

3.4 Subsidence Monitoring Program

3.4.1 Program Description

This monitoring program began in earnest in 2002. Prior to that, in 1994, Zone 7 had conducted a study of historical benchmark elevation data throughout the Main Basin to determine if there had been any recorded subsidence, possibly due to groundwater pumping from the basin. The conclusion then was that there was no evidence of significant inelastic (permanent) subsidence due to historical groundwater pumping.

Zone 7's Well Master Plan (WMP), which was adopted by the Board in 2005, included a recommendation to conduct high precision leveling surveys twice a year; in spring when groundwater levels are relatively high and again in fall when groundwater levels are relatively low. The spring and fall survey results, along with results from previous years, are used to identify potential occurrences of inelastic subsidence, and to get a better handle on the limits of groundwater pumping stress that result in only elastic subsidence (i.e., subsidence that can be recovered by aquifer recharge).

The 2009 program included surveying elevations in a network of about 80 benchmarks and other survey points in the spring and fall. Table 3.4-1 contains a list of all land surface elevation monitoring locations for the 2009 program, and Figure 3.4-1 shows the locations of each survey point. These points all tie into a main circuit (A1) that includes points in bedrock to the west and south of the Main Basin: Sites A1-1.0 and A1-17.0, respectively. Several smaller circuits (B1 to B5) branch off this main circuit. These benchmarks were surveyed by Kier & Wright Civil Engineers and Surveyors, Inc., of Pleasanton, California. For groundwater elevation reference points, Zone 7 also surveys small circuits in and around Zone 7 wells as needed. These small circuits branch off the Kier & Wright surveyed circuits.

3.4.2 2009 Results

Zone 7's survey points are graphed, along with Key Well water elevations, on Figure 3.4-2 (Bernal Subbasin) and Figure 3.4-3 (Amador Subbasin). Figure 3.4-4 (Bernal Subbasin - Hopyard 6 Well), Figure 3.4-5 (Amador Subbasin - Mocho Wellfield), and Figure 3.4-6 (Amador Subbasin - Stoneridge) show graphs of land surface elevation changes and groundwater elevation at Zone 7 municipal wells. These graphs show a one-time jump in ground surface elevation in Fall 2006. This is because when the program was started, Site A1-9.0 was believed to be on stationary bedrock. However, measurements taken up to the 2007 Water Year suggested that the site had actually been moving elastically. Therefore, starting with the Fall 2006 dataset, the data calculations were readjusted so that A1-9.0 elevations could vary.

The following changes were made to the program for the 2009 Water Year:

- Starting in 2009, staff began monitoring the elevation difference between the cement floor and the wellhead pedestals at several Zone 7 municipal wells. While it is unlikely that these sites (labeled in Table 3.4-1 with a suffix of “-Diff”) will show evidence of elastic subsidence or even

minor inelastic subsidence, they may provide evidence of significant, inelastic land subsidence in the unlikely event that it were to occur. These are measured monthly to investigate if such inelastic subsidence were to occur between Zone 7's semiannual surveying events.

- Sites A1-13.0 and B1-5.0, which were both destroyed during the construction of Zone 7's groundwater demineralization plant, were replaced by Sites A1-13.1 and B1-5.1.

Table 3.4-2 shows the most recent (Fall 2009) measurements and includes the elevation changes since the Fall 2008 and Spring 2009 measurements. Figure 3.4-7 shows that during the 2009 Water Year, most of Zone 7's survey benchmarks have dropped slightly from Fall 2008 to Fall 2009 (to 0.070 ft). The slight drop in land surface elevation, which corresponds with small groundwater elevation decrease observed in the Bernal and West Amador Subbasins during the 2009 Water Year, is within the range of elastic subsidence observed over the life of the monitoring program. Elevation changes from Spring to Fall 2009, which varied from -0.001 to -0.096, were also within the range of elastic movement.

3.5 Mining Area Monitoring Program

3.5.1 Program Description

Gravel pits in the Chain of Lakes area have been excavated and operated by the following entities:

Table: Mining Operators

Pond Names*	"K" Ponds	"R" Ponds	"C" Ponds	"P" Ponds
Original Owner	Kaiser Sand & Gravel	Rhodes & Jamieson	Cal Rock	Pacific Coast Aggregates
Other Owners	Hanson Aggregates	Calmat		RMC/Lonestar
Current Owner	PGC Legacy EBRP (SC) Zone 7 (Lake I)	Vulcan PGC	PGC	Cemex

* Prefix for pond names (e.g., K37, also known as Lake I) as shown on Figure 3.5-1

PGC Pleasanton Gravel Company

EBRP East Bay Regional Parks

SC Shadow Cliffs

Zone 7 monitors conditions and activities in the Chain of Lakes area because the gravel mining operations have an appreciable effect on groundwater levels, groundwater quality and salt loading in the Main Basin. Many of the quarry pits have been dug deep into the Upper Aquifer, creating 'windows' into groundwater basin, and exposing groundwater to large evaporative losses. Groundwater is also pumped from some of the pits and discharged to others or to the arroyos to facilitate the gravel mining occurring in the active pits. The Mining Area Monitoring Program includes water level measurements and water quality

TABLE 3.4-1
Zone 7 Water Agency
Subsidence Monitoring Program
Survey Points and Descriptions, 2009 Water Year

Sites Monitored by Kier & Wright

Site ID	Well ID	Survey Points	Description
A1- 1.0		G972	Brass disk located in sidewalk
A1- 2.0		Foot-La-Pos	Chisel mark on bridge footing
A1- 3.0		C972	Brass disk mounted on bridge platform
A1- 4.0		Mocho-Chabot	Brass disk located on access road
A1- 5.0		Mocho-Tass-W	Brass disk located on access road
A1- 6.0		Mocho-Tass-E	Brass disk located on access road
A1- 6.05		Mocho TP48	
A1- 6.1		Mocho_CB	Chisel mark on catch basin
A1-10.0		Vine-Pipe	Brass disk in concrete
A1-12.0		Mohr-RR	Spike at Mohr Ave and RR
A1-13.1		COP RE 25281	Replaced A1-13.0 on 4/13/09
A1-14.1		Bush-Valley	
A1-15.0		D8	Brass disk on bridge foundation
A1-15.1		BM-P929 Reset	
A1-16.0		V1	Brass disk
A1-17.0		K2	Brass disk (?) NGVD Benchmark
B1- 1.0		Mocho-san MP3	Disk located on bridge platform
B1- 2.0		Mocho-san MP2	Disk located on bridge platform
B1- 3.0		Mocho-san MP1	Disk located on bridge platform
B1- 4.0	3S/1E 8H 3	Army Well 2, Floor	Chisel mark on pumphouse floor
B1- 5.1	3S/1E 8H18	STP640 MN/W	Replaced B1-5.0 on 4/13/09
B1- 6.0	3S/1E 8H 2	Army Well 1, Floor	Chisel mark on pumphouse floor
B1- 7.0		Mocho-Stone MP1	Disk located on bridge platform
B1- 8.0		Mocho-Stone MP2	Disk located on bridge platform
B1- 9.0		Mocho-Stone MP3	Disk located on bridge platform
B1-10.0		Mocho-Stone MP4	Disk located on bridge platform
B1-11.0	3S/1E 8H 4	Army Well 3, Floor	Chisel mark on pumphouse floor
B1-12.0	3S/1E 8H13	Obs. Well, Casing	Chisel mark on casing
B1-13.0	3S/1E 9M 4	Mocho 3, Shiner	Shiner at entrance door
B1-14.1	3S/1E 9M 2	Mocho 1, Floor	
B1-16.1	3S/1E 9M 3	Mocho 2, Floor	
B2- 1.0		Tass-Las-Pos MP1	Disk located on bridge platform
B2- 2.0		Tass-Las-Pos MP2	Disk located on bridge platform
B2- 3.0		Tass-Las-Pos MP3	Disk located on bridge platform
B2- 4.0		Tass-Las-Pos MP4	Disk located on bridge platform
B3- 1.0		Mocho-Park	Brass disk on concrete vault
B3- 2.0		1H ALA	County Benchmark
B3- 3.0	3S/1E 17D12	Hop 9 BM	Benchmark, rod in access road
B3- 4.0		MP1 (Disc)	
B3- 5.0		MP2 (Disc)	
H7- C	3S/1E 17D10		Hopyard 7 Well (Punch)
B4- 1.0 S		AMP-Ctl S	Brass Disk on Control
B4- 1.0 N		AMP-Ctl N	
B4- 2.0	3S/1E 9B 1	Stoneridge, Floor	Chisel mark at entrance door
B5- 1.0		OSRR-BC	New Monument disk
B5- 2.0		OSRR-Andrew	New Monument disk
B5- 3.0		OSRR-Cafe	New Monument disk
B5-4.0		Tass-Rose	Disk on bridge foundation (formerly A1-8.0)
B6- 1.0		5608 Belleza	New Monument disk
B6- 2.0		FLORA-end	New Monument disk
B6- 3.0		Belleza-Verd	New Monument disk
B7- 1.0		Larame-Larame	New Monument disk
B7- 2.0		Suttr-Larame	New Monument disk
B7- 3.0		Suttr-Jones	New Monument disk

Additional Well Sites Monitored by Zone 7

Site ID	Well ID	Survey Points	Description
AW1-P	3S/1E 8H 2	Army Well 1, Pedestal	Army Well 1 well pedestal
AW1-RP	3S/1E 8H 2	Army Well 1, RP	Army Well 1 reference point
AW2-P	3S/1E 8H 3	Army Well 2, Pedestal	Army Well 2 well pedestal
AW3-Diff	3S/1E 8H 4	Army Well 3, Pedestal	Army Well 3 pedestal to ground difference
AW3-P	3S/1E 8H 4	Army Well 3, Pedestal	Army Well 3 well pedestal
H6-C	3S/1E 18A 6	Hopyard 6, Casing	Hop 6 casing / flange
H6-D	3S/1E 18A 6	Hopyard 6, Drain	Hop 6 drain
H6-Diff	3S/1E 18A 6	Hopyard 6, Pedestal	Hop 6 pedestal to ground difference
H6-F	3S/1E 18A 6	Hopyard 6, Floor	Hop 6 chisel mark on pumphouse floor
H6-P	3S/1E 18A 6	Hopyard 6, Pedestal	Hop 6 well pedestal
H6-RP	3S/1E 18A 6	Hopyard 6, RP	Hop 6 reference point
H9-T	3S/1E 17D12	Hopyard 9, Transformer	Hop 9 transformer pad
H9-C	3S/1E 17D12	Hopyard 9, Casing	Hop 9 casing / flange
H9-Diff	3S/1E 17D12	Hopyard 9, Pedestal	Hop 9 pedestal to ground difference
H9-F	3S/1E 17D12	Hopyard 9, Floor	Hop 9 chisel mark on pumphouse floor
H9-P	3S/1E 17D12	Hopyard 9, Pedestal	Hop 9 well pedestal
H9-RP	3S/1E 17D12	Hopyard 9, RP	Hop 9 reference point
M1-C	3S/1E 9M 2	Mocho 1, Casing	Mocho 1 casing / flange
M1-P	3S/1E 9M 2	Mocho 1, Pedestal	Mocho 1 well pedestal
M1-RP	3S/1E 9M 2	Mocho 1, RP	Mocho 1 reference point
M1-T	3S/1E 9M 2	Mocho 1, Transformer	Mocho 1 transformer pad
M2-Diff	3S/1E 9M 3	Mocho 2, Pedestal	Mocho 2 pedestal to ground difference
M3-C	3S/1E 9M 4	Mocho 3, Casing	Mocho 3 casing / flange
M3-Diff	3S/1E 9M 4	Mocho 3, Pedestal	Mocho 3 pedestal to ground difference
M3-P	3S/1E 9M 4	Mocho 3, Pedestal	Mocho 3 well pedestal
M3-RP	3S/1E 9M 4	Mocho 3, RP	Mocho 3 reference point
M3-T	3S/1E 9M 4	Mocho 3, Transformer	Mocho 3 transformer pad
M4-C	3S/1E 8H18	Mocho 4, Casing	Mocho 4 casing / flange
M4-Diff	3S/1E 8H18	Mocho 4, Pedestal	Mocho 4 pedestal to ground difference
M4-P	3S/1E 8H18	Mocho 4, Pedestal	Mocho 4 well pedestal
M4-RP	3S/1E 8H18	Mocho 4, RP	Mocho 4 reference point
M4-T	3S/1E 8H18	Mocho 4, Transformer	Mocho 4 transformer pad
S-C	3S/1E 9B 1	Stoneridge, Casing	Stoneridge casing / flange
S-D	3S/1E 9B 1	Stoneridge, Drain	Stoneridge drain
S-Diff	3S/1E 9B 1	Stoneridge, Pedestal	Stoneridge pedestal to ground difference
S-P	3S/1E 9B 1	Stoneridge, Pedestal	Stoneridge well pedestal
S-RP	3S/1E 9B 1	Stoneridge, RP	Stoneridge reference point

Monitoring Frequency

Circuit	Frequency	Last Measured	Next Measurement
A1 Circuit*	Semi-annually	Fall 2009	Spring 2010
B1 Mocho loop	Semi-annually	Fall 2009	Spring 2010
B2 Tassajara loop	As needed	Fall 2007	as needed
B3 Hopyard wells loop	Semi-annually	Fall 2009	Spring 2010
B4 Stoneridge well loop	Semi-annually	Fall 2009	Spring 2010
B5 Tassajara - Rosewood	Annually	Fall 2009	Fall 2010
B6 Verona loop	As needed	Apr-04	as needed
B7 Suttergate loop	As needed	Apr-04	as needed
Municipal Wells	As needed	Oct-07	as needed

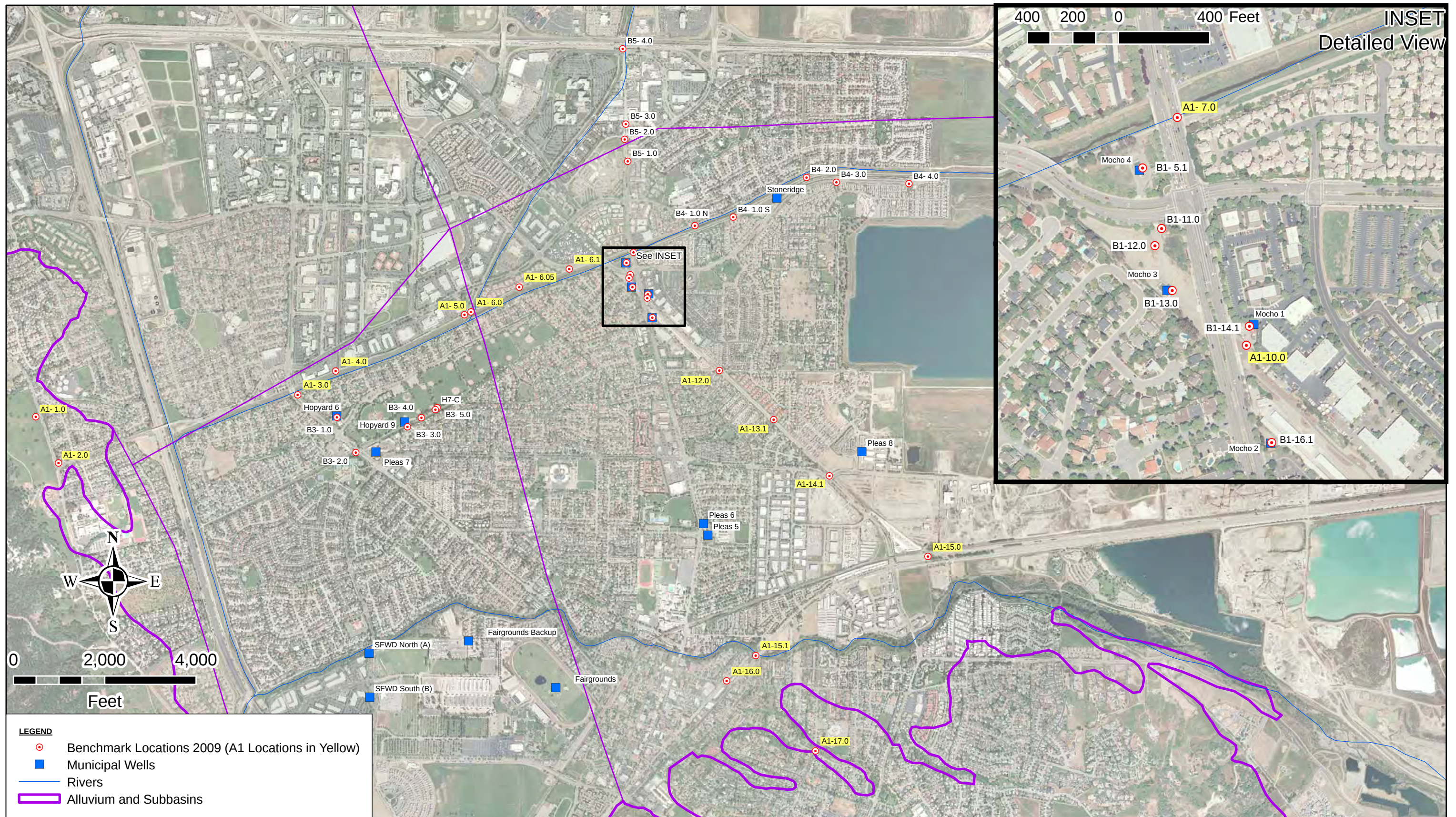
Legend

*	Not including the A1 North Segment, which was discontinued in 2007
	Probable bedrock sites

Table 3.4-2
Zone 7 Water Agency
Subsidence Monitoring; Kier & Wright Survey Measurements
2009 Water Year

Site	Site Description	Date Measured	Elev Fall 09 (ft NAVD88)	Elev Spr 09 (ft NAVD88)	Elev Fall 08 (ft NAVD88)	Change in Elevation (ft)	
						Fall 09 - Spr 09	Fall 09 - Fall 08
A1- 1.0	G972*	Sep 28, 2009	365.705	365.705	365.705	0.000	0.000
A1- 2.0	Foothill and Las Positas	Sep 28, 2009	405.449	405.462	405.442	-0.013	0.007
A1- 3.0	C972	Sep 28, 2009	330.583	330.612	330.57	-0.029	0.013
A1- 4.0	Arroyo Mocho at Chabot Crk	Sep 28, 2009	324.024	324.054	324.013	-0.030	0.011
A1- 5.0	Arroyo Mocho at Tassajara Crk West	Sep 28, 2009	327.140	327.173	327.154	-0.033	-0.014
A1- 6.0	Arroyo Mocho at Tassajara Crk East	Sep 28, 2009	327.782	327.817	327.787	-0.035	-0.005
A1- 6.05	Arroyo Mocho at Tassajara Crk East	Sep 28, 2009	329.211	329.217	329.184	-0.006	0.027
A1- 6.1	Arroyo Mocho Pleasanton Control	Sep 28, 2009	332.603	332.674	332.664	-0.071	-0.061
A1- 7.0	M1257	Sep 28, 2009	341.841	341.925	341.906	-0.084	-0.065
A1-10.0	Vineyard Pipeline at Santa Rita Rd	Sep 28, 2009	340.923	340.977	340.966	-0.054	-0.043
A1-12.0	Mohr Ave at Iron Horse	Sep 28, 2009	347.489	347.546	347.532	-0.057	-0.043
A1-13.1	COP RE 25281	Sep 28, 2009	349.958	350.019	350.003	-0.061	-0.045
A1-14.1	Busch and Valley	Sep 28, 2009	356.841	356.887	356.878	-0.046	-0.037
A1-15.0	D8	Sep 28, 2009	366.991	367.026	367.026	-0.035	-0.035
A1-15.1	D8	Sep 28, 2009	361.463	361.496	361.486	-0.033	-0.023
A1-16.0	V1	Sep 28, 2009	367.008	367.034	367.025	-0.026	-0.017
A1-17.0	K2*	Sep 28, 2009	399.808	399.808	399.808	0.000	0.000
B1- 5.1	Mocho 4	Oct 01, 2009	336.646	336.737	NA	-0.091	NA
B1-11.0	3S/1E 8H 4	Oct 01, 2009	337.935	338.031	338.005	-0.096	-0.070
B1-12.0	3S/1E 8H13	Oct 01, 2009	336.958	337.039	337.02	-0.081	-0.062
B1-13.0	3S/1E 9M 4	Oct 01, 2009	336.410	336.489	336.468	-0.079	-0.058
B1-14.1	3S-1E 9M 2 New	Oct 01, 2009	341.021	341.022	340.99	-0.001	0.031
B1-16.1	3S-1E 9M 3 New	Oct 01, 2009	341.813	341.895	341.879	-0.082	-0.066
B3- 1.0	MOCHO-PARK	Oct 02, 2009	323.169	323.213	323.158	-0.044	0.011
B3- 2.0	1H ALA	Oct 02, 2009	320.573	320.617	320.574	-0.044	-0.001
B3- 3.0	HOP9-BM	Oct 02, 2009	321.544	321.631	321.542	-0.087	0.002
B3- 4.0	PLEASANTON CANAL	Oct 02, 2009	323.591	323.635	323.595	-0.044	-0.004
B3- 5.0	HOP7 MP1	Oct 02, 2009	322.555	322.599	322.555	-0.044	0.000
H7-C	Hop7 Casing	Oct 02, 2009	324.858	324.887	324.857	-0.029	0.001
B4- 1.0 S	AMP-CTL S	Sep 30, 2009	322.010	322.083	322.059	-0.073	-0.049
B4- 1.0 N	AMP-CTL N	Sep 30, 2009	322.151	322.223	322.198	-0.072	-0.047
B4- 2.0	Stoneridge Wellhouse	Sep 30, 2009	344.740	NA	344.786	NA	-0.046
B4- 3.0	GUZMAN PKWY	Sep 30, 2009	343.851	NA	343.892	NA	-0.041
B4- 4.0	TREVOR PKWY	Sep 30, 2009	346.459	NA	346.498	NA	-0.039
B5- 1.0	OSRR-BC	Oct 02, 2009	343.986	NA	344.052	NA	-0.066
B5- 2.0	OSRR-ANDREW	Oct 02, 2009	343.050	NA	343.112	NA	-0.062
B5- 3.0	OSRR-CAFÉ	Oct 02, 2009	344.497	NA	344.551	NA	-0.054
B5- 4.0	Tass-Rose	Oct 02, 2009	349.624	NA	349.657	NA	-0.033

* Fixed reference point
Elev Ground Surface Elevation
NM Not Measured
NA Not Applicable/Available



ZONE 7 WATER AGENCY
100 North Canyons Parkway
Livermore, CA

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REVIEWED: TR

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SCALE: 1 in = 2,000 ft
INSET SCALE: 1 in = 400 ft

DATE: May 6, 2010

Figure 3.4-1
Benchmark Locations
2009 Subsidence Monitoring Program
Livermore Valley Groundwater Basin

Figure 3.4-2
Cumulative Land Surface Elevation Changes Since Start of Program
Bernal Subbasin

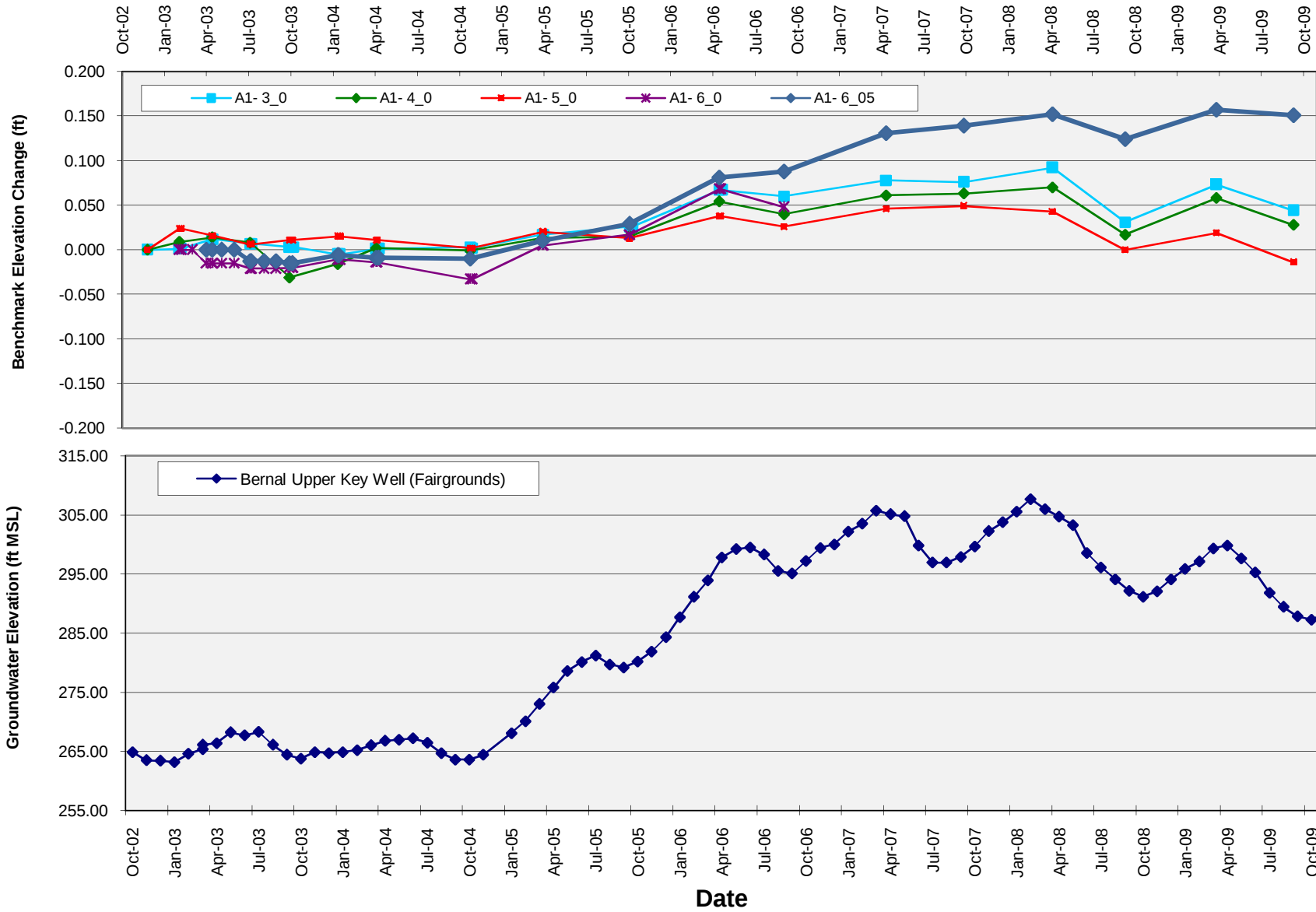


Figure 3.4-3
Cumulative Land Surface Elevation Changes Since Start of Program
Amador Subbasin

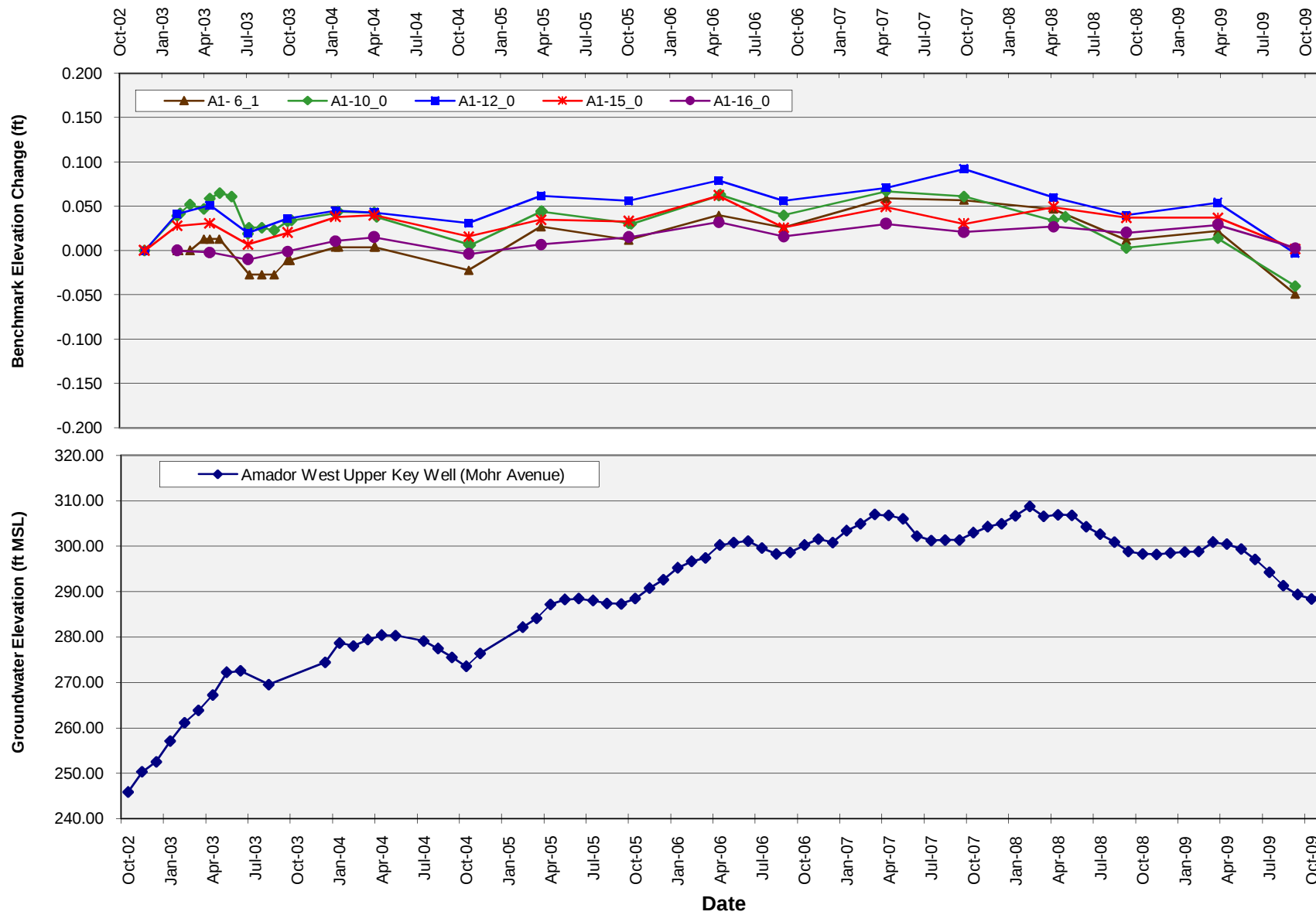


Figure 3.4-4
Graphs of Land Surface Elevation and Groundwater Elevation Versus Time
Bernal Subbasin - Hopyard 6 Well

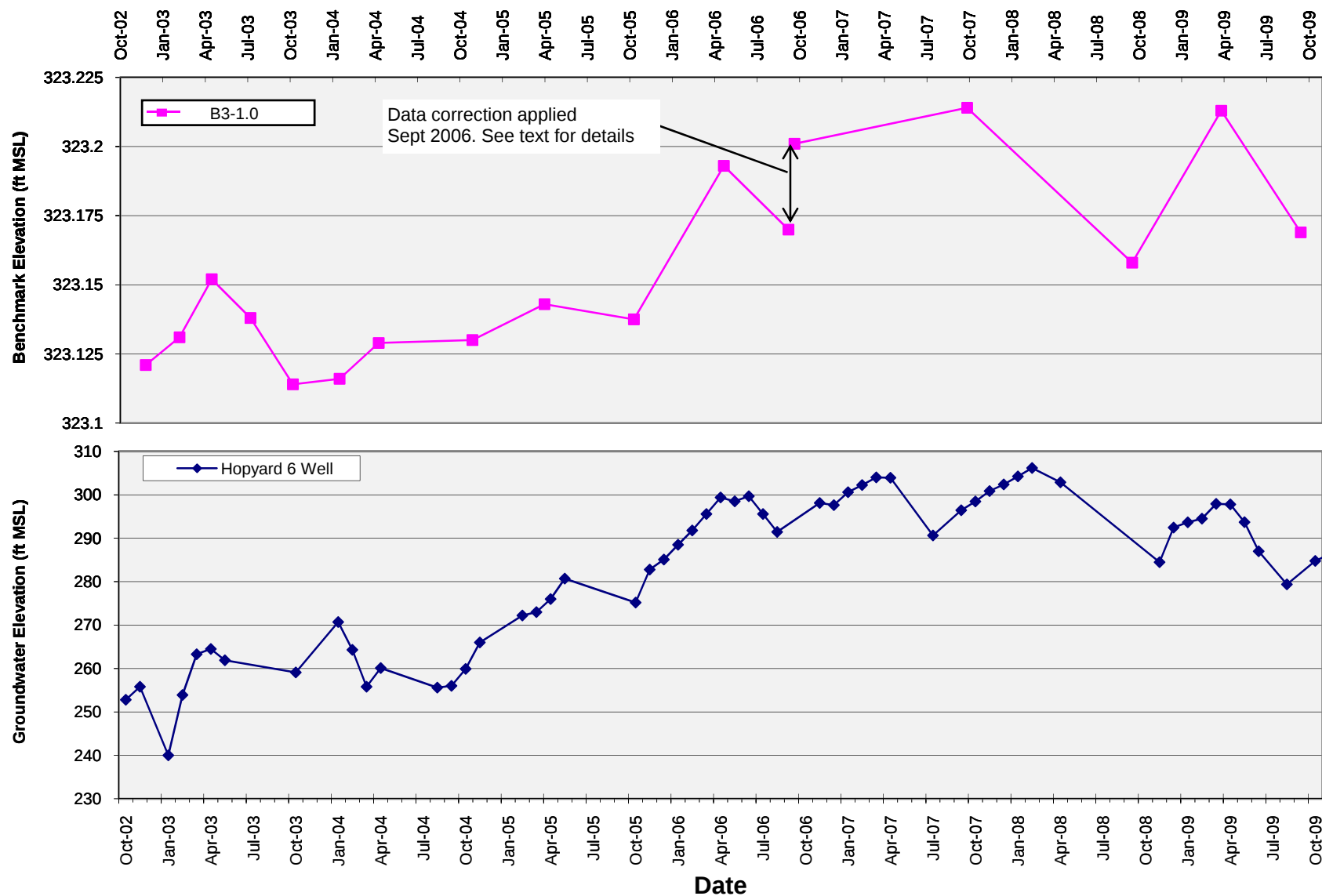


Figure 3.4-5
Graphs of Land Surface Elevation and Groundwater Elevation Versus Time
Amador Subbasin - Mocho Wellfield

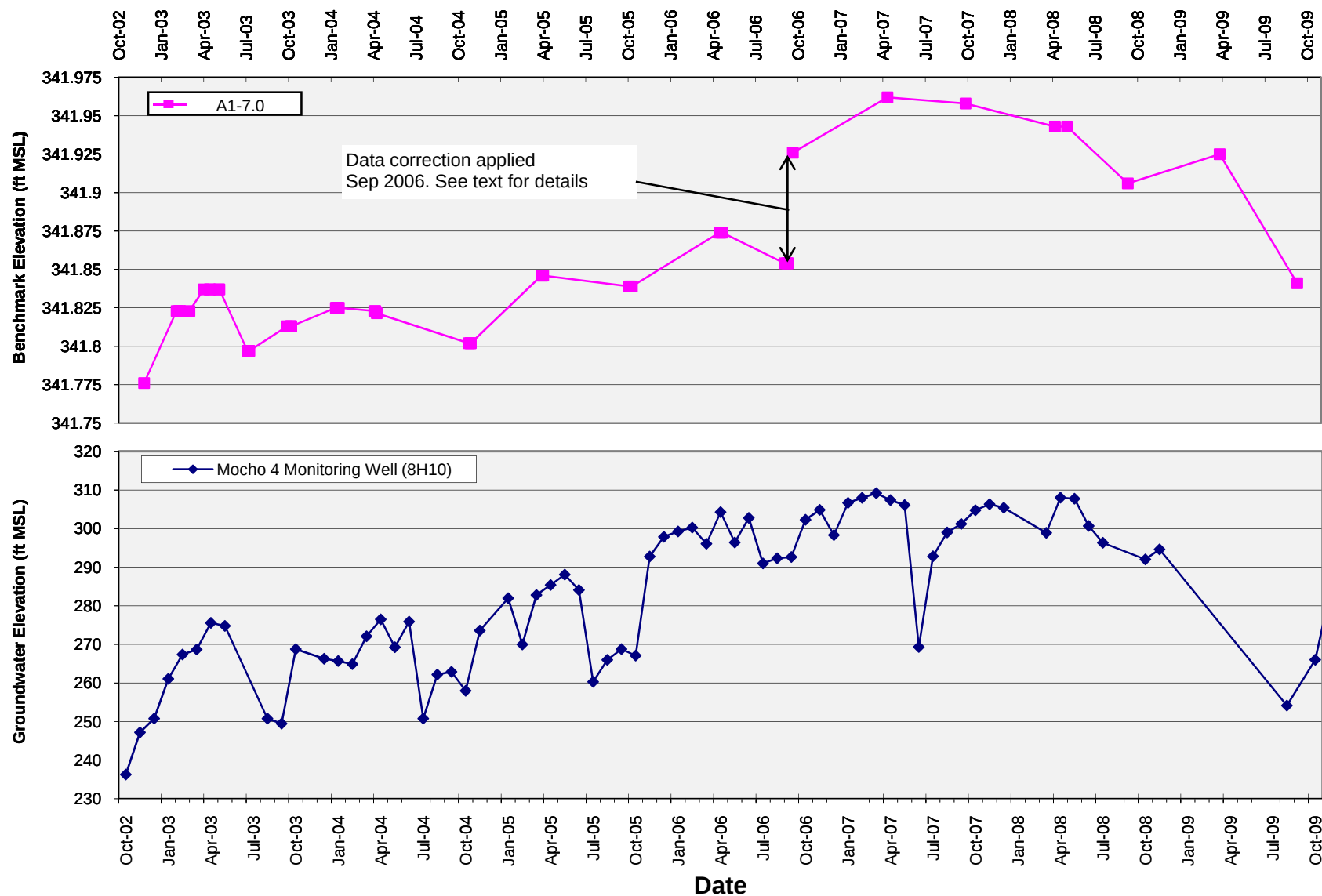
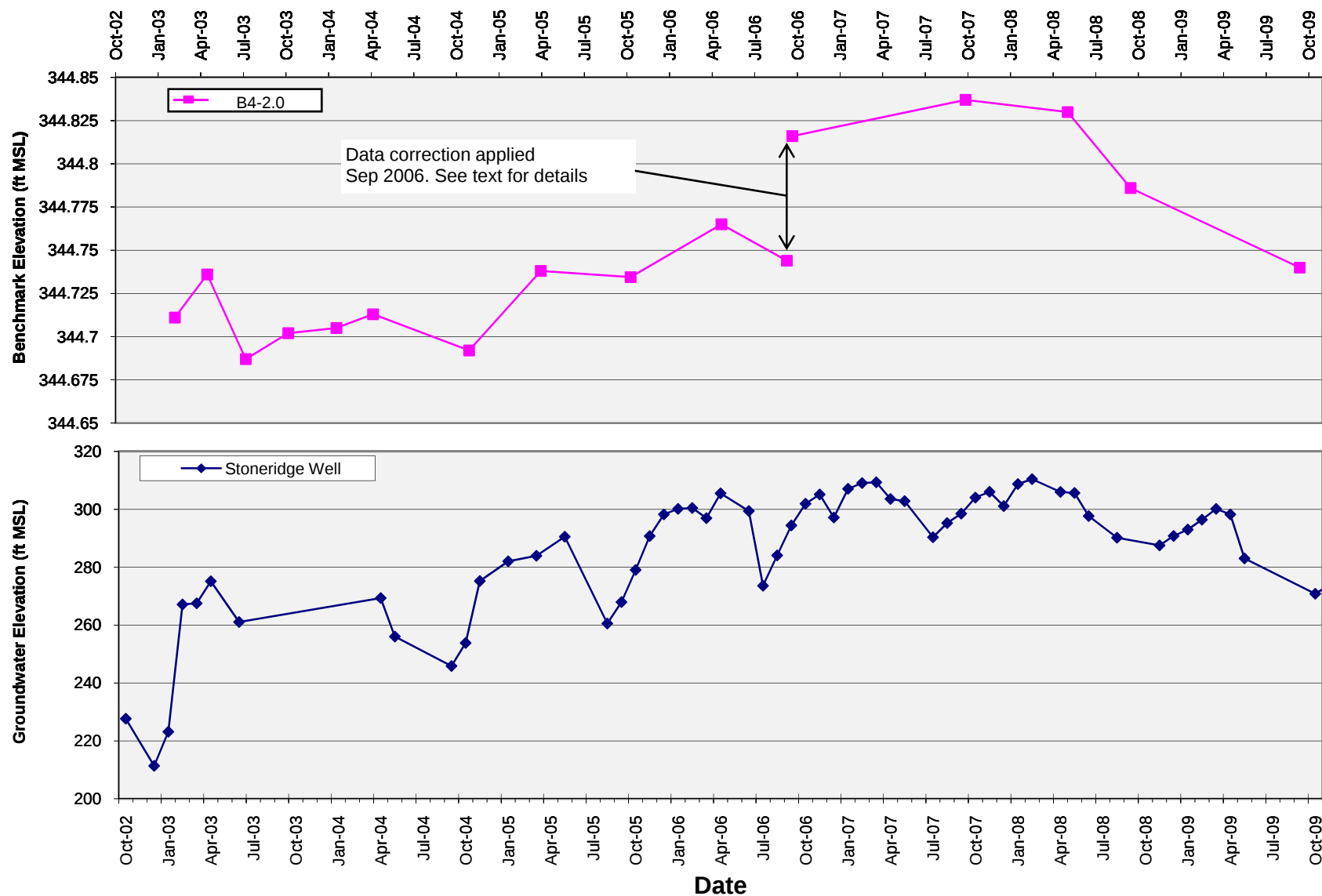
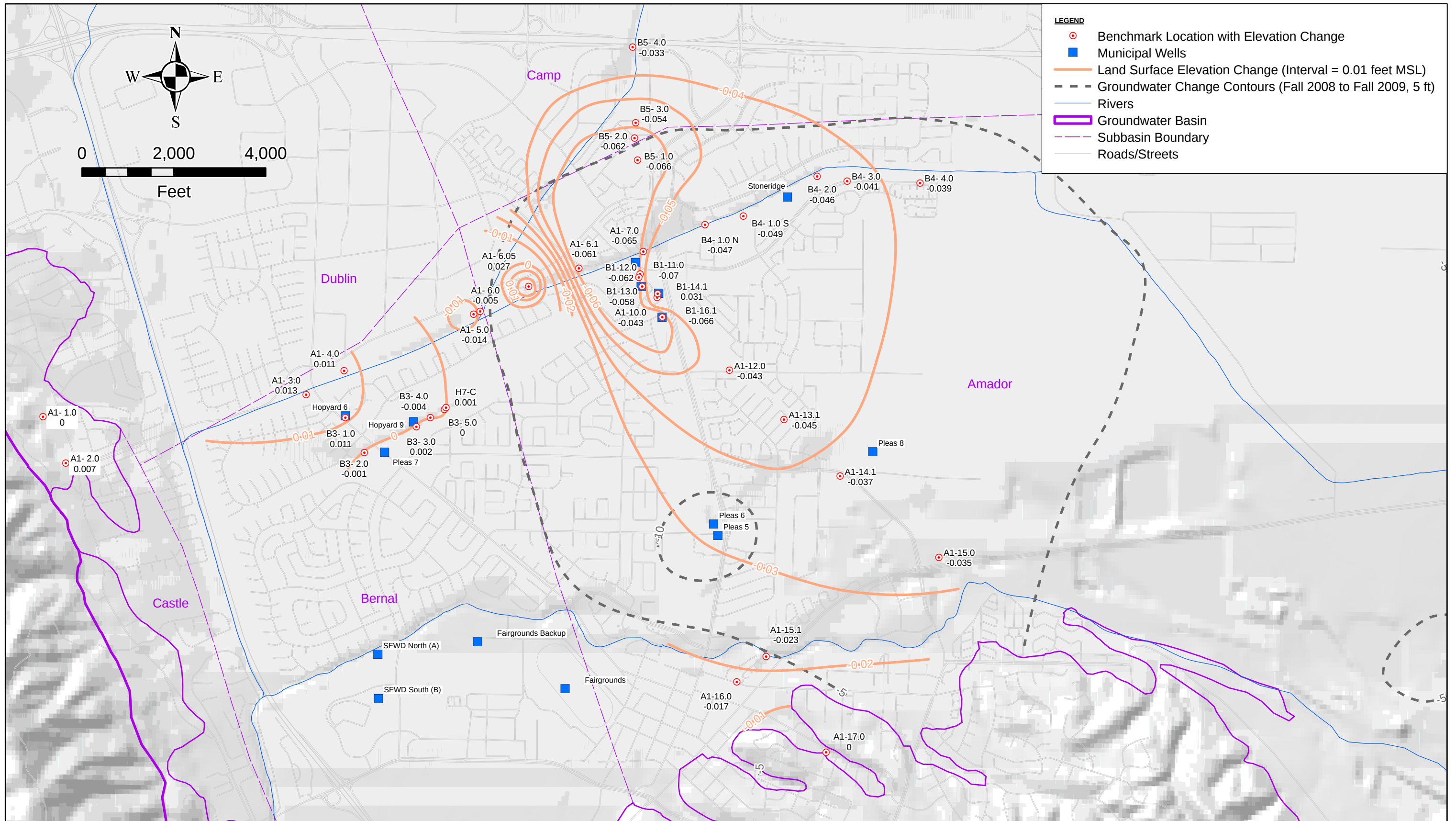


Figure 3.4-6
Graphs of Land Surface Elevation and Groundwater Elevation Versus Time
Amador Subbasin - Stoneridge Well





ZONE 7 WATER AGENCY
100 North Canyons Parkway
Livermore, CA

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SCALE: 1 in = 2,000 ft

DATE: May 6, 2010

Figure 3.4-7
Ground Surface Elevation Change (ft)
Fall 2008 to Fall 2009
Livermore Valley Groundwater Basin