Appendix H

CMWD Water Supply and Demand Study

CASITAS MUNICIPAL WATER DISTRICT

WATER SUPPLY AND USE STATUS REPORT

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TABLE OF CONTENTS

INDEX OF TABLES

INDEX OF FIGURES

CASITAS MUNICIPAL WATER DISTRICT

WATER SUPPLY AND USE STATUS REPORT

PURPOSE

The purpose of this report is to provide information on the status of water supply and use for the Casitas Municipal Water District (Casitas) and suggest strategies for meeting water use in the future.

BACKGROUND

Quantifying water supply and use patterns in the Ventura River Basin can be a complicated task. To aide in the understanding of these patterns and their implications to water management activities, this section provides useful definitions of water supply and use terms, describes previous water supply and use studies, and summarizes recent changes to water supply and use within the district.

USEFUL DEFINITIONS

Water Supply: Quantity of water managed by Casitas.
This term refers to the quantity of surface water and groundwater resources managed by Casitas within the Ventura River Basin.

Safe Yield: Rate at which the available water supply can be "safely" depleted.
This term was defined by Meinzer (1) as "the rate at which water can be withdrawn from an aquifer for human use without depleting the supply to such an extent that the withdrawal at this rate is harmful to the aquifer itself, or to the quantity of water, or is no longer economically feasible." The calculation of safe yield for Casitas is based on the storage volume of Lake Casitas (the aquifer), the surface water and groundwater supply managed by Casitas, and the length of time that the water supply needs to last (i.e. longest drought on record). The safe yield value is an interpolated value that is held constant over the period of the critical drought, bringing the level of storage to the desired minimum volume.

Water Use: Quantity of water delivered from Lake Casitas to the conveyance system, as measured at the start of the system at Casitas Dam.
This term is used to describe the volume of water that is directly taken from the available water supply. Casitas measures the rate of water use by quantifying the amount of water delivered to the water distribution system from Lake Casitas. The measurement of water use is performed through the use of accurate flow tube sensors.

Metered Water Sales: Quantity of water that is metered and sold at the individual service connections in the water distribution system.

This term refers to the summation of the quantity water measured through water service connections within the Casitas district. The metered water sales are categorized by the type of customer (i.e. residential, business, resale, and agriculture) and summarized on an annual basis.

Water Allocation: Quantity of water assigned to service connections.
This term refers to the primary tool used by Casitas to manage the quantity of water used by customers (i.e. metered water sales). Service connections are assigned an allocation (limited quantity of water). Residential, business, industrial, resale, and interdepartmental service connections have individual allocations. Agricultural service connections are combined into a single allocation for the entire group. The allocation program was designed as a price-driven water conservation measure that provides for a base cost that escalates once metered water sales exceed service connection allocations.

PREVIOUS WATER SUPPLY AND USE STUDIES

The ability of local water supplies to meet demands was evaluated by the Bureau of Reclamation, in the 1954 evaluation of Ventura River Project, and later by the District during the 1989 drought period. Each of these evaluations considered the ability of Lake Casitas storage, under the hydrology determined as the most critical drought period of record, to meet the water demands of the District's service area. The critical drought period of record is considered to have occurred during 1944 through 1965. The findings of each report are summarized in a memorandum prepared by Richard Barnett, dated June 7, 1989, were as follows:

1) The safe yield of Lake Casitas without an integrated Matilija Dam was 21,500 acre-feet, and 21,920 with Matilija Dam as a part of the system;
2) The estimated total water supplies in the District service area was 30,907 acre-feet and the water demands for the same service area were approximately 30,320 acre-feet;
3) The District should consider implementing a variety of alternatives for balancing water supply and demand.

RECENT WATER SUPPLY/USE CHANGES

In 1989, the District's service area was in the middle of a short-term drought that began in 1987 and ended in March 1992. The Ventura River and Ojai groundwater basins were being depleted and Lake Casitas water storage dropped to near fifty percent capacity. The District-wide water usage was beginning to escalate because of the lack of rainfall and the depletion of groundwater supplies. The Casitas Municipal Water District recognized that water use was very rapidly approaching the availability of supply (Barnett Memorandum, June 7, 1989) and that the District needed to apply strategies to meet future water needs. The District moved to a temporary moratorium on providing new water service connections. The moratorium continued for approximately two years until an additional 300 acre-feet of water was developed from Mira Monte Well. The Mira Monte Well supply, therefore, was available for issuance of new water service connections.

During the 1990's, the drought pattern ended with the occurrence of three heavy rainfall years (1992, 1995, and 1998). Lake Casitas and the groundwater basins filled to full capacity. The District continued to issue new service connections on the basis of water made available from the Mira Monte Well supply. The addition of new water service connections in the District's service area grew slowly, averaging approximately 25 new service connections each year for the 1990's.

One major water use change occurred in 1991. The City of San Buenaventura reduced their use of Casitas water due of the lack of filtration treatment of Lake Casitas water supplies. The City purchased 9,510 acre-feet during 1989 and reduced water purchases to only 1,370 acre-feet in 1992. The reduction in metered water sales by the City continued until 1997, when the District finally met the filtration requirements. The City and the District came to agreement that the annual metered water sales to the City from Casitas supplies would be a minimum of 6,000 acre-feet.

In 1997, the National Marine Fisheries Service (NMFS) listed anadromous steelhead in Southern California as endangered under the Endangered Species Act. The Ventura River Basin has been identified as important spawning habitat for Southern California steelhead. A result of this listing was the requirement for the District to construct a fish passage facility at the Robles Diversion Dam and change the Robles Diversion operational release criteria to one that provided additional downstream release of flows for fish passage. The issuance of the Biological Opinion (BO) by the NMFS in March 2003 set into place the revised operational criteria for the Robles Diversion Dam and Fish Passage Facility. The change of operational criteria for the Robles Diversion Facility has caused Casitas to take immediate management actions to ensure the protection of long-term water supplies.

On April 23, 2003, Casitas suspended the issuance of new water service connections. The suspension has remained in effect through June 8, 2004. It will remain in effect as long as deemed necessary by the Casitas Board of Directors. Since suspending new service connections, Casitas has implemented water conservation measures, evaluated potential supplies of additional water, and initiated an evaluation of water supply and use within the district. The purpose of this narrative is to present results of the water supply/use analysis.

Another significant potential change to Casitas water supplies is the future disposition of Matilija Dam. This facility is presently being evaluated for the potential decommissioning and removal. Sediment deposition in the Matilija Reservoir has reduced the water storage volume behind Matilija Dam to approximately 600 acre-feet. NMFS has made the determination that the dam structure is a barrier to steelhead migration. The goals of the project proponents are to promote the migration of steelhead to the upper reaches of the Matilija Creek and enhance movement of sediment to Ventura County beaches. The removal of the Matilija Dam could impact water supply and water quality for both the short term and long term. It is important, therefore, for Casitas to have a clear understanding of these potential impacts.

CURRENT WATER SUPPLY AND USE STUDY

This study evaluated the: (1) potential impact of the Robles BO operating criteria and the removal of Matilija Dam on the Casitas water supply, (2) the effect of predicted water use on the Casitas water supply, and (3) levels of reductions in water use required to balance water supply and use. The study applies hydrology information from 1945 through 1965 as the critical drought period and information from 1966 through 1980 as the reservoir recovery period. These periods have empirical hydrology information that provide an opportunity to model different operating scenarios for the Robles Diversion Facility.

WATER SUPPLY

The Casitas water supply was evaluated with a reservoir routing model. It included application of the Robles BO Operating Criteria and the 1959 Trial Operating Criteria for Robles Diversion Facility during the drought and reservoir recovery periods. The evaluation also considered the benefit of Matilija Dam to water supply. The methods, assumptions, and summaries that were applied and developed for the water supply evaluations are outlined in **Appendix A**.

WATER USE

Predictions for Casitas water use were developed for the drought and reservoir recovery periods. Empirical information on the quantity of water delivered to the conveyance system was limited to the post 1959 period. Therefore, a model to predict Casitas water use for the drought (1945-1965) and reservoir recovery (1966-1980) periods was developed. The predicted water use is based on recent historical trends o water use in the District's service area and annual rainfall records for both periods. The methods, assumptions, and summaries that were applied and developed for the water use predictions are outlined in **Appendix B**.

BALANCING USE WITH SUPPLY

To determine the level of reduction required to balance water use (Appendix B) with water supply (Appendix A), for any operational scenarios that predicted a water shortage, four different scenarios were evaluated. These included: (1) a constant percent reduction in use, (2) a staged reduction in use, (3) an inverse staged reduction in use, and (4) a volume reduction in use. Implementation of any reduction in use, at this point, would rely on the Casitas Allocation Program. Casitas adopted the water allocation program to primarily provide water use guidelines and reductions in the event of a prolonged drought. **Appendix C** provides an assessment of the current level of allocation issued by the District and direction on further action on this program.

FINDINGS

CRITICAL DROUGHT PERIOD (1945-1965)

The critical drought study period represents the longest drought on record. Within the Ventura River Basin the longest drought on record occurred between the 1945 and 1965 water years. A numerical summary of the analytical results for the critical drought period is provided in Table 1.

Water Supply and Safe Yield: With the Matilija Dam remaining in operation, the reservoir routing model predicted the annual Lake Casitas safe yield for the 1959 Trial Operating Criteria and the Biological Opinion Operating Criteria at 22,770 and 21,630 acre-feet, respectively. The reduction of the annual safe yield, when moving from the 1959 Operating Criteria to the Robles BO Operating Criteria, is approximately 1,140 acre-feet. The total difference of safe yield volume of water that would accumulate through the change in operational criteria at Robles Diversion Dam over the 21-year critical dry period is 23,940 acre-feet. In the event Matilija Dam is decommissioned and removed, the available supply under the Robles BO Operating Criteria will be further reduced by

790 acre-feet. Under this scenario, the annual safe yield supply for the drought period would be 20,840 acre-feet. The difference between the annual safe yield available supplies under the 1959 Trial Operating Criteria with Matilija Dam and the Robles BO Operating Criteria without Matilija Dam is 1,930 acre-feet.

Predicted Water Use. Predicted water use patterns for this study period illustrated that consecutive dry year water demands could place stress water supplies in Lake Casitas. Based on the rainfall patterns of the critical drought period, the predicted average annual water use is 21,200 acre-feet, as shown on Table B6. The maximum to minimum values of predicted annual water use, based on consecutive dry year trend equation, is 27,057 and 15,610 acre-feet, respectively.

Comparison between Water Supply and Water Use. Water supplies exceeded water use, throughout the study period, in all but one operational scenario: Robles BO operating criteria without benefit of Matilija (Table 1). In this case, water use could exceed supplies by approximately 360 acre-feet per year. Over the 21-year study period, this annual difference could accumulate to a deficiency of supply in the amount of 7,560 acre-feet.

RESERVOIR RECOVERY PERIOD (1966 TO 1980)

The recovery period represents the hydrologic patterns immediately following the critical drought study period. For this analysis, it occurred from the time Lake Casitas would be at its lowest storage volume (as a result of drought conditions) until the reservoir was at full storage capacity. This time period was occurred form the 1965 through the 1980 water years. In actual perspective, this was the actual period that Lake Casitas went from a newly created lake to full capacity. A numerical summary of the analytical results for the reservoir recovery period is provided in Table 2.

Water Supply and Yield: Yield, for this study period, was determined by iteratively applying a constant rate of depletion to the water supply in Lake Casitas until a value was reached where the reservoir filled at the same point in time as the D20 study (February 1980). This approach was applied to each of the operational scenarios. Under the wetter conditions of this study period, the yield values vary from a maximum of 24,180 acre-feet under the 1959 Trial Operating Criteria with Matilija Dam, to a minimum of yield value of 19,780 acre-feet under the BO Operating Criteria without Matilija Dam.

Predicted Water Use. The higher rainfall years represented in the recovery study period tended to reduce water use within the District's service area. The average annual predicted water use for the period is 18,820 acre-feet, as shown on Table B9. The maximum to minimum range of predicted water use, based on consecutive dry year trend equation, are 22,704 and 15,249 acre-feet, respectively. These reduction in predicted water use, from that experienced during the drought cycle, is primarily due to lower quantities of water used for agriculture. For orchard crops, less water is required from Lake Casitas during the wet periods.

Comparison between Water Supply and Water Use. Under all four of the operational criteria conditions studied for the reservoir recovery period, the available yield (water supply) values are higher than the predicted water use values. The conclusion that could be developed is that under actual use conditions, the storage of Lake Casitas may restore to full capacity in less time than with theoretical yield values. The rate at which the reservoir fills would be diminished by moving from the historical 1959 Operational Criteria to the Robles BO Operating Criteria, and is further diminished with the loss of Matilija Dam. The risk of having Lake Casitas fill at a slower rate is that the reservoir may not achieve full storage capacity before onset of another long-term drought period.

BALANCING WATER USE WITH AVAILABLE SUPPLIES

The application of the Biological Opinion Criteria, at this time, is in place and will be the method by which the District operates the Robles Diversion Dam and Fish Passage Facility. The loss of reservoir storage resulting from the decommissioning of Matilija Dam or the sediment deposition of the remaining storage volume appears to be inevitable. Given these conditions, the District must continue to balance water use with the available water supply. In addition to the many options that have been prescribed by past studies and staff recommendations, this evaluation has further reviewed the application of mandatory reductions to water use during the study period.

Reduced Water Use through Conservation and/or Mandatory Use Curtailment. The District reviewed four different methods of water use reduction (Table 3). The key differences between the methods are the level of reduction and the time at which each reduction was applied. The goal of the reduction is to bring the average annual water use during the critical dry period to as close to the safe yield level of supply availability found with the Robles BO Operating Criteria (20,869 acre-feet) without the benefit of Matilija Reservoir.

The four different magnitudes and sequences of water use reductions were applied to the supply in such a manner that resulted in depleting Lake Casitas to minimum pool storage by the end of the critical dry period. The patterns of each water use reduction are presented in Table 3, along with the summaries for the safe yield and predicted water use values.

Prior to the implementation of any of these programs, the District should carefully consider the acceptability of water use reduction impacts to the water user, the realistic ability to attain such reductions, and the desirable frequency of causing the reductions. It is important to distinguish between curtailment and conservation. Conservation measures should focus on the long-term and lasting efficiencies that do not affect the quality of life. Curtailment measures focus on short term, temporary actions that may impact quality of life. The course of the District should consider the acceptability of the impacts on the quality of life cause by either conservation or curtailment.

OTHER FACTORS

During the study, there were several other issues that deserved acknowledgement and consideration by the District. These issues were not included in the development of the study's data or computations, but may be relevant points to include in the development of strategies and assessment of risks for managing the District's water supplies.

Minimum Lake Elevation. All studies on the Lake Casitas safe yield considered the extraction of water from Lake Casitas to a minimum pool. There may be some impacts that could arise when minimum pool is approached in Lake Casitas, such as:

Water Quality – the degree of the water quality impacts are unknown at this time. There is a potential for concentrating salts, organics, elements (manganese and/or boron) and nutrients as the water volume diminishes to minimum pool. Warm, shallow water may also promote the growth of algae, which in turn could lead to taste and odor problems in the drinking water supply. Storm runoff events into the minimum pool may have elevated turbidity that may exceed the capability of existing water treatment plant. Plant growth in the exposed beach areas of the lake may add to organic loading as the lake recovers its storage and the plant materials decay.

Water Delivery to the Distribution System –a certain level of water storage in Lake Casitas in order to adequately supply water to the distribution system. The District will have to consider other pump facilities (and associated costs), perhaps even barge pumps set into the lake, in order to move water through the treatment plant into the distribution system.

Recreation – the recreational opportunities are likely to be diminished at minimum pool. Boating and fishing would likely be curtailed, and the lack revenue generation from these activities may impact the District's ability to maintain recreation.

The study has indicated that the change of the minimum pool setting has a direct relationship to the safe yield value. For each 20,000 acre-feet of storage above minimum pool it is desired to add to the lake storage, there is a 1,000 acre-foot reduction impact to the safe yield value. The reduction of the safe yield of Lake Casitas in order to lessen the chance of impacts of minimum pool may not be the District's preferred solution.

Losses at Robles Diversion Dam. The District is in the process of constructing the fish passage facility. There may be inherent operational problems at the facility that could interfere with ability to divert water to Lake Casitas. These factors have not been quantified and were not included in the study conditions for diversion. The key problems that may occur are (1) the loss of water transfer through the fish screens, the plugging of the fine meshed screen that is used to protect fish from entering the Robles-Casitas Canal, and (2) silt deposition in the diversion facility that may be associated with the loss of Matilija Dam. This may be a target area for the District to document and develop data during future operations of the Robles Diversion and Fish Passage Facility.

Increase in Groundwater Extractions above Robles Diversion Dam. The study included the level of groundwater extraction that has historically occurred above Robles Diversion Dam. If there is an increase in the amount of groundwater extractions, there may be some impact to the amount of water available for diversion to Lake Casitas.

Socio-economic Impacts Associated with Water Use Reductions. The study has developed the values for safe yield and water use, and further reviewed the trends from applying water reductions. There are several issues that the decision-makers must consider when applying the water reduction measures. What level of water use reduction is attainable? What are the acceptable and unacceptable impacts to the water user's lifestyle and economic interest (agriculture, oil industry, tourism, and the residences of the service area)? Are the requests for water use reduction frequent and/or of long duration? These are questions that should be addressed as the District moves forward with the management of water supplies.

Variability of Supply. The Ventura River system is a highly variable water system with erratic and unpredictable periods of drought and rainfall. It should be noted that there is a large variation in the annual diversions, and thus the ability to restore supply, in both the drought and recovery periods. Table 4 provides a summary of the mean annual diversions, the range and confidence interval (CI) for diversions, under various study conditions. The water supply is highly variable in its occurrence over time. Small changes to climate or the natural sequences of rainfall events from the actual events of both periods can have an impact on the availability of water supply.

System Losses: Water losses occur within the Casitas water distribution system. Theoretically, the difference between water deliveries to the conveyance system and metered water sales represents system losses. **Appendix D** provides an explanation of water losses within the distribution system. Appendix D also provides an explanation of the significant differences between terms used by Casitas, and their relationship to actual data that is recorded by Casitas.

CONCLUSIONS AND RECOMMENDATIONS

The methods and model presented in this study provide decision-makers a tool for determining the level and timing of water use reductions needed to ensure a safe water supply. Water supply and use in the Casitas Municipal Water District has reached a balance and may be moving towards imbalance with the recently proposed changes to the water supply system.

During the course of developing the reservoir model and applying the individual runoff data, staff noted the sensitivity of the regional hydrology to each storm event or series of rainfall events. Given this potential for variation, it needs to be noted that small changes in hydrological patterns could result in different conclusions from this study.

In order to continue to meet future water demands and drought-proof the Casitas Municipal Water District service area, Casitas should actively develop and pursue a water conservation management program and while developing and implementing a strategy to secure alternative water supplies. Casitas should also perform a thorough accounting of the service connection allocations issued to date and propose to make adjustments to those allocations, where adjustments can be reasonably made, to benefit long-term water supply and continued water use by the customer.

Table 1. Predicted available water supply and water use for the Casitas Municipal Water District based on hydrologic conditions for the longest drought on record in the Ventura River Basin (1945-1965 water years).

Predicted Water Supply and Use Drought Period (1945-1965 WY)	1959 Operating Criteria		Robles BO Operating Criteria	
	With Matilija	Without Matilija	With Matilija	Without Matilija
Average Annual Volume of Water[1] (AF/YR)				
Ventura River Supply				
Ventura River Flows (Inflow to Robles Facility)	16,850	16,850	16,850	16,850
Water Loss (Robles Facility Operations)	(1,290)	(1,290)	(1,290)	(1,290)
Water Bypassed at Robles Facility	7,560	8,020	8,700	9,490
Water Diverted to Lake Casitas	8,000	7,540	6,860	6,070
Lake Casitas Supply				
Water Captured from Tributaries	6,000	6,000	6,000	6,000
Net Water Loss (Evaporation-Rainfall)	(2,630)	(2,630)	(2,630)	(2,630)
District Supply and Use: 21-Year Period				
Safe Yield: Available Supply[2] (Lake Casitas plus Mira Monte Well)	22,770	22,310	21,630	20,840
Water Use: Deliveries to Water Distribution System	21,200	21,200	21,200	21,200
Difference between supply and use	1,570	1,110	430	(360)
Total Volume of Water[1] (AF)				
Ventura River Supply				
Ventura River Flows (Inflow to Robles Facility)	353,850	353,850	353,850	353,850
Water Loss (Robles Facility Operations)	(27,090)	(27,090)	(27,090)	(27,090)
Water Bypassed at Robles Facility	158,760	168,420	182,700	199,290
Water Diverted to Lake Casitas	168,000	158,340	144,060	127,470
Lake Casitas Supply				
Water Captured from Tributaries	126,000	126,000	126,000	126,000
Net Water Loss (Evaporation-Rainfall)	(55,230)	(55,230)	(55,230)	(55,230)
District Supply and Use: 21-Year Period				
Safe Yield: Available Supply[2] (Lake Casitas plus Mira Monte Well)	478,170	468,510	454,230	437,640
Water Use: Deliveries to Water Distribution System	445,200	445,200	445,200	445,200
Difference between supply and use	32,970	23,310	9,030	(7,560)

1:Predicted values were based on methods outlined in Appendix A and B. Values presented in this table were rounded to the closest 10 AF. Furthermore, they are subject to revision following peer review.

2:These estimates were based on the same hydrologic period used in the Kienlen D20 study: October 1, 1944 through October 1, 1966. The safe yield was calculated by setting an annual extraction value that forced the reservoir to decrease from 237,890 AF to 4,800 for this period.

Table 2. Predicted available water supply and water use for the Casitas Municipal Water District based on hydrologic conditions for the period immediately following the longest drought on record in the Ventura River Basin (1966-1980 water years).

Predicted Water Supply and Use Recovery Period (1966-1980 WY)	1959 Operating Criteria		Robles BO Operating Criteria	
	With Matilija	Without Matilija	With Matilija	Without Matilija
Average Annual Volume of Water[1] (AF/YR)				
Ventura River Supply				
Ventura River Flows (Inflow to Robles Facility)	45,590	45,590	45,590	45,590
Water Loss (Robles Facility Operations)	(1,690)	(1,690)	(1,690)	(1,690)
Water Bypassed at Robles Facility	22,100	22,850	25,000	26,460
Water Diverted to Lake Casitas	21,800	21,050	18,900	17,440
Lake Casitas Supply				
Water Captured from Tributaries	21,700	21,700	21,700	21,700
Net Water Loss (Evaporation-Rainfall)	(3,670)	(3,670)	(3,670)	(3,670)
District Supply and Use: 15-Year Period				
Yield: Available Supply[2] (Lake Casitas plus Mira Monte Well)	24,180	23,500	21,180	19,780
Water Use: Deliveries to Water Distribution System	18,820	18,820	18,820	18,820
Difference between supply and use	5,360	4,680	2,360	960
Total Volume of Water[1] (AF)				
Ventura River Supply				
Ventura River Flows (Inflow to Robles Facility)	683,850	683,850	683,850	683,850
Water Loss (Robles Facility Operations)	(25,350)	(25,350)	(25,350)	(25,350)
Water Bypassed at Robles Facility	331,500	342,750	375,000	396,900
Water Diverted to Lake Casitas	327,000	315,750	283,500	261,600
Lake Casitas Supply				
Water Captured from Tributaries	325,500	325,500	325,500	325,500
Net Water Loss (Evaporation-Rainfall)	(55,050)	(55,050)	(55,050)	(55,050)
District Supply and Use: 15-Year Period				
Yield: Available Supply[2] (Lake Casitas plus Mira Monte Well)	362,700	352,500	317,700	296,700
Water Use: Deliveries to Water Distribution System	282,300	282,300	282,300	282,300
Difference between supply and use	80,400	70,200	35,400	14,400

1: Predicted values were based on methods outlined in Appendix A and B. Values presented in this table were rounded to the closest 10 AF. Furthermore, they are subject to revision following peer review.

2: These estimates were based on the same hydrologic period used in the Kienlen D20 study to fill the reservoir: October 1966 through February 1980. The yield was calculated by setting an annual extraction value that allowed the reservoir to increase from 4,800 AF to 254,000 AF within this period.

Table 3. Comparisons for the level of reductions in water use needed to balance water supply and use during a critical drought period without the benefit of Matilija Reservoir.

	Predicted Values		Water Use Reduction Scenarios			
Water Year	Safe Yield (AF)	Water Use (AF)	Constant 1.70% (AF)	Staged[1] 0, 1.7, 2.6% (AF)	Inverse 4, 2, 0% (AF)	Constant 360 AF (AF)
1945	20,840	18,936	18,614	18,936	18,179	18,576
1946	20,840	19,616	19,283	19,616	18,831	19,256
1947	20,840	19,697	19,362	19,697	18,909	19,337
1948	20,840	23,102	22,709	23,102	22,178	22,742
1949	20,840	23,966	23,559	23,966	23,007	23,606
1950	20,840	24,459	24,043	24,459	23,481	24,099
1951	20,840	27,057	26,597	26,597	26,516	26,697
1952	20,840	16,382	16,104	16,104	16,054	16,022
1953	20,840	22,305	21,926	21,926	21,859	21,945
1954	20,840	22,312	21,933	21,933	21,866	21,952
1955	20,840	24,402	23,987	23,987	23,914	24,042
1956	20,840	18,751	18,432	18,263	18,751	18,391
1957	20,840	21,309	20,947	20,755	21,309	20,949
1958	20,840	15,610	15,345	15,204	15,610	15,250
1959	20,840	21,688	21,319	21,124	21,688	21,328
1960	20,840	23,531	23,131	22,919	23,531	23,171
1961	20,840	25,175	24,747	24,520	25,175	24,815
1962	20,840	16,437	16,158	16,010	16,437	16,077
1963	20,840	19,604	19,271	19,094	19,604	19,244
1964	20,840	21,791	21,421	21,224	21,791	21,431
1965	20,840	19,068	18,744	18,572	19,068	18,708
All Years						
Total	437,640	445,198	437,630	438,009	437,758	437,638
Mean	20,840	21,200	20,840	20,858	20,846	20,840
Maximum	20,840	27,057	26,597	26,597	26,516	26,697
Minimum	20,840	15,610	15,345	15,204	15,610	15,250

1. Changes to the level of use reduction correspond with periods when Lake Casitas would drop below 127,000 and 65,000 Af of storage.

Table 4. Variability of Diversions for Study Conditions – Drought and Recovery Periods.

	Annual Diversion Rate (Acre-ft)					
	With Matilija			**Without Matilija**		
	Mean	95%CI	Range	Mean	95%CI	Range
Drought Period						
1959 Criteria	7,996	±6,087	0 to 57,990	7,534	±5,988	0 to 57,595
Robles BO Criteria	6,861	±5,169	0 to 49,689	6,066	±4,944	0 to 48,058
Difference	1,134	±953	0 to 8,302	1,469	±1,128	0 to 9,557
Recovery Period						
1959 Criteria	21,801	±11,549	589 to 68,645	21,050	±11,430	334 to 66,872
Robles BO Criteria	18,905	±9,953	589 to 58,553	17,438	±9,777	334 to 57,871
Difference	2,895	±1,924	0 to 10,262	3,612	±1,854	0 to 10,331

Appendix A – Casitas MWD Water Supply Predictions

Introduction

The reliability of water storage in Casitas Reservoir to adequately meet water use patterns through drought periods is dependent on the hydrology of the Ventura River Basin and the water use demands placed on reservoir storage. It is not possible to predict future weather patterns, and thus the hydrology, to an exact degree. The observation of recent weather and hydrology of the basin may provide adequate information that can be applied to a reservoir routing study. Determining the reliability of a water storage reservoir requires the review of relevant historical hydrology of the drainage basin and the assumption that the hydrology will repeat itself, in some manner, on a reliable basis (Figure A1). Further, determining the reliability of a water storage reservoir must also consider and apply system changes and influences that have or will occur in the foreseeable future.

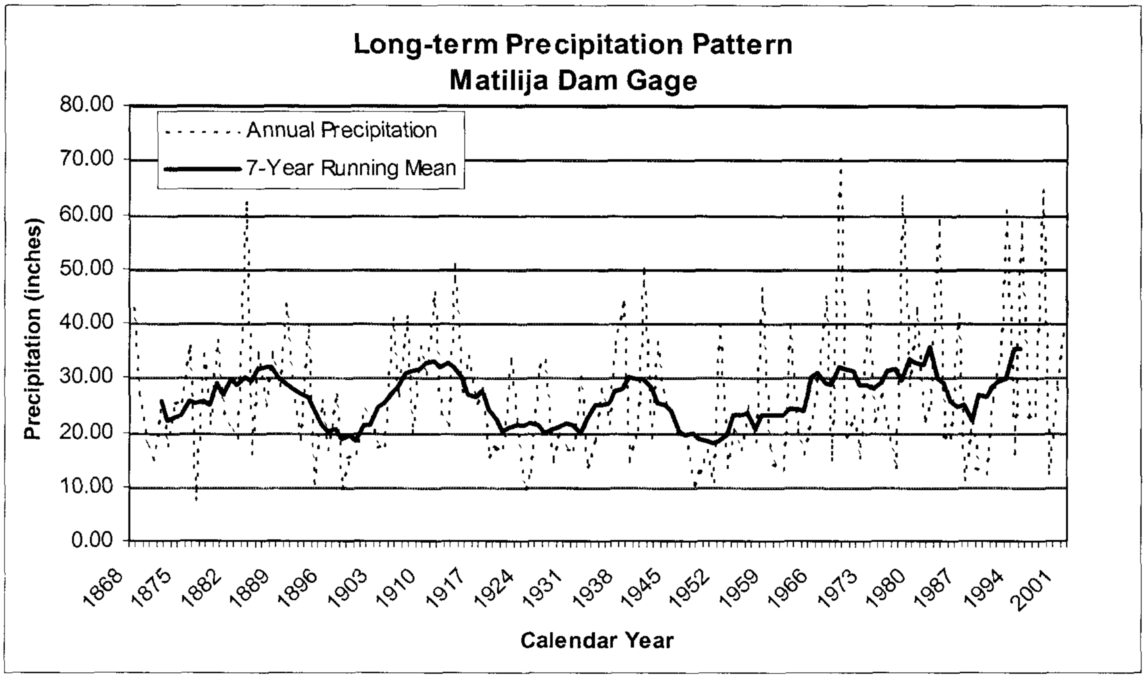


Figure A1. Long-term precipitation pattern as recorded at the Matilija Gage 1868-2001.

The District has compiled, to the best of their knowledge, the assumptions and historical data to develop a reservoir routing model that will consider the changes and influences that are foreseen at this time.

Background

The Ventura River watershed encompasses approximately 228 square miles in western Ventura County as illustrated in Figure A2. The area is subject to a Mediterranean type climate, with long periods of no rainfall followed by short periods of intense rainfall and high runoff peaks (1). The hydrology of the Ventura River system has been well documented since the early 1900's.

In the early 1940's, the agricultural communities in the Ventura River basin realized the inability of the local groundwater supplies to support water uses during drought periods. The first move to supplementing groundwater supplies was construction of Matilija Dam in the late 1940's. It was not long before the community leaders determined that the Matilija Dam project had limited value to water supplies and replenishment of the Ojai groundwater basin, particularly during long-term drought conditions. The next step, that the local communities pursued, to develop reliable water supplies was the construction of the Ventura River Project, under the guidance and initial funding of the United States Bureau of Reclamation.

The key components of the Ventura River Project were the Robles Diversion Dam, Robles-Casitas Canal, Casitas Dam, Casitas Reservoir, and the water distribution system (pipelines, pump plants, and steel reservoirs). Casitas Reservoir provides 254,000 acre-feet of reservoir water storage while Robles diversion system provides a maximum of 500 cubic feet per second conveyance capacity from the Ventura River to Casitas Reservoir. Figure A3 presents a representation of the river and water delivery system. The Casitas Reservoir and Robles diversion system became operable in January 1959. Since the initial operation of the Robles Diversion Dam and canal, the District operated diversions and downstream releases in accordance with a given set of guidelines, formally referred to as the 1959 Trial Operating Criteria (hereafter 1959 Operating Criteria) for the Robles Diversion Dam. The operating criteria provided for a minimum of 20 cfs bypass, when more than 20 cfs was available at Robles Diversion Dam, and criteria for bypassing less than 20 cfs when downstream aquifers were in full condition.

In 1998, the listing of the steelhead as an endangered species, and the desire to return the species to the Ventura River, led to changes in the operating criteria for Robles Diversion Dam (Robles Biological Opinion Operating Criteria: hereafter Robles BO Operating Criteria). In 2002, there developed an interest in the removal of Matilija Dam and restoration of steelhead migration to all mainstem reaches of the Ventura River. The County of Ventura is presently considering the full-scale removal of Matilija Dam.

Water Supply Prediction Components

An adequate water supply study must identify the periods and provide adequate data, and/or relatively sound basis for assumptions, to apply to the reservoir routing for each

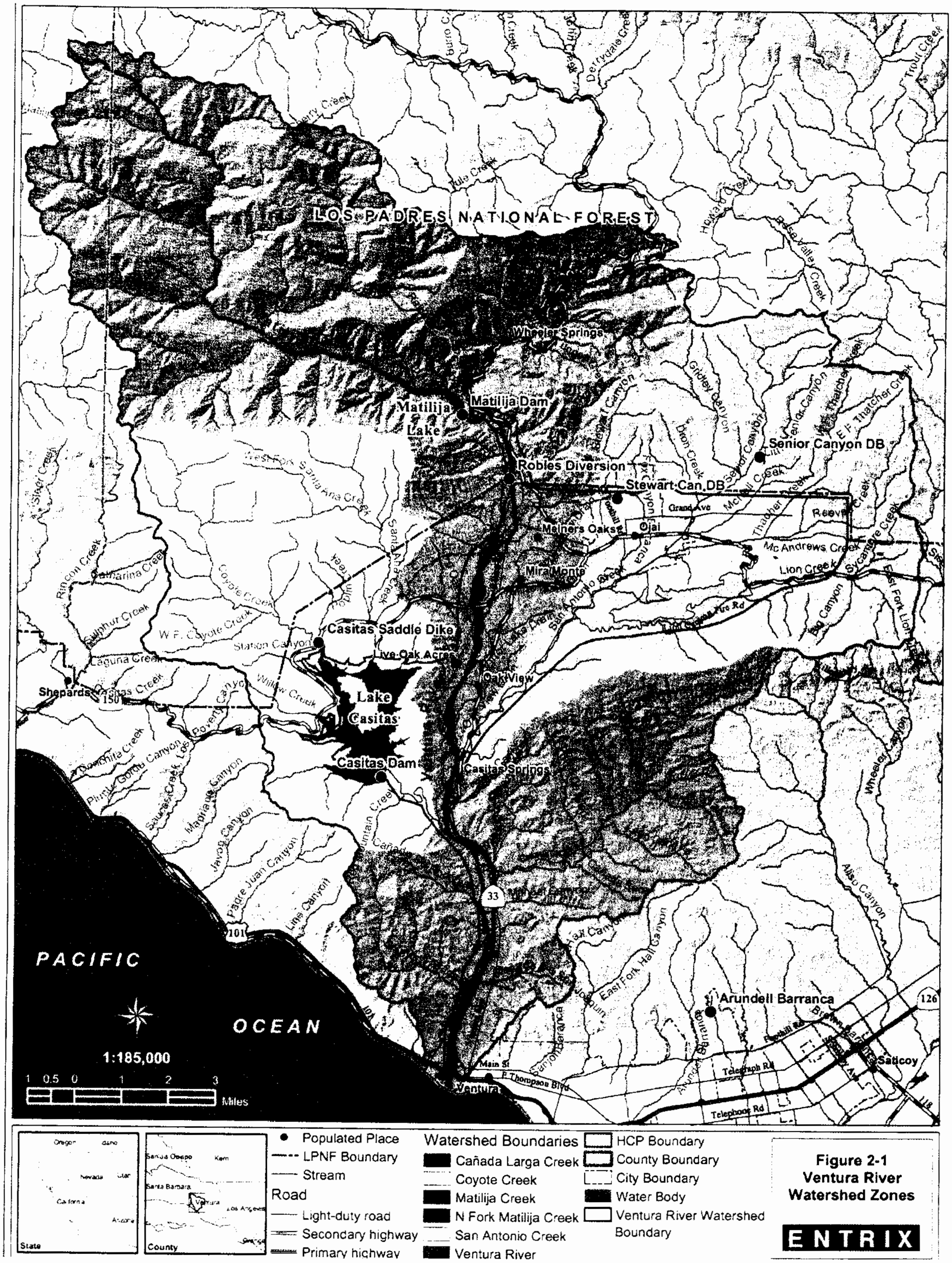


Figure A2. Ventura River Watershed (excerpt from the Habitat Conservation Plan – Entrix)

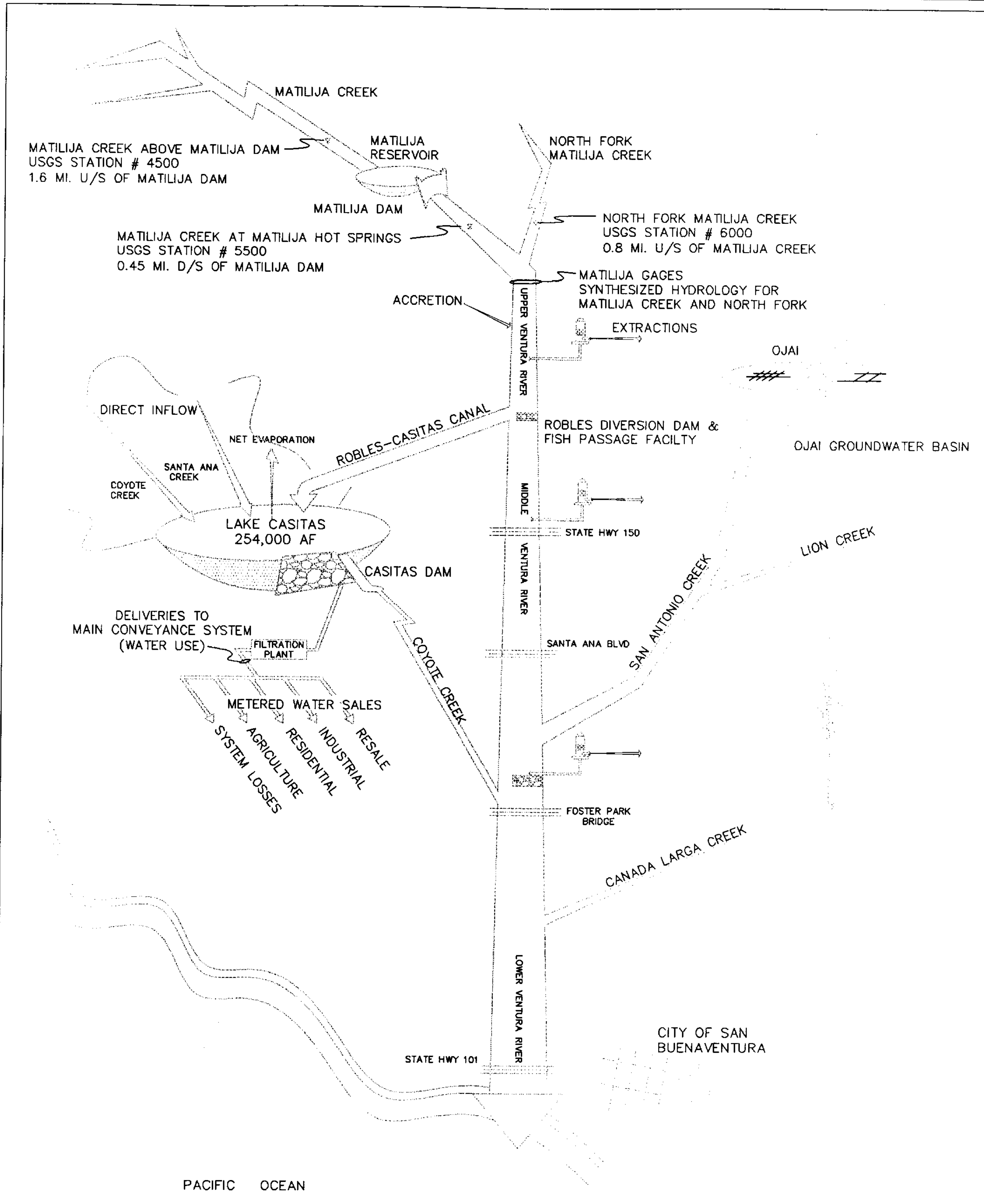


Figure A3. KEY ELEMENTS OF THE VENTURA RIVER WATER SUPPLY period. The outline provided in this appendix provides the supply data and assumptions that were applied in the reservoir routing analysis.

There are two specific periods that the District is concerned with in the reservoir routing and determination of supply reliability. The first period is the longest period of drought. Assuming the reservoir is at full capacity, test the ability of the reservoir to withstand the longest drought of recent record. The second period is the recovery period of the reservoir from minimum storage level, after the reservoir has experienced the longest drought period, to full stage and ready for the next drought sequence.

The District has identified the period of 1944 through 1965 as the longest period of drought. The hydrology of the period is well documented. Other factors such as the current demands for the water supply are represented by the data gathered for the period. Such data will have to be extrapolated from current conditions to meet the hydrology of the study period.

The period of 1946 to 1980 has been identified as the recovery period. It is known that the Ventura River hydrology during the 1959 to 1978 period contributed to the initial filling of Casitas Reservoir to full capacity. Other factors and data, such as the demand for water supply and evaporation rates, may not be available from the study period or are not representative of current levels of influence. These factors must be reasonably developed from current data and trends, and then applied to the reservoir routing study. Many of these factors have been developed during prior studies and should be considered for this study.

Water Supply Prediction Methods

The analysis of water supply for Casitas Municipal Water District was derived from the methods used by Kienlen in the late 1980s and early 1990 to evaluate a series of alternatives for utilizing water supplies in the Ventura River Basin (Murray, Burns and Kienlen 1990). These methods developed a water balance model for the Ventura River Basin and Lake Casitas that accounted for: 1) surface flows in the Ventura River, Matilija Creek, North Fork Matilija Creek, Coyote Creek, and Santa Ana Creek; 2) groundwater and surface water extraction above Robles diversion; 3) flow accretion above Robles Diversion; 4) operational efficiency of the Robles Diversion; 5) evaporation and rainfall at Lake Casitas; and 6) an estimate of the available supply from Lake Casitas on an annual basis expressed as annual yield. For this analysis, the approach used by Kienlen for the D20 study was used as a basis for the calculations in this analysis. Since Kienlen performed the D20 analysis additional water supplies have been developed, new operational criteria for Robles have been established, methods have been refined, and understanding the role of Matilija Reservoir to Casitas water supply has become more important. Therefore, the methods and/or assumptions used in the Kienlen D20 analysis were modified as appropriate based on current and/or relevant information and methods.

Ventura River Inflow to Robles

This is an estimate of the volume of water flowing into the Robles facility. It is based on the hydrologic records from USGS gauging stations, operational criteria for Matilija Reservoir, an estimate of the volume of accretion flow between the gages and robles, and an estimate of the volume of water that is depleted between the gages and Robles.

In review of the data from each gaging station and understanding that the Matilija Dam changed flows entering the Robles Diversion Dam location, the model had to consider development of the Ventura River hydrology with and without the influence of Matilija Dam. Records of flow above Matilija Dam had been gathered until 1969, at which time the station had been destroyed and not replaced. The synthesis of the hydrology has been determined by developing an unencumbered flow (no Matilija Dam) at the Matilija Creek at Matilija Hot Springs station and then combining with the flow recorded at the North Fork Matilija Creek station. Where no records of flow were gathered for above Matilija Dam (the period of 1969 to 1980), a correlation was used to develop the unencumbered flow. The correlations are described in the equations outlined in the following sections. This method provided the baseline hydrology for the upper Ventura River without the influence of the Matilija Dam, which is one of the conditions that was later applied to the scenarios of this study. From the baseline hydrology and the operational criteria for Matilija Dam, a second hydrology was synthesized for the condition of Matilija Dam in operation for the entire study period. To provide accurate estimates for these values, calculations were based on daily values.

The combination of the synthesized hydrology for the Matilija Creek with the records for North Fork of the Matilija Creek has provided the flow values for water at the confluence of the Matilija Creek and the North Fork Matilija Creek. The term used for the combination of the records is "Matilija Gages". To develop the quantity of water that is available at the Robles Diversion Dam, the factors for accretion, upstream flow depletion and facility losses are applied to the "Matilija Gages" hydrology record.

<u>Drought Period Hydrology – October 1 1944 through September 30 1965</u>

1) Matilija Creek hydrology
    a. Empirical USGS gage records
        i. #5500: Matilija Hot Springs - October 1 1944 – May 31 1948
        ii. #4500: Above Matilija - June 1 1948 – September 30 1965

2) North Fork Matilija Creek hydrology
    a. Empirical USGS gage records
        i. #6000: October 1 1944 – September 30 1965

<u>Reservoir Recovery Period Hydrology – October 1 1965 through September 30 1980</u>

1) Matilija Creek hydrology
    a. Empirical USGS gage records

i. #4500: October 1 1965 – September 30 1969
ii. #5500: October 1 1973 – October 31 1973

b. Daily flows predicted from NF Matilija daily USGS records
    i. Loss at Matilija Reservoir = 0.1167%
        01) Added to Annual AF estimate for #5500
    ii. Equation: #5500 = ((Annual AF 5500/Annual AF 4500)*#4500)
    iii. Estimated: October 1 1969 – September 30 1973
    iv. Estimated: November 1 1973 – September 30 1980

2) North Fork Matilija Creek hydrology
    a. Empirical USGS gage records
        i. #6000: October 1 964 – September 30 1973
        ii. #6000: November 1 1973 – September 30 1978

    b. Flows predicted from Matilija Creek USGS daily records
        i. Equation: #6000 = (0.00003*(#5500^2))+(0.3158*#5500)
        ii. Estimated: October 1 1973 – October 31 1973

Matilija Reservoir Operations: Influence and Benefit

1) Storage Capacity
    a. Maximum storage: 650 AF
    b. Minimum storage: 250 AF

2) Operational Criteria
    a. Fill with storm events and available flows
    b. Reduce to minimum storage once full
        i. Generally post storm events (Figure A2)
        ii. Release up to 100-150 cfs

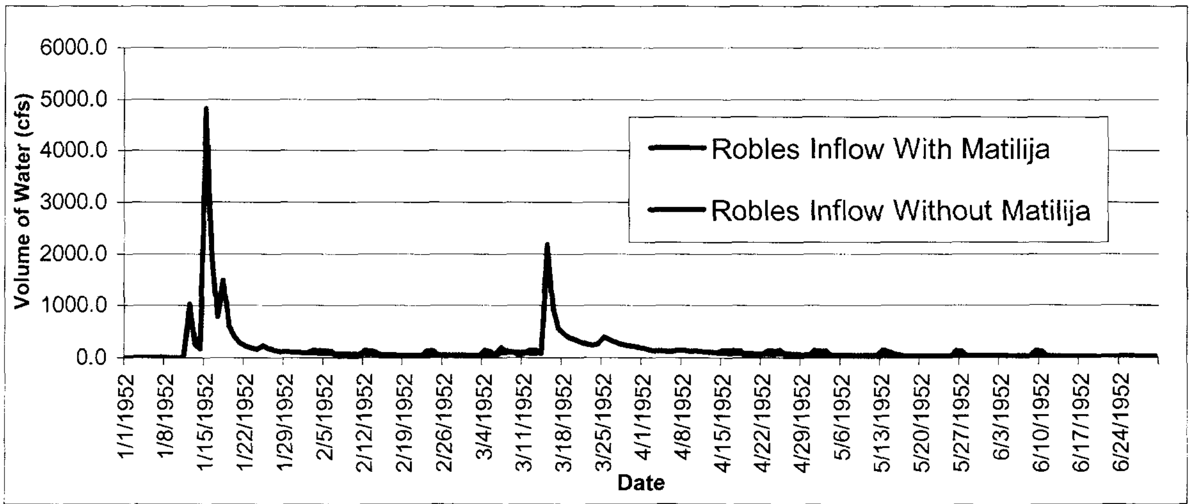


Figure A4. Potential effect of Matilija Reservoir operations on Ventura River flows.

Flow Accretion

This is an estimate of the volume of water that is gained between the USGS gauging stations and the Robles Diversion. Accretion flows would generally occur in association with storm events.

1) Variable – associated with rain events

2) Applied to average daily combined flow at Matilija and North fork Matilija Creek gages

3) Correction Factors: Applied to estimated average daily flow
    a. 0.05 increase applied to combined records from #5500 and #6000 gages
    b. 0.11 increase applied to combined records from #4500 and #6000 gages

Flow Depletion /Extraction

This is an estimate of the volume of water that is depleted between the gauges and Robles diversion. The volume of these depletions are generally related to water extractions via wells and surface diversions to beneficial water use, and replenishment of the groundwater aquifer.

1) Characteristics: variable on a monthly basis
    i. October: 7.58% of annual extraction volume
    ii. November: 5.35% of annual extraction volume
    iii. December: 4.34% of annual extraction volume
    iv. January: 4.75% of annual extraction volume
    v. February: 0.328% of annual extraction volume
    vi. March: 4.94% of annual extraction volume
    vii. April: 7.01% of annual extraction volume
    viii. May: 10.41% of annual extraction volume
    ix. June: 14.06 % of annual extraction volume
    x. July: 16.18% of annual extraction volume
    xi. August: 12.10% of annual extraction volume
    xii. September: 9.99% of annual extraction volume
    b. Related to substrate permeability/groundwater recharge and extraction
    c. Dependent upon direct diversions

2) Annual Estimates were used from the Kienlen D20 study
    a. Drought period:
        i. Up to 2800 AF/yr
        ii. Average of 2,168 AF/yr for 1944-1965 period (11.8% of gages)
    b. Wet period:
        i. Up to 2,800 AF/yr
        ii. Average of 1,628 AF/yr for 1966 – 1980 period (3.7% of gages)
    c. Applied to average daily combined flow values from Matilija and North fork Matilija Creek gages

Robles Diversion Operations

This is an estimate of the volume of water flowing out of the Robles facility. It is based on the volume of water flowing into the facility (described above), water losses associated with facility operations, the volume of water available for diversion, diversion operational criteria, and the volume of water that bypasses the facility. To provide accurate estimates for these values, calculations were based on daily values.

Facility Losses

This is the volume of water loss from operating the diversion. It reduces the volume of water available for diversion. It is assumed that the majority of this volume of water goes subsurface and recharges groundwater aquifers.

1) Estimates used from Kienlen D20 Study
    a. Drought period: average 1,321 AF (7.7% of inflow)
    b. Wet period: average 1,628 AF (3.7% of inflow)
    c. Applied to average daily flow coming into the Robles facility

2) BOR (1959) estimated operational loss for the diversion at 5%

Water Available for Diversion

This is an estimate of the volume of water coming into the Robles Facility minus the volume of water loss due to operating the facility.

Volume of Water Diverted

This is the volume of water diverted into the Robles/Casitas Canal based on the 1959 and Robles BO operating criteria.

1) 1959 Operating Criteria estimates:
    a. Operating period
        i. October 1 through June 30
        ii. Initiated after surface flows occur at Santa Ana Blvd Bridge
        iii. Diversion cease when storage volume in Lake Casitas reaches 248,616 acre-feet (2 feet from spill elevation)
    b. Diversion volume
        i. Maximum diversion: 500 cfs
        ii. Minimum diversion: 5 cfs
    c. Minimum release (if available)
        i. Surface flow at Santa Ana Blvd. Bridge: release 3 cfs
            1. Assume after 2nd storm, and
            2. Drought period: Cumulative Robles inflow >11,000 AF/yr
            3. Recovery period: Cumulative Robles inflow >26,000 AF/yr
        ii. No surface flow at Santa Ana Blvd. Bridge: release 20 cfs
            1. Kienlen study assumed 20 cfs release/bypass at all times

2) Robles BO operating criteria estimates
    a. Operating period
        i. Fish passage operating period criteria
            1. January 1 – June 30
            2. Initiate after 1^{st} storm event
            3. Initiate if sandbar has breached
        ii. 1959 operating criteria
            1. Apply whenever fish passage criteria are not met
            2. Initiated after October 1
        iii. General criteria
            1. Diversions cease when the storage volume in Lake Casitas is 248,616 acre-feet (2 feet below spill elevation)
    b. Diversion volumes
        i. Maximum diversion: 500 cfs
        ii. Minimum criteria: 5 cfs
    c. Fish releases (if available)
        (This is the quantity of water released off of the diversion canal to satisfy fish requirements outlined in the Robles BO and based on the volume of water flowing into the Robles Facility)
        i. Ratcheted release over 12 day period from 171 cfs to 30 cfs
        ii. Associated with storm events
        iii. Reduced fish releases would occur if Lake Casitas storage volume drops to < 100,000 AF and again at <65,000 AF through agreement and based on an equitable sharing of the temporary reduction in water allocations to customers (i.e. demonstrated reduction in water use)
        iv. Will cease if Lake Casitas storage volume is < 17,000 AF and until it reaches a volume of 65,000 AF
    d. Minimum release (if available)
        i. 30 cfs after first storm event and until June 30

<u>Volume of Water Bypassed.</u>
This is the total volume of water that bypasses the Robles Diversion facility. It includes the volume of water that is not diverted and bypasses the facility as well as the volume of water that is released from the Robles/Casitas canal for steelhead migration in the Ventura River.

1) Estimation
    a. Kienlen D20 study: bypass = Total inflow – loss – diversions
    b. Drought period: 50.7% of inflow
    c. Wet period: 52.9% of inflow
    d. Entire period: 52.1% of inflow

Lake Casitas Supply
The supply of water in Lake Casitas is dependent upon inflows from the Robles/Casitas canal, Santa Ana Creek, Coyote Creek, and unnamed tributaries as well as reductions associated with evaporation.

Volume from Robles/Casitas Canal
This is the volume of water diverted to Lake Casitas from the Robles Diversion. It is based on the calculations described above.

Santa Ana Creek
This analysis used estimates from the Kienlen D20 study.

Coyote Creek
This analysis used estimates from the Kienlen D20 study

Unnamed Tributaries
This analysis used estimates from the Kienlen D20 study.

Net Evaporation
This analysis used estimates from the Kienlen D20 study.

Mira Monte Well Supply

Annual yield estimated at 300 AF per year.

Safe Yield: Drought Period – Casitas Municipal Water District

Safe yield is a risk management tool used to estimate the volume of water that can be withdrawn from a water supply to the extent that the withdrawal is not harmful to recreation, water quality, or physical facilities. Methods for this assessment were based on the previous safe yield studies conducted by the BOR and Kienlen. However, this study accounted for three additional supply factors that were not included in the Kienlen analysis: 1) under the 1959 operating criteria minimum releases could be 3 cfs under specific conditions; 2) Mira Monte well supply; and Matilija Reservoir supply.

1) Estimates based of Kienlen D20 study variables and values:
    a. Timeframe: 21 years – 1945-1965 water years
    b. Minimum pool: approximately 4800 AF (based on D20 study)
    c. Monthly Distribution of Yield:
        i. October: 7.12% of annual yield
        ii. November: 6.07% of annual yield
        iii. December: 6.09% of annual yield
        iv. January: 6.69% of annual yield
        v. February: 4.5% of annual yield
        vi. March: 6.41% of annual yield

vii. April: 7.59% of annual yield
viii. May: 9.55% of annual yield
ix. June: 10.99 % of annual yield
x. July: 13.2% of annual yield
xi. August: 12.04% of annual yield
xii. September: 9.75% of annual yield

2) Water supply from the Mira Monte well was included in the safe yield estimate:
   a. 300 AF per year
   b. Applied at a constant rate for each month

3) Water supply from Matilija Reservoir was estimated.

4) Safe yield estimates made for four scenarios
   a. 1959 Operating Criteria
      i. With and without Matilija
   b. Robles BO Operating Criteria
      i. With and Without Matilija

Yield: Recovery Period – Casitas Municipal Water District

Yield is used to estimate the volume of water that can be withdrawn from a water supply to the extent that the withdrawal allows the reservoir to fill in a timely fashion. Methods for this assessment were based on the timeframe in which the reservoir filled following the longest period on record from previous studies conducted by Kienlen. However, this study accounted for three additional supply factors that were not included in the Kienlen analysis: 1) under the 1959 operating criteria minimum releases could be 3 cfs under specific conditions; 2) Mira Monte well supply; and Matilija Reservoir supply.

2) Estimates based of Kienlen D20 study variables and values:
   a. Timeframe: 15 years – 1966-1980 water years
   b. Initial pool: approximately 4800 AF (based on D20 study)
   c. Monthly Distribution of Yield:
      i. October: 7.12% of annual yield
      ii. November: 6.07% of annual yield
      iii. December: 6.09% of annual yield
      iv. January: 6.69% of annual yield
      v. February: 4.5% of annual yield
      vi. March: 6.41% of annual yield
      vii. April: 7.59% of annual yield
      viii. May: 9.55% of annual yield
      ix. June: 10.99 % of annual yield
      x. July: 13.2% of annual yield
      xi. August: 12.04% of annual yield
      xii. September: 9.75% of annual yield

2) Water supply from the Mira Monte well was included in the safe yield estimate:
    a. 300 AF per year
    b. Applied at a constant rate for each month

3) Water supply from Matilija Reservoir was estimated.

4) Safe yield estimates made for four scenarios
    c. 1959 Operating Criteria
        i. With and without Matilija
    d. Robles BO Operating Criteria
        i. With and Without Matilija

Water Supply Prediction Results

The following Tables and Figures present summary information from the analysis described above.

Table A1. Predicted water supply for the 1945-1965-drought period based on the 1959 operating criteria and with the benefit of Matilija Reservoir.

Water Year	Predicted Water Supply (AF)										
	Ventura River							Lake Casitas			District
	Flows Above Robles Diversion			Robles Operations							
	Matilija Gages	Accretion	Extraction	Inflow	Loss	Bypass	Diversion	Tributaries	Net Loss	Storage Volume	Available Supply
1945	19222	961	2652	17531	1350	8198	7984	6812	4711	225510	22770
1946	23289	1164	2611	21842	1682	9339	10821	3377	4529	212710	22770
1947	12435	622	2035	11021	849	4932	5241	2654	4255	193881	22770
1948	2822	171	1728	1264	97	1167	0	48	3901	167559	22770
1949	3564	392	1712	2243	173	1839	232	131	3537	141916	22770
1950	4785	526	1722	3589	276	2748	565	1378	3145	118244	22770
1951	1810	199	1356	652	50	602	0	89	2682	93182	22770
1952	58089	6390	2611	61868	4764	21709	35395	27231	3582	129758	22770
1953	10343	1138	2342	9139	704	5838	2597	2270	2940	109215	22770
1954	9916	1091	2183	8823	679	4251	3892	3520	2599	91559	22770
1955	5139	565	2002	3702	285	3183	234	703	2078	67949	22770
1956	10412	1145	2131	9426	726	4835	3866	5792	1773	53365	22770
1957	6822	750	1811	5761	444	2867	2451	1008	1260	33095	22770
1958	93554	10291	2702	101142	7788	35365	57990	32125	3204	97537	22770
1959	13670	1504	2157	13016	1002	6487	5527	2909	2374	81130	22770
1960	4406	485	1668	3222	248	2591	383	936	1834	58298	22770
1961	2243	247	1189	1300	100	1185	16	150	1307	34687	22770
1962	57999	6380	2514	61865	4764	32151	24950	27154	2379	61943	22770
1963	7323	806	2317	5811	447	3731	1633	2338	1554	41891	22770
1964	4432	487	1702	3217	248	2216	753	863	1029	20008	22770
1965	8501	935	1935	7500	578	3544	3379	4537	636	4819	22770
Total	360775	36249	43081	353943	27254	158779	167911	126025	55309		478170
Mean	17180	1726	2051	16854	1298	7561	7996	6001	2634	97060	22770

Table A2. Predicted water supply for the 1945-1965-drought period based on the 1959 operating criteria and without the benefit of Matilija Reservoir.

Water Year	Predicted Water Supply (AF)										
	Ventura River							Lake Casitas			District
	Flows Above Robles Diversion			Robles Operations							
	Matilija Gages	Accretion	Extraction	Inflow	Loss	Bypass	Diversion	Tributaries	Net Loss	Storage Volume	Available Supply
1945	19179	959	2652	17486	1346	8245	7894	6812	4711	225881	22309
1946	23283	1164	2611	21836	1681	10826	9329	3377	4529	212050	22309
1947	12552	628	2035	11145	858	5911	4376	2654	4255	192817	22309
1948	2830	171	1728	1273	98	1175	0	48	3901	166956	22309
1949	3496	385	1712	2169	167	1874	128	131	3537	141670	22309
1950	4858	534	1722	3671	283	2882	506	1378	3145	118400	22309
1951	1810	199	1356	653	50	602	0	89	2682	93799	22309
1952	58270	6410	2611	62068	4779	23640	33649	27231	3582	129089	22309
1953	10060	1107	2342	8824	679	6601	1543	2270	2940	107955	22309
1954	9941	1094	2183	8852	682	4810	3360	3520	2599	90227	22309
1955	5169	569	2002	3736	288	3319	128	703	2078	66973	22309
1956	10460	1151	2131	9479	730	5659	3091	5792	1773	52074	22309
1957	6732	741	1811	5662	436	3050	2176	1008	1260	31990	22309
1958	93605	10297	2702	101200	7792	35812	57595	32125	3204	96498	22309
1959	13591	1495	2157	12929	995	7013	4920	2909	2374	79945	22309
1960	4424	487	1668	3243	250	2810	183	936	1834	57374	22309
1961	2292	252	1189	1355	104	1190	61	150	1307	34269	22309
1962	57924	6372	2514	61782	4757	32798	24226	27154	2379	61262	22309
1963	7321	805	2317	5809	447	4014	1348	2338	1554	41386	22309
1964	4503	495	1702	3296	254	2263	780	863	1029	19991	22309
1965	8435	928	1935	7428	572	3928	2928	4537	636	4813	22309
Total	360735	36240	43081	353895	27250	168422	158223	126025	55309		468489
Mean	17178	1726	2051	16852	1298	8020	7534	6001	2634	96449	22309

Table A3. Predicted water supply for the 1945-1965-drought period based on the Robles BO operating criteria and with the benefit of Matilija Reservoir.

Water Year	Predicted Water Supply (AF)										
	Ventura River							Lake Casitas			District
	Flows Above Robles Diversion			Robles Operations							
	Matilija Gages	Accretion	Extraction	Inflow	Loss	Bypass	Diversion	Tributaries	Net Loss	Storage Volume	Available Supply
1945	19222	961	2652	17531	1350	10206	5976	6812	4711	224636	21635
1946	23289	1164	2611	21842	1682	10547	9614	3377	4529	211763	21635
1947	12435	622	2035	11021	849	4932	5241	2654	4255	194068	21635
1948	2822	171	1728	1264	97	1167	0	48	3901	168880	21635
1949	3564	392	1712	2243	173	1839	232	131	3537	144371	21635
1950	4785	526	1722	3589	276	2748	565	1378	3145	121834	21635
1951	1810	199	1356	652	50	602	0	89	2682	97906	21635
1952	58089	6390	2611	61868	4764	28626	28478	27231	3582	128698	21635
1953	10343	1138	2342	9139	704	5838	2597	2270	2940	109290	21635
1954	9916	1091	2183	8823	679	4778	3366	3520	2599	92241	21635
1955	5139	565	2002	3702	285	3183	234	703	2078	69766	21635
1956	10412	1145	2131	9426	726	5532	3168	5792	1773	55618	21635
1957	6822	750	1811	5761	444	3148	2169	1008	1260	36201	21635
1958	93554	10291	2702	101142	7788	43667	49688	32125	3204	93474	21635
1959	13670	1504	2157	13016	1002	7627	4388	2909	2374	77062	21635
1960	4406	485	1668	3222	248	2591	383	936	1834	55364	21635
1961	2243	247	1189	1300	100	1185	16	150	1307	32888	21635
1962	57999	6380	2514	61865	4764	34519	22582	27154	2379	58910	21635
1963	7323	806	2317	5811	447	3985	1379	2338	1554	39738	21635
1964	4432	487	1702	3217	248	2335	634	863	1029	18871	21635
1965	8501	935	1935	7500	578	3544	3379	4537	636	4817	21635
Total	360775	36249	43081	353943	27254	182600	144090	126025	55309		454335
Mean	17180	1726	2051	16854	1298	8695	6861	6001	2634	96971	21635

Table A4. Predicted water supply for the 1945-1965-drought period based on the Robles BO operating criteria and without the benefit of Matilija Reservoir.

Water Year	Predicted Water Supply (AF)										
	Ventura River							Lake Casitas			District
	Flows Above Robles Diversion			Robles Operations							
	Matilija Gages	Accretion	Extraction	Inflow	Loss	Bypass	Diversion	Tributaries	Net Loss	Storage Volume	Available Supply
1945	19179	959	2652	17486	1346	12287	3852	6812	4711	223307	20840
1946	23283	1164	2611	21836	1681	12594	7560	3377	4529	209175	20840
1947	12552	628	2035	11145	858	5911	4376	2654	4255	191410	20840
1948	2830	171	1728	1273	98	1175	0	48	3901	167017	20840
1949	3496	385	1712	2169	167	1874	128	131	3537	143200	20840
1950	4858	534	1722	3671	283	2882	506	1378	3145	121399	20840
1951	1810	199	1356	653	50	602	0	89	2682	98266	20840
1952	58270	6410	2611	62068	4779	31687	25602	27231	3582	126976	20840
1953	10060	1107	2342	8824	679	6601	1543	2270	2940	107310	20840
1954	9941	1094	2183	8852	682	5788	2382	3520	2599	90072	20840
1955	5169	569	2002	3736	288	3319	128	703	2078	68286	20840
1956	10460	1151	2131	9479	730	6701	2049	5792	1773	53813	20840
1957	6732	741	1811	5662	436	3345	1881	1008	1260	34902	20840
1958	93605	10297	2702	101200	7792	45349	48058	32125	3204	91341	20840
1959	13591	1495	2157	12929	995	8755	3178	2909	2374	74515	20840
1960	4424	487	1668	3243	250	2810	183	936	1834	53411	20840
1961	2292	252	1189	1355	104	1190	61	150	1307	31775	20840
1962	57924	6372	2514	61782	4757	35778	21247	27154	2379	57256	20840
1963	7321	805	2317	5809	447	4388	974	2338	1554	38475	20840
1964	4503	495	1702	3296	254	2299	743	863	1029	18512	20840
1965	8435	928	1935	7428	572	3928	2928	4537	636	4801	20840
Total	360735	36240	43081	353895	27250	199265	127379	126025	55309		437640
Mean	17178	1726	2051	16852	1298	9489	6066	6001	2634	95487	20840

Table A5. Predicted water supply for the 1966-1980-recovery period based on the 1959 operating criteria and with the benefit of Matilija Reservoir.

Water Year	Predicted Water Supply (AF)										
	Ventura River							Lake Casitas			District
	Flows Above Robles Diversion			Robles Operations							
	Matilija Gages	Accretion	Extraction	Inflow	Loss	Bypass	Diversion	Tributaries	Net Loss	Storage Volume	Available Supply
1966	55445	2772	2446	55771	2064	18020	35687	21289	1387	37926	24177
1967	56372	2819	2767	56423	2088	8722	45613	27258	2437	85911	24177
1968	8024	401	2536	5889	218	4450	1221	2392	1765	65310	24177
1969	171353	8568	2793	177128	6554	104275	66300	78737	4630	183497	24177
1970	16807	840	2725	14922	552	7731	6639	4662	3767	168904	24177
1971	20184	1009	2481	18712	692	10504	7516	7225	3640	158148	24177
1972	10739	537	2046	9230	341	4269	4619	5394	3345	142578	24177
1973	58322	2916	2754	58484	2164	22499	33821	33070	4342	184252	24177
1974	18424	921	2426	16919	626	8593	7700	7417	3936	173398	24177
1975	23671	1184	2658	22197	821	9419	11957	10670	3940	170361	24177
1976	9711	486	2167	8029	297	4278	3454	3239	3584	151212	24177
1977	4977	249	1925	3301	122	2590	589	1056	3164	127285	24177
1978	135760	6788	2615	139933	5178	66111	68645	73222	5366	244222	24177
1979	27918	1396	2800	26514	981	9193	16340	11740	4872	246144	24177
1980	69835	3492	2800	70527	2610	51007	16911	38299	4892	237956	24177
Total	687544	34377	37939	683982	25307	331662	327012	325670	55067	2377102	362655
Mean	45836	2292	2529	45599	1687	22111	21801	21711	3671	158473	24177

Table A6. Predicted water supply for the 1966-1980-recovery period based on the 1959 operating criteria and without the benefit of Matilija Reservoir.

Water Year	Predicted Water Supply (AF)										
	Ventura River							Lake Casitas			District
	Flows Above Robles Diversion			Robles Operations							
	Matilija Gages	Accretion	Extraction	Inflow	Loss	Bypass	Diversion	Tributaries	Net Loss	Storage Volume	Available Supply
1966	55495	2775	2437	55495	4299	18672	35094	21289	1387	37045	23497
1967	56267	2813	2767	56267	4336	10198	44031	27258	2437	82243	23497
1968	8040	402	2536	8040	455	5032	655	2392	1765	61768	23497
1969	171355	8929	2793	171355	13667	104284	66293	78737	4630	178779	23497
1970	16800	1848	2725	16800	1226	8790	5574	4662	3767	163672	23497
1971	20191	2221	2481	20191	1535	10589	7437	7225	3640	153137	23497
1972	10730	1180	2046	10730	760	4230	4649	5394	3345	138184	23497
1973	58322	6415	2754	58322	4773	23802	32518	33070	4342	178101	23497
1974	18421	2026	2426	18421	1388	9739	6551	7417	3936	166596	23497
1975	23675	2604	2658	23675	1819	10837	10542	10670	3940	162404	23497
1976	9930	1092	2167	9930	682	4935	3018	3239	3584	143424	23497
1977	4817	530	1925	4817	263	2683	334	1056	3164	119950	23497
1978	135694	14926	2615	135694	11396	67816	66872	73222	5366	233727	23497
1979	27929	3072	2800	27929	2172	9567	15977	11740	4872	235179	23497
1980	69813	3491	2803	69813	2609	51683	16209	38299	4892	237452	23497
Total	687478	54326	37934	687478	51378	342858	315755	325670	55067	2291661	352455
Mean	45832	3622	2529	45832	3425	22857	21050	21711	3671	152777	23497

Table A7. Predicted water supply for the 1966-1980-recovery period based on the Robles BO operating criteria and with the benefit of Matilija Reservoir.

Water Year	Predicted Water Supply (AF)										
	Ventura River							Lake Casitas			District
	Flows Above Robles Diversion			Robles Operations							
	Matilija Gages	Accretion	Extraction	Inflow	Loss	Bypass	Diversion	Tributaries	Net Loss	Storage Volume	Available Supply
1966	55445	2772	2446	55771	2064	18020	35687	21289	1387	36443	21184
1967	56372	2819	2767	56423	2088	16551	37784	27258	2437	79612	21184
1968	8024	401	2536	5889	218	4450	1221	2392	1765	62024	21184
1969	171353	8568	2793	177128	6554	112021	58553	78737	4630	175431	21184
1970	16807	840	2725	14922	552	7850	6520	4662	3767	163732	21184
1971	20184	1009	2481	18712	692	10504	7516	7225	3640	155997	21184
1972	10739	537	2046	9230	341	4269	4619	5394	3345	143441	21184
1973	58322	2916	2754	58484	2164	32221	24099	33070	4342	178309	21184
1974	18424	921	2426	16919	626	10153	6140	7417	3936	168952	21184
1975	23671	1184	2658	22197	821	11490	9885	10670	3940	166838	21184
1976	9711	486	2167	8029	297	4911	2821	3239	3584	150121	21184
1977	4977	249	1925	3301	122	2590	589	1056	3164	129207	21184
1978	135760	6788	2615	139933	5178	76373	58383	73222	5366	239268	21184
1979	27918	1396	2800	26514	981	11264	14269	11740	4872	242051	21184
1980	69835	3492	2800	70527	2610	52424	15493	38299	4892	239269	21184
Total	687544	34377	37939	683982	25307	375094	283581	325670	55067	2330695	317760
Mean	45836	2292	2529	45599	1687	25006	18905	21711	3671	155380	21184

Table A8. Predicted water supply for the 1966-1980-recovery period based on the Robles BO operating criteria and without the benefit of Matilija Reservoir.

Water Year	Predicted Water Supply (AF)										
	Ventura River							Lake Casitas			District
	Flows Above Robles Diversion			Robles Operations							
	Matilija Gages	Accretion	Extraction	Inflow	Loss	Bypass	Diversion	Tributaries	Net Loss	Storage Volume	Available Supply
1966	55495	2775	2437	55832	2066	22510	31256	21289	1387	37022	19775
1967	56267	2813	2767	56313	2084	18095	36135	27258	2437	78056	19775
1968	8040	402	2536	5906	219	5032	655	2392	1765	61296	19775
1969	171355	8929	2793	177130	6554	112706	57871	78737	4630	173461	19775
1970	16800	1848	2725	14915	552	10129	4234	4662	3767	160696	19775
1971	20191	2221	2481	18719	693	10589	7437	7225	3640	153876	19775
1972	10730	1180	2046	9221	341	4230	4649	5394	3345	142637	19775
1973	58322	6415	2754	58484	2164	32465	23855	33070	4342	177592	19775
1974	18421	2026	2426	16916	626	12084	4205	7417	3936	167422	19775
1975	23675	2604	2658	22201	821	13301	8079	10670	3940	164412	19775
1976	9930	1092	2167	8259	306	5521	2433	3239	3584	148531	19775
1977	4817	530	1925	3133	116	2683	334	1056	3164	128772	19775
1978	135694	14926	2615	139863	5175	78146	56542	73222	5366	236013	19775
1979	27929	3072	2800	26526	981	15573	9971	11740	4872	235179	19775
1980	69813	3491	2803	70500	2609	53978	13914	38299	4892	238762	19775
Total	687478	54326	37934	683918	25305	397043	261570	325670	55067	2303725	296625
Mean	45832	3622	2529	45595	1687	26470	17438	21711	3671	153582	19775

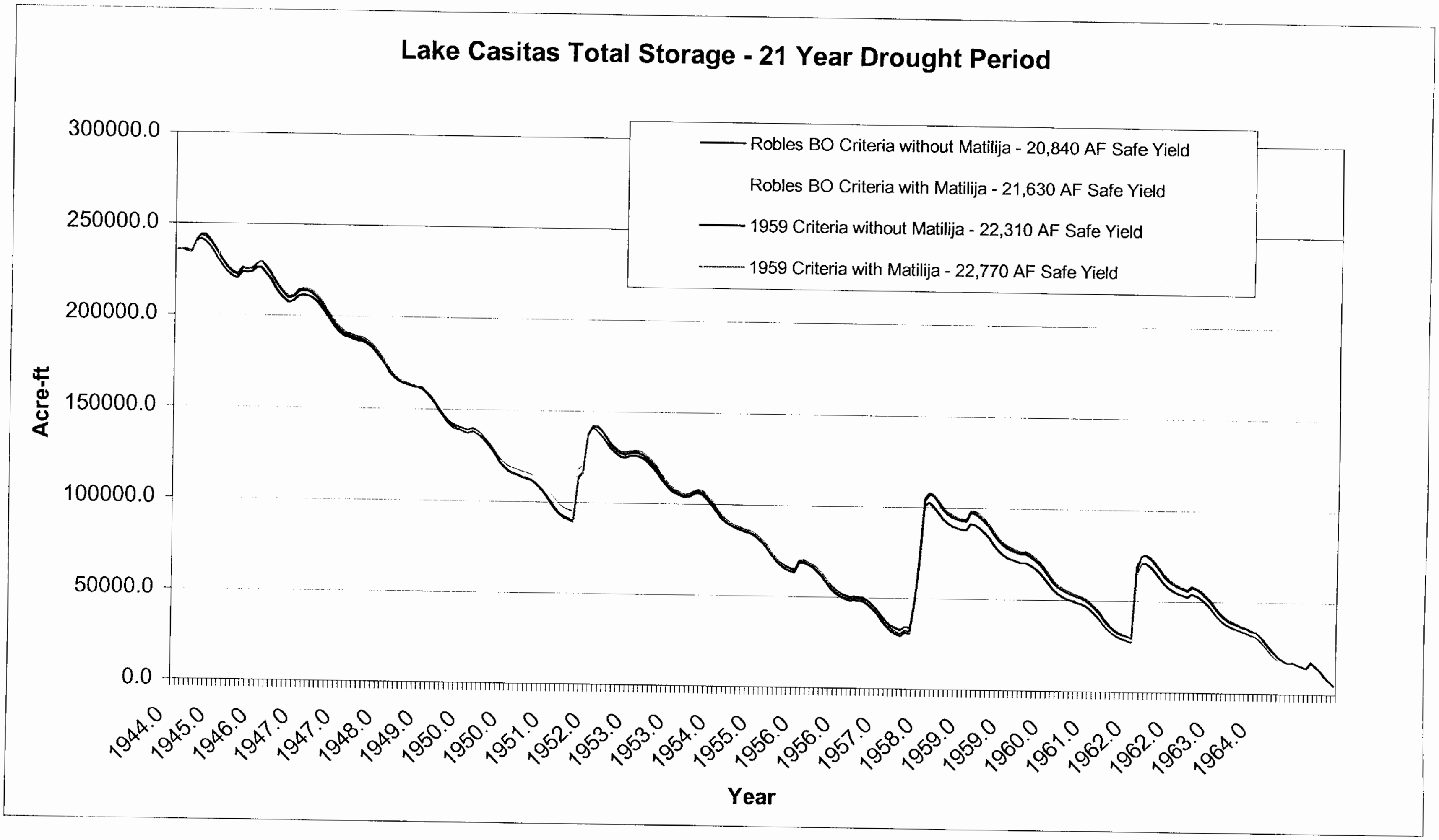


Figure A5. Comparisons of the storage volume in Lake Casitas based on different operating and safe yield scenarios for the longest drought on record.

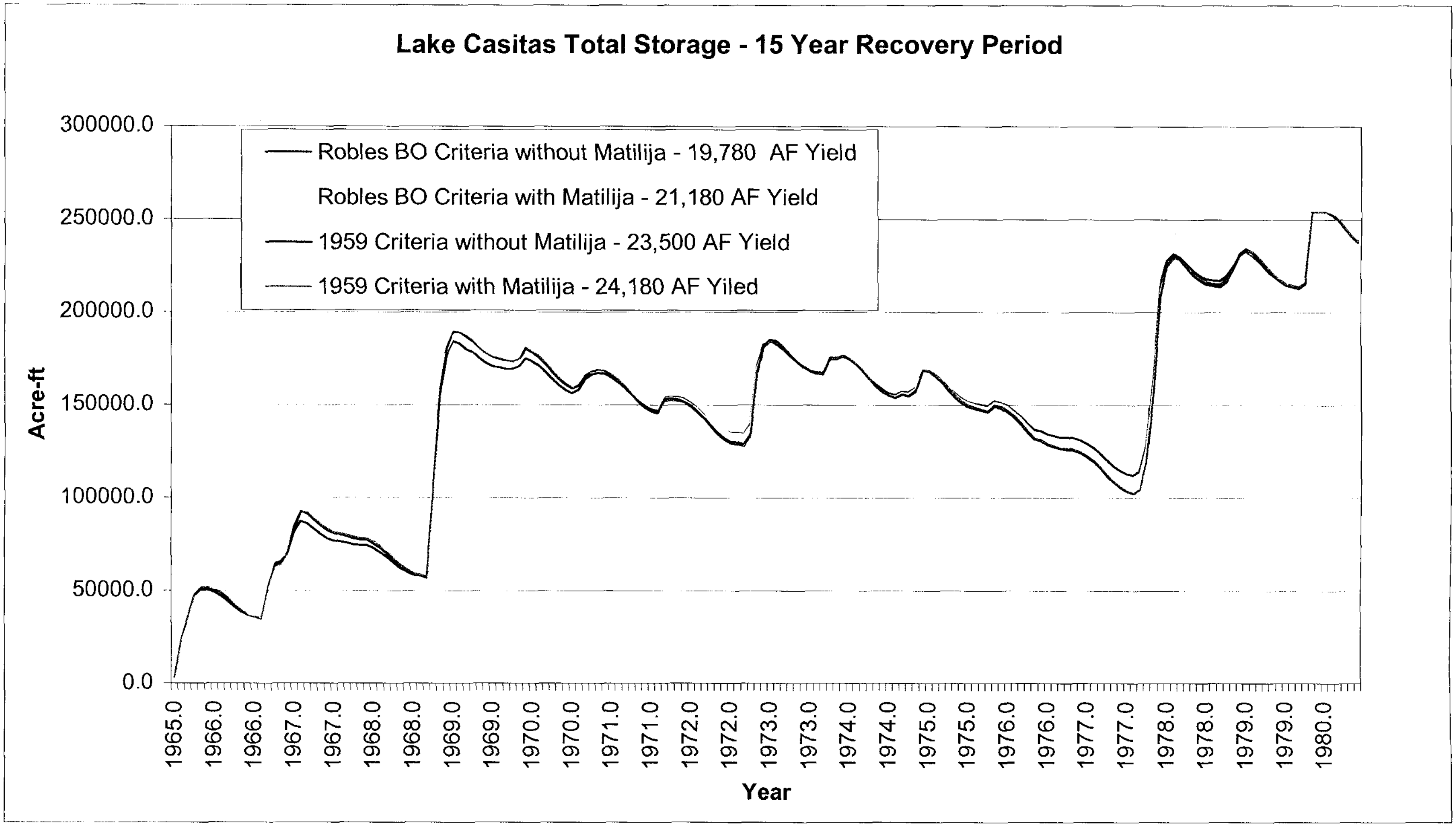


Figure A6. Comparisons of the storage volume in Lake Casitas based on different operating and yield scenarios for the recovery period following the longest drought on record.

Appendix B - Casitas MWD Water Delivery and Use Predictions

The information that is available for the 1945 through 1965 study period is limited to the rainfall and hydrology occurrences in the Ventura River. The Ventura River Project that brought about Lake Casitas and the District's service facilities did not become operational until 1959. Water deliveries from Lake Casitas and customer use during this study period are not available and would not have been at the same level as today. Therefore, the study must predict water deliveries based on present water use and the study period's hydrology.

The following was considered in the development of the water delivery for the study period:

1. The critical drought period is 1945 through 1965;
2. Each year is based on Water Year hydrology data;
3. Good data source for hydrology and annual rainfall exists for the study period;
4. Rainfall data used in this evaluation has been gathered at the Santa Ana weather station, from 1944 to 1959, and the Lake Casitas Recreation Area weather station from 1959 to present;
5. Limited water delivery data for the study period – the District began delivery of water from Lake Casitas in 1959.
6. Water use data during the study period should reflect current level and trends of water delivery and use.
7. Factors that tend to influence the amount of water deliveries are rainfall patterns, irrigation use, municipal and industrial use, resale use, and groundwater availability.
8. Growth may be a factor in the water deliveries and use. The initial years of District (1959-1977), the trend of water use was primarily based on growth and development. During the last 20 years, slow growth has been more representative of the deliveries and use trends.
9. The District does have detailed data on the hydrology, annual rainfall, water delivery and use for the period 1959 to 2002.
10. The District's data for the annual water delivery is in Calendar year format, need to convert data to a water year format in order to apply deliveries to the Supply model.
11. Consider the adjustment of the deliveries where unusual anomalies exist in the data. (The City of San Buenaventura, period 1991 to 1997, to reflect the current agreement to purchase 6,000 acre-feet on an annual basis. This period's actual deliveries to the City were temporarily reduced to below 6,000 acre-feet due to water quality reasons.)
12. The District deliveries include water delivered from Casitas Dam to the main conveyance system and the deliveries from the Mira Monte Water Well.

Historical Data

The Casitas Municipal Water District has an extensive collection of water use and hydrology data that can be applied to the water supply and use analysis. The data, in some cases, needed to be converted into a water year calendar time sequence in order be consistent with all other data and the time sequence used in the analysis.

The following is a representation of the historical data that has been assembled from District records for the analysis.

Table B1 - lists the water deliveries from Casitas Dam and the Mira Monte Well are presented in a water year calendar format. Also presented are the rainfall totals for each water year.

Figure B1 - illustrates the relationship between the District's deliveries and annual rainfall. It is noted that there appears to be a direct correlation between rainfall and the level of deliveries made by the District.

Figures B2 through B5 were developed to further define and explain the annual variance in water delivery. The District has compiled water use data for each of its major user types and larger customers. The user trends also illustrate the influence of rainfall and at times, the loss of alternative water supplies (i.e. groundwater supplies) on the use patterns. The review of individual use does validate the delivery-rainfall relationship that is illustrated in Figure B1.

Figure B2 - illustrates the water sales patterns for the District's agricultural customers. There appears to be a direct correlation between rainfall and the amount of water sales made to the District's agricultural customers. The District serves water to approximately 5,600 acres of orchard cropland and supplements agricultural groundwater use during periods of drought. When rainfall does not occur, water sales from the District's distribution system supplement the lack of rainfall. The figure also illustrates the coincidence of agricultural water sales with the deliveries from Casitas Dam.

Figure B3 - illustrates the water sales pattern for direct residential customers of the District. As a comparative illustration, the water sales pattern of the agricultural customers is presented. It appears that the residential water sales do not appear to be influenced by annual rainfall variations. It also appears that the growth pattern has been gradual over the recorded 26-year period.

Figure B4 - illustrates the water sales pattern for the two types of resale customers and any relationship between the sales and annual rainfall. The Resale Pumped customer is primarily to other water agencies, such as Ventura River County Water District and Southern California Water Company, that also rely on groundwater supplies to meet demands within their water service areas. The Resale Pumped customers have demanded Lake Casitas supplies generally when they are not able to meet all demands from their groundwater supplies (Ventura River and Ojai). A specific increase in demands from Lake Casitas is noted in the 1989 to 1991 period. The rise in demand was approximately 1300 acre-feet from the base demand in 1989 to the maximum demand in 1991. This change is primarily due to the depletion of groundwater supplies during the drought period.

Figure B4 - provides an insight to the water sales pattern of Resale Gravity. The primary customer in the Resale Gravity is the City of San Buenaventura (Ventura). The City has alternative groundwater supplies from the Ventura River and the groundwater basins in the eastern section of the City. The City has a series of agreements with the District concerning water service. The City has agreed to annually certify that water delivered from the Casitas system does not supply customers that are outside of the boundaries of the Casitas Municipal Water District. The district boundaries are not contiguous with the City's boundaries, and therefore, many sections of the City of are not a part of the original financial setting for repayment of contracts for the Ventura River Project (Lake Casitas). This became an issue in 1990, at the height of a drought period. The City decided to become more reliant on its alternative supplies and drastically reduced its demand on Lake Casitas. The District's water sales to the City went from a high of 9,510 acre-feet in 1989 to a minimum purchase 1,370 acre-feet in 1992, and less than 2,000 acre-feet in each of the following years, until 1997. In 1995, the City and the District agreed to guarantee a stable purchase from the District. In this agreement, the City agreed to purchase at a minimum 6,000 acre-feet annually from Lake Casitas. The City began to meet the minimum demand in 1997 and have continued to do so since that time.

Figure B4 illustrates the water demand fluctuations that resulted from the abovementioned series of events. Besides the municipal and industrial use of the water within the City, the City has a sphere of water service influence that includes oil production. The oil production in this area requires water injection to force the oil out of the geologic formations. The period between the mid 1980's to the mid 1990's experienced a reduction in oil production, and thus a reduction in water demand. The City's in-District water use plummeted from a high of 10,886 acre-feet in 1987 to a low of 7,037 acre-feet in 2002. The City also has plans to develop its water well facilities on the Ventura River. It is likely that the City will be able to maintain a balance of deliveries from Lake Casitas with the use within the common City-District boundaries.

Figure B5 illustrates the historical sales to the Business, Industry, and Other customer types of the District. For the Industry customers, the sales patterns do not appear to be influence by rainfall patterns. The Business and Other customers are primarily irrigated golf courses, public and private schools, and recreational areas, and may be influenced by rainfall patterns. There are some Business and Other customers that rely on Lake Casitas supply to supplement rainfall in the irrigation of large turf areas that are associated with these customers. In general, the annual water delivery for each of these customers is generally less than 800 acre-feet and the annual variation of demand is seldom greater than 200 acre-feet. There does not appear to be a growth trend in the annual demands from these three customer types.

Water Deliveries Adjustment – City of San Buenaventura

Figure B4 illustrates that there may be several factors that have may have influenced the City of Ventura's water use, other than the influence of annual rainfall events. Several of those factors have been resolved by the agreement of a minimum water demand from Lake Casitas. In the recent years, the City has maintained its minimum demand on Lake Casitas at approximately 6,000 acre-feet. To develop a current Lake Casitas demand trend that may be extrapolated to other study periods, there must be an adjustment of the historical water use data to reflect the current level of demand by the City of Ventura. In Table B2, the water sales to the City of Ventura, for the period of 1991 to 1997, were adjusted to reflect the minimum City of Ventura demand on Lake Casitas of 6,000 acre-feet. The adjustment amount for the City of Ventura was also added to the District's deliveries to main conveyance, and further listed under the column entitled "Adjusted WY Deliveries to Main Conveyance." Figure B6 illustrates the adjustment to the annual water deliveries.

The period prior to 1990 has not been adjusted primarily because the city did not exceed its in-District demand by the deliveries from Lake Casitas. It should be noted that given a future extensive dry period, and/or re-emergence of the oil industry, the City of Ventura demands could potentially increase back to the water deliveries recorded in the 1980's.

Trending Deliveries

From the review of historical data, it appears that the annual rainfall is a key factor that has influenced the District water deliveries. It is also apparent that multiple years of dry conditions cause an escalation of the delivery occurring in any one year. In Table B3, the annual rainfall totals and corresponding water deliveries are ranked from lest rainfall to most recorded rainfall. The rainfall data has been gathered at the Lake Casitas Recreation Area and assumed to be a representative influence for the majority of the District's customers. Table B3 lists the data for the 1976 to 2002 and the 1984 to 2002 periods. The later period being more representative of current water use and growth trends.

The rainfall data is further separated and compared for each 10-inch increment of rainfall. The average of rainfall and deliveries for each 10-inch increment and each period is calculated in Table B3 and illustrated in Figures B7 and B8. A polynomial trend line has developed from the graphical representation of the average deliveries for each period. Table B4 uses the trend line from the 1984 to 2002 period and sequential 10-inch rainfall totals to determine the delivery from each rainfall total. The polynomial trend line equation from the 1984 to 2002 period was selected for the linear trend calculations.

In the study period, there are several consecutive dry years. The rainfall and delivery data in Table B1 and Figure B1, for the period of 1984 to 1990 demonstrates that when the system experiences multiple and consecutive dry rainfall years (less than 20 inches), the delivery for the following year tends to escalate with each consecutive dry year. Table B5 presents the rainfall and deliveries for the 1984 to 1990 period. Figures B9 and B10 illustrate the delivery data and linear trend line for the escalation of multiple consecutive dry years. In Figure B10, a shorter period of time is evaluated, removing the heavy rainfall of 1986 from influence on the trend line. Each year in Table B10 was assigned a consecutive dry year multiplier number, and from the trend lines, the deliveries for each year are calculated and compared to the actual delivery data. The slope of line (1,377) from 1986 to 1990 escalating trend line equation, Figure B10, was selected as a representative equation for application to multiple consecutive dry years found in the study period (1945-1965).

Modeling Deliveries for the Critical Dry Period

The objective of the close review of rainfall-delivery response and the development of trend line equations and escalation factors is to be able to predict deliveries for a period of time during which no delivery record exists. In Table B6, the annual rainfall at the Lake Casitas Recreation area is listed for each year of the study period. The polynomial trend equation

$$y=1.7488x^2 - 269.1x + 24300$$

is applied to each annual rainfall and the water delivery is calculated and recorded for each year. For each year during which the annual rainfall is less than 20 inches, a consecutive year multiplier and the escalation slope are applied to the linear trend equation in

$$y=1.7488x^2 - 269.1x + 24300 + (\text{Dry Year Multiplier})(1{,}377).$$

The water deliveries from each equation are shown in Table B6. Figure B11 illustrates the predicted water deliveries for each equation and the annual rainfall for each year of the study period.

The derivation of an equation to predict a finite number has risk in the confidence that the number would be comparable to actual results. In Table B7, the actual water deliveries for the period 1984 to 1990 is compared to the delivery numbers that are generated from the polynomial and escalating trend equations. As expected, the actual deliveries fall between the two equation lines during the period, as shown in Figure B12. The development of trend deliveries for the period of 1966 through 2003, Table B8 and Figure B13, illustrates a higher confidence of following actual use in the last ten years of historical data.

The deliveries that have been derived in Table B6 are accounted against the available Lake Casitas supply to determine the impacts on Lake Casitas.

Modeling Deliveries the Recovery Period

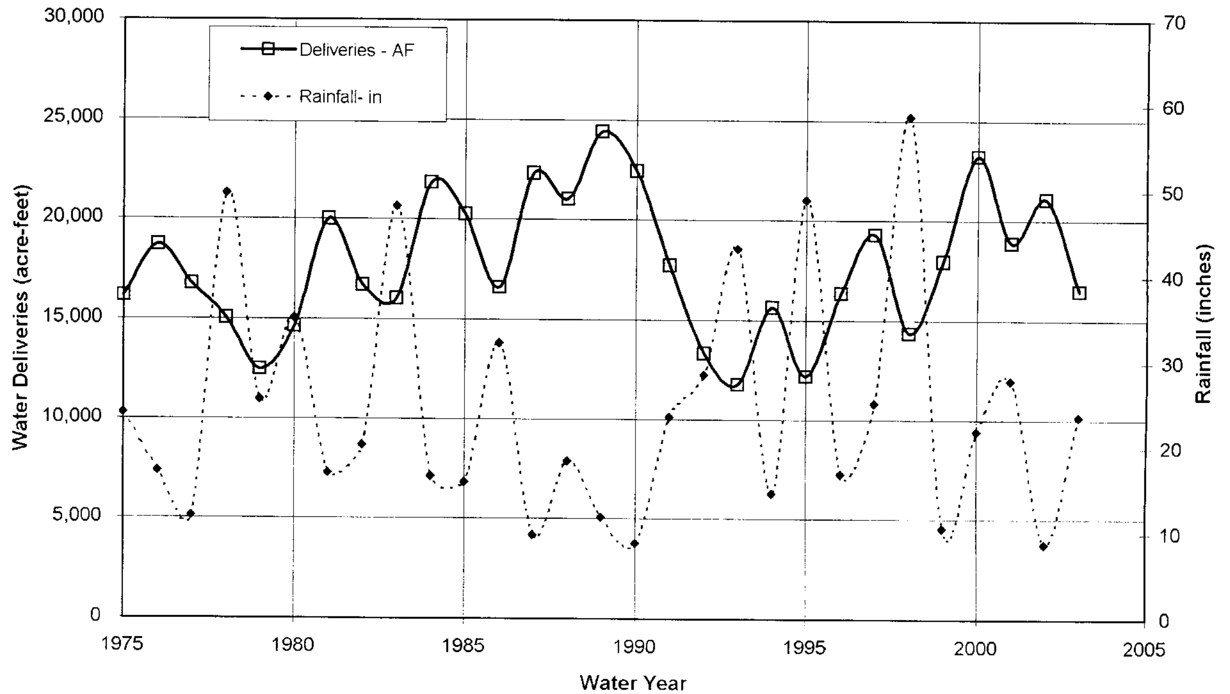
The supply and demand study for the critical dry period takes the water surface elevation of Lake Casitas to minimum pool. The modeling needs to demonstrate the ability of the hydrology to recover Lake Casitas storage to full capacity, during the wet trend period and under each of the two diversion operating criteria. There is an importance to restore the full capacity of Lake Casitas prior to the onset of another critical dry period. The actual occurrence following 1965, the end of the critical dry period, Lake Casitas reached full storage capacity in 1978. The modeling of the recovery period should include the hydrology experienced during the 1966 to 1978 period and compare the capacity response of Lake Casitas for each of the diversion operational criteria.

For the recovery period, the deliveries were determined from the same trend equations that were used in the critical dry period study. During this recovery period, 1977 was the only year receiving the additional escalating factor. Table B9 provides the prediction of water deliveries for the 1966 to 1978 period, and the actual deliveries made by the District. It is noted that the actual deliveries are much less than the predicted value, primarily because the actual water uses from Lake Casitas were in development and had not matured to the current level of use. The predicted deliveries are based on the current level of water use. Figure B14 illustrates the predicted deliveries for each year of the recovery period. The deliveries that are derived in Table B9 are accounted against the available supply in Lake Casitas for the recovery period.

Table B1 - Casitas Water Deliveries to the System and Rainfall at Lake Casitas Recreation Area

Water Year	Rainfall at LCRA (in.)	Deliveries to Main Conveyance System @ Casitas Dam (AF)	Mira Monte Well (AF)	Total Deliveries (AF)
1975	24.05	16,156		16,156
1976	17.23	18,725		18,725
1977	11.98	16,779		16,779
1978	49.66	15,080		15,080
1979	25.64	12,499		12,499
1980	35.15	14,651		14,651
1981	16.99	20,012		20,012
1982	20.34	16,702		16,702
1983	48.22	16,026	0	16,026
1984	16.63	21,832	0	21,832
1985	15.93	20,274	0	20,274
1986	32.2	16,606	0	16,606
1987	9.83	22,339	0	22,339
1988	18.4	21,032	0	21,032
1989	11.85	24,416	0	24,416
1990	8.86	22,454	0	22,454
1991	23.59	17,723	0	17,723
1992	28.53	13,189	129	13,318
1993	43.31	11,694	46	11,740
1994	14.69	15,555	85	15,640
1995	49.04	12,107	78	12,185
1996	16.91	16,135	221	16,356
1997	25.27	18,996	305	19,301
1998	58.78	14,372	0	14,372
1999	10.67	17,942	0	17,942
2000	21.94	23,060	169	23,229
2001	27.86	18,743	130	18,873
2002	8.77	21,066	0	21,066
2003	23.69	16278	198	16,476

Figure B1 - Casitas Water Deliveries to the System and Rainfall (1975 to 2003)



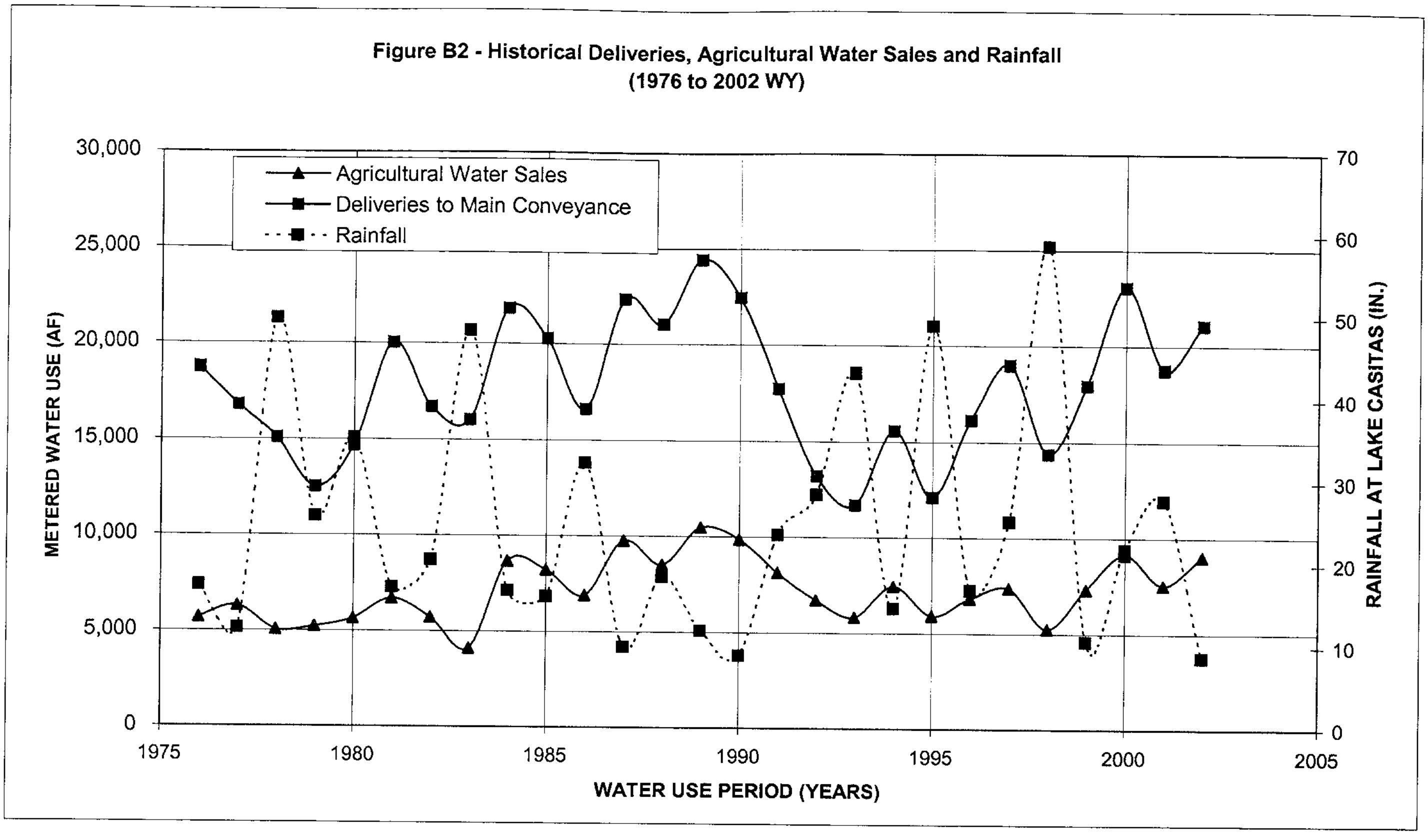


Figure B2 - Historical Deliveries, Agricultural Water Sales and Rainfall
(1976 to 2002 WY)
Agricultural Water Sales
Deliveries to Main Conveyance
Rainfall
METERED WATER USE (AF)
RAINFALL AT LAKE CASITAS (IN.)
WATER USE PERIOD (YEARS)
30,000
25,000
20,000
15,000
10,000
5,000
0
70
60
50
40
30
20
10
0
1975
1980
1985
1990
1995
2000
2005

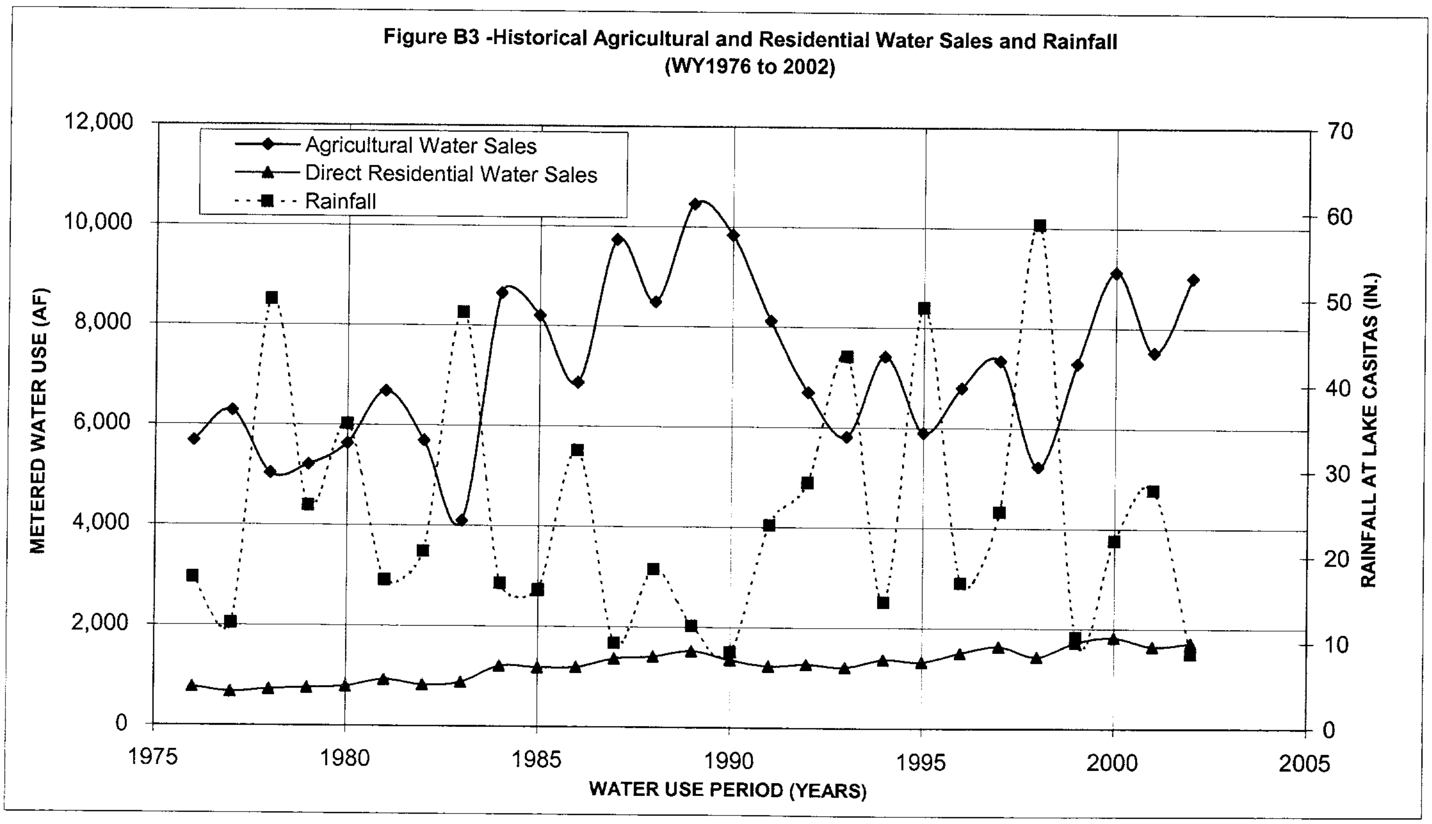


Figure B3 -Historical Agricultural and Residential Water Sales and Rainfall
(WY1976 to 2002)
Agricultural Water Sales
Direct Residential Water Sales
Rainfall
METERED WATER USE (AF)
RAINFALL AT LAKE CASITAS (IN.)
WATER USE PERIOD (YEARS)
12,000
10,000
8,000
6,000
4,000
2,000
0
70
60
50
40
30
20
10
0
1975
1980
1985
1990
1995
2000
2005

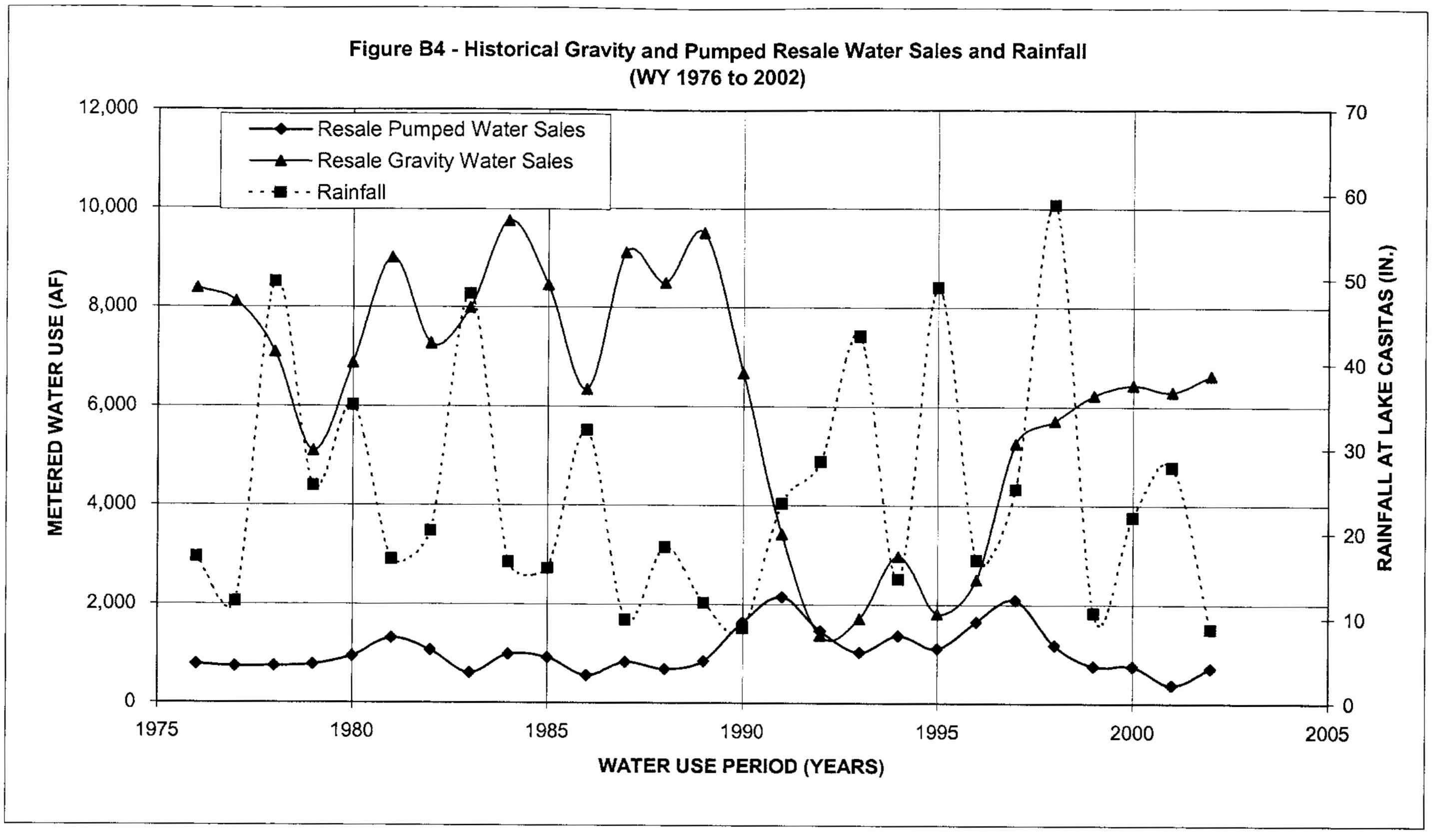


Figure B4 - Historical Gravity and Pumped Resale Water Sales and Rainfall
(WY 1976 to 2002)
Resale Pumped Water Sales
Resale Gravity Water Sales
Rainfall
METERED WATER USE (AF)
RAINFALL AT LAKE CASITAS (IN.)
WATER USE PERIOD (YEARS)
12,000
10,000
8,000
6,000
4,000
2,000
0
70
60
50
40
30
20
10
0
1975
1980
1985
1990
1995
2000
2005

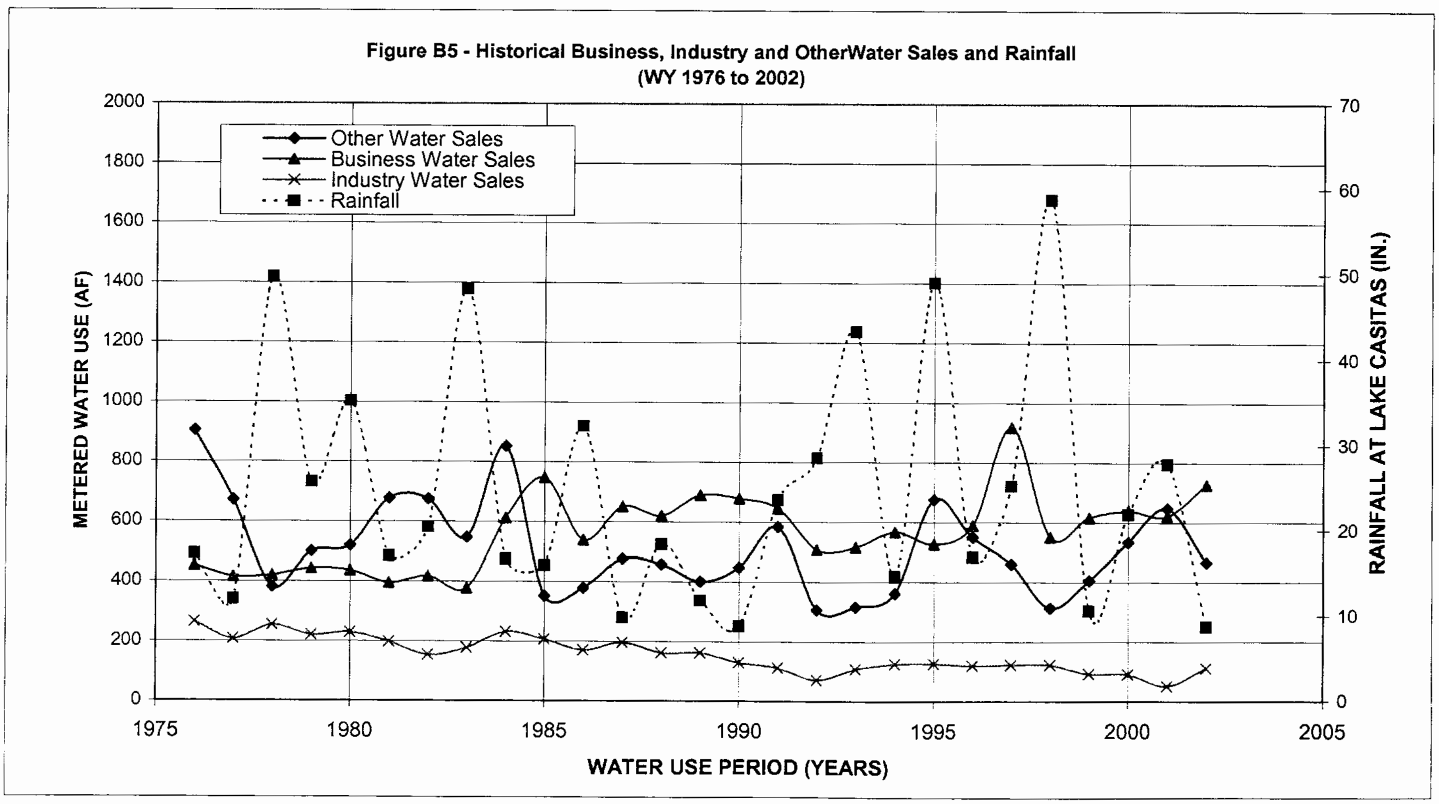
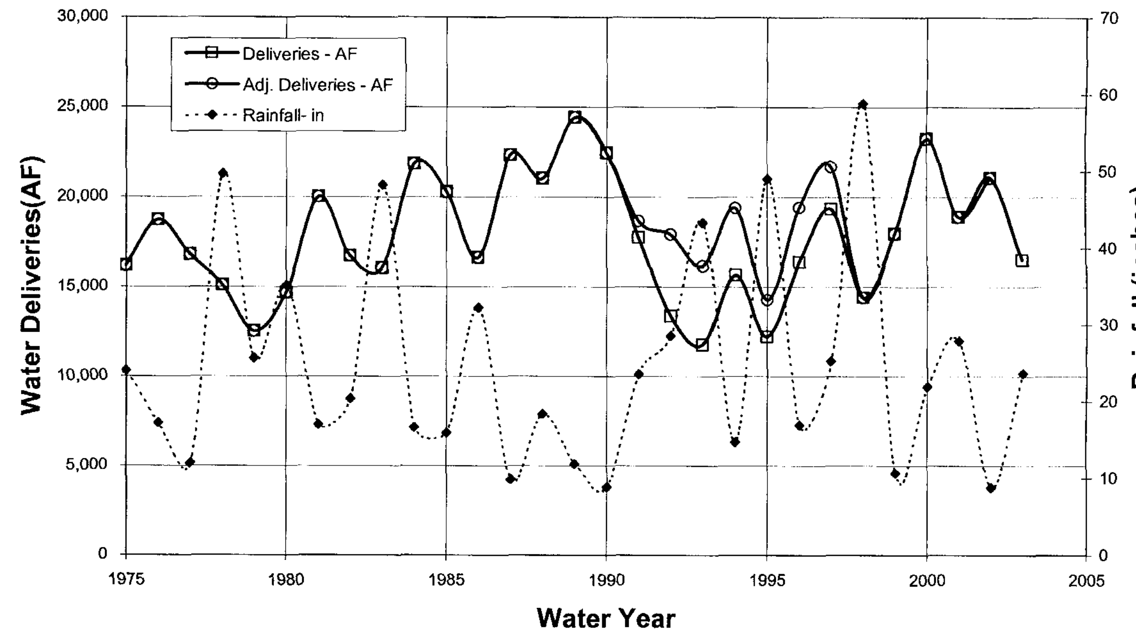


Figure B5 - Historical Business, Industry and OtherWater Sales and Rainfall
(WY 1976 to 2002)
Other Water Sales
Business Water Sales
Industry Water Sales
Rainfall
METERED WATER USE (AF)
RAINFALL AT LAKE CASITAS (IN.)
WATER USE PERIOD (YEARS)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
70
60
50
40
30
20
10
0
1975
1980
1985
1990
1995
2000
2005

Table B2 - Water Deliveries Adjustment - City of Ventura Agreement for Minimum 6,000 AF Annual Purchase

Water Year	Rainfall at LCRA (in.)	Deliveries to Main Conveyance (AF)	Water Sales to City of Ventura (AF)	Adjusted Deliveries for the City of Ventura (AF)	*Adjusted WY Deliveries to Main Conveyance (AF)
1975	24.05	16,156			16,156
1976	17.23	18,725			18,725
1977	11.98	16,779			16,779
1978	49.66	15,080			15,080
1979	25.64	12,499			12,499
1980	35.15	14,651			14,651
1981	16.99	20,012			20,012
1982	20.34	16,702			16,702
1983	48.22	16,026			16,026
1984	16.63	21,832			21,832
1985	15.93	20,274	8,591		20,274
1986	32.2	16,606	7,737		16,606
1987	9.83	22,339	7,822		22,339
1988	18.4	21,032	8,629		21,032
1989	11.85	24,416	8,875		24,416
1990	8.86	22,454	8,734		22,454
1991	23.59	17,723	5,073	927	18,650
1992	28.53	13,318	1,408	4,592	17,910
1993	43.31	11,740	1,605	4,395	16,135
1994	14.69	15,640	2,263	3,737	19,377
1995	49.04	12,185	3,943	2,057	14,242
1996	16.91	16,356	2953	3,047	19,403
1997	25.27	19,301	3622	2,378	21,679
1998	58.78	14,372	7,189		14,372
1999	10.67	17,942	6,030		17,942
2000	21.94	23,229			23,229
2001	27.86	18,873			18,873
2002	8.77	21,066	6,042		21,066
2003	23.69	16,476			

Figure B6 - Adjustment to Annual Water Deliveries - City of Ventura Agreement



*Adjusted deliveries includes the difference between the City of Ventura's actual purchase of Lake Casitas water and the requirement for the annual purchase by the City of 6,000 AF from Casitas. City purchases during the 1990's were reduced due to water treatment deficiencies and other. In those years where 6,000AF were not purchased, the additional purchase to get 6,000 AF was added to the actual deliveries and stated in the "Adjusted Deliveies to Main Conveyance column.

Table B3 - Casitas Municipal Water District Deliveries - Water Year Ranking
Rainfal Totals for Periods 1976 to 2002 and 1984 to 2002

Rainfall Increments	Water Year	Period 1976 to 2002 Rainfall at LCRA (Inches)	Period 1976 to 2002 Deliveries to Main Conveyence System Water Year (AF)	Period 1984 to 2002 Rainfall at LCRA (in.)	Period 1984 to 2002 Deliveries to Main Conveyence System Water Year (AF)
	2002	8.77	21,066	8.77	21,066
0-10 inches Rainfall	1990	8.86	22,454	8.86	22,454
	1987	9.83	22,339	9.83	22,339
	1999	10.67	17,942	10.67	17,942
	1989	11.85	24,416	11.85	24,416
	1977	11.98	16,779		
	1994	14.69	19,377	14.69	18,587
	1985	15.93	20,274	15.93	20,274
10-20 inches Rainfall	1984	16.63	21,832	16.63	21,832
	1996	16.91	19,403	16.91	19,633
	1981	16.99	20,012		
	1976	17.23	18,725		
	1988	18.40	21,032	18.40	21,014
	1982	20.34	16,702		
	2000	21.94	23,229	21.94	23,060
	1991	23.59	18,650	23.59	18,650
	2003	23.69	16,476	23.69	16,476
20-30 inches Rainfall	1997	25.27	21,679	25.27	21,679
	1979	25.64	12,499		
	2001	27.86	18,873	27.86	18,743
	1992	28.53	17,910	28.53	17,910
	1986	32.20	16,606	32.20	16,606
30-40 inches Rainfall	1980	35.15	14,651		
	1993	43.31	16,135	43.31	15,986
40-50 inches Rainfall	1983	48.22	16,026		
	1995	49.04	14,242	49.04	16,294
	1978	49.66	15,080		
> 50 inches Rainfall	1998	58.78	14,372	58.78	14,372
Average for 0-10 inches Rainfall		9.15	21,953	9.15	21,953
Average for 10-20 inches Rainfall		15.60	19,681	15.01	20,528
Average for 20-30 inches Rainfall		25.22	18,474	25.15	19,420
Average for 30-40 inches Rainfall		33.68	15,629	32.20	16,606
Average for 40-50 inches Rainfall		49.80	15,171	50.38	15,551
Average for greater than 50 inches Rainfall		58.78	14,372	58.78	14,372

Note the adjustment for the City of Ventura Agreement is included in the deliveries for the period 1990-1997.

Figure B7 - Average Water Deliveries based on 10-inch Rainfall Increments 1976 to 2002 period

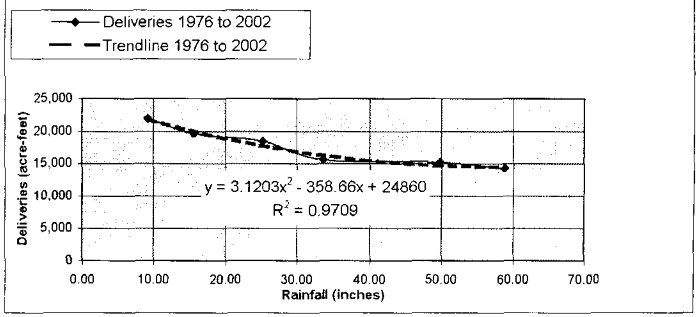


Figure B8 - Average Water Deliveries based on 10-inch Rainfall Increments 1984 to 2002 Period

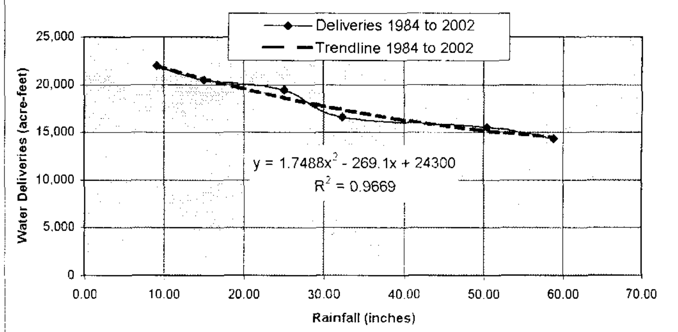


Table B4 - Trendline Comparison

Rainfall (in.)	Deliveries 1976-2002 (AF)	Deliveries 1984-2002 (AF)
10	21,585	21,784
20	18,935	19,618
30	16,908	17,801
40	15,506	16,334

Table B5 - Dry Period Escalation of Deliveries					
Water Year	Rainfall at LCRA (Inches)	Deliveries to Main Conveyence System Water Year (AF)	Consec. Dry Year	Fig. 9 Trendline Applied to Rainfall (AF)	Fig. 10 Trendline Applied to Rainfall (AF)
1984	16.63	21,832	0	20,309	20,309
1985	15.93	20,274	1	20,978	21,834
1986	32.20	16,606	0	17,448	17,448
1987	9.83	22,339	0	21,824	21,824
1988	18.40	21,032	1	20,462	21,318
1989	11.85	24,416	2	22,399	24,111
1990	8.86	22,454	3	23,616	26,184

Figure B9 - Escalating Trend for 1984 to 1990 Dry Period

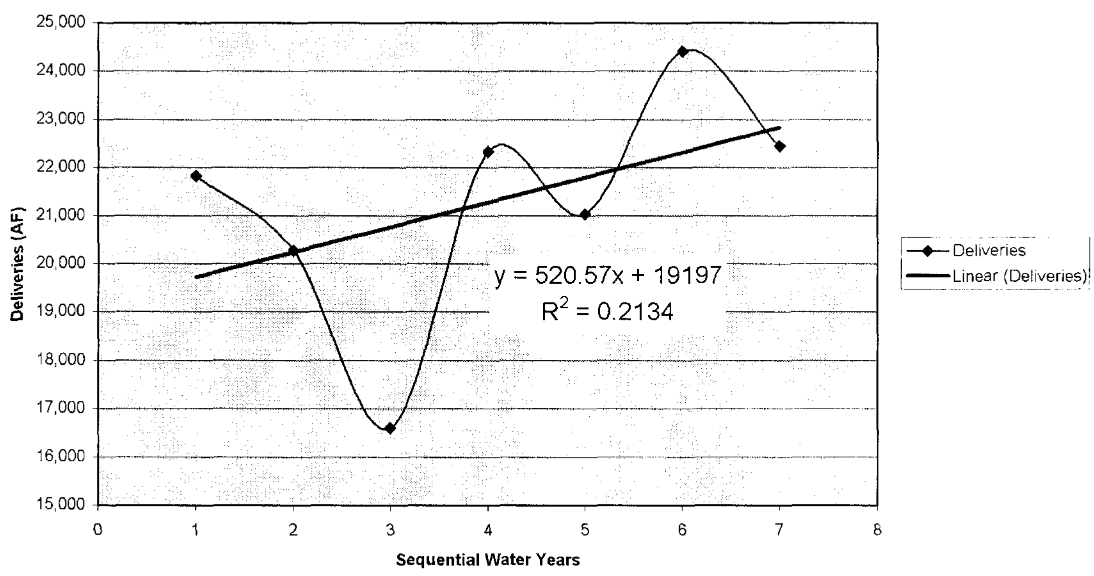


Figure B10 - Escalating Trend for 1986 to 1990 Dry Period

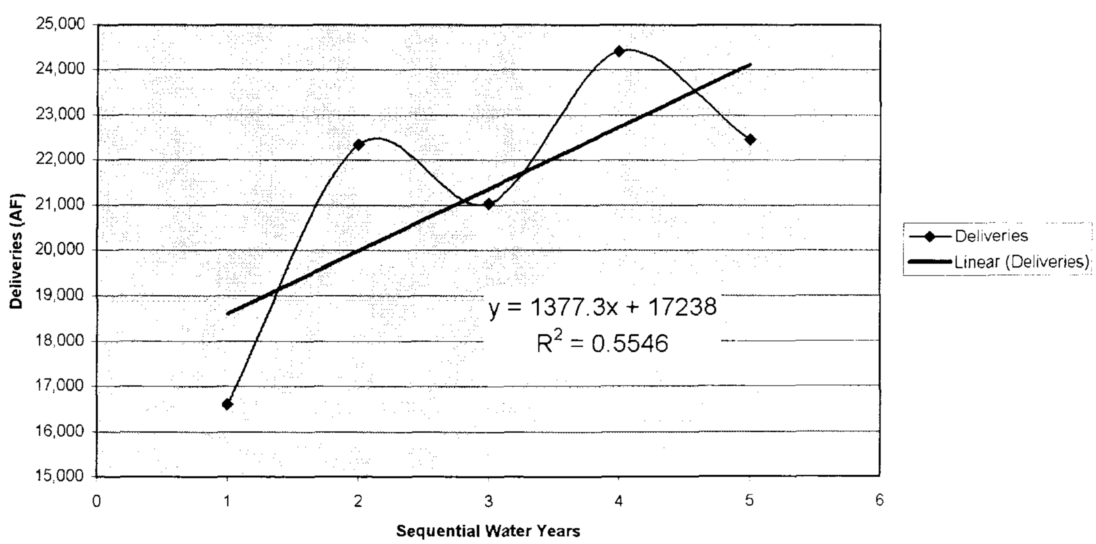
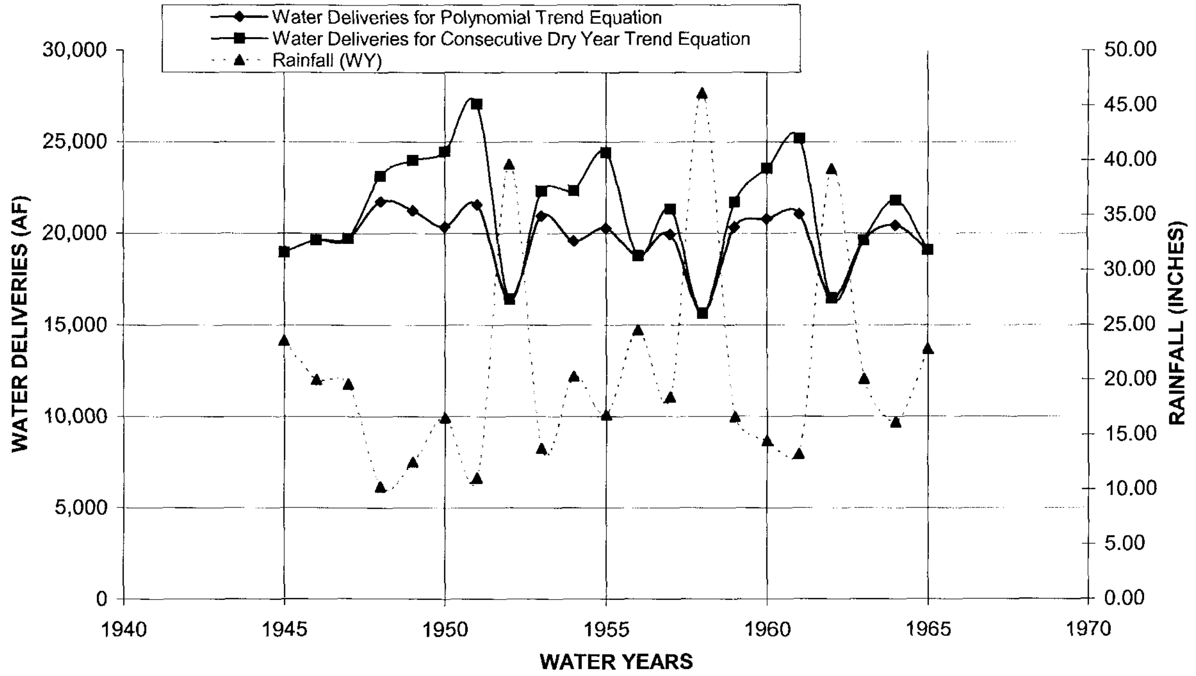


Table B6 - Estimated Water Delivery Based on Polynomial Trend and Escalating Trend Equations for Period 1945 thru 1965

Year	Rainfall at LCRA (inches)	Consec. Dry Year Multiplier	Water Deliveries: Polynomial Trend Eqn. (AF)	Water Deliveries: Consec. Dry Year Trend Eqn (AF)
1945	23.53		18,936	18,936
1946	20.01		19,616	19,616
1947	19.60	0	19,697	19,697
1948	10.25	1	21,725	23,102
1949	12.49	2	21,212	23,966
1950	16.54	3	20,328	24,459
1951	11.01	4	21,549	27,057
1952	39.63		16,382	16,382
1953	13.76	1	20,928	22,305
1954	20.30	2	19,558	22,312
1955	16.81	3	20,271	24,402
1956	24.53		18,751	18,751
1957	18.44	1	19,932	21,309
1958	46.11		15,610	15,610
1959	16.62	1	20,311	21,688
1960	14.45	2	20,777	23,531
1961	13.24	3	21,044	25,175
1962	39.21		16,437	16,437
1963	20.07		19,604	19,604
1964	16.13	1	20,414	21,791
1965	22.83		19,068	19,068
Total			412,150	445,198
Average	20.74		19,626	21,200

Figure B11 - Estimated Water Deliveries for Period 1945 thru 1965



Notes:

Polynomial Trend Equation Delivery - polynomial equation based on rainfall and historical water use data for the period of 1984 through 2002, with the adjustment of Resale Gravity during the 1991 through 1997 period remaining at a constant 6,000 AF demand throughout period of study. City would use alternate well supplies to supplement loss of Ventura River supply during the study period.

Consecutive Dry Year Trend Equation Delivery - use of polynomial trend equation to determine annual water demand, upon first year of less than 20 inches of rainfall add 1377 AF demand to the trend water demand. For the second consecutive year under 20 inches of rainfall, add 2 times 1377 AF to polynomial trend, for the third consecutive year, add three times 1377 AF to polynomial trend. Similar escalation applied to each of the following consecutive yuears of less than 20 inches of rainfall. Use of consecutive dry year multiplier to escalate delivery for each water year.

Deliveries Verification - apply the polynomial trend equation and the multiple dry year trend equation to the historical rainfall data for the period WY 1984 through WY 1990.
Compare the application of trend equations to historical water delivery data for the same period.

The multiple dry year trend equation data followed the actual delivery data, except for the 1990 water year. In 1990, extremely dry year, there may have been an additional reduction in deliveries to the City of Ventura (Resale Gravity) because of alternative supply use.
With only 8.86 inches of rainfall in the fourth year of a drought, deliveries would have been expected to rise above the previous year's deliveries.

Table B7 - Deliveries Verification

WY	Rainfall (in.)	Actual (AF)	Polynomial Trend Eqn. (AF)	Dry Yr. Multiplier	Multiple Dry Year Trend Equation (AF)
1984	16.63	21,823	20,309	1	21,686
1985	15.93	20,274	20,457	2	23,211
1986	32.2	16,606	17,448	0	17,448
1987	9.83	22,339	21,824	1	23,201
1988	18.4	21,033	19,941	2	22,695
1989	11.85	24,416	21,357	3	25,488
1990	8.86	22,454	22,053	4	27,561

Figure B12 - Deliveries Verification - Comparison of Trend Equations and Actual Deliveries

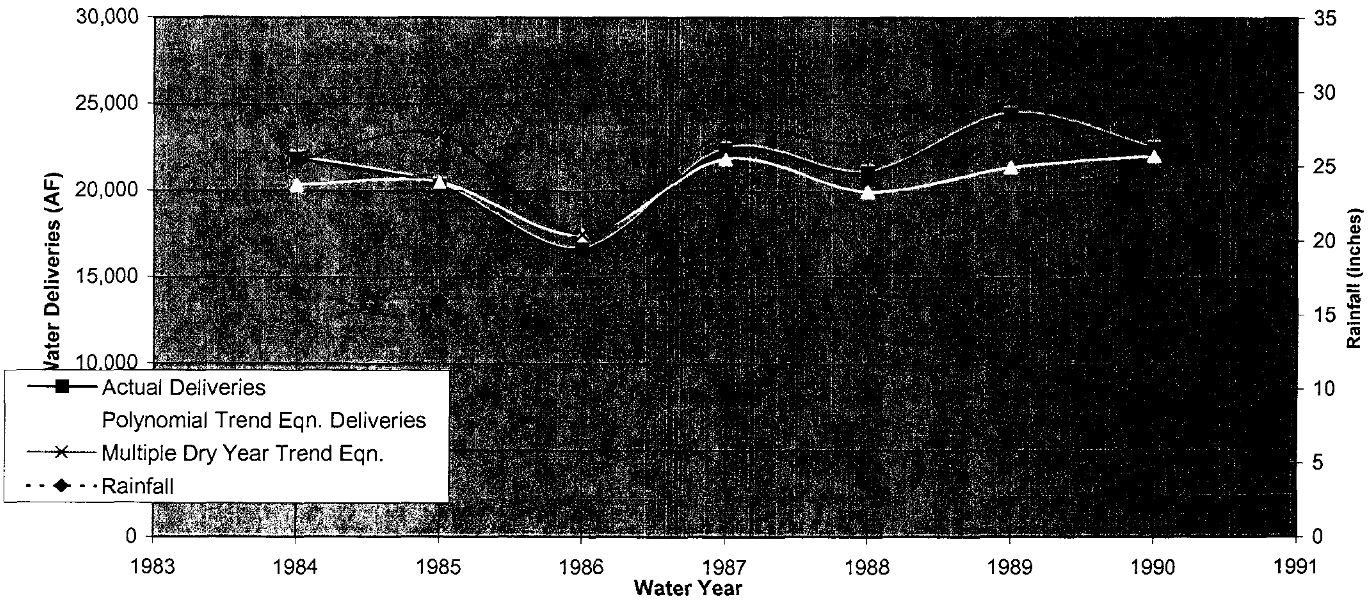
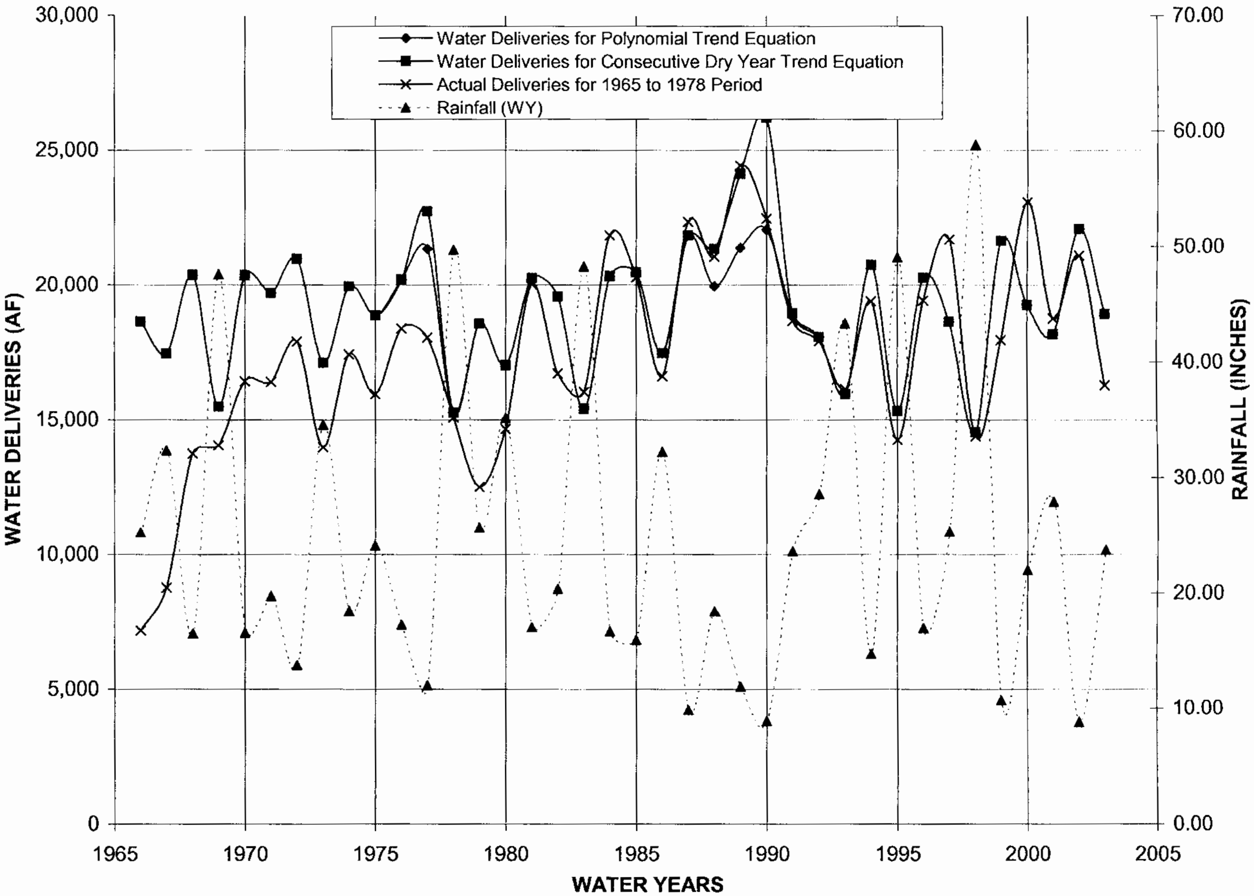


Table B8 - Trend and Actual Water Delivery Comparison -1966 through 2003

Year	Rainfall at LCRA (inches)	Consec. Dry Year Multiplier	Water Deliveries: Polynomial Trend Eqn. (AF)	Water Deliveries: Consec. Dry Year Trend Eqn (AF)	Water Deliveries: Actual (AF)
1966	25.23		18,624	18,624	7,162
1967	32.30		17,433	17,433	8,759
1968	16.44		20,349	20,349	13,729
1969	47.55		15,458	15,458	14,040
1970	16.52		20,332	20,332	16,417
1971	19.71		19,675	19,675	16,392
1972	13.72		20,937	20,937	17,878
1973	34.56		17,089	17,089	13,963
1974	18.43		19,934	19,934	17,400
1975	24.05		18,840	18,840	15,937
1976	17.23	0	20,183	20,183	18,371
1977	11.98	1	21,327	22,704	18,035
1978	49.66		15,249	15,249	15,080
1979	25.64		18,550	18,550	12,499
1980	35.15		17,002	17,002	14,651
1981	16.99		20,233	20,233	20,012
1982	20.34		19,550	19,550	16,702
1983	48.22		15,390	15,390	16,026
1984	16.63		20,309	20,309	21,832
1985	15.93		20,457	20,457	20,274
1986	32.2		17,448	17,448	16,606
1987	9.83	0	21,824	21,824	22,339
1988	18.4	1	19,941	21,318	21,032
1989	11.85	2	21,357	24,111	24,416
1990	8.86	3	22,053	26,184	22,454
1991	23.59		18,925	18,925	18,650
1992	28.53		18,046	18,046	17,910
1993	43.31		15,926	15,926	16,135
1994	14.69		20,724	20,724	19,377
1995	49.04		15,309	15,309	14,242
1996	16.91		20,250	20,250	19,403
1997	25.27		18,617	18,617	21,679
1998	58.78		14,525	14,525	14,372
1999	10.67		21,628	21,628	17,942
2000	21.94		19,238	19,238	23,060
2001	27.86		18,160	18,160	18,743
2002	8.77		22,074	22,074	21,066
2003	23.69		18,906	18,906	16,278
Total			376,920	378,297	315,159
Average			18,879	18,985	14,859

Figure B13- Trend Estimated Water Deliveries and Actual Deliveries - 1966 thru 2003

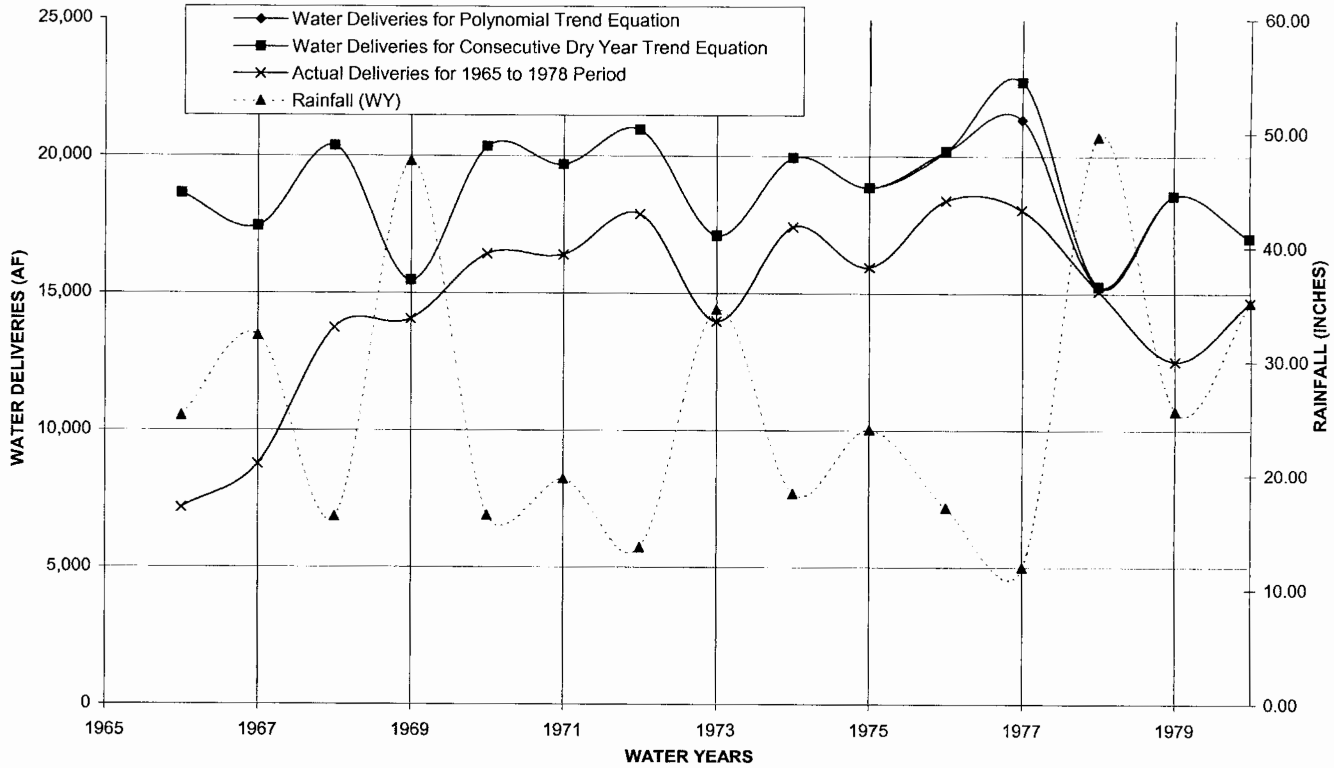


Note that the period 1978 thru 1980 was a rare multiple wet year occurrence that is not reflected in the trend equations. Therefore, the Estimated water deliveries are higher than Actual deliveries.

Table B9 - Recovery Study Period - 1966 through 1980

Year	Rainfall at LCRA (inches)	Consec. Dry Year Multiplier	Water Deliveries Polynomial Trend Eqn. (AF)	Water Deliveries Consec. Dry Year Trend Eqn (AF)	Water Deliveries Actual (AF)
1966	25.23		18,624	18,624	7,162
1967	32.30		17,433	17,433	8,759
1968	16.44		20,349	20,349	13,729
1969	47.55		15,458	15,458	14,040
1970	16.52		20,332	20,332	16,417
1971	19.71		19,675	19,675	16,392
1972	13.72		20,937	20,937	17,878
1973	34.56		17,089	17,089	13,963
1974	18.43		19,934	19,934	17,400
1975	24.05		18,840	18,840	15,937
1976	17.23	0	20,183	20,183	18,371
1977	11.98	1	21,327	22,704	18,035
1978	49.66		15,249	15,249	15,080
1979	25.64		18,550	18,550	12,499
1980	35.15		17,002	17,002	14,651
Total for 1966-80			280,981	282,358	220,313
Avg. for 1966-80			18,732	18,824	14,688

Figure B14- Estimated Water Deliveries for Recovery Period 1966 thru 1980



Note that the period 1978 thru 1980 was a rare multiple wet year occurrence that is not reflected in the trend equations. Therefore, the Estimated water deliveries are higher than Actual deliveries.

Appendix C - Casitas MWD Water Allocation Assignments

In the aftermath of the District's water shortage emergency of 1989, the District developed a method for implementing a reduction of water use during times of drought. The method considered priorities for water service, equality among similar types of customers, water rate incentives to keep water use from overwhelming available water supplies, and the manner in which the District would meet the additional demands for new water service. The concepts contained in the methods emerged as the District's Water Allocation Program.

The allocation program is a price-driven water conservation measure that can provide a base water use at a reasonable cost rate and escalates water cost rates once the base use (allocation) is exceeded by the customer. The application of the allocation program provides the customer the financial decision to pay more for their water use or conserve water. Without the application of the price-driven structure, the allocation has no bearing on limiting the actual water use that is applied by individual customers. It should be noted that, to date, the District has not implemented the price-driven allocation structure.

The District has assigned water allocations to various users types and individual customers. The initial water allocations were based on the water use from 1989, less twenty percent of that 1989 annual metered use. The District assigned individual allocation to each customer in the residential, business, industrial, resale, and interdepartmental classifications of service. The agricultural classification was assigned an overall allocation based on eighty percent of the total agricultural metered use of 1989. A summary of the allocation assignment is presented in the Standard Current Allocation Status, dated November 12, 1991.

In 1992, the District made available 300 acre-feet of water to be allocated in a limited and controlled manner. The additional water came from the reactivation of the Mira Monte Well and the installation of blending pipeline. The well had historically provided approximately 300 acre-feet to the Mira Monte Mutual Water Company, but use had been discontinued in the early 1980's because of elevated nitrate content in the well water. From 1992 to April 23, 2003, the District issued limited water allocations to new and existing customers.

In 2003, the District made 7 acre-feet of allocations available for assignment to new customers. The allocations came from the removal of the last fourteen homes from the Teague Memorial Watershed. Prior to April 2004, the District had assigned the 7 acre-feet.

In this review of the allocation status, it was found that tracking of the allocations is made difficult by the changes that occurred in tracking systems and personnel responsibilities. In comparing the initial 1991 allocation to the District's accounting records for total allocation as of May 3, 2004, there are several discrepancies in the data. This is an area that needs further attention by staff prior to the application of the allocation program stages. The comparison for the individual user types is presented in Table C1. There are three distinct user types in Table C1 that have extreme changes in allocations from 1991 to present. Also presented in Table C1 is the fiscal year 2002-2003 water use data for each user type. This data provides an indication of the level of use and a comparison to the allocation assignment for each user type.

The first user type is the Agriculture-Domestic (AD). AD accounts are the agricultural accounts that also have a residence on the same property. These customers are billed at the residential rate for the base amount of water use and billed at the agricultural rate for all water use above the base usage. In 1991, this user type was considered a part of the agricultural user type, and included in the 8,880 acre-foot allocation for the agricultural user type. The District's Administration records does separate the AD from the Agricultural (AG) user type, but the listed totals from the combination of the two types does not equal the initial 1991 allocation assignment for AG. The District's Administration records should reflect the 8,880 acre-feet of original allocation assignment and any additional allocation assignments that occurred after1992.

The second noted change is in the Interdepartmental (DI) user type category. This particular category is an accounting of the District's metered water use at the Lake Casitas Recreation Area, flushing points, main office, and other District facilities. The use number for 1989 may have also included drought water transfers to the City of Santa Barbara. A recent review of the accounting of the calendar year 1989 metered use for Interdepartmental is 190.35 acre-feet, not the 354 acre-feet expressed in the 1991 "Standard Current Allocation Status". The allocation assignment appears to need further consideration, given the discrepancy between the 1991 allocation assignment and current District records.

The third change is in the Residential allocation assignment, where allocations have increased by 472 acre-feet since 1991. This change appears to be high and a verification of the change is recommended. The change of 472 acre-feet could mean that as many as 1004 minimum allocation changes would have to been made over that last 12 years. This number appears to be high and should be reviewed further by staff. One specific change that did occurred in the residential allocation block was the change of the Taormina Community's single 0.47 allocation into 73 individual 0.47 allocations. This change occurred when the District took over the Taormina service area and the service moved from a single master water meter, with one 0.47 acre-foot allocation, to 73 single water meters at each residence, each with an individual 0.47 allocation.

In summary, it appears that there is a need for the District to perform a detailed accounting of the allocation assignments.

STANDARD
CURRENT ALLOCATION
STATUS

November 12, 1991

Customer Type	1989	October 1 Allocation	Current Allocation
Agriculture	11,096	10,081 (-9)	10,081/8,880*
Residential	1,548	1,906 (+23)**	1,238
Business	718	575 (-20)	575
Industrial	160	130 (-20)	130
Interdepartmental	354	282 (-20)	282
Others	213	170 (-20)	170
RESALE ~~Residential~~ Pumped	953	763 (-20)	763
Gravity RESALE	10,066	6,610 (-35)	7,090
Total	25,110	20,518	20,330/19,129
Losses	1,158	1,315	1,315
Total Releases	26,268	21,833	21,645/20,444
Safe Yield	21,920	21,920	21,920/21,920
Remaining	<4,348>	87	275/ 1,476

Issues:

* Small trees on Agricultural properties
** New Residential growth due to pre-April 11,1990 will serves

All values are in Acre Feet

Table C1 - District Allocation Assignments

	User Code	ALLOCATION ASSIGNMENT 1991 Allocation Assignment (AF)	District's Records 5/3/2004 Total Allocation (AF)	Allocation Change 1991-2004 (AF)	WATER USE CY 1989 (AF)	FY 2002-03 (AF)
AD	Agriculture Domestic	0	17	17	11,096	4,597
AG	Agriculture	8880	604	-8,276	718	3,378
C	Business	575	605	30	354	681
DI	Interdepartmental	282	46	-236	0	173
F	Fire	0	0	0	0	0
HY	Hydrants	0	0	0	160	0
I	Industrial	130	146	16	213	58
OT	Other	170	192	22	1,548	233
R	Residential	1238	1,710	472	11,019	1,648
RS	Resale	7853	7,717	-136	0	7,084
TE	Temporary	0	0	0		18
	Sub-Total------->	19,128	11,037	-8,091	25,108	17,870
	Mira Monte Well Allocation	300				
	Total Allocations	**19,428**				

Note the "Water Use" is the summation of all individual metered water uses for each user types served by the District.

CASITAS Municipal Water District

INTER-DEPARTMENTAL
MEMORANDUM

DATE: June 6, 1994

TO: General Manager

FROM: Conservation Supervisor

SUBJECT: Allocation Totals - Mira Monte Well

Attached to this memo is a list of customers who have purchased allocations from the water made available by the Mira Monte well project. The first list sorts and totals the allocations by customer classification. The second list sorts and totals the allocations by agency.

ALLOCATION TOTALS - MIRA MONTE WELL

Class (Type)	Last Name	A.F. Allocation
Agriculture	Hudson	2.50
	Roll	10.0
Total:		12.50
Business	Cuccia	1.30
	Farmont Corp.	2.98
	Happy Valley Foundation	0.99
	Happy Valley School	4.00
	Ojai Valley School	6.50
Total:		15.77
Residential	Droney	0.47
	Erickson (John)	0.47
	Farmont Corp.	1.98
		1.98
		1.98
		1.98
		1.98
		1.98
	Fruchey	0.99
	Gorman	1.98
	Habitat for humanity	0.47
	Hart	0.47
	Humphrey	0.47
	Klein	0.99
	Kreitzers	0.99
	Mangum	0.99
	Marietta	0.99
	Miles	0.47
	Necochea	0.99
	Oquist	0.99
	Patterson	0.47
	Peets	0.47
	Prain	0.47
	Reyes	0.99
	Richardson (Gilbert)	0.47
	Robinson	0.47
	Ross (Hamm-J)	2.00
	Sanders	0.47
	Sherman	0.47
	Tenpenny	0.47
	Vork	0.47
	Walbridge	0.99
	Warren	0.47
	West	0.47
Total:		32.76
Total:		61.03

Agency	Last Name	Class (Type)	A.F. Allocation
asitas	Cuccia	Business	1.30
	Erickson (John)	Residential	0.47
	Farmont Corp.	Residential	1.98
		Residential	1.98
		Business	2.98
		Residential	1.98
		Residential	1.98
		Residential	1.98
		Residential	1.98
	Fruchey	Residential	0.99
	Gorman	Residential	1.98
	Habitat for humanity	Residential	0.47
	Happy Valley Foundation	Business	0.99
	Happy Valley School	Business	4.00
	Hart	Residential	0.47
	Humphrey	Residential	0.47
	Klein	Residential	0.99
	Marietta	Residential	0.99
	Miles	Residential	0.47
	Necochea	Residential	0.99
	Ojai Valley School	Business	6.50
	Patterson	Residential	0.47
	Peets	Residential	0.47
	Reyes	Residential	0.99
	Richardson (Gilbert)	Residential	0.47
	Robinson	Residential	0.47
	Roll	Agriculture	10.0
	Ross (Hamm-J)	Residential	2.00
	Sanders	Residential	0.47
	Sherman	Residential	0.47
	Vork	Residential	0.47
	Warren	Residential	0.47
Total:			52.69
Meiners Oaks	Kreitzers	Residential	0.99
	Mangum	Residential	0.99
	Oquist	Residential	0.99
	Prain	Residential	0.47
	Tenpenny	Residential	0.47
	Walbridge	Residential	0.99
Total:			4.90
Rincon Road and Water	Hudson	Agriculture	2.50
Total:			2.50
Senior Canyon	West	Residential	0.47
Total:			0.47
Taormina	Droney	Residential	0.47
Total:			0.47
...tal:			61.03

Mira Monte Well Allocations
Totals as of June 1994

Last Name	Class (Type)	APN	A.F. Allocation
Cuccia	Business	034-0-140-165, 295, 405	1.30
Droney	Residential	017-0-342-045	0.47
Erickson (John)	Residential	060-0-420-295	0.47
Farmont Corp.	Business	011-0-052-170	2.98
	Residential	011-0-052-180	1.98
	Residential	011-0-052-220	1.98
	Residential	011-0-260-010	1.98
	Residential	011-0-260-020	1.98
	Residential	011-0-260-030	1.98
	Residential	011-0-260-040	1.98
Fruchey	Residential	034-0-010-620	0.99
Gorman	Residential	011-0-220-285	1.98
Habitat for humanity	Residential	061-0-034-245	0.47
Happy Valley Foundation	Business	030-0-130-045, 105	0.99
Happy Valley School	Business	030-130-045, 105	4.00
Hart	Residential	060-0-072-325	0.47
Hudson	Agriculture	008-0-180-505	2.50
Humphrey	Residential	061-0-250-095	0.47
Klein	Residential	028-0-112-10, 13	0.99
Kreitzers	Residential	010-0-050-130	0.99
langum	Residential	018-0-150-195	0.99
Marietta	Residential	061-0-150-030, 270	0.99
Miles	Residential	061-0-013-120	0.47
Necochea	Residential	061-0-055-255	0.99
Ojai Valley School	Business	030-0-020-075	6.50
Oquist	Residential	?	0.99
Patterson	Residential	061-0-012-225	0.47
Peets	Residential	061-0-042-085	0.47
Prain	Residential	017-0-121-270	0.47
Reyes	Residential	030-0-220-275	0.99
Richardson (Gilbert)	Residential	060-0-390-055	0.47
Robinson	Residential	030-0-070-105	0.47
Roll	Agriculture	?	10.0
Ross (Hamm-J)	Residential	035-240-11, 15, 16	2.00
Sanders	Residential	061-0-043-08	0.47
Sherman	Residential	061-0-140-055	0.47
Tenpenny	Residential	017-0-061-250	0.47

Mira Monte Well Allocations
Totals as of June 1994

Last Name	Class (Type)	APN	A.F. Allocation
Vork	Residential	061-0-055-565	0.47
Walbridge	Residential	017-0-180-580	0.99
Warren	Residential	061-0-055-605	0.47
West	Residential	029-0-020-080	0.47

Appendix D – System Losses

There have been several terms used in the past to describe the rate of water consumption. The terms most commonly used are "Safe Yield", "Deliveries to Main Conveyance System", and "Metered Water Sales". Quite often, these terms have been used in an interchangeable fashion without the clear understanding of the difference between these terms and their relationships. The following are definitions for each term.

Safe Yield – defined by Meinzer (1) as "the rate at which water can be withdrawn from an aquifer for human use without depleting the supply to such an extent that withdrawal at this rate is harmful to the aquifer itself, or to the quality of the water, or is no longer economically feasible." The concept of safe yield has received considerable criticism and there has been suggestion that the term be abandoned because of its frequent interpretation as a permanent limitation on the permissible withdrawal (2).

Safe yield must be recognized as a quantity determined for a set of controlling conditions and subject to change as a result of changing economic or physical conditions (3). The controlling conditions in determining the safe yield may include precipitation, evaporation, water quality, inflows and outflows over the term of a selected period of time.

The safe yield quantity is a theoretical constant value that is derived from stochastic evaluation of the hydrology. The assumption that is made in stochastic hydrology methods is that the time-hydrology sequence for a known period will repeat itself with some degree of reliability.

Deliveries to Main Conveyance System – The Casitas Municipal Water District continuously measures the rate of water delivered from Casitas Dam to the start of the distribution system. The delivery measurements are performed through the use of accurate flow tube sensors that are located at the discharge side of each filter vessel. Each flow tube sensor is regularly calibrated for accuracy. The collected flow tube data is transformed to quantities (acre-feet) of water delivered from Lake Casitas, each and every day of the year.

For the purposes of this study, the terms "Water Use" and "Deliveries" are synonymous with the term "deliveries to main conveyance system". The study is referencing the water that is directly taken from the Lake Casitas supply.

Metered Water Sales – Metered water sales is the summation of all individual water service meters in the water distribution and piping system. In the Casitas Municipal Water District water distribution system, at each point of connection by the consumer, the District has installed individual water meters to continuously measure each consumer's water use. Each meter in the District is calibrated and read bi-monthly to assure operation of the meters. It should be noted that meters can stop reading flow due to a mechanical malfunction, but rarely do meters record a higher value than the actual usage.

Differences between Terms. From the definitions, it is established that the value for safe yield is developed through stochastic hydrology evaluations and it is a theoretical value, and that the deliveries (or water use) and metered water sales are developed through continuous monitoring of actual annual water consumption.

The difference between deliveries and metered water sales values is commonly referred to as a "system loss". In any water distribution system, there are several factors that can collectively attribute to the loss of water. These factors include, but are not limited to pipeline and service lateral leaks, pump packing leakage, meter failures and/or loss of meter accuracy, accounting errors, and water theft. Even slight errors in meter calibrations or accounting can magnify the losses that are calculated for an entire year.

In Table D1 are the deliveries and metered water sales recorded by the Casitas Municipal Water District for the period of 1976 through 2002, and the system losses that are a result of the difference between the deliveries and metered water sales. It is noted that with the exception of 1992, 1996, and 2000, the loss of water in the Casitas distribution system is generally less than ten percent of the annual deliveries to the system. Given that the higher loss years were not associated with disaster years and loss of pipelines during storm events, the loss is likely attributed to calibration and/or accounting errors.

The District has maintained an annual evaluation of the distribution system to assure that the pipelines are sound and as leak-free as possible. Indeed, the pipelines have been maintained in good condition. There have been occasional pipeline and service line leaks, followed by immediate response to repair by District staff.

1. *Meinzer, O.E.: Outline of Groundwater Hydrology, U.S. Geological Survey Water-Supply Pap. 494, 1923.*
2. *Kazmann, R.G.: "Safe Yield" in Ground-WaterDevelopment, Realility or Illusion?, J. Irrigation Drain. Div. ASCE, vol. 82, November 1956;* see also discussion by *Mcguinness, Ferris, and Kramsky, in ibid., vol 82, May 1957.*
3. *R. K. Linsley, Jr., M. A. Kohler, J.L.H. Paulhus: Hydrology for Engineer, 3rd ed., McGraw-Hill Book Company, page 195.*

Table D1 - Water Deliveries, Metered Use and System Losses

Water Year	Deliveries to Main Conveyance System Water Year (AF)	Water Sales in System Water Year (AF)	System Losses Water Year (AF)	% Loss
1976	18,725	17,244	1,481	8%
1977	16,779	17,096	(317)	-2%
1978	15,060	14,661	399	3%
1979	12,499	13,005	(506)	-4%
1980	14,651	15,434	(783)	-5%
1981	20,012	19,184	828	4%
1982	16,702	16,106	596	4%
1983	16,026	14,664	1,362	8%
1984	21,832	22,281	(449)	-2%
1985	20,274	20,051	223	1%
1986	16,606	16,058	548	3%
1987	22,339	22,359	(20)	0%
1988	21,032	20,326	706	3%
1989	24,416	23,589	827	3%
1990	22,454	20,743	1,711	8%
1991	17,723	16,255	1,468	8%
1992	13,318	11,687	1,631	12%
1993	11,740	10,703	1,037	9%
1994	15,640	14,172	1,468	9%
1995	12,185	11,467	718	6%
1996	16,356	13,715	2,641	16%
1997	19,301	17,822	1,479	8%
1998	14,372	14,533	(161)	-1%
1999	17,942	17,111	831	5%
2000	23,229	19,389	3,840	17%
2001	18,873	17,152	1,721	9%
2002	21,066	19,365	1,701	8%
Average	17,820	16,895	925	
Maximum	24,416	23,589	3,840	
Minimum	11,740	10,703	(783)	

Average losses 1976 to 1990	440
Average losses 1999 to 2002	2,023

Note that (##) is a system gain.

Appendix E - Peer Reviews

Upon completion of the initial draft of the Casitas Water Supply and Use Report, the District contracted with Entrix and MBK Engineers to perform an independent peer reviews and evaluations of the report. A written peer review has been prepared by each contractor and submitted to the District. Copies of each peer review are included in this section of the report. The District has considered each peer review and provided a written statement regarding the peer review issues. The written statement on each of the review issues is included in this section of the report. In some cases the comments have resulted in changes to the report, while other comments may have been further clarified or discounted by the District.

District Comment to the Peer Reviews

The District has reviewed each and every recommendation and comment contained in each peer review. The following are the District's actions and responses to each of the issues that were developed from the two peer reviews:

MBK Engineers

General

1) Monthly depletion factor allows Robles inflow to become a negative number, considering limiting to a minimum of zero.
   District comment - The negative inflows are a result of the formulas in developing the river hydrology, influenced by the assumptions made for the flow accretion above Robles Diversion Dam. The negative numbers result when no flow conditions are present above Robles Diversion Dam, generally during the months of July thru October. The range from –0.1 to -0.2 cfs, with one maximum one-day negative number of –3.0 cfs noted for the 1966-1980 period. The occurrence of a negative number in the model is infrequent and occurs during periods that do not influence the quantity of water available for diversion to Lake Casitas. Agreed that the minimum flow should be no less than zero, but minor changes to the model suggested by MBK does not impact the resulting numbers for available supply at Lake Casitas. No adjustments to these numbers have been made by the District.

2) Recommend using monthly evaporation rate applied to end of month lake surface area, more accurately reflect evaporation from Lake Casitas for varying storage levels.
   District comment - For consistency purposes, the District used the evaporation rates from the D-20 study. Agreed that the evaporation rate from a full reservoir is different than that from a near empty reservoir, but the evaporation rates from the reservoir in the D-20 study and a similar reservoir levels in each of the scenarios should be comparable and very near equal. Minor adjustments as suggested will not result in any significant changes to the trends or lake storage values. No adjustments to these numbers are made by the District.

Report

1) Recommend adding a table contents to the report.
   District comment - A Table of Contents will be added to the final report.

2) Recommend clarifying the synthesis of Matilija Creek hydrology.
   District comment – the final report shall include the reasoning and logic behind the synthesis of the Matilija Creek hydrology.

3) Explain more thoroughly the flow accretion methodology, identifying that these factors are multipliers.
   District comment – The method for accretion is explained in Appendix A. Add to the description of accretion that the water gained is from minor watersheds located between the USGS gaging stations and Robles Diversion Dam. Clarification of many

factors in this report is gained by showing the location of the gaging stations on the maps.

4) Recommend showing locations of each gaging station on the map.
   District comment – The map will be revised to show the locations of the key gaging stations in the upper Matilija Creek and Ventura River. The description of these locations will also assist in the explanation of the synthesis of Matilija Creek hydrology. The final report will have the locations of the Matilija Creek stations.

5) Recommend renaming the column heading currently labeled as "Matilija Gages" to the more accurate "Matilija Creek below North Fork Matilija Creek".
   District comment – Rather than confusing the report with the naming of yet a fourth labeled station (non-existent station) being generated from the synthesis of Matilija Creek hydrology, the report will describe the resulting synthesis of the Matilija Creek hydrology as combining to "Matilija Gages". The use of the term "Matilija Gages" is further clarified by the added discussion regarding the synthesis of the Matilija Creek hydrology. The heading on the tables will remain the same.

6) On graphs A19 and A20, consider eliminating the symbols on the graph lines. Difficult to differentiate lines.
   District Comment – the lines in Figures A5 and A6 have been revised, minus the line symbols. The final report will contain the revised figures.

Entrix

Overall Approach

1) Need to explain the differences in Tables A1 to A4 start and end points of the drought period and recovery period, and why they differ for each scenario.
   District Comment – The Peer Reviewer is comparing the start-end points of the D-20 study with the start-end points used in the present analysis. The approach taken in the report was to start the hydrology with the beginning of a water year, October 1945 as in the start of the drought cycle, and end the drought cycle at the end of a water year, September 30, 1965. The D-20 report hydrology sequence started in May 1944 with a full level of storage in Lake Casitas. During the period of May 1944 to October 1944 there were no diversion or rainfall events that would have, under the different scenarios of Robles operating criteria and/or loss of Matilija Dam, caused a change in the rate of decline in Lake Casitas storage levels. The initial starting level of Lake Casitas storage begins with the same storage for October 1, 1994 contained in the D-20 study.

   The storage volumes for Lake Casitas stated in each of the tables is a water year-end value. So by varying the scenario with Robles Operating criteria and with/without

Matilija Dam), the water year-end value will vary. The District believes that the period assignment made in the present analysis is appropriate and does not skew the resultant safe yield estimates.

2) Include more information on how he Mira Monte well supply was applied to the supply numbers.

   District comment – Under the sections "Safe Yield: Drought Period" and "Yield: Recovery Period", the application of the Mira Monte Well supply is described as having been included in the safe yield estimate. The rate of application is stated as being 300 acre-feet per year, constant rate for each month. No further explanation is provided in the final report.

3) Recovery period, if a shorter recovery period occurs, a lower safe yield value than presented would be required to recover the lake in the shorter time. The effect of the length of the recovery period on predicted safe yield could be addressed in a sensitivity analysis.

   District Comment – The analysis performed by the District considered the hydrology and water use patterns that are likely to occur during the recovery period under each scenario for Robles and Matilija Dam and by these occurrences, running the sequence out until full storage capacity is reached at Casitas Dam. The risk is in the event that the recovery cycle is not prolonged to the full term necessary to restore Lake Casitas storage capacity, i.e. the drought cycle restarts in year 8 of the recovery period instead of starting in year 15. This should be a key point for further consideration, but not a part of this analysis.

<u>Water Supply</u>

1) Useful to provide a description of the methods used to derive the factors and assumptions used in both the D20 study and this analysis.

   District Comment – The methods for each of the factors is outlined in Appendix A. The description of development of the factors would detract from the actual purpose of the analysis, therefore the District has provided the factors and assumptions without the description of the factor development.

<u>Other</u>

2) Minimum Pool – District should monitor conditions at various stages in lake Casitas and use this data to assist in managing potential effects in the future should concerns arise.

   District Comment – So noted. As later discussed with the reviewer, a definite outcome of this analysis should be the heightened awareness of the impacts of lowering lake storage and the need to monitor and plan for the eventuality of these occurrence and minimize the impacts to the water users.

3) Water Loss at Robles associated with the fish screens – sediment at base of screens is most likely problem that will reduce efficiency of the screens. Loss of max. 1,000 AF/day if diversions through fish screens are completely impaired. District should monitor conditions in the channel and after each storm to determine potential impact.

District Comment – So noted. The value of this assessment stresses the importance of good operation and maintenance practices at Robles Diversion Dam and how other factors (i.e. incoming water impurities such as plant material or sediment) could impact the ability to divert water to Lake Casitas, and thereby impact available water supply in Lake Casitas.

4) Increased groundwater extraction – largest impact to the District's supply would likely occur during early storm events prior to recharge of the unconfined aquifer upstream of Robles. Not likely to have significant impact.

   District Comment – So noted. Present water rights are limited at this time and recharge of the upper groundwater basin is not likely to differ much given the flashy nature of the upper Ventura River/Matilija Creek system.

<u>Water Demand</u>

1) Over-prediction of water use for the period of 1970 to 2003, in comparing the actual water use with the predictive equation. Provides a factor of safety in evaluating water use versus supply.

   District Comment – The reference to over-estimation is evident in Table B8. One of the primary objectives in the development of the water use patterns for each cycle was to adequately predict water use based on the present-day levels of demand. It was recognized very early on that from 1959 through the mid-1980s the water use from Lake Casitas was in a development stage. Therefore, the actual water use data from this development period could not be relied upon to make an estimate the of present day water use applied to the model scenarios. In comparing the predicted water use to the actual water use for the period of 1984 to 2003, there is an over-estimation of 6,168 acre feet for the twenty-year period, an annual average of 294 acre-feet. Given the correlations and variability of water use based on the high variability of rainfall events, and their influence on the agricultural water use within the District, the District feels that the methods applied to predict water use, and the resulting data, provide a sound basis for this study.

2) Recommend a discussion of the maximum obligation to the City of Ventura and oil industry, that may add to the water use at a future date.

   District Comment – The City of San Buenaventura and the Casitas Municipal Water District do have a contract that requires the City to annually purchase a minimum of 6,000 acre-feet of Lake Casitas water. The City must also certify that the amount of water purchased from Casitas matches, or is less than, the water consumption within the joint Casitas-City boundaries. This limits the City purchase to no more than this area's annual water consumption. The water use trends considered the City's water use escalation that occurred during the drought of the late 1980's, so this type of escalation related to weather factors is considered in the model. The placement of long-term and permanent demands, such as an insurgence of oil production, may require additional consideration because it was not predicted by the current model and not included in this final report.

Water Conservation

1) The report should explain the objective of these measures and indicate the intent of these measures is not provide a comprehensive evaluation of potential water conservation and reduction measures for the District.

   District Comment – It was not the intent of this study to develop and present detailed and focused water conservation measures. Rather, in Table 3, the report presents four concepts on the level of reduction needed to balance water supply and demand during the critical drought period, given the scenario of the BO criteria and without the benefit of Matilija Dam. It is likely that detailed and focus water conservation measures and water use planning will result from the details of this report.

MBK ENGINEERS
Water Resources • Flood Control • Water Rights

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1913 - 1985

CONSULTANTS:
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DONALD E. KIENLEN, P.E.

November 1, 2004

Mr. Steve Wickstrum
Casitas Municipal Water District
11311 Santa Ana Road
Ventura, CA 93001

Subject: Review of "Casitas Municipal Water District Water Supply and Use Status Report"

Dear Steve:

We have completed our review of the report entitled "Casitas Municipal Water District Water Supply and Use Status Report" (report). Based on our review, we believe overall the report is well done and technically accurate. There are a few relatively minor items which we suggest correcting before finalizing the report. However, applying these suggested corrections is not anticipated to greatly affect the results or findings of the report.

The remainder of this correspondence details the findings of our review. We have divided our review into two components. The first part of our review focuses on the analysis performed (modeling) to support the findings in the report. The second portion of our review focuses on the report itself and the presentation of the findings from the analysis.

Analysis

Overall, the analysis supporting this report was appropriately applied and is technically accurate. We commend the preparers on the systematic approach taken in modeling the different scenarios. As a reviewer, this made the methods, approach, and quality of the work easier to verify. This clarity is also important for the eventual acceptance of this work by others.

Particularly noteworthy is the methodology utilized for predicting the water deliveries. With this innovative methodology, not only are the predicted deliveries based on rainfall patterns, but also the longer-term hydrology (drought sequence). It is one thing to recognize this trend, but this analysis incorporates these trends into a predictive tool. This level of sophistication is uncommon, even in tools developed by professional full-time modeling personnel.

We had some questions and concerns of a relatively minor nature regarding the technical analysis supporting the report. These are as follows:

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- The monthly depletion factor allows the Robles inflow to become a small negative number during some periods. Please consider limiting the Robles inflow to a minimum of zero, since negative inflows do not physically make sense.

- The Lake Casitas net water loss (evaporation minus rainfall) should not be the same for all scenarios, since the storage levels in Lake Casitas are different for each of these scenarios and evaporation depends upon surface area, and thus storage. We recommend using a monthly evaporation rate (in inches) that can be applied to the end-of-month surface area of Lake Casitas. This will more accurately reflect the expected evaporation from the Lake and will shows the differences in evaporative losses between the different scenarios. We would be happy to provide guidance with the evaporation rates, if this path is pursued.

Report

We conclude that, overall, this is a concise, clearly written report that identifies the key issues of the water supply and its use by the District. The report provides the main methodology and primary results without adding unnecessary details of the analysis to the main body of the report. The appendices are properly organized and presented, so the reader can review the additional details of the analysis, if desired.

There are a few areas of the report which we believe require clarification. As such, we have recommended clarification or corrective action to these sections. These are detailed, as follows:

- A table of contents in the front of the report would allow portions of the report to be quickly accessed as a reference. We recommend adding a table of contents to the report.

- It is not entirely clear how the Matilija Creek hydrology was synthesized for the period of time without an operable Matilija Creek gage (i.e., when neither USGS #4500 nor #5500 were operable). The report mentions that USGS #5500 was prorated by the annual volume of USGS #4500. Shouldn't this reference to USGS #4500 actually be to USGS #6000, the North Fork Matilija Creek gage? It is also not clear how the annual volumes could be prorated when one of the gages was not operable. The ratio changes from water year to water year, so we assume that these are not long-term average volumes used in prorating. We recommend that this section be clarified in the analysis and report.

- We recommend that the flow accretion methodology used in this study be explained more thoroughly. There are two factors applied depending upon which Matilija Creek gage was operable. We assume this is due to geographical differences between the two gages. Judging from the accretion multipliers applied, USGS #4500 must be further upstream. We recommend showing the locations of all three USGS gages used in this study on a map. Identifying that these factors are multipliers should also be explained in the report.

- In the summary tables A1-A8, we recommend renaming the column heading currently labeled as "Matilija Gages" to the more accurate "Matilija Creek below North Fork Matilija Creek".

- For the graphs on page A19-A20, please consider eliminating the symbols on the graph lines. It is very difficult to differentiate between the plotting lines with the relative density of these symbols and the closeness of the lines themselves

As mentioned in our review, we believe this is a well written and organized report that can be completed with the minor modifications we have suggested. We hope this review allows you to proceed with your analysis, results, and report in their desired capacities. If you have any questions regarding our review or its findings, please contact me at your convenience.

Sincerely,
MBK ENGINEERS

Marc Van Camp

Marc Van Camp

BT/bt
2400/STEVE WICKSTRUM 11.01.2004.DOC

E N T R I X

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(805) 644-5948
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November 18, 2004

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CASITAS
MUNICIPAL WATER DISTRICT

Mr. Steve Wickstrum
Principal Civil Engineer
Casitas Municipal Water District
1055 North Ventura Avenue
Oakview, CA 93022

Re: Peer Review of the Casitas Water Supply and Use Report

Dear Mr. Wickstrum,

ENTRIX, Inc. (ENTRIX) has prepared this letter report to present the results of the peer review of the preliminary draft *Casitas Water Supply and Use Report* (Report) dated June 11, 2004. The Report's objective is to assess the Casitas Municipal Water District's (District) water supply given recent and future changes in water supply and demand including water releases associated with the Robles BO and the potential decommissioning of Matilija Dam. The Report is to be used by the District's governing body to assist in making decisions regarding future water management.

The objective of this peer review is to determine whether the Report accurately projects future water supply and water demand conditions and to evaluate the applicability and appropriateness of the methods utilized to make these projections.

This review presents a brief overview of the Report, a description of the methods used in the review, and the review results. The results of the review are organized into four primary categories: 1) the overall approach of the analysis; 2) the water supply analysis; 3) the water demand analysis; and, 4) the conservation and reduction measures required to balance water supply and use.

Overview of the Draft *Casitas Water Supply and Use Report*

The Report was developed to assess the potential impacts to the District's water supply associated with the recently adopted operating criteria specified in the Biological Opinion for the Robles Fish Ladder and with the potential removal of Matilija Dam. The Report also evaluates the effect of predicted water use on the District water supply, and conservation and reduction measures required to balance water supply and use. The study evaluated four separate operating scenarios:

- Water supply and use during the critical drought period, defined as between water years 1945 through 1965, with Matilija Dam;

- Water supply and use during the same critical drought period without Matilija Dam;
- Water supply and use during the reservoir recovery period, defined as between water years 1966 through 1980, with Matilija Dam; and,
- Water supply and use during the same reservoir recovery period without Matilija Dam.

The results of the Report indicate that the predicted water supply exceeds the estimated water demand for all modeled scenarios, with the exception of critical drought period under the Robles BO operating criteria without the benefit of Matilija Dam. This scenario, which is the most likely, could result in a deficit of approximately 360 acre-feet per year.

Review Methods

The review considered the draft Report, supporting documentation such as spreadsheets used to develop the water supply and bypass estimates, and the *Water Supply and Demand Status Report* prepared by the District's Engineering Department Manager on June 7, 1989. The review consisted of an evaluation of the overall approach used to determine safe yield and the methods, assumptions, and results used in developing the water supply and water demand estimates. The project team involved in the review consisted of the following personnel:

- David Blankenhorn, R.G. – Mr. Blankenhorn served as the project manager and was responsible for reviewing all aspects of the Report. He is a State of California Registered Geologist with over 9 years of experience working on various hydrology projects. Mr. Blankenhorn has significant experience in conducting hydrologic studies in Southern California including the Ventura River Watershed. He was the lead hydrologist in the preparation of the Ventura River HCP for which he evaluated surface water and groundwater hydrology within the lower Ventura River basin and the effects of water diversions and groundwater withdrawl on surface water flows. In addition, Mr. Blankenhorn conducted an evaluation of surface water flows and guidelines for water releases at the Robles Diversion in support of the Biological Assessment prepared by ENTRIX.

- Dr. Daniel Tormey, R.G. – Dr. Tormey assisted in the overall review and evaluation of the Report. He has analyzed water supply issues for withdrawal from the San Joaquin-Sacramento River delta, and locally in the Ventura County area. He has extensive experience analyzing hydrology and sediment transport in California coastal streams and the Sierra Nevada. Dr. Tormey has also conducted a water supply and water demand study in support of a wellfield design for a proposed golf course in the Sacramento area.

- Woody Trihey - Mr. Trihey assisted in the review of the design for the fish screen and evaluated potential impacts to the District water diversions following installation of the screen. He is a hydraulic engineer with significant hydrology and fish passage enhancement experience including the evaluation of fish screens.

- Dr. Gretchen Greene – Dr. Greene reviewed and evaluated the overall approach of the Report and the methodology used in the water demand analysis. She is a Senior Economist with significant experience in evaluating future water demand.

The review focused on four primary areas: 1) the overall approach of the analysis; 2) the water supply analysis; 3) the water demand analysis; and, 4) the conservation and reduction measures required to balance water supply and use. The Report was evaluated to determine the applicability and appropriateness of the methods and assumptions utilized in its preparation. The review of the water supply analysis included an evaluation of the mean daily flow data used in the water supply analysis, flow losses and additions between the existing stream gauges and the Robles Diversion, estimates of storage and release from Matilija Dam, bypass flows at Robles Diversion associated with the 1959 and BO operating criteria, losses in the Robles Diversion canal, losses at Lake Casitas, and input from tributaries to Lake Casitas. The evaluation of the water demand analysis included a review of the methodology used to predict future water use and a comparison to historic demand data. In addition, the water supply reduction/conservation measures required to balance water supply and use were reviewed to determine the level of reduction associated with each method.

Review Results

The results of the review are described below. The discussion is organized into the four primary review areas: 1) the overall approach of the analysis; 2) the water supply analysis; 3) the water demand analysis; and, 4) the conservation and reduction measures required to balance water supply and use. The comments do not include details such as spelling and typographical errors as it is assumed that the document will be edited prior to the final draft.

<u>Overall Approach</u>

The overall approach of the study is sound. The study uses a planning scenario the longest drought on record in the Ventura River Basin which was between 1944 and 1965. The safe yield for this period is determined using empirical stream gage data in conjunction with the recent and potential changes in operating conditions associated with the Robles BO and the potential decommissioning of Matilija Dam. The water demand is predicted based on recent use data. The study also evaluates the recovery period following the drought between 1966 and 1980 to determine the safe yield until the reservoir recovers to full storage capacity.

Several issues, however, need to be clarified in the document as follows:

- In the drought period analysis (Tables A1 to A4), the starting storage in Lake Casitas in year 1945 ranges between approximately 223,000 to 226,000 acre-feet (AF) and the minimum storage is fixed at approximately 4,800 AF. Based on discussions with the District, the starting and ending volumes for each scenario were derived using the storage values utilized in the D20 study at the beginning (October 1, 1944) and ending (September 30, 1965) of the analysis in order to be consistent with that study. Since these values effect the safe yield estimates for each scenario, the document should explain the basis for these values since they differ from the maximum usable storage capacity of 250,000 AF specified in the 1989 memo and the minimum storage capacity of 100 AF used in the D20 study which reportedly corresponds to the estimated storage volume in December 1965 rather than September 1965. In addition, the document should explain why these values vary between each modeled scenario.

- In the recovery period analysis (Tables A5 to A8), the starting storage in Lake Casitas in year 1966 ranges between approximately 36,000 to 38,000 AF and the maximum storage ranges between approximately 237,000 and 239,000 AF. As with the drought period analysis, the District indicated that the starting and ending volumes for each scenario were derived using the storage values utilized in the D20 study at the beginning (October 1, 1965) and ending (September 30, 1980) of the analysis in order to be consistent with that study. Since these values effect the safe yield estimates for each scenario, the document should explain the basis for these values since they differ from the maximum usable storage capacity of 250,000 AF specified in the 1989 memo and the minimum storage capacity of 100 AF used in the D20 study. In addition, the document should explain why these values vary between each modeled scenario.

- Based on discussions with the District, the water supply/safe yield estimates provided in Tables A1 through A8 include the supply provided by the Mira Monte well. However, the Report does not clearly specify that the supply from this well is included in the analysis. Accordingly, a column should be included in these tables to account for the supply from this well <u>or</u> a note should be added to the tables to indicate that the supply from this well is included in the analysis.

- The study results indicate that the lowest safe yield values occur during the recovery periods under the Robles BO operating criteria (21,180 AF with Matilija and 19,780 AF without Matilija). Although the predicted water demand for this period is less than the estimated safe yield, the predicted safe yield for this period would appear to be the limiting factor on water use allocation. The lower safe yield values for the recovery period appear to be caused by increased bypass flows associated with the Robles BO operating criteria and the constraint of the modeling approach which limits the number of years (15 years) to achieve full capacity. If a shorter time is allowed for recovery, corresponding to a shorter period between droughts, the safe yield value would be lower than presented in the Report. The effect of the length of the recovery period on predicted safe yield could be addressed in a sensitivity analysis.

The issues described above affect the principal objective of the Report which is to predict safe yield and future water use allocation. Accordingly, these areas should be clearly explained to assist in planning efforts.

Water Supply

The water supply assumptions and methodology appear sound and empirical data is used where available to model or validate the water supply under the different operating scenarios. However, the analysis relies heavily on the assumptions and factors developed as part of the D20 study. The basis for these assumptions was not available for review; therefore, it was not possible to verify their accuracy/applicability of these factors. It would be useful to provide a description of the methods used to derive these factors.

The assumptions and methodology used for the supply model need to be described in greater detail to allow for easier understanding and comprehension of the analysis. Following an initial review of the document, a meeting was held on September 29, 2004 to clarify the methods and assumptions used to develop the water supply estimates. The meeting was attended by Steve Wickstrum, Leo Lentsch, and Chip Blankenhorn. A copy of the issues discussed in the meeting is provided in Attachment A.

The Report also describes several concerns that could affect water supply which were not quantitatively captured in the analysis. These concerns include the following:

- Impacts associated with operations near minimum pool in Lake Casitas. Operations under these conditions could affect water quality, water delivery, and recreation.
- Water loss at Robles Dam associated with decreased efficiency of water transfer through the fish screens and plugging of the fish screens with fine sediment.
- Increased groundwater extraction above Robles Diversion Dam which may result in increased flow of surface water to groundwater, thereby reducing inflow to Lake Casitas.

A brief discussion of these issues is provided below.

Minimum pool impacts. It seems that the most important planning issue is related to the water delivery and distribution infrastructure. If not previously addressed by the District, the District should determine the stages at which the infrastructure could be affected and develop a contingency plan in the event that this occurs. With regards to water quality and recreation, the District should monitor conditions at various stages in Lake Casitas and use this data to assist in managing potential affects in the future should the concerns arise.

Water loss at Robles associated with the fish screens. ENTRIX reviewed the fish screen design and contacted the design engineer (Tim Buller at Wood-Rogers) to evaluate this issue. Based on a review of the design and discussions with the design engineer, it appears that the existing trash rack should be sufficient to trap large debris moving into the diversion canal. The fish screens include a traveling brush cleaning system which should prevent clogging due to brush. The design engineer indicated that the screen was designed to maintain an approach velocity of approximately 0.4 ft/s and a minimum sweeping velocity of approximately 0.8 ft/s in accordance with California Department of Fish and Game requirements. However, the design engineer indicated that the sweeping velocity would likely be greater than 0.8 ft/s and could be up to 1.5 ft/s. Based on the existing information, the flow velocities appear to be sufficient to transport silts and clays in suspension, but may not be sufficient to transport sands, if present. A thorough analysis of potential impacts would need to consider the suspended sediment concentration and particle sizes in suspension. The slot spacing of the fish screen is 1.75 mm which is within the coarse sand range and is likely greater than the particle sizes that would be in suspension. If an impact were to occur, it would likely be due to sediment deposition at the base of the fish screen and the existing design accommodates for approximately 1 foot of deposition by offsetting the base of the screen 1 foot from the bottom of the canal. There is a potential for this area to be filled during the seasonal operation period which could impact the diversion efficiency and/or the diversion operation if sediment removal is required. The maximum impact on water diversions would be the loss of approximately 1,000 AF/day which is the equivalent to a water diversion rate of 500 cfs (the maximum capacity of the diversion canal) over a 24-hour period. This situation could occur if the entire screen is clogged with sediment and/or debris or the diversion needs to shut-down for maintenance to remove sediment/debris. The District should monitor conditions in the channel during and after each storm event to determine any potential impact.

Increased groundwater extraction above Robles diversion dam. Increased groundwater extraction would result in a decrease of the water table elevation and would result in greater infiltration to the subsurface. The greatest use of groundwater would likely occur during the dry season when the diversion is not typically in operation. Assuming that the water table is lowest at the end of the dry season, the largest impact to the District's supply would likely occur during early storm events prior to recharge of the unconfined aquifer situated upstream of Robles. The aquifer in this portion of the basin typically fills relatively quickly, so increased losses would not likely have a significant impact on water supply at Robles.

Water Demand

The water demand analysis utilizes a correlation between water use and precipitation to develop a polynomial equation to predict future water demand. The basis for this correlation is sound in that historic data indicates that water use varies significantly with precipitation, primarily because agricultural use is the dominant water user and crops require less irrigation when there is high precipitation. The goodness of fit (R^2 value) for the water demand-precipitation correlation is approximately 0.97, which indicates a strong correlation between these variables.

The predicted water demand equation also includes a dry year multiplier to account for increased water demand associated with consecutive years with less than 20-inches of rainfall. Such a factor makes intuitive sense, since one would expect increasing water demand as a drought advances. The dry year multiplier was developed using the slope of a best fit line correlating recorded water use during the 1986 to 1990 drought. The multiplier is applied by multiplying the number of years with less than 20-inches of rainfall following an initial year with less than 20-inches of rainfall. The goodness of fit (R^2 value) for the dry year multiplier correlation is approximately 0.56, which indicates a relatively poor correlation between variables. The use of the dry year multiplier is good in that it adds a factor of safety to the water use-precipitation equation, but the relatively poor correlation indicates that other factors may be controlling the variation in water demand. In addition, the data used to develop the dry year multiplier includes the actual water use by the City of Ventura (City) between 1986 and 1990 which ranged between 7,737 and 8,875 AF. The dry year multiplier could be refined by adjusting the water use data to include only the minimum requirement to the City of 6,000 AF/year. However, this adjustment is unlikely to improve the correlation.

An evaluation of the predicted water demand and actual demand between 1970 and 2003 indicates that in general this equation overpredicts the actual annual demand by an average of approximately 1,300 AF. The data also indicates that actual water use exceeded the predicted demand in eight years over this period. Although water use is sometimes underpredicted by the equation, the total surplus between the predicted and actual demand between 1970 and 2003 is approximately 44,750 AF.

The predicted water demand for each model scenario utilizes the average water use for the drought period (21,200 AF) and for the recovery period (18,820 AF). The model water demand for each year is derived from the annual precipitation data for these periods. Based on the comparison of the predicted versus actual water demand, these values likely overestimate the water use for these periods which provides a factor of safety in evaluating water use versus supply.

One of the issues that was discussed in the meeting held on September 29, 2004 was the supply obligation to the City of Ventura. As discussed in the report, the minimum obligation to the City is 6,000 AF per year; however, the maximum obligation is not specified. The Report states that water use by the City could increase significantly if oil production increases and/or if there is an extensive dry-period. A discussion of the maximum obligation to the City should be included in the document to assist in determining the potential affects on water supply and demand in the future.

Water Conservation and Reduction Measures

The Report discusses several water conservation and reduction measures that could be implemented to balance safe yield with predicted water use. However, the focus of these measures is not clearly described. Based on discussions with the District, the objective of these measures is to evaluate options which could be implemented to balance the predicted safe yield with the predicted water use for the critical drought period under the Robles BO operating criteria without the benefit of Matilija Dam. This scenario, which is the most likely, could result in a deficit of approximately 360 acre-feet per year. Accordingly, the Report evaluates options which would provide a reduction of approximately 360 AF/year. The Report should explain the objective of these measures and indicate that the intent of these measures is not to provide a comprehensive evaluation of potential water conservation and reduction measures for the District.

Closure

ENTRIX appreciates the opportunity to perform this work for the District. Please call Dan Tormey or Chip Blankenhorn at (805) 644-5948 with any questions or comments.

Sincerely,

ENTRIX, Inc.

David B. Blankenhorn, R.G.
Senior Project Engineer/Geologist

Daniel Tormey, Ph.D., R.G.
Principal

ATTACHMENT A
SEPTEMBER 29, 2004 MEETING MEMO

E N T R I X

MEMO

ENTRIX, Inc.
2140 Eastman Avenue, Suite 200
Ventura, CA 93003
(805) 644-5948

To: Steve Wickstrum, Casitas Municipal Water District

From: Chip Blankenhorn, ENTRIX

Date: September 29, 2004

Re: **Initial Questions/Comments**

The purpose of this memo is to outline initial questions/comments on the *Water Supply and Use Status Report* dated June 11, 2004. After your review, I would like to discuss these with you prior to preparing our draft peer review report. The questions/comments are separated water supply and water demand/use as follows:

I. Water Supply

In general, the water supply estimates utilize factors developed as part of the Kienlen D20 study, but the report does not discuss the derivation of these factors. Accordingly, it is difficult to evaluate the applicability of these factors. These factors include the following:

- Reservoir Recovery Period Hydrology:
  - Item 1b is described as "daily flows predicted from NF Matilija daily USGS records". I am presuming that this is a typo since the header is for Matilija Creek hydrology and gages #4500 and #5500 are situated on Matilija Creek.
  - Item 1b*i* (loss factor at Matilija Reservoir) – how was this factor derived?
  - Item 1b*ii* - estimation of daily flows for #5500 are calculated by adjusting the flows at #4500 by a ratio of the annual water supply at each gage. Does this ratio represent the average over the overlapping period of record?
  - Item 2b*i* – how was the equation for #6000 derived?
- Matilija Reservoir Operations – how were the max. and min. storage capacity estimates derived?
- Flow Accretion – how were these factors derived?
- Flow depletion/extraction – how were these factors derived?
- Robles Diversion Operations – how were the facility losses derived and is there more recent data to assist in this estimation?

- Volume of water bypassed – how were these factors derived and how were they utilized in the study? If we are accounting for inflow from gage data, diversions at Robles, and bypass flows associated with the fish releases, then it seems like we can directly calculate annual bypass flows.

- Lake Casitas:

  – How were the estimates from the tributaries derived and what are the estimates from the D20 study (not provided)?

  – Also, with regards to net evaporation, the USBR study utilized an estimate of 3.08 feet/year and the D20 study used 1.9 feet/year. Is more recent data available to update this factor? Also, does the surface area that this factor is applied to vary annually based on storage levels or is an average value used?

  – It does not appear that sedimentation in Lake Casitas was addressed with regards to impacts on storage? Is there data available to estimate the approximate rate of sedimentation which can be used to evaluate potential impacts?

II. Water Use/Demand

- In general, it appears that it is primarily agricultural water use that changes in response to precipitation. Also, there appears to be a slight increasing trend in residential water demand between 1976 and 2002 and a relatively steep demand in gravity water sales between 1997 and 2002. Accordingly, it might be more useful to model these variables separately and sum them to assist in predicting future demand.

- Water sales to the City seem to be a wildcard as future use may revert to pre-1990 if the oil production increases and/or there is an extensive dry-period. What are the obligations to the city beyond the 6000 AF/year minimum?