Executive Summary

Over the past several years the Zone 7 Water Agency (Zone 7) has undertaken a series of studies to guide construction of new wells in the local groundwater basin. Results of this work were originally presented to Zone 7 in the following draft technical memorandums: *Preliminary Wellfield Design* (CH2M HILL, 2001a); *Conceptual Wellfield System Design and Cost Estimate* (CH2M HILL, 2002); *Groundwater Modeling of Wellfield Alternatives* (CH2M HILL, 2003a), and *Well Implementation Plan* (CH2M HILL, 2003b). These technical memorandums are reproduced in this report as individual chapters of this Well Master Plan, with generally minor modifications.

The intent of this Well Master Plan is to identify preferred locations for wells and wellfields, develop preliminary well construction details, assess probable production rates of individual wells, assess well spacing requirements, evaluate sustainable total well yields during drought, assess potential water quality impacts of new wellfields, develop preliminary well facility designs, and prepare preliminary cost estimates. Work involved in the preparation of this plan included developing hydrogeologic cross sections, compiling existing aquifer test data, groundwater modeling, reviewing available water quality data, visiting existing wells, and discussions with operations staff.

This Well Master Plan summarizes results of the above work and provides a flexible road map (the "Well Implementation Plan") intended to guide construction of new Zone 7 wells in the basin. The plan should be viewed as subject to modification as new information becomes available. In particular, water levels and subsidence will need to be monitored as new wells are installed and brought on line, and this information will be used to reassess the location and operation rates for additional new wells.

ES.1 Background

Zone 7 currently operates seven high-capacity municipal water supply wells in the Livermore Valley Groundwater Basin (LVGB) (Figure ES.1-1). Zone 7 needs to increase its groundwater production capacity to meet customer demands during projected droughts and water shortage emergencies. Based on recent State projections, Zone 7 estimates it will require about 45 million gallons per day (mgd) of its own pumping capacity to meet customer demands during worst case droughts. In addition, Zone 7 has a policy of being able to meet 75 percent of valley-wide, maximum day demand via groundwater during emergencies. Based on projected future demands, this translates to a required peak pumping capacity from Zone 7 wells of about 70 mgd. Zone 7 currently has the capacity to produce about 32 mgd of groundwater for short periods of time (a day or so), and 25 mgd for longer periods of time (e.g., to meet drought needs). Results of groundwater modeling indicate that production of more than 25 mgd for long periods of time leads to relatively large downturn below historic lows. Accordingly, Zone 7 would need to more than double its well capacity to meet this target.

Zone 7 previously developed a numerical groundwater model of the basin to use as an aid in assessing groundwater management options and effects. The model is documented in *Livermore Valley Groundwater Basin Model v2.0* (CH2M HILL, 1998). The model was used to assess salt management options, results of which are documented in *Phase 4 Groundwater Modeling: Salt Management Plan Simulations* (CH2M HILL, 1999). This model was used extensively as part of Well Master Plan work.

ES.2 Well Master Plan Approach

Potential new Zone 7 wellfields will be located in the Bernal and Amador subbasin portions of the LVGB. As part of Well Master Plan work, these areas were divided into 11 wellfields and the production potential of the deep aquifer within each of the areas assessed (Figure ES.2-1). Zone 7 is also considering construction of shallow desalting wells to help mitigate salt buildup in the basin. Potential effects of these desalting wells were assessed in select simulations.

Potential locations for new deep aquifer wellfields were identified based on discussion with District staff, initial results of Well Master Plan studies, and previous work in the basin. As part of well master planning efforts, a number of wellfield alternatives were developed and analyzed using Zone 7's groundwater model. For the most part these alternatives represent differences in well locations and pumping rates. The alternatives were grouped into three "scenarios" (Table ES.2-1):

- Scenario 1: Existing wells only
- Scenario 2: Existing well plus new deep aquifer wells
- Scenario 3: Existing wells plus new deep aquifer wells plus new shallow desalting wells

The District has an operational goal of not exceeding historic low water levels to maintain an "emergency" supply of water and protect against potential adverse effects of land subsidence. A map of composite low water levels was prepared and used as a benchmark for simulation results to assess how the various wellfield alternatives met this goal (Figure ES.2-2). Simulated water level lows in the deep aquifer during a severe drought and shorter-term water shortage emergencies were compared with these historic composite water level lows. Areas where simulated water levels decreased below historic lows were noted, and potential impacts were assessed. This was a major criterion in assessing feasibility of the various alternatives and identifying a "preferred alternative" (Figure ES.2-2).

Several levels of impact analysis were performed. Potential basinwide water level impacts were assessed by comparing simulated drought water levels with historical lows. Potential impacts of Zone 7's planned drought operations on individual municipal wells were evaluated by comparing simulated water level lows to well construction information. Instances where simulated water levels fall below either the pump setting or top of well screen were noted and potential impacts to the well assessed.

Potential impacts from individual new wells ("well interference") were assessed by simulating "typical" wells at each wellfield operating at projected peak pumping rates

(Figure ES.2-3). This provided an estimate of the cone of drawdown of individual new wells. These data were also used to assess optimal well spacing within new wellfields. Potential water quality effects new wellfields were assessed for the three scenarios using the groundwater model in a salt transport mode.

Well Master Plan work also included developing preliminary designs for well facilities, including civil, mechanical, electrical, instrumentation, control, and treatment aspects. Conceptual designs were developed for several well facility alternatives to address various siting considerations, treatment options, potential wellfield configurations, and uses of individual wells. Some new wells may be counted on to meet day-to-day demands, while others might only be used for emergency, drought, and peaking supply needs. Design options specific to each potential use, estimates of capital costs, and estimated construction costs for select alternatives were developed.

ES.3 Well Master Plan Summary Results

Following are summary results from Well Master Plan work. More detailed information regarding these issues is provided in individual chapters of the Well Master Plan.

ES.3.1 Hydrogeology

As part of Well Master Plan studies, four hydrostratigraphic zones were defined in the basin: the A, B, C, and D zones (see the example provided in Figure ES.3-1). The D-zone may correspond to Livermore Formation. Although flow is impeded vertically, recent pumping tests indicate significant vertical leakage between the zones. The B and C zones appear much more transmissive than the D-zone, and it appears that the B-zone may be more transmissive than the C-zone. In general, it is recommended that new wells in the basin be screened in lower portions of the B-zone through the bottom of the C-zone. Some areas may benefit from inclusion of the D-zone in the well screen interval. In areas of potential surface contamination it may be best to not screen the B-zone. However, deeper wells near the Fairgrounds have evidence of contamination, indicating that deeper aquifer zones are not free from this threat.

The Mocho Wellfield is located in the most productive proven portion of the LVGB but is already fully developed, as are the Stoneridge and Hopyard Wellfields. The Chain of Lakes, Gravel Pit, and Busch-Valley Wellfields also appear locally favorable. The Valley Avenue Wellfield offers a potentially large area of highly productive aquifer, but test wells are needed to confirm these properties and assess local groundwater quality. In general, significant portions of aquifer underlying each of these areas appears well-suited for construction of multiple high-capacity municipal water supply production wells.

Potential water level impacts from individual new wells on surrounding areas were modeled to assess potential well interference effects and assist in optimizing well spacing. Results indicate that wells should be spaced about 500 feet apart, on average, depending on local aquifer properties, screen intervals, and intended use. Aquifer tests need to be conducted after each new well is completed to better define these values.

To assess potential effects of new wellfields on salt movement in the basin, several salt transport simulations were conducted. Simulation results indicate that installation and use of new deep aquifer wells has relatively little effect on total dissolved solid (TDS) distribution in the deep aquifer (Figures ES.3-2 through ES.3-4). Installation of shallow desalting wells has the greatest effect and leads to a relatively large benefit in terms of reducing overall TDS in the basin and lowering TDS of pumped groundwater at individual production wells (Figure ES.3-5).

Because wells in the Chain of Lakes and Gravel Pit Wellfield areas are located within several hundred feet of surface water, they will likely need to undergo an assessment to determine if they are “under the direct influence” of the surface water. It is recommended that Zone 7 open discussions with California Department of Health Services (DHS) on this issue as soon as possible. These discussions should include agreement on required water quality testing and if existing or small test wells can be tested to expedite the analysis.

ES.3.2 Ground Subsidence

When a well is pumped in a confined aquifer, the water levels in the surrounding aquifer/aquitard system are lowered with a resultant decrease in hydrostatic pressures and increase in grain-to-grain effective stresses. This increase in stress compresses the soil structure and results in ground subsidence. The rate and total amount of subsidence are dependent on a number of factors, including local aquifer and aquitard properties, the amount and duration of drawdown, local geologic structures, and local changes in stratigraphy.

Of particular interest is the value of drawdown at which an aquifer/aquitard system changes from “elastic” to “inelastic” deformation. After the first cycle of historical drawdown, the change from elastic to inelastic deformation is typically coincident with the minimum historical heads (pore pressures) in aquitards interbedded and contiguous with pumped aquifers. When aquitard pore pressures in these zones decline below previous minima, the aquifer system releases a relatively large amount of water from “inelastic” aquitard storage, but at the cost of relatively large amounts of land subsidence. When aquitard pore pressures are maintained above historic low pressures, a confined aquifer/aquitard system gains and releases water largely from elastic storage, accompanied by relatively small movements of the land surface.

Historical low water levels (as measured in major aquifers) are often used as a guide of allowable pressure minima in the system; this is largely due to the fact that these are the only zones where abundant data are available. However, this approach assumes that the entire aquifer/aquitard system has fully equilibrated to these lower pressures, which is rarely the case. Historic low water elevations can therefore be used as a indicator of the threshold of inelastic response but not as an absolute reference.

For purposes of this report, historical low water levels were used as a key yardstick in evaluating results of model simulations. Wellfield alternatives that led to widespread and significant (generally more than 10 to 20 feet) declines in water levels below historical lows were rejected. Subsidence investigations currently underway by Zone 7 will help better define subsidence issues. As groundwater production from the basin increases, it is recommended that subsidence monitoring be implemented using a combination of survey points, satellite imagery (InSAR), and/or extensometers. Subsidence observations from a properly implemented monitoring program can be used to adjust pumping rates to mitigate subsidence.

ES.3.3 Wellfield Alternatives

Wellfields were screened and ranked based upon results of Well Master Plan work and other studies (Table ES.3-1). As shown in this matrix, four of the wellfields have significant limitations for new wells due to limited available drawdown above historic lows. The remaining Wellfields have similar ranking scores, with the Chain of Lakes and Gravel Pit Wellfields ranking highest overall. Test wells are recommended in all previously untested areas to confirm potential well yields, aquifer transmissivity, and water quality. These aspects of the Busch-Valley Wellfield have been adequately delineated by previous test drilling.

Zone 7 needs to increase its well production capacity to meet customer demands during drought periods when State Water Project allocations are reduced. Based on recent State Water Project allocation figures, Zone 7 projects it will need a total of about 45 mgd of groundwater production capacity to meet projected worst-case 1-year and 6-year drought demands. Results of groundwater modeling conducted as part of this study indicate that Zone 7 can produce 45 mgd of groundwater from the basin during drought with only minimal exceedance of historical low water levels under a number of wellfield alternative.

Modeled alternatives require construction of about seven to 15 new wells in "outer" wellfields to pump about 27 mgd of groundwater, with the remainder (18 mgd) coming from existing Zone 7 wells. Existing wells cannot be relied upon to produce more that 18 mgd of groundwater when new adjacent wellfields are operating without risk of potentially significant declines of water levels below historical lows. Fewer wells are required (possibly as few as seven) if the Chain of Lakes and Gravel Pit Wellfields are preferentially developed and prove productive. This alternative, "Scenario 2d," is herein referred to as the "preferred alternative" (Figure ES.3-6). More wells will be required (possibly as many as 15) if marginal wellfields are developed (such as Stanley Avenue and Isabel Wellfields), or the Chain of Lakes and Gravel Pit Wellfields prove less productive than currently thought. Figures ES.3-6 and ES.3-7 show the relationship of water levels to historical lows at the height of 1-year and 6-year droughts, respectively, under the preferred alternative. Positive numbers indicate modeled water levels are above historical lows, negative numbers below.

Under the preferred alternative, Zone 7's total instantaneous well capacity will be approximately 52 mgd—25 mgd from existing Zone 7 wells and 27 mgd from new wells. Modeling indicates that 52 mgd of groundwater production from these wells can be sustained for at least 4 days with water levels remaining above historical lows, but that after 30 days of continuous pumping, water levels fall significantly below historical lows in northern portion of the basin.

If maximum day demands of 70 mgd are to met for extended periods of time (30 days or more), then additional wells will need to be constructed in the eastern portions of the basin. The Chain of Lakes and Gravel Pit Wellfields are favorable in this respect. Expanded use of these wellfields under the preferred alternative could allow Zone 7 to pump about 70 mgd from the basin for extended periods of time (about 60 days) without water level declines below historical lows. This would require installation of a total of about three to eight more new wells than those required for drought protection.

Further modeling would likely be successful in optimizing Scenario 2d well locations and pumpage distributions to reduce all exceedances to less than historical maximums. However, this implies a level of accuracy relative to actual future response of the system that is unreasonable, given the assumptions made during modeling. In addition, simply keeping water levels above observed historical lows will not necessarily prevent subsidence. Therefore, results of this evaluation need to be viewed as a general guide as to how much groundwater might be produced from the basin not an absolute answer. As new wells and wellfields are installed, they will need to be tested and their effects monitored to assess actual impacts. Wellfield construction activities and well operations can then be adjusted as needed. The implementation plan lends itself to this systematic approach.

ES.4 Well Facility Design

Current and planned future land uses in the area indicate that most of the new wells will be located in an urban environment. Potential facility impacts to the surrounding environment include aesthetic, noise, traffic, and risk. Some of these potential impacts, such as aesthetics and noise, can be significantly reduced through design considerations. Potential impacts from other sources, such as equipment and chemical deliveries, can be partially reduced through design. Well facility design options specific to each of these areas were developed as part of the Well Master Plan. A conceptual design for a well in an urban setting is provided as Figure ES.4-1.

Pumping rates for new wells are expected to be in the range of 2,000 gallons per minute (gpm) to 4,000 gpm. The type of pumps used for the new wells may be either vertical turbine or submersible. Vertical turbine pumps are generally preferable because of ease of access to the electrical motor, generally higher pump efficiencies, and lower overall cost. To reduce noise levels, vertical turbines may require noise-insulated buildings. For areas where noise becomes an overriding consideration, the use of submersible pumps should be considered.

Groundwater pumped from wells will require disinfection prior to entering the distribution system. Disinfection at Zone 7’s existing wells consists of using chlorine and ammonia to form a chloramine residual. It is assumed that the new wells will undergo similar treatment. Future treatment may include addition of fluoride. Disinfection at the new wells may take place using one of two methods: on-site, salt-based chlorine generation, or bulk deliveries of liquid sodium hypochlorite. On-site chlorine generation is more desirable from a safety viewpoint because it avoids frequent truck deliveries, and large tanks of concentrated solution are not stored on site. However, on-site generation is more expensive and may not be appropriate for wells that will be used infrequently.

Based on site-specific considerations, treatment may occur in an adjacent building contiguous with the well or in a separate building. Within a given wellfield, each well may be manifold to a common treatment system or be outfitted with its own treatment system. Conveyance facilities will need to be constructed to connect new wells to the existing distribution system. New pipes will range in size from 10 to 36 inches in diameter, depending on well production rates. It is assumed that pipe materials will be ductile iron or welded steel, cement, mortar-lined, and coated.

ES.5 Construction Schedule

The well construction schedule is driven by increases in water demand as it relates to reliability. Based on these increases, the Well Implementation Plan indicates the need to construct about one new well each year for the next 5 years and two additional wells in following years (Table ES.5-1 and Figure ES.4-2). It is recommended that the first well be completed in 2005. However, the well construction schedule should remain flexible and responsive to potential revisions in demand projections, and actual well yields encountered as new wells are constructed. This schedule provides Zone 7 with a sustainable drought capacity that keeps up with increasing demand through buildout (Figure ES.5-1). Although it does not meet 75-percent maximum day demand projections, it does maintain or slightly improve the percent of maximum day demand that wells can meet (Table ES.5-1 and Figure ES.5-2).

ES.6 Cost Estimate

Construction cost estimates for select wellfield alternatives are summarized in Table ES.6-1. These cost estimates assume that new wells are serviced by individual treatment systems using on-site chlorine generation. This table indicates that construction of enough new wells to meet drought demands will cost between 23 and 36 million dollars. The higher cost estimates are associated with development of marginal wellfields, including the Stanley Avenue and Isabel Avenue Wellfields. Current information suggests that three to eight additional wells would be required to meet both the drought and future 70 mgd maximum day demand target. The incremental costs for these wells is estimated to be about $10 to $25 million (in 2003 dollars), assuming that the wells are built in the Chain of Lakes and Gravel Pit Wellfields as simple extensions of the preferred alternative.

ES.7 Recommendations for Additional Work

Based upon findings of this Well Master Plan, the following work is recommended:

- Pursue development of high-capacity municipal water supply wells in the Chain of Lakes and Gravel Pit Wellfields. Of key concern is testing that DHS might require to determine if municipal wells in these areas are “under the direct influence to surface water.” If DHS determines testing will be required, then test procedures and protocols should be agreed upon and implemented as soon as possible.

- Assuming discussions with DHS are favorable, install test wells at the Chain of Lakes and Gravel Pit Wellfields as soon as possible. The wells should be tested to assess local aquifer properties and sampled to determine local water quality.

- Review the groundwater model as the above data are collected. If observed aquifer properties are in line with those used in the model, then well spacing and total production rates developed in this report will remain valid, otherwise the model may need to be adjusted and wellfield expansion scenarios reassessed.

Scenario	Run	Existing Z7 Capacity			Additional New Well Capacity	Total Z7 Capacity			Comments
		Avail	Used	Idle		Avail	Used	Idle	
Scenario-1: Existing Wells									
1a	**504**	31.9	31.9	0.0	0.0	31.9	31.9	0.0	Average monthly pumping. Total max Z7 well Q=32 mgd
1a	**504a**	31.9	31.9	0.0	0.0	31.9	31.9	0.0	Peak monthly pumping. Total max Z7 well Q=32 mgd
1b	**504b**	31.9	25.1	6.8	0.0	31.9	25.1	6.8	Turn off Mocho-1 and Mocho-2. Total max Z7 well Q now is 25 mgd.
Scenario-2: Existing Wells + New Wells									
2a	**503a**	31.9	25.1	6.8	45.2	77.1	70.3	6.8	Turn off Mocho-1 & Mocho-2
2b	**503c**	31.9	7.2	24.7	63.1	95.0	70.3	24.7	Construct more wellfields. Turn off Mocho-1 & Mocbo-2. Reduce Q in other existing wells
2c	**503f**	31.9	13.4	18.5	41.7	73.6	55.1	18.5	Reduce peak Z7 pumpage to 55 mgd w/ "reasonable" wellfields.
2d	**506c**	31.9	17.9	14.0	27.4	59.3	45.3	14.0	Reduce peak Zone 7 pumpage to 45 mgd. Turn off Mocho-1 and Mocho-2. Use minimal new wells.
	805	31.9	25.1	6.8	27.4	59.3	52.5	6.8	*Max day demand simulation:* all wells on at max rates
	806	31.9	15.1	16.8	53.1	85.0	68.2	16.8	*Max day demand simulation:* Cut back existing well Q and drill additional new wells in outer wellfields
2e	**507**	31.9	17.9	14.0	27.1	59.0	45.0	14.0	Put at least one well in all outer wellfields
2f	**508**	31.9	17.9	14.0	27.4	59.3	45.3	14.0	Put at least two wells in all outer wellfields
Scenario-3: Existing Wells + New Wells + Desalting Wells									
3	**502a**	31.9	13.4	18.5	37.2	69.1	50.6	18.5	Add in an additional 5 mgd of shallow desalting pumpage to these values

TABLE ES.2-1
SUMMARY OF SELECT MODEL SIMULATIONS
(ALL VALUES IN MGD)
ZONE 7 WATER AGENCY
WELL WATER PLAN

Capacity Summary.xls - - Data Summary - - 10/09/2003

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Issue	Criteria	weight	Wellfield											
			Gravel Pit	Chain of Lakes	Bernal	Busch-Valley	Valley (north)	Stanley	Valley (south)	Isabel	Martin Avenue	Hopyard	Mocho	Stoneridge
Environmental	Current land use	2	3.0	3.0	2.5	3.0	1.0	3.0	1.0	3.0	2.0	1.0	1.0	2.0
Environmental	Proximity to nearby municipal wells	2	3.0	3.0	2.5	2.5	3.0	3.0	3.0	3.0	3.0	2.0	1.0	3.0
Environmental	Proximity to known local contamination	2	3.0	2.5	2.5	1.0	2.0	3.0	2.0	1.5	3.0	2.0	2.0	2.5
Environmental	Proximity to sensitive biologic resources	3	2.0	2.0	2.5	3.0	3.0	2.0	2.0	2.0	3.0	2.5	2.5	3.0
Physical	Avail drawdown above historic low WL	3	3.0	3.0	2.5	2.0	1.5	3.0	2.5	3.0	0.0	0.0	0.0	0.0
Physical	Potential discharge rate	3	3.0	3.0	2.0	1.0	3.0	1.0	3.0	1.0	2.0	3.0	3.0	3.0
Physical	Water quality - TDS	2	2.0	2.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0
Physical	Water quality - Hardness	2	2.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Cost	Possible GW under the influence impact	2	2.0	2.0	3.0	2.5	3.0	2.0	3.0	1.0	2.5	3.0	3.0	3.0
Cost	Proximity to existing infrastructure	3	1.0	1.0	1.0	3.0	2.0	1.5	1.0	1.5	3.0	3.0	3.0	3.0
		Score >>>>>	**57**	**56**	**55**	**55**	**55**	**53**	**52**	**48**	**53**	**50**	**48**	**58**

Issue	Criteria	Scoring Basis			
		0	**1**	**2**	**3**
		Very Unfavorable	**Unfavorable**	**Adequate**	**Very favorable**
Environmental	Current land use	no space	residential	commercial	open space parcel
Environmental	Proximity to nearby municipal wells	< 100 feet	100 to 500 feet	500 to 1,000 feet	> 1,000 feet
Environmental	Haz mat: number of sites in EDR report 9July02)	in major plume	12 sites present	5 to 6 sites present	1 to 2 sites present
Environmental	Proximity to sensitive biologic resources	in sensitive habitat	near known sensitive habitat	distant from known sensitive habitats	no sensitive habitats
Physical	Avail drawdown above historic low WL (pref alt)	0 feet	< 50 feet	50 to 100 feet	> 100 feet
Physical	Potential discharge rate	< 500 gpm	500 to 750 gpm	1,000 to 2,000 gpm	> 2,000 gpm
Physical	Water quality - TDS	> 1,000 ppm	600 to 1,000 ppm	400 to 600 ppm	< 400 ppm
Physical	Water quality - Hardness	> 500 ppm	300 to 500 ppm	200 to 300 ppm	< 200 ppm
Cost	Possible GW under the influence impact	known impact	within 500 feet of pit	500 to 1,000 feet from pit	> 1,000 feet from pit
Cost	Proximity to existing infrastructure	> 20,000 feet	> 5,000 feet	1,000 to 5,000 feet	< 1,000 feet

Wellfield ranking.xls - 10/10/2003

TABLE ES.3-1
WELLFIELD RANKING
ZONE 7 WATER AGENCY
WELL WATER PLAN

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YEAR	Valleywide Max-Day Demand	Zone 7 GW Demand During Drought	Zone 7 Drought Pumping from Existing Wells	**Number of New Zone 7 Wells**	**New Zone 7 Well Capacity**	**Total Zone 7 Well Capacity**	**Total Zone 7 Drought Well Capacity**	**Valley-Wide Emergency Well Capacity[1]**	**Percent Valley-Wide MDD**	**Busch-Valley**		**Chain of Lakes**		**Gravel Pit**		**Bernal**	
										Well Q	Number of Wells	Well Q	Number of Wells	Well Q	Number of Wells	Well Q	Number of Wells
	mgd	mgd	mgd		mgd	mgd	mgd	mgd		mgd		mgd		mgd		mgd	
2001	82.0	21.0	20.0			**20.0**	**20.0**	**40.9**	50%								
2002	84.2	21.0	25.1			**25.1**	**25.1**	**46.0**	55%								
2003	87.6	21.0	25.1			**25.1**	**25.1**	**46.0**	53%								
2004	91.1	23.0	25.1			**25.1**	**25.1**	**46.0**	51%								
2005	94.6	25.0	25.1	**1**	**2.9**	**28.0**	**28.0**	**48.9**	52%	2.9	1						
2006	98.3	29.0	25.1	**1**	**7.2**	**32.3**	**32.3**	**53.2**	54%			4.3	1				
2007	98.7	31.0	22.0	**1**	**11.5**	**36.6**	**33.5**	**57.5**	58%			4.3	1				
2008	101.3	33.0	17.9	**1**	**15.8**	**40.9**	**33.7**	**61.8**	61%					4.3	1		
2009	103.7	35.0	17.9	**1**	**20.1**	**45.2**	**38.0**	**66.1**	64%					4.3	1		
2010	105.8	37.0	17.9		**20.1**	**45.2**	**38.0**	**66.1**	62%								
2011	107.8	39.5	17.9	**1**	**23.7**	**48.8**	**41.6**	**69.7**	65%					3.6	1		
2012	110.0	41.0	17.9		**23.7**	**48.8**	**41.6**	**69.7**	63%								
2013	111.9	41.0	17.9		**23.7**	**48.8**	**41.6**	**69.7**	62%								
2014	113.0	41.0	17.9		**23.7**	**48.8**	**41.6**	**69.7**	62%								
2015	113.9	41.0	17.9	**1**	**27.3**	**52.4**	**45.2**	**73.3**	64%							3.6	1
2016	114.7	41.8	17.9		**27.3**	**52.4**	**45.2**	**73.3**	64%								
2017	115.5	42.6	17.9		**27.3**	**52.4**	**45.2**	**73.3**	63%								
2018	116.2	43.4	17.9		**27.3**	**52.4**	**45.2**	**73.3**	63%								
2019	117.0	44.2	17.9		**27.3**	**52.4**	**45.2**	**73.3**	63%								
2020	117.6	45.0	17.9		**27.3**	**52.4**	**45.2**	**73.3**	62%								
TOTALS				**7**	**27.3**	**52.4**	**45.2**	**73.3**		**2.9**	**1**	**8.6**	**2**	**12.2**	**3**	**3.6**	**1**

1. Assumes retailer pumping capacity remains 20.9 mgd and existing Zone 7 wells can pump 25.1 for the duration of the emergency

Well construction schedule v1.xls - - Data-Scen506c - - 4/21/2004

TABLE ES.5-1
SCENARIO 2D: WELL CONSTRUCTION SCHEDULE TO MEET DROUGHT DEMANDS

ZONE 7 WATER AGENCY
WELL WATER PLAN

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163304.WM.06_W102003001SFO_Z7 TABLE ES-5-1_10/23/03_mai

	Scenario-2d	Scenario-2e	Scenario-2f
Simulation run number	506c	507	508
Number of new wells	7	12	15
Cost Elements			
Well Drilling, Construction, & Testing	$2.8	$4.2	$4.6
Well Pump & Mechanical Equipment	$1.1	$1.5	$1.7
Wellhead Pipe, Valves & Fittings (On-site Piping)	$0.9	$1.2	$1.3
Chemical Treatment System Equipment	$0.9	$1.3	$1.3
Buildings, Residential Area, $150/sf	$2.1	$3.3	$3.6
Civil Site Work, Residential Area	$0.3	$0.4	$0.4
Electrical$0.5		$0.6	$0.7
Instrumentation and Controls	$0.7	$1.1	$1.2
Water Main, 4 ft cover, ac replacement	$3.9	$5.8	$5.4
General Conditions	$1.3	$1.9	$2.0
Construction Contingency	$4.3	$6.4	$6.7
Engineering & Legal	$4.7	$6.9	$7.3
Total Cost	**$23.3**	**$34.6**	**$36.3**

Notes:

All costs are in millions of dollars

All costs are for preliminary planning purposes only and are not site specific

All costs are based on 2002 prices.

Water main costs do not include any special utility, street or other crossing.

Zone 7 Cost Sheet for implementation plan v4.xls - - Cost Summary - - 10/10/2003

TABLE ES.6-1
PRELIMINARY CAPITAL CONSTRUCTION COST ESTIMATES
FOR SELECT SCENARIOS (MILLIONS)
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

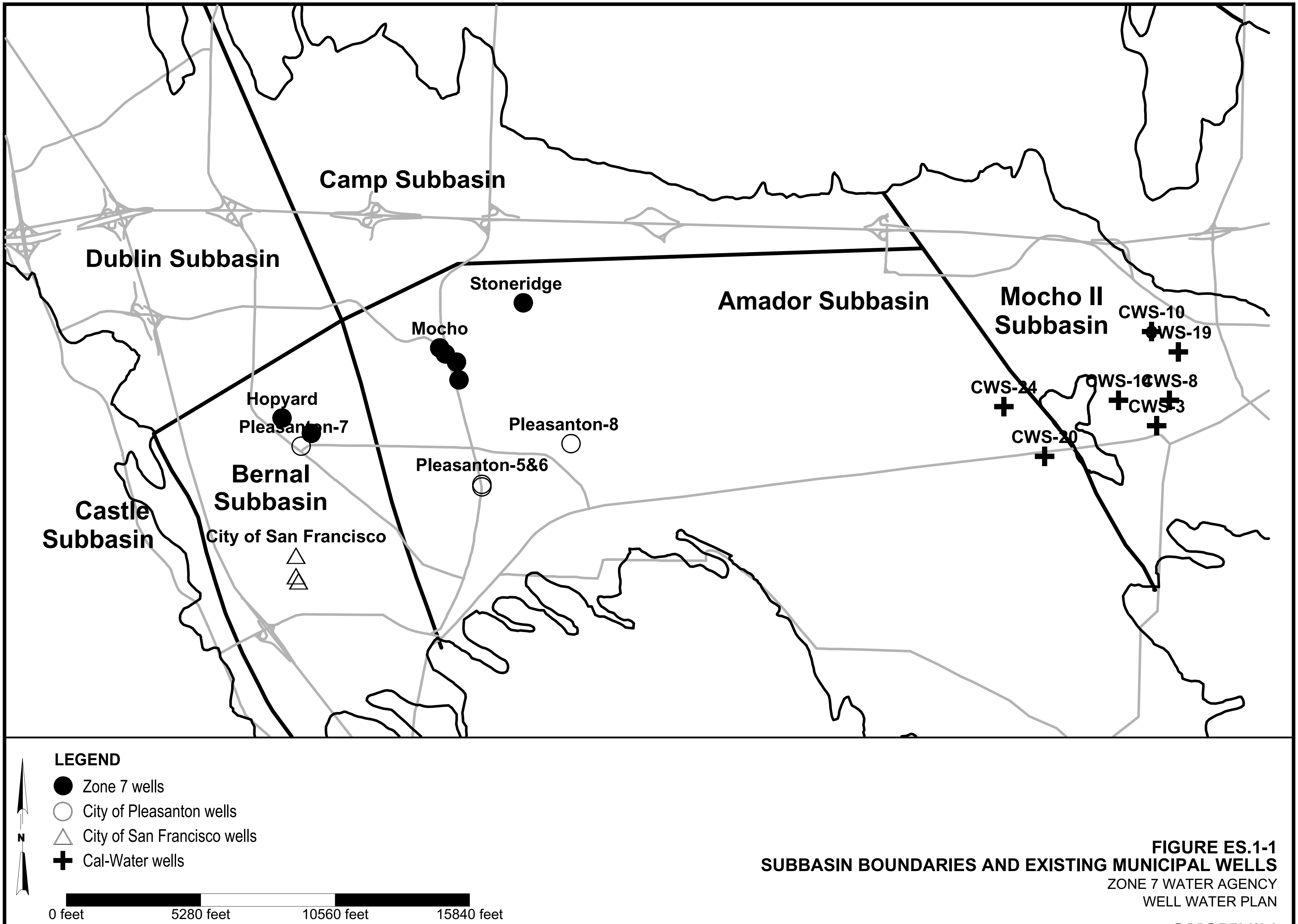
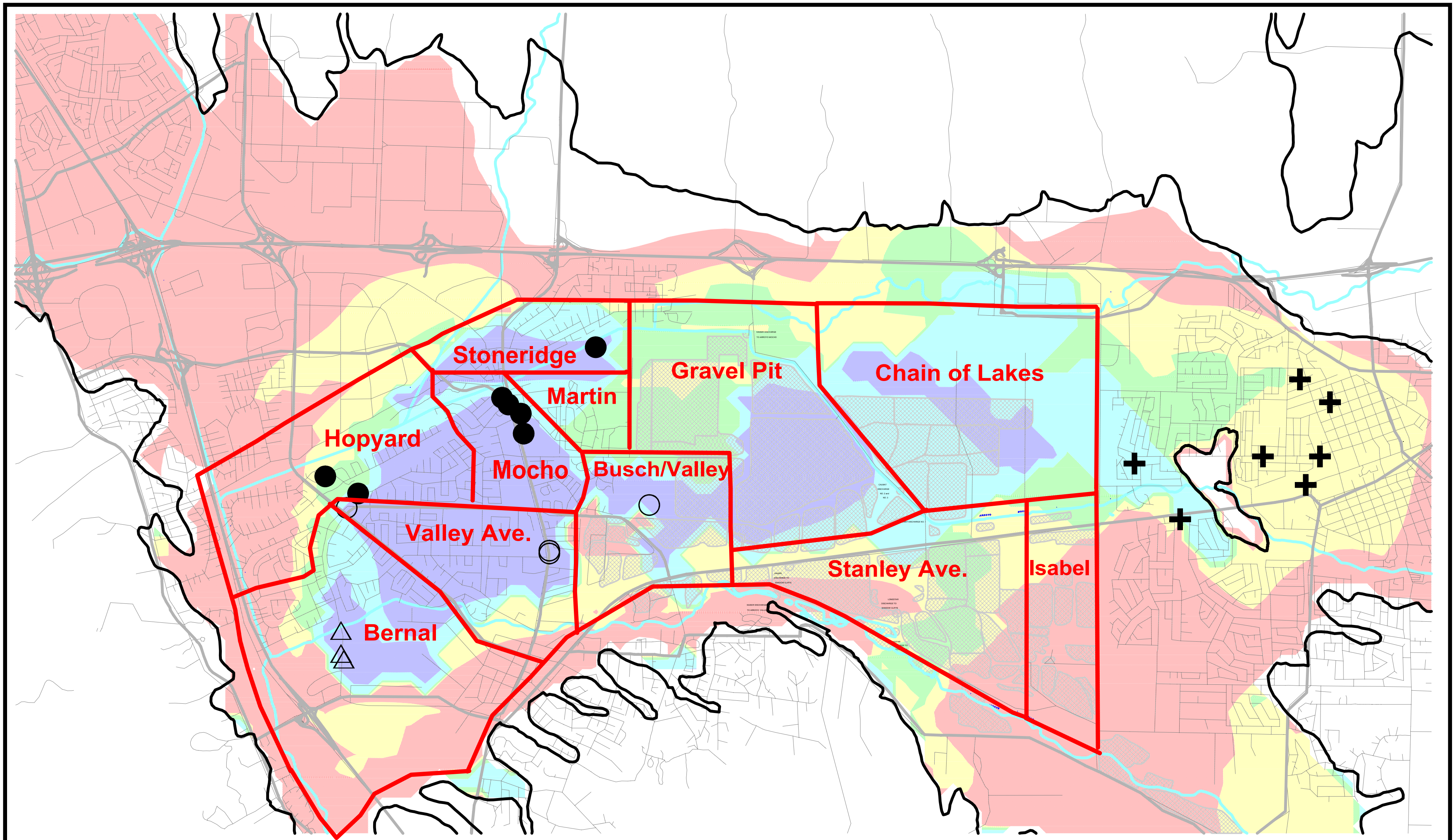


FIGURE ES.1-1
SUBBASIN BOUNDARIES AND EXISTING MUNICIPAL WELLS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE ES-1-1_10/10/03_ccc



N

LEGEND

- Zone 7 wells
- City of Pleasanton wells
- City of San Francisco wells
- Cal-Water wells

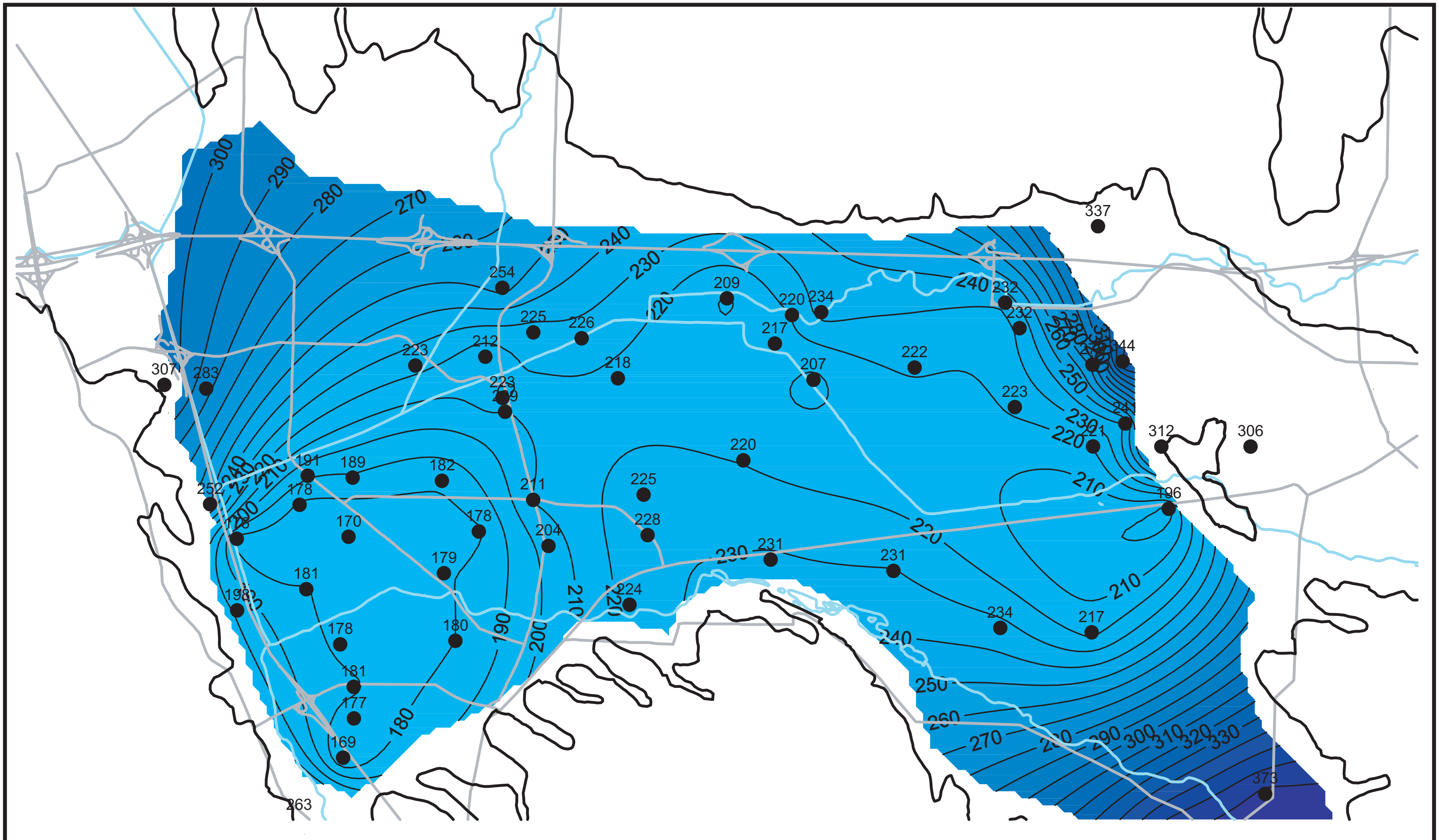
5,000 | 25,000 | 50,000 | 100,000 | 300,000

0 feet | 5280 feet | 10560 feet | 15840 feet

FIGURE ES.2-1
MODEL TRANSMISSIVITY AND WELLFIELD LOCATIONS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE ES.2-1_10/10/03_ccc



LEGEND

● Observation Well

N

0 feet 5280 feet 10560 feet 15840 feet

FIGURE ES. 2-2
HISTORIC COMPOSITE LOW WATER LEVELS IN THE DEEP AQUIFER
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE ES-2-2.ai_10/23/03_mai

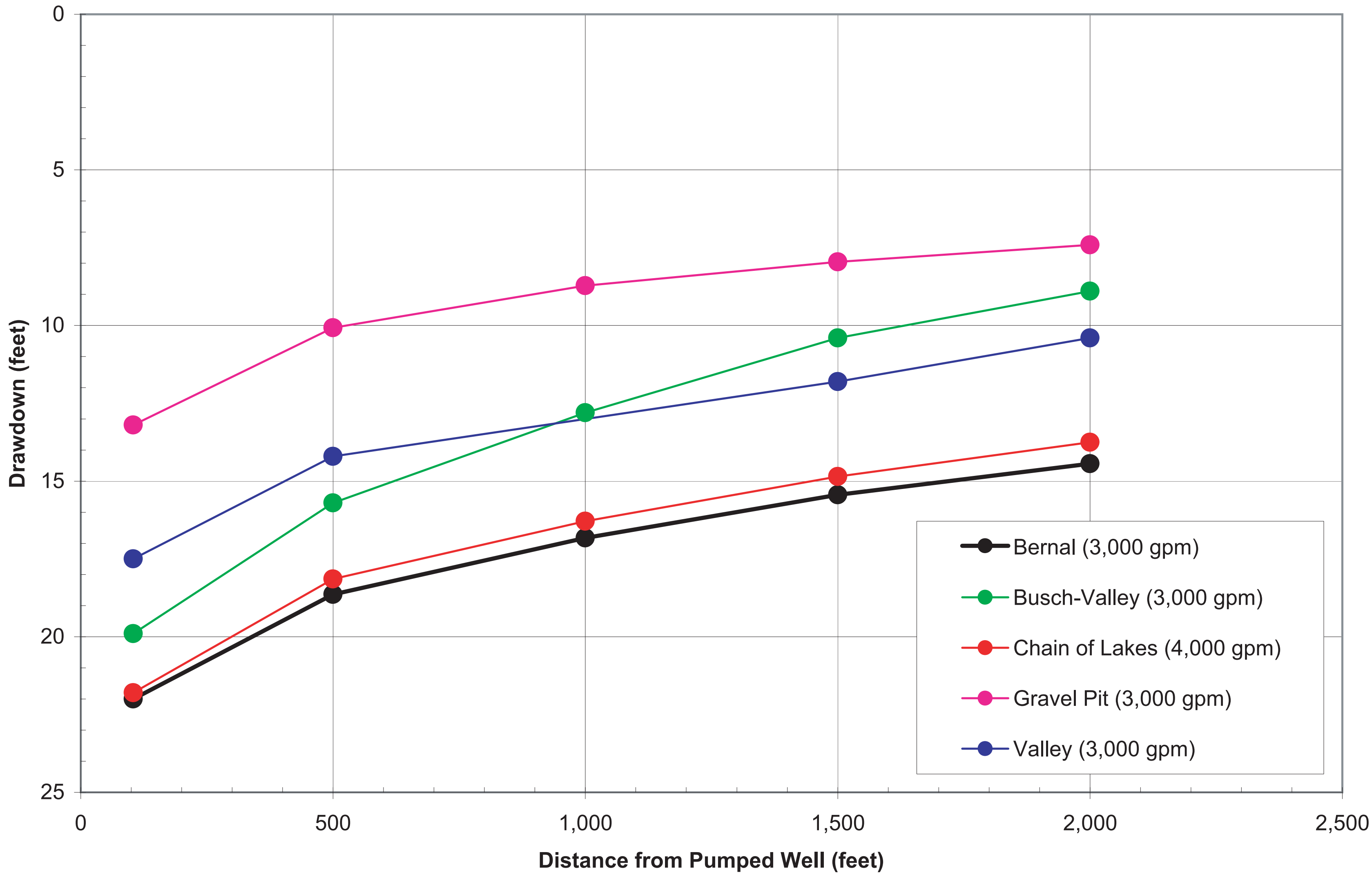


FIGURE ES.2-3
WELL INTERFERENCE: DISTANCE DRAWDOWN GRAPHS FOR PUMPING WELLS (ABOUT 10 DAYS PUMPING AT SPECIFIED RATES)
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

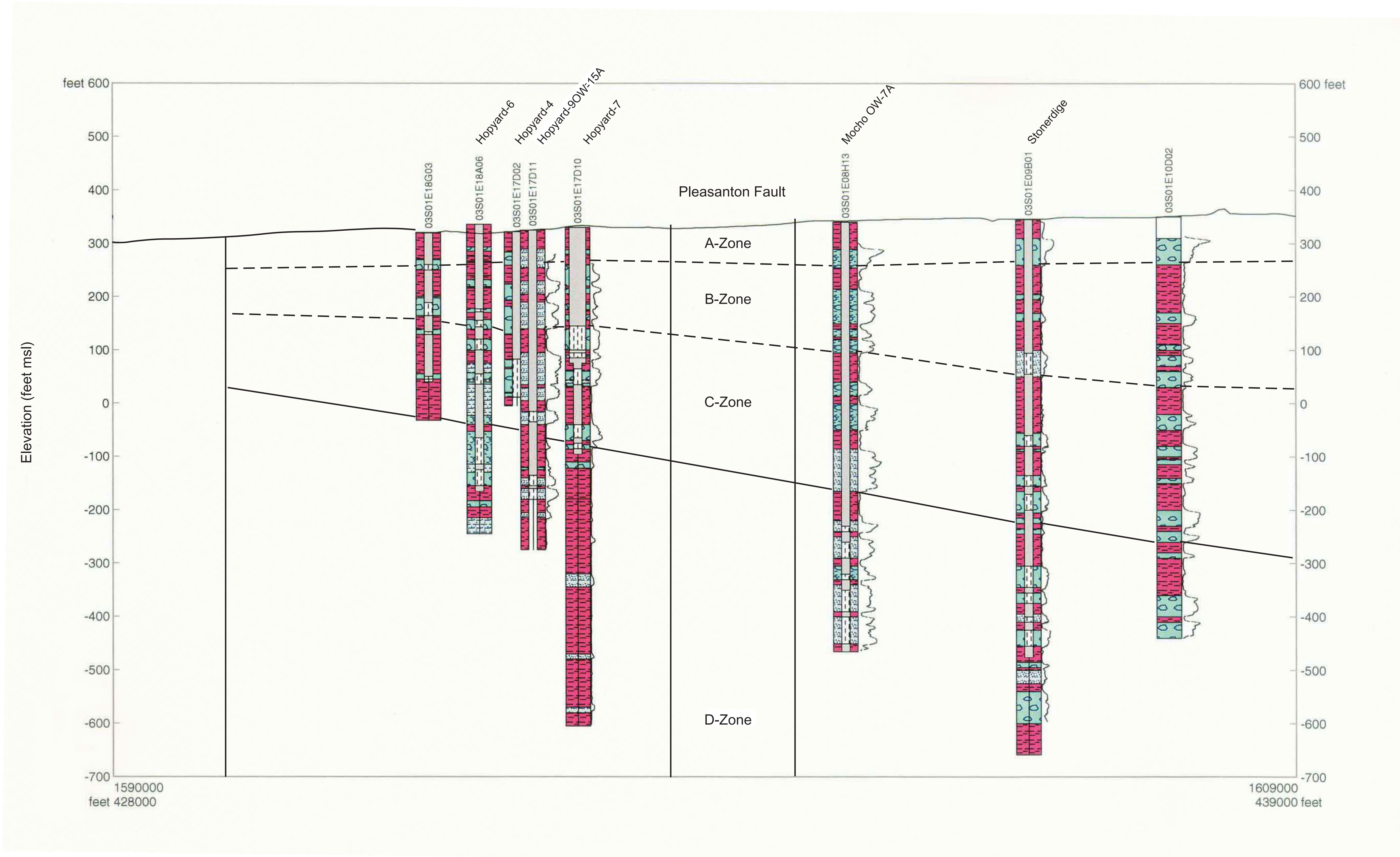


FIGURE ES. 3-1
HYDROGEOLOGIC CROSS SECTION
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_Figure ES.3-1 x-sect A-A.ai_10/23/03_mai_sfo

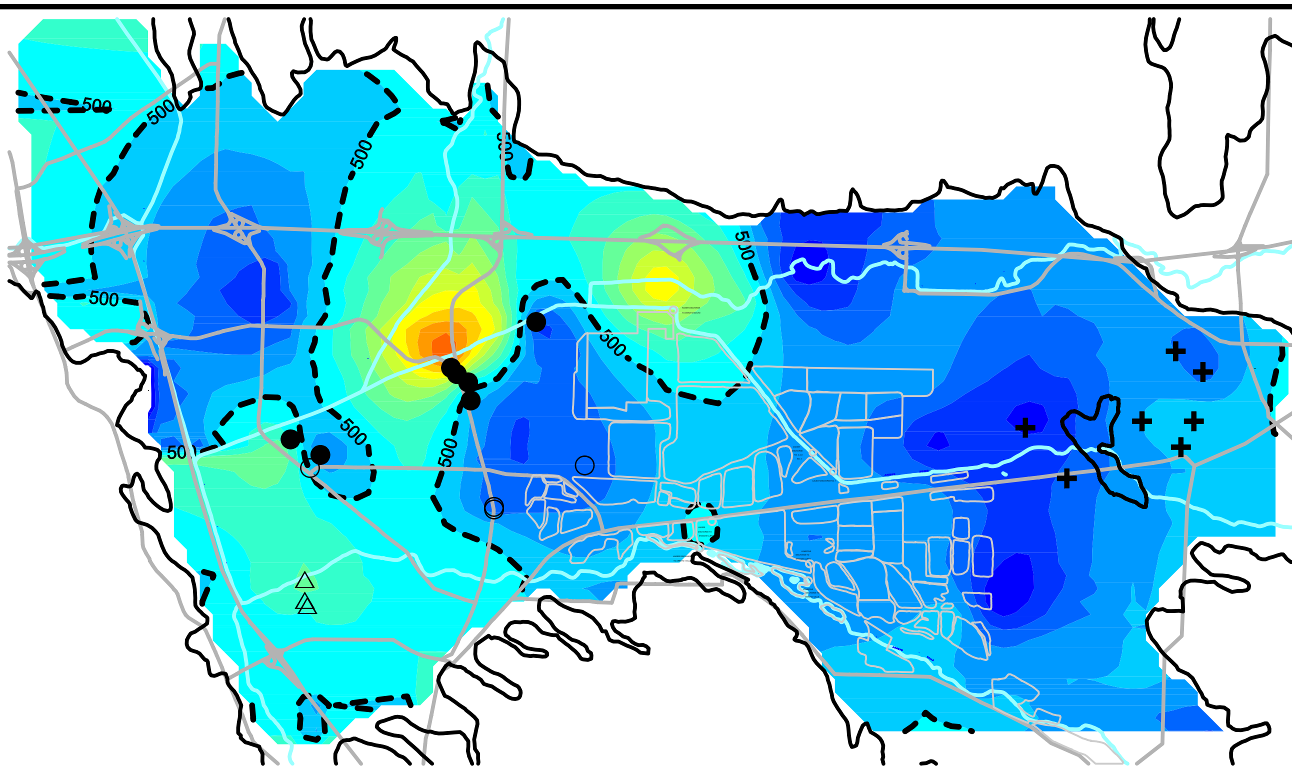
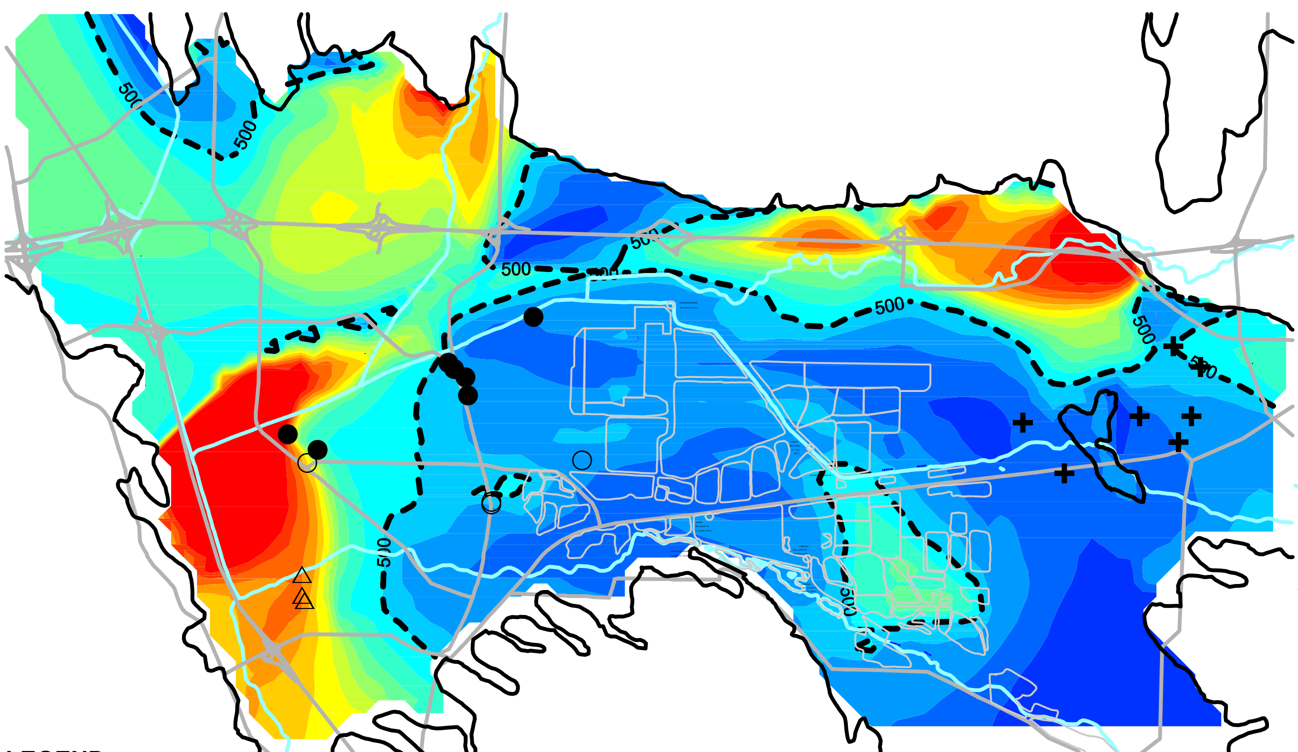


FIGURE ES.3-2
DEEP AQUIFER INITIAL TDS CONCENTRATION



LEGEND

- Zone 7 wells
- City of Pleasanton wells
- City of San Francisco wells
- Cal-Water wells

N

0 feet 5280 feet 10560 feet 15840 feet

FIGURE ES.3-3
SCENARIO 1: EXISTING WELLS ONLY
DEEP AQUIFER TDS CONCENTRATION IN 50 YEARS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

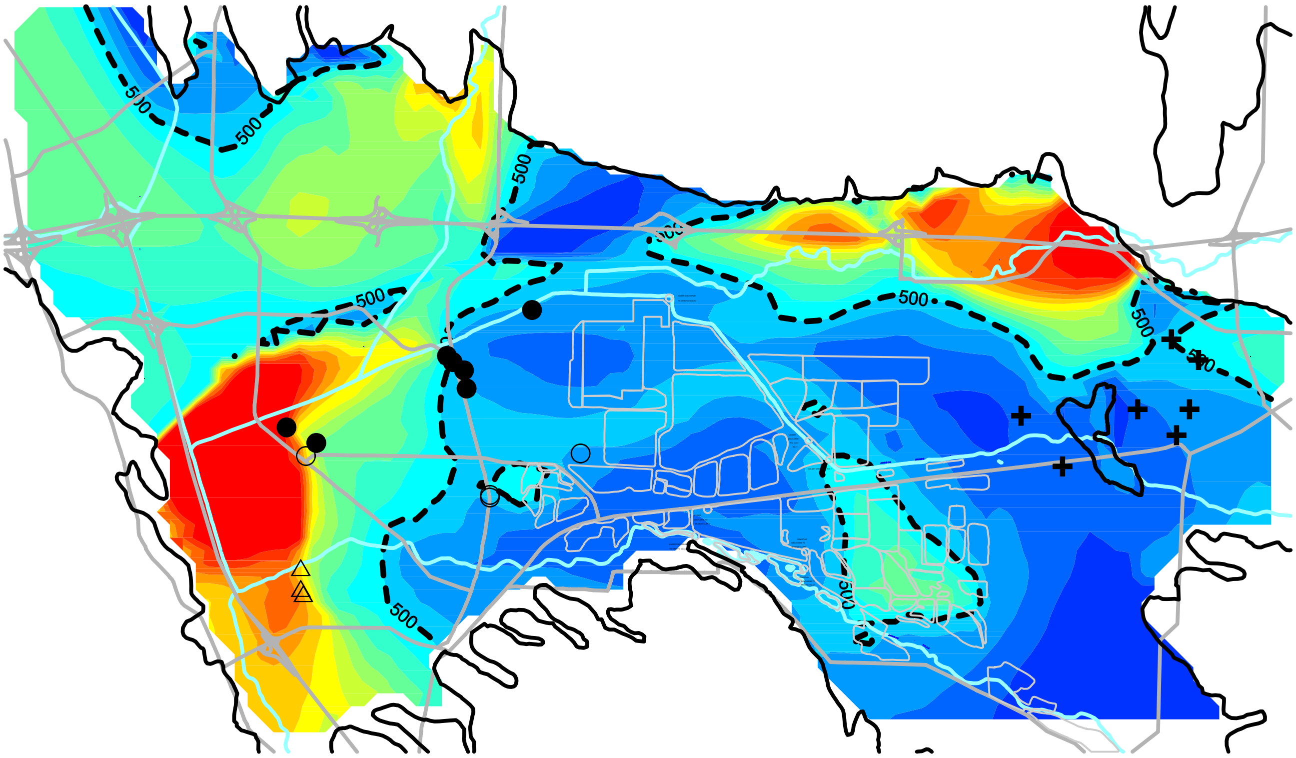


FIGURE ES.3-4
SCENARIO 2: EXISTING AND NEW WELLS
DEEP AQUIFER TDS CONCENTRATION IN 50 YEARS

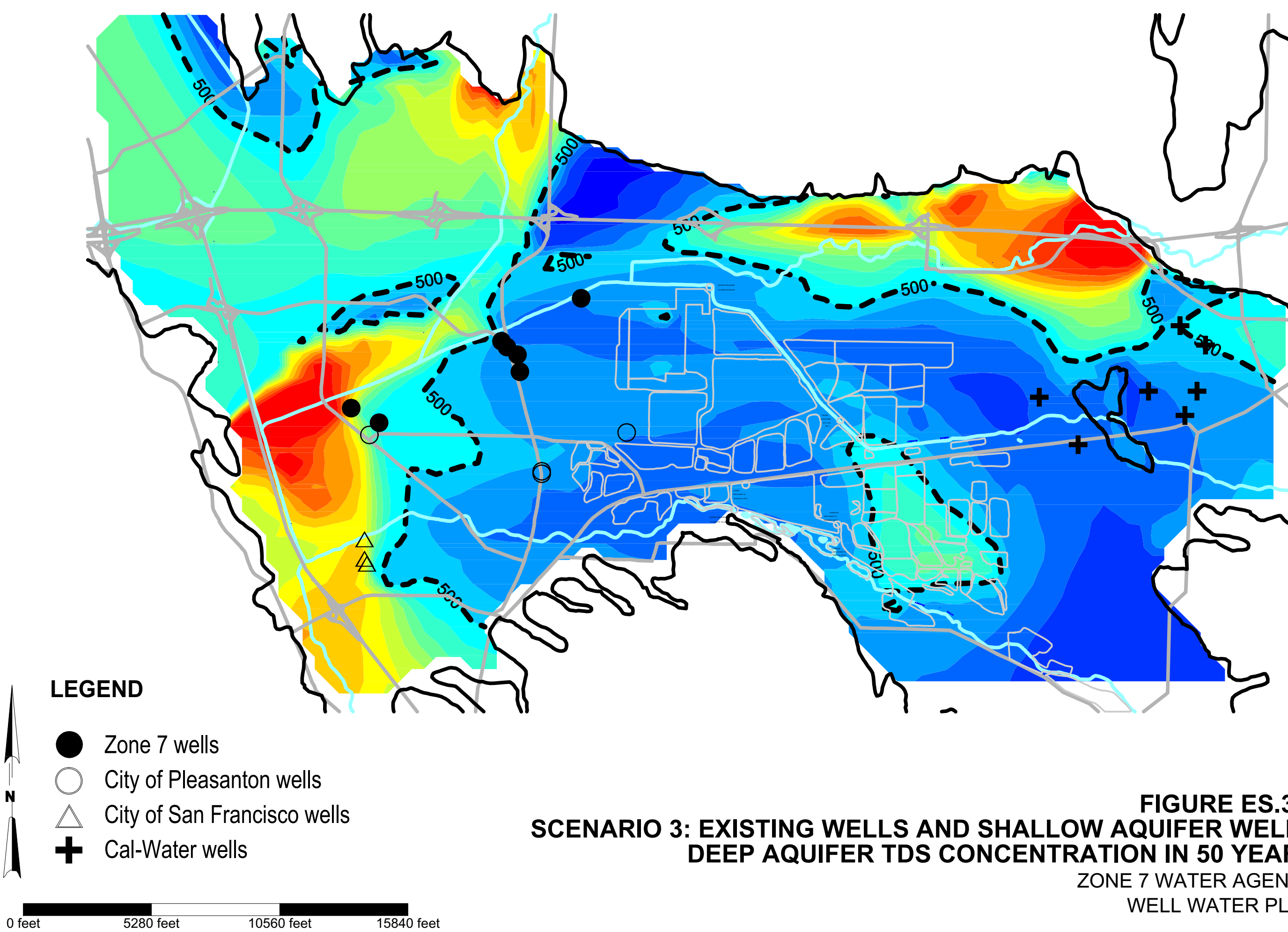


FIGURE ES.3-5
SCENARIO 3: EXISTING WELLS AND SHALLOW AQUIFER WELLS
DEEP AQUIFER TDS CONCENTRATION IN 50 YEARS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

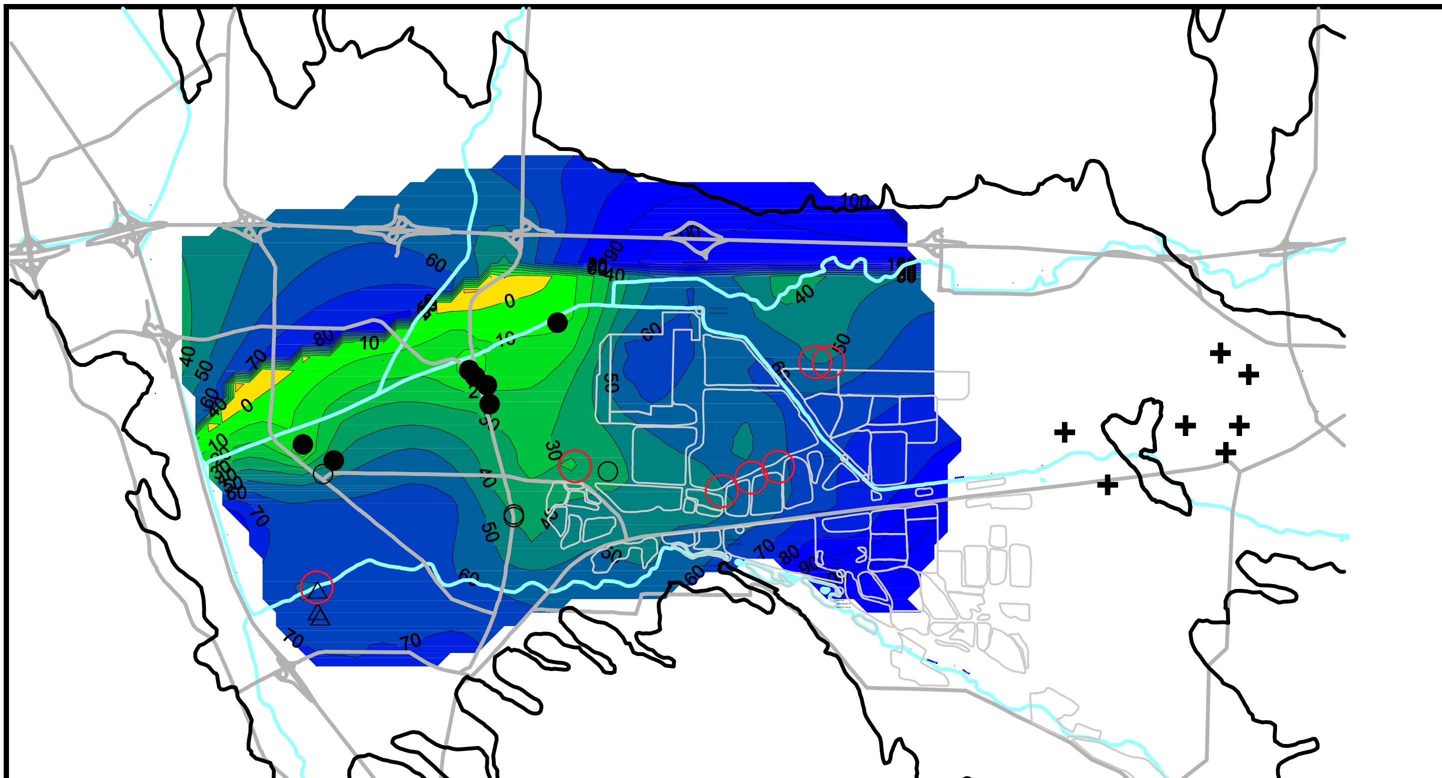
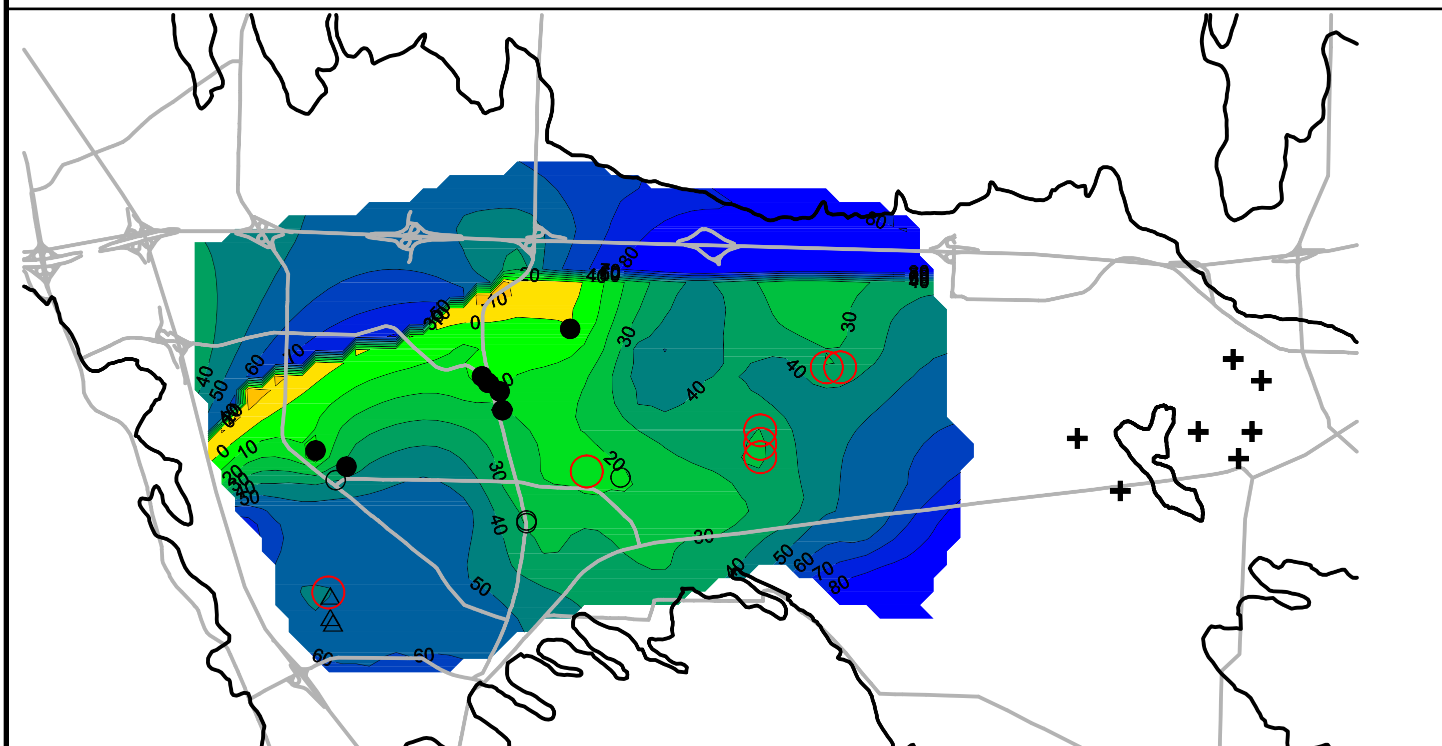


FIGURE ES.3-6
PREFERRED ALTERNATIVE: SCENARIO-2D
HEIGHT OF 1-YEAR DROUGHT, MAX 45 MGD ZONE 7 PUMPING
WATER LEVEL DIFFERENCE MAP FOR DEEP AQUIFER



LEGEND

- Zone 7 wells
- City of Pleasanton wells
- City of San Francisco wells
- Cal-Water wells

N

0 feet | 5280 feet | 10560 feet | 15840 feet

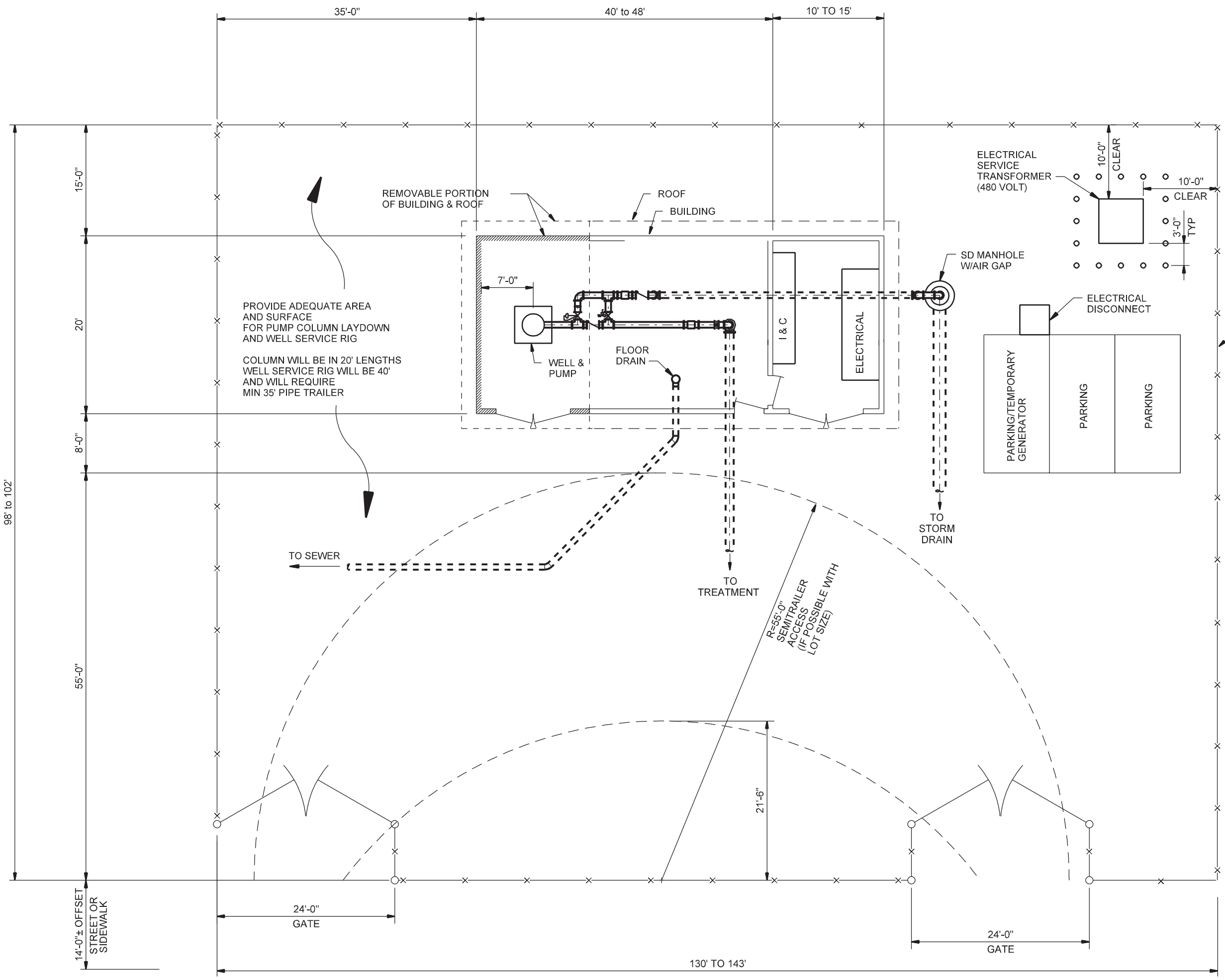
FIGURE ES.3-7
SCENARIO 2d: 45 MGD PUMPING CAPACITY
WATER LEVEL DIFFERENCE MAP FOR
THE DEEP AQUIFER AT HEIGHT OF 6-YEAR DROUGHT
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE ES-3-6 and 7_4/22/03_ccc

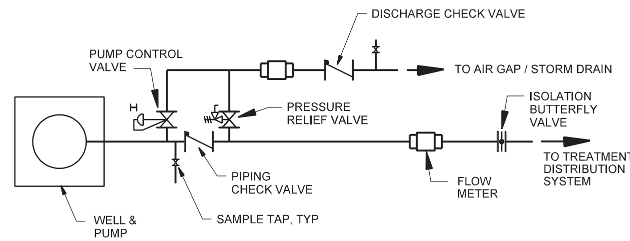
NOTES:

1. BUILDING SETBACKS IN RESIDENTIAL AREAS MUST FOLLOW LOCAL CODES AND MAY VARY FROM THAT SHOWN
2. THE SITE IMPROVEMENTS MUST BE ARRANGED TO CONFORM TO THE ACTUAL SITE SIZE. ALL FEATURES SHOWN MAY NOT BE POSSIBLE DEPENDING ON ACTUAL SITE SIZE.
3. DRAWING REPRESENTS BOTH BASE AND FEEDER WELLS IN ALL LAND USE AREAS. BASE AND FEEDER WELL DIFFERENCES ARE DESCRIBED IN THE TEXT.
4. PIPING ROOM REQUIRES 40' WIDTH FOR 10" PIPING, 48' WIDTH FOR 18" PIPING.
5. ELECTRICAL ROOM REQUIRES 15' WIDTH FOR 4160 VOLT SERVICE, 10' WIDTH FOR 480 VOLT SERVICE.
6. TRANSFORMER SHOWN FOR 480 VOLT SERVICE.



SITE PLAN

NTS



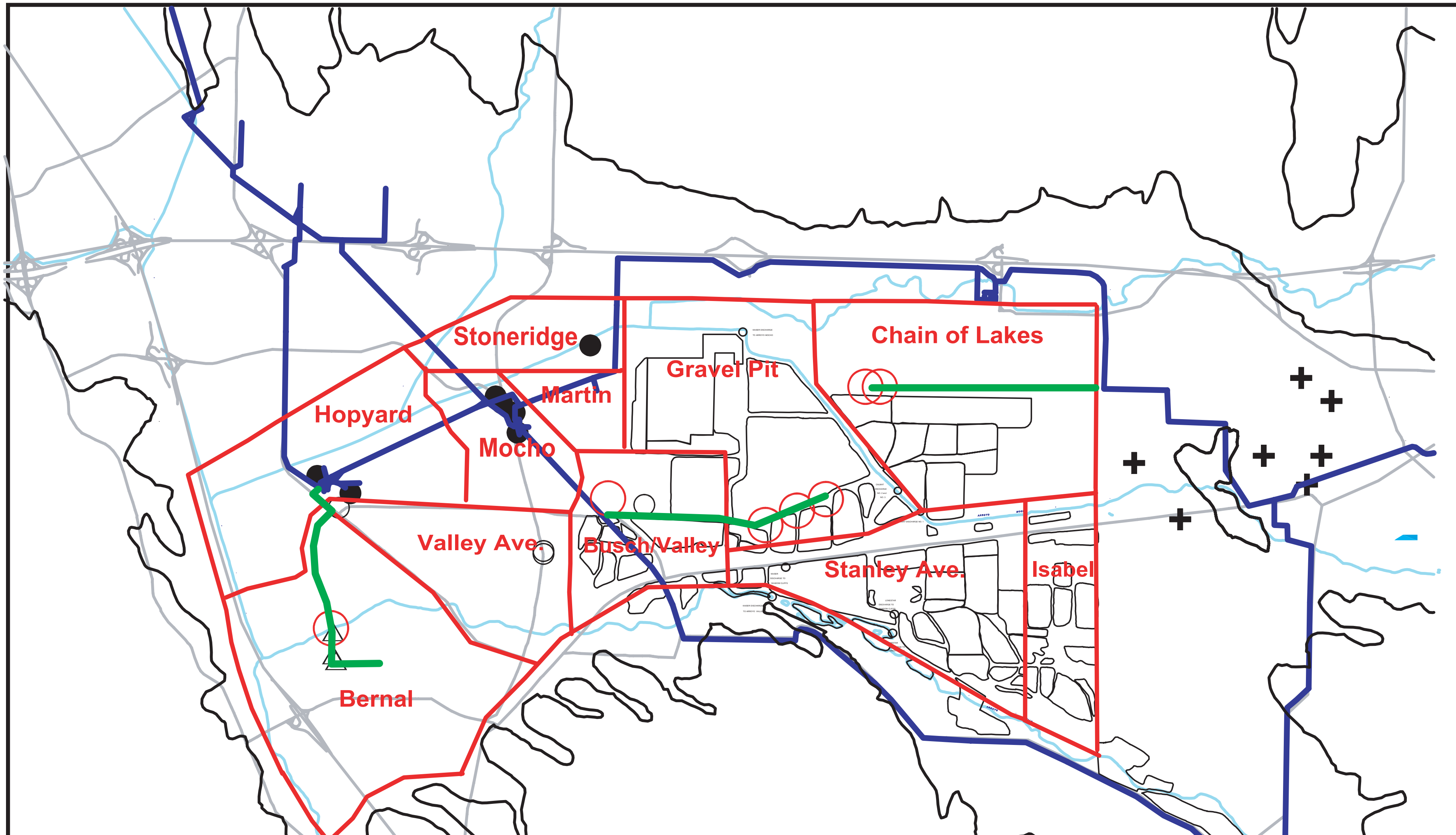
PIPING SCHEMATIC

NTS

FIGURE ES.4-1
TYPICAL WELL FACILITY WITHOUT ON-SITE TREATMENT
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE ES.4-1.ai_4/16/04_mai



LEGEND

- New Zone 7 Wells
- Zone 7 wells
- City of Pleasanton wells
- City of San Francisco wells
- Cal-Water wells

N

0 feet | 5280 feet | 10560 feet | 15840 feet

FIGURE ES.4-2
SCHEMATIC WELLFIELD LAYOUT
FOR THE PREFERRED ALTERNATIVE
SCENARIO-2D:506C
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE ES.4-2_4/16/04_mai

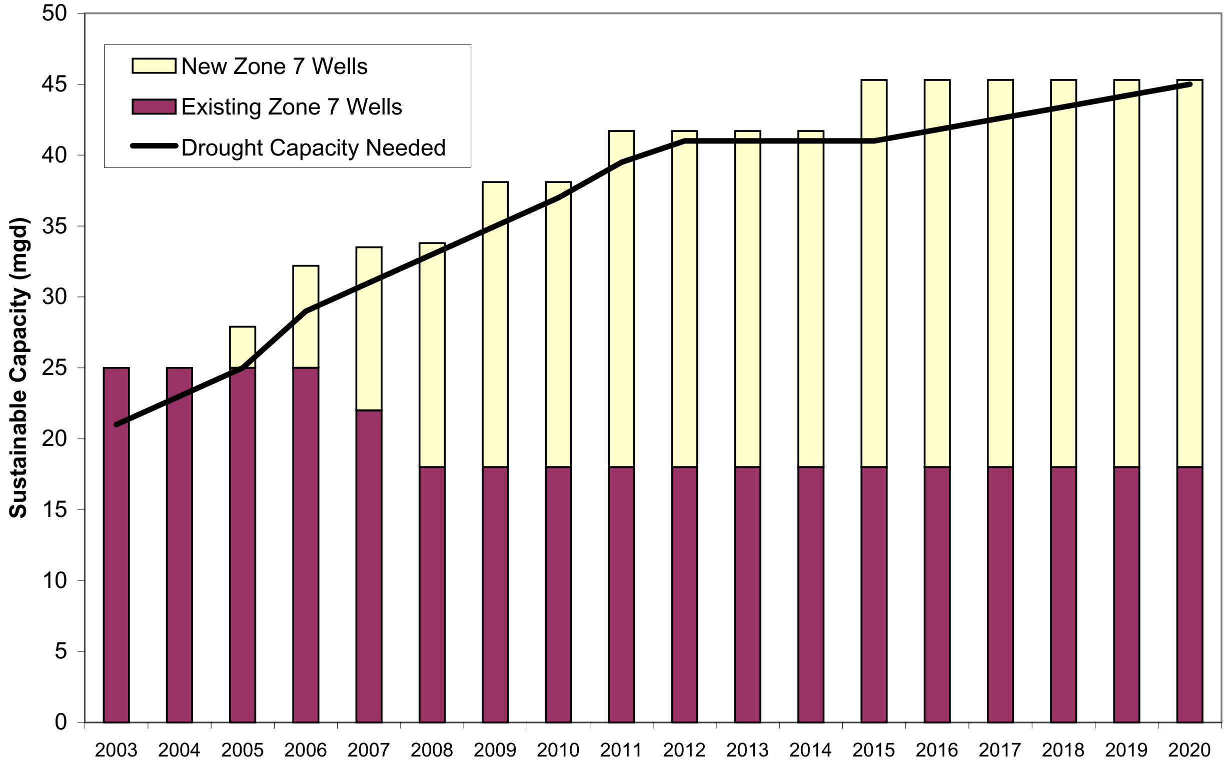


FIGURE ES.5-1
PREFERRED ALTERNATIVE: SCENARIO-2D DROUGHT CAPACITIES
ZONE 7 WATER AGENCY
WELL WATER PLAN

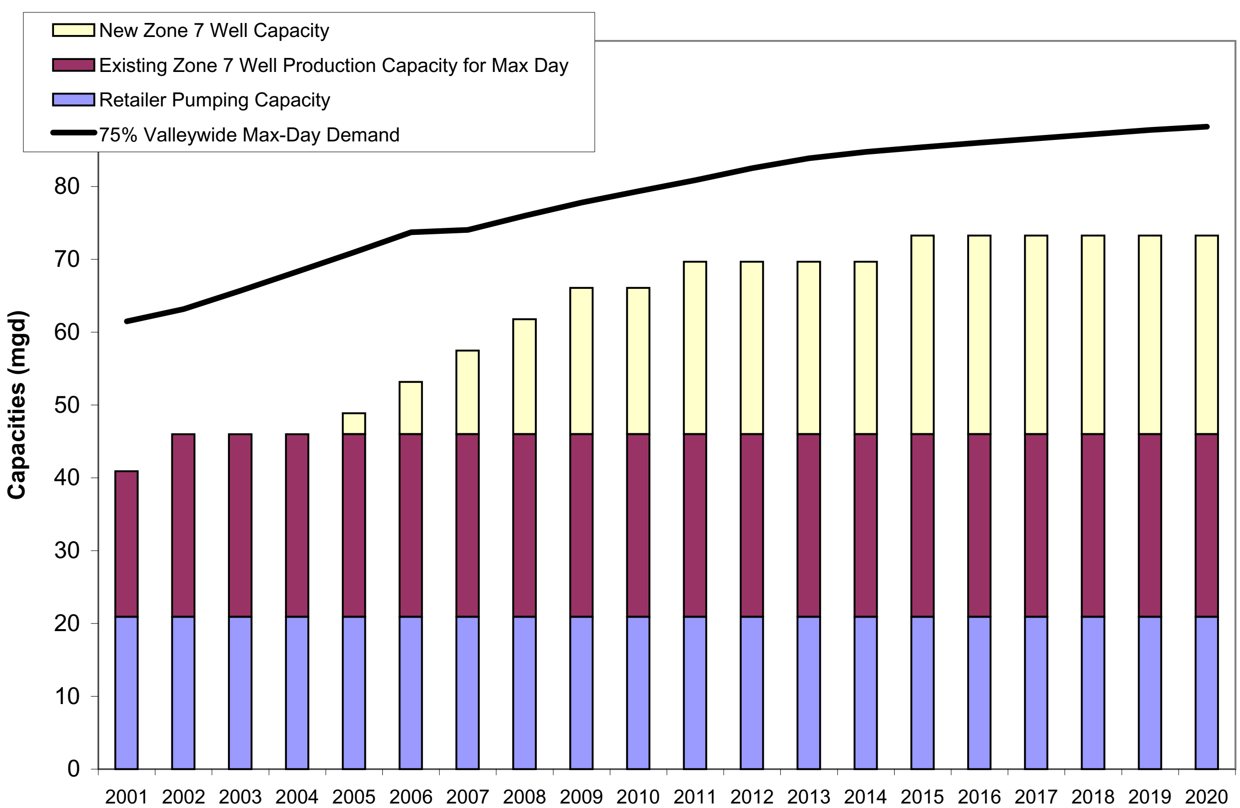


FIGURE ES.5-2
PREFERRED ALTERNATIVE: SCENARIO-2D WELL CAPACITY PROJECTIONS
ZONE 7 WATER AGENCY
WELL WATER PLAN

Well construction schedule v1.xls - C-506c - 10/09/2003

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE ES-5-2 and 2 _4/22/04_ccc