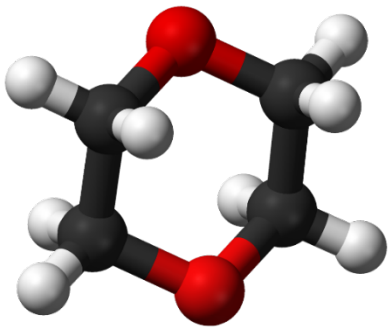
Groundwater Fact Sheet
1,4 Dioxane



Constituent of Concern
1,4 Dioxane

Synonym
1,4 Diethylene dioxide, 1,4 Dioxacyclohexane, p-dioxane, Glycol ethylene ether, Diethylene ether, Dioxane

Chemical Formula
$C_4H_8O_2$

CAS Number
123-91-1

Storet Number
A-032

Summary
The State Water Resources Control Board (SWRCB) has adopted a drinking water notification level (NL) of 1 microgram per liter (µg/L). 1,4 Dioxane is primarily used as stabilizer and solvent. It is also a component of some cosmetics, detergents, and shampoos. The US Environmental Protection Agency (EPA) classifies 1,4 Dioxane as a possible human carcinogen. 1,4 Dioxane is highly soluble in water. Exposure pathways include ingestion of drinking water, inhalation of vapors, and workplace contact. Maximum contaminant levels (MCL) have not been established for 1,4 Dioxane.

Based on SWRCB data from 2009 to 2019, 194 active and standby public water wells (of 1,539 sampled) had at least one detection of 1,4 Dioxane above the NL during this period. Most detections occurred in Los Angeles (162) and Orange (29) counties. There were also two detections above the NL in Monterey and one in Santa Barbara counties.

REGULATORY WATER QUALITY LEVELS[1] **1,4 DIOXANE**		
State and Federal MCL have not been established for this constituent.		
Type	**Agency**	**Concentration**
Health Advisory Level, based on 1 in 10^{-6} cancer risk	EPA[2]	0.35 µg/L
State NL[3]	SWRCB[4]	1 µg/L
Public Health Protective Concentration	OEHHA[5]	3 µg/L
Source Removal (Response Level)	SWRCB[4]	35 µg/L

[1]These levels are generally related to drinking water. Other water quality levels may exist. For further information, see "A Compilation of Water Quality Goals", 17th Edition (SWRCB 2016).
[2] EPA – United States Environmental Protection Agency
[3] The NL is only for the ingestion of drinking water and does not take into consideration possible dermal or inhalation exposures resulting from typical household uses of water containing a specific constituent of concern. Prior to 2004, NL were referred to as "Action Levels" in California.
[4] SWRCB - State Water Resources Control Board
[5] OEHHA – Office of Environmental Health Hazard assessment

Revised November 2019

1,4 DIOXANE DETECTIONS IN PUBLIC WATER WELL SOURCES[6]	
Number of active and standby public water wells with 1,4 Dioxane concentrations >1 µg/L[7]	194 of 1,539 wells tested
Top counties with detections in wells above NL	Los Angeles (162), Orange (29), Monterey (2), Santa Barbara (1)

[6] Based on 2009-2019 public standby and active well (groundwater sources) data collected by the SWRCB.
[7] Water from public active and standby public groundwater sources is typically treated to prevent exposure to chemical concentrations above MCL. Data from private domestic wells and wells with less than 15 service connections are not available.

ANALYTICAL INFORMATION		
Approved EPA methods	EPA 522	Modified EPA 8260
Detection Limit (µg/L)	0.020-0.026	12
Notes	Detection Limits depends on extraction option	Detection Limit based on preparation method 5031
Known Limitations to Analytical Methods	Measurement of 1,4 Dioxane at the micrograms per liter level (µg/L) can be difficult due to its high solubility in water.	
Public Drinking Water Testing Requirements	Testing is required, although an MCL has not been established for this constituent. Notification is recommended by SWRCB if concentrations above 1 µg/L are observed.	

1,4 Dioxane Occurrence

Anthropogenic Sources

1,4 Dioxane is primarily used as a stabilizer for chlorinated solvents. It is also used as a solvent for several compounds including resins, oils, fats, waxes, and greases. 1,4 Dioxane is also found as a byproduct in cosmetics and shampoos. 1,4 Dioxane is widely manufactured and distributed in the United States. Its occurrence as a byproduct in cosmetics is decreasing due to revised methodologies.

Natural Sources

1,4 Dioxane is a manufactured chemical that does not occur naturally in the environment.

History of Occurrence

The compound has been manufactured since the 1950s. As of 2001, 22 different domestic suppliers have been identified for 1,4 Dioxane. Production of the chemical has fallen significantly from the nearly 15 million pounds produced in 1982, possibly because most uses of trichloroethane, to which it was added as a stabilizer, have been banned in this country. According to the Toxic Release Inventory for 2017, 60, 753 pounds of 1,4 Dioxane were released to the air, 57,940 to surface water, 23,626 to land, and 420,771 pounds were transferred from the user to off-site disposal. The occurrence of 1,4 Dioxane in the environment is thought to be related to the disposal of chemical solvents

containing dioxane and from disposal of 1,4 Dioxane itself. Subsequent leaching of the chemicals from landfills has resulted in contamination of groundwater.

Contaminant Transport Characteristics

1,4 Dioxane is a volatile, flammable, colorless liquid at room temperature. It is miscible with water and highly mobile in soils, where it can rapidly migrate to groundwater. 1,4 Dioxane has been observed above notification levels in groundwater and public groundwater sources in California.

Remediation and Treatment Technologies

Some types of chemical treatment are highly effective in removing 1,4 Dioxane from water. Advanced oxidation processes, which use peroxide and Ultraviolet light (UV) or ozone, have been shown to destroy 1,4 Dioxane. Chlorination has also been found to be effective for the removal of 1,4 Dioxane. However, the byproducts that result from chlorination of 1,4 Dioxane are significantly more toxic than 1,4 Dioxane itself. Standard wastewater treatment methods and conventional activated sludge methods have proven to be ineffective. Air-stripping and granular activated charcoal do not remove 1,4 Dioxane from water.

Experimental remediation techniques include the use of specialized bacteria in bioreactors under specific conditions and phytoremediation, where trees are used to draw shallow groundwater towards the surface as well as remove the constituent of concern. Advanced electrochemical oxidation (AEO) technology was successfully tested for the treatment of groundwater contaminated with 1,4 Dioxane at concentrations exceeding 1,000 mg/L.

Health Effect Information

The primary exposure pathways for 1,4 Dioxane are through inhalation, ingestion, and dermal exposure. Inhalation of vapors can occur through occupational contact and through contact with water containing 1,4 Dioxane. Ingestion can occur through drinking contaminated water. Dermal exposure can occur at manufacturing facilities and through use of household products including cosmetics and shampoos. While trace amounts of 1,4 Dioxane are found in some cosmetics and shampoos, the levels observed in these products are generally very low.

Few studies are available that provide information about 1,4 Dioxane in humans. Deaths have been reported from accidental exposures to high amounts of vapors and skin absorption. Studies with workers exposed to lower levels of 1,4 Dioxane for longer time periods did not show significant harmful health effects. Controlled exposure of volunteers to the airborne contaminant for periods ranging from a few minutes to 6 hours produced eye, nose, and throat irritation.

Information was not available regarding reproductive, developmental, or immunological effects of 1,4 Dioxane in humans. However, available data is sufficient to clearly identify the liver and kidney as the target organs for 1,4 Dioxane toxicity following short-term exposure to relatively high concentrations regardless of the route of exposure. These findings have been corroborated in animal studies.

Key Resources

1. Agency for Toxic Substances and Disease Registry. 2012. U.S. Department of Health and Human Services. Division of Toxicology and Environmental Medicine ToxFAQs, 1,4-Dioxane. https://www.atsdr.cdc.gov/toxfaqs/tfacts187.pdf
2. Blotevogel, J., Pijls, C., Scheffer, B., de Waele, J.-P., Lee, A., van Poecke, R., van Belzen, N. and Staal, W. (2019), Pilot-Scale Electrochemical Treatment of a 1,4-Dioxane Source Zone. Groundwater Monit R, 39: 36-42. https://doi.org/10.1111/gwmr.12307
3. California Department of Public Health. 2012. Drinking Water Notification Levels https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/NotificationLevels.html
4. California State Water Resources Control Board. GAMA GIS. https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/
5. National Environmental Methods Index (NEMI), 1,4-Dioxane. https://www.nemi.gov/methods/keyword/?keyword_search_field=dioxane
6. National Toxicology Program. Department of Health and Human Services, 2014. 13th Report on Carcinogens. http://ntp.niehs.nih.gov/ntp/roc/content/profiles/dioxane.pdf
7. State Water Resources Control Board. A Compilation of Water Quality Goals, 17th Edition, (SWRCB, 2016). http://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/docs/wq_goals_text.pdf
8. Mohr, T.K.G., 2001. Solvent Stabilizers, Santa Clara Valley Water District, White Paper
9. United States Environmental Protection Agency. 2014. Technical Fact Sheet. 1,4-dioxane. https://www.epa.gov/sites/default/files/2014-03/documents/ffrro_factsheet_contaminant_14-dioxane_january2014_final.pdf
10. EPA. 2018 Edition of the Drinking Water Standards and Health Advisories. https://www.epa.gov/system/files/documents/2022-01/dwtable2018.pdf
11. EPA Technology Innovation and Field Services Division, Contaminated Site Clean-Up Information, 1,4 Dioxane, https://clu-in.org/contaminantfocus/default.focus/sec/1,4-Dioxane/cat/Overview/
12. Zenker, M.J., Borden R.C., and Morton B., 2003. Occurrence and Treatment of 1,4 Dioxane in Aqueous Environments. Environmental Engineering Science, v.20 pg:423-432 https://doi.org/10.1089/109287503768335913
13. EPA TRI Explorer. Release Chemical Report database. https://enviro.epa.gov/triexplorer/tri_release.chemical

Figure 1. Active and standby public drinking water wells that had at least one detection of 1,4 Dioxane above the NL, 2009-2019, 194 wells. (Source: GAMA GIS)