GROUNDWATER INFORMATION SHEET

Benzene

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	Benzene
Aliases	Annulene, Benxole, Benzole, Phene, Phenyl hydride, Pyrobenzole, Cyclohexatriene
Chemical Formula	C_6H_6
CAS No.	71-43-2
Storet No.	34030
Summary	Benzene is as a chemical found in crude oil, gasoline and cigarette smoke and occurs naturally in volcanoes and forest fires. Benzene is a known carcinogen both in human and in laboratory animals. The California Department of Public Health (CDPH) regulates benzene as a drinking water contaminant. The current State Maximum Contaminant Level (MCL) for benzene is 1 micrograms per liter (µg/L). Based on a CDPH data query dated November 2010 using GeoTracker GAMA, 29 active and standby public drinking water wells of 10,757 sampled have detected benzene above the State MCL at least once since 1984.

REGULATORY AND WATER QUALITY LEVELS[1]		
Type	**Agency**	**Concentration**
Federal MCL	US EPA, Region 9	5 µg/L
State MCL	CDPH	1 µg/L
Detection Limit for Purposes of Reporting (DLR)	CDPH	0.5 µg/L
Others:		
CA Public Health Goal (PHG)	OEHHA	0.15 µg/L
Cancer Potency Factor ($1/10^6$ cancer risk)	OEHHA	0.35 µg/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 DRINKING WATER WELLS [2,3]	
Detection Type	**Number of Groundwater Sources**
Number of active and standby public drinking water wells with benzene > 1µg/L	29 of approximately 10,757 sampled (see figure)

[2]Based on CDPH database query dated November 2010 using GeoTracker GAMA (data includes 1984 through 2009).
[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 (Quantitation Limit)**	**Note**
US EPA 502.2	0.01 µg/L	Gas chromatography with photo-ionization and electrolytic conductivity detectors
US EPA 8260/524.2	0.04 µg/L	Gas chromatography/mass spectrometry. US EPA Method 8260 is used at Leaking Underground Fuel Tank (LUFT) sites
US EPA 8020	0.2 µg/L	Gas chromatography with photo-ionization detector
Known Limitations to Analytical Methods	US EPA Method 8020 can detect benzene but may yield false positives when other volatile organic compounds are present and co-elute in the same chromatographic range. The presence of benzene should be confirmed by US EPA Method 524.2 or Method 8260 prior to utilizing this method for a long-term groundwater monitoring program.	
Public Drinking Water Testing Requirements	In accordance with federal regulations, California requires public water systems to sample their sources (wells) and have the samples analyzed for substances, including benzene, to determine compliance with drinking water standards (MCLs). MCLs are based on health protection, technical feasibility, and costs. The water supplier must notify the CDPH and the public when the MCL (1µg/L) has been violated and take appropriate action.	

BENZENE OCCURRENCE	
Anthropogenic Sources	Benzene is a naturally occurring chemical found in crude oil, gasoline and cigarette smoke. Benzene in unleaded gasoline is typically around 1 percent of total volume. By 2007, the worldwide annual demand for benzene was around 40 million tons. Most of it is used to produce styrene and cumene; chemicals in the manufacture of plastics, resins, adhesives and nylon. It is estimated that approximately 6 million tons of benzene was used annually in the USA in the 1990s. Benzene can be released to groundwater by leaking underground fuel storage tanks and piping, atmospheric deposition, fuel spills during transportation, and leaks at refineries. Underground storage tank or piping releases make up the majority of the releases that have impacted groundwater. Studies have shown that atmospheric deposition of benzene usually only results in trace concentrations in surface waters. In contrast, point sources of benzene contamination (i.e. underground storage tank sites) may result in benzene concentrations of milligrams per liter (mg/L) range.
Natural Sources	Benzene occurs naturally in the environment as a product of incomplete combustion of carbon-rich materials. Benzene is present in crude oil as well as gases from volcanic eruptions and forest fires.

History of Occurrence	Benzene replaced lead as a gasoline additive for its anti-knock properties. Concerns about negative health effects related to air quality led to regulation of gasoline's benzene content, to typically 1 percent. US EPA regulations will further lower benzene content to 0.62 percent in 2011. Based on a CDPH data query dated November 2010 using GeoTracker GAMA, 29 active and standby public drinking water wells of 10,757 sampled have detected benzene above the State MCL at least once since 1984 (see figure). Sixteen public supply wells with at least one detection of benzene above the MCL have been abandoned, destroyed or made inactive since 1984 (see figure). <u>Benzene in Environmental Monitoring Wells:</u> Benzene impacts are commonly associated with leaking underground fuel storage tanks and piping. Monitoring wells at environmental cleanup sites are typically completed in first encountered groundwater, while public water supply wells are usually much deeper. For an interactive map showing benzene concentrations in environmental monitoring wells, please visit: http://geotracker.waterboards.ca.gov/gama/pubmap/?bzrep=True
Contaminant Transport Characteristics	Benzene can volatilize into air from soil and water. Once in the atmosphere, benzene breaks down (biodegrades) within a few days. In soil and water, benzene breaks down more slowly. Benzene is slightly soluble in water and can pass through the soil column into groundwater. Benzene is a light non-aqueous phase liquid (LNAPL) and can collect on top of the water table. Once in groundwater, benzene biodegrades more slowly.

REMEDIATION & TREATMENT TECHNOLOGIES

Several effective remediation technologies remove benzene and other gasoline compounds from soil and groundwater. These include:

Soil Vapor Extraction (SVE) – Effective in reducing benzene in the unsaturated zone due to the high vapor pressure.

Air Sparging – Used in conjunction with soil vapor extraction. This can also oxygenate the groundwater and stimulate biodegradation of dissolved contaminants

In-situ Oxidation – Relies on the capacity of certain chemicals (e.g. hydrogen peroxide combined with iron) to rapidly oxidize organic molecules in water.

Bioremediation – Most effective under aerobic conditions.

Flushing (Pump and Treat) – Extracts contaminated groundwater and treats at the surface using air stripping, activated carbon, or advanced oxidation systems. For drinking water, the most common treatment options are air stripping, carbon adsorption, and advanced oxidation (combinations of ultraviolet light, chemical oxidants, and catalysts).

There are other emerging technologies for the remediation and treatment of benzene and gasoline compounds including permeable reactive barriers, and thermal treatment.

HEALTH EFFECT INFORMATION

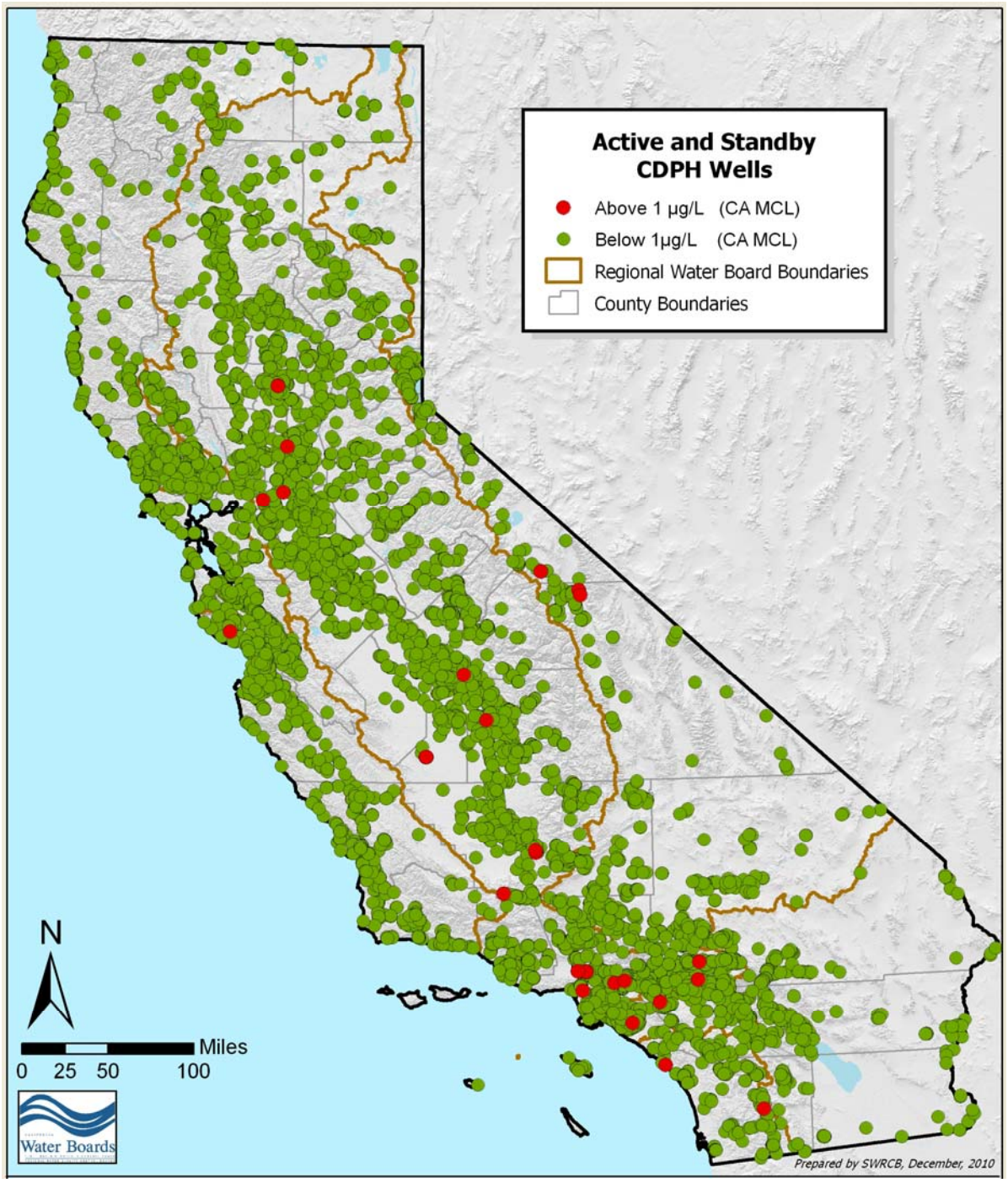
Exposure to benzene can occur through the lungs, gastrointestinal tract, and through skin (dermal contact). Health effects depend on two main factors: length of exposure and concentration (amount of benzene a person is exposed to). Brief exposure to very high levels of benzene in air can result in death, while breathing lower levels can cause drowsiness, confusion, dizziness, headaches, tremors and unconsciousness. The major effect of benzene exposure is to the blood. Long term exposure to benzene can affect the body's ability to produce red blood cells. When the bone marrow is affected, the result is usually a form of leukemia. It can also cause blood diseases (hematologic diseases), anemia, and cancers of blood-forming organs. The most common long-term health effects associated with benzene exposure are:

- Acute Myelogenous Leukemia (AML) in which cancer cells are present in the blood and bone marrow.
- Acute Lymphocytic Leukemia (ALL) in which the cancer affects the cells that make the lymphocytes for the bone marrow.
- Chronic Myelogemour Leukemia (CML) in which the leukemia develops from the white blood cells reducing the body's ability to fight disease and infection.

KEY REFERENCES

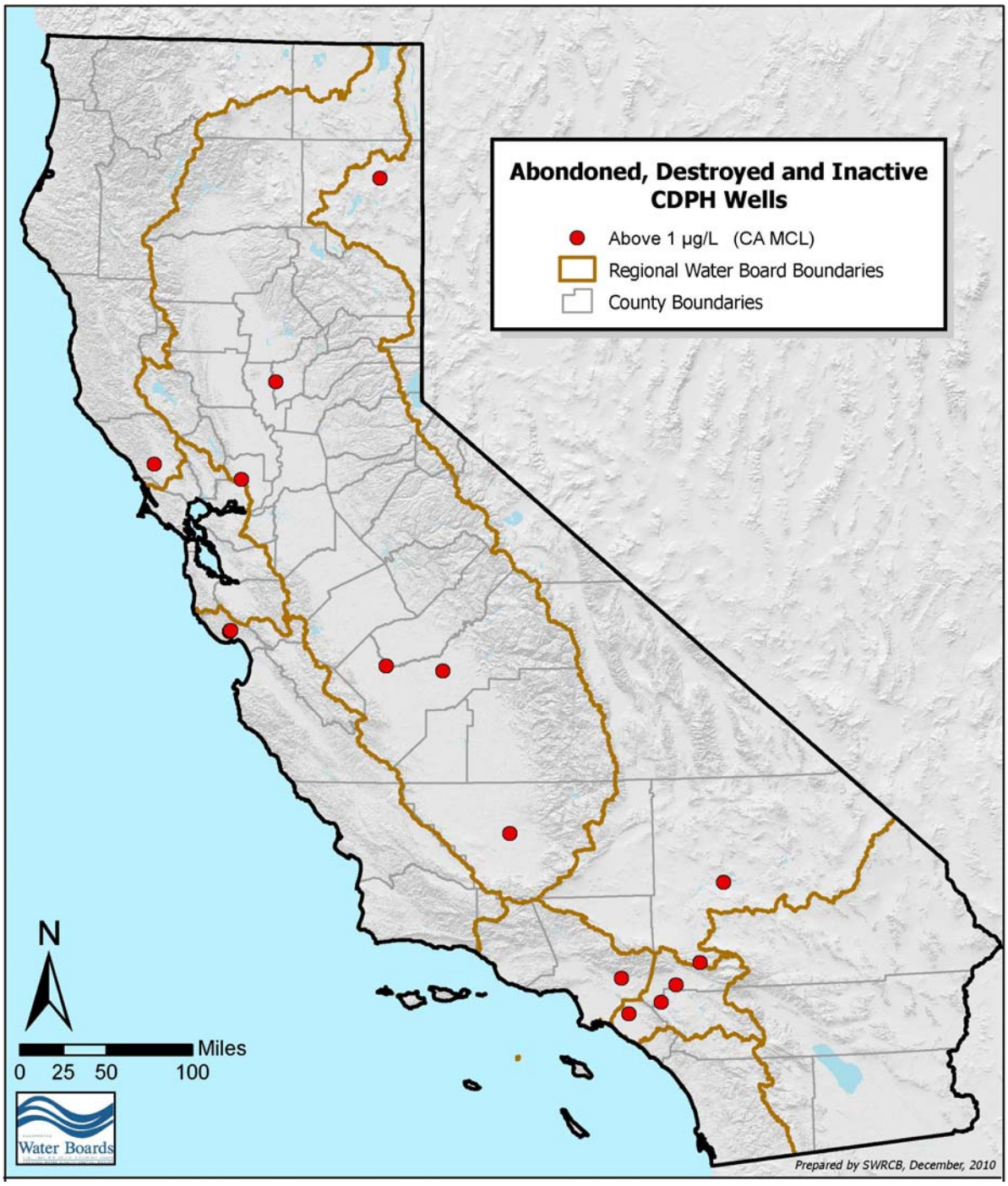
1. State Water Resources Control Board. GeoTracker GAMA (Groundwater Ambient Monitoring and Assessment) Database http://www.waterboards.ca.gov/water_issues/programs/gama/geotracker_gama.shtml
2. California Environmental Protection Agency Regional Water Quality Control Board, Central Valley Region. 2008. *A Compilation of Water Quality Goals*. Prepared by Jon B. Marshack http://www.swrcb.ca.gov/rwqcb5/available_documents/wq_goals/wq_goals.pdf
3. CDPH-California Regulations Related to Drinking Water June 24, 2010 http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Lawbook.aspx
4. Office of Environmental Health Hazard Assessment-California Environmental Protection Agency Public Health Goal for BENZENE In Drinking Water http://www.oehha.ca.gov/water/phg/pdf/BenzeneFinPHG.pdf
5. US Environmental Protection Agency. 2010. Clean-Up Information, http://www.clu-in.org/remediation/
6. US Environmental Protection Agency. 2010. Drinking Water Contaminants: Basic Information about Benzene in Drinking Water, http://water.epa.gov/drink/contaminants/basic information/benzene.cfm

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



Active and Standby CDPH Regulated Public Drinking Water Wells with at Least One Detection of Benzene above the MCL since 1984 (29 of 10,757 wells sampled).

Source: November 2010 well query of CDPH data using GeoTracker GAMA



Abandoned, Destroyed and Inactive CDPH Regulated Public Drinking Water Wells with at Least One Detection of Benzene above the MCL since 1984 (16 wells).

Source: November 2010 well query of CDPH data using GeoTracker GAMA