

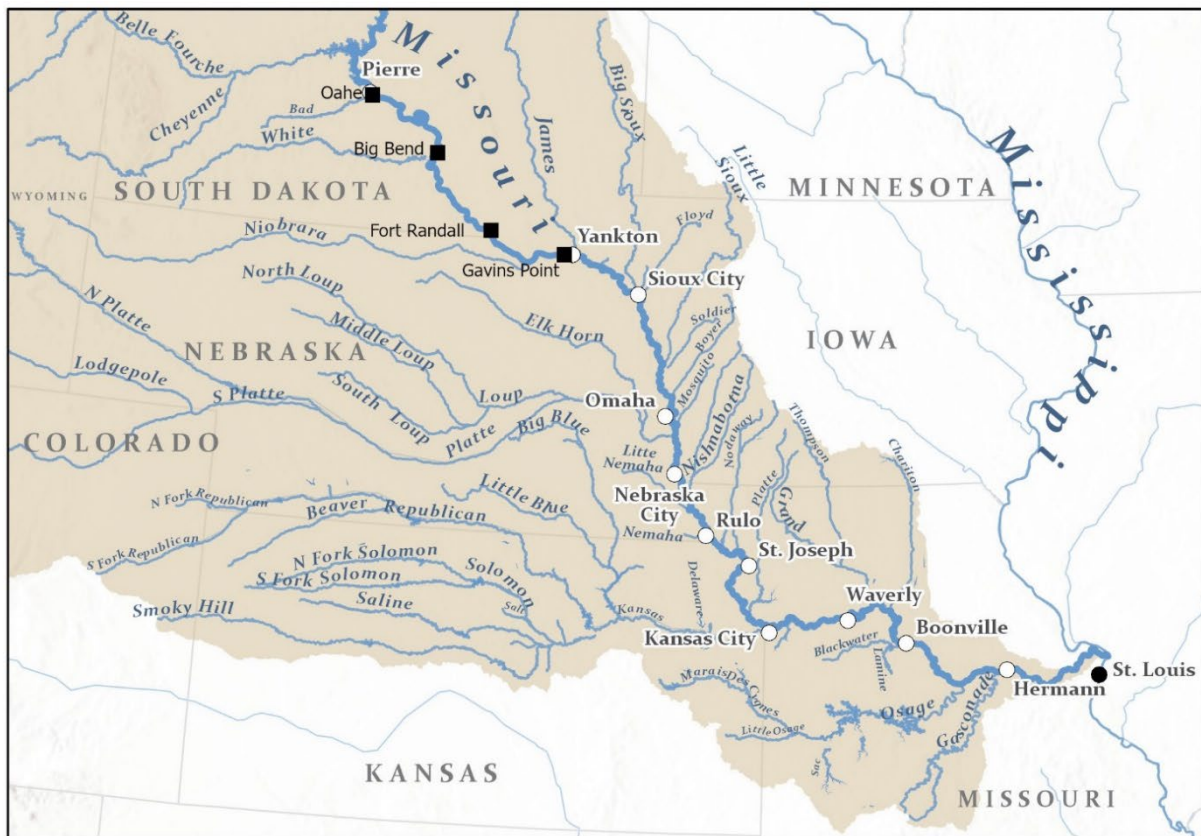


US Army Corps  
of Engineers®

# Missouri River Flow Frequency Study

## Yankton, South Dakota to Hermann, Missouri

### *Appendix B: Peak to Daily Flow Ratios*



U.S. Army Corps of Engineers  
Northwestern Division,  
Omaha District, Kansas City District, and  
Missouri River Basin Water Management

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## Introduction

The HEC-ResSim model uses daily mean data for input and output. In order to convert the daily mean values to peak instantaneous values for purposes of frequency analysis, a relation between published USGS instantaneous and daily means was determined at each gage. Water year maximum daily mean flows were determined at each gage and screened for consistency and validity with regards to the peak instantaneous flows. The water year maximum daily means were plotted on the x-axis and the corresponding peak instantaneous flow values were plotted on the y-axis. A linear trend-line was computed at each station: Yankton, Sioux City, Omaha, and Nebraska City, with the trend-lines were forced through the origin ( $y$  intercept = 0). Forcing the best-fit lines through the origin has two benefits. First, it prevents the computation of a negatively sloped trend-line, which, when extrapolated to high flows, will result in the instantaneous peak flow being less than the daily mean flow. Second, it has the effect of increasing the mean, while preserving the standard deviation and skew of the daily means. This effect helps to prevent the resultant instantaneous and 1-day flow frequency curves from crossing. By forcing the trend-line through the origin, the conversion is achieved by simply multiplying the daily mean flow by a factor, which is also the slope of the trend-line. This method is the same as that utilized in the Upper Mississippi River System Flow Frequency Study (USACE, 2003).

The flow frequency analysis utilizes a mixed population analysis at Yankton, Sioux City, Omaha, and Nebraska City. Unlike in the UMRSFFS, seasonal daily mean to peak instantaneous flow relationships were developed in addition to the “all-seasons” relationships by segregating the USGS data into the two seasons: the snowmelt season from January 1<sup>st</sup> through April 30<sup>th</sup>, and the rainfall season from May 1<sup>st</sup> through December 31<sup>st</sup>. These seasons are also frequently referred to as “early spring” and “late spring”, respectively.

Table B-1 shows the conversion factors used in the Upper Mississippi River System Flow Frequency Study (UMRSFFS) along with the conversion factors computed as part of this study for the snowmelt season, rainfall season, and all-seasons. The UMRSFFS utilized one set of conversion factors, which were all-seasons. The differences between the snowmelt season and rainfall season are more pronounced at Yankton and Sioux City, while they are more subtle at Omaha and Nebraska City. Decatur was not used as a node in this study, as it was in the UMRSFFS.

**Table B-1. Conversion Percentages of Daily Means to Instantaneous Flows**

Station	Percent, %			
	UMRSFFS (All Seasons)	2020 Update Season		
		All	Snowmelt	Rainfall
Yankton	3.6	3.6	3.9	2.9
Sioux City	2.3	3.3	3.7	2.2
Decatur	3.1	n/a	n/a	n/a
Omaha	3.9	3.8	4.1	3.6
Nebraska City	4.2	4.1	4.3	4.0

The seasonal daily mean to instantaneous peak conversion factors were the ones selected and applied to the maximum daily means to create the instantaneous peak flow datasets, in order to maintain consistency with the mixed population analysis.

## **B.1 Yankton, SD – USGS Gage 06467500**

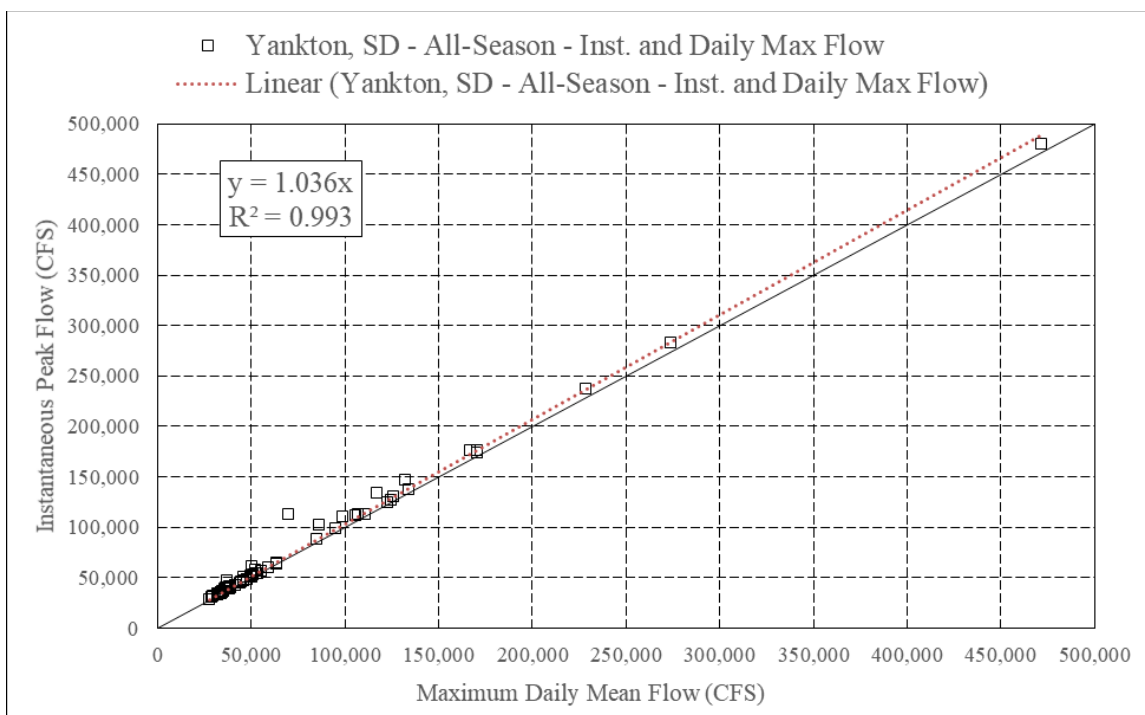
The daily mean USGS data on the Missouri River at Yankton span from water years 1931 through 1995. The water year maximum daily mean flows were examined for consistency and validity. The water year maximum daily means for water years 1972 and 1992 had to be changed to local maximums, because the instantaneous peak was during a different time of year than the water year maximum daily flow. Figure B-1 shows the all-seasons relationship, Figure B-2 shows the snowmelt season relationship, and Figure B-3 shows the rainfall season relationship between maximum daily mean and instantaneous peak flows for the Missouri River at Yankton, SD.

### **B.1.1 Changes for 1972**

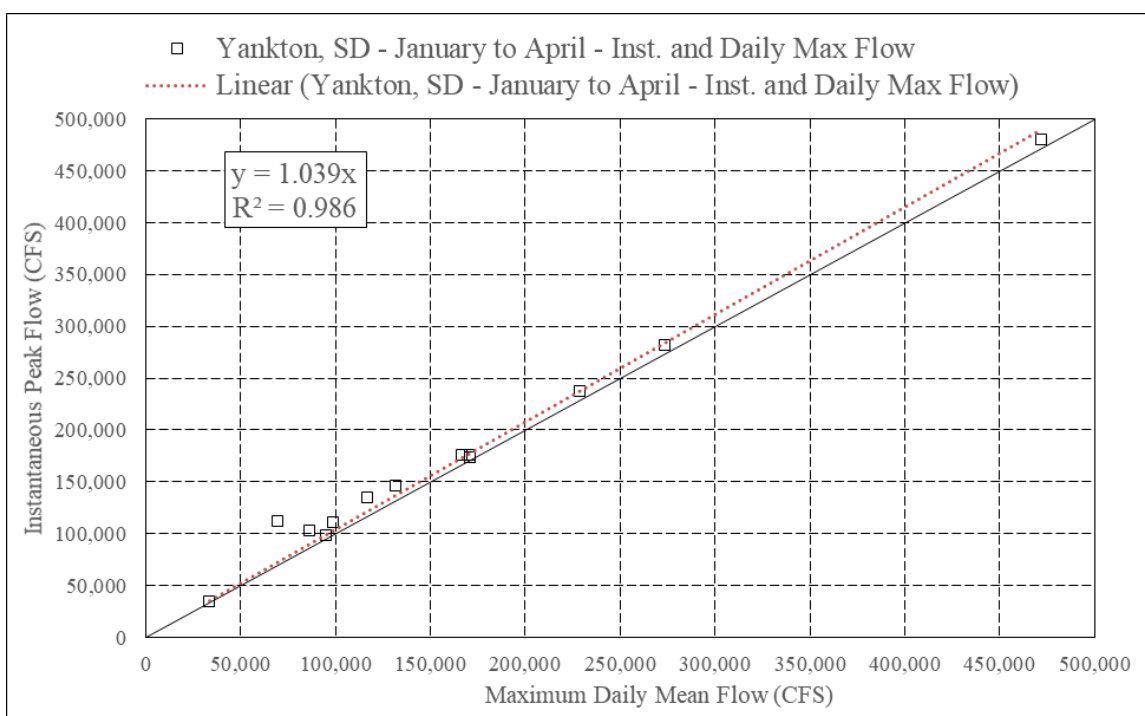
The maximum daily mean flow for water year 1972 was 54,500 cfs on November 23<sup>rd</sup>, 1971, while the instantaneous peak flow was 61,400 cfs on August 18<sup>th</sup> 1972. The local maximum daily mean flow of 50,100 cfs on September 30<sup>th</sup> 1972 was selected instead.

### **B.1.2 Changes for 1992**

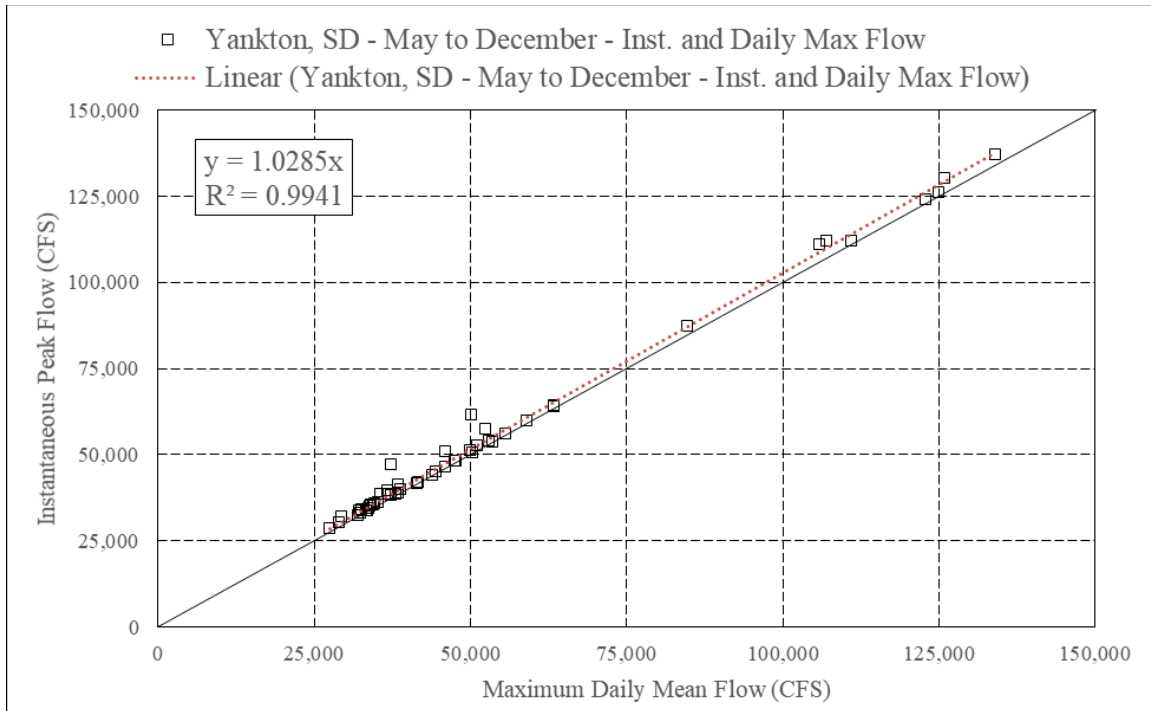
The maximum daily mean flow for water year 1991 was 31,100 cfs on October 1<sup>st</sup>, 1991, while the instantaneous peak flow was 30,100 cfs on May 16<sup>th</sup>, 1992. The local maximum daily mean flow of 29,100 cfs on May 9<sup>th</sup>, 1992.



**Figure B-1. Maximum Daily Mean to Instantaneous Peak Relationship – Yankton, SD – All-Seasons**



**Figure B-2. Maximum Daily Mean to Instantaneous Peak Relationship – Yankton, SD – Snowmelt Season**



**Figure B-3. Maximum Daily Mean to Instantaneous Peak Relationship – Yankton, SD – Rainfall Season**

## **B.2 Sioux City, IA – USGS Gage 06486000**

The daily mean USGS data on the Missouri River at Sioux City span from water years 1929 through 2019, with a gap from 1932 to 1938. The water year maximum daily mean flows were examined for consistency and validity. The water year peaks for 1971, 1972, 1981, 1985 and 2010 had to be changed. 1955 and 1977, and 1987 were excluded entirely. Figure B-4 shows the all-seasons relationship, Figure B-5 shows the snowmelt season relationship, and Figure B-6 shows the rainfall season relationship between maximum daily mean and instantaneous peak flows for the Missouri River at Sioux City, IA.

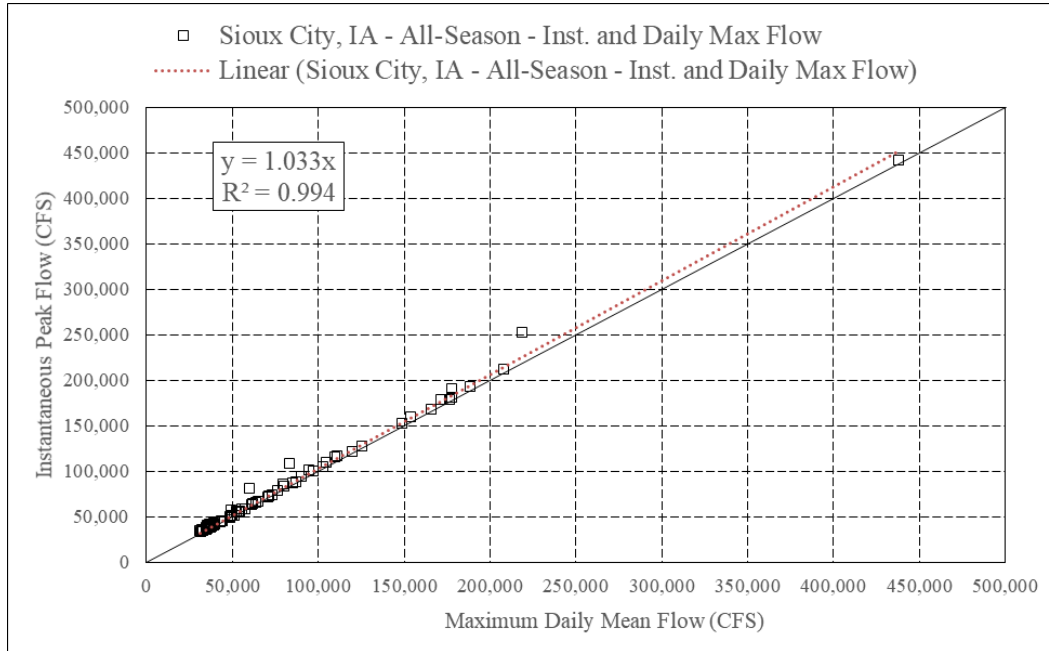
### **B.2.1 Changed Years**

The years 1971, 1972, 1981, 1985, and 2010 all had the annual peaks and maximum daily means spaced very far part in time, sometimes in different seasons. Local, same season maximum daily means were selected instead.

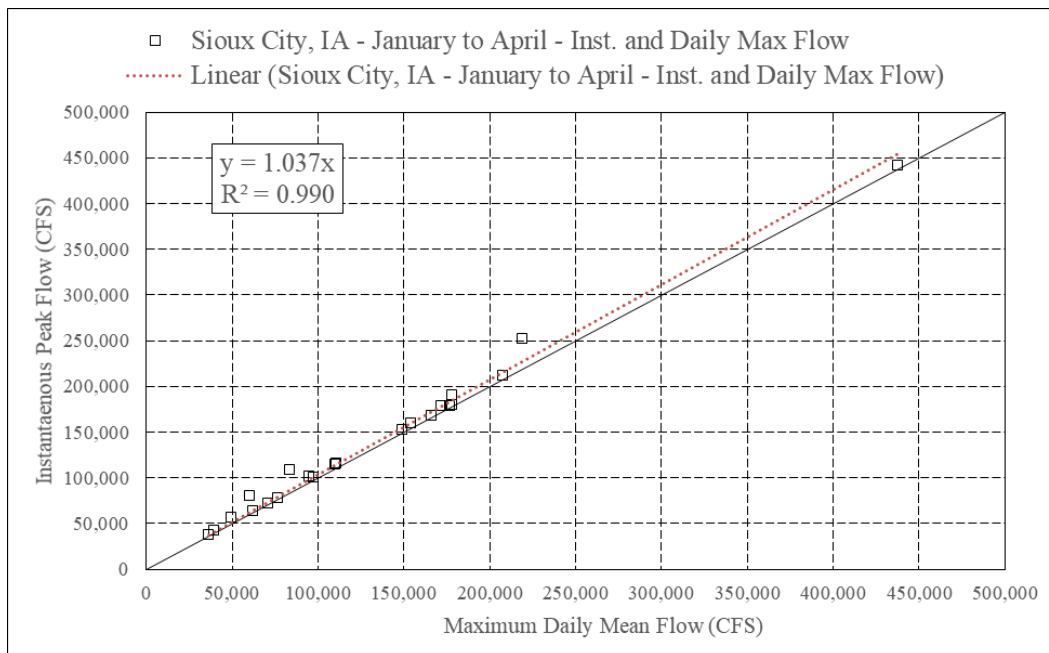
### **B.2.2 Excluded Years**

1955 was excluded because it was a low flow with a very high instantaneous peak flow (56,200 cfs on March 13<sup>th</sup>) relative to the same-event maximum daily mean 32,600 cfs. In 1977, flows were persistently low, and the instantaneous peak flow was in late 1976 and nearly twice as high as any of the 1977 flows. 1987 was removed because the

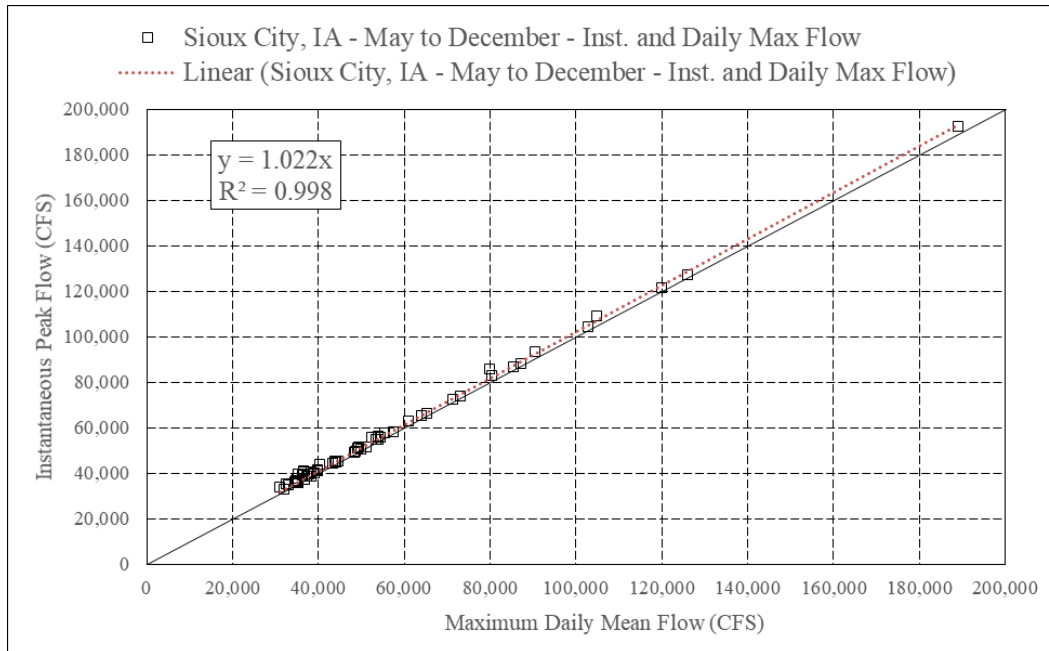
instantaneous peak flow was on October 2<sup>nd</sup>, while the 1986 instantaneous peak was on October 1<sup>st</sup>, so in effect, it was counting the same event.



**Figure B-4. Maximum Daily Mean to Instantaneous Peak Relationship – Sioux City, IA – All-Seasons**



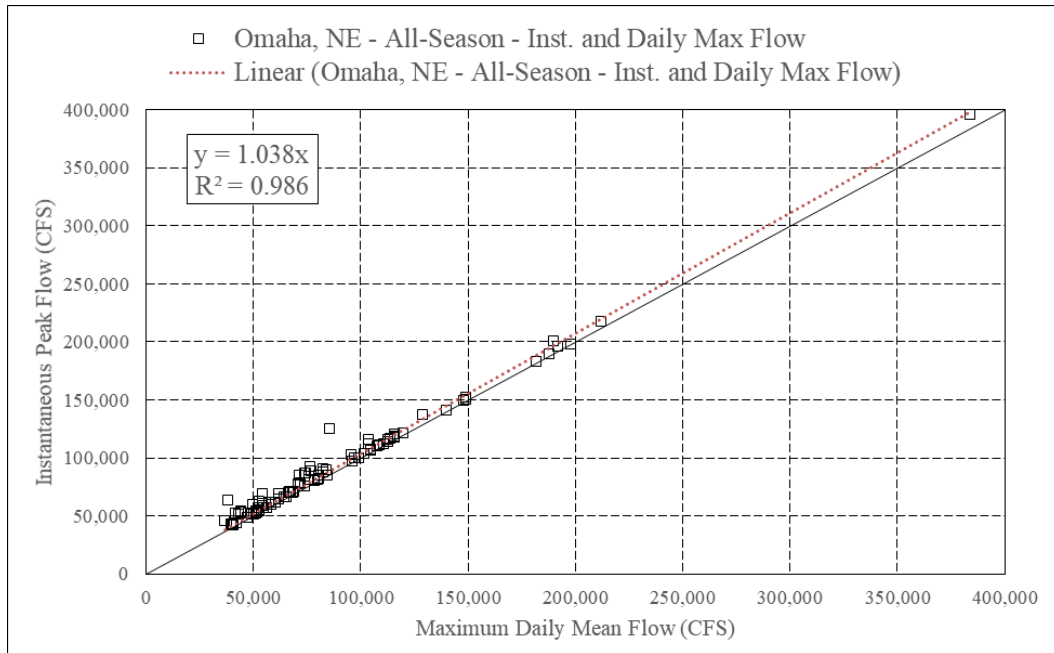
**Figure B-5. Maximum Daily Mean to Instantaneous Peak Relationship – Sioux City, IA – Snowmelt Season**



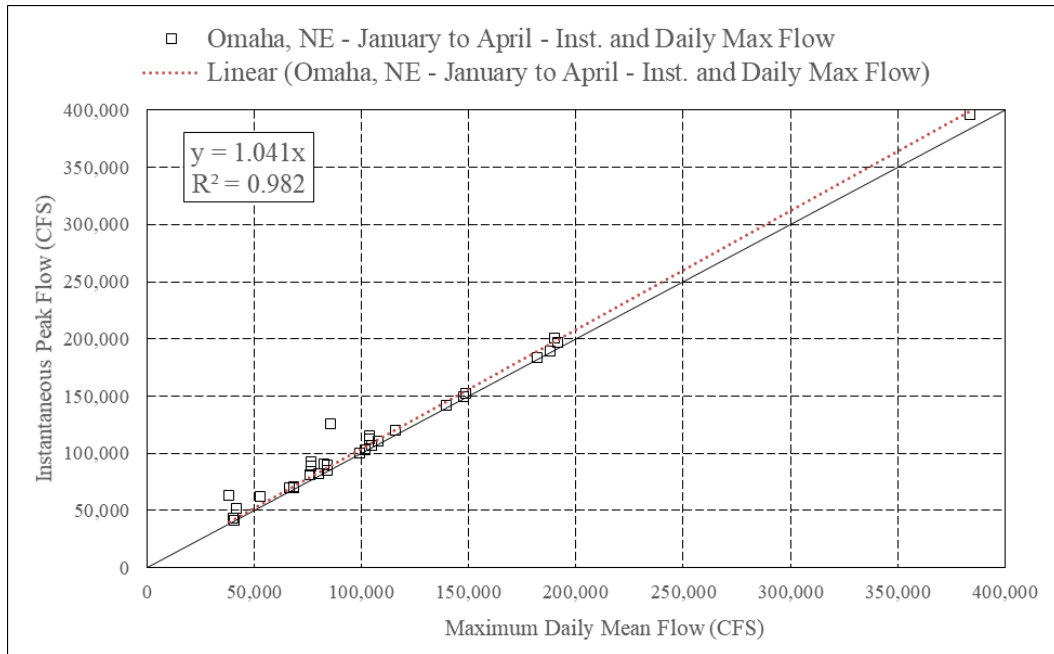
**Figure B-6. Maximum Daily Mean to Instantaneous Peak Relationship – Sioux City, IA – Rainfall Season**

### **B.3 Omaha, NE – USGS Gage 06610000**

The daily mean USGS data on the Missouri River at Omaha span from water years 1929 through 2019. The water year maximum daily mean flows were examined for consistency and validity. The water year maximum daily means for water years 1971, 1978, 1982, and 2012 had to be changed to local maximums, because the instantaneous peak was during a different time of year than the water year maximum daily flow. Figure B-7 shows the all-seasons relationship, Figure B-8 shows the snowmelt season relationship, and Figure B-9 shows the rainfall season relationship between maximum daily mean and instantaneous peak flows for the Missouri River at Omaha, NE.

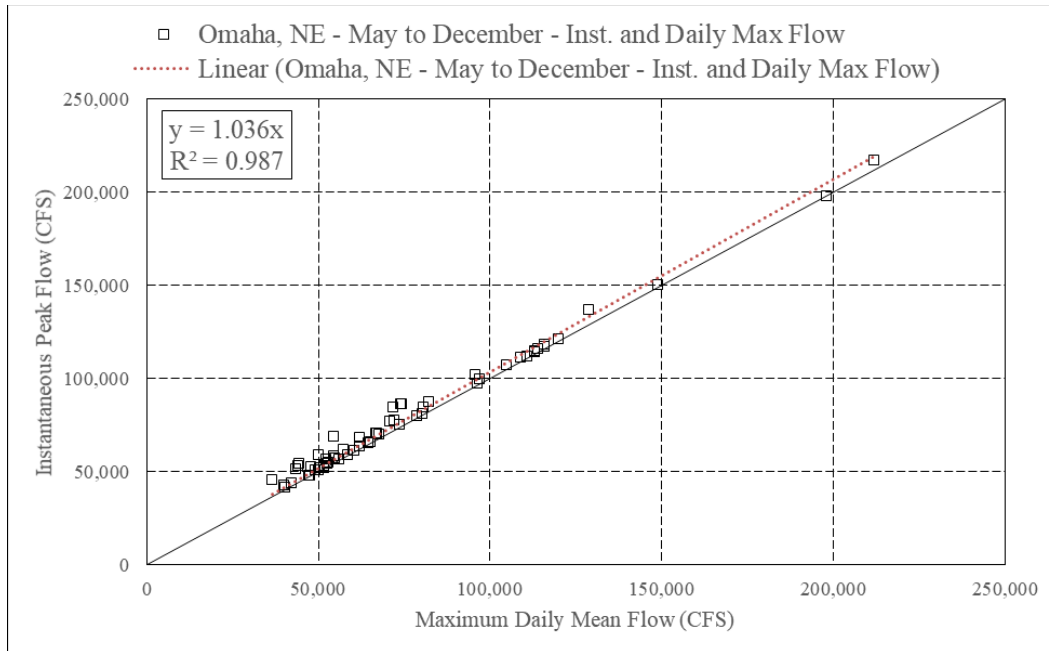


**Figure B-7. Maximum Daily Mean to Instantaneous Peak Relationship – Omaha, NE – All Seasons**



**Figure B-8. Maximum Daily Mean to Instantaneous Peak Relationship – Omaha, NE – Snowmelt Season**

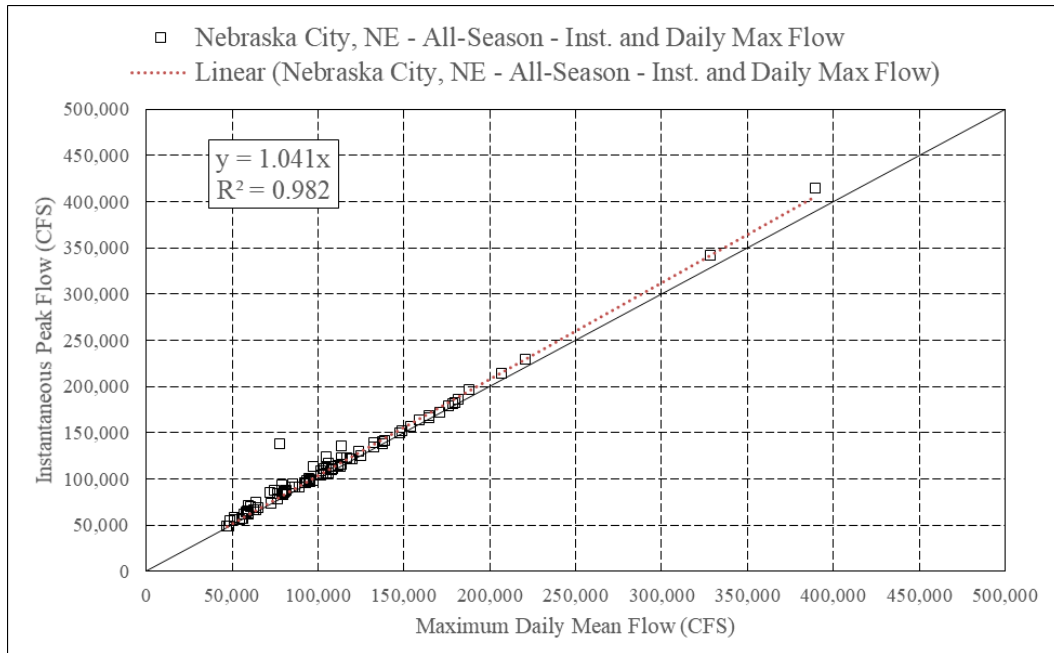




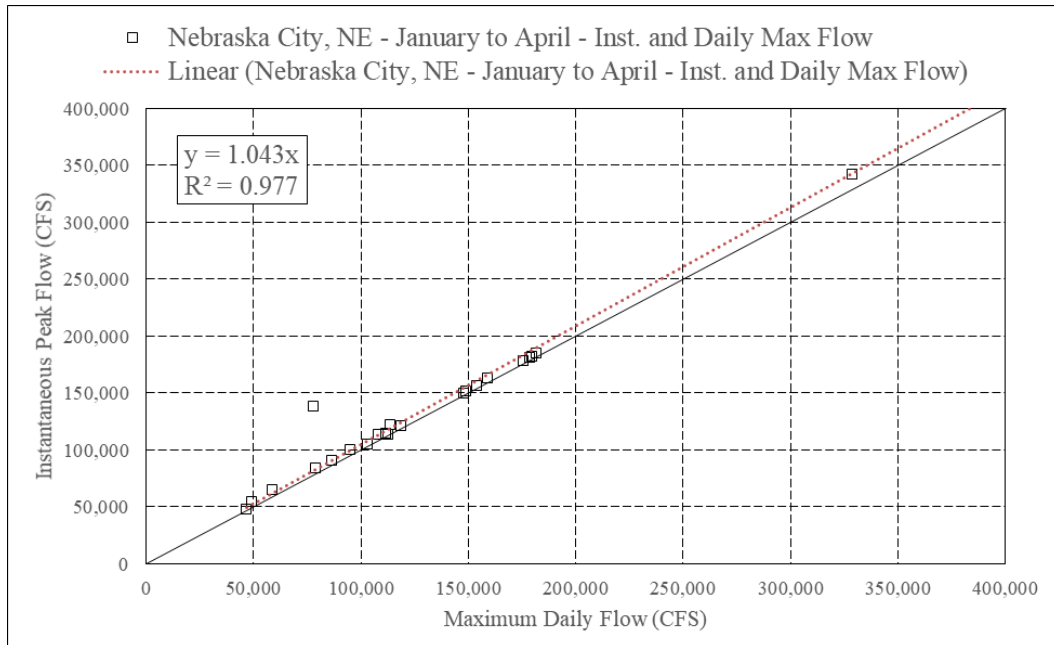
**Figure B-9. Maximum Daily Mean to Instantaneous Peak Relationship – Omaha, NE – Rainfall Season**

#### **B.4 Nebraska City, NE – USGS Gage 06807000**

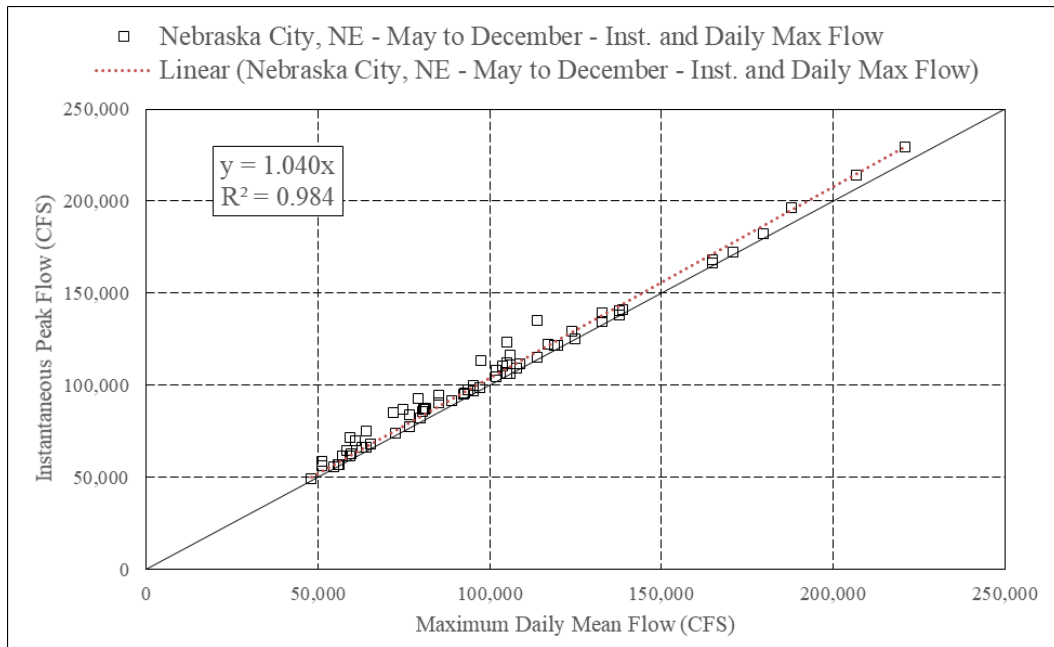
The daily mean USGS data on the Missouri River at Nebraska span from water years 1930 through 2019. The water year maximum daily mean flows were examined for consistency and validity. The water year maximum daily means for water years 1948 and 2012 had to be changed to local maximums, because the instantaneous peak was during a different time of year than the water year maximum daily flow. Figure B-10 shows the all-seasons relationship, Figure B-11 shows the snowmelt season relationship, and Figure B-12 shows the rainfall season relationship between maximum daily mean and instantaneous peak flows for the Missouri River at Nebraska City, NE.



**Figure B-10. Maximum Daily Mean to Instantaneous Peak Relationship – Nebraska City, NE – All Seasons**



**Figure B-11. Maximum Daily Mean to Instantaneous Peak Relationship – Nebraska City, NE – Snowmelt Season**



**Figure B-12. Maximum Daily Mean to Instantaneous Peak Relationship – Nebraska City, NE – Rainfall Season**