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Rector Reservoir Yield Study

Study Purpose

The purpose of this investigation was to determine the current volume of Rector Reservoir and to estimate the range of possible reservoir yields. This investigation included field measurements to determine the storage capacity change of the reservoir from sediment deposited by inflow from tributary streams, landslides, and wave erosion. A requirement of this investigation was the development of methodologies and a mathematical flow balance to calculate the current storage capacity of the reservoir, hydrologic and hydraulic parameters, and a range of deliverable yield. The results of this study are intended to guide the scope of planning for Rector Reservoir including a workplan to develop a reservoir operation plan to determine future levels of risk and a Water Management Plan to guide contract activities. The study was performed under contract with the California Department of Veterans Affairs.

Study Background

To perform this study, the best available hydrologic data was researched, evaluated, and incorporated into the study. Electronic depth sounding equipment incorporating a global positioning system was used to survey the reservoir topography for comparison with prior field surveys. The new survey improves accuracy and is more comprehensive than prior investigations. A stage-capacity curve was developed to provide the reservoir manager with the amount of water available on a daily basis as determined from daily stage elevations.

A reservoir operation computer flow balance was developed to simulate the performance of the reservoir during an extensive period of actual recorded rainfall data. This period of record has both extended wet and dry year periods. It is assumed that this past hydrologic record presents the best estimation of probable future conditions. The yield of the reservoir was determined based on a representative operation schedule, required carryover storage, and all water right restrictions.

Description of Reservoir and Watershed

Rector Creek Dam and Reservoir is located at the base of the foothills of the Howell Mountains, approximately three miles northeast of the Town of Yountville in Napa County, California. The location is shown in Figure 1. The dam is a 164-foot high, earth-fill structure with crest elevation at 381.5 feet. The spillway is a broad-crested weir with crest elevation at 372.5 ft and a curvilinear crest length of 141.5 ft. The spillway was constructed to the present configuration in 1989. Prior to that date, the spillway crest was at 370.0 ft with the same curvilinear crest length of 141.5 ft. An outlet tower with multiple intakes

at elevations of 270, 291, 307, 323, 339, and 335 ft provides controlled releases from the reservoir. The field investigation did not confirm the operational capabilities of the outlet tower; however, the bathymetric surveys indicate that the intake at the elevation of 270 ft would not be operable due to siltation. Another high level outlet was constructed in 1989, the time of the dam height and spillway crest increase. The outlet consisted of an 8-inch pipe for use in draining the upper 2.5 ft of reservoir volume. A profile of the dam and pertinent structures is shown in Figure 2. A three-dimensional view of the major facilities and reservoir is shown in Figure 5.

The watershed area is 10.7 square miles, composed mainly of rugged hills, portions of which are covered with brush and small trees. There are several vineyards and small reservoirs in the upper watershed. The primary source of inflow to the reservoir is from Rector Creek, which is a perennial stream flowing throughout the year. The watershed area is shown in Figure 4. The mean annual precipitation for the basin is estimated at 36 inches. For most years, the reservoir fills regularly and spills during the winter months because of high rainfall and rapid runoff.

Water Rights

The State Water Resources Control Board, Division of Water Rights issued the license for diversion and use of water on November 2, 1970. It contains five restrictions on the use of waters into and from the reservoir:

1. Direct diversion cannot exceed 5.55 cubic feet per second
2. Annual reservoir storage increase cannot exceed 1,767 acre-feet (af)
3. Direct diversion plus collection to storage cannot exceed 3,518 af
4. Maximum withdrawal from storage cannot exceed 1,767 af
5. Maximum reservoir storage cannot exceed 4,400 af

Field Surveys

A field investigation was conducted to estimate the current volume of the reservoir and the effects of sedimentation over the last 54 years since construction of the dam. The determination of the surface area and capacity values consisted of field data collection, processing and checking data for quality assurance and quality control, and analysis of the data using graphics software to develop depth, area, and volume.

The fieldwork consisted of a bathymetric survey of the flooded portion of Rector Reservoir. The bathymetric survey was performed using a single beam depth sounder and a real time differential correction global positioning system (SBDS-DGPS) synchronized to collect depth and location simultaneously at various points on the lake. The SBDS-DGPS was mounted to an outboard motor boat and collected data continuously as the boat traveled in a grid-like pattern

over the entire lake surface. Approximately 10,000 points were collected during the survey.

The bathymetric data was reviewed for accuracy. Any data points that were inconsistent with surrounding points were adjusted or removed depending on the type of data error. For example, if during the data collection, the global position system (GPS) lost contact with the Coast Guard signal which the GPS needs to perform real time correction, the point was corrected manually. The data file was then converted and uploaded into graphics software to create contours of reservoir bed elevations. These contours are shown in Figure 4 and are depicted three-dimensionally in Figure 5. From the contours, the software computed the surface area and volume at different elevations. The resultant capacity curve is shown in Figure 6. The portion of the reservoir above the water elevation at the time of the field survey, 371.5 ft, was estimated from the original capacity table. The full capacity of the reservoir at spillway crest is 4,535 af.

The original capacity curve is also shown on Figure 6. The capacity of the reservoir has decreased and the volume has been reduced by 245 af at spillway crest. It is estimated that deposition of sediment has occurred throughout the reservoir, with thicker deposits in the upper reaches of the reservoir. In addition, siltation has taken place around the outlet tower. The reservoir elevation at the base of the tower is now approximately 280.0 ft. This indicates that the lowest level intake at 270 ft has been silted in and is inoperable. The lowest operating intake is now at an elevation of 291 ft with a corresponding dead pool storage of 478 af.

Historical Hydrologic Data

Rector Creek is a perennial stream with flow coming into Rector Reservoir continuously throughout the year. Estimates of the inflow to the reservoir are needed to perform the reservoir yield studies. The only known available flow measurements are found in the "Report on Water Supplies from Rector and Conn Creeks in Napa County," dated August 1940, by the State Division of Water Resources. Gaging stations were established for brief periods of time in the 1930s at several locations on Rector Creek. The authors extended the data to estimate monthly and seasonal runoffs from December 1929 to September 1938. Because the estimation method was not clarified, the values are questionable and appear to be very low. However, actual measurements were taken during the dry year 1931, which indicate that Rector Creek flowed at a minimum of 25 af for the month of September.

Daily reservoir stage measurements were taken from November 1963 through September 1978. Using the storage-capacity curve for conditions at that time, daily storage values were determined from the stage measurements.

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Historical rainfall records are available for several sites near the basin: (1) the Veterans Home/Town of Yountville from November 1914 to the present, (2) the Napa State Hospital from February 1917 to the present, (3) Conn Dam from January 1947 to July 1998, and (4) Milliken Dam from January 1965 to December 1996. These are complete and continuous records.

Historical Operational Data

Records of diversions and deliveries made from Rector Reservoir exist for the period of January 1954 through November 1979. These include deliveries made through the treatment plant and also untreated waters to the Department of Fish and Game facilities downstream of the dam. In addition, delivery records from March 1986 to November 1999 are available.

Reservoir Simulation Flow Balance

The simulation of Rector Reservoir operation was accomplished by application of the mass balance (continuity) equation. Simply stated:

$$S_s + I + P - E - D - SPILL = S_e \quad \text{(for each time step)}$$

S_s = storage at start of time step
S_e = storage at end of time step
I = stream inflow and runoff
P = precipitation falling on reservoir surface
E = reservoir evaporation
D = deliveries from reservoir
SPILL = spillway overflow

The above equation was programmed into a spreadsheet in EXCEL. The time step is selected for the appropriate period of time such as year, month, or day.

Determination of Historic Reservoir Inflows

Direct measurements of the inflow to the reservoir over a long period of record are not available. Therefore, inflow values were computed from daily reservoir stage values and monthly reservoir deliveries using the continuity equation to simulate reservoir operation.

For purposes of this study, reservoir inflow was composed of streamflow and runoff into the reservoir, precipitation on the reservoir surface, and reservoir evaporation. This can be determined by rearranging the continuity equation:

$$\text{Reservoir Inflow} = (I + P - E) = S_e - S_s + D + SPILL \text{ (for each time step)}$$

By combining parameters, only the starting and ending storage, the deliveries and the spills must be specified to determine reservoir inflow.

- The time step was chosen as one month.
- Daily stage and monthly reservoir deliveries are known for the period from October 1963 to September 1978. The monthly deliveries are shown in Table 2. Daily reservoir storage values were determined from the recorded stage and the corresponding area-capacity curve for conditions at that time.
- Monthly deliveries were obtained from records from the Department of Fish and Game (DFG) and the Department of Water Resources (DWR) for the same time period.
- Spillway releases were determined from daily stage values and the spillway outflow equation, $Q = C\,L\,H^{3/2}$. The daily spillway flows were accumulated to estimate monthly spillway flow.

Historic monthly reservoir inflows were then estimated using the continuity equation for the period of October 1963 to September 1978.

To develop a method to estimate reservoir inflow for the years in which the above information is not available, the calculated annual reservoir inflows were correlated with the corresponding recorded annual rainfall. The correlation was attempted for both the Veterans Home/Town of Yountville Station and the Napa State Hospital Station. Correlations were substantially better using the Veterans Home/Town of Yountville Station's data. The recorded precipitation values are shown in Table 1. A non-linear correlation was developed to estimate annual reservoir inflow from annual precipitation recorded at the Veterans Home/Town of Yountville Station. The chosen correlation is shown in Figure 7. Using this correlation, annual reservoir inflows were estimated from 1914 through 1999. For each given water year, monthly reservoir inflows were estimated by prorating the calculated annual reservoir inflow for the year by the monthly percentages of annual precipitation for the same year.

Reservoir Yield Calculation

Yield calculations for Rector Reservoir were completed by simulation of reservoir operation based on the past hydrologic record, October 1914 to September 1999. The updated capacity versus stage curve as determined by this study was used in combination with the current spillway configuration and the current outlet capacity above 280 ft. Inflow to the reservoir was determined as previously described in the methodology in the section titled Determination of Historic Reservoir Inflows.

Operational criteria included the current water right. Annual reservoir storage increase cannot exceed 1,767 af; maximum withdrawal from storage cannot exceed 1,767 af. By consequence, the carryover storage requirement is set at 2,768 af (maximum reservoir capacity minus 1,767 af). Carryover storage

is the minimum amount of reservoir capacity that will remain unused during normal operations. All water right restrictions are met in accordance with the provisions in the section titled Water Rights.

An assumed delivery schedule was based on actual 1992 deliveries, as shown in Figure 8. The initial condition of the reservoir was set at 3,652 af, one-half of the working pool.

For purposes of this study, the following definitions are applied:

- **Safe yield** is the maximum annual delivery that can be met in all years of historic operation simulation. In the critical dry year, the reservoir would be drawn down to dead pool plus carryover storage. All water right restrictions are met.

- **Deficiency** is the shortage or amount of reduction in water delivery that could be imposed in a critically dry year.

- **Firm yield** is the maximum annual delivery that can be met in all noncritical years of historic simulation and partially met in critically dry years with a specific level of imposed deficiency. In the critical dry year, the reservoir would be drawn down to dead pool plus carryover storage. All water right restrictions are met.

- **Annual frequency of occurrence** for a specified level of yield is the probability that the specified values can be met.

The estimation of reservoir yield was made by application of the continuity equation to simulate reservoir operation. The methodology is summarized as:

1. Beginning storage equals ending storage from prior time step.
2. Estimate inflow.
3. Add inflow to storage.
4. If storage exceeds maximum storage, spill excess water down to spillway crest.
5. Make desired deliveries, if possible; do not withdraw storage below carryover storage elevation.
6. If storage does not allow full deliveries, deficiencies are imposed and only partial or no deliveries are met.
7. Final storage equals beginning storage for nest time step.

The mathematical flow balance was run with the above criteria. An annual demand was selected for delivery and then was input into the balance to determine the yield and associated frequency of occurrence. This process was repeated for a range of delivery demands. The results are shown on Figure 9 and are summarized in Table 3.

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Coordination Meetings and Scoping Future Work Activity

Coordination meetings were conducted with various stakeholder representatives to explain preliminary study results and the purpose of the investigation. Coordination was conducted with the Governor's Office, DFG, Department of Veterans Affairs (CDVA), Napa State Hospital, and the Town of Yountville. During these meetings, the water supply limits of the reservoir were identified and it was the consensus of the group that another investigation be undertaken by CDVA to complete a Water Management Plan. Such a plan could deal with matters of risk, water delivery deficiencies, contract matters, and reservoir operational rules. These matters are not a part of this investigation. However, to facilitate the transition to the Water Management Plan, DWR did evaluate the impact of proposed new operational criteria that will be a factor for a future Water Management Plan.

Elements that require consideration in connection with the scope of a future investigation include DFG instream fish flows and the amount of water required for operation of the new treatment plant currently under construction. In addition, continued review of the future needs and delivery schedules of all potential Rector Reservoir users is required.

The priorities of water needs are important to future Water Management Plans and have currently been established by CDVA as:

1. Stream releases
2. Treatment plant water
3. Veterans Home
4. DFG
5. Napa State Hospital
6. Town of Yountville

The operational criteria that were identified in connection with the stakeholder coordination meetings are under discussion and require finalization through the Water Management Plan.

To facilitate the development of a future Water Management Plan, the flow balance was run with projected future demands, schedule, priorities, and year types to determine the safe yield and yields at various probabilities of occurrence. The calculations were done for monthly normal, dry, and critically dry year conditions. For this study, the three designations were defined as:

- **Normal or wet:** Annual rainfall above 22 inches
- **Dry:** Annual rainfall above 16 inches but below 22 inches
- **Critically dry:** Annual rainfall below 16 inches

This criterion was based on judgement of the precipitation values recorded at Yountville and by evaluation of the histogram of values shown in Figure 10. The results are shown on Figure 11 and are summarized in Table 5.

Findings

- Sedimentation into the reservoir has been relatively minor. Field survey results indicate that deposition most likely occurred at the upper reaches of the reservoir and the area surrounding the outlet works.
- Comparison of the new volume estimate with the original construction estimate indicates that the capacity has decreased by 245 af at the current spillway elevation.
- The lowest intake level on the outlet tower at 270 ft has been silted in and is assumed to be inoperable. It is estimated that the lowest operable intake is at 291 ft with a corresponding dead pool of 478 af.
- There are relatively few dry or critically dry years of hydrologic record for the Rector Creek watershed and surrounding area. For this study, criteria was set to define dry years at less than 22 inches annual rainfall and critically dry years at less than 16 inches. For the past 86 years, there have been only five critically dry years and five dry years.
- The reservoir spills in all non-dry years.
- Annual reservoir inflow correlates well with annual precipitation recorded at Veterans Home/Town of Yountville.
- The criteria required by the current water right are critical to operation of the reservoir and set the amount of annual storage and delivery from the reservoir.
- The carryover pool was determined by the water right criteria. It was set at the minimum pool to which the reservoir could be lowered and then filled to not exceed the water right criterion on maximum storage. The carryover pool is at an elevation of 343.5 ft, 2768 af, and 61 percent of the total reservoir volume.
- With an assumed delivery schedule based on 1992 actual deliveries, the safe annual yield of the reservoir is 1670 af.
- With the instream flows proposed by DFG and the needs projected by all parties, the safe annual yield of the reservoir is 1190 af.
- Using the projected needs, the critical months for deliveries from the reservoir are September and October.

Conclusions

- Sediment deposition in the reservoir is not a major problem to reservoir capacity. However, it appears to have buried the lowest level intake on the outlet tower. This has increased the dead storage and negatively impacted the ability to flush the reservoir.
- Inflow to the reservoir is high in all non-dry years, but the water right criteria restrict the annual amount of storage and carryover.

- This study was based on the past hydrologic record as recorded at the dam site and at the Veterans Home/Town of Yountville. Future hydrologic events may vary substantially, but it is assumed that the overall probabilities of occurrence remain the same as the past hydrologic record.
- The precipitation recorded at Veterans Home/Town of Yountville correlates very well with the inflow into the reservoir and can be used to reasonably estimate inflow values.
- The safe yield of the reservoir based on historic hydrology is reduced from prior estimates.
- The reservoir yield can increase if risk and delivery deficiencies increase.
- The projected needs as presented by CDVA and DFG during stakeholder coordination meetings far outreach the available supply from the reservoir.
- The proposed instream flows have a major impact on reservoir yield.
- New operational schedules will have a significant impact on the reservoir yield.
- If operational scheduling could minimize the projected deliveries for the months of September and October, the available yield could be significantly increased. An operational study would clarify this possibility.

Recommendations

- The possibility of an increased water right for Rector Reservoir needs to be re-examined. In addition, the impact of instream flows on the water right should be clarified.
- The water needs for all recipients of Rector Reservoir supplies must be well defined, including the amount and schedule of delivery.
- A Water Management Plan must be completed for the reservoir to determine the acceptable level of risk.
- Each entity receiving supplies from the reservoir must determine their water management options for various acceptable levels of deficiency.
- Water Management Plans and reservoir operation criteria should be determined for the optimal operation scheme for the reservoir. This would combine projected available supplies with future State and local needs.
- Water quality concerns should be addressed in the Water Management Plans.
- The reservoir stage could be recorded daily to provide an estimate of reservoir inflow.
- The precipitation should be recorded at the dam site and at a suitable location within the basin.
- A monitoring program should be established to correlate future annual reservoir inflows with annual rainfall.

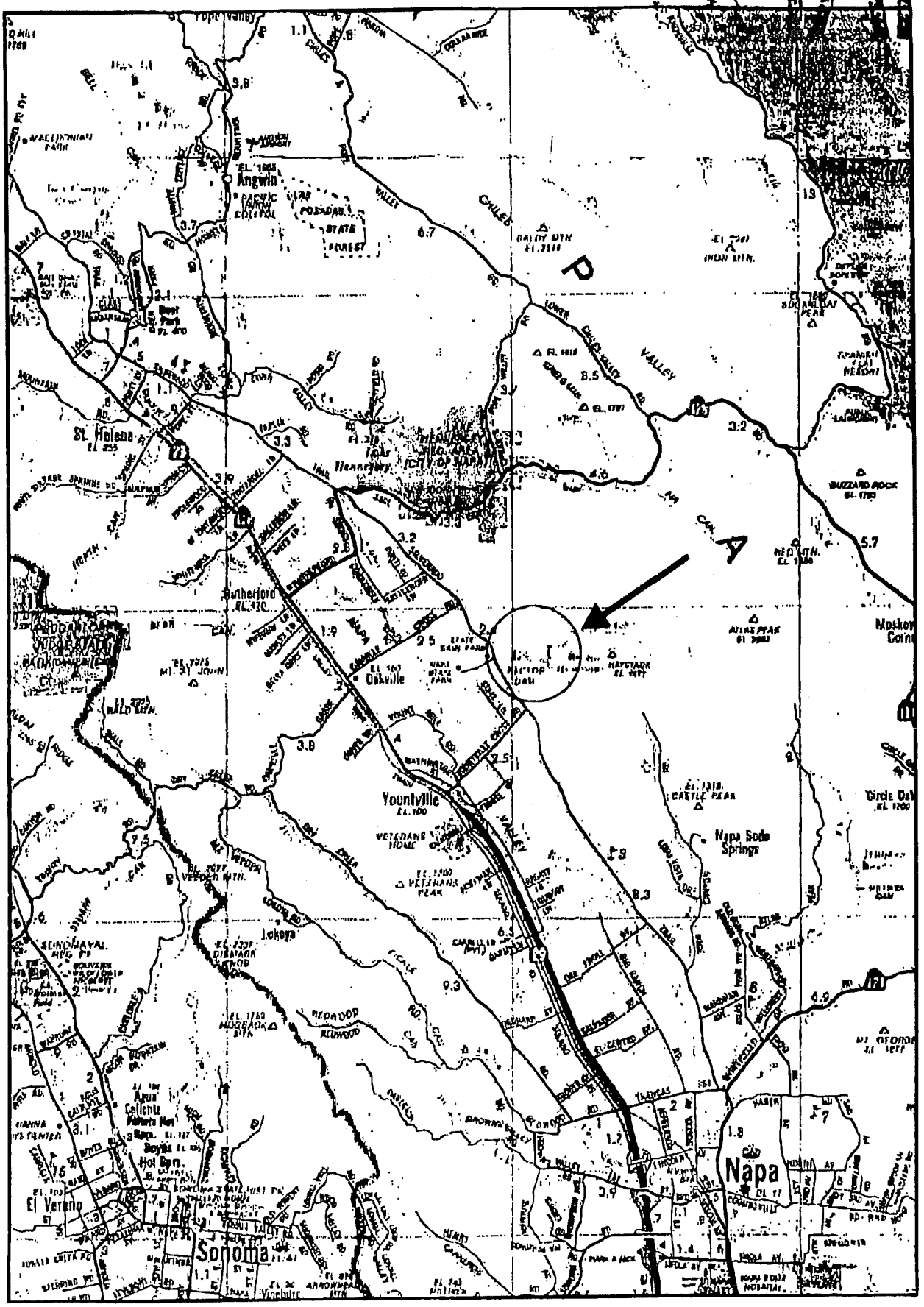

Figure 1

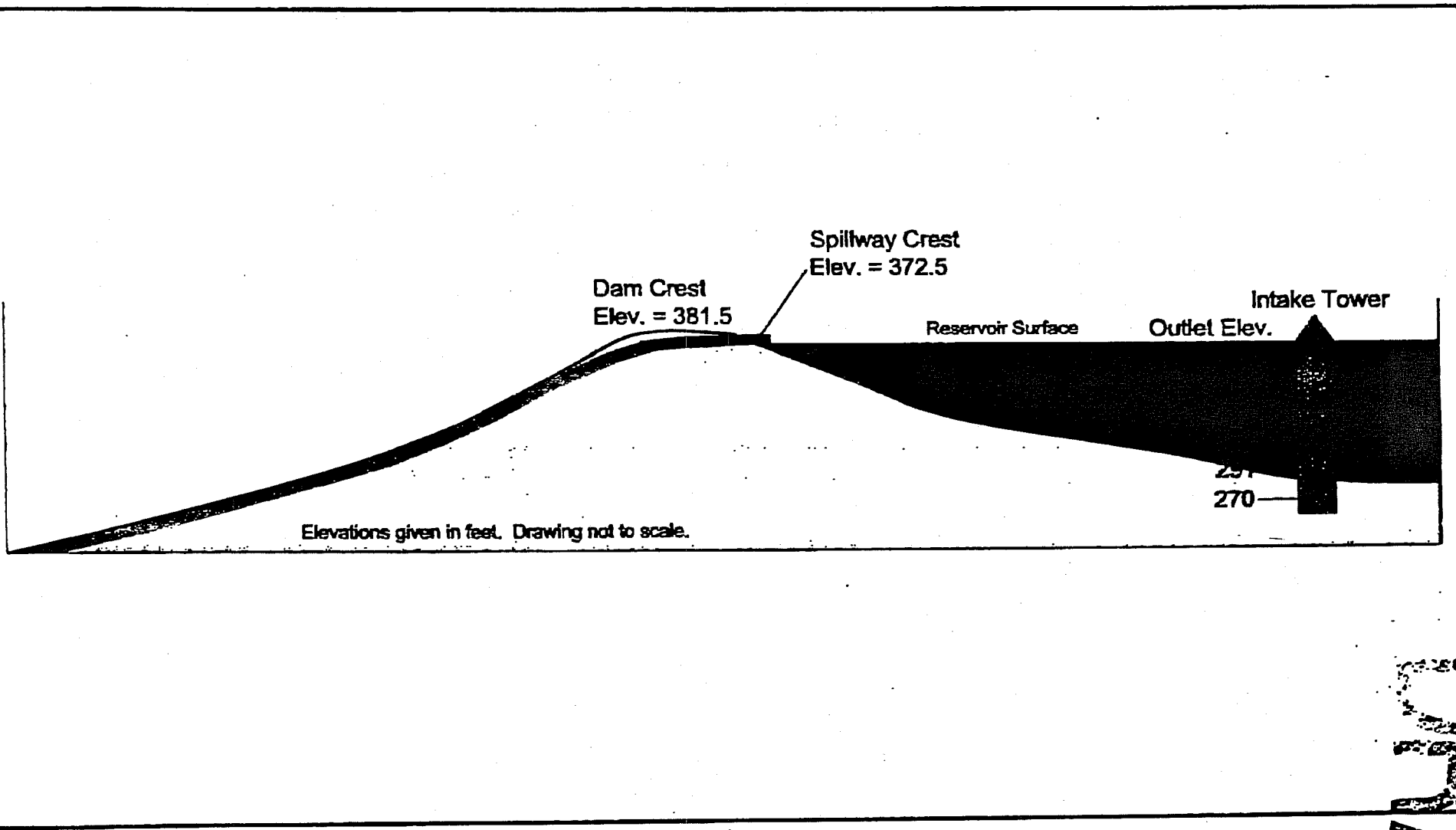

Figure 2
Profile of Rector Dam

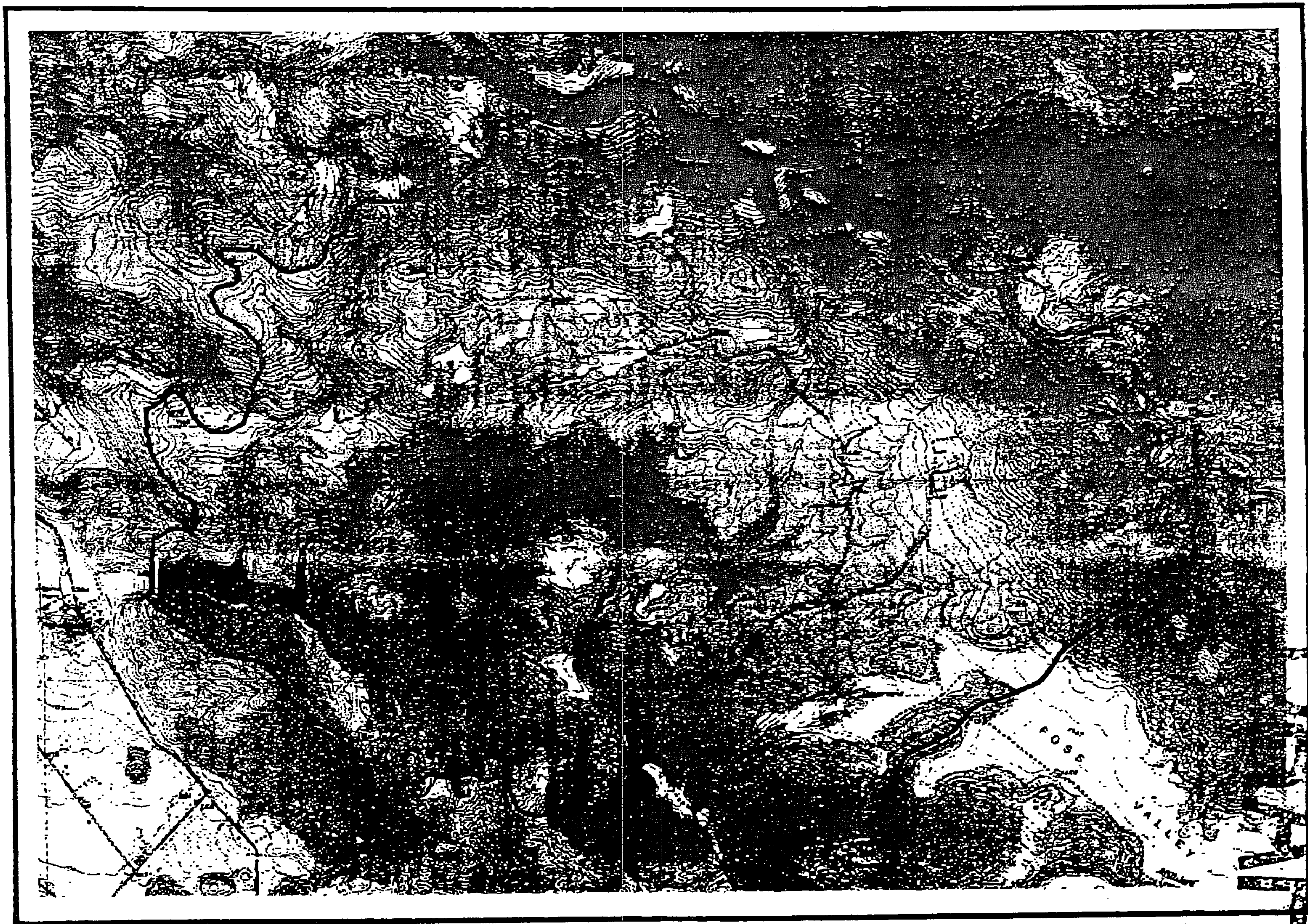

Figure 3.

Rector Creek Watershed

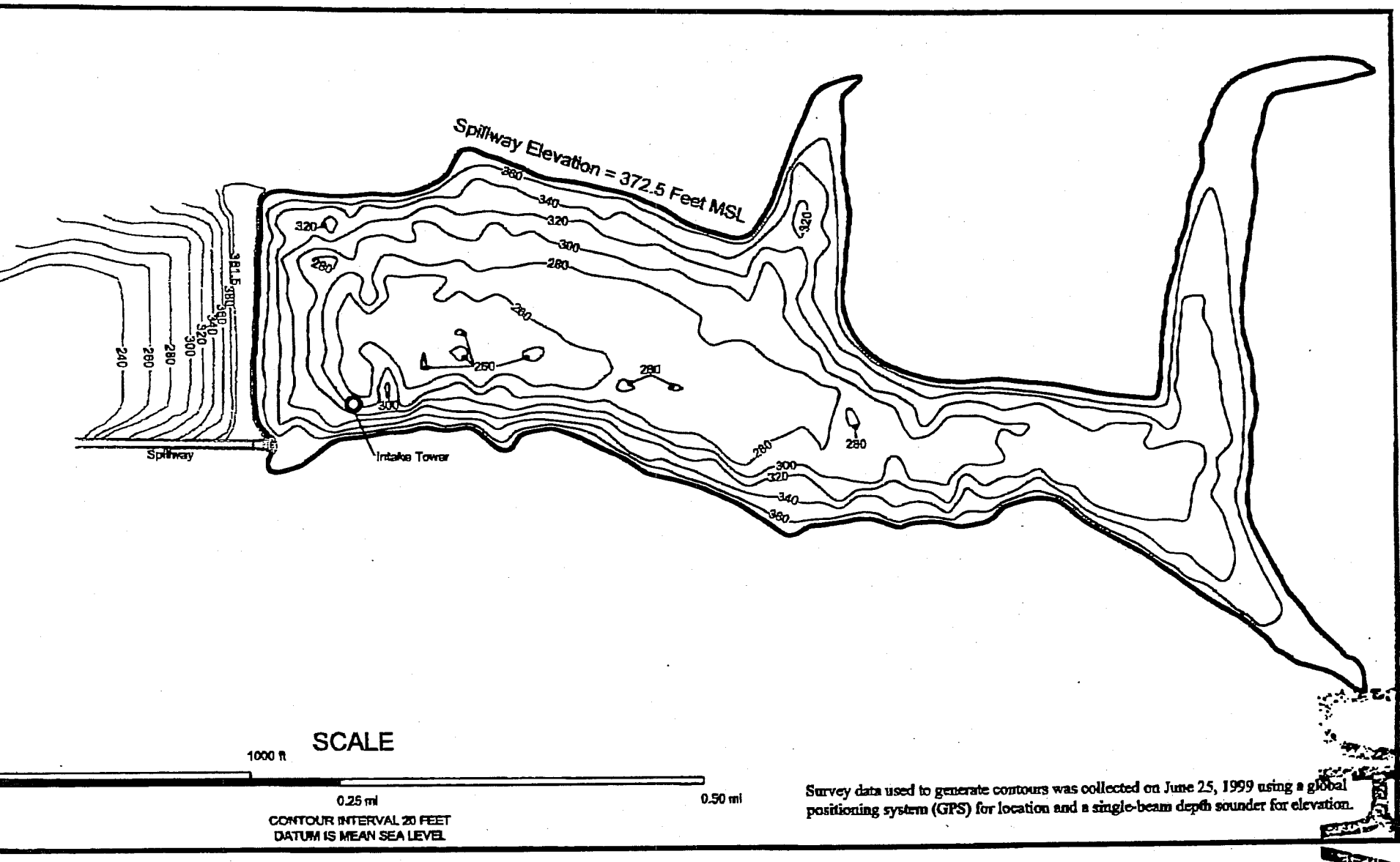

Figure 4

Elevation Contour Map

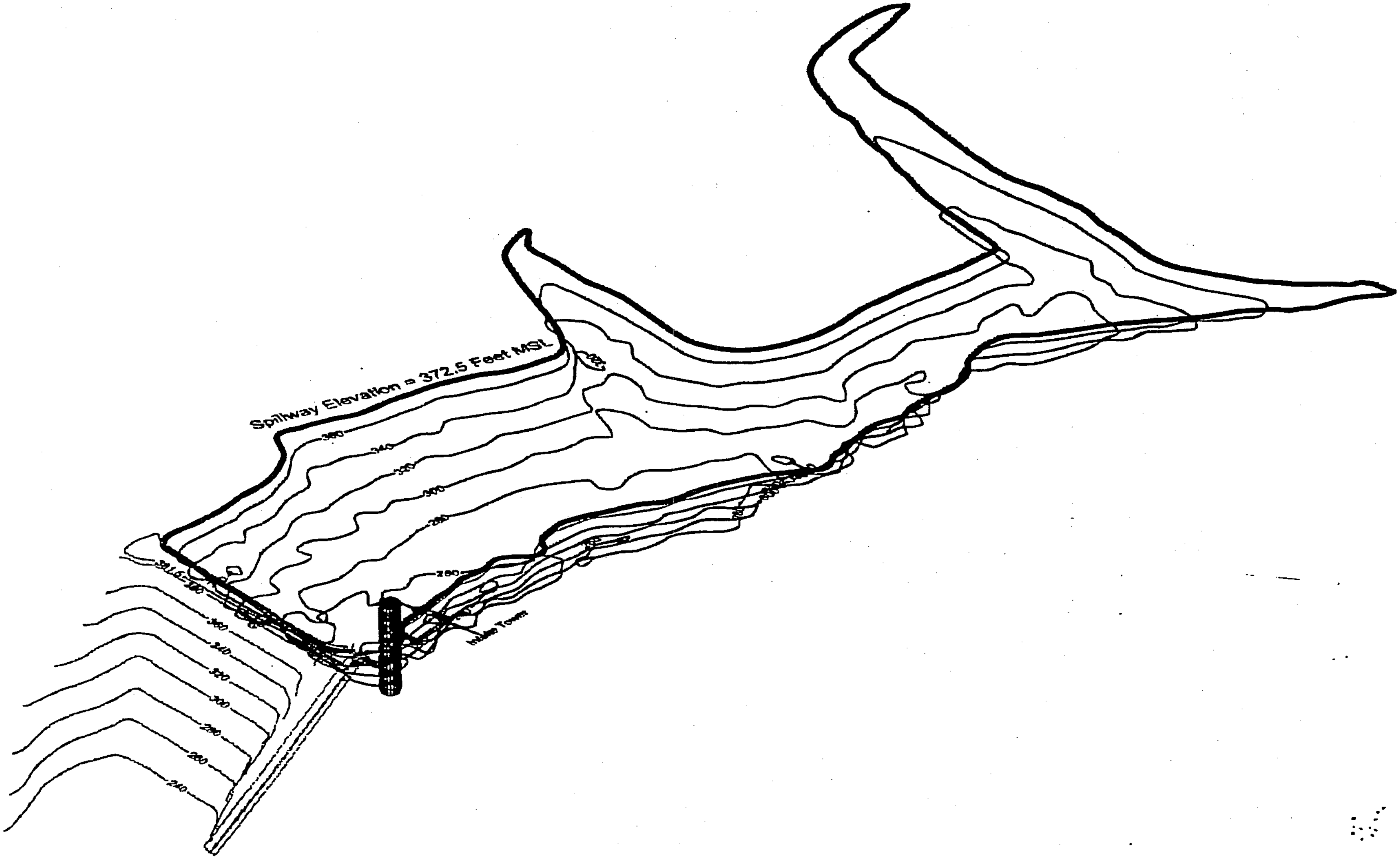

Figure 5
Isometric View of Rector Reservoir

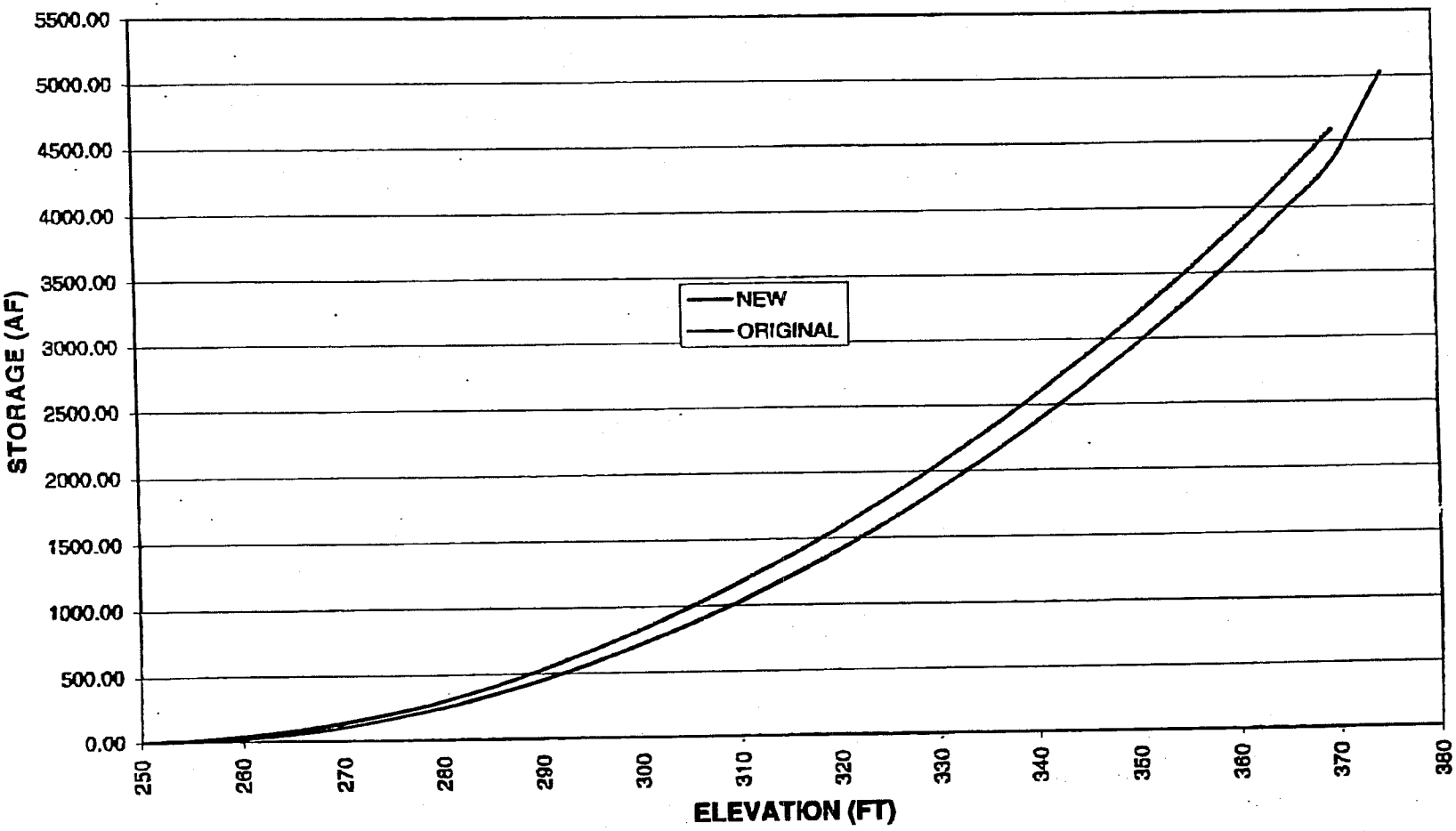

FIGURE 6
AREA - CAPACITY CURVES

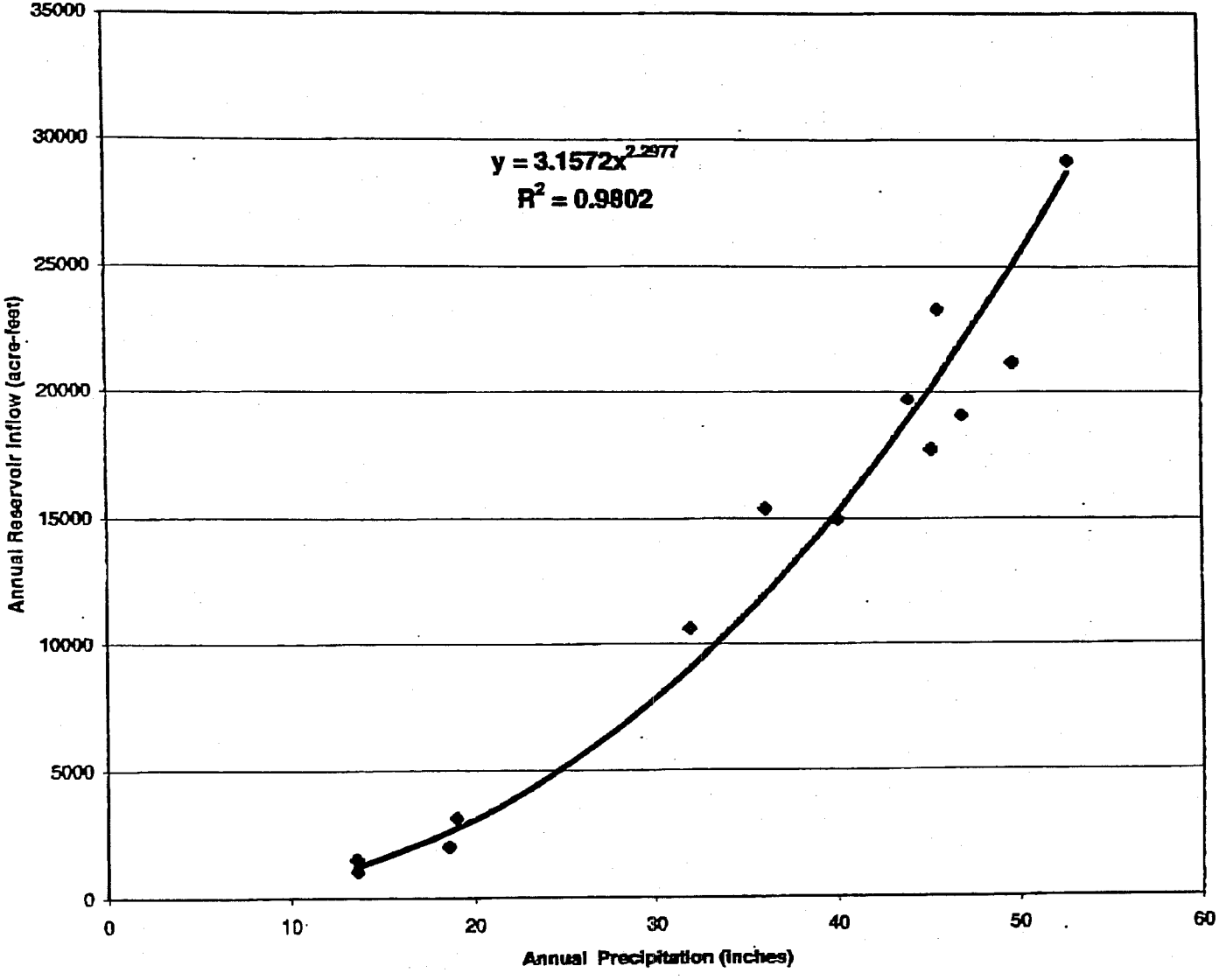

FIGURE 7
CORRELATION BETWEEN
ANNUAL RESERVOIR INFLOW AND ANNUAL PRECIPITATION

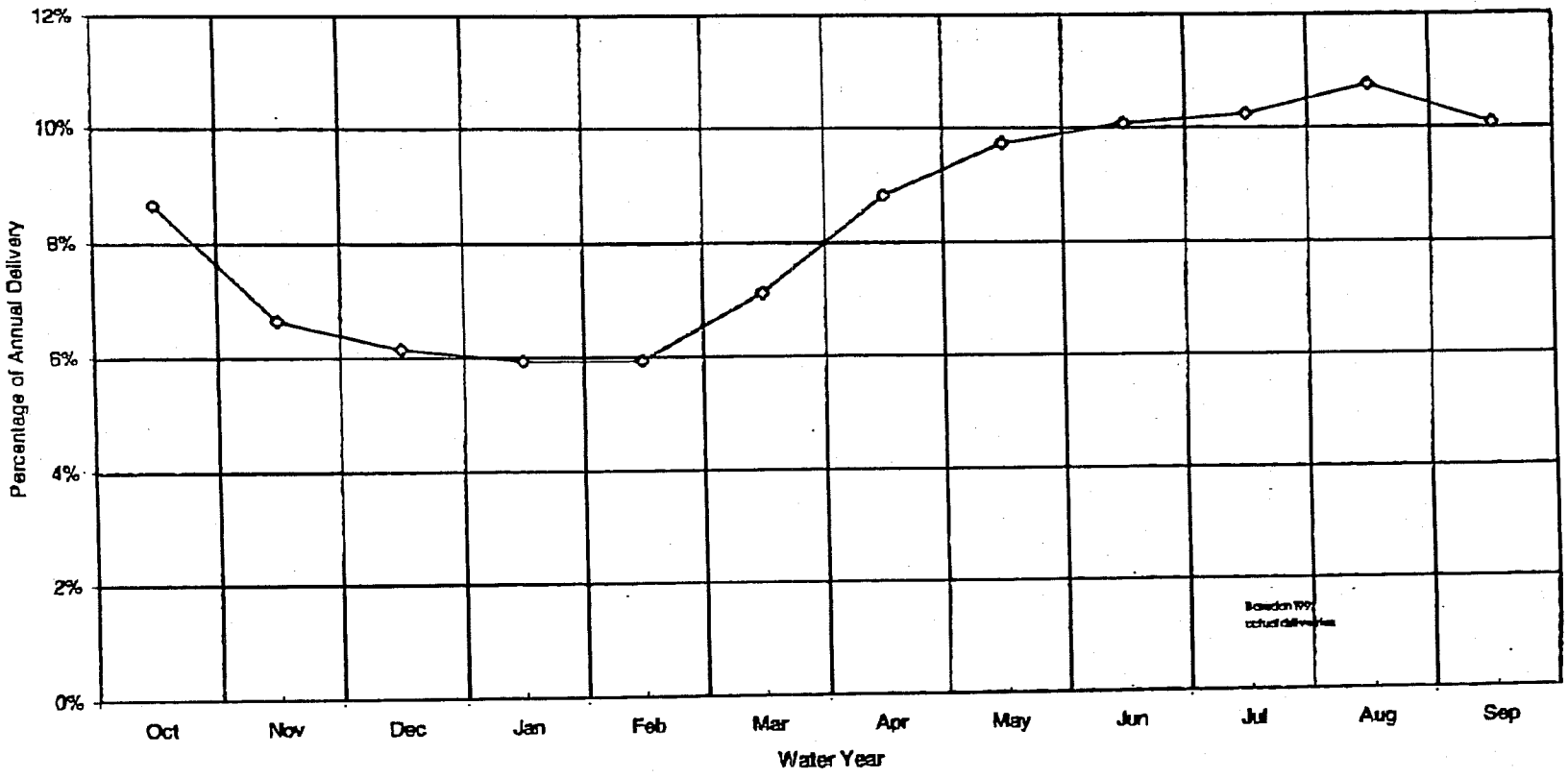

FIGURE 8
ASSUMED SCHEDULE OF DELIVERIES

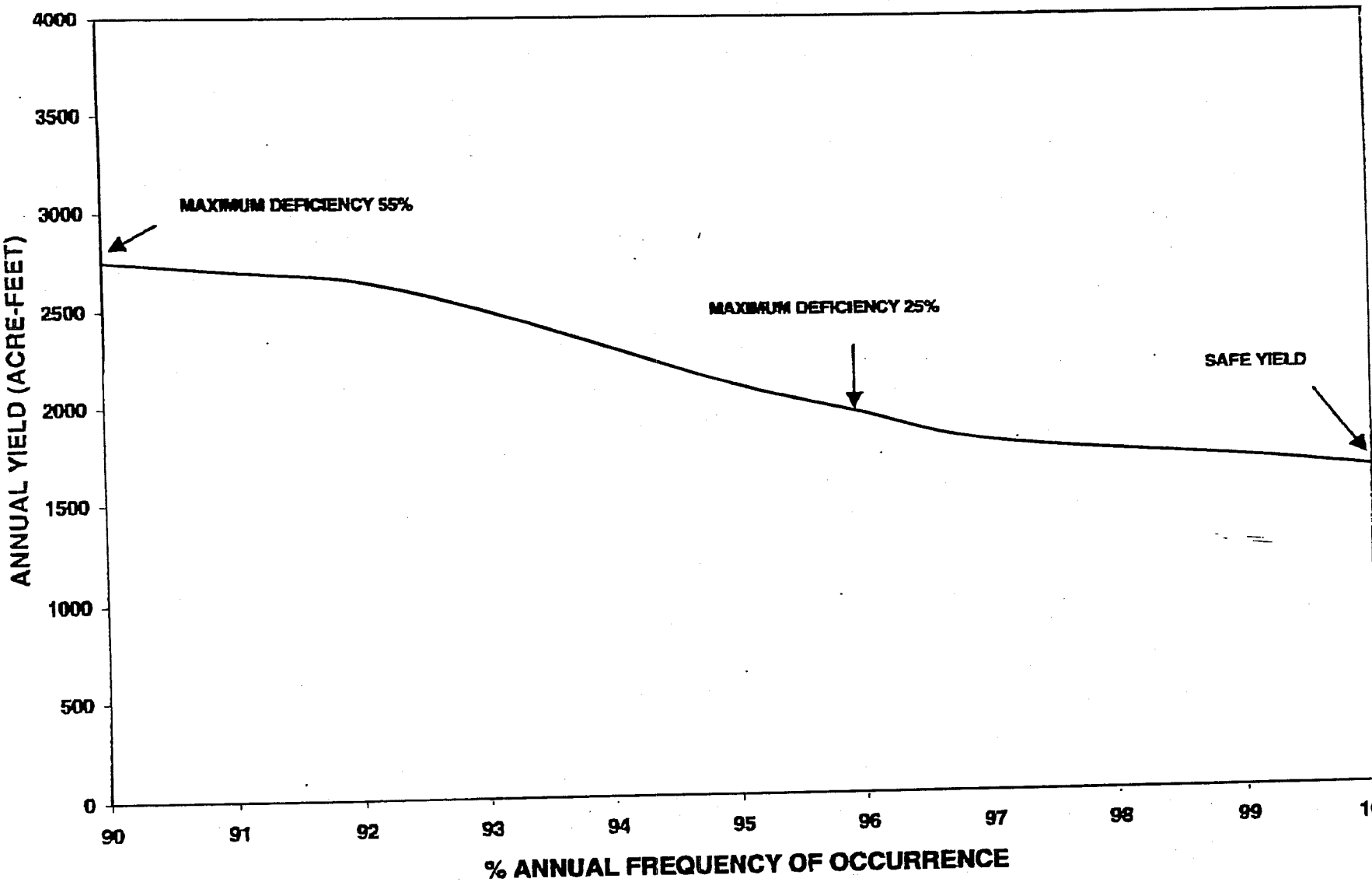

FIGURE 9
PRELIMINARY RANGE OF YIELDS

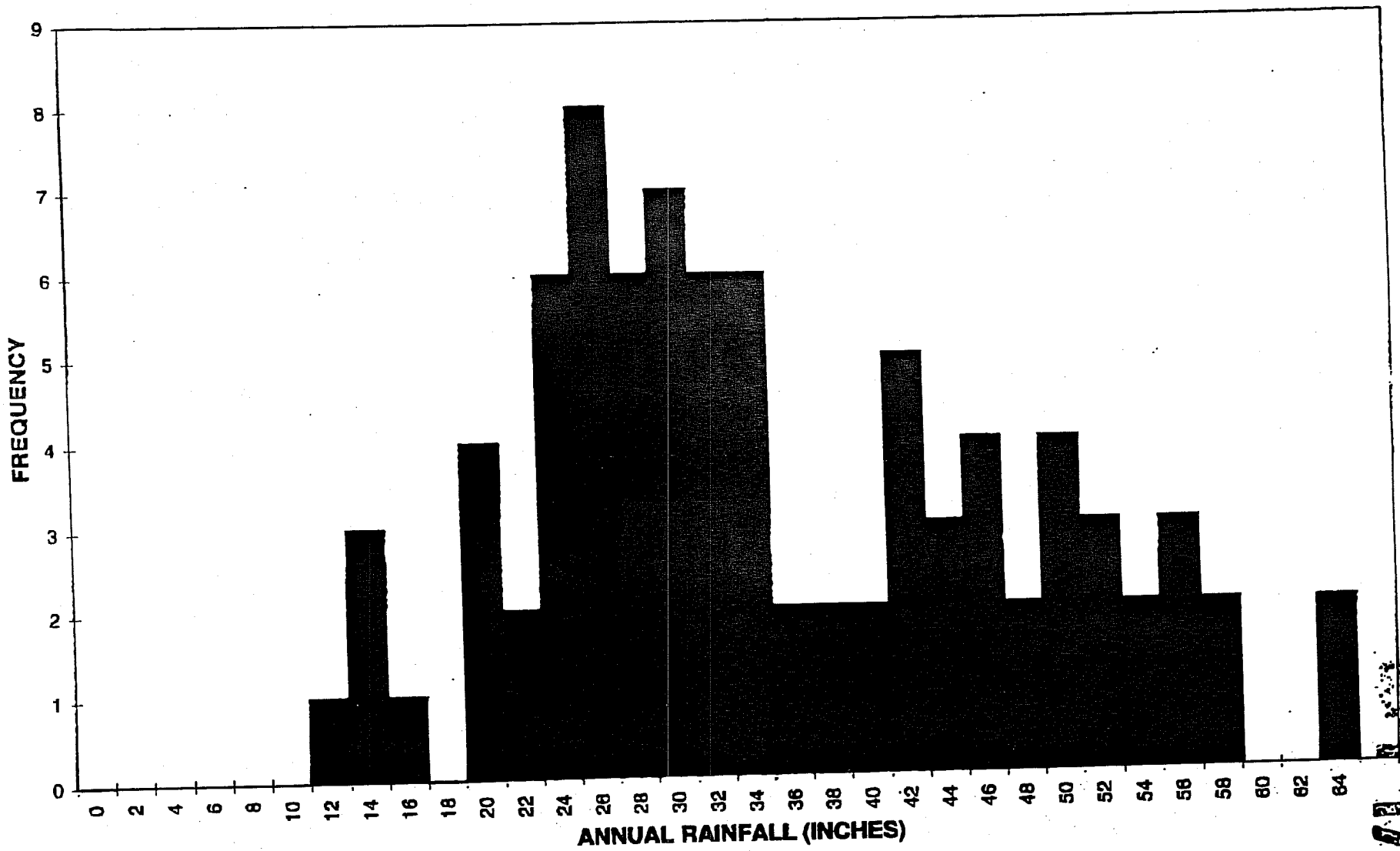

FIGURE 10
ANNUAL RAINFALL DISTRIBUTION AT YOUNTVILLE

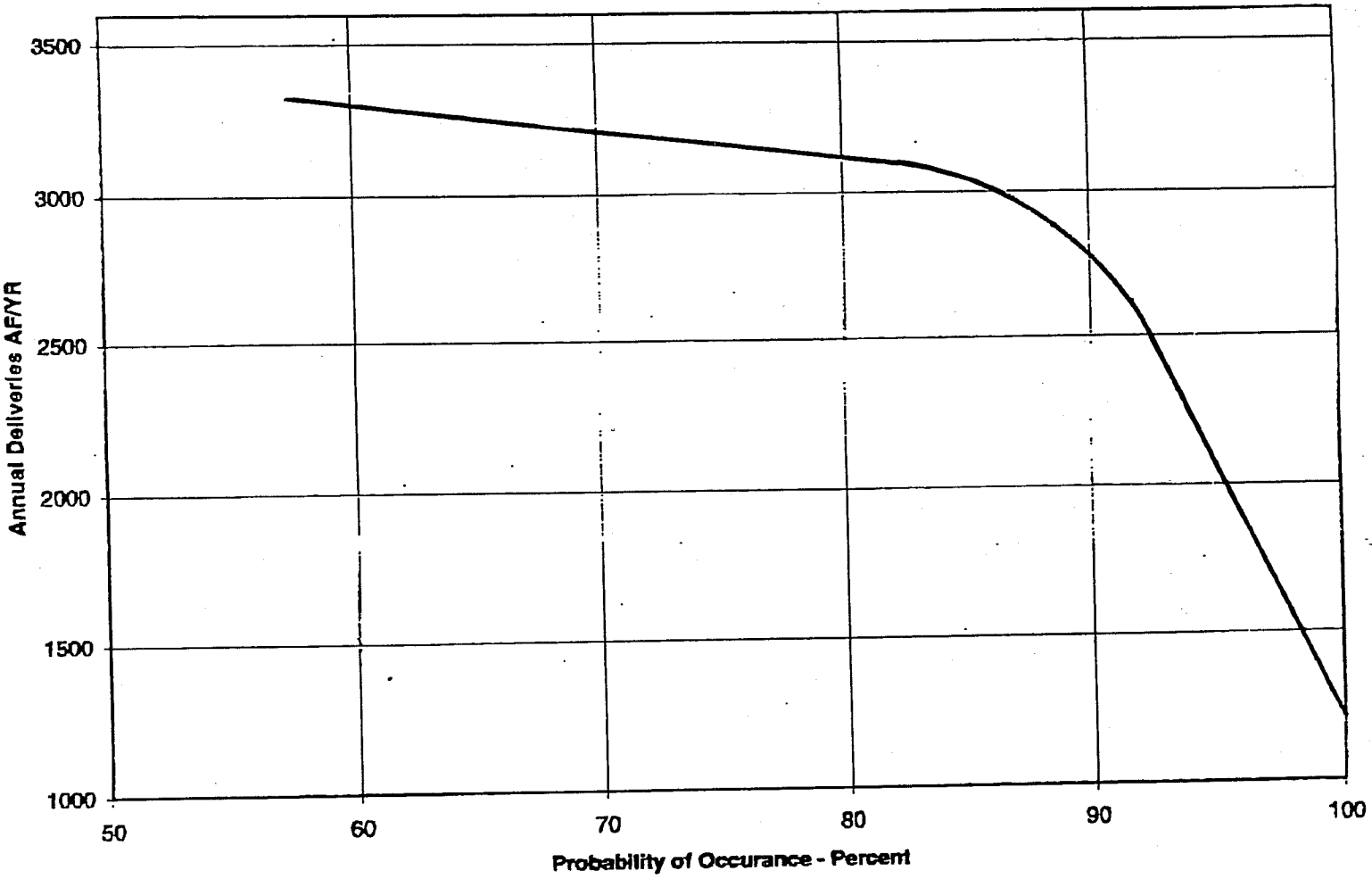

FIGURE 11
YIELD vs PROBABILITY OF OCCURANCE
FOR PROJECTED DELIVERIES

Table 1

Monthly Total Rainfall At Yountville Veterans Home

DWR # E30 9307 00

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
1914	0.00	8.11	15.97	22.06	6.96	1.75	1.71	0.75	0.29	0.00	0.00	0.10	57.70
1915	1.69	0.39	6.73	10.32	15.53	3.84	0.22	6.22	0.00	0.00	0.00	0.00	44.94
1916	0.05	1.18	10.99	21.47	4.52	2.81	0.00	0.18	0.04	0.06	0.04	0.32	41.66
1917	0.56	1.68	9.21	2.10	10.50	1.58	1.17	0.41	0.00	0.00	0.00	0.12	27.32
1918	0.00	0.60	2.81	1.17	8.52	3.63	0.75	0.00	0.00	0.00	0.00	2.54	20.02
1919	0.46	5.61	1.72	4.76	13.11	3.55	0.12	0.02	0.00	0.00	0.00	1.10	30.45
1920	0.72	0.04	5.92	0.12	0.76	2.78	3.67	0.00	0.31	0.00	0.00	0.17	14.49
1921	0.62	9.72	9.43	12.40	1.44	3.39	0.52	0.19	0.00	0.00	0.00	0.07	37.78
1922	0.52	4.75	7.30	1.81	9.01	3.32	0.46	0.28	0.07	0.00	0.00	0.00	27.52
1923	2.99	5.55	12.77	3.70	1.28	0.06	5.83	0.00	0.23	0.00	0.31	0.78	33.50
1924	0.24	0.27	1.20	4.49	4.66	1.49	0.09	0.27	0.00	0.00	0.08	0.00	12.79
1925	4.59	4.20	6.65	1.94	15.20	3.48	2.58	3.25	0.00	0.03	0.00	0.16	42.09
1926	0.45	3.26	2.13	6.99	11.17	0.07	7.96	0.32	0.00	0.00	0.13	0.00	32.48
1927	2.85	14.17	1.60	6.29	12.50	1.99	7.70	0.38	0.64	0.00	0.00	0.00	48.12
1928	0.72	8.31	5.17	3.43	4.71	7.64	2.63	0.35	0.00	0.00	0.00	0.00	32.96
1929	0.10	5.53	6.04	1.09	3.81	2.82	1.71	0.00	2.48	0.00	0.00	0.00	23.58
1930	0.02	0.00	10.91	4.82	4.68	4.60	2.60	0.41	0.00	0.00	0.00	0.27	28.31
1931	0.98	2.37	0.45	8.54	1.19	2.98	0.33	1.23	0.30	0.00	0.00	0.00	18.37
1932	2.05	2.99	13.60	3.68	2.30	1.08	1.12	1.98	0.17	0.00	0.00	0.00	28.96
1933	0.03	1.15	4.64	8.56	1.26	5.82	0.01	1.83	0.00	0.00	0.00	0.02	23.32
1934	3.13	0.00	10.02	2.32	6.14	0.51	0.63	0.85	0.52	0.00	0.06	0.10	24.28
1935	1.53	7.11	4.39	9.38	2.17	6.37	5.57	0.01	0.00	0.00	0.19	0.02	38.74
1936	1.27	1.11	3.16	9.76	11.59	2.23	2.73	0.44	0.99	0.00	0.02	0.02	33.32
1937	0.19	0.00	4.94	5.78	11.59	7.93	1.01	0.06	1.04	0.00	0.03	0.00	32.57
1938	0.94	6.04	8.64	4.97	17.64	11.16	2.95	0.02	0.00	0.00	0.00	0.17	52.52
1939	1.59	1.04	2.33	4.14	1.88	0.13	0.00	0.00	0.00	0.00	0.00	0.00	11.11
1940	0.00	0.73	2.66	16.02	16.45	8.85	1.42	1.62	0.00	0.00	0.00	0.09	47.94
1941	1.89	2.66	18.86	12.37	11.57	6.36	6.47	1.87	0.45	0.00	0.03	0.01	62.54
1942	1.31	3.73	12.99	8.29	10.80	3.84	6.36	2.98	0.00	0.00	0.00	0.00	50.30
1943	1.25	5.79	5.25	13.55	2.53	3.56	1.99	0.02	0.09	0.00	0.00	0.00	34.04
1944	0.62	0.99	2.24	6.03	9.30	4.31	2.70	1.60	0.30	0.00	0.02	0.00	28.11
1945	2.97	5.89	4.04	1.91	8.92	5.49	0.46	0.82	0.00	0.00	0.00	0.00	30.50
1946	6.34	4.92	12.64	1.11	2.19	2.11	0.61	0.69	0.00	0.09	0.00	0.05	30.75
1947	0.21	5.59	3.10	0.90	4.45	7.13	0.72	0.46	1.36	0.00	0.00	0.00	23.92
1948	6.92	0.87	1.02	2.50	1.56	5.72	7.27	1.04	0.10	0.00	0.02	0.23	27.25
1949	0.70	1.22	5.46	2.59	4.82	9.46	0.02	0.25	0.00	0.03	0.17	0.00	24.72
1950	0.00	4.54	3.16	11.28	5.36	2.77	1.64	0.48	0.00	0.00	0.00	0.00	29.23
1951	4.67	9.59	9.75	6.56	2.81	2.97	1.48	0.92	0.00	0.00	0.00	0.00	38.65
1952	2.64	6.37	12.62	14.54	4.25	6.48	0.82	0.66	0.94	0.00	0.00	0.00	49.32
1953	0.04	3.21	16.39	9.11	0.00	5.98	4.48	1.13	0.40	0.00	0.06	0.00	40.80
1954	0.65	5.34	0.98	11.45	5.75	6.18	3.25	0.20	0.11	0.02	0.50	0.00	34.43
1955	0.34	5.56	7.70	3.32	1.88	0.71	3.99	0.01	0.00	0.00	0.00	0.51	24.04

DRAFT

Table 1

Monthly Total Rainfall At Yountville Veterans Home

DWR # E30 9307 00

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
1956	0.19	3.34	25.82	12.05	10.12	0.21	2.50	0.51	0.03	0.00	0.00	0.26	55.03
1957	3.47	0.14	0.52	4.69	8.39	3.33	2.55	4.27	0.12	0.00	0.00	2.21	29.63
1958	6.05	1.06	5.46	8.24	17.52	8.63	7.68	0.78	0.43	0.00	0.00	0.02	55.88
1959	0.08	0.27	1.38	10.30	6.18	1.06	0.37	0.14	0.00	0.00	0.00	5.30	27.08
1960	0.00	0.01	2.24	6.34	9.00	3.85	1.58	1.78	0.00	0.00	0.00	0.00	24.80
1961	0.60	4.11	3.68	5.93	2.54	4.78	1.19	0.29	0.11	0.00	0.07	0.38	23.68
1962	0.13	4.42	4.57	2.86	13.34	5.84	0.31	0.00	0.00	0.00	0.02	0.00	31.49
1963	11.76	1.02	5.18	7.07	2.75	6.97	5.97	0.63	0.00	0.00	0.00	0.05	41.40
1964	2.63	6.66	0.76	4.76	0.23	2.90	0.26	0.16	0.56	0.02	0.03	0.00	18.97
1965	2.34	5.82	14.56	9.54	0.99	1.50	4.42	0.04	0.00	0.03	0.63	0.00	40.07
1966	0.03	7.29	4.93	10.22	3.65	0.47	0.75	0.09	0.15	0.20	0.28	0.07	28.33
1967	0.00	10.77	8.15	16.32	0.48	7.69	7.47	0.09	1.78	0.00	0.00	0.07	52.82
1968	0.89	1.99	5.09	12.17	4.42	4.14	0.35	0.29	0.00	0.00	0.53	0.00	29.87
1969	3.20	3.20	10.68	15.65	11.74	2.34	2.86	0.01	0.04	0.00	0.00	0.00	49.72
1970	2.62	1.34	13.00	19.44	4.06	2.99	0.18	0.00	0.37	0.00	0.00	0.00	44.00
1971	1.89	11.25	14.06	2.10	0.21	5.16	0.92	0.29	0.02	0.00	0.00	0.19	36.11
1972	0.16	2.79	6.39	2.66	2.93	0.42	2.14	0.10	0.20	0.00	0.00	0.76	18.56
1973	5.12	7.22	4.53	16.10	9.94	3.26	0.17	0.05	0.00	0.00	0.00	0.56	46.95
1974	2.41	14.38	6.64	5.57	2.64	10.13	2.68	0.11	0.00	1.19	0.00	0.00	45.65
1975	1.32	0.97	4.49	1.17	12.55	9.24	1.99	0.01	0.00	0.14	0.07	0.00	31.95
1976	4.44	0.67	0.74	0.46	1.02	2.34	1.66	0.00	0.04	0.00	1.00	1.04	13.61
1977	0.31	1.26	1.29	2.39	1.90	3.01	0.18	1.94	0.00	0.00	0.00	1.27	13.56
1978	0.56	6.33	6.34	14.59	6.11	5.79	4.51	0.03	0.00	0.00	0.00	1.00	45.26
1979	0.00	2.16	0.81	10.99	7.54	1.79	1.70	0.67	0.00	0.00	0.00	0.04	25.72
1980	4.48	3.49	7.23	8.95	12.04	2.25	2.49	0.55	0.18	0.07	0.00	0.00	41.73
1981	0.29	0.24	5.19	6.74	2.03	4.65	0.40	0.13	0.00	0.00	0.00	0.23	19.90
1982	3.79	8.46	8.78	9.54	4.54	9.23	5.87	0.00	0.06	0.00	0.00	1.42	51.69
1983	3.30	10.41	5.43	1.34	12.70	16.28	4.57	0.49	0.00	0.00	0.26	0.57	55.35
1984	0.94	10.96	11.92	0.59	2.28	2.81	1.08	0.15	0.20	0.01	0.35	0.09	31.38
1985	1.94	11.12	1.72	1.71	4.95	5.33	0.14	0.01	0.03	0.00	0.00	0.59	27.54
1986	1.96	4.16	3.81	6.36	24.42	9.38	0.61	0.32	0.00	0.00	0.00	1.23	51.67
1987	0.20	0.05	1.88	4.53	8.05	5.23	0.11	0.01	0.00	0.00	0.00	0.00	20.06
1988	1.47	3.53	9.19	6.18	0.57	0.28	2.86	0.67	0.16	0.00	0.00	0.00	24.91
1989	0.13	5.23	4.21	1.33	1.17	10.11	0.55	0.04	0.07	0.00	0.00	1.74	24.58
1990	2.66	2.59	0.00	5.97	4.71	1.44	0.15	4.50	0.00	0.00	0.00	0.07	22.29
1991	0.31	0.64	1.08	0.51	4.40	15.73	0.33	0.19	0.56	0.00	0.44	0.01	24.20
1992	1.73	1.22	2.84	2.16	10.20	6.77	0.89	0.00	0.88	0.00	0.00	0.00	26.69
1993	4.44	0.21	11.45	17.09	9.04	2.52	1.73	1.54	0.54	0.00	0.00	0.00	48.56
1994	1.49	3.53	5.37	2.79	5.90	0.17	1.83	1.42	0.01	0.00	0.00	0.00	22.51
1995	0.98	6.97	4.49	25.54	0.79	19.38	1.87	2.15	0.60	0.00	0.00	0.00	62.77
1996	0.00	0.16	12.30	10.69	11.24	2.82	4.03	3.99	0.00	0.00	0.00	0.00	45.25
1997	1.81	4.31	17.99	14.50	0.46	1.26	0.49	0.44	0.28	0.00	0.00	0.00	41.56

YIELD SUMMARY

USING ASSUMED DELIVERY SCHEDULE

Maximum reservoir capacity	4535 af
Carryover storage *	2768 af
Minumum reservoir stage	343.5 ft
Safe Yield (af)	1670

With deficiencies:

Yield	% Deficiency	Number of years with deficiencies
1670	0	0
1727	0 - 5	1
1811	0 - 10	3
1850	0 - 15	3
1890	0 - 20	3
1940	0 - 25	3

* Includes 478 (af) of dead pool storage

Table 3

TABLE 2
DELIVERIES FOR 1963 TO 1978

onth	Deliveries (af)															
	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
N		130.36	146.99	70.9	107.45	69.42	91.7	104.64	156.81	78	92.47	105	123.78	102.3	29.5	161.2
EB		118.31	136.35	107.51	90.49	66.56	82.18	98.88	139.84	75.76	92	139.67	116.52	109.8	111.2	167
AR		145.57	137.39	124	116.28	71.21	113.31	151.24	157.71	94.75	110	158.29	116.37	149.6	96.7	219.3
PR		177.32	170.05	272.84	105.3	108.69	209.79	343.02	153.15	124.57	120.75	198.05	149.07	107.9	98.9	318
AY		305.55	279.66	344.28	292.56	298.32	140.47	330.87	277.94	157.1	292.83	377.5	369.4	223.6	131	446
N		284.67	346.47	333	352.15	341.67	204.21	317.76	330.966	176.52	352.29	393.84	402.1	247.5	133.7	394.4
L		246.17	301.95	346	383.47	339.39	156.33	328.99	336.73	354.53	369.69	384.31	373.3	243	105.3	357.2
UG		343.01	339.93	353.81	363.97	319.14	327.81	328.76	409.11	338.47	372.97	345.91	335.2	116.1	93.9	213.5
EP		24.75	277.34	309.8	261.95	304.62	306.77	207.68	229.72	297.85	347.77	320.13	173.8	90.6	88.2	149.5
CT	168.36	548.89	312.85	274	786.81	207	306.47	160.82	329.88	121.7	299.79	222.55	292.42	105.6	60.7	159.8
OV	86.51	112.27	181	74.28	81.85	84.95	172.32	133.15	297	96.96	260.74	132.04	91.64	122.1	148.3	142
EC	150.35	157.73	71.65	94.88	73	88.75	105.19	125.35	191.76	84.31	109.33	127.65	92.4	106.9	171.1	140

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Table 4
Rector Reservoir

Projected Deliveries (acre-feet) for a Normal Year													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Creek Releases	0	0	0	30	95	95	95	95	95	95	95	95	790
Treatment Plt. Water	10	10	10	10	10	10	10	10	10	10	10	10	120*
Veterans Home	49	29	31	34	63	67	77	71	61	69	53	47	650
Fish & Game	120	120	150	150	150	150	10	10	10	10	60	60	1000
Napa State Hospital	26	22	24	26	43	45	64	66	56	63	22	24	481
Town of Yountville	10	10	20	25	50	70	75	75	60	50	30	25	500
Totals	215	191	235	275	411	437	331	327	292	297	270	261	3541

Projected Deliveries (acre-feet) for a Dry Year													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Creek Releases	0	20	61	61	61	61	61	61	61	61	61	61	630
Treatment Plt. Water	10	10	10	10	10	10	10	10	10	10	10	10	120*
Veterans Home	49	29	31	34	63	67	77	71	61	69	53	47	650
Fish & Game	90	90	90	120	120	60	1	1	1	1	60	60	694
Napa State Hospital	25	25	28	27	42	66	69	75	37	55	38	26	513
Town of Yountville	10	10	15	20	40	60	70	70	50	40	25	20	430
Totals	184	184	235	272	336	324	288	288	220	236	247	224	3037

Projected Deliveries (acre-feet) for a Critically Dry Year													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Creek Releases	61	61	61	61	61	61	61	61	61	61	61	61	732
Treatment Plt. Water	10	10	10	10	10	10	10	10	10	10	10	10	120*
Veterans Home	49	29	31	34	63	67	77	71	61	69	53	47	650
Fish & Game	60	60	60	80	80	40	1	1	1	1	40	40	464
Napa State Hospital	24	22	26	45	54	62	78	63	60	53	27	30	544
Town of Yountville	10	10	10	15	35	55	60	60	40	30	20	15	360
Totals	214	192	198	245	303	295	287	266	233	224	211	203	2870

*Plant water is for back washing and plant uses. This could be higher or lower depending on how much water is being treated and how dirty the water is. Plant water will be the same for all years.