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Technical Memorandum

Date: November 6, 2019

From: Spencer Harris, HG 633

To: Rob Miller, PE, Interim Executive Director
Los Osos Groundwater Basin Management Committee

SUBJECT: Lower Aquifer nitrate concentrations trends review and LA11 seawater intrusion evaluation.

Dear Mr. Miller:

As part of adaptive management for 2019, Cleath-Harris Geologists (CHG) has performed a review of trends in nitrate concentrations at various Lower Aquifer wells, along with an evaluation of the potential for seawater intrusion at Lower Aquifer well LA11 (Zone E; Pasadena Drive). The purpose of these efforts is to provide the Los Osos Basin Management Committee (BMC) with information and recommendations for making adjustments to the Los Osos Basin Plan (LOBP)[1], as appropriate. This memorandum presents the results of the adaptive management review.

Lower Aquifer Nitrate Trends

The 2018 Annual Report evaluated Upper Aquifer influence and associated increases in nitrate concentrations due to wellbore leakage in Lower Aquifer well LA10. As noted in Appendix J of that report, wellbore leakage is not the only mechanism for Upper Aquifer influence at Lower Aquifer wells. In fact, leakage of Upper Aquifer groundwater through the regional aquitard is one of the main sources of recharge to the Lower Aquifer.

For example, under current wastewater project conditions with no further development (LOPB Figure 74, Attachment A), recharge to the Lower Aquifer is estimated to average 680 acre-feet per year from Upper Aquifer leakage and 240 acre-feet per year of subsurface inflow from the Los Osos Creek valley. Historically, Upper Aquifer leakage was also the primary component of recharge to the Lower Aquifer. The estimated ratio of Upper Aquifer leakage to subsurface inflow from Los Osos Creek valley prior to the wastewater project ranged from approximately 60:40 to 70:30.[2]

[1]Updated Basin Plan for the Los Osos Groundwater Basin, January 2015.
[2]Cleath & Associates, 2005, Sea Water Intrusion Assessment and Lower Aquifer Source Investigation of the Los Osos Valley Groundwater Basin, October 2005.

Prior Studies

Two prior studies that projected future nitrate concentrations in groundwater over time have been performed, one using a solute transport model[3] and the other based on mass balance calculations.[4] The solute transport model study concluded that nitrate concentrations in several Lower Aquifer wells would continue to rise following wastewater project implementation, as existing nitrate concentrations in the Upper Aquifer are drawn into the Lower Aquifer zones. Mass balance calculations for the Salt/Nutrient Management Plan also indicate Lower Aquifer nitrate concentrations also projected to rise in the Central and Western Areas under wastewater project conditions. The solute transport study projected variable increases in Lower Aquifer nitrate concentrations, while the mass balance calculations projected roughly 2 milligrams per liter (mg/L) over 25 years following wastewater project implementation, equivalent to 0.08 mg/L per year. Attachment B includes graphical results of the two prior studies (Figure 23 from the solute transport study and Figures E11 and E15 from the Salt/Nutrient Management Plan).

The Los Osos Wastewater Project significantly reduces nitrogen loading to the Basin. Raw water influent to the Los Osos Water Recycling Facility averages over 50 mg/L as ammonia-nitrogen, while treated wastewater discharges to Broderson were initially close to 7 mg/L NO_3-N in 2016, and dropped below 2 mg/L in October 2018 as inflows to the treatment plant increased and the treatment process stabilized.[5,6]

The long-term equilibrium of NO_3-N concentrations in the basin salt/nutrient mass balance is projected to be approximately 5 mg/L (Figure E11, Attachment B), and assumes treated wastewater contains 6 mg/L NO_3-N. By comparison, the solute transport modeling in 2003 shows maximum NO_3-N concentrations at community supply wells approaching 7 mg/L under wastewater project conditions, and assumes NO_3-N in treated wastewater was also 7 mg/L (Figure 23, Attachment B). With lower average NO_3-N concentrations being achieved by the treatment plant, long-term basin equilibrium would be expected below 5 mg/L NO_3-N (less than half the State drinking water standard).

Nitrate Trends at Specific Wells

Historical nitrate data over time has been reviewed for Lower Aquifer community supply wells and monitoring wells. A summary of trends is presented in Table 1 below, followed by trend details for each well. Well locations are shown in Figure 1. Plots of nitrate-nitrogen (NO_3-N) over time with linear regression trend lines are shown in Figures 2, 3 and 4.

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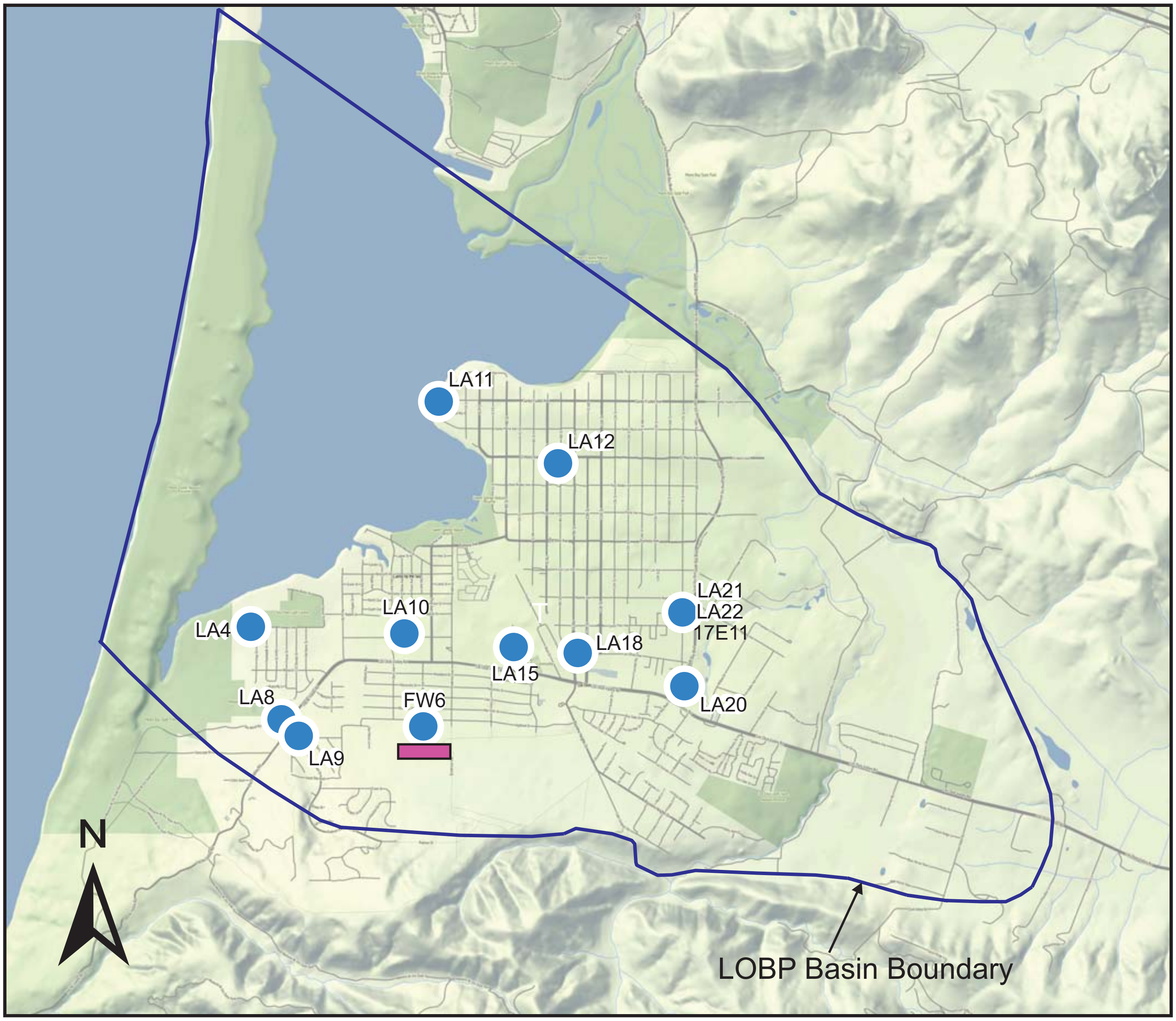
[3]Yates and Williams, 2003, Simulated Effects of a Proposed Sewer project on Nitrate Concentrations in the Los Osos Valley Groundwater Basin.

[4]CHG, 2017, Los Osos Groundwater Basin Assimilative Capacity and Antidegradation Analysis, prepared for San Luis Obispo County Public Works *in* Salt/Nutrient Management Plan for the Los Osos Groundwater Basin, Appendix C.

[5] Ibid

[6] CHG, 2018 Annual Groundwater Monitoring Report for the Los Osos Groundwater Basin, June 2019



Base Image: Stamen-Terrain

Scale: 1 inch ≈ 4,000 feet

Explanation

LOBP Monitoring Locations referenced in text

Broderson Site

Figure 1
Referenced Well Locations
Los Osos Groundwater Basin
2019 Adaptive Management TM

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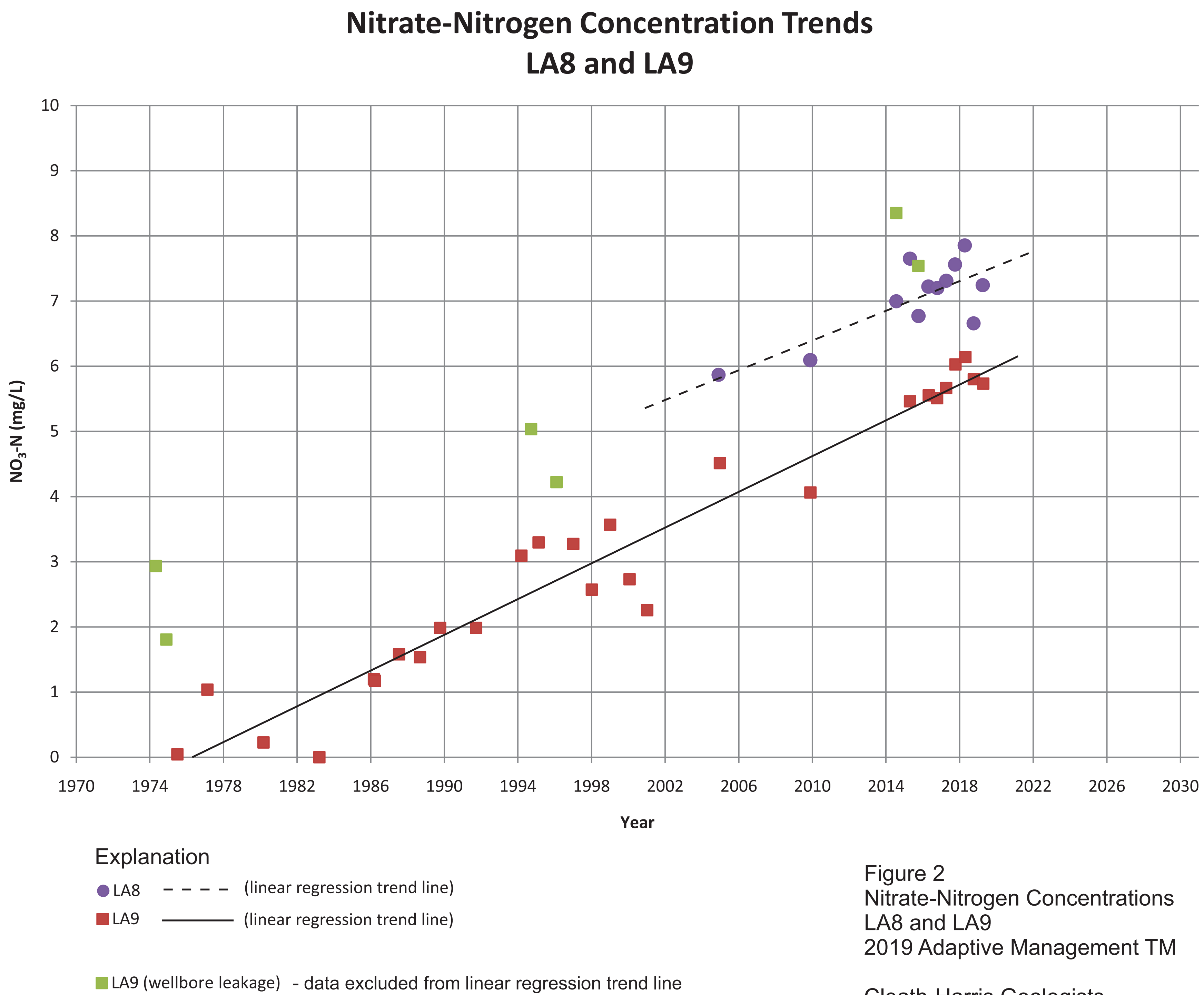

Figure 2
Nitrate-Nitrogen Concentrations
LA8 and LA9
2019 Adaptive Management TM

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Nitrate-Nitrogen Concentration Trends
LA10 and LA15

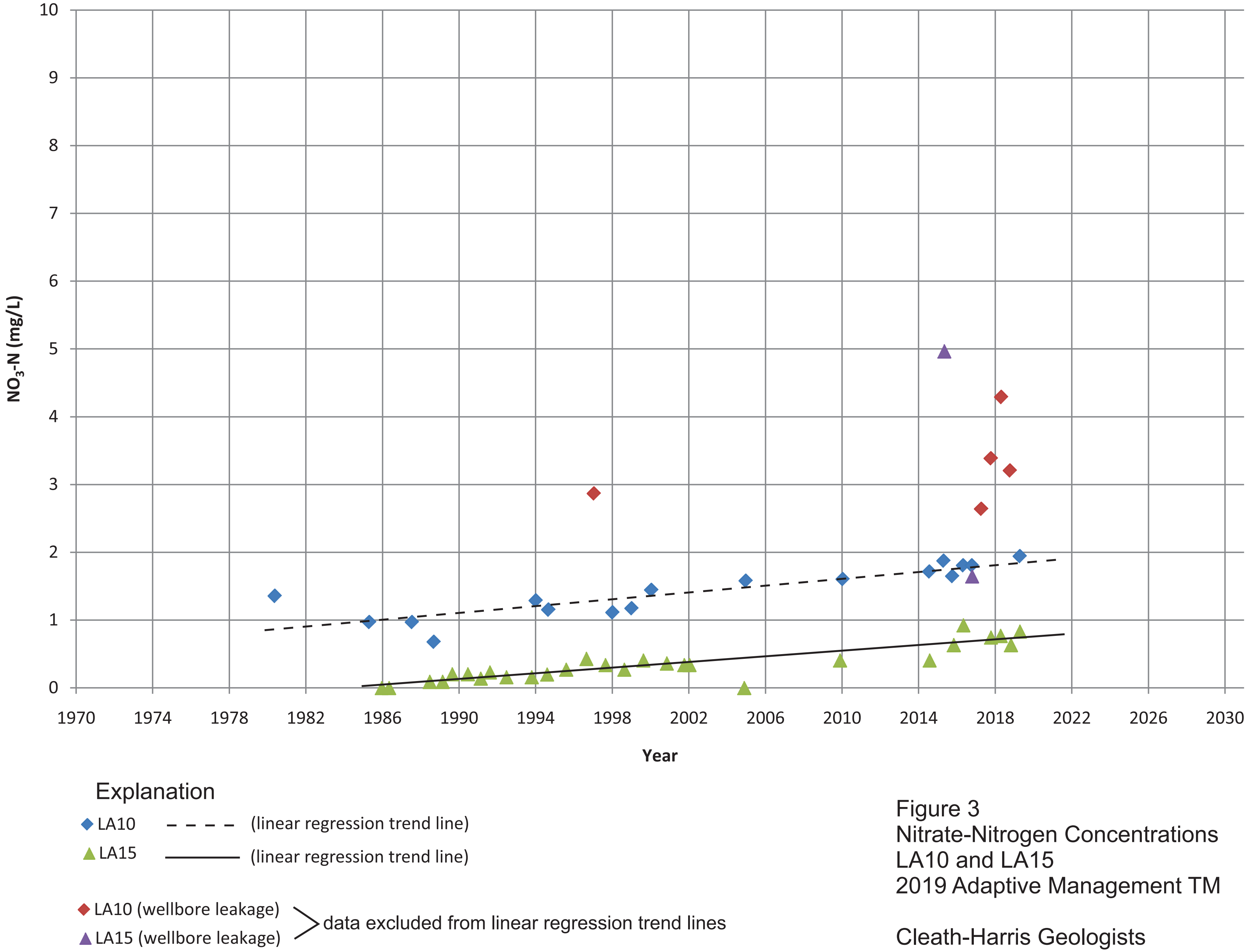

Figure 3
Nitrate-Nitrogen Concentrations
LA10 and LA15
2019 Adaptive Management TM

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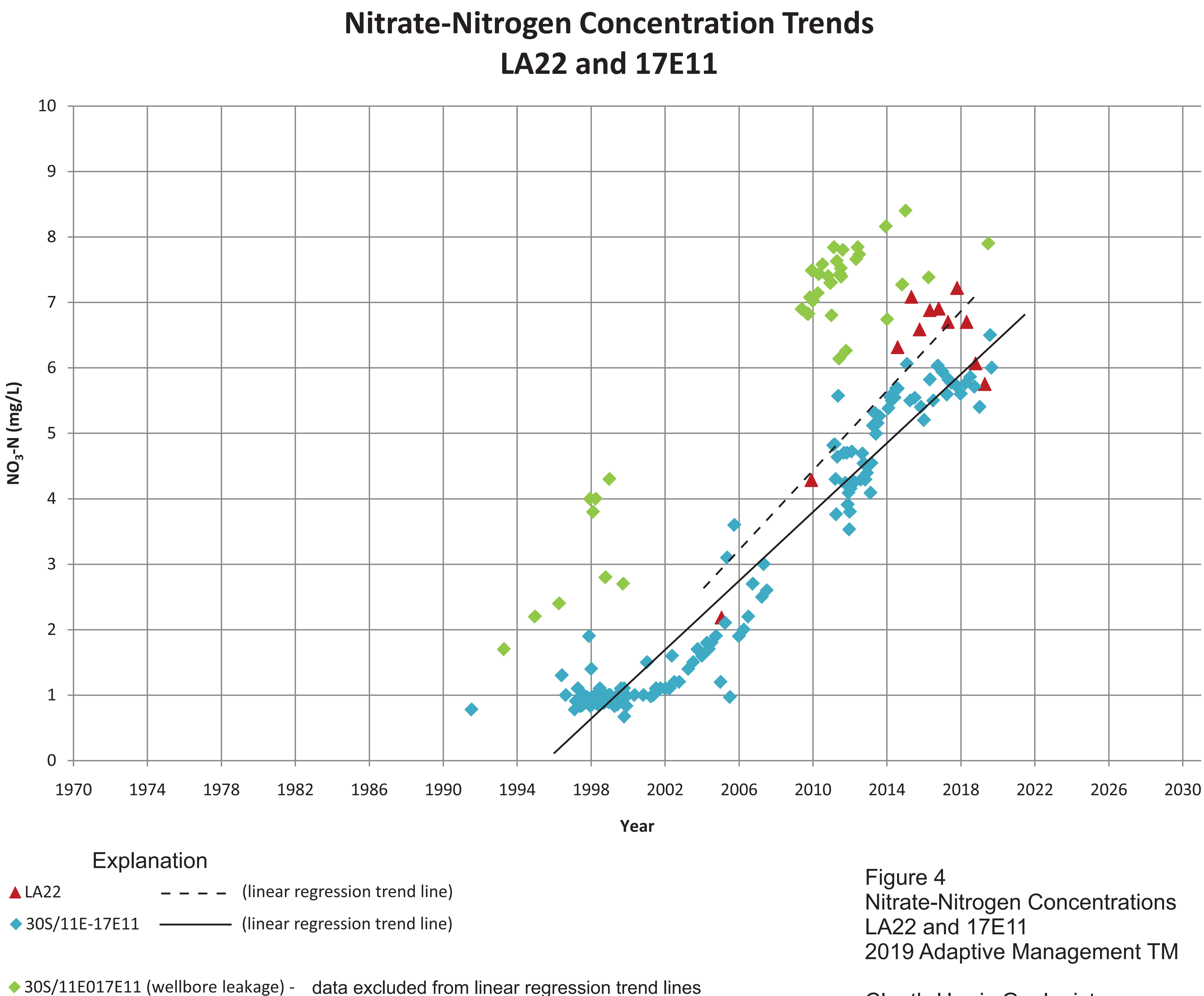

Figure 4
Nitrate-Nitrogen Concentrations
LA22 and 17E11
2019 Adaptive Management TM

Cleath-Harris Geologists

Table 1
Lower Aquifer NO_3-N Concentration Trends

Program ID	Name/Location	Basin Area	Aquifer Zone		NO_3-N trend	
			Zone D	Zone E	Direction	Rate (mg/L per year)
LA8	S&T Mutual #5	Western	x		increasing	0.12
LA9	GSWC Cabrillo	Western	x		increasing	0.14
LA10	GSWC Rosina	Western	x	x	increasing	0.025
LA11	Morro Bay Observation #5	Central		x	flat (no nitrate)	none
LA12	LOCSD 8th St. Lower	Central	x		flat (no nitrate)	none
LA15	LOCSD Palisades	Western	x		increasing	0.025
LA18	10th St. Observation East	Central		x	flat (no nitrate)	none
LA22	So. Bay Blvd Observation #2	Central	x		increasing	0.3
17E11*	LOCSD South Bay Lower	Central	x		increasing	0.26

*not a Program Well – ID taken from State Well Number 30S/11E-17E11

LA8 and LA9

LA8 is a Zone D supply well located in the Western Area (Figure 1). Nitrate-nitrogen (NO_3-N) concentrations have increased at an average rate of approximately 0.12 mg/L per year since 2004, and measured 7.2 mg/L in April 2019 (Figure 2). Projected average NO_3-N concentrations at LA8 would exceed the primary Maximum Contaminant level (MCL) in drinking water of 10 mg/L in approximately 20 years. Fluctuations from the average may result in exceeding the nitrate MCL much sooner, however.

LA9 is a Zone D supply well located in the Western Area (Figure 1). NO_3-N concentrations have increased at an average rate of approximately 0.14 mg/L per year since 1974, and measured 5.7 mg/L in April 2019 (Figure 2). Projected average NO_3-N concentrations at LA9 would exceed the primary MCL in drinking water of 10 mg/L in approximately 30 years, although fluctuations may result in exceeding the nitrate MCL much sooner. Data points at LA9 that are interpreted to be elevated due to wellbore leakage (short-term fluctuations of 2-3 mg/L) are shown in Figure 2 and excluded from the trend line.

LA9 and LA8 have similar NO_3-N concentration trends. These wells are hydraulically downgradient of Cabrillo Estates, a residential subdivision with septic systems (sources of nitrogen loading to groundwater). The short-term fluctuations in NO3-N concentrations at the wells, particularly LA9, are likely due to localized Upper Aquifer influence from wellbore leakage. The long-term nitrate trends, however, are attributable to broader Upper Aquifer leakage through the regional aquitard.

LA10 and LA15

LA10 is a Zone D/E supply well located in the Western Area (Figure 1) and was the subject of a wellbore leakage evaluation in 2018 (Appendix J of 2018 Annual Report). NO_3-N concentrations interpreted to be associated with Upper Aquifer water moving through the regional aquitard (as opposed to wellbore leakage) have increased at an average rate of approximately 0.025 mg/L per year since 1980 (Figure 3). A concentration of 1.9 mg/L NO_3-N was reported in April 2019. Lower Aquifer NO_3-N concentrations at LA10 are not expected to exceed the primary MCL.

LA15 is a Zone D supply well located in the Western Area (Figure 1). The NO_3-N concentration in groundwater produced by the well has been increasing at an average rate of 0.025 mg/l per year since 1985, and was reported at 3.7 mg/L in April 2019 (Figure 3). Lower Aquifer NO_3-N concentrations at LA10 are not expected to exceed the primary MCL.

LA10 and LA15 have similar NO_3-N concentration trends. Short-term fluctuations in NO_3-N concentrations at LA10 due to localized Upper Aquifer influence from wellbore leakage has been previously reported.[7] Evidence of wellbore leakage has also been reported at LA15, including 5 mg/L NO_3-N with 41 mg/L chloride in Spring 2015 after the well had been out-of-service for a few months.[8] The long-term nitrate trends shown in Figure 3 exclude elevated nitrate results due to wellbore leakage.

LA11, LA12, and LA18

LA11 is a Zone E monitoring well located in the Central Area (Pasadena Drive) and is also being evaluated herein for evidence of seawater intrusion. NO_3-N concentrations have generally been below detection levels in groundwater collected from LA11 since the well was constructed in 1970. No increasing trend in NO_3-N concentrations is present at this well.

LA12 is a Zone D community supply well located in the Central Area (LOCSD 8th Street Lower). NO_3-N concentrations have generally been below detection levels in groundwater collected from LA12 since the well was constructed in 1986. No increasing trend in NO_3-N concentrations is present at this well.

LA15 is a Zone E monitoring well located in the Central Area (10th Street at Los Olivos Avenue). NO_3-N concentrations have been below detection levels in groundwater collected from LA15 since water quality monitoring at the well started in 2005. No increasing trend in NO_3-N concentrations is present at this well.

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[7] Appendix J of 2018 Annual Groundwater Monitoring Report for the Los Osos Groundwater Basin, June 2019.
[8] CHG, 2015, October 2015 Lower Aquifer Monitoring Technical Memorandum, Los Osos Groundwater Basin, December 28, 2015.

LA22 and 17E11

LA22 is a Zone D monitoring well located in the Central Area at the LOCSD South Bay yard. NO_3-N concentrations have increased at an average rate of approximately 0.3 mg/L per year since 2005, and measured 5.8 mg/L in April 2019 (Figure 4). Projected average NO_3-N concentrations at LA8 would exceed the primary MCL of 10 mg/L in approximately 8 years, although concentrations have steadily declined over the last two years from a high of 7.2 mg/L in October 2017 (Figure 4).

17E11 is a Zone D community supply well located adjacent to LA22 in the Central Area (Figure 1). NO_3-N concentrations have increased at an average rate of approximately 0.26 mg/L per year since the well was constructed in 1991, and measured 6 mg/L in August 2019 (Figure 2). Projected average NO_3-N concentrations at 17E11 would exceed the primary MCL in drinking water of 10 mg/L in approximately 14 years. Fluctuations from the average may result in exceeding the nitrate MCL sooner, however.

LA22 and 17E11 have similar NO_3-N concentration trends. The short-term fluctuations in NO_3-N concentrations of up to 3 mg/L at 17E11 are likely due to localized Upper Aquifer influence from wellbore leakage. The long-term nitrate trends, however, are attributable to broader Upper Aquifer leakage through the regional aquitard. A greater rate of NO_3-N increase in Lower Aquifer groundwater at the South Bay yard, compared to the other sites evaluated, is interpreted to be due to locally permeable sand zones within the regional aquitard. The upper screen interval for 17E11 taps fine sands which are interbedded with the regional aquitard clay, and there is less than 10 feet of separation between base of the Upper Aquifer and the top of the well screen.

Nitrate Trends Discussion

The monitoring data show trends of increasing nitrate concentrations at several Lower Aquifer wells ranging from 0.025 mg/L to 0.3 mg/L NO_3-N per year, while concentrations at other wells remain low to non-detected for nitrate. Overall increases in Lower Aquifer nitrate concentrations were expected, since the Upper Aquifer, which has elevated nitrate concentrations, provides a significant amount of recharge to the Lower Aquifer. Spatial differences in nitrate trends and nitrate concentrations are controlled by many factors, including nitrogen loading areas, recharge areas, dilution through dispersion, and subsurface porosity and permeability.

The location where monitoring data show Lower Aquifer nitrate concentrations having the greatest potential to exceed the drinking water standard is at well 17E11, a community supply well in the LOCSD South Bay yard (Figure 1). There is also an Upper Aquifer community supply well at the yard, along with an existing nitrate removal system. Results of solute transport modeling for nitrates in 2003 (Figure 23, Attachment B) indicted that without the Los Osos Wastewater Project, NO_3-N concentrations at 17E11 would increase by approximately 0.2 mg/L per year (actual increases have averaged 0.26 mg/L).

Two other Lower Aquifer supply wells where nitrate concentrations have the potential to exceed the drinking water standard are LA8 and LA9 in the Western Area (Figure 1). Neither of these locations have nitrate removal systems currently available. Solute transport modeling (Figure 23, Attachment B) indicted that NO_3-N concentrations would increase by 0.04 mg/L to 0.08 mg/L per year without the wastewater project, and by 0.08 mg/L to 0.17 mg/L per year with the wastewater project (actual increases have been 0.12 mg/L to 0.14 mg/L per year). The increased impact to NO_3-N concentrations in groundwater at LA8 and LA9 under wastewater project conditions was attributed in part to anticipated increases in pumping volumes and changes in local flow patterns, including a more westerly hydraulic gradient following the development of the Broderson groundwater mound.[9]

The LOBP does not specifically discuss a potential threat to water quality from increasing nitrate concentrations in Lower Aquifer groundwater. Mitigation with respect to the threat of elevated basin nitrate concentrations is focused on the Upper Aquifer, although the same mitigation could apply to the Lower Aquifer. LOBP infrastructure programs have addressed basin nitrate issues through blending, nitrate removal, and water system interties.

Based on the nitrate trends currently identified in Lower Aquifer groundwater, provisions for future nitrate removal at LA8, LA9, and 17E11 and/or blending with low-nitrate water from other wells through an interconnected community water system are recommended. To the extent that these provisions may not be included in the existing infrastructure programs, modifications to the LOBP would be appropriate. Long-term NO_3-N concentrations in Lower Aquifer groundwater are expected to equilibrate below 5 mg/L (less than half the drinking water standard), but will peak at higher concentrations in the above production wells before declining.

Seawater Intrusion at LA11

LA11 is a monitoring well located along the bay in the Central Area (Pasadena Drive) and is screened in Lower Aquifer Zone E (Figure 1). The well was constructed in October 1970, reportedly flowing under artesian conditions in November and December 1970 with pressure heads of about 10 feet above sea level.[10] By comparison the groundwater elevation was measured at 3.1 feet above sea level in Spring 2019. LA11 is of particular interest because it serves as a sentry well for community supply well LA12, which taps zone D at the LOCSD 8th Street yard in Baywood Park.

[9] Yates and Williams, 2003, Simulated Effects of a Proposed Sewer project on Nitrate Concentrations in the Los Osos Valley Groundwater Basin.
[10] Department of Water Resources, 1972, Sea Water Intrusion: Morro Bay Area, San Luis Obispo County, February 1972.

Aquifer Zone E

The Lower Aquifer has been divided into two zones based on a relatively continuous clay bed (AT3 Clay) which parallels the regional aquitard, but at greater depth. Zone E is thicker than Zone D in the Western and Central Areas, and includes sands and gravels of the Paso Robles Formation underlain by Careaga Formation marine sands with sea shells.

Due to the greater density of seawater compared to freshwater, the difference in pressure between seawater and freshwater increases with basin depth. As a result, seawater intrusion into the deeper Zone E is more extensive than into Zone D, both in area and concentration. Zone E monitoring well LA4, located on Sea Pines Golf Course at the west end of Howard Avenue, has produced seawater since construction in 1985.[11] The farthest inland extent of seawater intrusion in the basin was observed at LA15 (Palisades Avenue), where Zone E chloride concentrations reached 1,910 mg/L in November 2012.[12] By comparison, chloride concentrations in Zone D at LA15 measured 85 mg/L following well modification in April 2013[13], and measured 102 mg/L in April 2019.

There are four monitoring wells specific to Zone E west of Los Osos Creek. LA4, mentioned above, is surveyed with downhole geophysics every three years to measure vertical changes in the seawater intrusion front.[14] Well LA21, located at the LOCSD South Bay yard, has unique water quality characteristics (elevated pH with carbonate alkalinity) and is not currently used for seawater intrusion monitoring.[15]

The two remaining Zone E monitoring wells, LA11 and LA18, are strategically positioned and monitored for seawater intrusion. LA18 (LOCSD 10th Street yard) is between water supply well LA15 (Palisades Avenue) and supply well LA20 to the east. Water quality at LA18 has been stable historically and has not shown evidence of seawater intrusion. LA11 (Pasadena Drive) is located on the bay, northwest of water supply well LA12. Seawater intrusion in Zone E is moving toward LA11, and is the focus of this adaptive management review.

Chloride Concentrations and Ion Ratios

Chloride concentration trends and ion concentration ratios are useful for interpreting seawater intrusion trends. Sodium and chloride are the main dissolved constituents in seawater. Sodium is a cation (positively charged ion) which interacts with the soil matrix through ion exchange, while chloride is an anion (negatively charged ion) and does not interact with the soil matrix.

[11] Yates and Wiese, 1988, Hydrogeology and Water Resources of the Los Osos Valley Ground-Water Basin. U.S.G.S. Water Resources Investigations Reoprt 88-4081.
[12] CHG, 2013, Palisades well chloride source testing and mitigation plan, Technical Memorandum, January 11, 2013.
[13] CHG, Palisades Well Modification, Technical Memorandum, June 18, 2013.
[14] CHG, 2018 Annual Groundwater Monitoring Report, June 2019.
[15] CHG, 2014 Seawater Intrusion Monitoring, Los Osos Valley Groundwater Basin, TM dated October 7, 2014.

Increasing chloride concentration is a simple indicator of seawater intrusion, but may also result from other sources of chloride (such as water softener and wastewater discharges).

The sodium-to-chloride ion ratio can be diagnostic of active seawater intrusion when the ion ratio drops below that of seawater (0.86 molar) due to ion exchange activity. Other major cations (calcium and magnesium) that are present in Basin fresh water have a greater valence and associated electrical charge than the sodium cations, and are preferentially sorbed to the ion exchange sites in the soil matrix (such as clay surfaces) prior to intrusion. The high concentration of sodium in seawater (compared to other cations) however, increases the sodium exchange potential, resulting in significant sodium ion replacement for calcium and magnesium ions in the soil matrix.[16]

Figure 5 shows the chloride concentration trends for LA11 and LA12. Sodium-to-chloride ion ratio trends for the wells are shown in Figure 6. Both LA11 and LA12 are shown because intrusion at LA11 represents a potential threat to supply well LA12.

The chloride concentration trend at community supply well LA12 (Zone D) has been increasing at approximately 1.8 mg/L per year since the well was constructed in 1986. By comparison, the chloride concentration at monitoring well LA11 (Zone E) was stable between 1970 and 2009, but has been increasing at 16.7 mg/L per year since then (Figure 5). The sodium-to-chloride ion ratio shows a decreasing trend at LA12 with stabilization close to 0.86 beginning in 2009, while the LA11 ratio is relatively stable through 2005, decreasing sharply to a low of 0.72 in October 2016 and 0.67 in April 2019 (Figure 6).

The data indicate that precursors to seawater intrusion in Zone D have been developing at LA12 in Baywood Park since 1986, although there appears to be stabilization in the ion ratios beginning in 2009. Overall chloride concentrations at LA12 are generally below 100 mg/L, and the increasing trend, at 1.8 mg/L per year, is not an imminent threat to water quality. The recommended secondary standard for chloride in drinking water is 250 mg/L.

Data at LA11, however, indicates that Zone E is experiencing active intrusion toward the well, with sodium-to-chloride molar ratios below the seawater value, and chloride approaching 200 mg/L. Seawater intrusion in Zone E has the capability to move beneath LA12, and to impact the well through upconing (rising into Zone D during pumping).

[16] Cleath & Associates, 2005, Sea Water Intrusion Assessment and Lower Aquifer Source Investigation of the Los Osos Valley Groundwater Basin, October 2005, *after* Bear, J., Cheng, A.H.-D., Sorek, S., Ouazar, D., and Herrera, I., editors, 1999, Seawater Intrusion in Coastal Aquifers – Concepts, Methods, and Practices, Kluwer Academic Publishers, Norwell MA, 625 p.

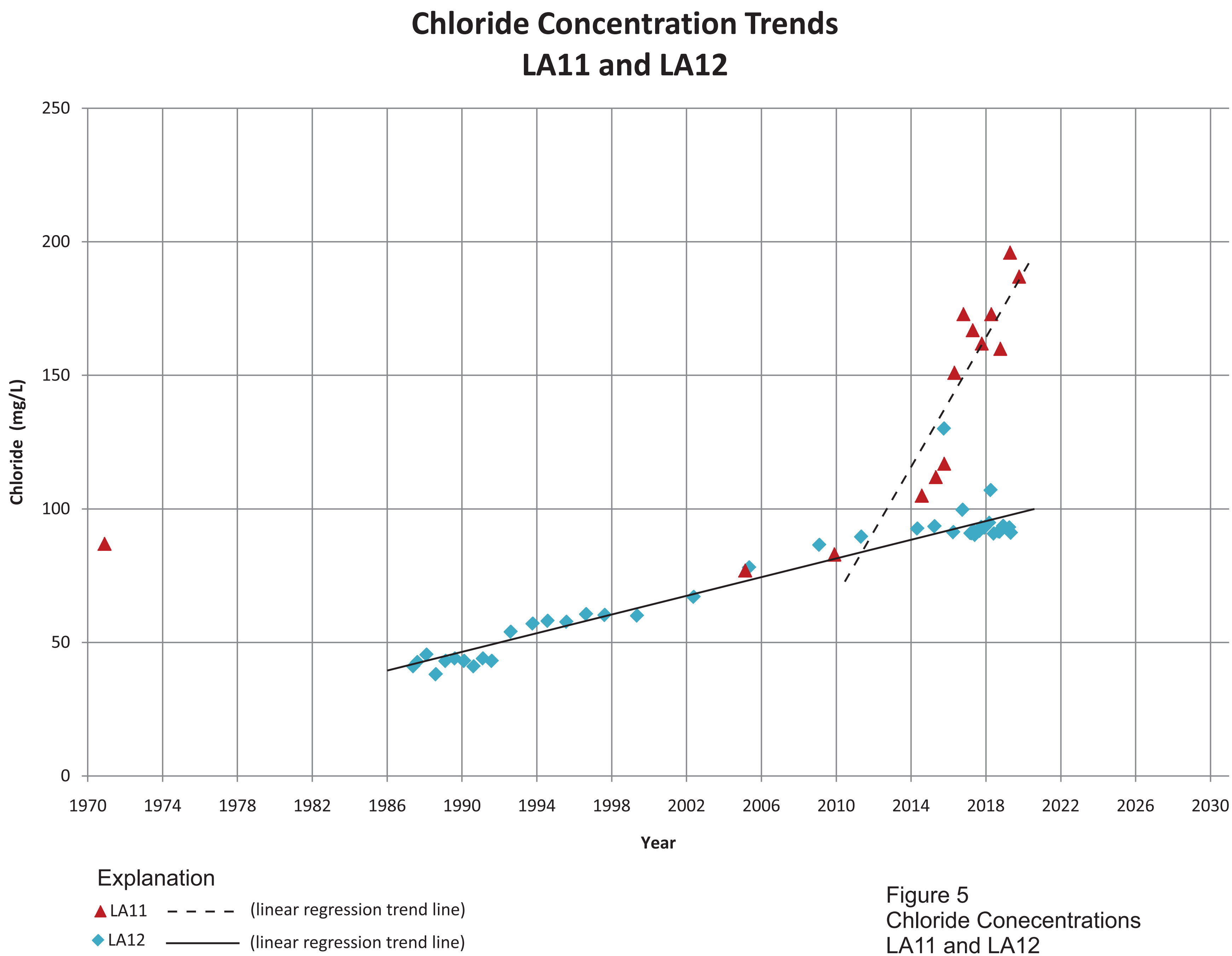


Figure 5
Chloride Conecentrations
LA11 and LA12
2019 Adaptive Management TM

Cleath-Harris Geologists

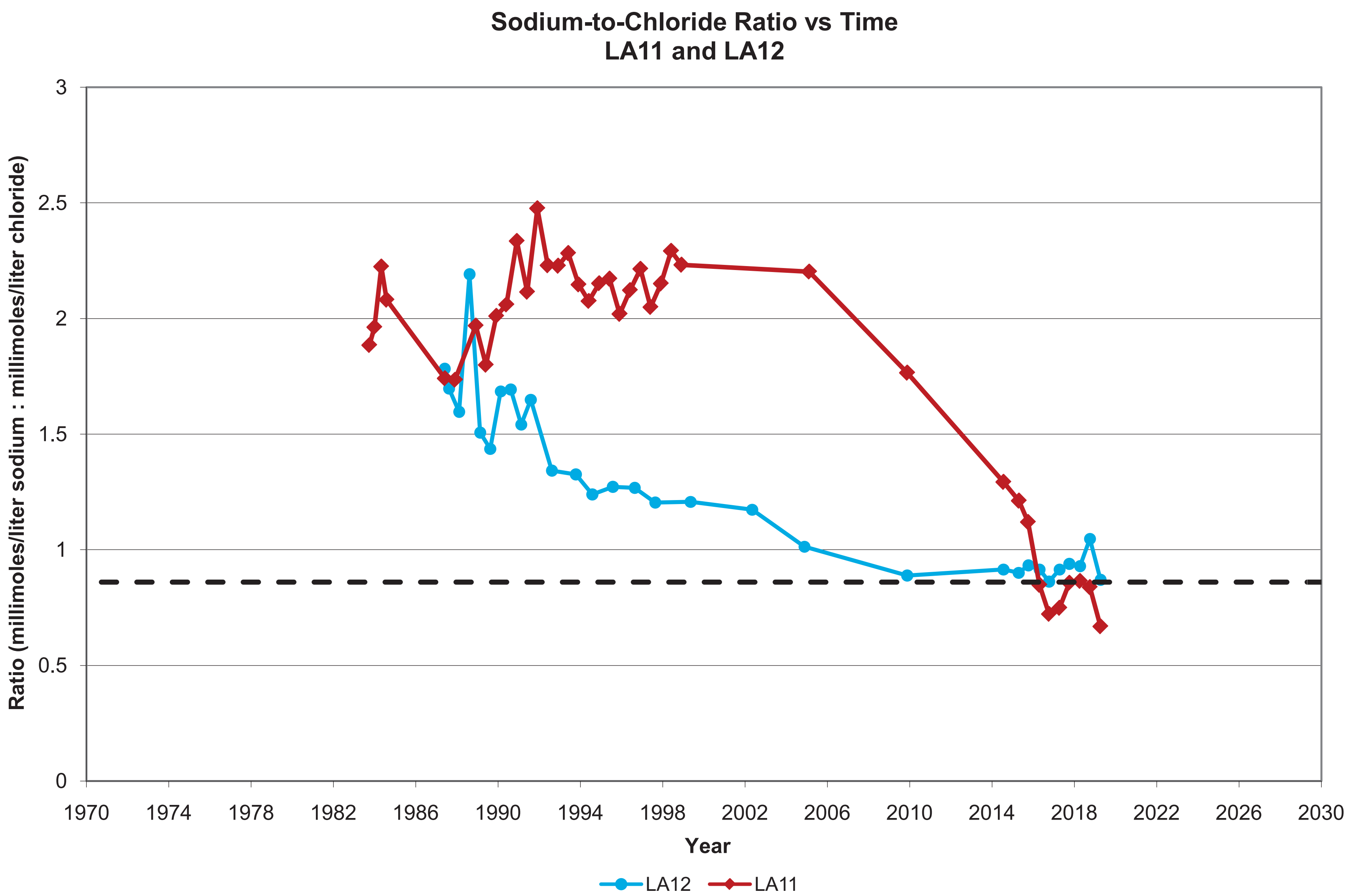


Figure 6
Sodium-to-Chloride Ion Ratios
LA11 and LA12
2019 Adaptive Management TM

Cleath-Harris Geologists

Basin Model Scenarios

The Basin Model allows a comparison between long-term (steady-state) conditions for various infrastructure programs and pumping distributions in the basin. The 2018 adaptive management analysis for LOBP infrastructure Program C included a 2017 sustainable yield scenario and a 2017 pumping distribution scenario.[17] Results of these scenarios indicated that a maximum sustainable yield of 2,760 acre-feet per year (afy) had been developed, and that the level of basin water demand (2,070 afy in 2017) was sustainable without any additional expansion wells.

Seawater intrusion in Zone E at monitoring well LA11 would be expected and is predicted by the Model for the 2017 sustainable yield scenario, which is at Basin Yield Metric (BYM) 100. By definition, BYM 100 scenarios are optimized so that no pumping well exceeds 250 mg/L chloride.[18] Since there are no pumping wells between LA11 and the coast, chloride concentrations at LA11 will exceed 250 mg/L under BYM 100 pumping. For the 2017 sustainable yield scenario, the chloride concentration in Zone E at LA11 stabilizes at approximately 4,200 mg/L, which is over ten times the recommended drinking water standard, whereas the chloride concentration in community supply Zone D at LA12 to the east stabilizes at 250 mg/L.

BYM 100 scenarios, however, are not used for planning future basin conditions in the LOBP. BYM 80 is the maximum level of pumping allowed under the LOBP, and the Basin Model predicts that the seawater front under BYM 80 conditions will retreat toward the coast before stabilizing. Under the 2017 pumping distribution, which is equivalent to BYM 75, chloride concentrations in Zone E at LA11 stabilize in the Basin Model at 50 mg/L.

The sustainability of the 2017 infrastructure and pumping distribution depends in large part on discharges to the Broderson community leachfield, which over time will create a groundwater mound to push water through the regional aquitard and into the Lower Aquifer. Basin Model scenarios operate under steady-state flow conditions, where the Broderson site has a fully developed mound, even though the mound will take several years to develop. Therefore, the trend of increasing chloride at LA11 reflects the current condition, which has not reached steady-state. Without Broderson operating, chloride concentrations at LA11 under the 2017 BYM 75 scenario stabilize at 2,800 mg/L in the Basin Model.

Seawater Intrusion Discussion

The seawater intrusion front, based on contouring the 250 mg/L chloride isopleth between Lower Aquifer wells in the Western and Central Areas, has retreated toward the coast in both 2017 and 2018.[19] However, as noted in the 2018 Annual Report, contours are a simplification of Basin

[17] CHG, Los Osos Basin Plan Metric Trends Review and Infrastructure Program C Evaluation, TM dated February 28, 2019.
[18] 2015 Los Osos Bain Plan Update
[19] CHG, 2018, Annual Groundwater Monitoring Report for the Los Osos Valley Groundwater Basin, June 2019.

conditions, and the calculated position of the intrusion front can vary significantly from year to year, and from Spring to Fall due to localized chloride fluctuations, particularly at Well LA10. Continued advance of seawater in Zone E toward LA11 is a reminder that the basin is still recovering from the effects of decades of overdraft, and the groundwater mound beneath the Broderson site is still years away from becoming fully functional as a means of mitigating seawater intrusion in the Lower Aquifer.

Upper Aquifer water levels at monitoring well FW6 (adjacent to the Broderson site) are rising at approximately 5.5 feet per year. The Basin model projects steady-state equilibrium in the Upper Aquifer will be reached at groundwater elevations that are approximately 30-40 feet higher than present under the Broderson site, which would be reached in 5-7 years. Until a known rate of increase in the Lower Aquifer attributable to Broderson mounding is measured, the timing of recovery will be uncertain. The Lower Aquifer water level metric is currently rising at approximately 0.4 feet per year, which projects basin water level metric recovery (to the target level of 8 feet above sea level) by 2033.[20] Lower Aquifer water levels are expected to begin rising at a faster rate once the influence of the Broderson groundwater mound takes effect.

One adaptive management action that would help provide early detection of Broderson influence on Lower Aquifer water levels would be to expand the pressure transducer network, both in the Upper Aquifer and the Lower Aquifer downgradient of the Broderson site. Now that the transducer at UA6 has confirmed groundwater is mounding on the regional aquitard, further characterize of mound development is recommended.

A second adaptive management action would be to construct a fully transient Basin Model, which would simulate variable density flow (seawater intrusion) with both seasonal and long-term basin flow conditions. This action would allow the Basin Model to provide better input on the timing of Basin recovery. In addition, an upgraded Basin Model could be used for nitrate solute transport simulations, which would be useful for projecting nitrate trends. The LOBP includes consideration for upgrading the Basin Model, particularly if grant funding becomes available from the state or federal governments.

The above adaptive management actions involve monitoring and interpretation, but do not change the actual Basin condition. A third action that would improve the Basin condition with respect to seawater intrusion mitigation would be to complete LOBP infrastructure Program B. Program B involves drilling new Upper Aquifer wells to allow further reductions in Lower Aquifer pumping. The greatest expense for Program B is a centralized treatment plant for nitrate removal. Implementing Program B may also be used to address the increasing nitrate trends at Lower Aquifer wells.

[20] CHG, 2018, Los Osos Basin Plan Trends Review and Infrastructure Program C Evaluation, February 28, 2019.

Conclusions and Recommendations

The following conclusions were reached during the Lower Aquifer nitrate trend review and LA11 seawater intrusion evaluation:

- Trends of increasing nitrate concentrations at several Lower Aquifer wells range from 0.025 mg/L to 0.3 mg/L NO_3-N per year, while concentrations at other wells remain low to non-detected for nitrate.

- Nitrate concentrations at three Lower Aquifer community supply wells (LA8, LA9, and 17E11) are projected to exceed the State drinking water standard in the future based on current trends. Long-term NO_3-N concentrations in Lower Aquifer groundwater are expected to equilibrate below 5 mg/L (less than half the drinking water standard), but will peak at higher concentrations in the above production wells before declining.

- Lower Aquifer Zone E is experiencing active seawater intrusion toward well LA11, with chloride concentrations approaching 200 mg/L and increasing by close to 17 mg/L per year. Seawater intrusion moving past LA11 in Zone E has the potential to continue southeast and adversely impact Zone D community supply well LA12.

- Seawater intrusion mitigation depends in large part on discharges to the Broderson community leachfield, which over time will create a groundwater mound to push water through the regional aquitard and into the Lower Aquifer. The Basin Model indicates that when fully developed, the Broderson groundwater mound will reverse seawater intrusion at LA11 and throughout the Western Area. Based on water level trends at monitoring well FW6, the mound will take several more years to develop in the Upper Aquifer, and longer in the Lower Aquifer. The trend of increasing chloride at LA11 reflects the current condition.

The following adaptive management recommendations are based on the above conclusions:

- Provisions for future nitrate removal at LA8, LA9, and 17E11, and/or blending with low-nitrate water from other wells through an interconnected community water system are recommended. To the extent that these provisions may not be included in the existing infrastructure programs, modifications to the LOBP would be appropriate.

- Expansion of the pressure transducer network is recommended to allow better characterization of the groundwater mound developing beneath the Broderson site and early detection of its anticipated influence on Lower Aquifer water levels.

- Consider initiating existing LOBP actions related to upgrading the Basin Model and completing infrastructure Program B.

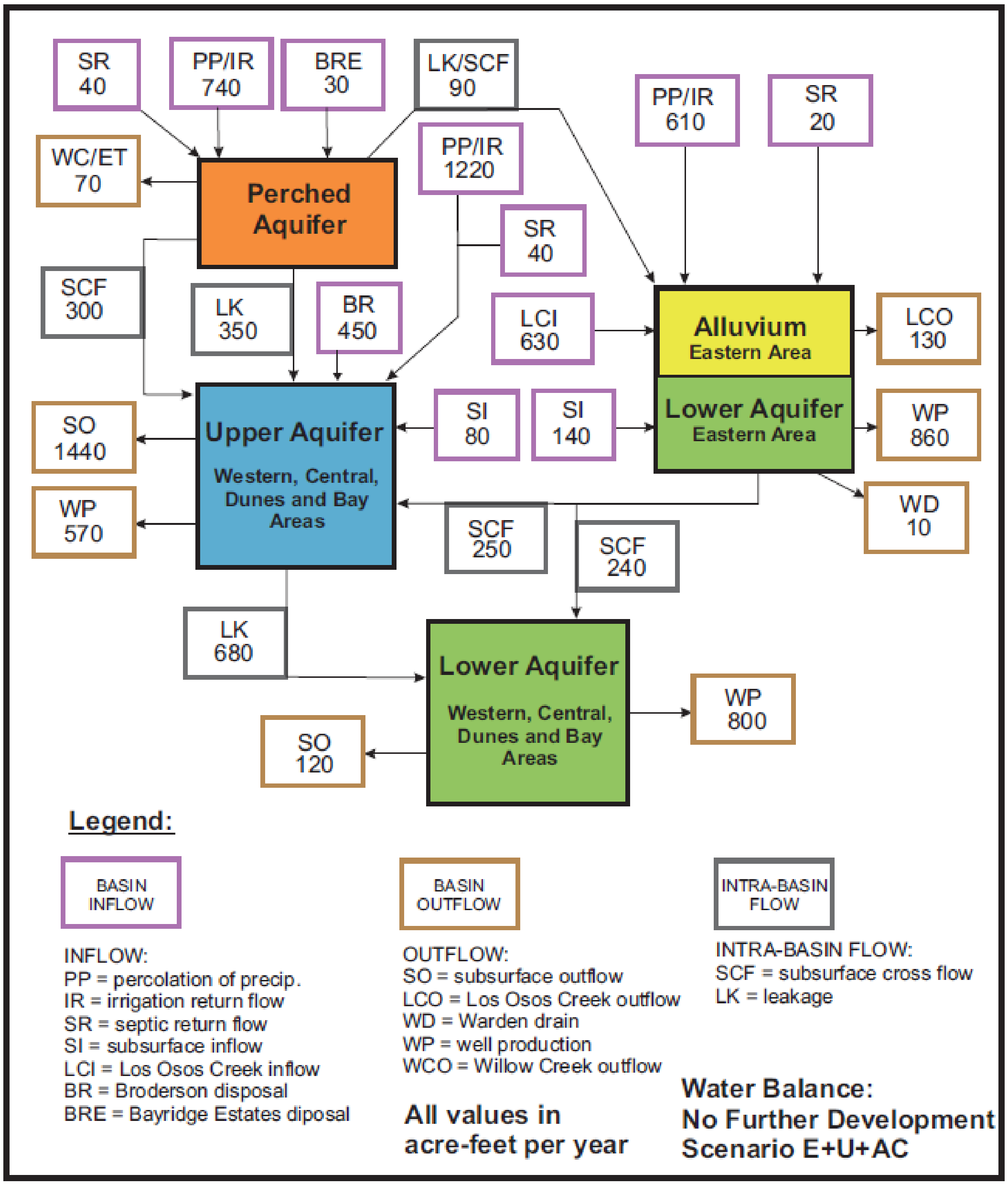
ATTACHMENTS

ATTACHMENT A:

Figure 74

Source:
2015 Los Osos Groundwater Basin Plan Update

Figure 74. Water Balance: No Further Development



Source: 2015 Los Osos Basin Plan Update

ATTACHMENT B

Figure 23

Source:
Yates, G., and Williams, D, 2003, Simulated Effects of a Proposed Sewer Project on Nitrate Concentrations in the Los Osos Valley Groundwater Basin

Figure E11 and Figure E15

Source:
2018 Salt/Nutrient Management Plan for the Los Osos Groundwater Basin

Source: 2003, Simulated Effects of a proposed Sewer Project on Nitrate Concentrations in the Los Osos Valley Groundwater Basin

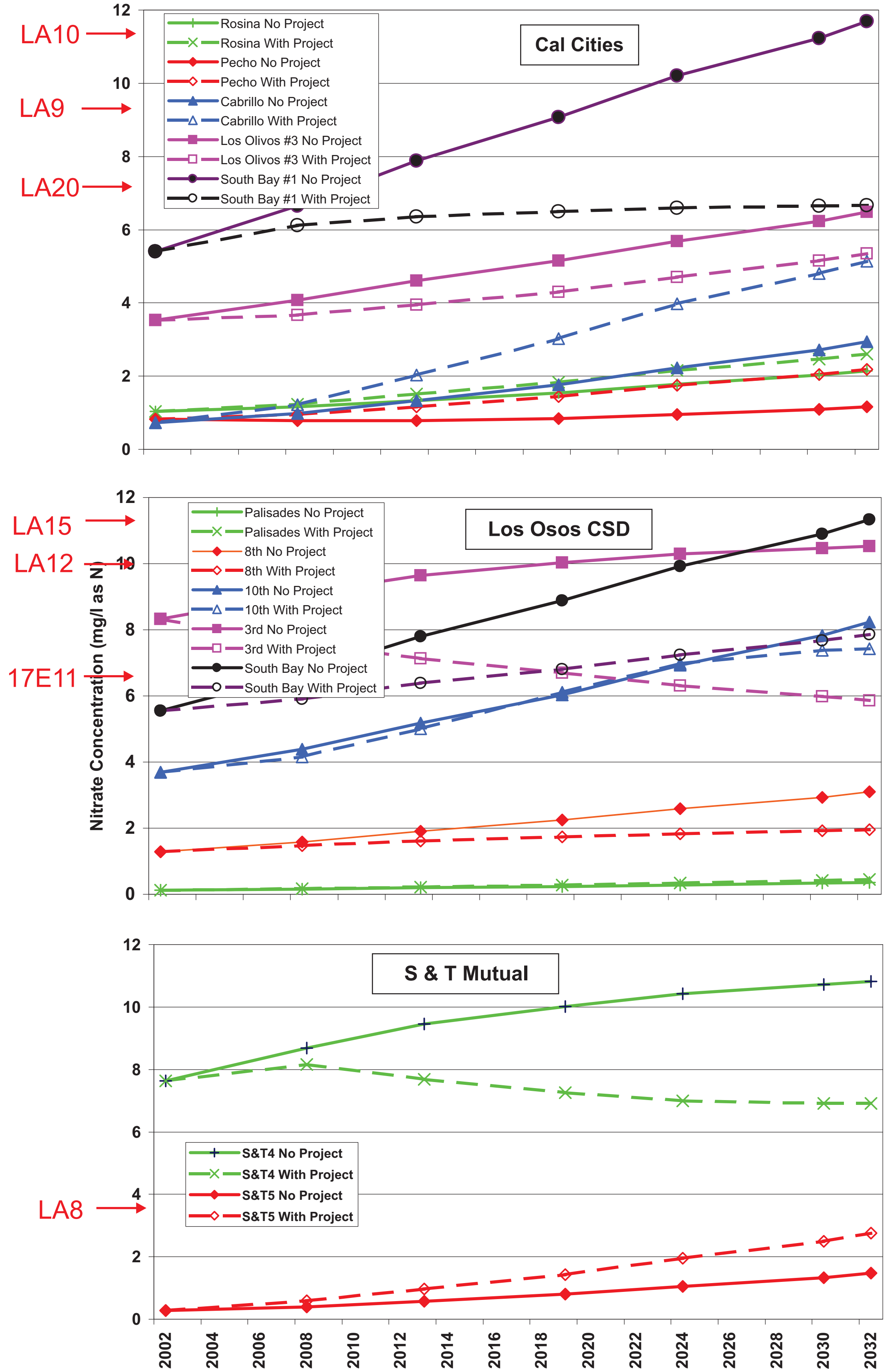
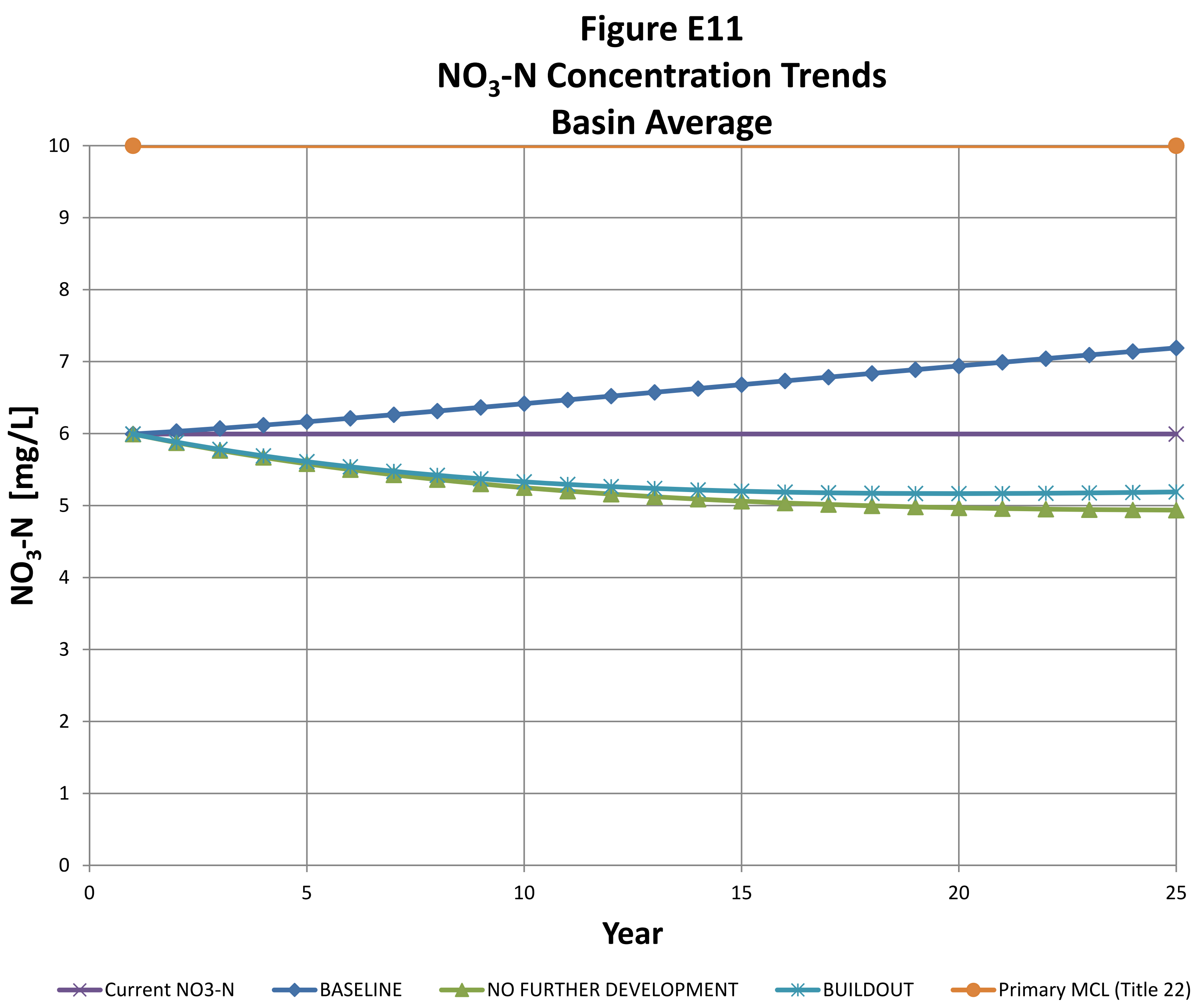


Figure 23. Chemographs of Simulated Nitrate Concentrations in Municipal Wells during 2003-2032, with and without Proposed Sewer Project

LOBP Program IDs added by CHG for 2019 Adaptive Management TM

Source: 2018 Salt/Nutrient Management Plan for the Los Osos Groundwater Basin



Source: 2018 Salt/Nutrient Management Plan for the Los Osos Groundwater Basin