SECTION 1.0

Preliminary Wellfield Design

This section summarizes work performed to identify preferred wellfield areas, general well construction details, probable production rates, required well spacing, and produced water quality. This work was supported by development of hydrogeologic cross sections, compilation of existing aquifer test data, analytical drawdown calculations, and review of available water quality data. As part of this work, eight potential wellfield sites covering most of the main portion of the local groundwater basin were delineated and reviewed. These wellfields were identified in consultation with the District and previous work in the basin. This chapter reflects work originally presented to Zone 7 in Draft Technical Memorandum *Preliminary Wellfield Design* (CH2M HILL, 2001a).

1.1 Hydrogeologic Evaluation

Available geologic and electric log and well construction data for municipal wells and related test holes in the study area were compiled and entered into Groundwater for Windows (GWW). The GWW software stores these data electronically and provides flexibility in defining lines of cross section and assigning wells to cross sections. Seven cross sections were constructed to assess hydrostratigraphy across the study area (Figure 1.1-1).

1.1.1 Hydrostratigraphy

Four hydrostratigraphic zones were defined in the study area and were named (from shallow to deep): A-zone, B-zone, C-zone, and D-zone (Figures 1.1-2 through 1.1-9). The D-zone may correspond to Livermore Formation. As defined, each hydrostratigraphic zone tends to be capped by low-permeability, clayey material. The Mocho Wellfield exhibits these stratigraphic relationships best (Figure 1.1-2). These stratigraphic relationships are fairly well-defined, at least out to the Stoneridge Well, located about 4,000 feet to the northeast but are less readily apparent elsewhere. Although dips of contacts between zones may appear locally large on the cross section, this is due to the 10x vertical exaggeration. Accounting for vertical exaggeration, dips between the A, B, and C zones are actually quite low (typically < 1 degree). The apparent dip of about 70 degrees between the C-zone and D-zone in section F-F′ is actually only about 15 to 25 degrees, after accounting for vertical exaggeration (Figure 1.1-8).

The hydrostratigraphic zones defined in this study are intended to define packages of sediment that appear to have more significant lateral hydraulic continuity relative to vertical. Recent pumping tests in the Mocho Wellfield indicate that, although the C-zone and D-zone in this area are somewhat hydraulically isolated from one another over a distance of 1,000 feet, there is significant vertical leakage (CH2M HILL, 2001b-c). It is likely that at greater distances this leakage is even more significant. As discussed below, historical water quality data may also indicate significant vertical leakage in the system.

1.1.2 Aquifer Transmissivity

The groundwater model provides key insight into large-scale transmissivity distribution in the basin. In the groundwater model, Layer-1 largely corresponds to A-zone, and Layer-3 includes B-zone, C-zone, and D-zone. Layer-3 transmissivity from the model is provided as Figure 1.1-10. It is interesting to note that many of the Zone 7 recent test wells are in areas peripheral to the main productive zones as outlined by the model. This may explain some of the relatively low transmissivity values measured during testing of these wells. Recent specific capacity data supplied by Zone 7 further support the modeled distribution: 6 to 10 gallons per minute per feet (gpm/ft) in the Isabel Avenue Wellfield area, and 14 to 50 gpm/ft in the Busch/Valley Wellfield area (Matt Katen, personal communication, July 2001).

Although the model should not be used as a detailed guide on where to drill productive wells, results of this study support its use as a tool to evaluate basinwide water level response to groundwater pumping. The distribution of transmissivity in the model also illustrates how aquifer properties can change significantly throughout the extent of a single wellfield (e.g., the Bernal Wellfield, Figure 1.1-10).

Recent aquifer tests in the Mocho Wellfield indicate that the B and C zones are much more transmissive than the D-zone (Table 1.1-1; CH2M HILL, 2001b-c). In addition, comparison of transmissivity values from Mocho-1 and Mocho-2 (screened in B and C zones) with Mocho-3 (screened solely in C-zone) suggests that the B-Zone may be considerably more transmissive than the C-zone (Table 1.1-1 and Table 1.1-2). Wells screened in the B-zone in the Hopyard Wellfield also have relatively high transmissivities. Results of recent video logging of the Hopyard-6 Well suggest that the uppermost well screen may be producing most of the water from this well. This supports the inference that shallower units are more transmissive, but may also reflect the fact that this portion of the well screen is closer to pump suction.

The degree and scale of vertical hydraulic connection between hydrostratigraphic zones is important in determining if stored water in lower units is being fully and efficiently developed by existing wells (which are typically screened across multiple zones). Flow velocity logging of production wells during pumping would help better assess this issue, as would aquifer testing using pumping and monitoring wells screened in discrete zones.

The relative relationship of decreasing transmissivity in lower zones may reflect the fact that these deeper zones are more consolidated (greater overburden pressure) and are more weathered to clay than overlying zones. This relationship has practical importance in deciding where to place the well screen. In general, available data suggest that wells screened in B-zone and below will have significantly higher transmissivity than those that omit this zone. Including this zone would decrease drawdown in the well, thereby lessening pumping lift, and generally decrease drawdown impacts to nearby deep wells at a given production rate.

To better assess potential aquifer properties in wellfield areas, thickness and transmissivity data were also compiled from the groundwater model (Table 1.1-2). An estimated average distribution of transmissivity for each wellfield area based on aquifer test results and model data is presented in Table 1.1-3. This table indicates that, if all productive zones are screened in the wells, that transmissivities will typically be 150,000 gallons per day per feet (gpd/ft) or more except in the Bernal Wellfield area (80,000 gpd/ft), Stanley Boulevard Wellfield area (60,000 gpd/ft), and Isabel Wellfield (18,000 gpd/ft). Excluding the B-zone, total transmissivity is typically 80,000 gpd/ft or more, except in the Bernal, Stanley Boulevard, and Isabel Wellfields, where it is significantly lower (see Table 1.1-3).

1.2 Groundwater Quality Evaluation

Existing water quality data were compiled and analyzed using mapped distribution, historical data ("chemographs") at major production wells, and depth-discrete data. Data on select water quality parameters, including total dissolved solids (TDS), hardness, chloride, nitrate, iron, manganese, and arsenic were evaluated. Results of this work are discussed below.

1.2.1 Groundwater Quality Maps

Maps of TDS and nitrate were reviewed for shallow (<100 feet below ground surface [ft bgs]), intermediate (100 to 250 ft bgs), and deep (>250 ft bgs) wells (see Figures 1.2-1 through 1.2-6). Shallow wells represent A-zone groundwater, intermediate wells the B-zone and locally C-zone, and deep wells C-zone and D-zone. Only data from wells whose entire screen interval is within the specified depth zone were used in this analysis.

Available data indicate that high concentrations of TDS are present in shallow northern groundwater (Figure 1.2-1). Although much of the high TDS groundwater is in the adjacent Camp and Dublin subbasins, it is also present along the northern fringe of the Bernal and Amador subbasins. Intermediate and deep wells exhibit significantly lower concentrations of TDS (Figures 1.2-2 and 1.2-3). Elevated concentrations of nitrate are present in shallow groundwater along the border of the study area, especially to the south and east (Figure 1.2-4). Nitrate is also present at elevated concentrations locally at intermediate and deep depths (Figures 1.2-5 and 1.2-6). Non-depth-specific maps of iron and manganese indicate elevated concentrations throughout the basin that are locally above their secondary drinking water standards (0.3 micrograms per liter [µg/L] and 0.05 µg/L, respectively) (Figures 1.2-7 and 1.2-8). Arsenic is present at low concentrations throughout the basin, though typically well below both the current maximum contaminant level (MCL) of 50 µg/L and future MCL of 10 µg/L (Figure 1.2-9). A striking anomaly is the elevated concentration of arsenic above the MCL in portions of the Hopyard Wellfield (Figure 1.2-9).

1.2.2 Groundwater Quality Chemographs

Available "average" water quality data for existing production wells and recent test wells is presented in Table 1.2-1. These data were used to help predict water quality of new wells in the various areas. "Chemographs" for major wells are provided as Figures 1.2-10 through 1.2-21. These figures indicate that, although water quality is relatively stable at most municipal wells, several wells exhibit considerable variations through time (e.g., the Mocho Wells and Hopyard-1). Decreases in TDS, chloride, hardness, and nitrate in Hopyard-6 and Hopyard-1 since 1998 are related to aquifer storage and recovery testing operations at Hopyard-6 during this time (Figure 1.2-10).

At Mocho-1, TDS varies from as little as 300 milligrams per liter (mg/L) in 1980 to nearly 1,000 mg/L in 1986 (Figure 1.2-13). The tendency for TDS to fluctuate does not clearly correlate to the depth of the uppermost screen. There appears to be some correlation with the relative amount of recharge versus pumpage, but not absolute values of either (compare Figures 1.2-22 and 1.2-23 with Figure 1.2-13). It appears that high TDS concentrations at the Mocho wells correspond to periods of relatively high recharge relative to pumpage. This may indicate that the B-zone near Mocho–1 and Mocho–2 is in significant hydraulic contact with the surface, and possible is related to its proximity to Arroyo Mocho. This would underscore the importance of vertical leakage defined by the recent aquifer testing. However, recent modeling of TDS in the basin did not mimic the observed TDS variation at the Mocho wells (CH2M HILL, 1999). This may indicate that modeled leakage from the shallow to deeper layers is too low in this area, and that this parameter may need to be recalibrated.

1.2.3 Groundwater Quality Trends with Depth

Depth-specific water quality data are available for three wells: Hopyard-6, Stoneridge, and Busch-Valley (Figures 1.2-24 through 1.2-26). These wells suggest that TDS decreases slightly with depth, but not markedly. Hopyard-6 exhibits a strong decrease in hardness and chloride concentration at a depth of about 400 feet, which corresponds to the contact between the C-zone and D-zone (Figure 1.2-24). Similar, but less dramatic, changes are present in the Busch-Valley Well data at a depth of about 500 feet, corresponding to a relatively coarse-grained zone at the bottom of the C-zone in this area (Figure 1.2-26). Water quality data from a number of different wells in the Mocho Wellfield are presented in Figure 1.2-27. The middle of the well screen was used for depth. This plot also indicates decreasing TDS concentrations with depth but no other sharp patterns.

Zone 7 has recently begun evaluation of volatile organic compounds groundwater contamination near the Fairground, located in the Bernal Wellfield area. This has included installation of a monitoring well at the site. Zone 7 staff mentioned that their preliminary review indicates the presence of contamination below the B-zone. This suggests that deeper aquifers are not fully protected from potential surficial contamination.

1.2.4 Groundwater Under the Influence of Surface Water

The Safe Drinking Water Act requires determination if groundwater developed by a well is “under the direct influence” of surface water. For regulatory purposes, wells located within several hundred feet of a stream or lake are commonly identified as being of concern, even if the wells are relatively deep and in confined aquifers. Some new Zone 7 wells may be constructed adjacent to or within several hundred feet of existing water bodies in the Chain of Lakes and Gravel Pit Wellfield areas. California Department of Health Services (DHS) is the agency responsible for evaluating these issues and may identify these wells as of potential concern. This issue could be of heightened importance if Zone 7 decides to store reclaimed water in any of the lakes.

There are no strict rules in California on how to assess whether groundwater produced by a well is under the direct influence of a surface water system. Water quality sampling is often conducted to assess the relationship between the surface water and adjacent well. Microscopic Particulate Analysis (MPA) is of particular importance in this respect. MPA of both waters is conducted to determine if unique material present in surface water is also present in well discharge. The United States Environmental Protection Agency has published detailed technical guidance documents for this purpose. Additional testing requirements might include time-series analysis of general water quality parameters and temperature to see if these two criteria correlate closely in time, which would indicate a "direct" connection.

DHS may require MPA and general water quality sampling and testing over a period of approximately a year. If Zone 7 decides to pursue wellfields in this area, it is recommended that discussions be held with DHS as soon as possible. These discussions should include agreement on required water quality testing and if existing or small test wells can be used to expedite this analysis.

1.3 Preliminary Wellfield Design

Preliminary wellfield designs were developed using results of the hydrostratigraphic analysis, historical water level data, available aquifer test data, and information from the groundwater model. Drawdowns within production wells were calculated using observed and estimated specific capacity data. Distance-drawdown effects of individual production wells were evaluated using analytical techniques assuming various pumping rates and estimated transmissivities. The groundwater model was subsequently used to more fully assess drawdown impacts and consider the presence of multiple wells. Results of modeling work are discussed in a following chapter.

Zone 7 has compiled data for historical low water level elevations at numerous wells in the basin during the 1960s. These data were contoured and are presented as Figure 1.3-1. It is assumed that the basin will be operated in such a fashion that future water levels will largely be kept above these historical minimums. More detailed maps of historic low water levels covering a larger interval of time are currently being prepared by Zone 7 staff. Historical high water levels reach near to land surface.

1.3.1 Projected Well Drawdowns

The maximum drawdown that a well can sustain is controlled by the pump setting. It is best to maintain water levels above the top of the uppermost well screen to avoid cascading water. This provides an additional design consideration. As part of this study, specific capacity data were used in conjunction with projected pumping rates and historic low water level data to estimate reasonable production rates, pump settings, and tops of well screens.

The Theis equation was used to evaluate distance-drawdown effects at various pumping rates and transmissivities, which provides the information needed to identify potential water level impacts to neighboring wells and determine appropriate well spacing. Results of these calculations are presented in Figures 1.3-2 through 1.3-5. As an example of how to use these graphs, wells spaced about 500 feet apart would have mutual interference of about 25 feet with an aquifer transmissivity of 150,000 gpd/ft, and 40 feet with a transmissivity of about 80,000 gpd/ft. These analytical solutions should be used in conjunction with results of numerical modeling presented in Section 2.0, Groundwater Modeling of Wellfield Activities, to arrive at estimates of well interference.

1.3.2 Preliminary Wellfield Designs

The Mocho Wellfield provides an example of the approach used to provide preliminary well designs for this report. The historical low water level in this area is about 200 feet above mean sea level (msl). The bottom of the B-zone is at elevation 90 ft msl. These data indicate that the B-zone has a saturated thickness of about 110 feet in this area during low water level conditions. This is adequate to support well screen in the lower portions of the B-zone. Therefore, it appears reasonable to place well screens in this zone. A well completed in the B, C, and D zones in this area (similar to Mocho-1 and Mocho–2) may have an average transmissivity of about 275,000 gpd/ft, which translates to a specific capacity of 138 gpm/ft (Table 1.3-1; Driscoll, 1986). For purposes of this report, it was assumed that wells should have mutual interference of about 25 feet or less.

Analytical curves of distance-drawdown were then reviewed to estimate distance from the well to a point of about 25 feet drawdown using a range of pumping rates (Figures 1.3-2 through 1.3-5 and Table 1.3-2). It was assumed that wells would be spaced 1,000 feet or less from one another. At the Mocho Wellfield, a pumping rate of 4,000 gpm in an aquifer with a transmissivity of about 275,000 gpd/ft (the average transmissivity) exhibits a drawdown of about 25 feet at a distance less than about 200 feet (Figure 1.3-5). Because drawdown is less than 25 feet within 1,000 feet of the well at a pumping rate of 4,000 gpm, the maximum recommended pumping rate is 4,000 gpm, and the recommended well spacing is about 500 feet (rounded up from 200 feet).

The above data were superposed on the historical low water level data to determine the recommended level of uppermost well screen and pump setting. In the above example, if it is assumed that the well is 100-percent efficient (worst case with respect to drawdown in the aquifer), then the B-zone will retain 81 feet of residual saturation when the basin is at historical low water levels and the well is pumping at 4,000 gpm. This level of saturation should be adequate to maintain production rates and, therefore, the overall preliminary design appears reasonable. Summary data of this sort for the other wellfields are provided in Table 1.3-3 along with estimated average TDS concentrations for wells in the area.

1.4 Summary

The Mocho Wellfield is located in the most productive proven portion of the Livermore Valley Groundwater Basin (LVGB) but is already fully developed, as are the Hopyard and Stoneridge wellfields. The Chain of Lakes, Gravel Pit, and Busch-Valley Wellfield areas also appear to have locally favorable aquifer properties. 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.

Well yields in significant portions of the Bernal Wellfield may vary from marginal (1,000 gpm or less) to very good (2,000 gpm or more), depending upon location. Some of the wells in this area may need to be operated at lower rates and/or spaced father apart. It is recommended that aquifer tests be conducted in existing deep wells in all the above areas prior to installation of any new wells. Model Layer-3 transmissivity values could be used as a rough guide in siting new test wells.

Based on available data, the Isabel and Stanley Boulevard Wellfield might support small-scale groundwater development but do not appear suited for multiple high-capacity production wells. The Isabel Wellfield area looks particularly poor. However, available field data in all three of these areas are sparse, and additional test drilling and aquifer testing are needed to better define local aquifer properties.

In general, it is recommended that wells be completed in lower portions of the B-zone to maximize well yield. Deep wells completed in this manner in the main portion of the basin should provide good quality water with respect to general mineral and physical constituents. However, as evidenced by water quality fluctuations at Mocho Well-1 and Mocho-2, the B-zone may have a relatively strong hydraulic connection with surficial zones. In areas of potential surficial contamination (e.g., near gas stations, dry cleaners, and industrial facilities) it may be best to not screen this interval. Unfortunately, deeper wells in the basin also have evidence of contamination (e.g., the Fairgrounds area) and, therefore, deeper zones are not necessarily free from threat of contamination. Due to observed variability in mineral water quality, as well as potential for presence of contamination, it is recommended that test wells be installed and water quality sampling conducted prior to installing new production wells.

Aquifer properties and water quality can change significantly throughout the extent of a single wellfield. Accordingly, it is recommended that test wells be installed, aquifer properties tested, potential well yields confirmed, and water quality samples collected prior to installation of each new production well.

Wells in the Chain of Lakes area, and anywhere else where wells are located within several hundred feet of a surface water body, will need to be assessed to determine if they are “under the direct influence” of surface water. It is recommended that Zone 7 open discussions with DHS on this issue for affected wells as soon as possible. These discussions should include agreement on required water quality testing and how existing or small test wells can be used to support this analysis.

											Transmissivity					Casing			Well Screen-1		Well Screen-2		Well Screen-3		Combined lower well		Historic Low Water Level	
Wellfield	Well Name	State Well Number	Date Constructed	Wellhead Elevation	Total Depth	Units Screened				Initial Specific Capacity	AQ Test	Sc	Total Screen	Average Hydraulic Conductivity	Telescope	Prod Dia	Prod Bottom Depth	Lower Dia	upper	lower	upper	lower	upper	lower	upper	lower	Water level	Water above top of screen
					feet	A	B	C	D		gpd/ft	gpd/ft	(feet)	ft/day		inch	ft bgs	inch	ft bgs	ft bgs	ft bgs	ft bgs	ft bgs	ft bgs	ft bgs	ft bgs	ft msl	feet
Existing																												
Busch-Valley	Pleasanton-5	03S01E16L05	Jul-62	345	650		X	X	X	116		232,000	279		X	18	325	12	149	180	201	212	228	265	278	650	205	9
Busch-Valley	Pleasanton-6	03S01E16L07	May-65	345	647		X	X	X	109		218,000	476		X	18	365	14	165	365	371	625	625	647			215	35
Busch-Valley	Pleasanton-8	03S01E16A02	Jul-92	355	500		X	X		46	160,000	92,000	140	153		20			200	230	272	292	320	380	400	495	225	70
Hopyard	Hopyard-1	03S01E18A01	Oct-43	318	380		X	X		34	110,000	68,000	100	147		16											190	
Hopyard	Hopyard-4	03S01E18D02	Jan-49	322	313			X		14	50,000	28,000	70	95		14			240	310							180	240
Hopyard	Hopyard-6	03S01E18A06	Feb-87	335	500		X	X	X	100	175,000	200,000	120	195		18			158	164	180	192	215	235	280	490	210	33
Hopyard	Hopyard-7	03S01E17D10	Jul-96	325	425			X		17	30,000	34,000	120	33	X	22	250	20	185	230	235	245	265	295	370	410	180	185
Hopyard	Hopyard-9	03S01E17D12	Oct-99	325	315			X		10	100,000	20,000	65	206	X	18	198	12	233	283	293	308					180	233
Hopyard	Pleasanton-7	03S01E18A05	Feb-68	318	480		X	X	X	35		70,000	320			18			120	440							180	120
Mocho	Mocho-1	03S01E09M02	Jul-64	345	530		X	X		278	450,000	556,000	300	201		16			150	270	330	510					200	5
Mocho	Mocho-2	03S01E09M03	Feb-68	345	575		X	X		165	325,000	330,000	200	217		18			250	330	450	570					200	105
Mocho	Mocho-3	03S01E09M04	Oct-00	340	500			X		58	140,000	116,000	100	187		20			310	335	355	410	468	493			200	310
Mocho	Mocho-4	03S01E08H18	Oct-00	340	745				X	23	60,000	46,000	195	41		20			510	530	545	610	620	730			200	510
Stoneridge	Stoneridge	03S01E09B01	Jun-92	345	820		X	X	X	125	200,000	250,000	210	127		20			250	290	405	425	480	500	515	800	225	130
Test Wells																												
Bernal	Rose-Fair Ave TW	03S01E20C07	Aug-00		505		X						80															
Busch-Valley	OW-11B	03S01E15M04	Mar-99		600			X		10	45,000	20,000	230	26					260	330	360	380	430	470	490	600		
Busch-Valley	OW-8B	03S01E16B02	Apr-99		740				X	1	2,000	2,000	75	4		12	565	6	605	635	655	675	715	740				
Busch-Valley	OW-9B	03S01E16A05						X		50	200,000	100,000	220	122					250	270	280	340	350	380	420	580		
Mocho	Mocho site MW	03S01E08H09							X																			
Mocho	Mocho site MW	03S01E08H10						X																				
Mocho	Mocho site MW	03S01E08H11					X																					
Mocho	Mocho-3 site, OW-7A	03S01E08H13							X																			
Mocho	Mocho-3 site, TW-7B	03S01E08H14							X																			

Impact Summary for Design.xls -- Table set A -- 10/13/2003

TABLE 1.1-1
SUMMARY WELL CONSTRUCTION INFORMATION
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

	Elev	b (ft)	Kx (ft/d)		T (gpd/ft)		Ss	S
			main	fringe	main	fringe		
Mocho								
Layer-1	222	120	134	17	120,000	15,000	1.80E-03	2.16E-01
Layer-2	192	30	0.020	0.030	0	0	1.00E-06	3.00E-05
Layer-3	-88	280	150	250	314,000	524,000	5.00E-06	1.40E-03
Hopyard								
Layer-1	225	100	60	60	45,000	45,000	1.00E-03	1.00E-01
Layer-2	184	40	0.020	0.020	0	0	1.00E-06	4.00E-05
Layer-3	-73	260	37	150	72,000	292,000	5.00E-06	1.30E-03
Busch-Valley								
Layer-1	199	160	134	60	160,000	72,000	2.40E-03	3.84E-01
Layer-2	179	20	0.080	0.200	0	0	1.00E-06	2.00E-05
Layer-3	-134	310	150	10	348,000	23,000	5.00E-06	1.55E-03
Bernal								
Layer-1	208	110	60	60	49,000	49,000	1.20E-03	1.32E-01
Layer-2	180	30	0.080	0.080	0	0	1.00E-06	3.00E-05
Layer-3	8	170	20	60	25,000	76,000	1.00E-05	1.70E-03
Chain of Lakes								
Layer-1	273	100	4	134	3,000	100,000	1.00E-03	1.00E-01
Layer-2	253	20	0.004	0.004	0	0	1.00E-06	2.00E-05
Layer-3	13	240	250	150	449,000	269,000	1.00E-05	2.40E-03
Valley Avenue								
LSD	331							
Layer-1	225	110	60	60	49,000	49,000	1.60E-03	1.76E-01
Layer-2	185	40	0.020	0.020	0	0	1.00E-06	4.00E-05
Layer-3	-108	290	150	150	325,000	325,000	5.00E-06	1.45E-03
Stanley Boulevard								
LSD	385							
Layer-1	288	100	134	80	100,000	60,000	1.80E-03	1.80E-01
Layer-2	274	10	0.004	0.010	0	0	1.00E-06	1.00E-05
Layer-3	21	250	20	37	37,000	69,000	1.00E-05	2.50E-03
				locally 150 ft/day				
Isabel Avenue								
LSD	410							
Layer-1	305	110	80	80	66,000	66,000	1.80E-03	1.98E-01
Layer-2	290	20	0.010	0.010	0	0	1.00E-06	2.00E-05
Layer-3	50	240	10	10	18,000	18,000	5.00E-06	1.20E-03

Transmissivity estimates.xls - - Model - - 10/13/2003

TABLE 1.1-2
WELLFIELD TRANSMISSIVITIES FROM MODEL
ZONE 7 WATER AGENCY
WELL WATER PLAN

	Transmissivity (gpd/ft)							
	Mocho	Hopyard	Busch-Valley	Bernal	Chain of Lakes	Valley Ave.	Stanley Blvd.	Isabel Ave.
A-Zone	-	-	-	-	-	-	-	-
B-Zone	150,000	70,000	70,000	40,000	100,000	100,000	25,000	6,000
C-Zone	140,000	50,000	50,000	30,000	100,000	70,000	25,000	6,000
Livermore Formation	60,000	30,000	30,000	10,000	30,000	30,000	10,000	6,000
TOTAL	**350,000**	**150,000**	**150,000**	**80,000**	**230,000**	**200,000**	**60,000**	**18,000**
Total without B-Zone	**200,000**	**80,000**	**80,000**	**40,000**	**130,000**	**100,000**	**35,000**	**12,000**

Transmissivity estimates.xls - - Aq Tst - - 10/13/2003

TABLE 1.1-3
ESTIMATED AVERAGE WELLFIELD TRANSMISSIVITIES
ZONE 7 WATER AGENCY
WELL WATER PLAN

			Water Quality							
Wellfield	Well Name	State Well Number	TDS	Cl	Total Hardness (CaCO3)	Nitrate	Fe	Mn	As	Radon
			mg/L	mg/L	mg/L	NO3	ug/L	ug/L	ug/L	pCi/L
			1,000			45	300	50	50	300
Existing										
Busch-Valley	Pleasanton-5	03S01E16L05	500	60	300	10.0	<10	<6	<2	
Busch-Valley	Pleasanton-6	03S01E16L07	450	40	250	10.0	<10	<6	<2	
Busch-Valley	Pleasanton-8	03S01E16A02	400	70	280	5.0	<10	<3	<2	
Hopyard	Hopyard-1	03S01E18A01	750	110	550	10.0	50	<5	1	
Hopyard	Hopyard-4	03S01E18D02	400	40	300	10.0	31	<3	2	
Hopyard	Hopyard-6	03S01E18A06	550	80	300	5.0	10	<5	1	
Hopyard	Hopyard-7	03S01E17D10	500	94	160	4.3	52	220	28	
Hopyard	Hopyard-9	03S01E17D12	490	48	305	12.4	30	5.3	1.6	
Hopyard	Pleasanton-7	03S01E18A05	550	55	375	10.0	50	3	2	
Mocho	Mocho-1	03S01E09M02	450	60	300	10.0	<10	<5	1	
Mocho	Mocho-2	03S01E09M03	500	60	300	10.0	<10	<5	1	
Mocho	Mocho-3	03S01E09M04	444	60	249	7.3	<10	<2	2	
Mocho	Mocho-4	03S01E08H18	469	87	299	9.9	<100	50	3.3	
Stoneridge	Stoneridge	03S01E09B01	375	40	250	10.0	<10	<5	2	
Test Wells										
Bernal	Rose-Fair Ave TW	03S01E20C07	418	95	190	5.2	NA	<5	3	
Busch-Valley	OW-11B	03S01E15M04	360	55	146	9.5	<100	4.6	NA	515
Busch-Valley	OW-8B	03S01E16B02	300	50	215	-	>300?	>50?	1.8	445
Busch-Valley	OW-9B	03S01E16A05	438	78	298	3.0	<100	3.1	NA	
Mocho	Mocho site MW	03S01E08H09	575	95	260	3.0	<10	<3	2	
Mocho	Mocho site MW	03S01E08H10	550	90	270	8.0	<10	<3	2	
Mocho	Mocho site MW	03S01E08H11	360	30	213	7.0	<10	<3	2	
Mocho	Mocho-3 site, OW-7A	03S01E08H13	359	65	190	2.6	60	100	2	
Mocho	Mocho-3 site, TW-7B	03S01E08H14	353	28	218	7.0	50	100	2	

Impact Summary for Design.xls -- Table set A -- 10/13/2003

TABLE 1.2-1
SUMMARY WATER QUALITY DATA
ZONE 7 WATER AGENCY
WELL WATER PLAN

Wellfield	Wellhead Elevation	Total Depth	Historical Low WL	Depth to Top of Zone (ft bgs)			Top of Zone Elevation (ft msl)			Transmissivity (gpd/ft)			Specific Capacity (gpm/ft)		
	ft msl	ft bgs	(ft msl)	B	C	D	B	C	D	Low	High	Average	low	high	avg
Bernal	330	620	200	60	230	525	315	75	-200	40,000	80,000	60,000	20	40	30
Busch/Valley	350	620	220	75	250	550	265	155	-25	80,000	150,000	115,000	40	75	58
Chain of Lakes	390	850	240	75	315	590	350	160	-115	130,000	230,000	180,000	65	115	90
Hopyard-1	325	580	180	60	170	350	275	100	-200	80,000	150,000	115,000	40	75	58
Isabel	410	800	300	60	250	525	240	90	-174	12,000	18,000	15,000	6	9	8
Mocho-1	340	800	200	100	250	514	270	100	-195	200,000	350,000	275,000	100	175	138
Stanley Blvd	380	800	260	60	250	590	320	130	-210	35,000	60,000	47,500	18	30	24
Valley Ave	340	620	180	75	250	550	265	90	-210	100,000	200,000	150,000	50	100	75

Impact Summary for Design.xls - - Table set B - - 10/13/2003

TABLE 1.3-1
WELLFIELD DESIGN PARAMETERS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

Wellfield	Drawdown in Pumping Well (feet;1)			Saturated Thickness of B-Zone (feet;2)			
	2,000 gpm	3,000 gpm	4,000 gpm	0 gpm	2,000 gpm	3,000 gpm	4,000 gpm
Bernal	67	100	133	125	58	25	-8
Busch/Valley	35	52	70	65	30	13	-5
Chain of Lakes	22	33	44	80	58	47	36
Hopyard-1	35	52	70	80	45	28	10
Isabel	267	400	533	210	-57	-190	-323
Mocho-1	15	22	29	100	85	78	71
Stanley Blvd	84	126	168	130	46	4	-38
Valley Ave	27	40	53	90	63	50	37

1-Based on average specific capacity
2-Based on Drawdown in Pumping Well and Top of C-Zone Elevation

Impact Summary for Design.xls - - Table set B - - 10/13/2003

TABLE 1.3-2
PROJECTED WELL OPERATING CONDITIONS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

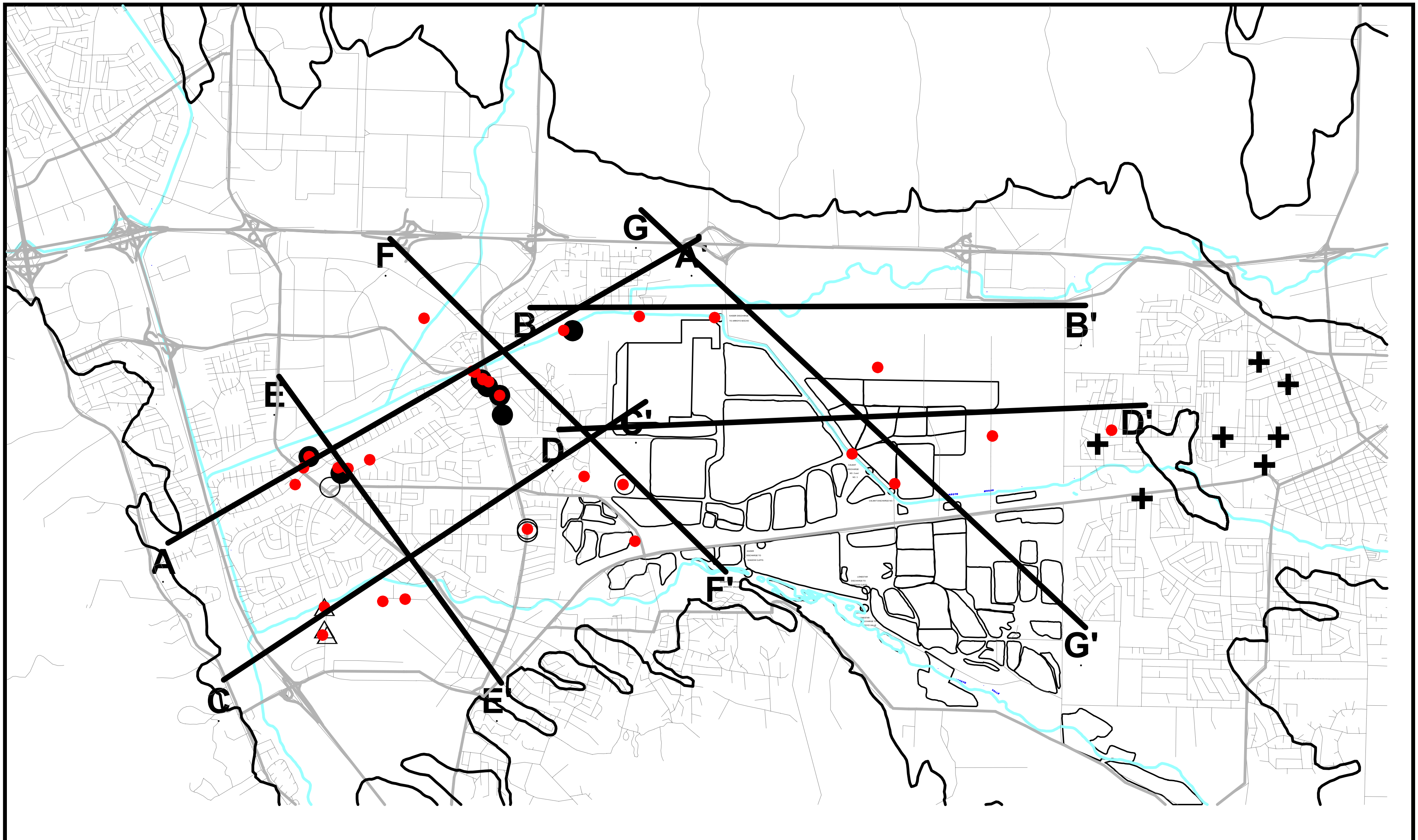
Wellfield	Average Well Spacing to Maintain <25' Interference (feet; 1)			Maximum Pumping Rate (2)	Well Screen Elevation (3) Top	Well Screen Elevation (3) Bottom	Well Depth	B-Zone Residual Saturation	TDS
	2,000 gpm	3,000 gpm	4,000 gpm	gpm	ft msl	ft msl	feet	feet	mg/L
Bernal	1,000	5,000	10,000	1,000	133	-290	620	58	420
Busch/Valley	500	1,000	5,000	3,000	168	-270	620	13	450
Chain of Lakes	100	500	1,000	4,000	196	-460	850	36	-
Hopyard-1	500	1,000	5,000	3,000	128	-255	580	28	550
Isabel	>1,000	-	-	500	33	-390	800	-57	-
Mocho-1	100	100	500	4,000	171	-460	800	71	500
Stanley Blvd	2,000	5,000	10,000	1,000	176	-420	800	46	-
Valley Ave	100	1,000	1,000	3,000	140	-280	620	50	500

1-Base on estimate of maximum transmissivity and distance-drawdown curves.
2-Based on maintaining about 1,000 feet well spacing or less
3-Based on pumping water level in well at maximum pumping rate

Impact Summary for Design.xls - - Table set B - - 10/13/2003

TABLE 1.3-3
PRELIMINARY WELL CONSTRUCTION RECOMMENDATIONS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL



LEGEND

- Zone 7 wells
- City of Pleasanton wells
- City of San Francisco wells
- Cal-Water wells
- Well used in construction

N

0 feet 5280 feet 10560 feet 15840 feet

FIGURE 1.1-1
CROSS-SECTION LOCATION AND WELLS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.1-1_10/10/03_ccc

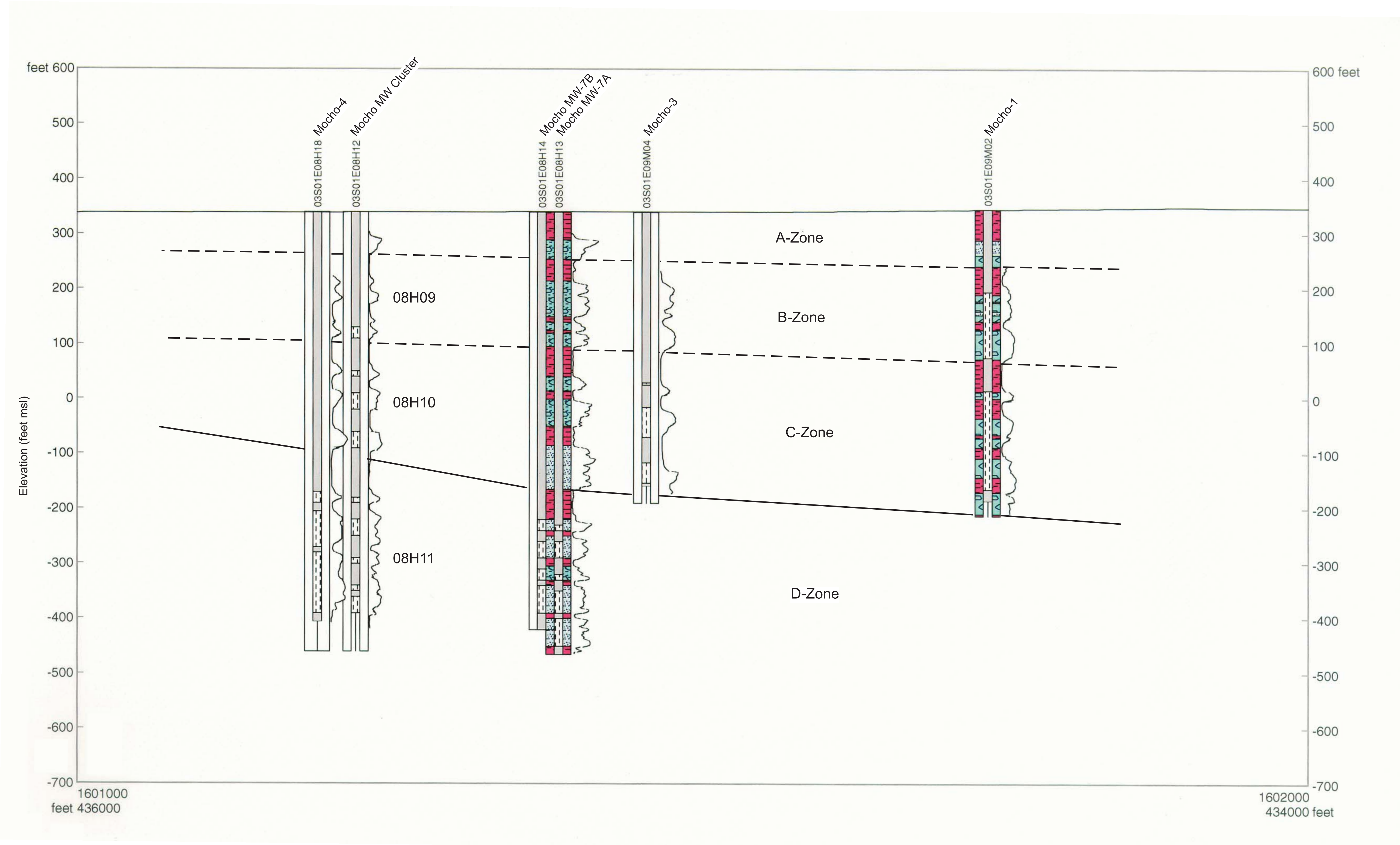


FIGURE 1.1-2
CROSS-SECTION MOCHO WELLFIELD
WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Figure 1.1-2 X Sec Mocho-rev_10/10/03_ccc

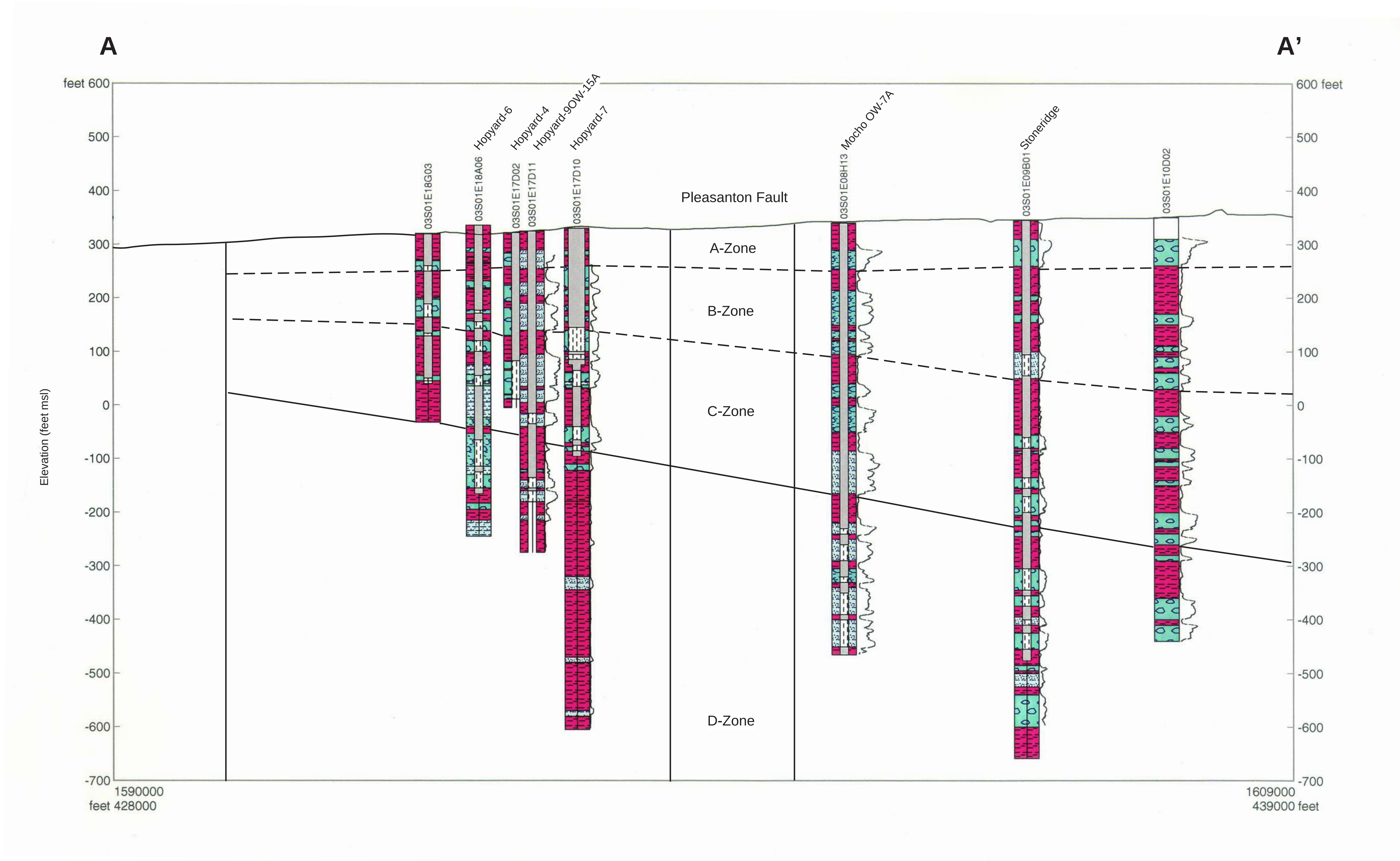


FIGURE 1.1-3
CROSS-SECTION A-A’
WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Figure 1.1-3 X Sec A-A_10/10/03_ccc

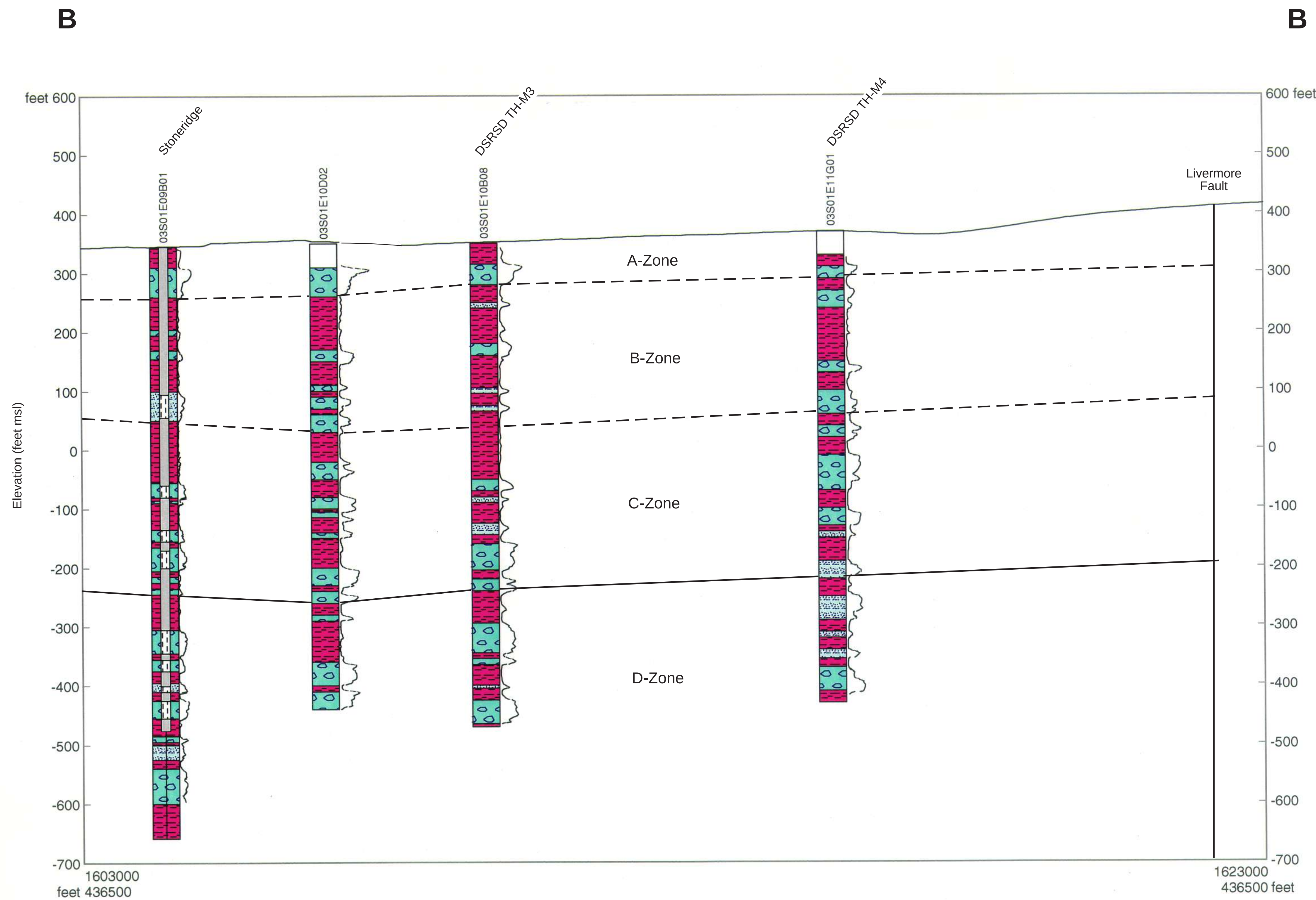


FIGURE 1.1-4
CROSS-SECTION B-B'
WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

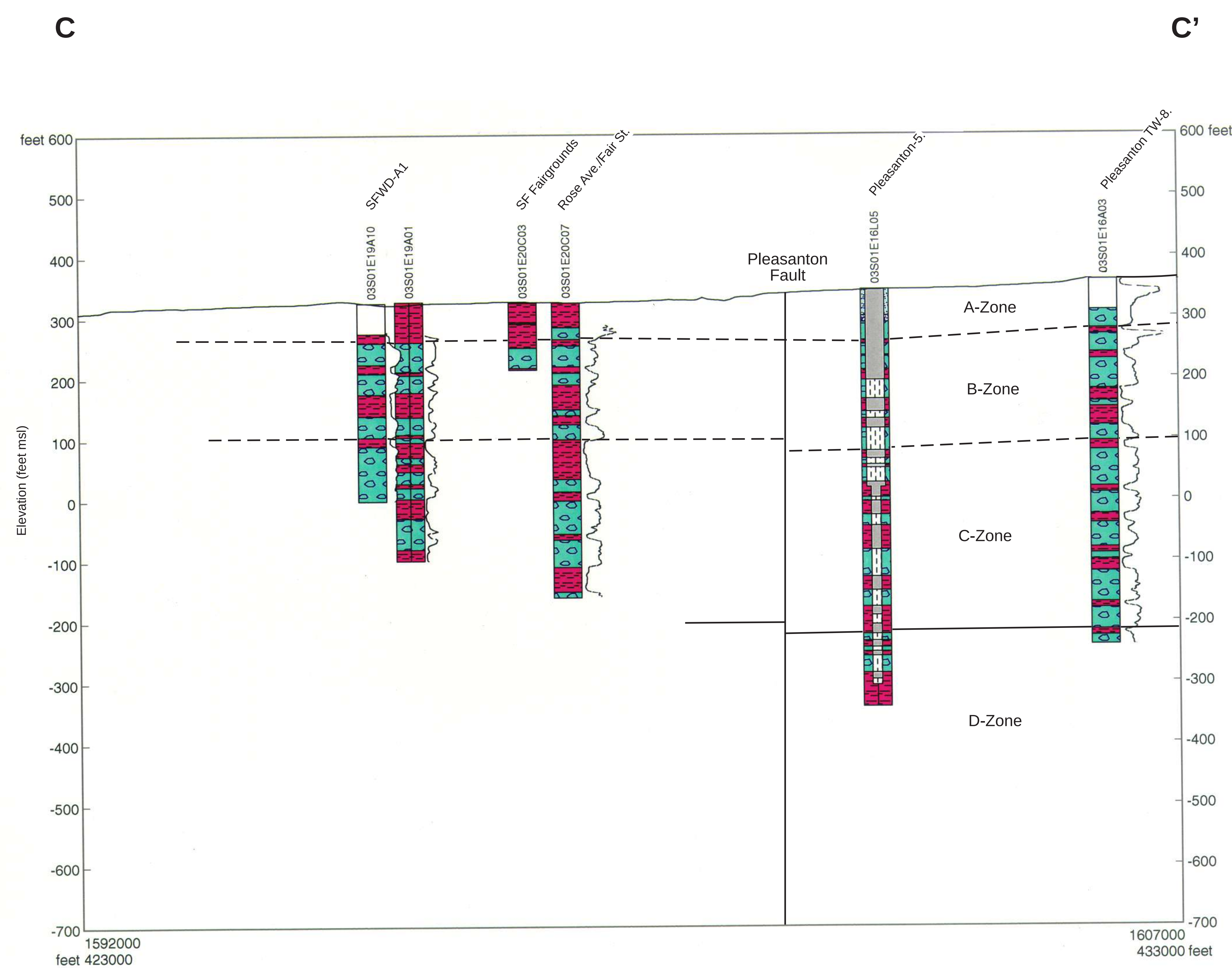


FIGURE 1.1-5
CROSS-SECTION C-C'
WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

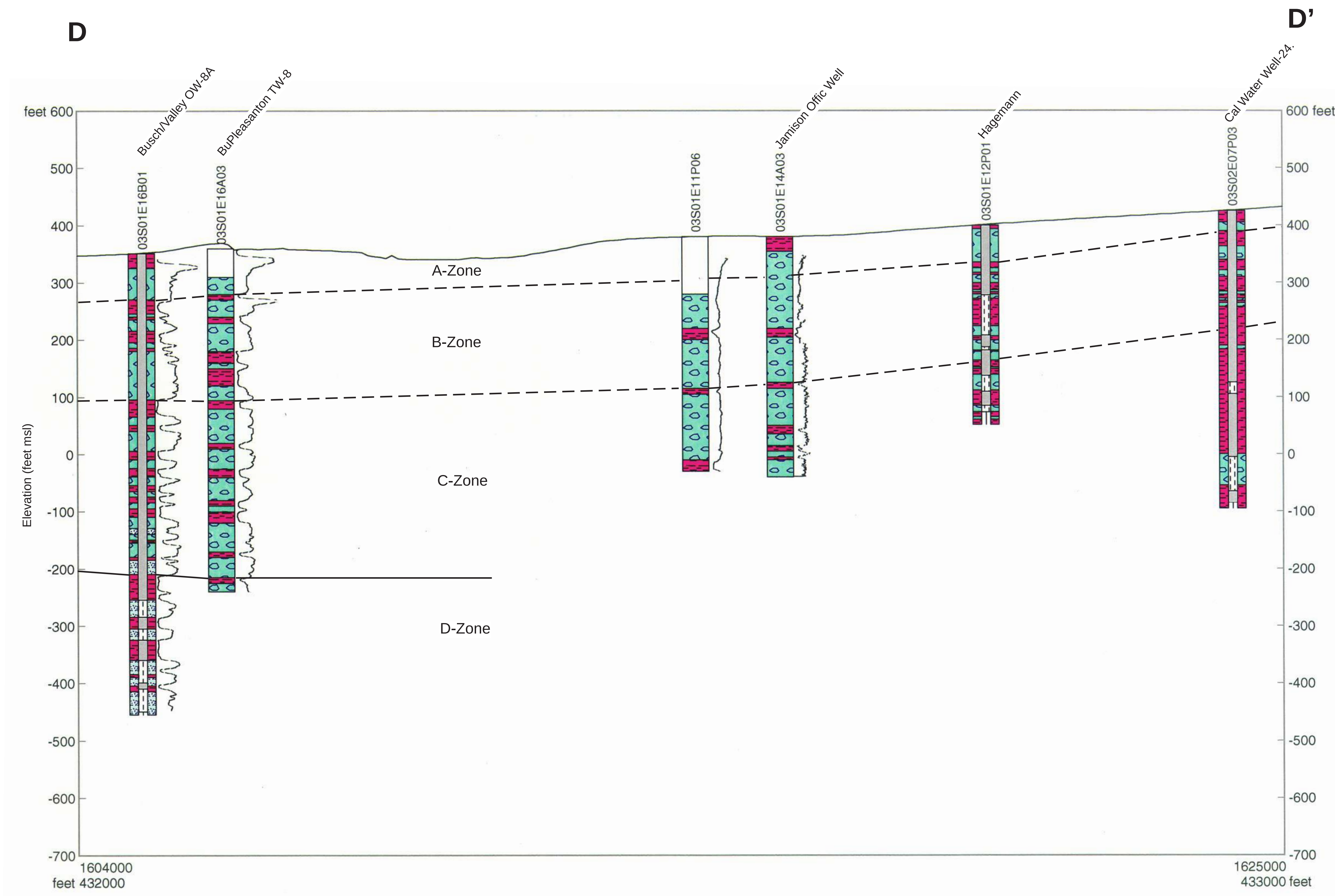


FIGURE 1.1-6
CROSS-SECTION D-D'
WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Figure 1.1-6 X Sec D-D_10/10/03_ccc

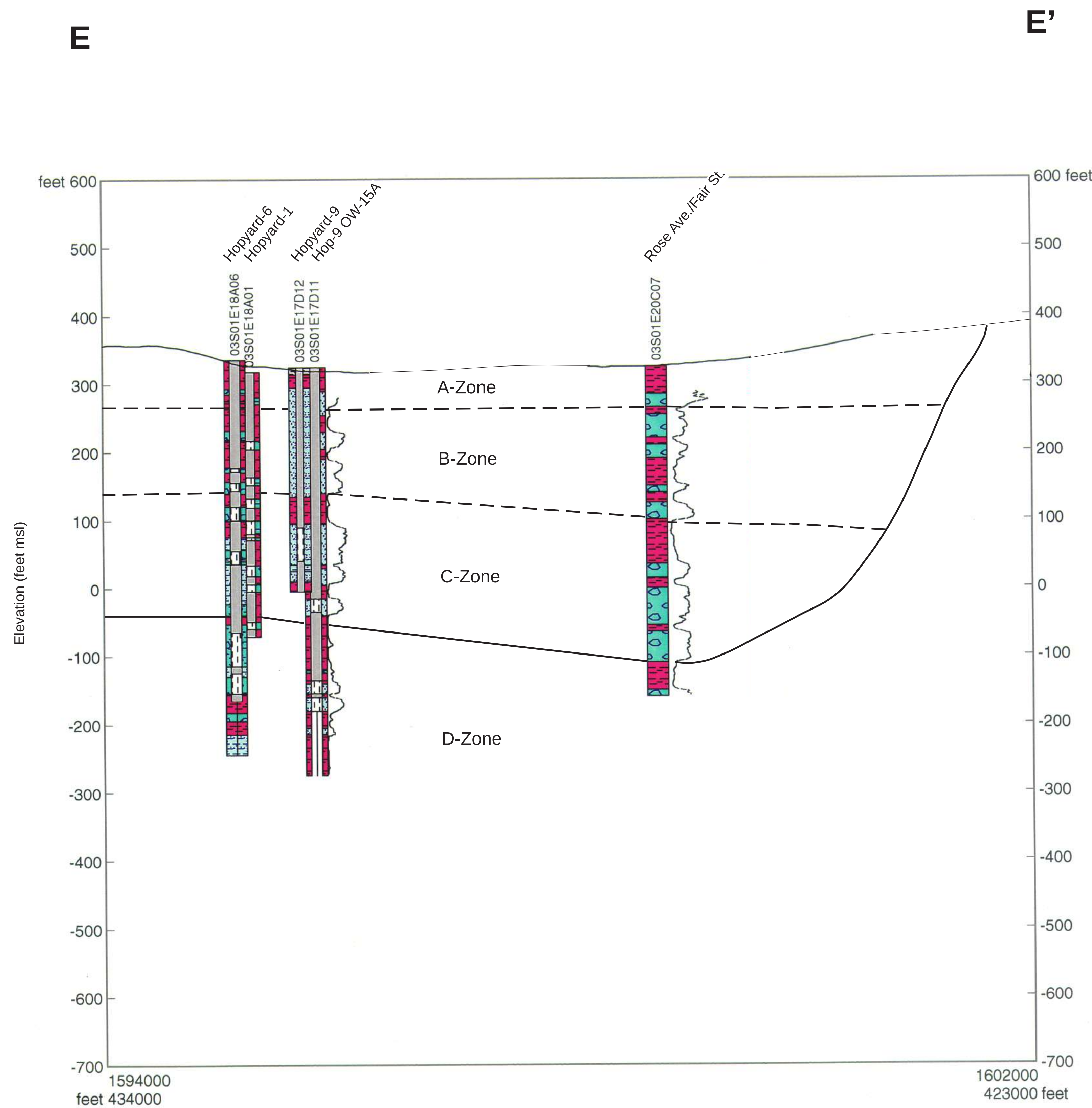


FIGURE 1.1-7
CROSS-SECTION E-E'
WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

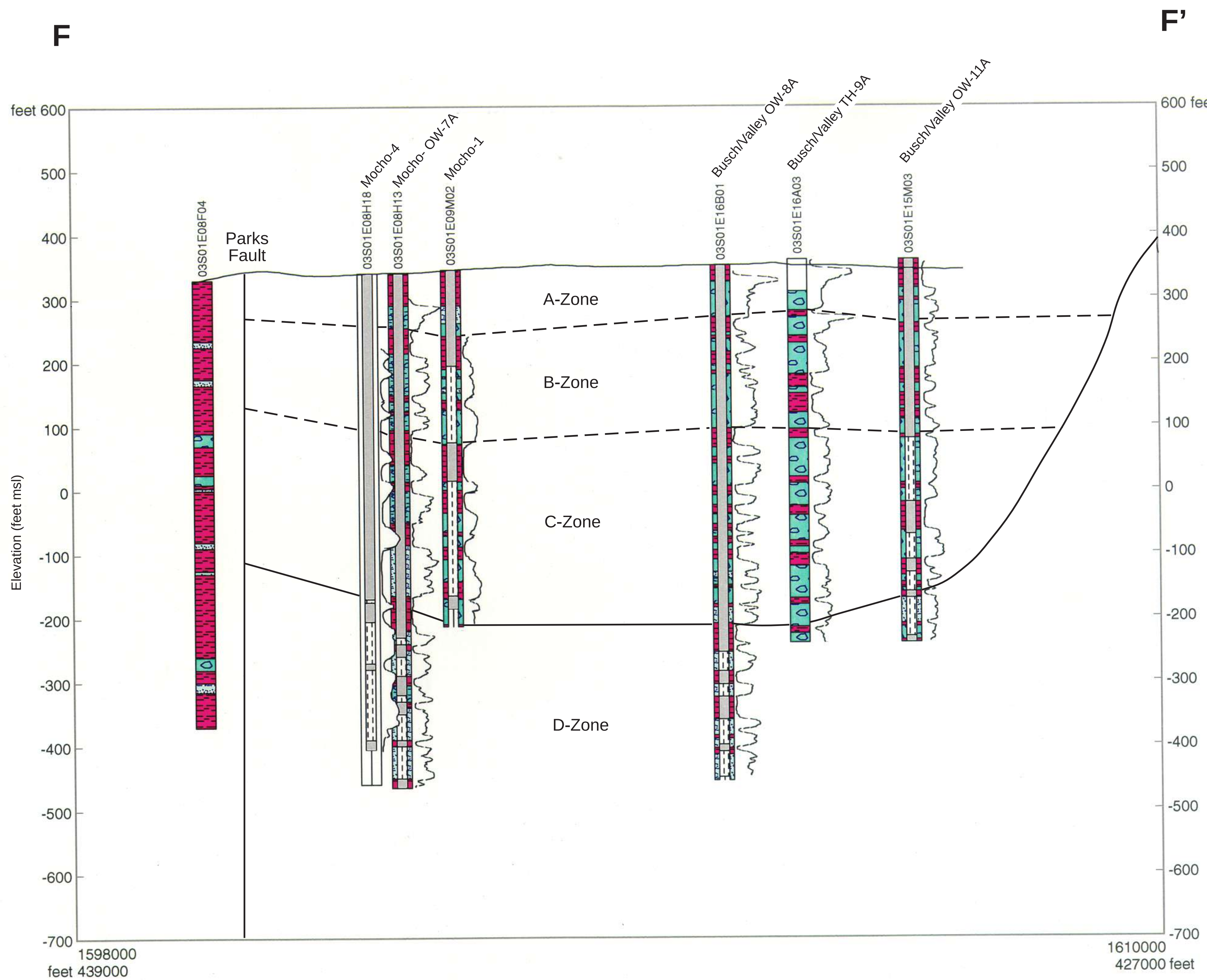


FIGURE 1.1-8
CROSS-SECTION F-F'
WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Figure 1.1-8 X Sec F-F_10/10/03_ccc

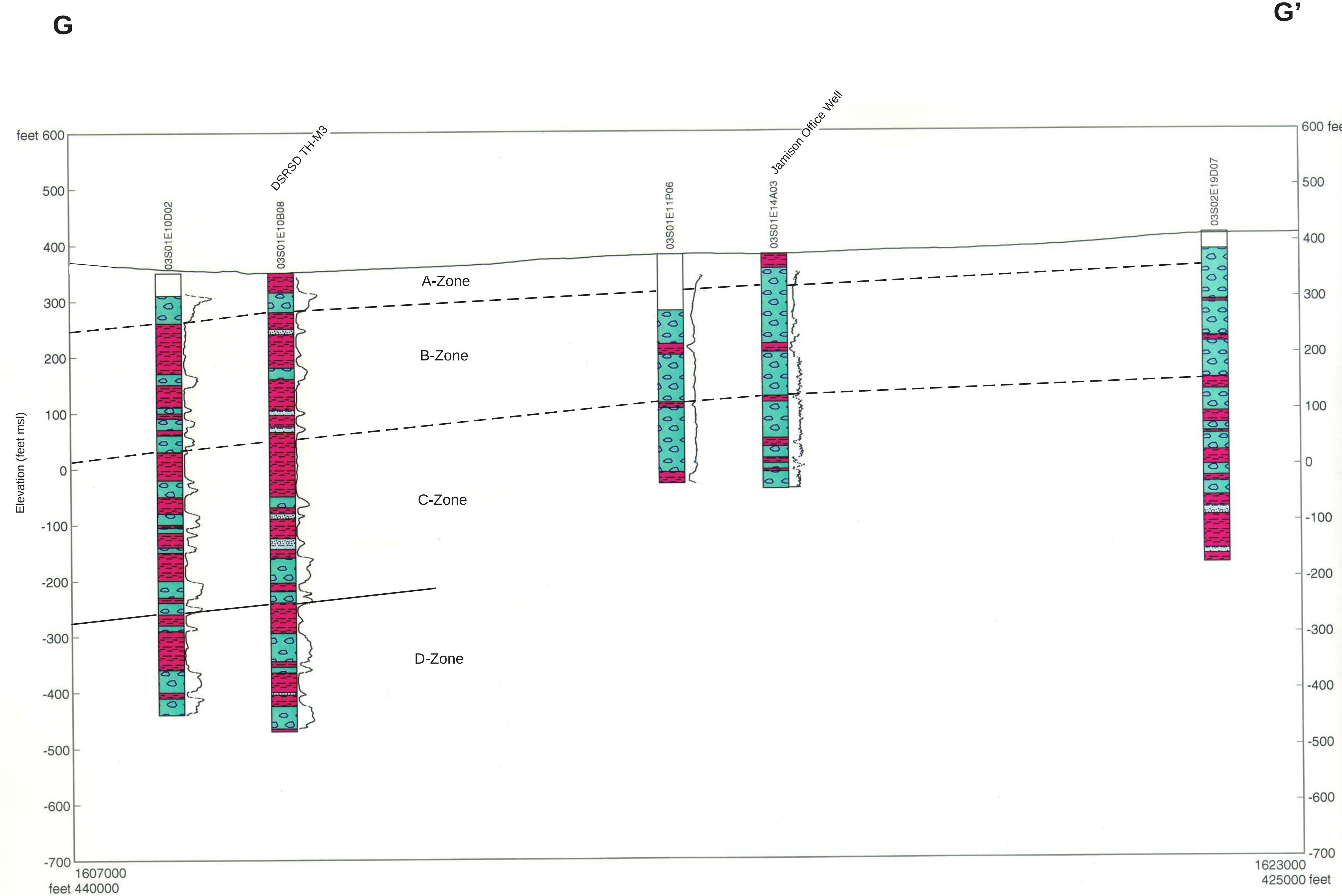
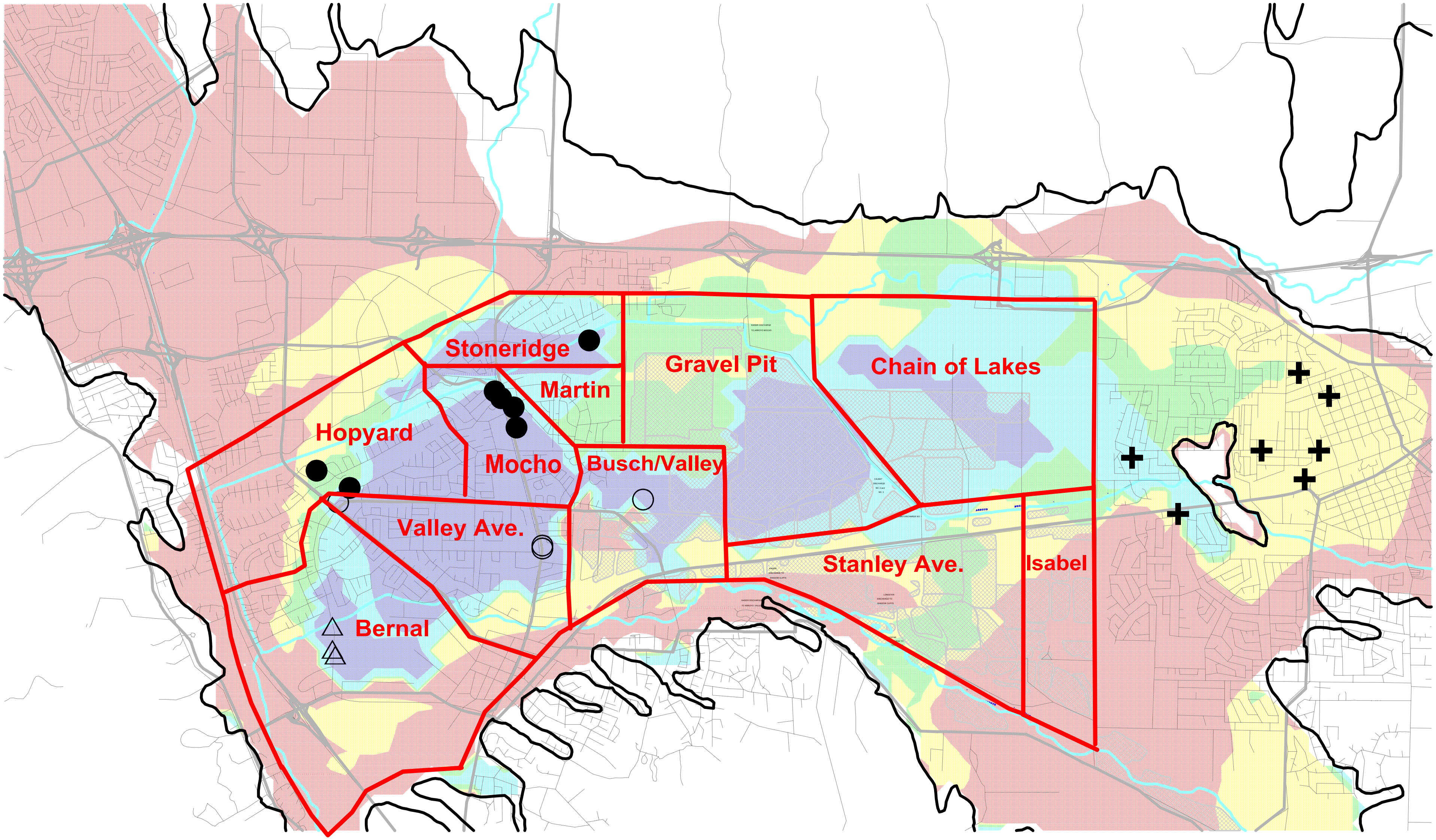


FIGURE 1.1-9
CROSS-SECTION G-G’
WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN



N

LEGEND

- ● Zone 7 wells
- ○ City of Pleasanton wells
- △ City of San Francisco wells
- ✚ Cal-Water wells

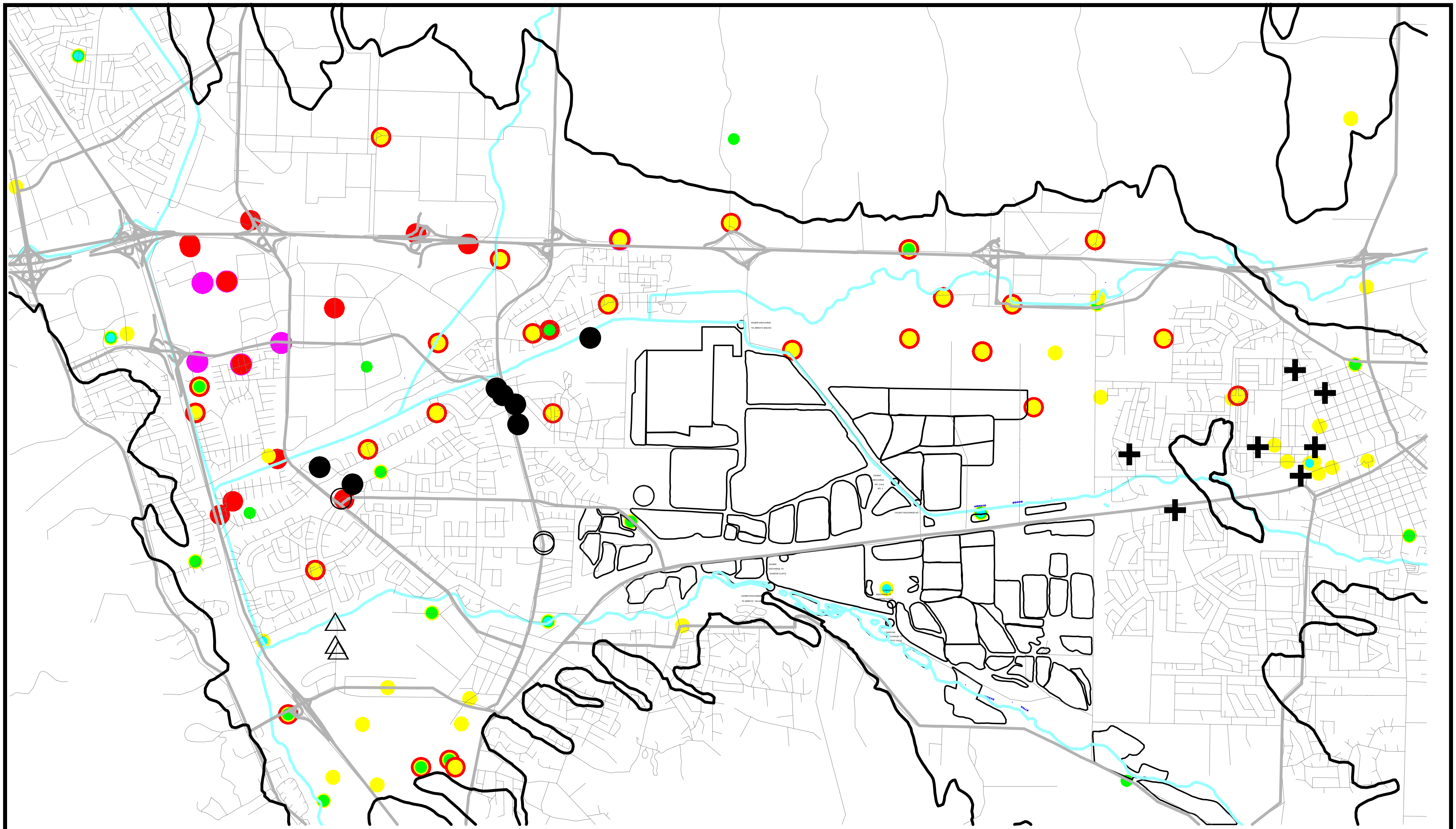
5,000 | 25,000 | 50,000 | 100,000 | 300,000

0 feet | 5280 feet | 10560 feet | 15840 feet

FIGURE 1.1-10
MODEL TRANSMISSIVITY AND WELLFIELD LOCATIONS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 3-3-10_10/09/03_ccc



LEGEND

- 0 to 250
- 250 to 500
- 500 to 1000
- 1000 to 5000
- 5000 to 40000

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

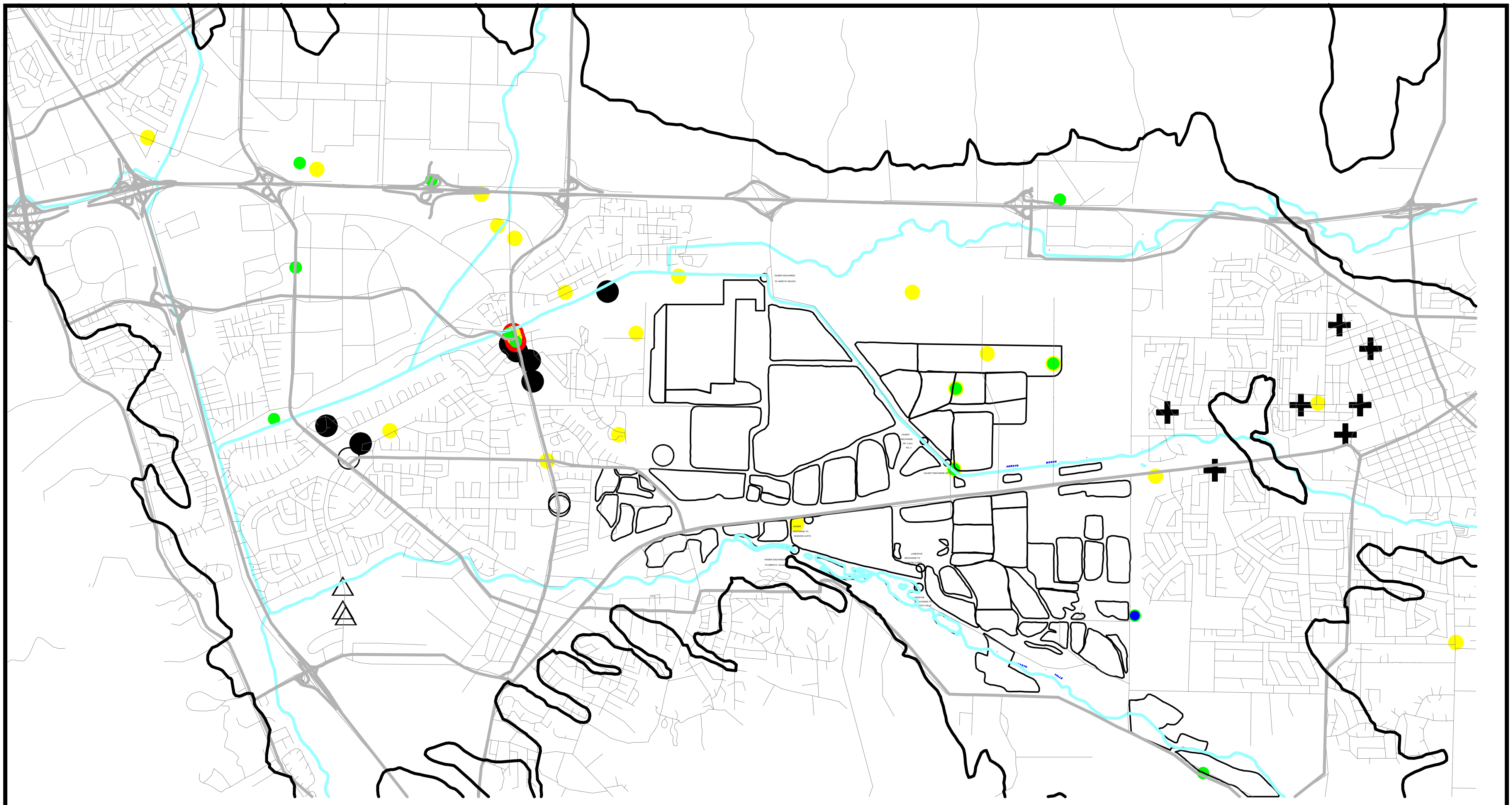
N

0 feet 5280 feet 10560 feet 15840 feet

FIGURE 1.2-1
TDS (µg/L) < 100 ft bgs
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-1_10/10/03_ccc



LEGEND

- 0 to 250
- 250 to 500
- 500 to 1000
- 1000 to 5000
- 5000 to 40000

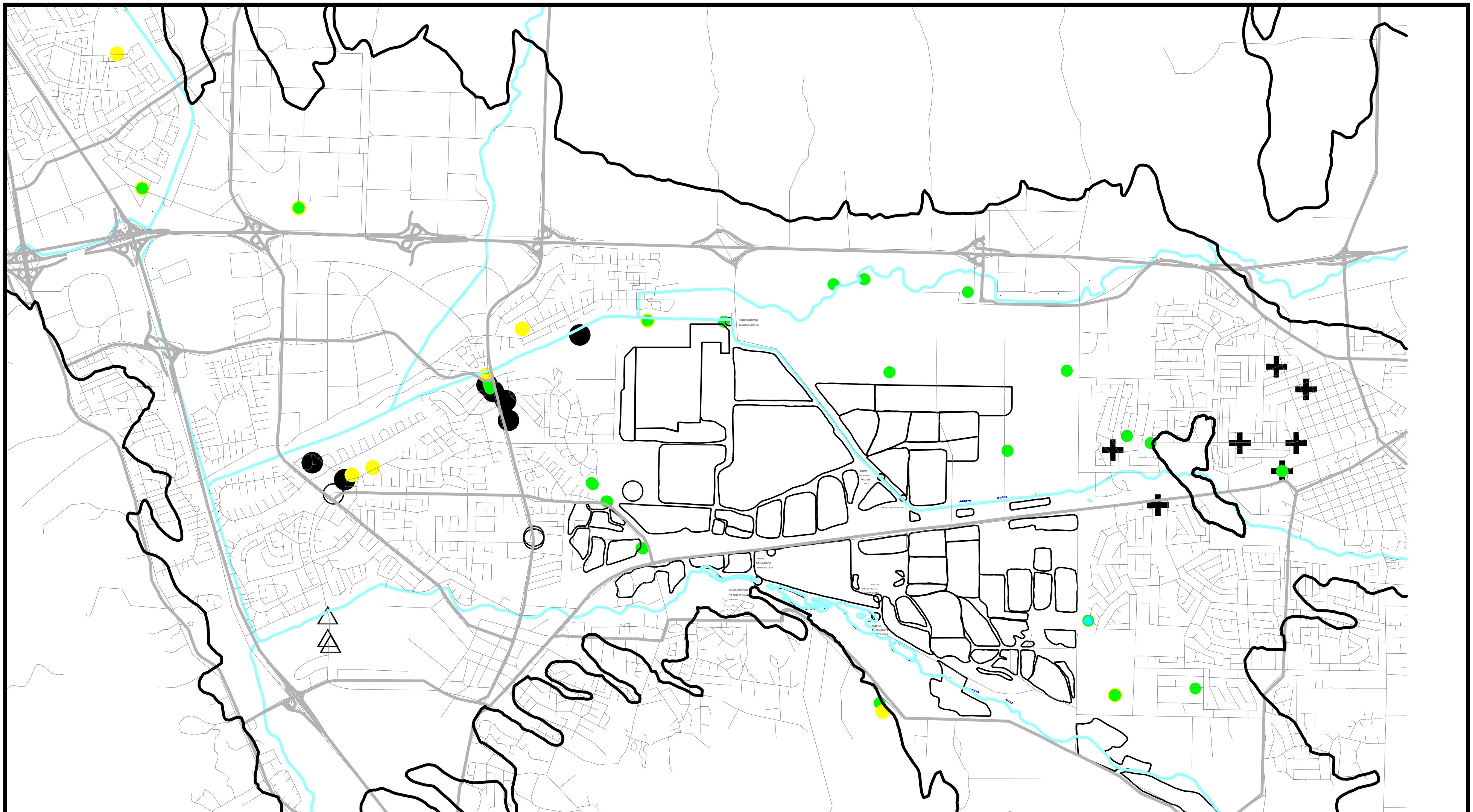
- Zone 7 wells
- City of Pleasanton wells
- City of San Francisco wells
- Cal-Water wells

N

0 feet | 5280 feet | 10560 feet | 15840 feet

FIGURE 1.2-2
TDS (μg/L) < 100 to 250 ft bgs
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL



LEGEND

- 0 to 250
- 250 to 500
- 500 to 1000
- 1000 to 5000
- 5000 to 40000

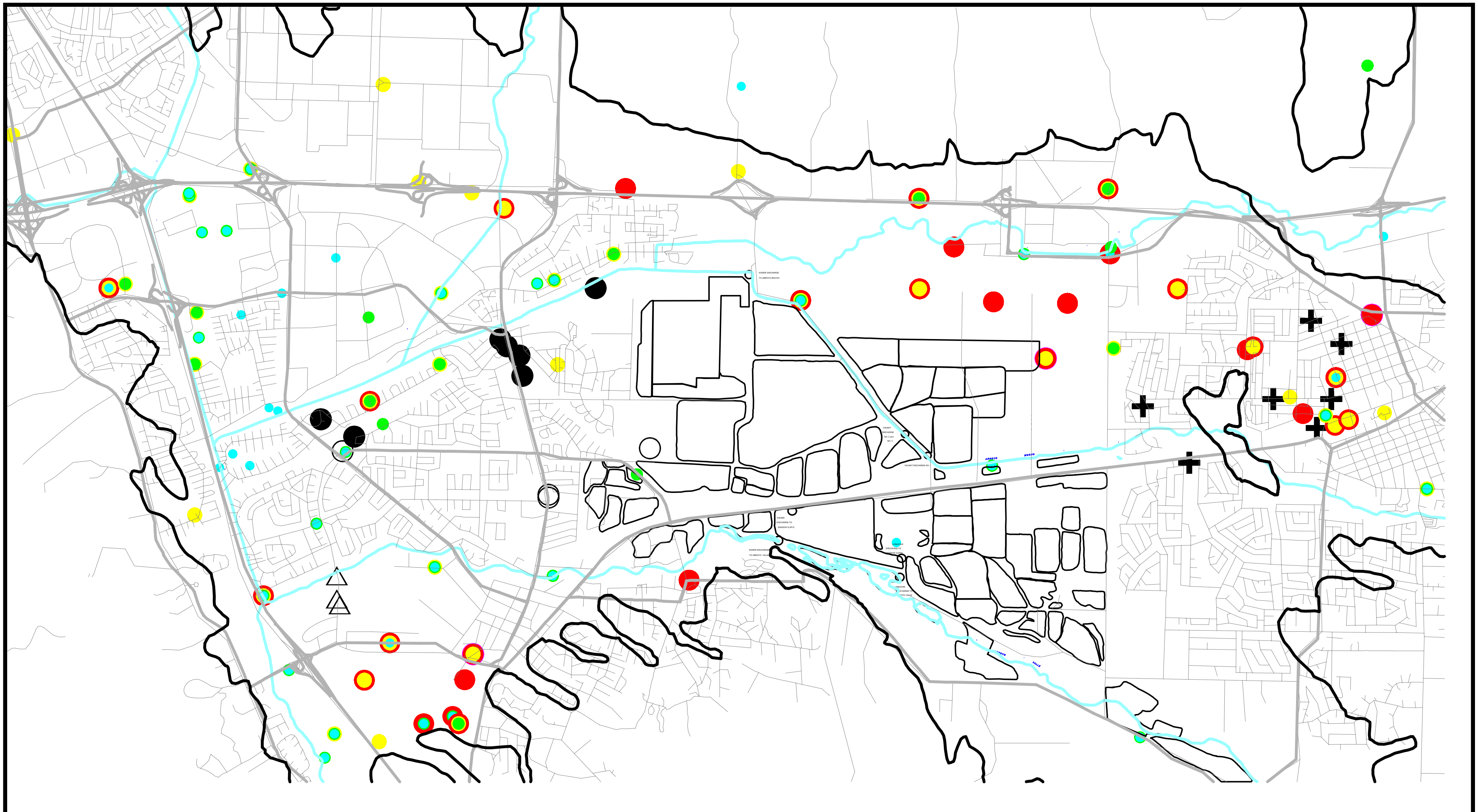
- Zone 7 wells
- City of Pleasanton wells
- City of San Francisco wells
- Cal-Water wells

N

0 feet 5280 feet 10560 feet 15840 feet

FIGURE 1.2-3
TDS (mg/L) > 250 ft bgs
ZONE 7 WATER AGENCY
WELL WATER PLAN
CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-3_10/10/03_ccc



LEGEND

- 0 to 5
- 5 to 20
- 20 to 45
- 45 to 100
- 100 to 250

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

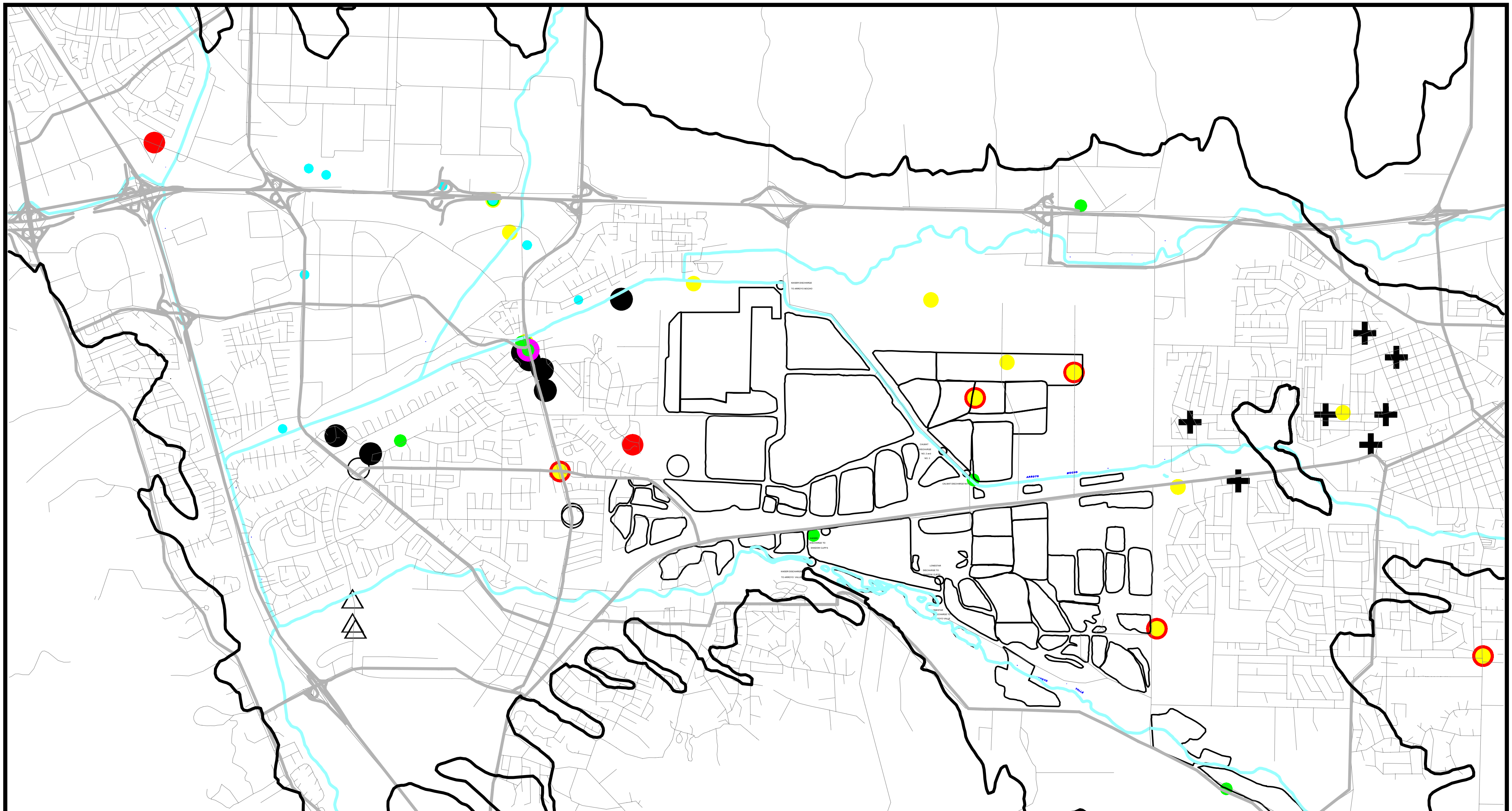
N

0 feet 5280 feet 10560 feet 15840 feet

FIGURE 1.2-4
NO3 (mg/L) <100 ft bgs
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-4_10/10/03_ccc



LEGEND

- 0 to 5
- 5 to 20
- 20 to 45
- 45 to 100
- 100 to 250

- 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 1.2-5
NO3 (mg/L) 100 to 250 ft bgs
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 2-4-5_10/08/03_ccc

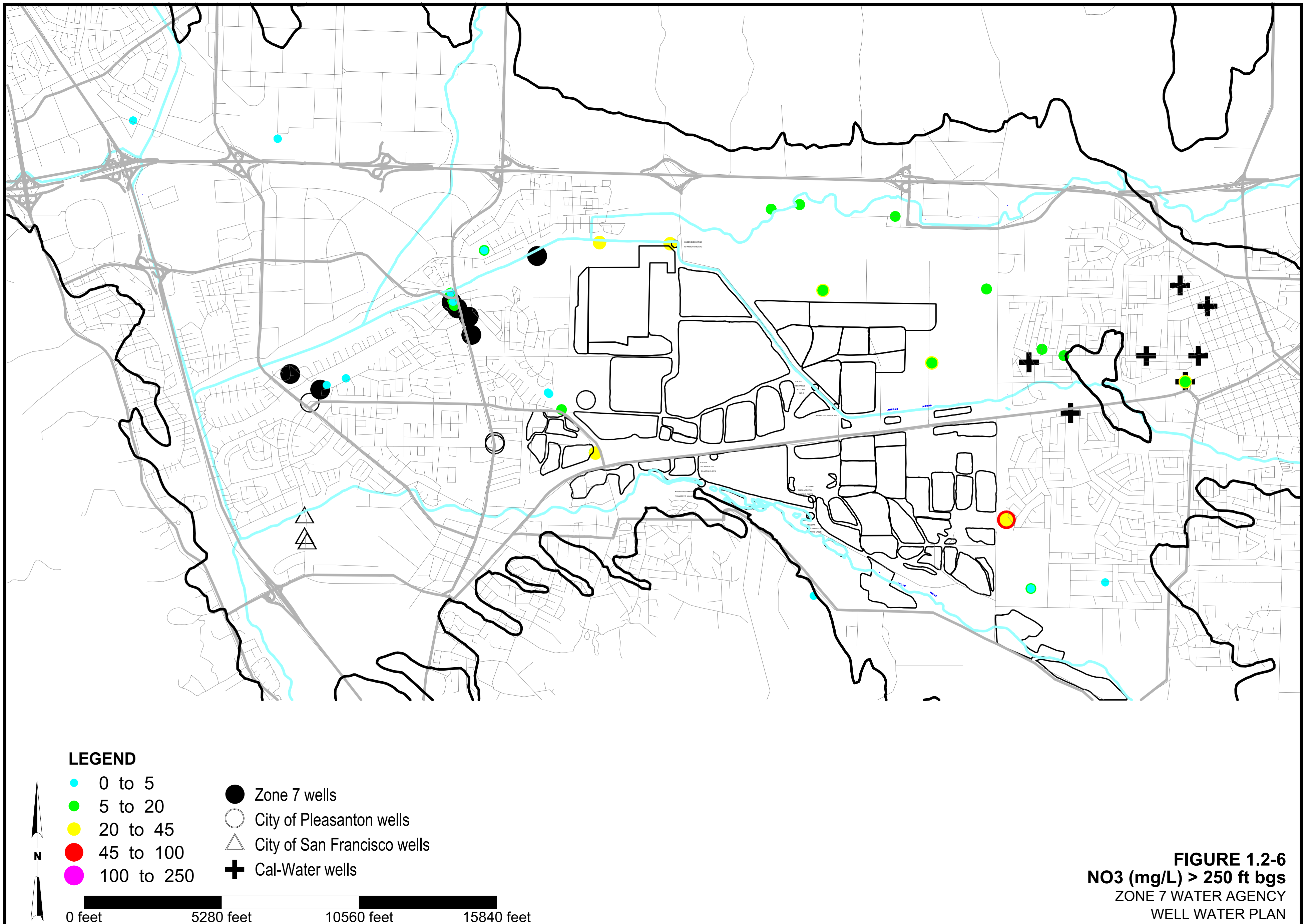
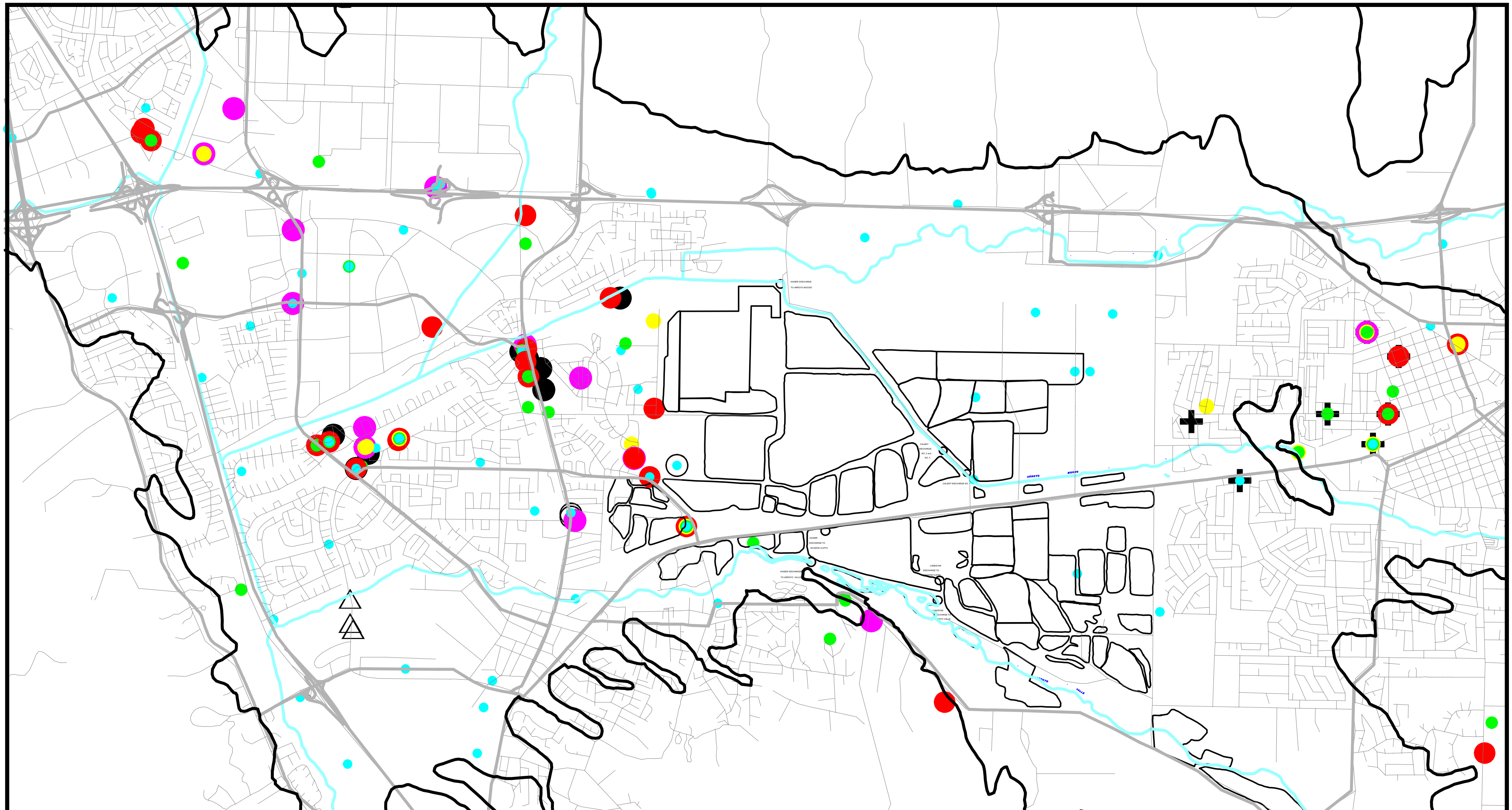


FIGURE 1.2-6
NO3 (mg/L) > 250 ft bgs
ZONE 7 WATER AGENCY
WELL WATER PLAN
CH2MHILL



LEGEND

- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- 0.3 to 1
- 1 to 85

- 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 1.2-7
IRON (μg/L) ALL WELLS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-7_10/10/03_ccc

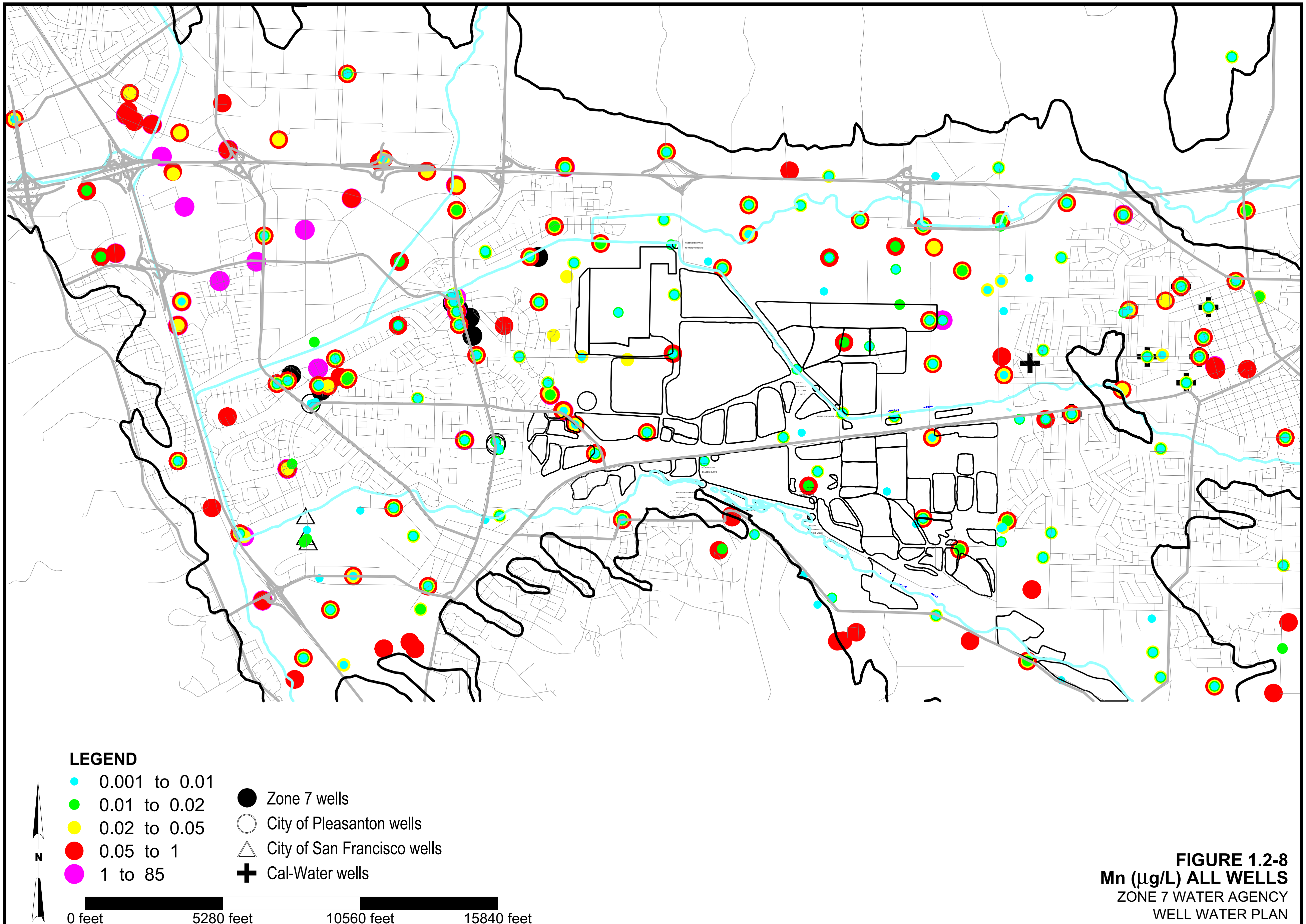


FIGURE 1.2-8
Mn (μg/L) ALL WELLS
ZONE 7 WATER AGENCY
WELL WATER PLAN
CH2MHILL

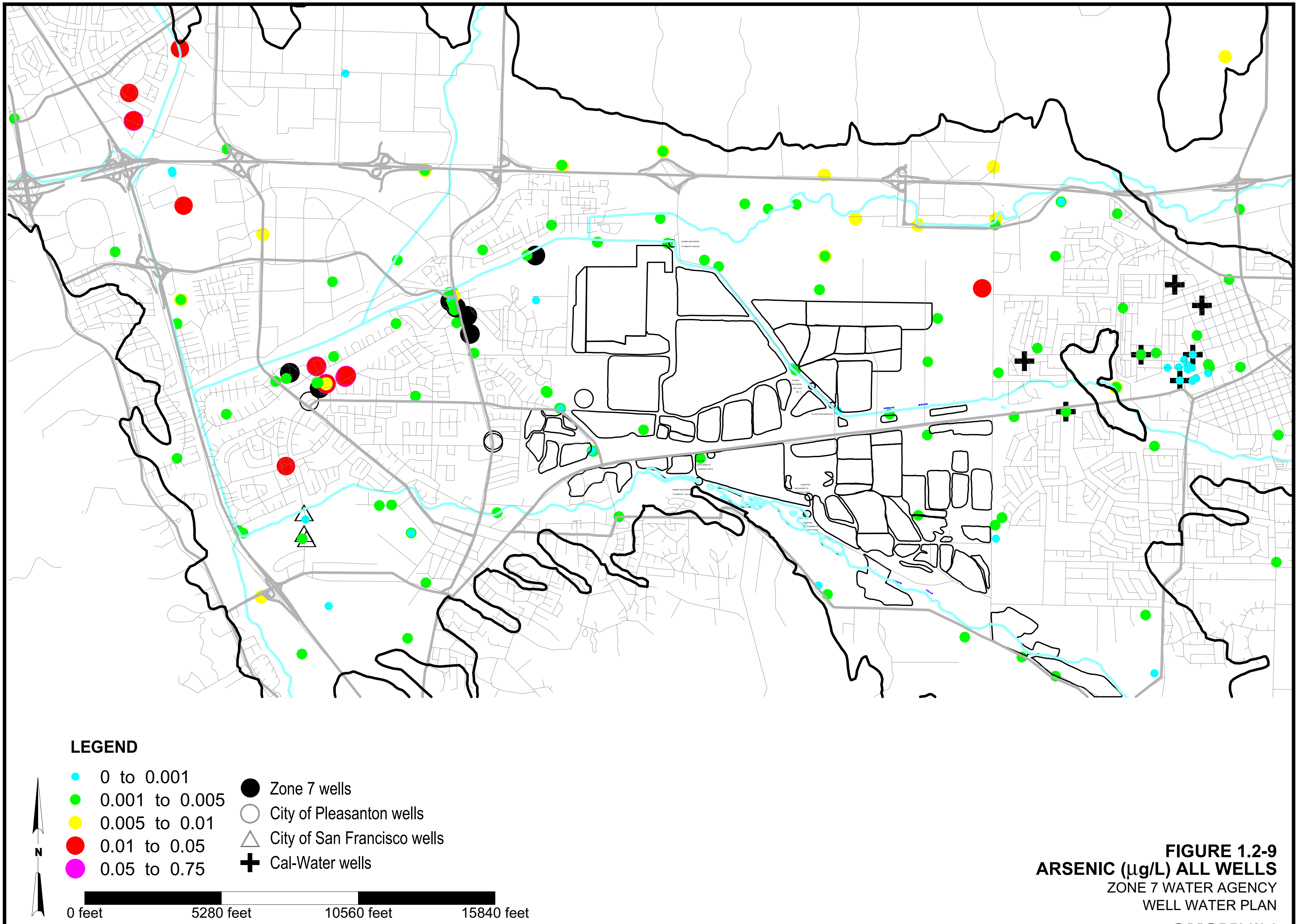
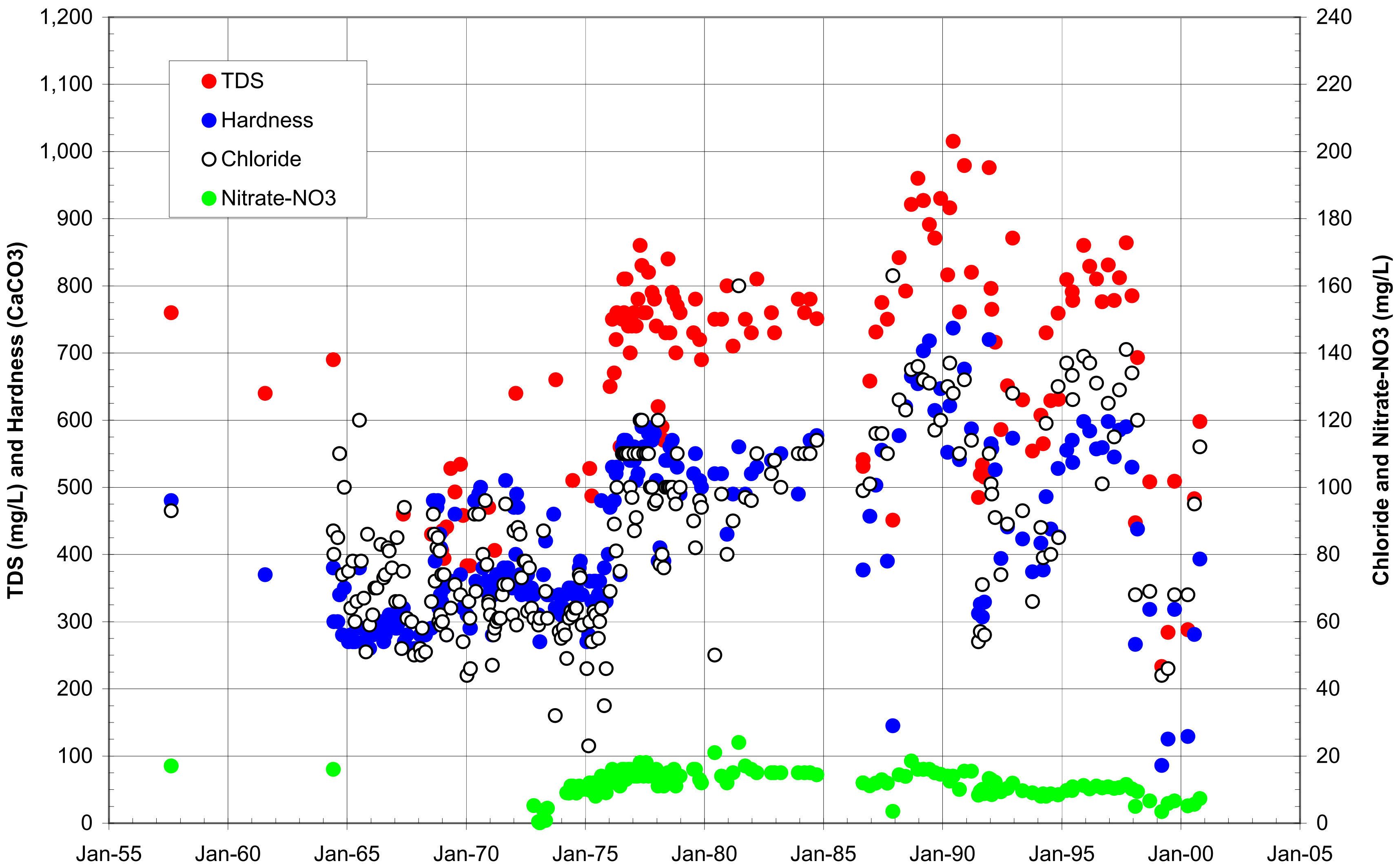


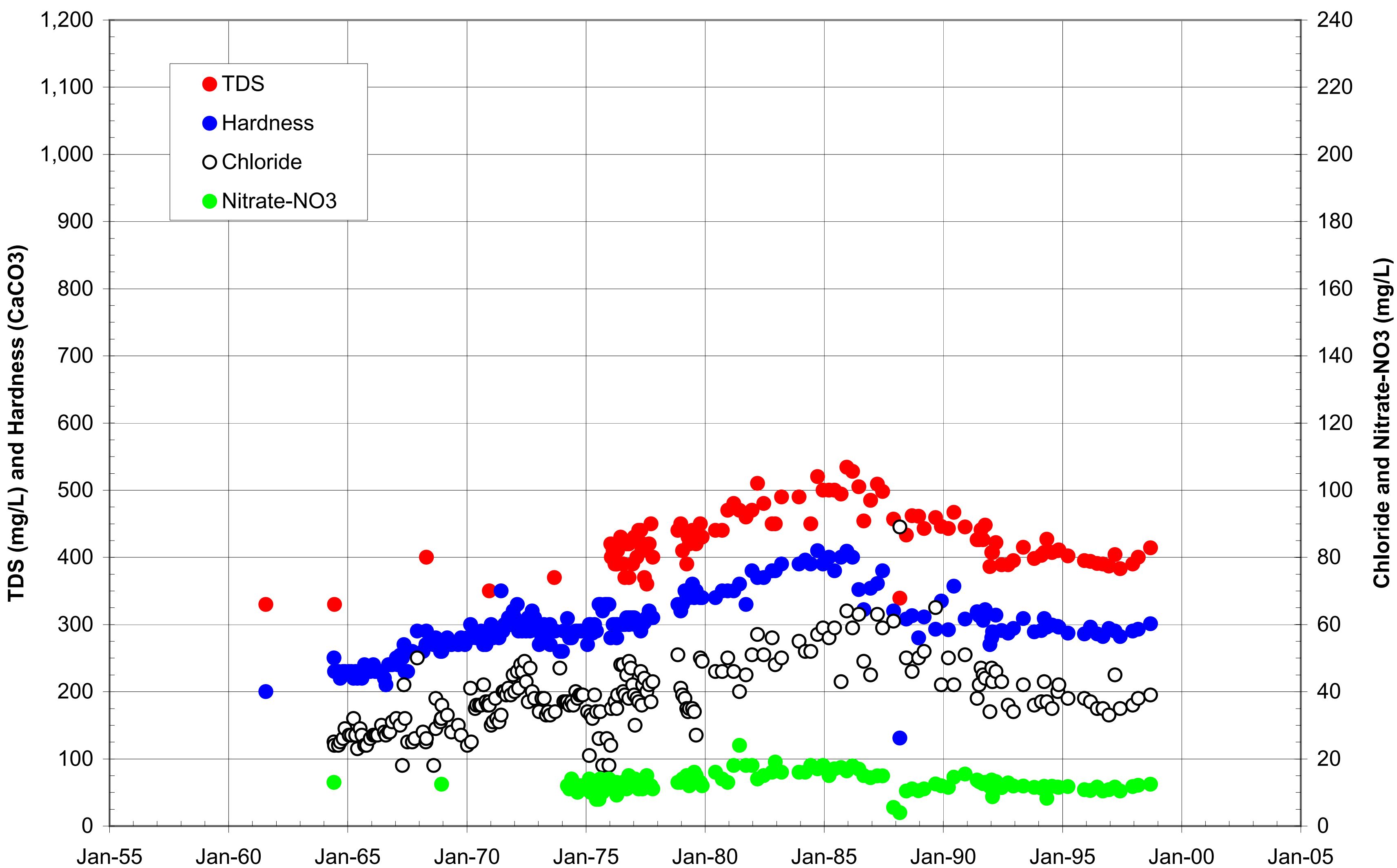
FIGURE 1.2-9
ARSENIC (µg/L) ALL WELLS
ZONE 7 WATER AGENCY
WELL WATER PLAN
CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 2-4-9_10/08/03_ccc



WQ for key wells.xls -- Hop1 -- 10/06/2003

FIGURE 1.2-10
HOPYARD-1
ZONE 7 WATER AGENCY
WELL WATER PLAN
CH2MHILL

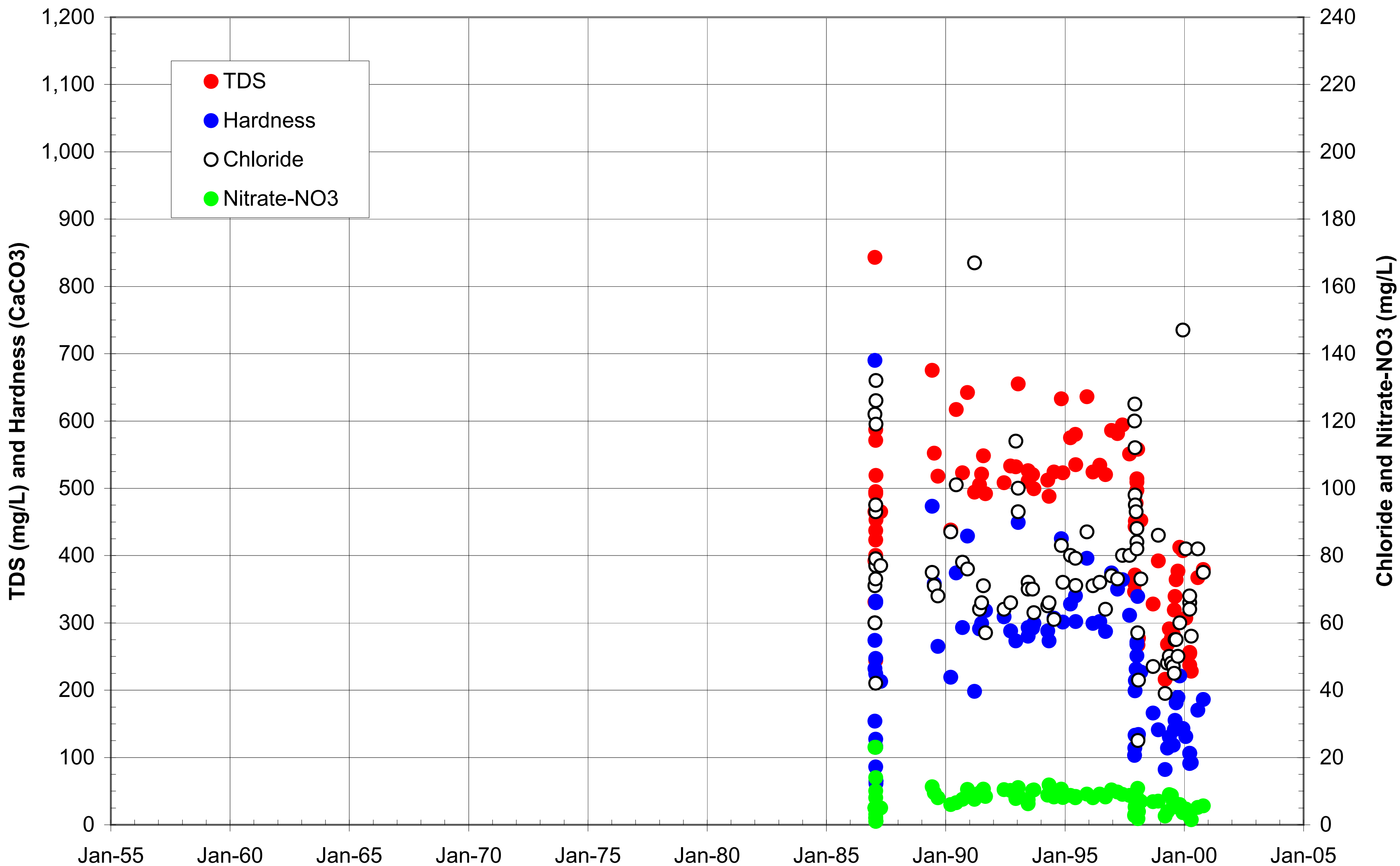


WQ for key wells.xls -- Hop4 -- 10/06/2003

FIGURE 1.2-11
HOPYARD-4
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-11_10/10/03_ccc

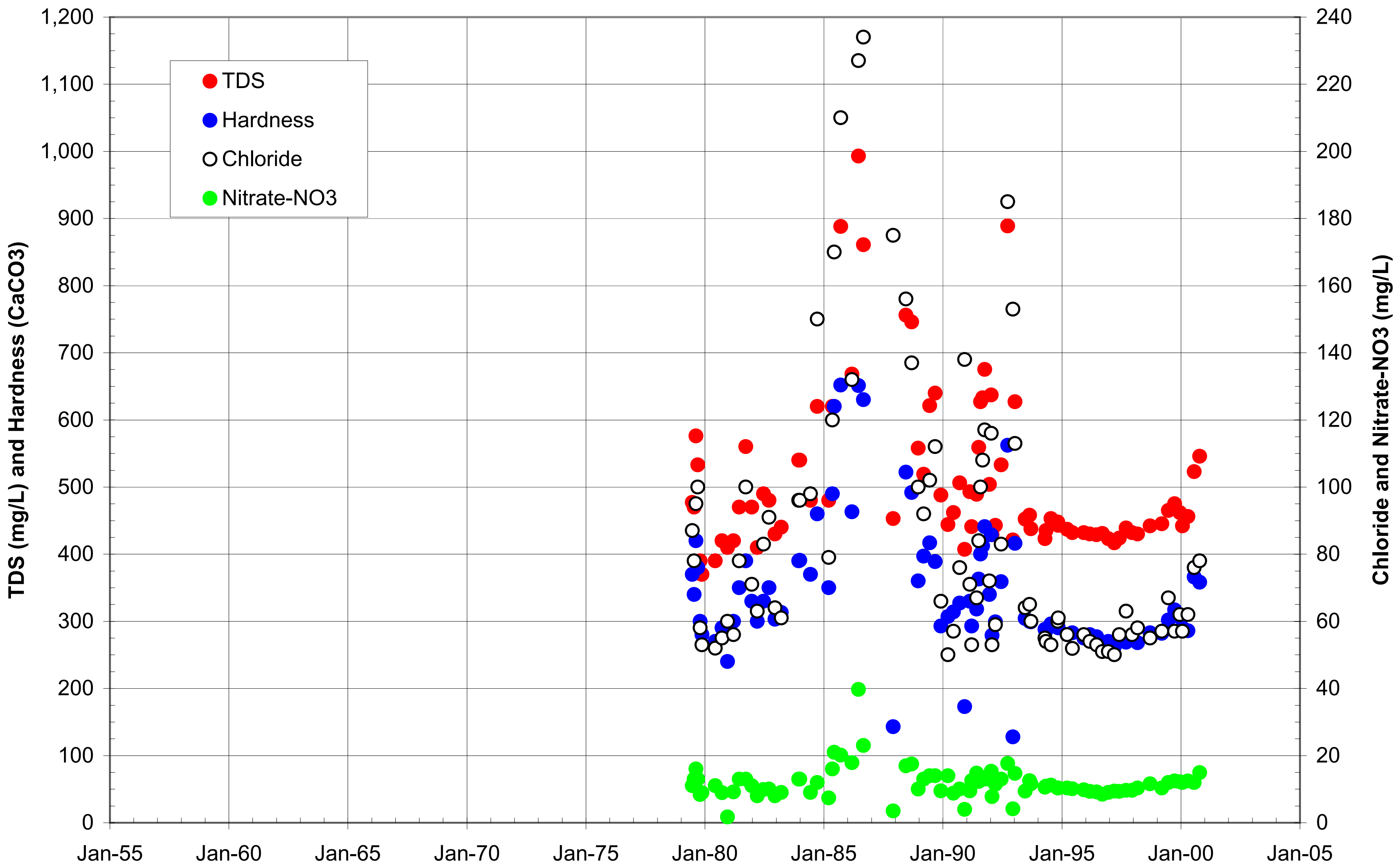


WQ for key wells.xls -- Hop6 -- 10/06/2003

FIGURE 1.2-12
HOPYARD-6
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

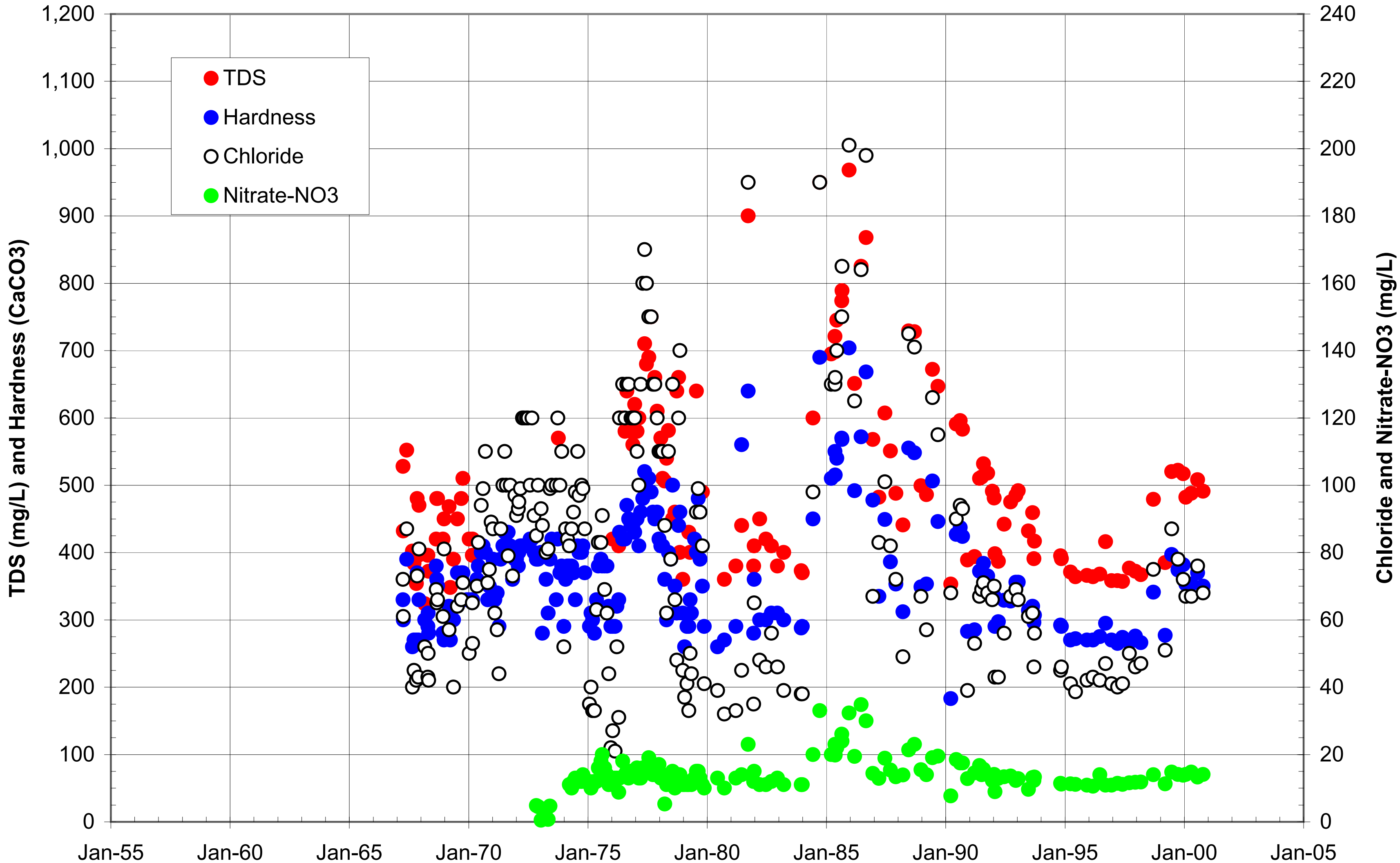
163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-12_10/10/03_ccc



WQ for key wells.xls -- Mocho-1 -- 10/06/2003

FIGURE 1.2-13
MOCHO-1
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

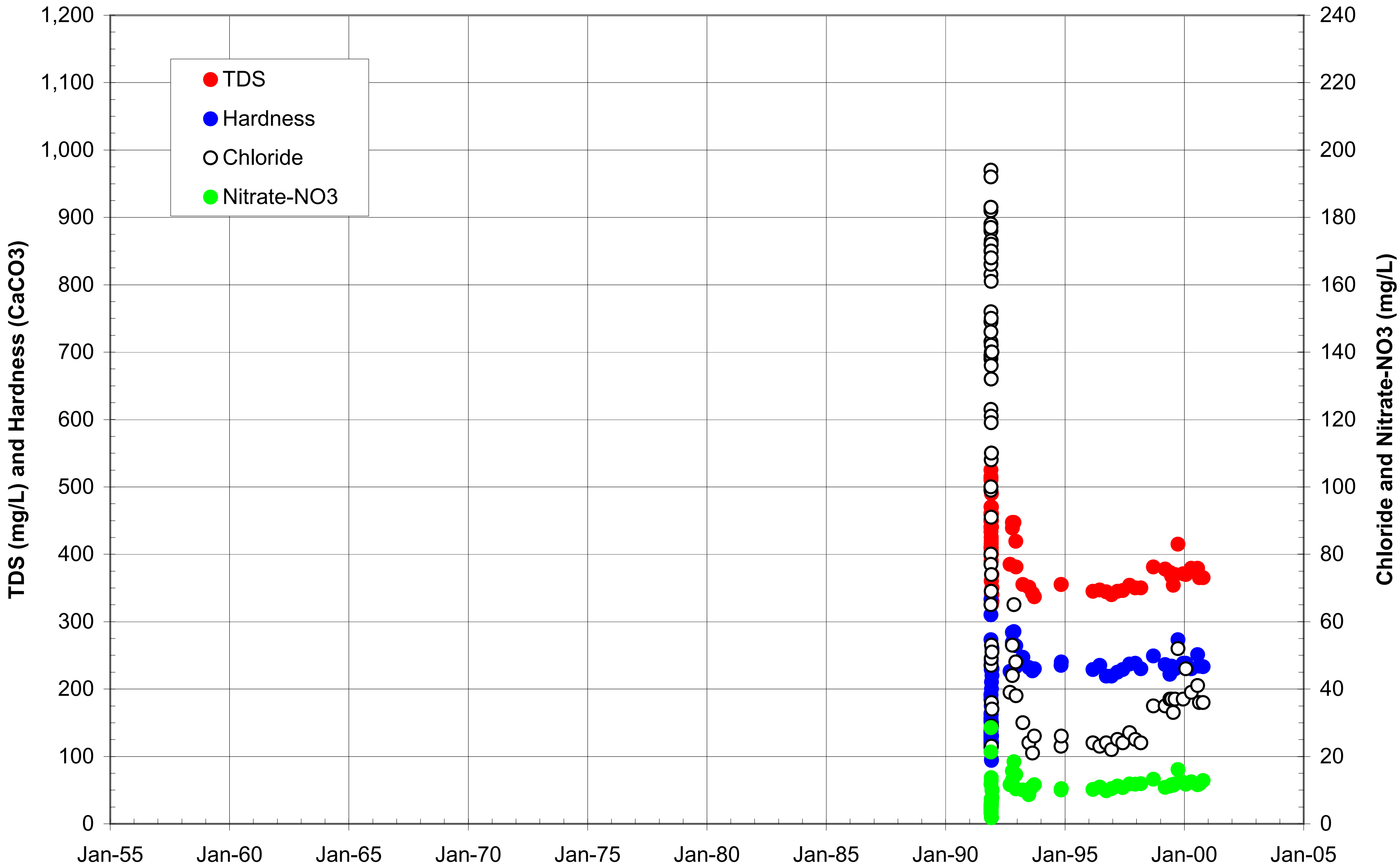


WQ for key wells.xls -- Mocho-2 -- 10/06/2003

FIGURE 1.2-14
MOCHO-2
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-14_10/10/03_ccc

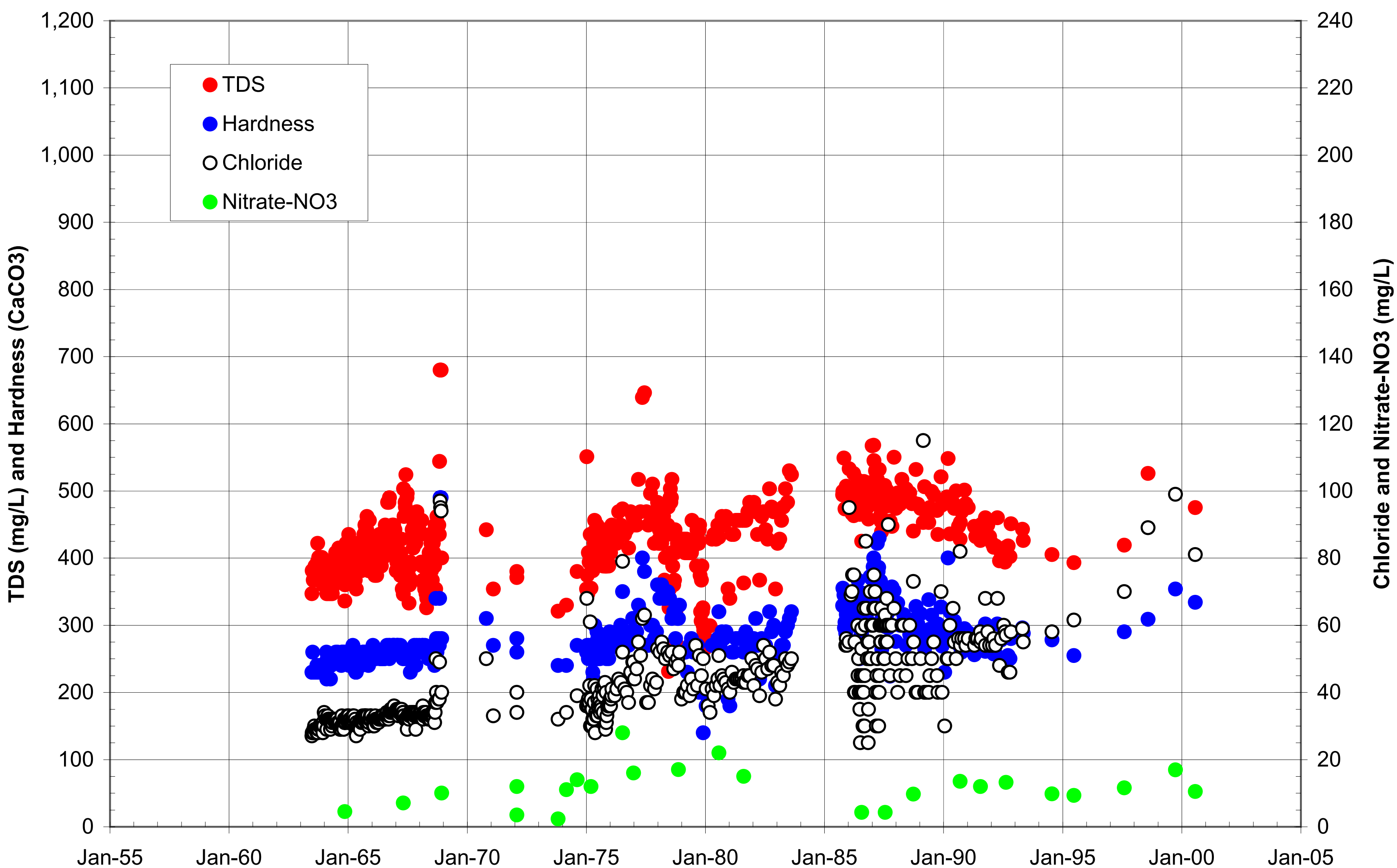


WQ for key wells.xls -- Stoneridge -- 10/06/2003

FIGURE 1.2-15
STONERIDGE
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-15_10/10/03_ccc

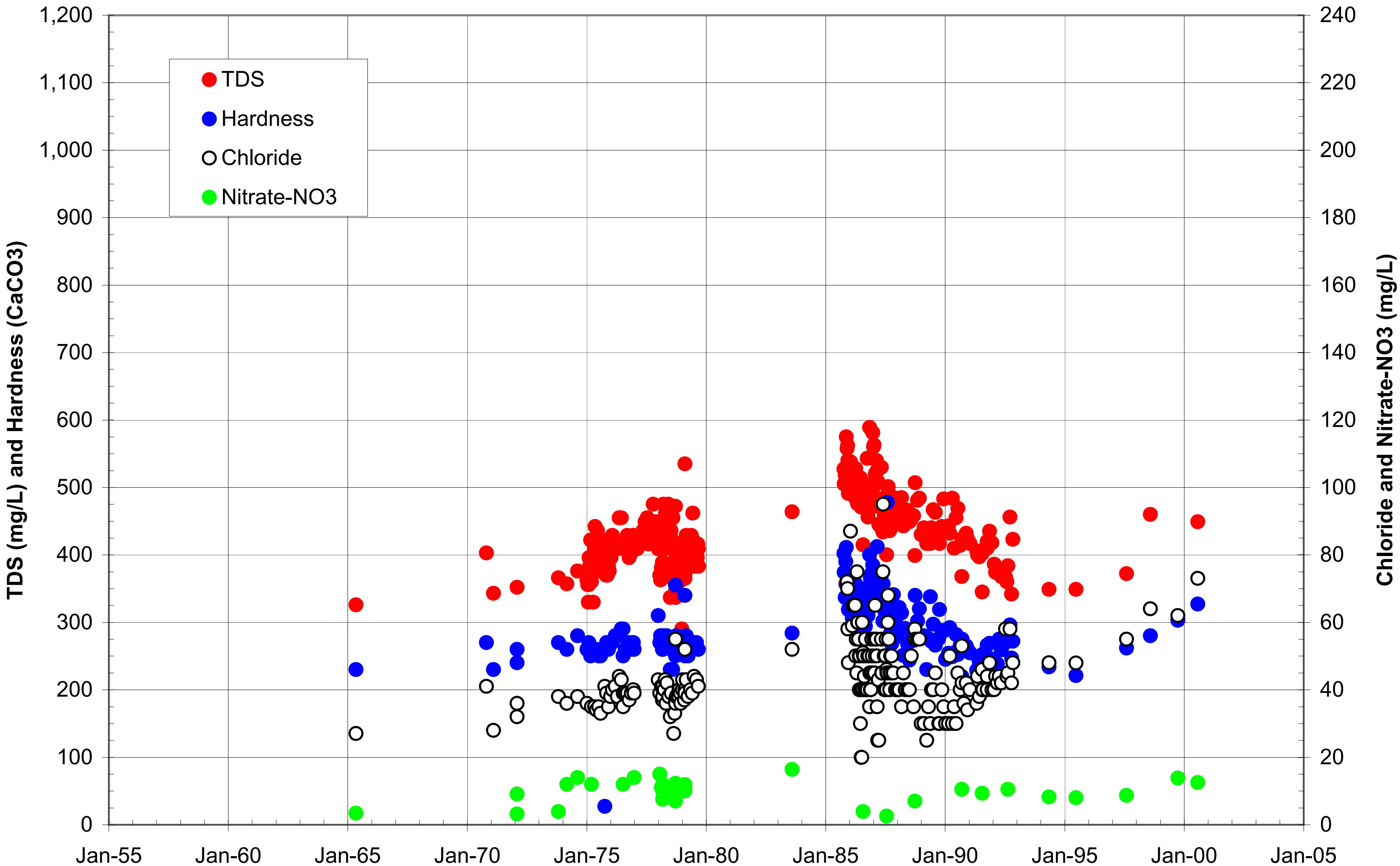


WQ for key wells.xls -- Pleas5 -- 10/06/2003

FIGURE 1.2-16
PLEASANTON-5
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-16_10/10/03_ccc

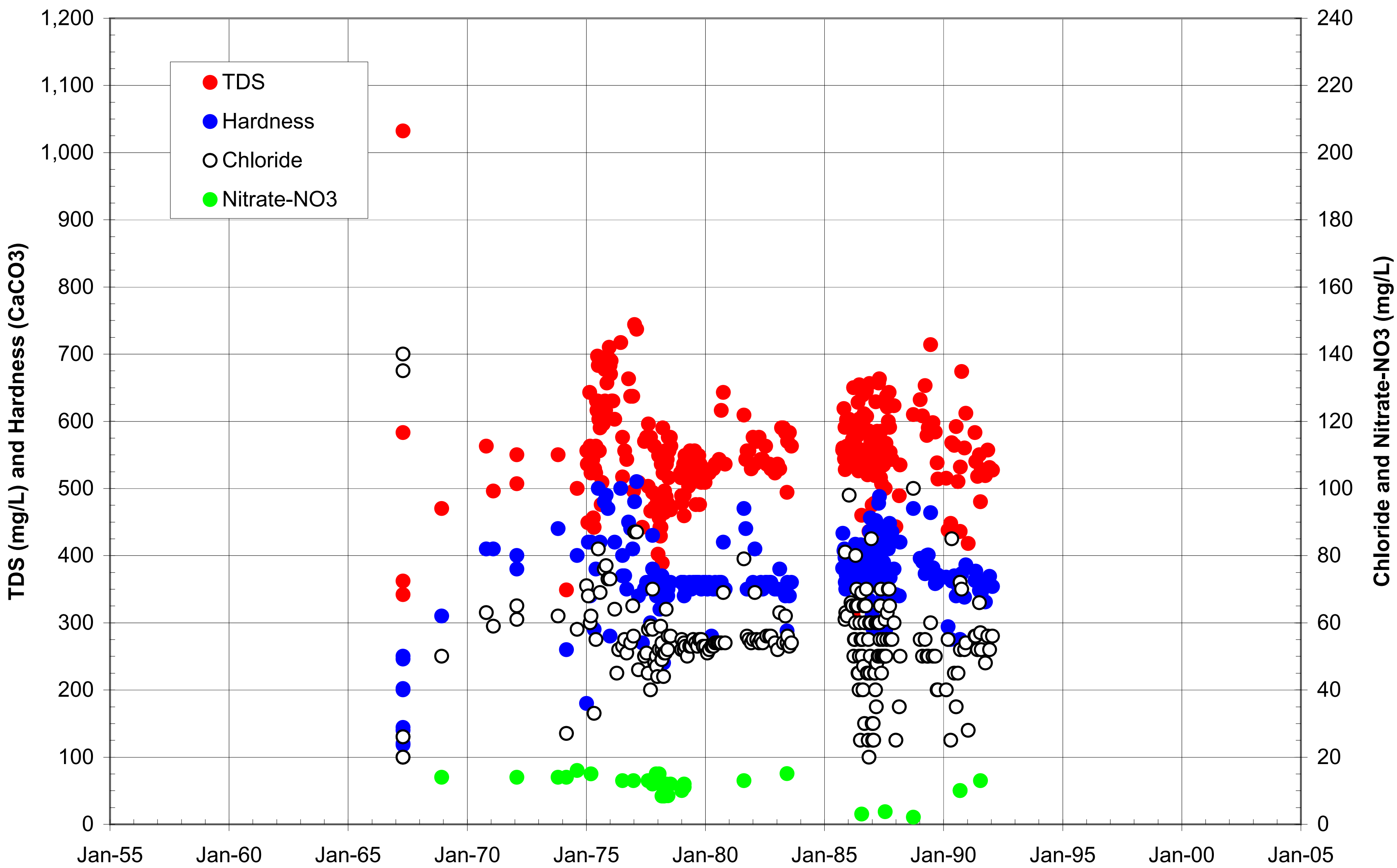


WQ for key wells.xls -- Pleas6 -- 10/06/2003

FIGURE 1.2-17
PLEASANTON-6
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-17_10/10/03_ccc

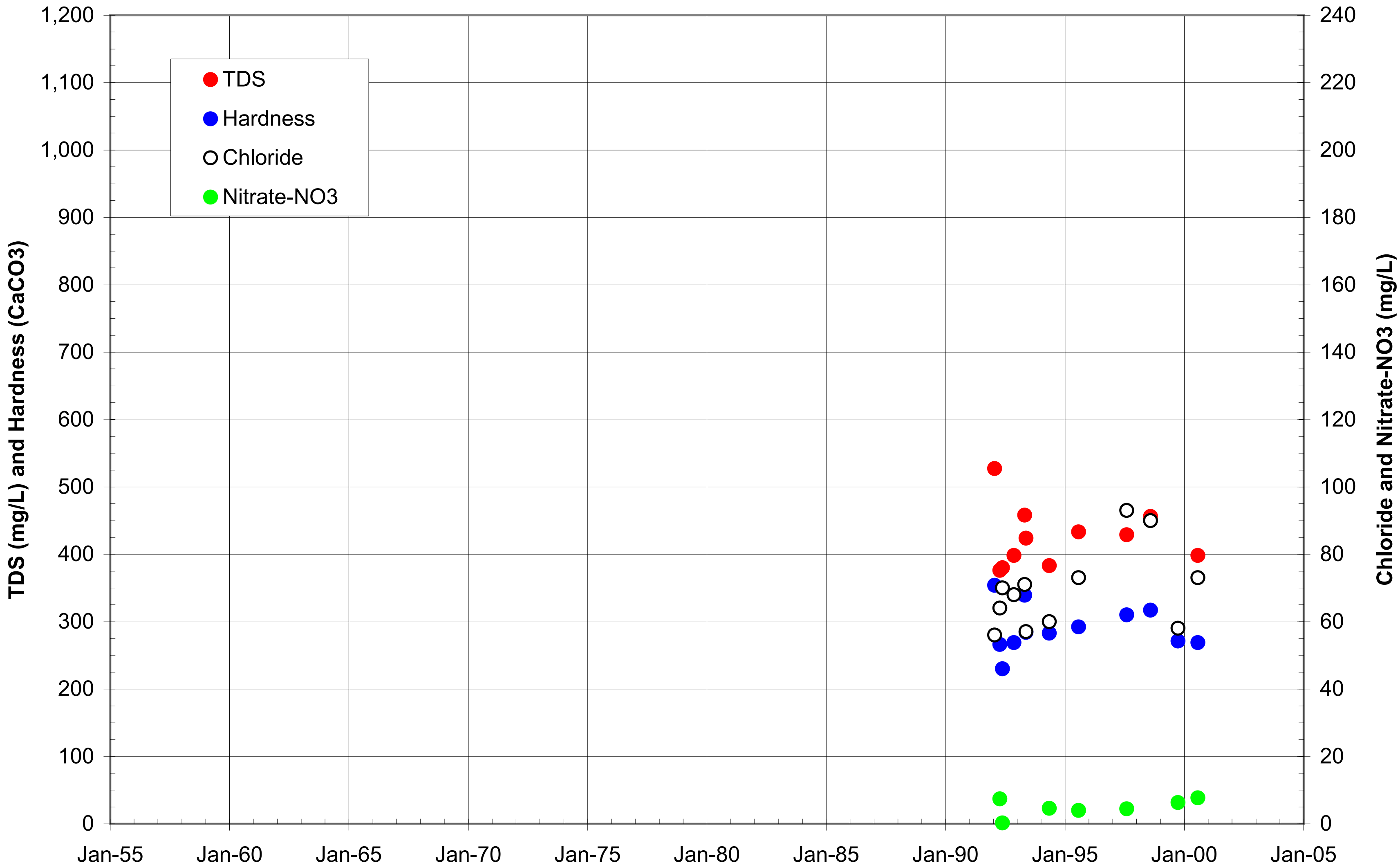


WQ for key wells.xls -- Pleas7 -- 10/06/2003

FIGURE 1.2-18
PLEASANTON-7
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-18_10/10/03_ccc

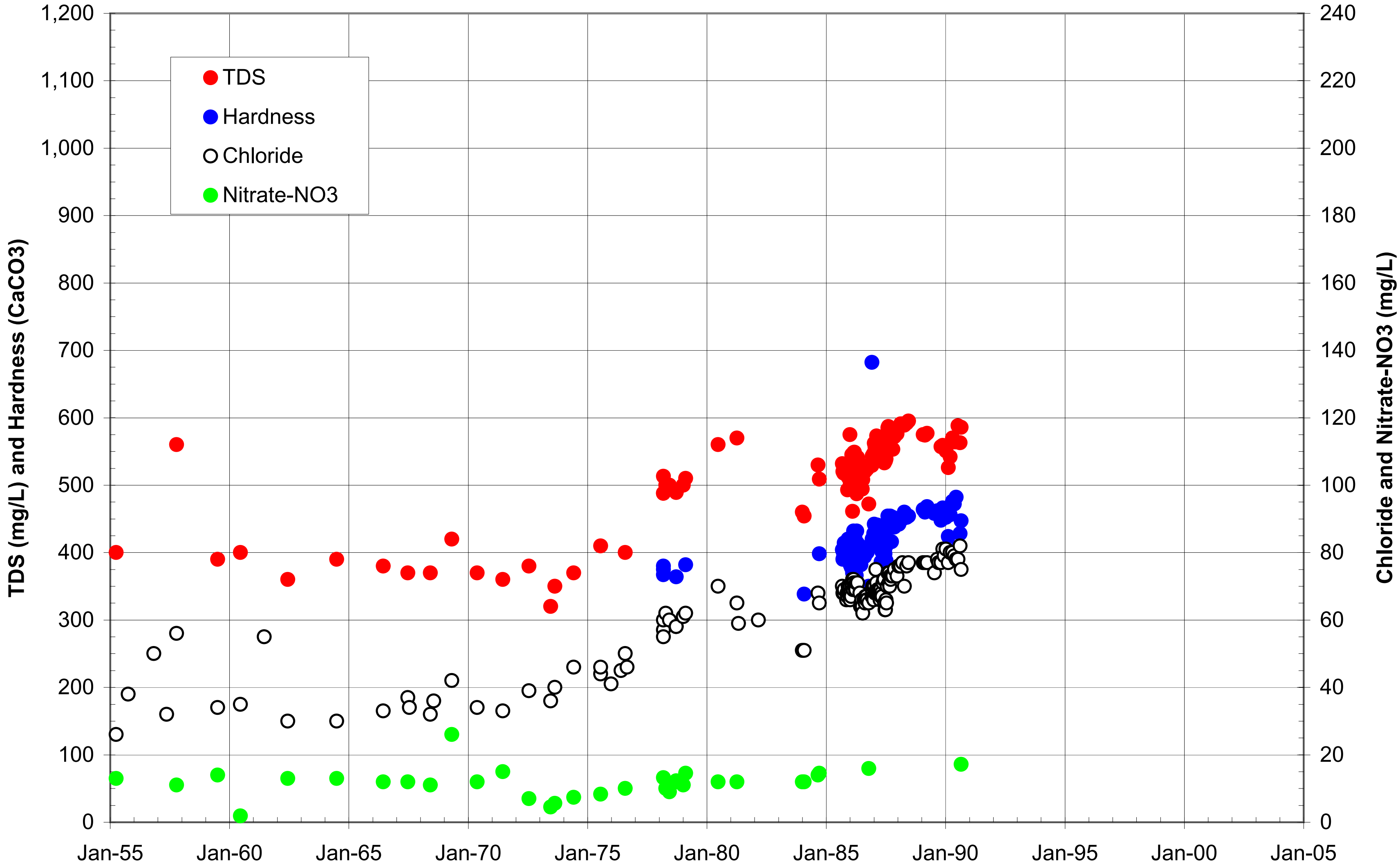


WQ for key wells.xls -- Pleas8 -- 10/06/2003

FIGURE 1.2-19
PLEASANTON-8
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

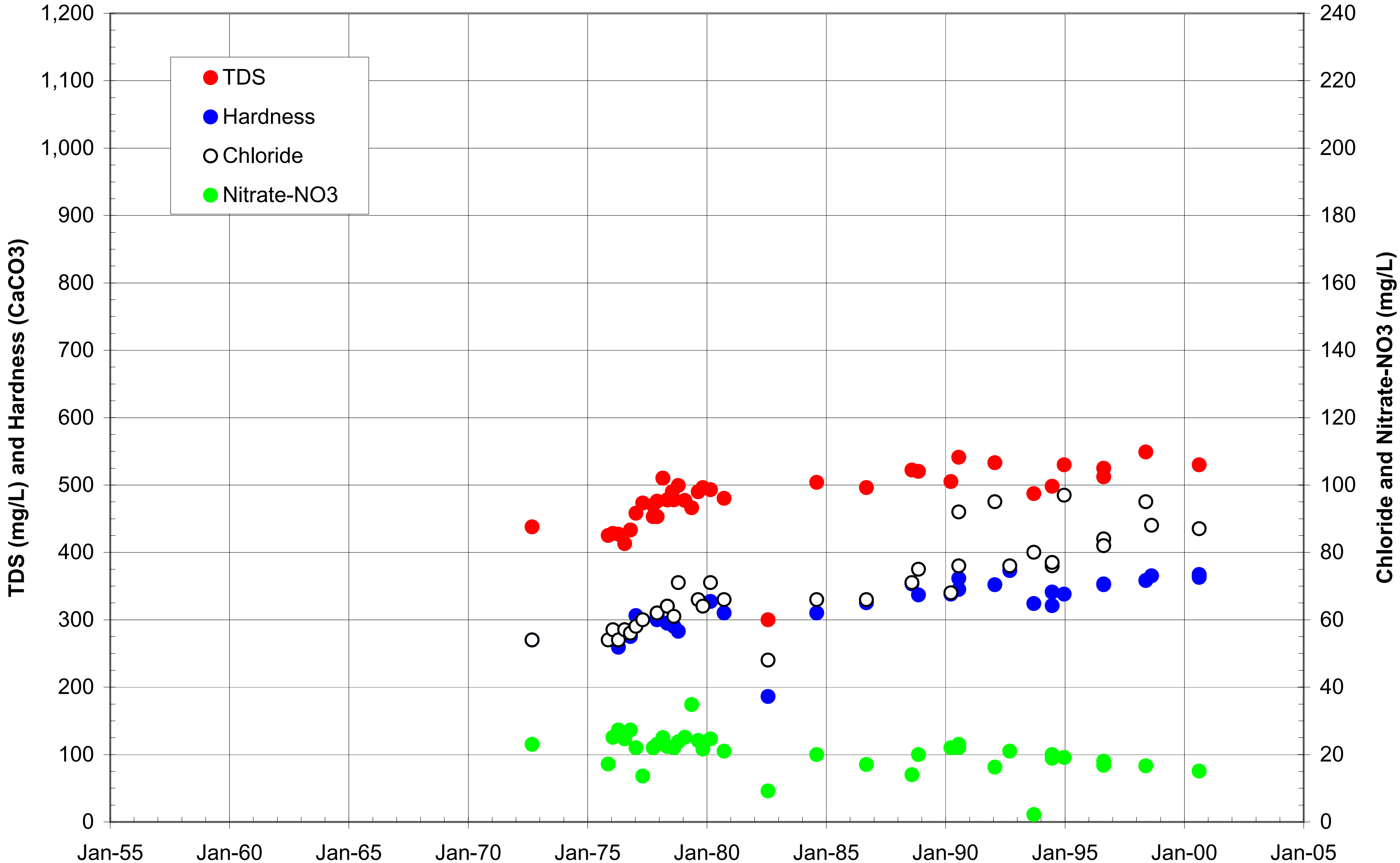
163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-19_10/10/03_ccc



WQ for key wells.xls -- sfa5 -- 10/06/2003

FIGURE 1.2-20
SAN FRANCISCO WATER DEPARTMENT WELL-A5
ZONE 7 WATER AGENCY
WELL WATER PLAN
CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-20_10/10/03_ccc

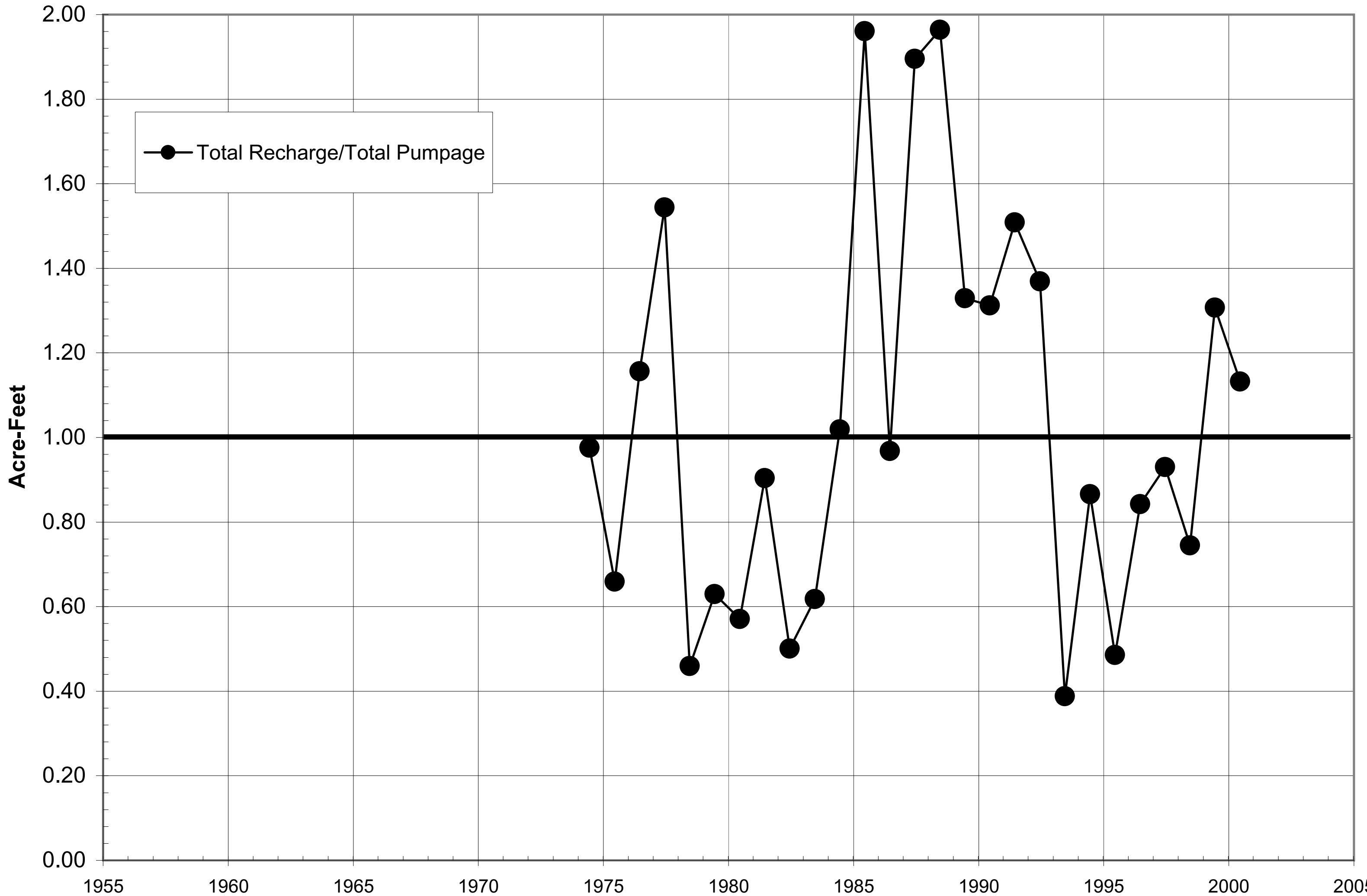


WQ for key wells.xls -- fg20b2 -- 10/06/2003

FIGURE 1.2-21
FAIRGROUNDS WELL-20B2
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-21_10/10/03_ccc

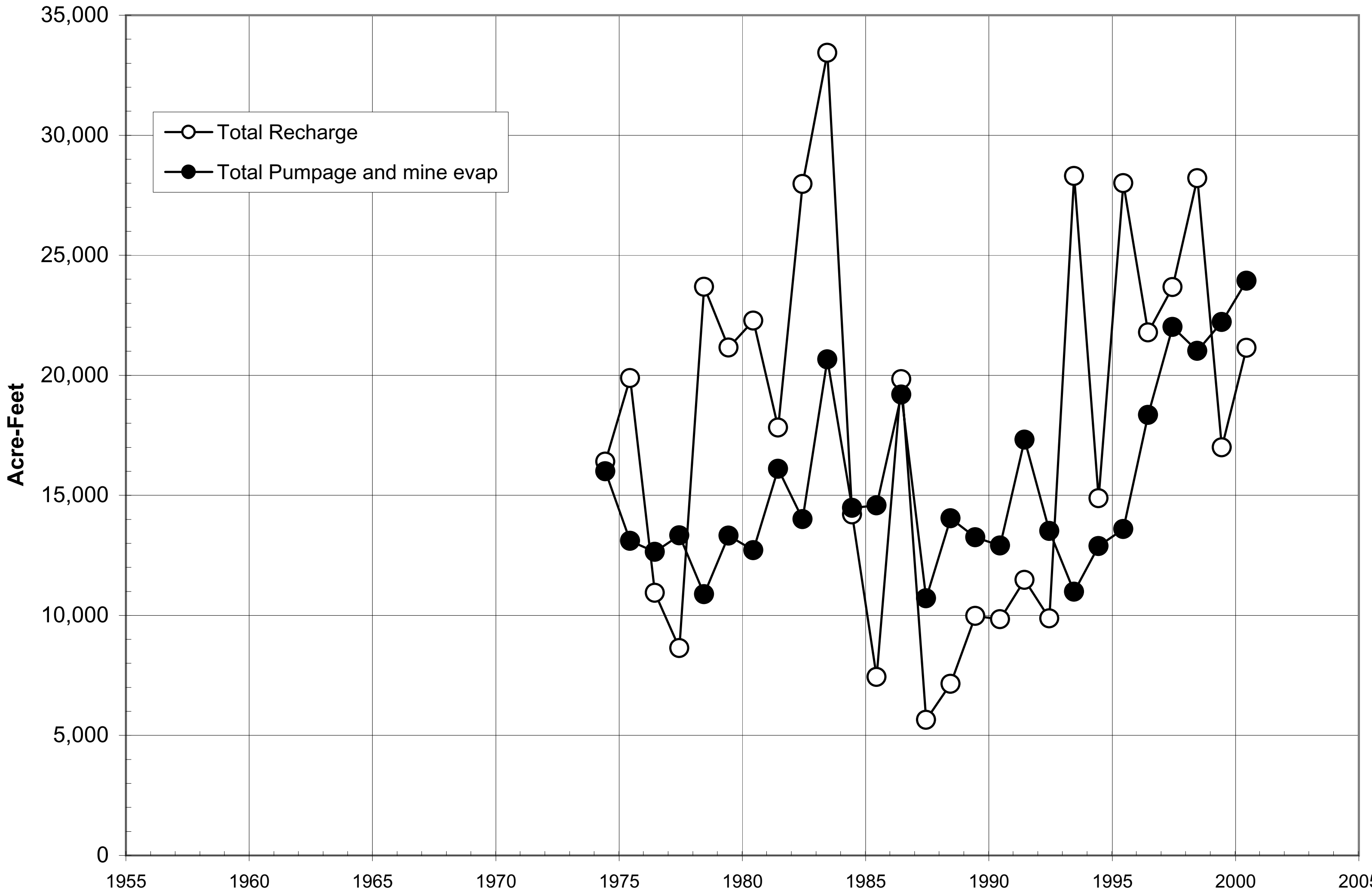


Historic Pumpage.xls -- C-Ratio -- 10/06/2003

FIGURE 1.2-22
GROUNDWATER RECHARGE/PUMPAGE RATIO
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-22_10/10/03_ccc

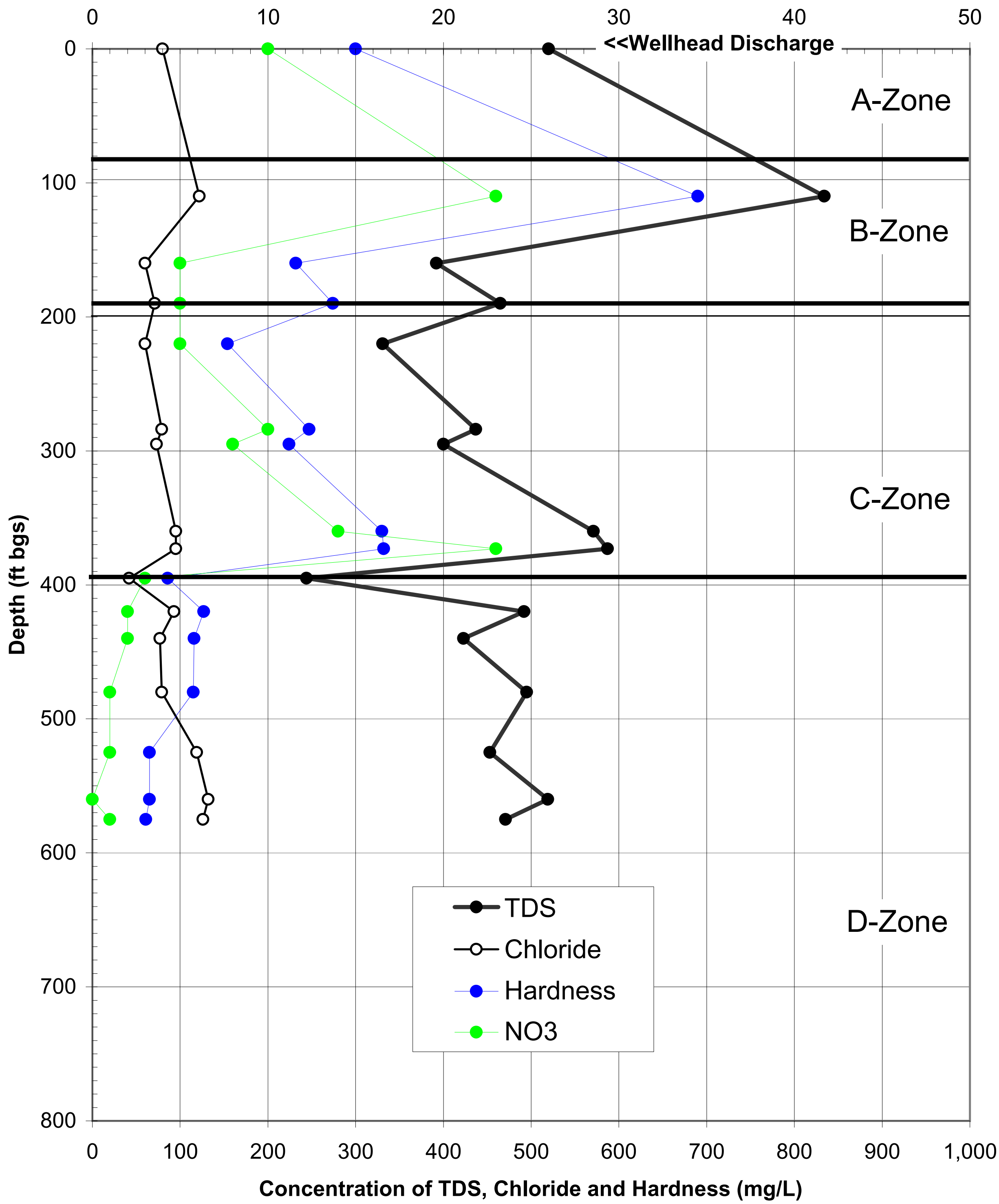


Historic Pumpage.xls -- C-Sum -- 10/06/2003

FIGURE 1.2-23
GROUNDWATER BUDGET COMPONENTS
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-23_10/10/03_ccc

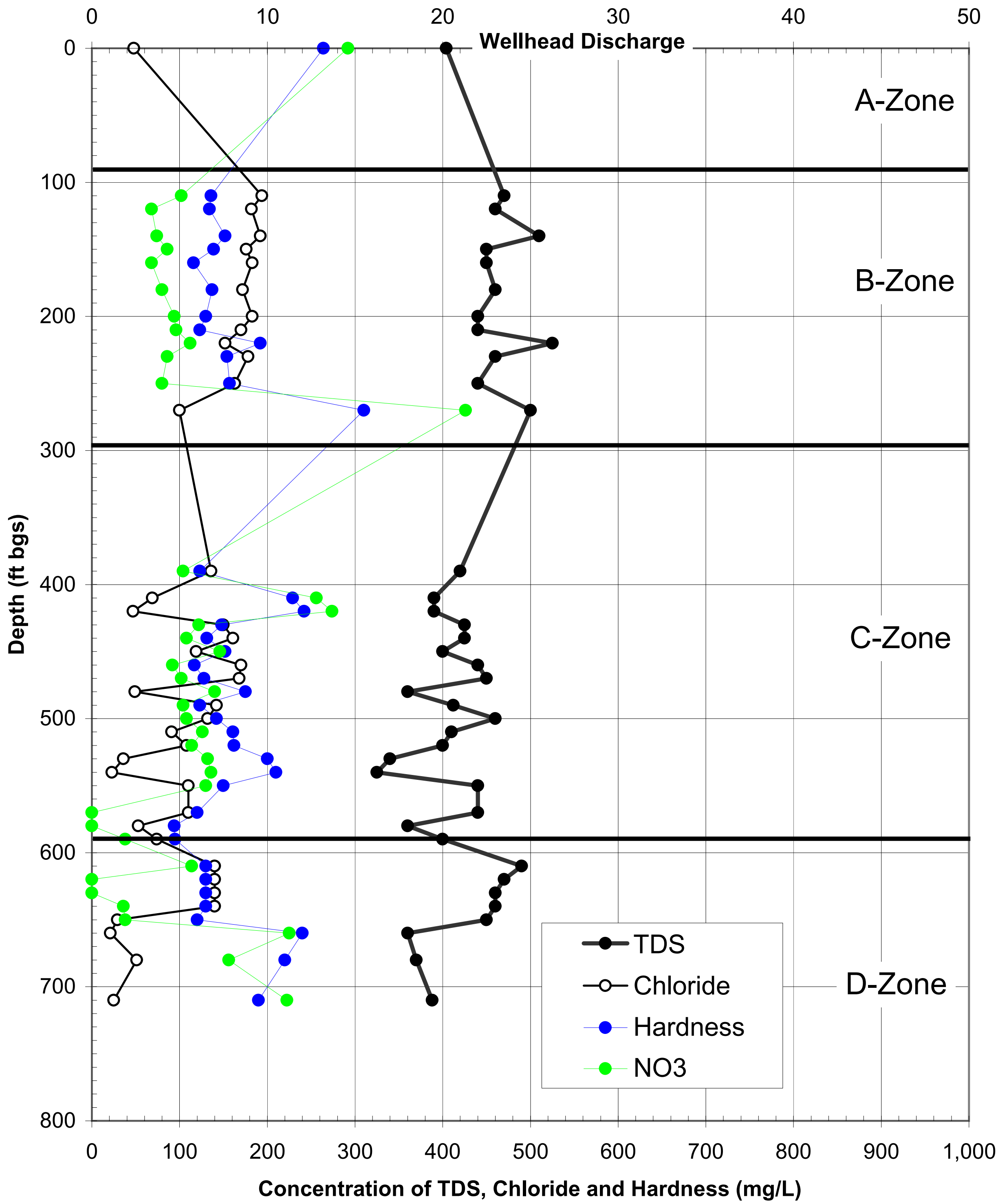


Water Quality Profiles.xls -- C-Hop-6 -- 10/06/2003

FIGURE1.2-24
HOPYARD-6: WATER QUALITY VERSUS DEPTH
CONCENTRATION OF NO3 (mg/L)
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-24_10/10/03_ccc



Water Quality Profiles.xls -- C-Stoneridge -- 10/06/2003

FIGURE 1.2-25
STONERIDGE WELL: WATER QUALITY VERSUS DEPTH
CONCENTRATION OF NO3 (mg/L)
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

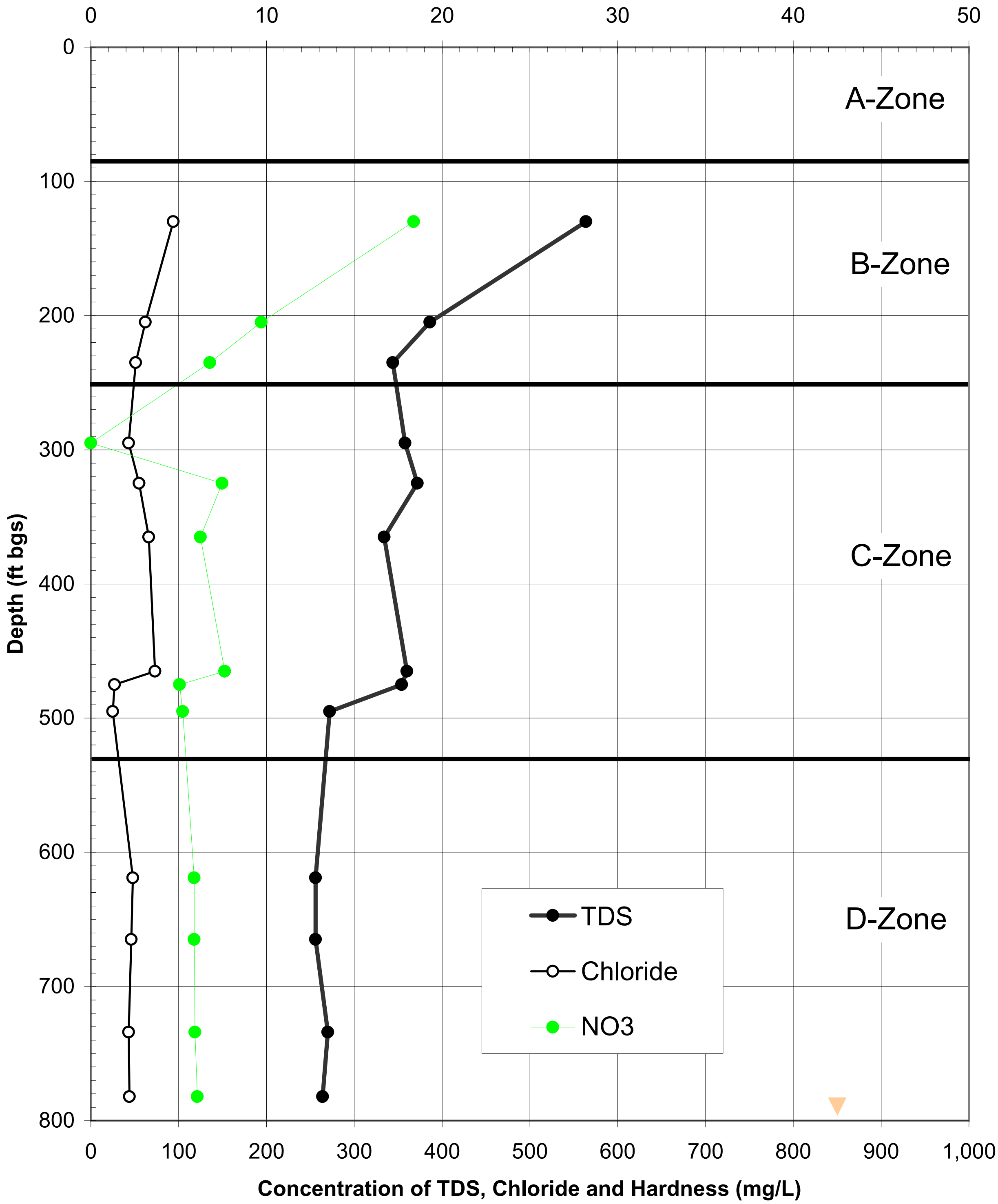
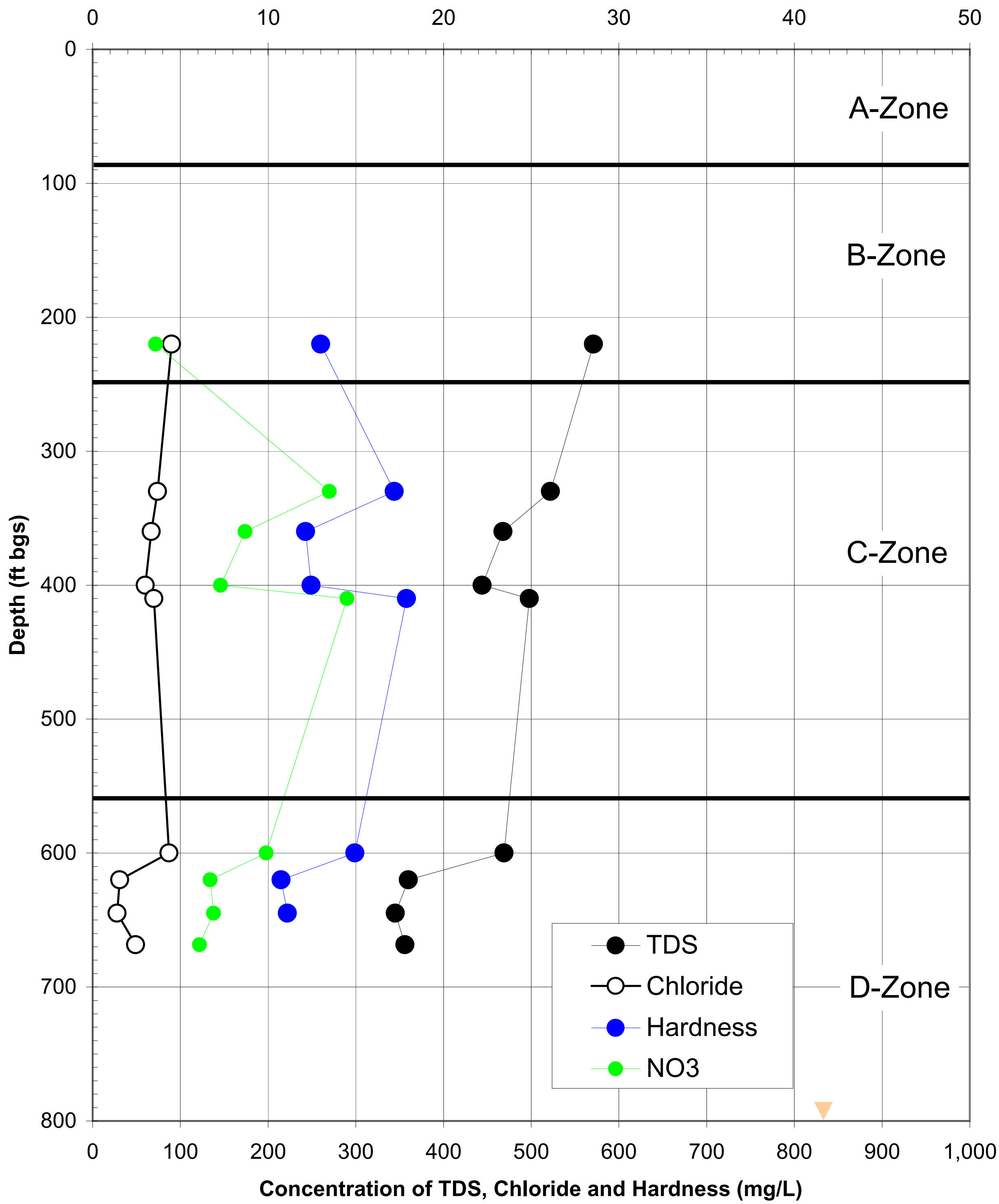


FIGURE 1.2-26
BUSCH-VALLEY OW-A & -B
WATER QUALITY VERSUS DEPTH
CONCENTRATION OF NO3 (mg/L)
ZONE 7 WATER AGENCY
WELL WATER PLAN

Water Quality Profiles.xls -- C-Busch-Valley -- 10/06/2003

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-26_10/10/03_ccc

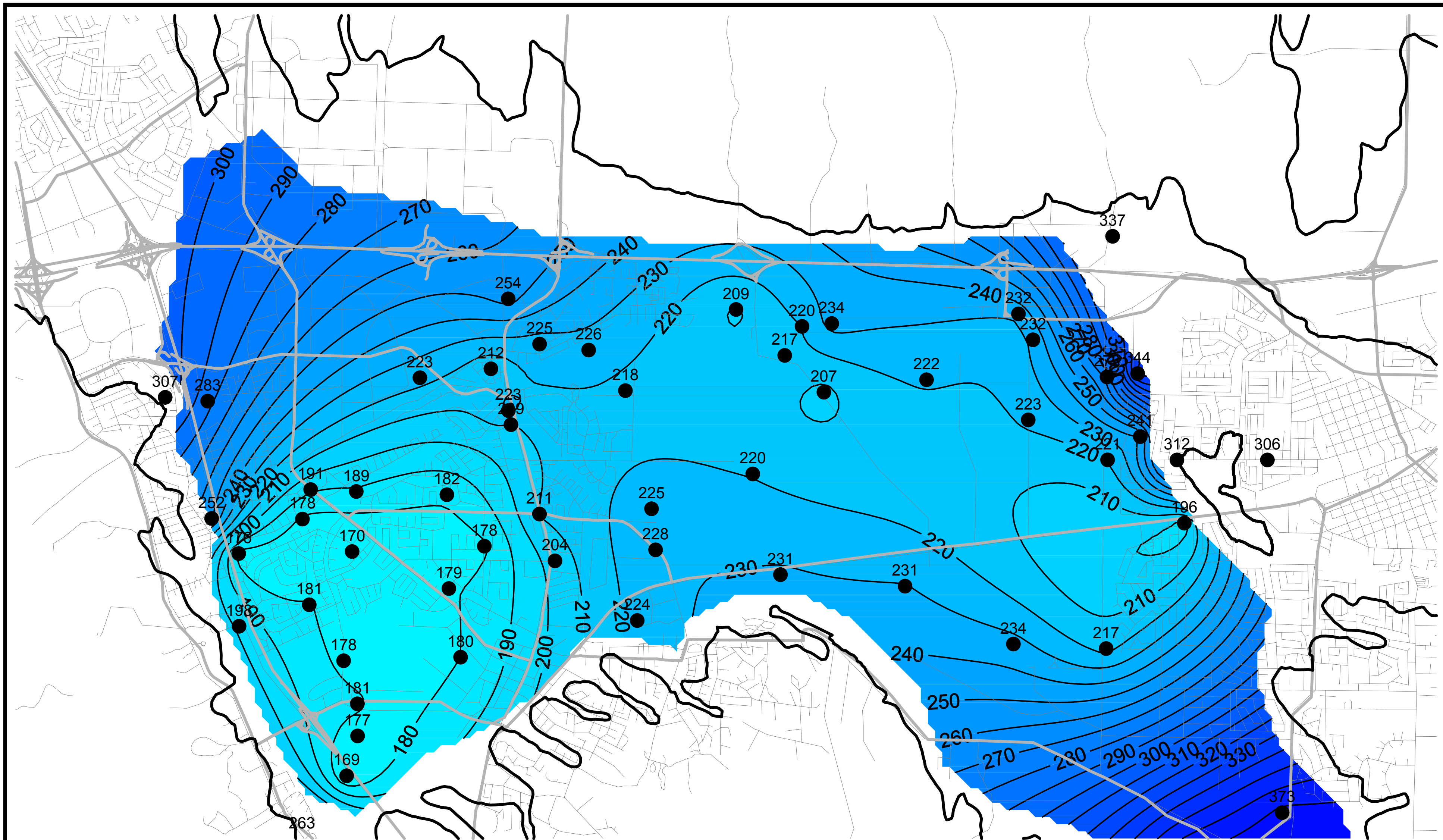


Water Quality Profiles.xls -- C-Mocho-3 and -4 -- 10/06/2003

FIGURE 1.2-27
MOCHO WELLFIELD WELLS:
WATER QUALITY VERSUS DEPTH
CONCENTRATION OF NO3 (mg/L)
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.2-27_10/10/03_ccc



LEGEND

● Well with water level data

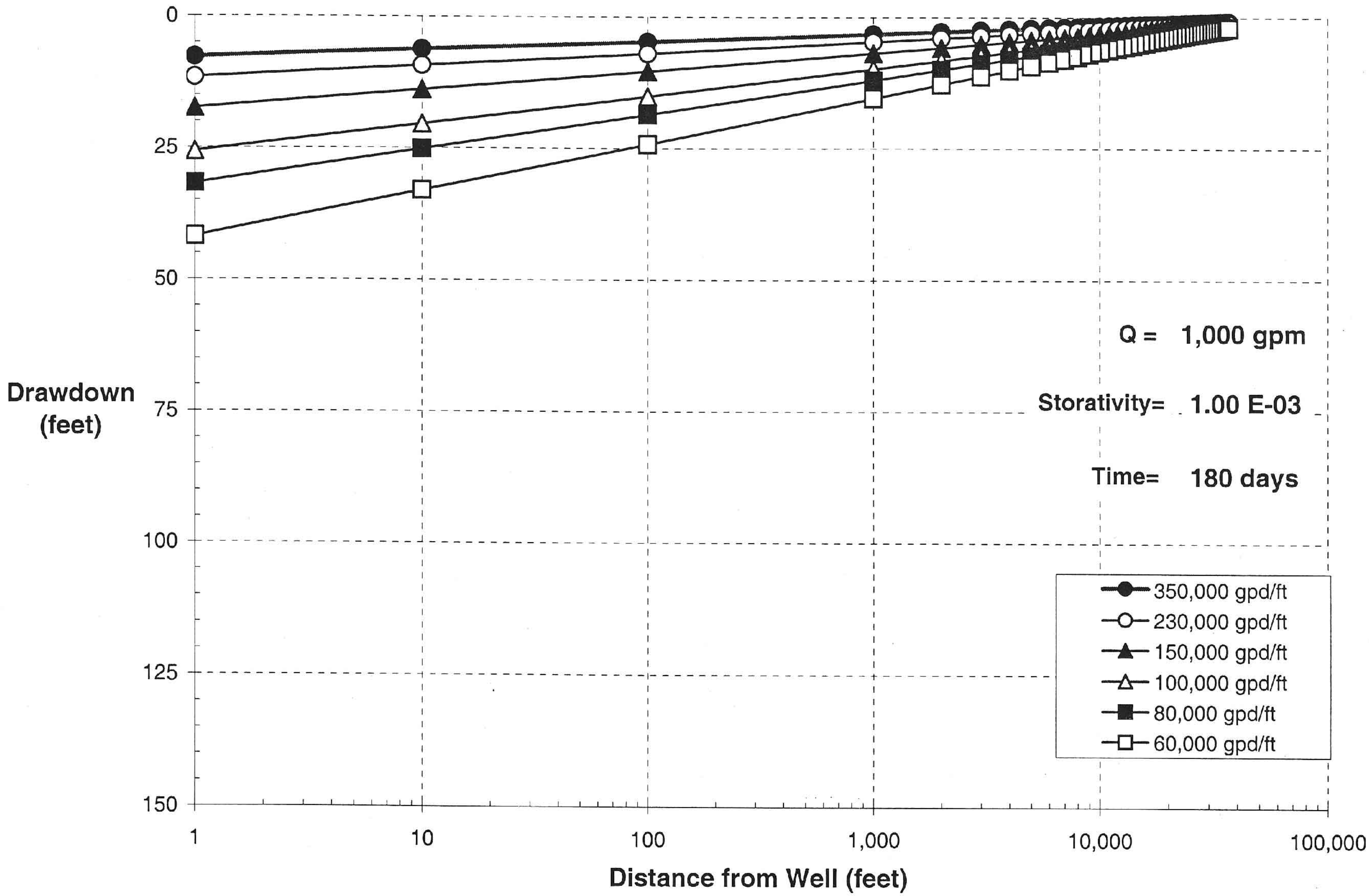
N

0 feet | 5280 feet | 10560 feet | 15840 feet

FIGURE 1.3-1
HISTORIC LOW WATER LEVELS IN THE DEEP AQUIFER
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 3-5-1_10/09/03_ccc

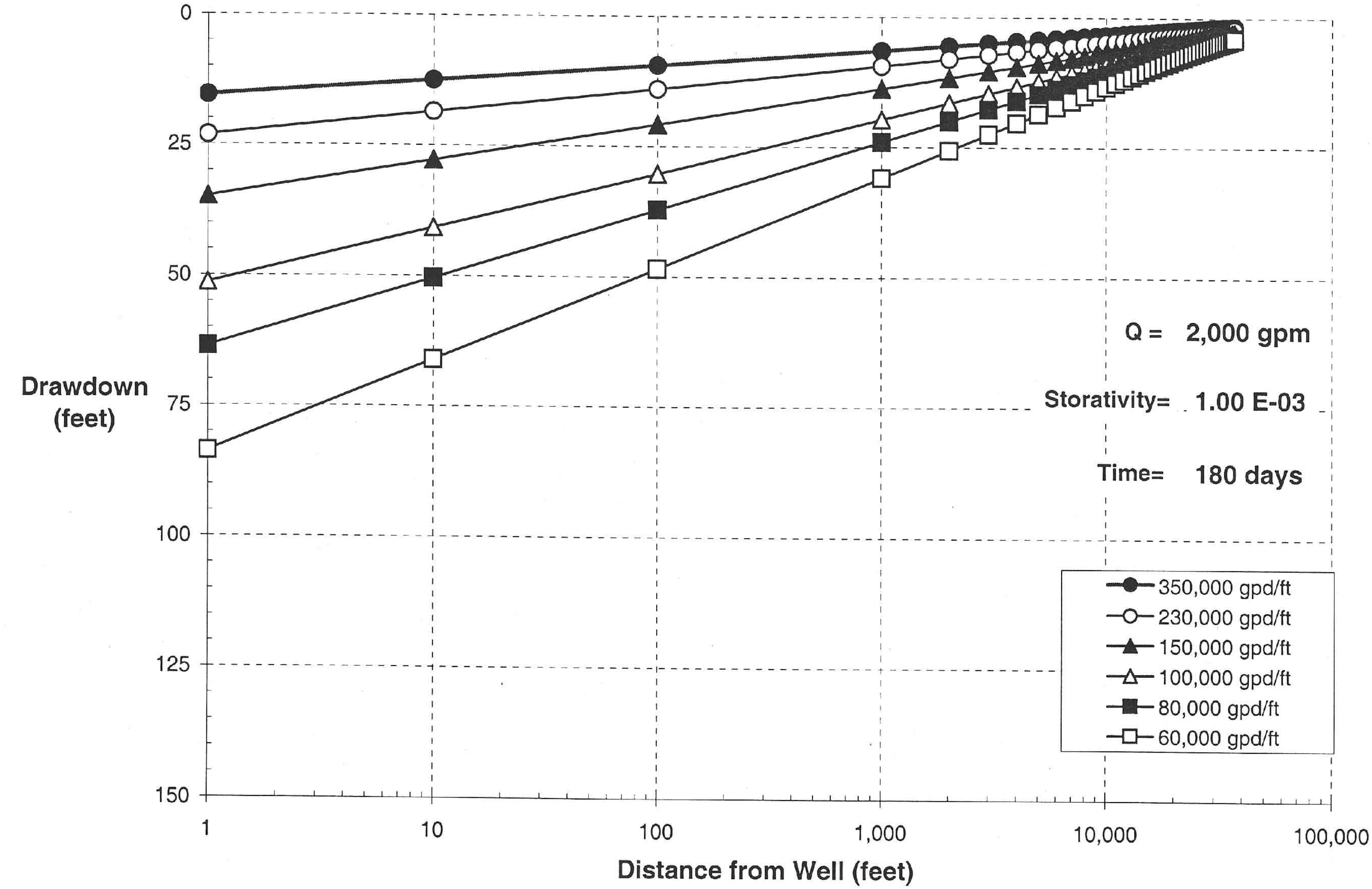


Theis analysis1.XLS: 07/06/2001

FIGURE 1.3-2
DRAWDOWN VS DISTANCE
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.3-2_10/13/03_ccc

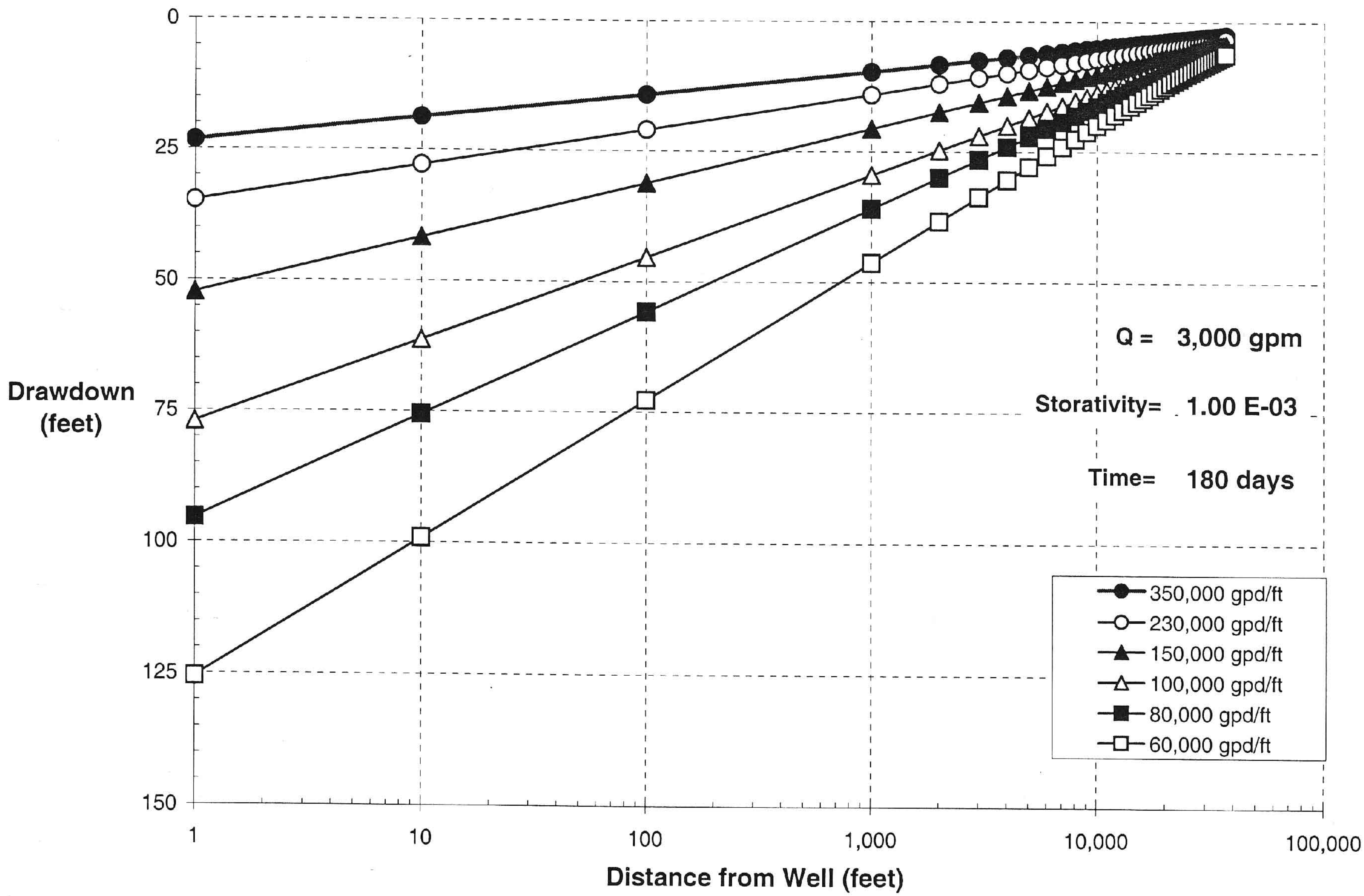


Theis analysis1.XLS: 07/06/2001

FIGURE 1.3-3
DRAWDOWN VS DISTANCE
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

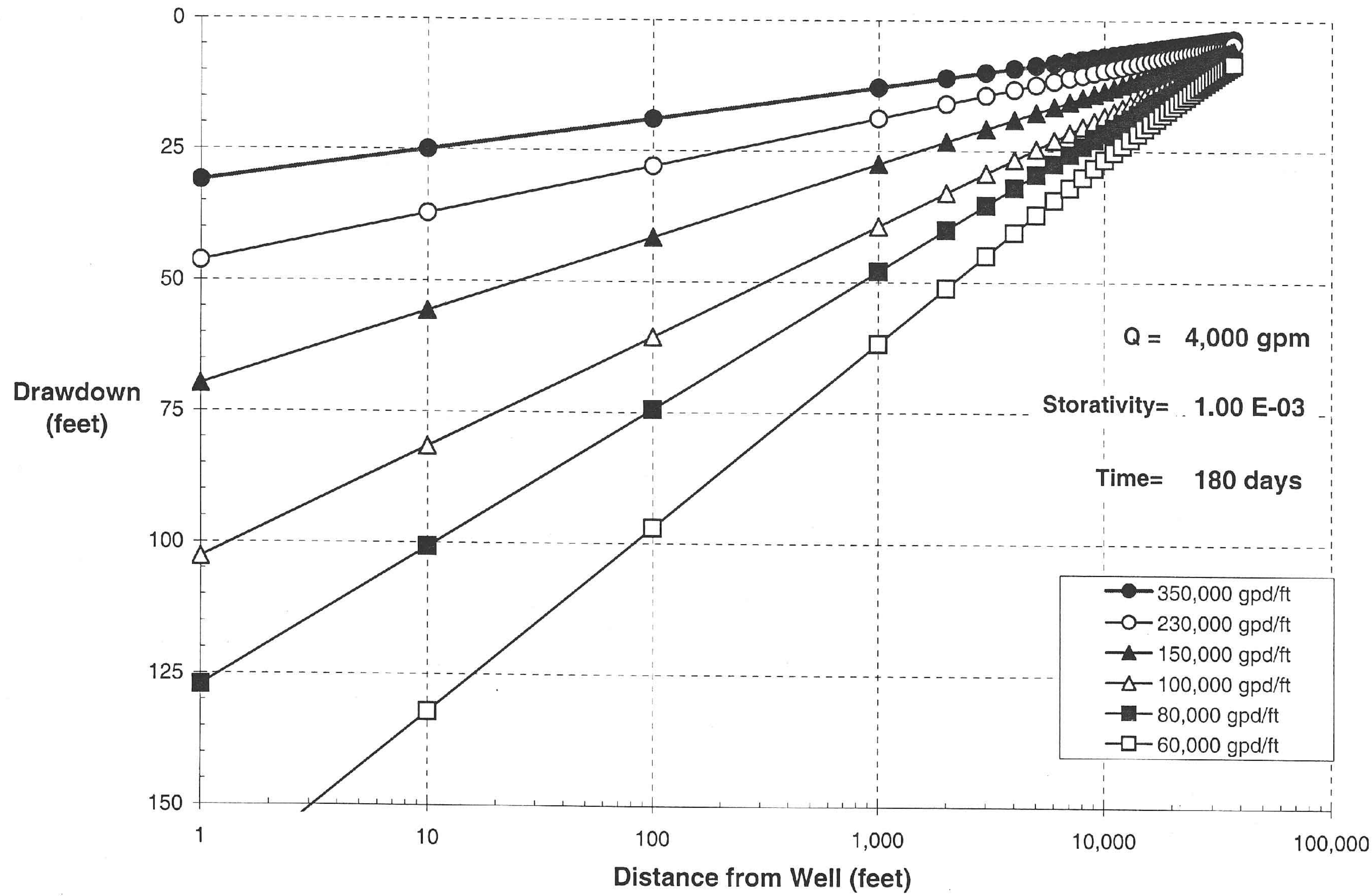
163304.WM.06_W102003001SFO_Z7 FIGURE 1.3-3_10/13/03_ccc



Theis analysis1.XLS: 07/06/2001

FIGURE 1.3-4
DRAWDOWN VS DISTANCE
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL



Theis analysis1.XLS: 07/06/2001

FIGURE 1.3-5
DRAWDOWN VS DISTANCE
ZONE 7 WATER AGENCY
WELL WATER PLAN

CH2MHILL

163304.WM.06_W102003001SFO_Z7 FIGURE 1.3-5_10/13/03_ccc