7 Land Surface Elevation

7.1 Program Description

This section describes the details of Zone 7's continued Land Surface Elevation Monitoring Program for the 2014 WY. The Land Surface Elevation Monitoring Program tracks ground surface elevation changes across the groundwater basin to help identify any significant long-term trends.

Land surface may exhibit changes in elevation over time due to several mechanisms such as: 1) regional tectonism; 2) localized shrinking and swelling of expansive soils; and 3) changes in groundwater levels.

The Livermore Valley is in a tectonically active part of the greater SF Bay Area, with the Calaveras fault passing through the western part of the Valley, and the active Mt. Diablo piercement bordering it on the north.

Expansive clayey soils are abundant in the upper 15 feet (and variably, as deep as 50 feet) in the north and central parts of Pleasanton where marshlands existed historically. Surface expressions of the shrinking and swelling of expansive soils would tend to be accentuated where surface and shallow conditions that affect soil moisture change abruptly (e.g., soil type; drainage patterns; impervious surfaces, such as pavement; vegetation; irrigation; and leaking pipes). Surface elevations may also rise and fall in response to groundwater level variations. The magnitude of the rise and fall depends on the thickness and arrangement of each aquifer\aquitard. Normally, changes in surface elevations related to groundwater levels are more regional in nature and cover larger areas as compared to surface elevation changes due to localized shrinking and swelling of expansive soils (e.g. historic subsidence in the Central Valley). When these elevation changes vary within historically observed values, where land surface elevation changes are fully recoverable, it is considered "elastic." Conversely, if a land surface elevation decline is not recoverable, it is considered "inelastic." More detailed description of potential ground movement processes in the Valley is provided in the Ground Movement Study –Livermore Valley, June 10, 2015 (Cal Engineering and Geology, 2015, *Appendix 7-1*).

Responsible groundwater basin management precipitated Zone 7's current Land Surface Elevation Monitoring Program in 2002, and the adoption of the Well Master Plan (WMP) in 2005 (*Zone 7 WMP EIR, 2005*) required continuation of the Land Surface Elevation Monitoring Program. Prior to the current land surface elevation monitoring procedures, Zone 7 conducted a study of historical benchmark elevation data throughout the western subbasins and concluded that there was no evidence of significant inelastic subsidence in the Valley up to that point in time. This was the technical basis for Zone 7 to use the historical low groundwater levels as a conservative operating guide to avoid inelastic land surface elevation changes. Otherwise, a detailed geologic study of the aquifers\aquitard arrangement for the Valley would have to be

performed to estimate the potential of inelastic land surface change if groundwater levels are lowered below the historic low groundwater levels.

The Land Surface Elevation Monitoring Program involves conducting high precision spirit level surveys across the Bernal and Amador Subbasins; starting and ending at stable bedrock elevation stations (A1-1.0 and A1-17.0) and passing through or near Zone 7 and City of Pleasanton wellfields (*Figure 7-1*). From this main circuit, several looped or branched circuits are also surveyed in the same manner to assess ground surface elevation changes within other Zone 7 wellfields (Circuits B1, B3 and B4) and across the northern Main Basin boundary (Circuit B5).

Circuit B4, which was originally created to monitor elevation changes near Stoneridge Well No. 1, was extended in 2013 to incorporate the Chain of Lakes wellfield into the monitoring program. Elevations and vertical distances between certain wellhead features, such as concrete pads, floors, pedestals, casing flanges and water level reference points are also monitored for change. The normal monitoring frequency is twice per year for Circuits A1, B1, B3 and B4 and the wellhead features, corresponding with the semi-annual groundwater level monitoring events (spring and fall), and only during the fall event for Circuit B5.

The 2014 WY program involved surveying elevations of about 35 benchmarks in four circuits (A1, B1, B3 and B4), as well as the wellhead features mentioned above (*Section 5.2*). Circuit B5 was surveyed once, during the fall. *Figure 7-2* contains a list of all land surface elevation monitoring locations for the 2014 WY program. These wellhead features, labeled with a suffix of "-Diff", were measured monthly to create a more extensive record. Kier & Wright Civil Engineers and Surveyors, Inc., of Livermore, California, performed the surveys of the circuit benchmarks, while Zone 7 staff surveyed the additional wellhead features.

7.2 2014 Results

Figure 7-3 contains the survey results for the 2014 WY and reports the seasonal and annual elevation changes between the Fall 2013 and Fall 2014 surveys. The spatial distribution of the changes in land surface elevations observed from Fall 2013 to Fall 2014 is shown on *Figure 7-4*.

The net elevation changes observed semiannually since 2002 at select benchmarks within and adjacent to major wellfields are graphed along with groundwater elevations from near-by monitoring wells on *Figure 7-5* (Hopyard), *Figure 7-6* (Mocho), *Figure 7-7* (Stoneridge), and *Figure 7-8* (Chain of Lakes) and *Figure 7-9* (Busch-Valley). Similar time series results for benchmarks along Las Positas Boulevard and Santa Rita Road are shown in *Figure 7-10* and *Figure 7-11*.

N W E S

0 2,000 4,000

Feet

Dublin

Camp

Stoneridge

Pleas 8

Hopyard 6

Dublin Uplands

Sinbad Uplands

Castle

Bernal

Amador

Pleas 6

Pleas 5

Pleas 7

Livermore Uplands

Pleasanton

B5- 4.0
B5- 3.0
B5- 2.0
B5- 1.0
B4- 2.0
B4- 3.0
B4- 4.0
B4- 5.0
B4- 1.0 N
B4- 1.0 S
COL 5
COL 1
COL 2
10K2
B4- 6.0
B4- 7.0
A1- 7.0
A1- 6.1
A1- 6.05
A1- 5.0
A1- 6.0
Mocho 4
See INSET
8H10
B1-11.0
B1-12.0
B1-13.0
B1-14.1
A1-10.0
B1-16.2
Mocho 2
A1-12.0
9P10
A1-13.0
A1-13.1
A1-14.1
A1-15.0
A1-15.1
A1-16.0
A1-17.0
A1- 4.0
A1- 3.0
A1- 1.0
A1- 2.0
B3- 5.1
17D5
B3- 1.0
B3- 4.0
B3- 2.0
SFWD North (A)
SFWD South (B)

400 200 0 400

Feet

INSET
Detailed View

A1- 7.0
8H10
B1- 5.1
Mocho 4
B1-11.0
B1-12.0
Mocho 3
B1-13.0
Mocho 1
B1-14.1
A1-10.0
Mocho 2
B1-16.1

LEGEND

- Benchmark Locations 2014 (A1 Circuit in Yellow)
- Municipal Wells

Groundwater Wells

- Supply, Lower
- Monitoring, Lower
- Municipal, Lower
- Nested, Lower
- Main Basin
- Subbasin Boundary
- Mining Area Pond

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
REVIEWED: TR	DATE: July 8, 2015
FILE: E:\MONITOR\Em\2014WY\Fig07-01-EMStations14.mxd	

Figure 7-1
2014 Benchmark Locations
Land Surface Elevation Monitoring Program
Livermore Valley Groundwater Basin

FIGURE 7-2
SURVEY POINTS AND DESCRIPTIONS
2014 WATER YEAR

Sites Surveyed 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- 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	
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
B4- 3.0		GUZMAN PKWY	
B4- 4.0		Trevor Pkwy at Stoneridge	
B4- 5.0		El Charro at Arroyo Mocho	
B4- 6.0	3S/1E 11M 3	Chain of Lakes 2	
B4- 7.0	3S/1E 10K 3	Chain of Lakes 1	
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)

Additional Wellhead Features Monitored by Zone 7

Site ID	Well Id	Survey Points	Description
COL1-Diff	3S/1E 10K 3	Chain of Lakes 1, Pedestal	COL1 pedestal to ground difference
COL2-Diff	3S/1E 11M 3	Chain of Lakes 2, Pedestal	COL2 pedestal to ground difference
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
A1 Circuit*	Semi-annually
B1 Mocho loop	Semi-annually
B3 Hopyard wells loop	Semi-annually
B4 Stoneridge well loop	Semi-annually
B5 Tassajara - Rosewood	Annually
Municipal Wells	As needed

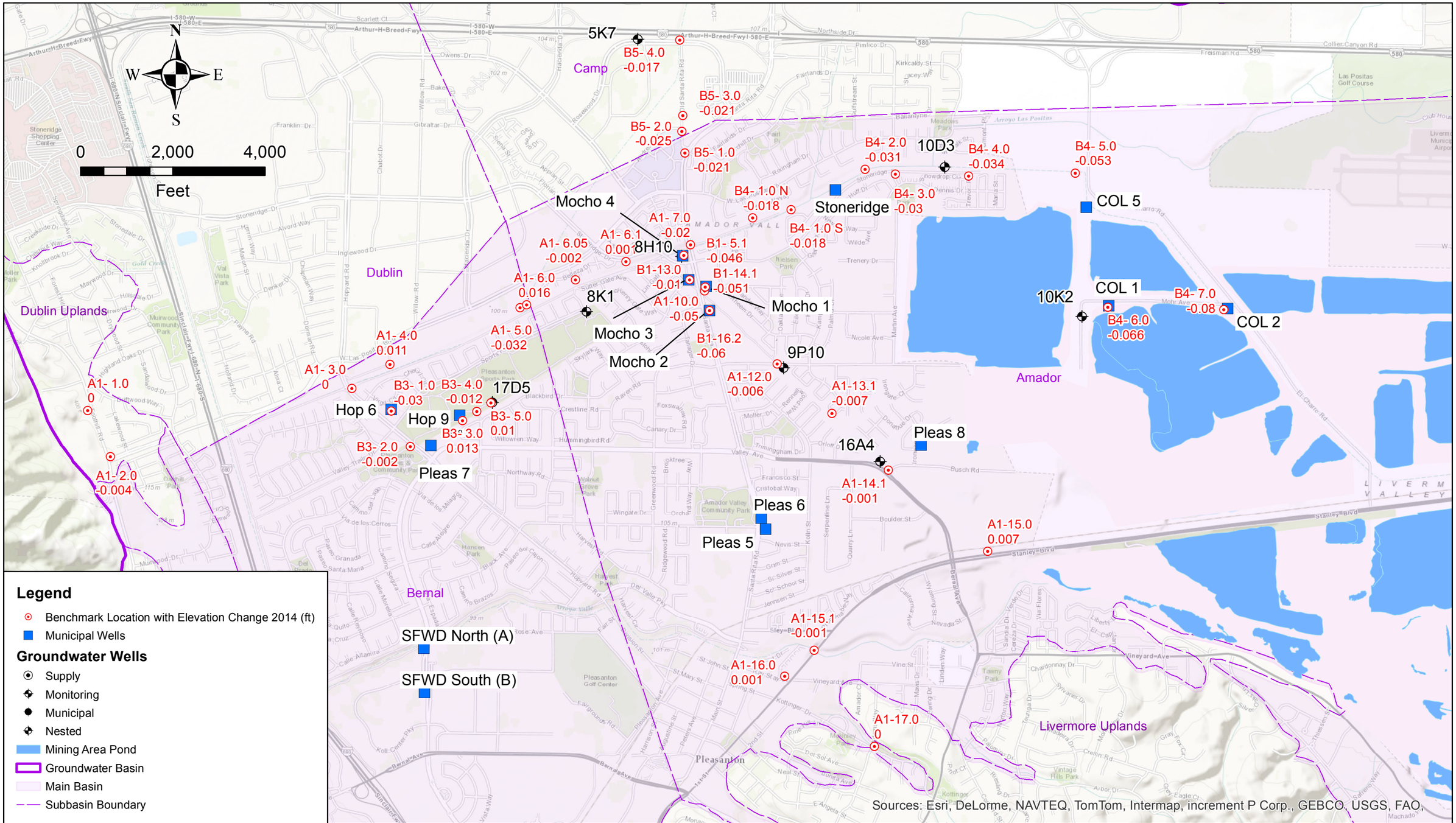
Legend

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

FIGURE 7-3
KIER AND WRIGHT SURVEY MEASUREMENTS
2014 WATER YEAR

Site	Site Description	Fall 2013 (Oct 8 & 10) Elevation in ft NAVD88	Spring 2014 (Apr 14-21) Elevation in ft NAVD88	Fall 2014 (Sep 19) Elevation in ft NAVD88	Change in Elevation (ft)		
					Seasonal		Annual
					Fall 13 to Spring 14	Spring 14 to Fall 14	Fall 13 to Fall 14
A1- 1.0	G972*	365.705	365.705	365.705	0.000	0.000	0.000
A1- 2.0	Foothill and Las Positas	405.461	405.443	405.457	-0.018	0.014	-0.004
A1- 3.0	C972	330.538	330.530	330.538	-0.008	0.008	0.000
A1- 4.0	Arroyo Mocho at Chabot Crk	323.985	323.980	323.996	-0.005	0.016	0.011
A1- 5.0	Arroyo Mocho at Tassajara Crk West	327.055	327.041	327.023	-0.014	-0.018	-0.032
A1- 6.0	Arroyo Mocho at Tassajara Crk East	327.729	327.721	327.745	-0.008	0.024	0.016
A1- 6.05	Arroyo Mocho at Flora Ct	329.310	329.303	329.308	-0.007	0.005	-0.002
A1- 6.1	Arroyo Mocho Pleasanton Control	332.586	332.613	332.587	0.027	-0.026	0.001
A1- 7.0	M1257	341.826	341.852	341.806	0.026	-0.046	-0.020
A1-10.0	Vineyard Pipeline at Santa Rita Rd	340.847	340.869	340.797	0.022	-0.072	-0.050
A1-12.0	Mohr Ave at Iron Horse	347.466	347.493	347.460	0.027	-0.033	-0.006
A1-13.1	COP RE 25281	349.927	349.962	349.920	0.035	-0.042	-0.007
A1-14.1	Busch and Valley	356.819	356.850	356.818	0.031	-0.032	-0.001
A1-15.0	D8	366.969	366.998	366.976	0.029	-0.022	0.007
A1-15.1	BM-P929 Reset	361.452	361.480	361.451	0.028	-0.029	-0.001
A1-16.0	V1	367.004	367.023	367.005	0.019	-0.018	0.001
A1-17.0	K2*	399.808	399.808	399.808	0.000	0.000	0.000
B1- 5.1	Mocho 4	336.632	336.641	336.586	0.009	-0.055	-0.046
B1-13.0	3S/1E 9M 4	336.405	336.429	336.395	0.024	-0.034	-0.010
B1-14.1	3S-1E 9M 2 New	340.935	340.966	340.884	0.031	-0.082	-0.051
B1-16.2	B1-16.2	341.534	341.559	341.474	0.025	-0.085	-0.060
B3- 1.0	MOCHO-PARK	323.035	323.042	323.005	0.007	-0.037	-0.030
B3- 2.0	1H ALA	320.553	320.536	320.551	-0.017	0.015	-0.002
B3- 3.0	HOP9-BM	321.536	321.569	321.549	0.033	-0.020	0.013
B3- 4.0	PLEASANTON CANAL	323.580	323.564	323.568	-0.016	0.004	-0.012
B3- 5.0	HOP7 MP1	322.543	322.530	322.553	-0.013	0.023	0.010
H7-C	Hop7 Casing	324.864	324.854	324.881	-0.010	0.027	0.017
B4- 1.0 S	AMP-CTL S	322.001	322.022	321.983	0.021	-0.039	-0.018
B4- 1.0 N	AMP-CTL N	322.141	322.162	322.123	0.021	-0.039	-0.018
B4- 2.0	Stoneridge Wellhouse	344.734	344.750	344.703	0.016	-0.047	-0.031
B4- 3.0	GUZMAN PKWY	343.842	343.852	343.812	0.010	-0.040	-0.030
B4- 4.0	Trevor Pkwy at Stoneridge	346.454	346.457	346.420	0.003	-0.037	-0.034
B4- 5.0	El Charro at Arroyo Mocho	357.580	357.574	357.527	-0.006	-0.047	-0.053
B4- 6.0	Chain of Lakes 2	363.863	363.855	363.797	-0.008	-0.058	-0.066
B4- 7.0	Chain of Lakes 1	358.285	358.230	358.205	-0.055	-0.025	-0.080
B5- 1.0	OSRR-BC	343.937	NA	343.916	NA	NA	-0.021
B5- 2.0	OSRR-ANDREW	343.012	NA	342.987	NA	NA	-0.025
B5- 3.0	OSRR-CAFÉ	344.451	NA	344.430	NA	NA	-0.021
B5- 4.0	Tass-Rose	349.585	NA	349.568	NA	NA	-0.017

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



Legend

- Benchmark Location with Elevation Change 2014 (ft)
- Municipal Wells

Groundwater Wells

- Supply
- Monitoring
- Municipal
- Nested
- Mining Area Pond
- Groundwater Basin
- Main Basin
- Subbasin Boundary

ZONE 7 WATER AGENCY
100 North Canyons Parkway
Livermore, CA

DRAWN: CW
SCALE: 1 in = 2,000 ft
REVIEWED: TR/MK
DATE: July 13, 2015
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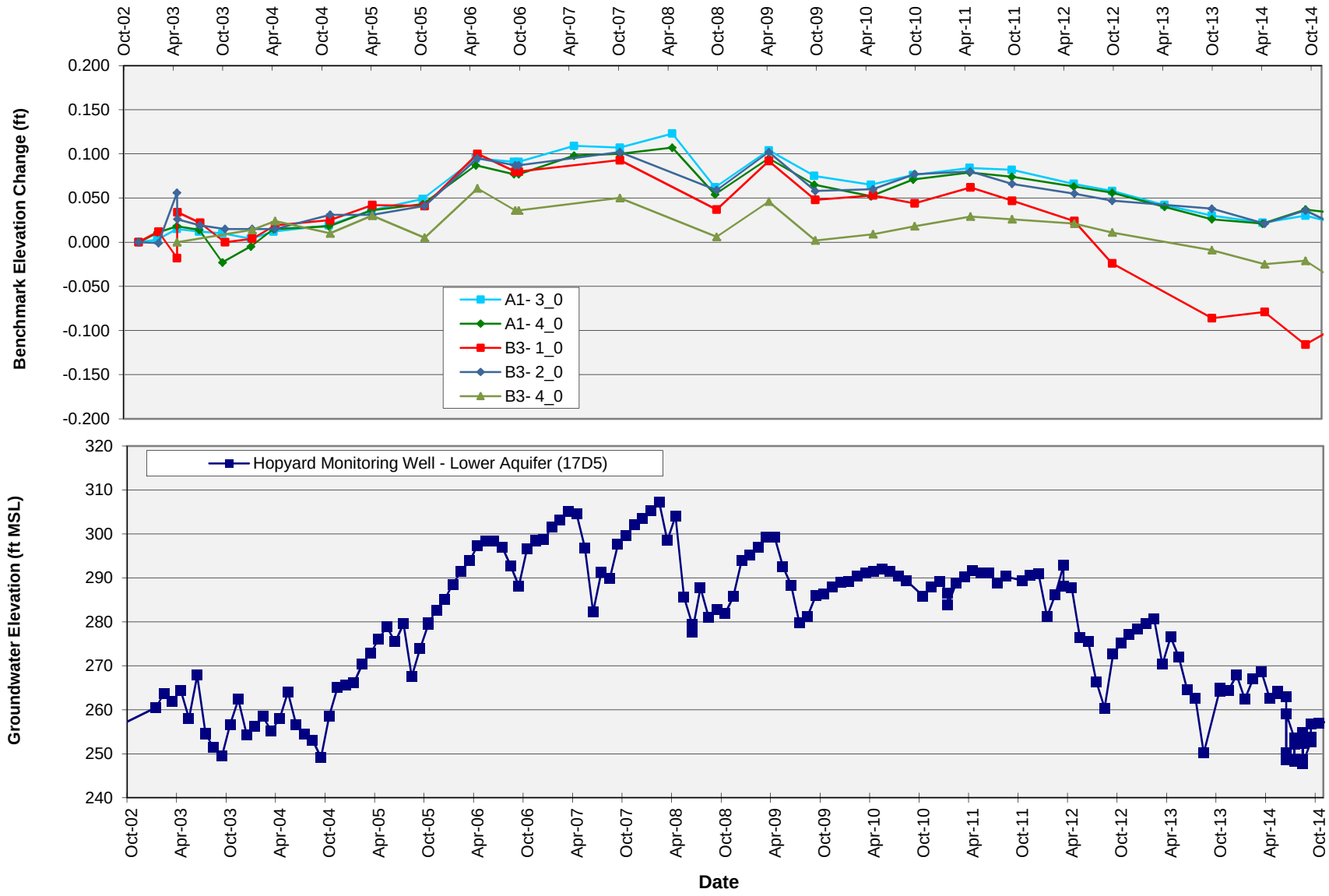
Figure 7-4
Ground Surface Elevation Change (ft)
Fall 2013 to Fall 2014
Livermore Valley Groundwater Basin

FIGURE 7-5
NET LAND SURFACE ELEVATION CHANGES
HOPYARD WELLFIELD



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7/30/2015

FIGURE 7-6
NET LAND SURFACE ELEVATION CHANGES
MOCHO WELLFIELD

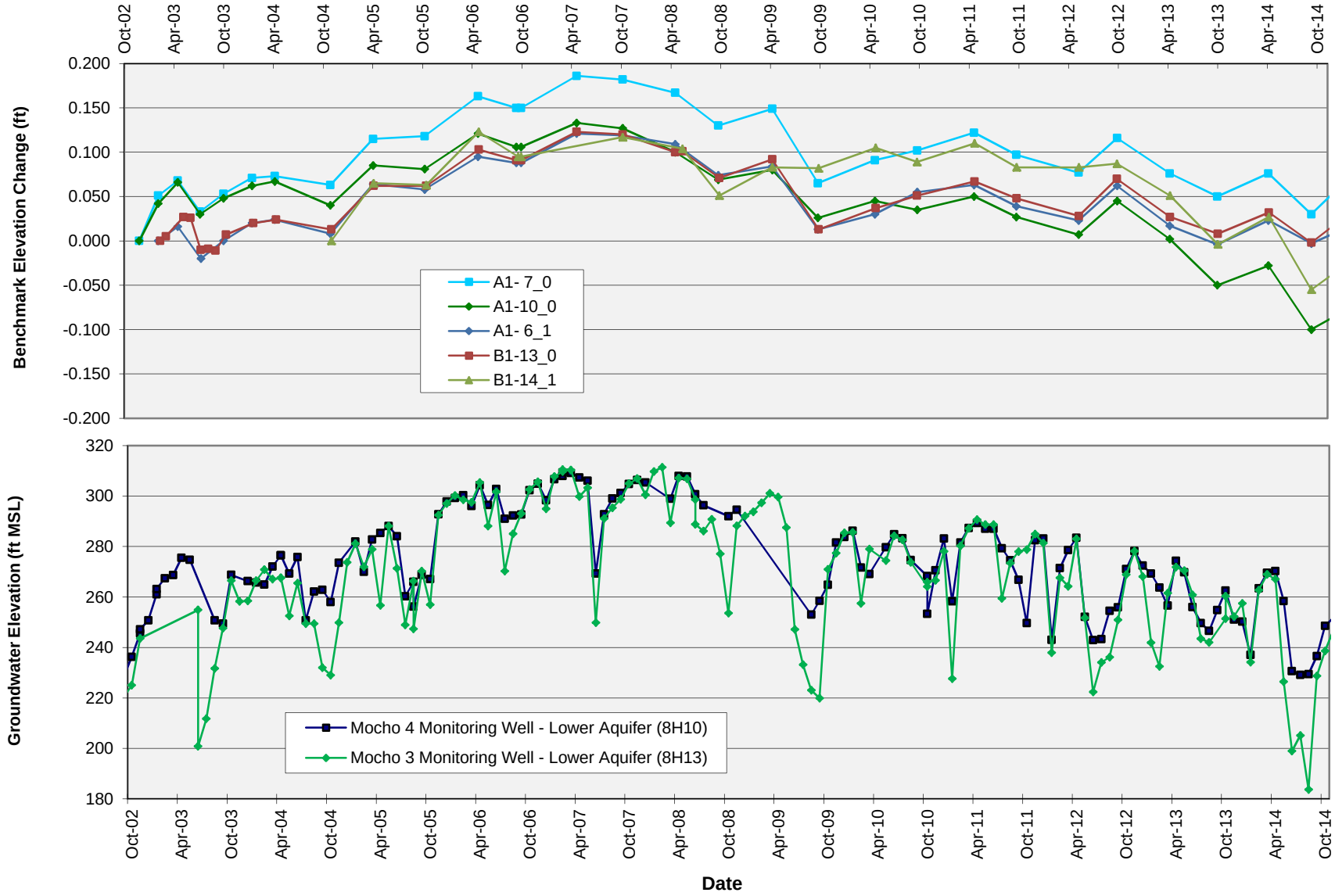

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FIGURE 7-7
NET LAND SURFACE ELEVATION CHANGES
STONERIDGE WELL

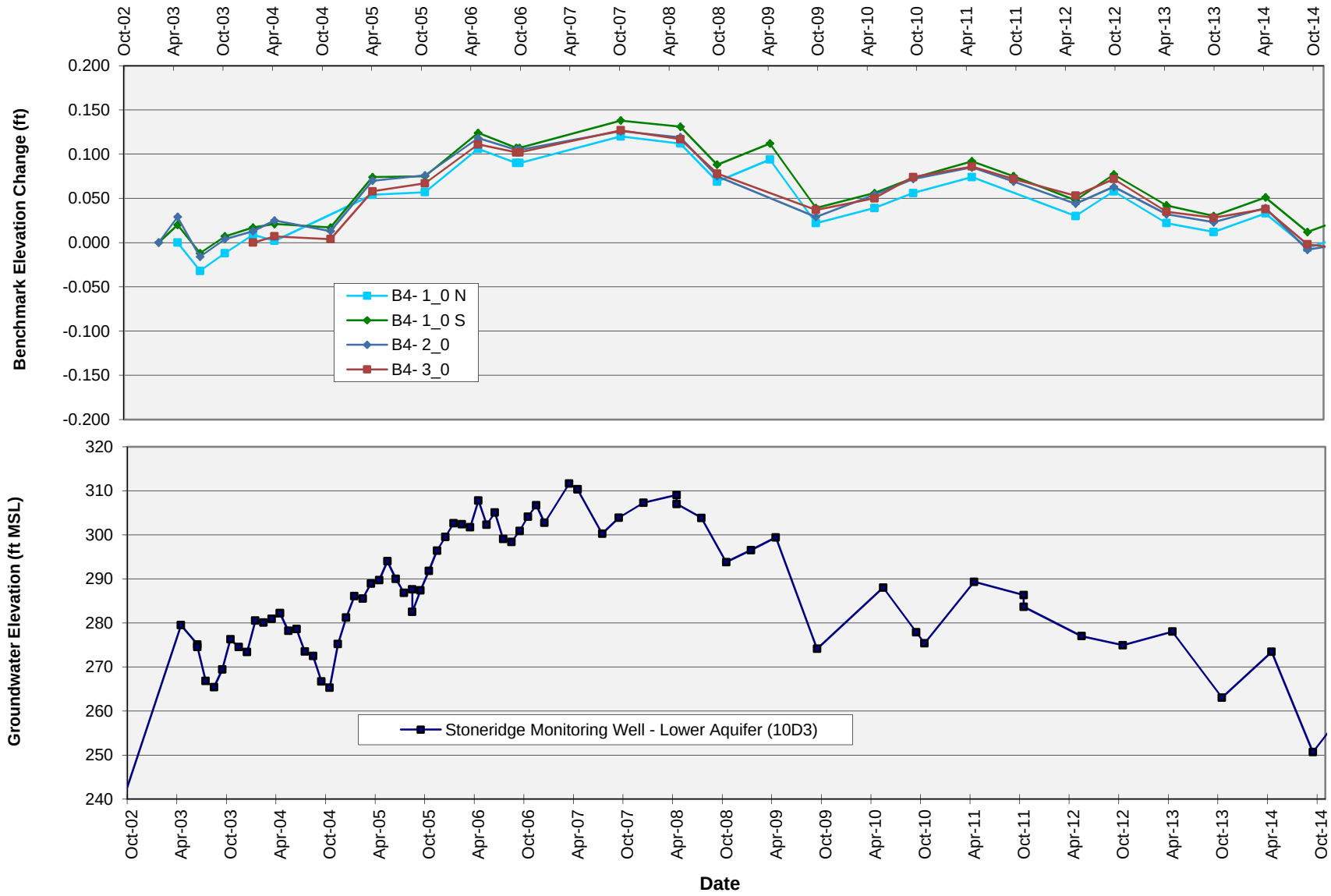

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FIGURE 7-8
NET LAND SURFACE ELEVATION CHANGES
CHAIN OF LAKES WELLFIELD

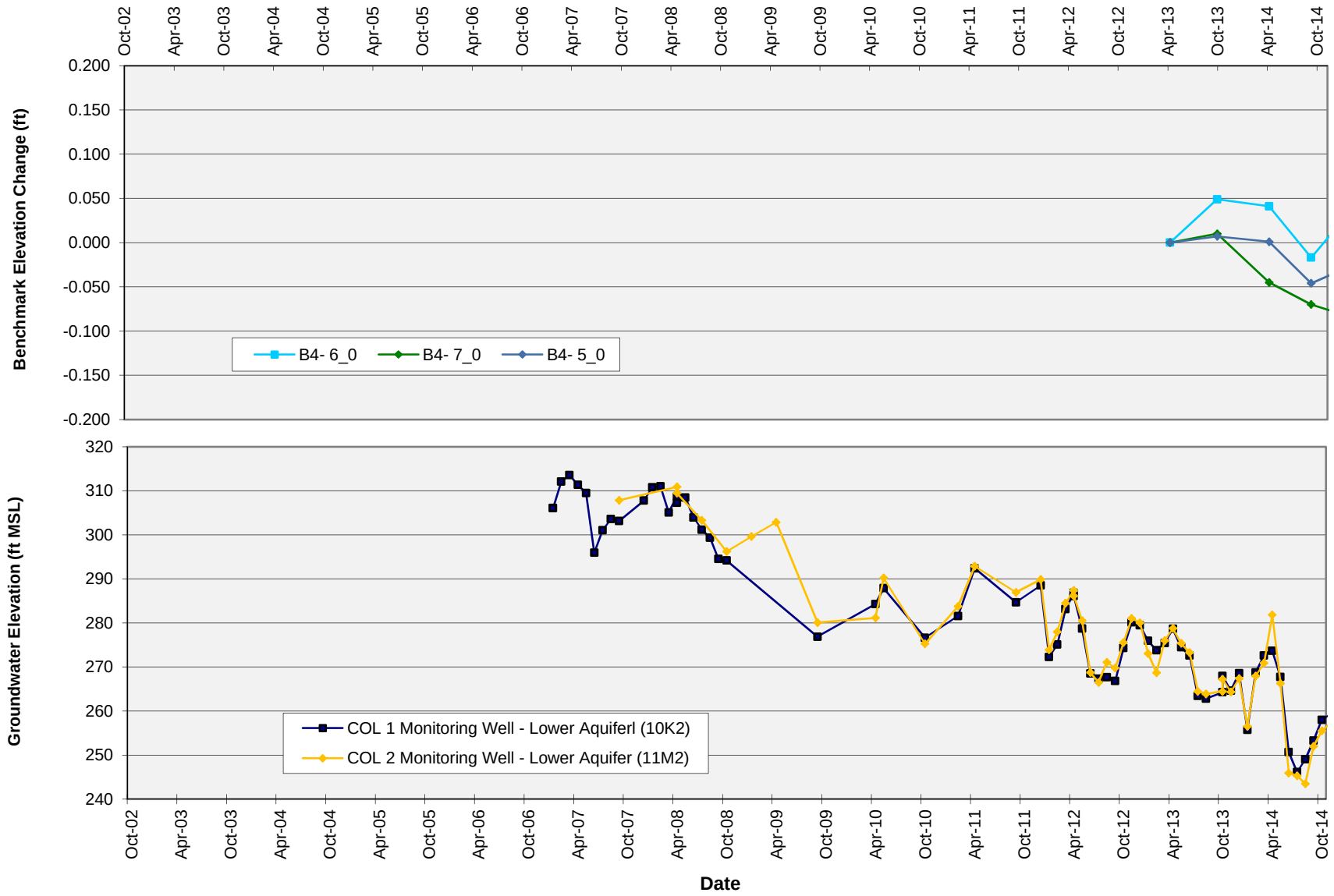

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FIGURE 7-9
NET LAND SURFACE ELEVATION CHANGES
BUSCH VALLEY WELL

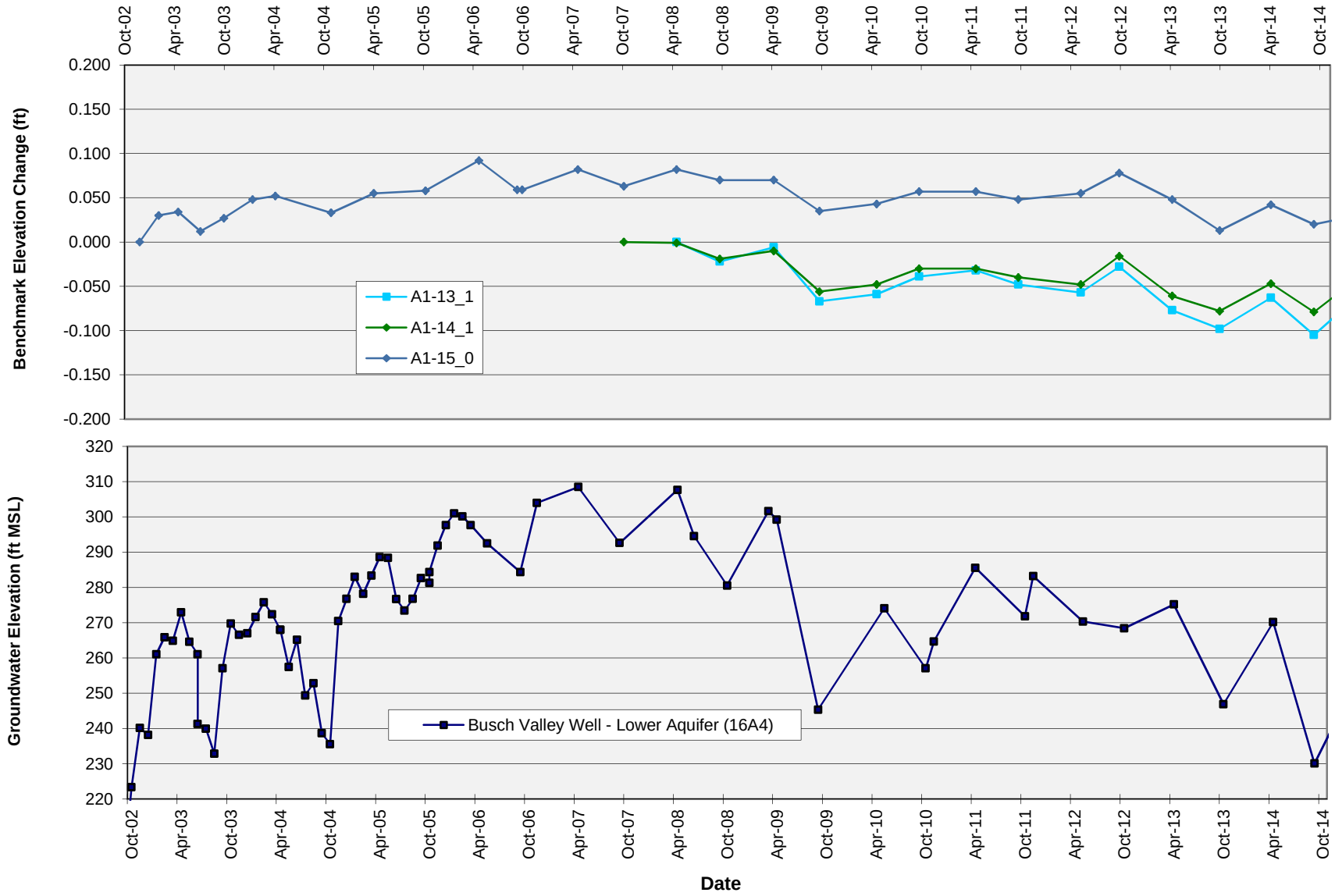

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FIGURE 7-10
NET LAND SURFACE ELEVATION CHANGES
LAS POSITAS AVENUE

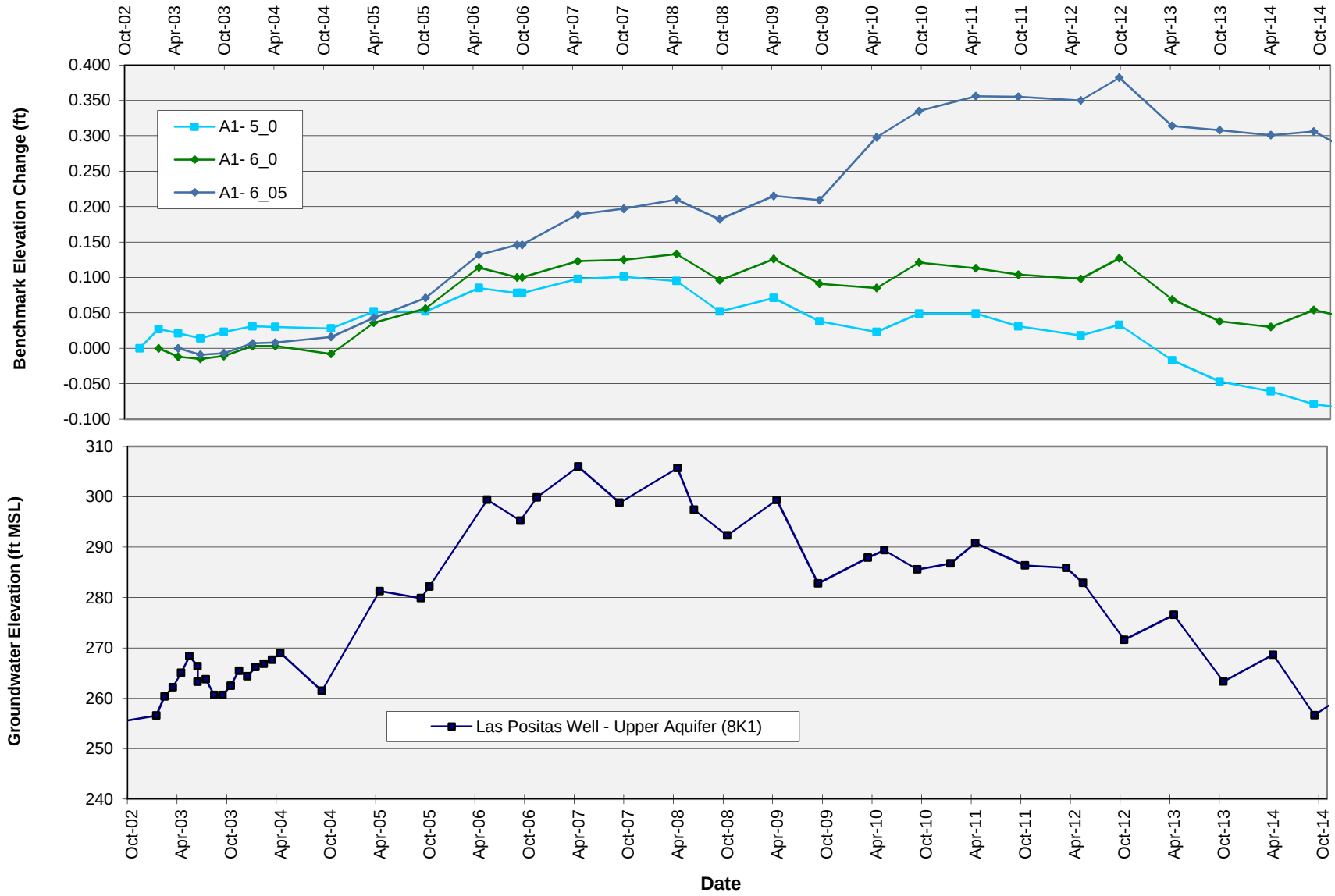

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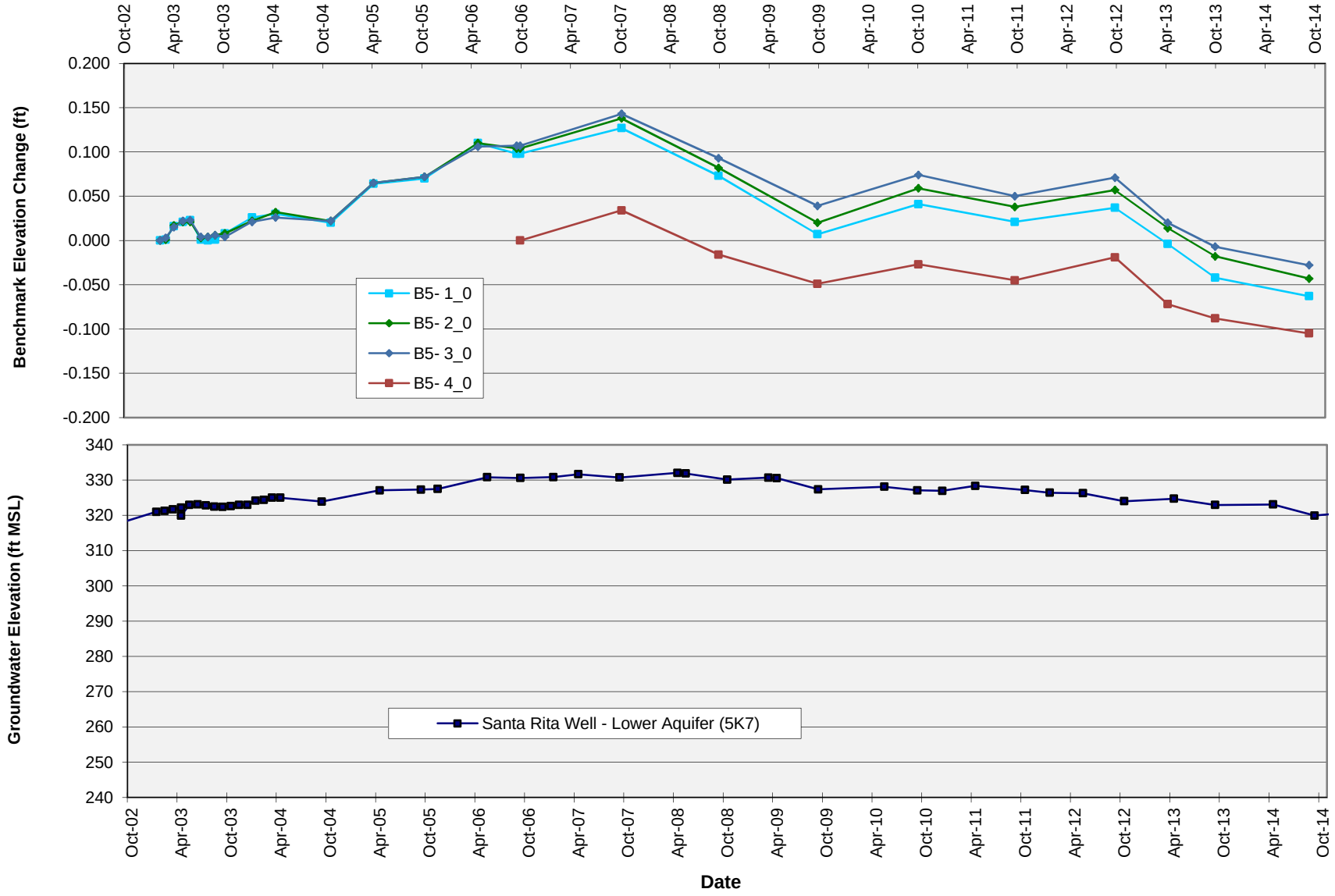
FIGURE 7-11
NET LAND SURFACE ELEVATION CHANGES
SANTA RITA AVENUE



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