Chapter 10

Key 2010 Salt Management Strategies Modeling

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10.1 Introduction

The 15 basic salt management strategies (referred to as "studies") described in Chapter 9 were first developed and refined by using the Zone 7 "spreadsheet" model which routes water and TDS through the water system on an annual basis for 2010 land and water use conditions and historic 1922-96 hydrology. The spreadsheet model analysis was used in part to confirm that a strategy is a viable plan for managing water facilities to meet customer demands under any historic hydrologic (1922-96) conditions. Zone 7, with input from the GMAC and water retailers, developed and evaluated each of the fifteen salt management strategies. The salt management strategies were evaluated using screening criteria that included: technical feasibility, timing, economics, impacts on delivered water quality and public or institutional acceptance. A significant conclusion was that composite salt management strategies (i.e., approaches using several individual salt management strategies) were most promising.

Zone 7 staff, with consultant assistance, developed two more sophisticated models to further evaluate the viability of the strategies and to evaluate the delivered water quality impacts of each strategy. A numerical groundwater basin model and a linear programming water system operations optimization model that routes water and salt through our system on a monthly basis were used to evaluate different basin salt management and water supply strategies. The simulation results from these models were presented at numerous GMAC, Technical Advisory Group (TAG) retailer meetings and several Board Groundwater committee meetings. All groups concluded that the strategies were viable (workable) and that the results provided reasonable estimates of future groundwater and delivered water quality.

Groundwater Model—In 1996, Zone 7 staff retained CH2M Hill to assist with the development of a groundwater flow and solute transport (salt) model for the main groundwater basin for use in the Salt Management Plan and for studying future main basin management options. The model uses Visual MODFLOW for Windows version 2.61 by Waterloo Hydrologic, Inc. This modeling package includes groundwater flow and solute transport simulation. Visual MODFLOW uses the three-dimensional MODFLOW code to simulate flow and the three-dimensional MT3D code to simulate solute transport. The Zone 7 hydrologic inventory data from 1974-96 were used to evaluate and calibrate the model. Then the salt balance data from 1974-96 were modeled for solute transport. Section 3.7 (Groundwater Model) describes the groundwater model and calibration in more detail. The overall agreement between the model groundwater quality results and actual groundwater quality provides a high degree of confidence in the regional water quality simulation capabilities of this groundwater model.

CH2M Hill completed a groundwater modeling evaluation of several salt management strategies in June 1998. At that time all of the strategies had anticipated RO recycled water injection as an integral part of future Zone 7 basin management activities. Between May and August 1998, public concerns over the injection of RO recycled water for potable reuse became a serious issue and in September 1998 the Zone 7 Board passed a resolution requiring demonstrated public acceptance prior to supporting injection. Following the September 1998 resolution on DSRSD's CWR project, Zone 7 staff developed additional strategies that did not include RO recycled water injection but that would still meet salt balance goals. Zone 7 staff completed the groundwater modeling simulations needed for these new strategies. The final report, *Phase 4 Groundwater Modeling: Salt Management Plan Simulations by Dan Wendell and Mike Basial of CH2M HILL* (Reference N), was completed in January 1999 and includes the simulation results for all modeled strategies (including the modeling completed by Zone 7).

Water System Operations Model—In 1997, Zone 7 staff contracted with Water Resources Management, Inc. (WRMI) for the development of a water operations optimization model. The model details are described in Section 2.6. Zone 7 staff working with WRMI, completed several model simulations designed to predict the delivered water quality at each of the Zone 7 turnouts. Retailers' groundwater pumping was input and simulations of each retailer's delivered water quality were also generated. Projected groundwater quality information from the groundwater model runs was used as input to this model. The results of these modeling simulations are presented in this chapter.

These modeling capabilities have provided Zone 7 the ability to much more rigorously evaluate alternative management strategies by which Zone 7 could manage the groundwater basin through the coordinated use of existing and planned facilities to correct the salt imbalance. The modeling simulations show how the groundwater basin and distribution system can be managed for sustainable groundwater quality and delivered water quality.

All the strategies except 14 and 14a were evaluated using the numerical groundwater model for the basin. Strategies 1, 11B and 15 were further evaluated using the linear programming water operations optimization model (WRMI). That model routes water and salt through the Zone 7 system on a monthly basis and computes monthly delivered water quality to each treated water turnout. This chapter describes the use of the models for evaluating salt management strategies and the model simulation results for strategies 1, 1A, 11B and 15.

10.2 Baseline and Key Strategy Assumptions and Descriptions

Out of the 15 salt management strategies evaluated in Chapter 9, eight strategies including 1, 1A, 11B, 13, 13a, 14, 14a and 15 made it through the first four screens (technical feasibility, timing, economics and delivered water quality). Strategy 1, 1A and 13a did not pass the public/institutional screen because they do not maintain groundwater quality. These strategies would create 3,100, 5,400 and 1,730 tons/year net salt loading, respectively. Strategies 11B, 13, 14, 14a and 15 would be salt neutral (i.e., zero net salt loading in 2010).

Strategies 1A and 1 failed the final screen ("public or institutional acceptance"), but are carried into this chapter for more detailed evaluation and description to serve as quantitative baselines for the two salt neutral strategies 11B and 15. Strategy 11B which is less expensive than 15, did not pass the final screen ("public or institutional acceptance") at this time because it included RO recycled water injection into the main groundwater basin. If and when RO recycled water injection is deemed acceptable or any other low TDS source (~100 mg/L) of groundwater recharge becomes feasible, Strategy 11B would be a preferred salt management strategy. Strategy 15 is the only strategy that currently passed all the screens. At this time it is the best strategy that would balance the salt loading without using RO recycled water (RW) injection.

Table 10.1 presents a summary of the key salt management strategies discussed in this chapter. Following is an explanation of terms used in Table 10.1.

Policy Options are described in Section 7.2. Option 1 is the Status Quo with basin groundwater quality continuing to degrade. Option 2 is to maintain Status Quo until a trigger or regulatory limit is reached. Option 3 is stabilize groundwater quality at current quality and Option 4 is to improve groundwater quality.

Net salt loading values are the expected salt loading to the main basin under the investigated salt management strategy and are rounded to the nearest 100 tons/year.

Net increase in TDS converts the net salt loading in the basin to a corresponding average annual increase in TDS (mg/L/year) of the groundwater. Implicit in this conversion is the assumption that all salts have been uniformly mixed with groundwater.

Projected groundwater TDS after 10 years assumes that the current groundwater contains 450 mg/L TDS and computes the expected TDS after 10 years based on salt loading. Implicit in this calculation is the assumption that the upper and lower aquifers are mixed and that all salt loading at the surface reaches the groundwater basin.

TDS of Zone 7 deliveries are calculated assuming constant surface water (250 mg/L) TDS and groundwater (450 mg/L) TDS concentrations. It should be noted that actual SBA concentrations could vary from 100 to over 700 mg/L and the actual groundwater TDS values also can vary, as described in Chapter 4.

Table 10.1
SUMMARY OF KEY SALT BALANCE STRATEGIES AT 2010 CONDITIONS

			LONG TERM AVERAGE						
Strategy No.	NAME	Policy Option	Net Salt Loading Tons/y	Net Increase in GW TDS mg/l	Projected GW TDS After 10 Yrs. mg/l	TDS of Zone 7 Deliveries mg/l	Zone 7 Incremental Operational Cost per Year	Per Acre-foot of TW Delivery	% Rate Increase
1A	Status Quo No RO RW injection	I	5400	18	630	275	$0	$0	0.0%
1	Status Quo plus 6 TAF RO RW injection	I	3100	10	550	300	$0	$0	0.0%
11B	Composite of 6 TAF RO RW injection, Increased Conjunctive Use & Demineralization of high TDS(1,000 mg/L) GW	III	0	0	450	277	$2,351,000	$40	7.9%
15	Composite of Increased Conjunctive use & Demineralization of High TDS GW	III	0	0	450	270	$2,607,000	$50	9.8%

Assumptions:

1 All strategies do not include salt loading due to future development outside the main basin or new recycled water irrigation water use.
2 Incremental operational cost is based upon total treated water deliveries (45,100 AF Zone 7 plus 7,214 AF GPQ pumpage).
3 Percent increase to Zone 7 water rate is based upon 1998 rate of $508/AF.

Annual incremental operational costs are conceptual planning level costs for unit operations and maintenance only. These costs include $60/AF for municipal groundwater pumping, $20/AF marginal cost to treat the water at one of the treatment plants, $400/AF for wellhead demineralization, $150/AF of brine disposed from associated wellhead demineralization, $40/AF for groundwater pumping to waste, and $70/AF SWP entitlement variable charges for replacement water.

10.2.1 Common Assumption for All Strategies (Baseline 1998 Conditions)

The following is a list of the assumptions that were used in all strategies except as noted otherwise. A brief description of these assumptions is also available in Section 9.5.

Zone 7 Water System Facilities—Although all the strategies include facilities in addition to those presently (1998) available, the majority of the strategies involve use of facilities already scheduled for construction as part of the Zone 7 expansion program (i.e., no new capital costs incurred solely for salt management).

Demand and Supply—Zone 7's treated water demand for 2010 is 45,100 AF and untreated demand is 8,700 AF/year. The hydrologic study period used for local supply and SWP water supply is 75 years (1922 through 1996). The SWP demand is assumed to be 4.1 MAF. The existing Zone 7 SWP entitlement is 46 TAF. An additional 15 TAF is assumed to be available by 2010. The available surface water supply for treated water deliveries is limited by the SWP yield for the year, Zone 7's water treatment plant capacity, the maximum instantaneous SBA flow rate, and the maximum monthly delivery from the SWP.

Water Quality—SBA water TDS was assumed at 250 mg/L, ASR pumpage TDS at 250 mg/L, and groundwater TDS at 450 mg/L. Annual average delivered water quality is calculated using these consistent concentration values proportioned to the blend of surface and groundwater delivered each year.

Wells—These strategies assume that there will be some groundwater pumpage required to meet peak demands. The required groundwater pumpage is the sum of pumpage for daily peaking and seasonal peaking. It was assumed that if ASR is successful, Zone 7 could use ASR wells to inject low TDS surface water into the basin and pump it out to meet peak demands. The studies assumed injection capacity of ASR wells to be approximately 8,300 AF/year by year 2010. If ASR wells were not to be used (due to well clogging problems), increased wellhead demineralization could be used to maintain delivered water TDS and the Chain of Lakes could be used for surface water recharge.

Storage—It is assumed that when total groundwater storage at the beginning of the water year is over 240 TAF, Zone 7 will pump groundwater for deliveries and surface water supplies will be carried over for the following year. It was assumed that Zone 7 would be allowed to carryover 10 TAF of local storage from one year to the next. Lake Del Valle supplies include the local water used as direct inflow and local water used after storage in the lake. It does not include the local water released from the lake for recharge to satisfy prior rights on the Arroyo Valle.

Recharge—The artificial stream capacity includes existing Arroyo Mocho recharge capacity, existing Arroyo Valle recharge capacity, and the recharge capacity of Lake I in the Chain of Lakes. The existing Arroyo Mocho recharge capacity is about 19 cfs from April through September and 14 cfs from October through March. The existing recharge capacity on the Arroyo Valle is approximately 3 cfs (reach 1&2). It was assumed that the stream capacity from June through August would be unusable due to the SBA capacity limit. Therefore, stream capacity is used for only nine months of the year. Delivery into Lake I is assumed to be 30 cfs for six months of the year. It is anticipated that Zone 7 would make recharge releases between October and June down the Arroyo Mocho at a rate at 50-60 cfs. Of this, 20-25 cfs would recharge in the Arroyo Mocho and 30-35 cfs would be diverted for storage and recharge in the Chain of Lakes.

Salts—All strategies except strategies 3, 4 and 12, assume that there is no vadose zone attenuation and that 100% of applied salts ultimately mix with and impact the groundwater.

10.2.2 Strategy 1A—Status Quo (Without RO Recycled Water Injection)

Strategy 1A is considered the baseline case and is based on Zone 7's historic operational criteria. The historic criteria are to maximize surface water deliveries and pump groundwater only for peaking and drought conditions. Strategy 1A does not include any salt management measures and minimizes operational costs.

Strategy 1A results in an average salt loading of 5,400 tons/year (Table 9.4a) and a delivered water TDS of 275 mg/L under year 2010 conditions. Since this is the baseline case in which no changes in operation and no additional facilities are required other than those already assumed to be in place in the year 2010, there are no incremental costs associated with this strategy. Strategy 1A defines the baseline conditions for salt management Strategy 15.

10.2.3 Strategy 1—Status Quo Plus 6 TAF/Y RO Recycled Water Injection

Baseline Strategy 1 varies from baseline Strategy 1A in that Strategy 1 includes 6 TAF of RO recycled water injection into the main basin. Since this 6 TAF/Y RO recycled water injection is a new source of recharge, it was assumed that Zone 7 would increase groundwater pumpage to offset this new supply. Strategy 1A also does not include any salt management measures other than the assumed 6 TAF of RO recycled water injection and increased groundwater pumpage (to offset the recycled water injection volume) common to strategies 1-13.

RO recycled water (or other low TDS water) injection or stream recharge of 6 TAF per year is 2,300 AF more than the amount potentially available through the existing Livermore and DSRSD projects. The Livermore and DSRSD projects could produce 840 AF/Y and 2,800 AF/Y, respectively. Strategy 1 assumed that these projects would be expanded and the additional 2,300 AF/Y would be recharged in the future Chain of Lakes. This is a significant potential component since the assumed injection of 100 mg/L TDS water and extraction of 450 mg/L groundwater elsewhere represents 2,300 tons per year of salt removal from the basin in 2010. Since Zone 7 would have to purchase additional supplies to meet 2010 demand, the cost to purchase the RO and injected recycled water from DSRSD and Livermore was assumed to be covered by Zone 7's connection fee program.

Strategy 1 conditions result in a salt loading of 3,100 tons/year and delivered water quality of 300 mg/L. Delivered water quality TDS increases from Strategy 1 due to increased non-ASR pumpage to offset recycled water injection. The groundwater basin salt loading for Strategy 1 decreases to 3,100 from 5,400 tons/year in Strategy 1A. Since this is also a baseline case and no additional Zone 7 facilities are required other than those already assumed to be in place in the year 2010, there are no capital or O&M incremental costs associated with this strategy. Strategy 1 defines the baseline for salt management strategies 1 through 13.

10.2.4 *Strategy 11B—Increased Conjunctive Use and Demineralization of High TDS Groundwater*

Strategy 11B evaluates the effect of conjunctive use plus demineralization of high TDS groundwater. This strategy assumes that 3 TAF of stream recharge and groundwater pumpage for conjunctive use will be implemented using existing facilities. The 3 TAF of new shallow groundwater pumpage would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

A fundamental premise of this strategy is that the salts residing in the higher TDS upper aquifer would eventually migrate vertically and degrade the higher quality lower aquifer. Section 2.6 discusses the groundwater movement between the upper and lower aquifers. By pumping and demineralizing the high TDS upper aquifer water, the movement of upper aquifer water to the lower aquifer can be minimized. Other more expensive salt removal alternatives involved demineralizing the lower TDS lower aquifer production wells (strategies 7 to 10 described in Section 9.6). These strategies require demineralization of a larger volume of lower TDS water to achieve the same salt removal shallow water demineralization and hence are more expensive. A key assumption is that the cost of this range of brackish water demineralization is a function of the volume of groundwater and not the TDS (i.e., O&M costs are constant for 450 mg/L or 1,000 mg/L groundwater).

As part of the groundwater modeling (section 10.3) for Strategy 11B, four high TDS groundwater sites were modeled: Camp Parks site, a line of wells along Arroyo Mocho, the Hopyard well field, and a future Bernal Property well field. The groundwater modeling simulation for Strategy 11B indicated that two shallow wells at the Camp Parks site could sustain about 900 AF/Y. Two wells along Arroyo Mocho would contribute about 800 AF/Y, one well in Hopyard well field about 900 AF/Y, and one well in the future Bernal Property well field would contribute 900 AF/Y. All of these shallow wells could go dry in the event of a prolonged drought. To make use of the demineralization facility during prolonged drought conditions, deep well pumpage could be used to replace the shallow well pumpage. Therefore, having a deep well and shallow wells connected to each demineralization facility would be the most flexible operational configuration arrangement.

Another net salt removal advantage of shallow over deep groundwater demineralization would occur if the pumpage were to be diverted to the arroyos during peak wet weather flows (i.e., seasonal groundwater export). This would be a lower cost alternative than pumping and demineralization, assuming necessary permitting and operational arrangements were negotiated with ACWD. In Strategy 11B, it was assumed that a first phase demineralization facility (1,700 AF/year) would be located at or near the Camp Parks well site. It would demineralize the pumpage from new or possibly renovated existing Camp Parks shallow wells plus pumpage from new shallow wells along Arroyo Mocho.

The second phase (1,800 Af/year) would require either a second demineralization facility located in the vicinity of the Hopyard well field or in the future Bernal Property well field, or else pipelines back to an expanded demineralization facility at the Camp Parks well site.

Strategy 11B eliminates the net salt loading (Table 9.15) to the main basin. The ten-year projected groundwater quality would stabilize at the current level of 450 mg/L TDS. Zone 7 delivered water quality would improve modestly by about 20 mg/L to about 280 mg/L. The increase in cost would be $40/AF.

10.2.5 Strategy 15—Increased Conjunctive Use and Demineralization of High TDS Groundwater

Strategy 15 evaluates the effect of conjunctive use plus demineralization of high TDS groundwater without any RO recycled water injection. Strategy 15 assumes that 8.5 TAF of stream recharge and groundwater pumpage for conjunctive use would be implemented using existing facilities. 5 TAF of shallow aquifer groundwater pumpage would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

Strategy 15 eliminates the positive net salt loading (Table 9.20) in the main basin. The ten-year projected groundwater quality would stabilize at the current level of 450 mg/L TDS. Zone 7 delivered water quality would remain at the baseline case Strategy 1A level (275 mg/L). The increase in cost would be approximately $50/AF.

The main differences between Strategy 15 and Strategy 11B are: 1) Strategy 15 has no RO recycled water injection, 2) Strategy 15 has more conjunctive use (8.5 TAF/year) and more ASR well recharge, and 3) Strategy 15 has more demineralization of high TDS groundwater pumpage (5 TAF/year versus 3 TAF/year).

As described earlier under Strategy 11B, a fundamental premise of Strategy 15 is also that the salts residing in the higher TDS upper aquifer would eventually migrate vertically and degrade the higher quality lower aquifer. Section 2.6 discusses the groundwater movement between the upper and lower aquifers. By pumping and demineralizing the high TDS upper aquifer water, the movement of upper aquifer water to the lower aquifer can be avoided. Strategy would similarly require two or three wellfields and one or more demineralization facilities. The assumption for siting and operating these wells and demineralization facilities are the same as for Strategy 11B except that the three wells in the future Bernal Property well field would need to be sized to contribute 2,900 AF/year.

Increased ASR injection in the western portion of the basin would improve the TDS in the lower aquifer in the Bernal and West Amador sub-basins. Alternatively, injecting in selective wells and pumping from different wells could create managed plumes of low TDS groundwater in the lower aquifer versus "bubbles" around the ASR wells. This low TDS water could also be pumped during drought conditions.

10.3 Groundwater Modeling Evaluations

As described in Chapter 9, Zone 7 developed over 15 "screening level" salt balance strategies in 1998. The goal of these strategies was to provide a preliminary evaluation of the relative effectiveness of available salt management strategies on the groundwater basin as a whole, to evaluate impacts on overall average delivered water quality TDS, and to provide planning level cost estimates. These strategies were performed using the "spreadsheet" water and salt routing model. This spreadsheet model used 2010 conditions and 1922-96 hydrology. Using all the system constraints, water supply and demand conditions, and salt management strategy conditions, this model determined how the treated and untreated demands would be met, and how the remaining surface water would be used for artificial recharge for each hydrologic year for the period 1922-96.

The spreadsheet model determined what the groundwater storage would be at the end of each year and the annual average TDS of Zone 7 water deliveries. The model also performed steady state average main basin salt loading calculations for each strategy. This type of evaluation was performed for each of the 15 salt management strategies. The model produced 75-year average recharge and discharge data that were subsequently used in the groundwater model.

One limitation of the "spreadsheet" model is that it treats the groundwater basin as a "bucket" and cannot deal with the full complexities of how groundwater would actually move in the basin and how the TDS of delivered water quality would vary in the Zone 7 distribution system under each strategy. These questions can be answered only by using the previously described numerical groundwater model (Section 3.7) and the water system operations optimization model (Section 2.6) together.

Zone 7's numerical groundwater model was developed in part to further evaluate potential basin management strategies. Zone 7 has used the model for the Salt Management Plan, Well Master plan, and for siting monitoring wells for the CWR and Livermore injection projects to track potential future injected water. All 15 salt management strategies except strategies 14 and 14a were evaluated using the model.

The numerical groundwater model includes the Visual MODFLOW for Windows version 2.61 by Waterloo Hydrologic, Inc. package to simulate groundwater flow and the three-dimensional MT3D code to simulate solute transport. These modeling programs are in common use and accepted by regulatory agencies for evaluating existing and potential water resource management strategies.

The Zone 7 model grid has four layers and a uniform 500 x 500 feet grid in the X and Y directions covering the entire Livermore-Amador Valley groundwater basin. It is a three dimensional model and the thickness of the grid cells varies throughout the model area. The top three layers represent the upper unconfined aquifer, the deep confined aquifer and an intervening aquitard layer, respectively. The model layer elevations for the major portion of the model are based upon a number of geologic well logs. The model was calibrated using 20 years of actual hydrologic inventory data. Section 3.7 describes the model and calibration in more detail.

The groundwater model simulations were performed to evaluate the impacts of salt management plan strategies on groundwater basin water levels and water quality. The simulations were performed using 75-year average water flux conditions (steady state) for each salt management strategy. Based upon the steady state flow modeling, transient solute transport simulations were performed for a 50-year period. Since the groundwater movement and mixing is a slow process, the 50-year period was selected to allow enough time for the groundwater basin quality to stabilize. Complete modeling simulation results for all the simulated strategies are summarized in the report "Phase 4 Groundwater Modeling: Salt Management Plan Simulations" (Reference N).

10.3.1 Initial Groundwater Quality Conditions

Figures 10.1 and 10.2 present the initial groundwater quality conditions used in the simulations for the upper and lower aquifers. These initial conditions define the groundwater quality at the beginning of each model simulation. The initial conditions maps represent the actual groundwater quality in the basin for the 1990-95 period and are prepared based upon the available actual data for the 1990-95 period. All groundwater quality TDS maps represent low TDS water as blue and high TDS water as red with a transition from blue to red used for intermediate TDS levels. The gray color dotted line represents the 500 mg/L contour.

As shown in Figure 10.1, the north portion of the Dublin sub-basin has a groundwater TDS of less than 400 mg/L in the shallow aquifer. This is due to the low TDS recharge from irrigation water (less than 100 mg/L) delivered by EBMUD. The rest of the Dublin subbasin has higher TDS (over 700 mg/L) groundwater in the shallow aquifer. This area has high TDS groundwater mainly due to chlorides and other salts precipitated in the valley fill materials and the high TDS recharge from urban irrigation. These salts dissolve in the groundwater and increase the groundwater TDS. The Camp subbasin shallow groundwater TDS ranges from 700-1,000 mg/L. This is mainly due to the salts dissolving into groundwater from the valley fill materials. The north portion of the Amador subbasin has high TDS shallow groundwater due mainly to high TDS recharge (1,500 mg/L) from the Arroyo Las Positas and recharge from urban irrigation. The rest of the Amador subbasin in the south has low TDS shallow groundwater due to the low TDS recharge on the Arroyo Mocho and Valle.

Most of the shallow groundwater in the Bernal sub-basin has high TDS due to high TDS recharge from irrigation recharge and high TDS subsurface inflow from Dublin subbasin, except some areas in the south where shallow groundwater TDS is not as high as the north due to inflow of low TDS Arroyo Valle artificial stream recharge. In the Mocho II sub-basin, in the north, the shallow groundwater has high TDS due to the high TDS recharge

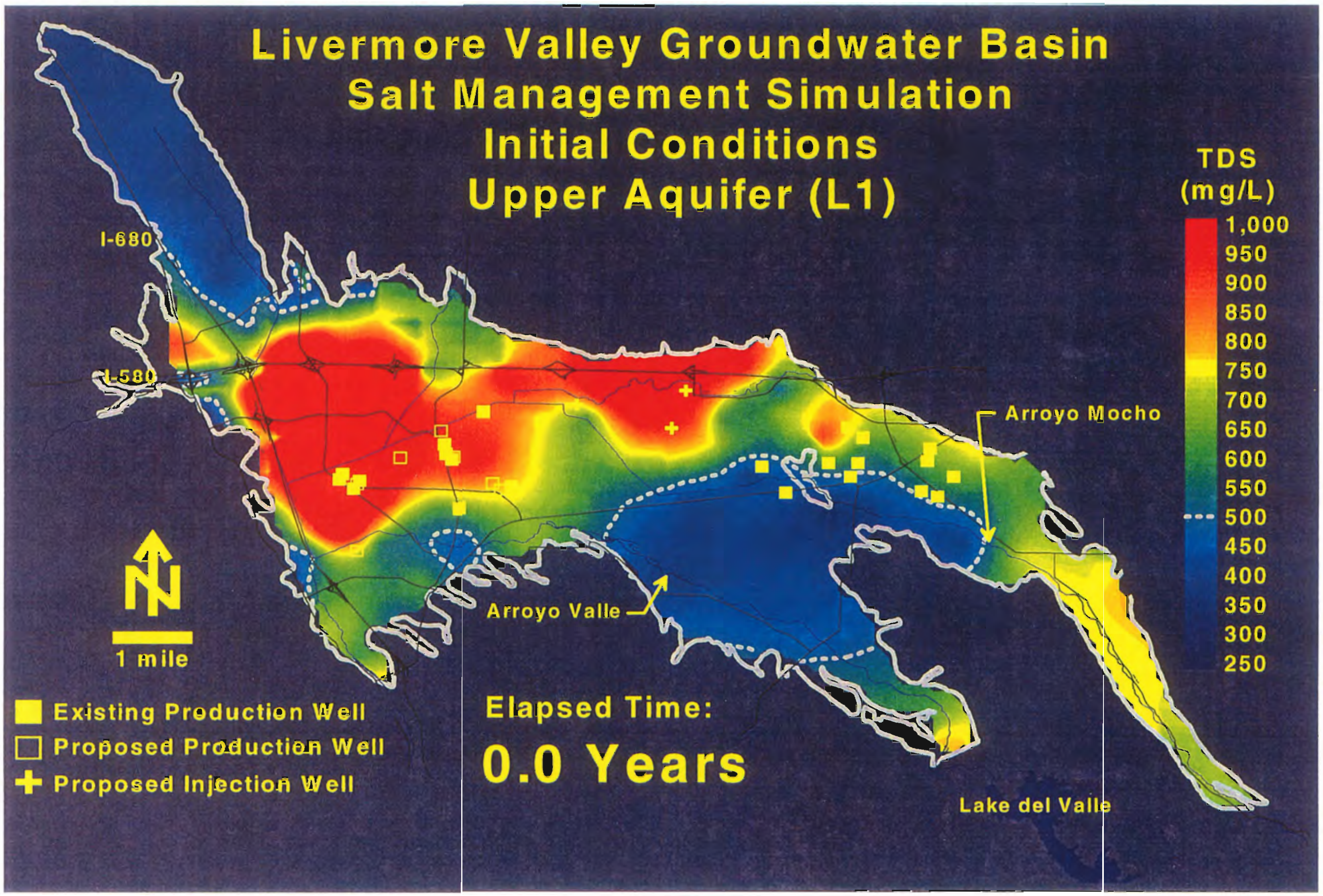

FIGURE 10-1
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\SFO\MJB\TDS Maps.xls: L1 Initial
7/13/98

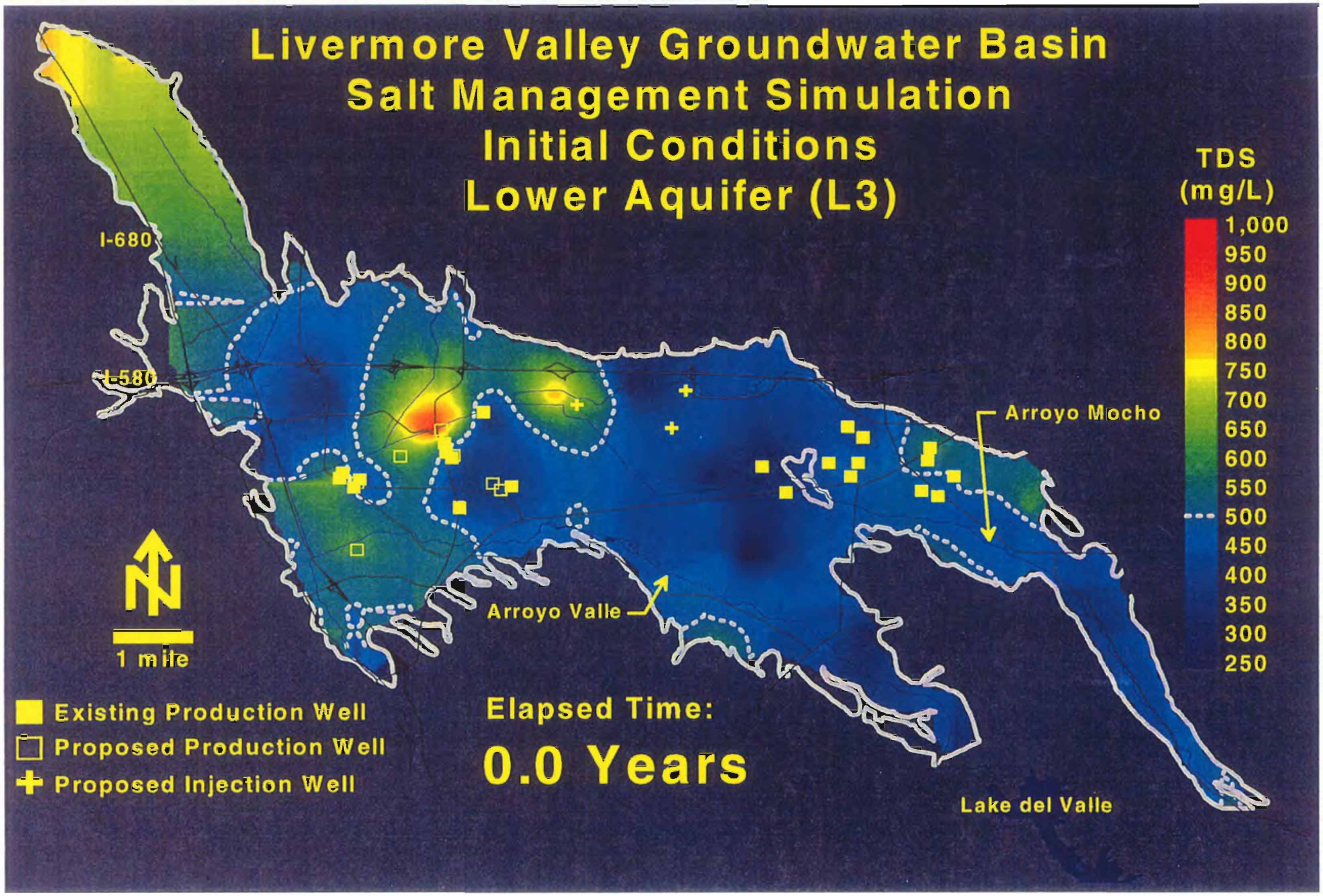

FIGURE 10-2

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\SFO\MJB\TDS Maps.xls: L3 Initial
7/13/98

Chemograph Wells
Livermore Valley Groundwater Basin
Salt Management Simulations

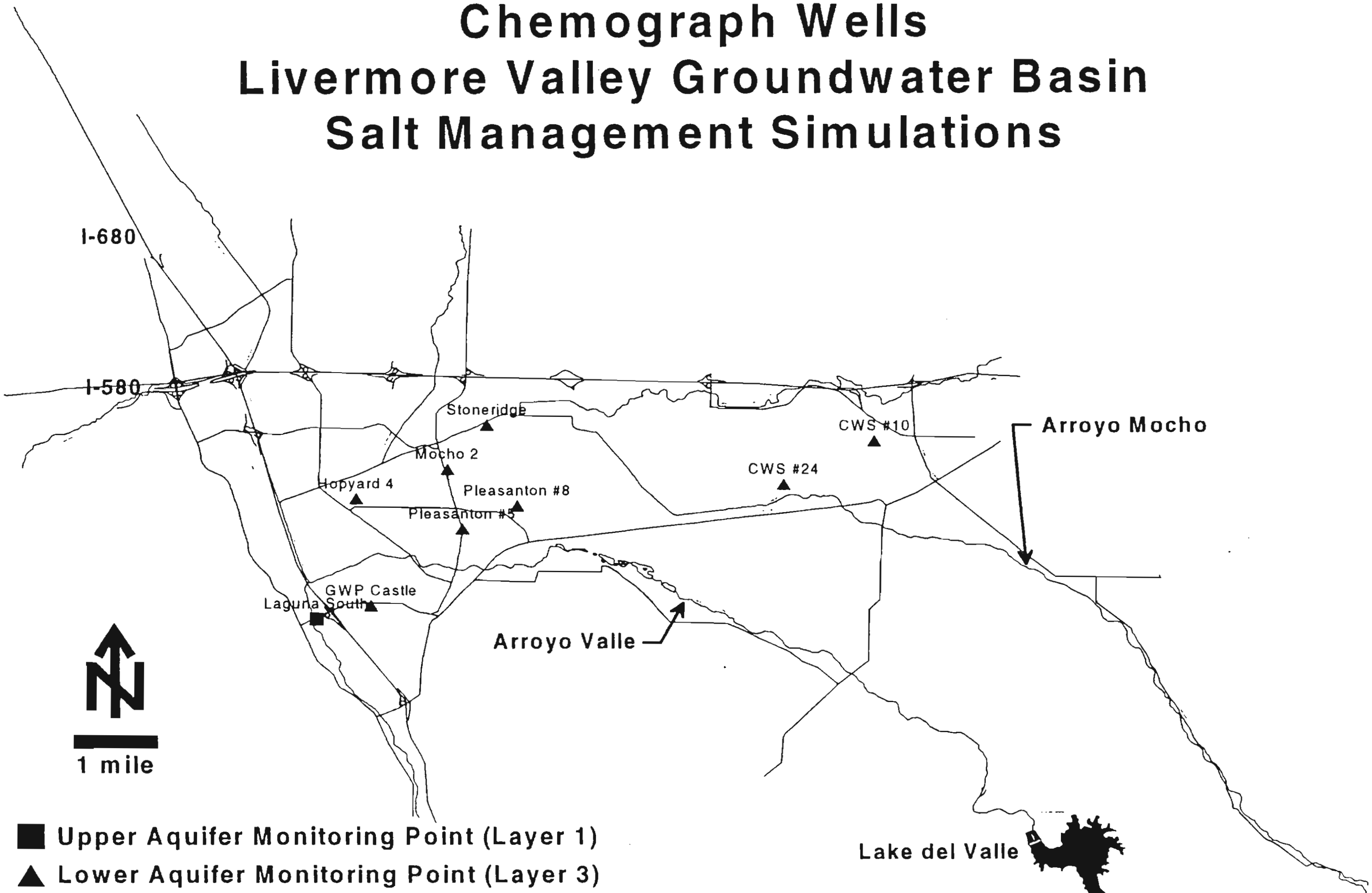

FIGURE 10.2A

Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

\RDD\MJB\Phase 4 Report.xls: Chemograph Wells
6/24/98

from the Arroyo Las Positas with concentrations approaching 1,000 mg/L, and to the south the groundwater quality is similar to the Arroyo Mocho water quality with concentrations barely exceeding 500 mg/L.

As shown in Figure 10.2, there is less groundwater TDS variation in the deep aquifer than in the shallow aquifer. The groundwater quality in the Dublin sub-basin varies from 350 mg/L to about 700 mg/L. The groundwater quality in the Bernal sub-basin ranges from 400 mg/L to 700 mg/L. Most of the Amador sub-basin is below 500 mg/L. Most of the Mocho II sub-basin is below 500 mg/L except a portion in the east where the TDS is 500-700 mg/L. This area is less influenced by the low TDS Arroyo Mocho artificial recharge.

Graphs showing groundwater TDS changes with time for nine selected locations (Figure 10.2A) were produced for all the strategies evaluated. The nine locations were selected to represent the major existing or potential future municipal pumping locations. These nine locations are Hopyard 4, Mocho 2, Stoneridge, Pleasanton #5, Pleasanton #8, CWS #10, CWS # 24, GWP Castle and Laguna South. All these locations except "Laguna South" represent TDS in the lower aquifer.

TABLE 10.1a - Initial GW Conditions

Well Location	Groundwater TDS in mg/L
Hopyard-4	409
Mocho-2	476
Stoneridge	361
Pleasanton # 5	375
Pleasanton # 8	367
CWS # 10	404
CWS # 24	299
GWP for Castlewood (SFWD)	542
Laguna South	582

Hopyard 4 represents the Hopyard wellfield, Mocho 2 represents the Mocho and Camp Parks well fields, Stoneridge represents the Stoneridge well field, Pleasanton #5 represents the Pleasanton #5 & #6 wells, CWS #10 represents CWS wells in the Mocho II sub-basin, CWS #24 represents CWS wells in the East-Amador sub-basin, GWP Castle represents the San Francisco Water District well field in the Bernal sub-basin and "Laguna South" represents the shallow aquifer groundwater near the Arroyo de Laguna in the Bernal sub-basin (basin subsurface outflow). Table 10.1a shows the representative groundwater quality for the nine locations at the beginning of the simulations (average 1990-95 data).

For each strategy, groundwater TDS maps at the end of the simulation (50 years) were created for the upper and lower aquifers. Lower aquifer groundwater model TDS was "animated" (i.e., annual time steps were captured in a computer slideshow movie) for the five selected strategies, 1A, 1, 10, 11B and 15. Following is a summary of the model output for the key Salt Management Plan strategies, 1, 1A, 11B and 15.

10.3.2 GW Model Results for Strategy 1A - Status Quo (Without RO Recycled Water Injection)

Strategy 1A is the baseline case for Strategy 15. Strategy 1A represents the historic operational practice of maximizing surface water delivery and pumping groundwater only for peaking and under drought conditions. This strategy minimizes operational costs.

Wellfields—Figure 10.3 presents the modeling predicted TDS changes over a 50-year period for the nine selected wellfield locations in the main basin for Strategy 1A. Figure 10.4 presents the zoomed in view showing the TDS changes only for a 25-year period. Table 10.2 lists the groundwater TDS and change from initial conditions after 25 years and 50 years for each location. From Figure 10.3 and Table 10.2 it is clear that the groundwater TDS would increase at all nine locations and the groundwater TDS increase would not be uniform. Under this scenario, the groundwater TDS at Stoneridge well increases at a higher rate during the earlier period of simulation. This is due to the fact that after the gravel mining operation stops in the vicinity of Stoneridge well (Kaiser operation), the upper aquifer high TDS groundwater (currently pumped by Kaiser) would move into the deep aquifer.

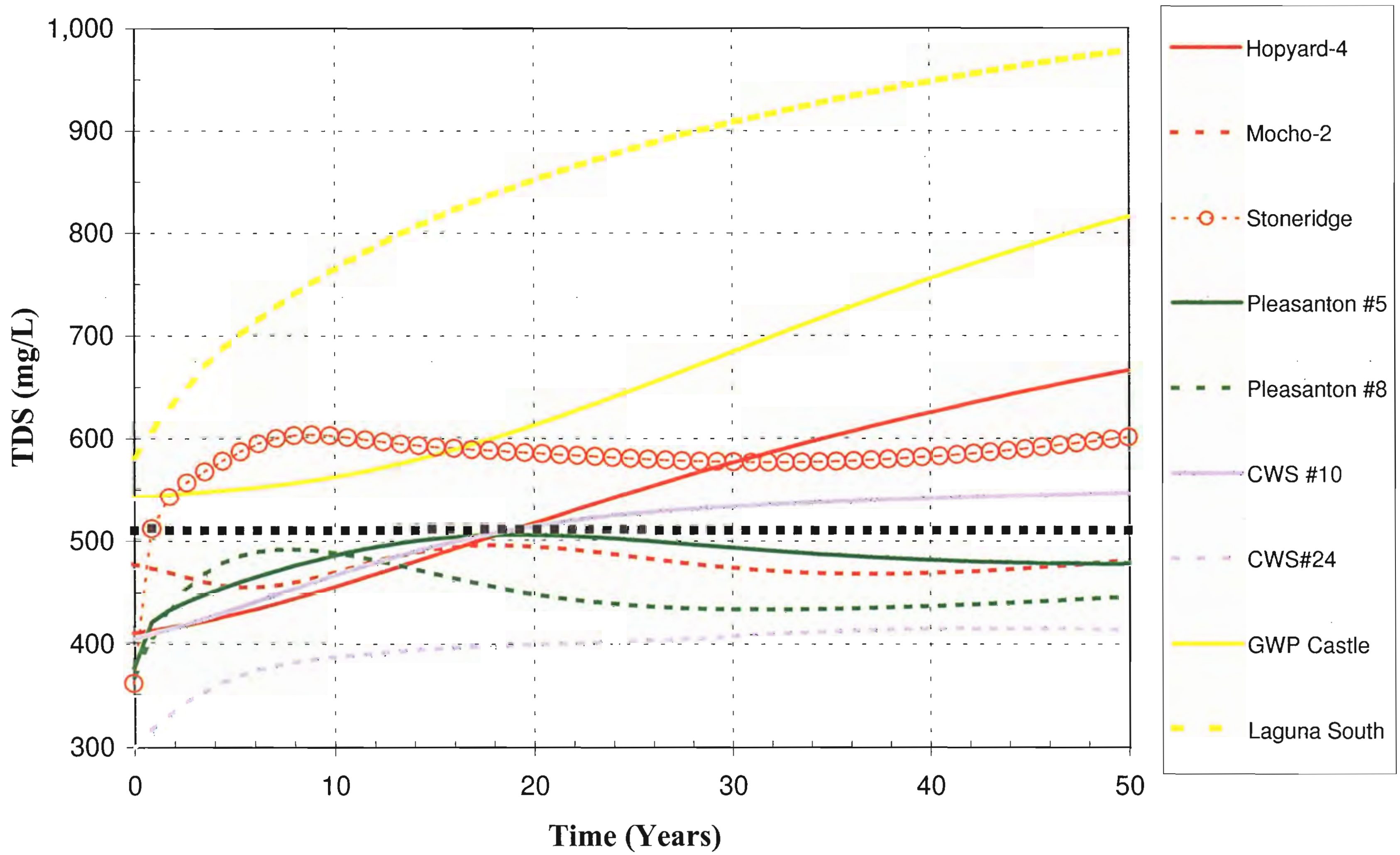

FIGURE 10.3

Scenario 1A: Base Case without Recycled Water Injection

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Zone 7 Water Agency

E:PROJECTS\SMP\SMPREPORT\CHP10\FIGURE 10.1 SMP1a

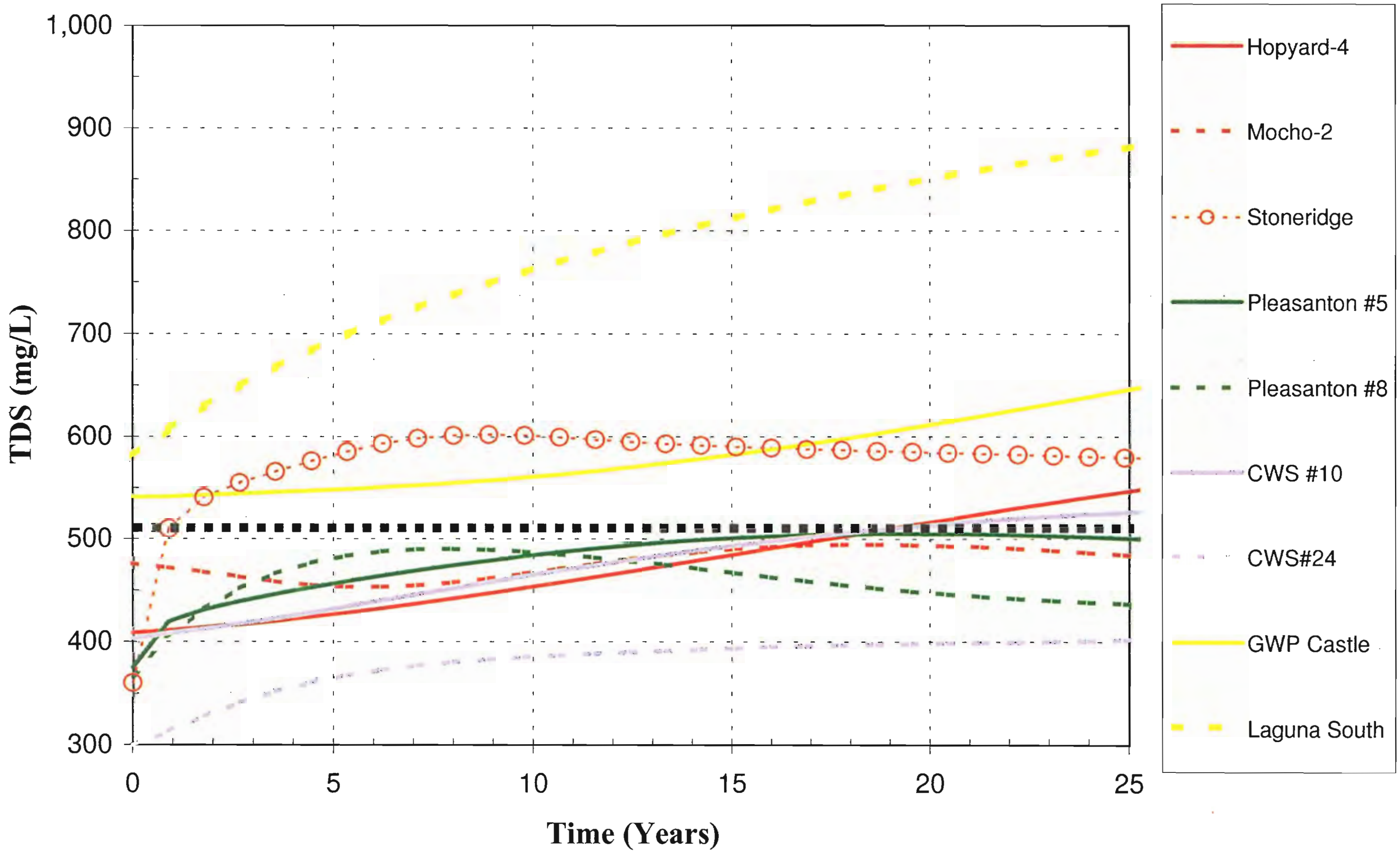

FIGURE 10.4

Scenario 1A: Base Case without Recycled Water Injection

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Zone 7 Water Agency

E:PROJECTS\SMP\SMPREPORT\CHP10\FIGURE 10.2 SMP1a

TABLE 10.2 - Strategy 1A Versus Initial Conditions Groundwater Model Simulation results

	Groundwater TDS and Net Change from Initial, mg/L			
Well Location	After 25 Years	Change	After 50 Years	Change
Hopyard-4	546	137	666	257
Mocho-2	484	8	481	5
Stoneridge	580	219	601	240
Pleasanton # 5	501	126	477	102
Pleasanton # 8	437	70	446	79
CWS # 10	526	122	546	142
CWS # 24	402	103	413	114
GWP for Castlewood (SFWD)	646	104	816	274
Laguna South	880	298	978	396

The groundwater TDS increases at Hopyard 4 and SFWD are also mainly due to the shallow aquifer high TDS groundwater moving to the deep aquifer. Under this scenario, the groundwater TDS increase at Mocho 2 is minimal and Pleasanton #8 would increase by only 70 to 80 mg/L. This is due to the low TDS Arroyo Valle stream recharge moving towards these locations. The groundwater TDS increase at CWS #10 & #24 is also less than at the Hopyard and SFWD locations due to the lower TDS Arroyo Mocho recharge influence. The groundwater TDS increase for the "Laguna South location" is highest. This location represents the shallow aquifer and the increase is mainly due to the high TDS recharge from urban irrigation and the lack of low TDS stream recharge in this part of the Bernal subbasin.

Upper Aquifer—Figures 10.5 and 10.6 map the basin-wide upper and lower aquifer groundwater TDS at the end of a 50-year period. From these figures, it is clear that the increase in upper aquifer TDS would be more than in the lower aquifer. Comparing Figure 10.5 with initial conditions for the upper aquifer (Figure 10.1), the far north portion of Dublin sub-basin would not change significantly. This is due to the low TDS recharge from low TDS urban irrigation (about 70-100 mg/L EBMUD deliveries). The groundwater quality in this area stays the same for all strategies. Under Strategy 1A, after 50 years the groundwater TDS in the rest of the Dublin sub-basin and in all of the Camp sub-basin would be over 1000 mg/L. Most of the Bernal sub-basin would be over 1,000 mg/L except a very small portion in the southeast where the TDS would be under 700 mg/L due to the influence of low TDS Arroyo Valle stream recharge. The high TDS area in the north portion of the Amador sub-basin along the Arroyo Positas increases. The rest of the Amador sub-basin in the south along the area of Arroyo Valle recharge would not change significantly. Similarly, the size of the high TDS area in the north part of the Mocho II

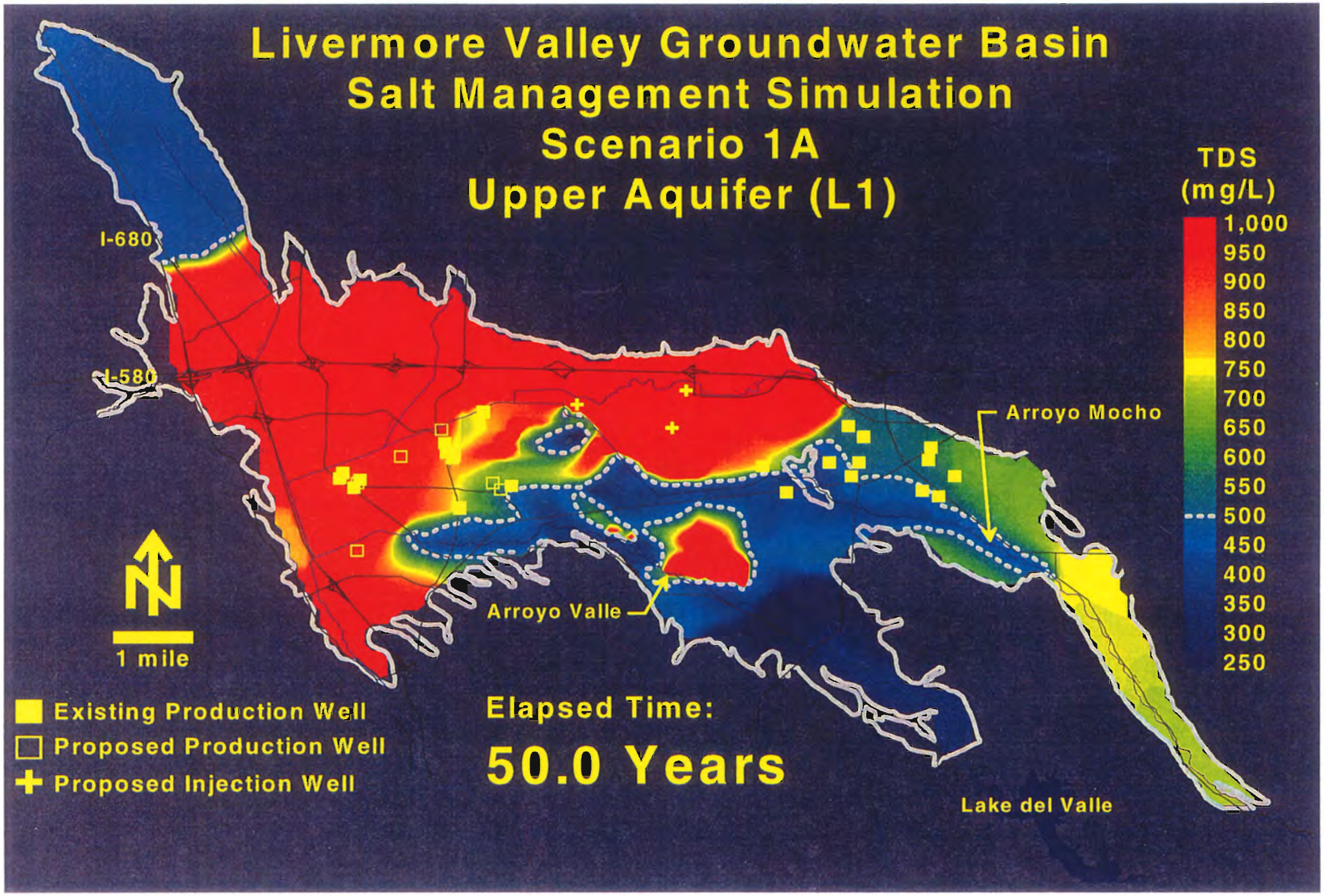

FIGURE 10-5

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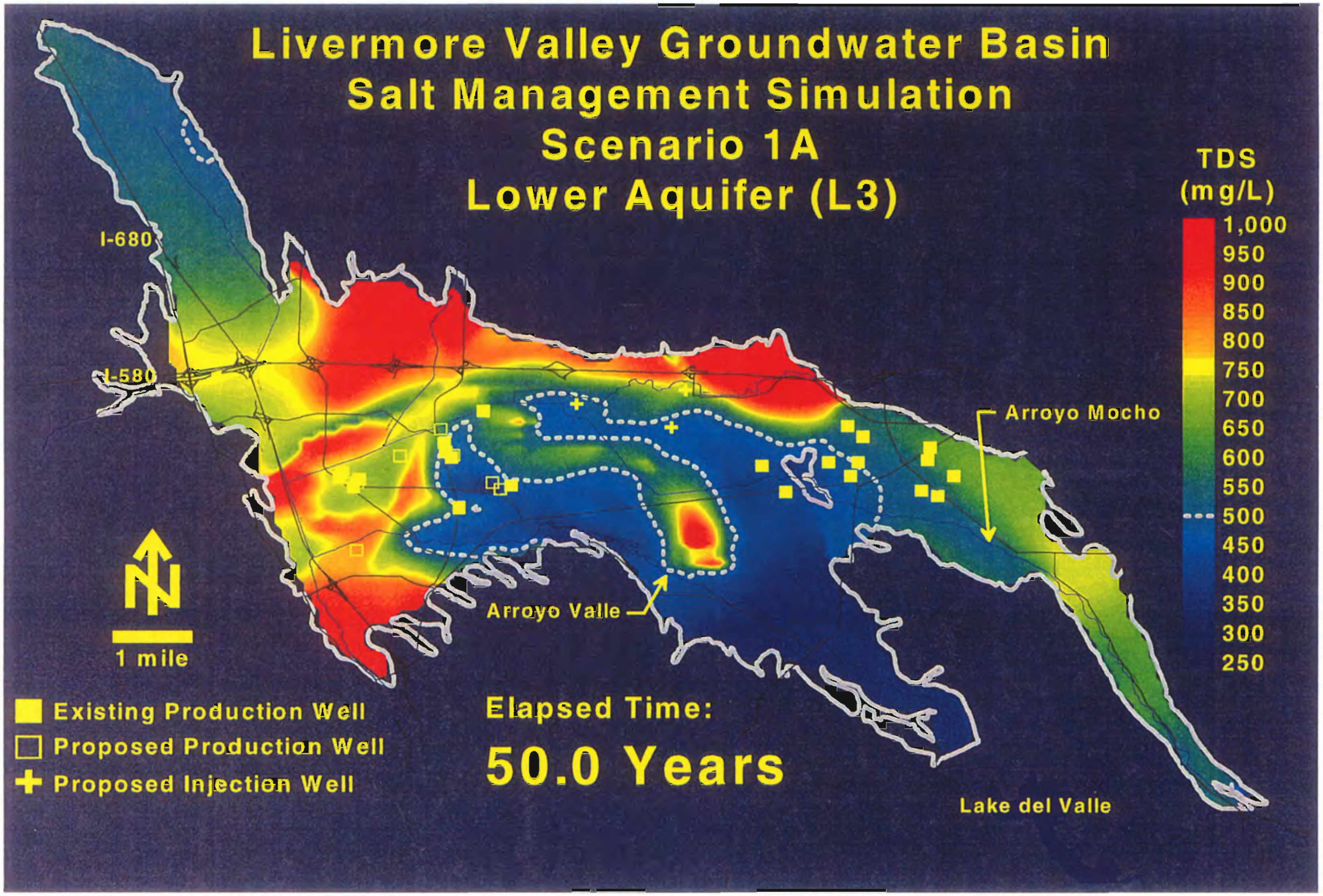

FIGURE 10-6

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subbasin would increase and the south portion would not change significantly due to the low TDS Arroyo Mocho recharge.

Lower Aquifer—Comparing Figure 10.6 with the initial conditions for the lower aquifer (Fig 10.2), the groundwater TDS would increase over most of the groundwater basin. The groundwater TDS in the south portion of Dublin sub-basin, in all of the Camp sub-basin, and in the Bernal sub-basin would increase significantly. The groundwater TDS in the area of the Amador sub-basin near the Stoneridge well would also increase significantly. Mocho II sub-basin groundwater TDS would also increase in the north, south and east portions. The groundwater TDS in the western portion of the Mocho II sub-basin would not increase significantly. Most of the groundwater TDS increase in the deep aquifer is due to the high TDS upper aquifer water moving into the deep aquifer over time.

10.3.3 GW Model Results for Strategy 1—Status Quo Plus 6 TAF/Y RO Recycled Water Injection

Strategy 1 is the baseline case for Strategy 11B. Strategy 1 represents the historic operational mode of maximizing surface water delivery and pumping groundwater only for peaking and drought conditions, except that it also includes the addition of 6 TAF/year or RO recycled water (or other low TDS water) injection into the Amador basin. Two thousand eight hundred (2,800) AF of RO RW was assumed to be injected by DSRSD at two sites. One of the sites was assumed to be located at El Charro Road and the Arroyo Mocho northwesterly of the Jamieson equestrian facility with the other near the southwest corner of the Livermore airport. Eight hundred forty (840) AF was assumed to be injected by Livermore in well #3S/1E 1N2 located north of the Livermore Water Reclamation Plant. The remaining 2,300 AF was assumed to be recharged into the upper aquifer through Lake I.

Wellfields—Figure 10.7 presents the TDS changes with time for a 50-year period for the nine locations in the main basin for Strategy 1. Figure 10.8 presents the zoomed in view showing the TDS changes for only the initial 25-year period. Table 10.3 lists the groundwater TDS and change from Strategy 1 for each location after 25 years and 50 years under this strategy.

Under this strategy, the groundwater TDS at the Mocho 2 and Stoneridge locations would be significantly lower and the Pleasanton #5 & #8 locations would be modestly lower as compared to Strategy 1A. The major reason for this improvement is the injection of RO recycled water (or other low TDS water) in the northern portion of the Amador subbasin. This low TDS water would move towards these pumping locations and reduce groundwater TDS in the deep aquifer. The groundwater TDS at the CWS #10, CWS #24, SFWD and Laguna South locations would be basically unchanged. This is due to the similar recharge and pumpage conditions under strategies 1 and 1A in the Bernal and Mocho II sub-basins. The groundwater TDS at the Hopyard 4 location would increase slightly.

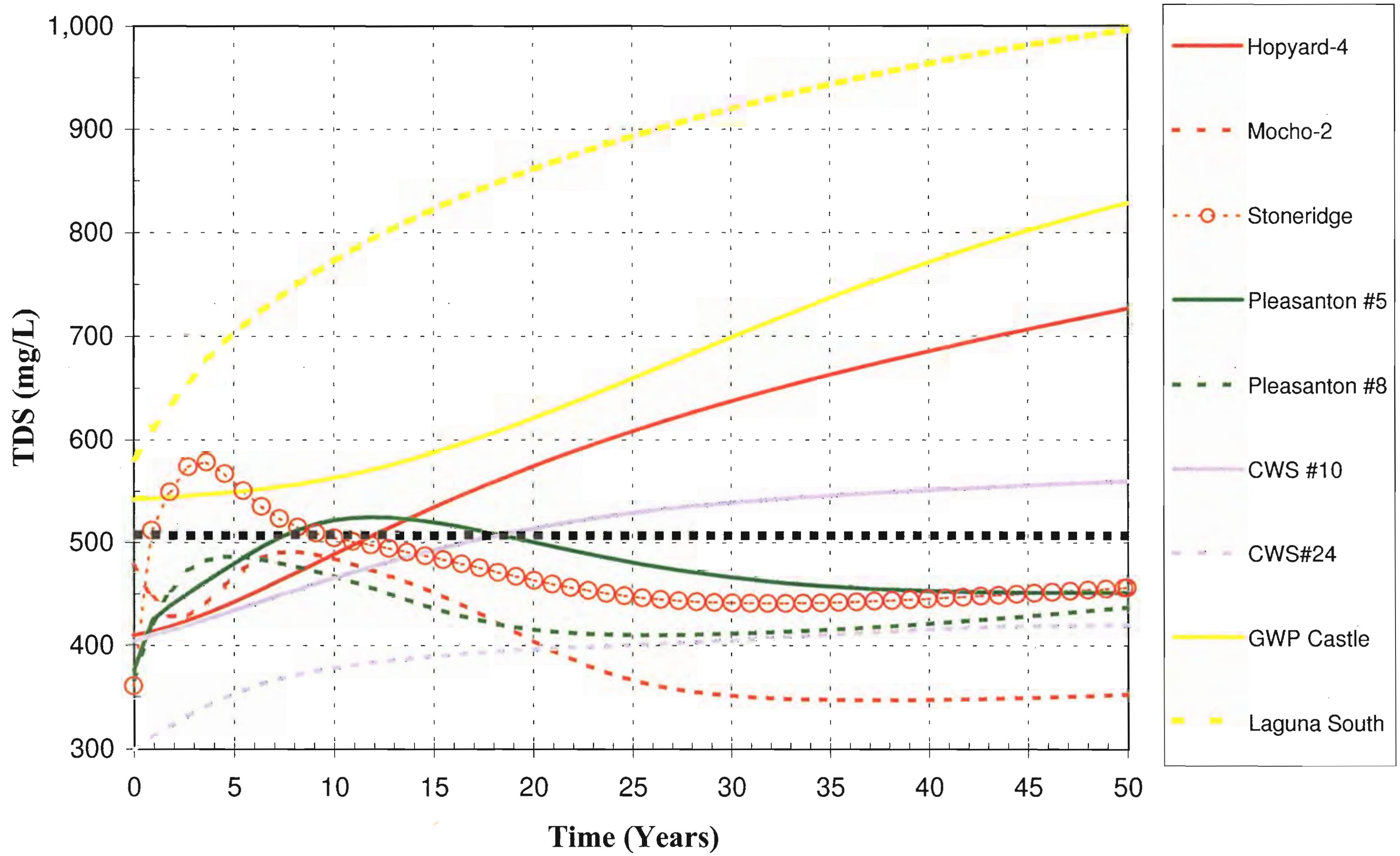

FIGURE 10.7

Scenario 1: Base Case with Recycled Water Injection

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E:PROJECTS\SMP\SMPREPORT\CHP10\FIGURE 10.5 SMP1

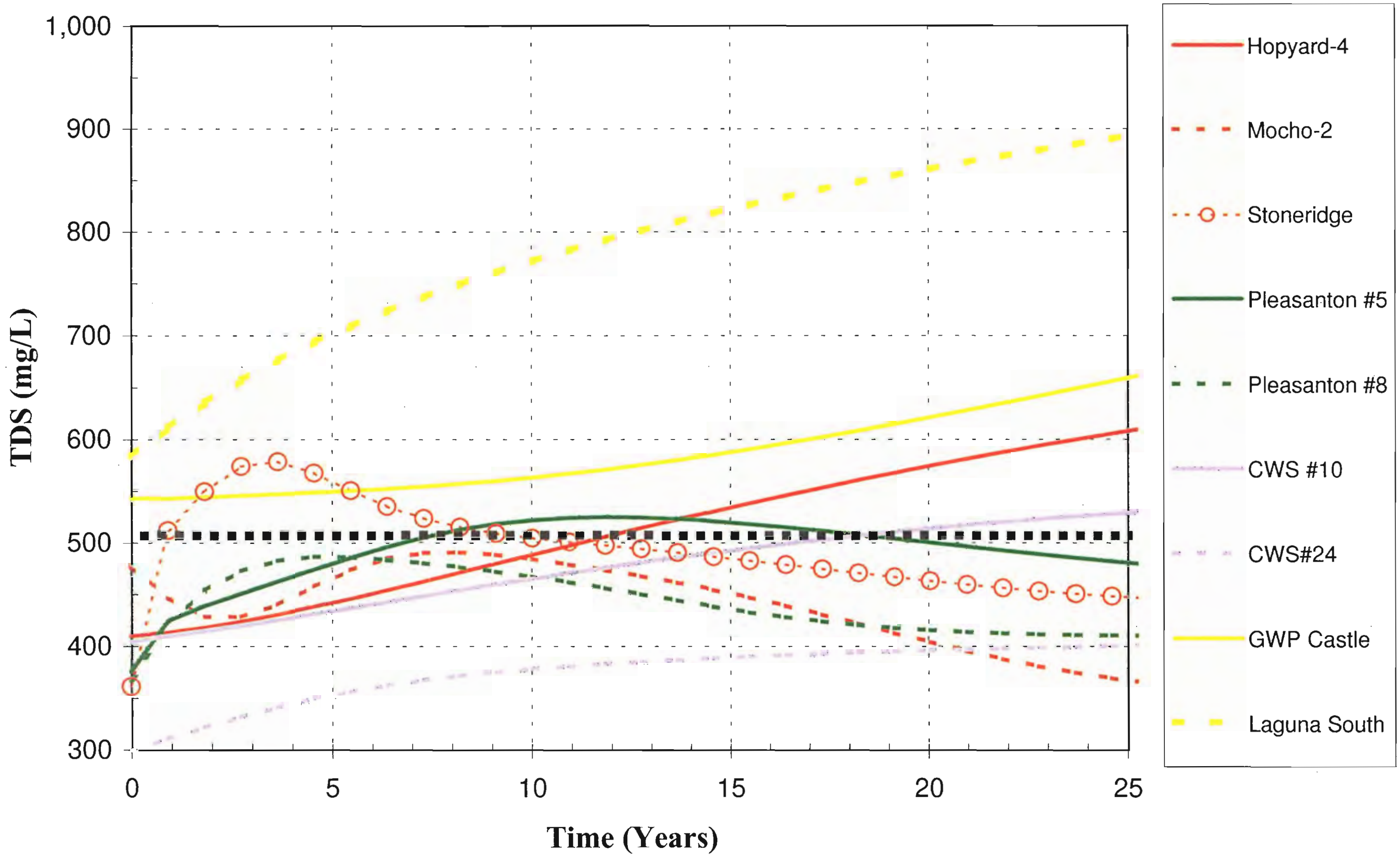

FIGURE 10.8

Scenario 1: Base Case with Recycled Water Injection

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Zone 7 Water Agency

E:PROJECTS\SMP\SMPREPORT\CHP10\FIGURE 10.6 SMP1

TABLE 10.3 - Strategy 1 Versus Strategy 1A Groundwater Model Simulation Results

	Groundwater TDS and Change from Strategy 1A, mg/L			
Well Location	After 25 Years	Change	After 50 Years	Change
Hopyard-4	609	63	727	61
Mocho-2	366	-118	352	-129
Stoneridge	448	-132	456	-145
Pleasanton # 5	481	-20	451	-26
Pleasanton # 8	410	-27	437	-9
CWS # 10	529	3	560	14
CWS # 24	401	-1	420	7
GWP for Castlewood (SFWD)	659	13	828	12
Laguna South	893	13	996	18

Upper Aquifer—Figures 10.9 and 10.10 map the upper and lower aquifer groundwater TDS at the end of a 50-year period. The only significant change in the upper aquifer groundwater TDS under this strategy over Strategy 1A is the lowered groundwater TDS in the area on the west of Lake I (Figure 10.9). This change is due to the increase in the low TDS recharge (2,300 AF/year) from Lake I.

Lower Aquifer—In the deep aquifer, the major difference between this strategy and Strategy 1A is that the groundwater TDS around the low TDS water injection sites is lower (Figure 10.10). Low TDS water injected into the basin moves towards the Mocho, Stoneridge and Pleasanton wells and this movement and mixing lowers the TDS in the deep aquifer in this area. The groundwater TDS in the deep aquifer in the rest of the areas is about the same as in Strategy 1A.

10.3.4 GW Model Results for Strategy 11B—Increased Conjunctive Use and Demineralization of High TDS Groundwater

Strategy 11B includes conjunctive use, demineralization of high TDS groundwater and RO recycled water (or other low TDS water) injection. This strategy assumes that 3 TAF of stream recharge and groundwater pumpage for conjunctive use will be implemented using existing facilities. The 3 TAF of new shallow groundwater pumpage would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

Wellfields—Figure 10.11 presents the TDS changes with time over a 50-year period at the nine locations in the main basin for Strategy 11B. Figure 10.12 presents the zoomed in view showing the TDS changes only for the initial 25-year period. Table 10.4 lists the

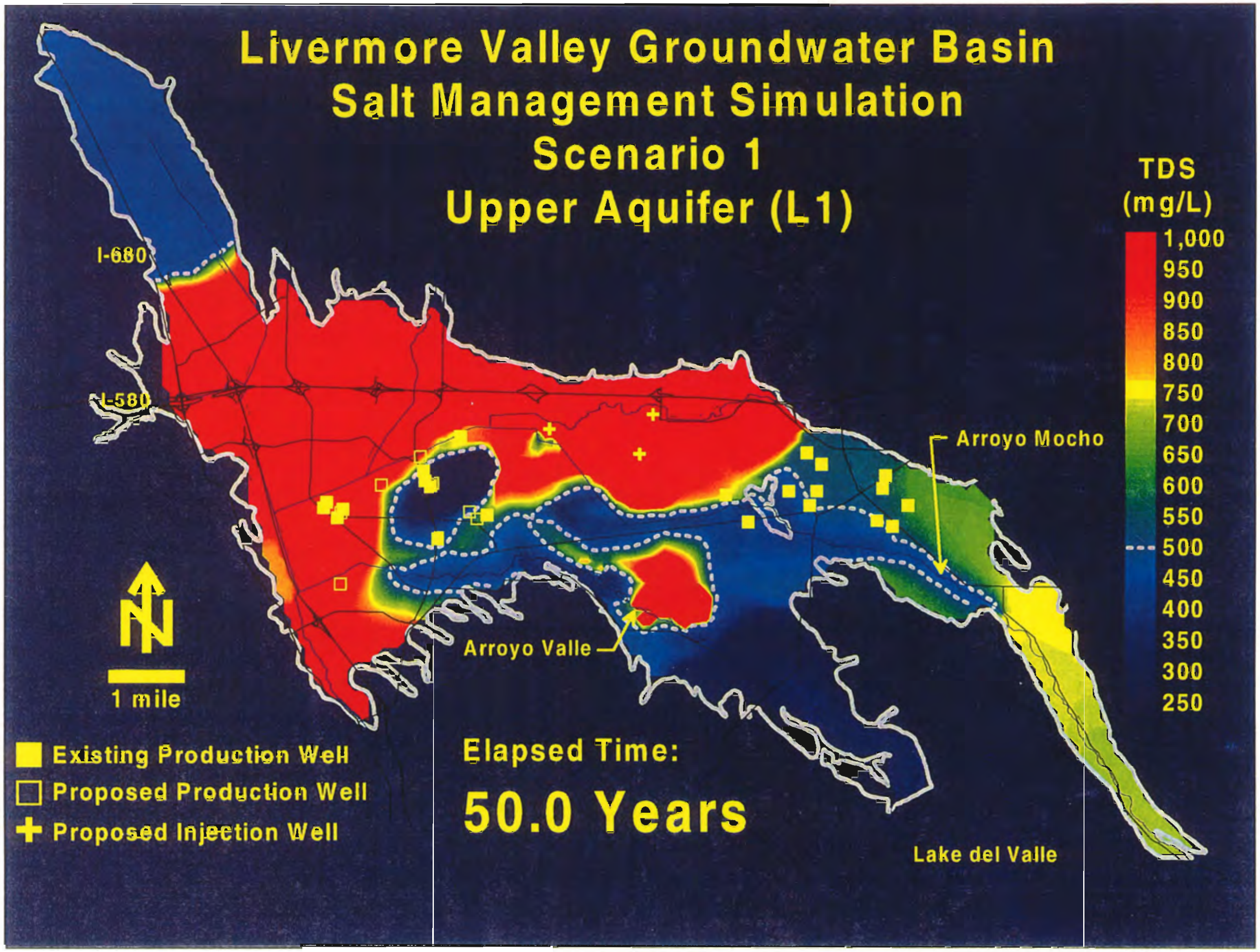

FIGURE 10-9

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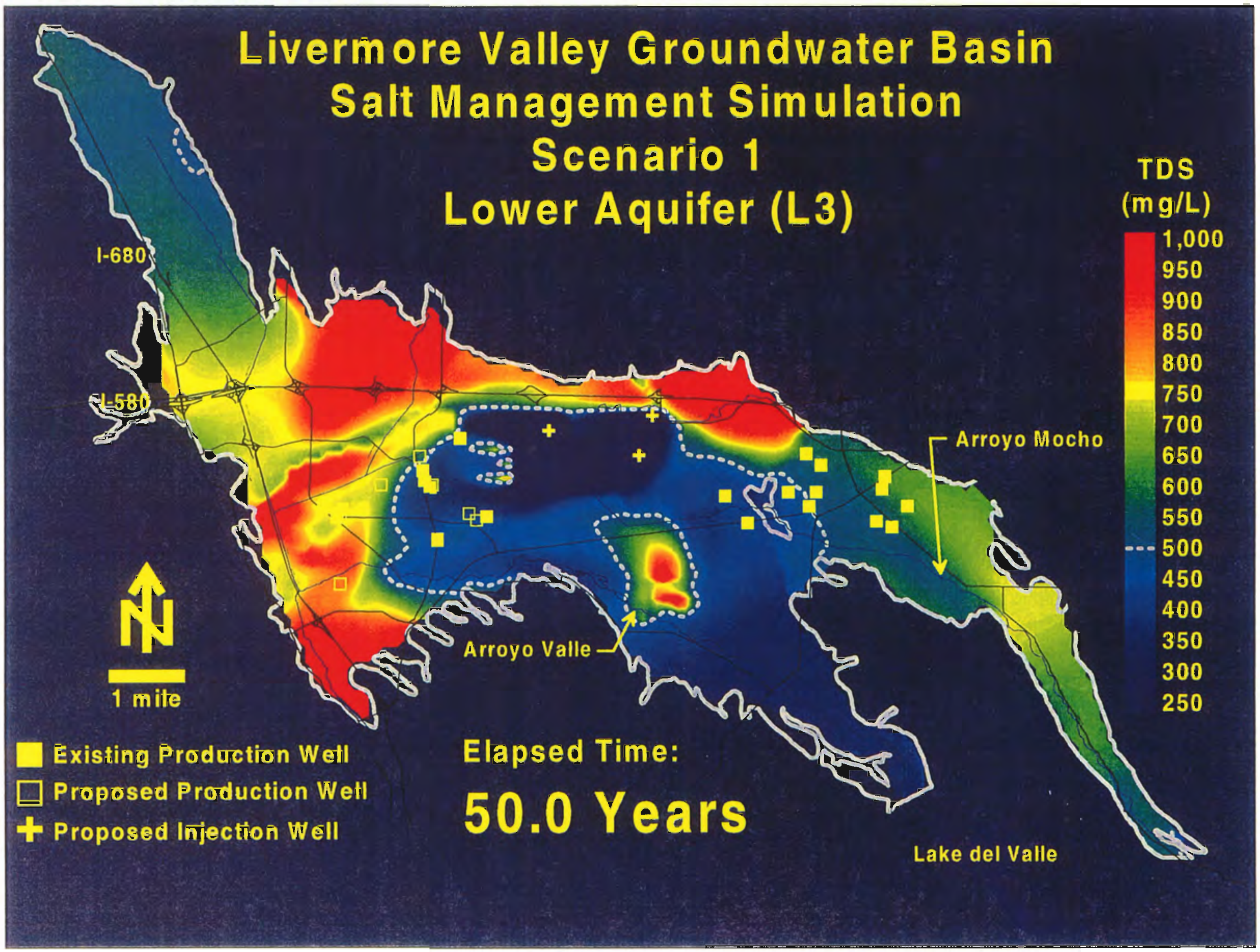

FIGURE 10-10

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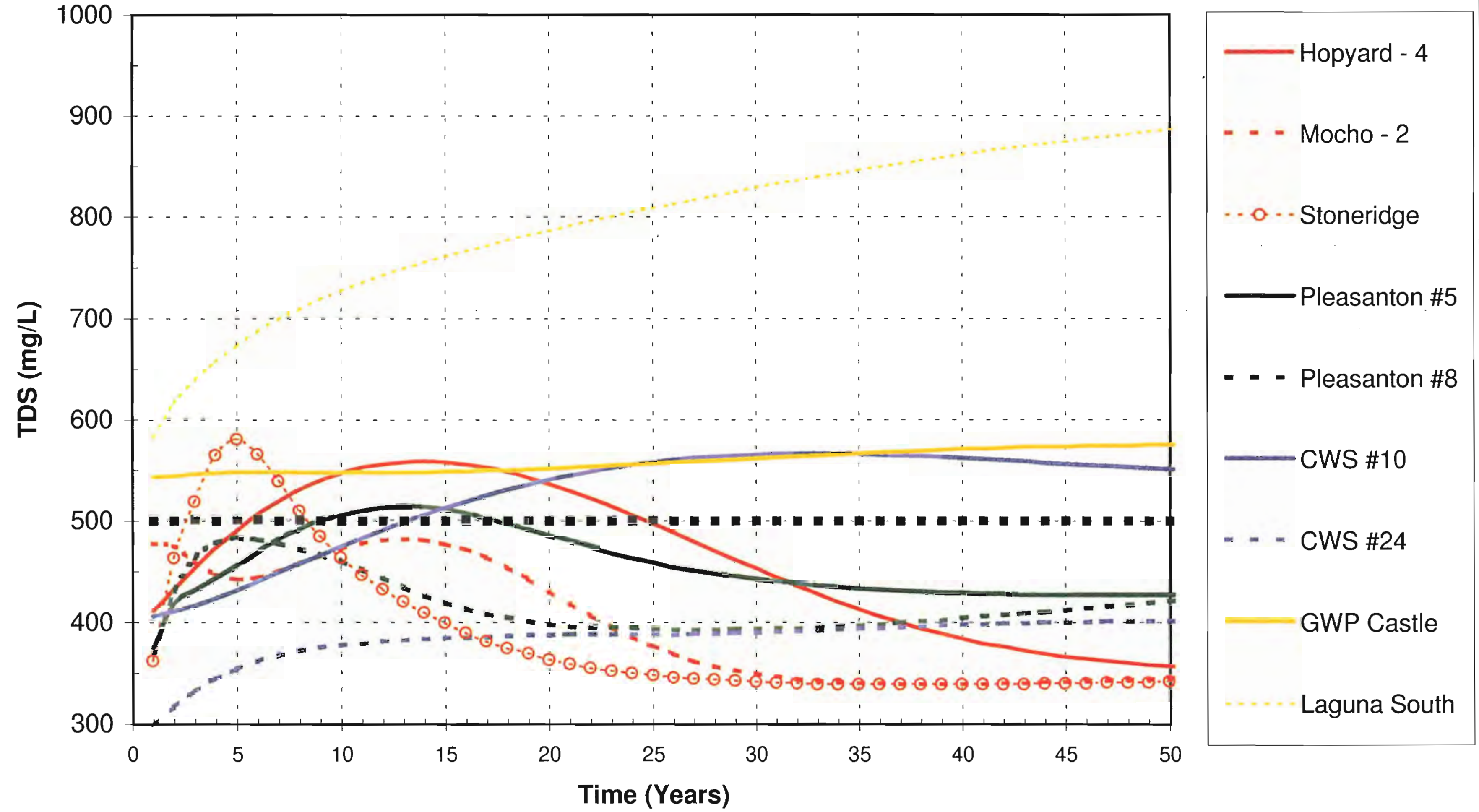

Figure 10.11
Scenario 11B: Conj use + Wellhead Demin
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Zone 7 Water Agency

E:\PROJECTS\SMP\SMPREPORT\CHP10\FIGURE 10.9 SMP11b

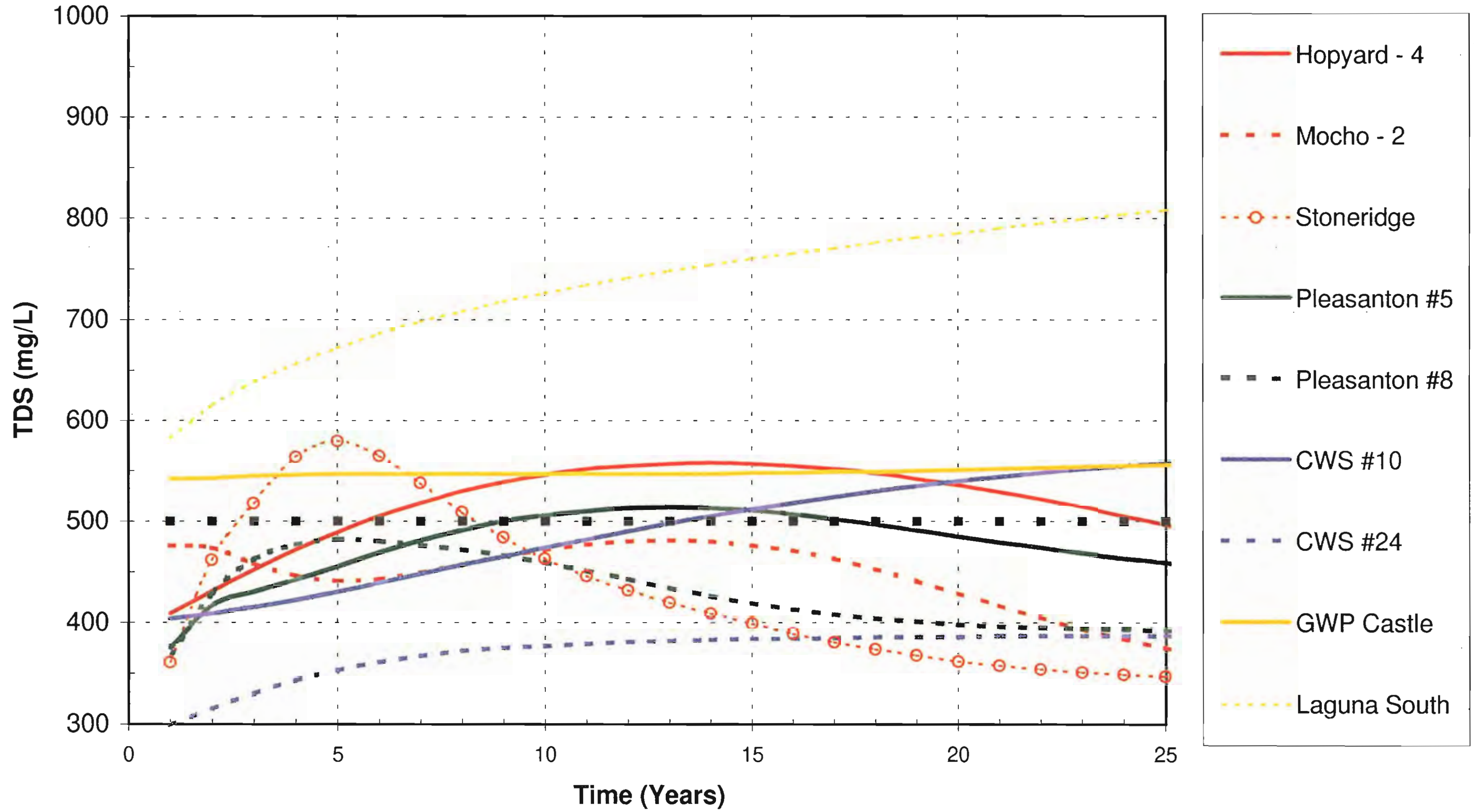

Figure 10.12
Scenario 11B: Conj use + Wellhead Demin
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groundwater TDS and changes compared to Strategy 1A for each location after 25 years and 50 years.

TABLE 10.4 - Strategy 11B Versus Strategy 1A Groundwater Model Simulation Results

	Groundwater TDS and Change from Strategy 1A, mg/L			
Well Location	After 25 Years	Change	After 50 Years	Change
Hopyard-4	488	-58	356	-310
Mocho-2	368	-116	346	-135
Stoneridge	345	-235	342	-259
Pleasanton # 5	454	-47	427	-50
Pleasanton # 8	392	-45	422	-24
CWS # 10	560	34	550	4
CWS # 24	387	-15	401	-12
GWP for Castlewood (SFWD)	557	-89	575	-241
Laguna South	812	-68	888	-90

From Table 10.4, the groundwater TDS after 25 and 50 years of operation under Strategy 11B would be lower than the baseline Strategy 1A at eight of the nine listed locations. After 25 years, the groundwater TDS at the Mocho and Stoneridge well locations would improve the most over Strategy 1A. At the Hopyard, Mocho and Stoneridge locations, the groundwater TDS would be even lower than initial conditions after 50 years. The future Bernal Property well field (GWP for Castlewood) location groundwater TDS would be significantly lower as compared to Strategy 1A. The Laguna South location groundwater TDS would be slightly lower from Strategy 1A. The Pleasanton #5 and #8 locations would also improve modestly from Strategy 1A. CWS wells groundwater TDS would be about the same as in Strategy 1A. This is due to the fact that the western part of the Amador and the Mocho II sub-basins where all of the CWS wells are located would be subjected to similar recharge and pumpage conditions under both strategies.

Upper Aquifer—Figures 10.13 and 10.14 map the upper and lower aquifer groundwater TDS at the end of 50-year period. Two major changes in the upper aquifer groundwater TDS under this strategy over Strategy 1A are:

1) The lowered groundwater TDS in the area on the west of Lake-I (Figure 10.13). This change is due to the increase in the low TDS recharge (2,300 AF/year RO recycled water) from Lake I.

2) The lower groundwater TDS in the central part of the Bernal subbasin as compared to Strategy 1A. This is due to the shallow groundwater pumpage for

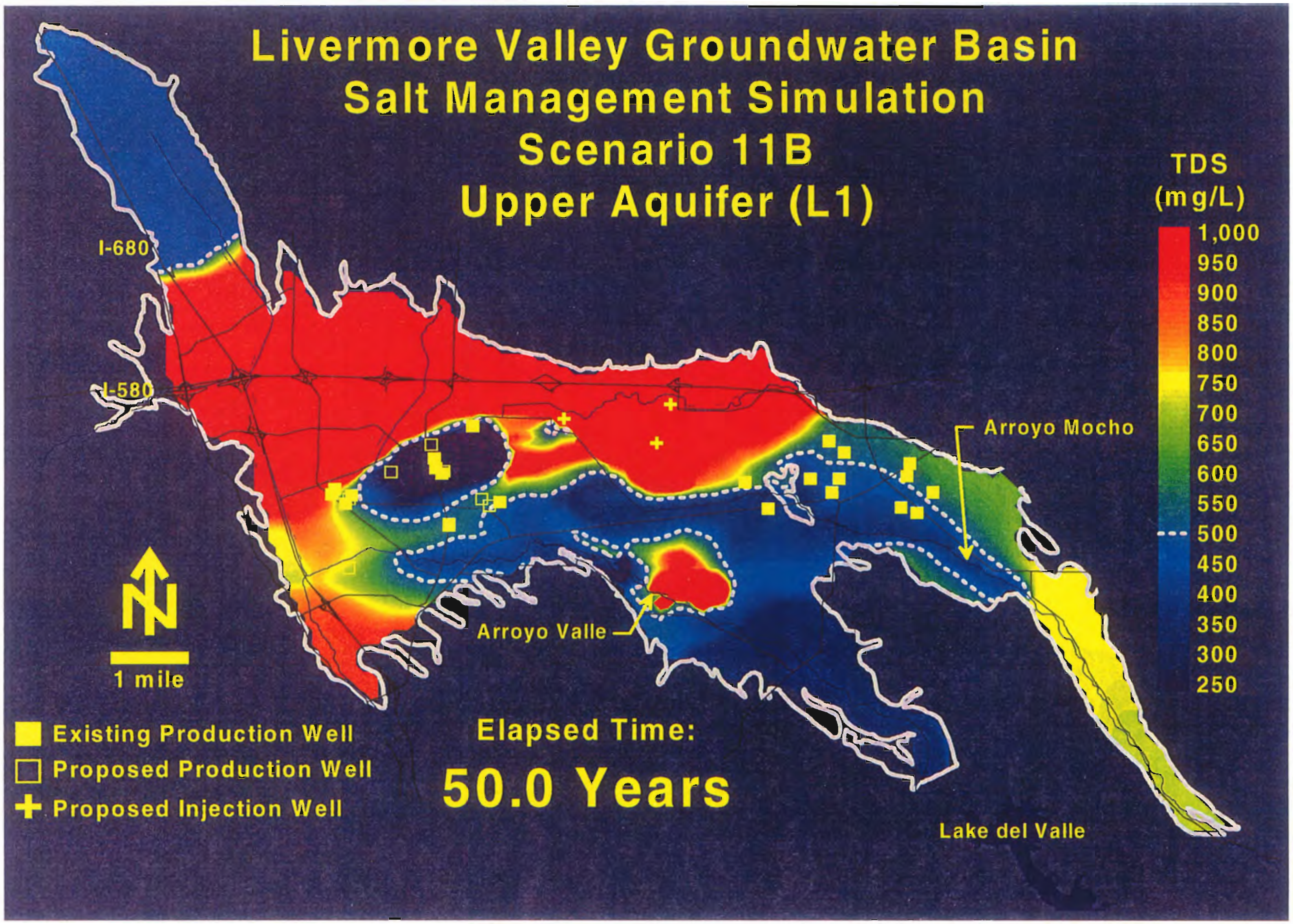

FIGURE 10-13

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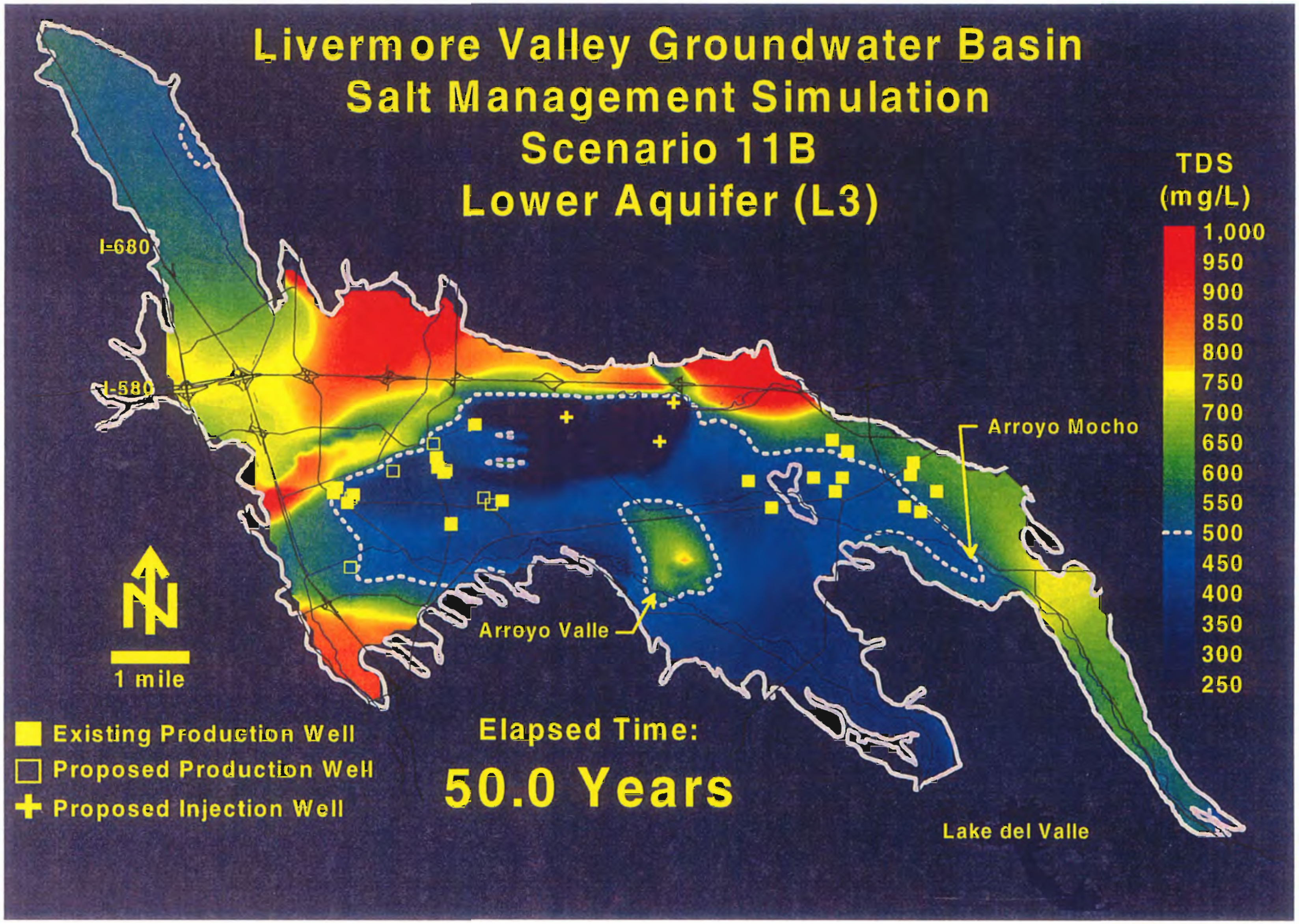

FIGURE 10-14
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Zone 7 Water Agency

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demineralization (3 TAF/year) under this strategy that would intercept the high TDS subsurface inflow from the Dublin sub-basin and high TDS recharge from urban irrigation. The low TDS Arroyo Valle recharge and recharge from Lake I would also move further into the Bernal basin due to the shallow groundwater pumpage.

The rest of the upper aquifer groundwater TDS would be about the same as in Strategy 1A.

Lower Aquifer—The major changes in deep aquifer groundwater TDS under this strategy from Strategy 1A are in the Amador sub-basin and the Bernal sub-basin (Figure 10.14). In general, the area of the basin with groundwater TDS below 500 mg/L (blue color) is larger than in Strategy 1A.

In the north part of the Amador sub-basin, the groundwater TDS around the low TDS water injection sites is significantly lower under this strategy. Low TDS water injected into the basin moves towards the Mocho, Stoneridge and Pleasanton wells and this movement and mixing lowers the TDS in the deep aquifer in this area. This is the main reason for the lower groundwater TDS at the Stoneridge, Mocho and Pleasanton well locations.

For most of the Bernal sub-basin, except for small portions along the north side and in the south, the groundwater TDS would be significantly lower than in Strategy 1A. The main reason for this change is the pumping of upper aquifer high TDS groundwater for demineralization which prevents it from moving into and degrading the deep aquifer.

The rest of the deep aquifer groundwater TDS would be about the same as in Strategy 1A.

Strategy 11B was the technically preferred strategy by the TAG and GMAC. However, the Zone 7 Board decided not to support RO recycled water injection into the main basin until further demonstration of public acceptance. Since Strategy 11B had been the preferred strategy, extra groundwater modeling work was done to: 1) Predict the flow (travel time and direction) and distribution of RO recycled water in the main basin, and 2) To predict the distribution of RO recycled water in future treated water deliveries.

1) Flow and Distribution of RO Recycled Water in the Main Basin Under Strategy 11B

Using the groundwater model simulation prepared for Strategy 11B, forward particle tracking was simulated to predict the flow direction and travel time of injected RO recycled water in the basin. The solute transport model was used to develop contours of the percentage of recycled water extending across the main basin lower aquifer. Following is a list of the principal assumptions for the modeling simulation used to predict the flow and percentage of recycled water in the main basin:

- Steady state model run using long-term average well pumpage and recharge data at year 2010 demand conditions (Strategy 11B).

- Zone 7 long-term average groundwater pumpage at about 15,000 AF per year. Zone 7 average pumpage distributed at Stoneridge well 2.3 TAF, Mocho well field 4.7 TAF, Hopyard well field 4.7 TAF and shallow groundwater pumpage of 3.3 TAF per year.

- Pleasanton average pumpage consistent with historic average, distributed at Pleasanton #5 0.7 TAF, Pleasanton #6 0.7 TAF, Pleasanton well #7 at 0.3 TAF, Pleasanton well #8 1.8 TAF per year.

- DSRSD average pumpage of 645 AF per year from the Camp Parks well field.

- CWS average pumpage of 3,069 AF per year with a distribution based upon their historic average for each well.

- DSRSD injecting 5,600 AF per year (50% blending, 2,800 AF RO recycled water and 2,800 AF Zone 7 provided treated water) in two injection wells.

- Livermore injecting 840 AF per year of RO recycled water without any blending.

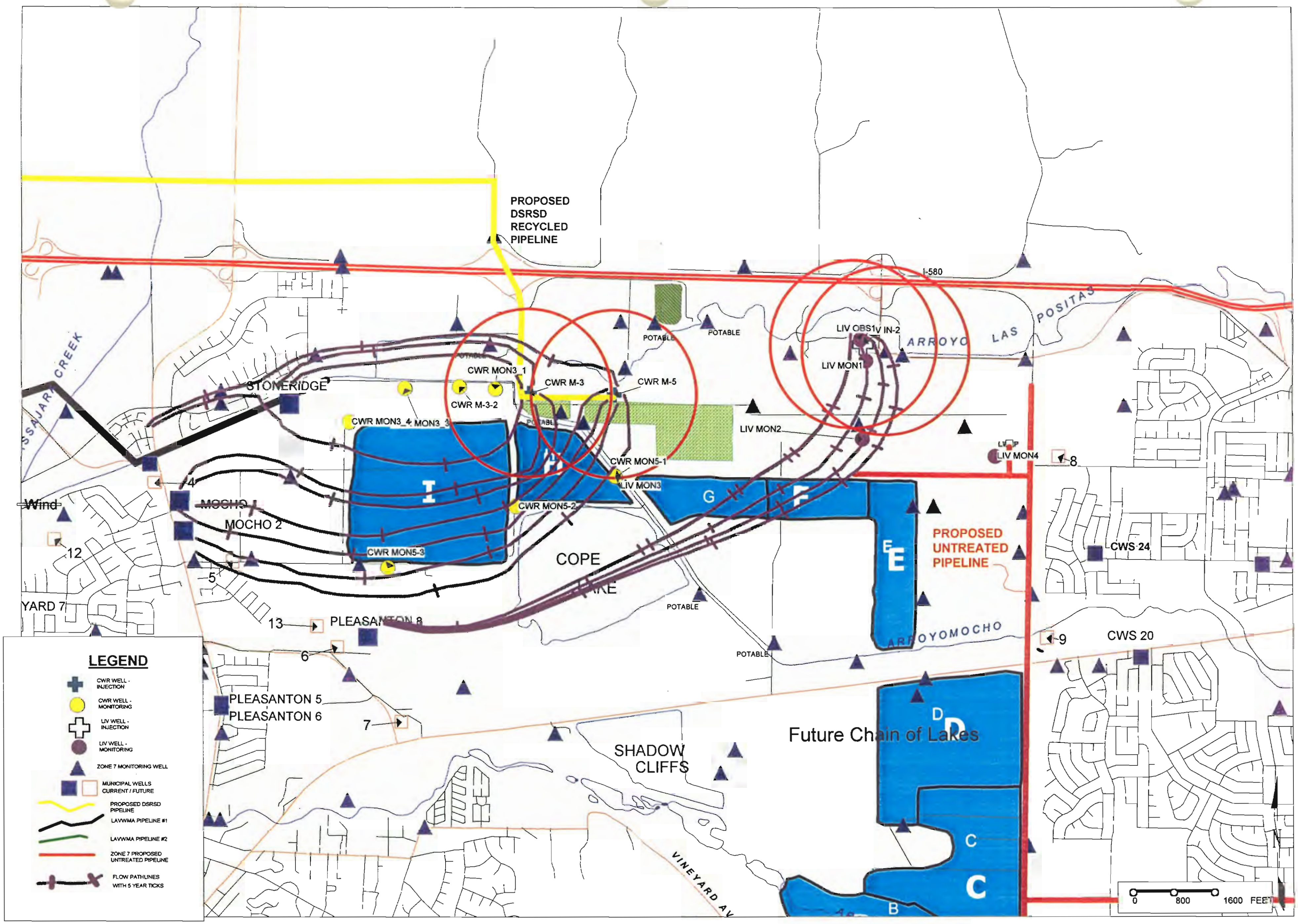
- 2300 AF per year of RO recycled water recharge in Lake I.

Figure 10.15 presents the pathlines of particles released in each injection well at the beginning of injection. The tick marks on the pathlines represent particle locations at five-year intervals. These pathlines indicate the direction and travel time of injected recycled water. These pathline maps were used in designing monitoring well locations for tracking the movement of recycled water in the groundwater basin. Noble gas tracers were to be added to injected water to track water movement and help verify model results.

Figure 10.16 displays contour lines showing the average percentage of RO recycled water in the deep aquifer after 50 years of operation. Figure 10.17 shows the percentage of recycled water in the deep aquifer at six production well locations over time.

In summary, the first water molecules from the RO RW injection wells could reach the Stoneridge well within three years. The Stoneridge well would receive the recycled water before any other existing production wells listed in Figure 10.17 and it would have the largest contribution at any time. It would take five years for water from the DSRSD RO facility to reach a 10% contribution in the Stoneridge well groundwater. For the 50-year model run, it appears that Stoneridge well would never exceed 40% water from RO recycled water. The Mocho wells would not exceed 30%.

FIGURE 3



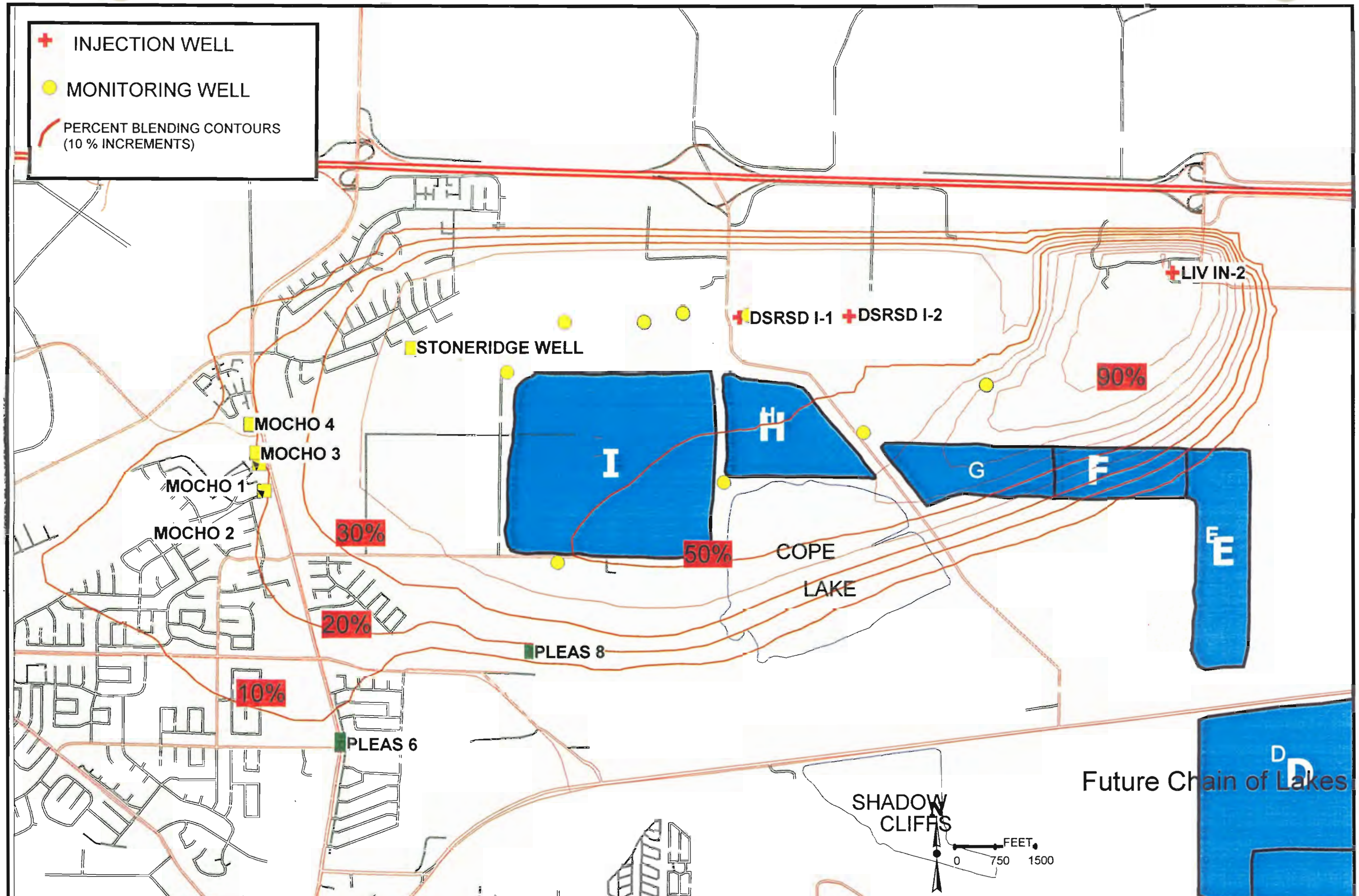
ZONE 7 WATER AGENCY
5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	G. GATES
DESIGNED	JEFF TANG
CHECKED	DAVID LUNN
APPROVED	

STRATEGY 11b

GROUNDWATER MODEL PARTICLE TRACKING OF INJECTED RO RECYCLED WATER

SCALE	1" = 3000'
DATE	24 JUN. 1998
FILE NO.	FIGURE 10.15



STRATEGY 11b

PECENT DISTRIBUTION of RO RECYCLED WATER in the DEEP AQUIFER AFTER 50 YEARS

DRAWN BY: G.GATES
DATE: 2 SEPT. 1998

FIGURE 10.16

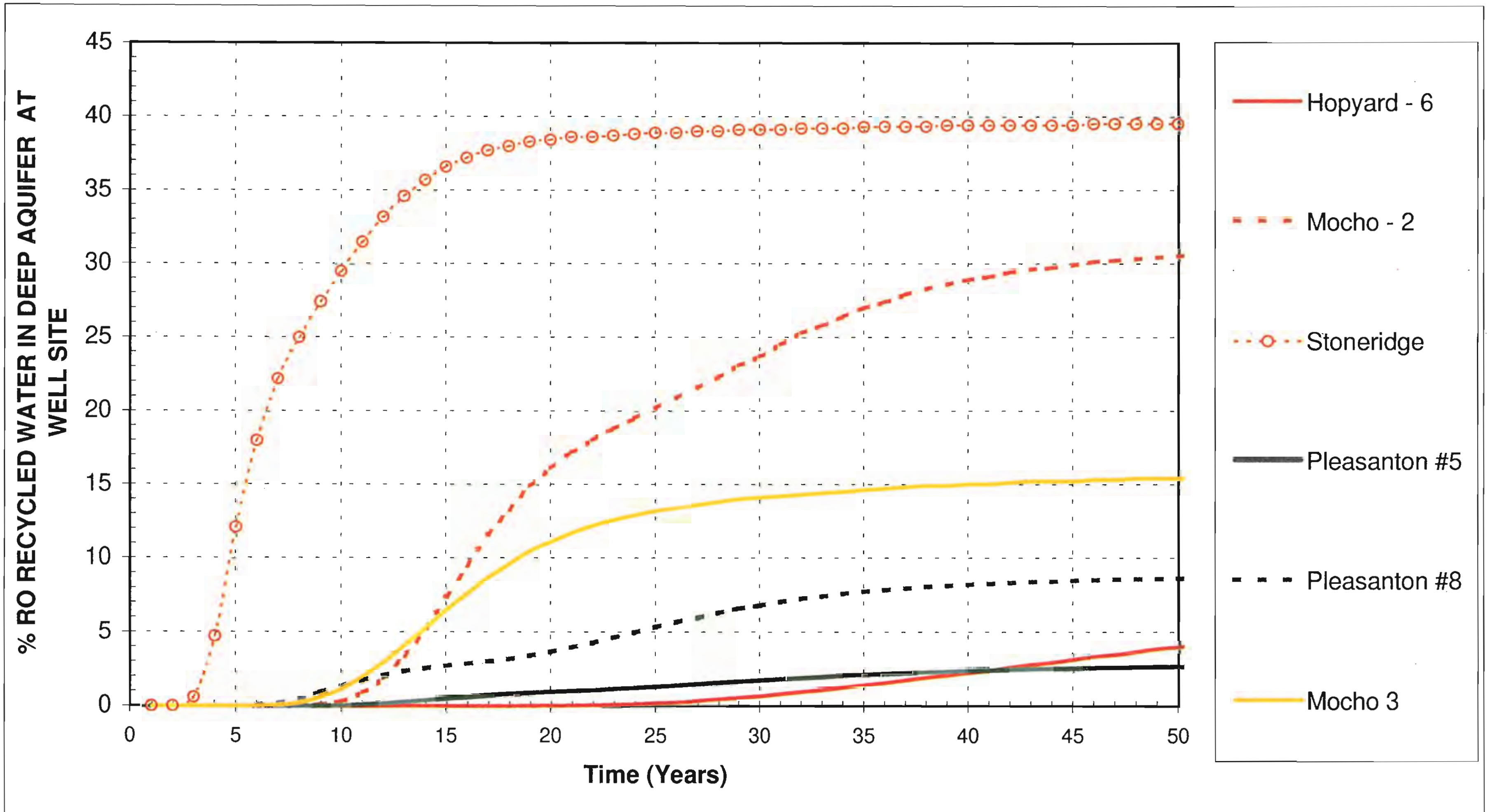


Figure 10.17
Scenario 11B: Conj use + Wellhead Demin
50% Blending for CWR and no blending for Livermore injection

It should be noted that the pathlines and travel times are very dependent on the distribution of groundwater pumpage between individual wells. By changing the groundwater pumpage distribution, the recycled water movement path could and would be affected. Also, these simulations assume that the various basin operating conditions described above would be exactly maintained throughout the entire 50-year simulation. In extreme dry and wet conditions, the recycled water movement would change since basin operating conditions would change. Other annual "fine tuning" is also likely as part of the adaptive management approach of Zone 7's annual operations plan.

RO recycled water movement can also be controlled by varying the amounts and locations of artificial stream and well recharge, and municipal pumpage. Under one conceptual scenario evaluated by Zone 7 staff (section 8.9), water injected in the vicinity of the proposed Livermore injection wells could be contained in the easterly end of the Amador sub-basin and extracted by new wells proposed to be constructed along the northerly edge of the Chain of Lakes Lake E. The extracted blend of groundwater and RO recycled water could be used for either non-potable (i.e., irrigation) or potable purposes.

RO recycled water movement could also be controlled by operating the injection wells as ASR wells and as needed to extract the injected water for irrigation or other non-potable purposes (strategies 14 and 14A, discussed in Chapter 9). However, ASR operation would provide limited salt removal benefits.

2) Modeling to Predict the Distribution of RO Recycled Water in Future Treated Water Deliveries

In October 1999, Zone 7 conducted modeling to provide information about the potential distribution of RO recycled water in the future treated water deliveries to the four valley retailers: Pleasanton, Livermore, California Water Service (CWS), and Dublin San Ramon Services District (DSRSD). First, the groundwater model was used to determine the distribution over time of recycled water in production wells as described earlier in this section. The Zone 7 distribution system pipeline model was then used to predict the contribution from each production source to Zone 7 turnouts of the valley retailers' systems.

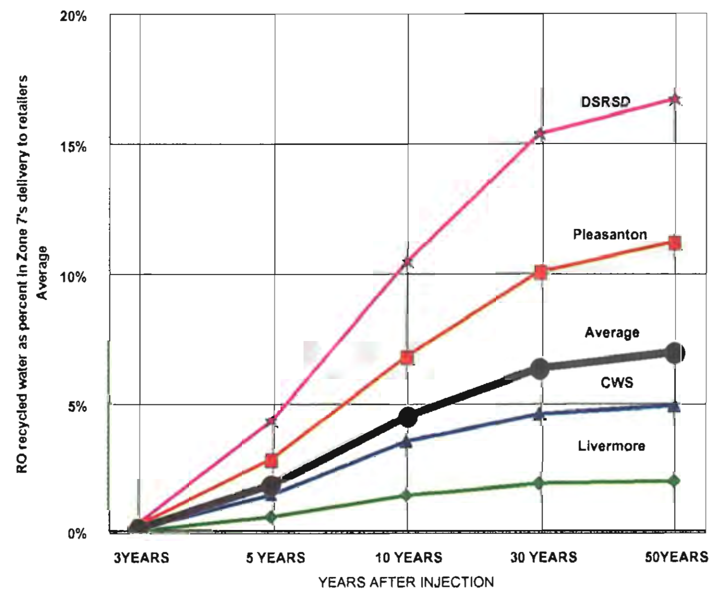
Four different operational conditions were modeled for the distribution system: 1) Summer operation, 2) Summer peak-day operation, 3) January alternate operation (groundwater pumped westwardly), and 4) January typical operation. The output from the groundwater model simulations (Figure 10.17) and the output from the distribution system hydraulic model were integrated in a spreadsheet to compute the potential distribution of RO recycled water in future treated water deliveries to the four valley retailers.

In addition to the assumptions listed earlier in the section, the following apply to the water distribution system model simulations:

- Distribution model used year 2001 operations plan demands.
- "Summer Operation" used August 2001 average demand of 50 MGD, 12 MGD production at Patterson Pass Water Treatment Plant (PPWTP), 23 MGD production at Del Valle Water Treatment Plant (DVWTP), 6.5 MGD at Stoneridge well, 5.4 MGD at Hopyard well #6, and about 3 MGD at Mocho well #2 (or Mocho well #1).
- "Summer Peak Day Operation" used 63 MGD as peak day demands, 13.4 MGD production at Patterson Pass Water Treatment Plant (PPWTP), 28 MGD production at Del Valle Water Treatment Plant (DVWTP), 6.5 MGD at Stoneridge well, 5.4 MGD at Hopyard well #6, 3 MGD at Mocho well #2 or Mocho #1, and 6 MGD at Mocho well #3.
- "January Operation" used January 2001 average demand of 19 MGD, 6.8 MGD production at Patterson Pass Water Treatment Plant (PPWTP), 11 MGD production at Del Valle Water Treatment Plant (DVWTP), and 6.5 MGD at Stoneridge well. It also assumed treated water injection into Hopyard wells #6 and #9. The "Alternate January" simulation assumed the rate control valve in the cross valley pipeline to be open which forces Stoneridge well pumpage to flow west. "Typical January" assumed the rate control valve in the cross valley pipeline to be closed which forces Stoneridge well pumpage to the east.

The results from these modeling simulations predict that water from the RO injection wells would first enter the Zone 7 distribution system within three years. Figure 10.18 shows the average annual percent contribution of RO recycled water Zone 7 would deliver to the various retailers. After 50 years, DSRSD would get the largest contribution, about 17%, while the City of Livermore would get the smallest contribution, about 2%.

Figure 10.18



The actual distribution of RO recycled water would not be constant but would vary from year to year, turnout to turnout, and would vary seasonally with changes in groundwater pumping. To show this seasonal variation in RO recycled water distribution we evaluated four conditions from the high demand "Summer Operations" to the low demand "Winter Operations" in January. Maps were prepared showing the seasonal distribution of RO recycled water throughout the Zone 7 distribution system. Tables were prepared presenting the computed RO recycled water as a percentage of that turnout's total delivery for the 3-, 5-, 10-, 30- and 50-year periods. Results are summarized below with an example map and table included for the summer operations conditions.

Summer Operations Distribution—Summer distributions represent the average high demand month conditions. Table 10.5 and Figure 10.19 show the distribution to each turnout for each retailer during typical August operations. The contribution to each of Pleasanton's eight turnouts has been computed for each time period. Within 50 years, Pleasanton turnouts would receive from 0-15% of their summer water supply from RO recycled water. Livermore and CWS turnouts would not receive any RO recycled water during a typical summer. DSRSD turnouts would receive from 0-22% of their summer water supply from RO recycled water.

Summer Peak-Day Distribution—Peak day distributions represent the highest demand day of the year, which is typically in July or August. Within 50 years Pleasanton turnouts would receive from 0-25% of their peak day water supply from RO recycled water. Livermore and CWS turnouts would not receive any RO recycled water during a typical summer peak day. DSRSD turnouts would receive from 0-17% of their peak day water supply from RO recycled water.

January Alternate (Groundwater Westward) Distribution—January distributions with groundwater being pumped to the west do not represent current winter operations but have been included to demonstrate the impacts of changing the pumping strategy. If during January Zone 7 pumped groundwater to the west, within 50 years Pleasanton turnouts would receive from 0-17% of their supply from RO recycled water.

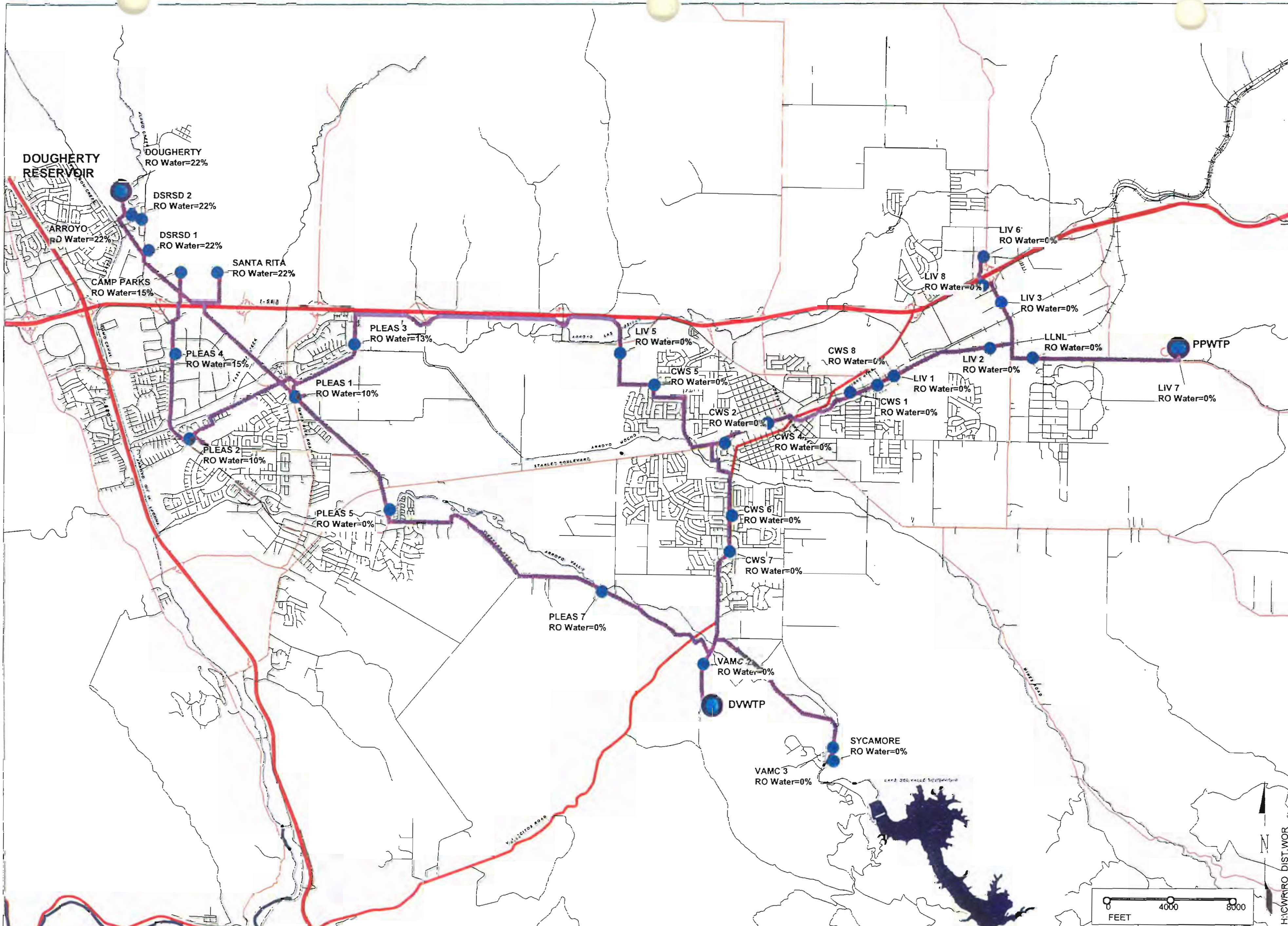
Livermore and CWS turnouts would not receive any RO recycled water if Zone 7 followed this winter operations plan and DSRSD turnouts would receive in the range of 0-9% RO recycled water.

January Typical (Groundwater Eastward) Distribution—January distributions with groundwater being pumped to the east represent current winter operations. Zone 7 pumps groundwater to the east in the winter to help equalize water quality, to facilitate salt removal as part of the Salt Management Plan, and to take the opportunity to inject surface water at the Hopyard well field. January distributions typically represent the low demand month. Under typical winter operations, within 50 years, Pleasanton turnouts would receive from 11-40% of their winter water supply from RO recycled water. Livermore turnouts would receive from 0-40%. CWS turnouts would receive from 0-40% RO recycled water. DSRSD turnouts would receive from 11-40% of their winter water supply from RO recycled water.

TABLE 10.5
RO RECYCLED WATER AS PERCENTAGE OF TOTAL TURNOUT DELIVERY

SUMMER OPERATION

RETAILER	ZONE 7 TURNOUT	WATER DELIVERY IN MGD	RO RECYCLED WATER AS PERCENTAGE OF TOTAL TURNOUT DELIVERY AFTER 3YEARS	5 YEARS	10 YEARS	30 YEARS	50YEARS
PLEASANTON	Pleas 1	5.38	0.00%	0.00%	0.16%	7.78%	10.05%
	Pleas 2	2.69	0.30%	3.57%	8.64%	12.00%	14.66%
	Pleas 3	4.27	0.32%	3.86%	9.33%	12.22%	12.87%
	Pleas 4	4.43	0.30%	3.57%	8.64%	12.00%	14.66%
	Pleas 5	2.37	0.00%	0.00%	0.00%	0.00%	0.00%
	Pleas 7 2"	0.16	0.00%	0.00%	0.00%	0.00%	0.00%
	Pleas 7 8"	0.16	0.00%	0.00%	0.00%	0.00%	0.00%
	P8 (future)	0.0005	0.30%	3.57%	8.64%	12.00%	14.66%
	RANGE		0% - 0.32%	0% - 3.86%	0% - 9.33%	0% - 12.22%	0% - 14.66%
LIVERMORE	LIV #1	1.11	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #2	0.0005	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #3	0.0005	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #5	1.27	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #6	2.06	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #7	5.86	0.00%	0.00%	0.00%	0.00%	0.00%
	LIV #8	0.79	0.00%	0.00%	0.00%	0.00%	0.00%
	RANGE		0%	0%	0%	0%	0%
CWS	CWS #1	2.85	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #2	2.53	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #4	1.74	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #5	1.27	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #6	1.58	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #7	0.0005	0.00%	0.00%	0.00%	0.00%	0.00%
	CWS #8	0.0005	0.00%	0.00%	0.00%	0.00%	0.00%
	RANGE		0%	0%	0%	0%	0%
DSRSD	DSRSD 1	3.96	0.41%	4.88%	11.89%	19.73%	21.85%
	DSRSD 2	1.74	0.41%	4.88%	11.89%	19.73%	21.85%
	DOUGHERTY	0.79	0.41%	4.88%	11.89%	19.73%	21.85%
	E. DUBLIN (Future)	0.95	0.00%	0.00%	0.00%	0.00%	0.00%
	CAMP PARKS W. DUBLIN	0.47	0.30%	3.57%	8.64%	12.00%	14.66%
	RANGE		0% - 0.41%	0% - 4.88%	0% - 11.89%	0% - 19.73%	0% - 21.85%
LARPD	LARPD/VA	0.000001	0.00%	0.00%	0.00%	0.00%	0.00%
	LARPD #1	0.00002	0.00%	0.00%	0.00%	0.00%	0.00%
	LARPD #2	0.00098	0.00%	0.00%	0.00%	0.00%	0.00%
	LARPD #3	0.00173	0.00%	0.00%	0.00%	0.00%	0.00%
	RANGE	0.00272	0%	0%	0%	0%	0%
VA	VA #2	0.019708	0.00%	0.00%	0.00%	0.00%	0.00%
	VA #3	0.26110	0.00%	0.00%	0.00%	0.00%	0.00%
	RANGE	0.28080	0%	0%	0%	0%	0%
GSA	SANTA RITA	0.82000	0.41%	4.94%	12.02%	20.04%	22.15%
DEPT. OF ARMY	CAMP PARKS	0.000001	0.30%	3.57%	8.64%	12.00%	14.66%
DUB. HOUS. AUTH.	ARROYO VISTA	0.08603	0.41%	4.88%	11.89%	19.73%	21.85%
GSA (EBRPD)	BOYS RANCH	0.00628	0.00%	0.00%	0.00%	0.00%	0.00%
LLNL		0.05673	0.00%	0.00%	0.00%	0.00%	0.00%
Total system	RANGE		0% - 0.41%	0% - 4.94%	0% - 12.02%	0% - 20.04%	0% - 22.15%



ZONE 7 WATER AGENCY

5997 PARKSIDE DRIVE PLEASANTON CA 94588

DRAWN	G. GATES
DESIGNED	G. GATES
CHECKED	DAVID LUNN
APPROVED	

WATER RESOURCES ENGINEERING

SUMMER OPERATION

RO WATER PERCENTAGES (After 50 Years)

SCALE	1" =8000'
DATE	31 JAN 2000
FIGURE 10.19	

10.3.5 GW Model Results for Strategy 15—Increased Conjunctive Use and Demineralization of High TDS Groundwater

Strategy 15 is the only strategy that passed all the screens for feasibility as described in Section 9.8. Strategy 15 includes conjunctive use, demineralization of high TDS groundwater and no RO RW injection. This strategy assumes that 8.5 TAF/Y of stream recharge and groundwater pumpage for conjunctive use will be implemented using existing facilities and 5 TAF/Y of new shallow groundwater pumpage would be demineralized from approximately 1,000 mg/L TDS to 100 mg/L TDS.

Wellfields—Figure 10.20 presents the TDS changes over time for a 50-year period at nine locations in the main basin under Strategy 15. Figure 10.21 presents the zoomed in view showing the TDS changes only for the initial 25-year period. Table 10.6 lists the groundwater TDS for each location after 25 years and 50 years.

TABLE 10.6 - Strategy 15 Versus Strategy 1A Groundwater Model Simulation Results

	Groundwater TDS and Change from Strategy 1A, mg/L			
Well Location	After 25 Years	Change	After 50 Years	Change
Hopyard-4	295	-251	258	-408
Mocho-2	421	-63	397	-84
Stoneridge	569	-11	547	-54
Pleasanton # 5	493	-8	426	-51
Pleasanton # 8	392	-45	387	-59
CWS # 10	573	47	554	8
CWS # 24	380	-22	389	-24
GWP for Castlewood (SFWD)	513	-133	493	-323
Laguna South	724	-156	760	-218

In comparing Table 10.6 and Table 10.2, it is clear that the groundwater TDS after 25 and 50 years of operation under Strategy 15 would be improved versus the baseline Strategy 1A at all the listed locations except at CWS #10. At the Hopyard, Mocho and future Bernal property well field (GWP for Castlewood) locations after 25 years, the groundwater TDS would improve (decrease) even when compared to initial (1990-95) conditions. For all other locations, TDS would increase versus the initial conditions but the increase would be less than that occurring under the baseline Strategy 1A.

The largest improvement would be in the Bernal sub-basin. Hopyard well field groundwater TDS after 25 years of operation would be 300 mg/L versus 550 mg/L under Strategy 1A. The future Bernal property wellfield would be at 510 mg/L after 25 years

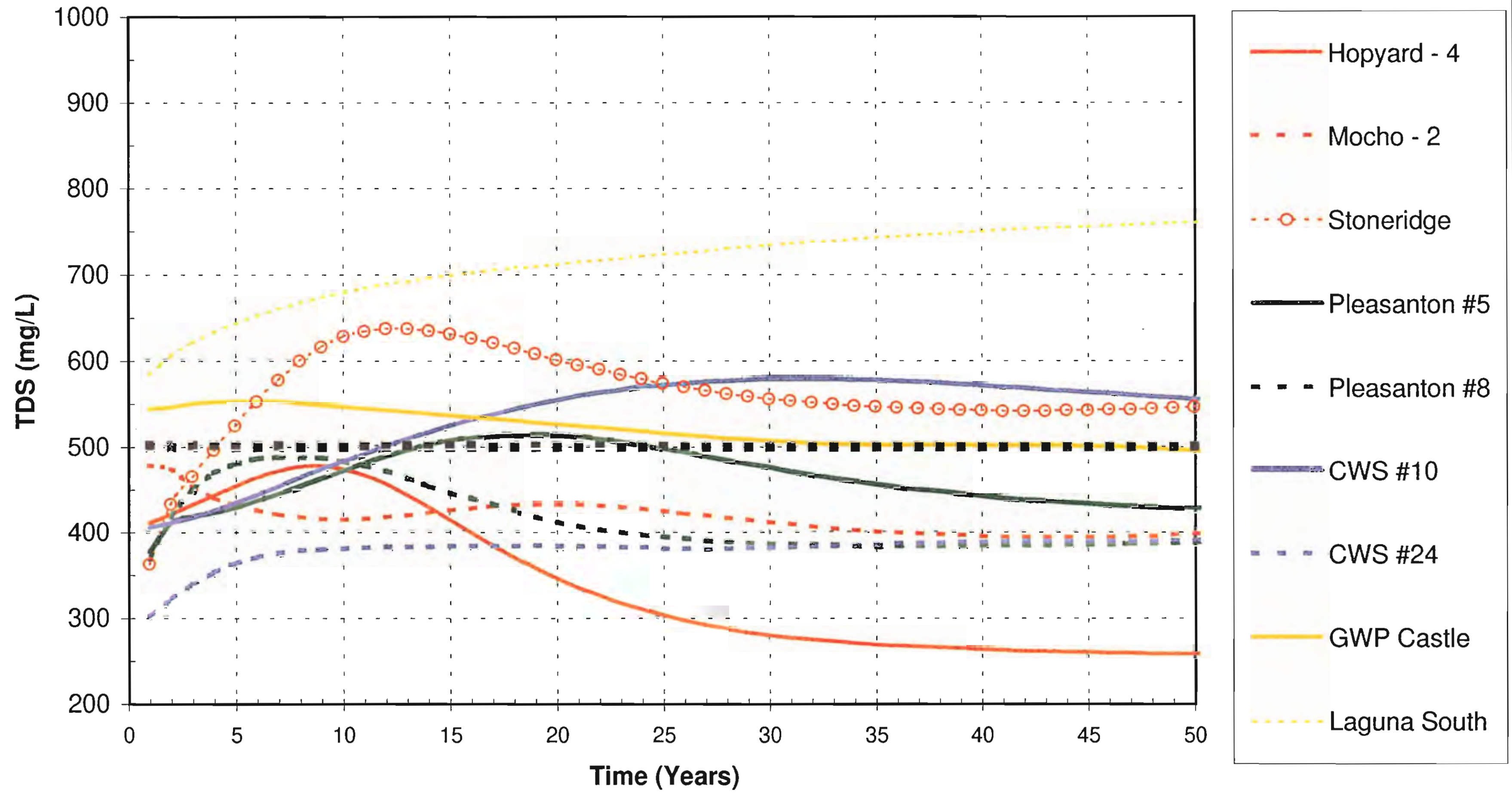


Figure 10.20
Scenario 15: Conj use + Wellhead Demin
Increased ASR injection
Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

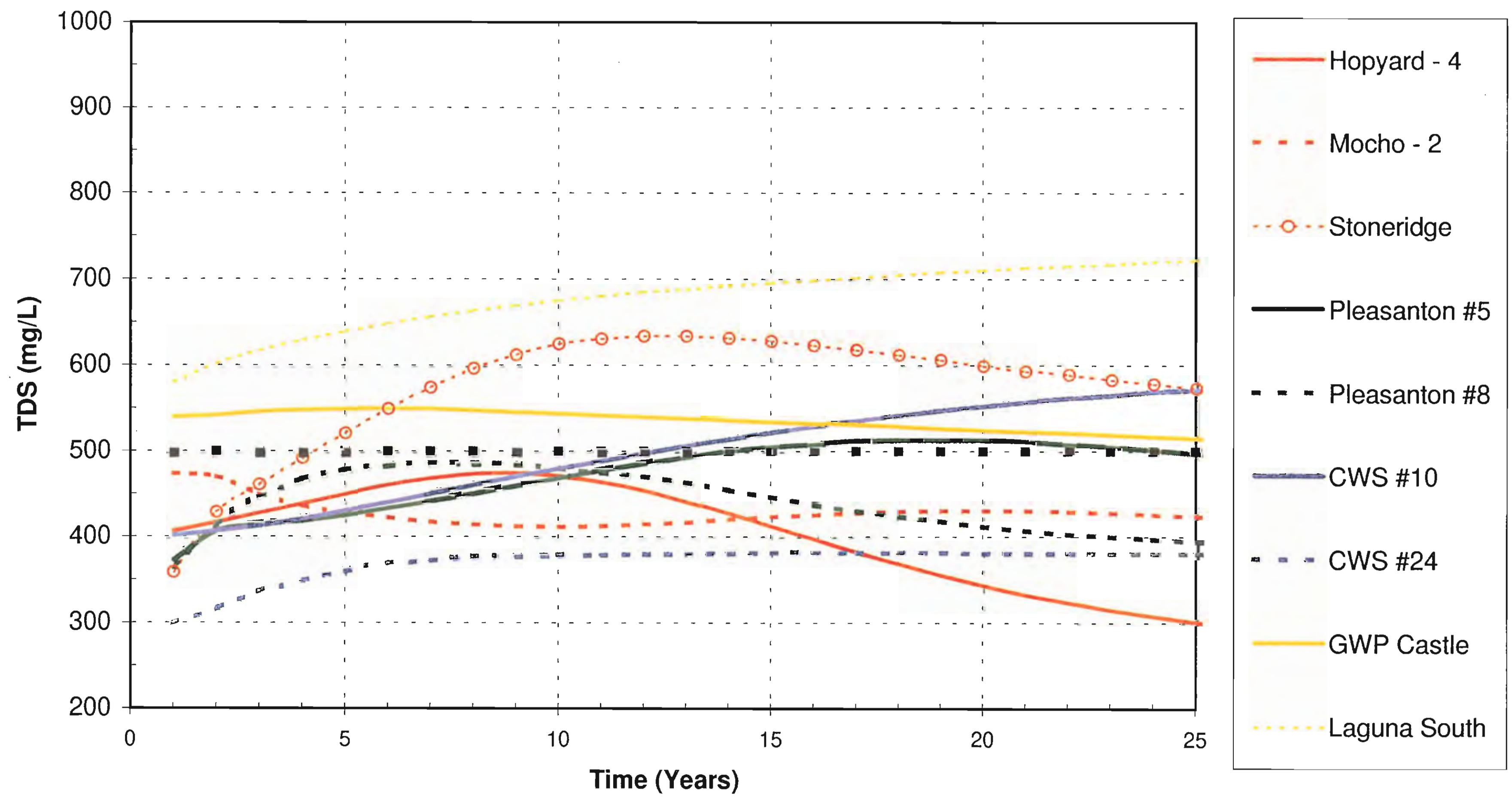


Figure 10.21

Scenario 15: Conj use + Wellhead Demin

Increased ASR injection

Documentation for Salt Management Plan Modeling

Zone 7 Water Agency

versus 650 mg/L for Strategy 1A. The improvement in the Bernal sub-basin under this strategy would be due to the increased ASR injection and pumpage, and demineralization of shallow groundwater that would otherwise degrade the lower aquifer. Groundwater TDS at CWS #10 would increase at about the same rate under Strategy 1A. This is due to recharge and pumpage conditions in the Mocho II sub-basin remaining the same under both strategies.

Upper Aquifer—Figure 10.22 maps the upper aquifer groundwater TDS at the end of a 50-year period. The major changes in groundwater TDS in the upper aquifer compared to Strategy 1A are in the western part of the Amador sub-basin and the central part of the Bernal sub-basin. Although groundwater TDS levels in these areas of the basin would improve over Strategy 1A, TDS would remain at over 650 mg/L for the most part. This improvement is due to the shallow groundwater pumpage for demineralization (5 TAF/year) under this strategy. This pumpage would intercept the high TDS subsurface inflow from the Dublin sub-basin and high TDS recharge from urban irrigation. The low TDS recharge from Arroyo Valle and Lake I would move further into the Bernal sub-basin and lower the groundwater TDS. The rest of the upper aquifer groundwater TDS would be about the same as in Strategy 1A.

Lower Aquifer—Comparing the lower aquifer TDS map Figure 10.23 (Strategy 15) with Figure 10.6 (Strategy 1A), it is clear that the area of the basin with groundwater TDS below 500 mg/L (blue color) would be significantly larger under Strategy 15. The Bernal sub-basin lower aquifer and western portion of the Amador aquifer would benefit the most under Strategy 15. Most of the main basin lower aquifer would stabilize around or below 500 mg/L.

Subsurface inflow from the Dublin sub-basin into the Bernal sub-basin was also computed to determine if pumping shallow groundwater would significantly increase subsurface inflow and thereby negate some of the salt mitigating benefits of Strategy 15. The model simulation computed the subsurface inflow through this boundary to be about 760 AF/year without any shallow groundwater pumpage and only about 900 AF/year with 5 TAF/Y of shallow groundwater pumpage included in Strategy 15.

10.4 Water System Operations Model Evaluations (WRMI)

The water system operations model (WRMI) as currently configured can produce various output parameters on a monthly basis including groundwater recharge, groundwater storage, treatment plant production, Lake Del Valle storage, delivered water quality, flow at any point in the system, etc. The most useful output parameter for the salt management plan strategies was delivered water quality (TDS). The model provided the monthly water quality (TDS) of Zone 7 deliveries to each retailer's turnout under varying hydrologic conditions equivalent to the 1922-96 hydrologic period. The ranges of delivered water quality for each retailer presented below were derived from this WRMI output. The model

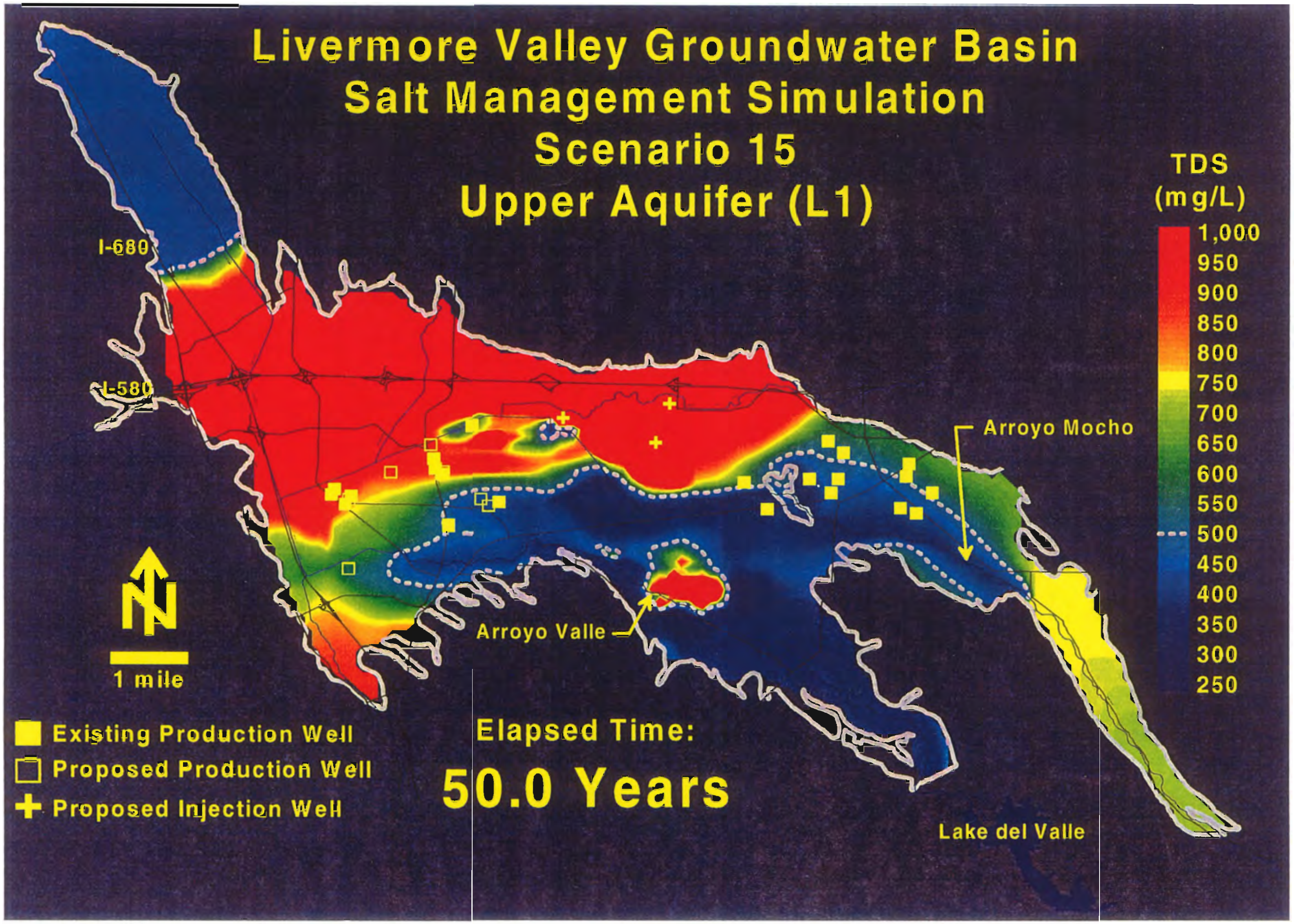


FIGURE 10-22
Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

\SFO\MJB\TDS Maps.xls: SMP15 L1 50 Yr
1/4/99

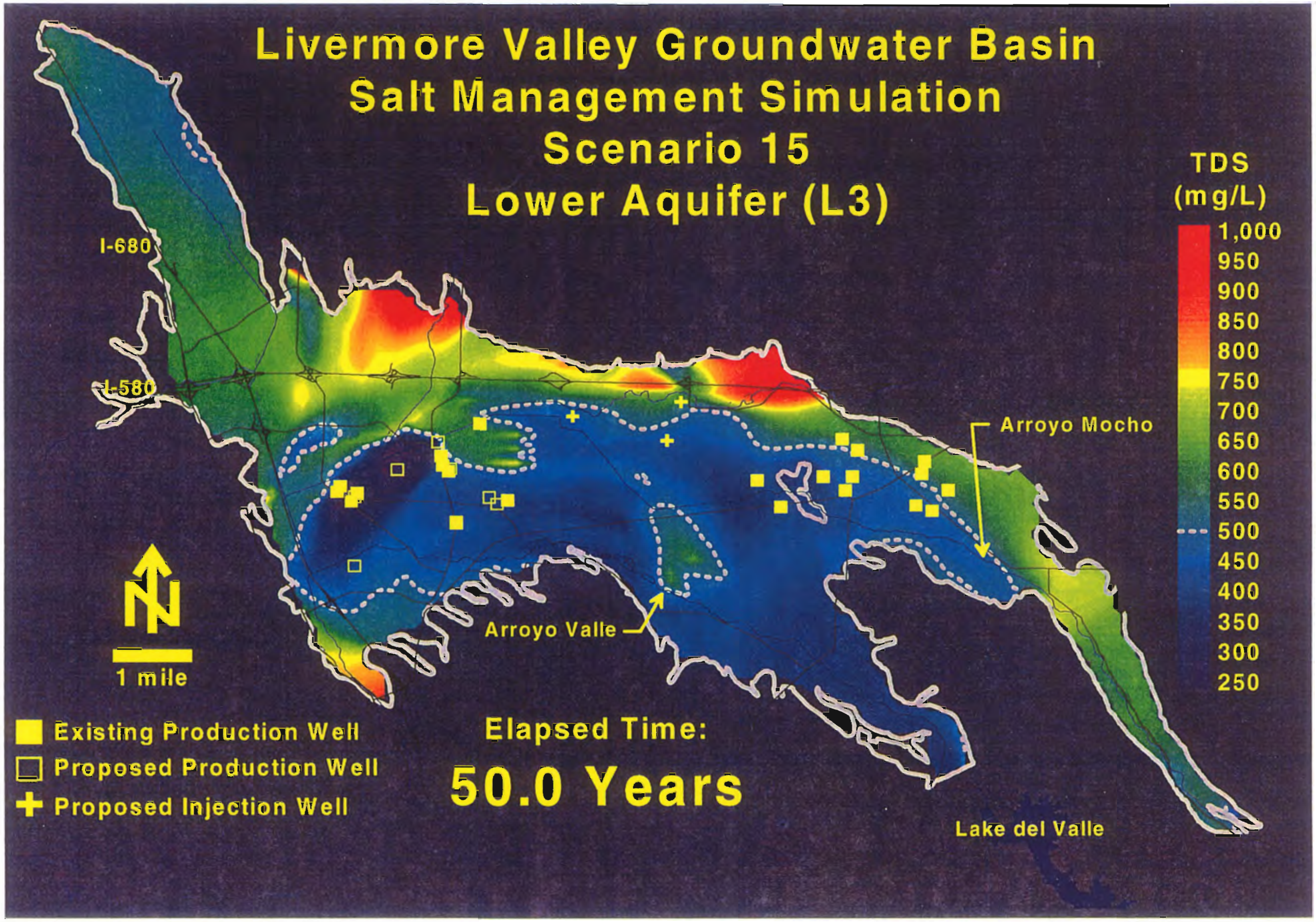


FIGURE 10-23

Documentation for Salt Management Plan Modeling
Zone 7 Water Agency

\SFO\MJB\TDS Maps.xls: SMP15 L1 50 Yr
1/4/99

is also capable of calculating the TDS of each retailer's deliveries, taking into account their individual monthly groundwater pumpage (see Reference O).

The water system operations model was used to predict the Zone 7 delivered water quality for each retailer under key salt management strategies 1, 11B and 15 (Study 1A was not run since it had not been developed when this modeling was conducted). The groundwater source water quality input for these strategies required the use of output from the groundwater model simulation for each respective strategy. The groundwater water quality projected by the groundwater model for each municipal well after 25 years of steady state operation was used as input for the water system model wells.

Figures 10.24 through 10.26 present the modeled delivered water quality for strategies 1, 11B and 15 respectively. These figures plot delivered water quality (TDS in mg/L) against the hydrologic year type. The hydrologic year type is represented in probability of exceedence units. A 99% probability of exceedence means a very dry year with 99% chance of it being wetter in a given subsequent year. A 1% probability of exceedence means a very wet year with only 1% chance of it being wetter. The four lines represent each of the four retailers: red for Pleasanton, blue for Livermore, green for CWS, and purple for DSRSD. The broken lines represent the long-term annual average delivered water TDS for each retailer (approximately equivalent to the 50% exceedence values from the figure).

The solid lines present the predicted TDS variability by retailer under the full range of dry to wet hydrologic conditions. In general, the flatter the lines the lower the variability with changing hydrologic conditions. The closer the lines are to each other the lower the variability in delivered water quality variability among the retailers.

10.4.1 Water System Operations Model Results for Strategy 1

The main feature of Strategy 1 is the injection of 6 TAF/Y of recycled water versus status quo operations. Section 10.2 describes Strategy 1 in more detail. The range of modeled water quality variability in the Zone 7 system for Strategy 1 under various hydrologic conditions is shown in Figure 10.24.

Table 10.7 data, extracted from Figure 10.24, summarizes Zone 7 delivered water quality for each retailer under dry (90%), average (50%) and wet (10%) hydrologic conditions for Strategy 1.

ZONE 7 WATER AGENCY
WATER RESOURCES ENGINEERING

AVERAGE ANNUAL ZONE 7 TDS DELIVERED TO RETAILERS
UNDER 2010 DEMANDS - SMP STUDY 1

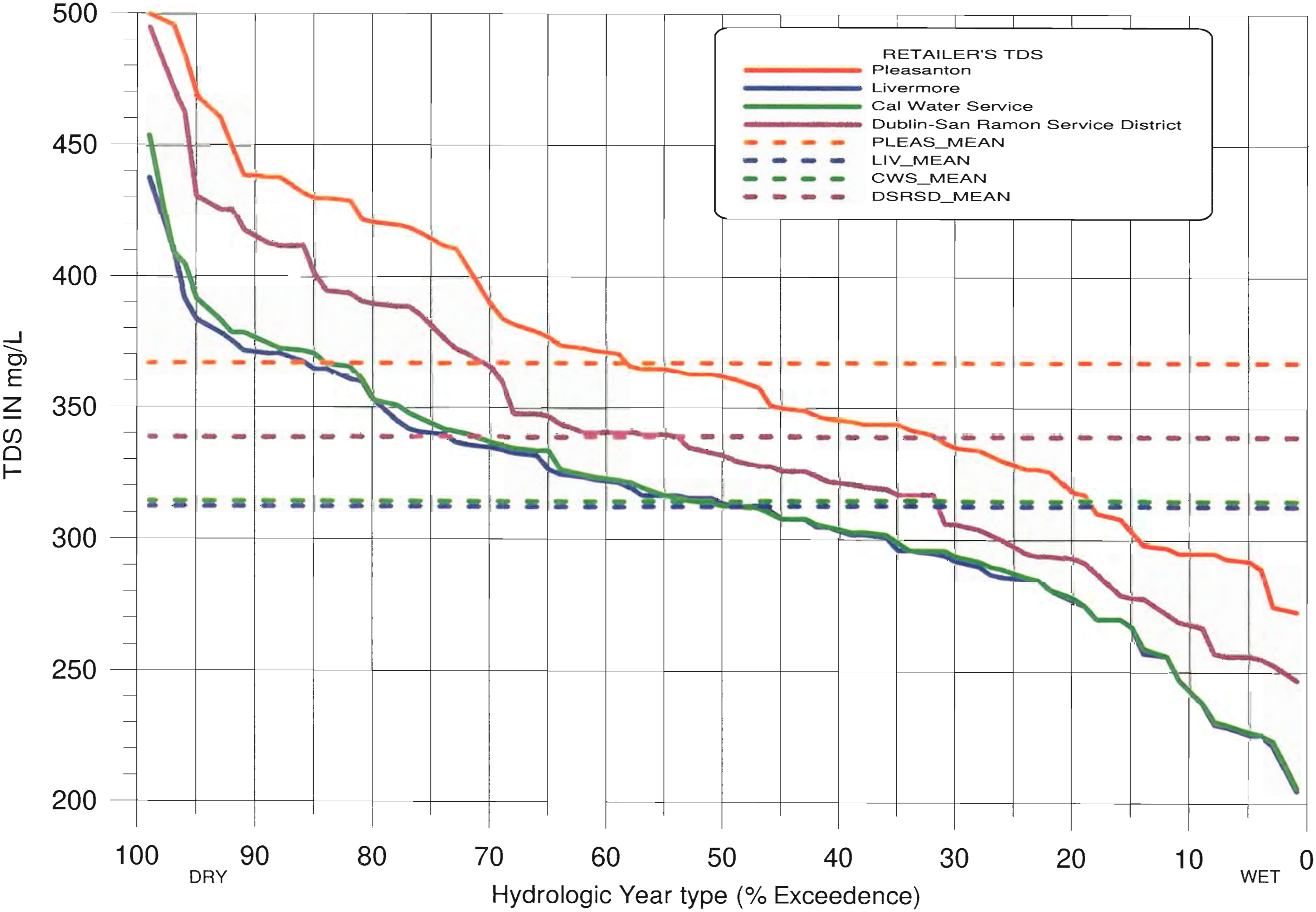


FIGURE 10.24

11/4/98

Table 10.7

Projected Annual Average TDS Delivered To Retailers Under Strategy 1

	Annual Average TDS (mg/L)		
	Dry Year (90%)	Average Year (50%)	Wet Year (10%)
Livermore	370	310	240
CWS	380	310	240
Pleasanton	440	360	300
DSRSD	420	330	270

Livermore and CWS would receive the lowest TDS, varying from 370 mg/L in dry years to 240 mg/L in wet years. In critically dry years (99%) the average would be as high as 440 mg/L and in very wet years (1%) as low as 200 mg/L.

Pleasanton would receive the highest TDS, varying from 440 mg/L in dry years to 300 mg/L in wet years. In critically dry years (99%) the average would be as high as 520 mg/L and in very wet years (1%) as low as 270 mg/L (Fig 10.24).

10.4.2 Water System Operations Model Results for Strategy 11B

The main features of Strategy 11B are increased conjunctive use (3 TAF/year), demineralization of high TDS groundwater pumpage (3 TAF/year), and the injection of 6 TAF/year of RO recycled water over current operation. Section 10.2 describes Strategy 11B in more detail. The range of modeled water quality variability in the Zone 7 system for Strategy 11B under various hydrologic conditions is shown in Figure 10.25.

Table 10.8 data, extracted from Figure 10.25, summarizes Zone 7 delivered water quality for each retailer under dry, average and wet hydrologic conditions under Strategy 11B. Table 10.8 also shows the net difference with respect to Strategy 1.

ZONE 7 WATER AGENCY
WATER RESOURCES ENGINEERING

AVERAGE ANNUAL ZONE 7 TDS DELIVERED TO RETAILERS
UNDER 2010 DEMANDS - SMP STUDY 11B

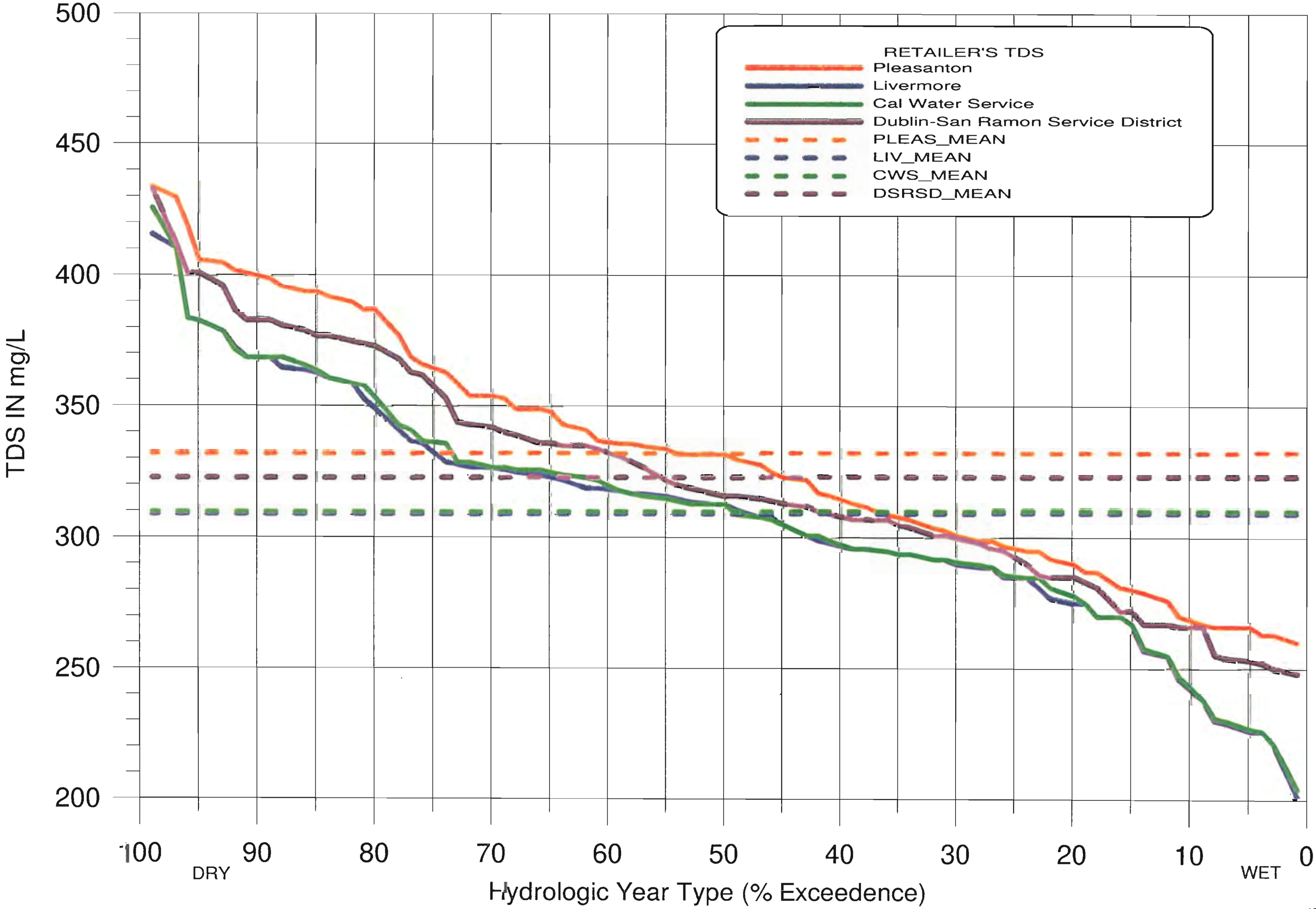


FIGURE 10.25

10/23/98

Table 10.8
Projected Annual Average TDS Delivered To Retailers Under Strategy 11B
and Net Change from Strategy 1

	Annual Average TDS and Net Change (mg/L)					
	Dry Year (90%)	Change	Average Year (50%)	Change	Wet Year (10%)	Change
Livermore	370	(0)	310	(0)	240	(0)
CWS	370	(-10)	310	(0)	240	(0)
Pleasanton	400	(-40)	330	(-30)	270	(-30)
DSRSD	380	(-40)	320	(-10)	270	(0)

Livermore and CWS would continue to receive approximately the same quality and the lowest TDS deliveries, varying from 370 mg/L in dry years to 240 mg/L in wet years. In critically dry years (99%) the average would be as high as 420 mg/L and in very wet years (1%) as low as 200 mg/L (Fig 10.25).

Pleasanton and DSRSD would receive better quality but still higher TDS deliveries than Livermore and CWS, varying from 400 mg/L in dry years to 270 mg/L in wet years. In critically dry years (99%) the average would be as high as 430 mg/L and in very wet years (1%) as low as 260 mg/L (Fig 10.25). Delivered water quality under Strategy 11B becomes much more similar for both east and west portions of the system.

10.4.3 Water System Operations Model Results for Strategy 15

The main features of Strategy 15 are increased conjunctive use (8.5 TAF/year) and increased demineralization of high TDS groundwater pumpage (5 TAF/year). Section 10.2 describes Strategy 15 in more detail. The range of modeled water quality variability in the Zone 7 system for Strategy 15 under various hydrologic conditions is shown in Figure 10.26.

ZONE 7 WATER AGENCY
WATER RESOURCES ENGINEERING

AVERAGE ANNUAL ZONE 7 TDS DELIVERED TO RETAILERS
UNDER 2010 DEMANDS - SMP STUDY 15

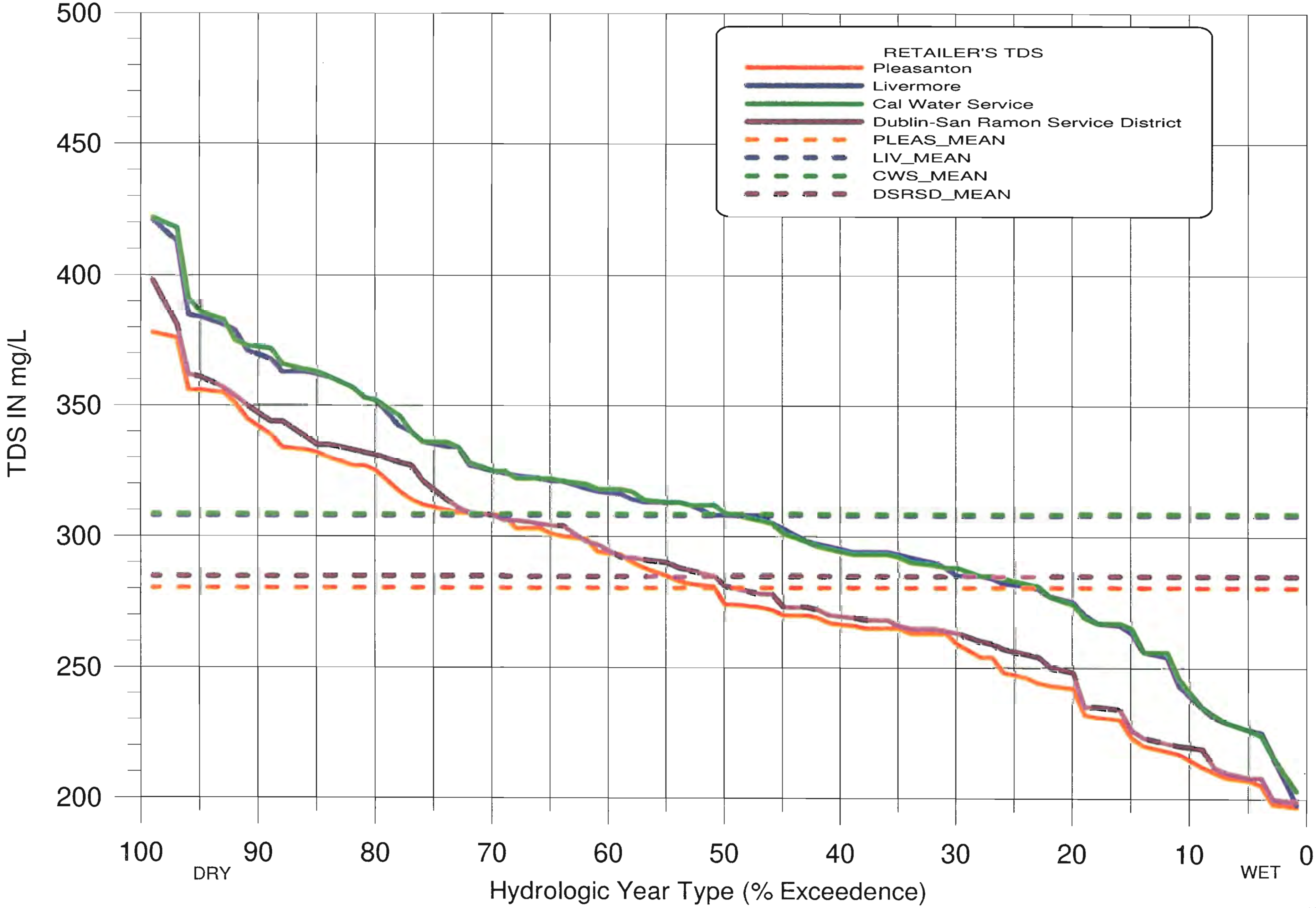


FIGURE 10.26

11/20/98

Table 10.9
Projected Annual Average TDS Delivered To Retailers Under Strategy 15
and Net Change from Strategy 1

	Annual Average TDS and Net Change (mg/L)					
	Dry Year (90%)	Change	Average Year (50%)	Change	Wet Year (10%)	Change
Livermore	370	(0)	320	(10)	240	(0)
CWS	370	(-10)	320	(10)	240	(0)
Pleasanton	340	(-100)	300	(-60)	220	(-80)
DSRSD	350	(-70)	300	(-30)	220	(-50)

Table 10.9 data, extracted from Figure 10.26, summarize Zone 7 delivered water quality for each retailer under dry, average and wet hydrologic conditions for Strategy 15.

Livermore and CWS would continue to receive essentially the same TDS deliveries (which would now be slightly higher than DSRSD and Pleasanton deliveries), varying from 370 mg/L in dry years to 240 mg/L in wet years. In critically dry years (99%) the average would be as high as 420 mg/L and in very wet years (1%) as low as 200 mg/L.

Pleasanton and DSRSD would receive the lowest TDS deliveries under Strategy 15, varying from 350 mg/L in dry years to 220 mg/L in wet years. In critically dry years (99%) the average would be as high as 380 mg/L and in very wet years (1%) as low as 200 mg/L (Fig 10.26).

10.5 Modeling Results Comparison of Key Strategies

10.5.1 Groundwater Model Results Comparison of Strategies 1A, 1, 11B and 15

Each strategy would have a different groundwater quality impact at a given well location. Figures 10.27 through 10.30 show the groundwater quality changes in the deep aquifer under the key strategies at Stoneridge well, Hopyard 4 well, Pleasanton 8 well and the future Bernal Property well field (GWP Castlewood) locations.

As shown in Figure 10.27, the groundwater TDS at the Stoneridge well location would increase significantly in the beginning under all proposed strategies. This is due to the fact that after the gravel mining operation stops in the vicinity of Stoneridge well (Kaiser operation), the upper aquifer high TDS groundwater (currently pumped by Kaiser) would start moving into the deep aquifer. The groundwater TDS under Strategies 1A and 15 at this location would be about the same and would stabilize at about 575 mg/L after 25

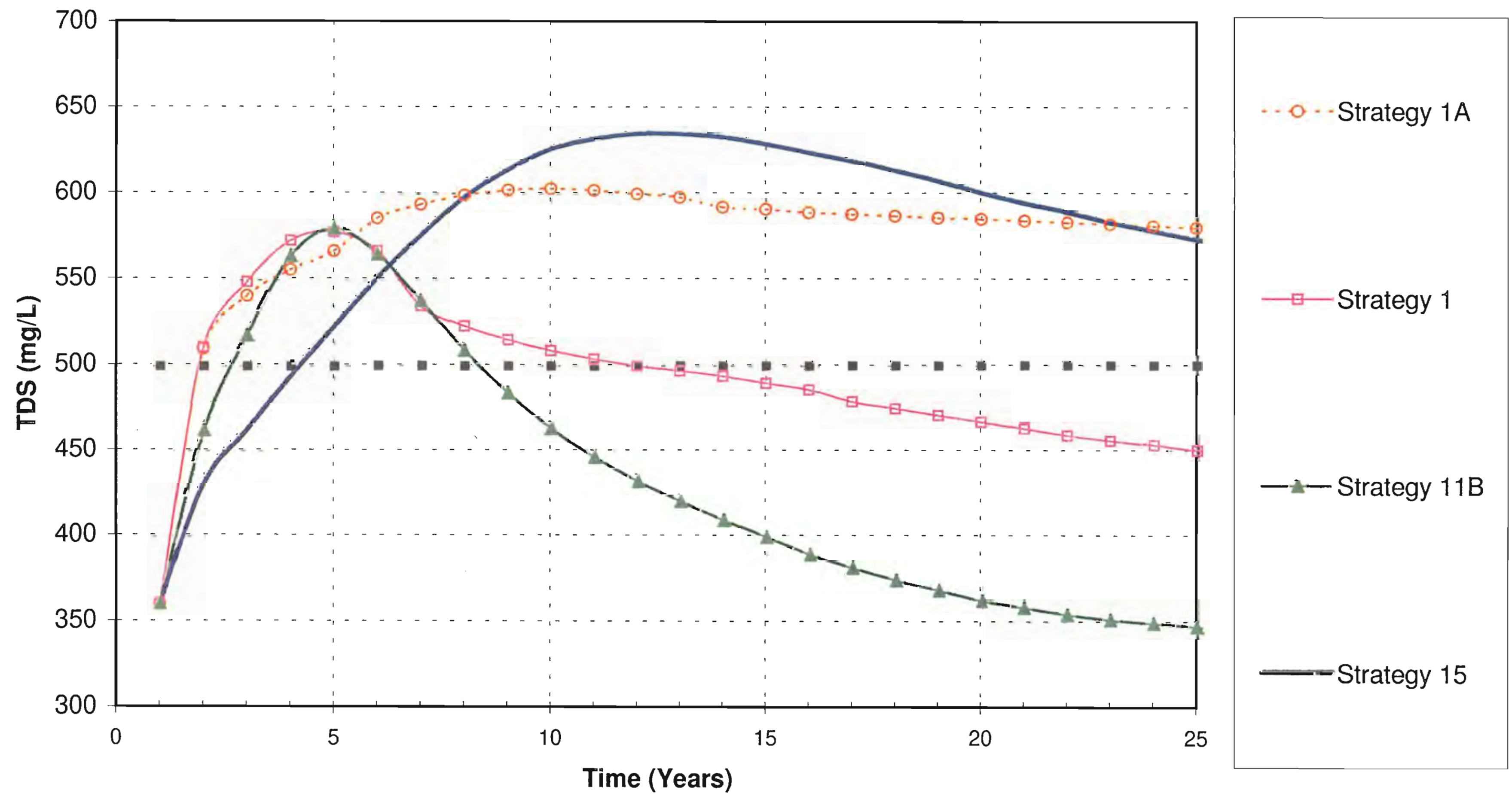


Figure 10.27
Stoneridge Well

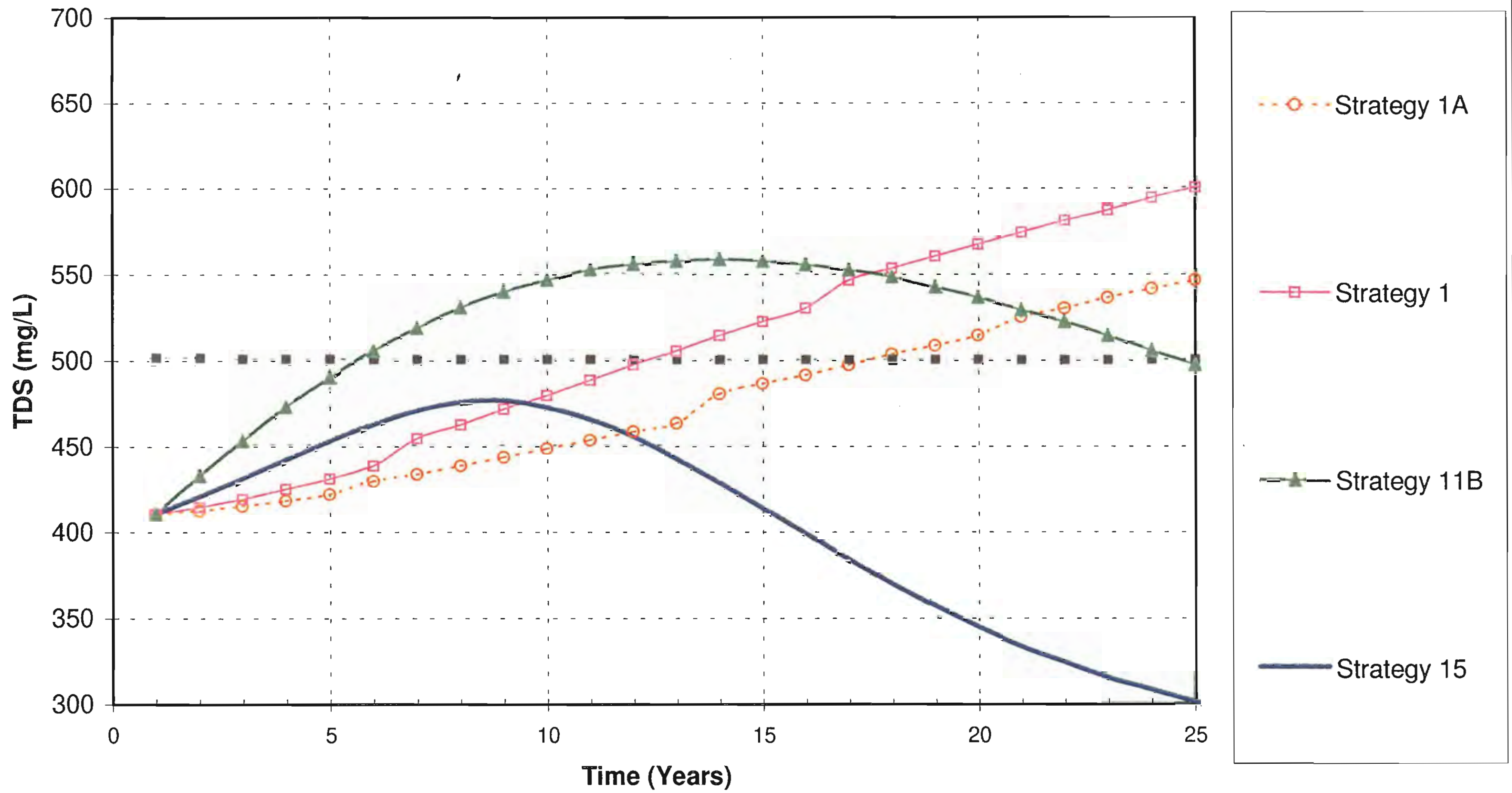


Figure 10.28
Hopyard #4 Well

years. Under strategies 1 and 11B (due to low TDS water injection), the groundwater TDS would start improving after about five years and would be significantly better than under strategies 1A and 15. The groundwater TDS after 25 years would be at about 450 mg/L and 350 mg/L under strategies 1 and 11B, respectively.

The Hopyard well field (Figure 10.28) groundwater TDS under Strategy 15 would be significantly lower than under strategies 1A, 1 or 11B. The groundwater TDS after 25 years under Strategy 15 would be 300 mg/L as compared to 500 mg/L for Strategy 11B and over 550 mg/L for strategies 1A and 1. This is due to the increased ASR injection and pumpage, and the pumpage and demineralization of shallow groundwater that would otherwise degrade the lower aquifer.

The groundwater TDS at the Pleasanton #8 well location responds similarly under all proposed strategies. TDS initially increases then drops to the 400 mg/L range under strategies 1,11B and 15 (Figure 10.29). Even under Strategy 1A (Status Quo), this location's groundwater TDS would stabilize at less than 450 mg/L after 25 years. This location receives a large contribution of low TDS Arroyo Valle recharge which has a primary influence in this area.

The future Bernal Property wellfield location (GWP Castlewood) groundwater TDS would improve significantly under Strategy 15 versus strategies 1A and 1 (Figure 10.30). Under strategies 1A and 1, the groundwater TDS would increase from 550 mg/L to 650 mg/L after 25 years. Under Strategy 11B
the groundwater would stay at about current TDS levels and under Strategy 15 the groundwater TDS would be trending down after 10 years to about 510 mg/L by the 25th year.

10.5.2 Water System Operations Model (WRMI) Results Comparison of Strategies 1, 11B and 15

Water quality in the Zone 7 distribution system varies with hydrologic conditions and with location in the distribution system. Water quality can also vary significantly due solely to seasonal water quality changes in the SWP's Delta pumping.

TDS reached higher levels in dry years as compared to average or wet years for two primary two reasons: 1) The TDS of surface water supplies is generally higher in dry years and 2) Total groundwater pumpage is higher due to deficiency in surface water supplies.

Summary Figure 10.31 and selected results shown in Table 10.10 below present how the overall average TDS of Zone 7 deliveries would compare for the three key strategies under dry (90%), average (50%) and wet (10%) conditions. In a dry year, the annual average of Zone 7 deliveries under Strategy 1 would be 400 mg/L, versus 380 mg/L for Strategy 11B and 350 mg/L for Strategy 15. Similarly, the overall average TDS of Zone 7 deliveries in

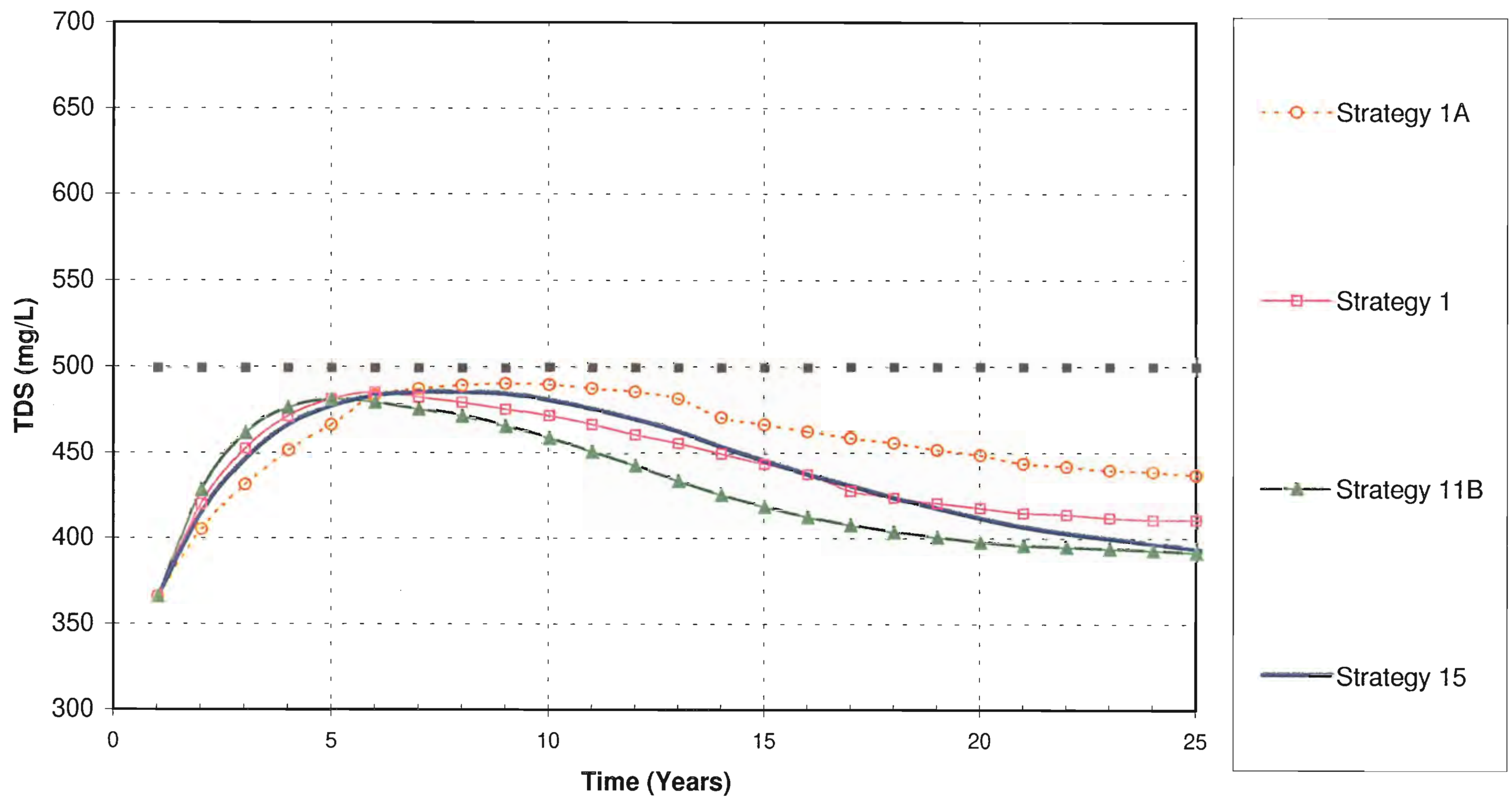


Figure 10.29
Pleasanton #8 Well

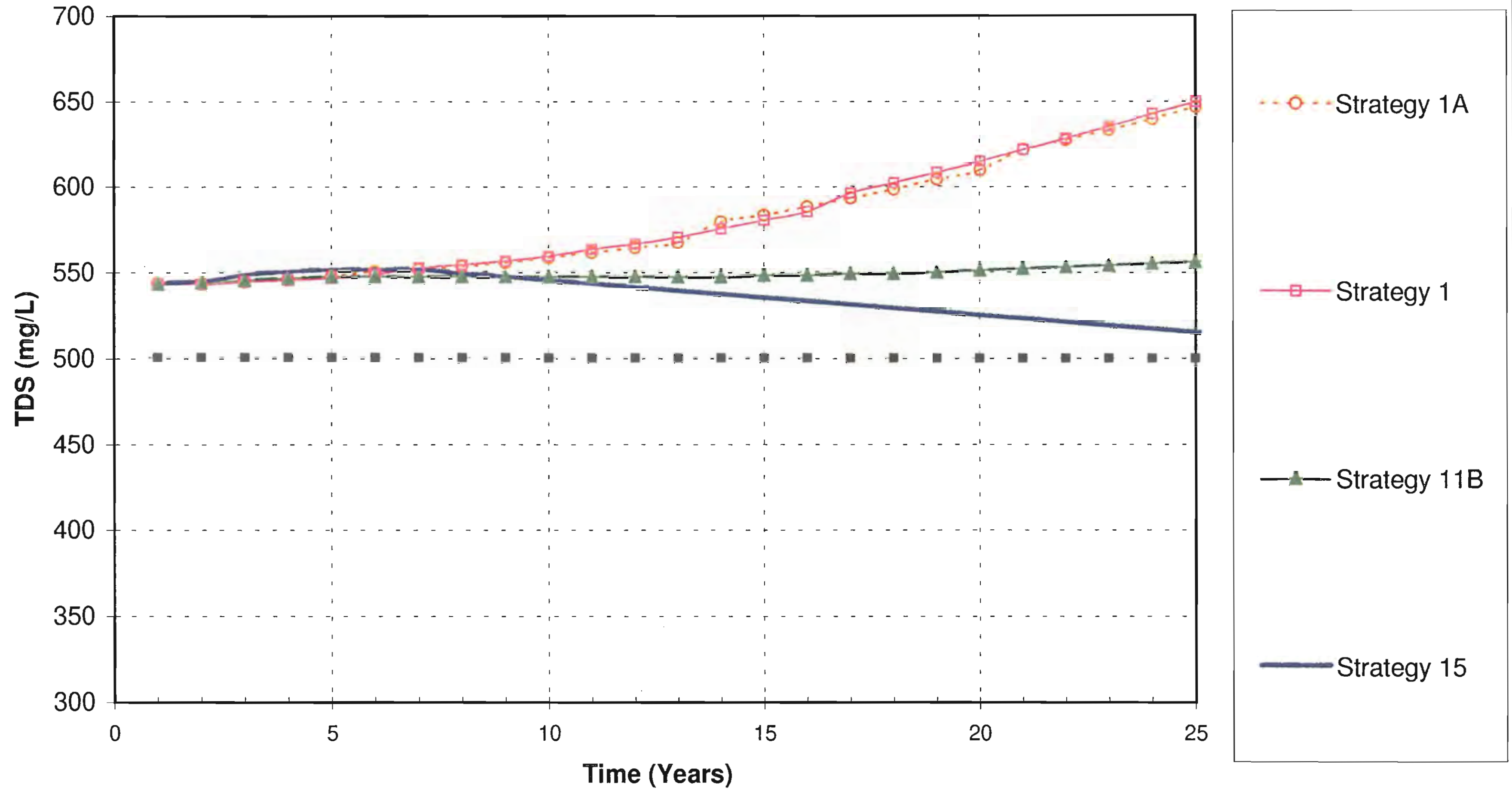


Figure 10.30
GWP Castlewood (SFWD)

average and wet years would improve by 10 and 40 mg/L under strategies 11B and 15, respectively versus under Strategy 1.

The differences are due to the differing amounts of demineralization (3 TAF/year under 11B versus 5 TAF/year under 15) and to the improvement in overall groundwater TDS under strategies 11B and 15. The long-term average of Zone 7 deliveries would also improve slightly from 335 mg/L for Strategy 1 to 320 for Strategy 11B and 290 mg/L for Strategy 15 (Figure 10.31 and Table 10.10).

Table 10.10

Overall Average Zone 7 Delivered Water Quality Variability with with Hydrologic Conditions under Strategy 1, 11B and 15

	Zone 7 Annual Average TDS (mg/L)		
SMP Strategies	Dry Year (90%)	Average Year (50%)	Wet Year (10%)
Strategy 1	400	330	270
Strategy 11b	380	320	260
Strategy 15	350	290	230

Table 10.11 presents the long-term average TDS of Zone 7 deliveries to individual retailers to illustrate the TDS variability under each strategy. Under Strategy 1, the long-term average TDS of Pleasanton's deliveries would be 370 mg/L (highest overall) as compared to 310 mg/L for Livermore (lowest). Under Strategy 11B, the respective long-term average TDS difference is reduced with Pleasanton deliveries of 330 mg/L as compared to 310 mg/L for Livermore. Under Strategy 15, the long-term average TDS of Pleasanton and Livermore deliveries would be equal at 310 mg/L.

Although there is only a 10% overall improvement (330mg/L to 300mg/L) in long-term average water TDS of Zone 7 deliveries between strategies 1 and 15, there is a more significant improvement in the equalization of delivered water TDS to the retailers. Equalizing delivered water TDS is one of the goals of the Salt Management Plan. To reiterate, the main reasons for this east-west variability improvement are the demineralization of groundwater pumpage and improved groundwater quality under strategies 11B and 15.

ZONE 7 WATER AGENCY
WATER RESOURCES ENGINEERING

COMPARISON OF SMP STUDY 1, STUDY 11B, AND STUDY 15
AVERAGE ANNUAL ZONE 7 DELIVERED WATER TDS

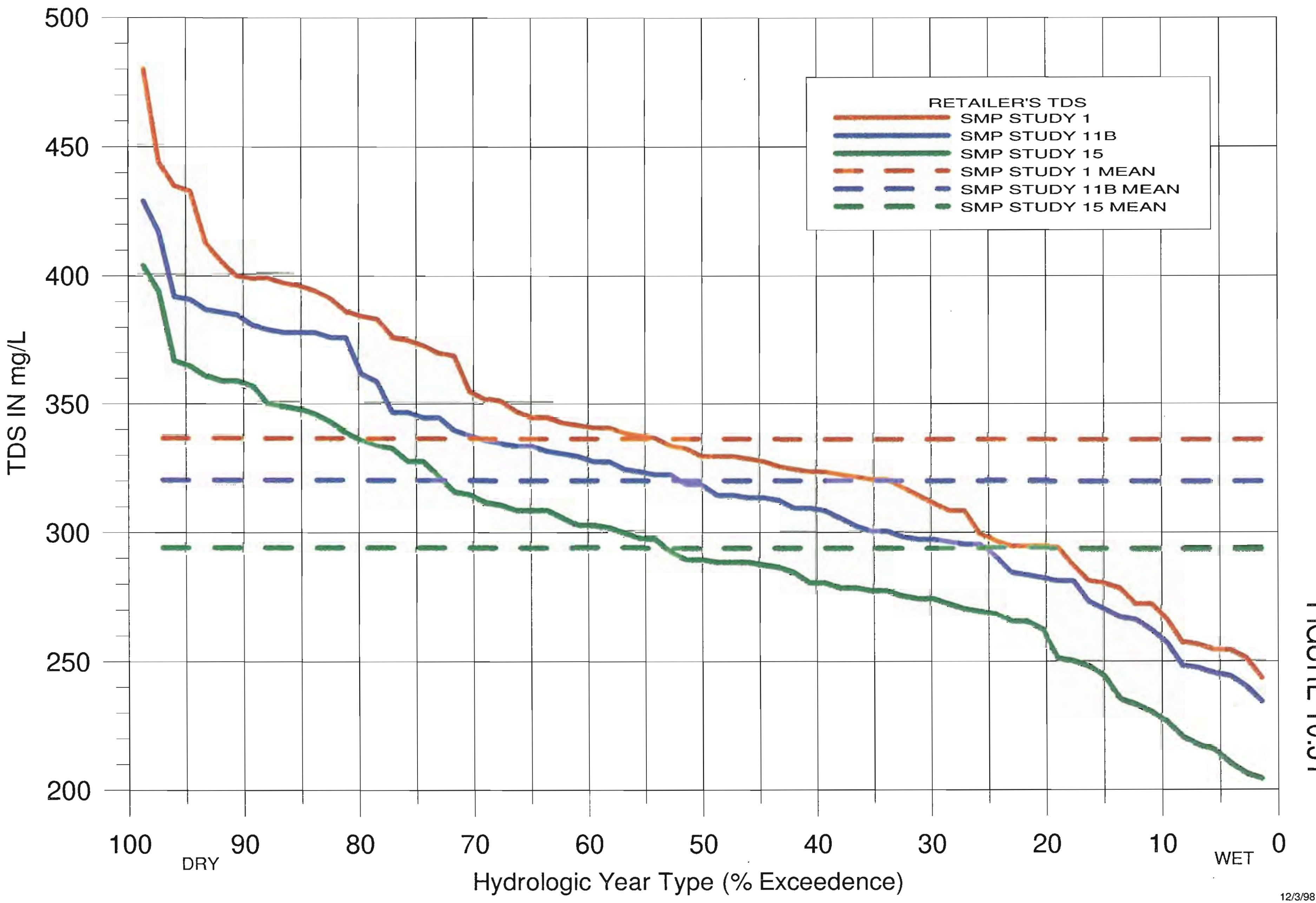


FIGURE 10.31

Table 10.11
Comparing Variability among Retailers under Strategy 1, 11B and 15.

	Long Term Average TDS (mg/L)		
	Strategy 1	Strategy 11b	Strategy 15
Livermore	310	310	310
CWS	320	310	310
Pleasanton	370	330	310
DSRSD	340	320	290
Zone7 Average	330	320	300

Pleasanton and DSRSD receive most of Zone 7's groundwater pumpage. Since the groundwater demineralization facilities are assumed to be connected into the water distribution system near the Hopyard wellfield and Camp Parks wellfield, Pleasanton and DSRSD would benefit the most due to the demineralization of groundwater pumpage under strategies 11B and 15.

Livermore and CWS delivered water quality would not change appreciably since both would continue to receive predominantly treated surface water from Zone 7 under all proposed strategies.

10.6 Apparent Best Year 2010 Strategy

These groundwater and WRMI system modeling results confirm the earlier feasibility screening of studies performed in Section 9.8 that Strategy 15 appears to be the best currently acceptable strategy to eliminate the basin net salt loading. Following is a brief summary of the benefits of Strategy 15 versus other key strategies:

- Lowered groundwater TDS in the upper aquifer in the western part of the Amador and the central part of the Bernal sub-basins. This improvement is due to the shallow groundwater pumpage for demineralization (5 TAF/year) under this strategy. This pumpage would intercept the high TDS subsurface inflow from the Dublin sub-basin and high TDS recharge from urban irrigation. The low TDS recharge from Arroyo Valle and from Lake I would move further into the Bernal sub-basin and help lower the groundwater TDS (Figure 10.22).

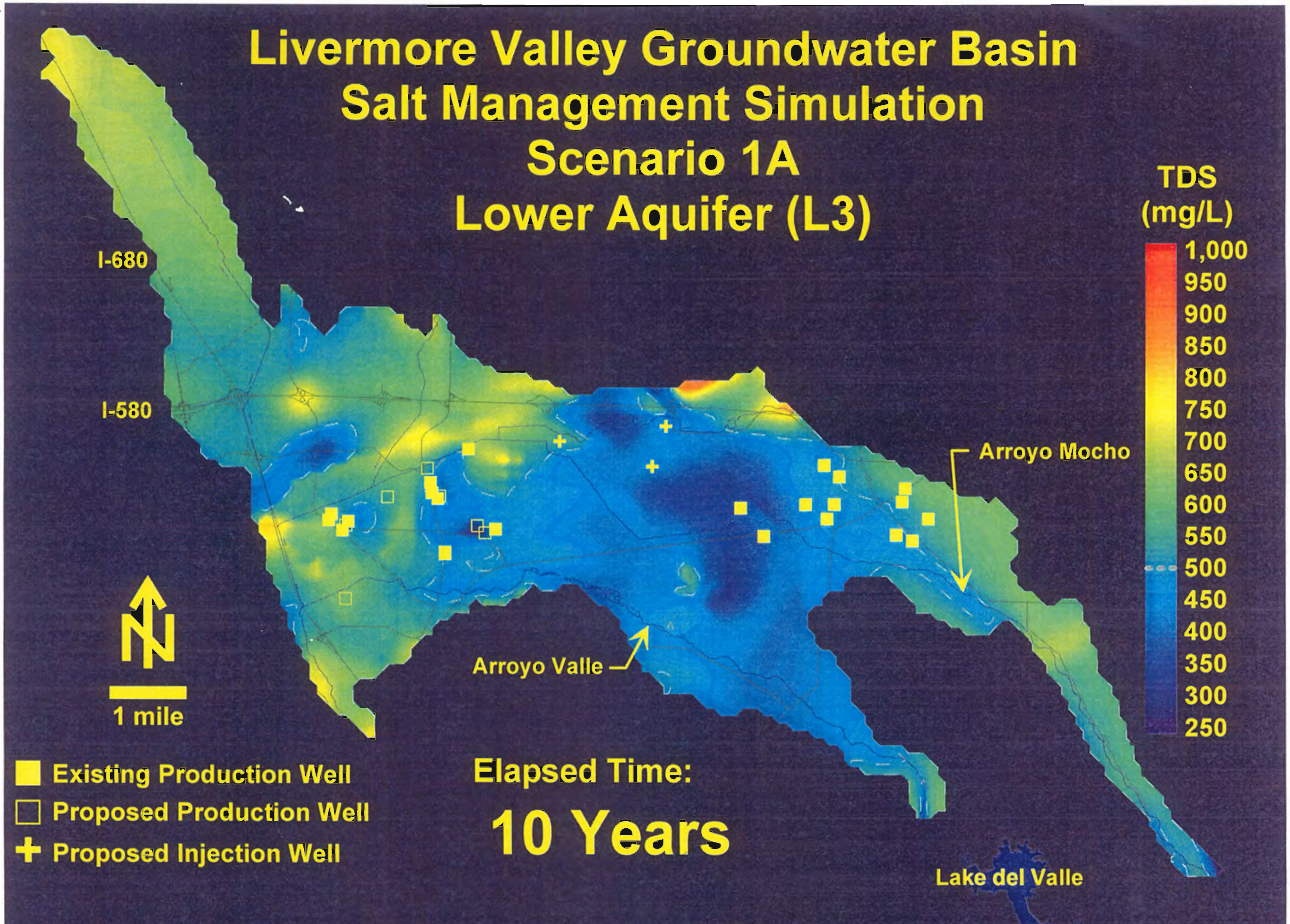
- Figures 10.32 and 10.33 map the modeled groundwater TDS for the lower aquifer after 10 and 25 years for Strategy 1A and figures 10.34 and 10.35 do the same under Strategy 15. When comparing these figures, it is clear that the area of the basin with groundwater TDS below 500 mg/L (blue color) would be significantly larger for Strategy 15 even during earlier time periods (versus the 50-year maps presented earlier in this chapter). The Bernal sub-basin lower aquifer and western portion of the Amador aquifer would benefit most under Strategy 15. Most of the main basin lower aquifer would stabilize around or below 500 mg/L.

- GW TDS at all the municipal well locations under Strategy 15 would be equal to or better than under the other strategies except at Stoneridge well (Figures 10.27-10.30). The Stoneridge well area location TDS could also be improved by increasing local area conjunctive use (beyond that assumed for Strategy 15) while injecting low TDS SWP water into the Stoneridge well or any other nearby future well.

- Zone 7 average delivered water TDS would be lower and more equivalent under Strategy 15 (tables 10.10 and 10.11).

- Strategy 15 would not require any additional facilities other than those already included in the Capital Improvement Program. The incremental O&M cost would add about $50/AF to the Zone 7 treated water rate. Assuming that average annual water use per house is one half acre-foot per year, this would increase the treated water cost by $25 per year per household.

- Strategy 15 doesn't preclude use of any other strategies as they become available in the future (such as groundwater export, RO recycled water injection, etc.). It would facilitate future lower cost seasonal groundwater export since facilities could be readily included to allow pumpage to be diverted to an arroyo, instead of to the demineralization facility, when environmental and institutional conditions permit.



Livermore Valley Groundwater Basin
Salt Management Simulation
Scenario 1A
Lower Aquifer (L3)
TDS
(mg/L)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
I-680
I-580
Arroyo Mocho
Arroyo Valle
N
1 mile
Existing Production Well
Proposed Production Well
Proposed Injection Well
Elapsed Time:
10 Years
Lake del Valle

FIGURE 10.32

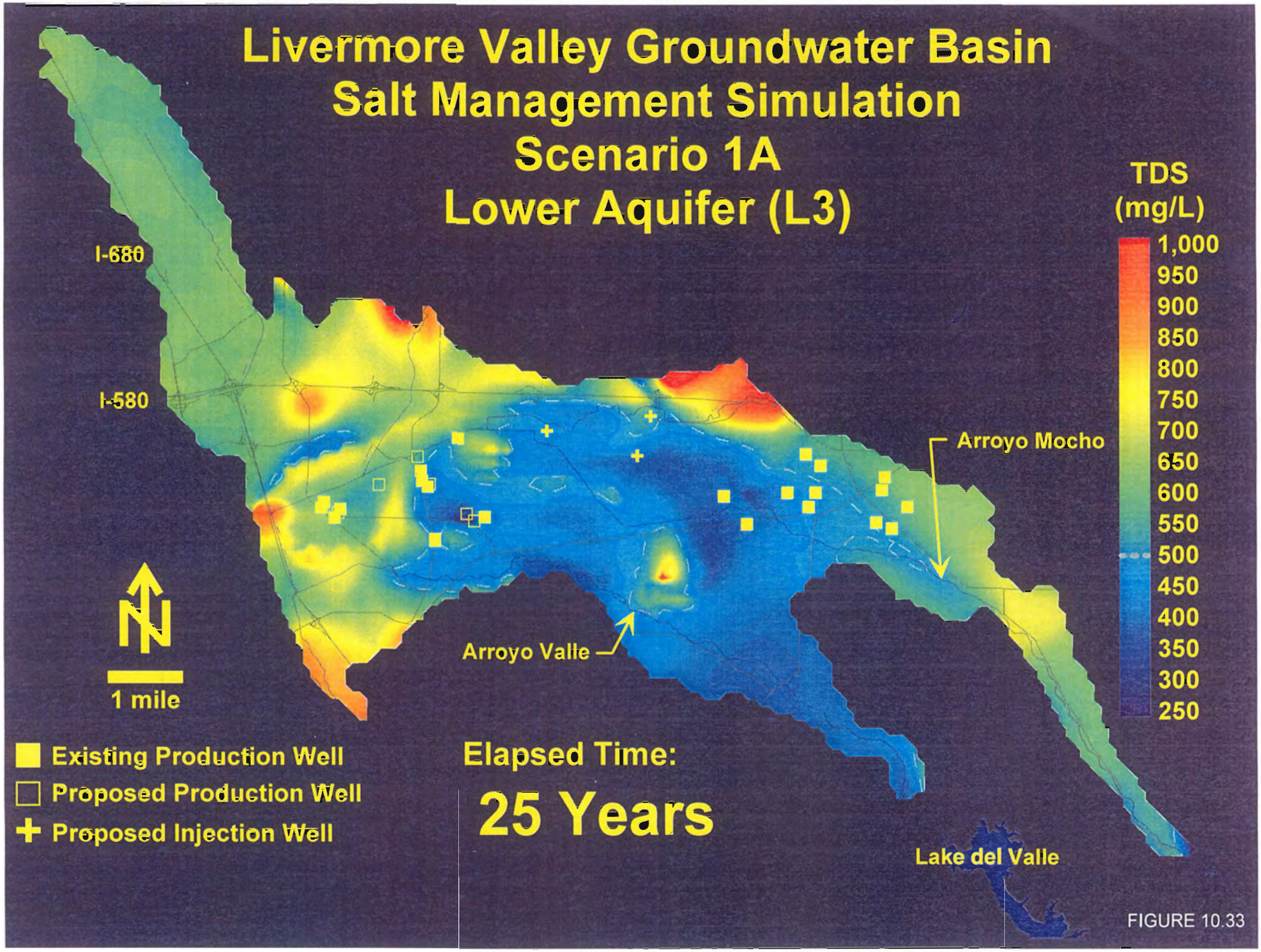

Livermore Valley Groundwater Basin
Salt Management Simulation
Scenario 1A
Lower Aquifer (L3)
TDS
(mg/L)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
I-680
I-580
Arroyo Mocho
Arroyo Valle
Lake del Valle
1 mile
Existing Production Well
Proposed Production Well
Proposed Injection Well
Elapsed Time:
25 Years

FIGURE 10.33

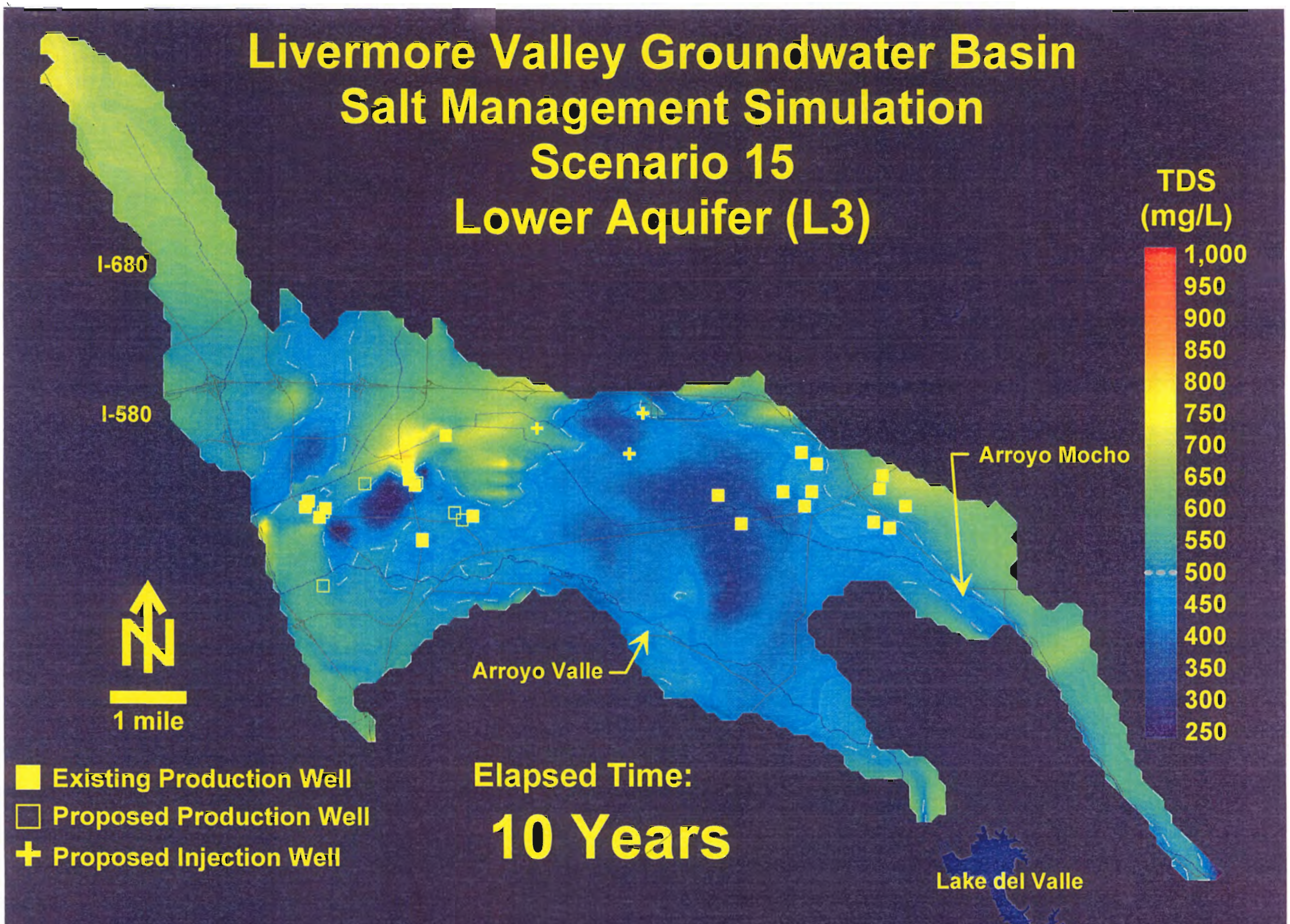
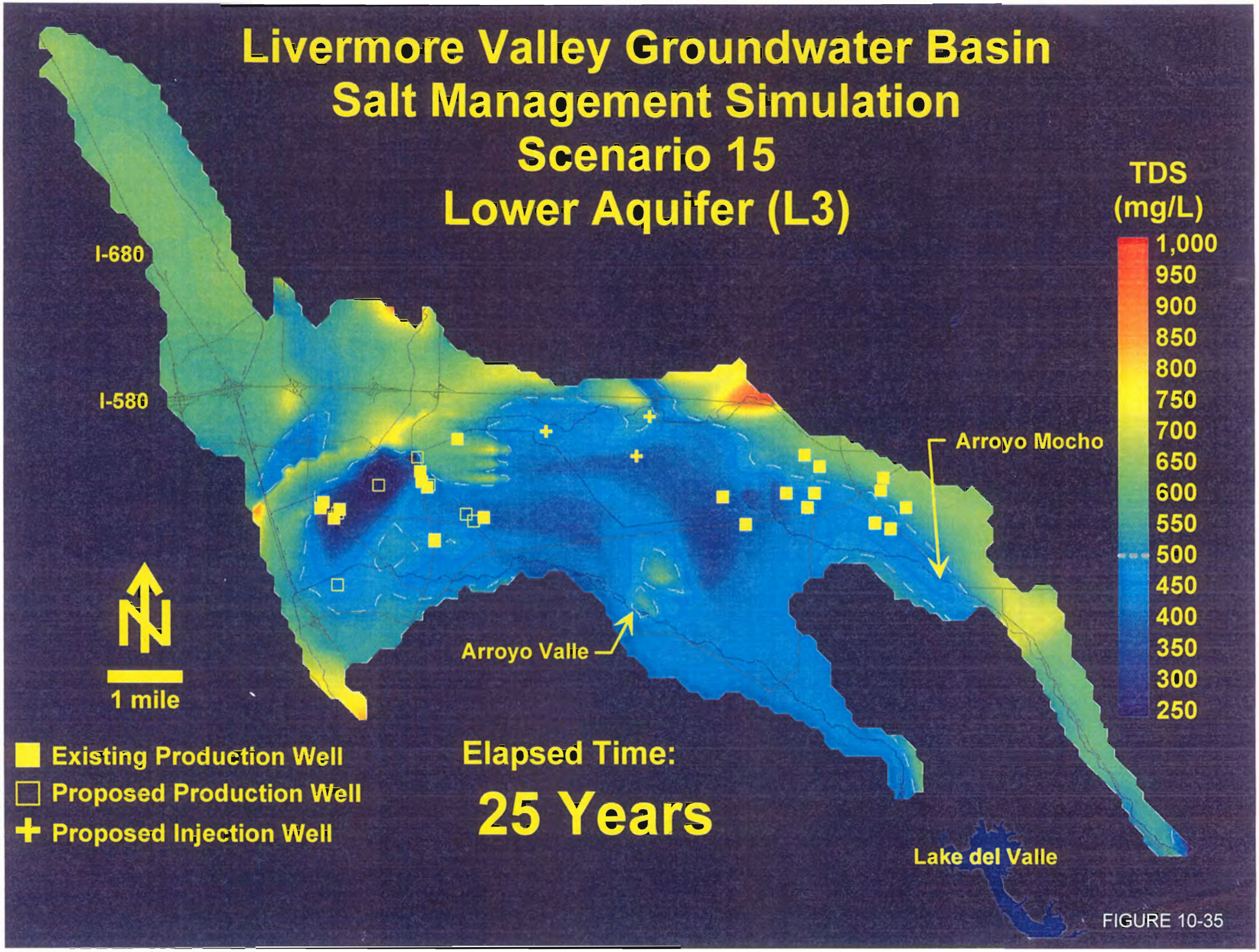

Livermore Valley Groundwater Basin
Salt Management Simulation
Scenario 15
Lower Aquifer (L3)
TDS
(mg/L)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
I-680
I-580
Arroyo Mocho
Arroyo Valle
1 mile
Existing Production Well
Proposed Production Well
Proposed Injection Well
Elapsed Time:
10 Years
Lake del Valle

FIGURE 10.34


Livermore Valley Groundwater Basin
Salt Management Simulation
Scenario 15
Lower Aquifer (L3)
TDS (mg/L)
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
I-680
I-580
Arroyo Mocho
Arroyo Valle
Lake del Valle
1 mile
Existing Production Well
Proposed Production Well
Proposed Injection Well
Elapsed Time:
25 Years
FIGURE 10-35