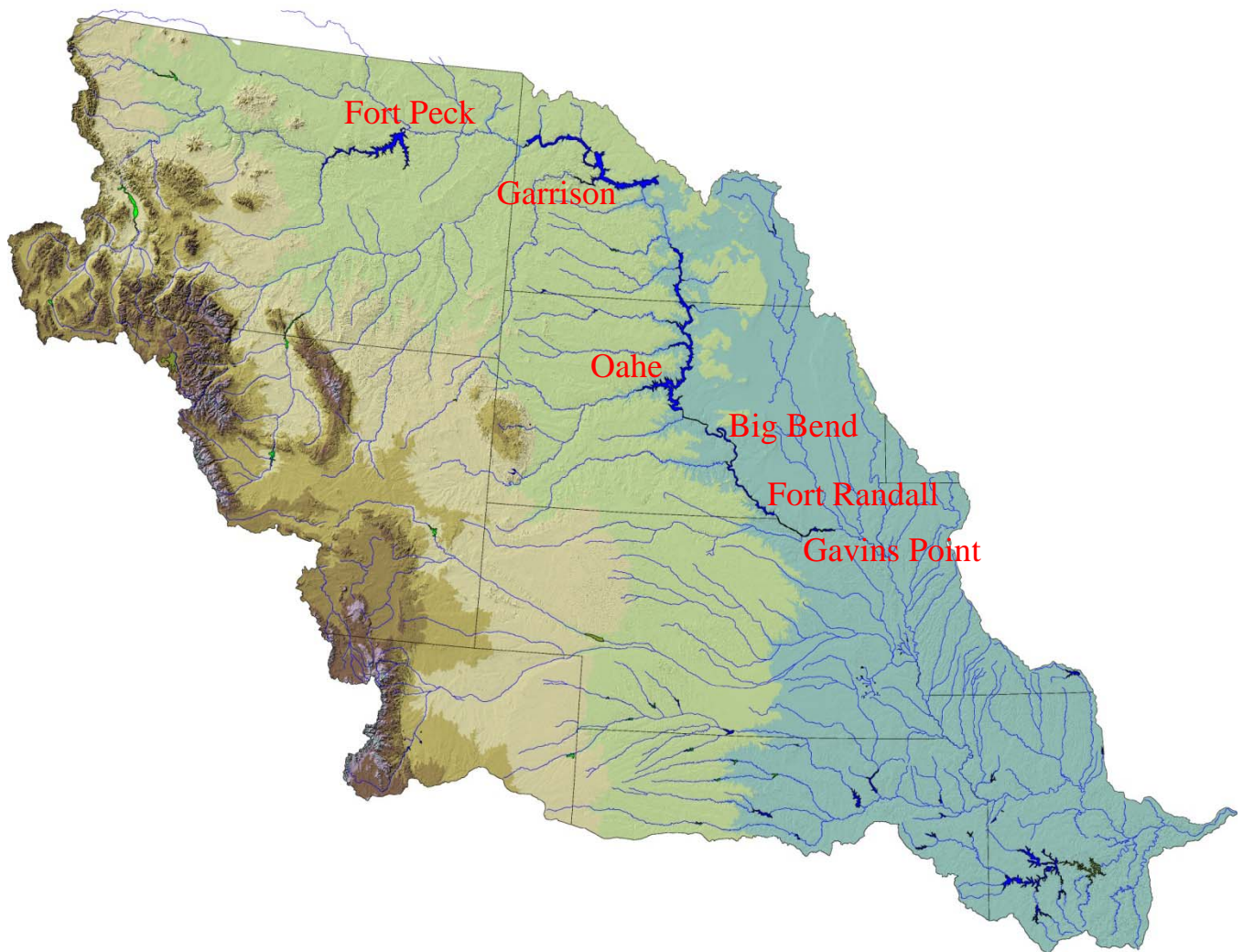




**US Army Corps
of Engineers** ®
Northwestern Division

*Determination and Analysis of Upper Basic and
Lower Basic Forecasts
Technical Report*



Missouri River Basin Water Management Division
Omaha, Nebraska

January 2015

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Missouri River Basin Water Management Division Technical Report

Determination and Analysis of Upper Basic and Lower Basic Forecasts

January 2015

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LIST OF ABBREVIATIONS AND ACRONYMS

AF	acre-feet
AOP	annual operating plan
ASD	annual standard deviation
Basin	Missouri River Basin
BEND	Big Bend Reservoir
CPC	National Oceanic and Atmospheric Administration Climate Prediction Center
FTPK	Fort Peck Reservoir
FTRA	Fort Randall Reservoir
GAPT	Gavins Point Reservoir
GARR	Garrison Reservoir
kAF	thousand acre-feet
MAF	million acre-feet
Master Manual	Master Water Control Manual
MRBWMD	Missouri River Basin Water Management Division
MSD	monthly standard deviation
NWS	National Oceanic and Atmospheric Administration - National Weather Service
NRCS	U.S. Department of Agriculture - Natural Resources Conservation Service
OAHE	Oahe
SNOTEL	NRCS Snowpack Telemetry
SUX	Gavins Point to Sioux City Reach
NWD	U.S. Army Corps of Engineers, Northwestern Division
System	Missouri River Mainstem Reservoir System
USBR	U.S. Bureau of Reclamation

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I. GENERAL

A. Purpose of Analysis

The Missouri River Basin Water Management Division (MRBWMD) performs the long-range Missouri River Mainstem Reservoir System (System) model simulation or monthly study at the beginning of each month for the purpose of regulating the System in order to meet the Congressionally authorized project purposes. The Basic runoff volume forecast (Basic) is used in the System model to provide a “most likely” simulation of forecast reservoir elevations and releases. The Upper Basic and Lower Basic forecasts are used to bracket the range of forecast reservoir elevations and releases given much wetter-than-expected or drier-than-expected conditions, respectively.

The purpose of this analysis was to update the monthly reach factors used in determining the Upper Basic and Lower Basic runoff forecast volumes for the Missouri River Basin (Basin) above Sioux City, Iowa (IA). The analysis included 116 years of observed monthly reach runoff from 1898 to 2013. Several methods for determining the Upper Basic and Lower Basic factors were analyzed and are discussed in this technical report. Both the previous Upper Basic and Lower Basic factors and the existing factors determined in the analysis of this technical report are listed in **Table 1**. The previous factors were used in all calendar year runoff forecasts through July 2014. Existing factors were used in forecasts beginning in August 2014.

Table 1
Monthly Upper Basic and Lower Basic Forecast Factors

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<u>Existing Factors (Post-Aug 2014)</u>												
Upper Basic												
Upper Group*	1.20	1.20	1.35	1.45	1.35	1.45	1.45	1.30	1.20	1.20	1.20	1.20
Lower Group**	1.40	1.40	1.50	1.55	1.55	1.45	1.40	1.35	1.35	1.35	1.35	1.35
Lower Basic												
Upper Group*	0.80	0.75	0.65	0.65	0.70	0.65	0.65	0.70	0.75	0.80	0.80	0.80
Lower Group**	0.75	0.75	0.55	0.50	0.50	0.50	0.55	0.65	0.75	0.75	0.75	0.75
<u>Previous Factors (Pre-Aug 2014)</u>												
Upper Basic	1.20	1.20	1.35	1.35	1.40	1.60	1.40	1.20	1.20	1.20	1.20	1.20
Lower Basic	0.80	0.80	0.65	0.65	0.60	0.60	0.60	0.80	0.80	0.80	0.80	0.80

* The Upper Group is comprised of the Fort Peck and Garrison reaches.

** The Lower Group is comprised of the Oahe, Fort Randall, Gavins Point and Sioux City reaches.

B. Annual Runoff Forecast

The calendar year runoff forecast, sometimes referred to as the Basic runoff volume forecast, is developed at the beginning of each calendar year. It is then updated at the beginning

of each month to show the actual runoff for past months of that year and the updated forecast for the remaining months of the year. This forecast presents annual and monthly runoff from six incremental drainage areas above Sioux City, IA as defined by the individual System projects (with the exception of Big Bend), plus the incremental drainage area between Gavins Point Dam and Sioux City, IA. Annual runoff and monthly runoff are defined as the unregulated volumes of runoff that would enter the System based on the 1949 level of Missouri Basin development.

C. Determination of Basic Runoff Forecasts

The Basic forecast is the “most likely” monthly and annual runoff forecast based on, but not limited to, the following factors: current drought conditions, soil moisture conditions, plains snowpack, mountain snowpack, antecedent precipitation, antecedent runoff, current streamflow and the National Oceanic and Atmospheric Administration’s Climate Prediction Center (CPC) long-range temperature and precipitation outlooks. The Basic forecast is then adjusted to produce the Upper Basic and Lower Basic forecasts, which bracket the range of expected runoff. The Upper Basic and Lower Basic forecasts provide a reasonable range of possible runoff volumes based on the variability in hydro-meteorological conditions and events that can occur over the remainder of the calendar year forecast period. As the year progresses, the range defined by the Upper Basic and Lower Basic forecasts generally lessens as the number of observed months increases and number of forecast months decreases.

At the beginning of a calendar year, the Basic forecast, which is the sum of the monthly reach forecasts, is made using MRBWMD forecasting methods. Upper Basic and Lower Basic forecasts are developed by multiplying monthly factors presented in **Table 1** by each monthly reach forecast volume. As the calendar year progresses and actual runoff is tabulated for past months, the Upper Basic and Lower Basic forecasts become a combination of observed and forecast runoff. For example, when a forecast is made on April 1, the forecast will include observed runoff in January, February and March and forecast runoff from April through December. In this case, the observed runoff will be the same in January, February and March in the Basic, Upper Basic and Lower Basic forecasts. The nine remaining months of the Basic runoff forecast will be used to develop Upper Basic and Lower Basic forecasts by multiplying the Upper Basic and Lower Basic factors by the Basic forecast volumes in the remaining nine months.

An example of the Upper Basic and Lower Basic forecast calculations are illustrated in **Table 2** using the actual April 1, 2012 Basic forecast. The precision of the forecasts are reported to the nearest thousand acre-feet (kAF) because the Basic forecast was an actual forecast, and reporting to the nearest kAF reduces rounding errors in the example. On April 1, 2012, the accumulated runoff, which is the sum of January, February and March runoff, is 4,871 kAF. The Basic forecast for the remaining months has been determined using MRBWMD forecasting methods resulting in a total Basic forecast of 23,396 kAF or 23.4 million acre-feet

(MAF). The previous Upper Basic and Lower Basic factors multiplied by the April through December monthly reach runoff forecasts resulted in an Upper Basic forecast of 30,570 kAF (30.6 MAF) and a Lower Basic forecast of 17,183 kAF (17.2 MAF).

Table 2
Example April 2012 Basic, Upper Basic and Lower Basic Forecast Volumes using the Previous Factors

Volumes in Thousand Acre-Feet (kAF)
Observed Volumes Highlighted in Red Text, Forecast Volumes Highlighted in Blue Text

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
<u>Previous Factors (Pre-2014)</u>													
Upper Basic	1.20	1.20	1.35	1.35	1.40	1.60	1.40	1.20	1.20	1.20	1.20	1.20	
Lower Basic	0.80	0.80	0.65	0.65	0.60	0.60	0.60	0.80	0.80	0.80	0.80	0.80	
<u>Basic</u>													
Fort Peck	334	429	528	580	1100	1550	760	340	330	380	380	325	7036
Garrison	233	543	881	960	1175	2295	1420	600	445	520	395	245	9712
Oahe	-46	183	232	270	270	380	175	65	110	65	65	0	1758
Fort Randall	140	140	130	120	130	135	50	35	35	4	5	10	934
Gavins Point	100	177	157	150	160	160	130	110	110	115	115	95	1578
Sioux City	219	174	319	370	300	290	220	135	100	80	80	80	2367
Total	980	1646	2246	2450	3135	4810	2755	1285	1130	1164	1040	755	23396
<u>Upper Basic</u>													
Fort Peck	334	429	528	783	1540	2480	1064	408	396	456	456	390	9264
Garrison	233	543	881	1296	1645	3672	1988	720	534	624	624	294	12904
Oahe	-46	183	232	365	378	608	245	77	132	78	78	0	2330
Fort Randall	140	140	130	162	182	216	70	42	42	5	5	12	1147
Gavins Point	100	177	157	203	224	256	182	132	132	138	138	114	1952
Sioux City	219	174	319	500	420	464	308	162	120	96	93	96	2973
Total	980	1646	2246	3308	4389	7696	3857	1541	1356	1397	1397	906	30570
<u>Lower Basic</u>													
Fort Peck	334	429	528	377	660	930	456	272	264	304	304	260	5118
Garrison	233	543	881	624	705	1377	852	480	356	316	316	196	6979
Oahe	46	183	232	176	162	228	105	52	88	52	52	0	1283
Fort Randall	140	140	130	78	78	81	30	28	28	3	4	8	748
Gavins Point	100	177	157	98	96	96	78	88	88	92	92	76	1237
Sioux City	219	174	319	241	180	174	132	108	80	64	64	64	1818
Total	980	1646	2246	1593	1881	2886	1653	1028	904	931	832	604	17183

A plot of the cumulative Basic, Upper Basic and Lower Basic runoff forecasts made on April 1, 2012 is shown in **Figure 1**. The plot illustrates how the range of cumulative runoff increases from April 1 to the end of the year due to the accumulation of monthly variability that could occur during the nine forecasted months. Although the Basic forecast is the most likely scenario that could occur in the 2012 example year, the actual observed runoff is expected to end up somewhere between the Upper Basic and Lower Basic forecasts.

As the calendar year progresses and runoff is observed in the Missouri Basin above Sioux City, the number of forecast months decreases. **Figure 2** illustrates the September 1, 2012 forecast of runoff in the 2012 calendar year. On September 1, 17,208 kAF of runoff had accumulated since January 1. The 2012 calendar year Basic forecast had been updated to 20,657 kAF (20.7 MAF) given the volume of runoff that had accumulated by September 1 and the four future months of forecasted runoff through the end of December 2012. The Upper Basic and Lower Basic factors multiplied by the September through December monthly reach runoff forecasts resulted in an Upper Basic forecast of 21,347 kAF (21.3 MAF) and a Lower Basic forecast of 19,968 kAF (20.0 MAF). Since there are fewer months being forecasted and there is less runoff and variability in the fall and winter months, the range of cumulative runoff that could occur by the end of the calendar year is much narrower compared to the April 1 forecast.

The September 1, 2012 runoff forecast for the Fort Peck reach is shown in **Figure 3** to illustrate the Basic, Upper Basic and Lower Basic forecasting method as it applies to reservoir reaches. The Basic forecast is 6,433 kAF (6.4 MAF), the Upper Basic forecast is 6,681 kAF (6.7 MAF), and the Lower Basic forecast is 6,185 kAF (6.2 MAF).

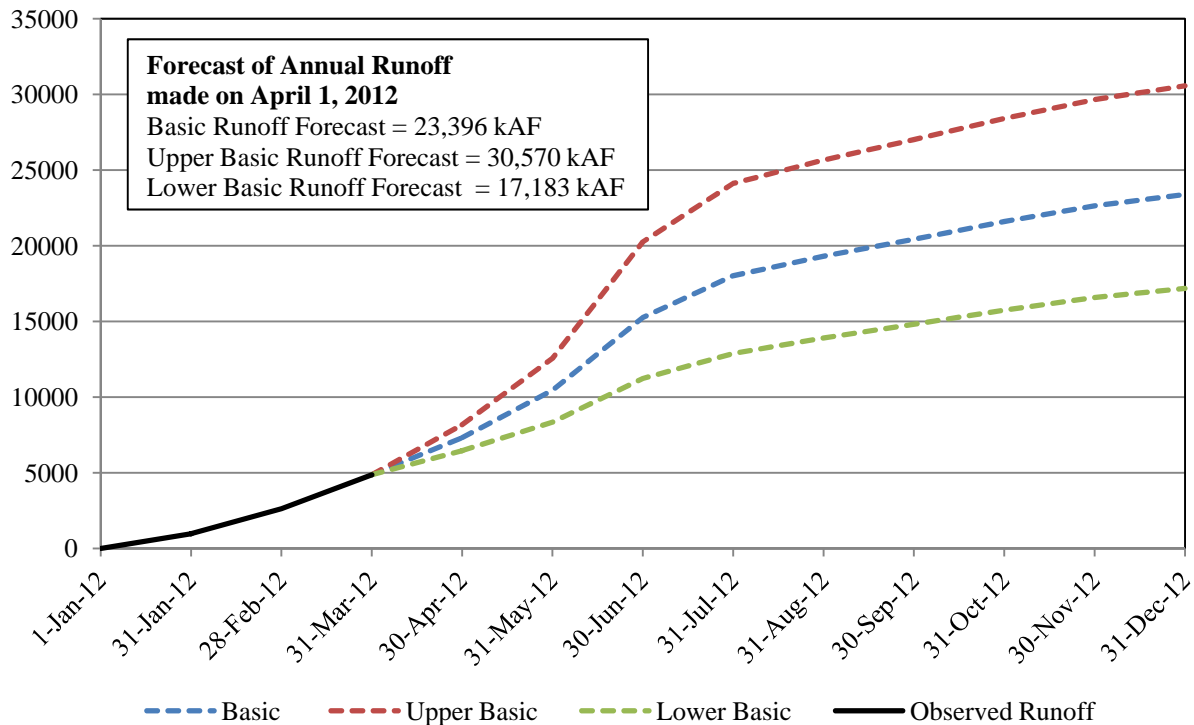


Figure 1. Example of the April 1, 2012 Basic, Upper Basic and Lower Basic Forecasts of Cumulative Annual Runoff Using the Previous Factors.

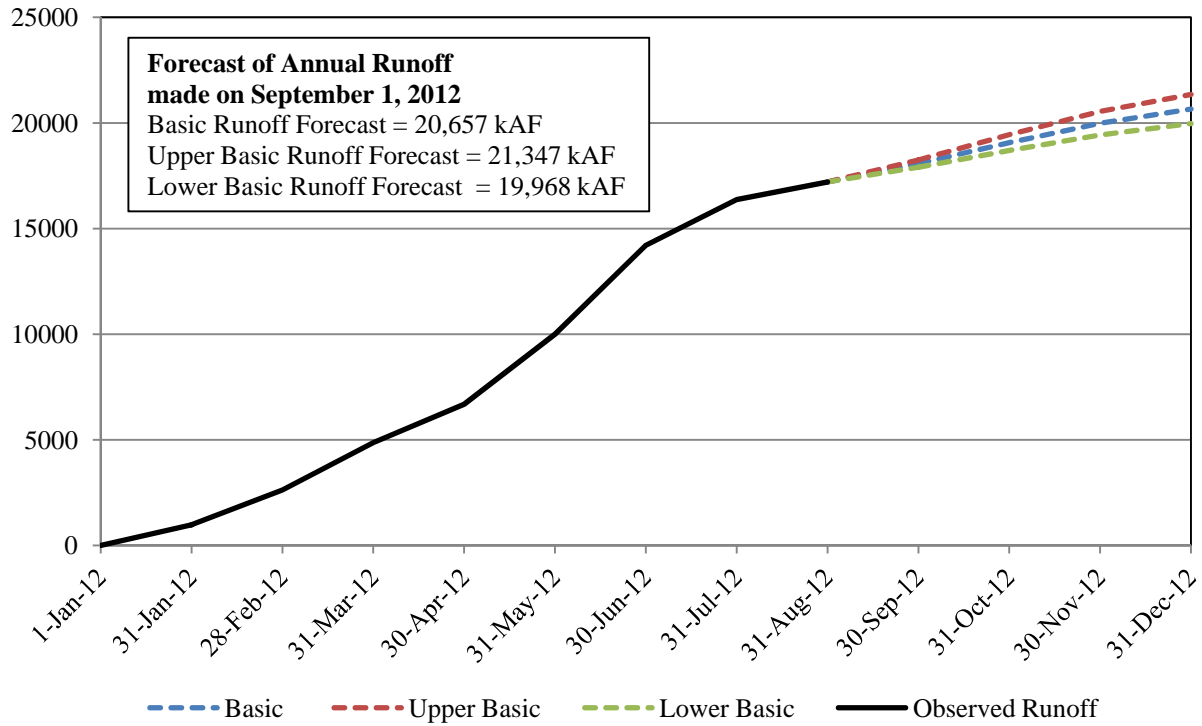


Figure 2. Example of the September 1, 2012 Basic, Upper Basic and Lower Basic Forecasts of Cumulative Annual Runoff Using the Previous Factors.

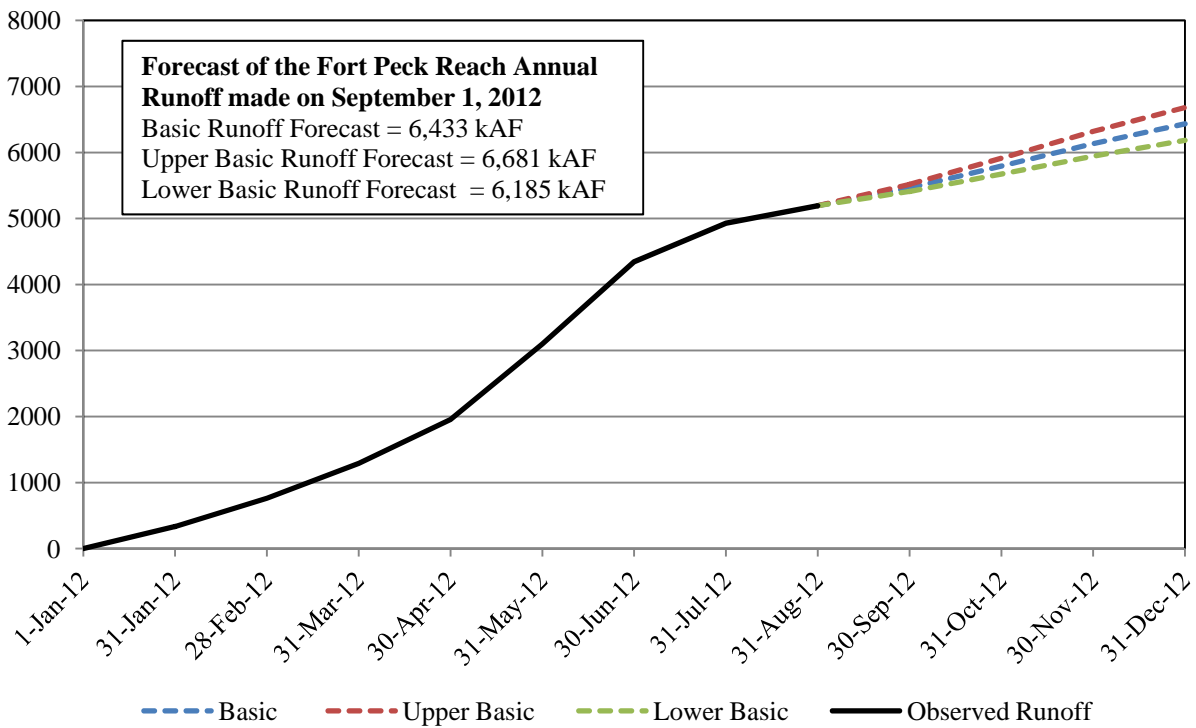


Figure 3. Example of the September 1, 2012 Fort Peck Reach - Basic, Upper Basic and Lower Basic Forecasts of Cumulative Annual Runoff Using the Previous Factors.

D. Annual Operating Plan Runoff Volumes

The purpose of the Annual Operating Plan (AOP) is to provide an array of expected System reservoir elevations and releases that could occur in the coming calendar years under varying levels of reservoir inflow. The array of operations is developed by simulating System reservoir operations under the guidelines of the Missouri River Mainstem Reservoir System Master Water Control Manual (Master Manual). The AOP simulations utilize statistically derived runoff volumes that reflect a varied range of runoff volumes based on historical runoff above Sioux City. The methods used to derive the runoff volumes for AOP reservoir studies are described in the MRBWMD Technical Report, Runoff Volumes for Annual Operating Plan Studies, August 2013 (AOP Studies). The AOP studies utilize five runoff levels with exceedance probabilities implied by their titles: upper decile, upper quartile, median, lower quartile, and lower decile. All volumes are adjusted to the 1949 level of water resources development in the Missouri Basin.

In contrast, the Upper Basic and Lower Basic forecasts are determined by factoring the Basic runoff volume forecast by the Upper Basic and Lower Basic factors. The Basic forecast is a forecast of runoff that is likely to occur using MRBWMD forecasting methods based on current and projected hydro-meteorological conditions. These Upper Basic and Lower Basic factors account for the wetter-than-expected and drier-than-expected conditions that could occur during the forecast period.

II. ANALYSIS OF PREVIOUS UPPER BASIC AND LOWER BASIC FACTORS

The Upper Basic and Lower Basic factor analysis included a comparison of Upper Basic and Lower Basic volumes to a statistical distribution of the 116 years (1898-2013) of observed reach runoff and to runoff statistics. The number of historic runoff years that occur above the Upper Basic volume, between the Upper Basic volume and Lower Basic volume, and below the Lower Basic volume were determined. Furthermore, the means and standard deviations of annual and monthly reach runoff volumes were compared.

Three other federal agencies, the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), the U.S. Bureau of Reclamation (USBR), and the National Weather Service (NWS) Northwest River Forecast Center (NWRFC) develop long-range water supply forecasts. These agencies' forecasts include a "most likely" forecast, which is similar to the Corps' Basic forecast. A brief description of the NRCS, USBR, and NWRFC runoff forecast methodologies are provided in Section II.C.

A. Runoff Analysis of the Upper Missouri River Basin

The mean (average) of the total annual runoff volume above Sioux City based on the 1898-2013 record is 25,231 kAF (25.2 MAF). By reservoir reach, the mean annual runoff is 7,236 kAF in Fort Peck; 10,701 kAF in Garrison; 2,464 kAF in Oahe, 904 kAF in Fort Randall; 1,697

kAF in Gavins Point; and 2,229 kAF in the Sioux City reach (**Figure 4**). Furthermore, the reservoir reach percent of the average total runoff is also provided in the figure. It is important to note that the Fort Peck and Garrison reaches contribute 28.7 percent and 42.4 percent, respectively, of the total annual runoff for a combined contribution of 71.1 percent (17,937 kAF), while the remaining reaches contribute 28.9 percent (7,294 kAF) of the total annual runoff.

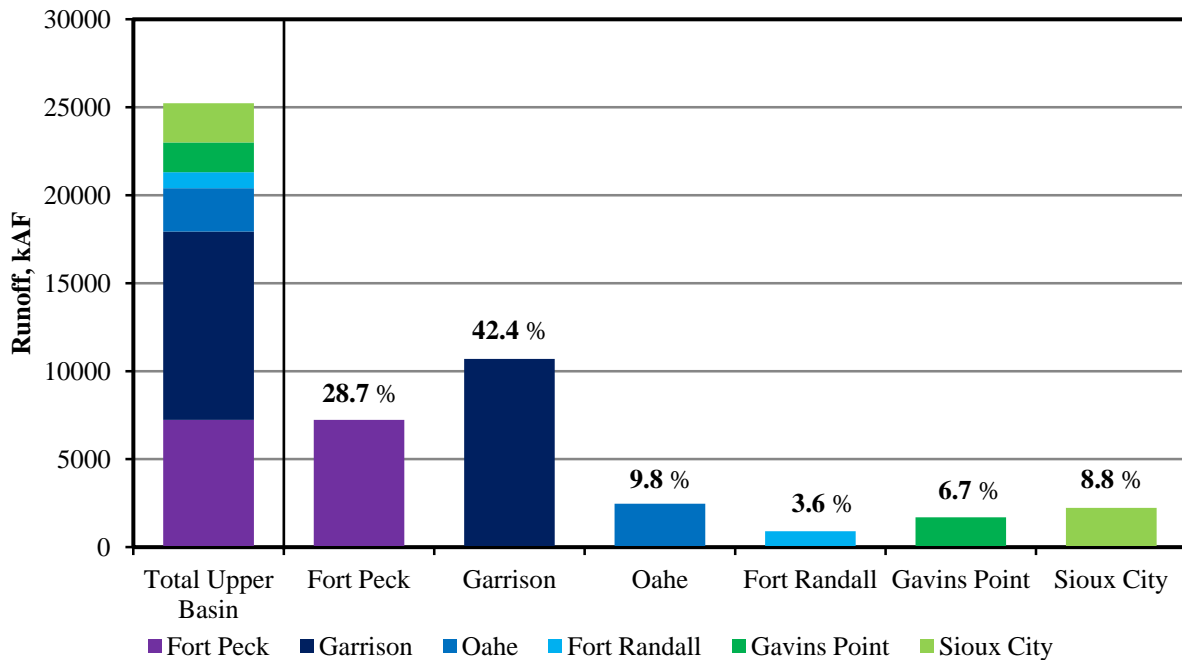


Figure 4. The Mean Annual Runoff above Sioux City and Mean Reservoir Reach Runoff Based on the 1898-2013 Runoff Record. Percent of Total by Reservoir Reach is Denoted.

Relating to the overall purpose of the technical report, an analysis of the previous method of determining Upper Basic and Lower Basic runoff volumes was conducted. By applying the previous monthly factors listed in **Table 1** to the average monthly runoff volumes for a Basic volume equivalent to the mean annual runoff, Upper Basic and Lower Basic volumes were determined to be 34,655 kAF and 16,898 kAF, respectively. Analysis of the historic annual runoff record indicated that runoff in 88 of 116 years, or 76 percent, was within the Upper Basic and Lower Basic volume bracket; 11 of 116 years, or 9 percent, was above the Upper Basic volume; and, 17 of 116 years, or 15 percent, was below the Lower Basic volume. This is illustrated in **Figure 5**, a bar chart showing the distribution of the 116 years of runoff record among the three categories and for each individual reservoir reach.

In the uppermost two reaches, Fort Peck and Garrison, the number of years distributed among the three categories is similar to each other and to the results for the total runoff. The Fort Peck and Garrison reaches are the dominant source of runoff variability as seen in **Figure 4**, which is why the total runoff variability mirrors these reaches. The analysis of the four lower

reaches of Oahe, Fort Randall, Gavins Point and Sioux City show a wider distribution among the three categories than for the total runoff. More historic runoff years occur above the Upper Basic volume and below the Lower Basic volume, while fewer years occur within the Upper Basic and Lower Basic bracket in the lower four reaches when compared to the Fort Peck, Garrison and total results. Gavins Point has slightly fewer years within than Fort Peck and Garrison; however, its overall influence is small because it contributes less than seven percent to the total runoff. The Oahe, Fort Randall and Sioux City reaches contain even fewer years within than Gavins Point.

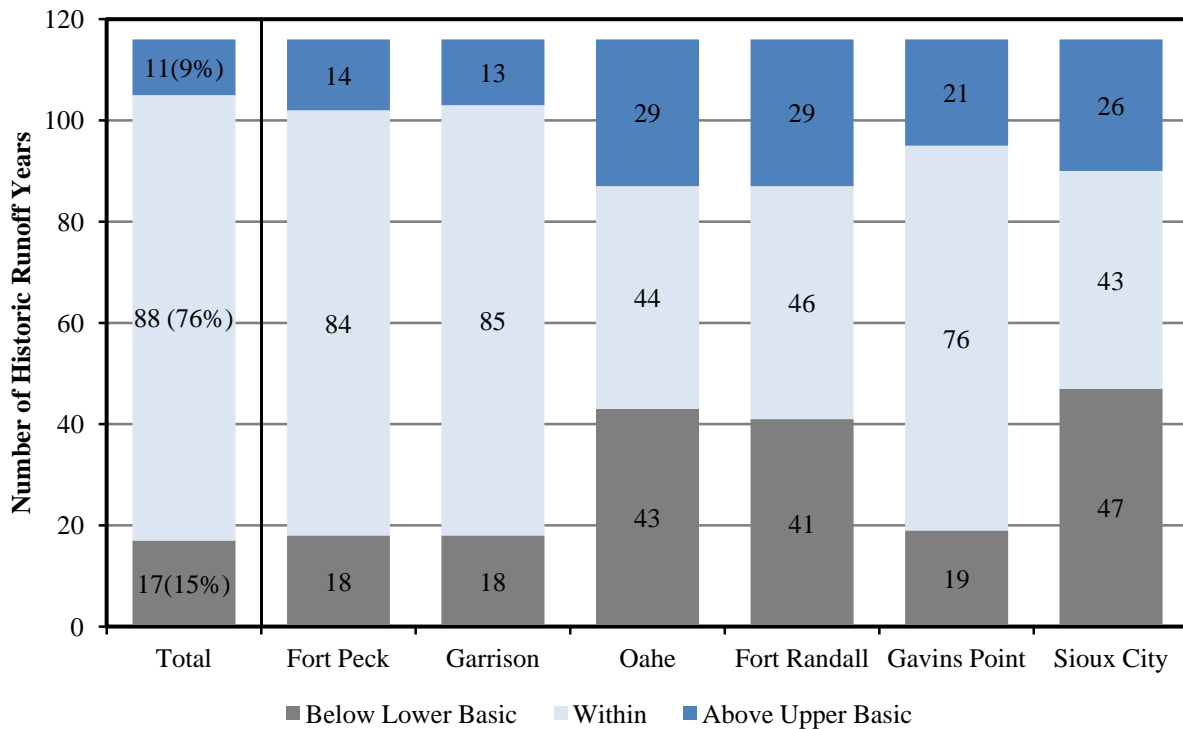


Figure 5. The Number of Historic Runoff Years Above, Below and Within the Upper Basic and Lower Basic Annual Volumes Using the Previous Factors.

This comparison of the distribution of historic runoff years in the uppermost two reaches and the remaining reaches demonstrate two different runoff distributions when viewed in the context of the Upper Basic and Lower Basic volume categories. These differences in runoff variability may be a result of differences in the dominant runoff mechanisms in the reaches. The uppermost two reaches are dominated by mountain snowmelt runoff during May, June and July, while a secondary portion of the runoff variability is influenced by rainfall runoff. The remaining four reaches are influenced by plains snowmelt runoff in March and April accompanied by rainfall runoff in other non-winter months. Furthermore, there are differences in overall watershed topography and tributary sources as well as impacts from climate cycles such as prolonged droughts or flood periods that influence runoff variability.

B. Comparison of the Basic Volumes to Runoff Statistics

The probability distribution of the 116 years of annual runoff record can be described by a normal probability distribution function or a Pearson Type III probability distribution function, both of which are commonly used in hydrologic engineering applications. For this analysis, the annual runoff record was applied to a normal probability distribution. A normal distribution curve as shown in **Figure 6** relates the frequency or probability of a random variable to its value, which is represented by the number of standard deviations above or below its mean. The standard deviation is a statistically derived measure of variability based on the random variable. The area under the curve represents the percent of the number of occurrences of the random variable with respect to the total number of occurrences. In a normal distribution, the number of occurrences of a variable between plus or minus one standard deviation from the mean is 68.2 percent of all variable occurrences. The number of occurrences greater than the mean plus one standard deviation (mean-plus-one) is 15.9 percent, while the number of occurrences less than the mean minus one standard deviation (mean-minus-one) is 15.9 percent.

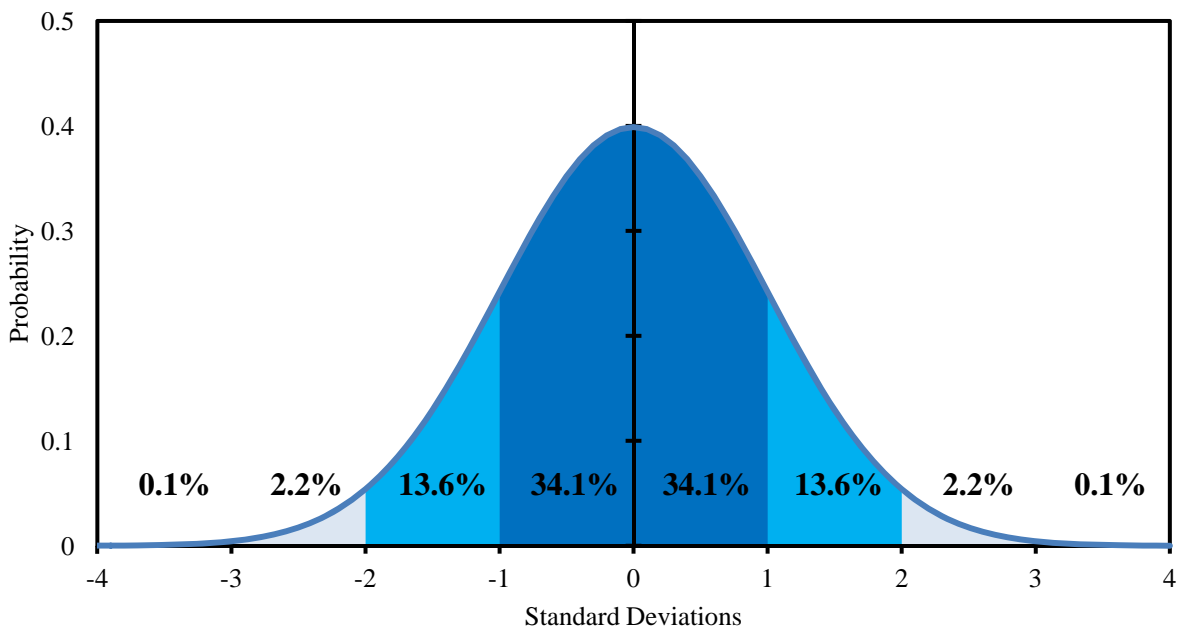


Figure 6. The Percent Area Under the Normal Distribution Curve Between the Number of Indicated Standard Deviations About the Mean.

Since the mean of the 1898-2013 record of annual runoff above Sioux City is 25,231 kAF, and the computed standard deviation is 8,007 kAF, the mean-plus-one volume is 33,238 kAF and the mean-minus-one volume is 17,224 kAF (**Table 3**). Based on these volumes, the number of historic years between the mean-plus-one and mean-minus-one volumes is 81, which is approximately 69.8 percent of the total runoff years. The number of years less than the mean-minus-one is 18 (15.5 percent) and the number of years greater than the mean-plus-one is 17

(14.7 percent), so the annual runoff record above Sioux City approximately fits a normal distribution.

In order to incorporate monthly variability into the statistical volumes, monthly standard deviations were determined for each month of the total runoff record and are shown in **Table 3**. Runoff viewed on a monthly basis reveals that the highest runoff months are May, June (highest) and July followed by March and April. These months also possess substantial variability as seen in the monthly standard deviations. For example, the average June runoff is 5,451 kAF with a standard deviation of 2,189 kAF, while the average April runoff is 2,937 kAF with a standard deviation of 1,802 kAF.

Table 3
Annual and Monthly Variability in the Runoff Summation above Sioux City
 Volumes in Thousand Acre-Feet (kAF))

	Annual Runoff	Monthly Runoff												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean (Average)	25231	763	1098	2926	2937	3315	5451	3272	1342	1142	1194	1045	746	25231
Std Deviation	8007	262	474	1346	1802	1338	2189	1662	587	485	458	328	310	11241
Mean-plus-one	33238	1025	1572	4272	4739	4653	7640	4934	1929	1627	1652	1373	1056	36472
Mean-minus-one	17224	501	624	1580	1135	1977	3262	1610	755	657	736	717	436	13990

The mean-plus-one-monthly and mean-minus-one-monthly volumes describe the unique monthly variability of runoff above Sioux City, and influence the annual variability of runoff. In total, the sum of the twelve monthly standard deviation volumes is 11,241 kAF, which is larger than the standard deviation of total annual runoff (8,007 kAF). Since the monthly standard deviation is 11,241 kAF, the total mean-plus-one-monthly volume is 36,472 kAF and the total mean-minus-one-monthly volume is 13,990 kAF (**Table 3**). The total of the mean-minus-one-monthly volumes is less than the annual mean-minus-one volume, and the total of the mean-plus-one-monthly volumes is greater than the annual mean-plus-one volume because the monthly standard deviations add more variability.

When the 116 years of historical runoff are evaluated by the statistical volumes in **Table 3**, the number of years that occur above, between and below the mean-plus-one and mean-minus-one annual and monthly volumes can be determined in **Table 4**. For the annual standard deviation volumes, 17 years are above the mean-plus-one volume and 18 years are below the mean-minus-one volume. Between the mean-plus-one and mean-minus-one volumes 81 historical runoff years occur. Categorized further, 36 years occur between the mean-plus-one and mean volumes, while 45 years occur between the mean and mean-minus-one volumes. For the monthly standard deviation volumes, six years are above the mean-plus-one-monthly volume, six years are below the mean-minus-one-monthly volume, and 104 years are between the mean-plus-one-monthly and mean-minus-one-monthly volumes. Similarly, 47 years occur

between the mean-plus-one-monthly and mean volumes, while 57 years occur between the mean-minus-one monthly and mean volumes.

Table 4
Number of Historic Runoff Years Above, Below and Between
Runoff Statistical Volumes
***Based on the 1898-2013 Mean Annual Runoff above Sioux City (25231 kAF)**

	<u>Annual Standard Deviations</u>		<u>Monthly Standard Deviations</u>	
	Volume, kAF	Number of Years	Volume, kAF	Number of Years
Above Mean-plus-one	33238*	17	36473*	6
Mean-plus-one to Mean	33238 – 25231	36	36473 – 25231	47
Mean to Mean-minus-one	25231 – 17224	45	25231 – 13990	57
Below Mean-minus-one	17224*	18	13990*	6

The mean monthly volumes, the mean-plus-one-monthly volumes and the mean-minus-one-monthly volumes are plotted in **Figure 7** with monthly Upper Basic and monthly Lower Basic volumes determined by applying the previous factors to average monthly runoff. This plot demonstrates the differences between monthly Upper Basic and Lower Basic volumes and the mean-plus-one-monthly volumes and the mean-minus-one-monthly volumes. The Upper Basic and Lower Basic volumes in **Figure 7** approximate the monthly runoff variability that can be seen in the mean-plus-one-monthly and the mean-minus-one-monthly volumes, but deviate from runoff statistics in some months. Of particular note are the significant differences between the mean-plus-one-monthly and the Upper Basic volume, and the mean-minus-one-monthly and the Lower Basic volume in April and June. In April the mean-plus-one-monthly and mean-minus-one-monthly volumes provide a wider range of runoff volumes than the Upper Basic and Lower Basic volumes. The April mean-plus-one-monthly volume is 800 kAF higher than the Upper Basic volume, while the mean-minus-one-monthly volume is about 800 kAF lower than the Lower Basic volume. In June the Upper Basic volume exceeds the mean-plus-one-monthly volume by more than 1,000 kAF. Although the Upper Basic and Lower Basic factors try to approximate monthly variability, this analysis indicates there are some differences in actual monthly variability that the Upper Basic and Lower Basic factors are not capturing.

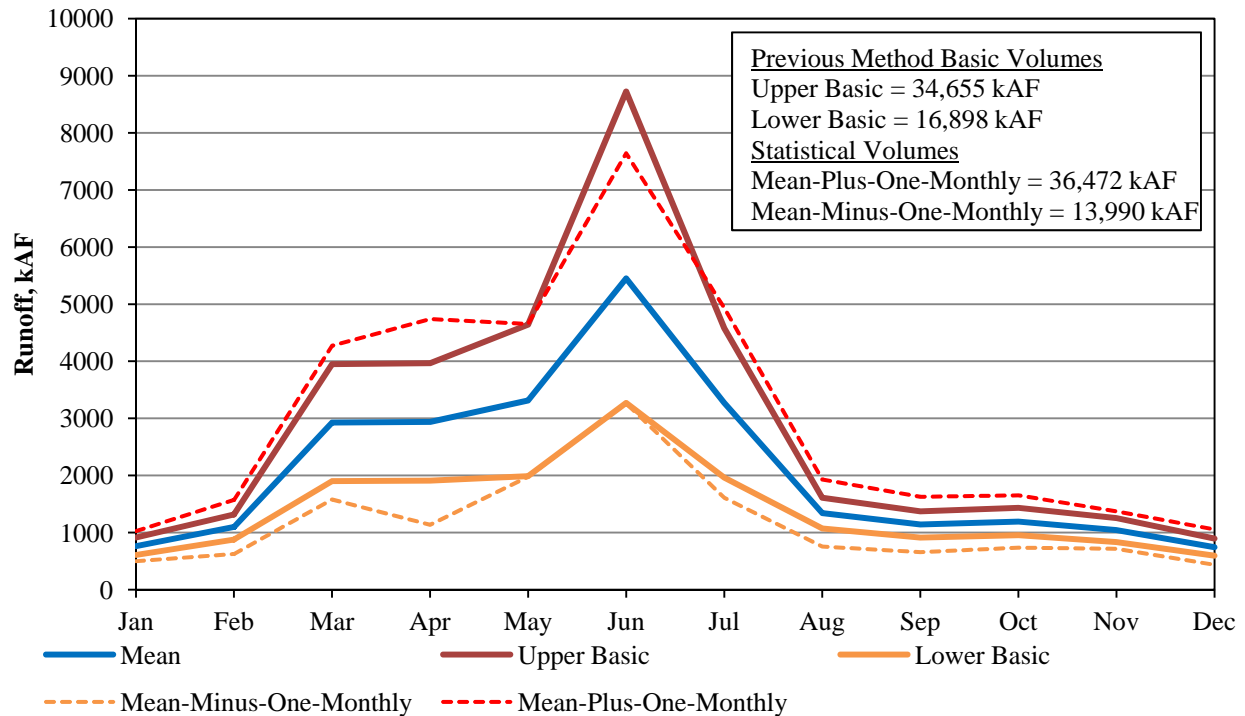


Figure 7. Comparison of Upper Basin – Upper and Lower Basic Volumes (Using Previous Factors) and the Mean-Plus-One-Monthly and Mean-Minus-One-Monthly Volumes, Based on the Mean Monthly Upper Basin Runoff Volumes.

C. Cooperating Agency Water Supply Forecasts

Cooperating federal agencies develop long-range water supply forecasts for western regions of the U.S. for water user and reservoir operation long-range planning studies. The NRCS develops water supply forecasts by performing multiple linear regression analysis of observed precipitation and snowfall accumulations collected by the NRCS Snowpack Telemetry (SNOTEL) network of gages. Based on the most current hydrometeorological conditions, a most probable forecast (NRCS-most-probable) is developed. Furthermore, the forecasts include an evaluation of the standard error of the model used to make the forecast. From this, the NRCS develops forecasts at 10 percent, 25 percent, 75 percent and 90 percent levels of exceedance. A reasonable maximum forecast (NRCS-reasonable-maximum) is equivalent to the 10 percent chance exceedance forecast. A reasonable minimum forecast (NRCS-reasonable-minimum) is equivalent to the 90 percent exceedance forecast. Consequently, the NRCS-reasonable-maximum and NRCS-reasonable-minimum encompass 80 percent of all probable forecast runoff scenarios that could occur during the runoff period.

The USBR develops seasonal water supply forecasts for their multi-purpose reservoirs. The USBR forecasts are based on a most probable reservoir inflow forecast, a probable minimum forecast and probable maximum forecast, the latter two encompassing approximately 80 percent of all probable forecast reservoir inflow scenarios.

A third agency that prepares water supply forecasts for the Columbia River Basin is the NWRFC. The NWRFC creates these forecasts in cooperation with the Columbia River Basin Water Management Division of the U.S. Army Corps of Engineers, Northwestern Division for the purpose of developing long-range reservoir regulation plans over the course of the calendar year. The NWRFC uses its Ensemble Streamflow Prediction (ESP) system, which is a forecasting system combining a hydrologic modeling system with an ensemble of historical meteorological conditions, to create probabilistic forecasts of river flow and volume. Based on the ensemble of outcomes, volumetric forecasts of runoff volumes cover a forecast range from the 90 percent to 10 percent exceedance probabilities, and include a 50 percent (most likely) forecast. Similar to the USBR and NRCS, the NWRFC forecasts encompass approximately 80 percent of all probable forecast runoff scenarios.

When the previous factors are applied to the mean annual runoff above Sioux City, and the historical annual runoff record is categorized by the Upper Basic and Lower Basic volumes, the Upper Basic to Lower Basic volume range encompasses 76 percent of the historical annual runoff volumes. In a similar manner, the mean-plus-one and mean-minus-one standard deviation volumes based on annual runoff encompass about 70 percent of the historical annual runoff volumes. Also, the mean-plus-one-monthly and mean-minus-one-monthly volumes encompass about 90 percent of the historical annual runoff volumes. While none of the analyzed ranges encompass an equivalent percentage of historic annual runoff volumes, they do appear to approximate a probability level similar to the cooperating agencies' 80 percent range.

III. ANALYSIS TO UPDATE UPPER BASIC AND LOWER BASIC FACTORS

A. Alternative Basic Forecast Criteria

The results of using common monthly factors across all reaches (e.g. **Table 1**, June Upper Basic and Lower Basic factors equal to 1.6 and 0.6, respectively, for all six reaches) as shown in **Figure 5**, prompted a more detailed statistical analysis of applying unique monthly reach factors. The reasoning for the analysis of unique monthly reach factors was to determine if unique factors could be applied per reach or groups of reaches when viewed at the monthly level. This change was analyzed in order to integrate differences in monthly reach variability into the Upper Basic and Lower Basic factors. Furthermore, the analysis adjusts factors to emulate the range of variability employed by other forecasting agencies. The analysis of unique monthly reach runoff progressed into two methods:

1. Method 1 – Monthly Reach Variability. This method involved an analysis of the 116 years of monthly reach inflows for the six reaches and determination of the mean-plus-one-monthly and mean-minus-one-monthly standard deviation volumes by reach. For the six reaches and twelve months, this resulted in 72 mean-plus-one volumes and 72 mean-minus-one volumes for a total of 144 volumes and potentially 144 unique factor values.

Particular attention was given to the months of April and June. As discussed earlier in this report, the Upper Basic April and June volumes using the previous factors (**Table 1**) differed from the April and June mean-plus-one-monthly and mean-minus-one-monthly volumes (**Figure 7**).

2. Method 2 - Emulating Other Agencies. Water supply forecasts developed by NRCS, USBR and NWRFC encompass 80 percent of the probable runoff forecast within the 90 percent and 10 percent exceedance levels. The previous Upper Basic and Lower Basic forecast factors produce runoff results that bracket 9 percent of the runoff record above the Upper Basic volume, 76 percent within the Upper Basic and Lower Basic volumes and 15 percent below the Lower Basic volume as shown in **Figure 5**. Analysis of this method involved applying the 10-80-10 range methodology to the six reaches each month.

Based on previous Upper Basic and Lower Basic practices and the analysis of runoff variability in the reservoir reaches, the following assumption was made. Rounding the Upper Basic and Lower Basic factors to the nearest five percent (e.g. 1.43 rounded to 1.45 or 145 percent) provides a reasonable level of accuracy to represent the variability within the Basic, Upper Basic and Lower Basic forecasts given the number of assumptions (e.g. soil moisture conditions, long-term precipitation and temperature outlooks, plains and mountain snow water equivalent) made in determining the Basic volume forecast.

B. Method 1 –Monthly Reach Variability

Method 1, the use of monthly reach standard deviations, was applied to the historical monthly reach data. For example, the Fort Peck May Upper Basic mean-plus-one-monthly volume was determined to be 1,533 kAF. As this methodology was applied to all 12 months in all 6 reaches, the 72 Upper Basic and 72 Lower Basic volumes were accumulated. The result was an Upper Basic volume of 40,795 kAF and a Lower Basic volume of 9,668 kAF. After rounding the Upper Basic and Lower Basic factors and applying those factors to the monthly reach means, the Upper Basic and lower Basic volumes totaled 40,540 kAF (40.5 MAF) and 9,700 kAF (9.7 MAF), respectively. When compared to the historical annual volumes, the Upper Basic volume (40,540 kAF) is at a 2.5 percent exceedance level (3 of 116 years higher). Interestingly and coincidentally, the percentage coincides with the percentage of data above two standard deviations in a normal distribution (see **Figure 6**). However, when compared with the historical annual volumes, the Lower Basic volume (9,700-kAF) is more than 1,000 kAF less than the minimum historical runoff volume (10,701 kAF, 1931). Thus, the decision was made to evenly adjust the Lower Basic monthly reach factors so that the Lower Basic volume mimicked the 2.5 percent exceedance level from the Upper Basic analysis. This adjustment resulted in a Lower Basic volume of 12,140 kAF. All monthly reach factors and Upper Basic and Lower Basic volumes are provided in **Exhibit 1** in the Appendix. The result of the Method 1 analysis is

that the Upper Basic and Lower Basic volumes bracketed 110 years (95 percent) of the historical annual runoff volumes (**Table 5**). By reservoir reach, the analysis exhibited some variation in the number of years occurring above the Upper Basic volume, below the Lower Basic volume and within the Upper Basic and Lower Basic volumes when compared to the total volume occurrences.

Table 5
Comparison of Methods – Basic, Upper Basic and Lower Basic Volumes
Based on the 1898-2013 Mean Annual Runoff (25231 kAF)

<u>Forecast Categories</u>	<u>Number of Years</u>						
	Fort Peck	Garrison	Oahe	Fort Randall	Gavins Point	Sioux City	Total
<u>Method 1</u>							
Above Upper Basic (40540 kAF)	8	7	9	6	12	9	3 (2.5%)
Within Upper and Lower Basic	100	103	101	103	102	84	110 (95%)
Below Lower Basic (12140 kAF)	8	6	6	7	2	23	3 (2.5%)
<u>Method 2</u>							
Above Upper Basic (34730 kAF)	15	14	23	22	25	20	11 (10%)
Within Upper and Lower Basic	83	82	64	56	60	62	93 (80%)
Below Lower Basic (16297 kAF)	18	20	29	38	31	34	12 (10%)
<u>Existing Method</u>							
Above Upper Basic (35045 kAF)	15	13	25	23	14	21	10 (9%)
Within Upper and Lower Basic	82	80	54	54	98	55	91 (78%)
Below Lower Basic (16616 kAF)	19	23	37	39	4	40	15 (13%)

Figure 8 shows a comparison of the monthly Upper Basic and Lower Basic volumes computed using Method 1 of 40,540 kAF and 12,140 kAF, respectively, against the previously discussed mean-plus-one-monthly and mean-minus-one-monthly volumes of 36,472 kAF and 13,990 kAF. Of note on **Figure 8** is the monthly variability within the year, both at the upper and lower levels, particularly during the high runoff months of March through July.

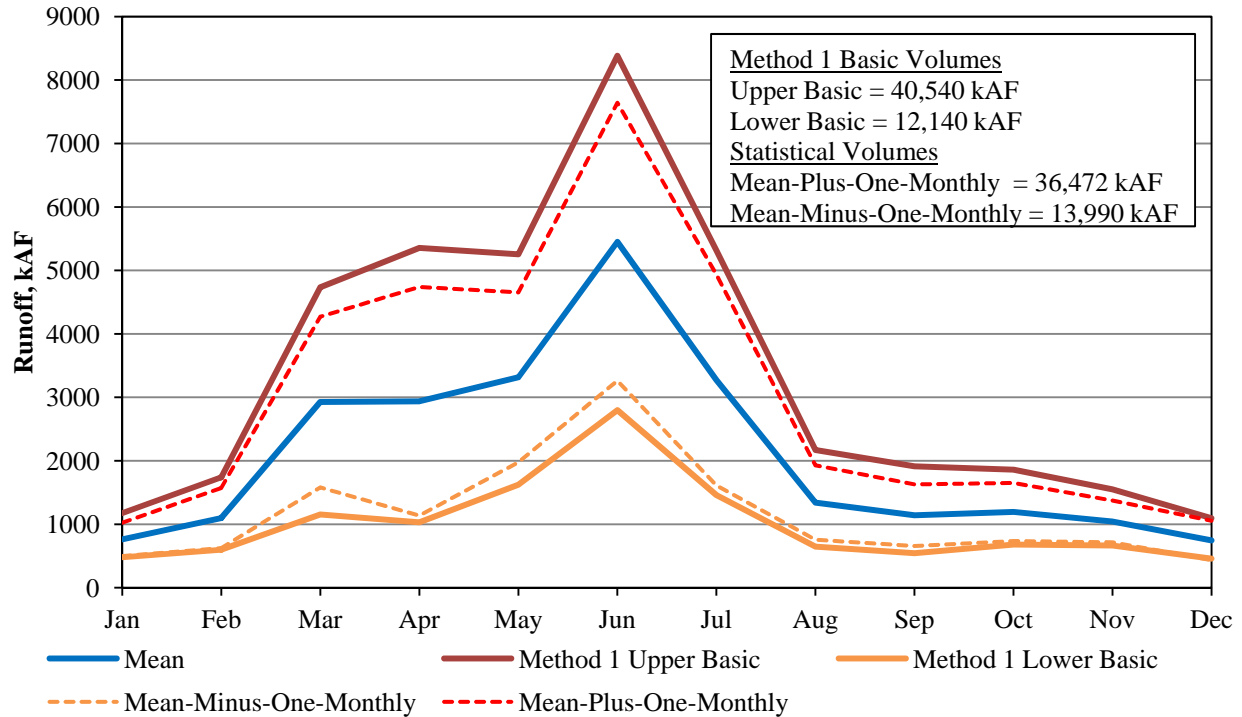


Figure 8. Comparison of Upper Basin – Method 1 Upper and Lower Basic Volumes and the Mean-Plus-One-Monthly and Mean-Minus-One-Monthly Volumes, Based on the Mean Monthly Upper Basin Runoff Volumes.

C. Method 2 – Emulating Other Agencies

Method 2 involves emulating the 10-80-10 methodology used by our partner agencies, as described in Section II.B. The unique Upper Basic and Lower Basic monthly reach factors were adjusted such that the Upper Basic and Lower Basic volumes encompassed 80 percent of the historical annual runoff record. The resulting Upper Basic and Lower Basic volumes were 34,730 kAF and 16,297 kAF, respectively (**Table 5**). All monthly reach factors and Upper Basic and Lower Basic volumes are provided in **Exhibit 2** in the Appendix. Furthermore, the monthly Upper Basic and Lower Basic volumes are plotted in **Figure 9** versus the mean-plus-one-monthly and mean-minus-one-monthly volumes in order to demonstrate how the monthly factors were adjusted to create a similar runoff variability pattern as the mean-plus-one-monthly and mean-minus-one-monthly volumes.

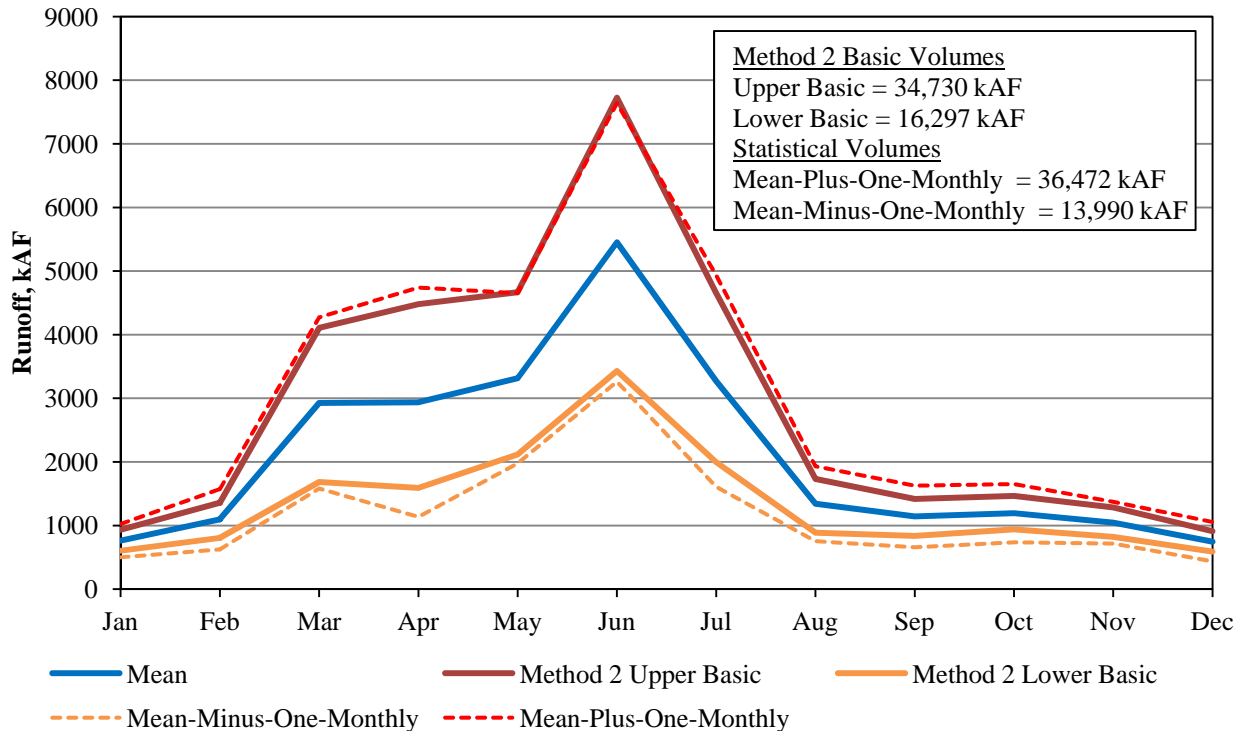


Figure 9. Comparison of Upper Basin – Method 2 Upper and Lower Basic Volumes and the Mean-Plus-One-Monthly and Mean-Minus-One-Monthly Volumes, Based on the Mean Monthly Upper Basin Runoff Volumes.

D. Selection of Existing Method

The following criteria were used to review the results for Method 1 and Method 2, and select the existing method:

1. The existing method should capture the monthly reach runoff variability.
2. The existing method should consider the quantitative and qualitative processes that are used in determining the Basic runoff forecast, weighing precision versus accuracy.
3. The existing method results can be compared in a commensurable manner to our partner agencies' results.

Based on the aforementioned criteria, Method 2 was selected as the Existing Method. While Method 1 captured reach and monthly variability described by mean-plus-one-monthly and mean-minus-one-monthly volumes, it encompassed 95 percent of observed historical volumes, which is a substantial amount of variability considering that it encompasses all but the most extreme runoff years. Method 2 provides a level of variability commensurable with partner agencies' forecasts without providing a range of variability that would suggest runoff forecasts that are highly improbable given the conditions that are used to determine the Basic forecast.

The six individual reaches were separated into two groups in the final analysis: the upper two reaches of Fort Peck and Garrison (Upper Group), and the lower four reaches of Oahe, Fort Randall, Gavins Point and Sioux City (Lower Group) based on the analysis in Section II.A. Thus, the Upper Basic and Lower Basic factors were the same for each reach in a group. This step was taken in order to simplify the application of reservoir reach factors in real-time applications by taking advantage of common reach variability. The existing factors are provided in **Table 6**.

Table 6
Existing Monthly Upper Basic and Lower Basic Forecast Factors

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<u>Existing Factors (Post-Aug 2014)</u>												
Upper Basic												
Upper Group*	1.20	1.20	1.35	1.45	1.35	1.45	1.45	1.30	1.20	1.20	1.20	1.20
Lower Group**	1.40	1.40	1.50	1.55	1.55	1.45	1.40	1.35	1.35	1.35	1.35	1.35
Lower Basic												
Upper Group*	0.80	0.75	0.65	0.65	0.70	0.65	0.65	0.70	0.75	0.80	0.80	0.80
Lower Group**	0.75	0.75	0.55	0.50	0.50	0.50	0.55	0.65	0.75	0.75	0.75	0.75
<u>Previous Factors (Pre-Aug 2014)</u>												
Upper Basic	1.20	1.20	1.35	1.35	1.40	1.60	1.40	1.20	1.20	1.20	1.20	1.20
Lower Basic	0.80	0.80	0.65	0.65	0.60	0.60	0.60	0.80	0.80	0.80	0.80	0.80

* The Upper Group is comprised of the Fort Peck and Garrison reaches.

** The Lower Group is comprised of the Oahe, Fort Randall, Gavins Point and Sioux City reaches.

There are several noteworthy differences between the existing factors and the previous factors. For the upper two reaches, the existing Upper Basic factors are lower than the previous factors in May and June, but they are higher than the previous factors in April, July and August. In the lower four reaches, the existing Upper Basic factors are higher than the previous Upper Basic factors in all months except June. Notable existing Upper Basic factor increases in March, April and May account for increased variability and runoff potential due to plains snowmelt and rainfall runoff in the lower four reaches. Existing Lower Basic factors in the upper two reaches are higher in May, June and July when compared to the previous factors. Existing Lower Basic factors in the lower four reaches are lower than the previous Lower Basic factors in order to encompass a wider range of lower runoff scenarios.

E. Evaluation of Existing Method

The existing Upper Basic and Lower Basic factors were applied to the mean annual runoff above Sioux City in order to determine the frequency of historical runoff volumes versus Upper Basic and Lower Basic volumes determined from the mean annual runoff above Sioux City. All existing monthly reach factors and Upper Basic and Lower Basic volumes based on the mean annual runoff are provided in **Exhibit 3** in the Appendix. The resulting Upper Basic volume was

35,045 kAF (35.0 MAF) and the Lower Basic volume was 16,616 kAF (16.6 MAF). Analysis of the historical runoff record shows that 10 historical runoff years (9 percent) are above the Upper Basic volume, 91 years (78 percent) are within the Upper Basic and Lower Basic volumes, and 15 years (13 percent) are below the Lower Basic volume (**Table 5**). Furthermore, there are similar numbers of years occurring in Fort Peck and Garrison within the Upper Group and similar numbers of years occurring in Oahe, Fort Randall and Sioux City within the Lower Group. Gavins Point is the exception in the Lower Group with 98 years occurring within the Upper Basic and Lower Basic volumes compared to 54 years in Oahe and Fort Randall, and 55 years in Sioux City.

Existing method Upper Basic and Lower Basic monthly volumes calculated from mean annual runoff above Sioux City are plotted in comparison to the mean-plus-one-monthly and the mean-minus-one-monthly volumes for the runoff summation above Sioux City in **Figure 10**. The existing factors produce Upper Basic and Lower Basic volumes that emulate the pattern of runoff displayed by the mean-plus-one-monthly and mean-minus-one-monthly volumes. When compared to the fit of the Upper Basic and Lower Basic volumes produced by the previous factors in **Figure 7**, it is clear that the existing factors produce volumes that emulate the historic pattern of runoff and emulate the monthly variability better, especially during the months of April and June.

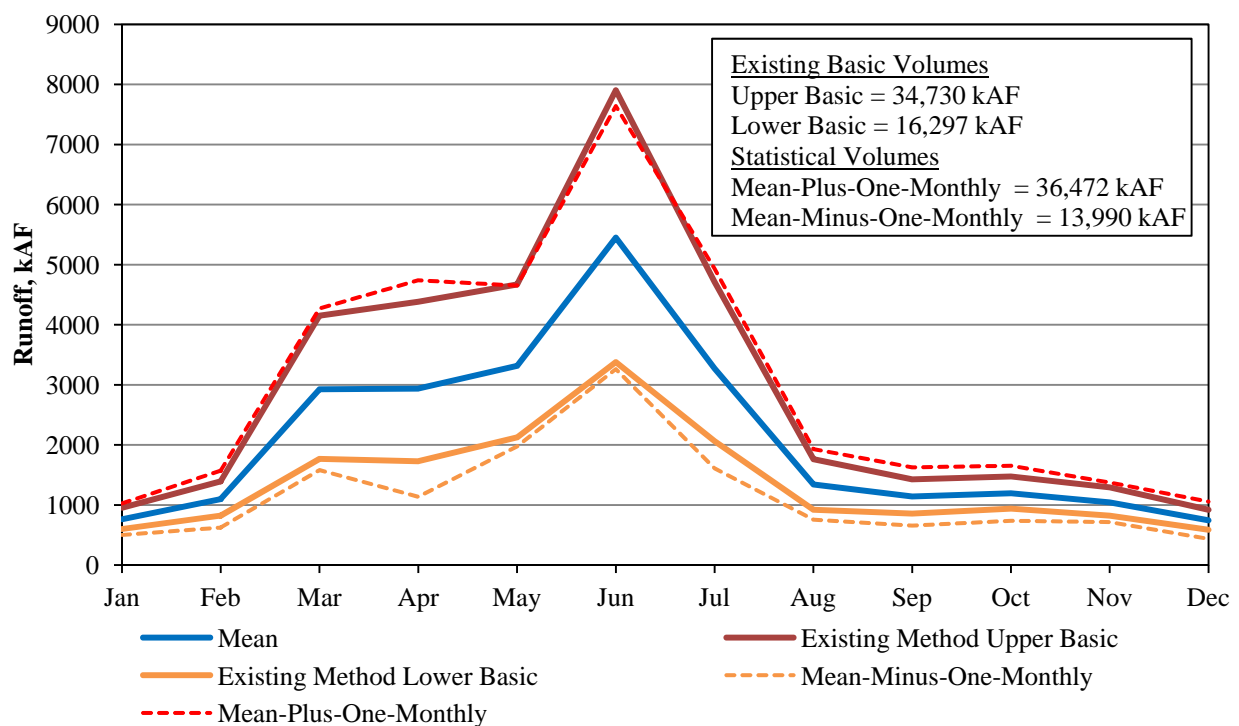


Figure 10. Comparison of Upper Basin – Existing Method Upper and Lower Basic Volumes and the Mean-Plus-One-Monthly and Mean-Minus-One-Monthly Volumes, Based on the Mean Monthly Upper Basin Runoff Volumes.

The Basic, Upper Basic and Lower Basic monthly volumes using both the existing and previous factors for the runoff summation above Sioux City and each of the six reservoir reaches are plotted in **Figures 11** through **17**. The purpose of these plots is to show the relative changes in monthly volume that would occur when the existing factors are applied to the 12 months of mean monthly runoff. Note that all runoff scales are different. The plot for monthly runoff above Sioux City in **Figure 11** shows the existing factors produce a wider range of volumes between the Upper Basic and Lower Basic volumes during March and April, and a narrower range of runoff in June, than the previous factors. For the Fort Peck and Garrison reaches, the plots in **Figures 12** and **13** show a wider range of runoff in April, a narrower range of runoff in May, and a narrower range of runoff in June, when compared to the previous factors. In the Oahe, Fort Randall, Gavins Point and Sioux City reaches, the plots in **Figures 14, 15, 16** and **17** show a wider range of runoff in all months when compared to the previous factors with the exception of June where the existing Upper Basic volume is lower than the previous Upper Basic volume.

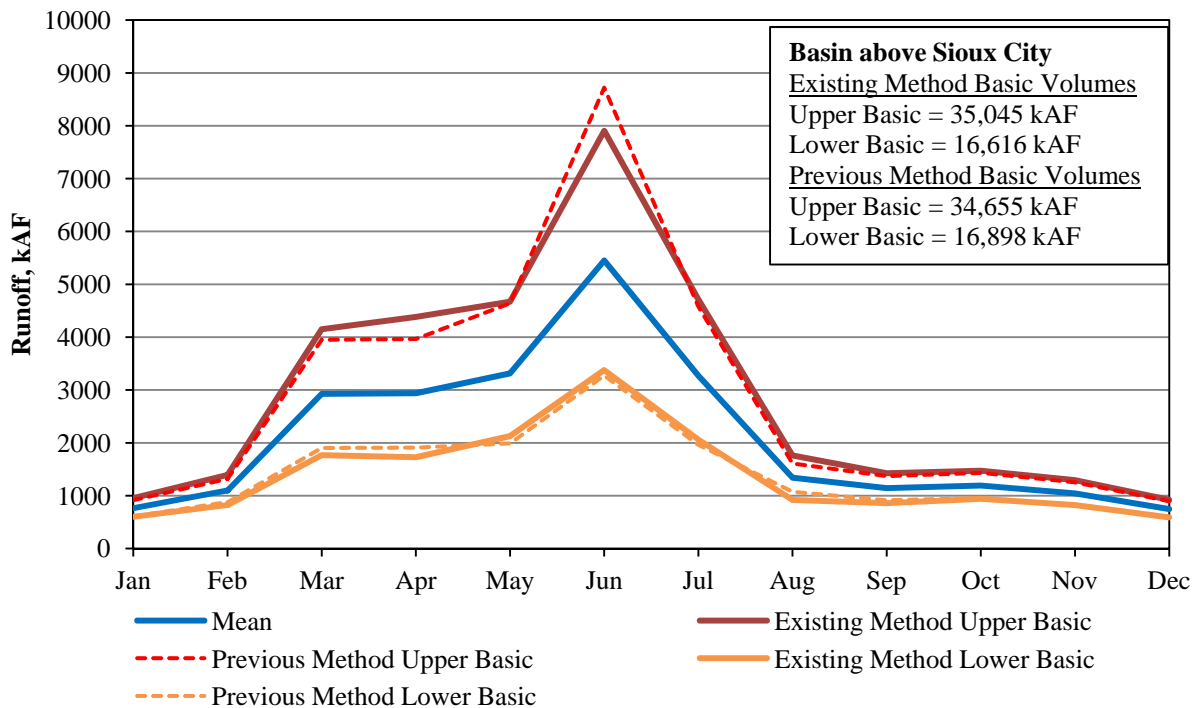


Figure 11. Comparison of Upper Basin - Existing Method Upper Basic and Lower Basic Volumes to Previous Method Upper Basic and Lower Basic Volumes, Based on Mean Monthly Runoff Volumes.

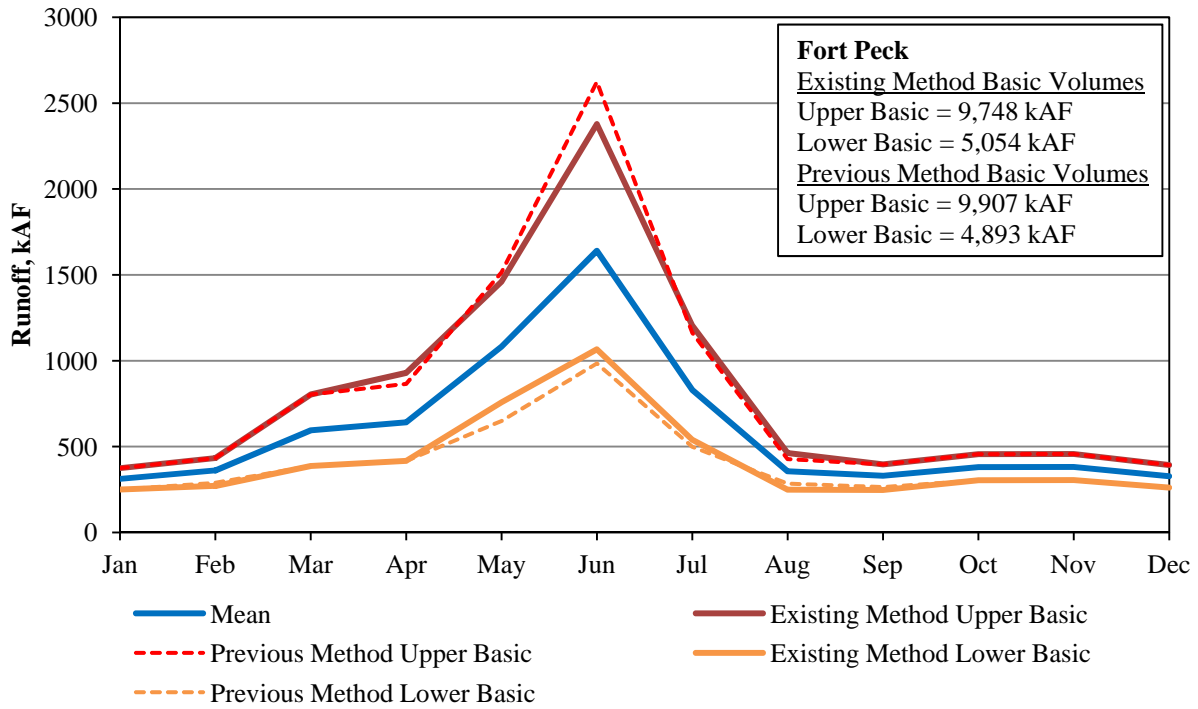


Figure 12. Comparison of the Fort Peck - Existing Method Upper Basic and Lower Basic Volumes to the Previous Method Upper Basic and Lower Basic Volumes, Based on Mean Monthly Runoff Volumes.

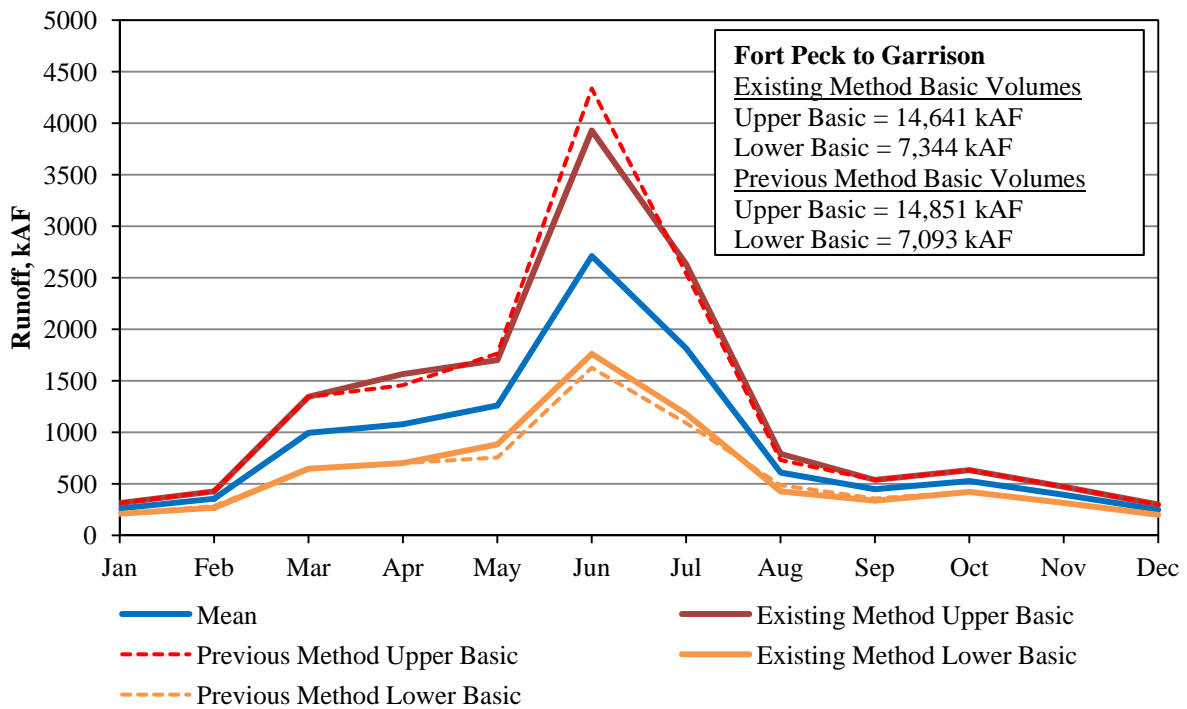


Figure 13. Comparison of the Garrison - Existing Method Upper Basic and Lower Basic Volumes to the Previous Method Upper Basic and Lower Basic Volumes, Based on Mean Monthly Runoff Volumes.

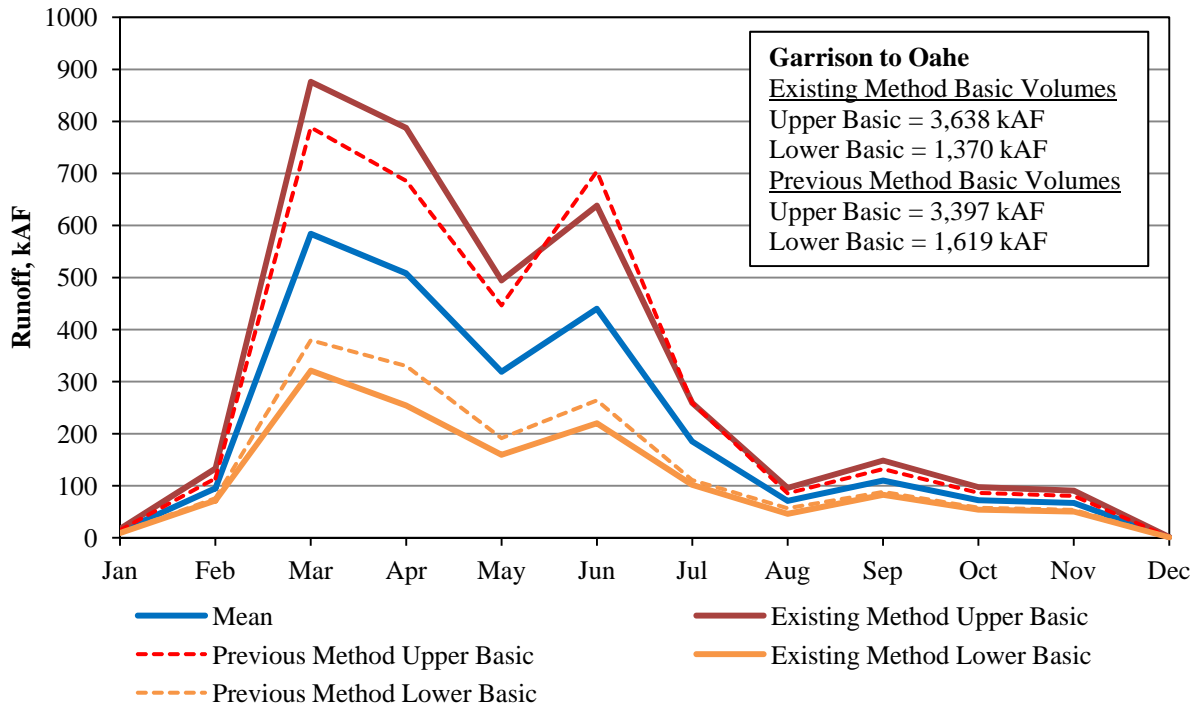


Figure 14. Comparison of the Oahe - Existing Method Upper Basic and Lower Basic Volumes to the Previous Method Upper Basic and Lower Basic Volumes, Based on Mean Monthly Runoff Volumes.

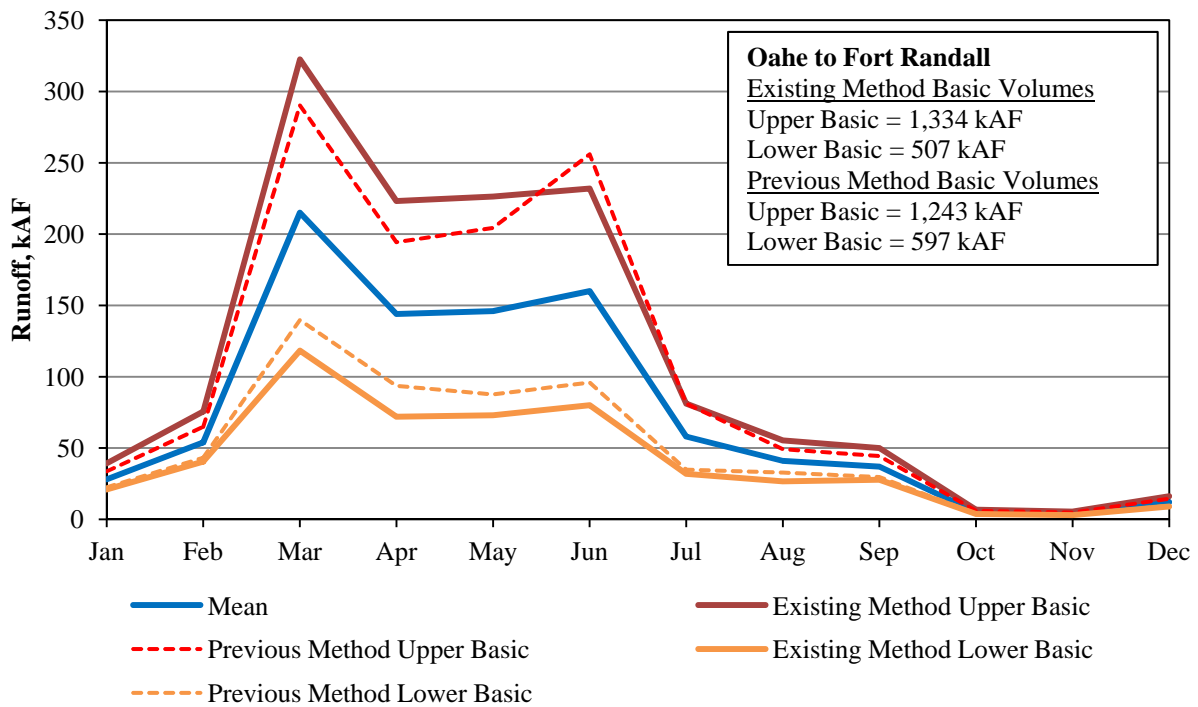


Figure 15. Comparison of the Fort Randall - Existing Method Upper Basic and Lower Basic Volumes to the Previous Method Upper Basic and Lower Basic Volumes, Based on Mean Monthly Runoff Volumes.

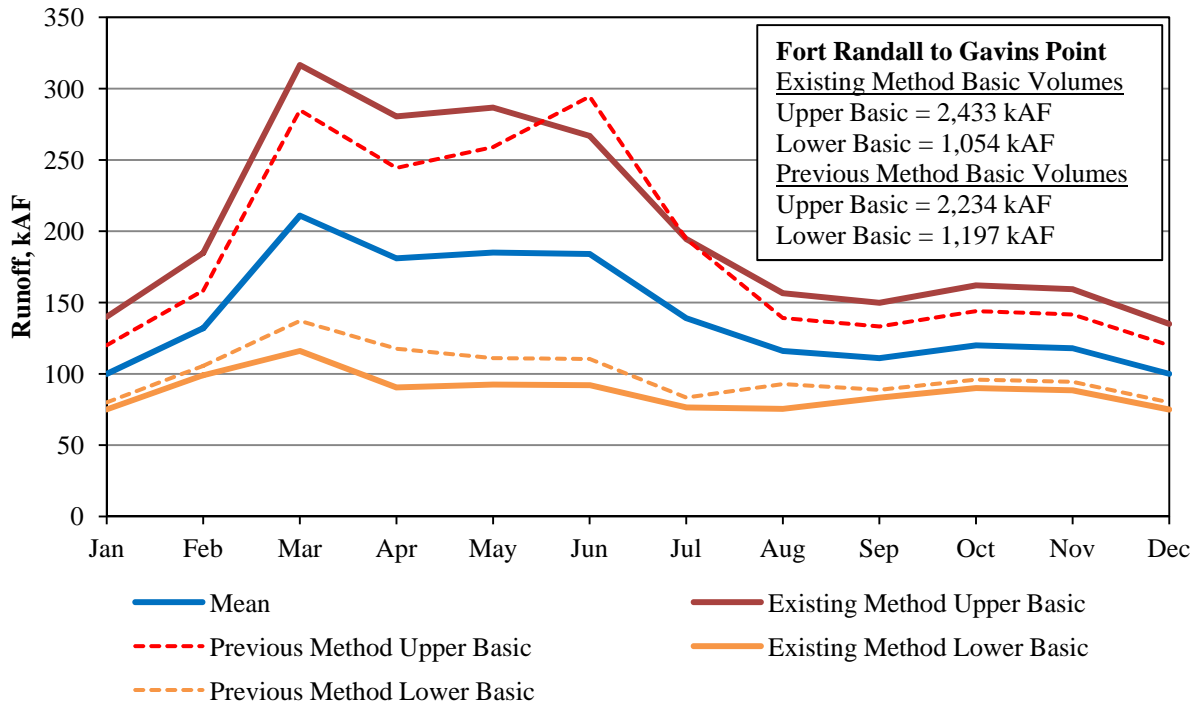


Figure 16. Comparison of the Gavins Point - Existing Method Upper Basic and Lower Basic Volumes to the Previous Method Upper Basic and Lower Basic Volumes, Based on Mean Monthly Runoff Volumes.

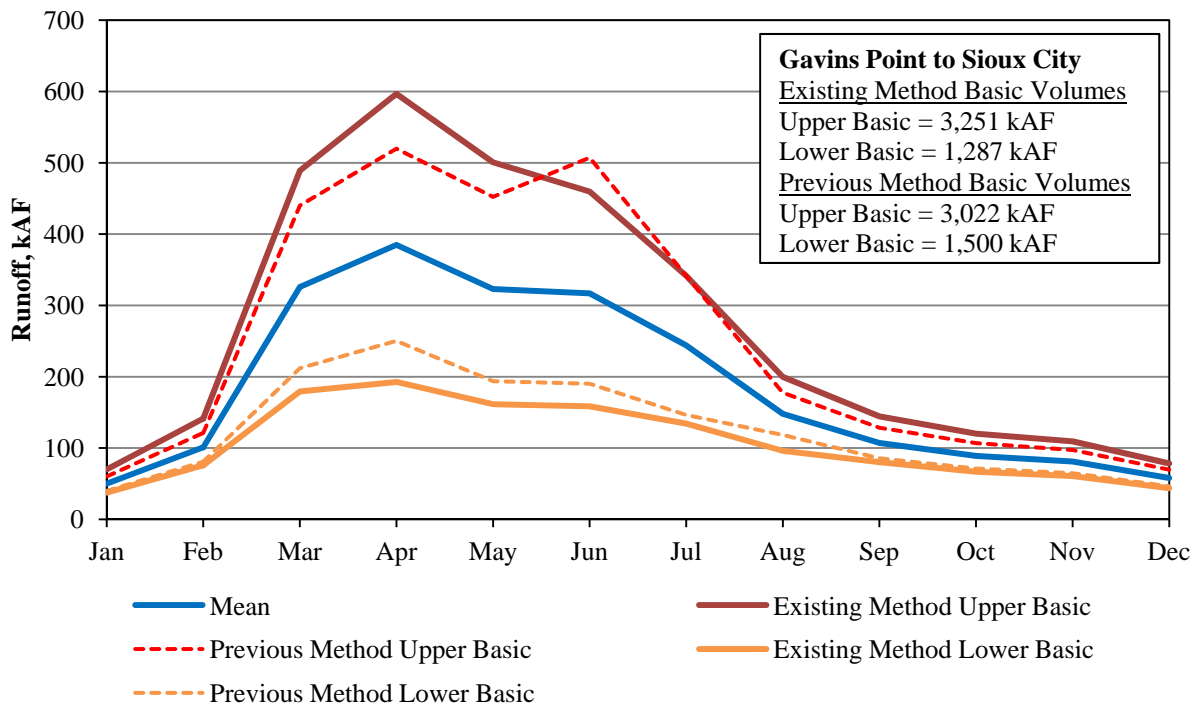


Figure 17. Comparison of the Sioux City – Existing Method Upper Basic and Lower Basic Volumes to the Previous Method Upper Basic and Lower Basic Volumes, Based on Mean Monthly Runoff Volumes.

IV. APPLICATION OF EXISTING UPPER BASIC AND LOWER BASIC FACTORS

The existing Upper Basic and Lower Basic factors will be applied to the Basic forecast developed at the beginning of each month in order to compute an Upper Basic forecast and Lower Basic forecast for the monthly reservoir studies. The Basic forecast is a runoff volume that is most likely to occur based on the best available antecedent hydrologic data, current hydrologic conditions, and predicted future weather. The Upper Basic and Lower Basic forecasts provide a reasonable range of possible runoff volumes for the calendar year based on the variability in hydro-meteorological conditions and events that can occur over the remainder of the calendar year forecast period. As the year progresses, the range defined by the Upper Basic and Lower Basic forecasts generally lessens as the number of observed months increases and number of forecast months decreases.

To illustrate the application of the existing Basic factors, the April 1, 1996 and April 1, 2012 Upper Basic, Basic and Lower Basic forecasts are plotted in **Figure 18** and **Figure 19**, respectively. On April 1, 1996 the runoff accumulation after three months of observed runoff was 8,710 kAF and the Basic runoff forecast accumulation for December 31, 1996 was 32,100 kAF. The existing factors were applied to the nine months of future runoff from the Basic forecast to produce a 12-month Upper Basic forecast of 41,319 kAF and a Lower Basic forecast of 24,060 kAF. All monthly reach volumes for the Basic, Upper Basic and Lower Basic forecasts are tabulated in **Table 7**. The observed runoff by the end of December 31, 1996 was 35,592 kAF, which was more than the April 1, 1996 forecast; however, it fell between the April 1, 1996 Upper Basic and Lower Basic forecasts, yet closer to the Upper Basic forecast.

On April 1, 2012 the runoff accumulation after three months of observed runoff was 4,871 kAF and the Basic runoff forecast accumulation for December 31, 2012 was 23,396 kAF. The existing factors were applied to the nine months of future runoff from the Basic forecast to produce a 12-month Upper Basic forecast of 30,615 kAF and a Lower Basic forecast of 17,216 kAF. All monthly reach volumes for the Basic, Upper Basic and Lower Basic forecasts are tabulated in **Table 8**. The observed runoff by the end of December 31, 2012 was 19,545 kAF, which was less than the April 1, 2012 forecast; however, it fell about midway between the Upper Basic and Lower Basic forecast range.

In both the 1996 and 2012 forecast cases the Upper Basic and Lower Basic forecasts encompass the eventual runoff summation at the end of the calendar year with a substantial volume buffer around the observed runoff. Furthermore the Upper Basic and Lower Basic forecasts maintain a curvature similar to the observed runoff accumulation. With the objective of providing a reasonable range of runoff forecast scenarios from which reservoir regulation plans can be made for the remainder of the calendar year, these examples demonstrate the utility of the procedure for developing Upper Basic and Lower Basic forecasts from the Basic runoff forecast.

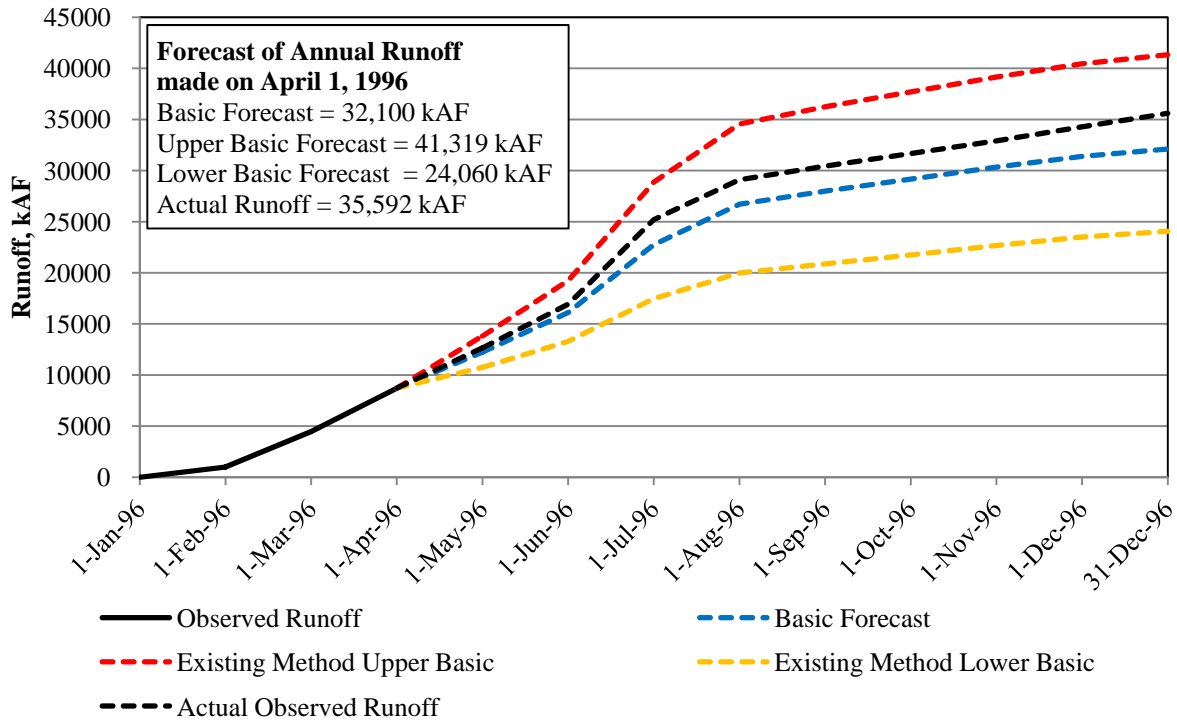


Figure 18. Example of the April 1, 1996 Basic, Upper Basic and Lower Basic Forecasts of Cumulative Annual Runoff above Sioux City using the Existing Factors.

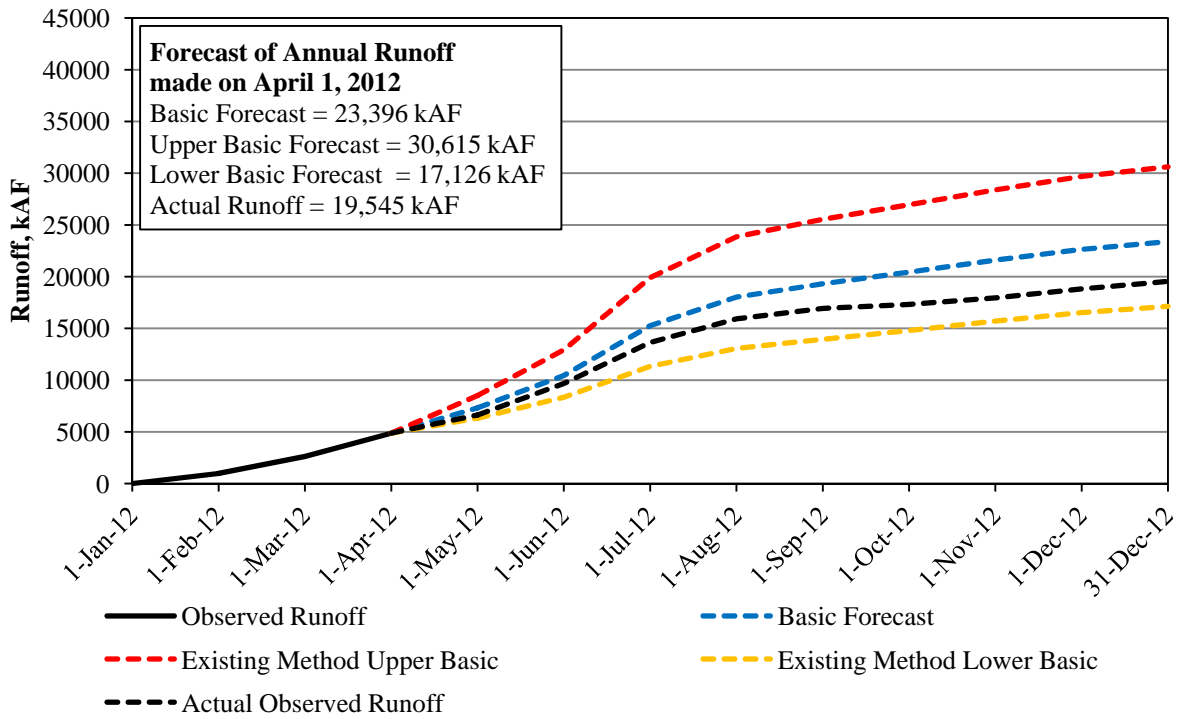


Figure 19. Example of the April 1, 2012 Basic, Upper Basic and Lower Basic Forecasts of Cumulative Annual Runoff above Sioux City using the Existing Factors.

Table 7
Example April 1996 Basic, Upper Basic and Lower Basic Forecast Volumes using the Existing Factors

Volumes in Thousand Acre-Feet (kAF)

Observed Volumes Highlighted in Red Text, Forecast Volumes Highlighted in Blue Text

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
<u>Existing Factors</u>													
Upper Basic													
Upper Group*	1.20	1.20	1.35	1.45	1.35	1.45	1.45	1.30	1.20	1.20	1.20	1.20	
Lower Group**	1.40	1.40	1.50	1.55	1.55	1.45	1.40	1.35	1.35	1.35	1.35	1.35	
Lower Basic													
Upper Group*	0.80	0.75	0.65	0.65	0.70	0.65	0.65	0.70	0.75	0.80	0.80	0.80	
Lower Group**	0.75	0.75	0.55	0.50	0.50	0.50	0.55	0.65	0.75	0.75	0.75	0.75	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
<u>Basic</u>													
Fort Peck	381	818	947	805	1330	1980	990	350	340	395	390	330	9056
Garrison	248	898	1512	1345	1715	3670	2420	615	480	525	410	250	14088
Oahe	158	896	1014	575	300	435	165	60	115	70	65	-5	3848
Fort Randall	-24	275	167	140	135	150	60	45	45	10	10	5	1018
Gavins Point	151	301	300	205	170	170	125	110	105	115	115	90	1957
Sioux City	90	273	304	360	235	240	180	110	85	65	60	40	2042
Total	1004	3461	4244	3430	3885	6645	3940	1290	1170	1180	1050	710	32009
<u>Upper Basic</u>													
Fort Peck	381	818	947	1167	1796	2871	1436	455	408	474	468	396	11616
Garrison	248	898	1512	1950	2315	5322	3509	800	576	630	492	300	18552
Oahe	158	896	1014	891	465	631	231	81	155	95	88	-7	4698
Fort Randall	-24	275	167	217	209	218	84	61	61	14	14	7	1304
Gavins Point	151	301	300	318	264	247	175	149	142	155	155	122	2477
Sioux City	90	273	304	558	364	348	252	149	115	88	81	54	2675
Total	1004	3461	4244	5102	5413	9635	5687	1693	1457	1455	1298	872	41319
<u>Lower Basic</u>													
Fort Peck	381	818	947	523	931	1287	644	245	255	316	312	264	6923
Garrison	248	898	1512	874	1201	2386	1573	431	360	420	328	200	10430
Oahe	158	896	1014	288	150	218	91	39	86	53	49	-4	3037
Fort Randall	-24	275	167	70	68	75	33	29	34	8	8	4	745
Gavins Point	151	301	300	103	85	85	69	72	79	86	86	68	1484
Sioux City	90	273	304	180	118	120	99	72	64	49	45	30	1443
Total	1004	3461	4244	2038	2552	4170	2508	887	878	931	828	562	24060

* The Upper Group is comprised of the Fort Peck and Garrison reaches.

** The Lower Group is comprised of the Oahe, Fort Randall, Gavins Point and Sioux City reaches.

Table 8
Example April 2012 Basic, Upper Basic and Lower Basic Forecast Volumes using the Existing Factors

Volumes in Thousand Acre-Feet (kAF)

Observed Volumes Highlighted in Red Text, Forecast Volumes Highlighted in Blue Text

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
<u>Existing Factors</u>													
Upper Basic													
Upper Group*	1.20	1.20	1.35	1.45	1.35	1.45	1.45	1.30	1.20	1.20	1.20	1.20	
Lower Group**	1.40	1.40	1.50	1.55	1.55	1.45	1.40	1.35	1.35	1.35	1.35	1.35	
Lower Basic													
Upper Group*	0.80	0.75	0.65	0.65	0.70	0.65	0.65	0.70	0.75	0.80	0.80	0.80	
Lower Group**	0.75	0.75	0.55	0.50	0.50	0.50	0.55	0.65	0.75	0.75	0.75	0.75	
<u>Basic</u>													
Fort Peck	334	429	528	580	1100	1550	760	340	330	380	380	325	7036
Garrison	233	543	881	960	1175	2295	1420	600	445	520	395	245	9712
Oahe	-46	183	232	270	270	380	175	65	110	65	65	0	1768
Fort Randall	140	140	130	120	130	135	50	35	35	4	5	10	934
Gavins Point	100	177	157	150	160	160	130	110	110	115	115	95	1578
Sioux City	219	174	319	370	300	290	220	135	100	80	80	80	2367
Total	980	1646	2246	2450	3135	4810	2755	1285	1130	1164	1040	755	23396
<u>Upper Basic</u>													
Fort Peck	334	429	528	841	1485	2248	1102	442	396	456	456	390	9107
Garrison	233	543	881	1392	1586	3328	2059	780	534	624	474	294	12728
Oahe	-46	183	232	419	419	551	245	87	149	88	88	1	2413
Fort Randall	140	140	130	186	202	196	70	47	47	5	7	14	1185
Gavins Point	100	177	157	233	248	232	182	149	149	155	155	128	2064
Sioux City	219	174	319	574	465	421	308	182	135	108	108	108	3120
Total	980	1646	2246	3644	4404	6975	3966	1687	1410	1436	1288	934	30615
<u>Lower Basic</u>													
Fort Peck	334	429	528	377	770	1008	494	238	248	304	304	260	5293
Garrison	233	543	881	624	823	1492	923	420	334	416	316	196	7200
Oahe	-46	183	232	135	135	190	96	42	83	49	49	0	1147
Fort Randall	140	140	130	60	65	68	28	23	26	3	4	8	693
Gavins Point	100	177	157	75	80	80	72	72	83	86	86	71	1138
Sioux City	219	174	319	185	150	145	121	88	75	60	60	60	1655
Total	980	1646	2246	1456	2023	2982	1733	882	848	918	819	595	17126

* The Upper Group is comprised of the Fort Peck and Garrison reaches.

** The Lower Group is comprised of the Oahe, Fort Randall, Gavins Point and Sioux City reaches.

APPENDIX

Exhibit 1

**Method 1 Monthly Basic, Upper Basic and Lower Basic Forecast Volumes using the
Average Monthly Reach Volumes as the Basic Runoff Forecast**

Volumes in Thousand Acre-Feet (kAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
<u>Method 1 Factors</u>													
<u>Upper Basic</u>													
Fort Peck	1.25	1.35	1.45	1.40	1.40	1.55	1.55	1.40	1.40	1.35	1.30	1.30	
Garrison	1.45	1.45	1.50	1.70	1.45	1.40	1.50	1.50	1.50	1.40	1.30	1.40	
Oahe	4.00	2.30	1.80	2.30	2.00	1.80	2.00	2.10	2.50	2.90	3.00	3.00	
Fort Randall	3.50	2.50	1.90	2.20	2.40	2.00	2.60	2.50	2.90	3.00	3.00	3.00	
Gavins Point	1.40	1.45	1.50	1.50	1.50	1.55	1.60	1.60	1.55	1.45	1.35	1.45	
Sioux City	2.45	1.90	1.85	2.25	2.00	2.05	2.30	2.15	2.10	2.35	2.10	2.40	
<u>Lower Basic</u>													
Fort Peck	0.75	0.65	0.55	0.60	0.60	0.45	0.45	0.60	0.60	0.65	0.70	0.70	
Garrison	0.60	0.55	0.50	0.30	0.55	0.65	0.50	0.50	0.50	0.60	0.70	0.60	
Oahe	0.40	0.40	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	
Fort Randall	0.20	0.20	0.20	0.10	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	
Gavins Point	0.60	0.60	0.50	0.50	0.50	0.45	0.40	0.40	0.45	0.55	0.65	0.55	
Sioux City	0.40	0.40	0.20	0.30	0.30	0.30	0.30	0.40	0.40	0.40	0.40	0.40	
<u>Basic</u>													
Fort Peck	312	361	595	641	1082	1640	831	356	330	380	381	327	7236
Garrison	261	355	995	1079	1260	2710	1815	609	448	527	393	249	10701
Oahe	12	95	584	508	319	440	185	71	110	72	67	1	2464
Fort Randall	28	54	215	144	146	160	58	41	37	5	4	12	904
Gavins Point	100	132	211	181	185	184	139	116	111	120	118	100	1697
Sioux City	50	101	326	385	323	317	244	148	107	89	81	58	2229
Total	763	1098	2926	2938	3315	5451	3272	1341	1143	1193	1044	747	25231
<u>Upper Basic</u>													
Fort Peck	390	487	863	897	1515	2542	1288	498	462	513	495	425	10376
Garrison	378	515	1493	1834	1827	3794	2723	914	672	738	511	349	15746
Oahe	48	219	1051	1168	638	792	370	149	275	209	201	3	5123
Fort Randall	98	135	409	317	350	320	151	103	107	15	12	36	2052
Gavins Point	140	191	317	272	278	285	222	186	172	174	159	145	2540
Sioux City	123	192	603	866	646	650	561	318	225	209	170	139	4702
Total	1177	1739	4735	5355	5254	8383	5315	2167	1913	1858	1549	1097	40540
<u>Lower Basic</u>													
Fort Peck	234	235	327	385	649	738	374	214	198	247	267	229	4096
Garrison	157	195	498	324	693	1762	908	305	224	316	275	149	5804
Oahe	5	38	117	102	64	88	37	14	22	14	13	0	514
Fort Randall	6	11	43	14	29	32	12	8	7	1	1	2	166
Gavins Point	60	79	106	91	93	83	56	46	50	66	77	55	860
Sioux City	20	40	65	116	97	95	73	59	43	36	32	23	700
Total	481	598	1155	1030	1625	2797	1459	646	544	680	665	459	12140

Exhibit 2
Method 2 Monthly Basic, Upper Basic and Lower Basic Forecast Volumes using the
Average Monthly Reach Volumes as the Basic Runoff Forecast

Volumes in Thousand Acre-Feet (kAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
<u>Method 2 Factors</u>													
<u>Upper Basic</u>													
Fort Peck	1.20	1.20	1.30	1.30	1.35	1.50	1.50	1.30	1.20	1.20	1.20	1.20	
Garrison	1.20	1.20	1.40	1.55	1.35	1.35	1.40	1.25	1.20	1.20	1.20	1.20	
Oahe	1.40	1.40	1.50	1.70	1.60	1.50	1.30	1.30	1.30	1.30	1.40	1.40	
Fort Randall	1.40	1.40	1.60	1.60	1.70	1.50	1.50	1.50	1.40	1.40	1.40	1.40	
Gavins Point	1.20	1.20	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.20	1.20	
Sioux City	1.40	1.30	1.40	1.70	1.60	1.50	1.50	1.40	1.40	1.40	1.40	1.40	
<u>Lower Basic</u>													
Fort Peck	0.80	0.75	0.70	0.70	0.70	0.60	0.60	0.70	0.80	0.80	0.80	0.80	
Garrison	0.80	0.70	0.60	0.55	0.70	0.70	0.65	0.65	0.70	0.80	0.80	0.80	
Oahe	0.70	0.70	0.45	0.40	0.50	0.50	0.50	0.60	0.70	0.70	0.70	0.70	
Fort Randall	0.80	0.80	0.60	0.45	0.40	0.45	0.50	0.70	0.80	0.80	0.80	0.80	
Gavins Point	0.80	0.80	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.80	0.80	0.80	
Sioux City	0.70	0.70	0.40	0.40	0.40	0.40	0.40	0.60	0.70	0.70	0.70	0.70	
<u>Basic</u>													
Fort Peck	312	361	595	641	1082	1640	831	356	330	380	381	327	7236
Garrison	261	355	995	1079	1260	2710	1815	609	448	527	393	249	10701
Oahe	12	95	584	508	319	440	185	71	110	72	67	1	2464
Fort Randall	28	54	215	144	146	160	58	41	37	5	4	12	904
Gavins Point	100	132	211	181	185	184	139	116	111	120	118	100	1697
Sioux City	50	101	326	385	323	317	244	148	107	89	81	58	2229
Total	763	1098	2926	2938	3315	5451	3272	1341	1143	1193	1044	747	25231
<u>Upper Basic</u>													
Fort Peck	374	433	774	833	1461	2460	1247	463	396	456	457	392	9746
Garrison	313	426	1393	1672	1701	3659	2541	761	538	632	472	299	14407
Oahe	17	133	876	864	510	660	241	92	143	94	94	1	3724
Fort Randall	39	76	344	230	248	240	87	62	52	7	6	17	1407
Gavins Point	120	158	264	226	231	230	174	145	139	150	142	120	2099
Sioux City	70	131	456	655	517	476	366	207	150	125	113	81	3347
Total	934	1358	4107	4481	4668	7724	4655	1730	1417	1464	1283	911	34730
<u>Lower Basic</u>													
Fort Peck	250	271	417	449	757	984	499	249	264	304	305	262	5009
Garrison	209	249	597	593	882	1897	1180	396	314	422	314	199	7251
Oahe	8	67	263	203	160	220	93	43	77	50	47	1	1231
Fort Randall	22	43	129	65	58	72	29	29	30	4	3	10	494
Gavins Point	80	106	148	127	130	129	97	81	78	96	94	80	1245
Sioux City	35	71	130	154	129	127	98	89	75	62	57	41	1067
Total	604	805	1683	1591	2116	3429	1995	886	837	938	820	592	16297

Exhibit 3
Existing Method Monthly Basic, Upper Basic and Lower Basic Forecast Volumes using
the Average Monthly Reach Volumes as the Basic Runoff Forecast

Volumes in Thousand Acre-Feet (kAF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
<u>Existing Method Factors</u>													
<u>Upper Basic</u>													
Upper Group*	1.20	1.20	1.35	1.45	1.35	1.45	1.45	1.30	1.20	1.20	1.20	1.20	
Lower Group**	1.40	1.40	1.50	1.55	1.55	1.45	1.40	1.35	1.35	1.35	1.35	1.35	
<u>Lower Basic</u>													
Upper Group*	0.80	0.75	0.65	0.65	0.70	0.65	0.65	0.70	0.75	0.80	0.80	0.80	
Lower Group**	0.75	0.75	0.55	0.50	0.50	0.50	0.55	0.65	0.75	0.75	0.75	0.75	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
<u>Basic</u>													
Fort Peck	312	361	595	641	1082	1640	831	356	330	380	381	327	7236
Garrison	261	355	995	1079	1260	2710	1815	609	448	527	393	249	10701
Oahe	12	95	584	508	319	440	185	71	110	72	67	1	2464
Fort Randall	28	54	215	144	146	160	58	41	37	5	4	12	904
Gavins Point	100	132	211	181	185	184	139	116	111	120	118	100	1697
Sioux City	50	101	326	385	323	317	244	148	107	89	81	58	2229
Total	763	1098	2926	2938	3315	5451	3272	1341	1143	1193	1044	747	25231
<u>Upper Basic</u>													
Fort Peck	374	433	803	929	1461	2378	1205	463	396	456	457	392	9748
Garrison	313	426	1343	1565	1701	3930	2632	792	538	632	472	299	14641
Oahe	17	133	876	787	494	638	259	96	149	97	90	1	3638
Fort Randall	39	76	323	223	226	232	81	55	50	7	5	16	1334
Gavins Point	140	185	317	281	287	267	195	157	150	162	159	135	2433
Sioux City	70	141	489	597	501	460	342	200	144	120	109	78	3251
Total	954	1394	4151	4382	4670	7904	4713	1762	1426	1475	1293	922	35045
<u>Lower Basic</u>													
Fort Peck	250	271	387	417	757	1066	540	249	248	304	305	262	5054
Garrison	209	266	647	701	882	1762	1180	426	336	422	314	199	7344
Oahe	9	71	321	254	160	220	102	46	83	54	50	1	1370
Fort Randall	21	41	118	72	73	80	32	27	28	4	3	9	507
Gavins Point	75	99	116	91	93	92	76	75	83	90	89	75	1054
Sioux City	38	76	179	193	162	159	134	96	80	67	61	44	1287
Total	601	824	1768	1727	2126	3378	2064	920	857	940	822	589	16616

* The Upper Group is comprised of the Fort Peck and Garrison reaches.

** The Lower Group is comprised of the Oahe, Fort Randall, Gavins Point and Sioux City reaches.

Exhibit 4 - Reservoir Reach Monthly and Annual Runoff Volumes

YEAR	FORT PECK RUNOFF IN 1000 ACRE- FEET ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT											WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL						
1898	313	278	419	776	1436	2668	1176	216	244	8482	353	339	313	8531		
1899	232	232	413	746	1323	2456	2027	528	345	9307	413	480	298	9493		
1900	309	315	504	730	1732	1379	335	79	194	6768	333	294	349	6553		
1901	270	226	371	464	1857	1339	454	67	147	6171	274	284	262	6015		
1902	240	220	264	331	1182	1644	873	171	179	5924	288	311	268	5971		
1903	296	236	339	676	968	1936	877	248	214	6657	375	339	411	6915		
1904	355	329	672	768	1325	1765	825	248	196	7608	286	309	353	7431		
1905	300	296	500	323	405	863	696	284	167	4782	234	284	274	4626		
1906	272	290	381	668	728	1386	605	216	248	5586	288	260	260	5602		
1907	222	296	506	819	1133	2412	2220	645	387	9448	460	367	357	9824		
1908	335	298	456	895	1176	4140	1722	563	468	11237	575	587	440	11655		
1909	363	365	538	676	1119	2938	1071	436	567	9675	623	462	317	9475		
1910	327	301	910	1351	1847	1384	470	311	365	8668	341	377	379	8363		
1911	248	270	720	589	893	2152	805	353	383	7510	395	411	333	7552		
1912	296	311	282	704	1396	2249	893	492	379	8141	545	526	379	8452		
1913	256	266	345	1111	1654	3140	1232	553	305	10312	633	520	347	10362		
1914	337	347	680	867	1597	2003	591	240	315	8477	494	407	339	8217		
1915	315	422	335	916	1148	1751	1010	591	413	8141	474	452	303	8130		
1916	315	488	799	712	1307	2612	1847	545	474	10328	409	381	347	10236		
1917	375	373	480	655	1914	3055	1325	383	298	9995	321	395	411	9985		
1918	395	347	492	607	1085	1503	551	371	270	6748	377	337	351	6686		
1919	383	413	672	559	781	520	216	93	169	4871	194	161	220	4381		
1920	228	385	553	551	1549	1819	776	325	280	7041	319	393	325	7503		
1921	294	296	436	704	1303	1857	583	242	260	7012	282	309	345	6911		
1922	282	238	415	666	1321	2249	454	307	309	7177	278	317	321	7157		
1923	298	270	428	726	1214	1593	918	452	309	7124	341	357	347	7253		
1924	305	399	391	647	1440	996	399	260	252	6134	382	305	319	5995		
1925	309	321	484	914	1353	1642	750	317	359	7355	486	490	421	7846		
1926	343	456	452	851	1279	589	438	325	337	6467	393	339	351	6153		
1927	395	303	659	492	1771	3904	1250	518	545	10920	567	508	421	11333		
1928	333	502	966	724	1924	1436	1396	432	377	9586	369	357	298	9114		
1929	280	250	391	466	946	1208	498	294	290	5647	317	288	200	5428		
1930	300	444	407	863	867	555	300	218	236	4995	301	298	303	5092		
1931	248	317	557	387	432	424	230	224	210	3931	220	179	157	3585		
1932	196	157	303	532	825	1406	516	422	240	5153	260	218	194	5269		
1933	222	212	488	434	908	1412	430	270	256	5304	226	339	177	5374		
1934	315	450	516	722	781	811	290	141	137	4905	204	256	210	4833		
1935	198	236	309	428	593	819	409	228	228	4118	262	182	190	4082		
1936	179	167	613	430	823	569	264	230	220	4129	246	244	196	4181		
1937	169	145	341	383	385	577	343	182	184	3395	260	163	137	3269		
1938	186	204	599	327	756	1682	1349	298	317	6278	272	327	272	6589		
1939	254	208	891	585	871	863	311	208	210	5272	238	244	222	5105		
1940	198	246	399	415	619	619	236	192	212	3840	246	186	262	3830		
1941	226	230	359	327	335	613	347	228	305	3664	411	347	349	4077		
1942	282	298	629	825	1131	2061	599	329	282	7543	331	357	301	7425		
1943	325	633	785	1117	1115	2892	1002	426	317	9601	399	375	335	9721		
1944	301	290	678	456	565	1740	914	375	309	6737	339	327	270	6564		
1945	375	343	492	353	613	1275	569	262	292	5510	345	288	242	5449		
1946	351	413	450	514	710	855	540	258	359	5325	385	303	399	5537		
1947	415	422	1226	960	1547	1500	659	272	361	8449	524	407	381	8674		
1948	367	351	504	879	1654	3255	1309	541	405	10577	422	417	256	10360		
1949	325	294	849	803	1150	1012	440	290	208	6466	323	384	232	6310		
1950	236	347	554	804	739	1711	1092	556	440	7418	483	409	436	7807		
1951	427	360	680	971	1366	1500	921	440	516	8509	573	512	370	8636		
1952	340	484	606	1773	1587	1148	598	394	355	8740	326	304	297	8212		
1953	307	358	477	366	872	3880	922	372	371	8852	334	361	312	8932		
1954	186	414	411	510	776	1142	791	409	288	5934	381	406	247	5961		
1955	187	241	310	662	824	1284	899	324	265	6030	291	196	292	5775		
1956	296	263	541	628	1075	1591	481	354	308	6316	336	407	316	6596		
1957	208	286	595	521	1005	1449	579	268	334	6304	390	456	382	6473		
1958	299	284	525	516	854	1330	711	349	319	6415	386	420	395	6388		
1959	323	322	1324	657	835	1510	876	303	314	7665	505	545	663	8177		
1960	337	516	877	714	1010	888	363	264	295	6977	280	331	313	6188		
1961	311	323	358	242	331	902	283	187	243	4104	388	443	240	4251		
1962	285	446	423	577	1178	1720	801	381	336	7218	414	391	315	7267		
1963	258	616	503	351	627	1326	724	319	353	6197	338	373	275	6063		
1964	304	370	364	387	1327	3233	1234	375	392	8972	418	420	354	9178		
1965	518	568	664	1168	1683	2229	1713	604	585	10924	726	621	489	11568		
1966	389	401	828	638	806	762	586	254	288	6788	324	438	381	6095		
1967	322	622	729	574	1141	3336	1426	398	506	10197	469	563	261	10347		
1968	448	486	752	543	880	1928	1016	474	589	8409	574	557	374	8621		
1969	410	432	1035	1264	1392	1161	1548	494	405	9646	443	497	377	9458		
1970	278	451	608	531	1902	2479	1147	469	451	9633	535	477	400	9728		
1971	409	872	790	763	1550	1865	1108	464	458	9691	517	474	312	9582		
1972	392	476	1169	682	1088	1988	771	570	426	8865	492	566	342	8962		
1973	364	350	484	492	796	822	507	292	329	5836	406	427	410	5679		
1974	410	435	489	567	1121	2015	977	525	462	8244	393	448	396	8238		
1975	258	289	563	923	2647	3257	2528	788	609	13099	667	666	643	13838		
1976	553	603	688	816	2147	1919	1076	562	566	10906	587	557	452	10526		
1977	277	444	422	455	559	592	349	265	344	5303	434	336	402	4879		
1978	312	370	1899	1508	1803	1727	1489	542	810	11632	638	447	423	11968		
1979	373	408	1913	1222	1430	1292	564	273	329	9312	311	415	352	8882		
1980	278	328	542	608	959	1750	802	282	371	6998	474	464	377	7235		
1981	445	392	522	473	1659	2404	775	323	251	8559	492	471	370	8577		
1982	284	612	841	766	1075	2498	1605	433	400	9847	566	508	502	10090		
1983	441	468	550	471	858	1215	1079	419	426	7503	579	560	321	7387		
1984	468	543	514	609	1054	1510	1025	479	422	8084	527	535	340	8026		
1985	397	320	609	703	771	645	201	288	340	5676	668	476	431	5849		
1986	481	385	1288	654	1157	1395	560	289	931	8715	588	431	418	8577		
1987	271	378	481	503	516	1311	405	403	345	5250	287	346	273	4719		
1988	220	335	425	387	645	454	253	115	144	3884	239	284	302	3803		
1989	241	214	840	713	1094	869	438	315	386	5935	388	491	344	6333		
1990	454	269	531	601	804	1097	548	294	272	6093	262					

FORT PECK
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1996	381	818	947	995	1210	2174	768	306	290	9473	377	362	424	9052
1997	512	582	717	631	1500	3023	1231	586	472	10417	458	491	394	10597
1998	278	458	458	528	792	1300	1447	469	335	7408	379	413	293	7150
1999	441	418	504	416	764	1472	766	312	292	6470	269	353	373	6380
2000	248	319	417	417	473	737	549	207	164	4526	276	253	237	4297
2001	313	234	395	313	432	574	460	256	150	3893	156	243	213	3739
2002	206	230	262	412	403	1467	812	336	228	4968	199	258	237	5050
2003	200	290	596	481	689	1029	435	266	146	4826	166	204	252	4754
2004	210	247	577	346	392	759	535	243	227	4158	238	274	219	4267
2005	209	310	319	295	637	1357	750	327	228	5163	228	326	202	5188
2006	413	223	446	702	861	1340	534	275	175	5725	289	347	258	5863
2007	256	362	627	498	826	1114	460	265	171	5473	218	232	208	5237
2008	200	246	393	315	867	2236	1155	388	335	6793	288	332	196	6951
2009	359	339	514	514	1130	1411	849	397	350	6679	385	360	300	6908
2010	330	319	582	395	892	1975	1253	459	425	7675	353	329	334	7646
2011	398	577	1010	891	2408	4825	2228	635	279	14267	380	416	430	14477
2012	332	455	523	605	961	1193	611	316	147	6369	205	356	297	6001
2013	278	335	416	386	567	1726	610	371	188	5735	251	286	261	5675
N	116	116	116	116	116	116	116	116	116	116	116	116	116	116
MEAN	312	361	595	641	1082	1640	831	356	330	7235	380	381	327	7234
STDEV	81	125	278	259	451	863	469	145	134	2157	125	106	90	2244
SKEW	0.535	1.332	2.334	1.464	0.736	1.096	1.187	1.031	1.478	0.527	0.595	0.205	0.763	0.589

FORT PECK - GARRISON
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1898	238	339	718	1228	1989	4380	2106	676	543	13284	458	309	186	13170
1899	272	280	557	3328	280	4209	3866	716	395	15929	303	341	268	15888
1900	337	399	1394	924	1749	3001	851	317	349	10233	484	329	216	10350
1901	228	282	1107	672	2725	2618	1488	534	597	11280	468	407	236	11362
1902	262	395	1414	587	1146	2386	1168	536	526	9531	528	325	222	9495
1903	276	474	934	851	696	2438	1805	811	599	9959	500	387	262	10033
1904	319	391	647	1204	1823	3527	2152	811	591	12614	424	301	194	12384
1905	248	311	851	484	672	3021	1660	506	317	8989	329	315	234	8948
1906	294	216	889	825	1837	4088	1896	904	748	12575	444	426	284	12851
1907	327	315	1020	613	1424	3737	4094	1500	724	14908	645	543	272	15214
1908	282	422	889	696	1359	3882	2902	998	528	13418	662	361	335	13316
1909	347	359	1023	607	1263	5086	3453	1067	776	15339	474	357	274	15086
1910	345	424	1065	912	1791	2055	1069	508	405	9679	371	319	97	9361
1911	157	242	724	555	857	3418	1825	962	950	10477	595	313	196	10794
1912	238	294	1525	2360	1634	3328	2884	1335	988	15690	926	666	389	16567
1913	413	335	887	1394	1452	3578	1878	1150	647	13715	510	460	353	13057
1914	381	361	902	783	1859	3406	1428	585	498	11526	573	565	240	11581
1915	264	286	1321	738	1142	2975	2416	1121	962	12603	861	452	422	12960
1916	381	417	1942	1077	1142	3124	3358	984	456	14616	549	498	349	14277
1917	327	333	1022	2573	1906	3864	3497	829	678	16425	559	488	290	16366
1918	456	458	1773	1424	1252	4643	2216	859	593	15011	512	432	319	14937
1919	387	292	807	988	843	724	300	212	196	6012	282	369	321	5721
1920	317	333	1192	948	1712	3465	2479	708	434	12560	357	363	387	12695
1921	280	415	1039	706	1144	4364	1382	367	274	11078	184	260	204	10619
1922	270	393	1212	893	1561	3235	1450	605	407	10674	323	401	218	10968
1923	246	357	841	1113	1210	2095	3094	766	585	11249	1912	902	534	13655
1924	666	908	1396	2735	2079	2934	1827	545	468	16906	666	579	383	15186
1925	694	988	1484	1125	1664	3314	2289	791	520	14497	611	510	405	14395
1926	484	553	1182	1144	1775	1833	1422	603	682	11204	583	490	369	11120
1927	327	615	984	1000	1968	4147	2515	1325	948	15271	678	565	434	15506
1928	436	419	1123	952	2626	2898	2753	833	591	14308	534	472	357	13994
1929	266	216	1575	1176	1585	3031	1747	405	397	11761	524	422	300	11644
1930	254	601	1311	1267	1035	1795	976	883	603	9971	541	415	212	9893
1931	190	290	260	385	653	1634	397	339	186	5502	339	224	180	5077
1932	198	173	500	1216	1500	3011	1583	415	432	9771	450	323	250	10051
1933	284	212	1422	625	1632	2876	797	383	581	9835	375	387	131	9705
1934	296	436	645	561	766	837	246	208	161	5049	282	254	109	4801
1935	113	256	397	609	538	2559	1730	403	232	7482	230	212	278	7557
1936	177	190	819	996	1146	1797	659	365	220	7089	383	363	258	7373
1937	167	167	469	649	764	2271	1381	327	208	7407	409	266	200	7278
1938	258	161	1170	577	1014	3189	2138	484	393	10259	417	266	58	10125
1939	341	159	2053	682	1244	2245	837	309	248	8859	432	365	272	9187
1940	145	206	327	821	1000	1726	635	224	177	6330	617	260	349	6487
1941	248	260	391	746	920	2106	659	724	960	8240	984	601	442	9041
1942	268	361	970	889	1410	2963	1626	492	343	11349	440	464	250	10476
1943	296	776	1724	2864	1289	3648	3076	891	518	16236	575	506	218	16381
1944	290	327	920	2063	1228	4346	2469	567	395	13904	460	428	250	13743
1945	238	365	1527	637	780	2362	2194	700	504	10445	498	333	292	10430
1946	415	315	1089	645	930	2136	1557	391	492	9093	690	440	333	9433
1947	286	526	1678	1718	1771	2803	2344	970	476	14035	549	371	280	13772
1948	290	266	956	1317	1220	3511	1787	583	256	11386	403	311	-28	10872
1949	222	224	1212	1674	1125	2101	1037	272	303	8856	510	504	149	9333
1950	292	317	578	2438	1030	2352	2107	801	589	11667	746	294	372	11916
1951	366	337	627	2022	1342	2206	1770	1132	855	12069	783	570	136	12146
1952	389	518	490	4865	2193	2463	1382	609	401	14799	446	457	226	14439
1953	285	361	468	598	820	3020	1444	604	322	9051	429	492	275	9118
1954	287	605	613	1252	1140	1248	1558	625	454	8978	308	392	283	8765
1955	137	272	453	1550	1272	1710	1210	478	228	8293	418	281	412	8421
1956	467	318	734	1010	1069	3063	1304	563	438	10077	346	446	253	10011
1957	258	292	661	747	1244	3423	2147	527	543	10887	569	535	342	11288
1958	300	246	537	703	896	1984	1010	401	326	7849	355	297	247	7302
1959	224	220	1698	742	632	1893	1398	351	326	8383	532	302	476	8794
1960	194	310	1526	1314	515	1183	409	185	191	7137	267	285	150	6529
1961	199	230	462	221	179	1450	321	178	375	4317	513	411	162	4701
1962	222	538	559	1100	1258	2938	2396	778	454	11329	567	429	273	11512
1963	163	572	935	612	1112	3524	1542	385	485	10599	468	320	146	10264
1964	223	233	365	585	1012	2852	2624	410	520	9758	372	318	205	9719
1965	337	287	420	1926	1705	3073	3383	989	742	13757	710	440	287	14299
1966	143	212	920	662	785	1212	855	273	340	6839	360	333	200	6295
1967	171	263	986	1431	1271	4060	3356	530	459	13420	475	423	203	13628
1968	249	330	1234	493	569	2969	1898	940	852	10635	567	569	255	10925
1969	238	255	1260	2118	1568	1911	2349	449	244	11783	331	410	215	11348
1970	76	336	558	922	1834	3210	2254	430	410	10986	526	324	224	11104
1971	175	831	1480	1604	1168	3428	2420	682	724	13586	962	564	280	14318
1972	187	402	3571	873	1186	3254	1481	920	662	14342	630	616	259	14041
1973	318	318	882	620	1562	2290	1145	477	852	9969	651	427	343	9885
1974	297	452	705	1076	1165	3387	2519	699	506	12227	395	509	301	12011
1975	141	152	741	1747	2740	2847	3987	983	487	15030	496	374	306	15001
1976	342	641	1361	993	1553	2947	2017	870	483	12383	460	345	273	12285
1977	72	289	595	571	894	1225	391	245	438	5798	492	124	229	5565
1978	104	134	1549	2415	2750	3428	2986	877	876	15964	549	203	290	16161
1979	111	236	1314	3213	1442	2034	1220	537	540	11689	329	357	174	11507
1980	71	166	493	697	945	1823	993	306	458	6812	652	468	110	7182
1981	335	250	505	207	741	2753	1013	272	83	7389	351	488	185	7183
1982	12	345	1031	1511	902	2489	2958	1041	561	11874	939	553	368	12710
1983	354	581	981	521	728	2253	2012	528	232	10050	662	581	36	9469
1984	294	458	703	551	1276	2295	1754	683	284	9577	651	502	75	9526
1985	248	165	869	704	587	1072	514	537	367	6291	674	308	218	6263
1986	291	216	2237	586	1491	3076	1608	416	640	11761	1248	459	462	12730
1987	217	383	797	777	919	1239	580	493	426	8000	373	336	96	6636
1988	-41	168	588	346	840	1212	399	-56	62	4323	276	201	146	4141
1989	35	107	716	1061	1176	1680	1069							

FORT PECK - GARRISON
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1996	248	898	1513	1526	1277	3545	2142	382	178	12556	360	246	300	12615
1997	267	646	1890	1974	1609	4652	2917	1271	608	16740	525	551	491	17401
1998	157	608	709	898	895	1722	2431	817	404	10208	875	642	274	10432
1999	393	506	1669	901	1431	3279	2176	672	532	13350	573	454	238	12824
2000	232	342	680	367	635	1946	1062	236	143	6908	550	263	183	6639
2001	348	263	1054	733	537	1290	985	245	34	6485	352	219	182	6242
2002	184	232	345	637	530	1838	1175	384	224	6302	480	238	153	6420
2003	143	320	1359	707	757	2446	1095	261	109	8068	355	154	269	7975
2004	162	225	912	616	376	1345	1202	409	276	6301	523	365	142	6553
2005	197	395	557	402	1207	2292	1919	366	129	8494	556	300	93	8413
2006	440	253	494	793	1012	1822	815	257	113	6948	507	270	112	6888
2007	184	211	917	635	1439	2340	800	287	119	7821	416	270	154	7772
2008	191	211	456	497	837	3164	2892	720	419	10227	607	314	293	10601
2009	400	353	1063	1352	1209	3100	2393	748	495	12327	523	398	247	12281
2010	319	285	754	695	980	3365	2527	616	507	11216	538	219	308	11113
2011	331	460	1436	2666	3887	6485	5566	1542	666	24104	721	368	384	24512
2012	248	539	839	554	980	2112	1340	428	111	8624	429	344	199	8123
2013	199	347	619	1085	1108	3144	1440	534	414	9862	898	358	282	10428
N	116	116	116	116	116	116	116	116	116	116	116	116	116	116
MEAN	261	355	995	1079	1260	2710	1815	609	448	10698	527	393	249	10702
STDEV	112	165	493	732	545	985	941	317	217	3250	216	121	104	3312
SKWEW	0.647	1.558	1.615	2.197	1.501	0.495	0.798	0.822	0.437	0.616	2.878	0.718	0.081	0.598

GARRISON - OAHE
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1898	-85	63	865	478	389	464	286	58	91	2488	46	180	6	2841
1899	12	36	1022	403	472	607	220	97	234	3335	61	77	-61	3180
1900	-95	28	778	337	63	264	208	99	212	1971	69	79	-58	1984
1901	-6	28	458	177	67	718	226	30	543	2331	159	-18	-4	2378
1902	4	40	752	173	163	266	115	38	349	2037	56	133	-22	2067
1903	-52	46	526	300	272	343	260	111	714	2687	276	103	-50	2849
1904	-44	87	573	321	220	791	182	61	212	2732	32	46	-93	2388
1905	-91	36	528	194	361	621	454	69	151	2308	-63	-4	28	2284
1906	-60	36	520	315	466	486	190	123	885	2922	488	319	161	3929
1907	180	58	534	190	468	778	512	44	167	3899	389	405	111	3836
1908	60	95	785	363	282	551	177	60	63	3341	-109	184	280	2791
1909	46	127	432	327	781	1214	565	161	186	4194	-2	73	-18	3892
1910	-48	67	811	307	151	371	216	67	-54	1941	46	-6	-42	1886
1911	12	40	157	165	87	198	101	56	492	1306	329	87	113	1837
1912	123	38	454	581	284	290	387	111	619	3416	266	341	617	4111
1913	252	4	149	44	50	77	38	12	555	2405	161	298	377	2017
1914	67	30	537	300	232	873	218	60	413	3566	248	641	292	3911
1915	296	131	373	458	389	1020	553	85	647	5133	494	387	97	4930
1916	-6	65	1250	375	359	607	288	113	111	4140	210	288	-8	3652
1917	8	95	744	629	208	401	204	58	286	3123	298	307	6	3244
1918	-85	26	492	460	266	298	260	93	234	2655	-200	-56	-228	1560
1919	258	56	286	268	159	192	133	20	-61	827	-42	-125	-103	1041
1920	-97	56	1004	631	482	946	325	83	52	3212	-40	-77	46	3411
1921	-50	26	631	359	238	300	262	67	121	1883	-60	-54	-89	1751
1922	-85	163	670	432	500	871	428	60	60	2896	8	63	-105	3065
1923	-97	73	601	561	260	978	563	131	349	3385	571	591	300	4881
1924	-48	46	482	272	44	450	133	40	71	2952	177	309	8	1984
1925	-175	42	424	484	230	1214	234	54	-40	2961	-8	-2	-133	2324
1926	-129	52	244	40	387	712	345	125	446	2079	288	109	-139	2480
1927	-137	65	1178	1638	986	893	577	167	345	5970	173	-46	-77	5762
1928	-50	42	726	385	294	1331	633	157	117	3685	4	77	-99	3609
1929	-18	69	1105	494	258	337	202	40	-18	2443	61	-14	-54	2462
1930	-69	-20	676	385	236	151	-99	52	8	1313	125	-69	-81	1295
1931	6	71	83	125	-8	6	58	48	18	382	2	0	22	431
1932	-32	60	381	421	242	637	-133	151	32	1783	-12	-40	-139	1568
1933	-8	-32	180	141	647	52	44	42	85	960	38	34	30	1253
1934	-30	-149	188	2	-44	-46	77	50	20	170	28	24	-50	70
1935	-22	44	121	200	151	452	79	20	16	1063	4	-42	-61	962
1936	-8	-2	393	208	-8	-8	-12	40	18	439	2	10	-8	542
1937	-30	-10	202	270	14	712	329	65	28	1584	-10	-44	-16	1510
1938	10	34	347	60	93	315	216	-22	69	1052	18	-77	-83	980
1939	28	12	934	-345	105	198	83	34	54	961	8	-6	8	1113
1940	18	8	22	202	77	52	6	24	65	484	28	-67	30	465
1941	14	16	113	329	75	1085	117	-48	36	1728	60	0	-65	1732
1942	8	4	109	333	1174	522	163	60	-24	2344	24	-54	22	2341
1943	54	226	986	1323	40	803	58	38	42	3562	-18	79	-111	3520
1944	44	60	18	1644	228	1299	40	145	61	3489	30	153	-105	3617
1945	16	365	1392	284	79	414	79	173	12	2892	83	89	62	3048
1946	24	42	317	60	258	628	224	18	107	1912	131	44	40	1893
1947	2	91	641	540	117	1065	-54	-56	10	2571	71	-95	-54	2278
1948	4	40	927	1121	254	133	89	-2	-34	2454	79	60	-36	2635
1949	46	52	1162	1478	165	115	38	24	6	3189	30	68	-9	3175
1950	-43	-31	575	3749	835	216	-103	72	68	5427	49	-89	23	5321
1951	67	9	260	943	-2	237	18	87	116	1718	60	-186	-140	1469
1952	-32	59	156	3953	238	27	117	-5	-11	4236	-24	-74	-57	4347
1953	56	39	551	197	354	1205	-27	84	-13	2291	0	-8	-67	2371
1954	-7	107	139	293	91	290	-20	84	135	1037	178	120	-44	1366
1955	27	15	250	207	94	70	106	25	32	1080	-16	-48	-24	738
1956	30	20	720	344	69	92	115	60	25	1387	-12	32	-73	1422
1957	-45	-42	199	99	370	230	150	-37	-18	853	-23	39	41	963
1958	-119	-8	252	418	106	165	269	9	-9	1140	28	-30	-30	1051
1959	28	8	478	204	69	63	31	-22	3	830	62	-158	72	838
1960	6	19	489	501	66	104	-40	34	-18	1137	0	-26	-209	926
1961	57	61	227	-1	117	37	-32	13	91	335	-58	60	-198	374
1962	25	76	287	242	598	1077	343	128	44	2624	42	-24	-132	2706
1963	-17	33	253	158	141	326	50	63	42	935	16	-57	-197	811
1964	-20	31	81	192	356	634	249	-36	4	1253	31	-110	-138	1274
1965	14	42	80	510	664	511	182	58	-80	1764	34	24	39	2078
1966	-123	80	1487	498	66	91	169	51	73	2489	-16	37	-25	2388
1967	-30	77	645	256	581	1001	154	102	22	2804	38	112	-112	2846
1968	56	41	213	219	65	216	95	37	76	1056	52	66	21	1157
1969	13	110	530	1087	180	117	555	31	48	2810	34	60	62	2827
1970	-68	55	118	579	972	285	136	106	110	2449	45	146	19	2503
1971	64	318	1101	805	460	714	147	20	33	3872	112	70	-37	3807
1972	42	112	1835	193	835	541	183	120	-4	4002	8	83	-12	3936
1973	236	183	593	241	247	177	57	30	75	1918	57	81	36	2013
1974	44	136	220	243	219	118	116	0	29	1299	37	29	112	1303
1975	-105	68	194	900	1169	327	54	15	-72	2728	-14	-5	45	2576
1976	-24	248	284	153	112	420	149	76	44	1488	-11	33	-9	1475
1977	46	116	267	140	101	157	88	-49	163	1042	90	-22	24	1121
1978	65	190	1772	1739	698	295	196	109	87	5243	-48	27	25	5155
1979	87	98	299	1002	207	201	303	111	105	2417	-73	25	-30	2335
1980	-42	29	279	83	7	89	-93	-71	9	212	92	33	65	480
1981	105	110	201	-1	49	154	119	225	71	1223	52	81	61	1227
1982	13	243	805	1529	1390	581	210	178	99	5242	324	214	137	5723
1983	-6	156	629	203	358	109	123	74	44	2365	-4	16	-57	1645
1984	125	261	324	265	467	794	71	-24	-57	2181	-14	38	-17	2233
1985	130	113	605	76	56	55	-12	37	17	1084	19	20	60	1176
1986	123	103	1629	908	1109	266	158	-7	66	4454	162	100	23	4640
1987	-63	203	2027	951	216	231	44	65	28	3987	-10	48	60	3800
1988	-18	105	187	43	83	-8	9	-56	-68	375	17	45	-49	290
1989	-45	93	338	272	269	62	33	0	110	1145	9	91	-30	1202
1990	184	90	232	23	79	185	129	92	82	1166	16	88	-25	1175
1991	89	155	227	104	375	567	124	38	-23	1735	44	71	62	1833
1992	79	158	230	41	10	160	195	131	74	1255	27	123	-76	1152
1993	27	163	780	321	405	336	1064	562	83	3815	53	154	104	4052
1994	65	143	1143	287	257	303	286	37	101	2933	176	67	102	2967
1995	91	459	1106	519	1443	657	276	32	119	5047	138	250	62	5152

GARRISON - OAHE
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1996	158	896	1014	688	597	1110	249	185	262	5609	145	340	154	5798
1997	168	516	2604	2828	841	336	263	4	-8	8191	-140	-39	14	7387
1998	-257	94	191	217	34	272	220	85	-15	676	169	72	-2	1080
1999	-43	207	687	270	811	482	232	103	31	3019	-79	-41	48	2708
2000	-64	99	386	406	400	285	223	48	132	1843	143	154	-16	2196
2001	146	117	1085	505	140	290	357	237	116	3274	24	95	29	3141
2002	19	73	57	130	96	60	49	50	110	792	23	96	10	773
2003	-53	61	424	160	344	167	106	41	81	1460	40	-39	7	1339
2004	-24	27	507	134	46	214	74	134	111	1231	-9	107	-56	1265
2005	16	93	116	57	189	344	181	105	74	1217	-9	39	-69	1136
2006	93	32	110	134	96	51	85	48	83	693	12	70	-60	754
2007	-9	19	203	190	73	429	134	149	69	1279	10	43	-38	1272
2008	-5	7	120	102	310	1384	393	118	67	2511	16	106	4	2622
2009	29	498	2098	3212	547	421	368	247	120	7666	66	67	0	7673
2010	38	69	1378	1013	592	661	307	175	129	4495	-55	42	59	4408
2011	90	282	1727	1600	912	1080	399	206	55	6397	79	38	106	6574
2012	-71	184	266	108	193	199	145	48	-24	1271	-47	70	58	1129
2013	14	108	158	215	416	818	260	203	204	2477	1138	176	3	3713
N	116	116	116	116	116	116	116	116	116	116	116	116	116	116
MEAN	12	95	584	508	319	440	185	71	110	2453	72	67	1	2465
STDEV	87	125	492	682	308	355	175	78	167	1547	157	132	112	1549
SKEW	0.555	3.265	1.582	3.157	1.597	0.873	1.535	2.313	2.346	1.140	3.473	1.694	1.943	1.042

OAHF - FORT RANDALL
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1898	-54	4	151	111	240	63	190	24	32	680	14	58	2	835
1899	4	14	510	143	125	179	67	34	75	1225	20	24	-38	1157
1900	-58	12	186	200	26	135	214	38	67	826	22	26	-36	832
1901	-4	16	228	147	46	284	38	24	175	966	52	-10	-2	994
1902	2	6	240	87	30	91	28	26	109	659	18	42	-12	667
1903	-32	20	220	179	79	105	141	24	228	1012	87	34	-30	1055
1904	-26	16	52	125	67	177	139	18	69	728	10	16	-58	605
1905	-58	10	248	109	192	226	95	24	48	862	-40	-2	10	862
1906	-36	12	276	280	129	119	10	56	282	1096	155	101	58	1442
1907	58	36	125	105	155	145	220	20	54	1232	125	129	36	1208
1908	20	20	188	117	157	222	85	26	20	1145	-65	58	89	937
1909	14	65	192	220	270	184	127	63	60	1277	-2	24	-12	1205
1910	-30	10	262	111	54	161	77	18	-32	641	16	-4	-26	617
1911	4	16	50	111	48	48	44	28	157	492	103	28	36	673
1912	40	12	159	226	67	65	139	40	194	1109	83	107	196	1328
1913	79	4	52	38	20	18	20	6	179	802	52	95	119	682
1914	22	24	127	286	75	147	54	18	129	1148	77	204	93	1256
1915	93	131	502	252	119	274	226	16	204	2191	157	123	32	2129
1916	-4	10	190	101	151	238	58	40	38	1134	67	91	-4	976
1917	2	20	417	226	149	113	60	18	89	1248	95	97	-2	1288
1918	-52	14	250	228	111	161	115	28	75	1124	-123	-34	-139	634
1919	81	26	103	115	48	139	61	10	-36	251	-26	-77	-63	381
1920	-60	40	409	377	200	397	89	18	18	1322	-24	-48	16	1432
1921	-30	4	216	63	117	83	145	38	40	620	-36	-32	-56	552
1922	-52	50	266	99	145	264	169	30	20	867	2	20	-63	950
1923	-60	6	202	165	103	422	159	93	111	1160	182	188	95	1666
1924	-30	26	159	40	14	180	22	26	24	926	56	99	2	618
1925	-105	16	52	109	32	323	61	24	-24	645	-4	-2	-79	403
1926	-77	8	8	4	95	184	149	24	141	451	91	34	-83	578
1927	-83	22	710	298	270	171	81	50	111	1672	54	-30	-48	1606
1928	-30	46	440	87	123	294	87	40	73	1136	-2	26	-61	1123
1929	-12	34	329	202	54	125	95	12	-12	790	-44	-50	-60	673
1930	-22	-52	409	-52	-18	-54	-53	61	12	77	10	-32	-91	118
1931	-6	169	20	73	67	-95	61	-8	46	214	4	0	-24	307
1932	-40	36	188	56	190	180	-163	165	0	592	-6	-73	-77	456
1933	0	14	135	129	165	-75	-6	149	-16	339	26	-22	-48	451
1934	36	-186	198	0	20	83	93	16	20	236	-16	-22	-60	182
1935	-28	18	20	105	186	149	67	-56	22	385	-18	-42	-91	332
1936	6	-6	597	32	-63	-65	-40	-6	36	340	-14	-4	-61	412
1937	-2	-16	149	18	50	248	-87	28	-63	246	-34	0	-32	259
1938	-18	-4	8	127	155	71	-93	-24	52	208	-2	-36	-30	210
1939	28	-4	490	-347	67	32	-46	34	-28	162	-42	-16	-14	154
1940	-46	-24	-4	111	20	-115	2	-40	34	-134	-38	-12	-40	-152
1941	-10	-22	40	-4	-65	32	-16	-48	46	-137	73	54	-24	56
1942	-32	-52	-2	149	1660	426	-50	125	67	2394	10	8	-4	2305
1943	4	-44	93	-20	54	230	-28	-4	4	303	-32	71	-99	229
1944	6	-26	117	224	214	490	179	180	54	1378	-8	50	-174	1306
1945	-69	55	421	60	-4	-10	8	63	-60	332	2	16	-36	446
1946	8	40	131	139	89	68	79	79	68	683	87	97	-143	742
1947	2	12	214	141	-83	395	-179	-2	-60	481	-8	18	-99	351
1948	65	111	238	-10	44	75	-141	10	4	307	-145	52	-38	265
1949	-38	10	555	-14	186	16	-91	-26	-6	461	52	35	2	681
1950	-76	39	411	234	205	-13	43	34	8	974	28	0	-30	883
1951	28	4	145	104	77	234	69	25	59	743	98	94	3	940
1952	52	122	379	1347	114	117	58	8	-56	2336	-36	-24	-65	2016
1953	-29	48	610	226	577	178	258	218	100	2061	179	29	-50	2344
1954	-45	92	93	-31	-6	159	23	58	8	599	-28	-5	-46	362
1955	43	12	401	91	55	167	30	130	111	875	137	-139	41	993
1956	9	15	52	69	95	96	16	95	-4	482	-55	39	-40	387
1957	-23	13	76	111	223	226	98	8	25	701	8	63	-20	808
1958	-43	22	126	203	55	29	54	-34	-22	441	29	0	-13	406
1959	13	4	59	9	71	32	22	13	49	288	6	-16	35	297
1960	-4	32	622	502	112	103	35	70	8	1505	54	-7	-6	1521
1961	37	45	47	33	132	121	65	17	9	547	-9	41	-32	506
1962	25	27	144	223	412	700	447	86	-39	2025	-52	-8	54	2019
1963	29	160	139	32	121	226	128	25	-34	820	20	-63	208	991
1964	173	83	12	187	205	218	90	72	-25	1180	-41	23	173	1170
1965	140	120	91	78	248	146	124	93	102	1297	-18	-30	90	1184
1966	210	104	591	165	109	158	146	189	90	1804	70	31	128	1991
1967	55	87	135	91	169	676	116	81	90	1729	52	41	51	1644
1968	87	128	76	244	105	366	126	103	65	1444	-8	3	-32	1263
1969	210	67	329	344	78	93	171	91	28	1374	36	43	10	1500
1970	151	84	130	323	119	91	24	15	60	1086	14	6	56	1073
1971	64	148	215	213	164	182	70	132	122	1386	116	55	116	1597
1972	100	135	183	127	421	193	222	196	139	2003	114	69	137	2036
1973	127	154	185	87	117	81	103	115	85	1374	47	-26	79	1154
1974	120	102	109	114	108	82	91	127	72	1025	35	18	50	1028
1975	48	58	98	246	152	148	111	85	48	1097	81	46	101	1222
1976	37	50	38	39	27	20	71	48	-18	540	-54	-45	45	258
1977	86	27	267	255	109	91	30	40	61	912	-18	10	75	1033
1978	69	38	924	191	174	129	93	92	157	1934	66	48	66	2047
1979	81	18	216	28	87	125	108	109	31	983	22	-34	53	844
1980	-52	77	54	40	46	35	-12	90	17	336	51	0	-20	326
1981	26	-2	6	-18	-27	-21	-21	43	-42	-25	-49	-38	-28	-171
1982	29	76	43	102	429	125	-16	-66	-49	558	43	-266	19	469
1983	81	76	65	104	356	176	47	44	-22	723	-4	-17	76	982
1984	98	157	168	234	95	268	-26	71	40	1160	-39	-86	83	1063
1985	86	84	210	40	-18	-8	4	36	-91	301	-149	-134	108	168
1986	32	102	460	477	420	201	-8	47	70	1626	-79	-83	23	1662
1987	114	61	444	369	122	20	11	-17	13	998	-35	-82	20	1040
1988	155	67	125	49	208	27	47	-19	34	596	-153	-8	68	600
1989	48	33	158	13	24	-35	-27	-24	0	97	-61	-15	53	167
1990	-15	54	7	-3	58	95	-61	-31	-57	24	-111	-6	-67	-137
1991	26	-12	21	31	206	445	-24	10	58	577	-169	48	69	709
1992	33	88	67	4	3	12	108	78	-77	264	-30	8	7	287
1993	172	11	221	104	108	186	221	31	-56	969	-81	-77	40	880
1994	50	137	401	22	24	62	27	-16	2	591	-57	-100	90	642
1995	41	51	57	634	812	470	-48	-45	-99	1806	-44	-12	167	1984

OAHF - FORT RANDALL
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1996	-24	275	167	10	259	178	-83	-134	-7	752	-38	17	75	695
1997	114	589	845	451	415	583	105	154	17	3327	16	-48	191	3432
1998	159	134	156	105	94	259	120	124	24	1334	65	-32	41	1249
1999	158	78	44	235	736	189	120	14	158	1806	60	-118	37	1711
2000	-7	84	42	120	27	-115	-104	-128	-158	-260	-320	20	50	-489
2001	67	46	375	542	222	113	18	-2	45	1176	-69	-53	50	1354
2002	64	25	92	81	36	56	28	48	52	410	-96	44	39	469
2003	-3	81	75	64	98	53	40	12	2	409	-23	-10	15	404
2004	-4	80	13	-5	29	42	12	5	60	214	-26	-26	26	206
2005	41	46	6	53	154	207	-19	-27	-26	409	-15	-33	47	434
2006	87	14	67	111	5	-5	-52	8	-15	219	-63	-24	94	227
2007	-17	94	146	3	106	84	-63	92	-61	391	48	-88	75	419
2008	-42	101	55	22	109	418	64	-29	-12	721	0	76	-86	676
2009	117	217	165	229	32	53	79	64	41	987	5	6	12	1020
2010	176	119	955	272	140	440	124	39	7	2295	-8	8	3	2275
2011	78	213	647	248	303	855	355	243	123	3068	0	12	84	3161
2012	131	127	106	73	91	-1	-63	-5	65	620	-51	-63	-8	402
2013	33	94	37	113	141	128	35	94	-3	550	135	-54	-46	707
N	116	116	116	116	116	116	116	116	116	116	116	116	116	116
MEAN	28	54	215	144	146	160	58	41	37	904	5	4	12	905
STDEV	68	79	202	174	199	164	96	62	71	648	74	64	72	670
SKEW	0.645	2.863	1.556	3.190	4.610	1.512	0.625	0.561	0.560	1.079	-0.572	-0.278	0.316	1.038

FORT RANDALL - GAVINS POINT
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1898	75	97	143	119	127	127	77	67	73	1186	99	91	75	1170
1899	73	93	141	115	125	125	73	67	71	1148	95	87	73	1138
1900	77	99	149	123	133	133	79	69	75	1192	101	93	77	1208
1901	85	109	165	135	147	147	87	75	83	1304	111	101	85	1330
1902	83	107	161	131	143	143	85	75	85	1310	109	99	83	1304
1903	79	101	153	125	135	137	83	73	77	1254	105	95	79	1242
1904	77	99	149	121	131	133	79	71	75	1214	101	91	77	1204
1905	89	113	171	139	153	153	91	83	83	1344	117	105	89	1386
1906	95	123	182	151	163	165	99	89	93	1471	125	113	95	1493
1907	85	111	165	135	147	147	89	81	85	1378	113	101	85	1344
1908	85	111	165	135	147	149	89	81	85	1346	113	101	85	1346
1909	91	117	175	143	157	159	95	85	89	1410	119	109	91	1430
1910	79	101	151	125	135	137	83	73	77	1280	103	93	79	1236
1911	75	97	145	117	129	131	79	69	75	1192	97	89	75	1178
1912	81	103	155	127	139	139	83	75	79	1242	105	95	81	1262
1913	79	101	153	125	137	137	83	75	77	1248	105	93	79	1244
1914	79	103	153	125	137	137	83	75	79	1248	105	95	81	1252
1915	99	127	188	155	169	171	103	91	97	1481	131	117	99	1547
1916	89	115	173	143	155	157	95	83	89	1446	119	107	91	1416
1917	75	97	147	119	131	131	79	71	75	1242	99	91	75	1190
1918	75	97	147	119	131	131	79	71	75	1190	99	91	75	1190
1919	76	99	150	121	133	135	81	71	77	1208	101	91	76	1211
1920	85	111	165	135	147	149	89	81	85	1315	113	103	85	1348
1921	85	111	163	135	147	149	89	79	85	1344	113	103	85	1344
1922	83	105	159	131	141	143	87	75	81	1306	109	99	83	1296
1923	89	113	171	139	153	155	93	81	87	1372	117	105	89	1392
1924	87	111	167	137	149	151	91	79	83	1366	113	103	87	1358
1925	79	101	151	123	135	137	83	73	77	1262	103	93	79	1234
1926	75	95	143	117	129	129	79	69	73	1184	97	89	75	1170
1927	81	103	155	127	139	141	85	85	71	1248	97	73	52	1209
1928	97	111	171	127	105	105	99	75	83	1195	103	109	99	1284
1929	56	67	175	109	113	141	89	69	95	1225	105	115	75	1209
1930	75	155	137	163	196	121	69	81	91	1383	111	99	107	1405
1931	109	137	125	129	105	79	65	71	67	1204	85	77	103	1152
1932	79	135	133	113	143	147	71	69	71	1226	91	89	65	1206
1933	73	83	151	105	131	67	73	91	73	1122	87	97	79	1140
1934	107	97	125	95	85	81	54	67	101	1075	93	95	77	1077
1935	69	133	125	147	119	133	75	65	69	1200	83	95	77	1190
1936	79	79	212	121	129	75	46	58	63	1117	93	85	107	1147
1937	77	83	79	111	60	67	87	83	155	1087	93	54	91	1040
1938	81	93	141	131	105	71	87	85	91	1123	95	83	91	1154
1939	95	63	155	131	71	58	84	95	85	1106	105	89	83	1114
1940	79	93	167	133	87	109	48	61	63	1117	77	81	111	1109
1941	75	93	131	117	85	89	81	67	75	1082	97	91	83	1084
1942	85	91	143	129	339	149	83	77	85	1452	93	91	87	1452
1943	67	117	137	117	99	139	73	65	65	1150	83	93	77	1132
1944	89	87	177	182	145	218	137	103	79	1470	101	107	87	1512
1945	113	133	214	139	115	173	91	111	81	1465	99	97	64	1430
1946	107	123	165	101	111	89	77	74	115	1222	157	115	93	1327
1947	99	109	173	159	115	488	171	34	155	1868	107	40	34	1684
1948	60	97	141	262	149	397	268	186	20	1761	157	67	52	1856
1949	61	91	438	240	222	153	143	56	163	1843	128	113	33	1841
1950	89	51	214	445	126	98	250	180	88	1815	151	137	80	1909
1951	73	91	178	290	230	265	96	276	257	2124	151	105	75	2087
1952	89	164	652	221	241	136	123	118	83	2158	74	66	45	2012
1953	138	118	334	124	169	79	20	4	-39	1132	-30	148	158	1223
1954	76	163	164	103	134	246	51	67	56	1336	114	135	140	1449
1955	38	42	274	85	75	69	36	-126	-26	856	-36	102	89	622
1956	68	77	173	55	3	-110	-27	14	-1	407	160	166	128	706
1957	73	124	190	173	264	258	177	116	98	1927	113	159	126	1871
1958	85	92	159	227	137	147	192	128	72	1637	89	129	75	1532
1959	60	99	193	100	211	101	89	118	99	1363	110	156	113	1449
1960	69	92	408	391	301	141	103	133	115	2132	111	137	92	2093
1961	73	157	178	86	168	132	125	111	99	1469	143	107	56	1435
1962	54	103	423	229	269	450	487	200	152	2673	144	158	100	2769
1963	91	150	210	157	167	195	167	118	127	1784	97	103	84	1666
1964	88	111	132	196	188	238	165	145	121	1668	99	109	45	1637
1965	76	88	87	140	133	176	84	98	129	1264	129	135	122	1397
1966	59	119	264	154	133	144	114	137	94	1604	72	110	30	1430
1967	120	90	123	88	133	369	141	126	130	1532	130	147	37	1634
1968	111	108	132	162	153	178	162	107	111	1538	140	135	41	1540
1969	103	82	246	309	180	165	173	218	202	1994	215	176	64	2133
1970	100	141	133	197	191	142	140	162	138	1799	134	143	79	1700
1971	67	167	304	207	219	255	238	158	144	2115	159	209	151	2278
1972	86	160	208	102	315	237	234	145	129	2135	126	208	106	2056
1973	133	191	347	181	310	215	159	146	234	2356	205	187	113	2421
1974	170	159	134	160	142	171	153	169	151	1914	184	157	138	1888
1975	114	122	219	254	183	215	244	308	202	2340	141	114	239	2355
1976	129	210	176	203	223	172	176	160	227	2170	189	138	113	2116
1977	100	160	239	220	316	273	230	234	202	2414	214	200	81	2469
1978	81	101	535	329	311	193	323	193	104	2665	52	57	231	2510
1979	86	62	319	215	154	136	119	115	108	1654	50	143	150	1657
1980	99	152	181	202	191	167	88	115	77	1615	51	78	101	1502
1981	114	114	95	148	180	163	192	170	145	1551	160	136	110	1727
1982	65	198	187	172	369	241	207	167	141	2153	127	165	84	2123
1983	222	185	271	274	368	326	250	115	68	2455	59	99	90	2327
1984	189	260	327	480	368	403	116	17	-12	2396	18	14	125	2305
1985	142	157	268	254	247	200	197	238	310	2170	277	186	118	2594
1986	197	195	348	333	292	318	250	134	254	2902	149	124	162	2756
1987	211	208	497	376	299	218	248	218	215	2925	190	254	161	3095
1988	89	203	368	279	366	222	242	173	183	2730	197	179	103	2604
1989	139	97	221	200	217	196	190	194	143	2076	162	115	130	2004
1990	170	161	157	207	273	245	215	204	178	2217	212	156	59	2237
1991	173	181	184	196	240	274	160	148	149	2132	172	135	137	2149
1992	132	127	126	131	149	175	205	165	120	1774	147	131	78	1686
1993	98	139	370	213	283	199	374	160	132	2324	120	139	137	2364
1994	122	184	372	223	250	290	257	214	198	2506	186	200	186	2682
1995	162	198	209	389	610	363	243	292	255	3293	262	208	264	3455

FORT RANDALL - GAVINS POINT
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1996	151	301	300	266	420	366	275	294	300	3407	248	187	182	3290
1997	258	436	405	356	375	337	274	287	244	3589	193	178	230	3573
1998	184	308	310	369	323	373	332	300	208	3308	254	312	228	3501
1999	215	317	308	408	360	346	427	209	224	3608	168	185	191	3358
2000	128	201	179	179	222	199	203	218	187	2260	190	96	77	2079
2001	157	92	360	437	247	127	182	63	66	2094	56	94	127	2008
2002	138	138	144	156	148	64	16	6	-10	1077	11	56	106	973
2003	42	116	160	109	154	140	113	80	66	1153	62	93	122	1257
2004	56	186	165	118	133	119	127	87	115	1383	114	97	76	1393
2005	83	165	115	168	176	316	123	82	91	1606	103	104	120	1646
2006	156	77	135	213	120	100	61	85	88	1362	103	90	118	1346
2007	73	199	335	196	210	147	80	126	82	1759	157	98	102	1805
2008	41	133	261	175	212	326	124	96	115	1840	148	141	44	1816
2009	129	188	198	242	169	170	181	147	120	1877	120	118	100	1882
2010	176	149	496	198	175	567	249	127	198	2673	104	118	120	2677
2011	61	232	375	184	76	436	263	135	72	2176	66	78	52	2030
2012	78	188	177	183	189	156	158	137	87	1549	119	188	131	1791
2013	156	145	142	151	171	160	91	120	50	1624	105	107	77	1475
N	116	116	116	116	116	116	116	116	116	116	116	116	116	116
MEAN	100	132	211	181	185	184	139	116	111	1696	120	118	100	1696
STDEV	41	58	102	85	89	100	86	68	63	612	51	43	43	610
SKEW	1.521	2.168	1.789	1.585	1.580	1.208	1.374	0.629	0.876	1.159	0.368	1.325	1.573	1.199

GAVINS POINT - SIOUX CITY
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1898	12	63	220	149	478	252	129	99	71	1571	28	24	16	1541
1899	10	42	194	157	381	300	91	60	46	1349	107	89	58	1535
1900	30	161	577	379	71	101	327	228	177	2305	87	79	50	2267
1901	26	137	524	343	268	508	286	190	147	2645	36	34	20	2519
1902	12	56	315	208	232	77	117	75	58	1240	103	91	60	1404
1903	32	165	631	440	210	139	339	240	180	2630	58	42	28	2504
1904	16	75	266	177	155	327	163	109	81	1497	48	36	26	1479
1905	14	69	246	135	301	307	161	109	61	1513	123	99	65	1690
1906	34	182	645	436	530	498	365	294	196	3457	99	77	50	3396
1907	28	137	480	393	657	694	284	246	145	3290	65	58	38	3225
1908	20	105	379	252	476	629	216	149	113	2500	125	105	69	2638
1909	38	194	708	421	589	736	419	284	210	3898	83	75	48	3805
1910	24	129	539	301	67	26	270	180	137	1879	24	18	12	1727
1911	6	32	111	73	58	26	65	54	44	523	81	71	46	667
1912	24	125	430	313	192	16	260	202	139	1899	73	61	42	1877
1913	22	113	415	268	486	206	228	165	133	2212	42	34	22	2134
1914	12	60	222	157	242	466	127	85	65	1534	101	85	58	1680
1915	32	159	573	438	478	462	345	238	175	3144	83	69	46	3098
1916	24	125	476	311	474	343	260	186	133	2530	46	38	24	2440
1917	14	67	252	222	129	179	133	93	69	1266	26	22	16	1222
1918	10	44	204	145	353	232	93	73	54	1272	36	30	20	1294
1919	10	56	208	129	95	198	111	75	58	1026	87	81	48	1156
1920	26	129	520	292	706	389	258	179	131	2846	73	65	42	2810
1921	22	115	389	244	250	40	238	165	125	1768	16	12	8	1624
1922	4	22	91	69	99	42	54	34	24	475	79	99	48	665
1923	26	131	436	317	244	417	276	206	157	2436	73	56	36	2375
1924	18	93	353	282	89	674	200	133	103	2110	6	4	2	1957
1925	2	6	28	20	32	129	16	10	6	261	12	10	6	277
1926	4	18	67	42	93	71	40	26	20	409	48	42	28	499
1927	14	75	309	198	486	69	157	79	79	1612	32	28	18	1572
1928	10	50	173	109	91	230	123	71	61	996	99	79	63	1159
1929	58	58	1224	621	484	393	192	71	48	3390	34	34	20	3237
1930	14	75	93	77	171	119	32	20	20	709	12	18	-2	649
1931	12	16	20	20	-50	50	61	0	4	161	0	18	-2	149
1932	20	36	280	119	69	119	139	61	56	915	12	4	-2	913
1933	10	10	50	40	20	10	10	18	111	293	8	-38	-6	243
1934	12	22	14	18	-10	65	28	24	14	151	-8	14	8	201
1935	6	8	65	-10	40	-56	36	75	16	194	-2	26	-4	200
1936	-4	-8	371	85	65	24	67	16	54	690	0	-36	50	684
1937	-18	-2	137	216	153	54	131	202	30	917	8	38	10	959
1938	2	67	391	109	151	42	313	127	149	1407	173	58	12	1594
1939	18	8	-6	292	-20	16	161	75	32	819	0	2	-20	598
1940	-6	-2	44	137	-16	58	91	36	14	378	20	34	-48	362
1941	30	46	177	117	56	-95	153	6	34	530	89	97	14	724
1942	6	-18	101	79	226	180	95	87	173	1129	36	125	16	1106
1943	36	79	-250	-101	309	71	145	184	-40	610	-58	10	26	411
1944	2	111	175	204	627	69	920	430	226	2742	145	77	-2	2984
1945	6	85	398	306	212	530	212	95	26	2090	16	16	24	1926
1946	-4	89	417	224	0	8	109	50	54	1003	264	200	12	1423
1947	67	56	20	490	319	214	36	123	44	1845	54	127	-30	1520
1948	30	97	421	589	208	200	240	171	93	2200	135	123	58	2365
1949	8	48	363	450	190	186	220	119	107	2007	19	150	-11	1849
1950	-6	22	463	-89	288	497	97	108	90	1628	85	52	-74	1533
1951	-23	59	308	770	428	611	622	278	327	3443	160	4	34	3578
1952	-64	239	384	1045	630	294	357	107	89	3279	59	43	23	3206
1953	17	44	328	211	368	178	-34	220	41	1498	4	22	-20	1379
1954	21	127	253	103	116	499	137	7	-5	1264	3	26	33	1320
1955	-11	-2	278	-30	-78	-44	-46	-77	-82	-30	-27	-40	20	-139
1956	31	-14	50	56	43	49	48	34	-12	238	8	2	1	296
1957	-34	35	63	44	42	246	186	26	6	625	-21	28	13	676
1958	18	57	58	92	45	22	44	-16	-22	360	-31	19	6	292
1959	4	18	64	77	146	92	22	16	0	433	-20	-8	51	462
1960	5	31	194	1686	327	169	133	168	126	2862	11	20	-7	2863
1961	-3	8	334	94	164	175	107	118	70	1091	41	60	-3	1165
1962	-6	41	264	1682	330	837	546	206	75	4073	44	29	12	4060
1963	39	40	86	13	54	83	43	82	29	554	28	31	-10	518
1964	69	41	61	114	106	73	19	68	78	678	38	52	8	727
1965	58	42	116	501	282	334	206	56	95	1788	120	46	91	1947
1966	31	254	280	185	167	157	66	77	73	1547	66	48	82	1486
1967	4	94	146	90	81	352	156	29	-2	1146	-44	2	19	927
1968	-10	49	84	22	36	32	2	4	15	211	80	21	-97	238
1969	-4	51	118	1664	444	210	314	23	8	2832	-21	-28	77	2856
1970	-36	101	316	252	235	169	29	4	-18	1080	15	37	100	1204
1971	-18	372	357	130	85	355	99	39	30	1601	4	63	36	1552
1972	-8	33	386	154	496	398	197	120	65	1944	20	54	16	1931
1973	131	144	733	303	127	128	205	65	26	1952	44	0	82	1988
1974	51	84	109	28	25	142	37	-8	-10	584	-52	39	96	541
1975	3	33	38	46	122	137	25	-38	31	480	43	40	67	547
1976	31	162	222	152	132	95	79	59	79	1161	26	2	-12	1027
1977	11	91	208	142	93	43	69	74	58	805	54	115	55	1013
1978	40	54	525	611	307	254	277	208	160	2660	163	181	13	2793
1979	50	57	594	691	551	394	371	412	302	3779	231	343	258	4254
1980	136	164	221	186	179	194	130	177	143	2362	162	199	71	1962
1981	112	81	63	32	27	89	48	47	23	954	33	65	96	716
1982	-4	149	280	182	227	217	188	88	95	1616	266	402	393	2483
1983	295	283	981	903	477	633	660	260	174	5727	171	172	-17	4992
1984	144	190	431	1706	950	1997	879	393	232	7248	378	248	123	7671
1985	76	75	609	611	353	250	119	113	213	3168	168	85	121	2793
1986	116	23	696	1255	1127	580	291	216	603	5281	481	254	196	5838
1987	110	86	411	603	230	127	154	80	56	2788	35	10	122	2024
1988	64	129	206	114	118	67	54	23	60	1002	-9	61	27	914
1989	94	15	185	151	72	33	55	35	37	756	13	33	-17	706
1990	8	51	61	23	109	194	115	64	38	692	33	53	-72	677
1991	6	8	38	66	132	285	103	67	63	782	21	47	65	901
1992	99	165	258	146	125	138	304	293	270	1931	270	195	126	2389
1993	97	73	569	1129	937	1110	2524	853	473	8356	312	239	170	8486
1994	157	381	930	588	527	598	336	214	142	4594	82	97	90	4142
1995	89	178	329	1184	1775	1196	517	495	249	6281	464	369	149	6994

GAVINS POINT - SIOUX CITY
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1996	90	273	304	462	506	904	540	298	214	4573	153	221	177	4142
1997	166	134	783	2376	1235	649	360	324	165	6743	184	155	116	6647
1998	198	121	186	584	347	349	208	144	61	2653	123	351	328	3000
1999	134	178	359	638	589	747	658	221	209	4535	170	117	174	4194
2000	199	98	145	183	340	220	131	91	97	1965	76	120	68	1768
2001	83	115	436	2060	1242	690	464	267	201	5822	154	189	152	6053
2002	120	170	252	344	343	177	121	198	154	2374	110	20	43	2052
2003	78	136	205	170	257	258	237	47	104	1665	35	78	111	1716
2004	53	145	371	191	341	503	210	134	175	2347	130	101	124	2478
2005	178	112	144	265	367	712	288	213	211	2845	255	205	310	3260
2006	195	289	252	771	485	297	130	142	163	3494	105	112	152	3093
2007	148	212	932	649	937	513	267	224	127	4378	269	142	187	4607
2008	208	247	449	418	521	972	386	189	125	4113	202	113	135	3965
2009	237	165	425	539	677	493	560	245	105	3896	78	76	52	3652
2010	262	188	1675	1211	738	1580	1460	1272	831	9423	830	295	215	10557
2011	310	571	1224	2104	1642	1159	1389	631	297	10667	318	323	282	10250
2012	236	187	333	236	627	301	98	78	-3	3016	-17	-27	50	2099
2013	49	120	211	243	453	528	333	241	159	2343	171	107	127	2742
N	116	116	116	116	116	116	116	116	116	116	116	116	116	116
MEAN	50	101	326	385	323	317	244	148	107	2226	89	81	58	2229
STDEV	72	89	277	476	324	333	318	169	119	1916	120	88	79	1952
SKEW	1.670	1.976	1.800	2.267	2.012	2.137	4.308	3.551	2.928	1.899	2.911	1.658	1.693	2.030

Summation Above Sioux City
RUNOFF IN 1000 ACRE-FEET
ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1898	499	844	2516	2861	4659	7954	3964	1140	1054	27691	998	1001	598	28088
1899	603	697	2837	4892	3779	7876	6344	1502	1166	32293	999	1098	598	32391
1900	600	1014	3588	2693	3774	5013	2014	830	1074	23295	1096	900	598	23194
1901	599	798	2853	1938	5110	5614	2579	920	1692	24697	1100	798	597	24598
1902	603	824	3146	1517	2896	4607	2386	921	1306	20701	1102	1001	599	20908
1903	599	1042	2803	2571	2360	5098	3505	1507	2012	24199	1401	1000	700	24598
1904	697	997	2359	2716	3721	6720	3540	1318	1224	26393	901	799	499	25491
1905	502	835	2544	1384	2084	5191	3157	1075	827	19798	700	797	700	19796
1906	599	859	2893	2675	3853	6732	3165	1682	2452	27107	1599	1296	908	28713
1907	900	953	2830	2255	3984	7913	7419	2536	1562	34155	1797	1603	899	34651
1908	802	1051	2862	2458	3597	9573	5191	1877	1277	32987	1301	1396	1298	32683
1909	899	1227	3068	2394	4179	10317	5730	2096	1888	35793	1295	1100	700	34893
1910	697	1032	3738	3107	4045	4134	2185	1157	898	24088	901	797	499	23190
1911	502	697	1907	1610	2072	5973	2919	1522	2101	21500	1600	999	799	22701
1912	802	883	3005	4311	3712	6087	4646	2255	2398	31497	1998	1796	1704	33597
1913	1101	823	2001	2980	3799	7156	3479	1961	1896	30694	1503	1500	1297	29496
1914	898	925	2621	2518	4142	7032	2501	1063	1499	27499	1598	1997	1103	27897
1915	1099	1256	3292	2957	3445	6653	4653	2142	2498	32693	2200	1600	999	32794
1916	799	1220	4830	2719	3588	7081	5906	1951	1301	34194	1400	1403	799	32997
1917	801	985	3062	4424	4437	7743	5298	1452	1495	33299	1398	1400	800	33295
1918	799	986	3358	2983	3198	6968	3314	1495	1301	28000	701	800	398	26301
1919	1195	942	2226	2180	2059	1908	902	481	403	14195	596	500	499	13891
1920	499	1054	3843	2934	4796	7165	4016	1394	1000	28296	798	799	901	29199
1921	601	967	2874	2211	3199	6793	2699	958	905	23705	499	598	497	22801
1922	502	971	2813	2290	3767	6804	2642	1111	901	23395	799	999	502	24101
1923	502	950	2679	3021	3184	5660	5103	1729	1598	26726	3196	2199	1401	31222
1924	998	1583	2948	4113	3815	5385	2672	1083	1001	30394	1300	1399	801	27098
1925	804	1474	2623	2775	3446	6759	3433	1269	898	26981	1200	1099	699	26479
1926	700	1182	2096	2198	3758	3518	2473	1172	1699	21794	1500	1103	601	22000
1927	597	1183	3995	3753	5620	9325	4665	2252	2099	36693	1601	1098	800	36988
1928	796	1170	3599	2384	5163	6294	5091	1608	1302	30906	1099	1120	657	30283
1929	630	694	4799	3068	3440	5235	2823	891	800	25256	997	795	481	24653
1930	552	1203	3033	2703	2487	2687	1225	1315	970	18448	1100	729	448	18452
1931	559	1000	1065	1119	1199	2098	872	674	531	11394	650	498	436	10701
1932	421	597	1785	2457	2969	5500	2013	1283	831	19440	795	521	291	19463
1933	611	499	2426	1474	3503	4342	1348	953	1090	17853	760	797	363	18166
1934	736	670	1686	1398	1598	1831	788	506	453	11586	583	621	294	11164
1935	336	695	1037	1479	1627	4056	2396	735	583	14442	559	431	389	14323
1936	429	420	3005	1872	2092	2309	984	703	611	13804	710	662	542	14339
1937	363	367	1377	1647	1426	3929	2184	887	542	14636	726	477	390	14315
1938	519	555	2656	1331	2274	5370	4010	948	1071	20327	977	621	320	20652
1939	764	446	4517	998	2338	3412	1430	755	601	17179	741	678	591	17271
1940	388	527	955	1819	1787	2449	1018	497	565	12015	950	482	664	12101
1941	583	623	1211	1632	1406	3830	1341	929	1456	15107	1714	1190	799	16714
1942	617	684	1950	2404	5940	6301	2516	1170	926	26211	934	991	672	25105
1943	782	1787	3475	5300	2906	7783	4326	1600	906	31462	949	1134	446	31394
1944	732	849	2085	4773	3007	8162	4659	1800	1124	29720	1067	1142	326	29726
1945	679	1346	4444	1779	1795	4744	3153	1404	855	22734	1043	839	648	22729
1946	901	1022	2569	1683	2098	3784	2586	870	1195	19238	1714	1199	734	20355
1947	871	1216	3952	4008	3786	6465	2977	1341	986	29249	1297	868	512	28279
1948	816	962	3187	4158	3529	7571	3552	1489	744	28685	1051	1030	264	28353
1949	624	719	4579	4631	3038	3583	1787	735	781	22822	1062	1254	396	23189
1950	492	745	2795	7581	3223	4861	3486	1751	1283	28929	1542	803	807	29369
1951	938	860	2198	5100	3441	5053	3496	2238	2130	28606	1825	1099	478	28856
1952	774	1586	2667	13204	5003	4185	2635	1431	861	35548	845	772	469	34232
1953	774	968	2768	1722	3160	8540	2583	1502	782	24885	916	1044	608	25367
1954	608	1508	1673	2230	2251	3584	2540	1250	936	19148	956	1074	613	19223
1955	335	580	1966	2565	2242	3256	2235	754	528	17104	767	352	830	16410
1956	901	679	2270	2162	2354	4781	1937	1120	754	18907	783	1092	585	19418
1957	437	708	1784	1695	3148	5832	3337	908	988	21297	1078	1280	884	22079
1958	540	693	1657	2159	2093	3677	2280	837	664	17842	856	835	680	16971
1959	652	671	3816	1789	1964	3691	2438	779	791	18962	1195	821	1410	20017
1960	607	1000	4116	5108	2331	2588	1003	854	717	21750	723	740	333	20120
1961	674	824	1606	675	1091	2817	869	624	887	11863	1018	1122	225	12432
1962	605	1231	2100	4053	4045	7722	5020	1779	1022	29942	1159	975	622	30333
1963	563	1571	2126	1323	2222	5680	2654	992	1002	20889	967	707	506	20313
1964	837	869	1015	1661	3194	7248	4381	1034	1090	23509	917	812	647	23705
1965	1143	1147	1458	4323	4715	6469	5692	1898	1573	30794	1701	1236	1118	32473
1966	709	1170	4370	2302	2066	2524	1936	981	958	21071	876	997	796	19685
1967	642	1233	2764	2530	3376	9794	5349	1266	1205	30828	1120	1288	459	31026
1968	941	1142	2491	1683	1808	5689	3299	1665	1708	32393	1405	1351	562	23744
1969	970	997	3518	6786	3842	3657	5110	1306	935	30439	1038	1158	805	30122
1970	501	1168	1863	2804	5253	6376	3730	1186	1151	27033	1269	1133	878	27312
1971	761	2708	4247	3722	3646	6799	4082	1495	1511	32251	1870	1435	858	33134
1972	799	1318	7352	2131	4341	6611	3088	2071	1417	33291	1390	1596	848	32962
1973	1309	1340	3224	1924	3159	3713	2176	1125	1601	23405	1410	1096	1063	23140
1974	1092	1368	1766	2188	2780	5915	3893	1512	1210	25293	992	1200	1093	25009
1975	459	722	1853	4116	7013	6931	6949	2141	1305	34774	1414	1235	1401	35539
1976	1068	1914	2769	2356	4194	5573	3568	1775	1381	28648	1197	1030	862	27687
1977	592	1127	1998	1783	2072	2381	1157	809	1266	16274	1267	763	866	16080
1978	671	887	7204	6793	6043	6026	5364	2021	2194	40098	1420	963	1048	40634
1979	788	879	4655	6371	3871	4182	2685	1557	1415	29834	870	1249	957	29479
1980	490	916	1770	1816	2327	4058	1908	899	1075	18335	1482	1242	704	18687
1981	1137	945	1392	841	2629	5542	2126	1080	531	19651	1039	1203	794	19259
1982	399	1623	3187	4262	4392	6151	5152	1841	1247	31290	2265	1576	1503	33598
1983	1387	1749	3477	2476	3145	4712	4171	1440	922	28823	1463	1411	449	26802
1984	1318	1869	2467	3845	4210	7267	3819	1619	909	30646	1521	1251	729	30824
1985	1079	914	3170	2388	1996	2214	1023	1249	1156	18690	1657	941	1	

Summation Above Sioux City
 RUNOFF IN 1000 ACRE-FEET
 ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WAT-YR TOTAL	OCT	NOV	DEC	CAL-YR TOTAL
1996	1004	3461	4245	3947	4269	8277	3891	1331	1237	36370	1245	1373	1312	35592
1997	1485	2903	7244	8616	5975	9580	5150	2626	1498	49007	1236	1288	1436	49037
1998	719	1723	2010	2701	2485	4275	4758	1939	1017	25587	1865	1758	1162	26412
1999	1298	1704	3571	2868	4691	6515	4379	1531	1446	32788	1161	950	1061	31175
2000	736	1143	1849	1672	2097	3272	2064	672	565	17242	915	906	599	16490
2001	1114	867	3705	4590	2820	3084	2466	1066	612	22744	673	787	753	22537
2002	731	868	1152	1760	1556	3662	2201	1022	758	15923	727	712	588	15737
2003	407	1004	2819	1691	2299	4093	2026	707	508	17581	635	480	776	17445
2004	453	910	2545	1400	1317	2982	2160	1012	964	15634	970	918	531	16162
2005	724	1121	1257	1240	2730	5228	3242	1066	707	19734	1118	941	703	20077
2006	1384	888	1504	2724	2579	3605	1573	815	607	18441	953	865	674	18171
2007	635	1097	3160	2171	3591	4627	1678	1143	507	21101	1118	697	688	21112
2008	593	945	1734	1529	2856	8500	5014	1482	1049	26205	1261	1082	586	26631
2009	1271	1760	4463	6088	3764	5648	4430	1848	1231	33432	1177	1025	711	33416
2010	1301	1129	5840	3784	3517	8588	5920	2688	2097	37777	1762	1011	1039	38676
2011	1268	2335	6419	7693	9228	14840	10200	3392	1492	60679	1564	1235	1338	61004
2012	954	1680	2244	1759	3041	3960	2289	1002	383	21449	638	868	727	19545
2013	729	1149	1583	2193	2856	6504	2769	1563	1012	22591	2698	980	704	24740
N	116	116	116	116	116	116	116	116	116	116	116	116	116	116
MEAN	763	1098	2926	2937	3315	5451	3272	1342	1142	25213	1194	1045	746	25231
STDEV	262	474	1346	1802	1338	2189	1662	587	485	7895	458	328	310	8007
SKREW	0.747	2.109	1.268	2.434	1.221	0.756	1.075	1.496	0.944	0.922	1.423	0.587	0.790	0.929