Appendix A

East Bay Municipal Utility District Water Supply Reliability

East Bay Municipal Utility District

Water Supply Reliability

Freeport Regional Water Authority
Sacramento County Water Agency
East Bay Municipal Utility District

U.S. Department of Interior, Bureau of Reclamation

July 2003

Contents

Acronyms and Abbreviations

Act	California Urban Water Management Planning Act
af	acre-feet
BMP	best management practice
Board	EBMUD Board of Directors
CFP	Central Valley Project
DFG	California Department of Fish and Game
EBMUD	East Bay Municipal Utility District
FERC	Federal Energy Regulatory Commission
JSA	Joint Settlement Agreement
MCE	maximum credible earthquake
MGD	million gallons per day
MOU	memorandum of understanding
NRWRP	North Richmond Water Reclamation Plant
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TAF/yr	thousand acre-feet per year
USFWS	U.S. Fish and Wildlife Service
UWMP	Urban Water Management Plan
WCMP	Water Conservation Master Plan
WSMP	Water Supply Management Program

Assessing Drought Water Supply Reliability

Water supply planning is complicated by the great variability that exists in the amount of water available each year. Drought planning is complicated further by the inability to predict the amount of rainfall and runoff that will occur in future years. If East Bay Municipal Utility District (EBMUD) could be certain that no future drought will be as severe or more severe than those that have occurred historically, then it could plan accordingly. This report presents current EBMUD drought planning policies, describes the methodology adopted by EBMUD to assess its water supply reliability during droughts, and presents the rationale for adopting that methodology. This report also presents results of alternative assessments of EBMUD system drought reliability and compares EBMUD's approach with those used by other comparable urban water districts.

EBMUD Drought Planning Policy

EBMUD's "Water Supply Availability and Deficiency" Policy 52, originally adopted in 1985 and most recently revised on November 9. 1999, describes the appropriate level of reliability for EBMUD's water supply system. That policy states:

> "IT IS THE POLICY OF THE EAST BAY MUNICIPAL UTILITY DISTRICT TO:
>
> Evaluate the availability of the District's water supplies (supplies of the same or similar quality to that of the Mokelumne River supply) and determine the acceptable maximum level of average annual demand for the District's service area based on limiting the water supply deficiency to a maximum of 25% during an occurrence of the drought planning sequence described in the Final Environmental Impact Report for the Updated Water Supply Management Program, September, 1993." (East Bay Municipal Utility District 1999)

EBMUD Drought Planning Process

Introduction

EBMUD's experiences during recent drought events demonstrate that its water supply system is not sufficiently reliable to meet even current demands during droughts. Beginning with the drought of 1976, EBMUD has had to ration its customers in 6 of the last 27 years. During 1992 only 172,000 acre-feet (af) were available for delivery, 33% less than needed. Looking to the future, EBMUD's studies show that approximately 185,000 af of additional water will be needed during dry periods in order to meet 2020 demands. This need for supplemental water is in addition to amounts projected to be saved by expanded conservation and reclamation programs, and also assumes rationing not to exceed 25%. The amount of water needed to meet future needs is supported by studies of actual historical hydrology, as well as by the "drought planning sequence" discussed below. The supply of water available to EBMUD under its amendatory contract at Freeport will reduce or prevent rationing in dry periods and will assist in meeting future needs, but does not fully meet projected 2020 demands. Freeport deliveries are restricted to 133,000 af in any one year, not to exceed 165,000 af in any consecutive 3-year period when EBMUD total system storage is forecast to be less than 500,000 af.

EBMUD spent considerable effort in investigating reasonable approaches to evaluate the reliability of its system. An important tool that EBMUD uses is the "drought planning sequence." This tool, derived from EBMUD's experience during the 1976–1977 drought, allows it to determine how its system could respond to an extreme event. EBMUD also uses other measures to assess its system performance. This Appendix describes these measures and compares these methods to system reliability methods adopted by other major urban water suppliers in California. In particular, the results are compared to the approach prescribed in the Department of Water Resource's 1991 *Urban Drought Handbook* that calls for providing sufficient storage to meet essential health, safety, and firefighting needs, even at the end of the most extreme historical drought.

EBMUD Drought Management Program

EBMUD system storage generally allows it to continue serving customers during periods of low runoff. As described above, the District's "Water Supply Availability and Deficiency" policy limits drought demand reductions to no more than 25%. This drought rationing level is imposed in addition to the District's expanded conservation and reclamation programs that are projected to save 48 million gallons per day (MGD) every year, reducing 2020 demand levels from 277 MGD to 229 MGD.

Instead of immediately imposing 25% rationing whenever dry periods occur or postponing action until drought conditions are severe and supplies severely depleted, the District has developed guidelines that call for increasing amounts of rationing as supplies become increasingly diminished. By imposing some rationing in early years of potential prolonged drought periods, the necessity of more severe rationing in subsequent years is minimized. These guidelines are shown in Table 1 below

Table 1. Drought Management Program Guidelines

Drought Stage	Projected End-of-September Total System Carryover Storage	Reduction Goal
None	500 TAF or more	None
Moderate	500–450 TAF	0 to 15%
Severe	450–300 TAF	15 to 25%
Critical	300 TAF or less	25%

TAF = thousand acre-feet

Source: EBMUD Urban Water Management Plan 2000

Description of Drought Planning Sequence

During some historical dry periods, Mokelumne Basin runoff has been insufficient to meet service area demands. During these periods, most of EBMUD's demand was met by water previously diverted to storage. The worst drought event in EBMUD's history was the 1976–1977 drought, when runoff was only 25% of average and total reservoir storage decreased to 39% of normal, despite EBMUD's customer's 39% rationing efforts. (see Figure 1 showing Pardee Reservoir levels during this period). During this drought, the critically dry year of 1977 was followed by a very wet year (1978), allowing the system to recover rapidly. However, at the end of the 1977 water year, in September 1977, EBMUD could not know how much precipitation and runoff would occur the next year. Thus, EBMUD, as well as all other water suppliers in the State, could not allow its storage to become fully depleted at the end of 1977 in anticipation of plentiful water the following year. Had it done so, and if 1978 had turned out to be a third dry year, EBMUD would not have had sufficient water to meet its needs or its downstream obligations. EBMUD's drought planning sequence is based on these considerations. Ronald Robie, who was Director of DWR during 1977, stated this principal succinctly in his Forward to DWR's report on the "Continuing California Drought" written in August 1977, near the end of the 1977 water year:

> One of the most important tasks before us is planning for next year. We have no assurance that 1977–78 will not also be dry. We must plan for the worst on an assumption that the dry condition of 1976-77 will continue for another year. If such is the case, impacts will be far more severe than the last two years. We cannot permit the attitude that 'it can't happen here' to limit our efforts at assuring we are prepared for another very dry year.

While 1976–1977 was the worst drought on record, it is possible that a similar event will occur at some time in the future but without a very wet year like 1978 immediately following it. To plan for the possibility of such an event in the future, EBMUD has developed a three-year drought planning sequence. The first and second years of this drought planning sequence have the same runoff as occurred in 1976 and 1977, respectively. Although the District could have assumed that the third year runoff could have been as low as the second year (i.e. use the historic low of 1977 runoff of 129 TAF), it instead assumed a higher runoff by averaging the first and second year, which results in the third-year amount of 185 TAF. It was further assumed that such a severe drought would not continue beyond the third year of this sequence and that all accessible water in storage in EBMUD water supply system, including all water in its East Bay Reservoirs, would be depleted by the end of the third drought year. Therefore, the minimum storage level under this planning event is equal to the aggregate total amount of EBMUD's inaccessible, or dead, storage of 35.4 TAF.

Although there is no broadly agreed-upon approach for conducting water supply drought planning, the approach outlined above is reasonable. It is entirely consistent with other major infrastructure planning processes that attempt to take into account natural events with unknown and potentially very long periods between recurrences. Limiting the assessment of the potential for drought to the historic record would not be prudent for a public agency that provides an essential service necessary for public health and welfare to over 1.3 million customers. Most engineering planning processes for major public infrastructure projects attempt to address the potential for natural occurrences. In those planning processes, the historic record is only one small element of the information used to determine the need for facilities and design elements. The historic record is too limited to provide reasonable guidance when public health and welfare are at stake.

For example, when assessing the design needs of major structures located near active faults to withstand earthquakes, prudent public policy requires that those structures be designed to withstand the maximum credible earthquake (MCE) that could occur on that fault regardless of whether such an earthquake has occurred during recorded history. It would not be prudent to use only the recent historical record as an indicator of the MCE given the long period between recurrences on most faults.

Similarly, in conducting flood control planning, public policy dictates that more than the historical record should be examined in determining appropriate flood control measures. As with earthquakes, limiting analysis to only the historical record would create a high probability of providing an inadequate basis for design of an appropriate flood control project. Because of the potential extreme nature of flood events, the costs of facilities that would be required, and the infrequent occurrence of major events, flood control projects are rarely constructed to provide absolute protection; prudent public policy again dictates that the public be provided with as much flood protection as can reasonably be provided.

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Jones & Stokes

Figure 1
Pardee Reservoir on March 25, 1977
with 47,000 Acre-Feet in Storage

Investigations Leading to Development of Drought Planning Assumptions

Prior to selecting its drought planning sequence, EBMUD investigated several different approaches to system analysis, including the use of tree-ring studies and stochastic hydrologic methods. EBMUD has determined that, at the present time, these techniques cannot be relied upon to significantly improve the conclusions regarding system impacts resulting from using historical hydrology and the drought planning sequence. The primary problem with these other techniques is the length of the data set. Others have reached similar conclusions. The U.S. Army Corps of Engineers summarized the current problem of determining drought frequencies based on historical hydrology on page 32 of their September 1991 report *The National Study of Water Management during Drought* (IWR Report 91-NDS-2) as follows:

> One difficulty with computing frequency of drought, however, is the small record sample available. Unlike floods where a peak value is selected for each year, droughts of duration longer than a single year have fewer potential occurrences. This, together with problem of distinguishing independent events, makes computation of drought frequency from gauged records difficult at best and statistically questionable at worst.

EBMUD conducted its own investigation of the feasibility of accurately calculating the probabilities of extreme drought. The EBMUD investigation confirms that the lack of data places great doubt on the reliability of these calculations. To demonstrate this, EBMUD analyzed the effects that the addition of 12 years of data to a 69-year hydrologic database has on calculations of drought probabilities using stochastic techniques. The analysis showed that adding the 12 years of data (1976 through 1987) to the 1907 and 1975 hydrologic database dramatically increased the predicted frequency with which extreme drought events would occur. For instance, adding the 12 years of data changed the predicted frequency of a 2–3 year drought from once in 1,000 years to once in 200 years. Stated another way, what could have been calculated to be a very improbable drought in 1975 would have been calculated to be much more probable 12 years later in 1987. This increase in probability would have been even more dramatic if the additional drought years of 1988 through 1992 were included in the data set.

The sensitivity of this model's predictions to relatively small amounts of new data indicates that the data set is insufficient to provide reliable and stable results.

Stochastic hydrologic techniques use a statistical evaluation of historical precipitation and runoff patterns. This historical record is analyzed, and the likelihood that droughts of various magnitudes will occur is estimated, based on how frequently they occurred during the period for which data are available. Using this method, additional sequences of hydrologic data can be synthetically generated that preserve the mean and variance of the historical record. In effect, this technique attempts to extend the historic record.

Because of the unreliability of the statistical evaluation of hydrology and the tree ring analysis, EBMUD believes that the drought planning sequence, empirically incorporating lessons learned through the District's experience during the 1976–1977 drought, is the best method for quantifying the amount of additional water needed to improve system reliability.

In a span of 17 years between 1976 and 1992, EBMUD experienced the most extreme two-year drought and the most extreme six-year drought since records of precipitation and runoff have been kept for the Mokelumne basin. In contrast to the 47 years prior to 1976, the District has had to ration customers in 6 of the 27 years since 1976. EBMUD has concluded that it would not be prudent to ignore the possibility that a future drought could occur that is more severe than those that have already occurred. Given the lack of data, the degree of uncertainty in calculating drought probabilities, the lack of redundancy in the EBMUD water supply system, and the inability to predict the end of droughts during real-time events, EBMUD selected the drought planning sequence for long-term water supply planning. It has the advantages of being both reliable (because it is based on the actual worst drought event in EBMUD history) and prudent (because it involves a scenario somewhat more severe than the actual worst historical drought event).

Comparison of Other Urban Districts' Approach to Drought Management Planning

To provide an additional reasonability check on decisions regarding drought planning, the different approaches to drought management planning taken by several water agencies were reviewed. The agencies were: Santa Clara Valley Water District, San Diego County Water Authority, Los Angeles Department of Water and Power, Metropolitan Water District of Southern California, Contra Costa Water District, San Francisco Public Utilities Commission, and Alameda County Water District. Information was gleaned by reviewing the Urban Water Management Plans for these agencies.

Table 2 compares three elements of each agency's drought management planning: how they define the maximum credible drought, whether any triggers have been established that initiate drought management actions, and what demand-reduction targets have been set.

As seen in Table 2, each agency has developed a unique methodology based on its own sources of supply, storage capabilities, and drought experiences. The survey showed that, many water agencies plan supplies to provide full deliveries to customers even during severe droughts. By comparison, EBMUD plans for a maximum of 25% cutbacks to customers (32% to residential customers) during droughts, making EBMUD's drought planning more aggressive.

In addition, the survey found that all agencies include some provisions for dealing with more severe droughts than those experienced historically. Most

Table 2. Summary of Drought Planning Assumptions for Different Water Agencies

Agency	Source	Drought Planning Sequence	Drought Management Triggers	Build-Out Population	Build-Out Demand (af)	Total Storage Available (af)	Target Drought Demand Reduction
East Bay Municipal Utility District	Urban Water Management Plan 2000 (February 2001)	The basis for the multiple dry years drought scenario is a 3-year sequence using the runoff from the 1976-77 drought for the first two years of the sequence and assuming the third year runoff to be 185,000 af, an average of the runoff for the two worst years on record (1976-77).	When storage is projected to be less than 500,000 af, prepare a Drought Management Plan. (full capacity is approximately 755,620 af).	1,420,000 by the year 2020.	256,511 by the year 2020.	755,620	Maximum demand reduction target is limited to 25%.
Santa Clara Valley Water District	Urban Water Management Plan (April 2001)	The system is designed for a drought similar to the 1987-1992 drought extended to a 10-year duration and a 1-percent probability of occurrence (defined as the Critical Dry Period, CDP).	When groundwater end-of-the-year carryover storage falls below 350,000 af (full capacity is 500,000 af), following year considered to be at risk of water shortage.	1,930,700 by the year 2020.	420,000-480,000 by the year 2020.	670,000 including groundwater storage	No demand reduction required for a drought equivalent to the Critical Dry Period. Variable levels of reduction triggered by more severe shortages.
Metropolitan Water District of Southern California	The Regional Urban Water Management Plan (December 2000)	The basis for the multiple dry year drought scenario is the 1990-1992 drought, which resulted in the worst shortage situation experienced by MWD. Single dry year scenario is based on 1977, which is the worst year in the historical hydrologic record.	Metropolitan uses a monthly schedule to provide senior management with supply/demand information with which they make resource allocation decisions (no specific information provided on triggers).	21.3 million by the year 2020.	4,800,000 by the year 2020.	1,026,000	MWD is able to meet its full-service demands in the simulated drought conditions.
San Diego County Water Authority	2000 Urban Water Management Plan	Multiple dry year assessment based on assuming 1990-1992 drought year supplies for projected future 2001-2003 conditions.	No triggers given.	3,673,000 by the year 2020.	813,000 by the year 2020.	571,000 plus 30,000 groundwater storage	No demand reduction required for the simulated dry conditions, if projected imports and local supplies are developed.
City of Los Angeles Department of Water and Power	Urban Water Management Plan 2000 Update	Drought planning is based on a repeat of the three driest consecutive years in the hydrologic record (1959-61) following current year conditions.	No triggers given.	4,856,887 by the year 2020.	Approximately 800,000 by the year 2020.	35,000	Supplies are sufficient to meet the projected drought-year demands, with implementation of conservation measures. Exact demand reduction is not reported.

Agency	Source	Drought Planning Sequence	Drought Management Triggers	Build-Out Population	Build-Out Demand (af)	Total Storage Available (af)	Target Drought Demand Reduction
San Francisco Public Utilities Commission	Water Supply Master Plan (April 2000)	SFPUC plans its water deliveries in anticipation of a 6-year drought worse than the 1986-92 drought.	SFPUC has drought operating procedures that trigger different delivery deficiency levels relative to the volume of reservoir storage (total capacity in storage, 898,300 af - no exact figures given for trigger).	2,500,000 by the year 2030.	339,350 by the year 2030	1,469,000	Demand reduction targets not specified.
Contra Costa Water District	2000 Urban Water Management Plan. (December 2000)	CCWD determines the state of its available supplies annually. Multiple dry year (3 years), single dry year, regulatory restricted year, and normal year water supply assessments are projected in five-year increments over the next 20 years	The projected supply shortfall, calculated for each upcoming year, is used to trigger the adoption of a stage appropriate to the severity of the water shortage (no exact figure is given).	553,330 by the year 2020.	205,155 by the year 2020.	104,030	Demand reduction up to 50% may be enacted, in the final stage of the water shortage management program.
Alameda County Water District	1995 Integrated Resources Planning Study	Estimates of dry year deliveries from aqueducts and groundwater in the future are made with the IRMP model based on the period of record (1922-1992).	No triggers given.	331,300 by the year 2020	77,500 by the year 2020	7 plus groundwater storage	Maximum demand reduction target of up to 10% once every 30 years.

agencies utilize multiple sources of supply to increase flexibility and reliability. In contrast, the report points out that EBMUD relies on a single source of water, the Mokelumne River.

In summary, the survey concluded that "Each agency must assess its own risk of water supply shortage and develop a methodology to meet its individual planning needs."

Assessments of Mokelumne River Water Supply Reliability

This section describes model studies prepared by EBMUD using different approaches to assessing drought reliability of the District's water supply system. These studies do not include the drought planning sequence, but are instead based entirely on historic hydrologic conditions. They confirm that EBMUD's water supply system must be improved to continue providing reliable service, and confirm the quantity of additional supply needed.

As discussed above, EBMUD incorporates drought-related rationing into its water supply operations and planning, reducing demand during droughts by up to 25% of pre-drought levels. This results in EBMUD planning for less water supply in the future. Many water agencies plan to provide full water demand even during droughts.

Full Delivery Assessment. The first additional water supply study investigates whether EBMUD's system would be capable of delivering full demand under a repeat of historical hydrologic conditions, even if storage were allowed to completely deplete. This study demonstrates that EBMUD's water supply system is not capable of meeting full demands in all years. During the hydrologic conditions occurring in 1977 and 1992, EBMUD system storage would become completely depleted. During a year like 1992, only 172 thousand acre-feet per year (TAF/yr) could be delivered, 33% less than needed. Storage levels are severely depleted during all drought periods. (See Figure 2)

State Drought Guidelines. Water suppliers construct storage reservoirs to ensure adequate water supply during periods of insufficient runoff. In California, droughts lasting for several years are not uncommon. Since water suppliers in California cannot predict when droughts will begin and when they will end, they maximize the amount of carry-over storage remaining at the end of the year to ensure adequate supplies during droughts.

When assessing the reliability of their water supply systems, some water suppliers consider how much carry-over storage remains at the end of historic drought periods as a safeguard against more severe droughts in the future. The California Department of Water Resources describes this approach on Page 17 of their March 1991 *Urban Drought Guidebook* as follows: "At a minimum, the carry-over amount should be enough to meet essential health, safety, and firefighting needs if the subsequent winter is as dry as the driest year on record." (*Urban Drought Guidebook* 1991)

For the assessment of EBMUD's water supply, 235 TAF was assumed to be the minimum carry-over storage necessary to meet basic needs. That quantity is approximately equal to 75% of demand plus the amount of storage that is inaccessible, called dead storage. Thus, if it became necessary to use this storage, EBMUD would be able to release inflow for downstream prior rights and public trust resources while delivering previously stored water to its customers. Three separate model studies were prepared to assess supply under different assumed conditions. Key results from these studies are described below.

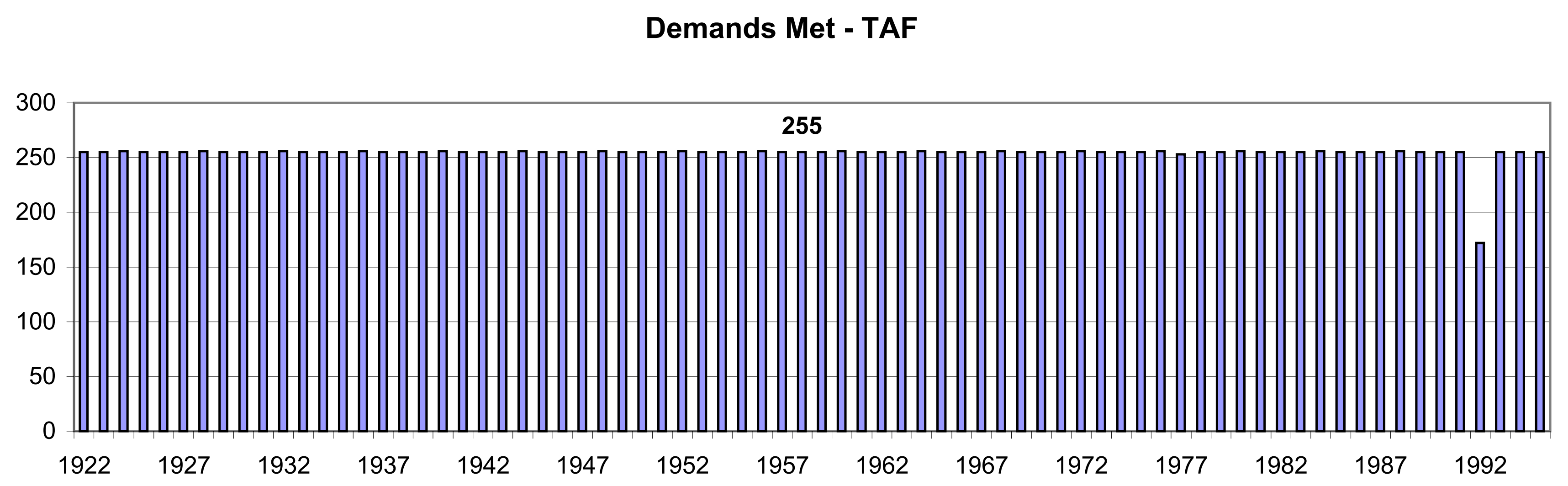
The review of other California water suppliers' drought planning efforts, described above, revealed that many water suppliers attempt to meet full demand during all years. To assess the EBMUD's Mokelumne River system's capability to meet full demands, a model run was prepared to deliver a constant rate in all years. This model run showed that EBMUD could only deliver 134 TAF each year, with no customer rationing, while maintaining minimum carry-over levels. 134 TAF is much less that current demand of 246 TAF/yr. To supply full demands in every year, a supplemental supply of 336 TAF would be needed over three years (112 TAF each year), much more than the 185 TAF over three years that the District is seeking. Resulting Total System Storage and Deliveries from this model run are shown in Figure 3.

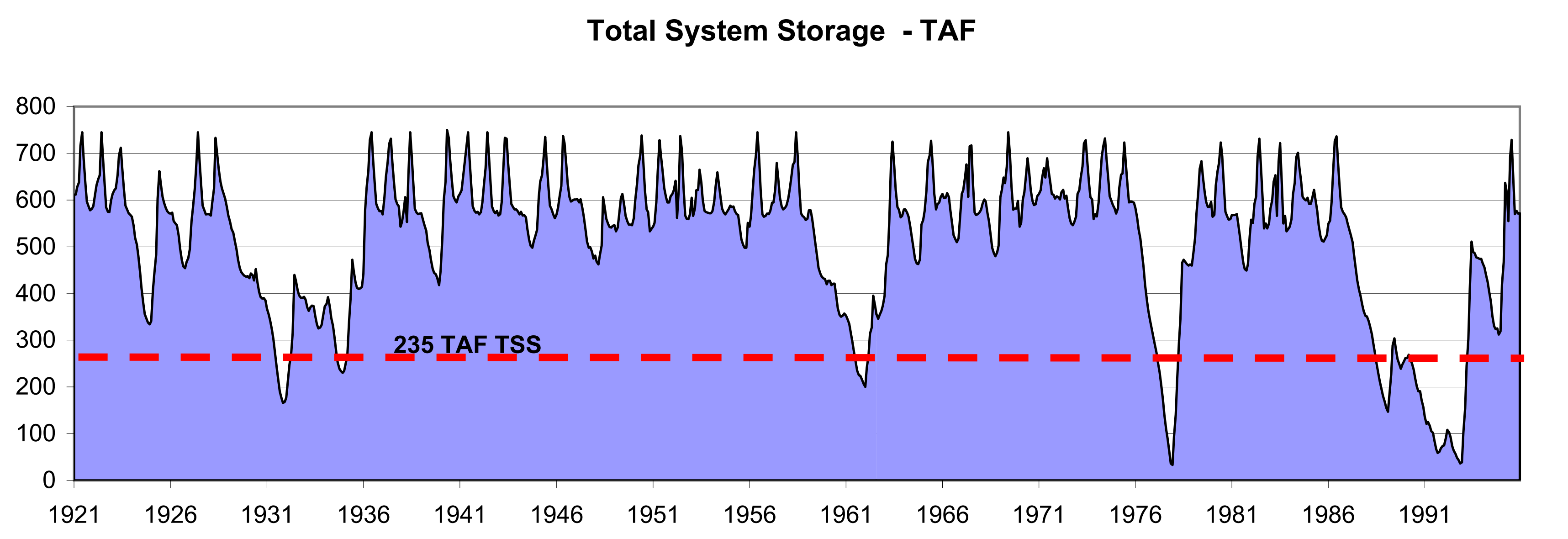
As described above, EBMUD plans to impose rationing on customers during droughts by up to 25%. To assess how much more water could be delivered from the Mokelumne system while accepting deficiencies during droughts, a model study was prepared that imposed EBMUD's drought management program. This model run showed that, even if EBMUD imposed rationing during the early years of drought, only 158 TAF could be delivered, still less than current demand levels of 246 TAF. Even with these rationing levels imposed, this study indicates a three-year total need of 264 TAF, still much more than the 185 TAF EBMUD is seeking. Storage and deliveries from this model run are shown in Figure 4.

Another model run was prepared, with a supplemental supply of up to 185 TAF provided over two years. This model run confirms the amount of water needed to improve EBMUD system water supply reliability. Even after providing 20 TAF for fishery gainsharing flows as required by the 1998 Joint Settlement Agreement[1], this model run indicates that with a supplemental supply of 185 TAF, 2020 demand levels can be met with rationing levels never exceeding 25%. Storage and deliveries resulting from this model run are shown in Figure 5.

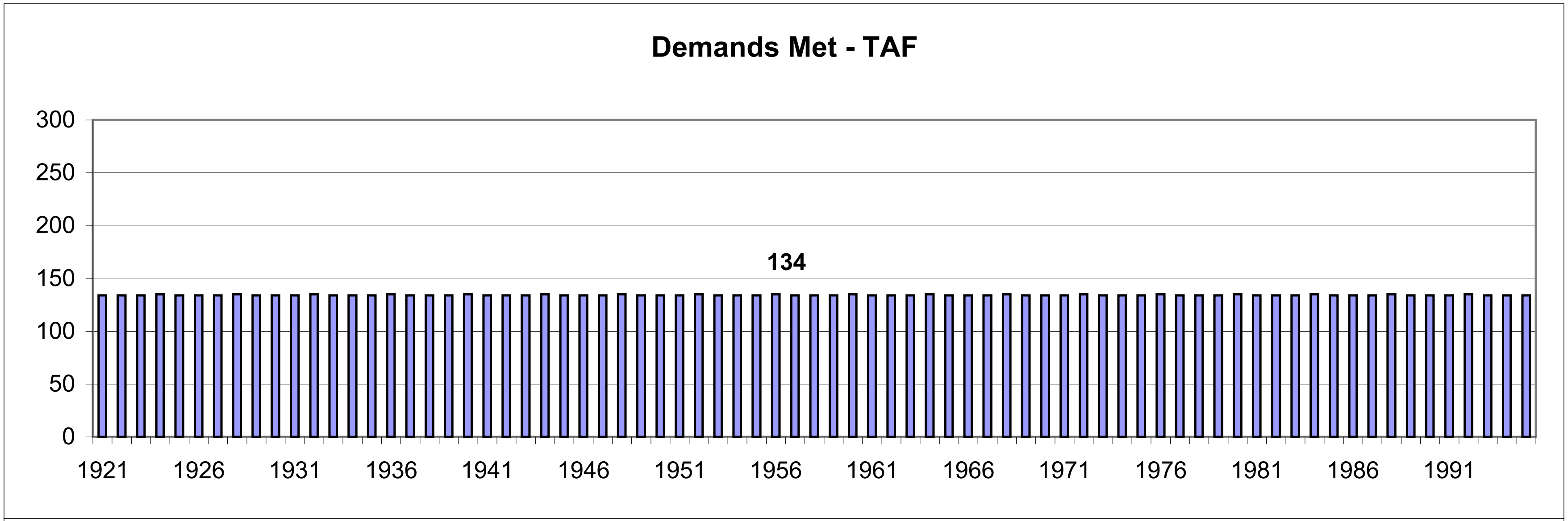
[1] The Joint Settlement Agreement among EBMUD, DFG, and USFWS, adopted by FERC on November 27, 1998, and by the SWRCB in D-1641, on December 29, 1999, sets flow and non-flow measures to protect the fish resources of the Mokelumne River ecosystem.

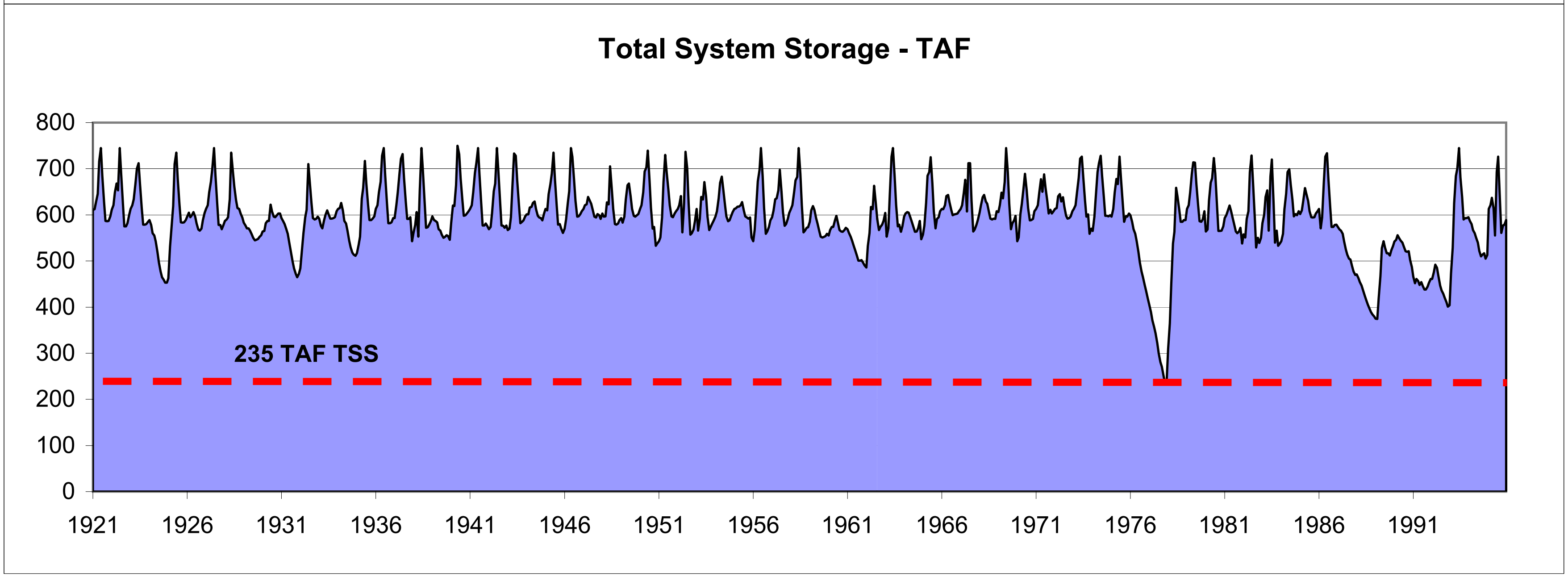
Demand - 228 MGD (255 TAF)
No Minimum Total System Storage
Full Deliveries, Reclamation and Conservation, No Supplemental Supply



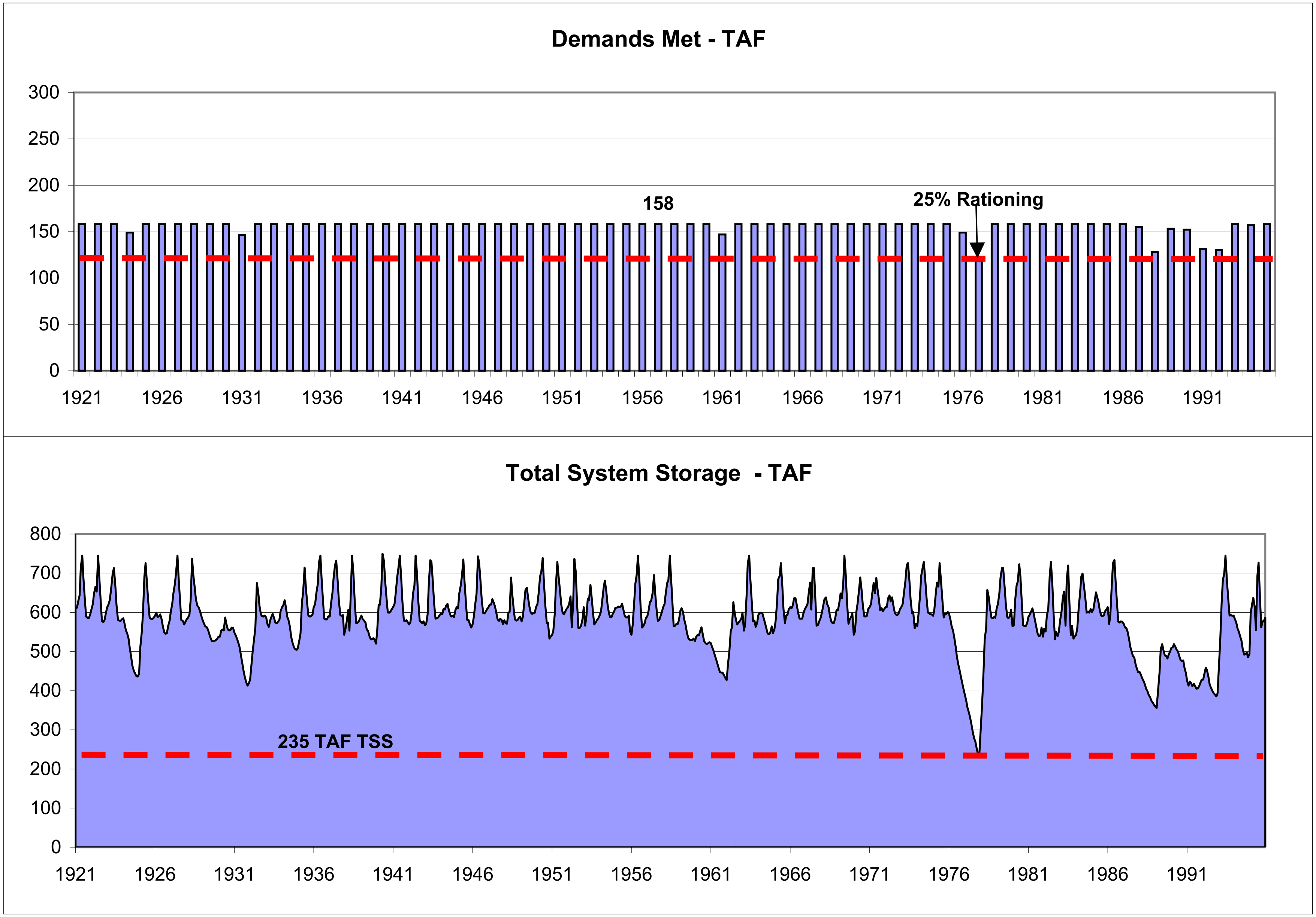


Maximum Sustainable Delivery - 120 MGD (134 TAF)
Minimum Total System Storage - 235 TAF
Full Deliveries, No Supplemental Supply

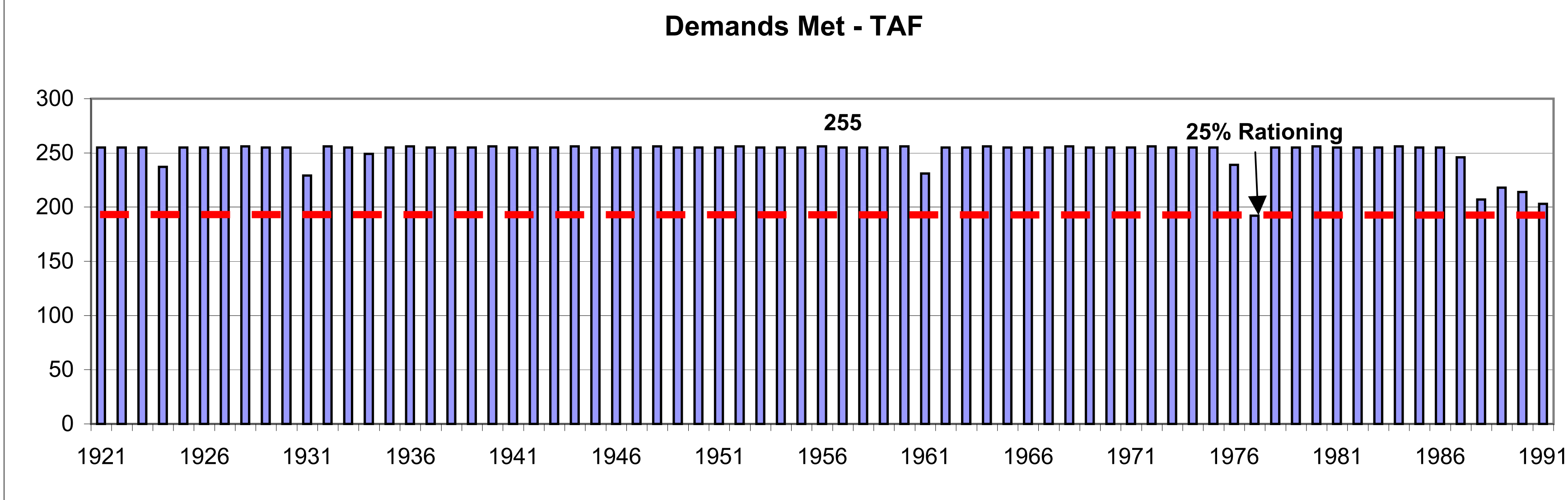


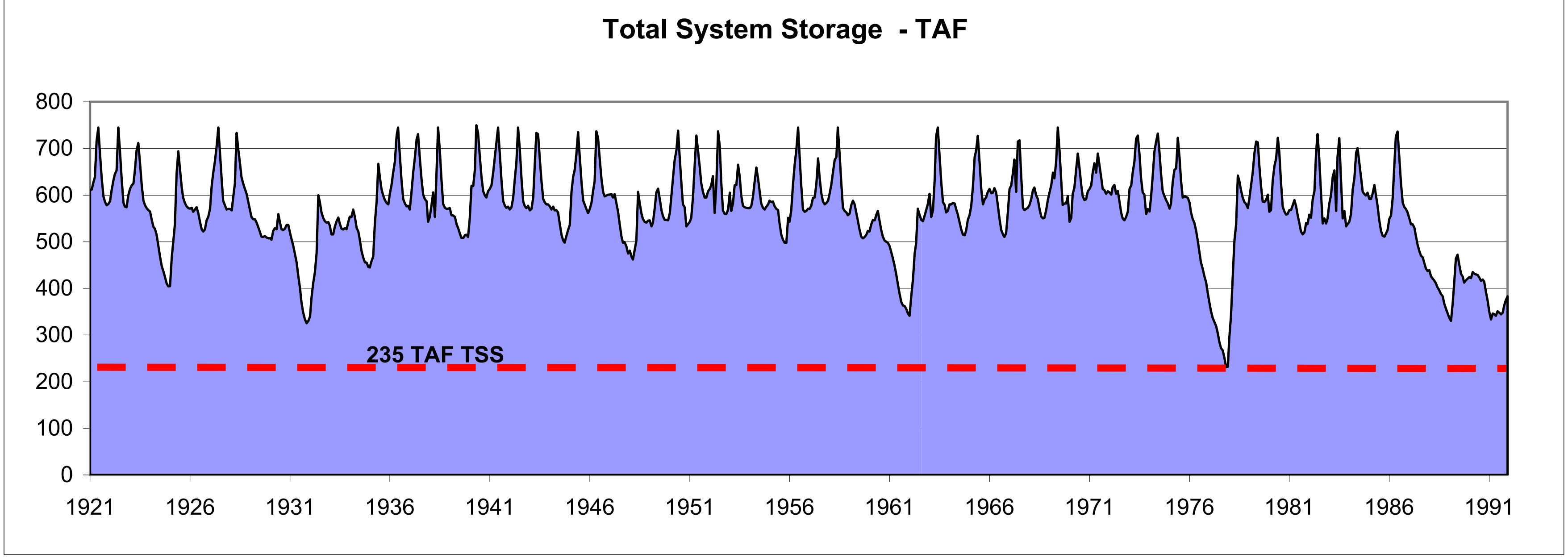


Maximum Sustainable Delivery - 141 MGD (158 TAF)
Minimum Total System Storage - 235 TAF
Early Customer Rationing, No Supplemental Supply



Maximum Sustainable Delivery - 228 MGD (255 TAF)
Minimum Total System Storage - 235 TAF
Early Customer Rationing, 185 TAF Supplemental Supply





Resulting Need for Additional Water

This section describes the results of using the above concepts to quantify the amount of additional water needed to ensure reliable drought year water supplies through 2020. Several factors must be taken into account to determine supplemental water supply needs. The contribution of each of these factors to quantifying EBMUD's need for supplemental water is described in this section. EBMUD has adopted a rigorous conservation program, projected to reduce year 2020 demand from 310 TAF/yr to 256 TAF/yr. In addition to the long-term demand reduction efforts, EBMUD's drought demand management program, reduces its need for additional water even further. The maximum 25% demand reduction level reduces water needs by an additional 64 TAF/yr. Despite these savings, EBMUD must still improve its water supplies by 185 TAF during droughts to continue providing reliable water service (Table 3). Although the maximum use of this supplemental supply would occur during the drought planning sequence, providing this supplemental supply is needed to improve EBMUD water supply system reliability during all drought periods.

Supplemental Supply for Consumptive Use Reliability

The No Action 2020 EBMUDSIM model study (presented in Volume 3, "Modeling Technical Appendix") indicates that shortages totaling 109 TAF would occur to EBMUD's customers and the river during the drought planning sequence.

Supplemental Supply for Public Trust Resources

Under the Joint Settlement Agreement, fishery releases to the lower Mokelumne River during the period from October through March are determined by carryover storage in Pardee and Camanche reservoirs on Nov. 5th. As EBMUD water supply reliability improves, increased carryover storage levels require more water to be released from Camanche Reservoir. This results in more water being required for water supply reliability during the drought planning sequence. This adds 33 TAF to the District's need for supplemental water. This is caused by increasing fishery releases from critically dry to dry for six months during the drought planning sequence.

Supplemental Supply for Public Trust Gainsharing

The Joint Settlement Agreement also provides that 20% of the yield from additional water supplies developed by EBMUD, up to maximum of 20 TAF, must be made available for public trust purposes as requested by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service (USFWS). This requirement adds 20 TAF to the District's supplemental water supply needs.

Supplemental Supply to Decrease First Year Rationing

To determine each year's water supply conditions, water suppliers must wait until after the winter's precipitation and snowpack accumulation is completed. During an initial year of drought, it can take several months to implement a rationing response. Thus, to effect a 10% annual savings in water use during the initial year of drought, customers must decreases use by 20% in the second half of the year. To alleviate the burden imposed by 20% rationing during the second half of a single drought year requires additional water supplies. To decrease rationing response to 5% annual savings during a single drought year (10% for half of the year) requires an additional 13 TAF of supplemental supply.

Supplemental Supply for Increased Evaporation

Improved water supplies result in higher reservoir levels. The increased surface area from higher water storage levels increases the amount of water lost by evaporation and seepage. This effect adds 10 TAF to the District's supplemental water supply needs.

Table 3. Supplemental Supply Needs

Supplemental Supply	
For Consumptive Use Reliability	109 TAF
For Public Trust Resources	33 TAF
For Public Trust Gainsharing	20 TAF
To Decrease First-Year Rationing	13 TAF
For Increased Evaporation	10 TAF
Total	**185 TAF**

Conclusion

After comparing water supply reliability planning approaches taken by other California water agencies, and after exhaustive studies of its own system reliability, EBMUD concludes that prudent planning requires it to obtain a supplemental source of supply during drought conditions. The analysis presented herein, supports the conclusion that a supplemental supply of 185 TAF would meet the District's water supply needs during dry periods, after implementing drought demand management programs to reduce demand by 25%. The earlier this water is delivered during a drought, the more effective it becomes for water supply purposes.

References Cited

California Department of Water Resources. 1991. *Urban Drought Guidebook*.

East Bay Municipal Utility District. 1999. *Water Supply Availability and Deficiency* Policy 52.

East Bay Municipal Utility District. 2001. Urban Water Management Plan 2000. February.

U.S. Army Corps of Engineers. 1991. *The National Study of Water Management during Drought*. IWR Report 91-NDS-2. September 1991.