GROUNDWATER INFORMATION SHEET

Nitrate

Revised: August 2010

The purpose of this groundwater information sheet is to provide general information regarding a specific constituent of concern (COC). The following information, compiled by the staff of the Groundwater Ambient Monitoring and Assessment (GAMA) Program, is pulled from a variety of sources and relates mainly to drinking water. For additional information, the reader is encouraged to consult the references cited at the end of this information sheet.

GENERAL INFORMATION	
Constituent of Concern	Nitrate
Aliases	None
Chemical Formula	Nitrate (NO_3)
CAS No.	Nitrate 14797-55-8
Summary	The California Department of Public Health (CDPH) regulates nitrate as a drinking water contaminant. CDPH's Maximum Contaminant Level (MCL) for nitrate (as NO_3) is 45 mg/L. Based on a CDPH data query dated June 2010 using GeoTracker GAMA, 1,077 active and standby drinking water wells of 13,153 sampled have had concentrations of nitrate above the MCL of 45 mg/L. The counties with the greatest number of detections are Los Angeles, San Bernardino, and Tulare. High concentrations of nitrate in groundwater are often associated with the use of fertilizer or animal/human wastes.

REGULATORY AND WATER QUALITY LEVELS[1] Nitrate		
Nitrate (NO_3)		
Type	**Agency**	**Concentration**
Federal MCL	US EPA	10 mg/L as Nitrogen (N)
State MCL	CDPH	45 mg/L as Nitrate (NO_3) or 10 mg/L as N
Detection Limit for Purposes of Reporting (DLR)	CDPH	2 mg/L as Nitrate (NO_3)
Others: Public Health Goal (PHG) IRIS Reference Dose (non-cancer health effect)	 OEHHA US EPA	 10 mg/L 11 mg/L

[1]These levels generally relate to drinking water, other water quality levels may exist. For further information, see *A Compilation of Water Quality Goals* (Marshack, 2008).

SUMMARY OF DETECTIONS IN PUBLIC WATER WELLS[2,3]	
Detection Type	**Number of Groundwater Sources**
Number of active and standby public drinking water wells with a nitrate concentration > 45 mg/L	1,077 of approximately 13,153 active and standby public drinking water wells
Top 3 counties with active and standby public drinking water wells with a nitrate concentration > 45 mg/L	Los Angeles (163), Tulare (108), and San Bernardino (105)

[2]Based on CDPH database query dated June 2010 using GeoTracker GAMA.

[3]In general, drinking water from active and standby wells is treated or blended so consumers are not exposed to water exceeding MCLs. Private domestic wells and wells used by small water systems not regulated by CDPH are not included in these figures.

ANALYTICAL INFORMATION		
Method	**Detection Limit**	**Note**
US EPA 300.0, 300.1	0.4 mg/L	Nitrate-Nitrogen by Ion Chromatography
US EPA 353.2	0.05 mg/L	Nitrate-Nitrite by Automated Colorimetry
US EPA 9056	1 mg/L	Nitrate-Nitrite
US EPA 9210	2.0 mg/L	Nitrate
Known Limitations to Analytical Methods	Both US EPA Method 9056 and Method 9210 have interference and concentration restrictions	
Public Drinking Water Testing Requirements	Public water systems are required to test for nitrate and must report the results to the CDPH.	

NITRATE OCCURRENCE	
Anthropogenic Sources	The largest source of anthropogenic nitrate is industrial production via the Haber-Bosch process. The Haber-Bosch process catalyzes atmospheric nitrogen gas with hydrogen to produce ammonia – which can then be further oxidized to produce nitrate. It is estimated that nearly 2 billion people are sustained with fertilizer generated by this process. Approximately 3 percent of the world's annual fossil fuel use is consumed in this process, producing approximately 100 million tons of ammonia fertilizer per year. Fertilizer that is not used by plants can leach into groundwater, and ammonia will rapidly convert to nitrate in the presence of oxygen. High concentrations of nitrate are often associated with fertilizer production and application. Other anthropogenic sources of nitrate to groundwater include septic systems, discharges from wastewater and agricultural ponds, leaky sewer lines, manure fertilizer application, and the production of explosives.
Natural Sources	Nitrogen is an important biologic element, and is a required component of amino acids and proteins. Although nitrogen is the most abundant gas in the atmosphere (as N_2), it is not easily used by most organisms in this form. N_2 must first be transformed to a more easily utilized compound, such as nitrate, before incorporation into biologic tissue or plant matter. Nitrate is naturally produced from N_2 through biologic fixation and from organic nitrogen through mineralization. Minor amounts may also be produced through oxidation of atmospheric nitrogen by lightening. Some nitrate from these sources may naturally enter groundwater. However, these concentrations are generally low. Nitrate concentrations greater than approximately 10 to 15 mg/L (as NO_3) are generally indicative of anthropogenic nitrate sources (Mueller, 1995).

History of Occurrence	Nitrate is the most common chemical contaminant in the world's groundwater aquifers (Spalding and Exner, 1993). The U.S. EPA has estimated that as many as 52% of community water wells and 57% of domestic water wells in the U.S have detectable concentrations of nitrate. According to estimates by the US Geological Survey, up to 15% of wells in agricultural and urban areas have nitrate levels above the MCL. In California, multiple areas including the San Joaquin Valley, Santa Ana Valley, and Salinas basin (see maps at the end of this fact sheet) are impacted by nitrate from a variety of potential sources.
Contaminant Transport Characteristics	Nitrate dissolves rapidly in water, and once dissolved is difficult to remove. Some natural degradation (denitrification) can occur under low or no-oxygen groundwater conditions. However, evidence suggests that aquifer-scale denitrification does not occur, and that once nitrate enters groundwater it can remain there for decades.

REMEDIATION & TREATMENT TECHNOLOGIES

There is no simple way to remove nitrate from water. Boiling, softening, and filtration as a means of purifying water do not reduce nitrate concentrations. Some of the methods that can reduce or remove nitrate are:

Demineralization

- **Distillation** - Removes nitrate and all other minerals from the water. Distillation is one of the most effective types of demineralization. This process involves boiling the water, then collecting and condensing the steam by using a metal coil.

- **Reverse osmosis** - Water is placed under pressure and forced through a membrane that filters out minerals and nitrate.

Both distillation and reverse osmosis are costly and require time and energy to operate efficiently. They are low-yield systems, and storage space for treated water is required.

Ion-exchange - Water containing nitrate flows through a tank filled with resin beads that are charged with chloride. As the water flows through the tank, the resin takes up the nitrate and exchanges with chloride.

Electro-dialysis – Water containing nitrate flows across anion-exchange and cation exchange membranes in a constant electric field. The use of these mono-anion-selective membranes offer additional possibilities of nitrate removal by enabling preferential flow of mono-valent anions (Rozanska A. and J. Wisniewski, 2003)

Other potential options include: phytoremediation, and above ground biochemical denitrification.

HEALTH EFFECT INFORMATION
High levels of nitrate in drinking water are associated with adverse health effects. Domestic well users are encouraged to test their well water regularly for nitrate. Infants under six months of age have greater risk of nitrate poisoning, called methemoglobinemia ("blue baby" syndrome). Toxic effects occur when bacteria in the infant stomach convert nitrate to more toxic nitrite. When nitrite enters the bloodstream, it interferes with the body's ability to carry oxygen to body tissues. Symptoms include shortness of breath and blueness of the skin around the eyes and mouth. Infants with these symptoms need immediate medical care since the condition can lead to coma and eventually death (CDPH, 2000). During pregnancy, it is common for methemoglobin levels of the pregnant woman to increase from normal (where 0.5 to 2.5% of the total hemoglobin is in the form of methemoglobin) to a maximum of 10% in the 30th week of pregnancy. The level of methemoglobin declines to a normal level after delivery. Pregnant women are susceptible to methemoglobinemia and should be sure that the nitrate concentrations in their drinking water are at safe levels. Some scientific studies suggested a linkage between high nitrate levels in drinking water with birth defects and certain types of cancer. However, long-term scientific studies are needed to determine a direct relationship. According to the EPA, long-term exposure to water with high nitrate levels may cause diuresis, increased starchy deposits, and hemorrhaging of the spleen. People with heart or lung diseases are more susceptible to the toxic effects of nitrate than others, because of reduced levels of gastric acidity.

KEY REFERENCES

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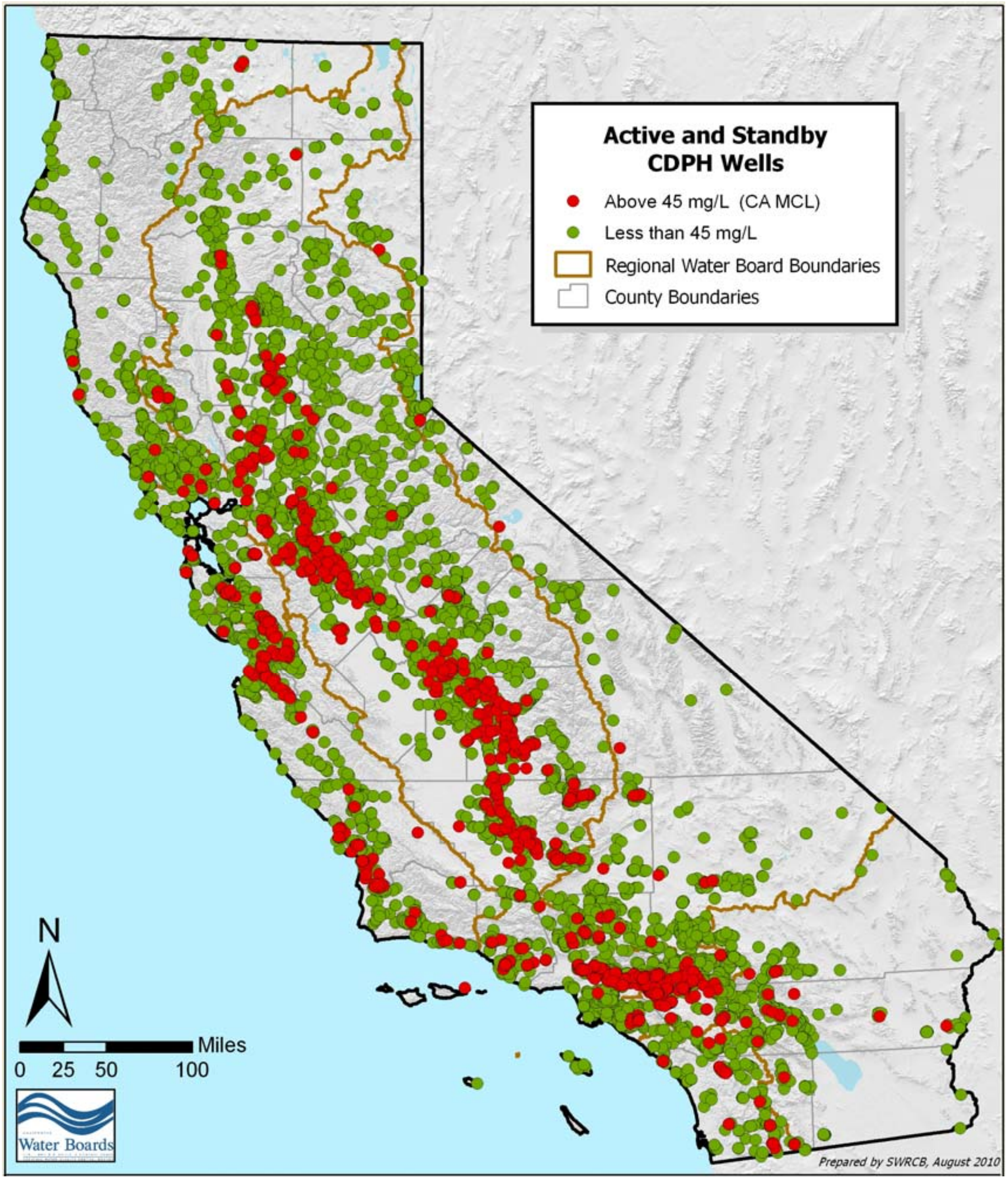
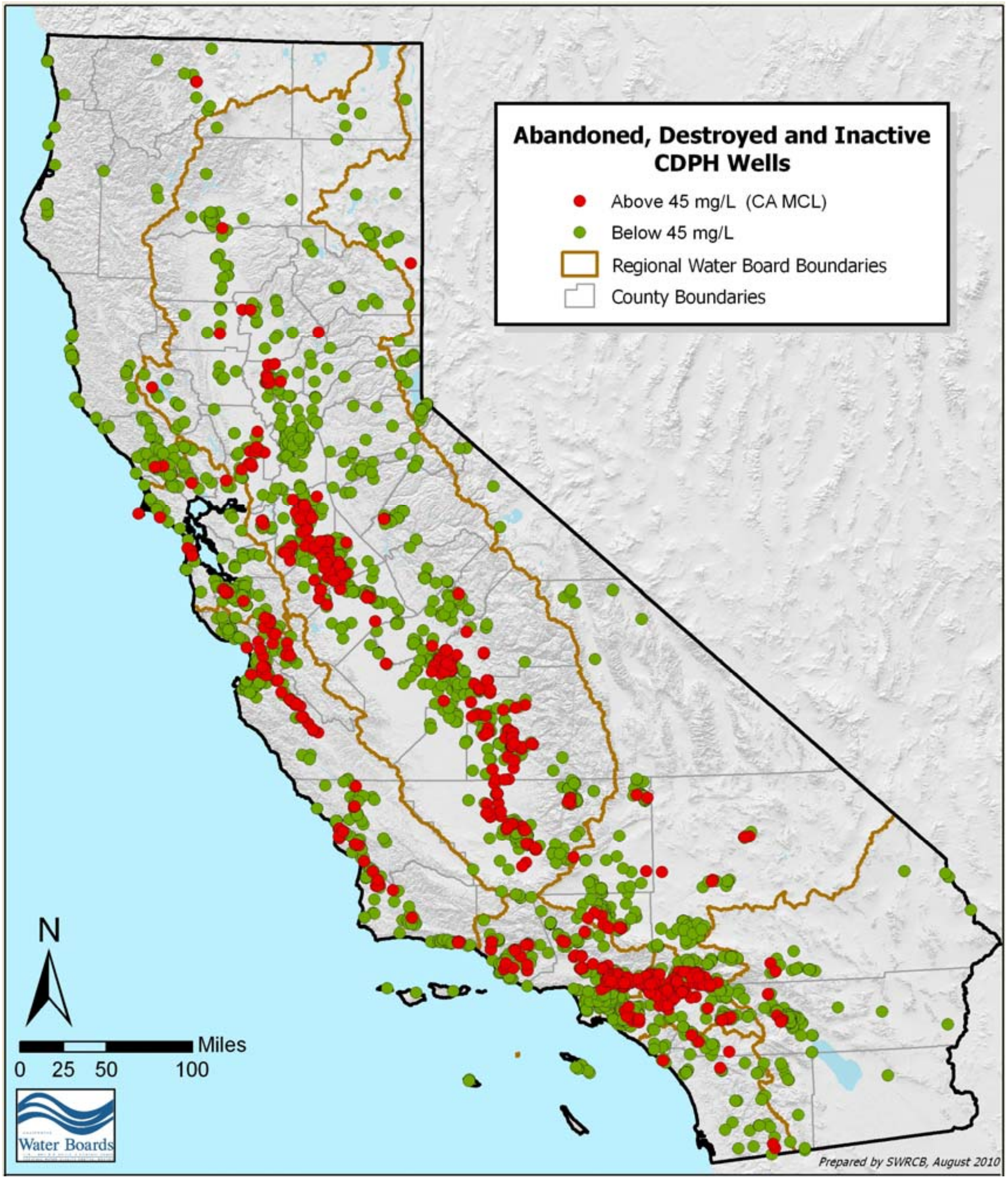
FOR MORE INFORMATION, CONTACT: John Borkovich, (916)-341-5779



Active and Standby CDPH Regulated Public Drinking Water Wells with at Least One Detection of Nitrate (as NO_3) Above the MCL (1,077).

Source: June 2010 well query of CDPH data using GeoTracker GAMA.

Revised August, 2010



Abandoned, Destroyed, and Inactive CDPH Regulated Public Drinking Water Wells with at Least One Detection of Nitrate (as NO_3) Above the MCL (596).

Source: June 2010 well query of CDPH data using GeoTracker GAMA.