Final

TECHNICAL MEMORANDUM

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FROM: John Hake, Parsons ES

DATE: 27 October 1995

RE: Water Balance Contingency Plan

CC: Rich Maurer, Parsons ES
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BACKGROUND

The data presented in this memorandum were generated by the water balance model. The water balance model was used to determine system requirements (storage volume and irrigation area) for alternatives 2 and 3, South and West County agricultural irrigation projects, respectively. A summary description of the Water Balance Model may be found in the Water Balance Model Summary and Results technical memorandum.

Before analyzing the contingency data and plan, it is helpful to review the water balance model's allocation priorities for reclaimed water distribution. The model allocates reclaimed water to irrigation, storage, and river discharge based on priorities programmed into spreadsheet equations. The first priority is irrigation and the model attempts to fulfill irrigation requirements using reclaimed water flows and storage. After irrigation, storage is the next priority and the model attempts to achieve target storage, a predetermined storage level for each month. The monthly targets for storage are collectively referred to as the target storage curve. After irrigation and storage requirements are considered, any reclaimed water that remains for disposal is discharged to the Russian River. The model uses a record of projected monthly Russian River flows over a 70-year period of record. No discharge to the Russian River is allowed from May 15 through September 30. The river discharge calculated by the model is compared to the allowable river discharge (based upon the design limit) and any river discharge in excess of the allowable is recorded as contingency volume. Allocation priorities for reclaimed water are summarized as follows:

1. Fulfill irrigation requirements;
2. Do not discharge to the Russian River during non-discharge months;
3. Achieve target storage;
4. Discharge above the design discharge rate only one month in twenty (or 95 percent reliability).

Contingency volumes are defined as monthly reclaimed water volumes in excess of that which may be irrigated, stored, or discharged to the Russian River under the design discharge rate. Actual permitted discharge rates will be set by the North Coast Regional Water Quality Control Board (RWQCB). The alternative design discharge rates under study are 1, 5, 10, and 20 percent of Russian River flow. The Water Balance Model assumes a contingency volume frequency (or reliability requirement) of 1 month for every 20 discharge months (equivalent to 95 percent reliability). Discharge months are October to mid-May. Based on this reliability requirement, contingency volumes could occur, on average, approximately once every 2 to 3 years. The reliability requirement was determined by agreement with the RWQCB.

PURPOSE

The purpose of this technical memorandum is to characterize contingency volume data generated by the Water Balance Model and to present a contingency program for handling these volumes. Various contingency measures will be described, and the frequency of utilization for these measures will be determined.

CONTINGENCY VOLUME CHARACTERIZATION

Contingency Volume Frequency

Monthly contingency volumes were calculated and recorded over the 70-year period of record for which the Water Balance Model was run, for both south and west county agricultural irrigation alternatives as well as for each design discharge rate for each alternative. Both south and west county alternatives include Sebastopol irrigation as a floating component. Because contingency averages and ranges are very similar between both alternatives, either with or without Sebastopol irrigation, contingency data characterization and planning are based on one representative alternative: south county irrigation, without Sebastopol. The contingency volume range and average for each design discharge rate for this alternative are as follows.

Table 1

Monthly Contingency Volume Ranges and Averages

Design Discharge Rate (Percent)	Contingency Volume Range (MG/month)	Contingency Volume Average (MG/month)
1	1 - 326	124
5	4 - 491	137
10	7 - 438	111
20	1 - 327	118

The range and average cover only one discharge month in 20 (approximately 28 months out of 560 discharge months in a 70-year period of record). There are no contingency volumes recorded in the other 532 discharge months during the period of record. There are a total of 840 months over the entire 70-year period of record.

The average contingency volume does not vary substantially among design discharge rates. However, the maximum contingency volumes for the 5- and 10-percent design discharge rates are greater than those for the 1- and 20-percent design discharge rates. The explanation for this discrepancy among maximum contingency volumes for each of the design discharge rates is subtle. Reclaimed water distribution between irrigation, storage, and river discharge is complex. The loss of capacity in one disposal or storage measure (e.g., irrigation, storage, river discharge) is not necessarily compensated equally by an increase in the capacity of another, for a particular contingency event. Each contingency event over the period of record arises from a unique set of circumstances. Over longer periods, the exchange in capacity between disposal/storage measures tends to compensate one another. So system reliability is equivalent for all the design discharge rates and the contingency volume averages are relatively close. However, each contingency event is unique, and contingency volumes for different design rates during the same month may be substantially different. These differences are reduced over the 70-year period of record but may be substantial for a single event. The discrepancy among maximum contingency volumes is representative of these singular substantial differences.

Contingency volume frequency curves were generated for each discharge rate option. The curves are shown in Figures 1 to 4, respectively. The curves only show the contingency volume frequency between 95 and 100 percent. Contingency volume is zero for 95 percent of the discharge months. Curves for the 1- and 20-percent discharge rates are similar, in that the contingency volume frequency is evenly distributed, meaning that between the maximum and minimum contingency volumes, the frequency curve decreases steadily. The curves for the 5- and 10-percent discharges are similar, in that the curve falls off the maximum rapidly (between 99 and 100 percent) before leveling off. This demonstrates that the 5- and 10-percent maximum contingency discharges are anomalous (occurring in less than one percent of all discharge months).

CONTINGENCY VOLUME MONTHLY OCCURENCES

The months in which contingency discharges occur over the 70-year period of record are tabulated below. No discharge to the Russian River is allowed during the summer months (mid-May through September), so those months are not included in the table. The maximum duration column indicates the maximum number of consecutive occurrences for contingency volumes over the period of record.

Table 2

Monthly Contingency Volume Occurences

Design Discharge Rate	Number of Contingency Discharge Occurrences								
	Oct.	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Max. Duration (months)**
1%	0	0	0	18	10	0	0	0	2
5%	4	0	14	6	2	0	2	0	3
10%	9	4	7	4	1	0	3	0	4
20%	18	3	1	2	1	0	3	0	4

All contingency volumes for the 1-percent design rate occur in January and February. As the design discharge rate increases, contingency volumes occur more frequently in the fall (October, November) and less frequently in the winter (January, February). The majority of contingency volumes for the 20-percent discharge occur in October. At the higher design discharge rates, Russian River discharges are distributed more broadly throughout the year, occurring more frequently in the spring and autumn. Spring and autumn Russian River flows are more variable than winter flows because these are transition periods between dry and wet seasons. As the design discharge rate increases and more flows occur during transition periods, more contingency volumes occur during these more variable flow periods.

The maximum duration of consecutive months for contingency events increases as the design discharge rate increases. At the 1-percent discharge rate, the maximum duration of events is two months (limited to January and February). At the 5-percent rate, the maximum duration of consecutive contingency events increase to three months (December, January, February), and at 10- and 20-percent design rates the maximum consecutive duration is four months (November, December, January, February). The increase in consecutive months as the design rate increases is related to the frequency of autumn and spring discharges as described above.

Total Russian River Discharge Frequency

Total Russian River discharge volume (including both design discharge and contingency volume) was analyzed. The purpose of this analysis was for comparison to contingency volume magnitude and frequency. The total Russian River discharge volume average, range, and frequency were calculated over the 70-year period of record for discharge months only (560 months total). The total Russian River discharge volume range and average for each design discharge rate are as follows.

Table 3

Total Russian River Discharge Ranges and Averages

Design Discharge Rate (Percent)	Total Russian River Discharge Volume Range (MG/month)	Total Russian River Discharge Volume Average (MG/month)
1	0 - 687	84
5	0 - 764	230
10	0 - 834	348
20	0 - 967	572

The total Russian River discharge frequency curves for the 1-, 5-, 10-, and 20-percent discharge rates are shown in Figures 5 through 8, respectively. As the design discharge rate increases, the range and average of total Russian River discharges increases. The shape of the frequency curve also changes so that discharges are larger and more frequent. As the system requirements decrease (for a higher discharge rate, less storage volume and irrigation area are required), more water is discharged during a greater number of months of the year. For the 1-percent discharge rate, river discharges occur only during 38 percent of the allowable discharge period (October through mid-May).

For the 20-percent discharge rate, the percentage of discharge months increases to 100 percent of the allowable discharge period.

Discharge Rate Distribution

Discharge rate distribution is shown in Figure 9. Numbers of monthly occurrences for specified ranges of discharge rates for the design discharge rates of 1, 5, 10, and 20 percent are displayed. As expected, the distribution of discharge rates broadens as the design discharge rate increases. There are 560 discharge months over the period of record, 28 months of which exceed the design discharge rate (in accordance with the 1 in 20 month reliability). The discharge rates shown in this figure assume that there is no contingency volume program in place to reduce discharge rates during contingency events.

CONTINGENCY VOLUME PROGRAM

Background

A contingency volume program was designed to reduce the incidence of discharges to the Russian River above the design discharge rate. Temporary measures will be needed during contingency events to adequately dispose of contingency volumes. A contingency program was drafted by CH2M Hill in the *Screening Evaluation of Long-Term Reclamation and Reuse Alternatives* (Screening Report), prepared in January 1993. Three contingency measures were identified in this report: emergency conservation, winter irrigation, and rapid infiltration. Because rapid infiltration was eliminated as an alternative for this long-term project, it has been eliminated from consideration as a contingency measure also. Emergency conservation and winter irrigation will be considered here as well as another contingency measure, contingency Russian River discharge (in excess of the design rate). Contingency program measures were selected based on ease of implementation and low capital cost. All of the contingency measures under consideration use the same facilities that would be utilized under normal discharge conditions.

Winter Irrigation

In the Screening Report, winter irrigation capacity was estimated based on 75 percent availability of the existing irrigated agricultural lands (3,750 acres) and a daily evapotranspiration (ET) rate of 0.05 inches. These assumptions were based on existing reclamation system experience, irrigation demand records, and Department of Water Resource (DWR) data. Under these assumptions, the potential for monthly winter irrigation was determined to be 150 MG/month.

Parsons ES requested a reevaluation of the winter irrigation assumptions by the agricultural irrigation specialists for the project. Their evaluation used a water budget model that takes into consideration precipitation, irrigation, and ET rates to calculate runoff, shallow groundwater flows, and streamflows. The water budget model for streamflow was run using an assumed irrigation rate of 0.05 inches per day (or 1.5 inches per month), and precipitation and ET rates typical of dry winter conditions. Dry winter conditions were assumed because dry winters result in low Russian River flows, and these are the predominant conditions under which contingency events occur. Water budget model results showed that impacts to streamflow were minimal (change of less than 0.1 cfs), and therefore the assumed irrigation rate is considered feasible for winter irrigation. The winter irrigation rate of 1.5 inches per month is considered suitable for all irrigation areas: west county, south county, Sebastopol, and existing lands. The availability of agricultural lands of 75 percent was also reviewed and confirmed. No more than 25 percent of the agricultural irrigation lands under review for this project are low-lying, susceptible to ponding, and consequently, unsuitable for winter irrigation.

Based on the previous assumptions and irrigation acreage requirements as determined by the water balance model, the following monthly winter irrigation capacities, rounded to the nearest 10 million gallons (MG), were calculated.

Table 4

Monthly Winter Irrigation Volume Capacities (MG)

Alternative Number	Description	Design Discharge Rate Alternatives			
		1%	5%	10%	20%
2	South County	300	260	230	170
2S	South County w/Sebastopol	330	290	260	170
3	West County	370	310	270	170
3S	West County w/Sebastopol	380	330	280	170

Winter irrigation capacity is directly proportional to the acreage requirements for the alternatives. As the design discharge rate decreases, irrigation acreage and winter irrigation capacity increase. Irrigation rates vary among the irrigation areas (e.g., South County - 28 inches annually, Sebastopol - 17 inches annually), and so acreage requirements change accordingly. As irrigation rates decrease (say from South County to Sebastopol), irrigation acreage requirements and the capacity for winter irrigation increase. Consequently, alternative 3 has a greater winter irrigation capacity than alternative 2, and alternatives that include Sebastopol also have a greater winter irrigation capacity.

Emergency Conservation

The original contingency plan presented in the 1993 Screening Report assumed a 5-percent reduction in average dry weather flow (ADWF) for the following emergency conservation measures: higher short-term water rates, more efficient laundry and dishwashing practices, and shorter showers. Based on an ADWF of 22.5 MGD, it was determined in the Screening Report that an influent reduction of 35 million gallons (MG) per month could be achieved. The ADWF was recently reevaluated based on both General Plan and ABAG growth estimates. As a result of the evaluation, a revised ADWF of 21 MGD was assumed for water balance calculations. Assumptions regarding the assumed 5-percent savings for emergency water conservation were reevaluated, and it was confirmed that a 5-percent savings in ADWF could be attained through an emergency water conservation program using the measures described in the 1993 Screening Report. Based on an ADWF of 21 MGD, a discharge reduction of approximately 31 MG per month could be achieved.

Contingency Measure Prioritization, Utilization, and Implementation Frequency

Contingency program measures are prioritized for implementation as follows: 1) winter irrigation, 2) emergency conservation, and 3) contingency Russian River discharge. The measures are prioritized based on ease of implementation and environmental acceptability. Contingency Russian River discharge is the least acceptable of the three alternative measures because the primary purpose of the contingency program is to avoid discharge to the river in excess of the design rate, except under the most extreme circumstances. Emergency conservation will require considerable public information and support. Public information campaigns should be communicated infrequently; otherwise emergency water conservation may not be perceived as an “emergency” by the public, diminishing its effectiveness over time. Winter irrigation facilities are in place and, therefore, should be the first measure utilized during a contingency event.

Contingency measure utilization and implementation frequency will depend upon both the alternative selected and the design discharge rate. As explained previously, relatively low rate irrigation areas (e.g., Sebastopol, West County) require more acreage for summer irrigation than higher rate irrigation areas (South County, Laguna). Because the winter irrigation rate is the same for all the alternatives, those alternatives with low summer irrigation rates and larger irrigation acreages (Sebastopol, West County) can dispose of more contingency volume during a contingency event. Because alternative 2, South County agricultural irrigation, has the least potential for winter irrigation contingency volume disposal, it will be evaluated as the worst case contingency scenario and serve as the example for subsequent discussion regarding utilization frequency.

Figure 10 displays maximum contingency measure utilization for Alternative 2, South County Agricultural Irrigation, for each of the design discharge rates. Contingency measure utilization in this bar chart is based on the maximum contingency flows taken from the contingency volume range, shown in Table 1. Maximum contingency measure utilization capacities for each of the design rates are given in the table below. For example, for the 1-percent design rate, the maximum contingency volume is 326 MG, as found in Table 1. Winter irrigation capacity for the 1-percent design rate is 300 MG (see Table 4), and the remaining contingency volume (26 MG) may be accommodated by emergency conservation (maximum capacity of 31 MG). For the 5-percent design rate, an additional contingency measure is required. The maximum contingency volume of 491 MG exceeds the capacities of both winter irrigation and emergency conservation combined. Winter irrigation is utilized to its maximum capacity of 260 MG, emergency conservation is utilized to its maximum capacity of 31 MG, and the remainder (200 MG) must be accommodated through contingency Russian River discharge.

Table 5

Maximum Contingency Measure Utilization

	Design Discharge Rates (all utilizations in MG/month)			
Contingency Measure	**1%**	**5%**	**10%**	**20%**
Winter Irrigation	300	260	230	170
Emergency Conservation	26	31	31	31
River Discharge	0	200	177	126
Total Max. Contingency Volume	326	491	438	327

Contingency Measure Utilization Frequency

It is important to note that the contingency measure utilization volumes shown in Figure 11 are maximum volumes, and are only implemented during the maximum contingency event. Contingency measures would not be utilized to the same degree for the majority of contingency events. Figures 1 through 4 are used to determine the frequency of utilization for the various contingency measures. In order of priority, each contingency measure capacity is matched against the frequency curve to determine the relative frequency of contingency measure implementation. For purposes of discussion, frequency of utilization percentages for contingency measures will be in percentage of contingency events, not total discharge events. This means that every percentage point on the frequency curves (Figures 1 through 4) for total discharge events (95 to 100 percent) is equivalent to 20 percentage points in terms of contingency events only (0 to 100 percent).

Table 6, below, gives the implementation frequency for each of the contingency measures in percentages measured by contingency events only. In parentheses are the total number of contingency events over the 70-year period of record for which the contingency measure is required. For example, at the 5-percent design discharge rate, winter irrigation will be utilized for every contingency event (28 events total). Emergency conservation is required for only 13 percent of all contingency events (approximately 4 out of 28 total). River discharge is required for 11 percent of all contingency events (approximately 4 out of 28 total).

Table 6

Contingency Measure Utilization Frequency

	Design Discharge Rates			
Contingency Measure	**1%**	**5%**	**10%**	**20%**
Winter Irrigation	100% (28)	100% (28)	100% (28)	100% (28)
Emergency Conservation	7% (2)	13% (4)	8% (3)	29% (8)
River Discharge	0% (0)	11% (4)	6% (2)	22% (7)

The maximum monthly contingency volume over the 70-year period of record is 326 MG at the 1-percent design rate. The combined 1-percent design rate winter irrigation and emergency conservation capacity is 331 MG/month, exceeding the requirement of the maximum contingency event. Therefore, no additional river discharge is required at this design rate. For the 5-percent discharge option, additional river discharge capacity is required. Maximum winter irrigation capacity is 260 MG/month. Based on the frequency curve shown in Figure 2, winter irrigation will adequately dispose of about 87 percent of all contingency events. Therefore, emergency conservation is required to assist in accommodating the remaining 13 percent of contingency events. Emergency conservation in conjunction with winter irrigation (291 MG/month) will accommodated approximately 89 percent of contingency events. Therefore, river discharge is required to assist in accommodating the remaining 11 percent of contingency events. Likewise, the contingency measure implementation frequencies for the 10- and 20-percent design rates were determined.

As the design rate for Russian River discharge increases, system requirements for irrigation acreage decrease. This reduces the available utilization capacity for winter irrigation and consequently increases dependency upon river discharge (above the design rate) as a contingency measure. Alternative 3 is less dependent upon river discharge as a contingency measure because more irrigation acreage is a component of this alternative. Similarly, both West and South county alternatives that include Sebastopol irrigation have less river-dependent contingency programs.

Contingency Event Russian River Discharge Rates

Table 7 shows the average and range of contingency discharge rates for each of the design discharge rates. The discharge rates shown below are based upon contingency events only. All other discharges (non-contingency events) are less than the design discharge rate. An "excess discharge event" is defined as a contingency event where the contingency volume exceeds the maximum capacity of winter irrigation and emergency conservation. Contingency volume in excess of this capacity is discharged to the river, in excess of the design rate. The number of excess discharge events is only a portion of the maximum possible number of 28 contingency events (in months) over the 70-year period of record (total of 560 discharge months).

Table 7

Contingency Event Russian River Discharge Rates

Total Contingency Event Discharge Rates	Design Discharge Rates			
	1%	**5%**	**10%**	**20%**
Avg. Discharge Rate	1.0%	5.6%	10.4%	20.8%
Max. Discharge Rate	1.0%	13.2%	17.3%	28.3%
Min. Discharge Rate	1.0%	5.0%	10.0%	20.0%
No. of Excess Discharge Events (out of 560 Discharge Months)	0	4	2	7

Because winter irrigation and emergency conservation measures accommodate the maximum contingency volume for the 1-percent design rate option, the Russian River discharge rate never exceeds the design rate. Average contingency discharge rates for the 5- to 20-percent design rate options are only slightly greater than the design rate, although the maximum rates are substantially higher than the design rates (by about 7 to 8 percentage points).

Additional "contingency" storage capacity was considered to mitigate the magnitude and frequency of excess discharge events for the 5- to 20-percent design rate options. A contingency storage of an additional 5 percent of design storage was assumed to be available to accommodate a portion of the contingency volume beyond the capacity of winter irrigation and emergency conservation. This contingency storage could be disposed to either irrigation or river discharge when conditions were more favorable for disposal. The contingency storage volumes for the 5-, 10-, and 20-percent discharge options are 145, 95, and 60 MG, respectively. These storage volumes are in addition to the 2900, 1900, and 1200 MG of design storage, determined for the 5-, 10-, and 20-percent design rates, respectively. Table 8 shows the average and range of contingency discharge rates for each of the design discharge rates when contingency storage is utilized.

Table 8

Contingency Event Russian River Discharge Rates: Contingency Storage

Total Contingency Event Discharge Rates	**Design Discharge Rates**		
	5%	**10%**	**20%**
Avg. Discharge Rate	5.1%	10.2%	20.2%
Max. Discharge Rate	7.3%	13.4%	28.3%
Min. Discharge Rate	5.0%	10.0%	20.0%
No. of Excess Discharge Events (out of 560 Discharge Months)	2	2	4

Average contingency discharge rates decrease only marginally when contingency storage is utilized, however, the maximum contingency discharge rates decrease by 4 to 6 percentage points for both the 5 and 10 percent design discharge rates. The use of contingency storage reduces excess discharge substantially, except for large contingency events during consecutive months, when contingency storage is required. Contingency storage may be utilized only once annually. The 20 percent maximum contingency discharge rate is not reduced by contingency storage because it occurs during a string of consecutive contingency events that would utilize contingency storage. For the 5 and 10 percent design discharge rates, excess discharges occur only twice over the 70-year period of record and are within a few percentage points of the design rate.

Another measure that may be undertaken to reduce contingency magnitude and frequency is operational. Actual operations could be modified slightly from the water balance model allocation priorities. The model places a higher priority on achieving target storage than on discharging to the river. Actual operations may be modified so that these priorities are reversed in the early discharge season (October through December). Utilizing river discharge potential at the expense of target storage early in the discharge season would increase available storage capacity and reduce the incidence of contingency events later in the discharge season.

SUMMARY

Contingency volume data differ for each of the design discharge rates. Although the reliability requirement is the same for the 1-, 5-, 10-, and 20-percent design rate options, the average contingency volume varies slightly, and the maximum contingency volume varies greatly. These variances are due to the unique set of circumstances surrounding each contingency event. This variance may be explained in part by monthly occurrences for each design discharge rate. As the design rate increases, discharges occur increasingly over a broader range of the discharge season. Contingency events occur only in January or February for the 1-percent design rate and most frequently in October for the 20-percent design rate. These differences in monthly occurrences lead to the discrepancy in maximum contingency volumes among the various design rates.

A contingency program of relatively low-cost, easily-implemented, contingency measures was developed to handle contingency events. In order of implementation, the contingency measures are winter irrigation, emergency conservation, and river discharge. Contingency river discharge is in excess of the design discharge rate and is implemented as a last resort, when other contingency measure capacity has been exhausted. Contingency river discharge is necessary for the 5-, 10-, and 20-percent design rate options. Contingency river discharge is more frequently utilized as a contingency measure as the design rate increases.

The maximum total Russian River discharge rates are 7 to 8 percentage points greater than the design rate when contingency river discharges are included. Contingency river discharge occurs approximately once every 10 years for the 20-percent design rate option. Contingency river discharges are mitigated by adding “contingency” storage. Contingency storage is defined as an additional 5 percent of the design storage volume for the 5-, 10-, and 20-percent design rates. Incorporating contingency storage approximately halves the difference between the maximum total Russian River discharge rate and the design rate (except for the 20-percent design rate), and almost halves the frequency of contingency river discharges for the 5- and 20-percent design rate options. The “maximum” discharge rate associated with each “design” discharge rate would be approved and contained in the permit issued by the RWQCB.

Figure 1
Contingency Volume Frequency
One Percent Discharge Option

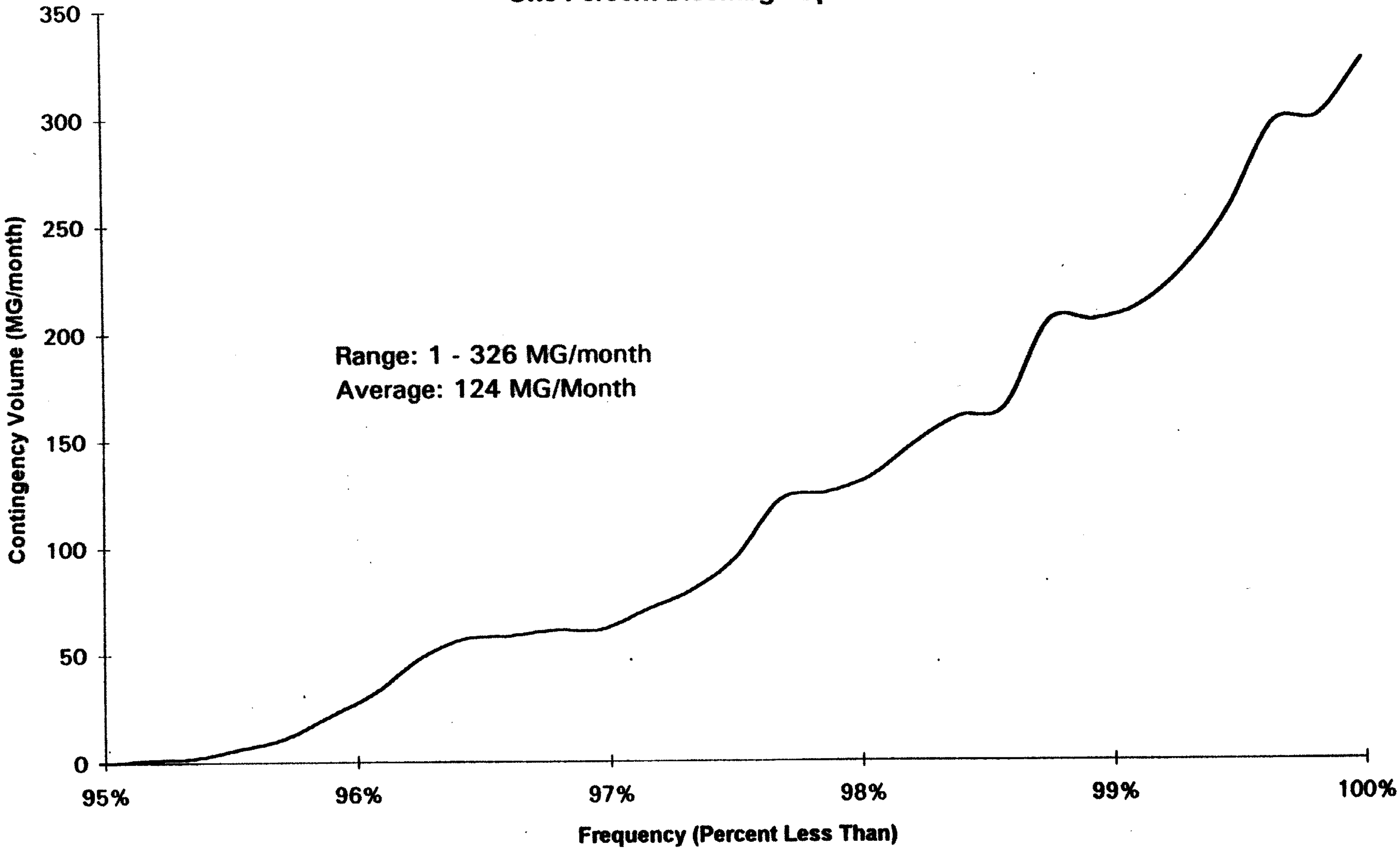

Figure 2
Contingency Volume Frequency
Five Percent Discharge Option

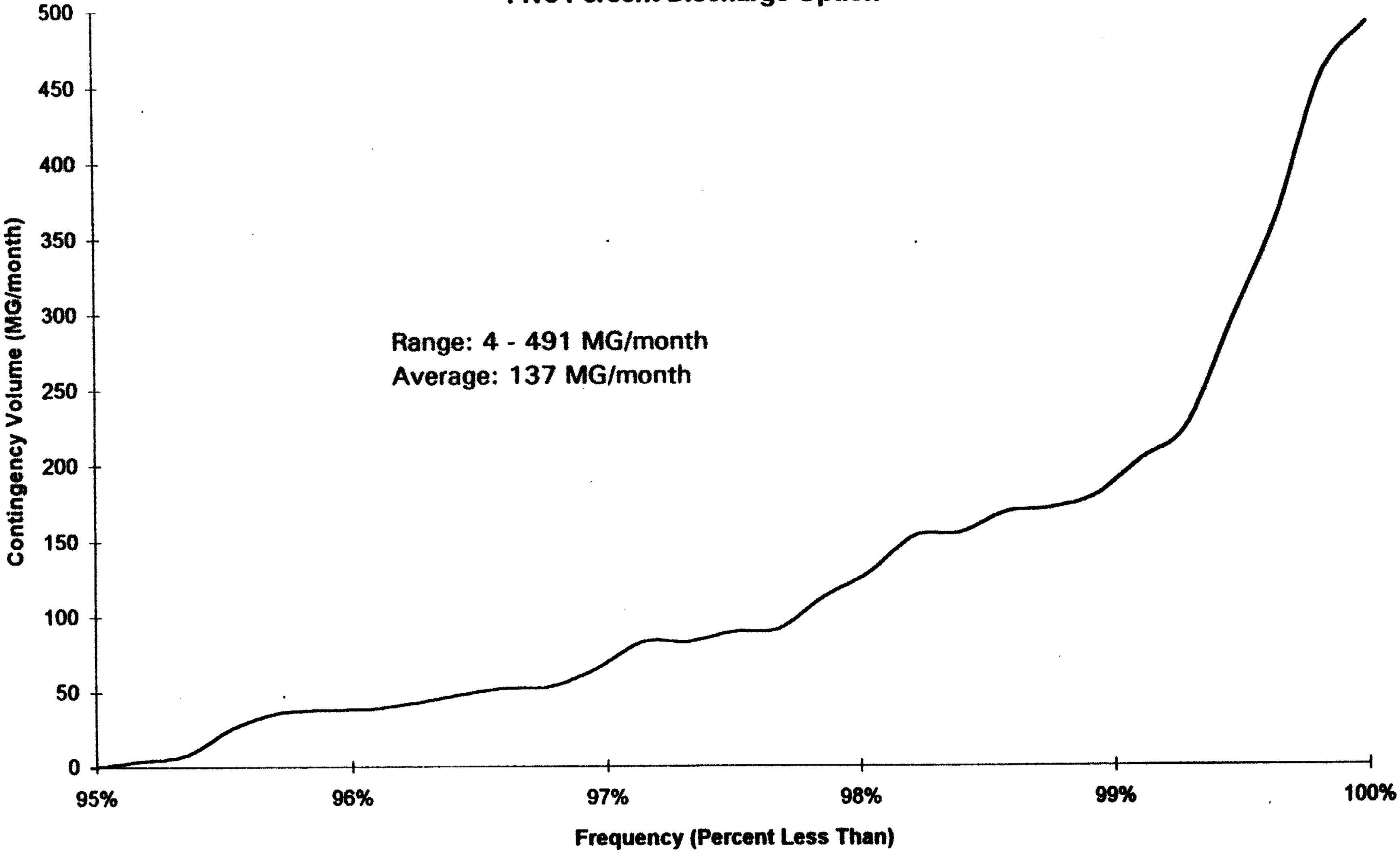

Figure 3
Contingency Volume Frequency
Ten Percent Discharge Option

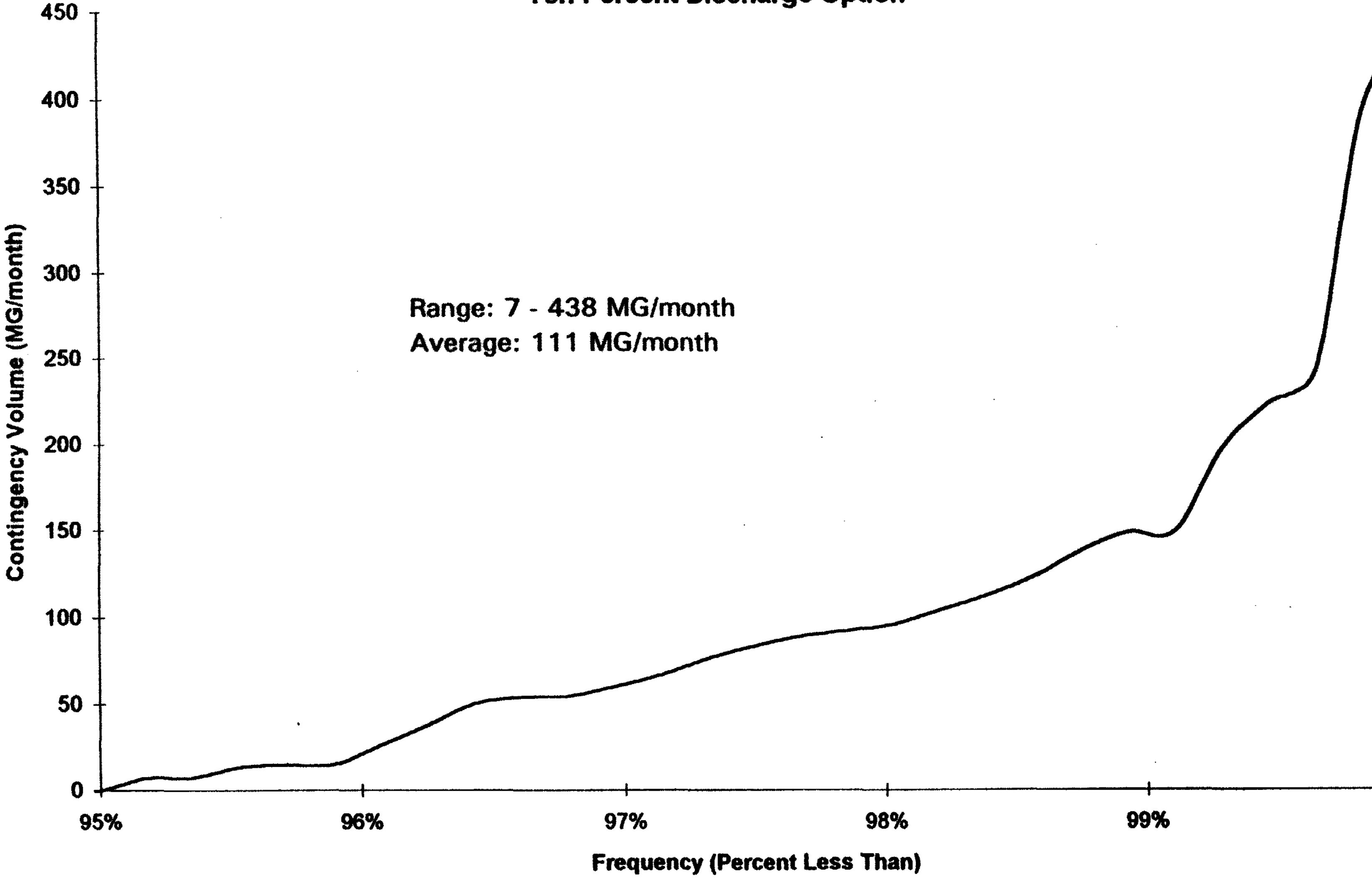

Figure 4
Contingency Volume Frequency
Twenty Percent Discharge Option

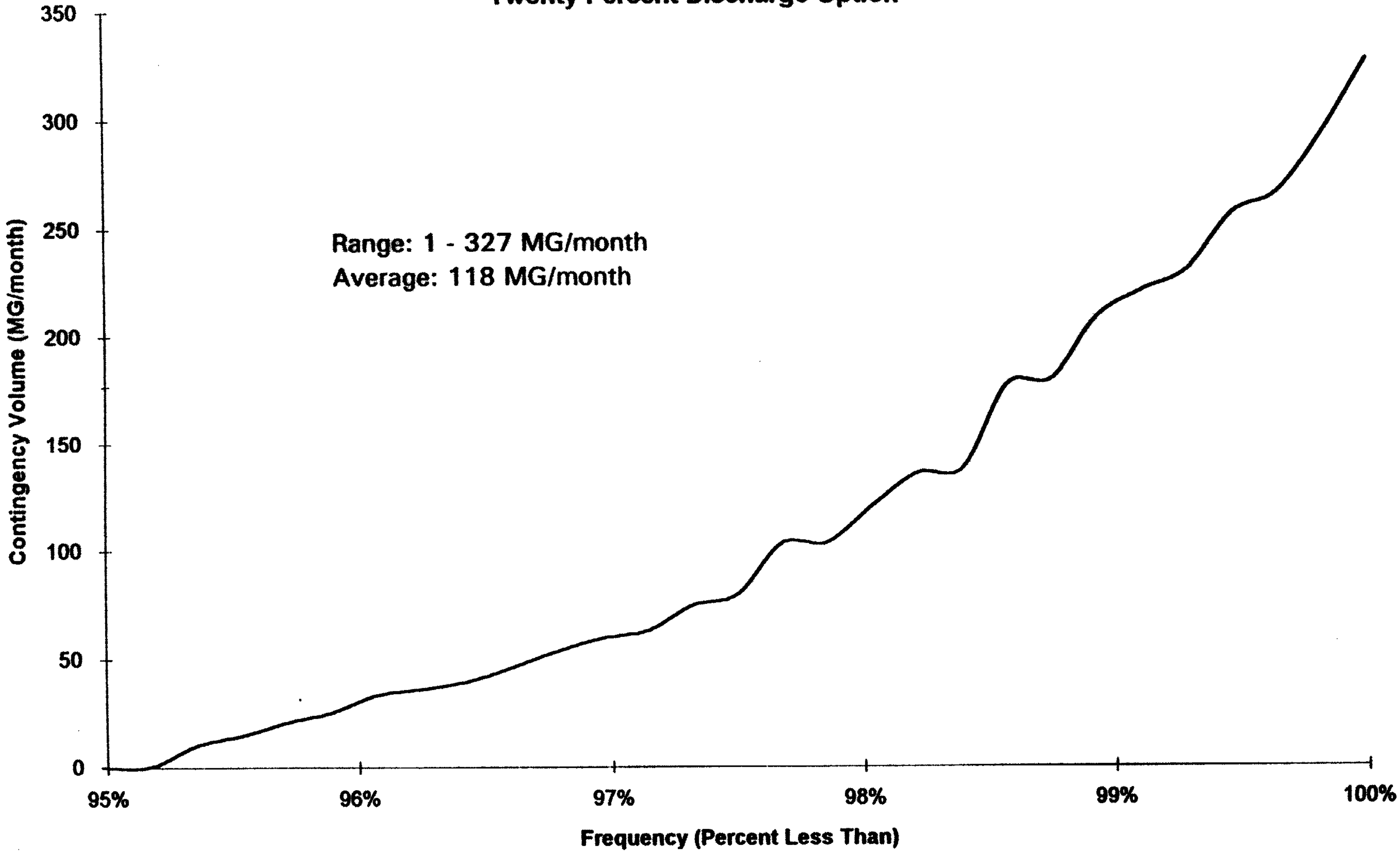

Figure 5
Russian River Discharge Volume Frequency
One Percent Discharge Option

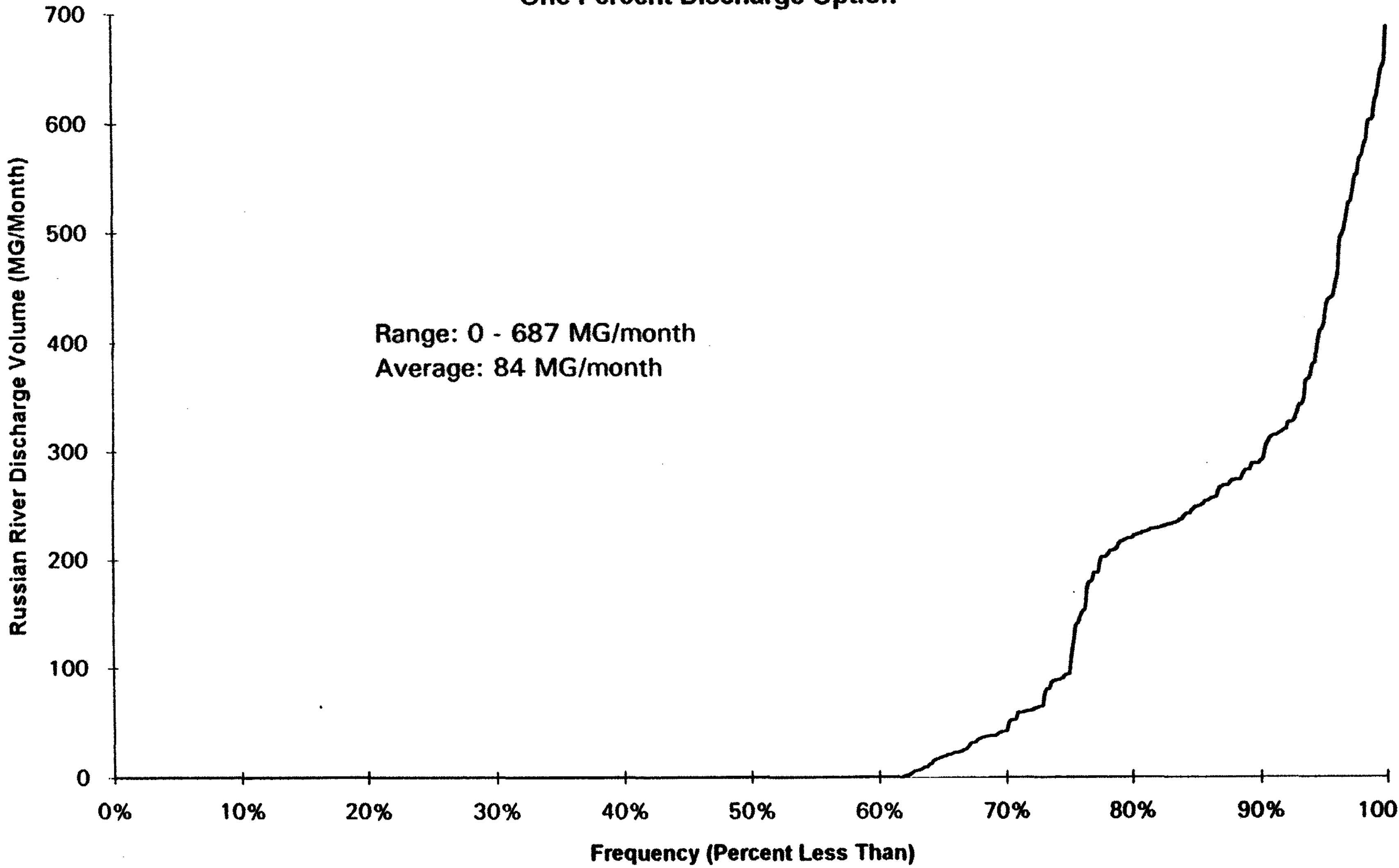

Figure 6
Russian River Discharge Volume Frequency
Five Percent Discharge Option

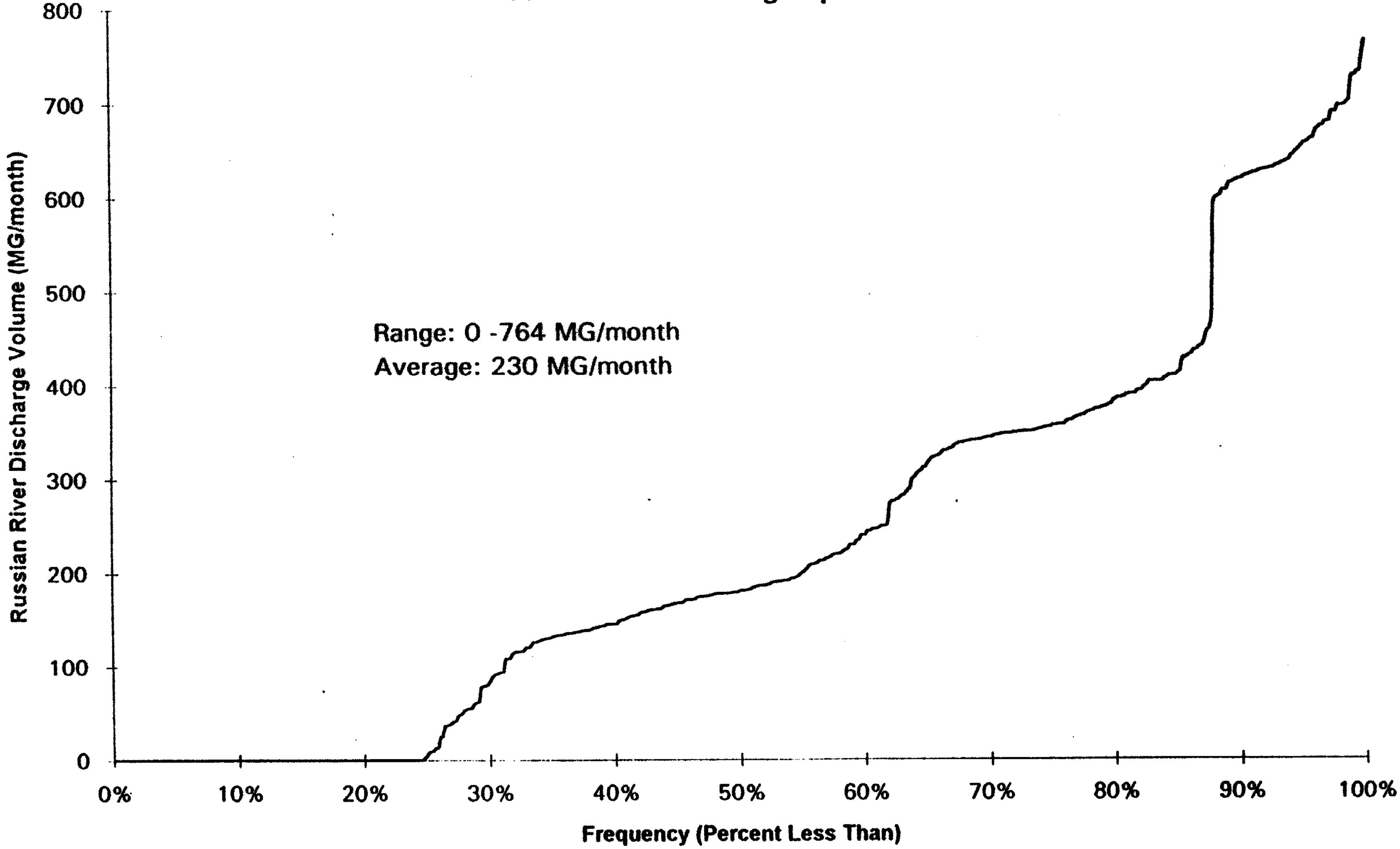

Figure 7
Russian River Discharge Volume Frequency
Ten Percent Discharge Option

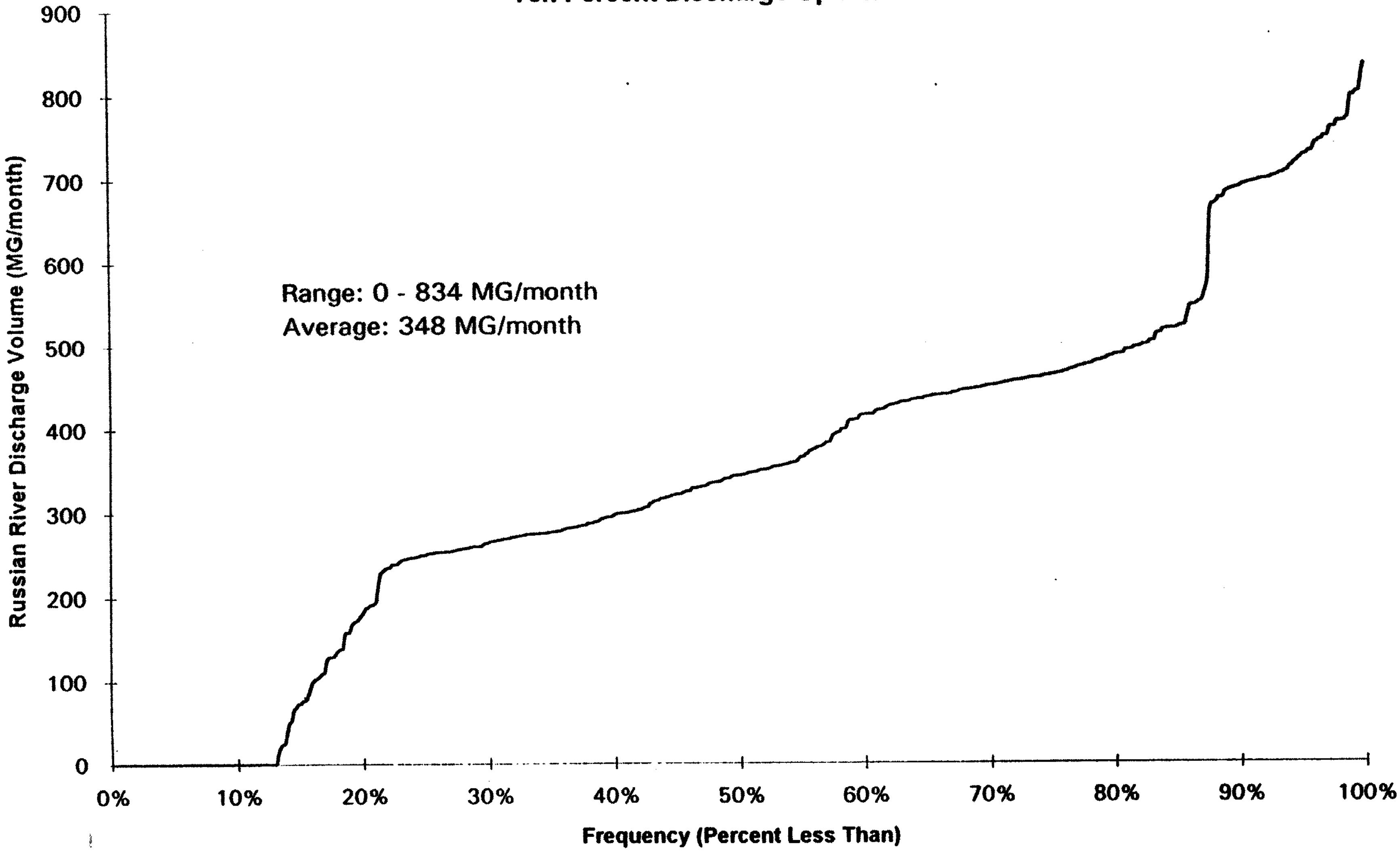

Figure 8
Russian River Discharge Volume Frequency
Twenty Percent Discharge Option

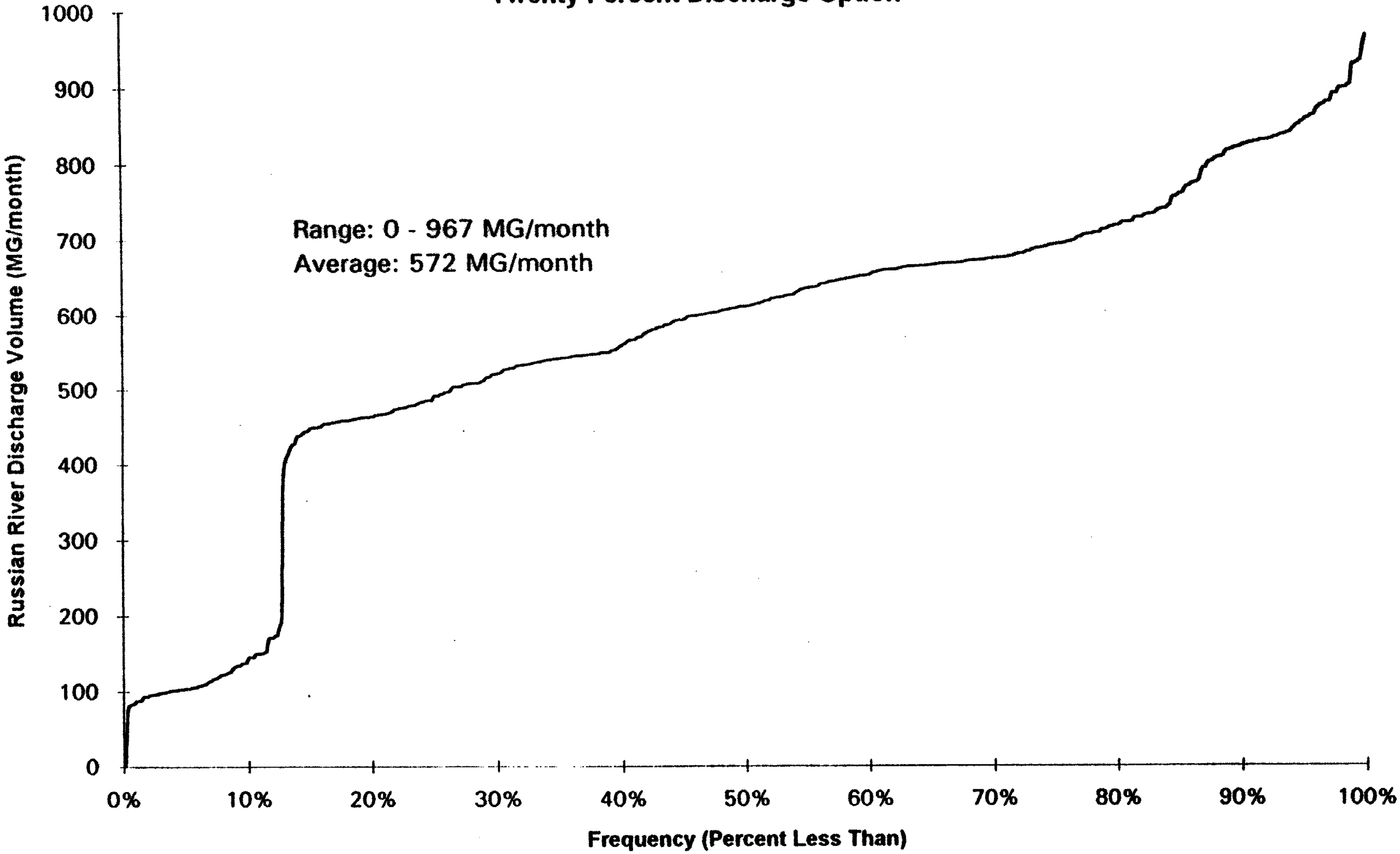

Figure 9
Distribution of Discharge Rates

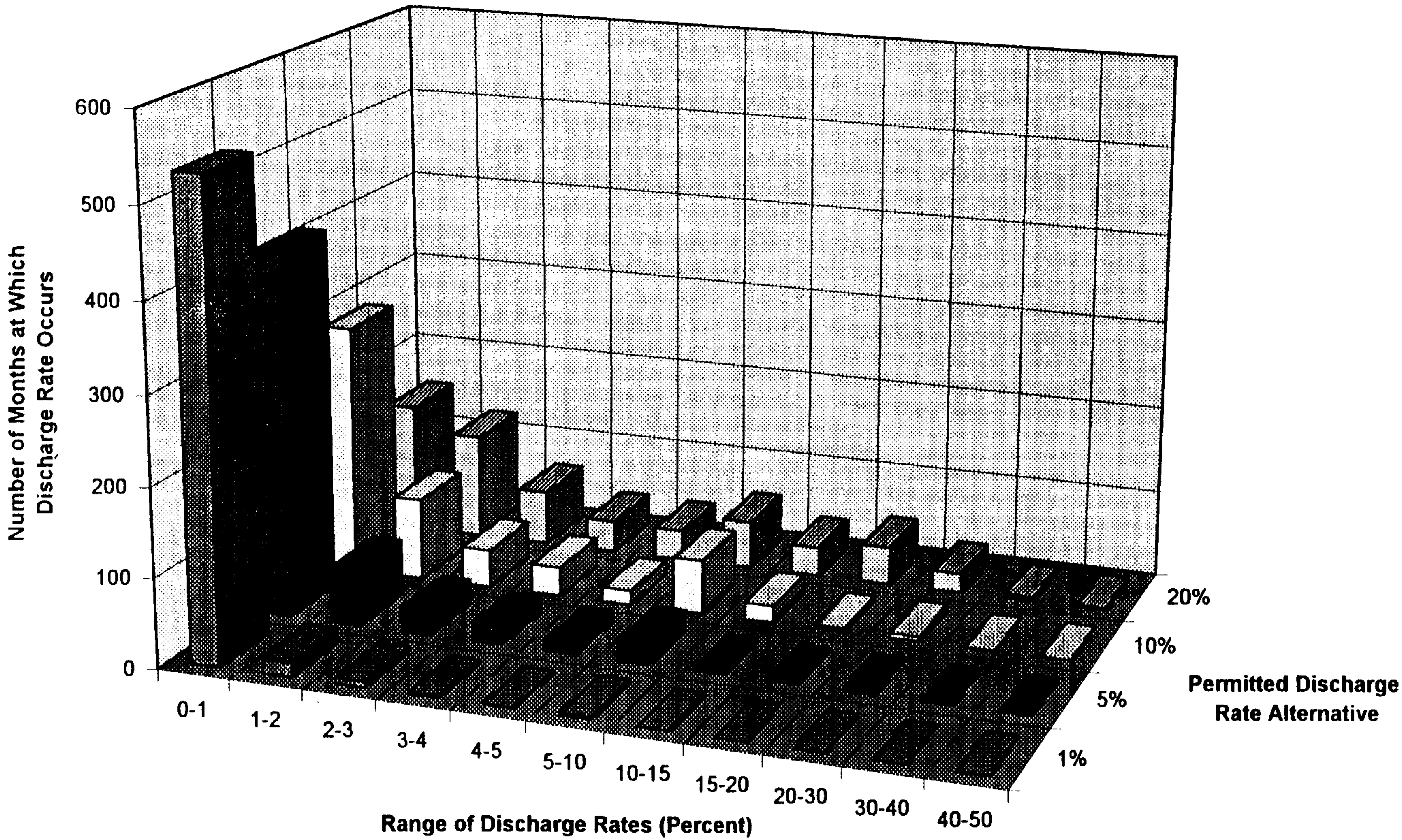

Figure 10
Maximum Contingency Measure Utilization