EXHIBIT E

EXAMPLES OF BUFFER POOL RELEASE SCHEDULE CALCULATIONS

PRADO DAM

SANTA ANA RIVER

RIVERSIDE COUNTY, CALIFORNIA

Los Angeles District Office

U.S. Army Corps of Engineers

September 1991

EXAMPLES OF BUFFER POOL RELEASE SCHEDULE CALCULATIONS

PRADO DAM WATER CONTROL MANUAL

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Exhibit E

I - BUFFER POOL RELEASE SCHEDULE CALCULATION

PURPOSE: This algorithm determines the release rate necessary to accomplish one of the following two objectives: 1) to not exceed the buffer pool WSE 494-ft, or 2) to return the WSE to 490-ft so that flood control releases can be initiated. The magnitude of the inflow forecast and the current state of Prado Reservoir will determine which one of the above objectives will be meet.

1-01 Introduction. The following method of calculating a release schedule when the WSE is within the buffer pool was prepared by the Reservoir Regulation Section and was presented in an unpublished report entitled "Prado Dam - Flood Season Water Conservation", dated May 1989. The drawdown release rate can be determined using the algorithm described in Section I below or by a set of rule curves described in the following Section II. The graphical rule curves described in Section II provide a means of obtaining a quick and approximate drawdown release rate.

1-02 Step 1: Determine Drawdown Volume. The volume of water which must be released is the lesser of V_{dd1} and V_{dd2}:

$$V_{dd1} = V_{cur} + V_{for} - 8{,}915 \qquad \text{(Eq. E-1)}$$

$$V_{dd2} = V_{cur} - 4{,}474 \qquad \text{(Eq. E-2)}$$

where:

V_{dd} = the drawdown volume which is either V_{dd1} or V_{dd2} whichever is the smallest). If either V_{dd1} or V_{dd2} is negative then no release is required because the resulting forecast inflow will not cause the WSE at Prado to exceed 494-ft;

V_{cur} = the current reservoir volume in ac-ft;

V_{for} = the forecast inflow volume in ac-ft (obtained from either the QPF/API algorithm, the SARRT Water Control System, or the Recession Limb Inflow Forecast Model;

8,915 = the combined volume of the debris pool (4,474 ac-ft) and the buffer pool (4,441 ac-ft).

Exhibit E

IMPORTANT NOTE:

> If V_{dd1} is the smallest value then the resulting release rate will result in a WSE of 494-ft AFTER the forecast inflow arrives. In this case, this algorithm accounts for both the existing pool and the forecasted inflow.
>
> If V_{dd2} is the smallest value then the resulting release rate will result in drawing the pool down to WSE 490-ft BEFORE the forecast inflow arrives. For this case, this algorithm only accounts for the existing pool. It does not address the forecasted inflow. This means that a release schedule must still be prepared to handle the forecast inflow. (i.e., this case returns Prado to WSE 490-ft in anticipation of the incoming flood volume.)
>
> If either V_{dd1} or V_{dd2} is negative then the forecasted inflow will not cause the WSE to exceed 494-ft. Therefore no release schedule needs to be generated.
>
> In all cases the drawdown volume should not lower the water surface elevation below the debris pool elevation of 490-ft.

1-03 Step 2: Determine Drawdown Discharge. Once the drawdown volume is calculated, the drawdown discharge can be calculated by:

$$Q_{dd} = (12.1)\ (V_{dd} / T_{dd}) + Q_{bf} \qquad \text{(Eq. E-3)}$$

where:

Q_{dd} = the drawdown discharge in cfs;
V_{dd} = the drawdown volume obtained from Eq-1 or Eq-2;
12.1 = the unit conversion constant;
T_{dd} = the time available to drawdown the reservoir in hours;
Q_{bf} = the current base flow in cfs.

1-04 Examples of Formulating a Reservoir Release Schedule. When water is impounded in the Buffer Pool the Water Control Manager will need to decide on which of the following types of releases need to be made from Prado Dam:

1. Water conservation releases which range from 200 to 500 cfs.

2. Flood-control releases which range from 500 to 2,500 cfs.

Flood control releases are initiated when inflow from a storm is so large that, even though the reservoir had been drawn-down to the top of the debris pool (WSE 490-ft.) prior to the onset of the storm, conservation drawdown releases are not sufficient to lower the pool back to elevation 490-ft. prior to the onset of the second forecast storm. The following four examples demonstrate the application of the buffer pool algorithms to different situations.

a. Example 1. A storm has been forecasted for the Santa Ana River basin. Current storage (V_{cur}) is 6,000 ac-ft (WSE 491.6-ft), forecasted inflow (V_{for}) is 8,000 ac-ft, and base flow (Q_{bf}) is 200 cfs. The runoff is expected to begin in 24 hours (i.e., T_{dd} is 24 hours) The drawdown volume is calculated using Eq. E-1:

$$V_{dd1} = V_{cur} + V_{for} - 8{,}915$$

$$V_{dd1} = 6{,}000 + 8{,}000 - 8{,}915 = 5{,}095 \text{ ac-ft}$$

however, Eq. E-2 results in a lower release volume:

$$V_{dd2} = V_{cur} - 4{,}474$$

$$V_{dd2} = 6{,}000 - 4{,}474 = 1{,}526 \text{ ac-ft}$$

Therefore, the drawdown volume is only 1,526 ac-ft.

The drawdown discharge is then calculated from Eq. E-3:

$$Q_{dd} = 12.1\ (V_{dd}/T_{dd}) + Q_{bf}$$

$$Q_{dd} = 12.1\ (1{,}526/24) + 200 = 969 \text{ cfs}$$

Since V_{dd2} was the lowest release volume, the resulting Q_{dd} will cause the pool to lower to WSE 490-ft in 24hrs., at which time a decision must be made regarding the 6,000 ac-ft of forecasted inflow.

b. Example 2. A storm has been forecasted for the Santa Ana River basin. Current storage (V_{cur}) is 6,000 ac-ft (WSE 491.6-ft), forecasted inflow (V_{for}) is 4,000 ac-ft, and base flow (Q_{bf}) is 200 cfs. The runoff is expected to begin in only 12 hours (i.e., T_{dd} is 12 hours) The drawdown volume is calculated using Eq. E-1:

$V_{dd1} = V_{cur} + V_{for} - 8{,}915$

$V_{dd1} = 6{,}000 + 4{,}000 - 8{,}915 = 1{,}085$ ac-ft

Eq. E-2 results in a higher release volume:

$V_{dd2} = V_{cur} - 4{,}474$

$V_{dd2} = 6{,}000 - 4{,}474 = 1{,}526$ ac-ft

Therefore, the drawdown volume from Eq. E-1 is used, i.e., 1,085 ac-ft.

The drawdown discharge is then calculated from Eq. E-3:

$Q_{dd} = 12.1\ (V_{dd}/T_{dd}) + Q_{bf}$

$Q_{dd} = 12.1\ (1{,}085/12) + 200 = 1{,}294$ cfs

Since V_{dd1} was the smallest release volume, the resulting Q_{dd} will cause the pool elevation to reach an elevation of 494-ft after the forecasted inflow arrives at Prado Dam.

c. Example 3. A storm has been forecasted for the Santa Ana River basin. Current storage (V_{cur}) is 6,000 ac-ft (WSE 491.6-ft), forecasted inflow (V_{for}) is 2,000 ac-ft, and base flow (Q_{bf}) is 200 cfs. The runoff is expected to begin in 24 hours (i.e., T_{dd} is 24 hours) The drawdown volume is calculated using Eq. E-1:

$V_{dd1} = V_{cur} + V_{for} - 8{,}915$

$V_{dd1} = 6{,}000 + 2{,}000 - 8{,}915 = -915$ ac-ft

Since the drawdown volume is negative, the pool will not rise above the buffer pool and no release is required prior to the storm.

d. Example 4. Same as example 3 above except that the actual storm produced 5,000 ac-ft of runoff instead of the forecasted 2,000 ac-ft. Since no drawdown release was made prior to the onset of the storm, the reservoir rose to an elevation of 495.5-ft (11,000 ac-ft). A new QPF is issued indicating that an additional 30,000 ac-ft of inflow will occur, beginning in 24 hours. The release determined by this new forecast is:

$$V_{dd1} = V_{cur} + V_{for} - 8{,}915$$

$$V_{dd1} = 11{,}000 + 30{,}000 - 8{,}915 = 32{,}085 \text{ ac-ft}$$

Eq. E-2 results in a lower release volume:

$$V_{dd2} = V_{cur} - 4{,}474$$

$$V_{dd2} = 11{,}000 - 4{,}474 = 6{,}526 \text{ ac-ft}$$

Therefore, the drawdown volume from Eq. E-2 is used, i.e., 6,526 ac-ft.

The drawdown discharge which would return the reservoir to the debris pool in preparation for the forecasted 30,000 ac-ft storm would be:

$$Q_{dd} = 12.1\ (V_{dd}/T_{dd}) + Q_{bf}$$

$$Q_{dd} = 12.1\ (6{,}526/24) + 200 = 3{,}490 \text{ cfs}$$

Note that this release is in excess of the 2,500 cfs maximum release from the buffer pool. The water control manager would therefore prepare a schedule which smoothly increases the outflow from Prado Dam to 2,500 cfs in preparation for WSE 494-520 regulation.

Note also that the buffer pool release determination is updated at intervals corresponding to receipt of revised QPF information and flood inflow volume forecasts.

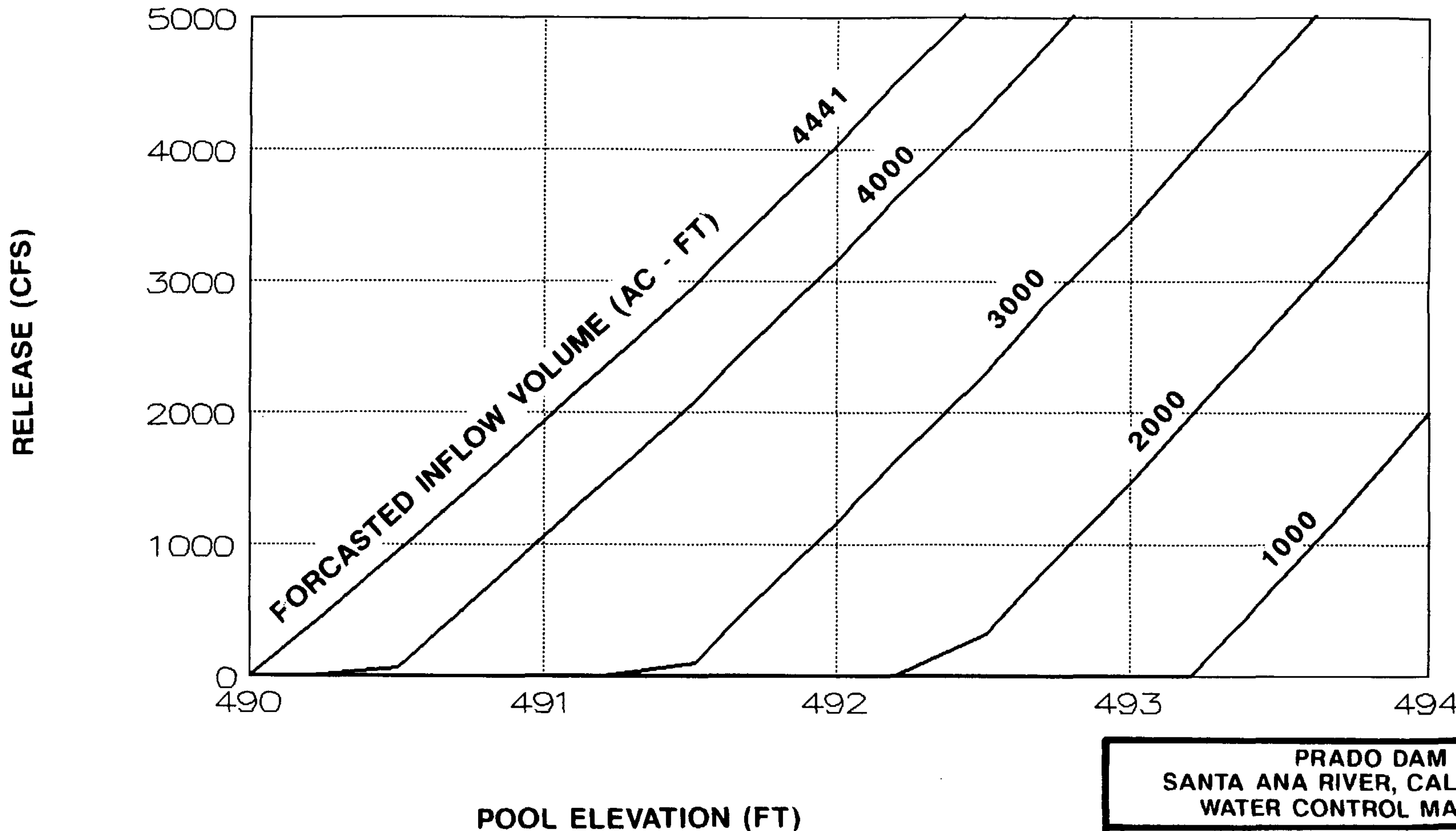
II - BUFFER POOL RULE CURVES

2-01 Buffer Pool Rule Curves. The following set of rule curves has been developed which can be utilized in place of the algorithm described in the preceding sections of this exhibit. Following these rule curves will result in bringing the WSE to 494-ft after the forecasted inflow arrives at Prado Dam. To use the rule curves the water control manager requires:

1. The current pool elevation at Prado Dam.
2. The forecast inflow volume in ac-ft (See Exhibit C).
3. The time to drawdown, T_{dd}, usually equal to the forecast time.
4. The base flow in cfs.

NOTE: IF YOUR CURRENT WSE OR THE FORECASTED INFLOW VOLUME FALL OUTSIDE THE LIMITS SHOWN ON THESE RULE CURVES, THEN YOU CANNOT USE THESE RULE CURVES. YOU MUST USE THE ALGORITHM OUTLINED IN SECTION I OF THIS EXHIBIT.

For example: If the current pool elevations were at 491.6-ft. and the forecasted inflow were 4,000 ac-ft twelve hours from now, one could use the 12 hour rule curve (Plate E-02) to determine that the required drawdown release rate should be approximately 1,200 cfs plus the base flow of 200 cfs making the required release 1,400 cfs.



PRADO DAM
SANTA ANA RIVER, CALIFORNIA
WATER CONTROL MANUAL

WATER CONTROL DIAGRAM
FOR RELEASE OF TEMPORARY WATER CONSERVATION STORAGE
1 OCTOBER - 1 MARCH
DURATION OF DRAWDOWN: 6 HOURS

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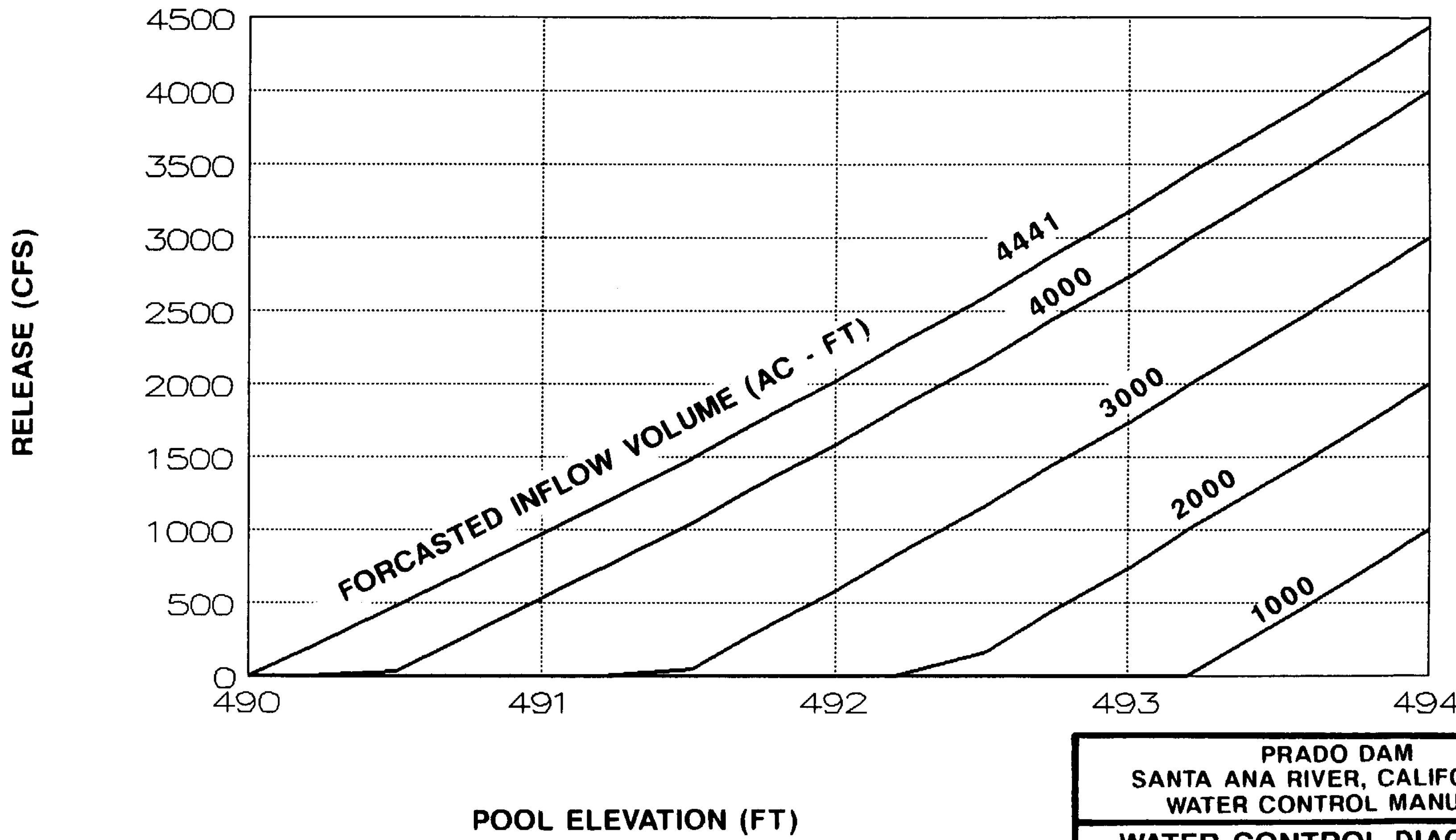

PRADO DAM
SANTA ANA RIVER, CALIFORNIA
WATER CONTROL MANUAL

WATER CONTROL DIAGRAM
FOR RELEASE OF TEMPORARY WATER CONSERVATION STORAGE
1 OCTOBER - 1 MARCH

DURATION OF DRAWDOWN: 12 HOURS

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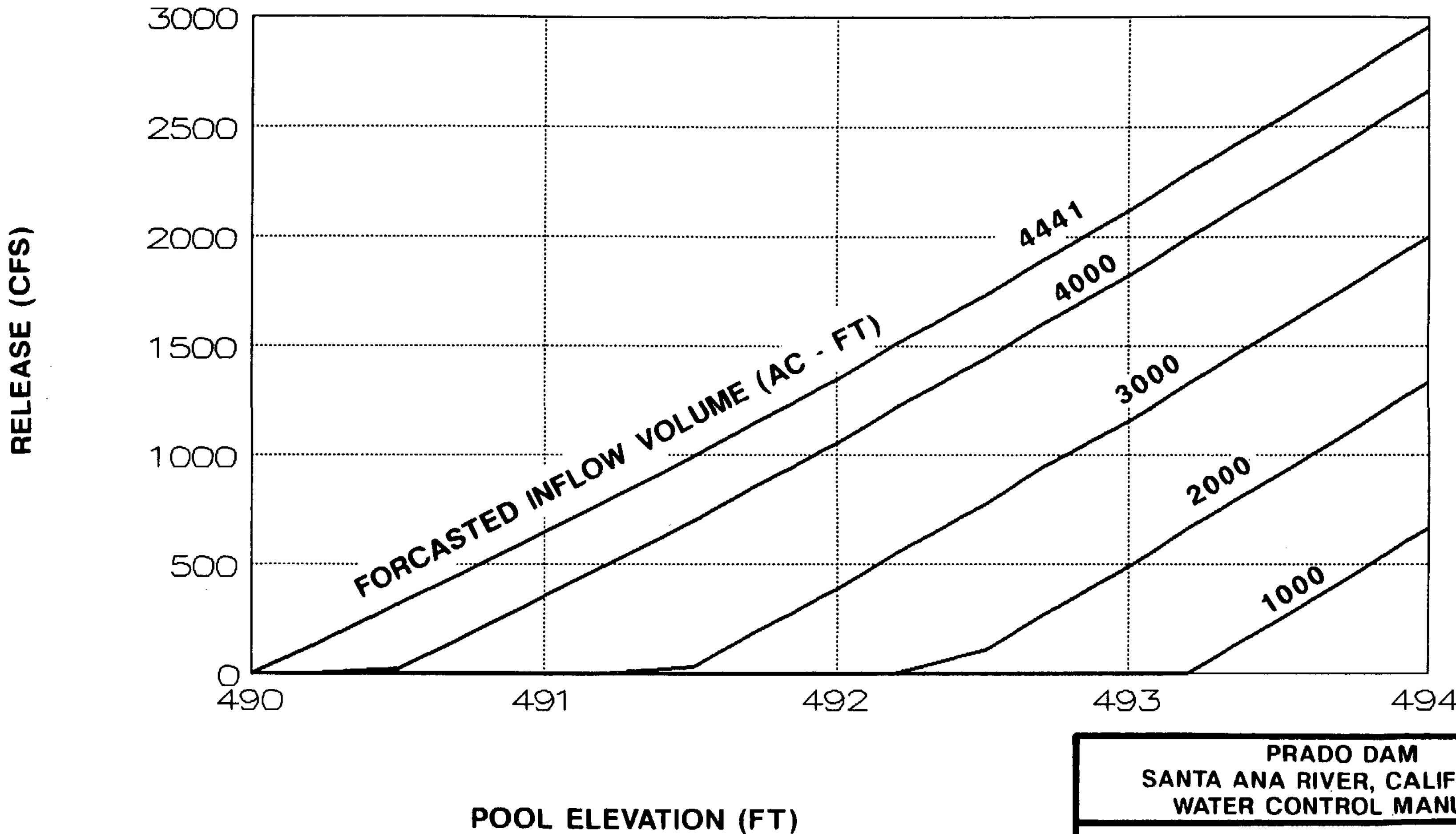

PRADO DAM
SANTA ANA RIVER, CALIFORNIA
WATER CONTROL MANUAL

WATER CONTROL DIAGRAM
FOR RELEASE OF TEMPORARY WATER
CONSERVATION STORAGE
1 OCTOBER - 1 MARCH
DURATION OF DRAWDOWN: 18 HOURS

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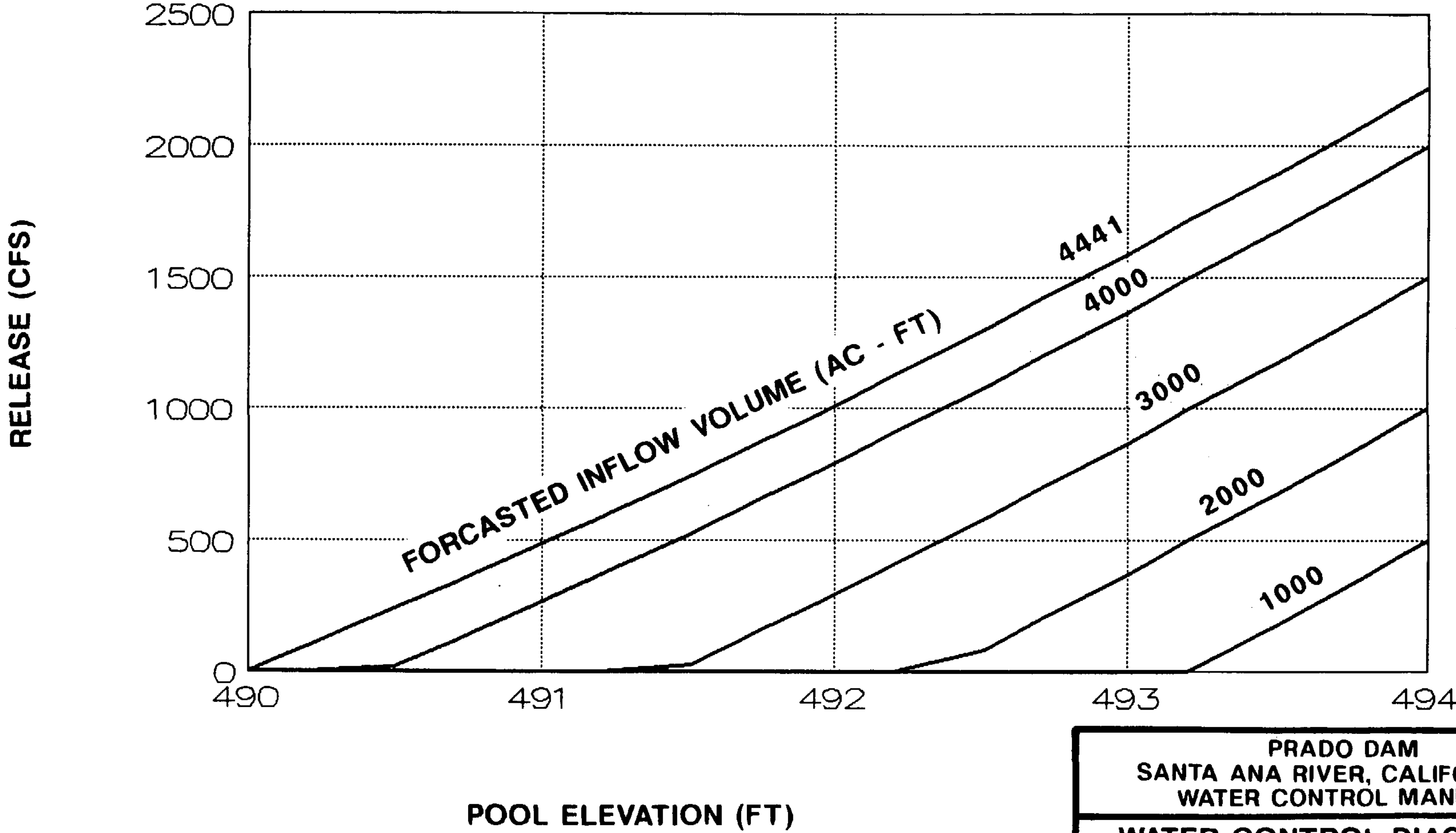

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WATER CONTROL DIAGRAM
FOR RELEASE OF TEMPORARY WATER CONSERVATION STORAGE
1 OCTOBER - 1 MARCH

DURATION OF DRAWDOWN: 24 HOURS

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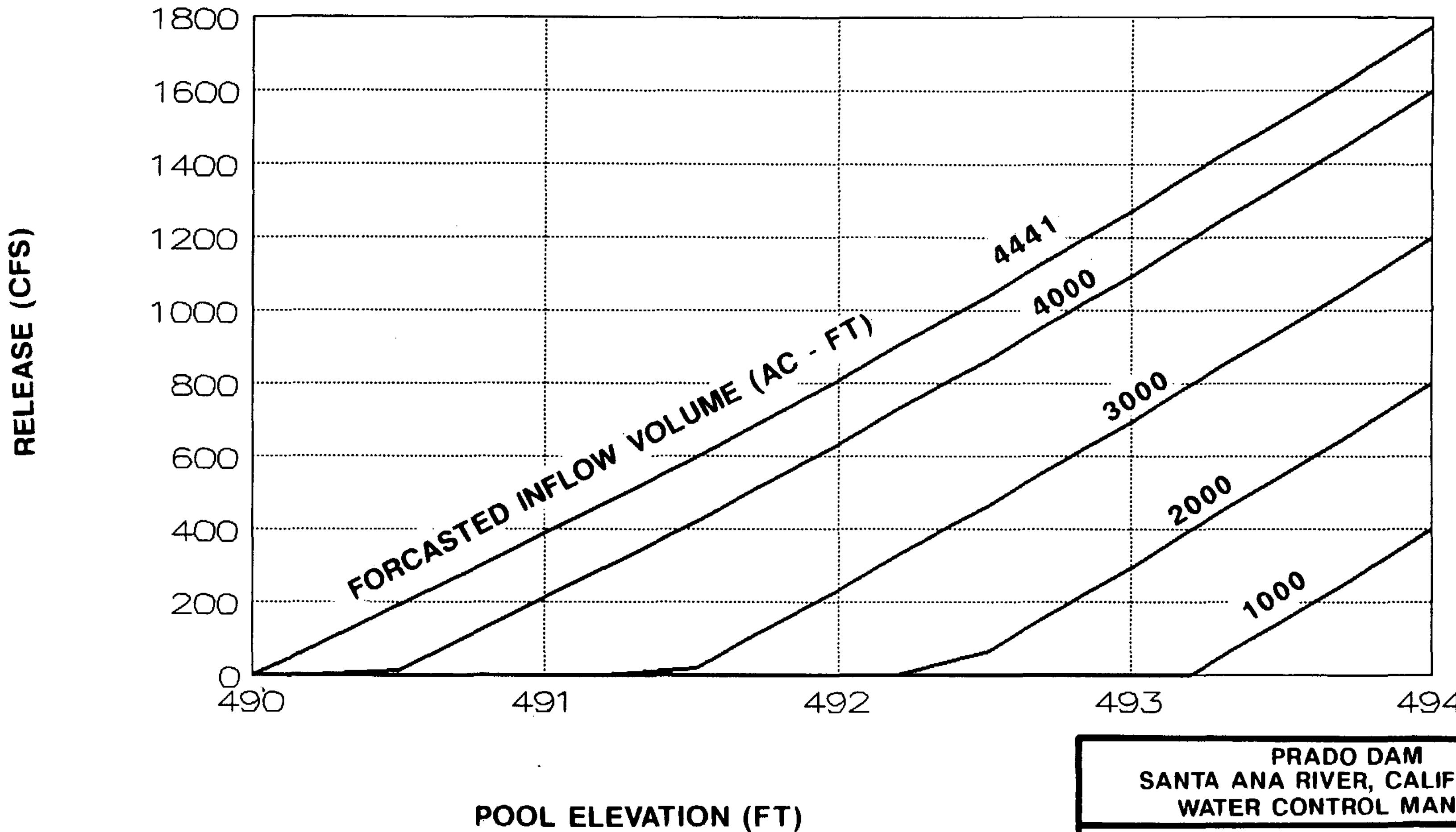

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WATER CONTROL DIAGRAM
FOR RELEASE OF TEMPORARY WATER CONSERVATION STORAGE

1 OCTOBER - 1 MARCH

DURATION OF DRAWDOWN: 30 HOURS

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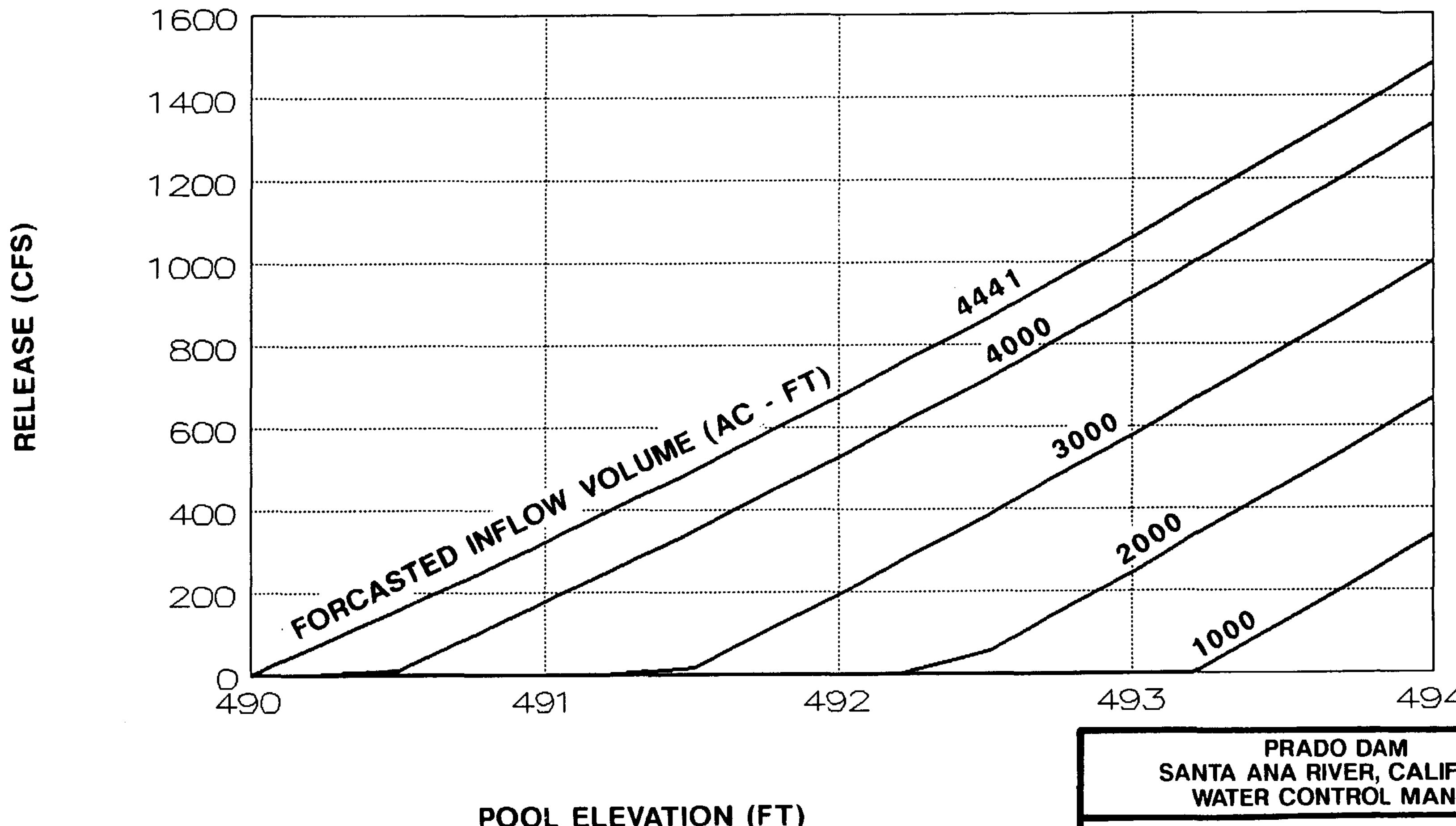

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SANTA ANA RIVER, CALIFORNIA
WATER CONTROL MANUAL

WATER CONTROL DIAGRAM
FOR RELEASE OF TEMPORARY WATER CONSERVATION STORAGE
1 OCTOBER - 1 MARCH
DURATION OF DRAWDOWN: 36 HOURS

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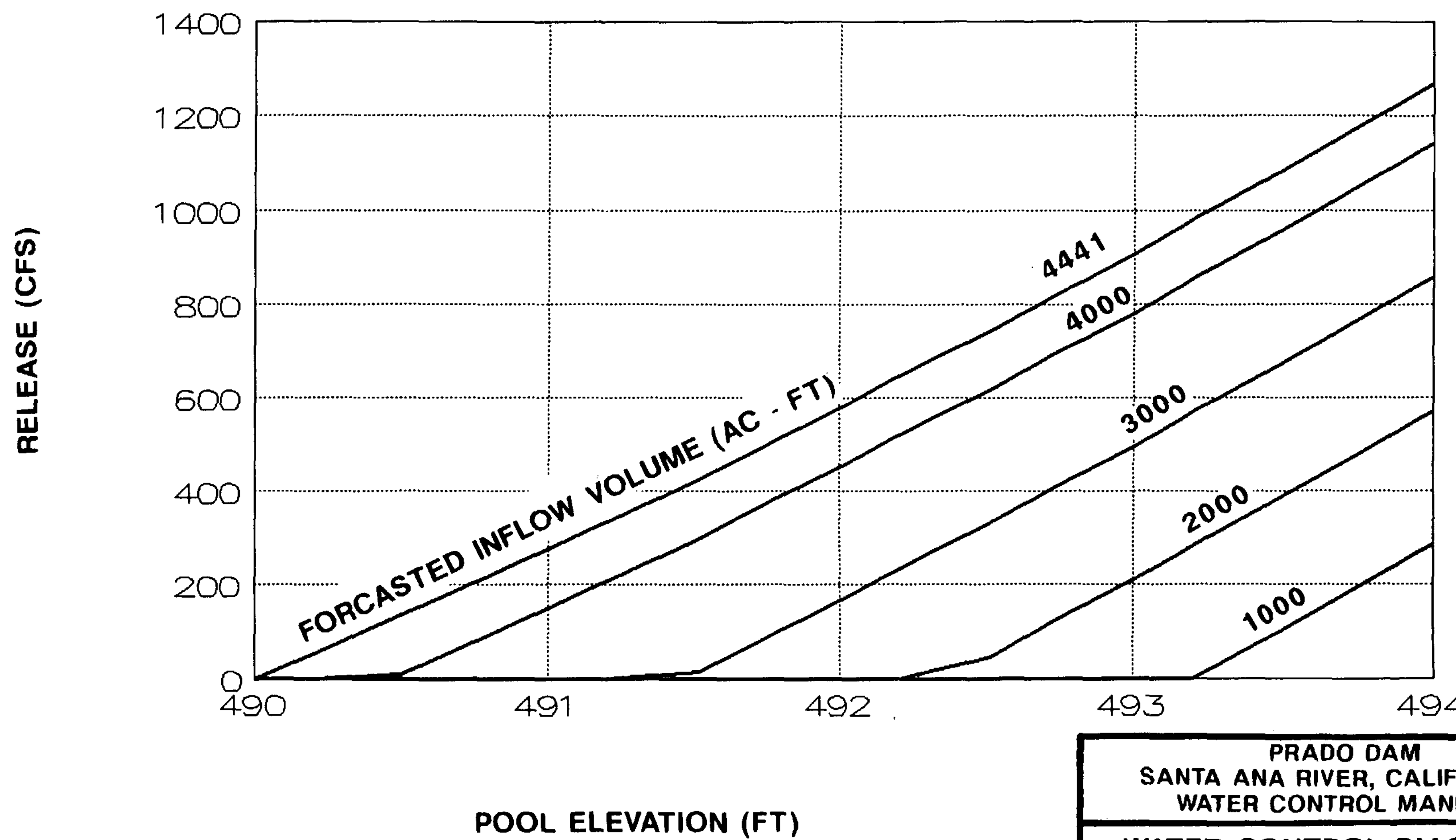

PRADO DAM
SANTA ANA RIVER, CALIFORNIA
WATER CONTROL MANUAL

WATER CONTROL DIAGRAM

FOR RELEASE OF TEMPORARY WATER CONSERVATION STORAGE
1 OCTOBER - 1 MARCH

DURATION OF DRAWDOWN: 42 HOURS

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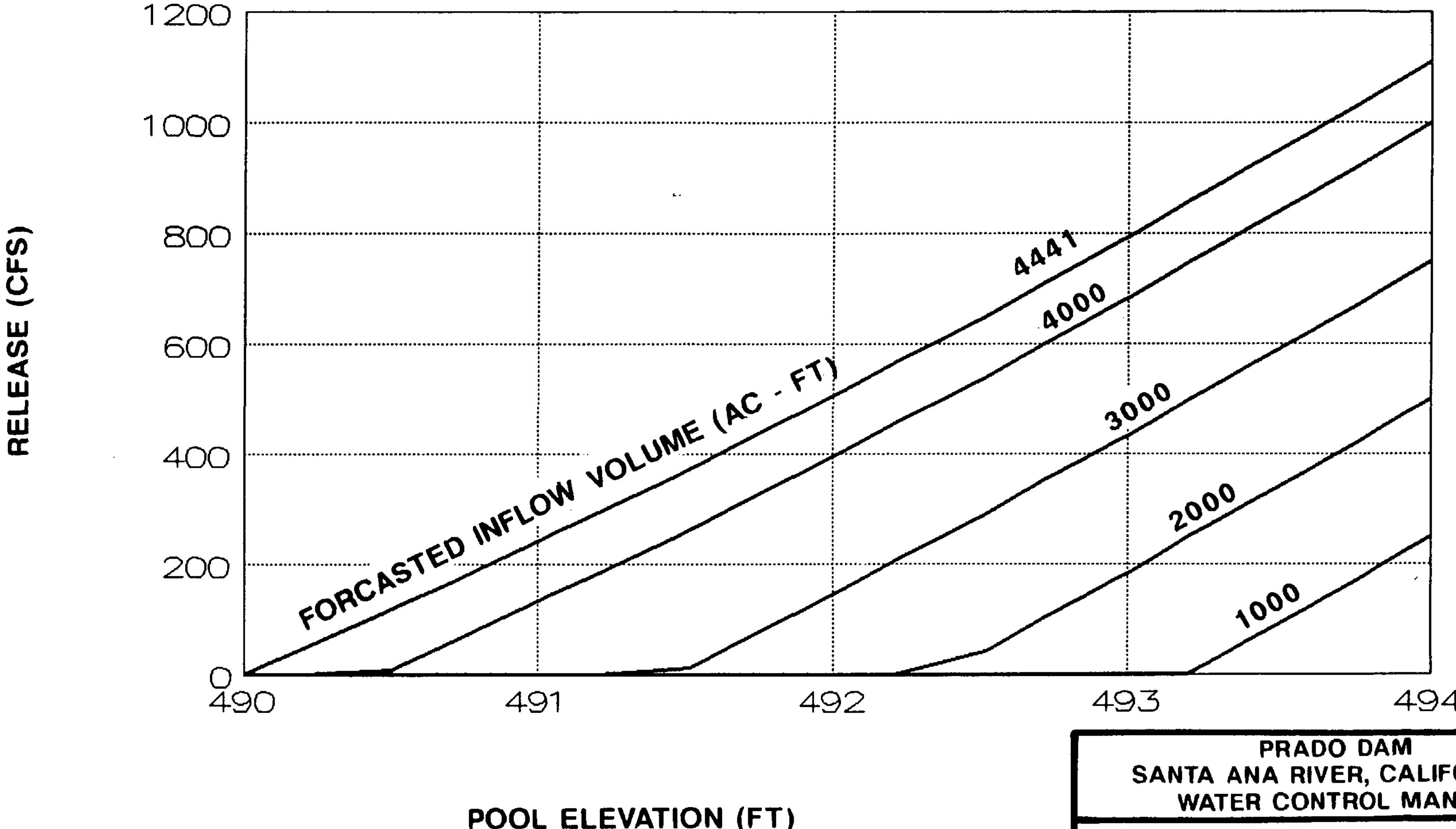

PRADO DAM
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WATER CONTROL DIAGRAM
FOR RELEASE OF TEMPORARY WATER CONSERVATION STORAGE
1 OCTOBER - 1 MARCH
DURATION OF DRAWDOWN: 48 HOURS

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