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. This provided the technical basis for the decision to maintain groundwater levels above historic lows.

Zone 7's 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 2012 Water Year program included surveying elevations in a network of about 60 benchmarks and other survey points in the spring and fall at approximately the same time that basin-wide groundwater levels were measured (Section 3.2.4). Table 3.4-1 contains a list of all land surface elevation monitoring locations for the 2012 Water Year program, and Figure 3.4-1 shows the locations of each survey point. These points all tie into a main circuit (A1) that begins and ends at 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.

Starting in the 2009 Water Year, staff began monitoring the elevation difference between the cement floor and the wellhead pedestals at several Zone 7 municipal wells. These sites (labeled in Table 3.4-1 with a suffix of "-Diff") are measured monthly to investigate whether there is any indication of potential inelastic subsidence occurring between Zone 7's semiannual surveying events.

3.4.2 Program Changes and Notes for 2012 Water Year

The following items have changed from the 2011 Water Year or are items of note for the 2012 Water Year:

Two benchmarks, B1-11.0 and B1-12.0, were removed from the monitoring program because they were destroyed during work done at the Mocho 3 supply well site. Because of existing adjacent benchmarks, replacements were not needed for these destroyed benchmarks.

3.4.3 2012 Water Year 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's municipal wells. These graphs show a one-time jump in ground surface elevation in Fall 2006. This is because Site A1-9.0 was originally believed to be on stationary bedrock and therefore its elevation was held constant. However, in 2007 Water Year it was determined 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, artificially creating the elevation shift seen in the graphs in 2006.

Table 3.4-2 shows the most recent (Fall 2012) measurements and includes the elevation changes since the Fall 2011 and Spring 2012 measurements. Figure 3.4-7 shows that most of Zone 7's survey benchmarks have changed less than +/- 0.030 from Fall 2011 to Fall 2012. One area, Line B-3 in the Bernal Subbasin, had a decrease in nearly all of the points (+0.004 to -0.071). These points are all located near the Hopyard supply wells and are likely related to the pumping of Hopyard Well 6. However, these and all other observed changes in land surface elevation for the 2012 Water Year are within the range of elastic subsidence observed over the life of the monitoring program. Elevation changes from Spring to Fall 2012, which varied from +0.044 to -0.049, were also within the range of elastic movement.

3.5 Mining Area Monitoring Program

3.5.1 Program Description

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 the 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 extraction in the active pits. The Mining Area Monitoring Program includes water level measurements and water quality sampling in many of the mining area pits. The program also maps and documents current mining activities, locations of discharge lines, circulation of water between pits, the back-filling of old pits, and the locations of flow barriers created by clay-lined or backfilled pits.

The table below identifies the previous owners, current owners, and current mining operator associated with each pond prefix and pond number as shown on Figure 3.5-1.

Table: Mining Pond Operators and Owners

Pond Prefix*	Previous Owner(s)	Pond Number	Current Owner	Current Operator (if different than Owner)	Other Name
K	Kaiser Sand & Gravel; Hanson Aggregates	K1-8,19,32,33	Various	backfilled/developed	
		K9-14,24	Legacy		
		K15	EBRPD		Shadow Cliffs
		K18	EBRPD		
		K28	PGC	Hanson Aggregates	Lake H
		K30	Zone 7		Cope Lake
		K37	Zone 7		Lake I
R	Rhodes & Jamieson	R3-4, 12	Vulcan		
		R5	PGC	Vulcan	Lake G
		R8,10,11,13,21,23,24,27,28	PGC	Vulcan	
		R22	PGC	Vulcan	Lake F
		R25	PGC	Vulcan	Lake E
C	Cal Rock	C1,2,6	PGC	Vulcan	Lake C
		C3,4	PGC	Vulcan	
		C5	Cemex	Cemex	
		C7-9	PGC	Vulcan	Lake D
P	Pacific Coast Aggregates; RMC/Lonestar	P1-11,13,21,27,34,40,43-45	Cemex		
		P12	EBRPD		
		P28, 41	Cemex		Lake A
		P39,42	Cemex		Lake B

* Prefix for pond names (e.g., K37)
PGC Pleasanton Gravel Company
EBRP East Bay Regional Parks

Water surface elevations are measured semi-annually in the ponds. The semi-annual measurements are collected at the same time as the semi-annual groundwater measurements.

Water quality is determined annually by sampling and analysis. Zone 7's laboratory analyzes these samples for a general mineral analysis that is consistent with the analyses performed for the groundwater monitoring program.

All stream discharges are metered, and the volume of water discharged from the Valley is computed by prorating the flows after accounting for any re-percolation back into the groundwater basin.

This program also includes the tracking of pond evaporative areas, total monthly evaporative losses for the ponds, and an estimate of groundwater lost due to the export of moist gravels. Mining area evaporation accounts for a large portion of the "Demand" component for the annual hydrologic inventory calculation; second only to "Municipal Pumping."

3.5.2 2012 Water Year Results

Mining activities continued for Vulcan Materials (formerly Calmat) and Cemex (formerly RMC and Lonestar). Vulcan Materials continued their mining in R28 (future Lake D), utilizing the tunnel and conveyor line built under Stanley Boulevard in 2006, and continued limited operations in R24 (future lake E). Cemex continued mining in P42 (Lake B, Figure 3.5-1). A summary of mining pit conditions including their areal extent and elevations are shown on Table 3.5-1.

For the 2012 Water Year Vulcan Materials discharged 6,463 AF into the Arroyo Mocho, of which 1,786 AF re-percolated back into the groundwater basin and 4,677 AF was lost as basin outflow. Zone 7 staff has begun collaborating with Vulcan Materials on a project that will re-capture their pit de-watering operations discharge in one of Zone 7's Chain of Lakes for subsequent recharge back into the aquifers. This project would eliminate water normally lost due to Mining Area discharges now being made to the Arroyo Mocho (2,000 to 5,000 AF annually).

Cemex did not discharge into the Arroyo Valle during the 2012 Water Year. The groundwater removed during their excavation activities was pumped to onsite ponds to use as a wash source. Some of this water repercolated into the aquifer, evaporated, or left the Valley as gravel moisture.

In addition to the 4,677 AF of mining discharge water that was exported from the Valley in the arroyos, approximately 2,946 AF of water evaporated from the mining ponds, and 700 AF left as gravel moisture during the 2012 Water Year.

Zone 7 resumed its cooperative off-site recharge program with East Bay Regional Parks District (EBRPD) and diverted approximately 650 AF to Shadow Cliff's lake from October 2011 to September 2012. As a result, water levels in Shadow Cliffs were maintained at about 333 ft in elevation through most of the year.

Water elevations were measured in most of the pits that contained water during the 2012 Water Year, and the results are shown on Figure 3.5-1 and Table 3.5-1. The water elevations measured in the mining area ponds that are in direct communication with the upper aquifer are included in the Groundwater Monitoring Program's dataset used for the upper aquifer groundwater elevation contour maps (Figure 3.2-6 and Figure 3.2-7).

Water quality was also monitored in certain mining ponds (Table 3.5-2). Salt concentrations, measured as TDS, in the mining area pits ranged from about 300 mg/L in the pits along the Arroyo Valle to over 1,000 mg/L in Cope Lake [K30]. The high TDS in Cope Lake is most likely due to evaporation which concentrates the salts in this clay-lined pond. The TDS, nitrate and boron concentrations measured in the mining area ponds that are in direct communication with the upper aquifer are included in the Groundwater Monitoring Program's dataset used to create the upper aquifer concentration maps (Figure 3.2-11, Figure 3.2-12, and Figure 3.2-13).

3.6 Land Use Monitoring Program

3.6.1 Program Description

Zone 7 monitors land use changes in the Valley as part of the long-range groundwater basin management program. The purpose of the program is to map and quantify Main Basin land use for areal recharge calculations (e.g., rainfall recharge, applied water recharge, and unmetered groundwater pumping for agriculture). The program identifies changes in land use with emphasis on impervious areas and the volume and quality of irrigation water that could impact the volume or quality of water recharging the Main Basin. Land use data are derived from aerial photography (when available), permit applications, field observations, and City and County planning documents. In addition, all areas receiving untreated water from Zone 7 are mapped.

As part of the revisions to the areal recharge spreadsheet model (described in Section 4.1), Zone 7 modified and subdivided the land use categories as follows:

Table – 2012 Water Year Land Use Categories

Previous Land Use	**New Land Use**
Urban	Residential (rural) Residential (low density) Residential (medium density) Residential (high density) Commercial and Business Industrial Public Public (Irrigated Park)
Irrigated/Agriculture	Agriculture (vineyard) Agriculture (non-vineyard)
Gravel Mining Area	Mining Area – Pit Water
Golf Courses	Golf Course
Unclassified	Open Space

Each of the land use polygons is also catalogued with the source of the water that supplies that area as follows:

- Delivered (municipal) water,
- Groundwater, or
- Recycled water

Also, starting in the 2011 Water Year and continued through the 2012 Water Year, land use categories are no longer quantified by DWR nodes in the Main Basin, and instead are assigned spatially to groundwater model cells (500 by 500 ft), which are also the spatial units used for the areal recharge calculations.

3.6.2 2012 Water Year Results

The 2012 Water Year land use areas were mapped and are shown in Figure 3.6-1. For the 2012 Water Year land use over the Main Basin remained relatively unchanged from the 2011 Water Year, and in fact still remains very similar to the land use of the early 2000s. New development continues to be slow due to the effect of the poor economy.

3.7 Groundwater Production Monitoring

3.7.1 Program Description

Zone 7 collects and compiles data for all large capacity pumping wells within the Main Basin. This includes daily and monthly pumping totals from the retailers. The relative locations of these municipal supply wells are shown in Figure 3.7-1. All Zone 7 and retailer municipal supply production wells are metered. Retailer wells are read by retailer staff and reported monthly to Zone 7 as required by their treated water contracts with Zone 7. The treated water contracts also allow each retailer to pump a certain specific volume of groundwater each calendar year from the Main Basin without charge. These volumes are referred to as their Groundwater Pumping Quota (GPQ). Zone 7 charges the retailers a “recharge fee” for groundwater pumped in excess of their respective annual GPQ unless the retailer has sufficient carry-over credit from a previous year of un-pumped GPQ allocation. Such carryover is limited to 20% of the GPQ.

Records of other pumping wells are obtained from well owners when available. Pumping records from significant wells without meters are estimated from utility records or from the associated land use (e.g. number of acres irrigated). Zone 7 obtains these records as part of the Groundwater Monitoring, Land Use and Untreated Water Contracts programs.

3.7.2 2012 Water Year and Calendar Year Results

For the 2012 Water Year about 20,558 AF of groundwater was pumped from the Main Basin for municipal and agricultural uses (summarized in Table 4.2-4). Zone 7 pumped approximately 12,105 AF of groundwater for the 2012 Water Year (11,995 AF for the Calendar Year) (about 200% of the sustainable average with current artificial recharge facilities), of which approximately 11,246 AF was delivered to Zone 7’s retailers (11,083 AF for the Calendar Year). This includes the 4,672 AF of water (4,399 AF for Calendar Year) that was sent through the reverse osmosis membranes of the Mocho Groundwater Demineralization Plant (MGDP) (described in Section 5.2.3).

In addition to the nine municipal wells operated by Zone 7 in Pleasanton, CWS operated 12 wells in the Livermore area, and the City of Pleasanton operated three wells in Pleasanton in 2012. Production volumes from the municipal wells (total pumped minus the pumped-to-waste and brine discharge volume) for the 2012 Water Year and Calendar Year are presented in Table 3.7-1 and discussed further in Section 5.1.3.

For the 2012 Calendar Year (January to December), Pleasanton, which had carried over 665 AF from the 2011 Calendar Year, pumped 3,459 AF, which is just below their GPQ (3,500 AF), and therefore is carrying over 700 AF into the 2013 Calendar Year. CWS, which has a GPQ of 3,069 AF and had a carry-over of 253 AF from the 2011 Calendar Year, pumped 3,253 AF and is carrying over 69 AF into the 2013 Calendar Year. Zone 7 pumped DSRSD's GPQ (645 AF) and Livermore did not pump their GPQ. All other groundwater production was about normal for the Main Basin.

3.8 Wastewater and Recycled Water Monitoring Program

3.8.1 Program Description

Zone 7 compiles and reviews data on the volume and quality of wastewater collected and recycled water used within the watershed from the LWRP, DSRSD Water Reclamation plant, and the Veterans Hospital sewage treatment plant. While salt and nutrients are the primary constituents-of-concern for wastewater and recycled water applications over the Main Basin, several other potential constituents-of-emerging-concern (CECs) and their surrogates are being considered by the State for future basin monitoring plans requirements.

Zone 7 also reviews Septic Tank Use Applications located within the Valley for compliance with Zone 7's Wastewater Management Plan. Zone 7 must approve all onsite disposal systems for new commercial developments or any residential system that will potentially exceed the loading allowed for the site. See Section 5.3.2 for a summary of Zone 7's 2012 Water Year activities relating to individual onsite wastewater treatment/disposal systems.

3.8.2 2012 Water Year Results

The results of the Zone 7 Wastewater Monitoring Program for the 2012 Water Year are presented in the following table. The two largest wastewater collection and treatment agencies (Livermore and DSRSD), which treat over 99% of the wastewater in the Valley, are listed first, followed by the much smaller Veterans Administration (VA) Hospital and the Main Basin Septic Tanks. The third row ("Volume Recycled") shows the volume recycled within the watershed. The fourth row ("Main Basin") shows the total volume of effluent that is applied over the Main Basin. The final two rows present average nitrogen (measured as Total Kjeldahl Nitrogen [TKN]) and TDS concentrations in the applied wastewater and recycled water.

Table: Wastewater Monitoring Results for 2012 Water Year

	Livermore (LWRP)	DSRSD	VA Hospital	Septic Tanks in Main Basin	Total
FLOW VOLUMES (AF)					
Total Influent	7,668	12,832	50*	80*	20,630
Volume Exported	7,121	9,844	0	0	16,965
Volume Recycled	1,718	2,763	0	0	4,482
Applied to Main Basin	1,143	0	50*	80*	1,273
WATER CHEMISTRY OF APPLIED WASTEWATER (mg/L)					
TKN	38-45	14-30	2.7 -17	30-40*	
TDS	450-670	498-704	260-680	500-700*	

* Estimated
TKN Total Kjeldahl Nitrogen
TDS Total Dissolved Solids

This table helps illustrate the relative magnitude of different sources of recycled water use and wastewater disposal on the basin and watershed. Moreover, only the portion of the water applied as irrigation eventually makes its way to the groundwater supply; most of the applied water is evaporated, taken up by plant roots or bound to the unsaturated soil. In total, less than one percent of groundwater supply is from wastewater or recycled water origin.

In the 2012 Water Year, 20,630 AF of wastewater was produced as compared to 21,092 AF in the 2011 Water Year. About 22% of the wastewater was recycled for irrigation projects; 1,718 AF by City of Livermore and 2,763 AF by DSRSD. About 67% (1,143 AF) of the recycled water produced by LWRP was applied over the Main Basin; whereas all of DSRSD's recycled water was applied on areas outside of the Main Basin, primarily on fringe basin areas. Zone 7 staff continues to investigate the hydrogeologic relationship between the fringe and Main basins as part of its Salt Management Plan (SMP) update to quantify the inflow of groundwater and salts from the fringe basins to the Main Basin. The remainder, not used for irrigation, was exported from the valley through the Livermore-Amador Valley Water Management Agency (LAVWMA) export pipeline.

The recycled water from both wastewater plants met the State Department of Public Health "Title 22" water quality standards for irrigation uses during the 2012 Water Year. TDS concentrations in the portion applied directly on the Main Basin ranged from 450 to 670 mg/L, while TKN concentrations ranged from 38 to 45 mg/L. About 847 tons (about 6%) of the Main Basin's gross salt loading (13,087 tons) was attributed to recycled water use over the Main Basin during the 2012 Water Year.

There is a small amount of non-recycled wastewater that is applied over Main Basin in the form of leachate from onsite domestic wastewater systems (septic systems) and from the VA Hospital wastewater treatment system located in southern Livermore. The contribution to the groundwater supply (130 AF) is estimated using "typical" wastewater flows since actual discharges are not monitored. There have been virtually no changes in land uses or septic system densities over the Main Basin that would change the estimated water contribution from these sources in recent years.

Some wastewater likely leaks from pipes on its way to the Valley's wastewater treatment systems (see Section 4.2.5 for a discussion of pipe leakage). The portion of leakage from wastewater pipes is estimated to be roughly 400 AF/year.

The ranges of nitrogen (measured as TKN) and TDS concentrations for each applied recycled water and wastewater component are shown in the table above. TKN represents the nitrogen content potentially available for conversion to nitrate as the water percolates through the soil. However, from a practical standpoint, some of the nitrogen will be removed from the percolate through soil denitrification and plant uptake processes. Conversely, Zone 7 assumes that all of the salt mass in the applied water is carried downward by the percolate and eventually reaches groundwater. This leads to a conservative (potentially high) estimate of the salt loading attributed to their applications. See Section 5.1.6 for further discussion on the contribution of salts from these recycled water and wastewater applications.

TABLE 3.4-1
SUBSIDENCE MONITORING PROGRAM
SURVEY POINTS AND DESCRIPTIONS, 2012 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 brdge 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- 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
B1-13.0	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
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 2010	Spring 2011
B1 Mocho loop	Semi-annually	Fall 2010	Spring 2011
B2 Tassajara loop	As needed	Fall 2007	as needed
B3 Hopyard wells loop	Semi-annually	Fall 2010	Spring 2011
B4 Stoneridge well loop	Semi-annually	Fall 2010	Spring 2011
B5 Tassajara - Rosewood	Annually	Fall 2010	Fall 2011
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
(orange)	Probable bedrock sites

TABLE 3.4-2
SUBSIDENCE MONITORING
KIER AND WRIGHT SURVEY MEASUREMENTS
2012 WATER YEAR

Site	Site Description	Fall 2011 (Sep 29-Sep 30) Elevation in ft NAVD88	Spring 2012 (May 15-May 17) Elevation in ft NAVD88	Fall 2012 (Oct 3- Oct 4) Elevation in ft NAVD88	Change in Elevation (ft) Seasonal Fall 11 to Spring 12	Change in Elevation (ft) Seasonal Spring 12 to Fall 12	Change in Elevation (ft) Annual Fall 11 to Fall 12
A1- 1.0	G972*	365.705	365.705	365.705	0.000	0.000	0.000
A1- 2.0	Foothill and Las Positas	405.441	405.447	405.439	0.006	-0.007	-0.002
A1- 3.0	C972	330.590	330.574	330.566	-0.016	-0.008	-0.024
A1- 4.0	Arroyo Mocho at Chabot Crk	324.033	324.022	324.015	-0.011	-0.007	-0.018
A1- 5.0	Arroyo Mocho at Tassajara Crk West	327.133	327.120	327.135	-0.013	0.015	0.002
A1- 6.0	Arroyo Mocho at Tassajara Crk East	327.795	327.789	327.818	-0.006	0.029	0.023
A1- 6.05	Arroyo Mocho at Tassajara Crk East	329.357	329.352	329.384	-0.005	0.032	0.027
A1- 6.1	Arroyo Mocho Pleasanton Control	332.629	332.613	332.652	-0.016	0.039	0.023
A1- 7.0	M1257	341.873	341.853	341.892	-0.020	0.039	0.019
A1-10.0	Vineyard Pipeline at Santa Rita Rd	340.924	340.904	340.942	-0.020	0.038	0.018
A1-12.0	Mohr Ave at Iron Horse	347.509	347.496	347.535	-0.013	0.039	0.026
A1-13.1	COP RE 25281	349.977	349.968	349.997	-0.009	0.029	0.020
A1-14.1	Busch and Valley	356.857	356.849	356.881	-0.008	0.032	0.024
A1-15.0	D8	367.004	367.011	367.034	0.007	0.023	0.030
A1-15.1	BM-P929 Reset	361.477	361.485	361.493	0.008	0.008	0.016
A1-16.0	V1	367.019	367.027	367.045	0.008	0.018	0.026
A1-17.0	K2*	399.808	399.808	399.808	0.000	0.000	0.000
B1- 5.1	Mocho 4	336.679	336.658	336.702	-0.021	0.044	0.023
B1-13.0	3S/1E 9M 4	336.445	336.425	336.467	-0.020	0.042	0.022
B1-14.1	3S-1E 9M 2 New	341.022	341.022	341.026	0.000	0.004	0.004
B1-16.1	3S-1E 9M 3 New	341.810	341.779	341.800	-0.031	0.021	-0.010
B3- 1.0	MOCHO-PARK	323.168	323.145	323.097	-0.023	-0.048	-0.071
B3- 2.0	1H ALA	320.581	320.570	320.562	-0.011	-0.008	-0.019
B3- 3.0	HOP9-BM	321.586	321.592	321.543	0.006	-0.049	-0.043
B3- 4.0	PLEASANTON CANAL	323.615	323.610	323.600	-0.005	-0.010	-0.015
B3- 5.0	HOP7 MP1	322.564	322.562	322.556	-0.002	-0.006	-0.008
H7-C	Hop7 Casing	324.869	324.866	324.873	-0.003	0.007	0.004
B4- 1.0 S	AMP-CTL S	322.046	322.019	322.048	-0.027	0.029	0.002
B4- 1.0 N	AMP-CTL N	NA	322.159	322.187	NA	0.028	NA
B4- 2.0	Stoneridge Wellhouse	344.780	344.755	344.774	-0.025	0.019	-0.006
B4- 3.0	GUZMAN PKWY	343.886	343.867	343.886	-0.019	0.019	0.000
B4- 4.0	TREVOR PKWY	346.492	346.475	346.496	-0.017	0.021	0.004
B5- 1.0	OSRR-BC	344.000	NA	344.016	NA	NA	0.016
B5- 2.0	OSRR-ANDREW	343.068	NA	343.087	NA	NA	0.019
B5- 3.0	OSRR-CAFÉ	344.508	NA	344.529	NA	NA	0.021
B5- 4.0	Tass-Rose	349.628	NA	349.654	NA	NA	0.026

* Fixed Reference Point NM = Not measured NA = Not applicable/available

TABLE 3.5-1
SEMIANNUAL WATER LEVELS IN MINING AREA PONDS
2012 WATER YEAR

Pit Number	Chain of Lakes Name	Frequency		Contact with Aquifer	Original Ground Elev	Deepest Mined Depth		Mining Use	Pond Elevation (ft MSL, NAVD88)	
		Levels	Quality			Elev	Depth	2012	Spring 12	Fall 12
CALROCK/RHODES & JAMIESON/VULCAN/PLEASANTON GRAVEL COMPANY/CALMAT										
C 1	C	SA	A	C	410	360	50	Unused	355.6	354.17
C 2	C			N	410	360	50	Clay Storage		
C 3				N	410	360	50	Clay Storage		
C 4				N	400	390	10	Clay Storage		
C 5				N	400	290	110	Clay Storage		
C 6	C			N	400	385	15	Unused		
C 7	D			N	400	330	70	Clay Storage		
C 8A	D			C	410	330	80	Unused		
C 8B	D			C	410	340	70	Unused		
C 9	D			N	410	310	100	Unused		
R 3		SA	A	CP	370	240	130	Water & Clay	333.96	335.61
R 4		SA	A	CP	380	240	140	Water Storage	312.27	311.27
R 5				N	380	240	140	Clay Storage		
R 8	G	SA	A	CP	365	260	105	Same as R22		
R10				N	380	370	10	Clay Storage		
R11				N	390	370	20	Clay Storage		
R12				N	370	240	130	Clay Storage		
R13				N	370	270	100	Clay & Debris		
R21				N	380	280	100	Water & Clay		
R22	F	SA	A	CP	380	290	90	Water Storage	361.46	362
R23		SA	A	CP	380	270	110	Water & Clay	358.84	359.03
R24	E	SA	A	C	390	200	190	Active Mining		
R25	E			-	395	300	95	Inactive Mining	201	201.51
R27				N	380	300	80	Water Storage		
R28	D	SA	A	CP	400	320	80	Active Mining		
KAISER GRAVELS/HANSON										
K 1				N	350	325	25	Backfilled with clay		
K 2				N	350	325	25	Backfilled with clay		
K 4				N	350	315	35	Backfilled with clay		
K 5				N	350	315	35	Backfilled with clay		
K 6				N	350	325	25	Backfilled with clay		
K 7				N	350	320	30	Backfilled with clay		
K 8				N	350	320	30	Backfilled with clay		
K 9				N	360	305	55	Backfilled with clay		
K10				N	370	355	15	Backfilled with clay		
K11				N	370	315	55	Backfilled with clay		
K12				N	370	275	95	Backfilled with clay		
K13				N	370	275	95	Backfilled with clay		
K14				N	370	275	95	Backfilled with clay		
K15	Sh.Cliff	SA	A	C	360	265	95	Water Storage	332.46	333.35
K18		SA	A	C	360	330	30	Unused	350.21	350.67
K19					350	335	15	Backfilled with clay		
K24				N	360	220	140	Backfilled with clay		
K24A	Busch Pit			N	360	220	140	Drainage/Stormwater		
K28	H	SA	A	C	360	220	140	Water Storage	288.68	284.29
K30	Cope	SA	A	N	370	240	130	Water & Clay		
K32				N	360	335	25	Backfilled with clay		
K33				-	360	335	25	Unused		
K37	I	SA	A	C	360	220	140	Water Storage	288.35	284.28
PACIFIC AGGREGATE/RMC/LONESTAR/CEMEX										
P 1					380	360	20	Clay Storage		
P 2				CP	380	360	20	Water Storage		
P 3					400	360	40	Clay Storage		
P 4					400	360	40	Clay Storage		
P 6					380	280	100	Clay & Debris		
P 7					380	280	100	Clay & Debris		
P 9					400	380	20	Clay Storage		
P10		SA	A	C	400	340	60	Unused	366.08	366.33
P11		SA	A	C	380	340	40	Unused		
P12		SA	A	C	360	330	30	Unused	350.45	350.95
P13				C	380	300	80	Water Storage		
P21					380	240	140	Clay Storage		
P27		SA	A	C	390	250	160	Water Storage	295.55	288.95
P28	A	SA	A	CP	420	360	60	Water Storage	403.18	402.95
P34					380	270	110	Clay & Debris		
P39	B				410	380	30	Inactive Mining		
P40		SA	A	C	390	260	130	Water Storage	302.21	297.57
P41	A	SA	A	CP	410	370	40	Water Storage	410.79	409.73
P42	B	SA	A	CP	380	310	70	Active Mining	281.32	280.25
P43				N	390	240	150	Water & Clay	345.84	344.41
P44		SA	A	CP	390	250	140	Water Storage	318.6	316.41
P45				CP	380	310	70	Water Storage		

A = Annual; SA = Semiannual
C = in contact with GW; CP = GW contact but subject to pumping; N = no contact with GW

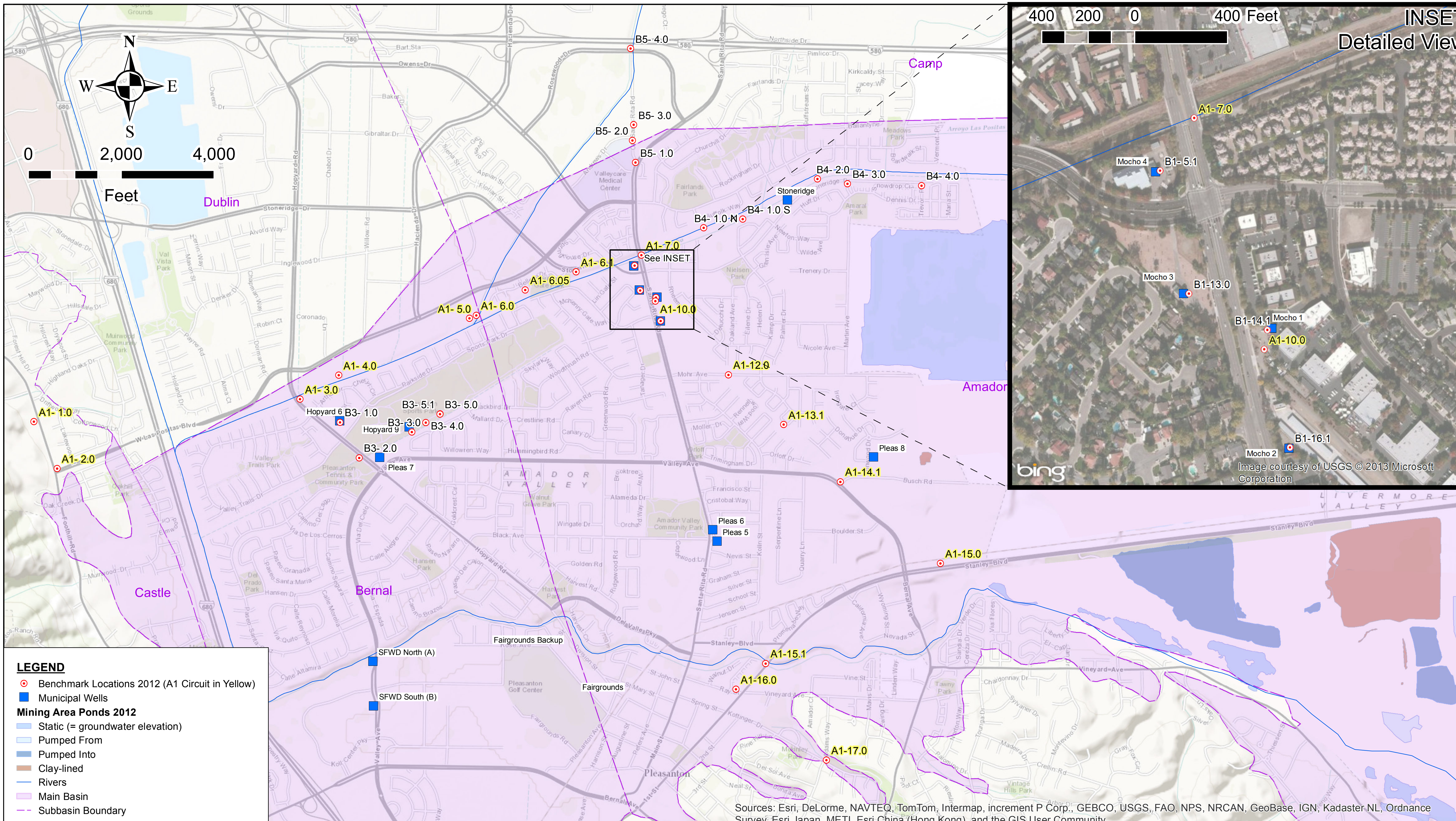
TABLE 3.5-2
WATER QUALITY RESULTS FOR MINING AREA WATER SAMPLES
2012 WATER YEAR

		TEMP.	EC		Mineral Constituents (mg/L)									Select Metals (mg/L)				TDS	Hard
SITE ID	DATE	^{o}C	umhos/cm	pH	Ca	Mg	Na	K	HCO3	SO4	Cl	NO3	SiO2	B	As	Fe	Mn	mg/L	mg/L
MA-C01	30-May-12	21.2	1401	8.9	37	81	132	3.1	359	98	245	<0.44	3.0	0.74	0.0059	<0.05	<0.01	803	425
MA-K15	24-May-12	22.9	692	8.8	32	32	68	2.9	202	49	95	<0.44	8.1	0.40	0.0024	<0.05	<0.01	398	212
MA-K18	29-May-12	23.0	523	8.9	36	17	49	2.1	138	45	70	<0.44	10.4	0.22	0.0012	<0.05	<0.01	308	161
MA-K28	24-May-12	21.6	839	8.7	25	52	66	1.9	251	53	118	<0.44	8.8	0.61	0.0022	<0.05	<0.01	460	275
MA-K37	24-May-12	22.7	990	8.9	32	58	84	2.2	280	69	153	<0.44	2.1	0.83	0.0034	<0.05	<0.01	559	318
MA-P10	29-May-12	25.5	552	9.2	25	26	53	2.4	173	21	72	<0.44	<1.1	0.28	0.0026	<0.05	<0.01	310	172
MA-P12	29-May-12	20.7	556	8.3	40	18	41	2.0	164	45	71	<0.44	11.9	0.23	0.0013	<0.05	<0.01	313	177
MA-P27	29-May-12	25.2	646	9.0	33	33	47	1.5	149	56	100	<0.44	6.1	0.38	0.0019	<0.05	<0.01	364	219
MA-P28	29-May-12	23.6	863	8.7	35	42	83	2.4	216	52	153	<0.44	2.8	0.33	0.0024	<0.05	<0.01	487	262
MA-P40	29-May-12	23.1	786	10.6	16	33	90	<0.5	40	44	133	<0.44	<1.1	0.65	0.0035	<0.05	<0.01	484	176
MA-P41	29-May-12	24.5	814	8.8	52	36	62	2.5	236	39	130	<0.44	5.5	0.27	0.0026	<0.05	<0.01	457	276
MA-P42	29-May-12	24.3	596	8.5	47	23	41	1.4	202	41	66	<0.44	14.7	0.29	<0.001	<0.05	<0.01	339	212
MA-P43	29-May-12	24.2	587	8.8	37	24	46	1.9	142	50	89	<0.44	6.6	0.31	<0.001	<0.05	<0.01	333	190
MA-P44	29-May-12	25.4	576	8.8	41	21	43	1.7	153	45	79	<0.44	10.1	0.30	<0.001	<0.05	<0.01	325	191
MA-R03	24-May-12	21.6	681	8.7	40	42	38	3.1	233	42	85	1.99	11.7	0.31	<0.001	<0.05	<0.01	389	273
MA-R04	24-May-12	23.1	691	8.7	42	43	33	2.0	239	41	83	2.66	12.3	0.28	<0.001	<0.05	<0.01	388	283
MA-R08	24-May-12	21.4	696	8.7	42	44	33	2.1	240	41	85	1.95	12.1	0.27	<0.001	<0.05	<0.01	391	286
MA-R22	24-May-12	20.7	714	8.6	42	48	32	1.8	258	41	80	6.02	16.4	0.28	<0.001	<0.05	<0.01	404	302
MA-R23	24-May-12	21.7	708	8.6	42	47	32	1.8	255	41	81	4.56	14.7	0.28	<0.001	<0.05	<0.01	399	297

TABLE 3.7-1
GROUNDWATER PRODUCTION FROM MUNICIPAL SUPPLY WELLS
2012 WATER YEAR (in Acre-feet)

Station ID	Well	Common Name	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WY*	CY**
Owner: **Zone 7**																
COL 1	3S/1E 10K 3	COL 1	1.0	3.0	3.0	153.0	148.0	2.0	15.0	31.0	45.0	34.0	47.0	14.0	**496**	**505**
COL 2	3S/1E 11M 3	COL 2	1.0	2.0	2.0	149.0	0.0	0.0	0.0	0.0	54.0	49.0	35.0	3.0	**295**	**490**
Hop 6	3S/1E 18A 6	Hopyard 6	0.0	0.0	19.0	227.0	69.0	12.0	19.0	338.0	276.0	266.0	386.0	222.0	**1834**	**1983**
Hop 9	3S/1E 17D12	Hopyard 9	0.0	0.0	0.0	35.0	4.0	0.0	0.0	0.0	0.0	14.0	80.0	14.0	**147**	**147**
MOCHO 1	3S/1E 9M 2	Mocho 1	258.0	184.0	274.0	248.0	94.0	111.0	180.0	154.0	208.0	149.0	33.0	0.0	**1893**	**1177**
MOCHO 2	3S/1E 9M 3	Mocho 2	0.0	0.0	159.0	286.0	293.0	156.0	99.0	321.0	196.0	125.0	96.0	31.0	**1762**	**1958**
MOCHO 3	3S/1E 9M 4	Mocho 3	0.0	9.0	27.0	481.0	128.0	18.0	170.0	316.0	375.0	543.0	551.0	495.0	**3113**	**3097**
MOCHO 4	3S/1E 8H18	Mocho 4	61.0	74.0	62.0	332.0	86.0	78.0	22.0	118.0	166.0	132.0	195.0	74.0	**1400**	**1322**
STONERIDGE_1	3S/1E 9B 1	Stoneridge	0.0	0.0	2.0	449.0	146.0	0.0	18.0	408.0	98.0	0.0	0.0	0.0	**1121**	**1280**
TOTALS															**12061**	**11959**
Owner: **Pleasanton**																
PLEAS #5	3S/1E 16L 5	Pleas 5	75.4	49.2	0.3	0.0	27.2	27.7	29.1	45.4	86.8	136.0	236.5	253.6	**967.1**	**981.7**
PLEAS #6	3S/1E 16L 7	Pleas 6	67.8	10.7	30.2	0.0	19.6	29.3	28.7	48.6	86.1	168.8	234.4	262.0	**986.1**	**956.8**
PLEAS #7	3S/1E 18A 5	Pleas 7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**	**0**
PLEAS #8	3S/1E 16A 2	Pleas 8	316.7	154.2	96.5	32.3	65.5	9.6	55.2	86.9	240.3	268.7	296.7	324.1	**1946.5**	**1520.2**
TOTALS															**3899.8**	**3458.8**
Owner: **California Water Service**																
CWS# 5(16B1)	3S/2E 16B 1	CWS STA 5	24.5	23.7	25.4	24.0	22.9	24.5	23.5	19.9	22.0	21.8	21.9	19.4	**273.5**	**251.5**
CWS# 8(8P 1)	3S/2E 8P 1	CWS STA 8	20.7	30.9	0.0	0.0	0.0	0.0	0.0	2.1	37.9	38.4	34.8	0.0	**164.7**	**124.7**
CWS# 9(9Q 1)	3S/2E 9Q 1	CWS STA 9	7.9	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**15.4**	**12.2**
CWS#10 (8F1)	3S/2E 8F 1	CWS STA 10	0.0	4.3	54.1	40.6	42.0	36.2	19.4	57.6	46.0	46.4	41.3	41.6	**429.4**	**513.8**
CWS#12 (9P1)	3S/2E 9P 1	CWS STA 12	6.8	20.9	20.5	33.8	32.4	36.3	32.1	34.9	33.9	44.2	53.5	60.3	**409.7**	**439.1**
CWS#14 (8N2)	3S/2E 8N 2	CWS STA 14	90.8	78.5	69.9	60.3	60.1	62.5	69.6	81.8	70.9	75.6	83.6	80.9	**884.4**	**756.4**
CWS#15 (16C1)	3S/2E 16C 1	CWS STA 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.3	45.8	38.8	36.1	**160.1**	**160.1**
CWS#17 (9L1)	3S/2E 9L 1	CWS STA 17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**	**0**
CWS#19 (8G1)	3S/2E 8G 1	CWS STA 19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**	**0**
CWS#20 (18B1)	3S/2E 18B 1	CWS STA 20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0	29.7	44.9	**91.6**	**110.7**
CWS#24 (7P3)	3S/2E 7P 3	CWS STA 24	17.8	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.4	33.3	47.0	**147.9**	**251.7**
CWS#31 (7R3)	3S/2E 7R 3	CWS STA 31	78.4	68.8	60.4	54.5	54.3	54.9	51.2	76.6	55.7	67.0	67.6	64.8	**754.1**	**630**
TOTALS															**3330.9**	**3250.2**

* Water Year - from October 2011 to September 2012;
** Calendar Year - from January 2012 to December 2012;
Does not include pumped volume to waste.



ZONE 7 WATER AGENCY 100 North Canyons Parkway Livermore, CA	DRAWN: MG/CW/TR	SCALE: 1 in = 2,000 ft INSET SCALE: 1 in = 400 ft	**Figure 3.4-1** **Benchmark Locations** **2012 Subsidence Monitoring Program** **Livermore Valley Groundwater Basin**
	REVIEWED: TR	DATE: Mar 29, 2013	
	FILE: E:\MONITOR\EM\2012wy\Annual\Figures\Fig3.4-1-EMBasemap2012.mxd		

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

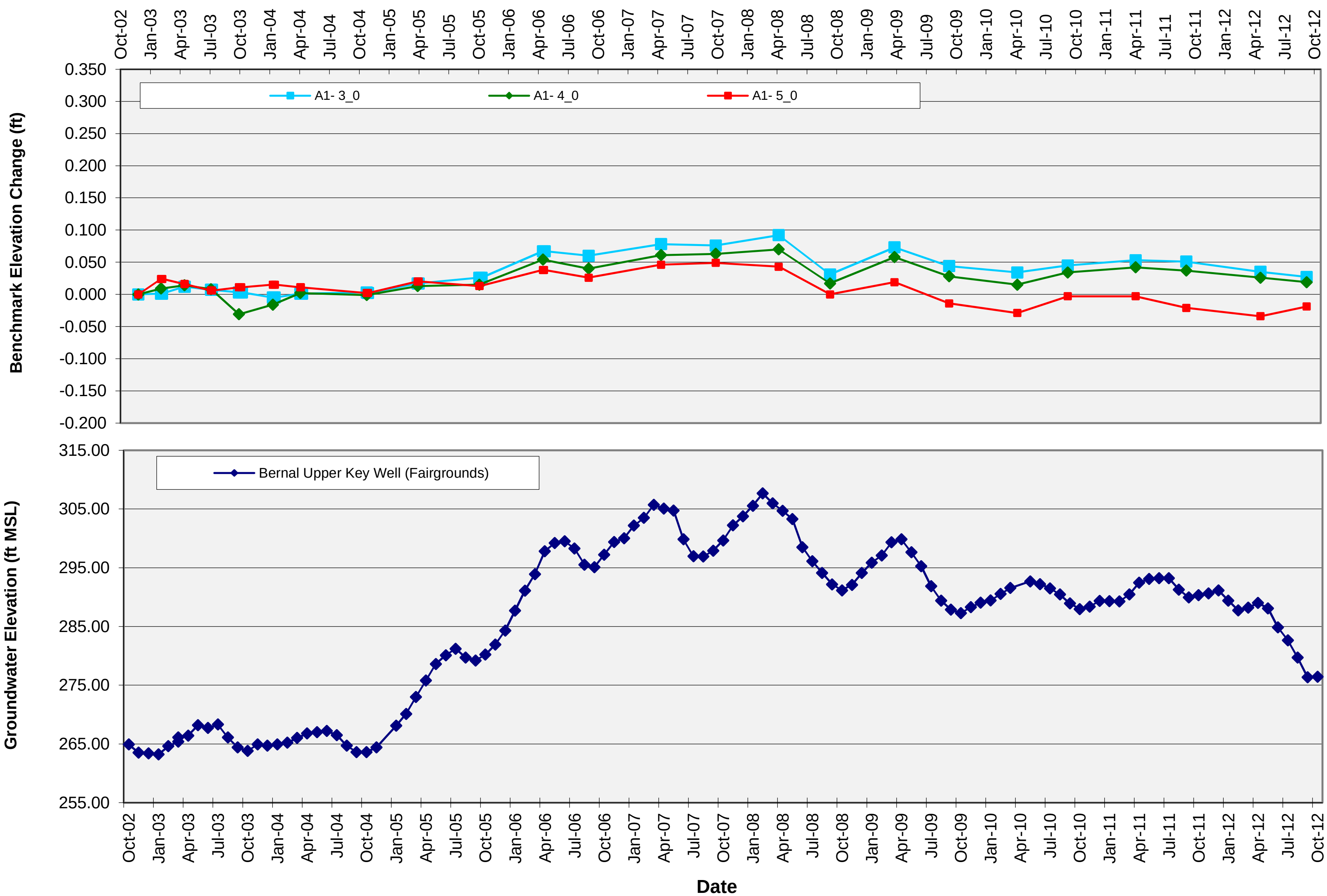


Figure 3.4-3
Cumulative Land Surface Elevation Changes Since Start of Program
Amador Subbasin

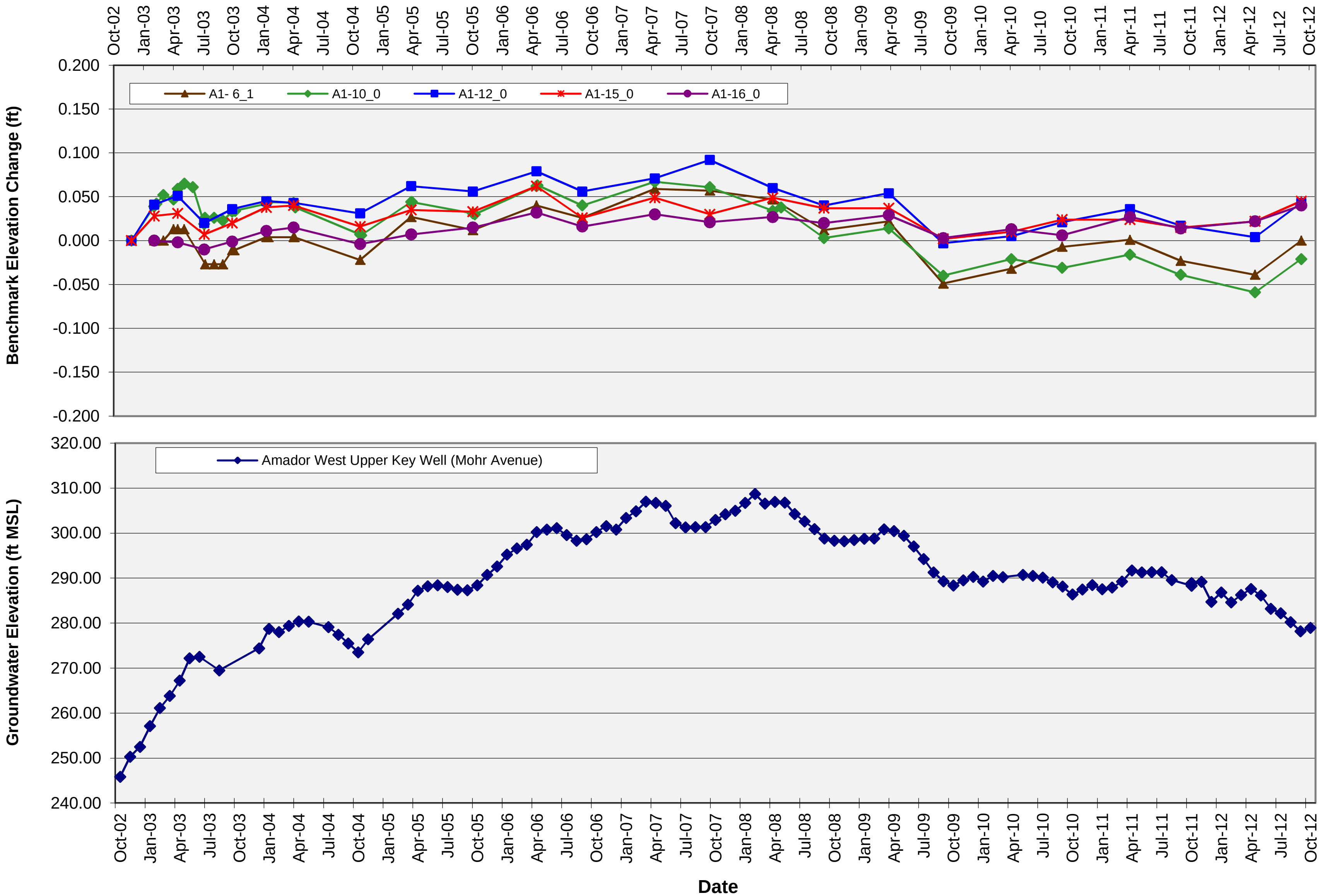


Figure 3.4-4
Graphs of Land Surface Elevation and Groundwater Elevation Versus Time
Bernal Subbasin - Hopyard 6 Well

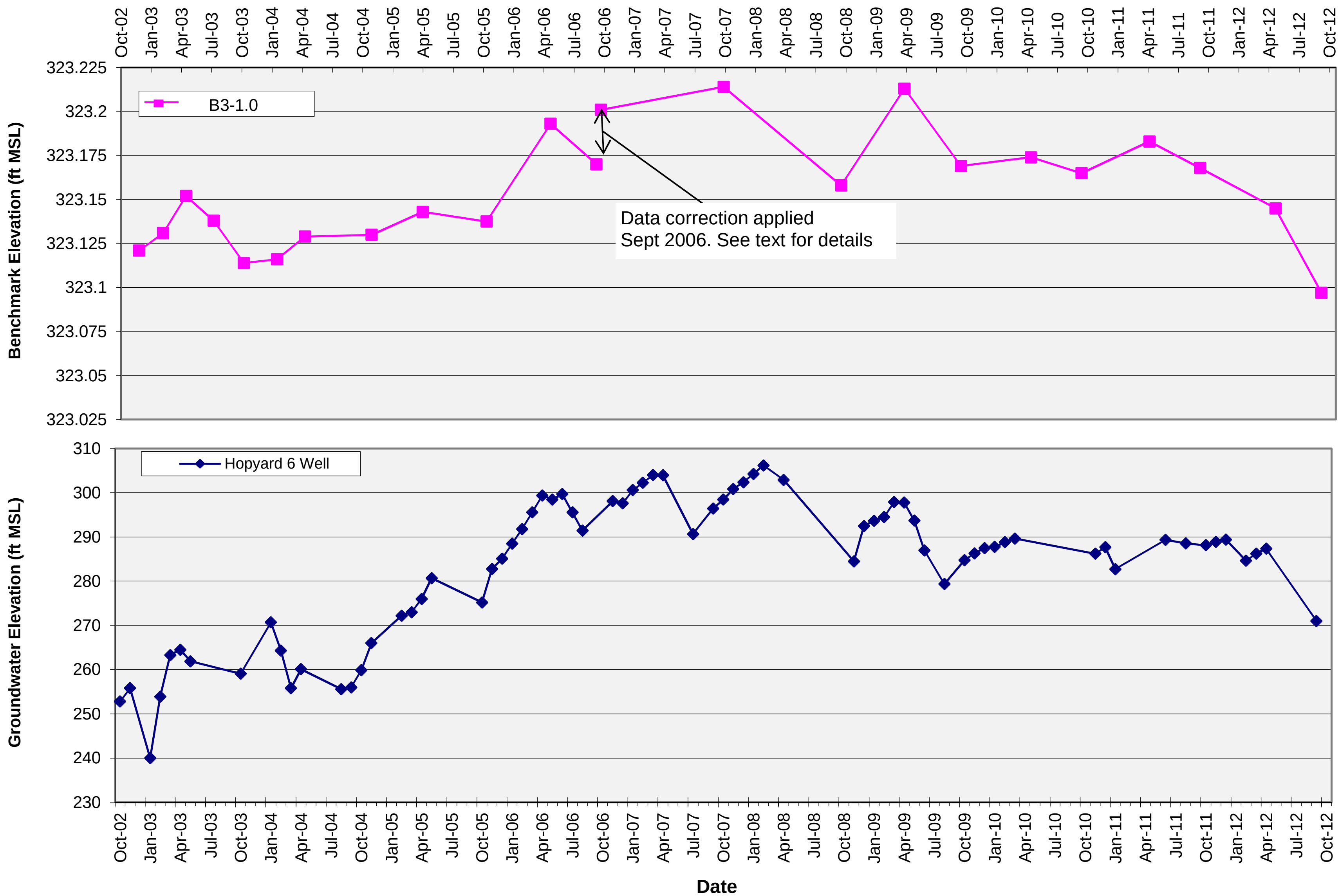


Figure 3.4-5
Graphs of Land Surface Elevation and Groundwater Elevation Versus Time
Amador Subbasin - Mocho Wellfield

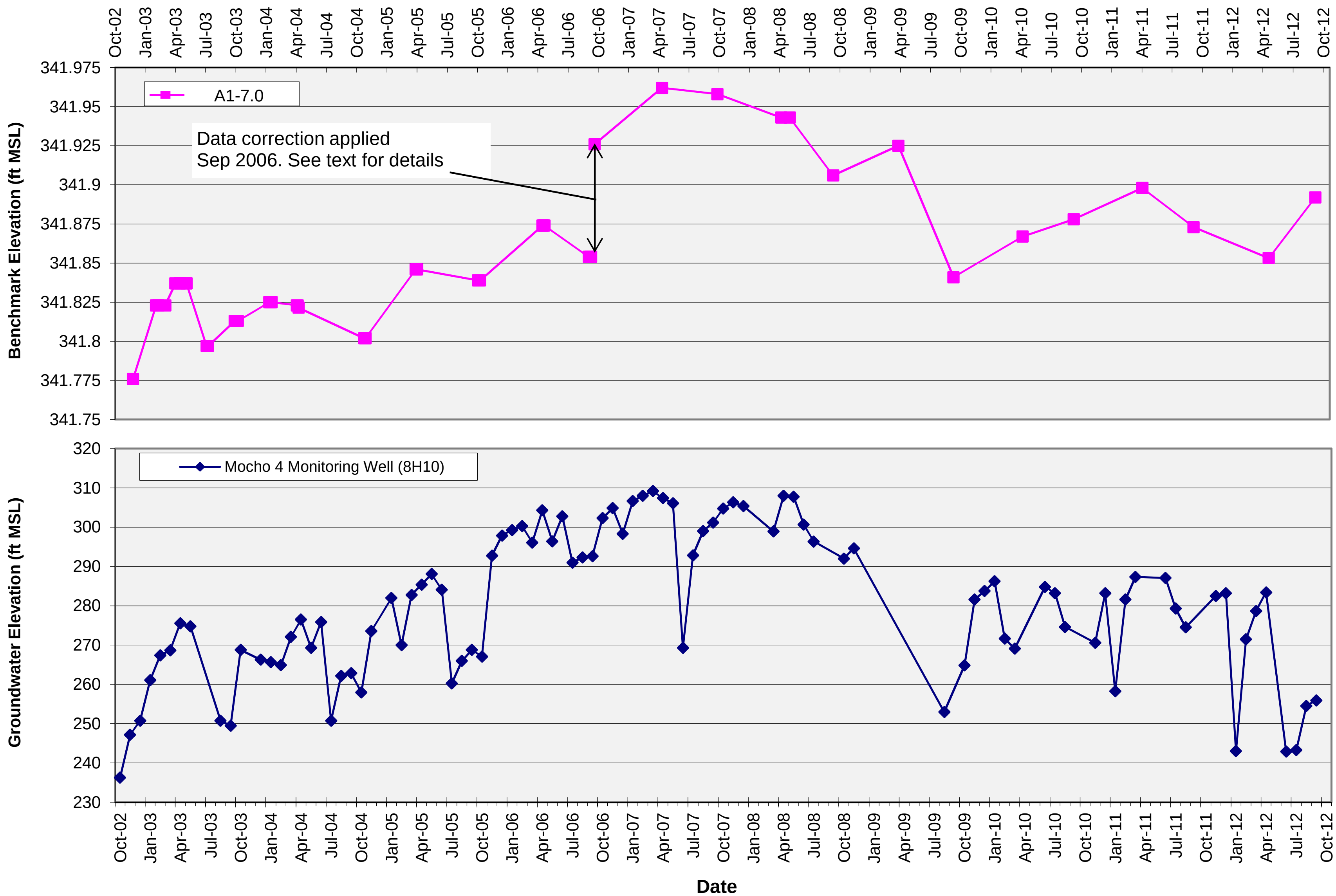
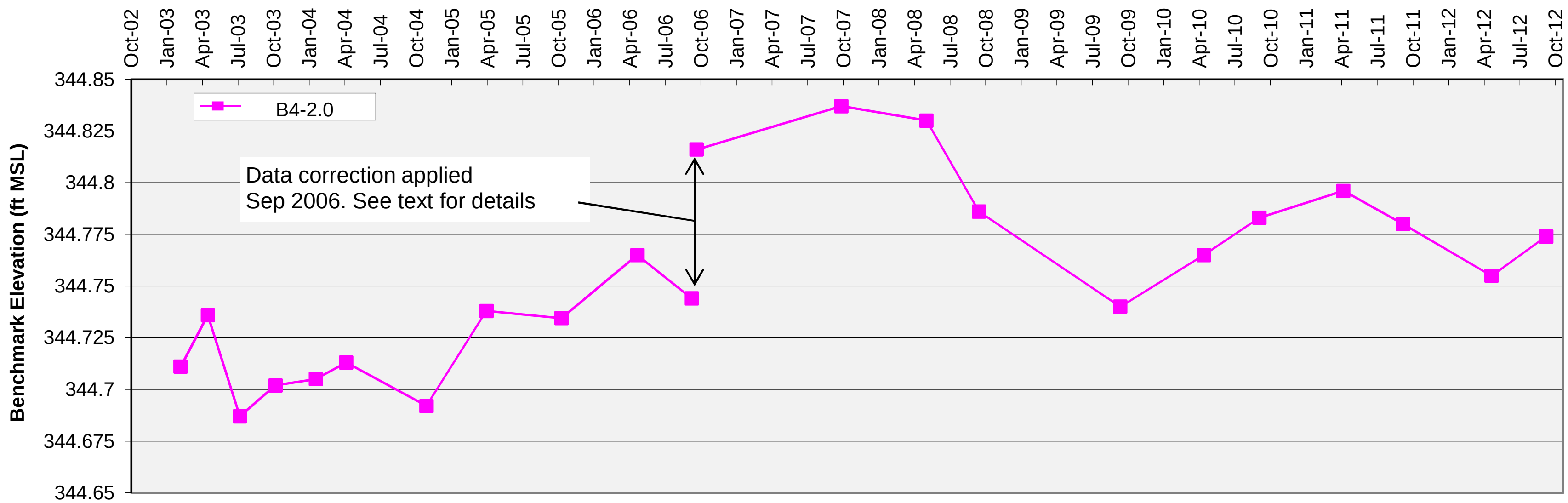
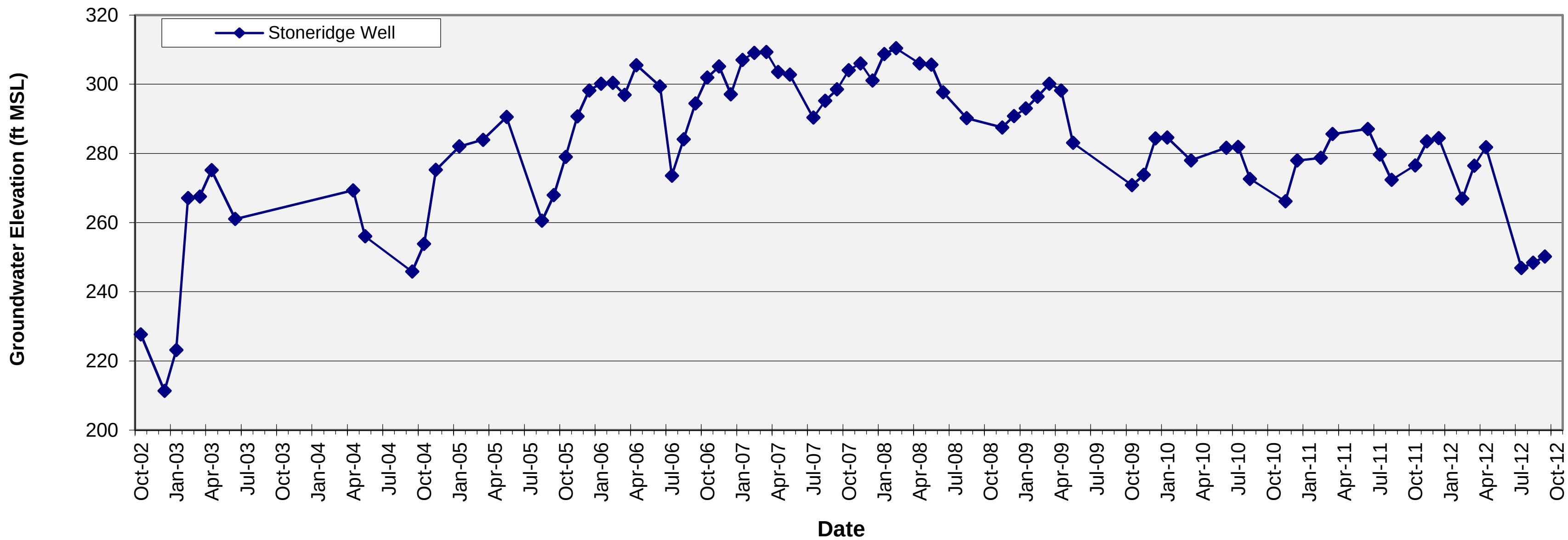
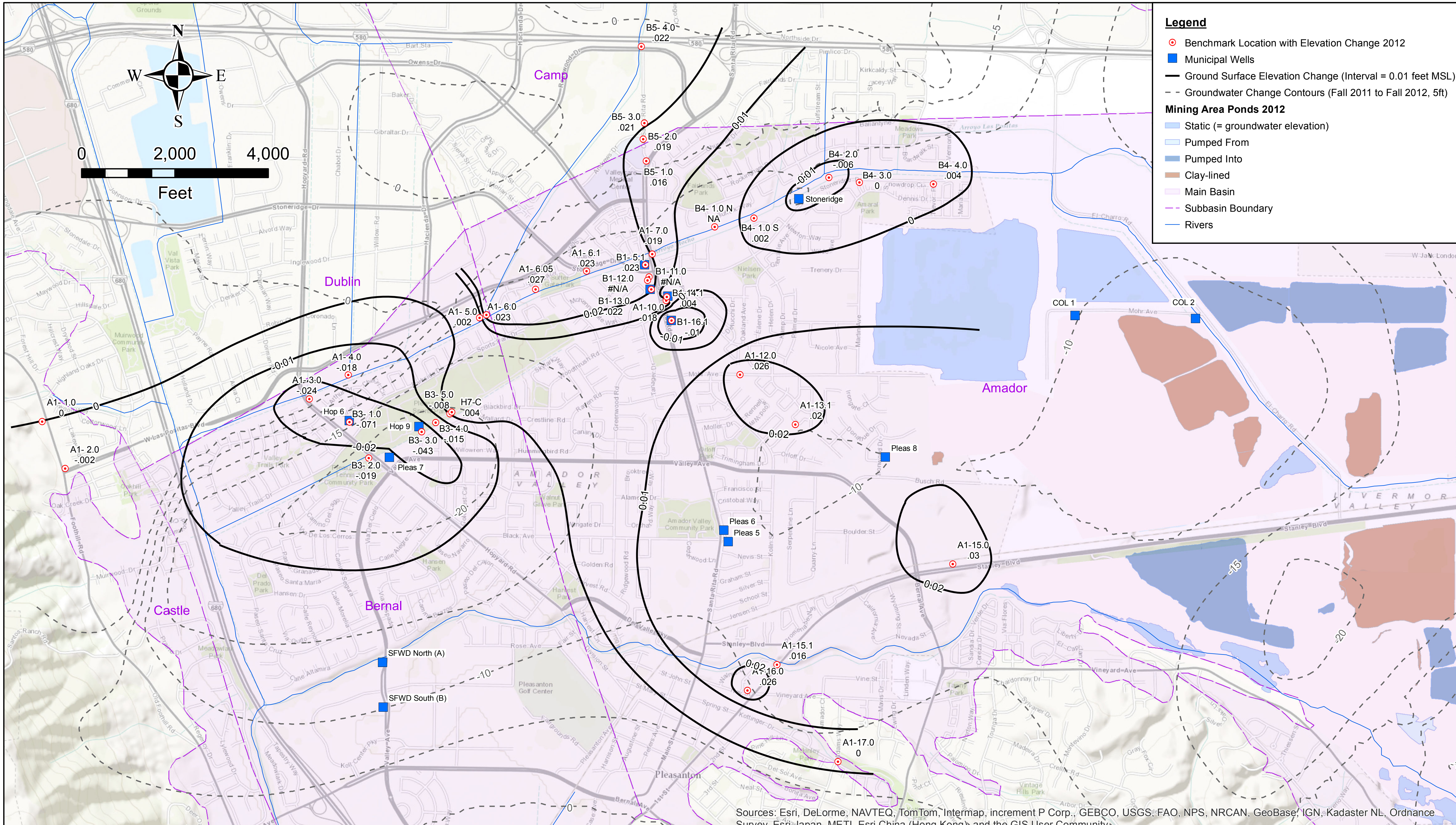


Figure 3.4-6
Graphs of Land Surface Elevation and Groundwater Elevation Versus Time
Amador Subbasin - Stoneridge Well







ZONE 7 WATER AGENCY
100 North Canyons Parkway
Livermore, CA

DRAWN: CW

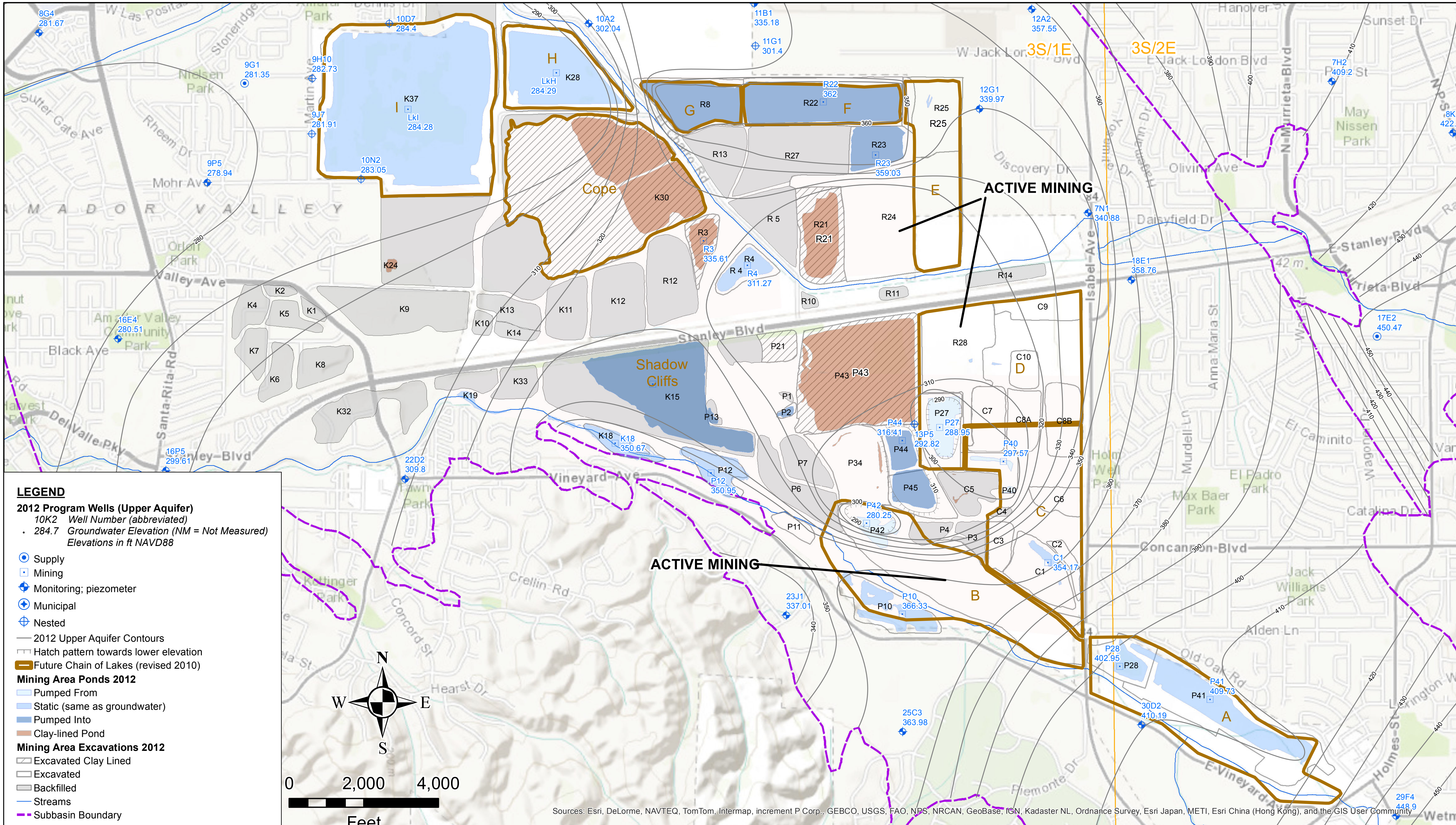
SCALE: 1 in = 2,000 ft

REVIEWED: MK

DATE: March 29, 2013

File: E:\MONITOR\Em\2012WY\Fig3.4-7-EMFall11toFall12.mxd

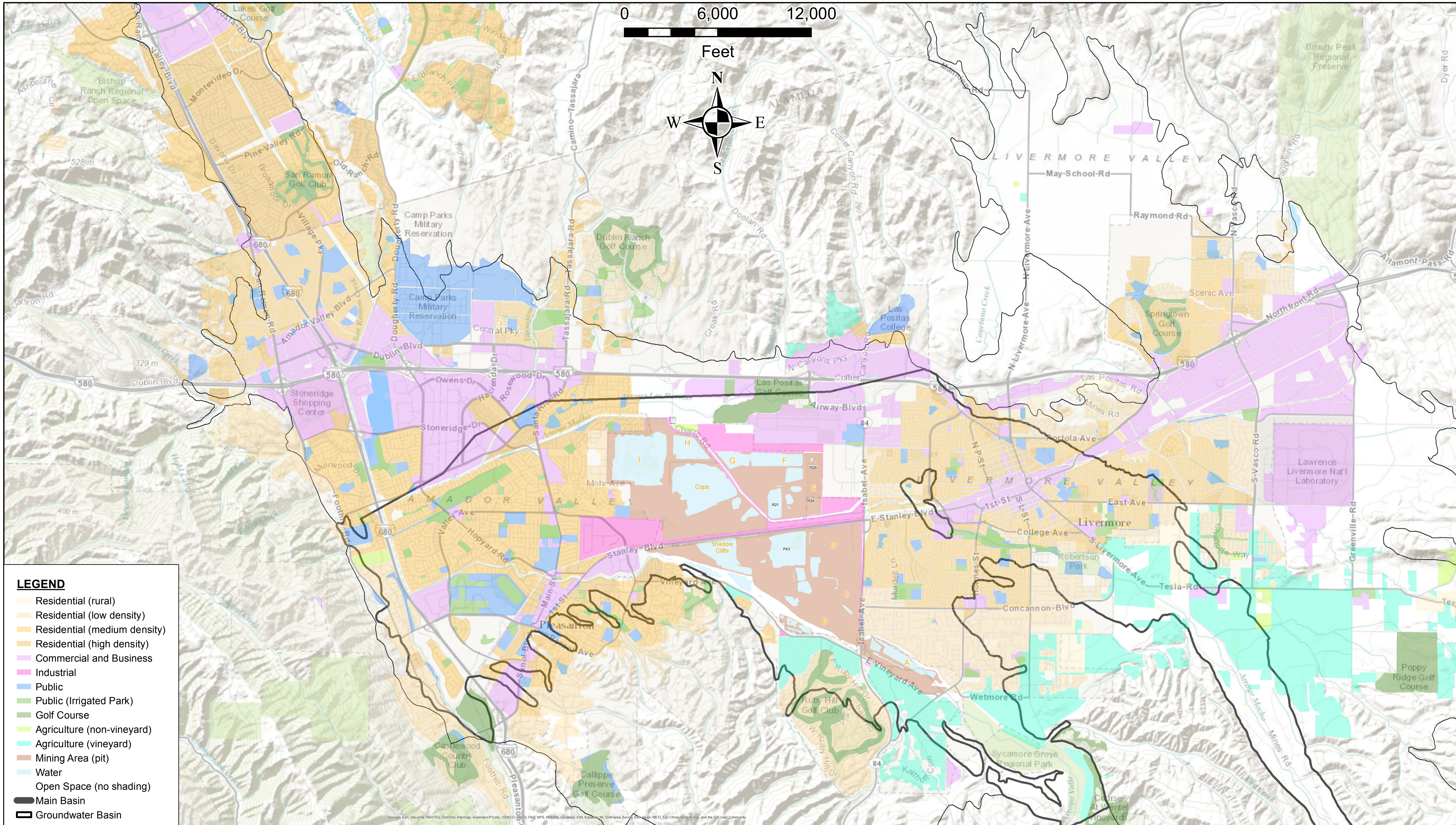
Figure 3.4-7
Ground Surface Elevation Change (ft)
Fall 2011 to Fall 2012
Livermore Valley Groundwater Basin



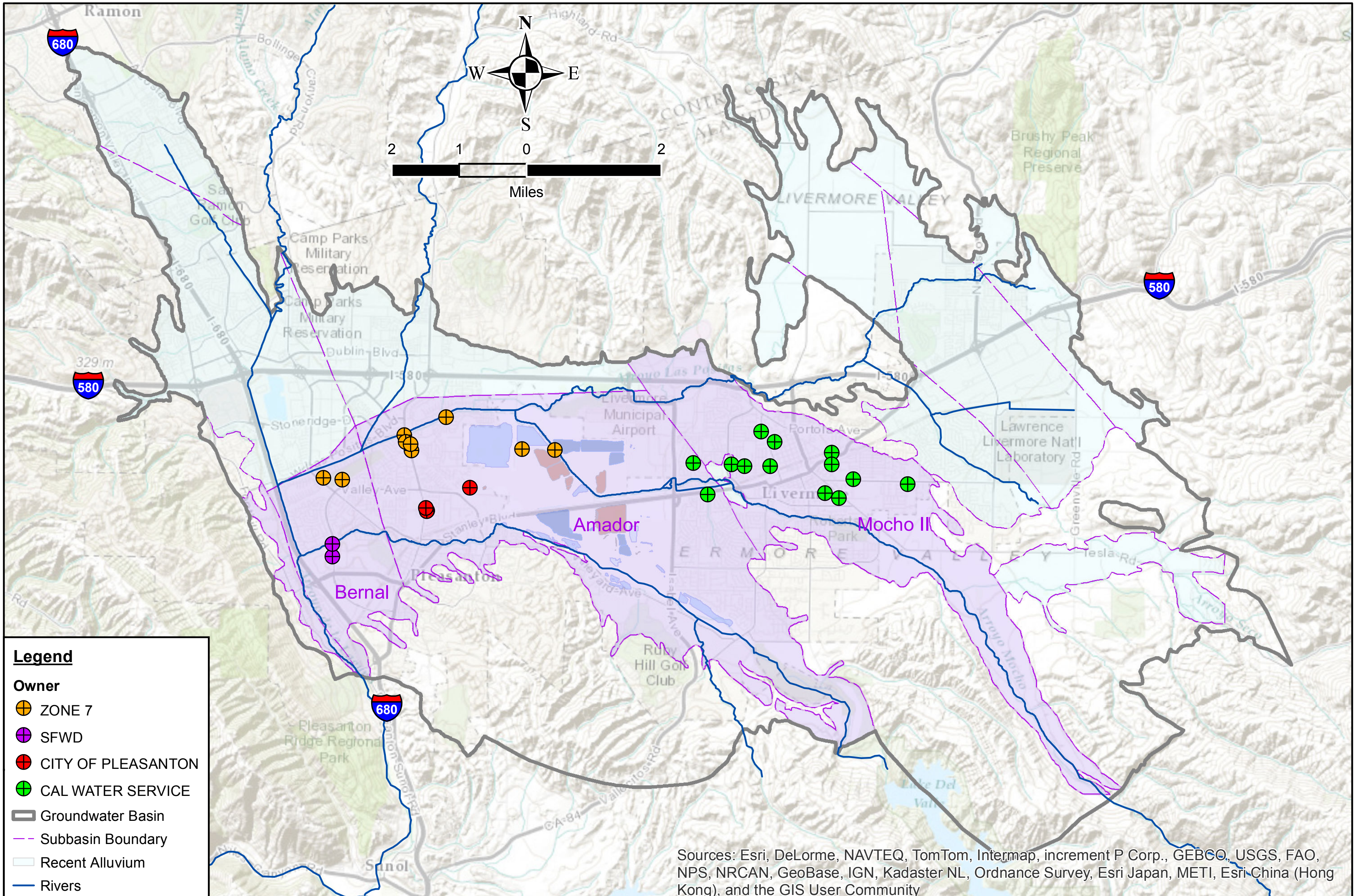
ZONE 7 WATER AGENCY
100 North Canyons Parkway
Livermore, CA

DRAWN: TR/CW	SCALE: 1 in = 2,500 ft
REVIEWED: MK	DATE: March 29, 2013
File: E:\MONITOR\MA\2012WY\Fig3.5-1-MiningArea2012.mxd	

Figure 3.5-1
Location of Gravel Mining Pits
2012 Water Year
Livermore Valley Groundwater Basin



ZONE 7 WATER AGENCY 100 North Canyons Parkway Livermore, CA	DRAWN: TR	SCALE: 1 in = 6,000 ft	**Figure 3.6-1** **Livermore Valley Land Use** **2012 Water Year**
	REVIEWED: MK	DATE: Mar 29, 2013	
	FILE: E:\MONITOR\LU\2012WY\Fig3.6-1-LU2012.mxd		



ZONE 7 WATER AGENCY 100 North Canyons Parkway, Livermore, CA	DRAWN: TR	Scale: 1" = 2 Miles	**Figure 3.7-1** **Locations of Sub-Basins and Municipal Wells**
	REVIEWED: TR	Date: May 2, 2013	
	File: E:\MONITOR\MUNI\2012WY\Fig3.7-1-BasinSubbasins.mxd		