November 24, 2015

TO: LOCSD Board of Directors

FROM: Robert Miller, District Engineer

SUBJECT: **Agenda Item 12A – 12/3/2015 Board Meeting**
October 2015 Seawater Intrusion Monitoring Report

DESCRIPTION

Cleath Harris Geologists (CHG) recently completed a draft report summarizing the findings of a semi-annual lower aquifer monitoring event. During the October, 2015 monitoring event, data was collected from the lower aquifer for both water levels and water quality.

SUMMARY OF STAFF RECOMMENDATION

Staff recommends that the Board receive the draft report and provide any comments or questions.

DISCUSSION

Lower aquifer groundwater monitoring in the Los Osos groundwater basin was performed by CHG in October, 2015. The purpose of groundwater monitoring is to collect and organize groundwater data on a periodic basis for use in management of the basin, including the evaluation of seawater intrusion. A total of 30 lower aquifer wells were included in the monitoring event. The draft report is included for review by the Board and public. Key findings from the report are as follows:

1. The water level and chloride metrics improved compared to April, 2015.
2. Chlorides at the District's Palisades Well increased to 104 mg/l, compared to 90 mg/l in July, 2014 and 43 mg/l in April, 2015.
3. The District's Water Shortage Contingency Plan includes a chloride trigger for the District's 8th and 10th Street Wells. The Stage III trigger for chloride was previously set at 150 mg/l. Chloride levels in the 8th and 10th Street Wells were measured and determined to be 91 mg/l and 31 mg/l, respectively. These values remain essentially unchanged from July, 2014, and slightly lower compared to April, 2015.

Staff will be available to answer questions, and feedback will be conveyed to CHG so that the draft report can be finalized.

FINANCIAL IMPACT

No financial impacts are anticipated. It should be noted that the District previously committed to paying its pro rata share of monitoring costs.

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Technical Memorandum

Date: November 19, 2015

From: Spencer Harris, HG 633

To: Los Osos ISJ Group

SUBJECT: October 2015 Lower Aquifer Monitoring, Los Osos Groundwater Basin.

Lower aquifer groundwater monitoring in the Los Osos groundwater basin was performed by Cleath-Harris Geologists (CHG) in October 2015. The purpose of groundwater monitoring is to collect and organize groundwater data on a regular basis for use in management of the basin, including the evaluation and mitigation of seawater intrusion.

Lower Aquifer Monitoring Program

Table 21 of the Updated Basin Plan (attached) lists 30 lower aquifer wells in the monitoring network, of which 20 are owned by the ISJ Parties (County of San Luis Obispo, S&T Mutual Water Company, Los Osos Community Services District and Golden State Water Company). Monitoring tasks are also listed in the attached Table 21 (with a few adjustments specific to seawater intrusion monitoring). Basin Plan monitoring network wells and tasks are shown in the attached Figure 1.

Monitoring Results

Water levels for monitoring program wells are presented in the attached Table 1. The analytical results of groundwater samples collected from basin wells are presented in the attached Table 2, including the results of prior groundwater monitoring events. Chloride concentrations at lower aquifer monitoring wells are shown in the attached Figure 1.

Chloride Metric

The chloride metric had been rising at a rate of close to 7 mg/l per year since 1995, but did not increase between April and October 2015. The metric is currently 188.2 mg/l (slightly lower than the April 2015 value of 190.4 mg/l). Figure 2 shows the updated chloride metric.

Chloride measurements at the key metric wells were available approximately every five years through August 2014, and have been monitored semi-annually since then. The current short-term stabilization of the chloride metric may be a delayed response to the water conservation efforts and lower purveyor groundwater production over the last several years, which has also resulted in a rising water level metric. Additional monitoring events will be needed to confirm this.

The LOCSD Palisades well was removed as a key metric well following its modification in 2013 due to the resulting decline in chloride concentrations. Since modification, the chloride concentrations at Palisades representing Zone D have increased from 91 mg/l in July 2014 to 104 mg/l in October 2015, therefore, continued movement of the seawater intrusion front in Zone D toward Palisades is inferred. Historical chloride concentrations in Zone D and Zone E at the Palisades well have been calculated using the information obtained during well modification (see Figure 1), which would enable the well to be reinserted into the chloride metric. Only two representative post-modification data sets are available for Zone D, due to the upper aquifer influence from borehole leakage during the April 2015 monitoring event (the well had been out of service for several months). Additional monitoring data would be recommended prior to reinstating LOCSD Palisades well back into the chloride metric.

Water Level Metric

After historical declines in the water level metric during the 1970's and 1980's, there was a brief recovery in the late 1990's with stabilization of the metric at sea level between 2000 and 2010. Since 2010, the water level metric has been rising at a rate of 0.4 feet per year through 2015. Given the exceptional drought conditions, a rise in lower aquifer water levels at the key metric wells is interpreted to be due to reduced purveyor production. Figure 2 shows the updated water level metric, which is based on spring water levels.

Geophysics

Induction and natural gamma logs were performed at deep monitoring wells 13M1 (Sea Pines golf course) and 18L6 (north end of Palisades Avenue). The log at 13M1 indicates the top of seawater in Zone D has declined approximately 15 feet from a high in 2009 (Figure 4). A drop in the seawater elevation in Zone D is consistent with a general reduction in west side lower aquifer pumping since 2009.

Geophysics at deep monitoring well 18L6 continues to show no indication of intrusion, despite documented intrusion in Zone E at the nearby LOCSD Palisades well, approximately 500 feet to the south. This is interpreted as an indication that Zone E intrusion toward the Palisades well was through a relatively narrow preferential pathway. Production from Zone E at the Palisades well was permanently eliminated through well modification in 2013.

Rate and Extent of Seawater Intrusion

As reported in the technical memorandum dated October 7, 2014, the estimated rate of lower aquifer seawater intrusion since 2005 has been approximately 200-250 feet per year in Zone D, and approximately 100-170 feet per year in Zone E. Seawater intrusion was continuing to advance inland through April 2015, although the leading edge of seawater intrusion in Zone E along the preferential pathway was interpreted to have slowed or stalled at Palisades Avenue.

The October 2015 monitoring results indicate a reduced rate of advance of the seawater intrusion front between April and October 2015. Zone D intrusion toward the LOCSD Palisades is inferred to be approximately 100-150 feet per year. Figure 1 shows the approximate location of the toe of the intrusion front, defined by the 250 mg/l chloride concentration contour.

Stabilization of the chloride metric and a reduced intrusion rate may be a delayed response to the water conservation efforts and lower purveyor groundwater production over the last several years, which has also resulted in a rising water level metric. Additional monitoring events will be needed to confirm this.

Comparing Monitoring Events

Rates of seawater intrusion are affected primarily by water levels (pressure gradients) and aquifer permeability. The rate of intrusion is typically not uniform over time, but varies seasonally according to pumping cycles, and is accelerated during drought periods. Intrusion may also not be uniform within the aquifer zones, but may follow preferential pathways along discrete sand and gravel layers being tapped by pumping wells.

The recommended method for indexing seawater intrusion monitoring events for comparison purposes is to perform monitoring in the fall (October) and to match events using cumulative departure from mean precipitation. Monitoring in October will minimize seasonal variations and is also when fall water level readings are collected. When two monitoring events are in similar positions on the cumulative departure from mean precipitation curve, they are more directly comparable for assessing long-term trends in seawater intrusion. Figure 5 shows the cumulative departure from mean precipitation curve for the Morro Bay Fire Department. The rainfall years corresponding to the seawater intrusion monitoring events (2004, 2009, 2014, and 2015) are successively drier years when compared to each other.

Data Interpretation

Seawater intrusion mitigation will result in a rising water level metric and a declining chloride metric. The rising water level metric since 2010 indicates that declines in purveyor production over the last several years have offset the drought impacts to lower aquifer pressure. The chloride metric, however, did not show any response to the lower purveyor production or rising water level metric until the October 2015 monitoring event.

There was a delay of 15-20 years between the onset of water level metric declines in the 1970's and chloride metric increases in the 1990's. If the current short-term stabilization of the chloride metric continues through future October events (supporting a long-term trend), then the current delay between the onset of a water level metric rise and a chloride metric response would be on the order of five years. This shorter response period under current conditions would be expected, given that

part of the historical delay period was movement of the intrusion front into the area monitored by the key wells.

The October 2015 monitoring results indicate a decreased rate of the seawater intrusion. This is only the third semi-annual monitoring event, however, with prior monitoring events being closer to five years apart. Additional monitoring events will be needed before a change in the long term intrusion trends can be confirmed.

ATTACHMENTS

Table 21 from Updated Basin Plan
Table 1 - Groundwater levels October 2015
Table 2 - Water Quality Results
Figure 1 - Lower Aquifer Chloride Concentrations
Figure 2 - Chloride and Water Level Metric
Figure 3 - Geophysics at 30S/10E-13M1
Figure 4 - Cumulative Departure from Mean Rainfall

Table 21. Lower Aquifer Monitoring Network				
Program ID	**Well Number**	**Area**	**Well Type**	**Monitoring***
LA1	30S/10E-2A1	Dunes and Bay	Monitoring	L
LA2	30S/10E-11A2	Dunes and Bay	Monitoring	L add G in Oct.
LA3	30S/10E-14B2	Dunes and Bay	Monitoring	L add G in Oct.
LA4	30S/10E-13M1	Western	Monitoring	L, GL
LA5	30S/10E-13L7	Western	Municipal	L
LA6	30S/10E-13L4	Western	Municipal	L, ~~G~~ remove G
LA7	Private	Western	Private	TL
LA8	30S/10E-13N	Western	Municipal	L, G
LA9	30S/10E-24C1	Western	Municipal	L add G
LA10	30S/10E-13J4	Western	Municipal	L, G
LA11	30S/10E-12J1	Central	Monitoring	L, G
LA12	30S/11E-7Q3	Central	Municipal	L, G
LA13	30S/11E-18F2	Central	Municipal	TL
LA14	30S/11E-18L6	Western	Monitoring	L
LA15	30S/11E-18L2	Western	Municipal	L, G
LA16	Private	Western	Private	L
LA17	30S/11E-24A2	Western	Monitoring	L
LA18	30S/11E-18K8	Central	Monitoring	L, G
LA19	30S/11E-19H2	Central	Monitoring	L
LA20	30S/11E-17N10	Central	Municipal	L, G
LA21	30S/11E-17E7	Central	Monitoring	L
LA22	30S/11E-17E8	Central	Monitoring	L add G
Private LA23	~~30S/11E-17C1~~	Central	Monitoring	L, G
LA24	Private	Eastern	Private	L
LA25	Private	Eastern	Private	L
LA26	Private	Eastern	Private	L
LA27	Private	Eastern	Private	TL
LA28	Private	Eastern	Private	L, G
LA29	Private	Eastern	Private	L
LA30	Private	Eastern	Private	L, G

Legend: L = groundwater level; GL = geophysical logging; G = groundwater quality: general mineral suite; TL = transducer site for groundwater level.

Add groundwater sampling at mixed aquifer (C/D) wells: LOCSD 10th Street (18K9) and Sea Pines (13M2)

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Table 1

Groundwater Levels - October 2015

Program ID	Well Number	Date	Depth to Water	Reference point elevation (ft)*	Groundwater elevation (ft)*	Monitoring data source
LA1	30S/10E-2A1	10/21/2015	8.45	16.0*	7.6*	COUNTY
LA2	**30S/10E-11A2**	10/21/2015	10.33	16.4*	6.1*	COUNTY
LA3	**30S/10E-14B2**	10/21/2015	13.59	16.8*	3.2*	COUNTY
LA4	30S/10E-13M1	10/24/2015	44.84	41.2	-3.6	CHG
(none)	30S/10E-13M2	10/24/2015	39.2	40.2	1	CHG
LA5	30S/10E-13L7					S&T (pending)
LA6	30S/10E-13L4			68		GSWC (pending)
LA7	30S/10E-13P2	Private well - program participation to be determined				
LA8	30S/10E-13N	10/6/2015	134	no survey		S&T
LA9	30S/10E-24C1			178.3		GSWC (pending)
LA10	30S/10E-13J4			95.3		GSWC (pending)
LA11	**30S/10E-12J1**	10/26/2015	5.22	8.4*	3.18*	CHG
LA12	30S/11E-7Q3	pending	34.9	24	-10.9	LOCSD
LA13	30S/11E-18F2			100		LOCSD (pending)
LA14	**30S/11E-18L6**	10/26/2015	83.6	76		COUNTY
LA15	30S/11E-18L2	pending	96	85	-11	LOCSD
LA16	**30S/11E-18M1**	Private well - program participation to be determined				
LA17	30S/10E-24A2	no access	--	210.4	--	COUNTY
LA18	30S/11E-18K8	10/19/2015	141.27	135.7	-5.6	CHG
(none)	30S/11E-18K9	pending	156.2	135	-21.2	LOCSD
LA19	30S/11E-19H2	10/27/2015	275.85	256.2	-19.7	COUNTY
LA20	30S/11E-17N10					GSWC (pending)
LA21	30S/11E-17E7	10/27/2015	118.51	105.9	-12.6	CHG
LA22	30S/11E-17E8	10/1/2015	129.19	105.9	-23.3	CHG
LA23	30S/11E-17C1	Private well - program participation to be determined				
LA24	30S/11E-17J2	Private well - program participation to be determined				
LA25	30S/11E-20Aa	Private well - program participation to be determined				
LA26	30S/11E-20G2	Private well - program participation to be determined				
LA27	30S/11E-16Ma	Private well - program participation to be determined				
LA28	30S/11E-16Mb	Private well - program participation to be determined				
LA29	30S/11E-21E3	Private well - program participation to be determined				
LA30	30S/11E-21H1	Private well - program participation to be determined				

Water Level Metric Wells in Blue

*Elevations with astrix are reported in NAVD 88. All others are reported in NAVD 29.

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Table 2
Water Quality Results - Lower Aquifer Monitoring

Station ID	Well Name	Basin Plan Well ID	Aquifer Zone	Date	HCO3	Total Hardness	Cond	pH	TDS	Cl	NO3	SO4	Ca	Mg	K	Na
					mg/l	mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
30S/10E-11A2	Sand Spit #1 East	LA2	D	3/14/2005	180	4600	16000	7.3	8900	5400	ND	430	770	640	20	1300
				10/21/2015	150	6640	17700	7.4	13100	6300	ND	740	1030	990	31	1560
30S/10E-12J1	MBO5 DWR Obs.	LA11	E	2/14/2005	350	370	1300	8.1	840	77	ND	190	51	58	6.1	110
				11/20/2009	300	360	1150	7.5	732	83	ND	190	51	58	4.4	95
				7/24/2014	360	489	1290	7.7	780	105	ND	212	69	77	5	88
				4/22/2015	360	475	1290	7.8	810	112	ND	189	65	76	5	88
				10/1/2015	250	486	1280	7.3	840	117	ND	188	68	77	4	85
30S/10E-13J4*	GSWC Rosina	LA10	D	12/20/2004	72	230	720	7.1	410	150	7	14	38	33	1.4	29
				1/14/2010	35	260	778	6	435	200	7.1	13	41	38	1.5	33
				7/24/2014	80	418	1200	7.3	910	303	7.6	16	67	61	2	39
				4/22/2015	80	431	1230	7.1	750	331	8.3	20	69	63	2	39
				10/5/2015	70	460	1280	7	950	329	7.3	19	74	67	2	41
30S/10E-13M2	Howard East	none	C,D	11/22/2004	51	810	2900	7.3	1500	810	2.4	140	130	120	4.7	210
				12/9/2009	55	1100	3740	7.1	2170	1100	2.2	220	160	160	4.8	370
				8/4/2014	60	757	3340	7.1	2450	990	2.5	178	117	113	5	382
				4/21/2015	60	739	3430	7.3	1930	950	2.5	178	117	113	5	382
				4/21/2015	30	756	3370	7.1	2140	960	2.4	185	115	114	5	342
30S/10E-13N	S&T #5	LA8	D	11/23/2004	42	80	390	6.9	200	67	26	9.2	13	12	1.7	38
				11/19/2009	41	89	386	6.8	267	73	27	11	15	13	1.4	38
				7/24/2014	50	100	438	7.4	270	76	31	10	17	14	2	38
				4/21/2015	50	98	445	6.9	280	77	33.9	11	16	14	2	38
				10/6/2015	40	98	422	7.2	310	75	30	10	16	14	1	38
30S/10E-14B2**	Sand Spit #3 Deep	LA3	D	3/15/2005	100	3600	30000	8	17000	8500	ND	960	1200	130	34	4300
				10/21/2015	ND	7140	29500	11	24700	10000	ND	530	2830	20	80	4040
30S/10E-24C1	GSWC Cabrillo	LA9	D	12/20/2004	64	130	610	7	310	110	20	19	22	19	1.6	50
				11/20/2009	60	150	611	7.1	347	130	18	22	23	22	1.6	52
				7/24/2014	40	69	339	7.6	240	46	37	6	11	10	1	32
				4/22/2015	70	117	530	7.3	320	95	24.2	16	19	17	2	45
				10/5/2015	50	75	349	7.6	270	50	33.4	7	12	11	1	34
30S/11E-7Q3	LOCSD 8th St.	LA12	D	11/18/2004	250	270	790	7.5	410	73	ND	39	44	40	2.3	48
				11/19/2009	220	290	782	7.4	465	92	ND	46	46	42	1.9	53
				7/23/2014	290	303	876	7.6	460	91	ND	43	49	44	2	54
				4/21/2015	290	305	897	7.7	500	101	ND	55	48	45	2	59
				10/6/2015	280	298	828	7.4	490	91	ND	46	47	44	2	55
30S/11E-17E8	So. Bay Obs. Middle	LA22	D	1/14/2005	150	150	440	7.5	290	34	9.7	11	24	22	1.4	28
				11/20/2009	120	160	455	7.3	255	42	19	12	25	23	1.3	29
				7/23/2014	150	166	500	7.6	270	43	28	10	27	24	2	28
				4/21/2015	150	157	481	7.6	270	49	31.4	13	25	23	1	28
				10/1/2015	120	164	475	7.4	290	44	29.2	10	26	24	1	28
30S/11E-17N10	GSWC So. Bay #1	LA20	C,D,E	Jan 2003	250	--	510	7.1	290	37	ND	21	41	25	1.3	35
				11/20/2009	230	220	638	7.3	357	41	2.4	30	35	33	1.7	37
				7/24/2014	280	232	646	7.7	370	37	2.3	24	37	34	2	41
				4/22/2015	290	234	653	7.4	360	43	2.5	27	36	35	2	42
				10/5/2015	280	227	614	7.2	370	38	2.4	23	35	34	2	41
30S/11E-18K8	10th St. Obs. East (Deep)	LA18	E	1/19/2005	260	290	650	7.5	370	33	ND	38	62	33	2.5	28
				11/20/2009	230	220	620	7.5	378	32	ND	40	51	24	1.8	23
				7/24/2014	290	271	647	7.5	380	28	ND	34	56	32	2	27
				4/21/2015	290	265	634	7.7	400	33	ND	39	55	31	2	27
				10/19/2015	230	256	621	7.3	370	29	ND	33	53	30	2	26
30S/11E-18K9	LOCSD 10th St.	none	C,D	May 2002	250	--	550	6.9	320	37	1	26	31	32	--	39
				11/20/2009	180	160	539	7.2	307	36	4.6	27	27	24	1.3	32
				7/23/2014	220	190	546	7.7	300	32	4.3	20	30	28	1	35
				4/21/2015	190	108	504	7.6	270	38	7	20	17	16	1	
				10/6/2015	50	62	248	7.2	190	31	26.2	3	10	9	ND	21
30S/11E-18L2***	LOCSD Palisades	LA15	D,E	11/18/2004	220	330	880	7.3	420	120	ND	31	54	48	2.2	40
			D,E	11/19/2009	200	590	1460	7.2	890	360	1.8	39	94	86	2	44
			D	7/23/2014	250	293	783	7.8	390	90	1.8	26	48	42	2	40
			D	4/29/2015	80	78	348	7.4	230	43	22	10	13	11	ND	30
			D	10/28/2015	230	288	782	7.4	420	104	2.8	29	46	42	ND	36

ND = Not Detected

Chloride Metric Wells in Green (13J4 weighted x2); current chloride concentrations in red

*Chloride concentrations at 13J4 have varied seasonally by 100+ mg/l, and are affected by well production, so fluctuations are expected.

**Alkalinity 140 mg/l as carbonate (ND as bicarbonate) due to high pH, possibly associated with shell zone.

***Water from 18L2 affected by borehole leakage/upper aquifer influence when inactive

Table 2 Legend and Detection Limits

Constituent	Description	Practical Quantitation Limit*
HCO3	Bicarbonate Alkalinity in mg/L CaCO3	10.0
Total Hardness	Total Hardness in mg/L CaCO3	--
Cond	Electrical Conductance in µmhos/cm	1.0
pH	pH in pH units	--
TDS	Total Dissolved Solids in mg/L	20.0
Cl	Chloride concentration in mg/L	1.0
NO3	Nitrate concentration in mg/L	0.5
SO4	Sulfate concentration in mg/L	2.0
Ca	Calcium concentration in mg/L	1.0
Mg	Magnesium concentration in mg/L	1.0
K	Potassium concentration in mg/L	1.0
Na	Sodium concentration in mg/L	1.0

*where dilution not required

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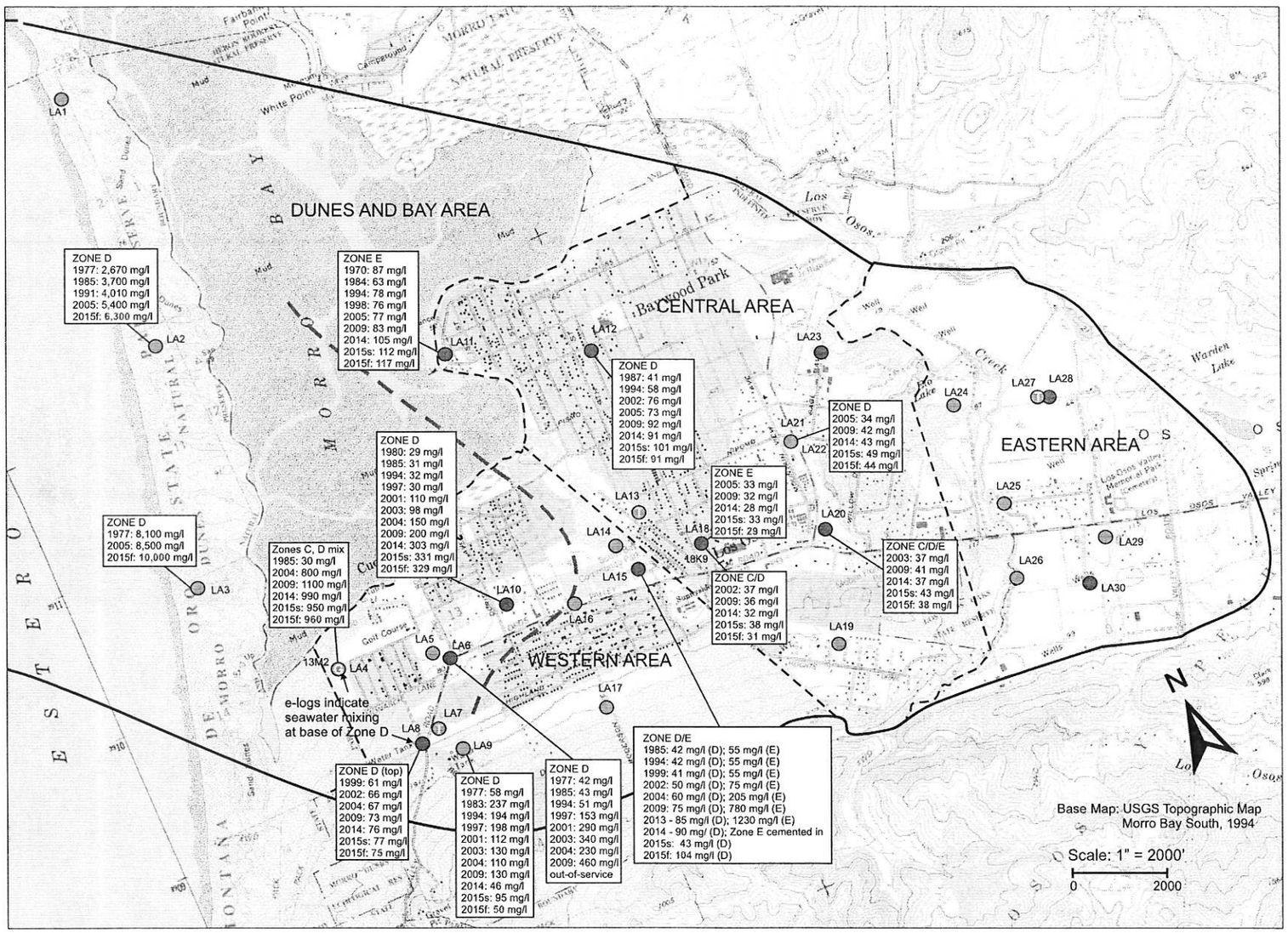

Explanation

Basin Plan Monitoring Tasks:

- Water level only
- Water level transducer
- Water level with geophysics
- Water level and water quality

2015s - Spring 2015
2015f - Fall 2015

101 October 2015 chloride concentration in mg/l shown in red

LA11 Well location

Inferred extent of 250 mg/l Zone D isochlor

NOTE: the isochlor lines are interpreted from water quality and geophysical data, and include consideration of well construction and use.

approximate basin limits

Figure 1

Lower Aquifer
Chloride Concentrations
October 2015 Lower Aquifer Monitoring
Los Osos ISJ

Cleath-Harris Geologists

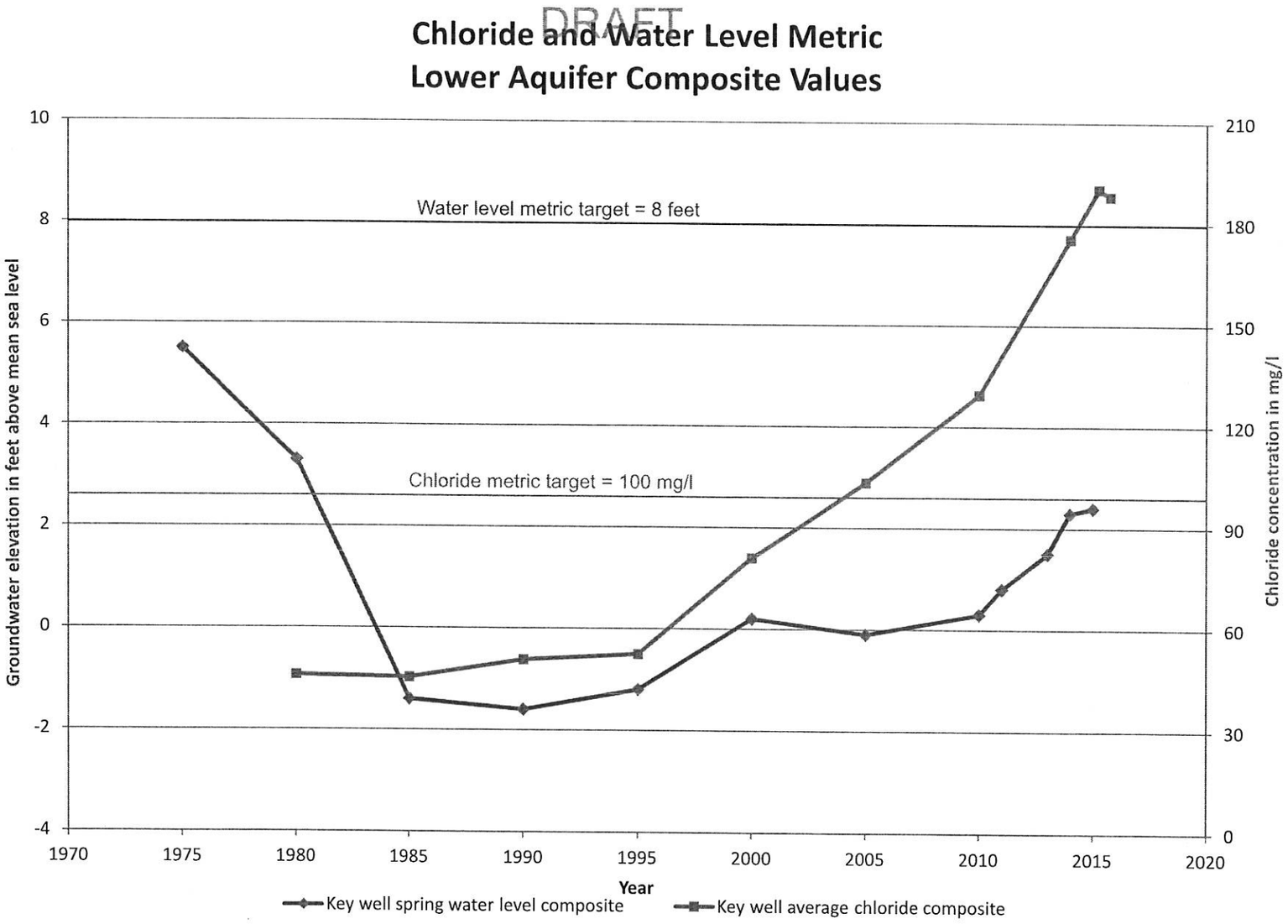

Figure 2
Chloride and Water Level Metric
October 2015 Lower Aquifer Monitoring
Los Osos ISJ

Cleath-Harris Geologists

Well 30S/10E-13M1

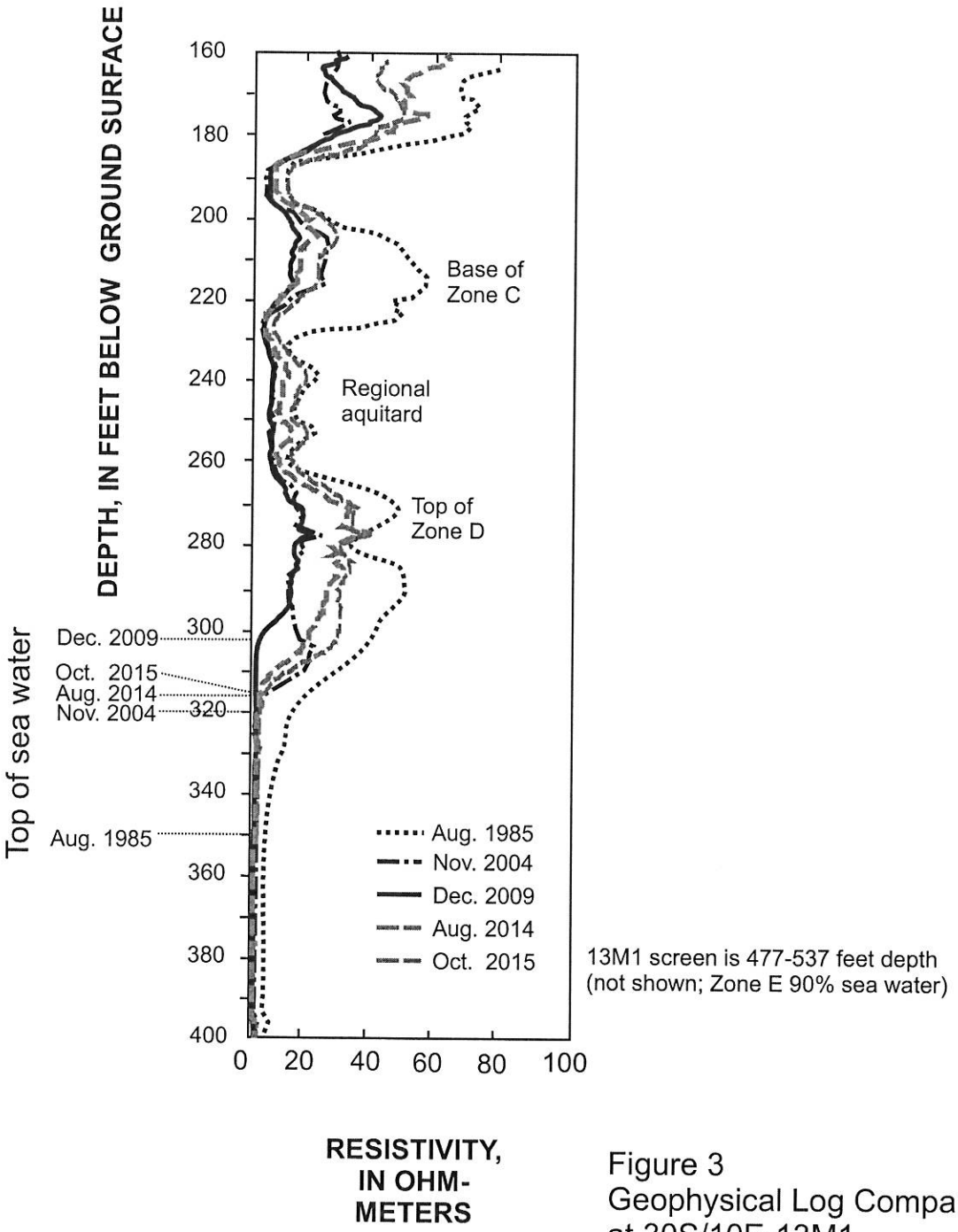

Figure 3
Geophysical Log Comparison
at 30S/10E-13M1
October 2015
Lower Aquifer Monitoring
Los Osos ISJ

Cleath-Harris Geologists

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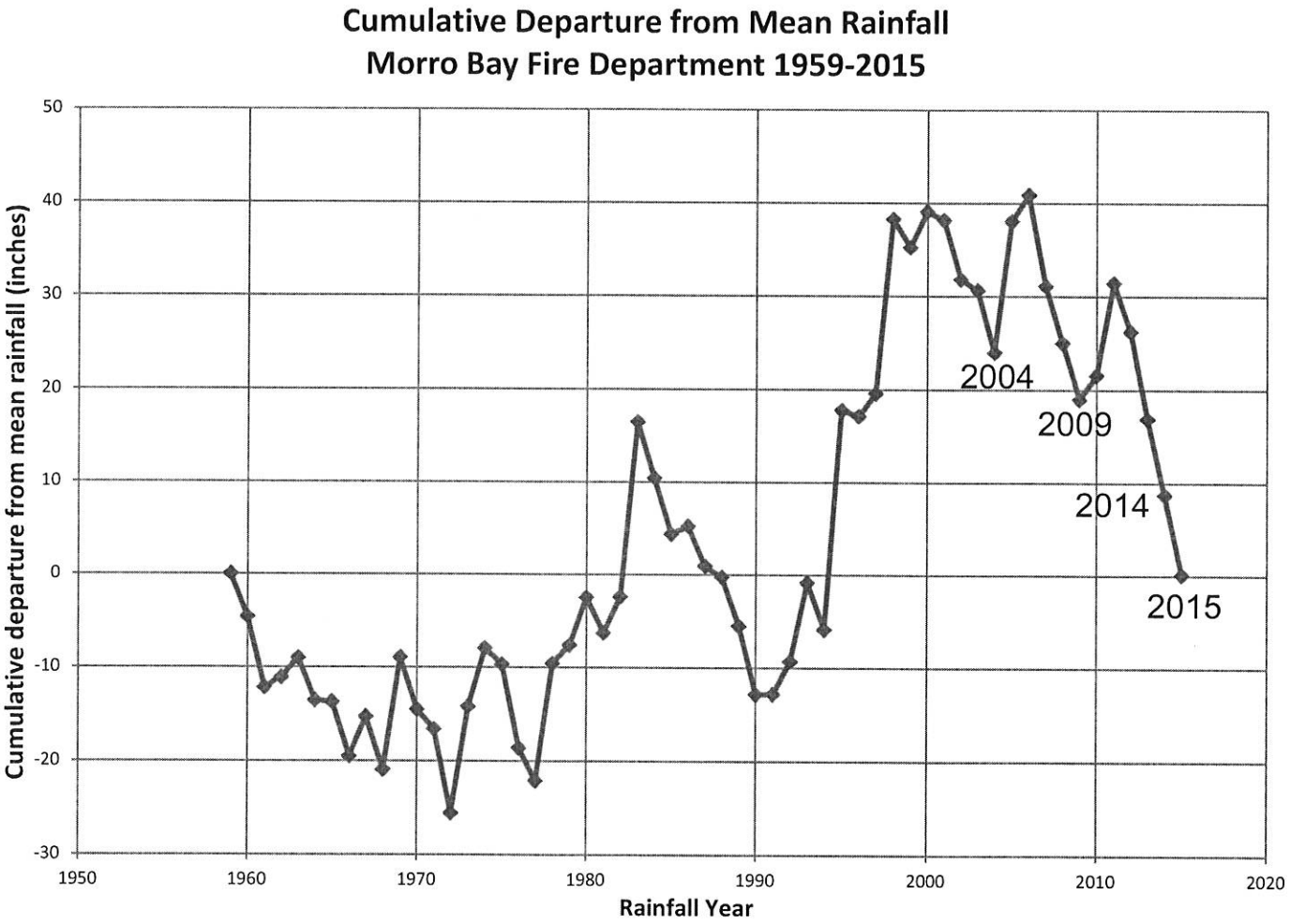

Figure 4
Cumulative Departure from
Mean Rainfall at Morro Bay
October 2015 Lower Aquifer Monitoring
Los Osos ISJ

Cleath-Harris Geologists