Missouri River Main Stem Reservoirs

Releases Needed to Support Navigation

RCC Technical Report 2000-A

INTRODUCTION

Study Purpose

The purpose of this report is to document the methodology, assumptions, data, and results of the analysis of main stem reservoir releases needed to support navigation requirements on the Missouri River. It also provides background information on navigation flow targets, and an analysis of how often each downstream key location serves as the control point for the navigation target. This report was prepared by the Reservoir Control Center, Northwestern Division - Missouri River Region, U.S. Army Corps of Engineers. It is published as RCC Technical Report 2000-A.

Missouri River reservoir regulation studies are conducted in the Reservoir Control Center to provide equitable support for authorized purposes including flood control, hydroelectric power, navigation, irrigation, water quality and water supply, recreation, and fish and wildlife including protection of threatened and endangered species.

The regulation of the main stem system considers in-reservoir needs, river flows within the open river reaches between the reservoirs, and downstream river flow requirements. In order to conduct intrasystem operation studies, reasonable estimates of the system (Gavins Point Dam) release requirements must be made, considering the interdependent nature of project releases, flows downstream from individual projects, and reservoir storages.

Although system regulation studies are frequently updated, the greatest effort is made in the late summer and fall during the development of the Annual Operating Plan (AOP) for the upcoming year. Five levels of runoff are considered in the development of the AOP. Assumptions are made regarding the release requirements for navigation support, which in turn affects the intrasystem regulation.

Background Information

Releases to support Missouri River navigation requirements are made from Gavins Point Dam located at river mile 811.1 near Yankton, South Dakota. The Missouri River navigation channel extends for 734 miles from near Sioux City, Iowa (river mile 732.3), to the mouth near St. Louis, Missouri. Construction of the navigation works was declared complete in September 1981 although maintenance and corrective work will be required as the river continues to form its channel in response to changing flow conditions.

Navigation on the Missouri River is limited to the normal ice-free season with a full length season extending from April 1 to December 1 at the mouth. To permit a viable navigation industry during the ice-free months, it is desirable to maintain navigable flows throughout this 8-month period. During past navigation seasons in years of adequate water supply, 10-day extensions either at the beginning or end of this normal season have been scheduled, downstream river ice conditions permitting. Normally, ice problems would preclude an early opening with the extension at the beginning of the navigation season. During the period of 1954 through 1999, an early opening has only occurred once, in 1970.

During drought and normal runoff years, navigation support for the 734-river mile navigation channel is dependent upon system releases. During flood periods, system releases are generally geared to evacuating floodwaters at rates that exceed navigation targets although releases may be temporarily reduced to meet downstream flood targets.

Main stem reservoir releases are scheduled to provide adequate flows for navigation according to established minimum and full service flow targets at Sioux City, Omaha, Nebraska City, and Kansas City. The target flows increase in a downstream direction because of the increased flow requirements needed to maintain similar flow depths with naturally increasing channel dimensions.

The assignment of target flows is based upon available water supply that, when combined with winter releases needed to ensure water supply requirements and winter hydropower demand, obligates all of the available water supply during a normal year. These target flows may need to be evaluated and adjusted periodically to ensure compatibility between available water supply and current navigation channel conditions.

Operating experience during the 1960's demonstrated that flows of 25,000 cfs at Sioux City and Omaha, 31,000 cfs at Nebraska City, and 35,000 cfs at Kansas City were the minimum flows that permitted navigation. During periods that require minimum flow levels, experience has indicated that it is necessary to reduce drafts by 1 foot and restrict tow sizes to reduce the number of lost time events and groundings. With the present level of streamflow depletions, inflows to the reservoir system are sufficient to support the minimum flow levels or higher for the full 8-month navigation season in 87 years of the 98-year period from 1898 - 1996.

When system storage reserves are adequate, it is desirable to maintain navigation flows above the minimum levels. This allows barge loadings to greater depths than would be possible with minimum flows. In addition, the increased releases which provide the improved service to navigation will reduce the probability of having to release at rates which provide little or no benefit to navigation or to hydropower generation during flood storage evacuation. Based upon numerous operation studies and consideration of the effects the flow levels will have on navigation, target flow levels 6,000 cfs greater than the minimum flows specified above have been selected as the “full service” level for navigation. With the present level of streamflow depletions, inflows to the reservoir system are sufficient to support full service flows for the

8-month navigation season in 39 years of the 98-year period from 1898 - 1996.

Operating experience has demonstrated that full service flow rates of 31,000 cfs at Sioux City and Omaha, 37,000 cfs at Nebraska City, and 41,000 cfs at Kansas City will be adequate to maintain the designed 9-by-300 foot channel with a minimum of groundings and little or no dredging. Slightly greater flows are required at the mouth of the Missouri (approximately 45,000 cfs) but tributary flows below Kansas City are usually adequate to provide the needed incremental flows. Although a 9-foot channel is not provided 100 percent of the time, the problem areas are generally transient and short term in nature. Increased flows would provide some relief, but experience has shown that regardless of the support provided, some groundings do occur.

Average monthly system releases needed to support navigation target flows were last updated in 1979. At that time, flow records for the period from 1954 through 1979 were analyzed. The values presented in Table I below are reprinted from the "Missouri River Main Stem Reservoir, System Description and Operation," dated Fall 1998. The monthly values represent the average Gavins Point release for the period 1954 – 1979 needed to meet both minimum and full service navigation flow targets.

Table I
Gavins Point Releases Needed to Meet
Navigation Requirements
1954 – 1979
(Discharges in 1,000 cfs)

Service Level	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Average
Minimum	22.8	22.8	24.8	24.0	26.7	28.2	28.5	27.5	27.5	25.9
Full	28.8	28.8	30.8	30.0	32.7	34.2	34.5	33.5	33.5	31.9

Past AOP studies did not recognize the difference in release requirements resulting from above or below normal runoff upstream and downstream from the reservoir system

The purpose of this reevaluation study was to update the release rates needed to support navigation. Additionally, a second goal was to determine if lower or higher runoff rates upstream from the reservoir system were coincident with above or below average releases needed to meet navigation flow targets. Experience has shown that during years of above normal runoff upstream from the reservoir system, runoff downstream from the system is also generally above normal, thus reducing system release requirements. During years of below normal runoff upstream from the system, release requirements for navigation support have generally been higher than normal.

DETERMINATION OF NAVIGATION RELEASES

Study History

In 1996 and 1997 two analyses were undertaken to estimate the releases required to support navigation requirements. The 1996 study looked at four methods of estimating release requirements. The methods used include the Reservoir Control Center's Forecasted Ungaged Inflow (FUI) model, the monthly Long Range Study model, and two analyses of observed USGS flow data, with and without lagging to account for travel times. The 1997 study looked at three methods, including FUI, the monthly Long Range Study model and the daily Long Range Study model. Although both studies were completed and draft reports produced, the results were not implemented. In 1999 both studies were thoroughly reviewed and a decision was made to implement new navigation release requirements in the development of the 1999-2000 AOP. This report documents the alternative chosen for implementation.

The alternative chosen for implementation was the Daily Long Range Study (DLRS) model. The DLRS model is the newest tool available to the Reservoir Control Center to perform operational studies. Because the model was recently developed, its accuracy was confirmed by comparing the study results with the full service flow requirements calculated from actual operations for the period 1986 through 1996. Only minor differences were noted.

Long Range Study Models

The monthly Long Range Study (LRS) model was developed when computers were in their infancy and was enhanced as the length of flow records and computer capabilities increased. The LRS model simulates reservoir operation for the period of record, dating back to 1898. The existence of the six main stem reservoirs is modeled for the entire period of record. Operating criteria can be varied in the model so that numerous scenarios can be evaluated to determine the effects they have on the authorized purposes. The monthly LRS model was used to develop and evaluate the regulation criteria contained in the current Missouri River Main Stem Reservoir System Master Manual (Master Manual) dated 1979.

A review of the current Master Manual and the regulation criteria it contains began in October 1989. During the study it was determined that the monthly time step model did not accurately reflect the system operation during several critical periods and therefore a new a daily time step model was developed. The Daily Long Range Study (DLRS) model, developed for the Master Manual Review, was used to determine the release requirements for navigation flow support.

Data

Although flow records in the Missouri River basin date as far back as 1898, it was felt that the flow record since the construction of the main stem reservoirs was more accurate than the earlier portion of the flow record. With the exception of Fort Peck, which was built in the 1930's, the main stem projects were constructed during the 1950's. Therefore, the 47-year period from 1950 through 1996 was used in the analysis. Flows were adjusted to the 1949 level of depletions.

Methodology

In the DLRS model runs completed for this study, the regulation criteria were adjusted to provide full service navigation flows and an 8-month navigation season in all years. Criteria were established so that flood control, water supply and other needs would not conflict with navigation. Knowing the observed tributary inflows downstream, the model adjusted Gavins Point releases to meet the full service navigation flow targets without regard to other project purposes. In order to accomplish this, several periods were used and numerous runs were made to preclude the need to evacuate floodwater from the system at greater than full service navigation flows.

Model Verification

Because the model was relatively new, it was necessary to confirm its accuracy. This was accomplished by comparing the study results with the full service flows calculated for the 11-year period from 1986 through 1996. Monthly averages were compared between the results of the actual operations adjusted to provide full service flows and the DLRS model outputs. Only minor differences were noted.

There were times during extreme events, like the flood in 1995, which showed differences between the two analysis of more than 3,000 cfs for two consecutive months, however most monthly differences were less than 1,000 cfs. On an annual basis, the greatest difference was 1,300 cfs, that occurring in 1996 due to the extremely large annual runoff. The average difference for the entire 11-year period was only 100 cfs. Therefore, it was concluded that the model would be a good tool for this analysis with greater precision than had been expected.

Study Results

Plate 1 presents the release requirements to support navigation determined using the DLRS model as described above. Monthly values in 1000 cfs are tabulated for the years 1950 through 1996 for each month April through November, as well as the average release for the navigation year. Also shown is the total annual runoff upstream from Sioux City, Iowa City for each year in million acre-feet (MAF).

The 1979 analysis did not differentiate the navigation release requirements based on whether the upper basin was experiencing a wet, dry or normal year. However, past experience operating the main stem system indicated that the release requirement for navigation support was less in years of high runoff in the upper basin, and more in years of below normal upper basin runoff, i.e. a significant correlation exists between upper and lower basin runoff.

To verify this correlation, the average Gavins Point release for the season was compared graphically with the total runoff upstream from Sioux City. Although there is a great deal of scatter, Figure 1 indicates that generally during years of below normal upstream runoff, the release requirements for navigation support are increased and vice versa. Sufficient correlation exists to conclude that regulation studies prepared for the Annual Operating Plan for differing levels of runoff should acknowledge the changed navigation release needs. For AOP study purposes this is most significant during low runoff years because flood control evacuation becomes the driving factor in determining Gavins Point releases during high runoff years. Therefore, for the purposes of the AOP studies, two navigation release requirement levels were determined, the first for median runoff, and the second for lower quartile/lower decile runoff.

Figure 1
Navigation Release Requirement
vs Annual Runoff Above SIoux City

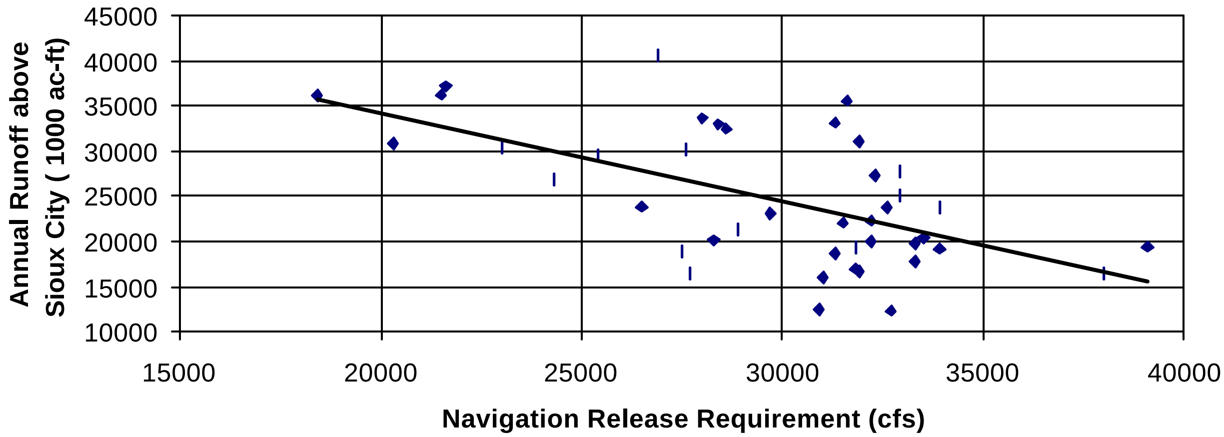

Plate 2 presents the monthly and annual release requirements sorted based upon total annual runoff upstream from Sioux City. The sorted table was divided into three parts representing the 15 years when the total runoff compared with lower decile and quartile runoffs, the 15 years when runoff approached median runoff, and the 11 years when total runoff resembles upper quartile/upper decile runoff conditions. The two driest years (1988 and 1961) were excluded from the analysis because it was felt that these extreme events would unduly influence the averages computed for the below normal runoff scenarios. Since releases in wet years are generally based on flood control evacuation, the upper quartile/upper decile evaluation with the 4 wettest years excluded (1993, 1986, 1995 and 1978) is provided for information purposes only.

The average monthly release requirement was computed for the median and lower decile/lower quartile runoff conditions and the results for full service navigation are summarized in Table II below. Minimum service flow requirements are 6,000 cfs less than the full service flows presented in the table.

Median release requirements are appropriate for use during high runoff years when flood evacuation is not controlling Gavins Point releases. The greatest difference between the median and lower runoff conditions is during the high spring runoff months, while the differences are smaller during the summer and fall months. These navigation release requirements were used for the first time in the development of the 1999-2000 AOP.

Table 2
Gavins Point Release Requirements
For Full Service Navigation
1950 – 1996
(Discharges in 1,000 cfs)

Runoff Scenario	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Average
Median, Upper Quartile, Upper Decile	26.7	28.0	27.9	31.6	33.2	32.6	32.0	31.1	30.4
Lower Quartile, Lower Decile	29.8	31.3	31.2	34.3	34.0	33.5	33.1	31.2	32.3

The values shown above, which result in an average seasonal release of 30,400 cfs to support full service navigation requirements for the median runoff scenario and 32,300 cfs in the lower quartile/lower decile scenario, are recommended for use in future regulation studies. These values are about 5 percent less than the 1979 values for median runoff and about 1 percent higher for lower quartile/lower decile runoff.

NAVIGATION TARGET LOCATION

An additional analysis was completed to compute the percent of time each downstream location becomes the control point for the navigation target. USGS daily stream flow data for the period of 1954-1995 were lagged for water travel time and used to compute the percent of time that each station controlled the navigation target during each month of the April through November navigation season. Results of this analysis are shown on Figure 2.

As shown on Figure 2, the Sioux City location is the primary control point for navigation releases, controlling about 70 percent of the time during the spring and early summer. That percentage drops to about 30 percent of the time during the late summer months as the control point shifts downstream to Nebraska City and to Kansas City.

The Omaha target rarely controls the navigation releases but can during dry periods when reach losses between Sioux City and Omaha exceed tributary inflows for that reach and Platte River and other tributary flows meet the additional increments at Nebraska City and Kansas City.

Nebraska City is the second most frequent navigation target control point ranging from about 10 percent of the time in the early spring to 40 percent of the time during the late summer.

Kansas City controls the navigation target about 10 percent of the time in the early spring to about 30 percent of the time in the late summer and fall months.

Although rare, incremental tributary flows would be sufficient to meet all navigation targets without supplemental releases about 4 percent of the time in the early spring and about 1 percent of the time in the early summer months.

For the average 8-month navigation season, Sioux City controls the navigation target 53 percent of the time, Omaha controls 2 percent of the time, Nebraska City 25 percent, Kansas City 19 percent, and incremental flows are sufficient to meet all targets about 1 percent of the time resulting in a minimum release from Gavins Point of 6,000 cfs. These values are based on navigation target only, and do not consider the effects of flood control targets and system releases to evacuate flood control storage from the main stem reservoir system.

Figure 2
Location of Navigation Target

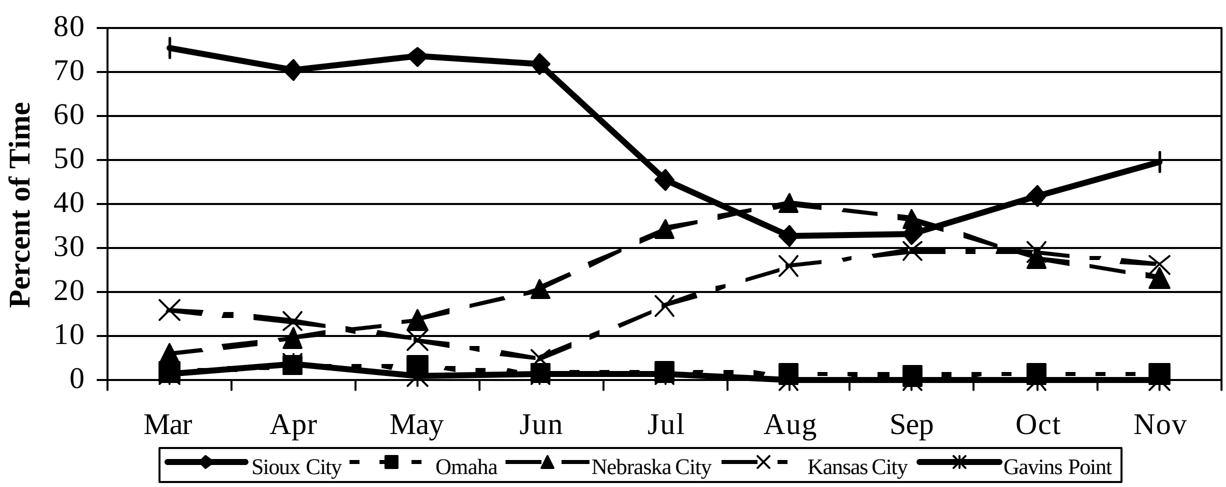

Plate 1

Gavins Point Release Requirements

for Full Service Navigation

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Ave	Runoff
					Flows in 1000 cfs					MAF
1950	32.9	27.7	29.3	33.3	32.9	33.6	33.0	35.0	32.2	29.4
1951	20.2	24.3	21.8	23.0	29.2	26.0	28.6	30.6	25.5	28.9
1952	20.7	22.6	29.5	31.8	34.0	33.9	35.9	33.5	30.2	34.2
1953	29.7	26.7	29.8	41.3	38.0	40.7	39.0	37.2	35.3	25.4
1954	33.7	31.5	23.8	39.0	37.4	38.6	33.5	33.6	33.9	19.2
1955	35.6	39.7	36.1	39.6	40.5	39.2	37.9	35.2	38.0	16.4
1956	37.9	38.9	40.5	40.1	39.8	40.5	39.3	35.8	39.1	19.4
1957	34.6	32.0	26.3	30.7	34.7	32.5	31.9	29.1	31.5	22.1
1958	29.4	31.2	32.6	31.0	33.5	33.2	34.4	29.4	31.8	17.0
1959	30.3	28.7	31.4	36.2	34.8	34.9	32.5	28.7	32.2	20.0
1960	14.5	25.7	28.9	33.1	31.6	31.1	32.8	28.9	28.3	20.1
1961	29.8	28.8	28.8	34.4	34.4	32.5	30.4	27.8	30.9	12.4
1962	10.6	20.3	12.7	22.3	29.8	29.9	30.2	28.5	23.0	30.3
1963	31.1	31.5	31.9	37.4	36.8	33.3	34.5	31.4	33.5	20.3
1964	30.9	30.6	31.1	35.1	36.5	30.9	34.3	31.2	32.6	23.7
1965	22.8	27.3	25.9	31.0	35.0	29.4	28.3	29.2	28.6	32.5
1966	27.9	30.7	31.7	38.5	34.5	33.6	34.8	34.5	33.3	19.7
1967	32.4	34.9	25.3	30.1	34.4	34.0	32.1	31.7	31.9	31.0
1968	32.6	34.4	34.5	37.7	35.8	34.3	31.3	30.7	33.9	23.7
1969	11.9	23.4	27.9	27.2	34.5	32.9	31.1	32.1	27.6	30.1
1970	27.1	28.8	30.6	37.6	38.5	34.4	31.4	29.9	32.3	27.3
1971	28.2	29.3	24.1	30.6	36.8	37.5	34.1	29.7	31.3	33.1
1972	29.6	22.4	25.3	30.6	31.0	30.2	30.8	27.5	28.4	33.0
1973	26.1	28.3	29.4	30.3	33.8	30.9	29.1	29.8	29.7	23.1
1974	30.0	29.9	29.9	36.3	34.8	35.7	34.3	32.4	32.9	25.0
1975	29.2	29.6	28.8	34.4	33.9	32.0	33.6	31.0	31.6	35.5
1976	27.6	28.7	31.2	34.2	36.6	36.8	33.9	34.2	32.9	27.7
1977	30.0	30.9	31.4	33.5	31.8	31.1	30.4	28.9	31.0	16.1
1978	19.3	25.4	26.8	25.4	28.8	30.1	29.7	29.5	26.9	40.6
1979	19.8	22.5	25.0	26.8	26.7	27.8	29.4	25.3	25.4	29.5
1980	27.5	28.4	28.3	33.7	33.4	34.0	33.0	32.2	31.3	18.7
1981	33.1	32.1	31.3	33.1	31.0	32.6	32.0	29.2	31.8	19.3
1982	28.1	27.8	28.2	28.6	30.0	29.9	26.5	25.1	28.0	33.6
1983	16.0	23.7	21.3	21.6	26.9	28.4	28.3	28.3	24.3	26.8
1984	9.8	16.0	13.7	18.3	25.6	27.4	25.0	26.8	20.3	30.8
1985	20.9	25.8	27.2	30.4	29.9	27.8	28.4	29.3	27.5	18.8
1986	10.3	13.6	21.6	27.0	28.1	21.1	23.2	26.8	21.5	36.2
1987	20.6	29.6	29.4	29.1	30.5	30.4	30.7	30.6	28.9	21.3
1988	29.6	30.0	33.0	33.0	35.6	35.0	33.2	31.9	32.7	12.4
1989	32.5	35.2	34.4	32.1	36.1	31.7	33.1	31.1	33.3	17.7
1990	33.0	30.5	29.3	30.8	31.9	35.1	33.5	31.2	31.9	16.7
1991	30.7	29.8	26.9	31.0	35.4	37.4	34.5	31.7	32.2	22.3
1992	29.0	29.3	29.0	26.6	26.8	26.5	26.6	27.8	27.7	16.4
1993	14.7	16.9	13.4	7.3	17.3	23.5	27.5	26.8	18.4	36.2
1994	21.8	23.5	22.2	26.5	28.3	29.8	29.6	30.2	26.5	23.9

1995	16.0	11.1	17.6	22.9	25.3	28.4	24.9	26.6	21.6	37.2
1996	24.8	24.7	19.7	25.0	31.6	28.2	28.9	27.8	26.3	35.6
47-year Average	25.8	27.5	27.4	30.8	32.6	32.1	31.5	30.3	29.8	25.3
Maximum	37.9	39.7	40.5	41.3	40.5	40.7	39.3	37.2	39.1	40.6
Minimum	9.8	11.1	12.7	7.3	17.3	21.1	23.2	25.1	18.4	12.4

Plate 2
Gavins Point Release Requirements
for Full Service Navigation
Based on Upstream Runoff Conditions

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Ave	Runoff
					Flows in 1000 cfs					**MAF**
1988	29.6	30.0	33.0	33.0	35.6	35.0	33.2	31.9	32.7	12.4
1961	29.8	28.8	28.8	34.4	34.4	32.5	30.4	27.8	30.9	12.4
<u>Lower Decile, Lower Quartile</u>										
1977	30.0	30.9	31.4	33.5	31.8	31.1	30.4	28.9	31.0	16.1
1955	35.6	39.7	36.1	39.6	40.5	39.2	37.9	35.2	38.0	16.4
1992	29.0	29.3	29.0	26.6	26.8	26.5	26.6	27.8	27.7	16.4
1990	33.0	30.5	29.3	30.8	31.9	35.1	33.5	31.2	31.9	16.7
1958	29.4	31.2	32.6	31.0	33.5	33.2	34.4	29.4	31.8	17.0
1989	32.5	35.2	34.4	32.1	36.1	31.7	33.1	31.1	33.3	17.7
1980	27.5	28.4	28.3	33.7	33.4	34.0	33.0	32.2	31.3	18.7
1985	20.9	25.8	27.2	30.4	29.9	27.8	28.4	30.0	27.6	18.8
1954	33.7	31.5	23.8	39.0	37.4	38.6	33.5	33.6	33.9	19.2
1981	33.1	32.1	31.3	33.1	31.0	32.6	32.0	29.2	31.8	19.3
1956	37.9	38.9	40.5	40.1	39.8	40.5	39.3	35.8	39.1	19.4
1966	27.9	30.7	31.7	38.5	34.5	33.6	34.8	34.5	33.3	19.7
1959	30.3	28.7	31.4	36.2	34.8	34.9	32.5	28.7	32.2	20.0
1960	14.5	25.7	28.9	33.1	31.6	31.1	32.8	28.9	28.3	20.1
1963	31.1	31.5	31.9	37.4	36.8	33.3	34.5	31.4	33.5	20.3
Average	29.8	31.3	31.2	34.3	34.0	33.5	33.1	31.2	32.3	18.4
Max	37.9	39.7	40.5	40.1	40.5	40.5	39.3	35.8	39.1	20.3
Min	14.5	25.7	23.8	26.6	26.8	26.5	26.6	27.8	27.6	16.1
<u>Near Median</u>										
1987	20.6	29.6	29.4	29.1	30.5	30.4	30.7	30.6	28.9	21.3
1957	34.6	32.0	26.3	30.7	34.7	32.5	31.9	29.1	31.5	22.1
1991	30.7	29.8	26.9	31.0	35.4	37.4	34.5	31.7	32.2	22.3
1973	26.1	28.3	29.4	30.3	33.8	30.9	29.1	29.8	29.7	23.1
1964	30.9	30.6	31.1	35.1	36.5	30.9	34.3	31.2	32.6	23.7
1968	32.6	34.4	34.5	37.7	35.8	34.3	31.3	30.7	33.9	23.7
1994	21.8	23.5	22.2	26.5	28.3	29.8	29.6	30.2	26.5	23.9
1974	30.0	29.9	29.9	36.3	34.8	35.7	34.3	32.4	32.9	25.0

Plate 2
Gavins Point Release Requirements
for Full Service Navigation
Based on Upstream Runoff Conditions

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Ave	Runoff
					Flows in 1000 cfs					MAF
1953	29.7	26.7	29.8	41.3	38.0	40.7	39.0	37.2	35.3	25.4
1983	16.0	23.7	21.3	21.6	26.9	28.4	28.3	28.3	24.3	26.8
1970	27.1	28.8	30.6	37.6	38.5	34.4	31.4	29.9	32.3	27.3
1976	27.6	28.7	31.2	34.2	36.6	36.8	33.9	34.2	32.9	27.7
1951	20.2	24.3	21.8	23.0	29.2	26.0	28.6	30.6	25.5	28.9
1950	32.9	27.7	29.3	33.3	32.9	33.6	33.0	35.0	32.2	29.4
1979	19.8	22.5	25.0	26.8	26.7	27.8	29.4	25.3	25.4	29.5
Average	26.7	28.0	27.9	31.6	33.2	32.6	32.0	31.1	30.4	25.3
Max	34.6	34.4	34.5	41.3	38.5	40.7	39.0	37.2	35.3	29.5
Min	16.0	22.5	21.3	21.6	26.7	26.0	28.3	25.3	24.3	21.3

Upper Quartile - Upper Decile

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Ave	Runoff
1969	11.9	23.4	27.9	27.2	34.5	32.9	31.1	32.1	27.6	30.1
1962	10.6	20.3	12.7	22.3	29.8	29.9	30.2	28.5	23.0	30.3
1984	9.8	16.0	13.7	18.3	25.6	27.4	25.0	26.8	20.3	30.8
1967	32.4	34.9	25.3	30.1	34.4	34.0	32.1	31.7	31.9	31.0
1965	22.8	27.3	25.9	31.0	35.0	29.4	28.3	29.2	28.6	32.5
1972	29.6	22.4	25.3	30.6	31.0	30.2	30.8	27.5	28.4	33.0
1971	28.2	29.3	24.1	30.6	36.8	37.5	34.1	29.7	31.3	33.1
1982	28.1	27.8	28.2	28.6	30.0	29.9	26.5	25.1	28.0	33.6
1952	20.7	22.6	29.5	31.8	34.0	33.9	35.9	33.5	30.2	34.2
1975	29.2	29.6	28.8	34.4	33.9	32.0	33.6	31.0	31.6	35.5
1996	24.8	24.7	19.7	25.0	31.6	28.2	28.9	27.8	26.3	35.6
Average	22.6	25.3	23.7	28.2	32.4	31.4	30.6	29.4	27.9	32.7
Max	32.4	34.9	29.5	34.4	36.8	37.5	35.9	33.5	31.9	35.6
Min	9.8	16.0	12.7	18.3	25.6	27.4	25.0	25.1	20.3	30.1
1993	14.7	16.9	13.4	7.3	17.3	23.5	27.5	26.8	18.4	36.2
1986	10.3	13.6	21.6	27.0	28.1	21.1	23.2	26.8	21.5	36.2
1995	16.0	11.1	17.6	22.9	25.3	28.4	24.9	26.6	21.6	37.2
1978	19.3	25.4	26.8	25.4	28.8	30.1	29.7	29.5	26.9	40.6