Addressing Perchlorate Contamination of Drinking-Water Sources in California

January 2004

This report represents an ongoing effort by the Senate Office of Research to review issues of drinking-water quality in California. In 2000-01, we examined contamination by chromium 6 in a briefing paper for the Senate Health and Human Services Committee. In May 1998, we reviewed the emerging issue of MTBE contamination in drinking water supplies throughout the state. The issue of perchlorate contamination of drinking water and its potential health effects is evolving. This report illustrates where the issue stood at the close of 2003.

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Introduction and Summary of Findings: The Horse Is Out of the Barn

Perchlorate is the common name for a family of salts that includes ammonium, potassium, magnesium and sodium perchlorate. While it can be naturally occurring, the great majority of perchlorate is man-made. Most perchlorate manufactured is in the form of ammonium perchlorate, a primary component in rocket fuel.

Though it has been a known contaminant of ground and surface water in the United States since the 1950s,[1] only recently have advances in detection capabilities helped identify perchlorate as a widespread and pervasive pollutant in local water supplies. Prior to 1997, detection techniques did not allow scientists to identify perchlorate at very low concentrations. Detections prior to 1997 were in the parts-per-hundreds range while after 1997 they were in the parts-per-billion range. There are 44 states in which perchlorate use or manufacturing has been confirmed. Twenty-five states, including California, have reported perchlorate ground or surface water contamination, though a systematic national survey of perchlorate occurrence has not yet been conducted.[2] Compounding the problem in California is the fact that the state derives as much as 30 percent of its drinking water from groundwater sources. In addition, the Colorado River, a major source of drinking and irrigation water in Southern California, is also contaminated with perchlorate.

California state and local officials have acted to protect human populations from known sources of perchlorate contamination by closing or remediating impacted wells, or providing alternative water supplies. However, to date, the extent of perchlorate groundwater contamination in California is not fully known. As a result, legislation was signed into law in September 2003 in California to regulate its use and disposal.[3] Earlier the Legislature required that a public health goal (PHG) and a maximum contaminant level (MCL) be established for its presence in drinking water.[4]

Perchlorate has been manufactured in large quantities since the 1940s primarily as an oxidizing agent to provide thrust in rockets and missiles. Most documented instances of perchlorate contamination are associated with the development, testing, or manufacture of defense and aerospace materials.[5] At present, production, use, and disposal of large quantities of perchlorate remain essential to the activities of both the U.S. Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA).[6]

In addition to its use in rocket propellant, perchlorate is used in the manufacture of explosives, munitions, pyrotechnics, military counter measures, highway safety flares, and fireworks, as well as in automotive air-bag inflators. Other industrial applications of perchlorate include use in nuclear reactors, electronic tubes, fixing dyes in fabrics, lubricating oils, electroplating, aluminum refining, tanning and finishing leather, rubber manufacture, and the production of paints and enamels.

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[1] *Journal of the American Water Works Association*. "Underground Waste Disposal and Control." 49(10): 1334-1342. 1957. As cited in "Rocket Science." Environmental Working Group. 2001.

[2] U.S. Environmental Protection Agency (EPA). "Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization." External Review Draft. January 16, 2002. And "EPA, Air Force Differ on Perchlorate Risks in Drinking Water," *Las Vegas Sun*, October 28, 2003.

[3] AB 826 (Chapter 608, Statutes of 2003).

[4] SB 1822 (Chapter 425, Statutes of 2003).

[5] U.S. Environmental Protection Agency (EPA) Op. cit.

[6] A July 9, 2003, article in *The Sacramento Bee* ("Pentagon targets a water pollutant" by Chris Bowman) reported that "the Pentagon has launched a top-priority search for an environmentally safer alternative" to perchlorate.

It has been known for decades that perchlorate affects the functioning of the thyroid gland. However, only in recent years has evidence arisen that suggests that it may have significant adverse impacts even in low doses. Because of the important role of the thyroid gland in fetal development, pregnant women and their developing fetuses may be at the most serious risk from perchlorate exposure.

No state or federal drinking water standard exists for perchlorate. The California Department of Health Services (DHS) established an advisory "action level" for notifying consumers of perchlorate-contaminated water supplies in 1997. That level was recently revised downward in response to improved detection capabilities and growing concerns about the effects of low-level exposure to perchlorate. By law,[7] the Office of Environmental Health Hazard Assessment (OEHHA) was to set a PHG by January 1, 2003, that established a perchlorate level to avoid risks to human health. DHS was required to issue a MCL no later than January 1, 2004, that protected human health while remaining as close to the PHG for perchlorate as technically and economically feasible.[8] However, both deadlines were held up by a court-ordered peer review and a delay in the University of California's appointment of a peer review committee.[9] The UC peer review began October 20, 2003, and was released by OEHHA on January 14, 2004. Therefore the PHG will probably not be adopted until early 2004 and the MCL not before early-to-mid 2004. This timetable may be altered further by an executive order by Governor Schwarzenegger on November 17, 2003, that suspended the adoption of regulations – or amendments to regulations – for up to 180 days.[10]

Finally, it should be noted that cooperation between the state and the agencies of the federal government seems limited. For instance, the Department of Defense has declined to share all of the results of a 2001 survey it conducted of perchlorate contamination at Defense Department sites.

This paper outlines what is known about perchlorate: its uses, occurrences in the environment, and possible health effects; the feasibility of cleaning up water contaminated by perchlorate; recent relevant actions by the Legislature and state and federal regulatory agencies; and options for future perchlorate policies. Among this paper's key findings:

- Perchlorate concentrations in excess of the state's precautionary action level have been detected in 335 of the more than 6,000 public water sources in California. These detections span 10 counties[11] and have forced actions to protect the drinking water of millions of Californians across many geographical regions.

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[7] Health and Safety Code §116275.
[8] SB 1822, op.cit.
[9] OEHHA submitted the PHG draft to the University of California in May 2003; however, the peer review process did not begin until October 20, 2003.
[10] Executive Order S-2-03.
[11] In order of the concentrations of perchlorate found in some drinking water sources, the counties are San Bernardino, Sacramento, Los Angeles, Riverside, Ventura, Tulare, Orange, Santa Clara, Sonoma and San Diego.

- Perchlorate has been detected in concentrations above the state action level in approximately 77 percent of state Senate districts and in approximately 82 percent of Assembly districts.

- The lower Colorado River, a major source of irrigation and drinking water for Southern California, also carries levels of perchlorate that in most instances exceed the state's action level.

- Most of the perchlorate already discovered in California's drinking water sources cannot be "cleaned up"[12] in the short-run, but will likely require costly, long-term treatment programs.

- The state of California does not have regulations in place to prevent future contamination through the monitoring of perchlorate transport, use, and disposal.[13]

I. Background

Perchlorate is a white or colorless powder that most commonly originates as a contaminant in the environment when perchlorate salts dissolve in water. The resulting perchlorate ion consists of four atoms of chlorine and one atom of oxygen, and carries a negative charge. Highly resistant to bonding with other matter, perchlorate moves very freely within bodies of water and does not easily biodegrade. As a result, it can spread widely and remain in water supplies for decades.

The defense and aerospace industries purchase more than 90 percent of all the perchlorate manufactured, or roughly 20 million pounds per year.[14] Perchlorate accounts for over 65 percent of the fuel in the Titan and the Minuteman III missiles,[15] and nearly 70 percent of the solid propellant aboard the space shuttle, or approximately 1.4 million pounds per shuttle launch.[16]

Because solid rocket fuel has a shelf life and goes "flat" over time, it must be flushed from rocket motors periodically and replaced. High-pressure jets of water are typically used to wash out the fuel, creating large volumes of perchlorate-contaminated waste water. Though perchlorate can be recovered from the solution and used again, the process has not been considered cost-effective.[17] The defense

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12 Action levels are health-based advisory levels established by DHS for chemicals in drinking water that lack regulated maximum contaminate levels. These chemicals must be tested for and reported to DHS.
13 The Legislature did pass in 2003, AB 826 (Chapter 608, Statutes of 2003) that directed the Department of Toxic Substances Control to adopt regulations for the management of perchlorate by December 31, 2005.
14 In 1989, DOD and NASA signed a seven-year contract with Western Electrochemical Company (Cedar City, UT) to purchase 20 million pounds of ammonium perchlorate a year. NASA Website, "Financing Arranged for Ammonium Perchlorate Plant." March 28, 1989. <http://spacelink.nasa.gov/NASA.News/NASA.News.Releases/Previous.News.Releases/89.News.Releases/89-03.News.Releases/89-03-35>.
15 EPA, op. cit.
16 NASA. 1995. NASA Website. <http://liftoff.msfc.nasa.gov/Shuttle/About/srb.html>.
17 EPA, op. cit.

and aerospace industries have disposed of large volumes of perchlorate in various states across the country since the 1950s. Many of these states have reported perchlorate contamination of their groundwater.

In coming years, more perchlorate will require safe disposal as weapons systems reach the end of their service life or treaty agreements require their dismantling. In the past, DOD practiced open burning or open detonation of rocket motors, but public and regulatory concern over incomplete destruction has curtailed these methods. Consequently, the inventory of perchlorate-containing propellant awaiting disposal is ever-growing, and is expected to surpass 164 million pounds by 2005.[18]

Documented perchlorate contamination of ground and surface water is not associated solely with the defense industry but also with perchlorate manufacturing, production of highway flares, fireworks manufacturing, and a variety of other industrial activities.

II. Perchlorate Concentrations Across California

Widespread perchlorate pollution was discovered shortly after development in early 1997 of an improved detection method[19] that is able to identify perchlorate at levels equivalent to a few grains of sand in an Olympic-sized swimming pool (parts per billion).[20] Detection of high-level contamination at a former defense contractor site east of Sacramento in Rancho Cordova in 1997 brought wide public attention to perchlorate for the first time.

The majority of California locations where perchlorate has been detected are associated with facilities that have manufactured or tested solid rocket fuels for the DOD or NASA. In a July 3, 2003 letter to Winston Hickox, then secretary of the California Environmental Protection Agency (Cal EPA), U.S. Assistant Deputy Undersecretary of Defense for Environment John Woodley, Jr., provided a list of 37 DOD and defense contractor sites that had known perchlorate contamination. However, there are also a number of nonmilitary manufacturing sites that have contaminated groundwater.

As of October 8, 2003, there were 335 drinking water sources in 10 California counties where perchlorate had been detected at or above the action-reporting level of 4 parts per billion (ppb).[21] These detections did not include agricultural sources, monitoring wells, or private wells (which are not currently tested). Approximately 77 percent of California's state Senate districts and 82 percent of its Assembly districts have perchlorate detections in drinking water sources above the 4 ppb

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[18] Siddiqui et al. "Occurrence of perchlorate and methyl tertiary butyl ether (MTBE) in groundwater of the American water system." September 30, 1998. As cited in EPA 2002.

[19] The ion chromatography analytical method achieves a method detection limit of approximately 1 part per billion and a minimum reporting limit of 4 ppb.

[20] Gary Pitzer. "Confronting a Legacy of Contamination: Perchlorate." *Western Water*. May/June 2003.

[21] As of December 1, 2003, DHS Website. <http://www.dhs.ca.gov/ps/ddwem/chemicals/perchl/monitoringupdate.htm>.

action level. (See Appendices pages A1- A6 for maps of perchlorate contamination by Senate and Assembly districts.)

Of the sources with reported detections at actionable levels, the concentrations broke down this way:

- 7 percent had peak perchlorate concentrations of more than 40 ppb,
- 6 percent had concentrations of 21 ppb to 40 ppb,
- 27 percent had concentrations of 11 ppb to 20 ppb, and
- 60 percent, 10 ppb or less. [22]

Peak concentrations greater than 40 ppb (more than 10 times the action level at which DHS recommends source removal or the removal of the contamination at the source of the drinking water) occurred in these counties:

- San Bernardino: five sources, ranging from 52 to 820 ppb.
- Sacramento: five sources, ranging from 72 to 400 ppb.
- Los Angeles: nine sources, ranging from 47 to 159 ppb.
- Riverside: four sources, ranging from 45 to 65 ppb.

Among the remaining six counties, the highest peak concentrations were as follows:

- Ventura: 20 ppb.
- Tulare: 11 ppb.
- Orange: 10.7 ppb.
- Santa Clara: 8.5 ppb.
- Sonoma: 5 ppb.
- San Diego: 4.7 ppb.[23]

The majority of the state's Regional Water Quality Control Boards face perchlorate contamination in their regions in excess of the actionable level. Listed below are some of the primary areas of concern in various regions:[24]

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[22] Parts per billion is the same measurement as µg/L or micrograms per liter.
[23] DHS website: <http://www.dhs.ca.gov/ps/ddwem/chemicals/perchl/monitoringupdate.htm>.
[24] This list is not an exhaustive compilation of regional detections. All data come from the "Geotracker" Website, which is no longer publicly available, unless otherwise attributed.

Central Coast Region

- *Morgan Hill/San Martin/Gilroy* – Perchlorate from an Olin Corp. site in Morgan Hill has spread through 7.5 miles of groundwater into northern Gilroy. To date, nearly 420 wells have been impacted by concentrations as high as 765 ppb.

- *Hollister* – Contamination associated with Whittaker Ordinance Inc. has impacted at least nine supply wells with groundwater detections of perchlorate in concentrations as high as 290,000 ppb.

Central Valley Region

- *Rancho Cordova* – Perchlorate concentrations in well water generally range as high as 360 ppb at the former Aerojet site east of Sacramento. However, where water previously treated for other contaminants was reinjected into the ground, the highest concentrations are in excess of 100,000 ppb. The perchlorate plume extends four miles offsite, and has impacted seven wells.

Colorado River Basin Region[25]

- *Colorado River* – The river is impacted with concentrations of perchlorate from 4 to 10 ppb from Lake Mead to the Mexican border. This region depends on these waters (transported via aqueduct or canal) for irrigation, drinking water, and groundwater recharge, and lacks alternative water sources. Currently, two water districts are suing each other over the issue of assessments for a groundwater recharge program. Mission Springs is suing Desert Water seeking a refund for a project that will import water from the Colorado River and put it underground to replace what is being pumped from the Mission Creek sub-basin aquifer. Mission Springs asserts that the Colorado River water is more polluted with perchlorate than the water that naturally lies in the sub-basin aquifer.

- *Desert Water Agency, Coachella Valley Water District, Torres Martinez Indian Reservation* – Several wells have been shut down with perchlorate concentrations ranging from 3 to 8 ppb.

Los Angeles Region

- *Pasadena* – As of December 2002, the city had decided to shut down nine of its 13 drinking water supply wells due to contamination associated with NASA's Jet Propulsion Laboratories complex.[26] The city of Pasadena must buy water from the city of Los Angeles to offset lost supply. Concentrations as high as 1,500 ppb have been detected at on-site wells, while off-site wells have registered 25 ppb.

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[25] "Executive Officer's Report." California Environmental Protection Agency, Regional Water Quality Control Board, Colorado River Basin Region. June 25, 2003.

[26] Dennis Dickerson. Executive Officer, California Regional Water Quality Control Board, Los Angeles Region. "Memorandum: Update on Perchlorate Groundwater Pollution Within the Los Angeles Region. April 28, 2003.

- *Santa Clarita* – Perchlorate concentrations in excess of 300,000 ppb have been detected in the groundwater at a Whittaker-Bermite site. Five supply wells with concentrations ranging from 5.9 to approximately 50 ppb have been shut down.

San Diego Region

- *Escondido* – At least one drinking water source has registered perchlorate concentrations up to 4.8 ppb.[27]

- *San Diego* – Perchlorate-contaminated water from the Colorado River with concentrations from 4 to 10 ppb represents a significant portion of the area's drinking water supply.[28]

San Francisco Bay Region

- *San Jose* – Test wells at the United Technologies site in San Jose have registered concentrations of perchlorate in excess of 100,000 ppb; but no contamination to drinking water has occurred. However, storm water and runoff sampling indicate perchlorate at levels of concern, since Anderson Reservoir, a source of community drinking water, is only half a mile away.[29]

Santa Ana Region

- *Crafton/Redlands* – Contamination from Lockheed Propulsion Co. has created a perchlorate plume measuring approximately seven square miles that has impacted 47 drinking water wells. Concentrations as high as 70 ppb have caused the shutdown of five wells.

- *Rialto/Colton* – Twenty wells in the area have been impacted by multiple sources of perchlorate contamination. The city of Rialto has shut down 5 of its 15 wells due to perchlorate concentrations as high as 74 ppb. The closed wells represent a loss of 47 percent of the city's pumping capacity. The plume of perchlorate underneath the city is spreading at a rate of approximately three feet per day and threatens still more wells. Should those wells become affected, the city's water supply could be lost within four days.[30]

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[27] DHS. Ibid.

[28] National Resource Defense Council. "What's On Tap? Grading Drinking Water in U.S. Cities." October 2002.

[29] An explosion at the site on August 7, 2003, set fire to 37 acres of brush land requiring 60 firefighters to answer the alarm. Officials reported that runoff from the firefighting efforts had entered local creeks that feed Anderson Reservoir, but it was not yet clear whether any chemical contamination of the reservoir had resulted.

[30] Rialto-specific information is derived from materials and presentation given by Brad Baxter (Inland Empire) and Sheri Lasick (Sylvir Consulting). "Case Study II: The Rialto/Inland Empire Case – Financing and Managing Public Water Utility Impacted by Perchlorate." July 31, 2003.

III. Health Effects of Perchlorate

Perchlorate interferes with the proper functioning of the thyroid gland, which helps to regulate metabolism and growth.[31] Specifically, perchlorate inhibits uptake of iodide to the thyroid, producing a decrease in thyroid hormone production. The human body does not metabolize perchlorate and data indicates that it does not accumulate in the body. Perchlorate is eliminated from the body fairly rapidly, with a half-life of only eight hours.[32] Adverse health effects from perchlorate are considered acute, producing a strong or serious short-term effect.

Certain subpopulations, including pregnant women and their fetuses, and individuals with hypothyroid conditions (too little thyroid hormone) are thought to be at particular risk to repeated perchlorate exposure, even at low levels. During pregnancy a woman's endocrine system (which includes the thyroid gland) is placed under greater than normal strain. The proper functioning of a mother's thyroid gland is critical to both the health of the mother and the proper development of her fetus. This is particularly true during the first and second trimesters when the fetal thyroid is not yet developed and able to function on its own.[33] Babies born to mothers with impaired thyroid functioning may exhibit changes in behavior, delayed development, and decreased learning capability.[34]

At very high doses, perchlorate has caused thyroid tumors in laboratory rats. However, it is not certain whether similar effects would occur in humans. In fact, because of its known adverse effects, little perchlorate research has been conducted on humans. Most of what is known about the specific impacts of high doses on humans comes as a result of the treatment of patients with Graves' disease in the 1960s. Perchlorate's ability to reduce thyroid hormone production prompted its use as a treatment for the severe hyperthyroidism (too much thyroid hormone) associated with Graves' disease. Unfortunately, high doses of perchlorate produced moderate to severe, and occasionally fatal, side effects in some patients and the treatment was discontinued.[35]

Only recently has attention begun to focus on the health effects of low-level perchlorate exposure. Given its propensity for blocking iodide uptake to the thyroid, these effects are thought to be similar to those caused by iodine deficiency. Because iodine deficiency in pregnant women has been linked to adverse neurological development and reduction of intelligence quotient (IQ) in their children, efforts are focused on establishing the level of perchlorate intake that will not increase the risk of these effects occurring.[36] Prior to 1997, detection techniques did not allow scientists to identify perchlorate at very low

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[31] State Water Resources Control Board (SWRCB). "Groundwater Information Sheet." Draft. October 23, 2002.
[32] Office of Environmental Health Hazard Assessment (OEHHA). "Public Health Goal for Perchlorate In Drinking Water." Draft. December 2002.
[33] SWRCB. Op. cit.
[34] EPA website: http://www.epa.gov/safewater/ccl/perchlorate/perchlorate.html.
[35] Barziali, D. et al. "Fatal complications following use of potassium perchlorate thyrotoxicosis: report of two case studies and a review of the literature." 1966. As cited by the Environmental Working Group. 2001.
[36] OEHHA. Op. Cit.

concentrations. But laboratories can now reliably identify perchlorate at levels as low as 4 ppb, and the technology continues to improve. Consequently, our full understanding of health effects from low-level exposure to perchlorate is still emerging.

IV. Perchlorate Pathways

Perchlorate enters the human body in one of several ways. It can be inhaled, absorbed through the skin or, more commonly, ingested by way of drinking water or certain foods.[37] Inhalation and skin absorption are less efficient pathways than ingestion, and generally occur only under industrial circumstances in which perchlorate salts are present. More often, perchlorate from an industrial source comes into contact with water, rapidly dissolves, and, unless properly contained, enters a local water system where it may travel great distances to enter irrigation and drinking water sources. For example, large volumes of perchlorate produced at a manufacturing site southeast of Las Vegas seeped into the nearby Las Vegas Wash where the perchlorate migrated over three miles into Lake Mead, and from there to the lower Colorado River. The Colorado River provides drinking water to over 15 million residents of California, Nevada, Arizona, and Mexico, and irrigates much of the United States' winter lettuce supply. Colorado River water contains perchlorate concentrations well above the state's action level when it enters California.[38]

While drinking water is probably the most common and best understood pathway for perchlorate to enter the human body, emerging research suggests that some food products may also carry perchlorate. A 2003 study conducted by the Environmental Working Group found perchlorate in excess of the California action level in lettuce samples taken from San Francisco Bay Area supermarkets. The winter lettuce tested was most likely grown in the regions of Southern California and Arizona irrigated by the waters of the Colorado River.[39] This study raises concern that perchlorate can accumulate in plants, and perhaps through the food chain.

These findings were substantiated when the USDA confirmed federal tests found perchlorate in winter lettuce irrigated with Colorado River water.[40] Canadian officials have expressed concern and are preparing to test lettuce and other crops imported from the rich agricultural regional straddling the California-Arizona border.[41]

In addition, researchers from the Institute of Environmental and Human Health at Texas Tech University reported perchlorate was found in supermarket milk at levels exceeding the federal government's recommended levels for drinking water.

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[37] EPA. Op Cit.
[38] Joint Presentation by James Giannopoulos (State Water Resources Control Board) and Karen Baker (Department of Toxic Substances Control). "Perchlorate Contamination of California's Groundwater Supplies."
[39] "Suspect Salads: Toxic Rocket Fuel Found in Samples of Winter Lettuce." Environmental Working Group. 2003.
[40] "Federal Tests Find Perchlorate in Food," *Riverside Press Enterprise*. November 26, 2003.
[41] Ibid.

Perchlorate levels in the milk ranged from 1.7 to 6.4 ppb – higher than the U.S. EPA's draft proposed safety standard of 1 ppb.[42] Dr. Phil Smith of Texas Tech University has said that very preliminary research indicates that perchlorate seems to be more easily absorbed when it is in water and that perhaps perchlorate in food may not be as easily bioaccumulated.[43]

However, more research is necessary to rule out any potential risks these possible pathways pose to humans.

V. Perchlorate Detection and Monitoring

In February 1997, the California Department of Health Services began sampling dozens of drinking water wells after perchlorate contamination was discovered in water supplies in eastern Sacramento County. In January 2001, DHS began requiring all community and non-transient non-community water systems that are vulnerable to perchlorate to sample their water supplies for perchlorate. Since that time, more than 1,100 of the state's approximately 4,400 water systems have reported the results of their monitoring efforts. The tested systems serve nearly 29 million Californians (or approximately 83 percent of the state population). Thus far, 85 systems across 10 counties have detected perchlorate in 335 active or standby drinking water wells.[44]

The current approved method of detection for perchlorate is by ion chromatography,[45] which allows identification of minute amounts of perchlorate in a water source (approximately 4 parts per billion). However, it would not be sufficient to meet the EPA's draft protective level of 1 ppb. Recent reports from Los Alamos National Laboratory[46] and Texas Tech University encourage hope that new technology will soon allow detection of perchlorate in concentrations of 1 ppb or lower (parts per trillion).

VI. Cleanup

Because perchlorate spreads so readily, contaminates large volumes of water, and does not tend to biodegrade, it defies any traditional notion of "cleanup." In most cases, true cleanup is currently infeasible due to the limitations of technology, the immense volume of water contaminated, and the impracticality of pumping large bodies of groundwater dry simply to clean them. Instead, remediation at the wellhead is used to clean the water for human consumption.
It should be noted, however, that wellhead remediation does not generally address perchlorate contamination of ground or surface water sources used for irrigation or as drinking-water sources for livestock or wild animals.

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42 See discussion of the U.S. EPA draft report on page 15.
43 Personal telephone conversation with Kip Wiley, November 11, 2003.
44 DHS Website: <http://www.dhs.ca.gov/ps/ddwem/chemicals/perchl/monitoringupdate.htm>.
45 "EPA Method 314.0 – Determination of Perchlorate in Drinking Water by Ion Chromatography."
46 "Method allows detection of small amounts of perchlorate." The Associated Press, State and Local Wire. July 18, 2003.

Several technologies are available or under development to remediate perchlorate-contaminated water, though some have been more thoroughly tested than others. (See Table 1 below.) These technologies include biological treatment, ion exchange, reverse osmosis and nanofiltration, and liquid granulated activated carbon. Generally speaking, there is no single preferred technology for perchlorate cleanup, although most pilot projects use either biological treatment or ion exchange.[47] Each of the methods described below is relatively costly.[48] The best methods are often determined by circumstances at the site and the proposed use of the water supply in question.

State funds to clean up perchlorate contamination have come from various sources:

- $3 million — State Water Resources Control Board – Cleanup and Abatement Account.
- $3 million — State Water Resources Control Board – Proposition 50 funds for water quality, drinking-water supply, safe drinking-water projects, and coastal wetlands purchase and protection.

In addition, AB 1747, a budget trailer bill authored by the Assembly Budget Committee in 2003, allows Proposition 50 bond funds to be used for grants for groundwater management and recharge projects. It instructs DHS to develop a program that places a priority on projects that reduce public and environmental exposure to contaminants that pose a significant health risk, including perchlorate.

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[47] Calgon Carbon Corp. has recently developed new ion exchange beads that will link with perchlorate but not other compounds, such as nitrates and sulfates, which are commonly found in water. The new beads can be kept in service longer, potentially reducing the maintenance costs for the systems treating perclorate-contaminated water.

[48] Some methods have higher capital start-up costs but lower operational and maintenance costs (e.g. biological treatment), while others have lower capital start-up costs but higher operation and maintenance costs (e.g. ion exchange). For example, at the Aerojet site in Rancho Cordova, the biological treatment technology in use costs approximately $165 per acre-foot of water treated, on top of the $5.5 million in initial capital costs. Meanwhile, at the La Puente site, capital costs for ion exchange were approximately $2 million with an additional cost of $145 per acre-foot of water treated.

Table 1
Methods of Perchlorate Cleanup/Remediation

Name of Treatment	Description/Comment[49] [50]
Biological	Uses microbes to break perchlorate into oxygen and chloride – destroys perchlorate; considered very expensive. Costs $2-3 million. *This method is in use.*
Ion Exchange	Removes perchlorate from source down to 4 ppb, but concentrates it in a "brine" that must be safely disposed. Costs $100/acre-foot of water treated; a more expensive version ($500/acre-foot) is able to destroy perchlorate. *This method is in use.*
Reverse Osmosis and Nanofiltration	*This experimental method is being tested***.**
Liquid Granulated Activated Carbon (GAC)	Requires frequent replacement (approximately once a month) of carbon beds, which are used to remove perchlorate. GAC treatment at 30 perchlorate-contaminated sites including Redlands, CA, was discontinued several years ago until a more economical alternative could be found. Methods are currently being developed to increase life of carbon beds.[51] *This method is in use.*

Because of the technological limitations and costs of detection and cleanup, water containing low concentrations of perchlorate is often "blended" with uncontaminated water to reduce perchlorate concentrations below maximum acceptable levels. This process, for example, is employed in several areas in Southern California that are dependent on the Colorado River for their drinking water. Where perchlorate concentrations are higher, however, blending is not appropriate, and unless wellhead treatment is feasible, water sources must be shut down. In Santa Clara County, hundreds of residents had to be supplied with bottled water until treatment equipment could be ordered and installed on wellheads closed due to perchlorate contamination. The cost of delivering safe drinking water to residents in that area ranged from $2 million to $150 million.[52]

VII. State Actions

California has not set a drinking water standard (the maximum contaminant level, or MCL) for perchlorate, but DHS was required to do so by January 1, 2004. Establishing a perchlorate regulation is a two-step process. First, the Office of Environmental Health Hazard Assessment (OEHHA) must set a "public health goal"

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49 SWRCB. Op. Cit.
50 Dennis Dickerson. Op. Cit.
51 Bruce E. Logan. "Assessing the outlook for perchlorate remediation." *Enrironmental Science and Technology*. December 1, 2001.
52 Kate Folmar. "Officials present clean-water options." *San Jose Mercury News*. May 4, 2003.

(PHG) that establishes a perchlorate concentration level that it believes does not pose a risk to human health. Second, DHS sets an MCL that is protective of human health, but remains as close to the PHG as is technically and economically feasible.

OEHHA set a revised draft PHG for perchlorate in December 2002, proposing a concentration of between 6 and 2 ppb. OEHHA will probably set a final PHG in early 2004 as discussed above. In the meantime, DHS has identified perchlorate as an "unregulated chemical requiring monitoring" (effective January 2001), and has instituted an "action level," requiring water systems to notify local government about detections of perchlorate above the action level. DHS originally established an action level of 18 ppb in 1997, but revised that number downward to 4 ppb on January 18, 2002.

Thus, California should have an enforceable regulation on perchlorate by sometime in 2004. However, it is important to note that the final MCL may be higher than would otherwise be the case due to the limitations of the technology available in most commercial laboratories for testing water quality. Recent studies indicate that concentrations as low as 1 ppb may present health risks, but at present most commercial labs cannot detect perchlorate in concentrations below 4 ppb (the current state action level).

California agencies on June 6, 2003, requested federal cooperation in cleaning up DOD installations in a letter[53] signed by Cal EPA Secretary Winston Hickox, Department of Toxic Substances Control Director Edwin Lowry, and SWRCB Executive Officer Celeste Cantu. They asked that the installations assist state agencies in identifying, investigating, and cleaning up perchlorate on their properties. In his July 3, 2003, reply, Woodley said the department was "investing in activities that will enable [DOD] to step out quickly *once EPA establishes the MCL*" [emphasis added]. However, moving more quickly, Senator Barbara Boxer announced on August 7, 2003, that Woodley and the DOD had publicly agreed to comply with California's safe drinking-water standard for perchlorate. In addition, the DOD committed to establishing a federal/state interagency working group, and providing the state information on perchlorate contamination and schedules for testing. The DOD also gave assurances that its attempts to gain exemptions from federal environmental laws were not an attempt to escape liability for cleanup of perchlorate contamination.[54]

In July and August 2003, the state's nine regional water quality control boards sent letters[55] to military commands requesting perchlorate information and sampling plans for 71 military installations and formerly used defense sites (FUDS). Responses to most of the letters were due September 30, 2003, although replies to some letters that were sent out later were due by October 30, 2003. To date none of the 71 installations has responded, all indicating that they are awaiting instruction from DOD. The regional water boards could take the next step

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53 See text of letter in Appendix D2.

54 "Boxer Announces Agreement On Perchlorate Contamination." Press Release. August 7, 2003. Official Website of U.S. Senator Barbara Boxer of California. <http://boxer.senate.gov/newroom/200308/20030807_env.html>.

55 See text of letters in Appendix D1.

and issue notices and orders to the installations, requiring that requested actions take place.

The Thursday Group, a coalition of lobbyists for various industry groups, including chemical companies and defense contractors, sent Governor Schwarzenegger a letter in late November 2003 expressing concern regarding the state's impending regulations on perchlorate. They expressed their desire that California wait until the National Academy of Sciences evaluated the health hazards of perchlorate before adopting regulations.[56]

VII. Federal Actions

The EPA placed perchlorate on its contaminant candidate list in 1998. The following year, the EPA began requiring drinking water monitoring for perchlorate and, in 2002, issued a draft assessment of perchlorate. Titled *Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization*, the report recommended a 1 ppb safety standard for perchlorate in drinking water – in other words, a level *four times* more restrictive than the current California action level. Though it has gone through extensive peer review, the EPA report has not yet been publicly released.

There is no national drinking water regulation for perchlorate, and it appears unlikely that there will be one anytime soon. On July 15, 2003, the U.S. EPA announced that it would not formulate safety standards for perchlorate or any of the other chemicals on its "contaminant candidate list." This means that perchlorate will not come up for review again for at least another three to five years, unless "emergency" procedures are followed to expedite the process.

In March 2003, the White House Office of Management and Budget referred perchlorate to the National Academy of Sciences (NAS) for six to 18 months of review. The EPA has banned public discussion of perchlorate by its employees until the NAS delivers its opinion. However, the federal EPA and DOD still widely differ in their assessments of what level of perchlorate is safe in drinking water. In presentations before the National Academy of Sciences' Committee to Assess the Health Implications of Perchlorate Ingestion on October 27, 2003, the federal EPA said its studies supported a 1 ppb standard.[57] Col. Dan Rogers, chief of the Environmental Law and Litigation Division of the Air Force, told the panel that the levels of perchlorate found in the environment today have no effect on human health and that a standard of 200 ppb is safe.[58] The Committee to Assess the Health Implications of Perchlorate Ingestion has also held a session in California in Irvine on December 12 and 13, 2003. At that time Col. Rogers presented a panel of experts that called into question the methodology and results of the EPA's risk assessment.

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[56] Michael Bustillo. "Foes of Environmental Regulation Woo Governor." *Los Angeles Times.* November 27, 2003.
[57] Associated Press. "EPA, Air Force Differ on Perchlorate Risks in Drinking Water." *Las Vegas Sun*, October 28, 2003.
[58] Ibid.

Based on this timeline, 2007 is the earliest that federal regulation of perchlorate could be expected. But U.S. Senator Barbara Boxer and U.S. Representative Lois Capps of Santa Barbara have introduced bills in their respective houses (S. 502 and H. R. 2123) that would bump the deadline for federal regulation forward to July 2004. Those bills remain in committee at present. Earlier last year, language was deleted from a fiscal year 2004 defense appropriations bill to require the EPA to restudy perchlorate groundwater contamination and set a drinking water standard within 180 days. The provision was removed before the bill (H.R. 2658) was adopted in September 2003.

Meanwhile, the DOD recently launched a top-priority search for a safer alternative to perchlorate, according to a *Sacramento Bee* report that cited an unnamed top Pentagon official.[59] On July 11, 2003, the DOD also agreed to help clean up perchlorate-polluted groundwater in San Bernardino County. And despite the recent agreement, noted above, to cooperate with California state officials, the DOD has declined to share all of the results of a 2001 survey it conducted of perchlorate contamination at Defense Department sites. This refusal has sparked accusations from some quarters that DOD is avoiding responsibility for polluting practices that span over 50 years.[60]

IX. Options

California is further along than most states in perchlorate detection, monitoring, and remediation processes; however, state efforts could be greatly assisted by better cooperation from federal departments and agencies. For example, full disclosure by the DOD of sites where perchlorate is known to have been used or dumped would allow the state to save resources by more quickly identifying contaminated water sources. More timely identification of contamination sites would also allow remediation efforts to begin more promptly and thus would aid in health-effect mitigation efforts.

Cleanup: A Long-term Effort with Significant Costs

Remediation of perchlorate contamination faces several hurdles. First, the costs are significant. Because low levels may endanger human populations, and because perchlorate spreads so readily within vast underground water systems, the size and scope of perchlorate cleanup in some areas is daunting. The sheer volume of water known to be affected is large and growing steadily as testing identifies new contaminated sites, and underground plumes of perchlorate spread. In the city of Rialto, five of the city's 15 wells have already been closed due to perchlorate contamination, while the perchlorate plume spreads at an estimated rate of *three feet per day*.[61]

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59 Chris Bowman. "Pentagon targets a water pollutant: Perchlorate alternative sought for rocket fuels." *Sacramento Bee*. July 9, 2003.

60 In May 2003, U.S. Representatives John Dingell (Michigan) and Hilda Solis (California), sent a letter to Secretary of Defense Donald Rumsfeld accusing the DOD of concealing the details of perchlorate contamination. Reported by Peter Waldman. "Pentagon Is Accused of Hiding Report on Perchlorate Pollution." *Wall Street Journal*. May 19, 2003.

61 Business Wire. "Rialto Toilet Exchange Program is a Success." July 29, 2003.

Meanwhile, the timeframe in which full remediation of some contaminated sites can be expected to take place is measured in centuries, not months or years. The Aerojet site in Rancho Cordova, for example, could require well over 200 years to fully remediate. Further complicating cleanup is the prospect that the perchlorate concentration levels deemed safe by scientists may exceed technological capabilities to remediate perchlorate pollution. Technology at many commercial laboratories is not even able to reliably detect perchlorate at the EPA's draft level of 1 ppb. Until better testing and cleanup technologies become available and more affordable, other strategies for dealing with perchlorate, such as "water blending" and containment will have to be employed.

Mitigation of Health Effects: More Research Necessary

With untold volumes of perchlorate already loose in the environment and full cleanup of some sites not feasible in the short-run, priority goes to effective mitigation of adverse human health effects from perchlorate contamination. This process begins with detecting and identifying perchlorate in water sources, as California agencies are already doing. Once an MCL is established, appropriate measures will be needed to ensure that communities whose water supplies exceed the MCL level have access to alternate water supplies until treatment can be implemented.

In addition, more research is needed to better understand the long-term health effects associated with perchlorate exposure both from water and food sources. While perchlorate as a water contaminant has received most of the attention, relatively little study has been given to the possibility of food pathways. For example, does perchlorate-contaminated water from the Colorado River concentrate in the alfalfa crops it irrigates in the Imperial Valley? If so, does that perchlorate become concentrated in dairy cows who are fed the alfalfa? And if so, is milk from those cows transmitting harmful levels of perchlorate to children, a group that is particularly at risk? These questions need to be answered.

Close the Barn Door: Prevent Future Contamination

Efforts to identify and remediate perchlorate contamination are hampered by a lack of detailed information about its transport, use, and disposal over the last 50 years. This problem is compounded by the fact that 90 percent of all perchlorate is used by the defense and aerospace industries, which may claim a need for secrecy in their activities. However, instituting regulations requiring notification to the state of transport, use, and disposal of perchlorate would better enable the state to prevent future contamination and facilitate swifter response in the event that contamination did occur.

State Action Needed in the Absence of a Federal Near-Term Response

The recent decision to delay regulatory action at the federal level highlights the importance of the state regulatory process. The state's present timeline should produce a California perchlorate regulation within the year. In addition, SB 1004 (Soto), enacted last year, will require notification to the State Water Resources Control Board of any discharge of perchlorate into the environment and impose penalties for failure to do so.[62] The new law also will require operators of facilities that have ever stored at least 500 pounds of perchlorate to report information about the storage to the state board.

X. Conclusion

California will bear the legacy of 50 years of perchlorate contamination for many decades to come. The cost of identifying and remediating all of the state's contaminated waters will be substantial. However, sensible steps can be taken to minimize the future costs associated with California's perchlorate problem:

- Now that both the federal EPA and the California Office of Environmental Health Hazard Assessment have indicated that perchlorate is harmful to humans, it should be monitored and regulated like other hazardous materials to prevent further contamination.

- Additional study of the human health effects of perchlorate exposure should be given a priority and, in the meantime, shorter-term efforts can focus on how best to protect susceptible populations, including pregnant women and people with hypothyroid conditions.

- Federal and state agencies should cooperate more fully with one another to expedite detection, monitoring, and remediation efforts. In particular, the Department of Defense should share with state agencies whatever it knows about perchlorate contamination in California, including its 2001 survey of DOD perchlorate-contaminated sites.

Although the drinking water of millions of Californians may be threatened by perchlorate contamination, it can be prevented from spreading further.

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[62] Chapter 614, Statutes of 2003.