 ft) on June 9th or 0.23 m (0.75 ft) above the FSL. Releases were maintained at approximately 3 m^3/s (106 ft^3/s) until early July. Releases were reduced to approximately 1 m^3/s (35.3 ft^3/s) in early July and then to 0.35 m^3/s (12.4 ft^3/s) in early August. A fall draw down was undertaken between September 25th and October 22nd with releases of approximately 2.2 m^3/s (77.7 ft^3/s).

Alameda Reservoir was at elevation of 560.91 m (1,840.26 ft) on December 31st or 0.09 m (0.3 ft) below its February drawn down target elevation of 561.0 m (1,840.55 ft). **Figure 18** shows the 2001 operations undertaken at Alameda Reservoir.

6.4. Upper Souris National Wildlife Refuge

On January 1st, the water level for Lake Darling was at elevation 1595.96 ft (486.4 m) with 98,940 ac-ft (122 041 dam^3) in storage and one sluice gate open to discharge 50 ft^3/s (1.4 m^3/s). On January 4th the release was reduced to about 26 ft^3/s (0.74 m^3/s) to lower Lake Darling elevation to approximately 1595.85 ft (486.4 m) by February 1st and to condition (erode) river ice below the Refuge. This flow continued through February 6th, when it was increased to lower the Lake Darling elevation to 1595.0 ft (486.2 m) and to further condition the river ice.

The February 1st Sask Water runoff forecast predicted a greater than 10-year event for the Sherwood Crossing (unregulated) flow. The 30-day runoff volume was estimated to be 239,160 ac-ft (295 000 dam^3). This estimated runoff volume triggered flood control events in Saskatchewan and North Dakota including drawing down Rafferty and Alameda reservoirs. Based upon expected runoff, the target flow at Sherwood was 3,180 ft^3/s (90 m^3/s) and the target flow at Minot was 4,696 ft^3/s (133 m^3/s). Lake Darling flood control releases were coordinated by the Corps of Engineers with assistance from the Fish and Wildlife Service.

By February 1st the level of Lake Darling was at elevation 1595.82 ft (486.4 m), below the target drawdown elevation of 1596.0 ft (486.5 m) specified in the International Agreement. Based upon anticipated runoff volume, the U.S. Fish and Wildlife Service voluntarily continued drawing down the reservoir to elevation 1595.0 ft (486.2 m). This decision was made to condition the river ice below the Refuge and subsequently to provide additional runoff storage in Lake Darling.

Pre-flood flows from the drawdown of Alameda Reservoir arrived at the International Border on February 21st. Flows at the Border were approximately 330 ft^3/s (9.3 m^3/s) through March 15th. Releases from the Refuge matched or exceeded inflows to lower Lake Darling. The first of three minimum spring drawdown elevations for Lake Darling occurred March 8th to the 12th at elevation 1595.21 ft (486.2 m). Uncontrolled spring snow melt runoff began March 16th at the Border. Local snowmelt was completed by the first week in April. Inflows at the Border peaked at an estimated 1,750 ft^3/s (49.6 m^3/s) on March 21st and began to decline. Releases from the Canadian reservoirs were reduced when the slow snow melt was predicted to produce less runoff than originally expected. It was the consensus of the FFOCG flood managers that it was time to begin storing water because the remaining expected runoff was only enough to fill the reservoirs to full supply levels. By early April, inflows at the Border had dropped to 798 ft^3/s (22.6 m^3/s) and outflows from the Refuge had dropped to 480 ft^3/s (13.6 m^3/s). Lake Darling water elevation increased one foot (0.3 m) to 1596.25 ft (486.5 m) by April 6th. On March 30th, Saskatchewan received 3 to 4 inches (75 to 100 mm) of wet snow at Weyburn and 6 to 12 inches (150 to 300 mm) of wet snow in the Moose Mountains that would eventually increase the anticipated runoff.

In early April, Long Creek flows increased a second time and Saskatchewan re-opened gates at Boundary and Rafferty reservoirs. Inflows at the Border increased to about 1,500 ft^3/s (42.5 m^3/s) by mid-April. Inflows from the Souris River and Moose Mountain Creek slowly increased the flow at the Border to a peak of 2,200 ft^3/s (62.3 m^3/s) on May 11th before declining to 303 ft^3/s (8.6 m^3/s) by the end of May. Runoff was unusually late and drawn out in Saskatchewan in 2001. Several peak flows occurred on Long Creek, followed by a slow but relatively high prolonged melt on the Upper Souris River and Moose Mountain Creek. Saskatchewan officials reported that normally runoff from the three rivers begins within a one week period; however, in 2001 there was a six week difference. Saskatchewan experimented with different flows from Rafferty Reservoir to determine impacts. At that time the maximum flow they planed to release was 1,590 ft^3/s (45 m^3/s). Since Rafferty water elevations exceeded the full supply level of 1806.1 ft (550.50 m), the oil wells in the upper end of the reservoir were reported to be de-mobilized so they could be flooded as needed without risk of damage or oil contamination to the reservoir.

Outflows from the Refuge were also increased in early April and climbed steadily to a peak flow of 2,210 ft^3/s (62.6 m^3/s) by May 7th, before declining to 77 ft^3/s (2.18 m^3/s) by the end of May. The end of month outflow was 226 ft^3/s (6.4 m^3/s) less than inflow. During this time, Lake Darling elevation peaked at 1596.63 ft (486.7 meters) on April 21st. The Fish and Wildlife Service made a decision, with the concurrence of the Corps of Engineers, to allow the elevation of Lake Darling to decline to 1596.05 ft (486.5 m) by May 5th to gain storage space. The purpose of the drawdown was to permit lower outflows as Saskatchewan releases began to taper off, somewhat reducing the duration of higher downstream flows. Subsequently, the lake elevation began to increase slowly in anticipation of tapering flows from Saskatchewan that did not occur as planned, because of additional runoff from Moose Mountain Creek. The Fish and Wildlife Service made a decision with concurrence by the Corps of Engineers to reduce Lake Darling for a third time to gain storage space. By May 29th the elevation of the Lake was 1595.97 ft (486.5 m) and the outflow was 112 ft^3/s (3.2 m^3/s), 185 ft^3/s (5.2 m^3/s) less than inflow.

Manitoba was in general agreement with the operation of reservoirs in Saskatchewan and North Dakota, which was well co-ordinated by conference calls. Manitoba was in agreement with increasing releases to above non-regulated flows in early May to reduce the duration of downstream flooding.

The total provisional inflow measured at Sherwood for the first five months of the year was 213,438 ac-ft (263 276 dam^3). This was 257 percent of the historic annual inflow (January-May), which was 83,061 ac-ft (102 454 dam^3) for the 65 year (water year) period from 1936 through 2000. Total provisional outflow measured at Baker Bridge on the south end of Upper Souris Refuge for the first five months of 2001 was 213,150 ac-ft (262 921 dam^3). The lake elevation on May 31st was 1596.26 ft (486.5 m) with 101,794 ac-ft (125 561 dam^3) in storage. The Lake Darling elevation on June 1st was 1596.34 ft (486.6 m).

Throughout the summer, water passed through the Refuge from flows received from Alameda and Rafferty reservoirs. Lake Darling filled to its full supply level of 1597.0 ft (486.8 m) on June 20th. This was also the peak elevation for the year. Following this date, outflows were increased to match inflows. Flows of approximately 120 to 225 ft^3/s (3.4 to 6.4 m^3/s) were released throughout the summer. Lake Darling gates were closed for the first time in 2001 on October 19th. The lake elevation was 1595.83 ft (486.4 m). Because of anticipated winter flows at the Border, the gates were re-opened October 30th to lower the lake to 1595.8 ft (486.4 m) and were closed on November 16th. The lake was lowered so it would not exceed the 1989 International Agreement target elevation of 1596.0 ft (486.5 m) by February 1st.

Total yearly provisional inflow at Sherwood was 253,485 ac-ft (312 674 dam^3). This was 254 percent of the historic average annual inflow (water year), which was 99,736 ac-ft (123 023 dam^3) for the 63 year period from 1938 through 2000. Total yearly provisional outflow measured at the Souris River near Foxholm gage on the south end of Upper Souris Refuge was 247,960 ac-ft (305 859 dam^3). This was 260 percent of the historic average annual outflow (water year), which was 95,330 ac-ft (117 588 dam^3) for the 63 year period (1938 through 2000). Total outflow was 5,525 ac-ft (6 815 dam^3) less than total measured inflow. Water was released throughout the year, except for the last half of October and from November 17th to the end of the year. The Des Lacs River contributed 8,690 ac-ft (10 719 dam^3) during the year. The flow peaked at 147 ft^3/s (4.2 m^3/s) on March 29th. The yearly flow through Minot was 250,900 ac-ft (309 486 dam^3). Flow through Minot peaked at 2,060 ft^3/s (58.3 m^3/s) on May 8th. On December 31, 2001, the Lake Darling water elevation was 1595.91 ft (486.4 m) with 98,466 ac-ft (121 458 dam^3) in storage and all gates were closed. The elevation of Lake Darling on February 1, 2002 was 1595.98 ft (486.5 m). **Figure 19** shows the 2001 operations undertaken at Lake Darling Reservoir. **Table 19** shows end of the month elevation and storage for all pools in the Upper Souris National Wildlife Refuge for 2001.

Table 19 - 2001 End of the Month Gage Heights and Water Storage
Upper Souris National Wildlife Refuge

2001	Pool 41		Pool 83		Pool A		Pool B		Pool C		Pool 87	
	Elev (ft)	Storage (ac-ft)	Elev (ft)	Storage (ac-ft)	Elev (ft)	Storage (ac-ft)	Elev (ft)	Storage (ac-ft)	Elev (ft)	Storage (ac-ft)	Elev (ft)	Storage (ac-ft)
Jan	E 1595.44	2,082	1595.83	97,708	1582.00	114	1579.50	91	1578.50	78	1578.50	670
Feb	E 1594.87	1,892	1595.23	92,057	1582.00	114	1579.50	91	1578.50	78	1578.30	636
Mar	E 1597.00	2,941	1595.65	96,007	1582.20	126	1580.00	126	1579.00	127	1577.70	551
Apr	E 1598.00	3,806	1596.31	102,271	1582.30	133	1580.00	126	1579.80	228	1579.80	969
May	E 1596.50	2,601	1596.26	101,794	1583.00	177	1579.70	104	1579.30	164	1578.40	653
Jun	E 1596.50	2,601	1596.95	108,412	1582.80	164	1579.70	104	1578.40	71	1578.20	620
Jul	E 1596.50	2,601	1596.90	107,930	1582.30	133	1579.50	91	1577.90	50	1578.00	591
Aug	1596.00	2,336	1595.38	93,464	1582.00	114	1578.90	55	1577.90	50	1577.90	577
Sep	E 1595.60	2,146	1596.00	99,320	1582.80	164	1578.40	31	1577.40	38	1578.40	653
Oct	E 1595.55	2,126	1595.95	98,845	1582.50	145	1578.10	19	1577.50	40	1578.00	591
Nov	E 1595.40	2,067	1595.80	97,424	1582.50	145	1578.10	19	1577.50	40	1578.30	636
Dec	E 1595.50	2,106	1595.91	98,466	1582.50	145	1578.00	16	1577.70	45	1577.90	577
Spillway Crest	1596.50	2,601	1598.00	118,630	E 1583.00	177	E 1580.50	179	E 1581.50	E 468	1578.20	620

E = Estimated.

Table 19 (Cont.) - 2001 End of the Month Gage Heights and Water Storage
Upper Souris National Wildlife Refuge

2001	Pool 87A		Pool 87B		Pool 96		Pool 96A		Pool 96B		Total Storage All Pools (ac-ft)
	Elev (ft)	Storage (ac-ft)	Elev (ft)	Storage (ac-ft)	Elev (ft)	Storage (ac-ft)	Elev (ft)	Storage (ac-ft)	Elev (ft)	Storage (ac-ft)	
Jan	1578.50	172	1575.90	11	1575.70	1,912	1579.10	108	1577.20	63	103,009
Feb	1578.50	172	1575.90	11	1575.50	1,796	1579.10	108	1577.20	63	97,018
Mar	1578.50	172	1577.20	22	1575.60	1,853	1579.00	103	1577.00	53	102,081
Apr	1578.50	172	1579.00+	43+	1576.40	2,397	1577.70	37	1578.00	112	110,294
May	1578.80	205	1578.50	37	1577.80	3,755	1578.10	54	1577.60	86	109,630
Jun	1577.50	71	1578.40	35	1577.70	3,641	1578.10	54	1577.60	86	115,859
Jul	1577.50	71	1578.20	33	1577.50	3,420	1577.90	45	1577.50	80	115,045
Aug	1576.80	26	1578.00	31	1576.00	2,105	1576.00	3	1575.50	10	98,771
Sep	1578.60	183	1577.20	22	1575.70	1,912	DRY	0	DRY	0	104,469
Oct	1578.20	139	1577.00	20	1576.00	2,105	DRY	0	DRY	0	104,030
Nov	1578.20	139	1577.00	20	1575.80	1,974	DRY	0	DRY	0	102,464
Dec	1578.20	139	1577.00	20	1575.70	1,912	DRY	0	DRY	0	103,426
Spillway Crest	1581.00	472	1578.50	37	1577.50	3,420	E 1580	164	E 1580	256	127,026

E = Estimated.
DRY = Water level below staff gage, indicating a dead pool.

During 2001 Lake Darling was managed by the Fish and Wildlife Service using the following spring runoff objectives:

1) Store water in Lake Darling to 1,597.0 ft (486.8 m) by June 1st for future refuge management uses.

2) Select releases that will help keep downstream flooding to a minimum, when possible.

3) Work with the North Dakota State Water Commission to receive water apportionment releases pursuant to the natural hydrograph if the runoff is less than a 10-year event.

4) Work with the North Dakota State Water Commission to fulfill legal obligations of senior water right holders.

5) If the predicted runoff is equal to or greater than a 10-year event, Coordinate and cooperate with the Corps of Engineers to operate Lake Darling dam gates to pass and/or store flood flows coming into Lake Darling pursuant to the International Agreement operating plan.

6) Pass runoff through the Refuge as quickly as possible, while reducing peak flows and decreasing the duration of the recession flows.

Since the spring runoff was greater than a 10-year event and ample runoff occurred, objectives 2, 4, 5 and 6 were accomplished. Because of summer-long releases from Saskatchewan, objective 1 was accomplished in late June. All senior water right holders received ample water.

6.5. J. Clark Salyer National Wildlife Refuge

6.5.1. Inflow

Significant local runoff plus releases from dams in Saskatchewan produced flood conditions on the Refuge from early April through early June. Favorable melting conditions reduced the local contribution. Total inflow at Bantry was 322,350 ac-ft (397 616 dam^3) for the calendar year or 197 percent of the historic annual discharge, which averaged 163,313 ac-ft (201 445 dam^3) for the 63 year period from 1938 through 2000. Measured inflow at Willow Creek and Deep River were 87,081 ac-ft (107 414 dam^3) and 15,910 ac-ft (19 625 dam^3), respectively. Total measured inflow to the Refuge was 425,341 ac-ft (524 654 dam^3).

Flow at Bantry peaked at 2,260 ft^3/s (64 m^3/s) on April 6th. Bantry flow remained above 1,000 ft^3/s (28.3 m^3/s) until June 1st and above 500 ft^3/s (14.2 m^3/s) until June 12th. Souris River flow at Bantry dropped below 200 ft^3/s (5.7 m^3/s) on July 19th, but rose again to 368 ft^3/s (10.4 m^3/s) on July 28th. Willow Creek flow peaked at 1,770 ft^3/s (50.1 m^3/s) on April 11th and remained above 200 ft^3/s (5.7 m^3/s) until May 22nd. Summer rains brought Willow Creek flows up to 462 ft^3/s (13.1 m^3/s) on August 7th.

6.5.2. Impoundment Operation

About 129 ft^3/s (3.7 m^3/s) was being passed to Manitoba at the beginning of the year. Flow through the Refuge pools was reduced to approximately 52 ft^3/s (1.47 m^3/s) in the first week of January to compensate for reduced inflow. Water from the increased Lake Darling release did not appear at the Refuge until the first week of March. Movement of gates to pass runoff and reservoir releases began on March 6th. Gates were operated to pass inflow and minimize pool elevation increases throughout the period. Water passed uncontrolled through the gates at Dams 320, 332 and 341 for most of April and May and through the Dam 326 gates for a short time in late May. Flow was being controlled by June 4th at all structures except at Pool 341 which was scheduled for drawdown.

Volume in the five major refuge impoundments peaked at approximately 86,804 ac-ft (107 072 dam^3) on April 17th, 47,370 ac-ft (58 430 dam^3) above the planned management target. Total pool volume on May 31st was 6,001 ac-ft (7 402 dam^3) above the planned management volume and 5,163 ac-ft (6 269 dam^3) above the January 1st volume. A summary of end of the month elevation and storage for all pools in the J. Clark Salyer National Wildlife Refuge for 2001 is provided in **Table 20**.

The basic management strategy through the summer was to pass inflows, slowly bring pool elevations to target levels, and reduce water levels in the construction area along an area known as the Scenic Trail Auto Tour. Pool 326 was operated slightly below target for much of the summer to assist in passing flows. A slow reduction in the Pool 326 level was continued through the fall in anticipation of dewatering of this unit in 2002. The total storage at the end of the year was 15,340 ac-ft (18 922 dam^3) less than the January 1st storage.

6.5.3. Outflow

Total outflow measured at Westhope for 2001 was 497,440 ac-ft (613 587 dam^3). This was 72,099 ac-ft (88 933 dam^3) more than total measured inflow.

Flow at Westhope peaked at 3,290 ft^3/s (93.2 m^3/s) on April 11th and remained above 2,000 ft^3/s (56.6 m^3/s) until June 6th. Flow remained above 400 ft^3/s (11.3 m^3/s) most of the time until the end of August and above 200 ft^3/s (5.7 m^3/s) until September 22nd. Flow at the Westhope gage was 72 ft^3/s (2.04 m^3/s) at the end of the year.

Outflow during the June 1st to October 31st period was 136,100 ac-ft (167 878 dam^3), 130,031 ac-ft (160 392 dam^3) above the 6,069 ac-ft (7 486 dam^3) required minimum. The lowest recorded flow during this period was 67 ft^3/s (1.90 m^3/s), well above the required 20 ft^3/s (0.57 m^3/s) minimum. The low flow structure was not used.

Table 20 – 2001 End of the Month Gage Heights and Water Storage
J. Clark Salyer National Wildlife Refuge

2001	Pool 320		Pool 326		Pool 332		Pool 341		Pool 357		Total Storage All Pools (ac-ft)
	Elev (ft)	Storage (1) (ac-ft)	Elev (ft)	Storage (1) (ac-ft)	Elev (ft)	Storage (1) (ac-ft)	Elev (ft)	Storage (1) (ac-ft)	Elev (ft)	Storage (1) (ac-ft)	
January	1420.5	342	1420.5	11,356	1418.0	4,001	1415.7	5,014	1414.5	16,233	36,946
February	1420.5	342	1420.5	11,356	1418.0	4,001	1415.7	5,014	1414.5	16,233	36,946
March	1423.1	3,272	1422.1	20,067	1419.4	9,468	1416.3	6,462	1414.6	16,579	55,848
April	1424.8	8,596	1421.8	18,321	1419.5	9,889	1417.5	10,004	1417.1	30,607	77,417
May	1424.4	7,111	1420.6	11,846	1418.0	4,001	1416.0	5,718	1414.6	16,759	45,435
June	1424.1	6,090	1421.3	15,516	1418.7	6,613	1414.5	2,493	1413.4	10,799	41,511
July	1424.5	7,469	1421.8	18,321	1419.0	7,812	1414.4	2,339	1412.7	7,787	43,728
August	1423.5	4,266	1420.9	13,371	1418.2	4,721	1414.3	2,198	1413.1	9,454	34,010
September	1423.2	3,503	1420.6	11,846	1417.5	2,534	1413.5	1,411	1413.3	10,344	29,638
October	1422.5	2,090	1420.3	10,404	1417.9	3,659	1414.4	2,339	1413.1	9,454	27,946
November	1422.2	1,611	1419.7	7,753	1417.6	2,779	1415.0	3,438	1413.3	10,344	25,925
December	1422.0	1,333	1419.8	8,174	1417.4	2,313	1415.1	3,658	1413.1	9,454	24,932
Spillway Crest	1425.8	12,879	1423.2	26,589	1419.6	10,313	1418.2	12,235	1418.0 (2)	35,765	97,781

(1) All storage volumes were calculated using 1988 area capacity tables, and all figures are for the end of the month.
(2) Maximum management level is at top of gates at elevation 1415.0.

7. IMPACTS OF THE 2001 SOURIS BASIN FLOOD

7.1. Saskatchewan

Overall, flood impacts in the Saskatchewan portions of the upper Souris basin were relatively subdued with only minor nuisance flooding occurring, affecting some rural roads and farmland. An unusually late melt of the Moose Mountain Creek basin in late April and early May produced some minor highway flooding in the Kisbey flats area. The slow sporadic melt pattern evident in the 2001 runoff along with high snowpack sublimation losses helped to lessen the threat. In addition, substantial pre-flood drawdowns made adequate flood control storage available for the anticipated runoff. Based on lessons learned from the 1999 Souris basin flooding, Rafferty releases were held at a level commensurate with frequency of the overall event. In this case, releases did not exceed 45 m^3/s (1,590 ft^3/s), a level that would not cause flooding in the Estevan area.

7.2. North Dakota

In North Dakota flooding impacts from the spring snowmelt runoff were mostly confined to the lower reaches of the Souris from Towner to Westhope, where river levels rose to generally 2 to 4 feet above flood stage, peaking in late March and early April. The upper Souris River in Ward County was less affected with the Souris River cresting below flood stage. A notable exception was the Souris River near Foxholm, where the passing of the flow releases from the Canadian reservoirs raised river levels almost 4 feet above flood stage.

Typical of the flooding damage was overland flooding in McHenry County, which nearly surrounded a home in the city of Upham. Also in neighboring McHenry County, floodwaters inundated four roads in Willow Creek Township. In nearby Pierce County, three roads were inundated by runoff in areas where significant amounts of rain fell before the fall 2000 freeze-up. Agricultural interests such as the Eaton Irrigation District in Towner, ND were also affected by the wet field conditions, which delayed getting water off of fields.

The North Dakota Agricultural Statistics Service reported in mid-April that the spring precipitation across most of the state in early April had delayed the start of fieldwork. The wet conditions made calving and lambing difficult and were causing problems in three feedlots. Topsoil moisture supplies were 59 percent adequate to 41 percent surplus, compared to 1 percent short, 7 percent short, 70 percent adequate and 22 percent surplus for the five previous years, respectively. North Dakota Agricultural Statistics Service reported that the starting date for fieldwork was April 29th, behind both the previous year's start of April 17th and the five-year average starting date of April 24th. The cool, wet spring hampered planting progress.

In Bottineau County, officials for the cities of Newburg and Westhope issued emergency declarations, while officials for the cities of Kramer and Souris declared disasters. Also in Bottineau County, city officials from Antler, Bottineau, Maxbass, and Willow City issued disaster/emergency declarations.

At the request of North Dakota Governor Hoeven, President Bush ordered the release of federal disaster funds to help communities in eastern and central North Dakota recover from damages caused by the 2001 flooding, severe storms and ground saturation. Included in the declaration, FEMA-1376-DR-ND, were the Counties of Bottineau, McHenry, Pierce and Rolette in the Souris basin.

A series of random violent thunderstorms impacted the state of North Dakota from June through early August. Officials from Rollette County reported the city of Rolla received 5 inches (130 mm) of rainfall over a 2-hour time period on July 17th, which resulted in extensive sheet runoff flooding. Several homes and businesses experienced basement flooding, while inundation of storm drains caused water to flood sewer lift stations. Bottineau County officials received reports that water had infiltrated basements, when gusty winds and heavy rain impacted the area on July 27th. Other damages included road and culvert washouts. Rainfall amounts ranged from 1.5 inches (40 mm) in Lansford to 6.5 inches (170 mm) in Maxbass. Some areas of Rolette County received up to 10 inches (250 mm) of rain in July. Water seepage in basements and mold were recurring problems for homeowners. In McHenry County, where crops were lodged, up to six inches (150 mm) of rain fell during a 12-hour period on July 27th. Pierce County officials reported more damage sites on roads after 7.33 inches (190 mm) of rain fell from July 6th to July 27th. All of these larger events were localized.

7.3. U.S. Fish and Wildlife Service Refuges

On January 1st, Lake Darling was completely frozen with a good snow covering. Ice thickness eventually reached an average of 42 inches (107 cm). Snow depths varied from very little snow to approximately 8 inches (20 cm). This was the first year that water with a flow of at least 350 ft^3/s (9.9 m^3/s) was flowing under the ice since February 21st.

The U.S. Fish and Wildlife Service identified several impacts and concerns from the 2001 flood associated with the J. Clark Salyer Refuge. Slow refilling of Pool 320 during the early growing season to enhance the effects of the delayed 2000 drawdown was not possible, and habitat damage occurred in all other major marsh impoundments. Strong inflow through the summer delayed dewatering of Pool 341, and desired effects were not fully achieved. Additional dike and island erosion was experienced in Pools 320, 326 and 341. The Scenic Trail Auto Tour again received significant damage, as in 1999. Water was still over the road in six places in early June, and summer rains caused re-flooding of the segment near Willow Creek. Planned rehabilitation of the Scenic Trail was delayed until fall, and one segment was not completed because of lingering wet conditions and higher than anticipated construction costs resulting from site conditions.

Other impacts and concerns noted by the Fish and Wildlife Service focused on modifications to Dams 83, 87 and 96 on Upper Souris National Wildlife Refuge above Minot. They deal with the performance of modifications made to these dams by the U.S. Army Corps of Engineers, as part of the Souris Basin Project. The specific impacts and concerns are noted below.

1) The discharge table for the tainter gates at Dam 83 (Lake Darling Dam) was not accurate, particularly at the lower end of the 1999 flow releases. The discharge tables showed higher

flows being released than actually occurred, when compared to the USGS gage flows at the Baker Bridge downstream. The U.S. Geological Survey recorded spring flow measurements below the dam in 1999 and Refuge staff recorded numerous flow observations from the Baker Bridge and gate openings from Lake Darling. After the 2001 flood began, an updated Lake Darling rating table was received. In 2001 the updated tables were underestimating the discharges by approximately 100 ft^3/s (2.8 m^3/s) at the discharge setting for 1,300 ft^3/s (36.8 m^3/s). With the gates set to release 1,900 ft^3/s (53.8 m^3/s), the Foxholm gage recorded 2,240 ft^3/s (63.4 m^3/s). The discharge errors evident in 2001 may have been caused in part when the Corps of Engineers adjusted the gate opening indicators in 2000. Subsequently, the rating table was adjusted and reprinted in the Draft March 2004 Water Control manual for the Souris River flood control project, published by the Corps of Engineers.

2) At the recommendation of the Corps of Engineers in March, operation of tainter gates 3 and 4 on Lake Darling dam were minimized. In August 2000, an inspection of the gates revealed cracks in the epoxy paint in the lower strut arm connections. Not knowing the extent of the damage to the gates, the Service chose not to use them. In the summer of 2001, the Corps of Engineers, scraped, electronically inspected and repainted the cracked areas. No cracks in the steel or welds were observed upon inspection and the gates were returned to full service.

3) A flow constriction problem in the vicinity of Dam 87, identified in 1999, was corrected by the Corps of Engineers in the fall of 2000. The Corps contracted to remove dirt from approximately 700 ft of river bank to allow water above elevation 1578.7 ft (481.2 m) to flow around Dam 87 by way of the lowered river bank. In 2001 water began to flow over the west end of the new spillway at an elevation of 1579.1 ft (481.3 m). The Dam 87 gate was wide open and approximately 1,300 ft^3/s (36.8 m^3/s) was flowing over the structure. Since the new spillway was not vegetated, an erosion mat was placed to prevent erosion. Following the flood, the spillway was leveled and seeded. It appears that several inches of soil were lost during the flood which should bring the spillway closer to design elevation.

4) 1999 was the first year that a discharge/flow problem was documented at Dam 96. When discharges exceeded approximately 2,000 ft^3/s (56.6 m^3/s), the flow could not be passed without undesirable backwater effects, even with both gates wide open. The result was the pool level increased above the spillway level of 1577.5 ft (480.8 m) to 1578.2 ft (481 m) at a discharge of 2,600 ft^3/s (73.6 m^3/s). Because almost the entire spillway was blocked with rooted cattails, water could not efficiently flow over the 700 ft (213.4 m) long spillway, causing the pool water level to go higher than if the cattails were not present. Operating Pool 96 above the spillway elevation raises the water level under Silver Bridge located less than 1 mile upstream. This causes further water constriction problems upstream to the Lake Darling embankment. In the fall of 2000, the Fish and Wildlife Service sprayed the cattails in front of the Dam 96 spillway with Rodeo, a systemic herbicide used to kill plants. After the cattails became dormant, they were burned to provide a short term solution for removal of the cattail obstruction. In 2002 the Service removed some of the silt in front of the Dam 96 spillway to further discourage cattail growth. In 2001 a maximum discharge of 2,200 ft^3/s (62.3 m^3/s) was passed through two wide open tainter gates with the pool elevation reaching 1577.3 ft (480.8 m). There was no vegetation obstructing the spillway. The effects of high

downstream backwater levels on the discharge capacity of the two tainter gates at Dam 96 continues to be closely watched under the Corp's operation and maintenance program.

5) The Dam 96 tainter gate rating tables had not been updated since discharge and water elevation measurements taken in 1999 and 2001 indicated that the tables were not correct. The Service recommended that the spillway crest be surveyed before developing new tables, as the top elevation varies at least several tenths of a foot from east to west. Notes taken in 1999 and 2001 were given to the Corps of Engineers in early 2002 and the tables were corrected.

7.4. Manitoba

The channel capacity of the Souris River in Manitoba varies from about 150 ft^3/s (4.2 m^3/s) near the Border, to about 1,400 ft^3/s (39.6 m^3/s) through Melita, to about 1,100 ft^3/s (31.1 m^3/s) near Lauder and 1,700 ft^3/s (48.1 m^3/s) near Hartney. North of Hartney the capacity increases to about 3,000 ft^3/s (85 m^3/s) and more. The river drops only about 6 in (15 cm) per mile between the Border and Hartney. The limited channel capacity and flat gradient of the Souris River from the U.S. Boundary to Hartney make this reach of the Souris River particularly susceptible to rural and agricultural flooding.

Flooding in the Manitoba portion of the basin from the U.S. Boundary to Hartney began in late March and continued until mid June. Flooding on tributaries was avoided due to the gradual melt, except along Pipestone Creek where some flooding occurred during April. Peak river levels in Manitoba were 2 to 4 feet lower than in 1999 and the duration of flooding was about one month less than in 1999.

The nature of the flood damages in Manitoba along the Souris River were very similar to those experienced along the lower Souris River in North Dakota. High upstream runoff combined with spring and early summer rainfall resulted in a prolonged period of moderate flooding of low areas with saturated field conditions from March through mid-June. The flooding washed out roads and culverts and caused a loss of agricultural productivity throughout this part of the basin in Manitoba in 2001. The loss was primarily due to late planting or the inability to plant seed in the wet ground, resulting in the lack of a crop for the year.

Souris River flows were above average throughout the summer and fall, despite dry weather, largely due to a high base flow and storage releases from the U.S. portion of the watershed. Dry weather from August onward resulted in a rapid decline of farm dugouts, some of which could not be filled before winter due to a lack of water sources.

8. EFFECTIVENESS OF THE SOURIS RIVER BASIN PROJECT

The operation of the Souris Basin Project in 2001 was effective in meeting flood control objectives for reducing flooding in the Minot area, where little flood damage occurred. Although minor to moderate flooding occurred further downstream in the rural agricultural reaches of the Souris River from Towner to Wawanesa, basin interests were generally pleased with the management of 2001 flood flows. Efforts were made by dam operators in Canada and the United States to lessen the duration of overbank flows through judicious use of reservoir storage at the proper time.

Figure 20 provides a graph of regulated versus non-regulated flows for the Souris River at Sherwood for the February 1st - October 31st period. From this graph one can readily see a significant reduction between the regulated flow that actually was observed at Sherwood versus the non-regulated flow that would have occurred without the storage afforded by the Canadian reservoirs. The peak flow was reduced by about 47 percent without an undue increase in the magnitude or duration of late spring and summer flows.

A progression of the flood hydrographs from Sherwood to Wawanesa is shown in **Figure 21**. It is readily apparent from this hydrograph progression that the upper Souris River was within the summer flow of 500 ft^3/s (14.2 m^3/s) required by Annex A of the 1989 Agreement and that river flows downstream of Verendrye were substantially higher. The relatively higher flows on the lower Souris were the result of saturated soil moisture conditions and generally higher spring and early summer rainfall than received in the more western portions of the basin.

9. REVIEW OF 1999 RECOMMENDATIONS AND 2001 LESSONS LEARNED

9.1. Review of 1999 Souris Post-Flood Report Recommendations and Actions Taken

Following the severe flooding in the Souris basin in 1999, the Corps of Engineers prepared and published a post-flood report on the event. The report, dated October 15, 2003, looked at a number of issues related to the first-time flood control operation of the Souris Basin Project under the 1989 Agreement between the Governments of Canada and the United States for water supply and flood control in the Souris basin. Based upon the information and conclusions presented in that report, four recommendations were offered to help improve the future operation of the project. These recommendations were the direct result of “lessons learned” and experience gained in operating the Souris Basin Project during the 1999 flooding in the Souris River basin. It was noted that implementation of these recommendations was the responsibility of the Governments of Canada and the United States and their “Designated Entities” (see Section 4.1) having operation and liaison responsibilities for the Souris Basin Project and responsibility for monitoring of the operation plan contained in Annex A of the 1989 International Agreement.

It is useful here to document the status of actions taken to-date on those recommendations. The four recommendations are listed below along with the current status of implementation.
Recommendation 1 – The “Designated Entities” must ensure that terminology used in runoff forecasts for the Souris Basin Project is commonly understood by all users and consistent with Annex A of the International Agreement, now and in the future.

Action Taken – During and following the 1999 flood event, members of the FFOCG, SRFFLC and Sask Water worked to develop more universally understandable language for the Sask Water spring runoff forecasts, consistent with Annex A. This effort continued into the 2001 flood event in which the forecast language and format were further refined (see **Tables 9-18** for forecast examples). Although the language and format of the forecasts are adequate, further refinements are desireable.

Recommendation 2 – The "Designated Entities" should establish a continuing review process to discuss runoff forecasting techniques and deficiencies, striving to ensure availability of the best possible forecasts for operational decision-making.

Action Taken – Although individual agencies involved in preparation and use of the spring runoff forecasts are certainly accomplishing a certain level review within their respective agencies, more emphasis needs to be put forth on establishing a regular collective review process. During the 1999 flood and since, some FFOCG members have expressed the view that additional sources of spring flow and volume forecasts would be helpful to lend confirmation to existing Sask Water forecasts and provide a safeguard against potential forecast errors during unusual or difficult forecasting circumstances. Possible sources that were mentioned included an updated flood-forecast model being developed by the National Weather Service and development of a Corps of Engineers model for the basin using the Corps Water Management System (CWMS) modeling suite. The NWS has since implemented their Advanced Hydrologic Prediction Service. Some work has been done to date on development of the Corps CWMS model, but funding has been a recent issue.

Recommendation 3 – The "Designated Entities" should resolve outstanding issues and be prepared to resolve any new issues that might arise with respect to the Interpretation of Annex A of the 1989 International Agreement. These issues include, but are not limited to the "Target Flow" and "Maximum Controlled Flow".

Action Taken –Little or no action has been taken to date on this recommendation, although changes in agency representation since 2001 have resulted in a move toward closer agreement over the differences discussed in the 1999 Souris Basin Post-Flood Report. Members of the FFOCG and The Natural Flow Methods Committee (NFMC) of the ISRB have discussed and considered moving forward on resolving these outstanding issues with a greater sense of urgency in recent years.

Recommendation 4 – The "Designated Entities" should undertake a thorough review of the operating plan in Annex A and establish policies to ensure periodic future reviews consistent with the provisions of Article V of the 1989 International Agreement.

Action Taken – Since the 1999 and 2001 floods, the need for a thorough review of Annex A has been a topic of discussion between members and staff of the ISRB as well as the NFMC and FFOCG. To date there has been no action beyond discussing the need, but there is general agreement that the time has come to accomplish this action. Inasmuch as the operation plan has not been reviewed or revised, since the completion of the project in the early 1990's, it seems appropriate that such a review be undertaken in the very near future. Funding may be an issue regarding accomplishment of this needed work.

9.2. 2001 Lessons Learned

The USGS reported dangerous ice conditions in the form ice layering at the Sherwood, Verendrye, Bantry, and Westhope gages in February that resulted in delays in obtaining mid-winter discharge measurements to monitor early pre-flood drawdown releases from Alameda Reservoir and Lake Darling. Although the Alameda Reservoir releases reached the Sherwood gage on February 20th, it was more than a month later that the first discharge measurement could be safely made. Measurements were attempted five times before conditions allowed completion of an accurate measurement. The dangerous ice conditions prohibited measurements by the USGS at the Verendrye, Bantry, and Westhope gages until late March to early April.

The layers of ice at Sherwood were most likely formed during the fall of 2000 when stepped down releases from Alameda Reservoir reached the Border during freezing weather in November. If releases had been stopped earlier, this may not have happened. Lake Darling releases occurred from mid-November 2000 until about February 10th. During this time flows increased, decreased and increased within a range of about 25 ft^3/s to 60 ft^3/s (0.7 m^3/s to 1.7 m^3/s). This may have caused some of the ice layering problems downstream at Verendrye, Bantry, and Westhope, but these locations have always been problems, because they are flat without much channel slope to help get the river open early in the spring. Subsequent to February 10th, Lake Darling releases were increased further to help condition the river channel by eroding the ice and to accomplish the required pre-flood Lake Darling drawdown to elevation 1595.0 ft, based upon the February 1st Sask Water forecast.

There is a lesson to be learned with regard to preventing the occurrence of the dangerous ice conditions that formed during the winter of 2000 and 2001. When winter releases are required to condition the downstream ice and/or accomplish evacuation of reservoir storage, it is desirable that outflows should be ramped up slowly or maintained. Decreasing outflows should be avoided during the winter months, if at all possible. Accurate winter flow measurements are important to the decision process of reservoir managers.

One of the major lessons learned from the 1999 flood event was that basin interests, especially the agricultural interest along the lower Souris River from Towner in North Dakota to Hartney, Manitoba, were universally willing to deal with higher spring releases to shorten the duration of flooding and hasten the return of the river to within its banks.

In 2001, an effort was made by the Fish and Wildlife Service and the Corps to reduce the duration of the flooding on the lower Souris by making higher releases from Lake Darling on two occasions to make more flood control storage available. In late April and again in late May, Lake Darling was lowered about 0.5 ft (0.15 m) to 0.75 ft (0.23 m). This temporarily increased downstream flows slightly above what they otherwise would have been, but allowed an earlier return of the river to within its banks, shortening the duration of overbank flooding slightly. It was not an overwhelming accomplishment to be sure, but it demonstrated to those affected by the flooding, a willingness on the part of the dam operators to help their situation. These efforts were well coordinated with Manitoba. Interests downstream of Hartney, Manitoba were in general agreement with the operation of reservoirs in Saskatchewan and North Dakota.

Manitoba was in agreement with increasing releases to above non-regulated flows in early May to reduce the duration of downstream flooding.

Discussions between some FFOCG members, following the 1999 flood event, highlighted an area of consideration with respect to the Sherwood Crossing target flow for that event. For any given frequency of flood exceeding the 10-year event trigger defined in Annex A, the target flows at the Sherwood Crossing are defined in Annex A. The flow at Sherwood Crossing is comprised of the routed releases from Boundary, Rafferty and Alameda reservoirs and the local flow between the dams and the International Boundary. Due to unique circumstances in 1999 with Alameda Reservoir still filling, having never attained its FSL since completion of construction, nearly all of the spring runoff into that reservoir was able to be stored. This left only the routed Boundary and Rafferty Reservoir releases and local runoff available to meet the Sherwood Crossing target flow. In retrospect, this placed an unfair burden on Rafferty Reservoir releases as the FFOCG attempted to meet the 10-year target flows at the Border in 1999. It was felt that the areal distribution of runoff in the Souris River basin and its potential impact on needed releases from Rafferty and Alameda reservoirs should be carefully considered in the future. In attempting to meet the Sherwood Crossing target flow, care should be exercised that unintentional flooding does not result below the Canadian reservoirs.

This issue came up again during the 2001 flood event. Based upon the February 1st Sask Water forecast, a Sherwood Crossing target flow of 90 m^3/s (3,180 ft^3/s) was indicated. However, runoff into Rafferty Reservoir began in the latter half of March, while runoff into Alameda did not commence until over a month later. For Sask Water to have provided sufficient flow to hit the indicated target flow would have caused unnecessary flooding in the Estevan area at a greater frequency than the overall 10-year event. Sask Water worked to find the highest combined release rate 45 m^3/s (1,590 m^3/s) from Rafferty and Boundary reservoirs without causing unintentional flooding in the Estevan area.

Since 1999 much improvement has been made in coordination with Sask Water, other agencies and the public involved in the flood damage reduction operations on the Souris River. Cooperation and coordination during the 2001 flood event continued this trend toward improvement.

10. SUMMARY

The 2001 flood in the Souris River basin produced minor flooding in Saskatchewan and the upper Souris River downstream to Verendrye. The lower Souris basin from Towner, North Dakota to Hartney, Manitoba experienced minor to moderate flooding. The flooding was the result of a combination of high fall moisture conditions in the eastern portions of the basin, a heavy snowpack in Saskatchewan above Rafferty and Alameda reservoirs and persistent spring rainfall. River levels on the lower Souris River below Towner peaked generally 2 to 4 feet above flood stage, 2 to 4 feet below 1999 levels. On the upper Souris River, levels peaked mostly at below flood stage levels with a few exceptions.

Initial flood forecasts by the NWS indicated that the lower Souris basin was likely to experience moderate to major flooding. However, the snowmelt in the basin in 2001 came early, beginning just after mid-March, and was characterized by a slow sporadic melt with alternating freezing and thawing, which served to lessen the flood potential. A delayed melt above Alameda Reservoir on Moose Mountain Creek served to further reduce the flood threat.

At the same time, major flooding in the Red River Valley coupled with widespread agricultural losses statewide from the saturated spring ground conditions prompted a FEMA disaster declaration on May 28th. Subsequently, sporadic heavy thunderstorms from June through August caused widespread damage throughout eastern North Dakota, including Bottineau, McHenry, Pierce and Rolette counties in the Souris basin. Localized heavy rainfall amounts of up to 10 inches (250 mm) were reported.

Flood impacts were moderate, but widespread through out the lower reaches of the lower Souris River in North Dakota and Manitoba. While overbank flooding from the Souris River played a key role in flood losses, interior drainage problems associated with standing water from the persistent and heavy rains of May through August, resulted in damages to infrastructure and agriculture. Numerous rural, county and township, state and provincial road washouts and closures were reported and access to some rural communities and farms was restricted or non-existent at various times. A number of bridges and culverts in the basin were washed-out or damaged. Sanitary facilities, storm sewers and water supplies were threatened or affected. Widespread home basement flooding was reported. The harvesting of hay meadows along the lower Souris was delayed and crop planting was pushed back to April 29th as reported by the North Dakota Agricultural Statistics Service.

One of the major lessons learned from the 1999 flood event was that basin interests, especially the agricultural interests along the lower Souris River from Towner in North Dakota to Hartney, Manitoba, were universally willing to deal with higher spring releases to shorten the duration of flooding and hasten the return of the river to within its banks.

Efforts to implement a lesson learned from the 1999 flood event in the Souris basin met with some limited success. Dam operators attempted to reduce the duration of flooding and return the lower Souris River back within its banks sooner, through prudent and judicious use of reservoir storage in Lake Darling. Peak flows at Sherwood were reduced by some 47 percent by the water stored in the Canadian reservoirs in 2001. All reservoir operations for the Souris Basin Project in 2001 were in compliance with Annex A of the 1989 International Agreement. Coordination and communication of reservoir operations among the reservoir regulators comprising the FFOCG was excellent, cooperative and much improved over that of the 1999 flood event.

Recommendations contained in the 1999 Post-Flood Report for the Souris River Basin were reviewed to determine the extent to which they have been implemented. It was found that Recommendations 1 and 2 dealing with spring runoff forecasts had received at least adequate attention. However, Recommendations 3 and 4 dealing with interpretation of certain terms in Annex A of the 1989 International Agreement and periodic reviews of the operating plan contained in Annex A, respectively, had received little action to date.

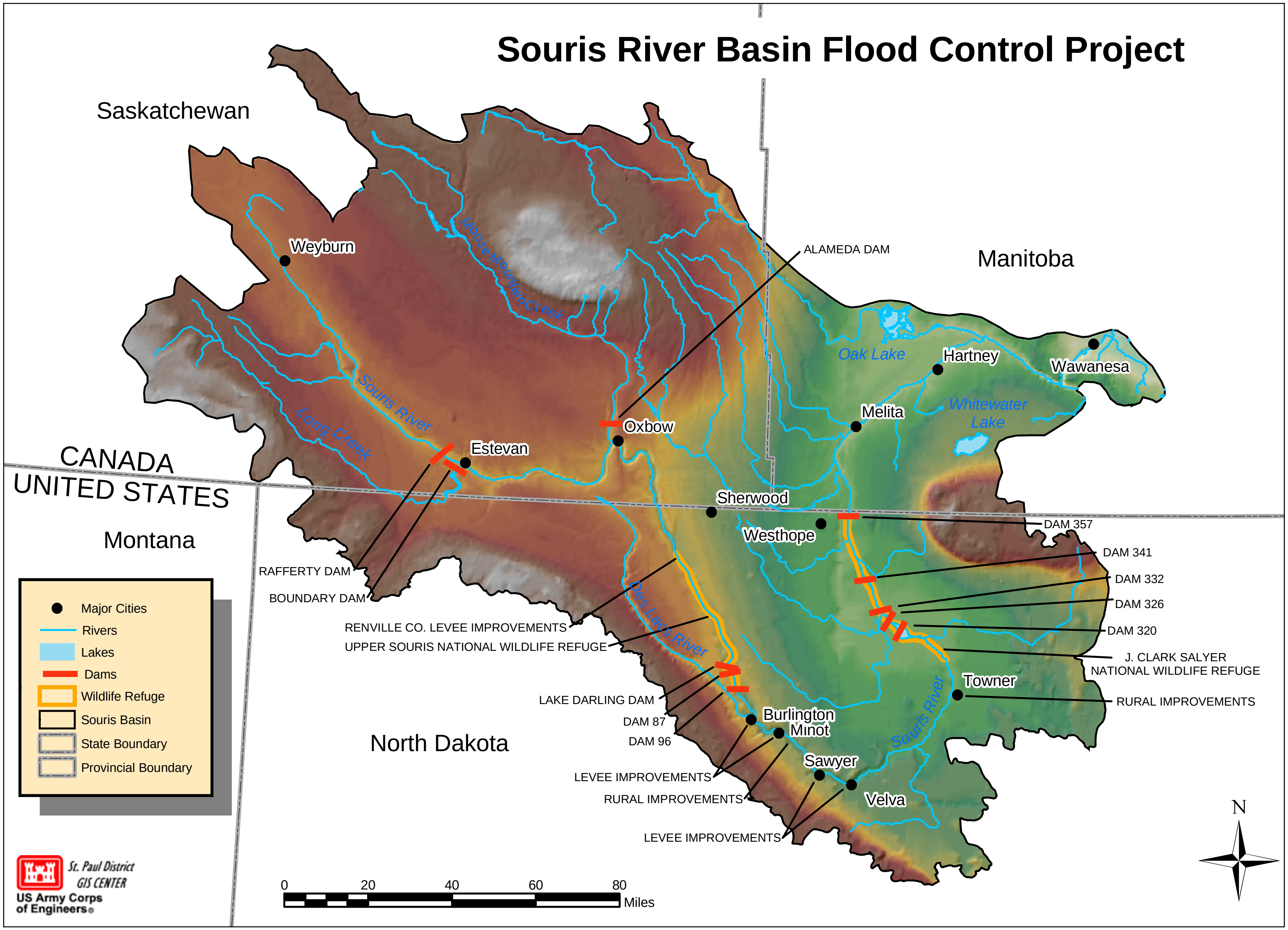
In the area of lessons learned it is desirable that reservoir outflows be ramped up slowly or maintained, when winter releases are required to condition the downstream ice and/or accomplish evacuation of reservoir storage. Decreasing outflows should be avoided during the winter months, if at all possible. These practices will help to avoid a future occurrence of the dangerous ice conditions that existed in the winter of 2000 and 2001 along portions of the Souris River.

Efforts aimed at reducing the duration of summer flooding through prudent and judicious use of Lake Darling storage for re-regulation purposes showed some limited success in 2001 and should be pursued and studied more closely in future flood events. The impact of the areal distribution of runoff above the Canadian reservoirs on meeting downstream target flows at Sherwood and Minot, without causing undue flooding below the reservoirs, should be considered carefully by Saskatchewan dam operators.

11. ACKNOWLEDGEMENTS

The preparation of this report was greatly facilitated by the contribution and use of various reports written by representatives of the agencies represented on the ISRB and associated with it. These agencies also supported the preparation of this report through their provision of the various data sets needed. This report is more a compilation of the work of these agency staff than an original work. Full acknowledgement is hereby given to the following agencies and groups and their staff, which include, but are not limited to, the U.S. Fish and Wildlife Service, Upper Souris and J. Clark Salyer National Wildlife Refuges; the U.S. Fish and Wildlife Service, Denver Regional Office; Saskatchewan Watershed Authority, Regina, Saskatchewan; the U.S. Geological Survey, Water Resources Division, Bismarck, North Dakota; the North Dakota State Water Commission; the U.S. National Weather Service, Bismarck, North Dakota; the Water Survey of Canada, Regina, Saskatchewan; Manitoba Water Stewardship, Winnipeg, Manitoba; the International Souris River Board; the International Souris River Board Natural Flow Methods Committee and Flow Forecasting Liaison Committee; Members of the FFOCG; and the North Dakota Division of Emergency Services.

APPENDIX A - FIGURES



\\mvpgis\data_arc\projects\souris_basin\arcgis_mxd_files\souris_basemap_rev23oct2003.mxd - ege 23 Oct. 2003

FIGURE 1

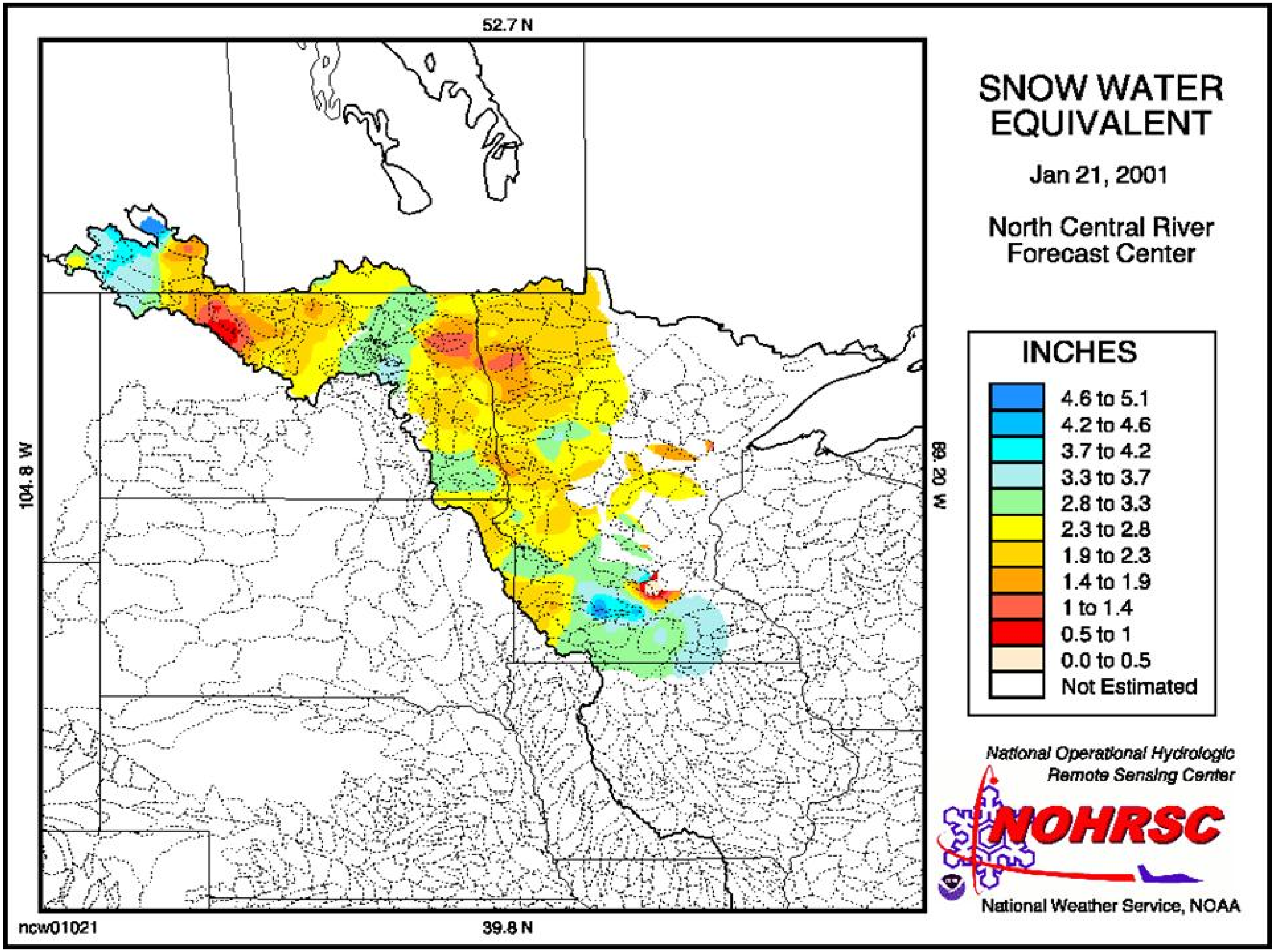

52.7 N
104.8 W
89.20 W
39.8 N
ncw01021
SNOW WATER EQUIVALENT
Jan 21, 2001
North Central River Forecast Center
INCHES
4.6 to 5.1
4.2 to 4.6
3.7 to 4.2
3.3 to 3.7
2.8 to 3.3
2.3 to 2.8
1.9 to 2.3
1.4 to 1.9
1 to 1.4
0.5 to 1
0.0 to 0.5
Not Estimated
National Operational Hydrologic Remote Sensing Center
NOHRSC
National Weather Service, NOAA

FIGURE 2

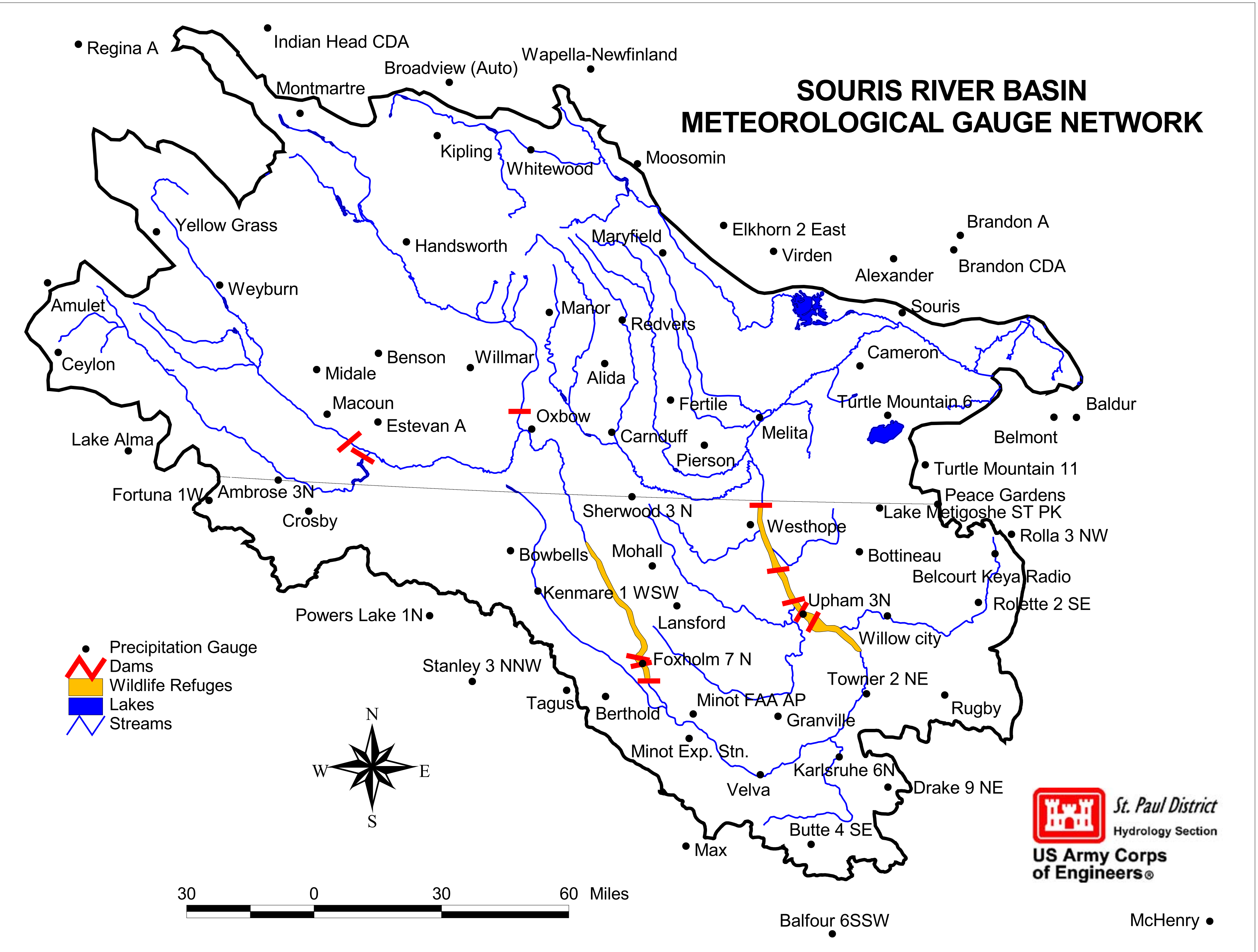
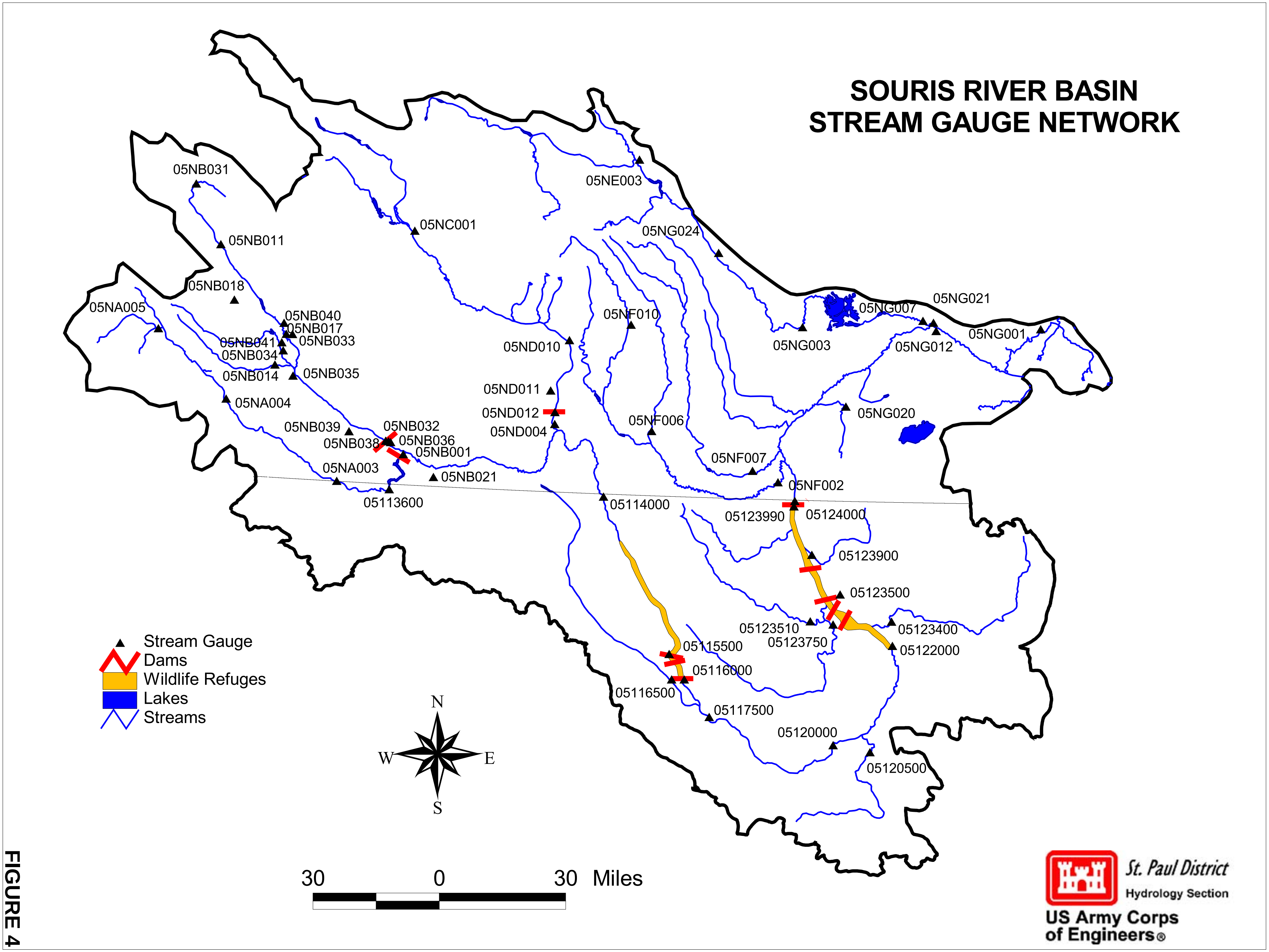
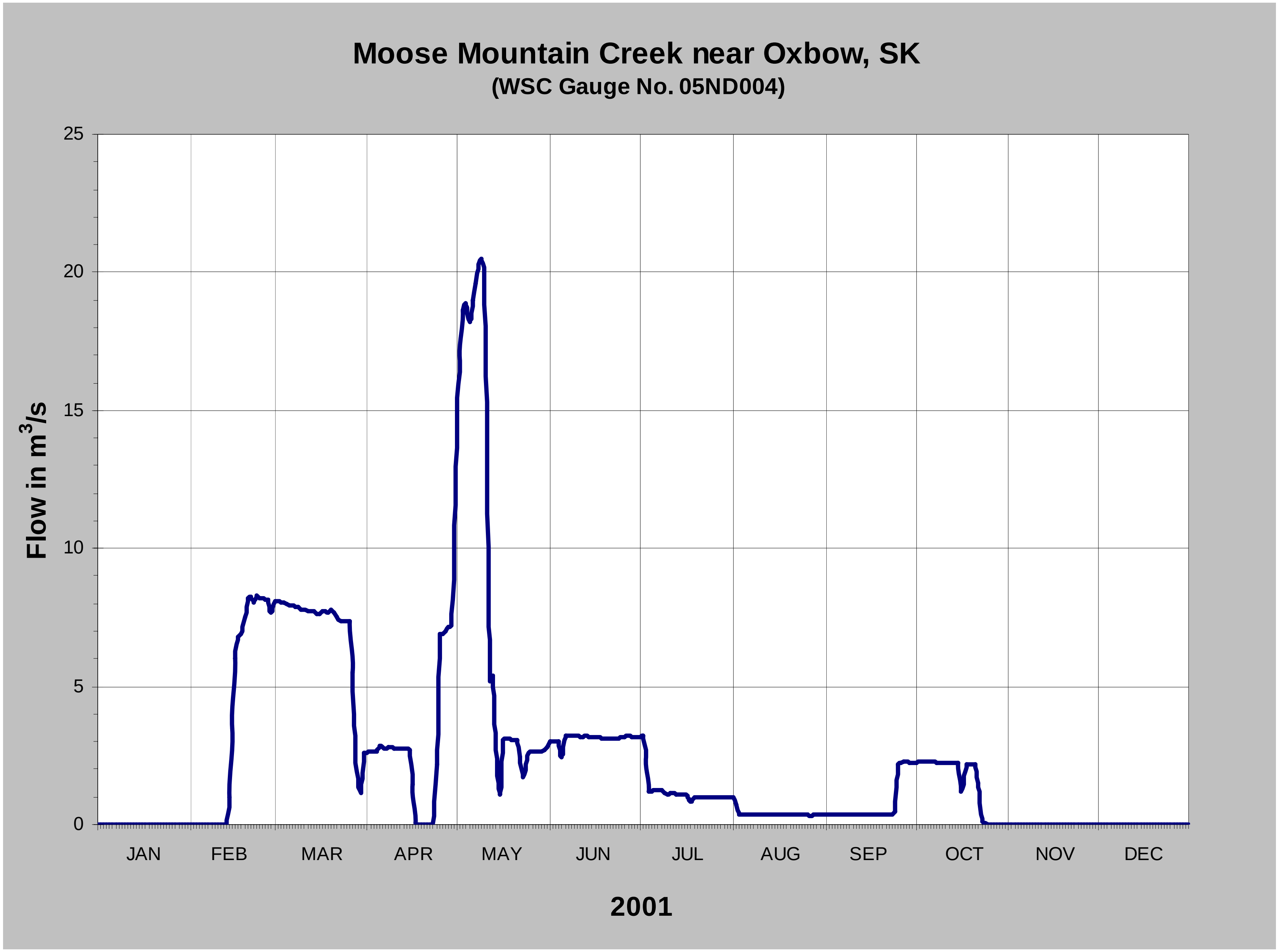

SOURIS RIVER BASIN
METEOROLOGICAL GAUGE NETWORK
Regina A
Indian Head CDA
Broadview (Auto)
Wapella-Newfinland
Montmartre
Kipling
Whitewood
Moosomin
Yellow Grass
Handsworth
Maryfield
Elkhorn 2 East
Virden
Brandon A
Brandon CDA
Alexander
Weyburn
Amulet
Manor
Redvers
Souris
Ceylon
Benson
Midale
Willmar
Alida
Cameron
Macoun
Estevan A
Oxbow
Fertile
Carnduff
Melita
Turtle Mountain 6
Baldur
Belmont
Lake Alma
Pierson
Turtle Mountain 11
Fortuna 1W
Ambrose 3N
Crosby
Sherwood 3 N
Westhope
Peace Gardens
Lake Metigoshe ST PK
Rolla 3 NW
Bowbells
Mohall
Bottineau
Belcourt Keya Radio
Kenmare 1 WSW
Upham 3N
Rolette 2 SE
Powers Lake 1N
Lansford
Willow city
Precipitation Gauge
Dams
Wildlife Refuges
Lakes
Streams
Stanley 3 NNW
Foxholm 7 N
Towner 2 NE
Tagus
Berthold
Minot FAA AP
Granville
Rugby
N
W
E
S
Minot Exp. Stn.
Karlsruhe 6N
Velva
Drake 9 NE
Butte 4 SE
Max
St. Paul District
Hydrology Section
US Army Corps of Engineers®
30
0
30
60
Miles
Balfour 6SSW
McHenry

FIGURE 3



SOURIS RIVER BASIN
STREAM GAUGE NETWORK
05NB031
05NB011
05NC001
05NE003
05NG024
05NB018
05NA005
05NB040
05NB017
05NB041
05NB033
05NB034
05NB014
05NB035
05NF010
05ND010
05NG003
05NG007
05NG021
05NG001
05NG012
05ND011
05ND012
05ND004
05NA004
05NF006
05NG020
05NB039
05NB032
05NB038
05NB036
05NB001
05NA003
05NB021
05NF007
05NF002
05113600
05114000
05123990
05124000
05123900
05123500
05123510
05123750
05123400
05122000
05115500
05116000
05116500
05117500
05120000
05120500
Stream Gauge
Dams
Wildlife Refuges
Lakes
Streams
N
W
E
S
30
0
30
Miles
St. Paul District
Hydrology Section
US Army Corps
of Engineers®

FIGURE 4



Moose Mountain Creek near Oxbow, SK
(WSC Gauge No. 05ND004)
Flow in m3/s
25
20
15
10
5
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2001

FIGURE 5

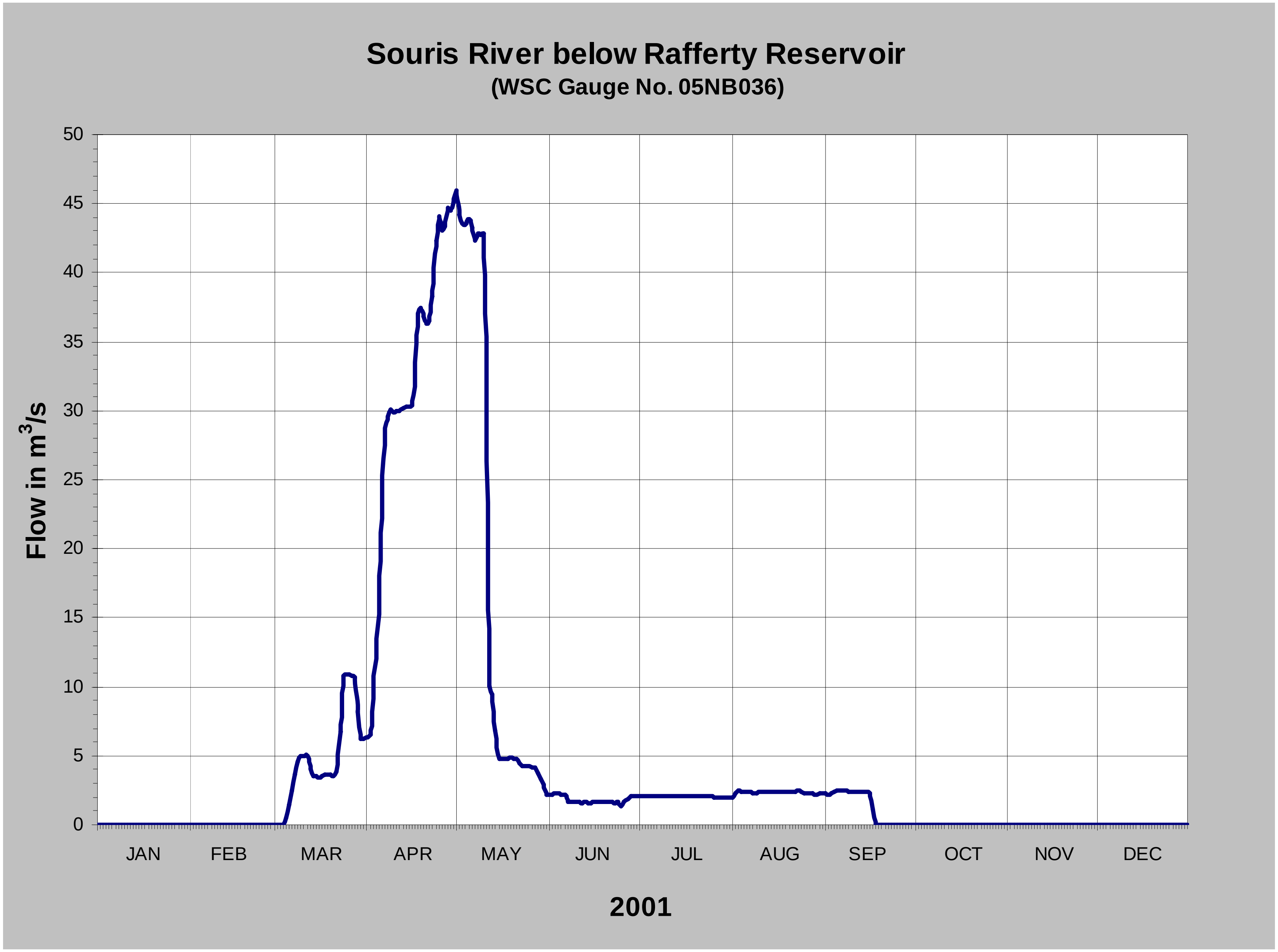
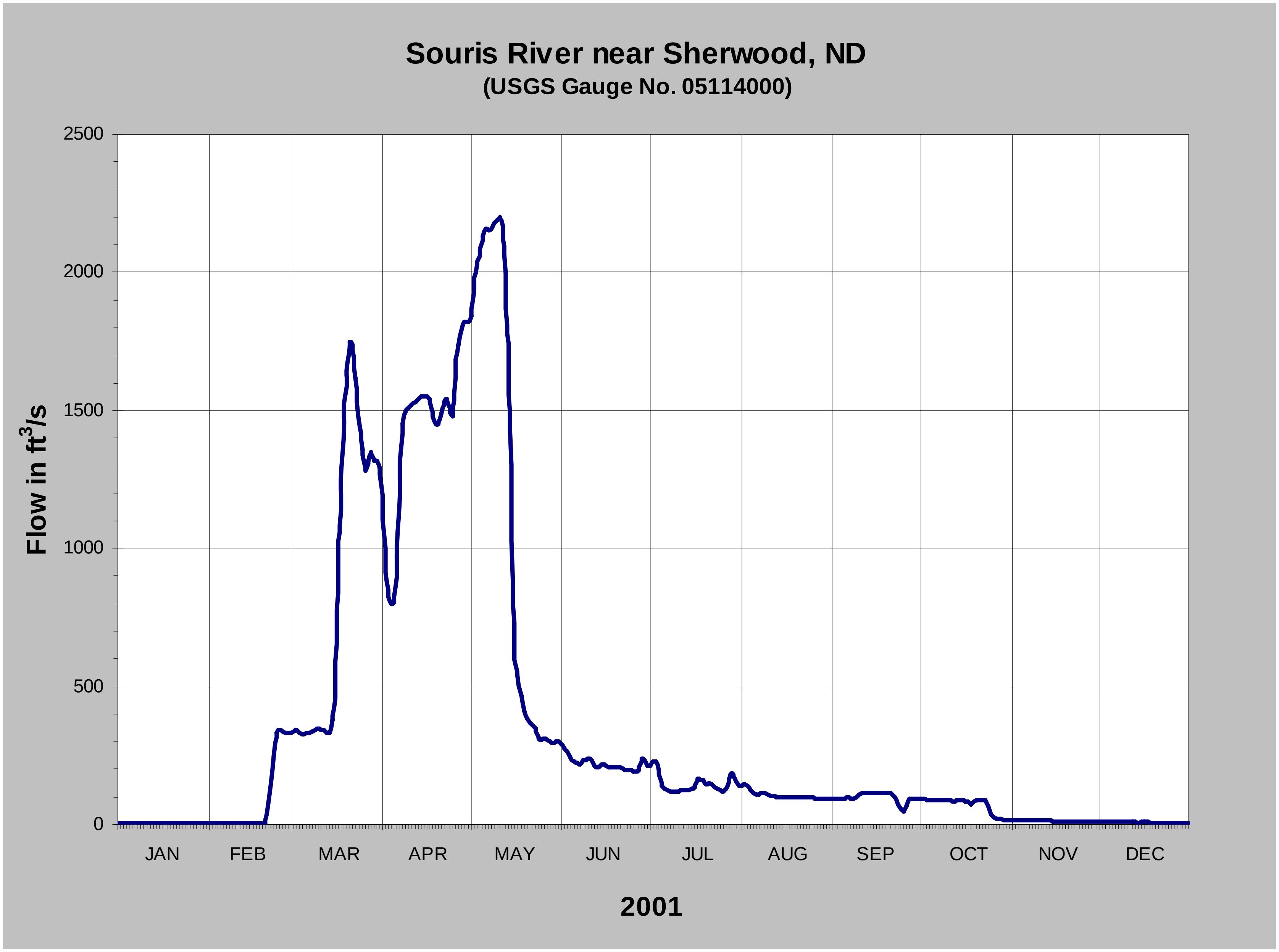
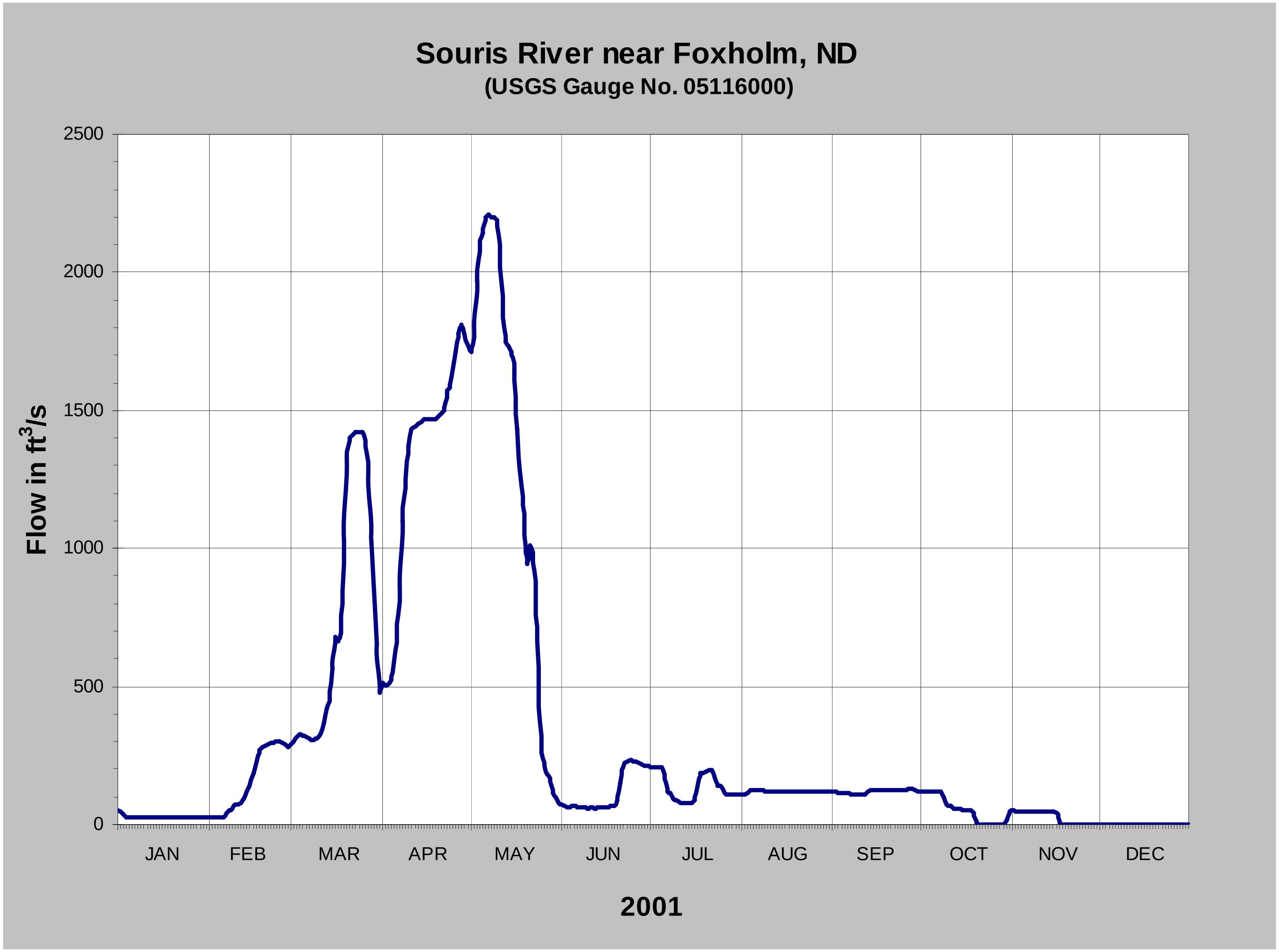

Souris River below Rafferty Reservoir
(WSC Gauge No. 05NB036)
Flow in m3/s
50
45
40
35
30
25
20
15
10
5
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2001

FIGURE 6



Souris River near Sherwood, ND
(USGS Gauge No. 05114000)
Flow in ft³/s
2500
2000
1500
1000
500
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2001

FIGURE 7



Souris River near Foxholm, ND
(USGS Gauge No. 05116000)
Flow in ft3/s
2500
2000
1500
1000
500
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2001

FIGURE 8

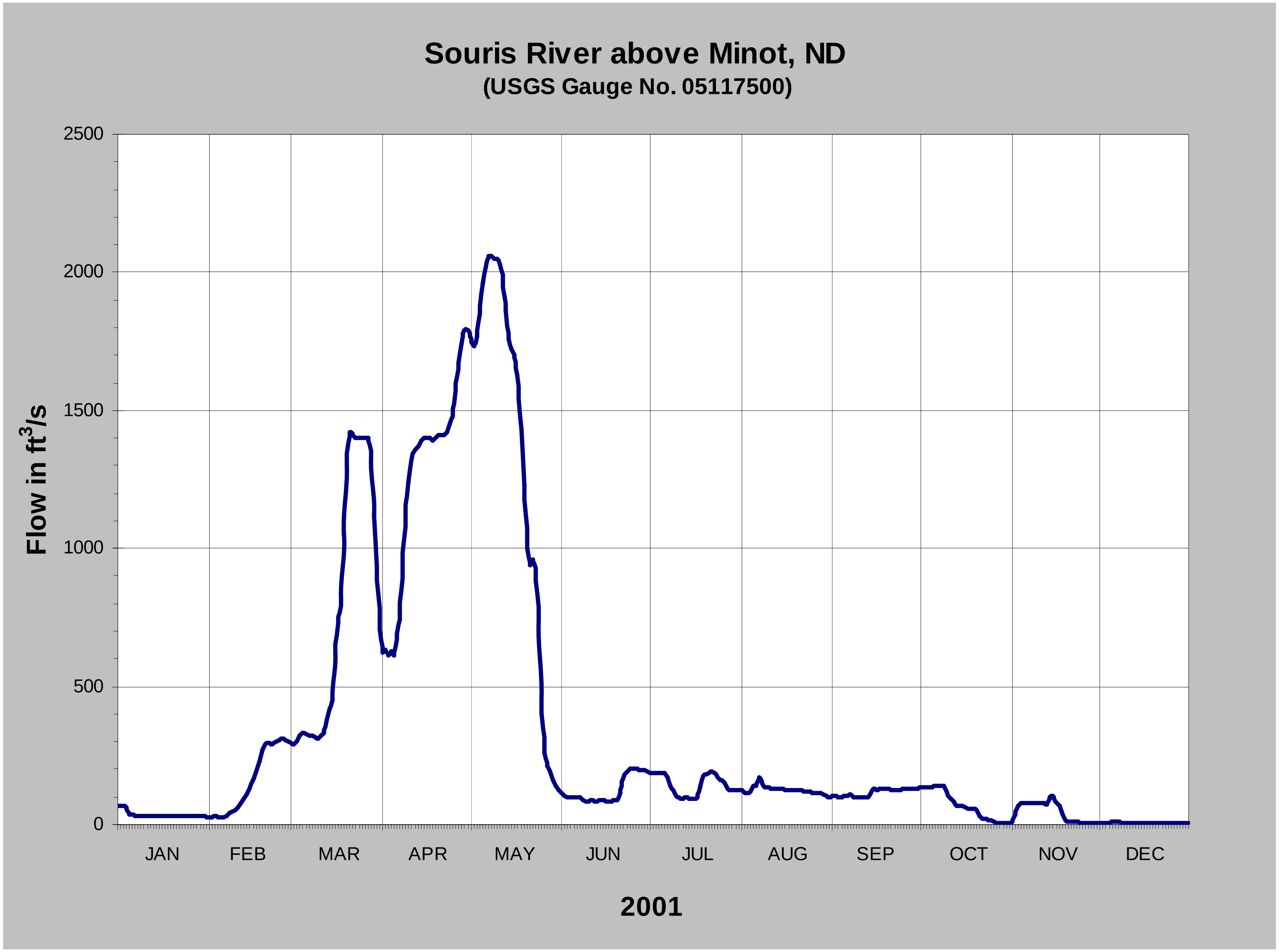

Souris River above Minot, ND
(USGS Gauge No. 05117500)
Flow in ft3/s
2500
2000
1500
1000
500
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2001

FIGURE 9

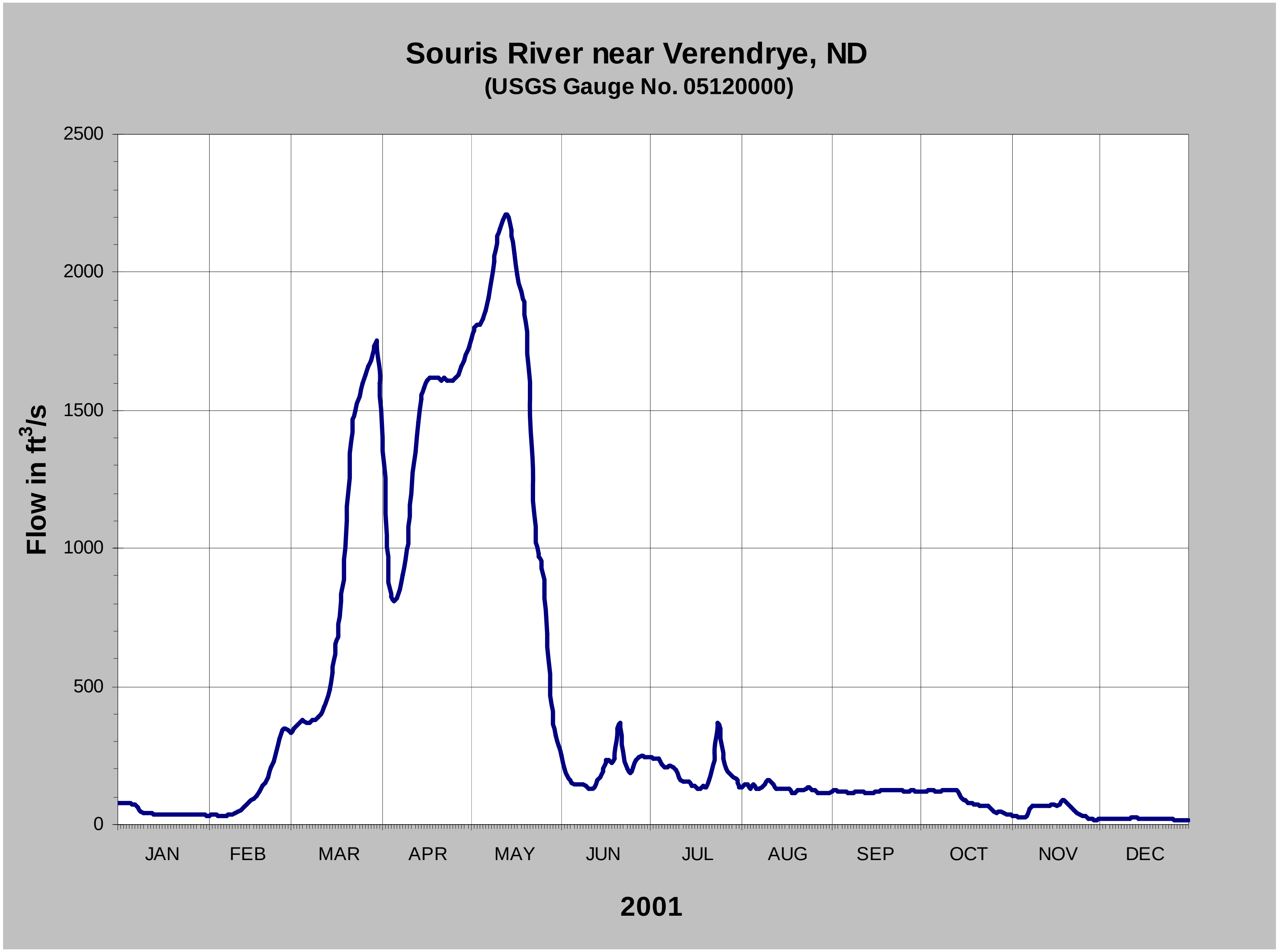

Souris River near Verendrye, ND
(USGS Gauge No. 05120000)
Flow in ft3/s
2500
2000
1500
1000
500
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2001

FIGURE 10

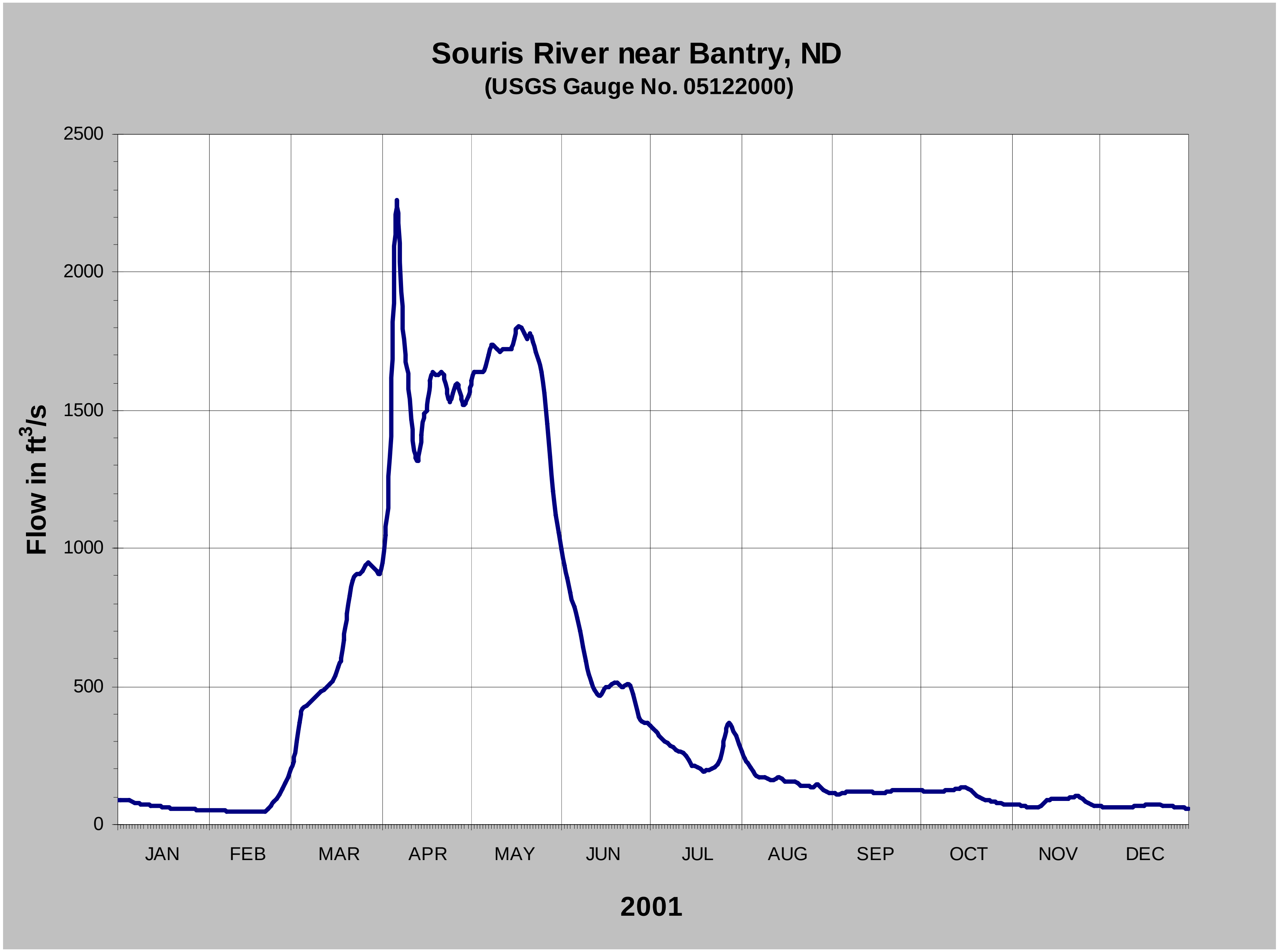

Souris River near Bantry, ND
(USGS Gauge No. 05122000)
Flow in ft³/s
2500
2000
1500
1000
500
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2001

FIGURE 11

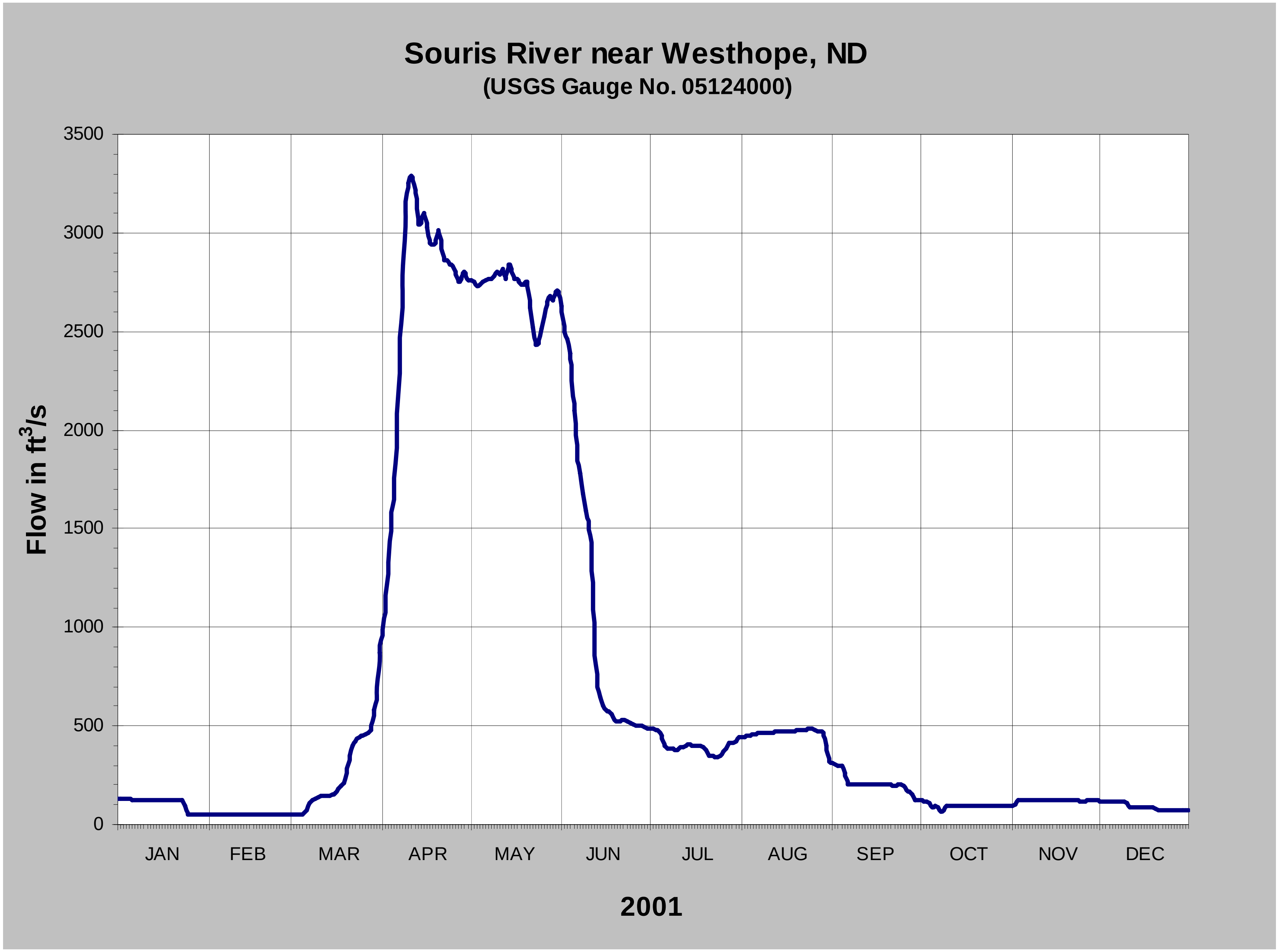
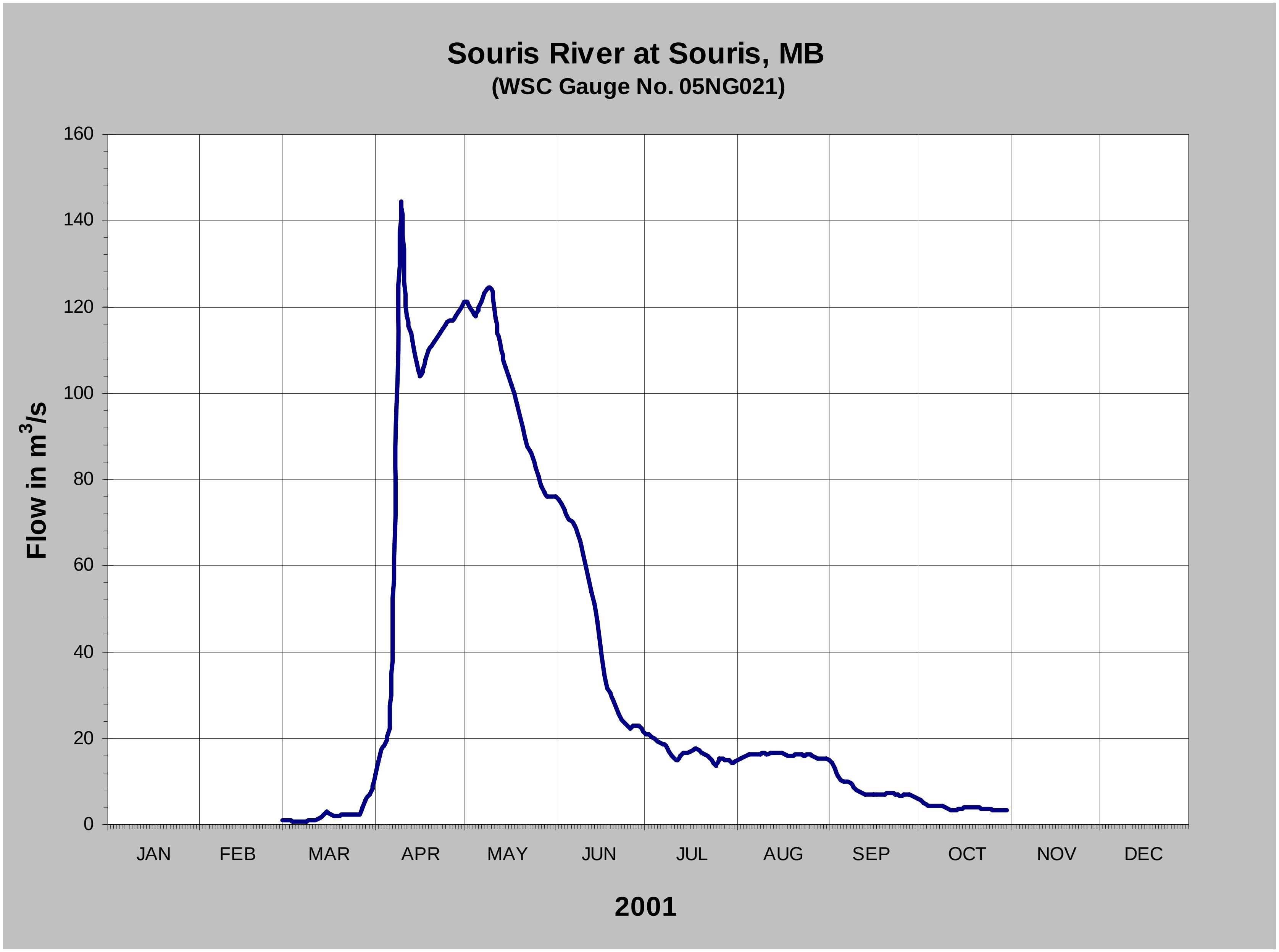

Souris River near Westhope, ND
(USGS Gauge No. 05124000)
Flow in ft3/s
3500
3000
2500
2000
1500
1000
500
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2001

FIGURE 12



Souris River at Souris, MB
(WSC Gauge No. 05NG021)
Flow in m3/s
160
140
120
100
80
60
40
20
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2001

FIGURE 13

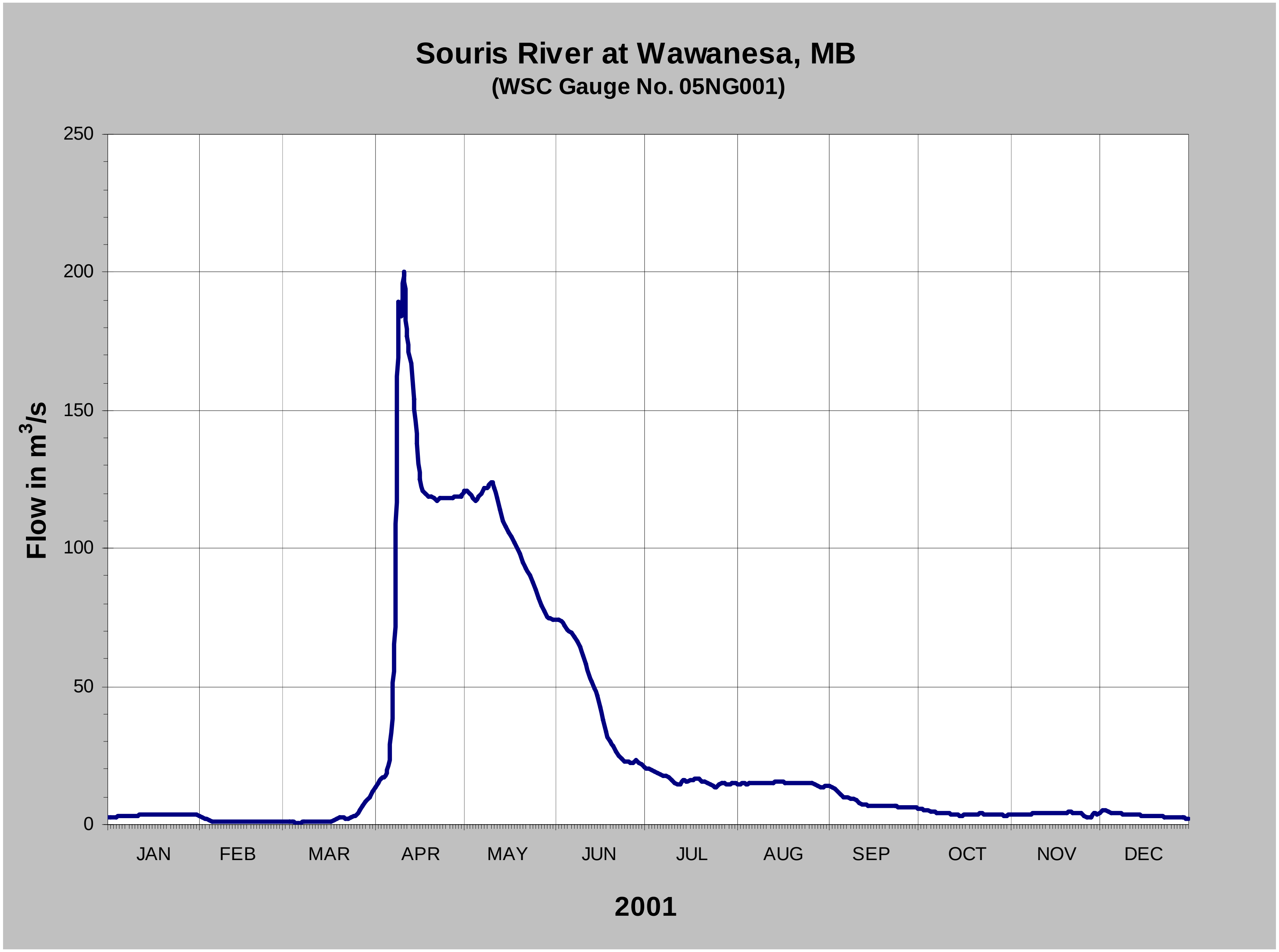

Souris River at Wawanesa, MB
(WSC Gauge No. 05NG001)
Flow in m3/s
250
200
150
100
50
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2001

FIGURE 14

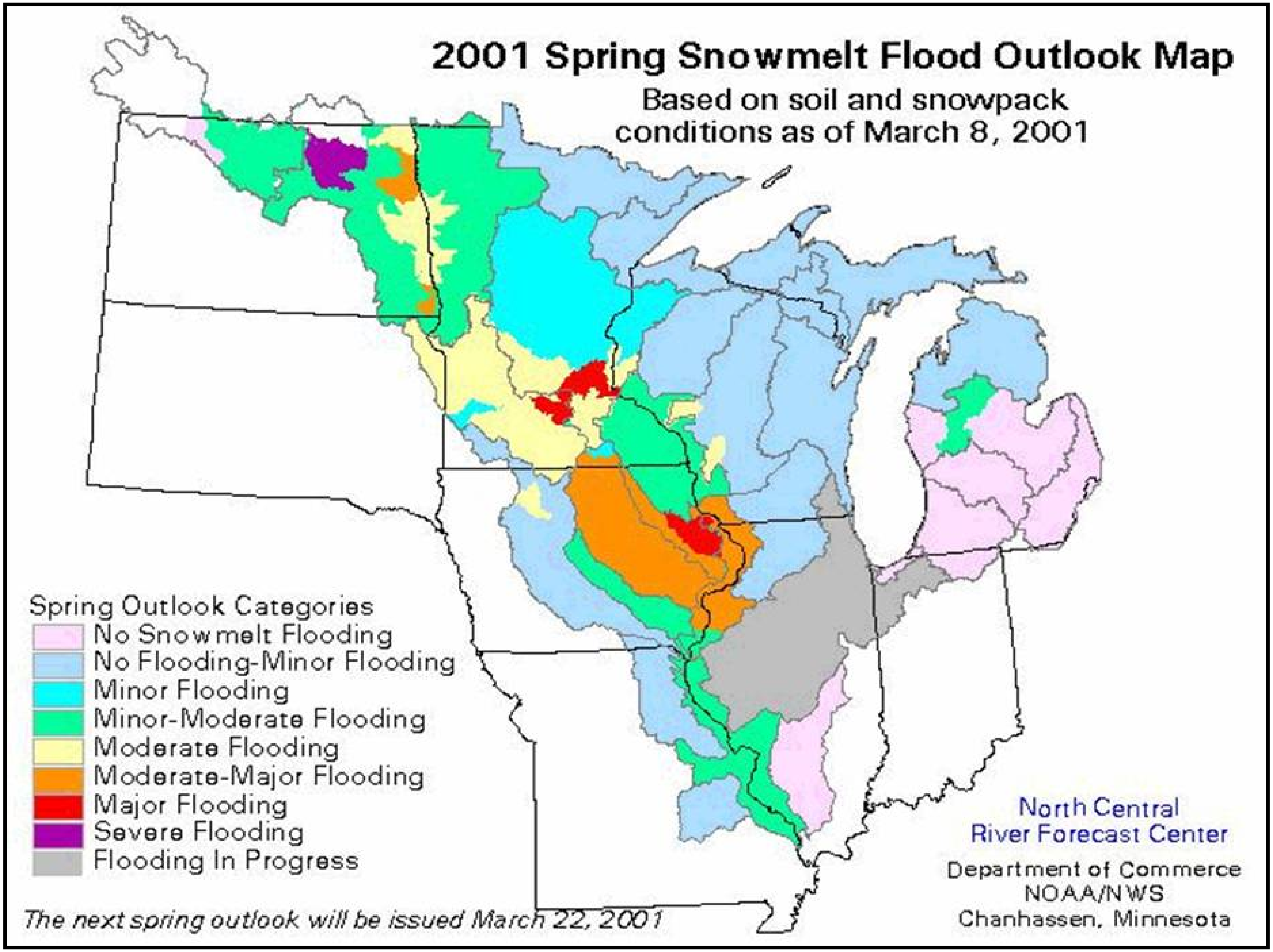

2001 Spring Snowmelt Flood Outlook Map
Based on soil and snowpack conditions as of March 8, 2001
Spring Outlook Categories
No Snowmelt Flooding
No Flooding-Minor Flooding
Minor Flooding
Minor-Moderate Flooding
Moderate Flooding
Moderate-Major Flooding
Major Flooding
Severe Flooding
Flooding In Progress
The next spring outlook will be issued March 22, 2001
North Central River Forecast Center
Department of Commerce
NOAA/NWS
Chanhassen, Minnesota

FIGURE - 15

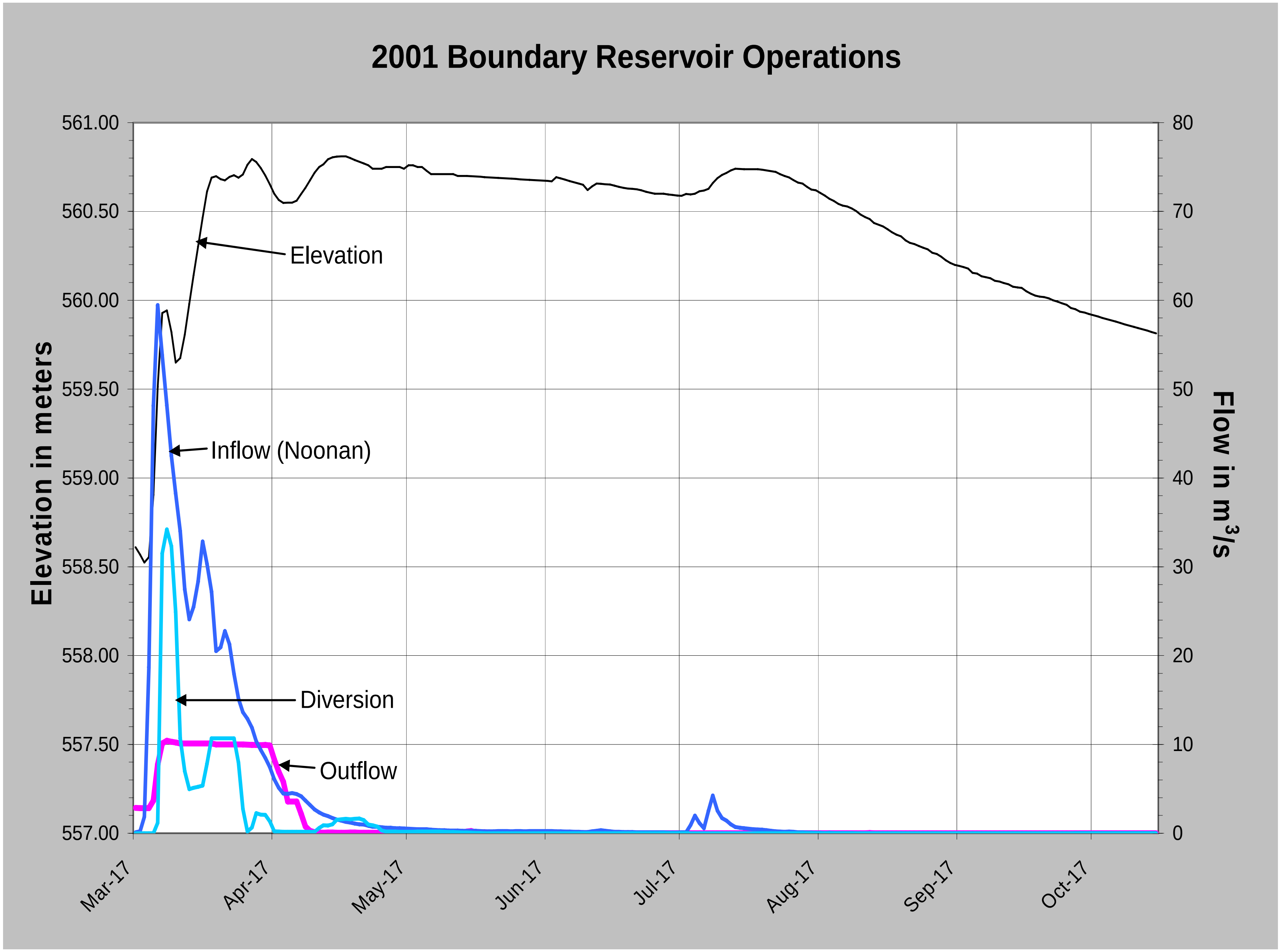

2001 Boundary Reservoir Operations
Elevation in meters
Flow in m^3/s
561.00
560.50
560.00
559.50
559.00
558.50
558.00
557.50
557.00
80
70
60
50
40
30
20
10
0
Elevation
Inflow (Noonan)
Diversion
Outflow
Mar-17
Apr-17
May-17
Jun-17
Jul-17
Aug-17
Sep-17
Oct-17

FIGURE 16

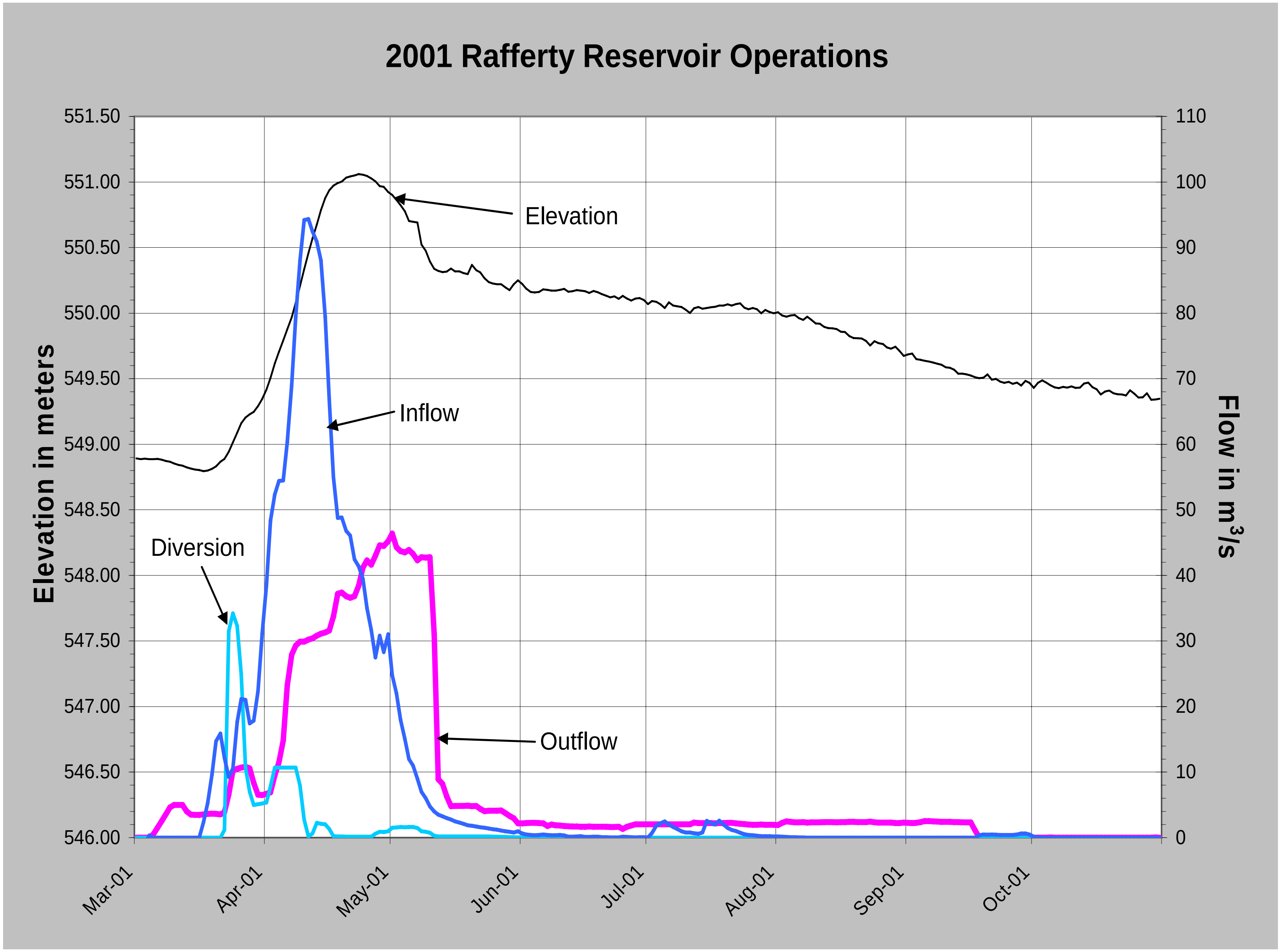

2001 Rafferty Reservoir Operations
Elevation in meters
Flow in m3/s
551.50
551.00
550.50
550.00
549.50
549.00
548.50
548.00
547.50
547.00
546.50
546.00
110
100
90
80
70
60
50
40
30
20
10
0
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Elevation
Inflow
Diversion
Outflow

FIGURE 17

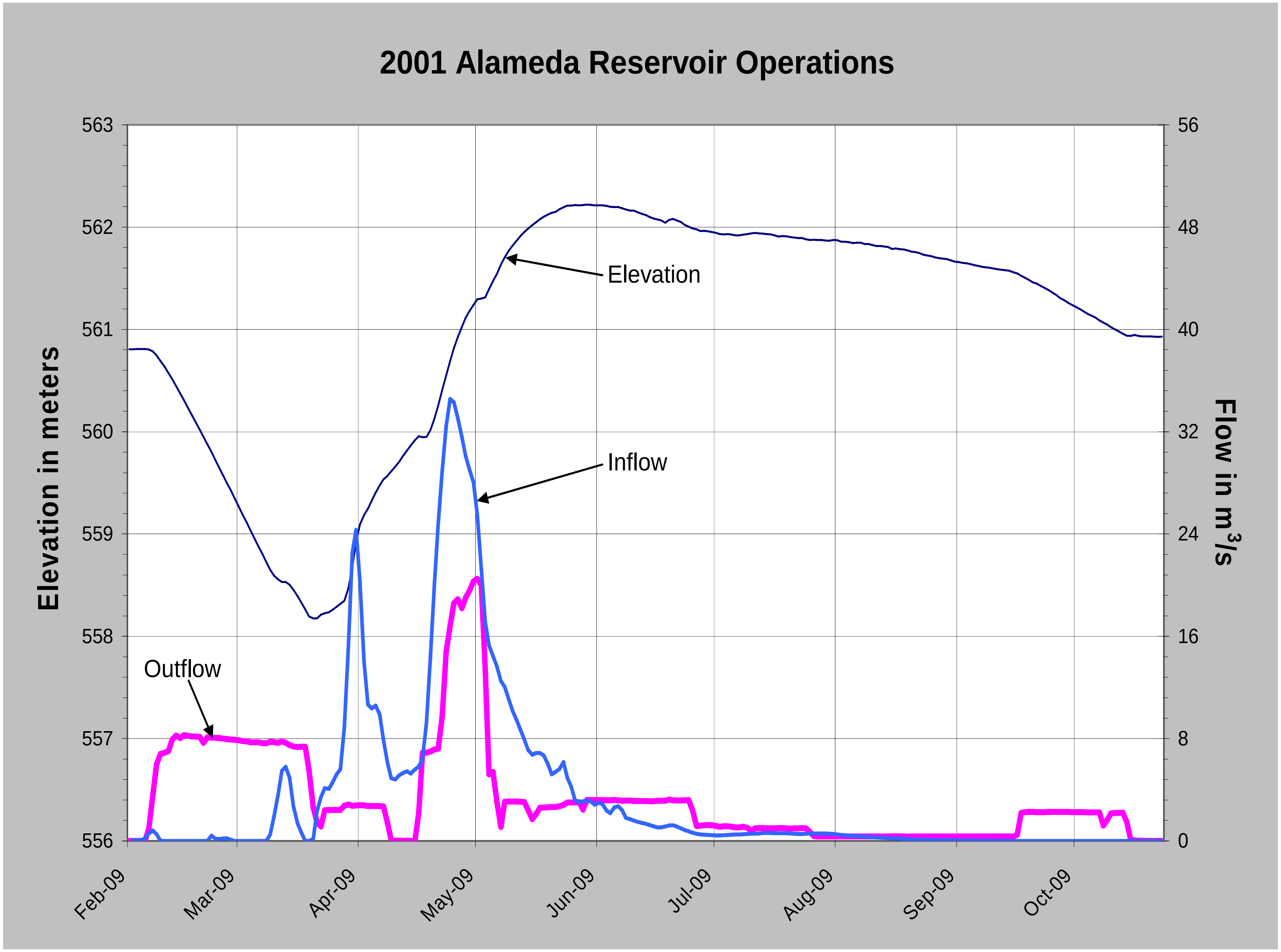

2001 Alameda Reservoir Operations
Elevation in meters
Flow in m3/s
563
562
561
560
559
558
557
556
56
48
40
32
24
16
8
0
Elevation
Inflow
Outflow
Feb-09
Mar-09
Apr-09
May-09
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09

FIGURE 18

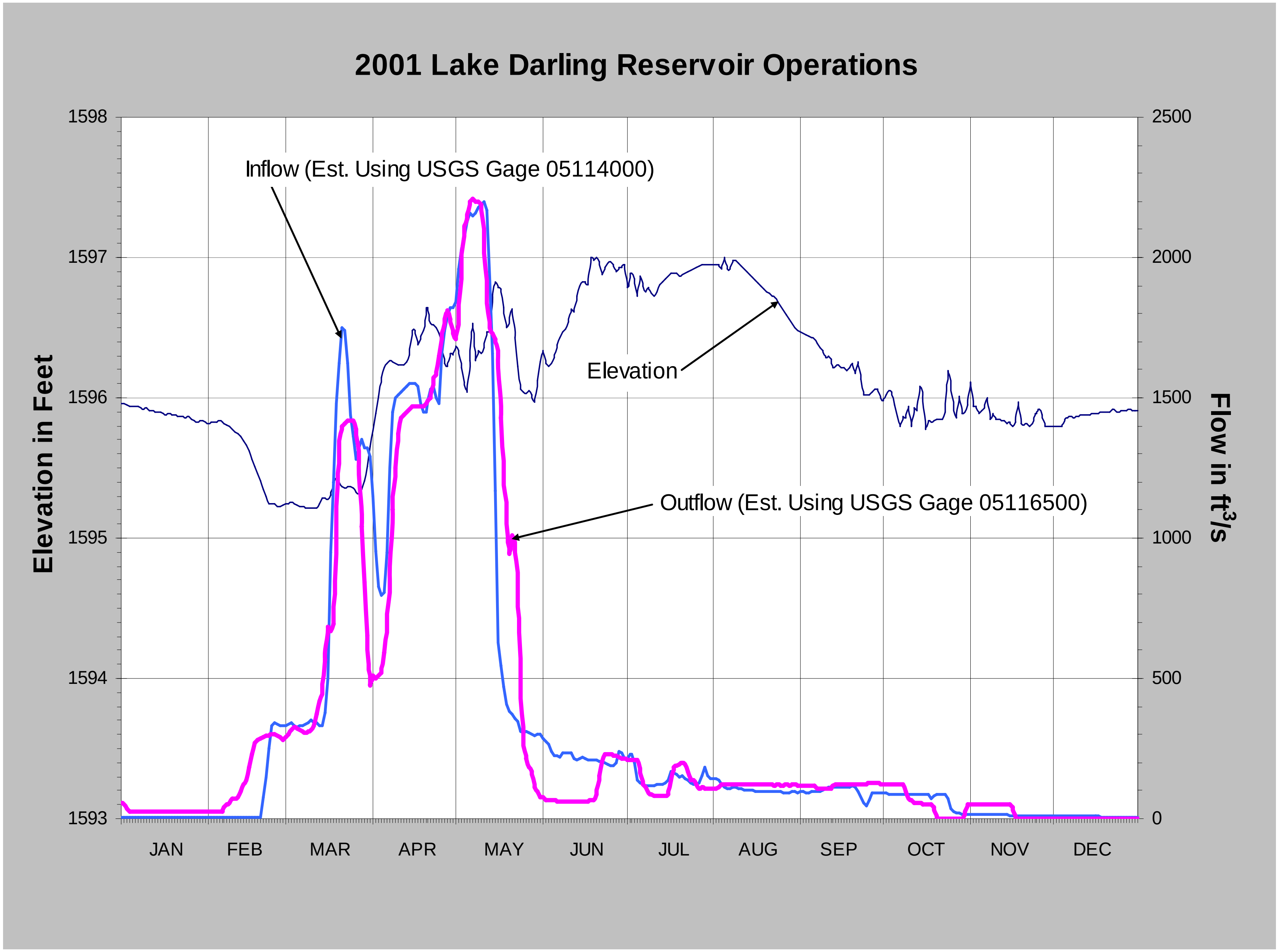

2001 Lake Darling Reservoir Operations
Inflow (Est. Using USGS Gage 05114000)
Elevation
Outflow (Est. Using USGS Gage 05116500)
Elevation in Feet
Flow in ft3/s
1598
1597
1596
1595
1594
1593
2500
2000
1500
1000
500
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

FIGURE 19

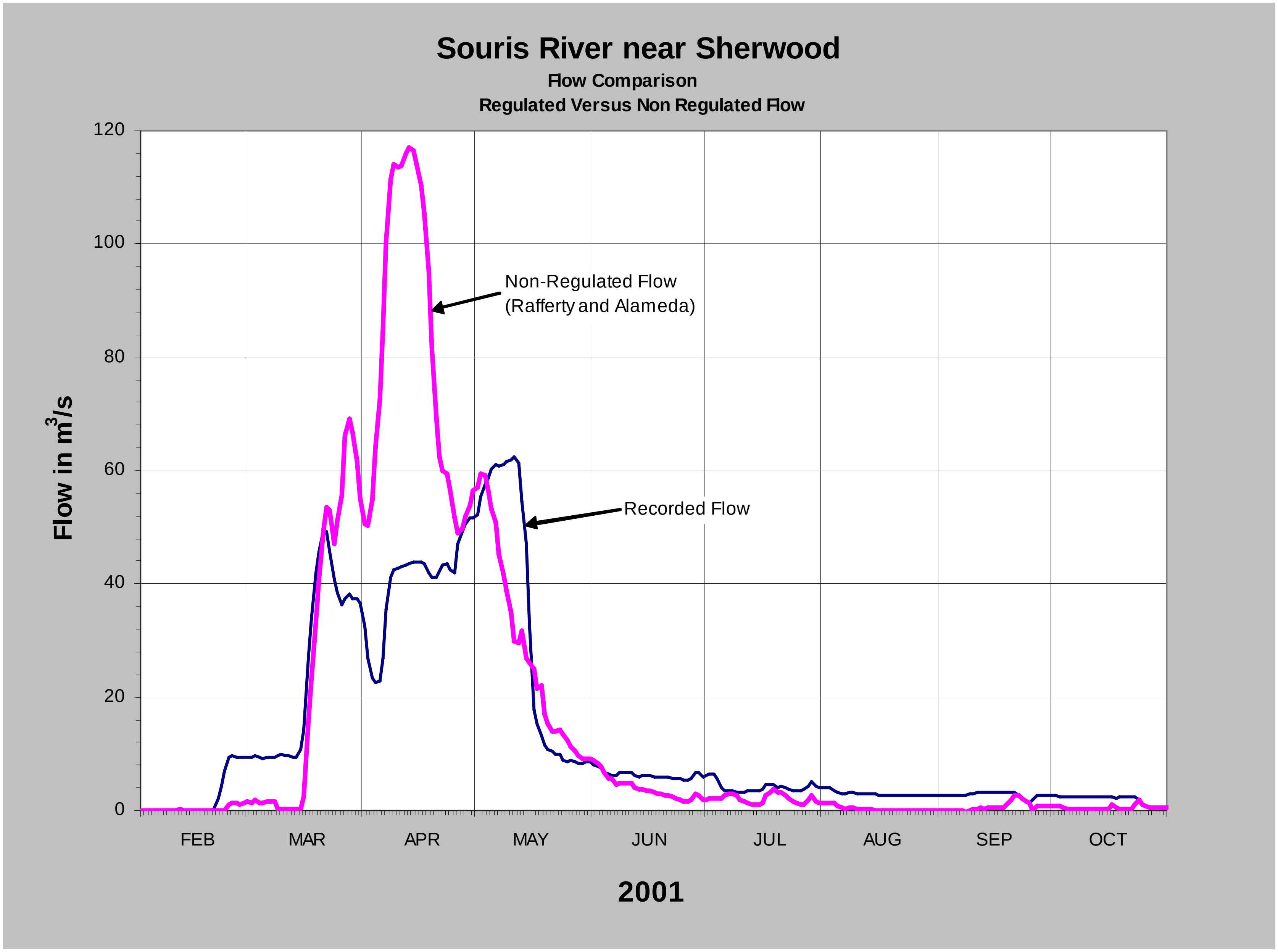
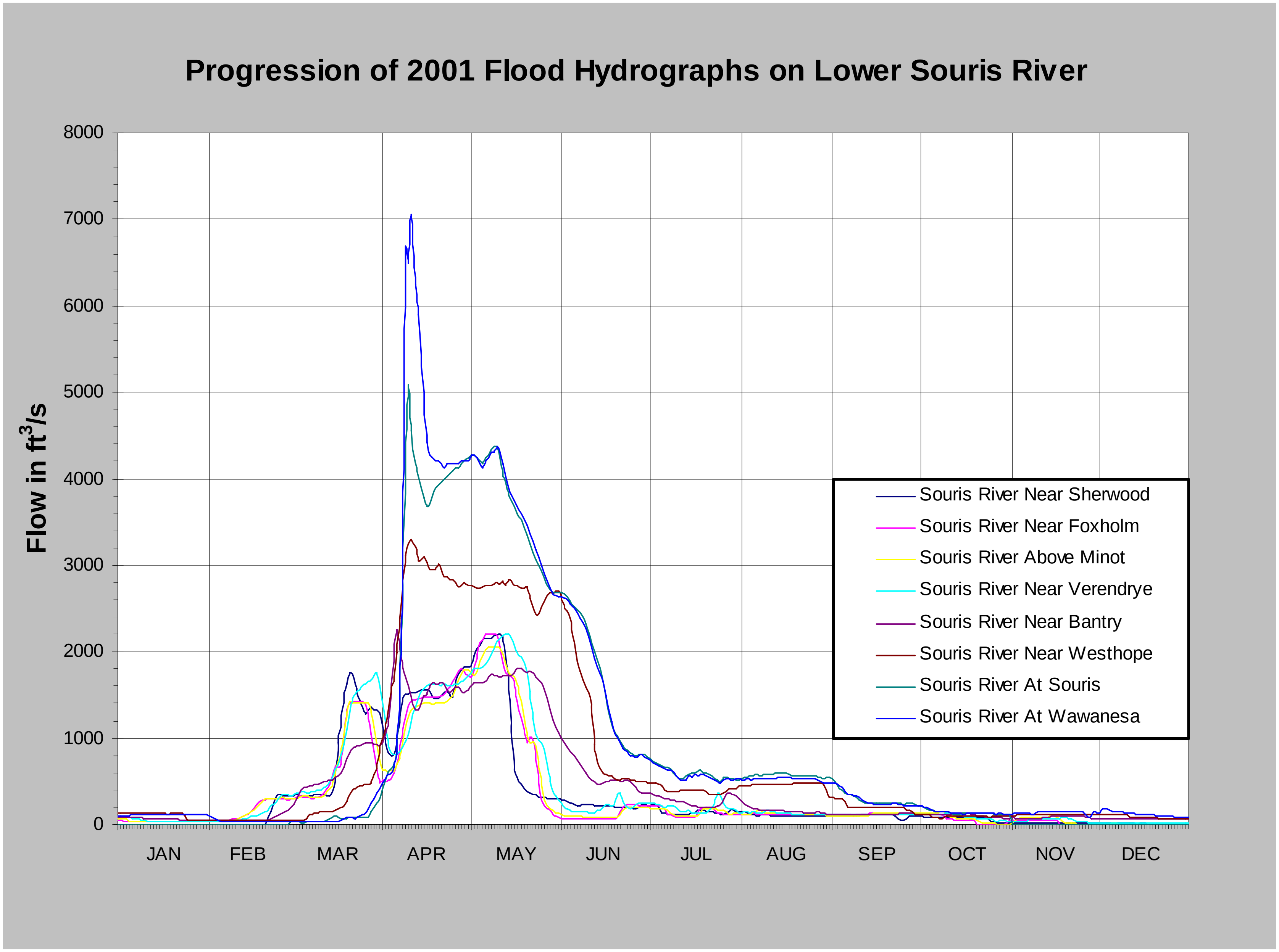

Souris River near Sherwood
Flow Comparison
Regulated Versus Non Regulated Flow
Flow in m3/s
120
100
80
60
40
20
0
Non-Regulated Flow
(Rafferty and Alameda)
Recorded Flow
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
2001

FIGURE 20



Progression of 2001 Flood Hydrographs on Lower Souris River
Flow in ft3/s
8000
7000
6000
5000
4000
3000
2000
1000
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Souris River Near Sherwood
Souris River Near Foxholm
Souris River Above Minot
Souris River Near Verendrye
Souris River Near Bantry
Souris River Near Westhope
Souris River At Souris
Souris River At Wawanesa

FIGURE 21

APPENDIX B – SUPPLEMENTAL INFORMATION

Table B-1 - Active Meteorological Stations - Souris River Basin in Saskatchewan (As of Feb. 2002)

STATION	P	T	SS	H	SYNO	N	S	E	LAT	LONG
ALIDA	X								49 27	101 48
AMULET EAST	X	X							49 39	104 33
BENSON	X	X							49 27	102 59
BROADVIEW (AUTO)	X	X		X					50 23	102 41
CARNDUFF	X								49 13	101 45
CEYLON	X	X							49 23	104 39
ESTEVAN A	X	X	X	X	X	X	X	X	49 13	102 58
FERTILE	X	X							49 20	101 27
HANDSWORTH	X	X							49 50	102 52
KIPLING	X	X							50 12	102 44
LAKE ALMA	X	X							49 04	104 15
MACOUN	X								49 14	103 14
MANOR	X	X							49 37	102 06
MARYFIELD	X	X							49 50	101 31
MIDALE	X	X							49 23	103 18
MONTMARTRE	X	X							50 15	103 28
OXBOW	X	X							49 13	102 10
REDVERS	X	X							49 36	101 43
REGINA A	X	X		X	X				50 26	104 40
WEYBURN	X	X							49 39	103 50
WHITEWOOD	X	X							50 10	102 14
WILLMAR	X								49 25	102 30
YELLOW GRASS	X	X							49 49	104 11

LEGEND:
P = Precipitation; T = Temperature
SS = Snow Survey; H = Hourly Real Time
SYNO = Synoptic Station; N = Nipher Shielded Snow Gage
S = Hours of Bright Sunshine; E = Evaporation
LAT = Latitude (North); LONG = Longitude (West)

Table B-2 - Active Meteorological Stations - Souris River Basin in North Dakota (As of Feb. 2002)

STATION	P	T	WE	H	SYNO	N	S	E	LAT	LONG
AMBROSE 3N	X		X						49 00	103 28
BALFOUR 6SSW	X		X						47 53	100 33
BELCOURT KEYA RADIO	X	X	X						48 50	99 45
BERTHOLD	X		X						48 19	101 44
BOTTINEAU	X	X	X						48 50	100 27
BUTTE 5SE	X	X	X						47 50	100 40
CROSBY	X	X	X						48 54	103 18
DRAKE 9NE	X	X	X						48 02	100 17
FORTUNA 1W	X	X	X						48 55	103 49
FOXHOLM 7N	X	X	X						48 26	101 33
GRANVILLE	X	X	X						48 16	100 51
KARLSRUHE 6N	X		X						48 08	100 32
KENMARE 1WSW	X	X	X						48 40	102 06
LAKE METIGOSHE	X		X						48 59	100 21
LANDA 3SE	X		X						48 52	100 52
LANSFORD	X		X						48 38	101 23
MAX	X	X	X						47 49	101 18
MINOT ASOS	X	X		X	X	X			48 16	101 17
MINOT EXP STA	X	X	X	X				X	48 11	101 18
MOHALL	X	X	X						48 46	101 31
ROLETTE 2SE	X		X						48 40	99 50
ROLLA 3NW	X	X	X						48 54	99 40
RUGBY	X	X	X						48 21	100 00
SHERWOOD 3N	X		X						49 00	101 38
TAGUS	X		X						48 20	101 56
TOWNER 2NE	X	X	X						48 21	100 24
UPHAM 3N	X	X	X						48 37	100 44
VELVA 3NE	X	X	X						48 04	100 56
WESTHOPE	X	X	X						48 55	101 02
WILLOW CITY	X	X	X						48 37	100 18

LEGEND:
P = Precipitation
T = Temperature
WE = Snow Water Equivalent
H = Hourly Real Time
SYNO = Synoptic Station
N = Nipher Shielded Snow Gage
S = Hours of Bright Sunshine
E = Evaporation
LAT = Latitude (North)
LONG = Longitude (West)

Table B-3 - Active Meteorological Stations - Souris River Basin in Manitoba (As of Feb. 2002)

STATION	P	T	SS	H	SYNO	N	S	E	LAT	LONG
ALEXANDER	X								49 50	100 18
BALDUR	X	X							49 18	99 20
BELMONT	X								49 18	99 27
BRANDON A	X	X	X	X	X	X	X		49 55	99 57
BRANDON CDA	X	X				X			49 52	99 59
CAMERON	X	X							49 28	100 28
ELKHORN 2 EAST	X	X							49 56	101 12
MELITA				X	X				49 17	100 59
PEACE GARDENS	X	X							49 00	100 03
PIERSON	X	X							49 11	101 16
SOURIS	X	X							49 39	100 15
TURTLE MOUNTAIN 6	X	X				X			49 18	100 19
TURTLE MOUNTAIN 11	X	X							49 08	100 07
VIRDEN	X	X				X			49 51	100 56

LEGEND:
P = Precipitation
T = Temperature
SS = Snow Survey
H = Hourly Real Time
SYNO = Synoptic Station
N = Nipher Shielded Snow Gage
S = Hours of Bright Sunshine
E = Evaporation
LAT = Latitude (North)
LONG = Longitude (West)

Table B-4 - Active Hydrometric Stations - Souris River Basin in Saskatchewan (As of Feb. 2002)

STATION #		STATION NAME
05NA003	@	Long Creek at Western Crossing of International Boundary
05NA004	*	Long Creek near Maxim
05NA005	@	Gibson Creek near Radville
05NA006		Larsen Reservoir near Radville
05NB001		Long Creek near Estevan
05NB011	@	Yellowgrass Ditch near Yellowgrass
05NB012	*	Boundary Reservoir near Estevan
05NB014	@	Jewel Creek near Goodwater
05NB016		Roughbark Reservoir near Weyburn
05NB017	@	Souris River near Halbrite (High flow Only)
05NB018		Tatagwa Lake Drain near Weyburn
05NB020		Nickle Lake near Weyburn
05NB021	@	Short Creek near Roche Percee
05NB030	*	Souris River near McTaggart (Wire Weight Gauge)
05NB031	*	Souris River near Bechard
05NB032		Rafferty Reservoir near Estevan
05NB033		Mosely Creek near Halbrite
05NB034		Roughbark Creek near Goodwater
05NB035		Cooke Creek near Goodwater
05NB036		Souris River below Rafferty Reservoir
05NB037		Unnamed Reservoir near Goodwater (Rafferty @ Causeway)(Inactive Station)
05NB038	@	Boundary Reservoir Diversion Canal near Estevan
05NB039		Tributary near Outram
05NB040		Souris River near Ralph
05NB041		Roughbark Creek above Rafferty
05NC001	*	Moose Mountain Creek below Moose Mountain Lake
05NC002	@	Moose Mountain Lake near Corning
05ND004	@	Moose Mountain Creek near Oxbow
05ND008	*	White Bear (Carlyle) Lake near Carlyle
05ND009	*	Kenosee Lake near Carlyle
05ND010	@	Moose Mountain Creek above Alameda Reservoir
05ND011		Shepherd Creek near Alameda
05ND012	@	Alameda Reservoir near Alameda
05NE002	@	Moosomin Lake near Moosomin
05NE003		Pipestone Creek above Moosomin Reservoir
05NF006		Lightning Creek near Carnduff
05NF010		Antler River near Wauchope

Note: Except as Noted, All Stations Operated by Water Survey of Canada, Regina.
@- Stations Equipped With Data Collection Platforms (DCP).
* - Operated by Saskatchewan Water Corporation.

Table B-5 - Active Hydrometric Stations - Souris River Basin in North Dakota (As of Feb. 2002)

STATION #		STATION NAME	EQUIPMENT
05113520		Long Creek Tributary near Crosby (High Flow Only)	
05113600		Long Creek @ Noonan	DCP
05113750		East Branch Short Creek Reservoir near Columbus	DCP
05114000		Souris R. @ Sherwood CR 15W	DCP, Datalogger
05115500		Lake Darling @ Foxholm 7N (Dam #83)	DCP
		Upper Souris Refuge: Dam #87 and Dam #96	Observer
		Des Lacs Refuge: Units 1-8	Observer
05116000		Souris R. @ Foxholm 3E	LARC, DCP
05116100		Souris R. Tributary Near Burlington (High Flow Only)	
05116135		Tasker Coulee Tributary near Kenaston (High Flow Only)	
05116500		Des Lacs R. @ Foxholm	LARC, DCP
05117500		Souris R. @ Minot 4NW	LARC, DCP
		Souris R. @ Logan	Observer
		Souris R. @ Sawyer	Observer
		Souris R. @ Velva	Observer
05119410		Bonnes Coulee near Velva (High Flow Only)	
05120000		Souris R. @ Verendrye 3N	DCP
05120180		Wintering R. Tributary near Konsberg (High Flow Only)	
05120500		Wintering R. @ Karlsruhe 5NE	Datalogger
		Souris R. @ Towner	Observer
05122000		Souris R. @ Bantry 8E	Datalogger
	*	Dam #320 on Souris River (J. Clark Salyer Refuge)	Observer
	*	Dam #326 on Souris River (J. Clark Salyer Refuge)	Observer
	*	Dam #332 on Souris River (J. Clark Salyer Refuge)	Observer
	*	Dam #341 on Souris River (J. Clark Salyer Refuge)	Observer
	*	Dam #357 on Souris River (J. Clark Salyer Refuge)	Observer
05123300		Oak Creek Tributary near Bottineau (High Flow Only)	
05123410		Willow Creek @ Willow City 7W	DCP
05123510		Deep R. @ Upham 6W (Seasonal)	LARC
05124000		Souris R. @ Westhope 7NNE	DCP, Datalogger

Note: Except as Noted, All Stations Operated by the U.S. Geological Survey and/or the U.S. National Weather Service.
* - Operated by the U.S. Fish and Wildlife Service.

Table B-6 - Active Hydrometric Stations - Souris River Basin in Manitoba (As of Feb. 2002)

STATION #		STATION NAME
05NF001	+	Souris River at Melita (Mar-Jun)
05NF002	+	Antler River near Melita
05NF007	+	Gainsborough Creek near Lyleton (Mar-Oct)
05NF008	+	Graham Creek near Melita (Mar-May)
05NF014	+	Waskada Creek near Cranmer (Mar-May)
05NF805	*	Sharpe Lake near Deloraine (Apr-Oct)
05NG001	+	Souris River at Wawanesa
05NG003	+	Pipestone Creek near Pipestone (Mar-Oct)
05NG004	+	Stony Creek near Bede (Mar-May)
05NG007	+	Plum Creek near Souris (Mar-May)
05NG008	*	Oak Lake at Oak Lake Resort (Apr-Oct)
05NG012	+	Elgin Creek near Souris (Mar-May)
05NG014	*	Deloraine Reservoir near Deloraine (Apr-Oct)
05NG020		Medora Creek near Napinka (Mar-May)
05NG021	+	Souris River at Souris
05NG023		Whitewater Lake near Boissevain (Apr-Oct)
05NG024	#	Pipestone Creek near Saskatchewan Boundary
05NG801	*	Plum Lake above Deleau Dam (Apr-Oct)
05NG803	*	Elgin Reservoir near Elgin (Apr-Oct)
05NG804	*	Metigoshe Lake near Metigoshe (Apr-Oct)
05NG806	*	Souris River above Hartney Dam (Apr-Oct)
05NG807	*	Souris River above Napinka Dam (Apr-Oct)
05NG809	*	Plum Lake near Findlay (Apr-Oct)

Note: Except as Noted, All Stations Operated by Water Survey of Canada, Winnipeg.
* - Operated by Manitoba Water Resources Branch.
\# - Operated by Water Survey of Canada, Regina.
\+ - Stations Equipped with electronic data transmission.