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Supervising Water Resources
Control Engineer

FROM: Eric Rapport, C.HG, C.E.G.
Senior Engineering Geologist,
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DATE: 22 July 2014

SIGNATURE: *Original Signed By Eric Rapport*

SUBJECT: POTENTIAL SOURCES, CHRONIC NITRATE IN PRIVATE DOMESTIC WELLS, ANTELOPE BLVD. AREA, NEAR RED BLUFF, TEHAMA COUNTY

Summary:

In 2013, the Central Valley Regional Water Quality Control Board Redding Office (Central Valley Water Board) assisted the Department of Water Resources, Northern District (DWR) with an ongoing investigation of chronic nitrate in domestic wells near Red Bluff, in the Antelope Boulevard Area. DWR sampled 64 domestic wells for total nitrate and major ions. Central Valley Water Board staff assisted with a directed subsample for isotopes and wastewater indicators. United States Geological Survey (USGS) Menlo Park staff provided assistance with isotope data interpretation.

Results indicate that most nitrates are likely from point- and non-point wastewater sources, and continuously dispersing generally southeast in shallow permeable gravels and sands. Based on a preliminary review of potential wastewater sources, I recommend that we take appropriate further regulatory action near-term on three permitted facilities; Rio Vista Estates, Berrendos Community Services District, and Red Bluff RV Park. I recommend that the Tehama County Environmental Health Department take similar near-term action on Snug Harbor Mobile Village. These four facilities have high-capacity, community onsite wastewater treatment systems (OWTS) that may act as chronic point-sources of wastewater-related nitrate pollution. Combined, high-density, low-capacity individual OWTS in residential subdivisions also likely act as non-point nitrate sources. Effect of non-point source wastewater sources on the total nitrate extent is currently indeterminate, and possibly significant.

Therefore, I recommend that the County further review their files for other potential chronic point- and non-point wastewater related nitrate sources. Based on their findings, longer term we should consider requesting a groundwater monitoring well network and numerical pollutant transport model to assess changes in groundwater quality following regulatory action.

Introduction:

The Antelope Boulevard Area has identified chronic nitrate in domestic wells. The subject area, east of the Sacramento River and unincorporated, has mixed agricultural, residential, commercial, light-industrial, and institutional land uses. The area lacks piped potable water and sanitary sewers; individual dwellings have private domestic wells and OWTS. Some larger developments have high-capacity, community OWTS.

In 1987, Department of Water Resources (DWR) staff detected nitrate in private domestic wells in the area; this prompted informal restrictions on further building. DWR found nitrate as NO_3 to 62 milligrams/Liter (mg/L), and attributed detections to agricultural practices and wastewater. In 1988, the Tehama County Environmental Health Department and Central Valley Regional Water Quality Control Board (Central Valley Water Board) agreed informally to restrict building in the area based on State Water Resources Control Board Report 88-11WQ (Report) to the State Legislature. The Report suggests nitrogen removal for residential parcels less than one acre.

More recently, public agencies have considered sanitary sewer extension. Also, further sampling showed nitrate above its primary maximum contaminant level (PMCL). In 2000, the Tehama County Public Health Department issued a Declaration of Public Health Concern, and proposed a time schedule for sanitary sewer construction. The Central Valley Water Board requested a related master plan. In 2002, DWR sampled 88 domestic wells; 20% showed nitrate as NO_3 above 45 mg/L, the California Department of Public Health PMCL and our Water Quality Objective for chemical constituents. In 2003,170 local residents sampled their wells voluntarily; 54% were greater than ½ of the PMCL. In 2007, the State Water Resources Control Board granted the City of Red Bluff $43,673 for planning and designing a sanitary sewer. In 2010, the Tehama County Board of Supervisors authorized a Joint Powers Act to form a related governing agency.

However, affected domestic well owners would likely have mixed opinions on sanitary sewer connection. In the interim, lacking demonstrable correlation between Dischargers and potential receptors, our agency has limited means to address the identified pollution.

To help characterize key potential nitrate sources, in 2013 we assisted DWR with fieldwork and laboratory analyses. In October, Redding Office staff accompanied DWR's field teams. At our suggestion, along with total nitrate DWR requested their contract laboratory to run major ions on their total sample of 64 domestic wells. We added a directed subsample, $25,165 in laboratory fees. With DWR's guidance, we chose 12 wells, 10 with chronic nitrate greater than the PMCL, 1 with nitrate about ½ of the PMCL, and 1 blind duplicate. In the subsample, we requested our contract laboratories to run selected isotopes and wastewater indicators. United States Geological Survey (USGS) Menlo Park staff generously helped interpret isotope data.

The following sections summarize;

- Hydrogeological Setting,

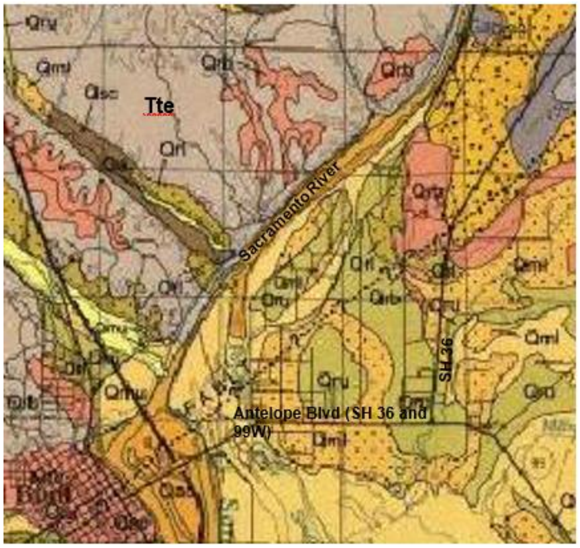
- Total Nitrate and Major Ion Geochemistry Results,
- Isotope Results,
    - Tritium
    - Delta Oxygen-18 and Delta Deuterium of Water
    - Delta Nitrogen-15 and Delta Oxygen-18 of Nitrate
    - Total Boron and Delta Boron-11
- Sucralose and Acesulfame-K Results,
- Interpretations, and
- Recommendations.

Hydrogeological Setting:

The shallowest local aquifer units are Pleistocene and older alluvial sediments. Youngest to oldest, the area overlies the Pleistocene (Quaternary) Modesto, Riverbank, and Red Bluff Formations. Most of the area has exposures of the upper and lower members of the Modesto, and the slightly older Riverbank Formation, upper member. The area has limited exposures of the Red Bluff Formation, a terrace deposit. The Pliocene (Tertiary) Tehama Formation occurs only west of the subject area; erosion has removed most of the relatively younger deposits there. The Tehama, modestly permeable, is locally 1,000 to 2,000 feet thick. All younger deposits, highly permeable, have a local composite thickness typically less than 100 feet (Tehama County Flood Control and Water Conservation District 2012).

Figure 1 is an excerpt enlargement from USGS's geological map mosaic, (http://ngmdb.usgs.gov/maps/mapview/), (portion shown cites Blake, et.al. 2000). Find the Sacramento River, State Highway 36, and Antelope Blvd. (State Highways 36 and 99W). The subject area is east of the river, west of State Highway 36, and to about 3 miles north, and 2 miles south of Antelope. The Tehama (Tte) extends over a broad area west of the river. Riverbank, Modesto, and Red Bluff, (Qru, Qmu, Qml, and Qrb) are east. Of potential interest, also note the buried, inferred Red Bluff Fault, down-to-the-south, with about 450 feet of estimated vertical offset (Harwood and Helley 1987).

Figure 1, Geological Map Excerpt



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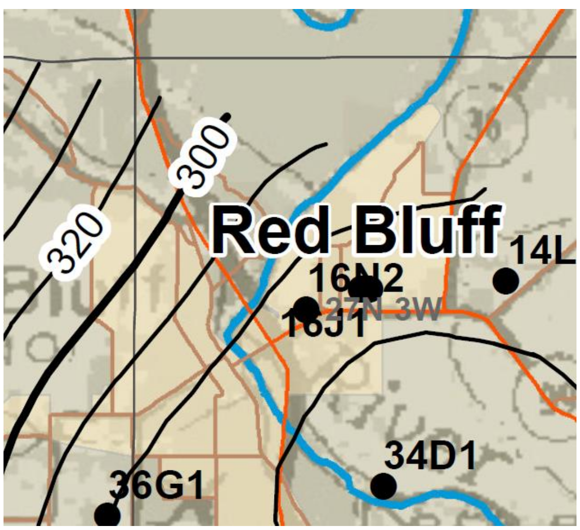
Soils derived from Qru, Qmu, and Qml are generally sandy loams and silt loams. Soils from Qrb are clay loams. Soils from Tte are gravelly sandy loams; see (http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/california/redbluffCA1912/Soil_map.pdf) (I excluded the local soils map; it is similar to the geological map.)

Shallowest hydraulic gradient is generally southeast. Figure 2 is an excerpt from DWR, (http://www.water.ca.gov/groundwater/data_and_monitoring/northern_region/GroundwaterLevel/SacValGWContours/100t400_Wells_Spring-2013.pdf) .

Figure 2, Shallow Hydraulic Gradient Excerpt



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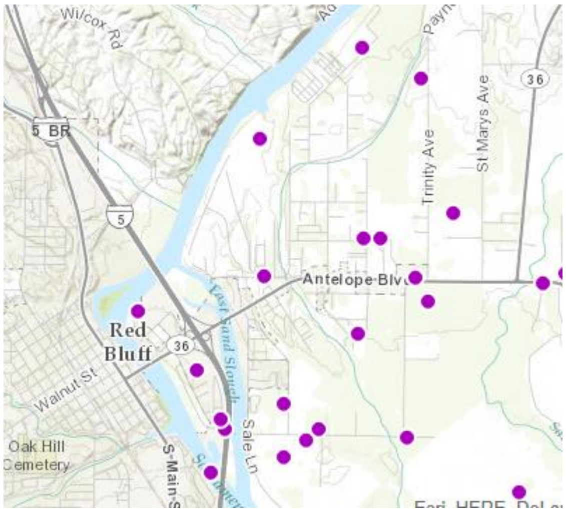
Shallowest groundwater flows are likely within the Modesto and Riverbank Formations, mostly sands and gravels with hydraulic conductivity (K) of 100 to 200 feet/day (ft/day).

Assuming hydraulic gradient (i) of 0.0001 to 0.001, and effective porosity (n_e) of 30%, groundwater velocity (actual, Ki/n_e), may range 0.03 to 0.6 ft/day, ~10 to 220 ft/year. Velocities are probably slower in the underlying Tehama Formation, locally mostly silts. Steeper gradient west of the river might be in part due to greater impedance to flow in the Tehama than in younger sediments. Flatter gradients east of the river are also likely due to aquifer recharge. Depth to the water table has ranged 20 to 40 feet below grade surface, based on several wells in the area. Figure 3, also from DWR, (http://www.water.ca.gov/waterdatalibrary/), shows wells with hydrographic data.

Figure 3, Wells with Hydrographs Excerpt



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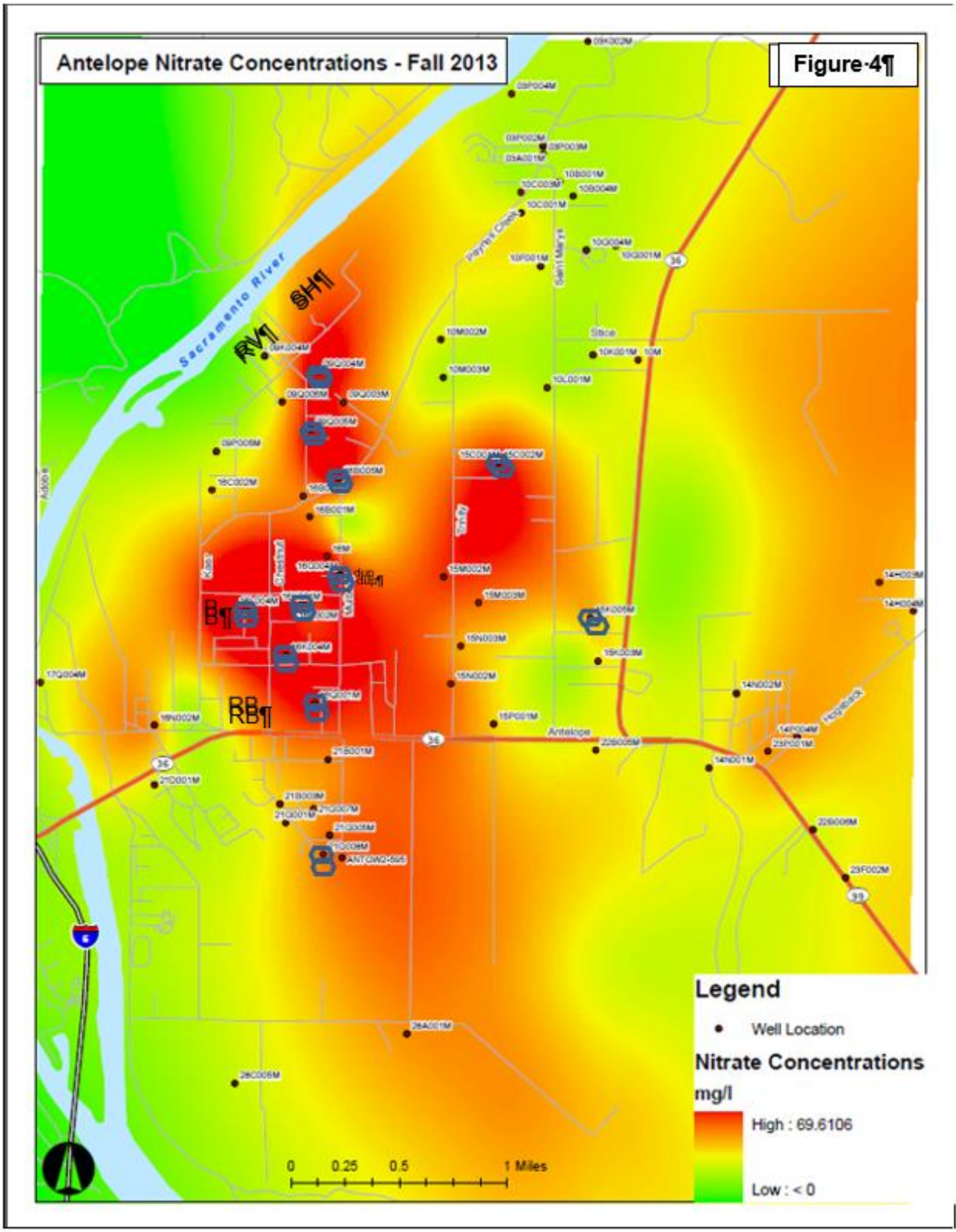
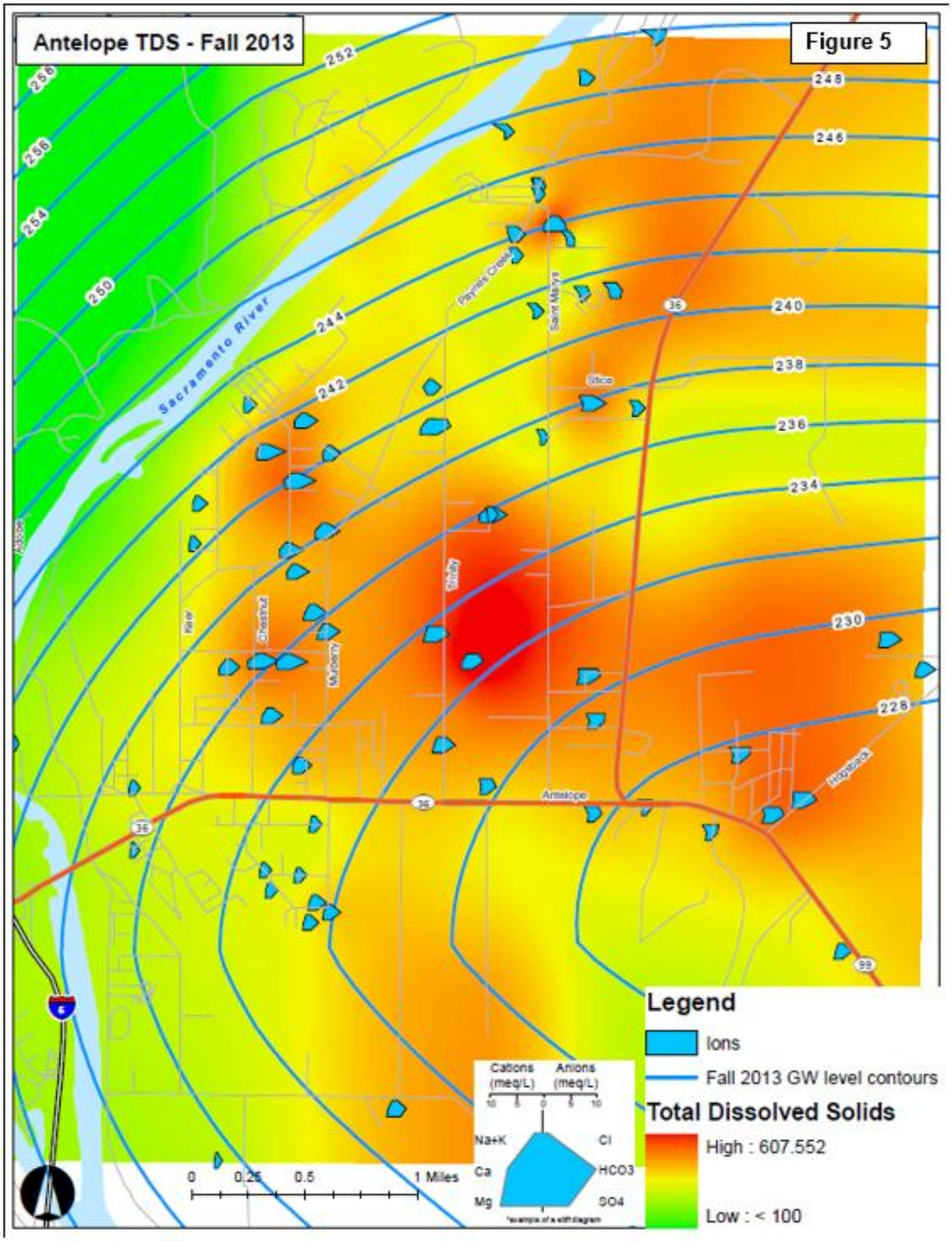
The wells in DWR's data library generally have confidential total depths and perforated intervals. However, 11 of the 64 wells sampled have publicly available records; these show terminal depths ranging 80 to 140 feet below grade surface (bgs). Of these, 3 have recorded perforated intervals; 60 to 80, 72 to 77, and 80 to 120 feet bgs. Therefore, wells with records likely penetrate the Modesto, Riverbank, and Tehama Formations. Several owners we met expressed concern that the water table has recently fallen abruptly due to the drought, and are considering installing deeper wells.

Total Nitrate and Major Ion Geochemistry Results:

Figures 4 and 5, from DWR, show total nitrate, and total dissolved solids (TDS) along with major ions as Stiff Diagrams. Using ArcGIS, DWR staff mapped nitrate and TDS by inverse distance weighting. Nitrate is in milligrams/Liter (mg/L) as NO_3, TDS in mg/L, and major ions, in millequivalents/Liter (meq/L). Our staff assisted with Stiff Diagrams using GeoStiff, a shape file generator from the Texas Water Development Board. According to DWR staff, nitrate distributions are similar to previous events. Of the 64 wells sampled, 10 exceeded the PMCL for total nitrate, about 16%. Blue hexagons on the nitrate map show the directed subsample; see following sections. The well denoted "dup." had the blind duplicate.

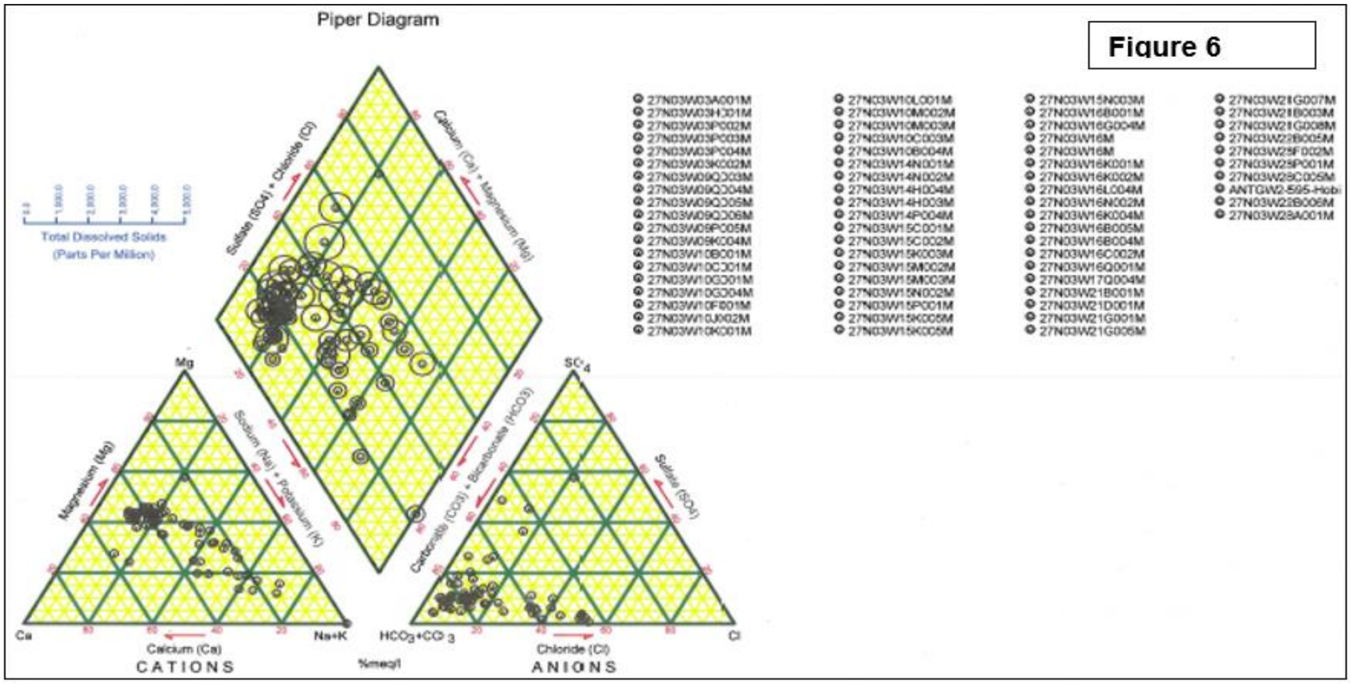
On Figure 4, symbols RV, B, and RB show locations of three facilities with permitted, high-capacity community OWTS; Rio Vista Estates, Berrendos Community Service District, and Red Bluff RV Park, respectively. SH is an identified County regulated facility with closely-spaced, high-capacity OWTS; Snug Harbor Mobile Village. Further discussion on these follows summaries of analytical results.


Antelope Nitrate Concentrations - Fall 2013
Figure 4¶
Sacramento River
Legend
Well Location
Nitrate Concentrations
mg/l
High : 69.6106
Low : < 0
0
0.25
0.5
1 Miles



Antelope TDS - Fall 2013
Figure 5
Sacramento River
Legend
Ions
Fall 2013 GW level contours
Total Dissolved Solids
High : 607.552
Low : < 100
Cations (meq/L)
Anions (meq/L)
Na+K
Ca
Mg
Cl
HCO3
SO4
0 0.25 0.5 1 Miles
256
254
252
250
248
246
244
242
240
238
236
234
230
228
Antelope

For Figure 5, ion balances in wells with nitrate as NO_3 <20 mg/L (0.32 meq/L) showed relative percent differences (RPDs) between cations and ions generally <5%. Higher nitrate caused imbalances, with RPDs to >20%. Addition of nitrate, in meq/L, generally restored balances. Qualitatively, highest TDS correlates with modal calcium and bicarbonate; see also Figure 6, a Piper Diagram via RockWorks® 2006.



Isotope Results:

On 7 and 8 October 2013, we collected our directed subsample. Due to general uncertainty on well perforation depths relative to local aquifer stratigraphy, we requested analyses of tritium, and oxygen-18 and deuterium of water, to assess potential variation of groundwater ages and origins. To assess between potential nitrate sources, for example whether synthetic fertilizer, animal manure, wastewater, or some mixture, we requested oxygen-18 and nitrogen-15 of nitrate. To further check for wastewater, we requested boron-11 and total boron, as potential evidence of household bleach and detergent. Our contract laboratory, ExcelChem, Roseville, subcontracted isotope analyses to ZymaX. Results follow:

Tritium

Table 1 shows results for tritium (^3H), in tritium units (TU), where 1 TU = 1 $^3H/10^{18}$ hydrogen atoms, 3.19 picoCuries/Kilogram. Most tritium, with a short half-life, 12.43 years, occurs in modern groundwater due to atmospheric testing of thermonuclear bombs from 1951 to 1980, with peak production in 1963 (Clark and Fritz 1997; see Chapter 7).

Table 1, Tritium Results Summary

Well ID	Tritium of H_20 (TU)
16Q001M	2.18
16K004M	2.26
09Q004M	2.26
09Q005M	1.53
16K001M	2.21
16B005M	2.39
16L004M	2.66
15C001M	2.03
15K005M	2.39
21G008M	2.20
16G004M	2.11
16G004M-dup	2.13

Results show low variation, ranging 1.53 to 2.66 TU, with an average of 2.20. Difference between duplicates was 0.02 TU. Reported analytical precision was 0.17 TU. For continental groundwater, qualitatively this indicates a mixture of sub-modern (pre-1952) and recent recharge. Overall, data indicate similar age among wells.

Delta Oxygen-18 and Delta Deuterium of Water

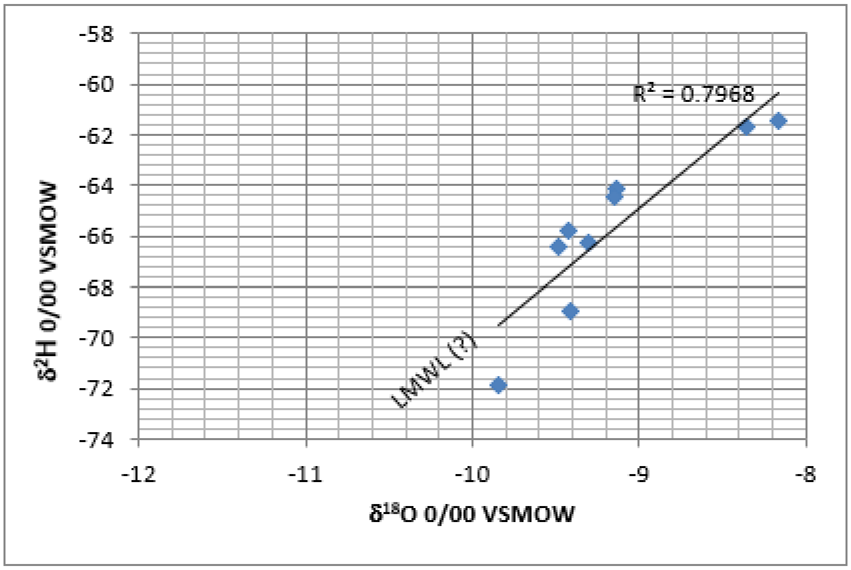
Table 2 shows results for delta oxygen-18 ($\delta^{18}O$) and delta deuterium (δ^2H), in parts per thousand (per mil, 0/00) relative to Vienna Standard Mean Ocean Water (VSMOW).

Table 2, Oxygen-18 and Deuterium of Water Summary

Well ID	$\delta^{18}O$ of H_20 (‰ VSMOW)	$\delta^{2}H$ of H_20 (‰ VSMOW)
16Q001M	-9.83	-68.15
16K004M	-9.72	-67.35
09Q004M	-9.48	-66.63
09Q005M	-9.43	-65.82
16K001M	-9.14	-64.10
16B005M	-9.15	-64.46
16L004M	-9.41	-68.96
15C001M	-8.36	-61.67
15K005M	-8.16	-61.44
21G008M	-9.84	-71.89
16G004M	-9.49	-66.42
16G004M-dup	-9.31	-66.27

Differences between duplicates for $\delta^{18}O$ and $\delta^{2}H$ were 0.18, and 0.15 0/00, respectively. Reported analytical precisions were 0.10, and 0.40 0/00. Results show that oxygen-18 and deuterium are fairly co-linear; regression coefficient is ~0.8; see Plot 1.

Plot 1, Oxygen-18 versus Deuterium



Assuming the regression represents a local meteoric water line (LMWL), data indicate no obvious oxygen-18 enrichment relative to deuterium, therefore no current evidence of a partially evaporated source (Clark and Fritz 1997, see Chapter 4). Generally low variation indicates similarity between wells; oxygen-18 ranges -9.84 to -9.28 0/00, and deuterium, -71.89 to -61.44 0/00, with averages of -9.28 and -66.05.

Delta Nitrogen-15 and Delta Oxygen-18 of Nitrate

Table 3 shows delta nitrogen-15 ($\delta^{15}N$) and oxygen-18 ($\delta^{18}O$) of nitrate, in parts per thousand (per mil, 0/00) relative to air standard.

Table 3, Nitrogen-15 and Oxygen-18 of Nitrate

Well ID	$\delta\ ^{15}N$ of NO_3 (‰ Air)	$\delta\ ^{18}0$ of NO_3 (‰ Air)
16Q001M	7.35	-0.41
16K004M	7.53	-0.27
09Q004M	7.65	0.39
09Q05M	7.82	0.39
16K001M	7.28	0.05
16B005M	7.52	0.18
16L004M	7.42	-0.20
W15C001M	7.34	0.38
15K005M	7.09	-0.17
21G008M	7.59	0.12
16G004M	7.45	-0.13
16G004M-dup	7.33	-0.03

Results show low variation; nitrogen-15 ranges 7.09 to 7.82 0/00 and oxygen-18, -0.41 to 0.39 0/00, with averages of 7.45 and 0.03. Differences between duplicates for

δ^{15}N andδ^{18}0 were 0.12, and 0.10 0/00. Reported analytical precisions were 0.20, and 0.47 0/00. Results generally counter-indicate a mixture of sources.

Total Boron and Delta Boron-11

Table 4 shows total boron (B) in micrograms/Liter (µg/L), and delta boron-11 (δ^{11}B) in parts per thousand (per mil, 0/00) relative to a standard reference material (SRM-951).

Table 4, Total Boron and Boron-11

Well ID	B (µg/L)	δ^{11}B (‰ SRM-951)
16Q001M	149	19.4
16K004M	83.2	21.2
09Q004M	<50#	7.6
09Q005M	<50#	8.3
16K001M	67.9	17.6
16B005M	<50#	16.5
16L004M	96.4	15.4
W15C001M	<50#	19.2
15K005M	1030	30.3
21G008M	92.1	9.7
16G004M	55.9	*23.6*
16G004M-dup	56.0	*3.2*

Method Reporting Limit, MRL

In contrast to other isotopes, total boron and boron-11 show high local variation. Total boron data appear accurate; RPD of duplicates is 0.18%. Well 15K005M has highest total boron; see Figure 4. This well is east of Trinity, closest to State Highway 36. For δ^{11}B, the difference between duplicates is 20.4 0/00 and the reported analytical precision is 0.3 0/00, which indicates a data quality issue.

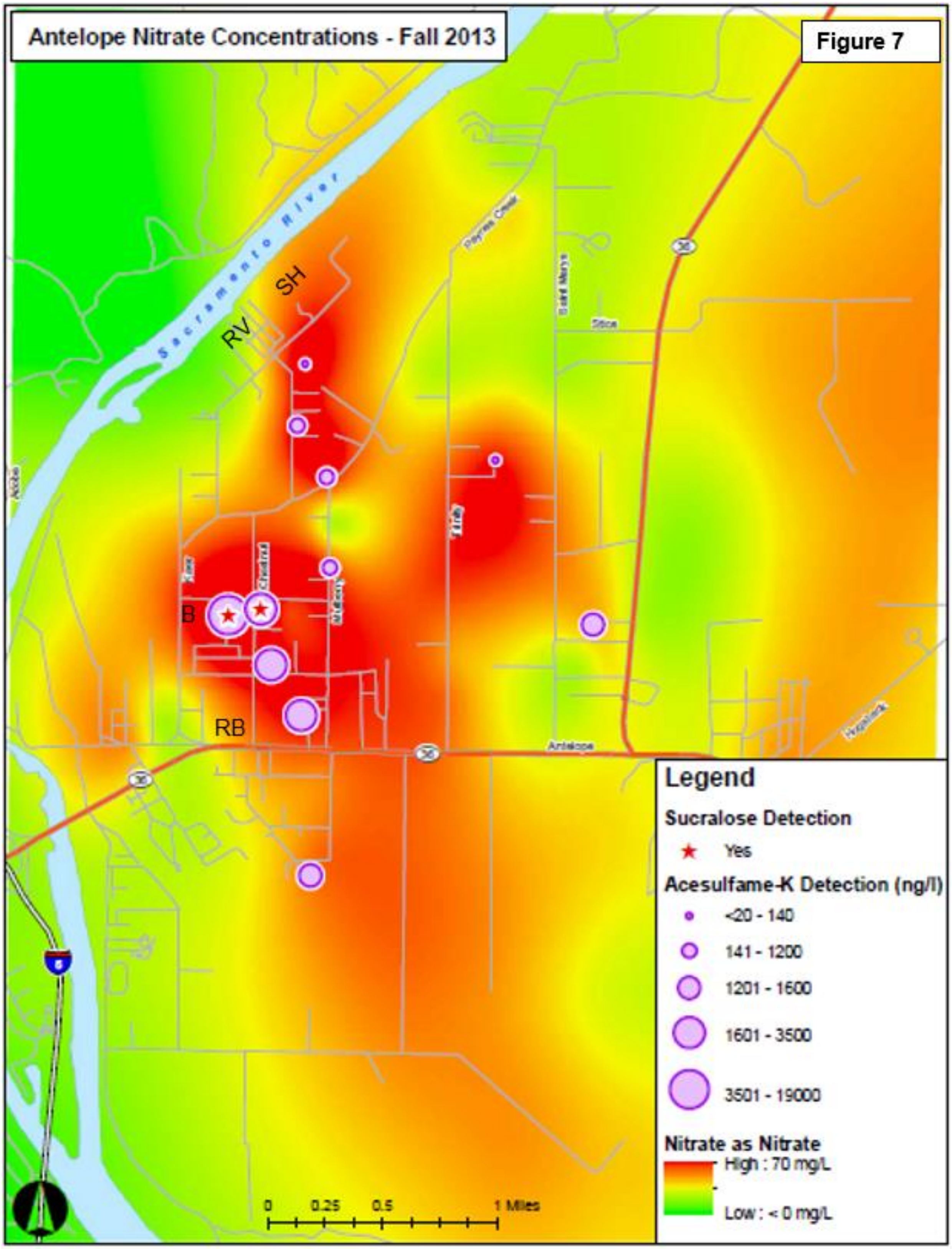
Sucralose and Acesulfame-K Results:

We first chose sucralose (i.e., Splenda®) as a wastewater indicator due to its stability relative to others such as caffeine (Oppenheimer, et al 2011, 2012). Based on further reviews of current technical literature, we added another artificial sweetener, acesulfame-K, which is reportedly more stable than sucralose in groundwater. (Buerge, et al 2009, Van Stempvoort et al 2011). ExcelChem subcontracted to Eurofins Eaton Analytical for sucralose and acesulfame-K analyses. Table 5 shows results in nanograms/Liter (ng/L).

Table 5, Sucralose

Well ID	Sucralose (ng/L)	Acesulfame-K (ng/L)
16Q001M	<100	3,500
16K004M	<100	3,300
09Q004M	<100	140
09Q005M	<100	770
16K001M	160	3,000
16B005M	<100	1,000
16L004M	1200	19,000
W15C001M	<100	<20
15K005M	<100	1,600
21G008M	<100	1,600
16G004M	<100	1,200
16G004M-dup	<100	1,200

Two wells showed positive for sucralose, 16K001M and 16L004M; these wells are east and west of Chestnut, about ½ mile north of Antelope. Ten of eleven wells showed positive for acesulfame-K. RPD of duplicates for acesulfame-K was lower than analytical precision. Figure 7 from DWR, shows nitrate and wastewater indicators. Also annotated are local high-capacity community OWTS; see *Interpretations*, next section.


Antelope Nitrate Concentrations - Fall 2013
Figure 7
Sacramento River
SH
RV
B
RB
Antelope
Legend
Sucralose Detection
Yes
Acesulfame-K Detection (ng/l)
<20 - 140
141 - 1200
1201 - 1600
1601 - 3500
3501 - 19000
Nitrate as Nitrate
High : 70 mg/L
Low : < 0 mg/L
0 0.25 0.5 1 Miles

Interpretations:

Based on the above, total nitrate in the subject area is continuously migrating southeast. Nitrate is chronic, with generally similar detections in domestic wells for over 20 years. The following is an analysis of potential sources.

Based on major ion geochemistry, tritium, and oxygen-18 results, nitrate pollution has likely followed consistent pathways. Spatially, total nitrate does not correlate strongly with TDS and major ions; see Figures 4 and 5. TDS, and modal calcium and bicarbonate from the total sample do correlate spatially; see Figures 5 and 6. While calcium and bicarbonate anomalies might be anthropogenic, they do not appear to correlate with nitrate pollution. Because total nitrate affects overall major ion balance, overall major ion distributions may have pre-existed nitrate discharge; calcium and bicarbonate anomalies might indicate flow paths that nitrate followed. Groundwater from wells in the directed subsample is similar in age and origin; see tritium, and delta oxygen-18 and delta deuterium of water results. Therefore, nitrate appears to have generally dispersed along consistent pathways, generally southeast through the area.

While current data are limited, boron in the directed subsample shows high variation, similar in overall magnitude to TDS and major ions; see total boron results. Local results may likewise be from an ambient source (Megan Young, PhD, Isotope Geochemist, USGS, pers. comm. 2013). Therefore, further boron data could help indicate overall flow paths. (Because boron-11 data have precision issues, I do not consider them in this analysis.)

While some dilute oxygen-18 of nitrate results might be imprecise, nitrogen-15 from all wells in the subsample is from one similar source, rather than a mixture; see delta nitrogen-15 and delta oxygen-18 of nitrate results. The total range of nitrogen-15 is very small in the directed subsample, counter-indicating a mixture of sources (Megan Young, pers. comm. 2013). Two wells in the subsample were positive for sucralose, ten for acesulfame-k, wastewater indicators. Therefore, nitrate in all wells from the directed subsample is mostly from wastewater.

Wastewater sources in the area include high-capacity, community OWTS and low-capacity, closely spaced individual OWTS; therefore nitrate could disperse from point- and non-point sources.

Assuming continuous point-source nitrate injection for infinite time, holding nitrate source (effluent) concentration and other parameters constant, overall plume size is a function of injection rate; for example, let;

$C_{(x,y)} = (C_0(\mathbf{Q}/b)/(2\pi(D_L/D_T)^{1/2} \exp(v_x x/2D_L)K_0[(v_x{}^2/4(D_L)(x^2/D_L+y^2/D_T))^{1/2}]$

(Fetter 1999, Equation 2.3a)

Where:

$C_{(x,y)}$ = solute (nitrate) concentration, down-gradient (x) and cross-gradient (y) from a source (x,y= 0,0) at infinite time,
C_0 = point source concentration (nitrate in effluent)
Q *= injection rate (nitrate loading)*,
b = aquifer thickness,
D_L = hydraulic dispersion coefficient, lateral (down-gradient),#
D_T = hydraulic dispersion coefficient, transverse (cross-gradient),#
v_x = actual groundwater velocity (see *Hydrogeological Setting*),
x = distance down-gradient from the source, along plume centerline,
y = distance cross-gradient from the source, and
K_0 = modified Bessel function of the second kind and zero order.

#, D_L and D_T are logarithmic functions of total plume length and groundwater velocity.

Table 6, a preliminary conceptual site model (CSM) based on the above equation, assumes a point source, and a total plume length of 2,000 feet. The CSM is subject to change based on further site investigations.

Table 6, Preliminary CSM, Nitrate Dispersion from Point Sources

Parameter	**Individual Low-Capacity OWTS on Large Parcel**	**Community High-Capacity OWTS**
C_0, mg/L nitrate as NO_3	135	135
Q, ft^3/day	*40*	*700*
b, ft	20	20
D_L, ft^2/day	7.4	7.4
D_T, ft^2/day	0.74	0.74
v_x, ft/day	0.5	0.5
x to PMCL, ft (45 mg/L)	<100	>2,000
x to 1/2 PMCL, ft (22.5 mg/L)	<100	>2,000
$C_{(x,y)}$ at x = 2,000 ft, y=0	2.8	48.9

The above estimate for an individual, low-capacity OWTS on a relatively large parcel is generally consistent in length with published studies (e.g., EPA 2002; see Chapter 3). For such a relatively isolated OWTS, assigned Q is 300 gallons/day (gpd), conservative assuming an average person uses 70 gpd. For high-capacity community OWTS, assigned Q is 5,000 gpd. While individual low-capacity OWTS on large parcels might impact nearby domestic wells, the preliminary CSM indicates that high-capacity community OWTS are more capable of producing plumes of the general scale shown on Figure 4. Table 7 summarizes the facilities shown on Figure 4 with high-capacity community OWTS.

Table 7, Identified Potential Sources of High Nitrate Loading Rates from Wastewater

Facility	**Type**	**Lead Agency**	**Permit**	**Q, gpd**	**Q, ft^3/day**
Rio Vista Estates	Treatment and percolation ponds	Central Valley Water Board	Order 93-086	15,300	2,045
Berrendos CSD	Individual pretreatment septic tanks, community treatment system	Central Valley Water Board	Order 98-132	>5,760	>770
Red Bluff RV Park	High-capacity community septic tank and leach-field	Central Valley Water Board	Order 91-185	7,000	936
Snug Harbor Mobile Village	Several closely spaced, high-capacity septic tanks and leach-fields	Tehama Co. Env. Health Dept.	local agency	~6,000	~800

Rio Vista Estates discharges approximately 15,300 gpd from 190 mobile homes to aerated stabilization/percolation ponds (Finding 3, Order 93-086). The facility, constructed in 1970, consists of a wet well with an outlet to a 70,000-gallon, concrete lined aerated lagoon. Sewage flows by gravity to a 90,000-gallon stabilization pond, then to two ½-million gallon oxidation/percolation ponds. Some domestic wells sampled southeast of the treatment system, on North Kaer Avenue, Drury Lane, and West Avenue, show relatively low nitrate concentrations. However others, on Krueger, Chucker, and Dunvin Courts, show chronically high nitrate concentrations, possibly attributable to this facility due to limited information on the system's construction currently in our case file. The Monitoring and Reporting Program in the Order requires groundwater monitoring, and the Discharger has complied. However, monitoring results are limited, from one, typically dry groundwater monitoring well northwest of the system.

Berrendos Community Services District discharges 5,760 to 6,000 gpd from 21 individual, 1,500-gallon septic tanks; these flow to recirculating textile filters, a four-compartment 5,300-gallon fiberglass tank, an up-flow filter, and then a leach-field (Finding 4, and Discharge Specification 4, Order 98-132). Nearby domestic wells, east and southeast of the facility on Sunset Place, Chestnut Avenue, and Roundup Avenue, show chronically high nitrate. Two have both sucralose, and among the highest acesulfame-K detections. The Monitoring and Reporting Program in the Order currently requires no groundwater monitoring.

Red Bluff RV Park discharges up to 7,000 gpd from 70 recreational vehicles to a septic tank and sand filter/leach-field (Finding 2, Order 91-185). A nearby domestic well, east of the facility on Block Lane, has chronically high nitrate, along with recent high acesulfame-K. The Monitoring and Reporting Program in the Order requires groundwater monitoring, specifically to address public agencies' concerns regarding the identified nitrate. The Discharger historically complied, sampling from two groundwater monitoring wells. From 1992 to 2001, peak nitrate in their North Monitoring Well was ~135 mg/L as NO_3 (~30 mg/L as N). Based on information in the case file, this monitoring well might be cross-gradient to the facility's leach-field. As of 2009, the Discharger had delinquent monitoring reports.

Snug Harbor Mobile Village discharges about 6,000 gpd from 7 septic tanks, each with a capacity of 800 to 900 gallons. Each septic tank services 10 to 15 mobile homes (Tim Potanovic, Tehama County Environmental Health Department, pers. comm. 2013). Domestic wells south of the facility, on Krueger, Chucker, and Dunvin Courts, have chronically high nitrate concentrations, possibly attributable to this facility.

The above analysis does not consider the cumulative effect of non-point source nitrate sources on overall local pollution extent. The subject area includes several subdivisions with closely spaced, low-capacity OWTS. For example, a sample residential block between Berrendos, Chestnut, Roundup, and Kaer Avenues covers about 41 acres. Based on a preliminary review of a recent aerial photograph, the block averages roughly 5 homes per acre; see Figure 6:

Figure 6, Example Residential Block

~1:5,400

Hantzsche and Finnemore (1992) predict generalized nitrate impacts over an area with the following equation:

$N_r = IN_W(1\text{-}d) + RN_b/(1 + R)$

Where:

N_r = nitrate in shallow groundwater,
I = average wastewater over a given acreage,

N_W = nitrogen in wastewater
d = de-nitrification losses to the atmosphere
R = average recharge
N_b = background nitrate

I is the key parameter; my local estimate follows:

I=[(70 gal/person)*(4 persons/home)*(5 homes/ac)*(365 days/yr)]/[(43,560 ft^2/ac)(7.48 gal/ft^3)*(0.08 in/ft)] = 18.8 in/yr, ~ 19 in/yr.

Then, assuming N_w of 135 mg/L as NO_3, d of 30% (0.3, qualitatively a function of soil type), R of 18 in/yr, and negligible N_b (for argument's sake), average N_r as NO_3 solely from non-point source, low-capacity OWTS sources could be about 50 mg/L. Without de-nitrification, average N_r could be about 70 mg/L. The potential effect of non-point sources on overall local nitrate extent is currently indeterminate, and possibly significant.

Recommendations:

Based on the above, for the three identified permitted facilities with high-capacity community OWTS that may act as point-sources, I recommend near-term that we request the Dischargers to submit an appropriate work plan to further investigate subsurface conditions. Work scope should be sufficient to;

- Locate all potential waste discharge sources in the wastewater treatment system, whether by design or leakage,
- Characterize hydraulic gradient, and hydraulic conductivity and thickness of the shallowest water-bearing unit, effluent strength, and discharge rates from dispersal fields,
- Further assess threats to local receptors, and
- Recommend upgrades to further denitrify wastewater and further monitor groundwater, as appropriate based on findings.

A qualified licensed California Professional Engineer or Geologist should stamp the Plan.

For Snug Harbor Mobile Village, another potential point-source, I recommend that we advise Tehama County Environmental Health Department to request a similar Plan near-term, and consider transferring lead agency status to us for Waste Discharge Requirements.

We should also advise the County to further review their records for other potential chronic point- and non-point wastewater-related nitrate pollution sources. Based on their findings, longer term we should consider requesting an appropriate monitoring well network and numerical pollutant transport model to assess changes in groundwater quality following regulatory action.

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