Initial Statement of Reasons
Perchlorate Primary Maximum Contaminant Level (MCL)
Title 22, California Code of Regulations

All suppliers of domestic water to the public are subject to regulations adopted by the U.S. Environmental Protection Agency (USEPA) under the Safe Drinking Water Act (42 U.S.C. 300f et seq.) as well as by the California Department of Health Services (Department) under the California Safe Drinking Act (Sections 116270-116751, Health and Safety Code [H&S Code]). California has been granted "primacy" for the enforcement of the Federal Act. In order to receive and maintain primacy, states must promulgate regulations that are no less stringent than the federal regulations.

In accordance with federal regulations, California requires public water systems to sample their sources and have the samples analyzed for inorganic and organic substances in order to determine compliance with drinking water standards, including maximum contaminant levels (MCLs). Primary MCLs are based on health protection, technical feasibility, and costs. The water supplier must notify the Department and the public when a primary MCL has been violated and take appropriate action.

Section 116293(b) of the H&S Code mandates that the Department adopt a perchlorate MCL as close as possible to the public health goal (PHG) established by the Cal/EPA Office of Environmental Health Hazard Assessment (OEHHA), while considering the cost and technical feasibility of treatment and analysis.

This regulation package proposes the following amendments to Chapter 15, Division 4, Title 22 of the California Code of Regulations.

- Amend Section 64413.1 (Classification of Water Treatment Facilities) to include points for perchlorate treatment when calculating the classification of a treatment facility and to update the radionuclide section references, which changed as a result of the radionuclide regulations adopted in June 2006 .
- Amend Section 64431 (Maximum Contaminant Levels – Inorganic Chemicals) to adopt a perchlorate MCL and clarify the wording in subsection(a);
- Amend Section 64432 (Monitoring and Compliance – Inorganic Chemicals) as follows:
    - (a) and (b) to specify which water systems are required to monitor for perchlorate and cite the sections that provide the detailed requirements;
    - Table 64432-A to adopt perchlorate with its detection limit for purposes of reporting (DLR);
- Adopt a new section 64432.3 (Monitoring and Compliance – Perchlorate) to establish the monitoring and compliance determination requirements for perchlorate and provide variances for systems unable to afford compliance;
- Adopt a new section 64432.8 (Sampling of Treated Water Sources) to require monthly monitoring of the treated water for sources being treated for compliance with any inorganic MCL;
- Amend Section 64447.2 (Best Available Technologies (BAT) – Inorganic Chemicals) to include perchlorate with its best available technology in Table

64447.2-A and list a new technology that is specifically applicable to perchlorate, i.e., biological fluidized bed reactor;

- Repeal Article 17 and Section 64450 (Unregulated Chemicals – Monitoring), to eliminate obsolete requirements (the deadline for monitoring has passed); and
- Amend Section 64465 (Health Effects Language – Inorganic Chemicals) to adopt health effects language for perchlorate.
- Amend Section 64481 (Typical Origins of Contaminants with MCLs) to adopt the typical origins of perchlorate.

The net effects of the proposed regulations would be as follows:

- Community Water Systems (CWS) and Non-Transient Community Systems (TNCS) would be required to monitor for, and comply with, an MCL for perchlorate;
- CWS and NTNCS unable to afford treatment to comply with the perchlorate MCL would be able to apply for a variance;
- CWS and NTNCS that treat a drinking water source to comply with an inorganic chemical MCL would be required to monitor the treatment effluent monthly;
- CWS and NTNCS that violate the perchlorate MCL would be required to use specific health effects language for the public notification; and
- Best available technologies would be specified for perchlorate removal.

None of the proposed amendments would affect California's primacy status, because the net effect of these amendments is that the state's regulation would be more stringent than the federal regulation, which is allowed. The USEPA has not yet proposed or adopted an MCL for perchlorate.

The following paragraphs describe and explain the proposed amendments.

Article 2. General Requirements

Section 64413.1. Classification of Water Treatment Facilities

The purpose of amending this section would be to include points for perchlorate treatment when calculating the classification of a treatment facility. Perchlorate, similar to nitrate and nitrite, is considered an acute contaminant and a treatment failure would pose an acute risk to public health. Additionally, the section would be revised to update the radionuclide section references, which changed as a result of the radionuclide regulations adopted in June 2006.

Article 4. Primary Standards – Inorganic Chemicals

Section 64431. Maximum Contaminant Levels – Inorganic Chemicals.

The purpose of this section is to list the chemicals for which maximum contaminant levels (MCLs) have been established to protect the health of consumers of drinking water served by community and nontransient-noncommunity water systems. The text in subsection (a) would be revised for clarity.

A perchlorate MCL of 0.006 mg/L would be added to Table 64431-A. The rationale for the proposed MCL is provided below; it includes perchlorate characteristics, history,

analytical methodology, occurrence in water, health effects, and a cost-benefit analysis summary.

- **About Perchlorate**

Perchlorate (as the chemical ion, ClO_4^-) results from the dissociation of perchlorate-containing salts, such as potassium perchlorate (a chemical used historically in the medical treatment of hyperactive thyroid glands) and ammonium perchlorate (a chemical with many uses, including in rockets, fireworks, and explosives). Perchlorate salts have a long history of use in medicine and industry.

Ammonium perchlorate is used as solid rocket propellant at aerospace development and testing facilities. In California, perchlorate contamination of groundwater has emerged primarily near such facilities. Contamination has also been found in a surface water source, the Colorado River, as the result of contamination from historic ammonium perchlorate manufacturing facilities in the state of Nevada.

- **Recognition of Perchlorate as a Drinking Water Contaminant**

Although used by industry for decades and recognized as an environmental contaminant in the 1980s, it was not until 1997 that perchlorate was identified as a significant drinking water contaminant. This happened when the Department of Health Services drinking water program was informed by the regional water quality control board and operators of an aerospace facility in eastern Sacramento County that drinking water wells near the facility were contaminated. Contamination was presumed to have resulted from cleanup operations at the facility (a federal Superfund site) that pumped shallow groundwater containing volatile organic chemicals (VOC) and perchlorate to a treatment unit that extracted only the VOCs, and injected the perchlorate-containing treated water into a deeper aquifer below the site. The deeper aquifer is a source of drinking water to nearby community systems.

In 1997, analytical methods could not detect perchlorate at levels below 100 micrograms per liter (µg/L). However, a review of the available health risk evaluations of perchlorate indicated that concentrations of 4 to 8 µg/L would not adversely affect the thyroid gland (the target organ for the chemical). Since there was a significant gap between the detection level and "safe" levels, the Department's Sanitation and Radiation Laboratory developed an analytical method that could detect perchlorate at concentrations as low as 4 µg/L. This method evolved into the one currently approved by USEPA for perchlorate analysis: Method 314.0 — Determination of Perchlorate in Drinking Water by Ion Chromatography.

- **Occurrence**

In 1997, with the more sensitive analytical method, the Department was able to identify dozens of perchlorate-contaminated wells in Sacramento County and in southern California, principally in the counties of Los Angeles, Riverside, and San Bernardino. The contamination of the Colorado River was also identified at this time.

Since 1997, perchlorate has been found in groundwater at various locations throughout the United States, including Massachusetts, New York, Texas, and Nevada. Colorado River contamination has been documented in Nevada and Arizona.

Wells are subject to perchlorate contamination primarily from (1) past practices related to improper handling of perchlorate during the testing of solid rocket propellant, (2) improper hazardous waste disposal, (3) reinjection of water that has had other contaminants (but not perchlorate) removed, and (4) groundwater replenishment with perchlorate-containing water, such as recycled water from the Colorado River.

Surface water contamination seems to be less pervasive than groundwater contamination, but can still be significant in terms of the large number of people exposed (e.g., the Colorado River).

In 1999, the Department adopted a regulation requiring monitoring of perchlorate as an unregulated chemical to address the need to better document the extent of perchlorate contamination of drinking water supplies (22 California Code of Regulations section 64450). Subsequent monitoring indicated significant groundwater and surface water contamination by perchlorate.

As of April 2004, 89 systems reported perchlorate detections in 351 of approximately 6,500 sources sampled. Of the 351 sources, nearly all were groundwater. The few surface water sources were almost all representative of water from the Colorado River.

More than half of the state's community and nontransient-noncommunity systems' drinking water sources have been sampled. The data indicate both a significant level of drinking water contamination and a potential for adverse health effects.

- **Health Concerns about Perchlorate—State Action Level**

Perchlorate exposure is of public health concern because it interferes with the ability of the thyroid gland to produce hormones. In the very young, hormones are needed for normal prenatal and postnatal growth and development, particularly normal brain development; therefore, a diminution of thyroid hormones is a problem. In the adult, thyroid hormones are needed for normal body metabolism.

In 1997, in response to the findings of perchlorate in drinking water wells in eastern Sacramento County, the Department established an action level (health guidance level) of 18 µg/L. The action level was based on a 4- to 18-µg/L range derived from perchlorate risk assessments done in 1992 and 1995 by the USEPA for use in its Superfund program that deals with hazardous wastes.. The range was derived from an estimated no-observed-adverse-effect-level (NOAEL) for non-carcinogenic effects on the thyroid gland in human studies, with an uncertainty factor incorporated to provide an adequate margin of safety.

Since 1997, the perchlorate action level has served as non-regulatory guidance to the Department's Drinking Water Program, County Health Departments, utilities and the

public on the significance of detections in drinking water, in the absence of federal or state drinking water standards.

In January 2002, reflecting concerns highlighted by a new draft risk assessment by the USEPA's National Center for Environmental Assessment, the Department revised its action level to 4 µg/L, the lower end of the earlier identified 4- to 18-µg/L range. The USEPA draft document suggested a 1µg/L protective level, a value that is lower than the reporting limit of 4 µg/L for perchlorate analytical results.

The 4-µg/L action level was used in an advisory capacity until March 11, 2004, when it was revised to 6 µg/L, the same level as OEHHA's PHG for perchlorate, which was released on that date. Once an MCL is in place, the Department's action level for perchlorate will cease being used to provide guidance.

- **Public Health Goal for Perchlorate: Basis for the Proposed MCL**

PHGs are strictly health-based exposure levels established by OEHHA pursuant to section 116365(c) of the H&S Code, which requires OEHHA to assess the risks to public health posed by a contaminant for which the Department proposes a primary drinking water standard. OEHHA's risk assessment is required to contain "an estimate of the level of the contaminant in drinking water that is not anticipated to cause or contribute to adverse health effects, or that does not pose any significant risk to health. This level shall be known as the public health goal for the contaminant."

In March 2004, OEHHA released a final document, "Public Health Goal for Perchlorate in Drinking Water" in which it established a PHG of 0.006 mg/L, derived from studies on effects of perchlorate on the thyroid gland observed in people. At the PHG, exposures to perchlorate would not affect the human thyroid gland, and would not be anticipated to cause or contribute to adverse health effects or to pose any significant risk to human health.

Pursuant to section 116365(a) and (b) of the H&S Code, the Department is to adopt an MCL that is as close as feasible to the corresponding PHG and "that, to the extent technologically and economically feasible" avoids any significant risk to public health. In addition, the Department must consider any national primary drinking water standard that may exist, and the "technological and economic feasibility of compliance with the proposed primary drinking water standard." The feasibility determination is to address "the costs of compliance to public water systems, customers, and other affected parties with the proposed primary drinking water standard, including the cost per customer and aggregate cost of compliance, using best available technology."

To determine whether the primary MCL for perchlorate should be proposed at the PHG level of 0.006 mg/L, the Department first established that there was no existing national primary standard, nor one soon to be developed or promulgated to be used as an additional point of reference.

Next, the Department evaluated feasibility in terms of available analytical methods for detecting perchlorate, monitoring costs, available treatment technologies for removal to the proposed MCL level, and the estimated fiscal impact on California drinking water utilities to comply with the proposed standard.

- **Feasibility of Compliance with the Proposed MCL: Cost-Benefit Analysis**

Section 116293(b) of the H&S Code mandates that the Department adopt a drinking water standard for perchlorate [maximum contaminant level (MCL)]; Section 116365 mandates that the MCL be set as close as possible to the public health goal (PHG), while considering cost and technical feasibility.

H&S Code Section 116365's reference to considering cost and feasibility requires a review of:

- The availability and costs of analytical methods for determining the presence of perchlorate,
- The availability and costs of appropriate technologies for mitigating its presence,
- The estimated costs to the regulated water systems for contaminant monitoring and,
- The estimated costs for treatment to systems with sources that violate the MCL and must be treated to come into compliance.

Consequently, the Department reviewed analytical method availability, best available technologies (BATs), and conducted a comprehensive cost benefit analysis using the monitoring data in the Division of Drinking Water and Environmental Management Water Quality Monitoring database (WQM). The Department estimated costs and benefits associated with five possible MCLs [0.006, 0.008, 0.010, 0.015, and 0.020 milligrams per liter (mg/L)], using the identified analytical method and the BAT ion exchange (the most commonly used treatment at this time).

Based on the results of the analysis, the Department proposes to adopt an MCL at the PHG level of 0.006 mg/L. The cost-benefit analysis and the Department's rationale for the proposed MCL are presented below.

- **Monitoring Feasibility**

The Department reviewed monitoring feasibility in terms of methods available, analytical detection levels, and water system costs.

Analytical method availability - USEPA Method 314.0—Determination of Perchlorate in Drinking Water by Ion Chromatography—is approved for perchlorate analysis and currently being used to test for perchlorate under existing monitoring requirements. The Department's Sanitation and Radiation Laboratory has determined that the accuracy and precision at 0.004 mg/L support its use as a minimum detection level for reporting data. This level has been used informally as a "detection level for reporting purposes" (DLR) for perchlorate monitoring for several years and is being proposed as a regulatory DLR in this regulation package.

Data for cost estimate
The Department used the perchlorate detections from the Department's Water Quality Monitoring (WQM) database for the period January 1, 2000 through December 31, 2003. Since January 7, 1999, perchlorate sampling data came from required monitoring of vulnerable sources under unregulated chemical monitoring regulations. Note that in terms of a comprehensive identification of all possibly affected sources in California, the data set cannot be assumed to be complete at the time of the download (March 18, 2004) for the following reasons:

- Under the unregulated chemical monitoring requirements, only water sources identified by the Department as vulnerable were required to monitor; therefore, there are likely to be some sources which were not identified as vulnerable that may be found to be contaminated during the initial monitoring required under the new regulations; and
- In the past, the local primacy agencies were not required to submit hard copies of data to the Department for small systems (<200 service connections). Therefore, this data did not start entering the WQM data base until electronic data transmission (EDT) of the results by the laboratory was required under new reporting regulations that took effect June 14, 2001.

The monitoring results in the downloaded WQM data were reduced to obtain an average level of contamination for each affected active source. The averages were then compared to the evaluated MCLs to estimate the number of sources that would be in violation of each MCL. The number of affected systems was also estimated. The systems (and their sources) were grouped on the basis of size into large (serving 200 or more connections) and small (serving less than 200 connections). The population served by each source was estimated using information obtained from the Department's Permits, Inspections, Compliance, Monitoring and Enforcement (PICME) database.

Monitoring costs (initial, routine, and quarterly) for all evaluated MCLs - The initial, routine, and quarterly monitoring costs would be the same for all reviewed MCLs. The procedure for estimating these monitoring costs follows.

Monitoring status of sources - Between January 1, 2001 and December 31, 2003, under the unregulated chemical monitoring requirements, sources designated "vulnerable" to perchlorate contamination were required to conduct monitoring consisting of two samples in one year. As of January 2004, approximately 55 percent of the drinking water sources in California had been monitored (6,150 "vulnerable" sources), and 45 percent had not been monitored (5,500 "nonvulnerable" sources).

Proposed monitoring frequencies
Initial - If a drinking water source had not previously been monitored for perchlorate, the water system would have to conduct initial monitoring to determine whether perchlorate is present and whether the source is in compliance with the MCL.
Routine - Subsequent to meeting the initial monitoring requirement, sources without detections would be required to monitor once every year (surface water) or once every three (groundwater) years.

Quarterly for sources with detections - A water system with one or more drinking water sources with detected perchlorate would be required to monitor those sources quarterly unless/until four consecutive quarters of data findings are "non detects".

Initial monitoring costs (first year only) - As of January 2004, 2,434 large water system sources and 3,066 small water system sources had not been monitored because they were not considered vulnerable under the unregulated chemical monitoring rule. These "nonvulnerable" sources would need to conduct initial monitoring under the proposed regulations consisting of 2 samples during the first year after adoption, at an average cost (based on a laboratory survey) of $88 a sample. Approximate total costs for this one-time initial monitoring would be $428,000 for large system sources and $540,000 for small system sources. These costs would be associated with any adopted MCL.

Routine monitoring costs (no perchlorate detection)

Costs for sources using previously-collected data - The proposed regulations would allow water systems to make use of previously-collected perchlorate data to minimize costs. Much of that data is the result of monitoring under the State's unregulated chemical monitoring rule that required "vulnerable" sources to be monitored for perchlorate by December 31, 2003.

Sources able to use previously collected data (~6,150: 2719 large water system sources and 3427 small water system sources) would need to conduct routine monitoring (1 sample/year for surface water sources and 1 sample every 3 years for groundwater sources). Total annualized costs for this ongoing monitoring would be approximately $93,000 for large water system sources and $114,000 for small water system sources.

Costs for sources that had to conduct initial monitoring of "nonvulnerable" sources - The Department assumes that most of the ~5,500 sources conducting initial monitoring during the first year the proposed regulation takes effect would not detect perchlorate and, therefore, would subsequently conduct routine monitoring. Consequently, the annualized routine monitoring for these sources would be $83,000 and $101,000 for large and small water system sources, respectively.

Costs for annualized routine monitoring all sources - Starting with the second year after the regulation is adopted, the total annualized costs for routine monitoring for all sources without perchlorate detections would be approximately $176,000 and $216,000, respectively, for large and small water system sources for the 11,650 sources that would then be conducting routine monitoring. These costs would be associated with any adopted MCL.

Quarterly monitoring costs for sources with detections **-** Any active source with a perchlorate detection (level at or above the DLR) would be required to conduct quarterly monitoring until the subsequent data demonstrates that levels are consistently below the DLR. The annual cost of this monitoring for all active sources

with detections would be $62,600 and $45,700 for large and small system sources, respectively. These costs would be associated with any adopted MCL.

Summary of estimated source monitoring costs

The estimated monitoring costs are summarized in Table 1; note that initial, routine and quarterly monitoring costs would be the same for any proposed MCL. Also note that initial monitoring costs of $968,000 occur only during year 1; the estimate of ongoing annualized monitoring costs of $500,300 is presented for year 2, and would be expected to be approximately the same for subsequent years.

Table 1
Summary of Estimated Source Monitoring Costs – Any MCL

System size	*Initial monitoring (yr 1 only) ($)*	*Routine monitoring, annualized (year 2 and into the future) ($)*	*Quarterly monitoring for all sources with detections (yr 2) ($)*	*Total annualized ongoing monitoring (year 2 and into the future) ($)*
large	428,000	176,000	62,600	238,600
small	540,000	216,000	45,700	261,700
Totals	***968,000***	***392,000***	***108,300***	***500,300***

Monitoring costs for treated water sources exceeding the MCL

Estimated monitoring costs for treated water sources are provided in Table 2; these costs would differ with each evaluated MCL, since the number of affected sources would vary. The total treated water monitoring costs of $134,300 for the proposed MCL of 0.006 mg/L would increase the monitoring costs by about 27% over the $500,300 annualized monitoring costs associated with any of the evaluated MCLs. That percentage would drop at the other evaluated MCL levels, but the Department does not consider the magnitude of the incremental savings to be significant enough to justify proposing an MCL other than at the PHG level of 0.006 mg/L.

Table 2
Estimated Annual Treated Water Monitoring Costs

Source type/MCL	*# Large system sources*	*# Small system sources*	*Large water system costs ($1000)*	*Small water system costs ($1000)*	*Total Treated Water Monitoring Costs ($1000)*
For sources with treatment installed under the proposed regulations:					
Groundwater					
0.006 mg/L MCL	84	10	88.7	10.6	99.3
0.008 ”	54	7	57.0	7.4	64.4
0.010 ”	31	4	32.7	4.2	36.9
0.015 ”	8	0	8.4	---	8.4
0.020 ”	3	0	3.2	---	3.2
surface water					
0.006 mg/L MCL	1	2	1.1	2.2	3.3
0.008 ”	0	2	0	2.2	2.2
For sources with existing perchlorate treatment					
Groundwater					
0.006 mg/L MCL	30	0	31.7	---	31.7
0.008 ”	25		26.4		26.4
0.010 ”	19		20.1		20.1
0.015 ”	8		8.4		8.4
0.020 ”	5		5.3		5.3
surface water					
All five MCLs	0	0	---	---	----

Rate of perchlorate detections - As noted, the set of monitored sources to date consists mainly of those designated vulnerable to perchlorate contamination. The Department evaluated whether to use the current “rate of detections” to project to the future monitoring of nonvulnerable sources in order to develop possible costs.

The highest rate of detections is from 0.004 (the DLR) to the proposed MCL of 0.006 mg/L: ~ 3.4%. The percentage of systems found to be greater than 0.006 mg/L among the “vulnerable” sources is ~ 3.4% for groundwater and 0.5% for surface water sources in large water systems, with 0.3% for groundwater and 0.9% for surface water sources in small water systems.

In order to project from the known rates of detection and violation of any of the evaluated MCLs for “vulnerable” sources to possible rates in “nonvulnerable” sources that have not been monitored, the Department believes that a safe assumption would be that the rates of detections and MCL violations would be less than half the rates found to date. However, the Department decided not to attempt to project costs based on this assumption, given the high level of associated uncertainty. Any additional monitoring costs due to perchlorate detected in the nonvulnerable sources during the initial monitoring would be relatively insignificant; treatment costs would be more significant, but difficult to estimate given the lack of data.

- **Treatment Feasibility**

Treatment technology availability - The Department has determined that two treatment technologies meet the best available technology (BAT) criteria provided in Section

116370 of the H&S Code: Biological fluidized bed reactor and ion exchange (see discussion below under Section 64447.2). The Department used ion exchange treatment with disposable resin as the basis for its estimate of costs associated with treating sources in violation of the MCL, because it is currently the treatment being selected to address most drinking water contamination problems.

Treatment and Operations and Maintenance (O&M) Costs)
The capital and O&M costs for treatment were based on an average of available costs from two treatment providers. The tables below present summaries of capital costs, annualized capital costs, and annual O&M costs (associated with the evaluated perchlorate MCLs for large and small public water systems. The following assumptions were used in the cost analysis:

1. Water quality data from the Department's compliance monitoring database provides a sufficient basis for a fiscal impact analysis for the proposed regulations.
2. Average day demand = 150 gallons/person/day; peaking factor for maximum day demand = 1.5.
3. Each source with existing treatment (i.e., treatment provided specifically for perchlorate; treatment/blending provided for nitrate that also remediates perchlorate) will continue to be treated. Therefore there are no additional capital or operation and maintenance (O&M) costs to come into compliance with the MCL.
4. Each source without treatment will install ion exchange with disposable resin to comply with the proposed perchlorate MCL.

Total capital costs To estimate capital costs and O&M costs, the Department used an approach similar to that used by the USEPA for ion exchange treatment of arsenic (see Table 3.1, Section 3.8, and Appendix E from Technologies and Costs for Removal of Arsenic from Drinking Water, December 2000, EPA 815-R-00-028, www.epa.gov). The perchlorate approach differs in that the preliminary capital cost does not include the cost of the resin, whereas for the arsenic cost evaluation, the resin was included as a capital cost. For arsenic, the O&M approach identified three major components: Resin regeneration frequency, regeneration dose, and incremental labor. The perchlorate approach differs in that the regeneration frequency/dose has been replaced with resin replacement/disposal and the incremental labor used represents an average of small and large water system rates.

Table 3
Estimated Total Capital Cost Summary for Evaluated MCLs

MCL (mg/L)	*No. Affected Sources by System Size*		*Capital Costs by System Size ($1000)*	
	Large	*Small*	*Large*	*Small*
Groundwater				
0.006	84	10	70,159	396
0.008	54	7	42,853	302
0.010	31	4	25,058	208
0.015	8	0	4,683	---
0.020	3	0	2,019	---
surface water				
0.006	1	2	708	62
0.008	0	2	---	62
0.010	0	0	---	---
0.015	0	0	---	---
0.020	0	0	---	---

Annualized treatment costs The estimated total annualized treatment, and operation and maintenance (O&M) costs from the cost-benefit analysis for the considered MCLs are shown in Table 3. As indicated, the Department estimates that 85 large water system sources (32 systems) and 12 small water system sources (11 systems) would need to be treated for compliance with the proposed MCL. Some of these sources might be able to meet the MCL by blending their drinking water supplies as already occurs during drinking water distribution, at minimal cost. However, if these sources were to be treated using ion exchange, the annualized capital and operations and maintenance costs would total approximately $23,700,000 for large water system sources and $250,000 for small water system sources (Table 4). Average per system costs would be $719,700 for large systems and $23,500 for small (Table 6) for the proposed MCL of 0.006 mg/L; average per system costs are essentially the same for all the MCLs evaluated.

Table 4
Estimated Total Annualized Treatment Costs (Active Sources) for Evaluated MCLs

MCL (mg/L)	*Number of Affected Sources by System Size*		*Total Annualized Capital Costs by System Size ($1000)*		*Total Annual O&M Costs by System Size ($1000)*		*Total Annual Treatment Costs for all Affected Systems ($1000)*	
	Large	*Small*	*Large*	*Small*	*Large*	*Small*	*Large*	*Small*
Groundwater								
0.006	84	10	6,600	40	16,900	170	23,500	210
0.008	54	7	4,000	30	10,400	120	14,400	150
0.010	31	4	2,400	20	6,200	70	8,600	90
0.015	8	0	400	----	1,000	----	1,400	----
0.020	3	0	200	----	400	----	600	----
surface water								
0.006	1	2	70	6	120	30	190	36
0.008	0	2	---	6	----	30	----	36
0.010	0	0	---	----	----	----	----	----
0.015	0	0	---	----	----	----	----	----
0.020	0	0	---	----	----	----	----	----

Table 5 summarizes both the estimated annualized treatment and treated effluent monitoring costs by system size and the population avoiding exposure for the evaluated MCLs. Note that although there are minimal cost impacts at MCL levels higher than 0.010 mg/L, very little public health benefit would be achieved, i.e., an MCL above 0.010 mg/L would result in close to half a million people being exposed to perchlorate levels that have the potential to adversely affect their health.

Table 5
Estimated Total Annualized Treatment and Monitoring Costs and Reduction in Population Exposed for Evaluated MCLs

MCL (mg/L)	*Number of Affected Systems (sources)*		*Total Annual Treatment & Treated Effluent Monitoring Costs for all Affected Systems ($)*		*Estimated Reduction in Population Exposed*	
	Large	*Small*	*Large*	*Small*	*Large*	*Small*
0.006	34 (85)	11 (12)	23,690,000	246,000	517,900	1,700
0.008	24 (54)	8 (9)	14,400,000	186,000	314,200	1,300
0.010	16 (31)	4 (4)	8,600,000	90,000	187,400	960
0.015	7 (8)	0	1,400,000	----	30,000	---
0.020	3 (3)	0	600,000	----	12,900	---

Table 5 shows that at an MCL of 0.010 mg/L, 16 large water systems would be impacted at an annual cost of $8.6 million with a reduction of 187,000 in the population exposed to potential adverse health effects, while at an MCL of 0.006 mg/L, 34 large water systems would be impacted at an annual cost of $23.69 million with a reduction of 517,900 exposed. The magnitude difference in total costs between the higher MCL of 0.010 mg/L and the MCL set at the PHG level of 0.006 mg/L is the same as that of the population avoiding exposure (~2.75), while the cost per source treated stays approximately the same. The Department believes that reducing exposure for as large a population as possible to the PHG level is an important public health measure.

To further evaluate feasibility, the Department estimated the average annual per service connection cost for systems that would exceed the proposed MCL to assess the impact on individual households. The large systems have about 1,349,000 service connections, for an average annual cost of approximately $18 per connection for treatment and monitoring for an MCL of 0.006 mg/L. However, for some of the affected small community water systems, annual costs per service connection could range from $300 to $1,580, with an average of $590.

Since the PHG of 0.006 mg/L establishes the level of no significant health risk and an MCL at this level would eliminate the potential for adverse health effects for more than half a million people at an average annual cost of only $18 per customer for affected large water systems, the Department believes that it has no alternative but to propose the MCL at this level. However, the cost per service connection for small water systems at that level ranges from $300 to $1,580 per service connection per year, with an average of $540, while the total estimated population that would avoid exposure is only about 1700. The median household incomes in the areas served by these water systems range from ~$16,300 to ~$49,300. This cost versus benefit for these small systems is considerably less favorable than that for larger systems, given the small number of persons both potentially affected by exposure and having to bear the treatment costs. To address this difference, the Department is proposing to provide for variances for small water systems based on affordability criteria; the proposal is detailed under in the discussion below for Section 64432.3 and data provided in Table 8.

Given no national standard as a reference point, the OEHHA PHG of 0.006 mg/L, the feasibility of monitoring and treatment costs for large water systems, and the provision for variances for those small water systems for which the treatment costs would not be affordable, the Department proposes that the MCL for perchlorate be set at the level of the PHG, 0.006 mg/L.

Table 6 summarizes the total costs and benefits associated with the proposed MCL level of 0.006 mg/L. Ongoing monitoring costs for sources not in violation of the proposed MCL are included, although these costs would be associated with any of the MCLs evaluated.

Table 6
Summary of Estimated Total Annual Costs and Benefits for Proposed MCL by System Size

System size	*Ongoing monitoring for sources ND and < MCL*				*Sources in Violation*			*Total Annual Costs for Systems > MCL*	*Average Cost per System with Treated Sources*	*Total Population Avoiding Exposure*
	Annualized Routine		*Quarterly for detections ≤ MCL*		*Total Annualized Treatment & O&M costs*		*Source and Trtd Wtr Moni-toring*			
	# sources.	*$1000*	*# sources*	*$1000*	*# sources*	*$1000*	*$1000*	*$1000*	*$1000*	*#*
Small	6493	216	118	41.5	12	250	16.9	267	23.5	1,700
Large	5153	176	93	32.7	85	23,800	119.9	23,920	698.5	514,300
Totals	*11,646*	*392*	*211*	*74.2*	*97*	*24,050*	*136.8*	*24,187*	-----	*515,100*

Section 64413.1. Classification of Water Treatment Facilities
(b)(4) Amending this section would include points for perchlorate treatment when calculating the classification of a treatment facility. Perchlorate, similar to nitrate and nitrite, is considered an acute contaminant and a treatment failure would pose an acute risk to public health.

(b)(4), (5), (7), and (13) Each of these sections reference Table 4, section 64443, of article 5 (Radioactivity). As a result of the adoption of revised radioactivity regulations in June 2006, table 4 of section 64443 no longer exists. These sections have therefore been amended to reference the correct tables, as reflected in the existing regulations.

Section 64432. Monitoring and Compliance – Inorganic Chemicals
The purpose of this section is to establish the monitoring and compliance requirements for inorganic chemicals in drinking water, and to define the levels of detection for reporting purposes (DLRs) for all chemicals with MCLs.

(a) This subsection establishes the applicability of the monitoring requirements for the different inorganic chemicals (IOCs); some of the IOCs, such as nitrate and perchlorate, require different monitoring and compliance approaches, which are laid out in separate sections. Amendments would be made to this subsection to add perchlorate with its section reference. Further, the existing references would be simplified for clarity.

(b) This subsection establishes the basic monitoring requirements for the IOCs; asbestos and nitrate/nitrite are exceptions and perchlorate would be added to the list, since a separate section is being proposed to address its monitoring.

(c) The purpose of this subsection is to establish standardized reporting levels for the IOCs. The Department proposes to add perchlorate with its DLR of 0.004 mg/L to Table 64432-A, along with a reference to the section being proposed for perchlorate monitoring and compliance. DLRs should be achievable within acceptable limits of precision and accuracy by at least 75% of the commercial laboratories in the state. All inorganic chemicals with MCLs have regulatory DLRs. The proposed perchlorate DLR of 0.004

mg/L is based on the Department's experience with monitoring for perchlorate as an "unregulated chemical" and input from the Department's Sanitation and Radiation Laboratory and commercial laboratories. This is the same reporting limit that has been used since 1997 for voluntary occurrence monitoring, and since 1999, for the "unregulated chemical." monitoring.

(f) The purpose of this subsection is to establish compliance determination procedures; IOCs addressed separately are specified as exceptions; perchlorate would be added to this list.

(m) The purpose of this subsection is to specify IOC-related requirements for transient water systems. It would be amended for clarity.

Section 64432.3. Monitoring and Compliance – Perchlorate.
The purpose of this proposed section is to establish the monitoring and MCL compliance determination requirements for perchlorate. Since perchlorate can affect the thyroid and development of an infant or fetus within a relatively short period of time, it is considered to be a chemical that poses an "acute" risk. For that reason, it would not be appropriate to address it with the responses provided for the "chronic" risk chemicals such as mercury and arsenic.

(a) This subsection would establish the "initial" monitoring requirements for perchlorate. When a new MCL is adopted, initial monitoring is always required to identify any contaminated sources for which more frequent monitoring or treatment might be needed.

In its unregulated chemical monitoring rule, to obtain a representative picture of the presence/absence of perchlorate in a source, U.S.EPA required two samples collected five to seven months apart with one collected during a "vulnerable" to contamination period. Subsequently, the Department adopted this approach for California's unregulated chemical monitoring regulations. The perchlorate monitoring of vulnerable sources required under the unregulated chemical monitoring rule was completed by December 31, 2003, as noted earlier.

The same approach is proposed for initial monitoring in these regulations for two reasons: Monitoring twice during one year with one sample collected during a "vulnerable" time period (summer) when perchlorate is more likely to show up because there would be no dilution from rainfall, would provide a reasonable evaluation of whether perchlorate was present in the source; and those systems that have already monitored could use their previously-collected data to satisfy the new regulations.

(b) This subsection allows previously collected samples to be used to meet the initial monitoring requirements. Since the purpose of initial monitoring is to ensure that all sources have been evaluated, if a source has already been monitored, that objective has been met.

(c) This subsection establishes the ongoing routine monitoring requirements for water sources without detected perchlorate that have met the initial monitoring requirements. It is consistent with the routine monitoring for all other IOCs, except asbestos, nitrate and nitrite. The Department has found this frequency to be adequate for most IOC monitoring and believes that it is appropriate to use the same approach for perchlorate, given the sources of perchlorate contamination.

(d) The purpose of this subsection is to provide the compliance determination for any source with a sample result exceeding the perchlorate MCL. It is constructed similarly to the determination for nitrate and nitrite, the primary difference being a longer timeframe for reporting and followup sample collection. Since perchlorate poses a relatively acute risk of adverse effects, it is important to move quickly to determine compliance and subsequent actions. However, the risk is not as immediate as that for nitrate and nitrite, so the timeframe is slightly longer, minimizing the hardship of water systems to ensure that the requisite actions are taken on a timely basis. Based on its review of the PHG document cited earlier, the Department believes that the 48-hour time frame would ensure adequate public health protection, while acknowledging that the risk associated with perchlorate is not as acute as that with nitrate and nitrite.

As with nitrate and nitrite, water systems are required to ensure that someone is available at all times to receive notice of results that exceed the MCL, that the laboratory will notify the Department if for some reason the water system cannot be reached, that followup sampling is conducted on a timely basis and, if for some reason it is not, that the public is notified so that it can take precautions. All these measures are to ensure that public health is protected.

(e) The purpose of this subsection is to require more frequent monitoring of any source with a detection to collect more information on the contamination in that source and determine any data trends. The quarterly monitoring is particularly necessary because the DLR of 0.004 mg/L (reporting level) and the MCL of 0.006 mg/L are very close together, and frequent monitoring can provide information to the water system and the Department about whether the perchlorate level is moving towards the MCL . Based on the Department's experience, quarterly monitoring would provide sufficient data to evaluate the source and ensure that the public is not being exposed to perchlorate levels exceeding the MCL.

This subsection also would allow reduced monitoring for sources triggered by a perchlorate detection into quarterly monitoring that subsequently have results below the DLR on a consistent basis. Such sources would be unlikely to exceed the MCL and would not really need to monitor quarterly. They would still be subject to the routine monitoring frequencies (once every three years for groundwater and annually for surface water).

(f) The purpose of this subsection is to enable a water system that cannot afford to install treatment to obtain a variance by demonstrating that it meets the affordability criteria developed by the National Drinking Water Advisory Council (NDWAC)

(Recommendations of NDWAC to U.S. EPA on Its National Small Systems Affordability Criteria, July 2003).

The NDWAC criteria were developed to address the provision in the cited provisions of the federal Safe Drinking Water Act (SDWA) Sec. 300g-4. (e)(3)(A) specifying that a variance can only be available to a system "….that cannot afford to comply, in accordance with affordability criterion established by the Administrator (or the State in the case of a State that has primary enforcement responsibility under section 300g-2 of this title)…". California has not developed its own affordability criteria, but was active in the NDWAC that drafted the Recommendations cited above and believes that they provide an excellent basis for evaluating a water system's ability to pay for treatment.

Based on the recommended NDWAC approach, the proposed regulations would establish that a water system must be able to demonstrate that the estimated annualized cost per household (i.e., service connection) for treatment to comply with the perchlorate MCL exceeds 1% of the median household income in the community within which the customers served by the water system reside to apply for a variance. The Department would thoroughly review the documentation provided and ensure that the water system did indeed meet the criteria and had exhausted any possible alternatives, such as connecting up to another water system, consolidation with one or more systems, and obtaining grant monies to pay for treatment.

Median household income data is available for census tracts and is currently used in making other kinds of determinations related to funding and affordability. Based on census data, the average population associated with a household (service connection) is 2.9 persons. The Department developed the following table listing five small water systems that could be impacted by the proposed MCL and would meet the NDWAC affordability criteria:

Table 8
Compilation of Costs vs Median Household Income
for Compliance with Proposed Perchlorate MCL of 0.006 mg/L

System	*County*	*Total Annual Costs for Treatment Installation, Operation, Maintenance & Monitoring ($)*	*Number of Service Connections*	*Annual Cost per Service Connection ($)*	*1% of MHI for Census Tract ($)*
A	Kern	20,598	32	644	430
B	San Benito	20,598	13	1,584	493
C	Kern	20,598	68	303	163
D	Orange	20,598	35	589	441
E	Tulare	20,598	43	479	321

Section 64432.8. Sampling of Treated Water Sources.
This purpose of this proposed section would to ensure that the water treated to remove a contaminant prior to its distribution to the public consistently meets the MCL.

(a) Although this requirement for monthly treated water monitoring would be new in the regulations for IOCs, such monitoring is already required in the regulations for organic chemical treatment (Section 64445.2). Further, the Department's field offices regularly incorporate treated water monitoring into water system permit amendments for treated waters to ensure public health protection and consistent MCL compliance. Monthly monitoring enables the Department to monitor the adequacy of the contaminant treatment process. Frequent monitoring of the treated water assures that any possible problems with the treatment process will be brought to the Department in a timely manner.
(b) This subsection would allow the Department to require more frequent monitoring if a treatment process necessitated more frequent surveillance to ensure consistent MCL compliance. This might be necessary in situations such as co-contamination, anomalous data, media reaching exhaustion on an inconsistent timeframe, or extreme fluctuations of treatment influent concentrations.

Article 12. Best Available Technologies (BAT)
Section 64447.2. Best available technologies – inorganic chemicals
The purpose of this section is to identify the best available technologies (BATs) for reducing the level of inorganic chemicals in drinking water in order to comply with the MCLs, pursuant to section 116370 of the H&S Code.

Section 116370 of the H&S Code states that the Department's finding of BAT "shall take into consideration the costs and benefits of best available treatment technology that has been proven effective under full-scale field applications."

To determine BAT, the Department:

- Identified potential treatment technologies by consulting with technical staff and district offices working with water systems with installed perchlorate treatment,
- Reviewed USEPA and AWWA websites and the Journal AWWA (1995 – 2003), and
- Performed a literature search through the Internet that included the following websites:

Website Name	Website Link
United States Environmental Protection Agency	**www.epa.gov**
USEPA – Technology Innovation Program, Hazardous Waste Clean-Up Information	**www.clu-in.org/perchlorate**
American Water Works Association Research Foundation	**www.awwarf.com**
Groundwater Remediation Technologies Analysis Center	**www.gwrtac.org**
Defense Environmental Network & Information Exchange	**www.denix.osd.mil/denix/denix.html**
Federal Remediation Technologies Roundtable	**www.frtr.gov**
American Society of Civil Engineers	**www.asce.org**

Ixquick (meta search engine)	www.ixquick.com

Based on the Department's review, the following technologies were determined to be cost-effective based on full-scale field applications and capable of reducing perchlorate to < 0.004 mg/L (the DLR).

- Biological fluidized bed reactor
- Ion exchange

The following matrix summarizes the information relevant to the determination of BAT for drinking water treatment that was available as of August, 2004; it includes the name of the technology, scale on which technology has been evaluated, whether its effectiveness has been demonstrated in a full-scale application (as required under the H&S Code), whether actual cost data are available, and any comments.

Perchlorate BAT Determination Matrix

Technology	Project Scale	Effective Under Full-Scale Field Applications ?	Actual Costs Based on Full-Scale Field Applications[1]	Comments
Biological Fluidized Bed Reactor (BFBR)	Lab, Pilot, Full	Yes	Reference	Microbiological seed source must be identified and characterized as free of human pathogens. Post-reactor treatment needed to comply with the SWTR.
Biological Treatment Other Than BFBR[2]	Lab, Pilot, Prototype	No	Not available	
Chemical Reduction	Lab	No	Not available	
Enhanced Coagulation	Full	No	Not available	
Granular Activated Carbon[3] (GAC)	Lab, Pilot, Full	Yes	Not available	Limited data (~1 month) from full-scale plant using conventional GAC showed technology was effective for removing perchlorate, but not for very long. Based on data to date, GAC does not appear to be cost-effective. Demonstration study at full-scale plant using tailored GAC is underway for the next 4 – 9 months. Study objective is to obtain DHS acceptance and develop cost data. Currently pursuing ANSI/NSF Standard 61 certification for tailored GAC.
Ion Exchange	Lab, Pilot, Full	Yes	Capital cost – lower O&M cost – higher	Resin requires disposal or regeneration with brine disposal/destruction.
Membrane Processes	Lab	No	Not available	

Footnotes:

1. Cost estimates are relative, using biological fluidized bed reactor as the reference.
2. Alone or in combination with membrane processes.

[3.] Alone or in combination with advanced oxidation processes.

Treatment costs will vary significantly depending upon many site-specific parameters including the level of perchlorate in the source, the physical qualities of the water and any other regulated chemicals present, the availability of land, the cost of construction labor and water treatment plant operating staff, etc.

Article 17. Special Monitoring Requirement for Unregulated Chemicals
Section 64450. Unregulated Chemicals
The purpose of this section is to list those chemicals for which monitoring must be conducted to determine their occurrence in drinking water supplies. The proposed regulation would repeal this section because the deadline for monitoring has passed. At this time, there are no additional chemicals for which the Department needs to collect occurrence data.

Article 18. Notification of Water Consumers and the Department.
Section 64465. Public Notice Content and Format.
The purpose of this section is to provide language to be communicated to the public when an MCL for a contaminant has been violated; the language is intended to inform the public about the possible health effects associated with the contaminant. The proposed regulation would amend this section by adding (in alphabetical order, in the table in Appendix 64465-D) the public notification language for a perchlorate MCL violation. The language is proposed for conformance with the language for other chemicals with primary MCLs to be included in the notice sent to the public if the water system violates the MCL. The U.S. EPA initiated this specific language requirement in regulations for primary MCLs in 1991; as mandated, the Department has adopted language for all federal MCLs and, for consistency, has adopted language for state-mandated MCLs as well.

Section 64481. Content of the Consumer Confidence Report.
The purpose of this section is to provide language to be communicated to the public in consumer confidence reports (CCRs) when a contaminant has been detected; the language is intended to inform the public of the typical origins, or source, of the contaminant. The proposed regulation would amend this section by adding (in alphabetical order, in the table in Appendix 64481-A) the major sources of the contaminant in drinking water. The language is proposed for conformance with the language for other chemicals with primary MCLs to be included in CCRs sent by water systems to their consumers. The U.S. EPA initiated this specific language requirement in regulations for primary MCLs in 1998; as mandated, the Department has adopted language for all federal MCLs and, for consistency, has adopted language for state-mandated MCLs as well.

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Note that the Department finds that adoption of the subject regulations constitutes action by a regulatory agency, which action is expressly authorized by state statute for protection of the environment and does not involve the relaxation of any standard for protection of the environment; and is therefore categorically exempt from compliance with the California Environmental Quality Act (CEQA) as a Class 8 exemption pursuant

to CEQA Guidelines, 14 CCR 15308. The Department further finds that the adoption of the subject regulations does not fall within any exception to categorically exempt projects described in Public Resources Code 21084.

APPENDIX A: References

For PHG:

OEHHA, 2004, Public Health Goal for Perchlorate in Drinking Water, March, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

For BAT:

Reference	*Internet Links and Comments (as of 8/4/04)*
AwwaRF. AwwaRF Projects Related to Special Topics, Perchlorate Projects.	Hardcopy only.
Burge, S.; Halden, R. Nitrate and Perchlorate Removal from Groundwater by Ion Exchange, Pilot Testing and Cost Analysis, Livermore National Laboratory, Environmental Protection Department, UCRL-IC-135639, Sept 1999. http://clu-in.org/perchlorate (accessed 4/17/03).	www.clu-in.org/perchlorate
Calgon Awarded $6.5 M Contract for Perchlorate Removal, Water and Wastewater Newsletter, Vol. 4, No. 97, April 15, 2002. www.waterandwastewater.com/www_services/newsletter/april_15_2002.htm (accessed 12/11/02).	www.waterandwastewater.com/www_services/newsletter/april_15_2002.htm
California Department of Health Services. Letter from Richard H. Sakaji, DHS to Donald E. Vanderkar, Aerojet, Condition Acceptance of Biological Treatment (Fluidized Bed Reactors) for the Removal of Perchlorate During Drinking Water Production, April 2, 2002.	Hardcopy only.
Cannon, F. S.; Na, C. Perchlorate Removal Using Tailored Granular Activated Carbon and Chemical Regeneration. Presented at the Perchlorate Workshop of the Pollution Prevention Technology Transfer Conference of the Joint Armed Services, San Antonio, TX, August 23-24, 2000. https://www.denix.osd.mil/denix/Public/Library/Water/Perchlorate/technology.html (accessed 12/10/02).	Direct access to web site and page is not available. User must type "DENIX" in a search engine to find the home page (www.denix.osd.mil/denix/denix.html), then click on the Perchlorate Information link and then the Treatment Technology Documents link.
Catts, J. G. Biological Treatment of Perchlorate at Low Concentrations in Water, Baldwin Park Operable Unit, San Gabriel Basin. Presentation from Speaker's Note from the Henderson, NV Perchlorate Stakeholders Forum, May 19 - 21, 1998. www.epa.gov/safewater/ccl/perchlorate/tab2.html (accessed 12/10/02).	www.epa.gov/safewater/ccl/perchlorate/tab2.html

Reference	***Internet Links and Comments (as of 8/4/04)***
Catts, J.; McCullough, M. L. Final Phase 1 Treatability Study Report, Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin, Harding Lawson Associates, April 1999. http://www.clu-in.org/perchlorate (accessed 4/17/03).	www.clu-in.org/perchlorate
Coppola, E., Applied Research Associates, Inc., personal communication, 2003.	
Envirogen. Groundwater Study Program Initiates Pilot Test for Possible Perchlorate Treatment, Envirogen Press Release, May 22, 2002. www.envirogen.com/pr052202.htm (accessed 12/11/02).	www.envirogen.com/pr052202.htm
Girard, M. Aerojet's Experience with Development of a Perchlorate Treatment Process. AwwaRF, New Projects, Perchlorate Issue Group Presentations.	Hardcopy only
Graham, J. R.; Cannon, F. S.; Parette, R.; Headrick, D.; Yamamoto, G. Commercial Demonstration of the Use of Tailored Carbon for the Removal of Perchlorate Ions from Potable Water. Presented at the GRA 2004 Conference on Perchlorate in California Groundwater, Glendale, California, August 4, 2004.	Hardcopy reference provided.
Gu, B.; Brown, G. M., Alexandratos, S. D.; Ober, R.; Patel, V. Selective Anion Exchange Resins for the Removal of Perchlorate CLO4- from Groundwater, Oak Ridge National Laboratory, Environmental Sciences Division, Publication No. 4863, ORNL/TM-13753, Feb 1999. http://clu-in.org/perchlorate (accessed 4/17/03).	www.clu-in.org/perchlorate
Harding ESE, Final Phase 2 Treatability Study Report, Aerojet GET E/F Treatment Facility, Sacramento, California, Harding Engineering and Environmental Services, Sept 2001. http://clu-in.org/perchlorate (accessed 4/17/03).	www.clu-in.org/perchlorate
Hatzinger, P. B.; Greene, M. R.; Frisch, S.; Togna, A. P.; Manning, J.; Guarini, W. J. Biological Treatment of Perchlorate-Contaminated Groundwater Using Fluidized Bed Reactors, Presented at the 2nd International Conference on Remediation of Chlorated and Recalcitrant Compounds, Monterey, CA, May 22 - 25, 2000. http://clu-in/perchlorate (accessed 4/17/03).	www.clu-in.org/perchlorate
Hurley, J. Perchlorate Treatment Process Developed at Tyndall Air Force Base. AwwaRF, New Projects, Perchlorate Issue Group Presentations.	Hardcopy only
Li, L.; Coppola, E. N. Final Report: Hydrothermal/Thermal Decomposition of Perchlorate (Project Description). http://cfpub.epa/gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/1261/report/F (accessed 12/10/02).	http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/1261/report/F

Reference	***Internet Links and Comments (as of 8/4/04)***
Ling, S.; Scott, K.; Palencia, L.; Bruno; J-M. Perchlorate Treatment by Enhanced Coagulation, Oxidation, and Membranes. Presentation from Speaker's Note from the Henderson, NV Perchlorate Stakeholders Forum, May 19 - 21, 1998. http://www.epa.gov/safewater/ccl/perchlorate/tab2.html (accessed 12/10/02).	www.epa.gov/safewater/ccl/perchlorate/tab2.html
Liu, J.; Batista, J. A Hybrid (Membrane/Biological) System to Remove Perchlorate from Drinking Waters. Date and location of presentation not listed. https://www.denix.osd.mil/denix/Public/Library/Water/Perchlorate/technology.html (accessed 12/10/02).	Direct access to web site and page is not available. User must type "DENIX" in a search engine to find the home page (www.denix.osd.mil/denix/denix.html), then click on the Perchlorate Information link and then the Treatment Technology Documents link.
Losi, M. E.; Hosangadi, V.; Tietje, D.; Giblin, T.; Frankenberger, W. T. Bioremediation of Perchlorate in Groundwater and Reverse Osmosis Rejectates. Date and location of presentation not listed. https://www.denix/osd/mil/denix/Public/Library/Water/Perchlorate/technology.html (accessed 12/10/02).	Direct access to web site and page is not available. User must type "DENIX" in a search engine to find the home page (www.denix.osd.mil/denix/denix.html), then click on the Perchlorate Information link and then the Treatment Technology Documents link.
Na, C.; Cannon, F. S.; Hagerup, B. Perchlorate Removal Via Iron-Preloaded GAC and Borohydride Regeneration, JAWWA, 2002, 94(11), 90-102.	Hardcopy only.
Nerenberg, R.; Rittman, B. E., Najm, I. Perchlorate Reduction in a Hydrogen-Based Membrane-Biofilm Reactor, JAWWA, 2002, 94(11), 103-114.	Hardcopy only.
Polk, J.; Murray, C.; Onewokae, C.; Tolbert, D. E.; Togna, A. P.; Guarini, W. J.; Frisch, S.; Del Vecchio, M. Case Study of Ex-Situ Biological Treatment of Perchlorate - Contaminated Groundwater at LHAAP. Presented at the 4th Tri-Services Environmental Technology Symposium, June 18-20, year not listed, San Diego, CA. https://www.denix.osd.mil/denix/Public/Library/Water/Perchlorate/technology.html (accessed 12/10/02).	Direct access to web site and page is not available. User must type "DENIX" in a search engine to find the home page (www.denix.osd.mil/denix/denix.html), then click on the Perchlorate Information link and then the Treatment Technology Documents link.
Praskins, W. Treatment of Perchlorate in Water. USEPA, Technology Innovation Program, Archived Internet Seminars, Presentation from Perchorate Update, June 4, 2002. http://www.clu-in.com/new1.cfm (accessed 12/10/02).	www.clu-in.com/new1.cfm
Roote, D. Technology Status Report: Perchlorate Treatment Technologies, 1st edition, May 15, 2001, Ground-Water Remediation Technologies Analysis Center (GWRTAC). http://www.gwtac.org/html/tech_status.html (accessed 12/10/02).	www.gwrtac.org/html/tech_status.html
Theis, T. L.; Zander, A. K.; Li, X.; Anderson, M. A.; Sene, J. Assessment of the Electrochemical Reduction of the Perchlorate Ion, AWWA Research Foundation and American Water Works Association, 2001.	Hardcopy only.

Reference	***Internet Links and Comments (as of 8/4/04)***
Theis, T. L.; Zander, A. K.; Li, X.; Sene, J.; Anderson, M. A. Electrochemical and Photocatalytic Reduction of Perchlorate Ion (Abstract), J Water SRT - Aqua, 2002, 51, 367 - 374. www.iwapoline.com/jws/051/jws0510367.htm (accessed 11/25/02).	www.iwaponline.com/jws/051/jws0510367.htm
Upadhye, R. Carbon Aerogel. AwwaRF, New Projects, Perchlorate Issue Group Presentations.	Hardcopy only.