MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

INFORMATION

- **Board of Directors**
  Water Planning, Quality, and Resources Committee

June 11, 2002 Board Meeting

10-2

Subject

Review of Perchlorate Action Plan

Description

Earlier this year, the U.S. Environmental Protection Agency (U.S. EPA) and California's Office of Environmental Health Hazard Assessment (OEHHA) released draft perchlorate risk assessment reports and the California Department of Health Services (CDHS) lowered the existing perchlorate Action Level. These activities have heightened concerns over perchlorate and highlighted the need for Metropolitan to expand its efforts to address perchlorate in Colorado River water. The attached Perchlorate Action Plan describes a comprehensive program to address this issue.

Specifically, in January 2002 U.S. EPA released a revised draft perchlorate risk assessment report based on animal studies. The draft report recommended a perchlorate reference dose equivalent to a concentration of 1 part per billion (ppb) in drinking water, assuming no other sources of exposure. In response, CDHS lowered the perchlorate Action Level from 18 ppb to 4 ppb, which is the detection limit. Shortly thereafter, OEHHA proposed a Public Health Goal (PHG) of 6 ppb based on human health studies. The PHG is a key element in the development of an enforceable standard. The draft drinking water equivalent level, Action Level and draft PHG are not enforceable standards, but they suggest that perchlorate may be associated with adverse health effects at levels lower than previously thought. Perchlorate can adversely affect the functioning of the thyroid.

Metropolitan has been addressing the issue of perchlorate contamination since it was first detected in Colorado River water in 1997. The Perchlorate Action Plan (Plan) (**Attachment 1**) describes a comprehensive program that builds upon existing efforts to address perchlorate contamination in Colorado River water supplies. The Plan's components include: monitoring, resource assessment, tracking health effects studies, tracking remediation efforts, modeling, legislative and regulatory strategies, and outreach activities. The Plan describes these and other actions in detail. The Perchlorate Background Document (**Attachment 2**) provides information on perchlorate's characteristics and uses, health effects, and occurrence. The document also reviews Metropolitan's efforts to date to address perchlorate and reviews recent regulatory and non-regulatory developments.

Policy

By Minute Item No. 42820, the Board, at its February 10, 1998 meeting, adopted legislative policy principles on Source Water Quality Protection.

Fiscal Impact

None

Eddie A. Rigdon 5/29/2002
Date

Eddie A. Rigdon
for *Jill T. Wicke*
Manager, Water System Operations

Ronald R. Gastelum 5/29/2002
Date

Ronald R. Gastelum
Chief Executive Officer

Attachment 1 – Perchlorate Action Plan

Attachment 2 – Perchlorate Background Document

BLA #1792

PERCHLORATE ACTION PLAN

Summary

The Perchlorate Action Plan (Plan) builds upon Metropolitan's past efforts to address the issue of detectable levels of perchlorate in Colorado River water emanating from the Las Vegas Wash. The Plan's objectives are to: (1) expand existing perchlorate monitoring programs to provide a more comprehensive picture of source and distribution system water quality; (2) assess the impact of perchlorate from other sources on local groundwater supplies to determine whether there may be increased demand for Metropolitan's water; (3) continue tracking health effects studies that could influence the development of a perchlorate drinking water standard; (4) continue tracking remediation efforts in the Las Vegas Wash undertaken by Kerr-McGee Chemical LLC (Kerr-McGee) and support an aggressive cleanup schedule; (5) initiate modeling of perchlorate levels in the Colorado River to better forecast the effects of the Kerr-McGee cleanup on water served by Metropolitan; (6) help determine whether additional resource management strategies are necessary to limit the levels of perchlorate; (7) pursue legislative and regulatory options for facilitating and accelerating cleanup activities within California and ensuring that federal and state regulatory standards are based on sound science; (8) incorporate information on perchlorate for consumers, sensitive sub-populations, and health care providers into existing outreach activities; and (9) ensure that the Board and Member Agencies are aware of the status of perchlorate-related activities through periodic reports.

Background

Perchlorate is an anion that forms in ground and surface waters when its ammonium, magnesium, potassium or sodium salts dissolve in water. A major source of perchlorate is from the improper disposal of ammonium perchlorate, a primary component of solid rocket propellants, missiles, munitions and fireworks.

Perchlorate is of health concern because it interferes with the thyroid's uptake of iodide, an essential component of thyroid hormones. In adults, the thyroid helps to regulate metabolism. In children, the thyroid is important for proper development in addition to metabolism. Impairment of thyroid function in expectant mothers may impact the fetus and newborn and result in changes in behavior, delayed development and decreased learning capability.

First detected in February 1997 in drinking water wells in Northern California, perchlorate has since been detected in surface and groundwater sources in 11 California counties. Low levels of perchlorate are found in Colorado River water (CRW) entering from a Kerr-McGee chemical manufacturing facility near Lake Mead. Fifteen of Metropolitan's Member Agencies with groundwater supplies have reported detecting elevated levels of perchlorate from local sources in groundwater supplies or reservoirs.

There is no enforceable drinking water standard for perchlorate, but the California Department of Health Services (CDHS) is proceeding to develop one. California has a non-enforceable, advisory Action Level (AL) which CDHS lowered in January 2002 from 18 to 4 parts per billion (ppb). This step was taken in response to the release of a draft perchlorate risk assessment report by the U.S. Environmental Protection Agency (EPA) which recommended a "drinking water equivalent level" (DWEL) of 1 ppb. In March 2002, California's Office of Environmental Health Hazard Assessment (OEHHA) released a draft Public Health Goal (PHG) report recommending a PHG of 6 ppb. The PHG and DWEL differ because OEHHA and U.S. EPA based these draft goals on different health effects studies.[1]

Although the U.S. EPA and OEHHA reports were released just this year, Metropolitan's efforts to assess perchlorate's impact on water supply and explore options for minimizing these impacts dates to 1997. Metropolitan initiated an ongoing monitoring program and has since evaluated treatment options and undertaken pilot-plant studies, strongly encouraged and closely followed remediation efforts to address perchlorate concentrations at the source, and supported (if amended) prior legislation requiring a drinking water standard. These efforts are described more fully in the accompanying Perchlorate Background Document. The document also contains additional information on perchlorate's characteristics and uses, human health effects, occurrence, and historical monitoring results.

The following sections describe the Plan's major components. Each section concludes with the action items indicated in the red text.

Monitoring

Metropolitan began monitoring for perchlorate in June 1997 when it was detected in the Colorado River Aqueduct and the Lake Mead outlet at Hoover Dam. Extensive sampling within the Colorado River watershed in July and August of the same year indicated that the perchlorate originated in the Las Vegas Wash, and the most likely source was the Kerr-McGee chemical manufacturing site located in Henderson, Nevada. A quarterly monitoring program was initiated in August 1997 at Lake Mead and monthly monitoring was initiated in October 1997 at the following locations: the Colorado River aqueduct, source water reservoirs, treatment plant influents and effluents and representative locations within the distribution system. Perchlorate levels in CRW have ranged from non-detect (< 4 ppb) to 9 ppb, while none has been detected in State Project water (SPW) supplies. Perchlorate levels in water treated at the Diemer, Weymouth, and Skinner plants have ranged from non-detect to 8 ppb. Perchlorate has not been detected in water treated at the Jensen and Mills plants, except once in the Mills plant when 100 percent CRW was treated at the time of sampling. *(Also see Metropolitan Perchlorate Monitoring Program discussion in the Background Document.)*

Monitoring within Metropolitan's System

Two of the Plan's action items are to expand Metropolitan's current monthly monitoring program and provide monthly updates to Member Agencies. Expanded monitoring was initiated in April 2002 when distribution system monitoring was expanded from 5 to 14 locations, bringing the total number of monitoring sites to 31. Water Quality staff will continue to revise the program as necessary to characterize perchlorate levels that are representative of Metropolitan's system. Member Agencies also now receive a monthly perchlorate monitoring report to facilitate more timely responses.

Source Water Monitoring at Lake Mead

For the Lake Mead monitoring program, quarterly samples are collected by the U.S. Bureau of Reclamation (USBR) at 12 depths from the Hoover Dam outlet tower and analyzed by the Water Quality Laboratory. Metropolitan will continue quarterly monitoring to provide early indication of perchlorate levels entering Metropolitan's intake at Lake Havasu. In addition, the Southern Nevada Water Authority (SNWA) is collecting considerable perchlorate information to monitor the effects of Kerr McGee's cleanup efforts.

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[1] OEHHA based the draft PHG on human health studies that examined the effect of perchlorate on the thyroid's uptake of iodide. U.S. EPA based the draft DWEL primarily on animal studies that examined the effect of perchlorate on the level of thyroid hormones.

Monitoring: Action Items and Status

Item	Status
• Increase the number of monitoring locations within the distribution system from 5 to 14.	• Additional locations added in April 2002.
• Continue monthly monitoring of source water reservoirs, Colorado River Aqueduct, plant influent and effluent, and representative distribution system locations.	• Ongoing
• Continue quarterly monitoring at Lake Mead.	• Ongoing
• Initiate monthly perchlorate monitoring report to Member Agency water quality managers.	• First report was sent in May 2002 (11/01 – 4/02 data).

Assessment of Impacts on Local Resources

A potential consequence of perchlorate in local drinking water wells is increased demand for deliveries from Metropolitan. One of the Plan's actions is to assess the impact of perchlorate from local sources on demand for Metropolitan water.

As of May 2002, the following Metropolitan agencies have reported closure of wells due to perchlorate: Anaheim, Central Basin MWD, Foothill MWD, Pasadena, San Marino, Three Valleys MWD, Western MWD, and Upper San Gabriel Valley MWD. Total lost production due to well closures is estimated at 57,000 acre-feet (AF) annually. This loss of production capacity due to perchlorate could result in increased demand for Metropolitan water supplies, although there have been no formal requests for additional deliveries from the Member Agencies to date.

Member and sub-agencies are considering various options for removing or reducing perchlorate concentrations. Anaheim, Foothill MWD, Glendale, Inland Empire Utilities Agency, Long Beach, Los Angeles, San Marino, and Three Valleys MWD are among those considering or already blending. Treatment options are under consideration by Eastern MWD, Foothill MWD, and Upper San Gabriel Valley MWD. Municipal Water District of Orange County (MWDOC - Tustin), and Three Valleys MWD (Pomona) have been using reverse osmosis and ion exchange, respectively. Beverly Hills, Fullerton, Pasadena, Santa Ana, and Upper San Gabriel Valley MWD will have new wells on-line soon.

Assessment of Impacts on Local Resources: Action Items and Status

Item	Status
• Determine potential and actual Member Agency demand for additional Metropolitan deliveries due to perchlorate contamination of local groundwater wells.	• Initial assessment completed. Total lost production is estimated at 57,000 AF annually, but there have been no formal requests for additional deliveries.

Tracking Health Effects Studies

In order to better understand the health issues associated with perchlorate, Metropolitan recently retained Dr. Douglas Crawford-Brown, Chair of the Environmental Studies Program at the University of North Carolina. Dr. Crawford-Brown has extensive experience in the area of environmental health risk assessment. He has served as a scientific advisor to U.S. EPA's Office of Groundwater and Drinking Water and provided technical reviews of various health-based issues, including perchlorate, for the American Water Works Association.

Dr. Crawford-Brown has provided Metropolitan with an independent review of U.S. EPA's draft perchlorate risk assessment document and OEHHA's draft PHG report, assisted in the preparation of Metropolitan's comment letters on these reports, and increased staff's understanding of the health effects issues. In his review of the OEHHA draft PHG report, Dr. Crawford-Brown concluded that "the study is based on a reasonable review of existing scientific information … and that there is high confidence that a PHG of 6 ppb will be protective of public health even if the assumptions used in the assessment prove incorrect". *(Also see Human Health Effects section in Background Document and Appendices nos. 1,3 and 4 for copies of Dr. Crawford-Brown's review, and Metropolitan's comment letters to U.S. EPA and OEHHA.)*

Metropolitan staff will track future health effects studies that can have a material effect on setting regulatory standards. Both U.S. EPA and OEHHA are revising their respective draft reports, and there will be an opportunity for public comment once the revised reports are released. Staff will review the revised documents when available and determine whether further comments are warranted. If necessary, outside expertise, such as that provided by Dr. Crawford-Brown, will be enlisted.

Tracking Health Effects: Action Items and Status

Item	Status
• Retain consultant to assist in review of U.S. EPA and OEHHA draft risk assessments.	• Completed
• Submit comments on draft risk assessments.	• Completed
• Review revised OEHHA draft perchlorate PHG report and submit comments, if necessary.	• Revised report is not expected until late summer.
• Review revised U.S. EPA perchlorate risk assessment and submit comments, if necessary.	• Revised report is not expected until late summer or fall.

Tracking Remediation Activities

Cleanup of perchlorate at the Kerr-McGee site started in 1998 and currently consists of: (1) an evaporation pond to retain extracted groundwater for treatment; (2) a slurry wall which is a 1,700-foot (long) by 30-foot (deep) physical barrier to slow the migration of perchlorate toward the Las Vegas Wash; (3) additional extraction wells to remove perchlorate-contaminated groundwater; (4) an interim unit to treat water seeping into the Las Vegas Wash; and (5) a large-scale ion exchange unit to treat the water retained in the evaporation pond, groundwater extracted from the new wells; and perchlorate-containing water that is seeping directly into the Wash. An important element of the Plan is to continue tracking these remediation activities and work with the SNWA to encourage the Nevada Department of Environmental Protection (NDEP) and U.S. EPA to establish water quality criteria for the cleanup that are protective of human health. Specifically, Metropolitan recommends that levels of perchlorate entering the Wash be reduced to the lowest levels achievable by best available current technology. The goal is to ensure that perchlorate is not detected in water entering Metropolitan's system. *(Also see the Remediation section in the Background Document.)*

As part of Metropolitan's ongoing tracking of remediation activities, Metropolitan staff visited the Kerr-McGee site in March 2002 and met with NDEP and SNWA. The meeting provided staff with an opportunity to express concerns about perchlorate levels in Colorado River water, in light of the lowering of the Action Level by CDHS. Staff also pointed out that (1) the AL has heightened public awareness of perchlorate and (2) the general public may not distinguish between an Action Level, which is not enforceable, and a Maximum Contaminant Level, which is enforceable.

Although Kerr-McGee's large-scale ion exchange unit was started on March 29, 2002, there were several start-up problems and the unit is currently off-line. This may present a serious setback to the cleanup schedule. The system was expected to restart by May 6, 2002, but is not yet operational. In the meantime, the interim unit continues to operate.

Metropolitan staff will be visiting the site in June for further inspection and will meet with NDEP and SNWA staff to review the status of the remediation activities. A tour of the site has also been scheduled for Metropolitan's Board on June 18.

Metropolitan staff will continue to keep abreast of the cleanup efforts by Kerr-McGee. As part of an Administrative Order of Consent (AOC) that Kerr-McGee signed with the NDEP in October 2001, Metropolitan receives copies of monthly progress reports on the new large-scale ion exchange unit.

Tracking Remediation Activities: Action Items and Status

Item	Status
• Continue monitoring remediation efforts through monthly progress reports from Kerr-McGee and ongoing discussions with NDEP and SNWA.	• Ongoing
• Quarterly staff visits to Kerr-McGee site to track remediation progress.	• Next visit is scheduled for June.

Modeling

The installation of Kerr-McGee's large-scale ion exchange unit for treating perchlorate is expected to decrease the levels of perchlorate over time. A key element of the Plan is the development of a model to estimate how quickly perchlorate levels will decrease at Metropolitan's intake. This model will help Metropolitan determine the sufficiency of planned remediation efforts and the extent to which other options should be pursued.

Metropolitan has contacted a consultant to provide a preliminary scope-of-work and cost estimate for a perchlorate "washout" model. The study will consist of two phases. In Phase I, historical data from Lake Mead to Parker Dam will be obtained and analyzed. Data will include perchlorate and salinity concentrations, temperature, dissolved oxygen levels, reservoir topography, and reservoir operating conditions. A graphical assessment of perchlorate transport will be undertaken to illustrate mixing and level of reservoir stratification. A model will then be chosen by the consultant and Metropolitan. Phase I will produce a clearer understanding of perchlorate movement from Lake Mead to Parker Dam and result in a recommendation of an efficient way to model the system.

In Phase II, the model for the Lake Mead/Lake Mojave/Lake Havasu system will be developed and validated against existing data. Modeling runs will be performed for a wide variety of scenarios. Phase II will produce a probability distribution of perchlorate levels at Metropolitan's intake along the Colorado River. The model will show the probability that perchlorate levels will be below a predicted amount by a specified time.

It is estimated that it will take five to six months to complete the model and prepare a final report. The costs range from $70,000 to $105,000, depending on the complexity of the model chosen by the consultant and Metropolitan.

The USBR and the SNWA are potential partners in this effort. Both agencies collect extensive perchlorate monitoring data in Lake Mead and these data would form the primary data set for model validation. The USBR also maintains extensive hydrological data on the Lake Mead/Lake Mojave/Lake Havasu system. The SNWA has already initiated an effort to model wastewater discharges from Las Vegas Wash into Las Vegas Bay and to SNWA's intake structure at Saddle Island in Boulder Basin. Metropolitan would like to build upon these efforts and enlist the aid of a consultant to develop a more comprehensive "washout" model to address perchlorate levels entering our system. The costs of the study may be recoverable from Kerr-McGee at a later date.

Modeling: Action Items and Status

Item	Status
• Contract with consultant to develop a "washout" model.	• Notice to Proceed with model will be issued by end of May, with an anticipated completion date by January 2003.
• Initiate collaborative modeling effort with SNWA.	• In progress.
• Ask SNWA to send Metropolitan regular updates of their perchlorate monitoring program.	• Request made.

Resource Management

The impact that perchlorate may have on Metropolitan's resource strategies will depend upon: (1) the perchlorate MCL that CDHS adopts; (2) any changes in the Action Level; (3) reliable projections of increases in demand for Metropolitan water due to perchlorate in Member Agency groundwater supplies; (4) remediation of the Kerr-McGee site and expected changes in perchlorate levels in Colorado River water as a result of remediation; and (5) the impact of the resource management strategy on Metropolitan's ability to meet other regulatory requirements (e.g., ability to meet the Disinfectants/Disinfection By-Products Rule if the percentage of SPW is increased). Other elements of the Plan (e.g., monitoring, tracking remediation efforts, modeling) will help answer some of these questions and assist in determining what analyses and changes, if any, to Metropolitan's resource management programs and strategies should be investigated.

Resource Management: Action Items and Status

Item	Status
• Assess whether any changes in the AL, the adoption of an MCL, expected demand for Metropolitan water, projected levels of perchlorate in CRW supplies, or other factors suggest that changes, if any, to Metropolitan's resource programs should be investigated.	• Assessment will occur as new information becomes available.

Legislative and Regulatory Strategy

Metropolitan, in consultation with its Member Agencies and other stakeholders, will develop a state legislative strategy to facilitate the remediation of perchlorate in ground and surface water supplies. Member Agencies that have detected perchlorate in their groundwater supplies must first identify the remediation activities they want to pursue and the type of legislation needed to facilitate these activities. This will enable the crafting of a coherent legislative strategy that has regional support. Efforts to identify local remediation projects that could benefit from a legislative strategy were initiated at the Member Agency Legislative Strategy Committee meeting in May and will be discussed again at upcoming meetings. Similar discussions also need to occur among Metropolitan, SNWA and Kerr-McGee to see if there are any federal legislative actions that could accelerate the cleanup activities at the Kerr-McGee site.

California is moving forward with legislative efforts aimed at addressing perchlorate in drinking water. Senate Bill 1822 by State Senator Byron Sher of Palo Alto calls for the establishment of a PHG and an MCL for perchlorate by January 1, 2003 and July 1, 2003, respectively. SB 1822 has received widespread support in the Legislature and is expected to become law by year-end. However, the Association of California Water Agencies (ACWA) and the California Municipal Utilities Association (CMUA) have taken more neutral positions of "watch and amend" and "watch", respectively. The absence of a "support" position reflects concerns about the bill's deadlines.

Although the deadline for OEHHA to adopt a PHG is reasonable since a significant amount of work has already been completed, the deadline for adopting the MCL is problematic. The bill requires CDHS to adopt an MCL in as little as six months after the PHG is adopted. Statutory administrative requirements for adopting an MCL (i.e., public comment periods, review by the Office of Administrative Law) can take well over three months[2], leaving CDHS with as little as two months for developing the MCL. CDHS has indicated a more reasonable deadline would be one year after the PHG is adopted, or January 2004.

Recognizing that CDHS may not be able to meet the MCL deadline, Metropolitan should still "support" the legislation. A "support" position signals Metropolitan's strong interest in establishing a perchlorate regulatory standard. While legislation that mandates fixed timelines for the regulatory process generally is not desirable because it can compromise the scientific process, the PHG deadline is reasonable even if the MCL deadline may not be attainable. CDHS can take the steps it believes are necessary with the bill's author to seek an extension for adopting the MCL. Currently, no federal legislation has been introduced to regulate perchlorate in drinking water or authorize funding for associated treatment or clean-up costs.

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[2] Statutorily, CDHS must provide a 45-day public comment period when it proposes a regulation and a 15-day public comment period if there are "post-hearing" changes. The Office of Administrative Law has 30 working days (six weeks) to review and approve or reject it.

A statewide initiative, entitled the *Safe, Clean, Reliable, Water Supply Bond Act of 2002*, will appear on the November ballot. If enacted, this bond would make available an unspecified amount of funds for treatment and removal of several contaminants including perchlorate.

Legislative and Regulatory Strategy: Action Items and Status

Item	Status
• Consult with Member Agencies to identify groundwater remediation activities that could benefit from State or Federal legislation.	• Discussions were initiated in May.
• Meet with SNWA and Kerr-McGee to determine whether there is any federal legislation that would be helpful in accelerating clean-up efforts.	• Date to be determined.
• Support SB 1822.	• Bill is moving quickly through the legislature.
• Support the *Safe, Clean, and Reliable Water Supply Bond Act of 2002*	• To appear on November 5, 2002 statewide ballot.

Outreach

As part of its ongoing outreach program on water quality, Metropolitan will be incorporating information about perchlorate to inform consumers and sensitive sub-populations and to help health care providers in advising their patients. The information will be part of Metropolitan's broader "Know Your Water" campaign which aims at creating a better informed consumer base. This campaign also provides information about tap water alternatives since these are not necessarily safer, reminds consumers of the benefits of drinking adequate amounts of tap water, and helps place the risks associated with tap water into an understandable perspective.

Strategies for engaging the medical community in water quality issues like perchlorate have been ongoing since initial efforts with *Cryptosporidium*. The Community Partnering Program has, in part, focused on broadening Metropolitan's network in the health community. Although Metropolitan developed a coordinated and effective response to the lowering of the perchlorate AL and the draft risk assessments released earlier this year, the response was primarily geared to the general consumer and media rather than individuals at greatest risk and health care providers. A risk communications consultant will help in developing strategies and tools for informing these important groups as well as improving current strategies for addressing potential health-related risks associated with drinking water.

In conjunction with Metropolitan's Member Agency Rapid Response efforts, the consultant will also conduct a seminar on risk communications with a focus on perchlorate. A Member Agency Rapid Response team has been formed to respond to events requiring a quick response such as the publication of any future health effects studies, from whatever source, that raise doubts about the safety of tap water. A risk communications seminar will provide an opportunity for Member Agencies to learn how to increase the effectiveness of their communications about health-related issues in general and perchlorate in particular.

To ensure Member Agency input, a working group of Member Agency technical experts will be convened, in coordination with the Member Agency Rapid Response team, to participate in the process of developing effective communication strategies and tools on health-related issues. The specific work product of this group will be determined with input from the risk communications consultant, but will include recommended language for the Consumer Confidence Report (CCR) and an information sheet or brochure on perchlorate (and possibly other health risks associated with tap water). Materials developed by the working group will be integrated into the broader Know Your Water campaign and reported to the Board when available.

Initial steps have already been taken to craft perchlorate language that is suitable for the CCR. Metropolitan's CCR for 2001 contains the following non-mandatory language in a section called "In the News":

> Perchlorate is of concern because it can affect the production of thyroid hormones. The thyroid plays an important role in body growth, mental development, and metabolism. Pregnant women who are iodine-deficient and their fetuses, infants and small children with low levels of iodine in their diets, and individuals with hypothyroidism may be particularly sensitive to the effects of perchlorate. If you have any questions about whether you or your family should consider alternatives to tap water that may contain perchlorate, contact your local health provider.

This language and examples of language on perchlorate that several Member Agencies were planning to use in their CCRs were presented and discussed at a Member Agency Water Quality Manager CCR workgroup meeting held in April 2002.

Outreach: Action Items and Status

Item	Status
• Conduct risk communications seminar, focusing on perchlorate.	• Seminar is targeted for July.
• Convene Member Agency working group and develop strategies and tools for communicating information about perchlorate.	• Will be initiated after seminar.
• Integrate strategies and tools into the Know Your Water campaign.	• Integration expected in the Fall 2002.

Communications with Member Agencies and Board

In addition to the monthly perchlorate monitoring reports to the Member Agencies initiated in April, the Member Agencies and Board will receive quarterly progress reports on the Plan's action items. The progress reports will take the form of updates at meetings of the Member Agency Managers and the Board's Water Planning, Quality, and Resources Committee. More frequent updates will occur, if necessary.

Communications with Member Agencies and Board: Action Items and Status

Item	Status
• Provide quarterly updates on Plan's action items to Member Agencies and Board.	• Ongoing

PERCHLORATE BACKGROUND DOCUMENT

Introduction

This document provides background information on perchlorate and the actions Metropolitan has taken to date to address perchlorate in Colorado River water. The document describes:

- Perchlorate characteristics and uses
- Human health effects
- Occurrence
- Metropolitan's monitoring program
- Remediation activities
- Treatment alternatives
- Non-regulatory developments
- Regulatory developments

Appendices to the document that provide more detailed information include:
1. Comments on OEHHA's Public Health Goal for Perchlorate prepared for Metropolitan by Dr. Douglas Crawford-Brown
2. Perchlorate Treatment Technology Review
3. Metropolitan's Comment Letter to OEHHA on the Draft Perchlorate Public Health Goal Report
4. Metropolitan's Comment Letter to U.S. EPA on the Draft Perchlorate Risk Assessment
5. Setting Health-Based Drinking Water Standards
6. Summary of Terminology Used in Setting Drinking Water Standards and Goals
7. Chronology of Metropolitan's Actions

New perchlorate-related activities that Metropolitan will undertake are described in the Perchlorate Action Plan.

Perchlorate's Characteristics and Uses

Perchlorate (ClO_4^-) is an anion that forms in groundwater and surface water sources when its ammonium, magnesium, potassium or sodium salts dissolve in water. Perchlorate is highly mobile, extremely soluble, non-volatile, and exceedingly persistent in water.

Perchlorate comes from a variety of chemical and industrial uses. A major source of perchlorate is the improper disposal of ammonium perchlorate, a primary component of propellants for solid rockets, missiles, munitions and fireworks. Perchlorate compounds are also used in air bag inflators, nuclear reactors, electronic tubes, lubricating oils, electronic plating, aluminum refining, leather tanning and finishing, rubber and fabric manufacture and in the production of paints, enamels and dyes. Perchlorate is also a laboratory waste by-product of perchloric acid.

Human Health Effects

Perchlorate interferes with iodide uptake into the thyroid gland. Because iodide is an essential component of thyroid hormones, perchlorate disrupts how the thyroid functions. In adults, the thyroid helps to regulate metabolism. In children, the thyroid is important for proper development in addition to metabolism. Impairment of thyroid function in expectant mothers may impact the fetus and newborn, resulting in effects including changes in behavior, delayed development and decreased learning capability. Changes in thyroid hormone levels may also result in thyroid gland tumors. Sensitive sub-populations include: pregnant women who are iodine deficient and their fetuses, infants and small children with low dietary iodide intake, and individuals with hypothyroidism. (See Appendix No. 1 for further information on how the thyroid functions and the effects of perchlorate on human health.)

Occurrence

Nationwide
As of November 2000, perchlorate release into the environment (water and soil) has been reported by the U.S. EPA in 17 states. States with confirmed perchlorate in drinking water sources include Arizona, California, Maryland, Nebraska, Nevada, New Mexico, New York, and Utah. The majority of drinking water wells where perchlorate has been detected are in California, primarily associated with defense and aerospace facilities that have manufactured or tested solid rocket propellants. Perchlorate has also been found in the Colorado River, affecting the states of California, Nevada and Arizona that depend on this surface water source.

An AWWA Research Foundation (AWWARF) funded survey of perchlorate occurrence identified 196 perchlorate facilities located in 39 states. Results of targeted and non-targeted sampling of drinking water supplies and vulnerability assessments suggest that the areas of high vulnerability to perchlorate are relatively localized. These areas are associated with sites of significant perchlorate manufacture or propulsion systems maintenance/testing/disposal.

California
Perchlorate in California drinking water wells was first found in February 1997 in eastern Sacramento County (up to a level of 260 parts per billion, ppb), near Aerojet General Corporation's facility. Clean up of contaminated shallow groundwater to remove volatile organic chemicals at Aerojet's chemical manufacturing and rocket testing facility resulted in the reinjection of the treated water into groundwater aquifers in the area. Perchlorate levels at up to 8,000 ppb concentrations were detected in the reinjected water.

After the development of a more sensitive analytical method in April 1997, California Department of Health Services (CDHS) initiated a statewide perchlorate monitoring program that targeted groundwater wells located near defense and aerospace facilities. On January 7, 1999, CDHS adopted perchlorate as an unregulated chemical for which monitoring is required.

As of May 1, 2002, 670 of California's drinking water systems (serving about 66 percent of the state's population) have reported perchlorate monitoring data to CDHS[1]. Of these, 11 percent had detections (a "detection" indicates at least two positive findings in a source; the current detection limit for purposes of reporting is 4.0 ppb). More than 40 percent of the systems' sources have been sampled, of which 6.4 percent had detections. Counties with reported perchlorate detections from 1997 to this date include Los Angeles (34 systems/108 sources), Riverside (7/43), San Bernardino (14/66), Orange (8/15), Sacramento (3/15), Ventura (1/2), Imperial (1/1), Santa Clara (2/2), Sonoma (1/1) and Tulare (1/1). Potential sources of perchlorate in Southern California include an Aeroject facility in Azusa, the Whittaker-Bermite site in Santa Clarita, the Jet Propulsion Laboratory in Pasadena, and a non-operational fireworks site near Rialto. Perchlorate is also in a TCE plume associated with previous operations of the Lockheed Propulsion Company. (See Figure 1 for the location of sites in the Los Angeles area.)

[1] Source: CDHS website

Perchlorate has also been detected in some agricultural wells in California that were located away from known perchlorate facilities. Earlier studies in 1998 and 1999 suggested that fertilizers could be a potential source of perchlorate and conflicting information was sometimes reported. To clarify this issue, the U.S. EPA conducted a comprehensive study and concluded that the only confirmed perchlorate detections in fertilizers are the natural saltpeter from Chile and products derived from it. The report stated that "The data obtained here fail to suggest that fertilizers contribute to environmental perchlorate contamination other than in the case of natural saltpeter or their derivatives". The results of limited investigation into this issue included in the AWWARF perchlorate occurrence study were consistent with the U.S. EPA report.

Metropolitan's Member Agencies
Among Metropolitan's 26 member agencies with groundwater sources, 15 have reported perchlorate detections in wells and reservoirs. These include Anaheim, Central Basin Municipal Water District (MWD), Eastern MWD, Foothill MWD, Fullerton, Glendale, Inland Empire Utilities Agency, Los Angeles, MWD of Orange County, Pasadena, San Marino, and Santa Ana, Three Valleys MWD, Upper San Gabriel Valley MWD and Western MWD. In 1992 these water utilities reported at least 92 wells/reservoirs with perchlorate levels ranging from >4 parts per billion (ppb) to 41 ppb, and many have been taken out of service.

Metropolitan Water District's Source Waters
Metropolitan conducted initial perchlorate sampling in June 1997, and detected perchlorate in the Colorado River aqueduct and the Lake Mead outlet at Hoover Dam. Follow-up sampling within the Colorado River watershed was conducted in July and August 1997 to determine the source. The results indicated that the perchlorate originated in the Las Vegas Wash, where high concentrations of perchlorate were discharged into Lake Mead.

Two companies have manufactured perchlorate compounds in Henderson, Nevada since the 1950s. The main source of perchlorate entering into the Las Vegas Wash was attributed to the Kerr-McGee Chemical LLC (Kerr-McGee) site. Perchlorate waste from decades of poor disposal practices has permeated into the groundwater under the manufacturing site which flows into the Las Vegas Wash and then into Lake Mead.

Metropolitan's Perchlorate Monitoring Program

After initial monitoring of Colorado River water (CRW) and State project water (SPW) supplies in June 1997, Metropolitan initiated monthly monitoring for perchlorate in October of the same year with the collection of samples from the Colorado River aqueduct, source water reservoirs, treatment plant influents and effluents, and select distribution system locations. In April 2002, the program was expanded to include nine additional distribution system locations, bringing the total number of monitoring sites to 31.

Since the inception of the monitoring program, perchlorate levels in CRW supplies have ranged from non-detect (<4 ppb) to 9 ppb. None has been detected in SPW water. (See Figure 2 and Table 1a for perchlorate levels in Metropolitan's source waters.) Perchlorate levels in treated water from Diemer, Weymouth and Skinner have ranged from non-detect to 8 ppb, with the variation primarily due to changes in the percent SPW blend at these plants (Table 1b). Similar perchlorate levels have been detected in the distribution system (Table 1c), ranging from non-detect to 7 ppb.

CDHS has recommended that Metropolitan observe the new Action Level of 4 ppb at the Deimer and Weymouth plants based on the 6-month running averages of the combined Diemer and Weymouth plant effluents (Figure 3) and the 6-month running average of the Skinner plant effluent (Figure 4). (Also see Table 2 for 6-month running averages at other locations.)

Remediation Activities

In 1997, monitoring of groundwater at the Kerr-McGee facility in Henderson, Nevada confirmed that the site was a source of perchlorate. The site had already been undergoing cleanup for hexavalent chromium since the mid 1980s when Kerr-McGee installed 22 wells to capture and treat groundwater. Monitoring of these wells in 1997 revealed that groundwater also contained perchlorate with levels averaging 1,700,000 ppb after treatment for chromium. Additional perchlorate was identified in spring of 1999, when a groundwater seep was discovered near the surface of the Las Vegas Wash. The seep was traced upstream to old industrial ponds owned by Kerr-McGee. Perchlorate concentrations in the seep water were around 100,000 ppb.

Kerr-McGee's remediation efforts for perchlorate began in 1998 with the construction of an evaporation pond to retain groundwater containing this chemcial. Since then, Kerr-McGee has constructed a slurry wall to slow the movement of the perchlorate plume, undertaken interim cleanup actions to remove perchlorate from seep water, constructed additional extraction wells, and introduced a new, larger ion-exchange unit to treat both ground and seep water. Remediation is subject to two consent agreements with the Nevada Division of Environmental Protection (NDEP). The first agreement, dated June 28, 1999, required the capture of groundwater seep before it enters the Las Vegas Wash. The second consent agreement, dated October 8, 2001, was for the implementation of a large-scale system by March 29, 2002.

Kerr-McGee estimates that it will take six months to two years to clean up the groundwater seep which surfaces at the Wash and the groundwater at the Wash. There is no official estimate as to how long it will take to clean up the entire site. Cleanup timelines appear to depend on the amount of wastewater discharged into rapid infiltration basins operated by the City of Henderson which are in close proximity to the Kerr-McGee site. Wastewater discharged into infiltration basins increases the volume of groundwater that Kerr-McGee needs to treat, thereby prolonging the cleanup schedule. Kerr-McGee has been unofficially told that the City will no longer use the infiltration basins. Figure 5 shows the location of the remediation projects which are described in further detail below.

Evaporation Pond

In 1998, Kerr-McGee constructed an 11-acre evaporation pond to retain groundwater that had been extracted and treated for hexavalent chromium. Previously this water had been injected back into the ground. The water, however, still contained high levels of perchlorate. The evaporation pond allows for the retention of the extracted water in anticipation of further treatment by a new large-scale ion exchange system. The extracted groundwater that was previously injected back is now replaced by water from Lake Mead. This clean water will serve as an indication of when the plume is completely extracted.

Slurry Wall

Kerr-McGee has also constructed a slurry wall[2] in order to slow the plume from migrating to Las Vegas Wash and to increase the capture of extracted groundwater. The wall, which was constructed just downstream of the 22 on-site extraction wells, has been successful in slowing the plume from further migration to the Wash which is approximately three miles further downstream. Extraction rates have more than doubled from 20 gallons per minute (gpm) to 50 gpm since construction. The wall is 1,700 feet in length, 3 feet wide, and 30 feet deep.

Interim System for Treating Seep Water

On November 13, 1999 Kerr-McGee began operation of a 450 gpm interim ion-exchange system which treats the groundwater seep that surfaces at the Las Vegas Wash. Perchlorate levels downstream of the Kerr-McGee site

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[2] The slurry wall is a 1,700-foot (long) by 3 feet (wide) by 30-foot (deep) physical barrier to slow the migration of perchlorate toward the Las Vegas Wash.

were as high as 1,000 ppb before the interim unit was operated, compared to an average of 437 ppb within the last year. Thus, it is estimated that the seepage represents approximately 50 percent of the perchlorate entering the Wash. Operating costs for the interim system are approximately $500,000 a month, as the resin is not regenerated.

Perchlorate concentrations in the groundwater seep were historically 100,000 ppb, but have been reduced to 80,000 ppb recently. The reduction may reflect the benefits of the slurry wall and retaining water in the evaporation pond. The seep flow is typically 400 gpm, but varies from 100-600 gpm. Seep flows vary due to transpiration of salt cedar[3] in the Wash and whether or not the City of Henderson's wastewater treatment plant is discharging their treated wastewater effluent into the Wash. After treatment through the interim system, the water is discharged back to the Wash at around 1,000 ppb of perchlorate. Kerr-McGee's discharge permit does not state a numerical limit for perchlorate concentration in the discharge, but requires a 97 percent removal efficiency for the interim system. The interim system normally achieves 99 percent removal.

Additional Extraction Wells

In 2001, four extraction wells were installed approximately 100 feet upgradient of the groundwater seep to capture groundwater near the Las Vegas Wash that does not surface. Another eight wells have been installed at Athens Road, which is the midpoint between the Kerr-McGee site and the Las Vegas Wash.

Flows from the four wells at the seep (plus the original groundwater seep) are expected to total 500 gpm and contain perchlorate at approximately 100,000 ppb. Flows from the eight wells at Athens Road are expected to total 275 gpm, with perchlorate levels of 330,000 ppb.

New Ion Exchange

In order to address long-term treatment needs, Kerr-McGee has installed a new 825 gpm large-scale ion exchange unit. The new unit will treat: (1) water from the seep (surface and groundwater) which contributes 500 gpm, (2) groundwater from Athens Road which contributes 275 gpm, and (3) water from the evaporation pond at 50-75 gpm. Treated water will be discharged to the Wash. NDEP estimates that the new unit will be able to reduce perchlorate concentrations ranging from 100,000 - 330,000 ppb in untreated water to 1,000 ppb, and Kerr-McGee believes that even lower concentrations can be achieved once the system is optimized.

After the Athens Road wells start pumping, the groundwater seep that surfaces at the Wash should dry up. Once that source has been addressed, treatment will focus on the subsurface groundwater and the wells at Athens Road. In addition to larger capacity, the unit will be able to destroy perchlorate in the brine so that the resin can be regenerated.

Kerr-McGee's large-scale ion exchange unit was started on March 29, 2002, but there were several start-up problems. These included (1) airlocking in the effluent line, (2) a leak in the influent line, (3) access to the influent line due to a fire in the Wash, and most recently (4) an unknown material plating out on the heat exchangers and the catalyst. The plated material inhibits destruction of perchlorate in the brine which is necessary to regenerate the resin and operate the system. This may present a serious setback to the cleanup schedule. The system was expected to restart by May 6, 2002 but is not yet operational. In the meantime, the interim unit continues to operate.

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[3] Salt cedar is a plant which is dormant in the winter and takes up less water.

Regulatory oversight
U.S. EPA Region IX has been involved in the cleanup effort since 1997, first under the Superfund program, and most currently under the Resource Conservation and Recovery Act (RCRA) program. Because Nevada is a delegated state for the RCRA program, NDEP has the primary responsibility for overseeing the Kerr-McGee cleanup. NDEP is required to report on the progress of the cleanup to USEPA on a quarterly basis. Due to the high-profile nature of this project, NDEP holds conference calls with USEPA twice a month, and USEPA representatives visit the site once a quarter.

Perchlorate Treatment Alternatives

In addition to site remediation, perchlorate can be separated from drinking water using a variety of technologies. Importantly, perchlorate must still be destroyed once separated and prior to environmental discharge.

There are several treatment options for perchlorate removal from drinking water. These include physicochemical processes such as granular activated carbon (GAC) adsorption, ion exchange, and membrane separation, and biological processes such as anaerobic treatment. Because perchlorate is highly oxidized and does not absorb radiation in the ultraviolet light spectrum, neither oxidation technologies (e.g., ozone or UV/hydrogen peroxide) nor ultraviolet irradiation (e.g., low pressure, medium pressure, or pulsed UV) reduce perchlorate.

Metropolitan has evaluated the feasibility and cost of various treatment options. Removal by GAC is difficult and expensive because of the high solubility of perchlorate. The efficiency of ion exchange is reduced because ions such as sulfate interfere with perchlorate adsorption. Also, regeneration of the ion exchange resin creates a brine that can cause disposal problems because of high perchlorate concentrations. Note that ion exchange is viable as a site remediation strategy when extremely high levels of perchlorate occur, e.g., in contaminated groundwater (100,000 – 300,000 ppb). It is less effective when concentrations are less than 100 ppb.

Reverse osmosis and nanofiltration membranes are effective removal technologies but merely transfer the perchlorate to the waste brine and cost $300-350/acre-foot. Biological treatment has been shown to be effective with highly contaminated wastewater and groundwater. It is not clear whether bioreactors would produce potable drinking water from sources with the low levels of perchlorate such as found in drinking water supplies. CDHS, however, recently issued conditional approval for the use of a biological process using a fluidized bed of granular activated carbon for perchlorate removal from water that is a potential source of drinking water supply.

Implementation of any of these technologies could take up to five years. Remediation at the source is a more effective method for reducing perchlorate levels within a comparable timeframe. (See Appendix No. 2 for further information on treatment options.)

Non-Regulatory Developments

California has had an Action Level (AL) for perchlorate since May 1997 when CDHS established an AL of 18 ppb in response to the detection of perchlorate in groundwater supplies. CDHS lowered the AL to 4 ppb in January 2002 following the release of U.S. EPA's draft perchlorate risk assessment document. The draft risk assessment suggested that U.S. EPA's current reference dose for perchlorate, which is equivalent to a range of 4-18 ppb if all exposure is through the ingestion of drinking water, was not adequately protective of human health. The draft risk assessment recommended lowering the reference dose to a level equivalent to 1 ppb in drinking water. Perchlorate, however, can only be reliably detected at concentrations of 4 ppb or greater, and the revised AL reflects these quantitation limits.

An AL is a health-based "advisory" level established by CDHS for drinking water contaminants for which there is no MCL. The AL is the level of a contaminant in drinking water at which there is no significant risk to persons ingesting water on a daily basis. Unlike an MCL, an AL is not an enforceable standard.

The Health and Safety Code (§ 116455) requires drinking water utilities to notify within thirty days the governing bodies in which the users of the drinking water reside if a contaminant exceeds the AL in a *drinking water well or the well* is closed because of the contaminant (emphasis added). There is no parallel requirement for exceedances of an AL in surface water sources.

CDHS recommends that, if a contaminant exceeds the AL in water that is delivered, the utility inform its customers and consumers about the presence of the contaminant and its potential for adverse health effects at high levels of exposure. Utilities may use the annual Consumer Confidence Report, a separate mailer or other method for notification.

CDHS further recommends that the drinking water system take the source out of service if a contaminant is present at more than:

- 10 times the AL, if the AL is based on noncancer endpoints. A level greater than 10 times the AL reduces the margin of safety provided by the AL.
- 100 times the AL, if the AL is based on cancer risk and at the 10^{-6} risk level. A level 100 times the AL corresponds to a theoretical lifetime risk of up to one excess case of cancer in 10,000 people, the upper value of the 10^{-6} to 10^{-4} risk range typically allowed by regulatory agencies.

CDHS' recommended actions appear to apply to both ground and surface water sources of supply.

Regulatory Developments

California

California is proceeding with promulgating a health-based drinking water standard for perchlorate. The regulatory process begins with the development of a Public Health Goal (PHG) by California's Office of Environmental Health Hazard and Assessment (OEHHA). For an acutely toxic substance, the PHG is the maximum concentration of a contaminant in drinking water for which there is no known adverse health effects, with an adequate margin of safety.

In March 2002, OEHHA released a draft report recommending a PHG of 6 ppb. A public workshop on the proposal was held on April 29. A revised draft should be available by late summer, followed by a 30-day comment period. OEHHA expects to finalize the PHG by the end of this year. Next, CDHS will establish a Maximum Contaminant Level (MCL). The MCL must be set as close to the PHG as possible, taking into account economics and technical feasibility. If enacted, legislation introduced by State Senator Byron Sher of Palo Alto (SB 1822) would require OEHHA to adopt a PHG no later than December 2002 and CDHS to adopt an MCL no later than July 1, 2003. The bill's date for adopting a PHG is already consistent with OEHHA's time schedule, but the date for adopting the MCL may not be achievable if a PHG is not finalized until the end of the year.

U.S. EPA

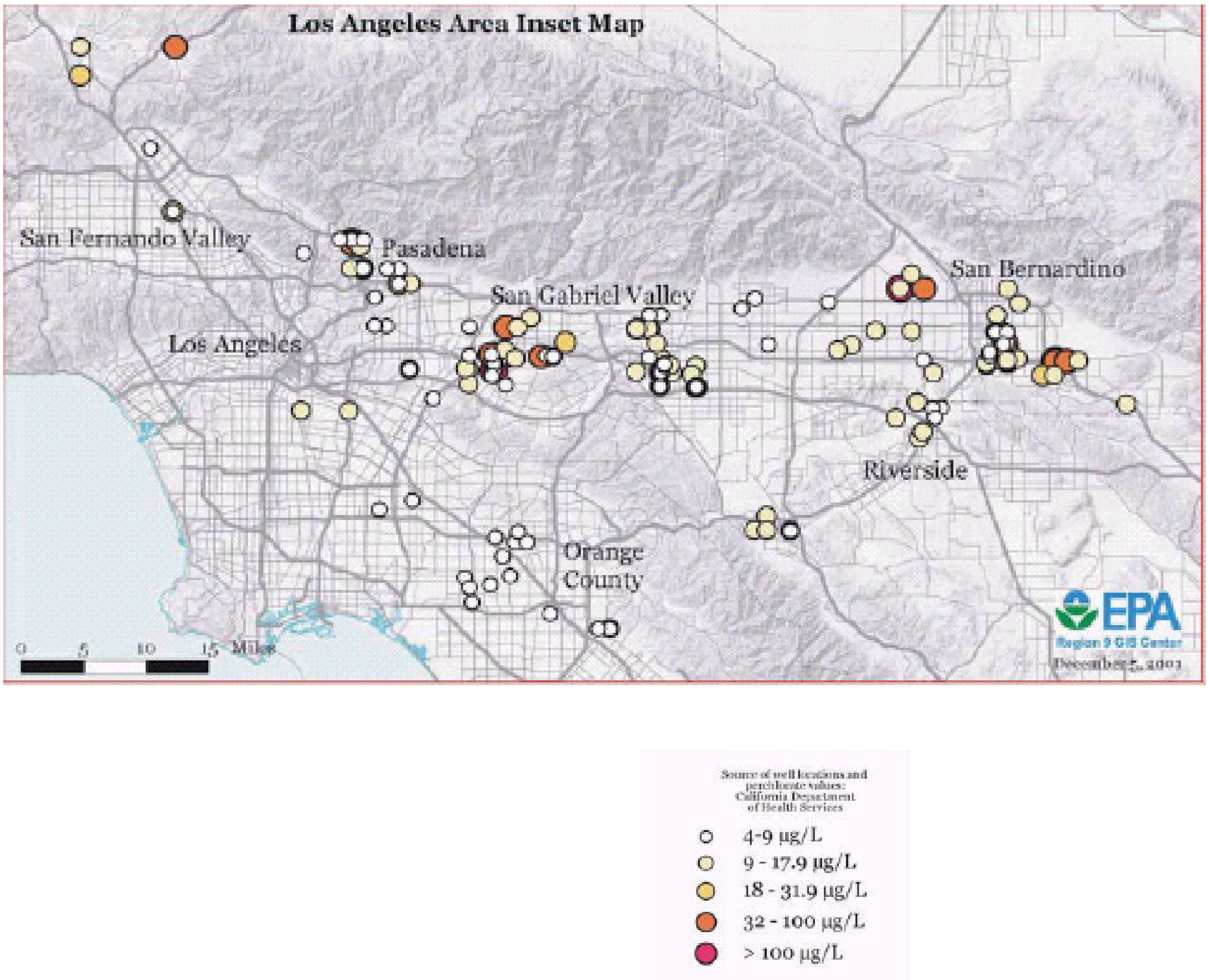
The U.S. Environmental Protection Agency (U.S. EPA) has not yet determined whether perchlorate should be regulated at the federal level. The agency is in the process of collecting national occurrence data to assist in that determination. Data collection will not be complete until the end of 2003, and the decision of whether or not to regulate is not expected until 2006.

In January 2002, however, U.S. EPA released a draft risk assessment document that revises the reference dose (RfD) for perchlorate. The RfD is defined as an estimate, with uncertainty spanning perhaps an order of magnitude, of daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of adverse effects over a lifetime. The draft perchlorate RfD translates into a drinking water equivalent level (DWEL) of 1 ppb.

In February, U.S. EPA convened an external scientific peer review panel and the agency could finalize the RfD as early as this fall. If U.S. EPA decides to regulate perchlorate, the RfD along with other health effects information, economic considerations, and technical feasibility would be utilized in establishing a federal MCL. However, any federal standard would occur after California promulgates its own MCL, and any California standard must be at least as stringent as the federal MCL.

Metropolitan submitted comments to OEHHA and U.S. EPA on the draft PHG and RfD reports, respectively. (See Appendices Nos. 3 and 4 for copies of the comment letters.) The comments were prepared with the assistance of Dr. Douglas Crawford-Brown, Chair of the University of North Carolina's Department of Environmental Studies. Appendix No. 1, which was prepared by Dr. Crawford-Brown, discusses the basis for the PHG and RfD and some of the issues related to their development. Also see Appendices Nos. 5 and 6 for a description of the state and federal regulatory and non-regulatory processes and definitions of terms used.

Figure 1
Perchlorate Detections in Southern California



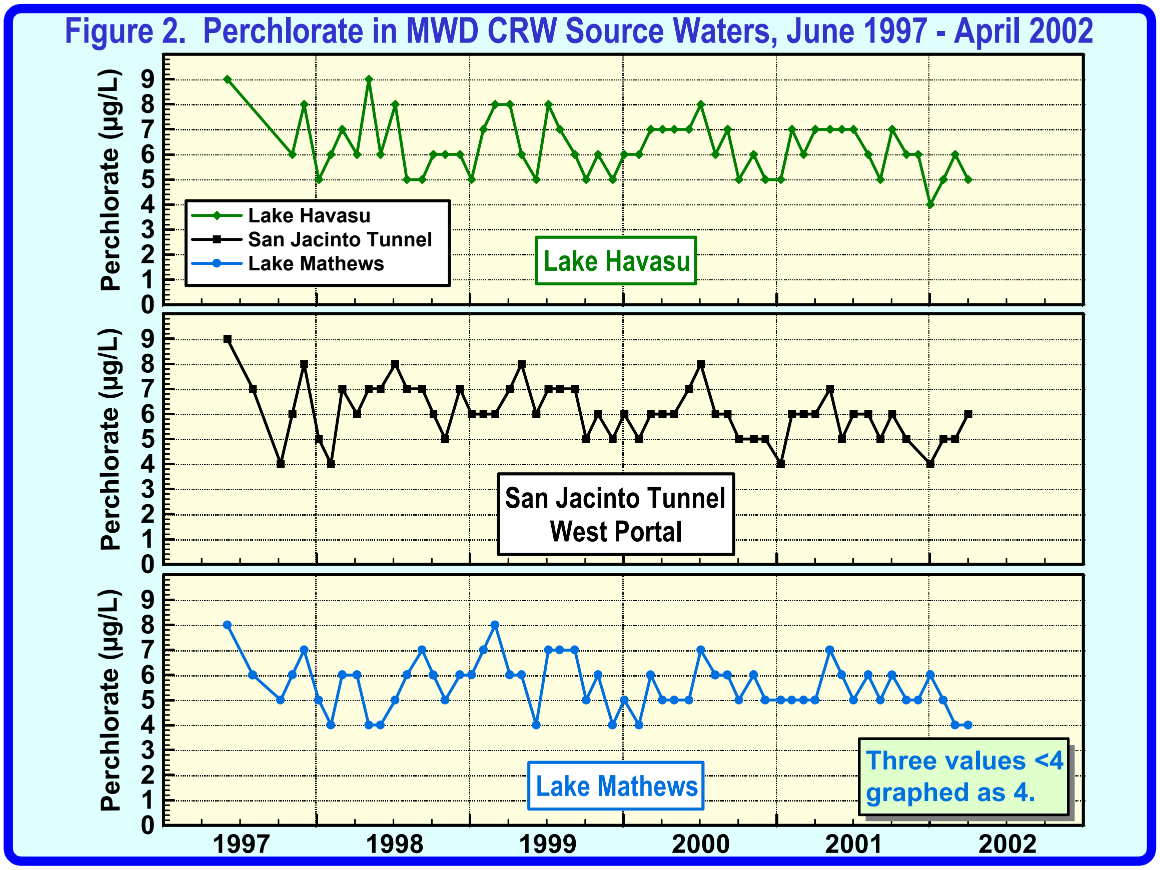


Figure 2. Perchlorate in MWD CRW Source Waters, June 1997 - April 2002
Perchlorate (µg/L)
Lake Havasu
San Jacinto Tunnel
Lake Mathews
Lake Havasu
San Jacinto Tunnel
West Portal
Lake Mathews
Three values <4
graphed as 4.
1997
1998
1999
2000
2001
2002

Figure 3. 6-Month Running Average Perchlorate of Combined Diemer and Weymouth Effluents

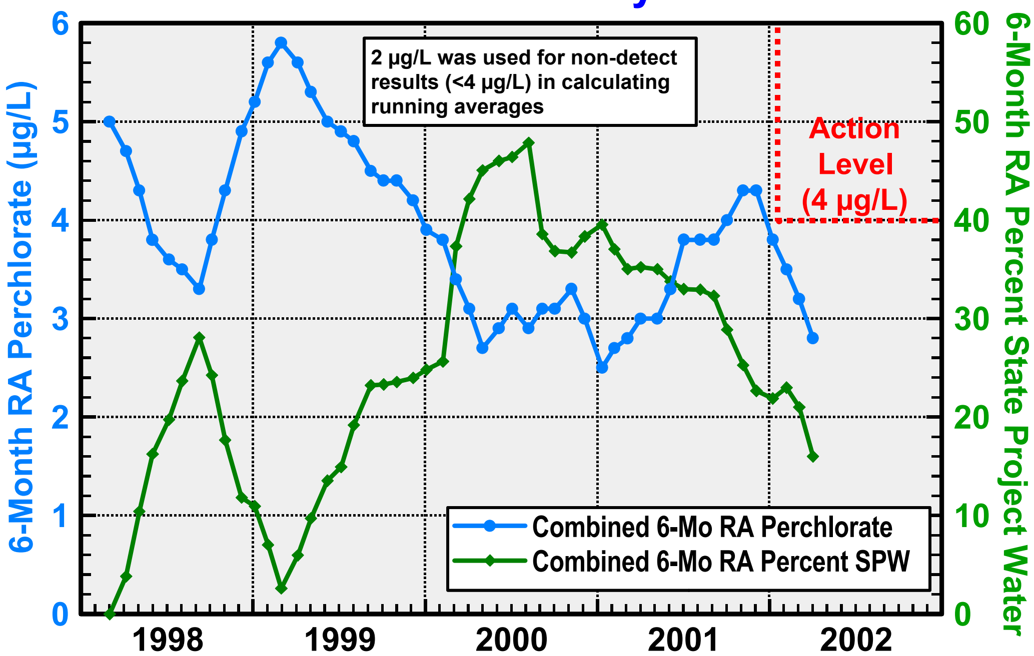


Figure 4. 6-Month Running Average Perchlorate of Skinner Plant Effluent

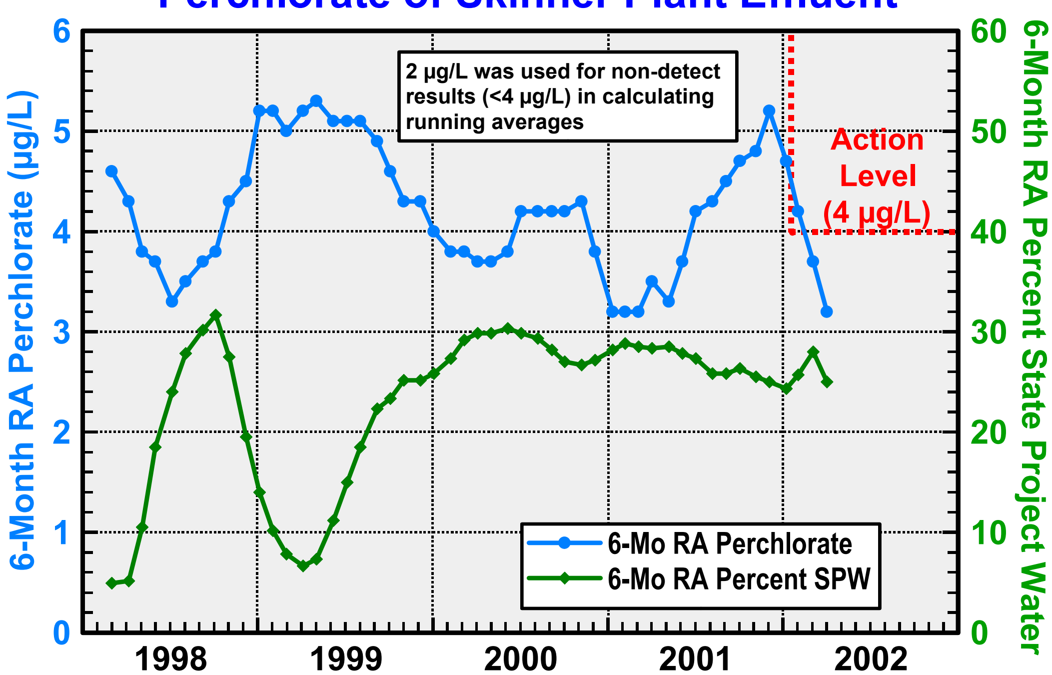


Figure 5

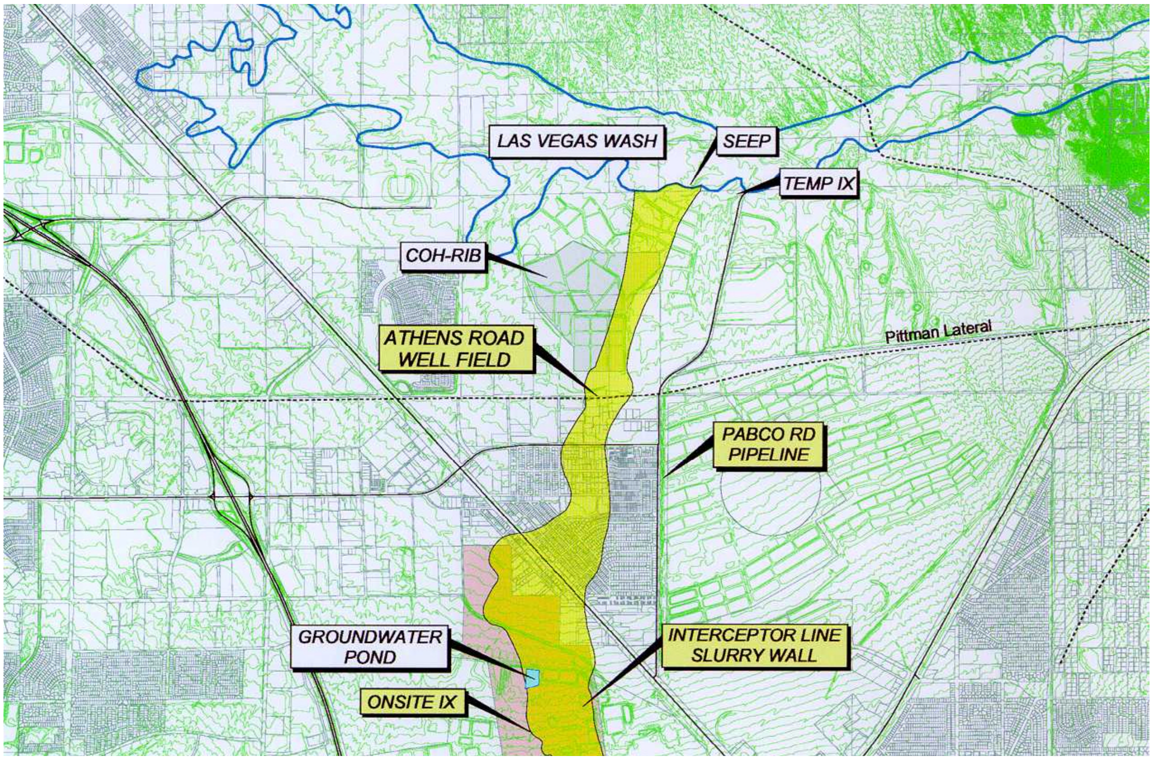

LAS VEGAS WASH
SEEP
TEMP IX
COH-RIB
ATHENS ROAD
WELL FIELD
Pittman Lateral
PABCO RD
PIPELINE
GROUNDWATER
POND
INTERCEPTOR LINE
SLURRY WALL
ONSITE IX

Table 1A
Perchlorate Concentrations in Metropolitan's Source Waters
Values in micrograms per Liter (µg/L)
May 22, 2002

	Colorado River Water			State Project Water			Blended Water	
Date	Lake Havasu	San Jacinto Tunnel West Portal	Lake Mathews	Castaic Lake Effluent*	Lake Silverwood	Lake Perris	Lake Skinner Effluent	Diamond Valley Lake
June-97	9	9	8		ND	ND	NC	
August-97	NC	7	6		ND	ND	7	
October-97	NC	4	5		ND	ND	4	
November-97	6	6	6		ND	ND	5	
December-97	8	8	7		ND	ND	6	
January-98	5	5	5		ND	ND	8	
February-98	6	4	4		ND	ND	4	
March-98	7	7	6		ND	ND	6	
April-98	6	6	6		ND	ND	6	
May-98	9	7	ND (3.2)		ND	ND	ND	
June-98	6	7	4		ND	ND	5	
July-98	8	8	5		ND	ND	ND	
August-98	5	7	6		ND	ND	5	
September-98	5	7	7		ND	ND	5	
October-98	6	6	6		ND	ND	4	
November-98	6	5	5		ND	ND	4	
December-98	6	7	6		ND	ND	5	
January-99	5	6	6		ND	ND	6	
February-99	7	6	7		ND	ND	5	
March-99	8	6	8		ND	ND	5	
April-99	8	7	6		ND	ND	5	
May-99	6	8	6		ND	ND	6	
June-99	5	6	4		ND	ND	4	
July-99	8	7	7		ND	ND	6	
August-99	7	7	7		ND	ND	5	
September-99	6	7	7		ND	ND	4	
October-99	5	5	5		ND	ND	4	
November-99	6	6	6		ND	ND	4	
December-99	5	5	4		ND	ND	4	
January-00	6	6	5		ND	ND	4	
February-00	6	5	4		ND	ND	4	
March-00	7	6	6		ND	ND	4	
April-00	7	6	5		ND	ND	ND	ND
May-00	7	6	5		ND	ND	4	ND

Table 1A
Perchlorate Concentrations in Metropolitan's Source Waters
Values in micrograms per Liter (μg/L)
May 22, 2002

	Colorado River Water			State Project Water			Blended Water	
Date	Lake Havasu	San Jacinto Tunnel West Portal	Lake Mathews	Castaic Lake Effluent*	Lake Silverwood	Lake Perris	Lake Skinner Effluent	Diamond Valley Lake
June-00	7	7	5		ND	ND	5	4
July-00	8	8	7		ND	ND	6	5
August-00	6	6	6		ND	ND	4	5
September-00	7	6	6		ND	ND	4	4
October-00	5	5	5		ND	ND	ND	5
November-00	6	5	6		ND	ND	5	4
December-00	5	5	5		ND	ND	ND	ND
January-01	5	4	5		ND	ND	ND	4
February-01	7	6	5	ND	ND	ND	4	ND
March-01	6	6	5	ND	ND	ND	4	ND
April-01	7	6	5	ND	ND	ND	4	4
May-01	7	7	7	ND	ND	ND	4	4
June-01	7	5	6	ND	ND	ND	4	5
July-01	7	6	5	ND	ND	ND	6	5
August-01	6	6	6	ND	ND	ND	6	4
September-01	5	5	5	ND	ND	ND	5	5
October-01	7	6	6	ND	ND	ND	4	5
November-01	6	5	5	ND	ND	ND	5	6
December-01	6	NA	5	ND	ND	ND	5	ND
January-02	4	4	6	ND	ND	ND	ND	ND
February-02	5	5	5	ND	ND	ND	4	ND
March-02	6	5	ND	ND	ND	ND	ND	ND
April-02	5	6	ND	ND	ND	ND	ND	ND

*** Collected at Foothill Pressure Control Structure**
ND = Not detected at 4 μg/L
NC = Not collected
NA = Not analyzed

Table 1B
Perchlorate Concentrations in Metropolitan's Treatment Plants
Values in micrograms per Liter (µg/L)
May 22, 2002

Date	Diemer Influent	Diemer Effluent	Weymouth Influent	Weymouth Effluent	Skinner Effluent	Jensen Influent	Jensen Effluent	Mills Influent	Mills Effluent
June-97	NC	ND	NC	7	ND (<6)	NC	ND	NC	ND
August-97	5	7	7	5	7	ND	ND	ND	ND
October-97	7	5	5	5	4	ND	ND	ND	ND
November-97	6	5	6	5	6	ND	ND	ND	ND
December-97	7	6	6	5	4	ND	ND	ND	ND
January-98	6	6	4	5	8	ND	ND	ND	ND
February-98	4	4	4	4	4	ND	ND	ND	ND
March-98	4	5	5	5	5	ND	ND	ND	ND
April-98	ND	ND	4	4	6	ND	ND	ND	ND
May-98	ND	ND	4	4	ND	ND	ND	NC	NC
June-98	ND	ND	ND	ND	4	ND	ND	ND	ND
July-98	5	5	4	4	ND	ND	ND	ND	ND
August-98	4	ND	4	4	5	ND	ND	ND	ND
September-98	4	4	4	4	6	ND	ND	ND	ND
October-98	6	6	5	6	4	ND	ND	ND	ND
November-98	6	6	6	6	5	ND	ND	ND	ND
December-98	5	5	6	6	5	ND	ND	ND	ND
January-99	6	6	6	6	6	ND	ND	ND	ND
February-99	6	6	6	6	5	ND	ND	ND	ND
March-99	5	5	6	6	5	ND	ND	ND	ND
April-99	4	4	5	5	5	ND	ND	ND	ND
May-99	5	5	4	4	6	NA	NA	ND	ND
June-99	ND	ND	4	5	4	ND	ND	ND	ND
July-99	6	6	5	5	6	ND	ND	ND	ND
August-99	5	5	5	5	5	ND	ND	ND	ND
September-99	4	4	4	4	4	ND	ND	ND	ND
October-99	4	4	4	4	4	ND	ND	ND	ND
November-99	5	5	4	4	4	ND	ND	ND	ND
December-99	ND	ND	ND	ND	4	ND	ND	ND	ND
January-00	4	4	4	4	4	ND	ND	ND	ND
February-00	4	4	4	4	4	ND	ND	ND	ND
March-00	ND	ND	ND	ND	4	ND	ND	ND	ND
April-00	ND	ND	ND	ND	ND	ND	ND	ND	ND
May-00	ND	ND	ND	ND	4	ND	ND	ND	ND
June-00	ND	ND	5	5	5	ND	ND	ND	ND
July-00	5	5	5	5	6	ND	ND	ND	ND
August-00	ND	ND	4	4	4	ND	ND	ND	ND
September-00	4	4	ND	ND	4	ND	ND	ND	ND
October-00	ND	ND	ND	ND	ND	ND	ND	ND	ND
November-00	ND	ND	4	4	5	ND	ND	ND	ND
December-00	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 1B
Perchlorate Concentrations in Metropolitan's Treatment Plants
Values in micrograms per Liter (µg/L)
May 22, 2002

Date	Diemer Influent	Diemer Effluent	Weymouth Influent	Weymouth Effluent	Skinner Effluent	Jensen Influent	Jensen Effluent	Mills Influent	Mills Effluent
January-01	ND	ND	ND	ND	ND	ND	ND	ND	ND
February-01	4	4	4	4	4	ND	ND	ND	ND
March-01	4	4	4	4	4	ND	ND	ND	ND
April-01	ND	ND	4	4	4	ND	ND	ND	ND
May-01	4	4	ND	ND	4	ND	ND	ND	ND
June-01	4	4	4	4	4	ND	ND	ND	ND
July-01	5	5	5	5	5	ND	ND	ND	ND
August-01	4	4	4	4	5	ND	ND	ND	ND
September-01	4	4	4	4	5	ND	ND	ND	ND
October-01	4	4	5	4	5	ND	ND	ND	ND
November-01	5	5	4	4	5	ND	ND	ND	ND
December-01	4	4	5	5	6	ND	ND	NC	4*
January-02	ND	ND	ND	ND	ND	ND	ND	ND	ND
February-02	ND	ND	ND	ND	ND	ND	ND	ND	ND
March-02	ND	ND	ND	ND	ND	ND	ND	ND	ND
April-02	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected at 4 µg/L unless otherwise noted.
NC = Not collected
NA = Not analyzed
* Mills plant was treating CRW

Table 1C
Perchlorate Concentrations in Metropolitan's Distribution System
Values in micrograms per Liter (µg/L)
May 22, 2002

Date	FM-1	Garvey Res. Effluent	PVR2E	WB-28	Cenb-44	Cenb-1	Cenb-14	Cenb-50	SMN-1	LB-4	T-1	219th Street	OC-88	SD-7
October-97	6		5	5	7									
November-97	6		7	6	5									
December-97	7		5	5	4									
January-98	7		4	7	ND									
February-98	4		4	4	4									
March-98	5		5	5	5									
April-98	5		5	ND	5									
May-98	NA		ND	ND	ND									
June-98	ND		ND	ND	ND									
July-98	4		ND	4	4									
August-98	ND		ND	ND	ND									
September-98	4		4	5	5									
October-98	6		4	5	6									
November-98	6		6	6	6									
December-98	5		5	5	5									
January-99	5		6	6	5									
February-99	5		5	5	5									
March-99	5		5	5	5									
April-99	4		4	4	4									
May-99	5		5	5	5									
June-99	4		4	4	5									
July-99	5	5	5	5	5									
August-99	5	5	5	5	5									
September-99	4	5	4	4	4									
October-99	4	4	4	4	4									
November-99	4	4	4	ND	4									
December-99	4	4	4	4	4									
January-00	4	4	ND	4	4									
February-00	4	4	ND	4	4									
March-00	ND	ND	ND	ND	ND									
April-00	ND	ND	ND	ND	ND									
May-00	ND	ND	ND	ND	ND									
June-00	4	ND	ND	ND	ND									
July-00	5	ND	ND	ND	ND									
August-00	4	4	ND	ND	ND									
September-00	ND	4	ND	ND	4									

Table 1C
Perchlorate Concentrations in Metropolitan's Distribution System
Values in micrograms per Liter (µg/L)
May 22, 2002

Date	FM-1	Garvey Res. Effluent	PVR2E	WB-28	Cenb-44	Cenb-1	Cenb-14	Cenb-50	SMN-1	LB-4	T-1	219th Street	OC-88	SD-7
October-00	ND	ND	ND	ND	ND									
November-00	4	ND	ND	ND	ND									
December-00	ND	ND	ND	ND	ND									
January-01	ND	ND	ND	ND	ND									
February-01	4	4	ND	ND	4									
March-01	4	4	ND	ND	NC									
April-01	ND	4	ND	ND	ND									
May-01	4	ND	ND	ND	ND									
June-01	4	ND	ND	ND	4									
July-01	5	5	ND	ND	4									
August-01	4	5	ND	ND	4									
September-01	4	4	ND	ND	5									
October-01	4	4	ND	ND	5									
November-01	4	4	4	5	4									
December-01	4	4	ND	4	5									
January-02	ND	ND	ND	ND	ND									
February-02	ND	ND	ND	ND	ND									
March-02	ND	ND	ND	ND	ND									
April-02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected at 4 µg/L unless otherwise noted.
NC = Not collected
NA = Not analyzed

Table 2A
Perchlorate Concentrations in Metropolitan's Source Waters - Six-Month Running Averages
Values in Micrograms per Liter (µg/L)
May 22, 2002

	Colorado River Water			State Project Water			Blended Water	
Date	Lake Havasu	San Jacinto Tunnel West Portal	Lake Mathews	Castaic Lake Effluent*	Lake Silverwood	Lake Perris	Lake Skinner Effluent	Diamond Valley Lake
March-98	6	6	6		ND	ND	5	
April-98	6	6	6		ND	ND	5	
May-98	7	6	5		ND	ND	5	
June-98	7	6	5		ND	ND	4	
July-98	7	7	5		ND	ND	4	
August-98	7	7	5		ND	ND	4	
September-98	7	7	5		ND	ND	4	
October-98	7	7	5		ND	ND	4	
November-98	6	7	6		ND	ND	4	
December-98	6	7	6		ND	ND	4	
January-99	6	6	6		ND	ND	5	
February-99	6	6	6		ND	ND	5	
March-99	6	6	6		ND	ND	5	
April-99	7	6	6		ND	ND	5	
May-99	7	7	7		ND	ND	5	
June-99	7	7	6		ND	ND	5	
July-99	7	7	6		ND	ND	5	
August-99	7	7	6		ND	ND	5	
September-99	7	7	6		ND	ND	5	
October-99	6	7	6		ND	ND	5	
November-99	6	6	6		ND	ND	4	
December-99	6	6	6		ND	ND	4	
January-00	6	6	6		ND	ND	4	
February-00	6	6	5		ND	ND	4	
March-00	6	6	5		ND	ND	4	
April-00	6	6	5		ND	ND	4	
May-00	6	6	5		ND	ND	4	
June-00	7	6	5		ND	ND	4	
July-00	7	6	5		ND	ND	4	
August-00	7	7	6		ND	ND	4	
September-00	7	7	6		ND	ND	4	4
October-00	7	6	6		ND	ND	4	4
November-00	7	6	6		ND	ND	4	5
December-00	6	6	6		ND	ND	4	4
January-01	6	5	6		ND	ND	ND	4
February-01	6	5	5		ND	ND	ND	4
March-01	6	5	5		ND	ND	ND	ND
April-01	6	5	5		ND	ND	4	ND
May-01	6	6	5		ND	ND	ND	ND
June-01	7	6	6		ND	ND	4	4
July-01	7	6	6	ND	ND	ND	4	4
August-01	7	6	6	ND	ND	ND	5	4

Table 2A
Perchlorate Concentrations in Metropolitan's Source Waters - Six-Month Running Averages
Values in Micrograms per Liter (µg/L)
May 22, 2002

	Colorado River Water			State Project Water			Blended Water	
Date	Lake Havasu	San Jacinto Tunnel West Portal	Lake Mathews	Castaic Lake Effluent*	Lake Silverwood	Lake Perris	Lake Skinner Effluent	Diamond Valley Lake
September-01	7	6	6	ND	ND	ND	5	4
October-01	7	6	6	ND	ND	ND	5	5
November-01	6	6	6	ND	ND	ND	5	5
December-01	6	6	5	ND	ND	ND	5	4
January-02	6	5	6	ND	ND	ND	5	4
February-02	6	5	5	ND	ND	ND	4	ND
March-02	6	5	5	ND	ND	ND	ND	ND
April-02	5	5	4	ND	ND	ND	ND	ND

ND = Not detected at 4 µg/L

Table 2B
Perchlorate Concentrations in Metropolitan's Treatment Plants - Six-Month Running Averages
Values in micrograms per Liter (µg/L)
May 22, 2002

Date	Diemer Influent	Diemer Effluent	Weymouth Influent	Weymouth Effluent	Skinner Effluent	Jensen Influent	Jensen Effluent	Mills Influent	Mills Effluent
March-98	6	5	5	5	5	ND	ND	ND	ND
April-98	5	5	5	5	6	ND	ND	ND	ND
May-98	4	4	5	5	5	ND	ND	ND	ND
June-98	ND	4	4	4	5	ND	ND	ND	ND
July-98	ND	ND	4	4	4	ND	ND	ND	ND
August-98	ND	ND	4	4	4	ND	ND	ND	ND
September-98	ND	ND	4	4	4	ND	ND	ND	ND
October-98	4	4	4	4	4	ND	ND	ND	ND
November-98	5	4	4	4	4	ND	ND	ND	ND
December-98	5	5	5	5	5	ND	ND	ND	ND
January-99	5	5	5	5	5	ND	ND	ND	ND
February-99	6	6	6	6	5	ND	ND	ND	ND
March-99	6	6	6	6	5	ND	ND	ND	ND
April-99	5	5	6	6	5	ND	ND	ND	ND
May-99	5	5	6	6	5	ND	ND	ND	ND
June-99	5	5	5	5	5	ND	ND	ND	ND
July-99	5	5	5	5	5	ND	ND	ND	ND
August-99	5	5	5	5	5	ND	ND	ND	ND
September-99	4	4	5	5	5	ND	ND	ND	ND
October-99	4	4	4	5	5	ND	ND	ND	ND
November-99	4	4	4	5	4	ND	ND	ND	ND
December-99	4	4	4	4	4	ND	ND	ND	ND
January-00	4	4	4	4	4	ND	ND	ND	ND
February-00	4	4	4	4	4	ND	ND	ND	ND
March-00	4	4	ND	ND	4	ND	ND	ND	ND
April-00	ND	ND	ND	ND	4	ND	ND	ND	ND
May-00	ND	ND	ND	ND	4	ND	ND	ND	ND
June-00	ND	ND	ND	ND	4	ND	ND	ND	ND
July-00	ND	ND	ND	ND	4	ND	ND	ND	ND
August-00	ND	ND	ND	ND	4	ND	ND	ND	ND
September-00	ND	ND	ND	ND	4	ND	ND	ND	ND
October-00	ND	ND	ND	ND	4	ND	ND	ND	ND
November-00	ND	ND	4	4	4	ND	ND	ND	ND
December-00	ND	ND	ND	ND	4	ND	ND	ND	ND

Table 2B
Perchlorate Concentrations in Metropolitan's Treatment Plants - Six-Month Running Averages
Values in micrograms per Liter (µg/L)
May 22, 2002

Date	Diemer Influent	Diemer Effluent	Weymouth Influent	Weymouth Effluent	Skinner Effluent	Jensen Influent	Jensen Effluent	Mills Influent	Mills Effluent
January-01	ND	ND	ND	ND	ND	ND	ND	ND	ND
February-01	ND	ND	ND	ND	ND	ND	ND	ND	ND
March-01	ND	ND	ND	ND	ND	ND	ND	ND	ND
April-01	ND	ND	ND	ND	4	ND	ND	ND	ND
May-01	ND	ND	ND	ND	ND	ND	ND	ND	ND
June-01	ND	ND	ND	ND	4	ND	ND	ND	ND
July-01	4	4	4	4	4	ND	ND	ND	ND
August-01	4	4	4	4	4	ND	ND	ND	ND
September-01	4	4	4	4	5	ND	ND	ND	ND
October-01	4	4	4	4	5	ND	ND	ND	ND
November-01	4	4	4	4	5	ND	ND	ND	ND
December-01	4	4	5	4	5	ND	ND	ND	ND
January-02	4	4	4	4	5	ND	ND	ND	ND
February-02	ND	ND	ND	ND	4	ND	ND	ND	ND
March-02	ND	ND	ND	ND	ND	ND	ND	ND	ND
April-02	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Not detected at 4 µg/L

Table 2C
Perchlorate Concentrations in Metropolitan's Distribution System Locations - Six-Month Running Averages
Values in micrograms per Liter (µg/L)
May 22, 2002

Date	FM-1	Garvey Res. Effluent	PVR2E	WB-28	Cenb-44	Cenb-1	Cenb-14	Cenb-50	SMN-1	LB-4	T-1	219th Street	OC-88	SD-7
March-98	6		5	5	5									
April-98	6		5	5	4									
May-98	6		4	4	4									
June-98	5		4	4	ND									
July-98	4		ND	ND	4									
August-98	4		ND	ND	ND									
September-98	ND		ND	ND	ND									
October-98	4		ND	ND	4									
November-98	4		ND	4	4									
December-98	5		4	5	5									
January-99	5		5	5	5									
February-99	5		5	5	5									
March-99	5		5	5	5									
April-99	5		5	5	5									
May-99	5		5	5	5									
June-99	5		5	5	5									
July-99	5		5	5	5									
August-99	5		5	5	5									
September-99	5		5	5	5									
October-99	5		5	5	5									
November-99	4		4	4	5									
December-99	4	5	4	4	4									
January-00	4	4	4	4	4									
February-00	4	4	ND	4	4									
March-00	4	4	ND	ND	4									
April-00	ND	ND	ND	ND	ND									
May-00	ND	ND	ND	ND	ND									
June-00	ND	ND	ND	ND	ND									
July-00	ND	ND	ND	ND	ND									
August-00	ND	ND	ND	ND	ND									
September-00	ND	ND	ND	ND	ND									
October-00	ND	ND	ND	ND	ND									
November-00	4	ND	ND	ND	ND									
December-00	ND	ND	ND	ND	ND									

Table 2C
Perchlorate Concentrations in Metropolitan's Distribution System Locations - Six-Month Running Averages
Values in micrograms per Liter (µg/L)
May 22, 2002

Date	FM-1	Garvey Res. Effluent	PVR2E	WB-28	Cenb-44	Cenb-1	Cenb-14	Cenb-50	SMN-1	LB-4	T-1	219th Street	OC-88	SD-7
January-01	ND	ND	ND	ND	ND									
February-01	ND	ND	ND	ND	ND									
March-01	ND	ND	ND	ND	ND									
April-01	ND	ND	ND	ND	ND									
May-01	ND	ND	ND	ND	ND									
June-01	ND	ND	ND	ND	ND									
July-01	4	4	ND	ND	ND									
August-01	4	4	ND	ND	ND									
September-01	4	4	ND	ND	4									
October-01	4	4	ND	ND	4									
November-01	4	4	ND	ND	4									
December-01	4	4	ND	ND	5									
January-02	4	4	ND	ND	4									
February-02	ND	ND	ND	ND	ND									
March-02	ND	ND	ND	ND	ND									
April-02	ND	ND	ND	ND	ND	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*

*** Based on one monitoring result only (April 2002)**
ND = Not detected at 4 µg/L

Appendix No. 1
Comments on the OEHHA's Public Health Goal for Perchlorate in Drinking Water

Prepared for the Metropolitan Water District by:

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General Comments

The authors of the document rely wisely on available human studies, rather than on the animal studies that formed the primary basis of the federal EPA's recent assessment in Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization (NCEA-1-0503; 2002). It is well established that humans generally are more sensitive to the effect of thyroid-active agents such as perchlorate. This is why the federal EPA did not feel it necessary to apply a 10x Uncertainty Factor for interspecies extrapolation when using the animal data to estimate a Reference Dose (RfD) for humans. Still, there remains a possibility that humans might be more sensitive in some cases. As a result, the use of data directly obtained in humans is likely to be more protective of public health, in the sense of providing a more accurate understanding of acceptable levels of exposure, than would extrapolation from animal data. The OEHHA analysis should, therefore, provide a sounder basis for public health protection than the federal EPA analysis.

To understand both the OEHHA and federal EPA arguments, it is necessary to consider the process by which the thyroid acts. One of the roles of the thyroid (and the one of interest here) is as a regulator of the ability of cells throughout the body to get and use oxygen and nutrition. The thyroid performs this task by producing two hormones, T3 and T4, and releasing them into the bloodstream. Each of these hormones contains iodine, with T3 containing 3 iodine atoms and T4 containing 4. The more active, and therefore probably more important, hormone is T4. It is necessary for the thyroid to have access to iodine to produce the T3 and T4. This iodine ultimately comes from absorption into the thyroid from the bloodstream, and the iodine in the bloodstream comes from the diet (including iodized salt). Given the importance of the iodine in the process of T3 and T4 production, the thyroid also stores iodine as a buffer against times when there is low iodine in the diet.

The thyroid is part of a set of glands that together control the rate at which energy is used in cells and organs (by controlling oxygen and nutrition). If the levels of T3 and T4 in the bloodstream drop too low, in the sense that cells are not using enough oxygen and nutrition to function properly, the hypothalamus in the brain senses this and releases Thyrotropin–Releasing Hormone (TRH). This in turn stimulates the pituitary gland to release Thyroid Stimulating Hormone (TSH), which then interacts with the thyroid to increase production of T3 and T4. In this way, the three glands form a feedback or homeostatic system in which increases in T3 and T4 in the blood ultimately cause the thyroid to reduce production of the hormones, and decreases of these hormones in the blood lead ultimately to the thyroid increasing production. If the feedback system is not operating properly, which might take place from changes in any of the three glands, the levels of T3 ad T4 in the blood will fail to be optimal and cells will either use energy too rapidly (the disease associated with hyperthyroidism) or too slowly (the disease associated with hypothyroidism).

Note that the change in these T3 and T4 hormones circulating in the blood need not indicate that the thyroid itself has been damaged. The change in levels of T3 and T4 in the blood could have been the result of changes to the hypothalamus, the pituitary gland, the TPH and TSH hormones after they were released into the bloodstream, or even to the T3 and T4 after they have been released into the bloodstream. The most common cause of disease associated with the thyroid, however, is a change in the ability of the thyroid to obtain iodine from the bloodstream or to utilize the iodine in producing T3 and T4. *It is reasonable, therefore, to consider whether perchlorate is capable of altering the T3 and T4 levels in the bloodstream, and whether it does this by changing the ability of the thyroid to obtain and use iodine (i.e. place iodine atoms into T3 and T4).*

A measured decrease in T3 and T4 after giving a person perchlorate is not necessarily an indication that an adverse effect will take place. This is an essential distinction because public health protection focuses on protection against *adverse effects*, and not simply protection against *effects*. This is the distinction drawn at the federal and Cal EPA between a quantity such as a No Observed Effects Level (NOEL) and a No Observed Adverse Effects Level (NOAEL). It is the latter (the NOAEL) that is used in calculating an RfD. The NOAEL will be at a concentration equal to or higher than the NOEL, since there can be low concentrations at which an effect is seen but the effect is not adverse to health (or even noticeable). It is important, therefore, to determine whether the effects observed in the human studies cited in the OEHHA document are adverse, or simply are effects with no adverse consequences.

The reasoning in the document is as follows:

1. Perchlorate appears to reduce the amount of iodine in the thyroid in human studies, in the sense that the concentration of iodine is lower than would have been the case without the perchlorate in studies involving acute uptake of iodine (i.e. uptake of larger doses of iodine provided during the experiments). Bear in mind that the concentration might be lower either because less iodine was getting into the thyroid or because it was leaving the thyroid at a faster rate.

2. Since it is unlikely that perchlorate is causing the iodine to be removed at a faster rate, it probably is causing iodine to enter the thyroid at a slower rate.

3. Since iodine enters the thyroid by crossing the membranes of thyroid cells through a specialized process, the perchlorate probably is blocking this process (i.e. using up sites that otherwise would be available to transport iodine across the membranes).

4. This blocking of the iodine moving into the thyroid should cause lower production of T3 and T4. This is confirmed by studies (many of which were used in the federal EPA perchlorate assessment) showing that exposure to perchlorate reduces T3 and T4 concentration in the bloodstream. *Note: the primary human studies cited by the OEHHA did not show similar changes in T3 or T4, although a possible reason for this is discussed later.*

5. This reduced T3 and T4, if maintained, should reduce the energy use by cells. If this reduction in energy use is at a critical developmental stage (e.g. a stage in the fetus or developing child), it could result in developmental effects. If the developmental effects are sufficiently severe, they could be considered adverse.

6. For many people, the drop in T3 and T4 would cause the hypothalamus-pituitary-thyroid homeostatic system to increase production of T3 and T4, which would raise the levels in the bloodstream back to normal values. In addition, the thyroid normally stores excess iodine for use in such times when iodine is not getting to the thyroid in sufficient quantities, either because it is not present in the diet or is being blocked. For these people, assuming their homeostatic system is operating properly, the blocking of iodine uptake by perchlorate might be compensated for.

7. There exists at least a subset of people who for any of a variety of reasons are just barely able to produce enough T3 and T4, or perhaps even cannot produce enough for proper health under the best of conditions. In those cases, the homeostatic system and the storage of iodine in the thyroid

must have been compromised (not by perchlorate exposure, but by genetic factors, developmental effects, etc). Their thyroids are already taking in as much iodine as they can "get their hands on" and utilizing it. The homeostatic system is not able to compensate for any drop in iodine uptake. For these people, any blockage of iodine uptake by perchlorate will result in a further drop in T3 and T4.

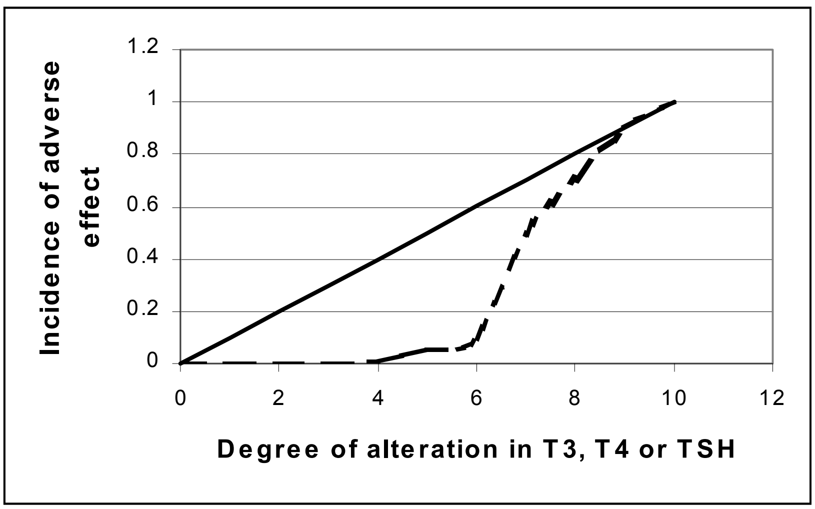
8. For some of this subset of people, the drop in T3 and T4 caused by the perchlorate might not produce an adverse effect. The cells will use less energy, but the change will have no significance for life. For others in this subset, however, their cells were already using too little energy to maintain good health prior to exposure to perchlorate (i.e. people with not only hypothyrodism, but those who also have adverse effects from this hypothyroidism). Any decrease in the uptake of iodine in the thyroid will reduce T3 and T4 and increase the severity of the adverse effect. *This group, therefore, is the focus of regulatory concerns, since the homeostatic system will not be able to compensate for the blockage of iodine uptake into the thyroid by perchlorate, and the effects will not only appear but will be adverse*.

Based on this argument, both the federal EPA and OEHHA chose to focus on the ability of perchlorate to block uptake of iodine into the thyroid, and to alter T3 and T4 in the bloodstream. The OEHHA document focuses on blockage of iodine uptake in humans as measured by a decrease in the amount of iodine in the thyroid following a bolus administration of a high dose of iodine (so they are assuming that this decrease is due to blockage, not to increased rate of removal of iodine from the thyroid; their assumption is reasonable). They then *note* that there is evidence this change in uptake will cascade to lower T3 and T4 levels and adverse effects in a sensitive subpopulation; their NOAEL and RfD, however, are based on data concerning blocking of iodine uptake. By contrast federal EPA relies primarily on changes in T3 and T4 measured in animals after intakes of perchlorate. They then use the same reasoning as to why decreases in T3 and T4 might be of health concern for a sensitive subpopulation. So, the OEHHA document uses human data more directly (a strength) but relies more strongly on measurements of iodine uptake rather than T3 or T4 concentrations in the bloodstream (a weakness), while the federal EPA uses animal data more directly (a weakness) but relies more strongly on T3 and T4 concentrations in the bloodstream (a strength). It is important to remember here that changes in T3 and T4 are "closer" to an adverse effect in the chain of events leading to that effect than is blockage of the iodine uptake into the thyroid. It also is important to note that the human studies cited in the OEHHA document did not show a change in T3 or T4 resulting from this decrease in iodine in the thyroid.

Both the federal EPA and the OEHHA documents use the reasoning listed above as the 8 bullets. It is significant to note that the reasoning is indirect and qualitative, rather than providing direct evidence that perchlorate causes developmental and other effects in this sensitive subpopulation. No evidence is invoked in either document to support directly a claim that changes in iodine blockage by perchlorate will result in an adverse health effect. In other words, neither document bases the RfD or PHG primarily on data in which the effect measured is an actual adverse effect. Instead, the reasoning is that such an adverse effect might be *expected* given the 8 steps of reasoning above. This is not scientifically unreasonable, since the steps of reasoning are consistent with the best available science in the sense that this science cannot exclude these possibilities and does provide at least limited support for all of the steps. But there is still a significant degree of uncertainty about the relationship between small drops in T3 and T4 likely to be caused by perchlorate at low environmental concentrations and the appearance of adverse effects, since there are other feedback mechanisms that control development and functioning of the body.

Whether or not the small changes noted in either iodine uptake or T3/T4 concentrations cascade upwards to a full adverse effect will depend on the mathematical relationship between these factors and the incidence or severity of an adverse effect such as developmental change or cancer. Several possibilities are shown below using the example of changes in T3 or T4 or even TSH. The solid line represents a case where the degree of alteration of T3, T4 or TSH is related proportionally to the incidence or severity of the adverse effect. In that case, reducing the degree of alteration always reduces the incidence or severity of the effect that really is of interest. Reducing exposure to anything that reduces T3, T4 and TSH concentrations in the bloodstream would be expected in this case to also reduce the adverse effect.

The dashed line shows a threshold in this relationship. Until the degree of alteration goes above 4 in this case (the units are purely arbitrary in this figure and are shown here only to get across a concept), the incidence or severity of the adverse effect does not rise. This is because feedback mechanisms have compensated for the change in hormones. Reducing the degree of alteration further below 4 (e.g. by reducing perchlorate concentration in water), therefore, has no effect.



The figure above shows the problem that arises in the case of the federal EPA assessment, where the change in T3, T4 and TSH was the basis for the RfD. The OEHHA assessment is slightly more complicated, since the effect is, in a sense, one step "further upstream" in the argument. This is because the OEHHA assessment relies on measured changes in iodine uptake, not on measured changes in the next step (T3 and T4 production). It certainly is reasonable to assume that large changes in iodine uptake will result in changes in T3 and T4 when the homeostatic system cannot compensate for the lower amount of iodine available (although such changes were not noted in the human studies). It even is reasonable to conclude (based on the federal EPA assessment) that perchlorate can cause changes in T3 and T4, and that these latter changes are probably caused by the blocking of iodine uptake by perchlorate. This still leaves a step of reasoning, however, that is unsupported by direct data: that small changes in T3 and T4 in the bloodstream of at least a sensitive subpopulation such as fetuses and neonates, caused by perchlorate blockage of iodine into the thyroid, will produce an increase in the incidence or severity of adverse effects such as developmental effects.

This doesn't mean the conclusions drawn by either the federal EPA or OEHHA are scientifically unsound. The two groups have reached a qualitatively reasonable conclusion in the sense that there could well be a sensitive subpopulation that will be affected by perchlorate at environmental levels even if the general population has homeostatic mechanisms to compensate for any effect. And so it might be a reasonable public health practice to assume that changes in iodine blockage and T3/T4 production must be avoided for this sensitive subpopulation. If that is the case, then basing the RfD on a NOAEL for alterations of iodine uptake (in the OEHA document) or T3/T4/TSH concentration may be reasonable.

Neither report presents such an analysis showing which curve in the figure above is to be expected, other than the qualitative argument given in the 8 steps. The use of this qualitative reasoning in the case of perchorate runs the risk of identifying a NOAEL that is inappropriate, as it is unconnected to the production of any adverse effect. It might appear reasonable on the basis of some argument of precaution, but this argument cannot be taken for granted. There remains a possibility that small alterations in iodine uptake, T3, T4 and TSH are counterbalanced by any of a myriad of other feedback and homeostatic mechanisms that exist in development and cellular growth. If this is the case (and neither report confirms nor refutes it), control of perchlorate in water at the RfD recommended may be associated with no benefit to health. This is not precaution, it is a misdirection of resources that could be used to reduce other, better established, risks.

In summary, the OEHHA assessment (i) relies primarily on measured changes in iodine uptake into the thyroid following exposure to perchlorate; (ii) notes properly that changes in uptake could result in changes in T3 and T4 in the bloodstream; (iii) notes properly that decreases in T3 and T4 could result in adverse effects in some highly sensitive people; (iv) justifies item (iii) somewhat convincingly by invoking data on developmental effects associated with exposure to perchlorate; and (v) notes properly that there exists a subpopulation of sensitive individuals whose homeostatic mechanisms and/or dietary intake of iodine are inadequate to compensate for significant changes in the amount of iodine able to be taken up into the thyroid, and hence might display adverse health effects. There is, however, no reliable quantitative assessment of the percentage of the population who will display such adverse heath effects, or of the severity of any adverse health effect that might appear. There also is no direct evidence provided as to which of the two curves shown in the figure above will apply at low concentrations of perchlorate (near the concentrations of regulatory interest), despite that fact that this is crucial in determining whether the NOAEL for an adverse effect is significantly above that for alterations in iodine uptake, T3, T4 and TSH.

Having said all of this, it is my professional opinion that OEHHA has performed a scientifically reasonable assessment in their document, given the state of the science at the moment. They have selected a reasonable set of studies on which to begin their assessment, although they rely too heavily on the idea of "critical studies". By this, I mean they have selected only those studies that tend to show the lower NOAEL (leading to a more restrictive Public Health Goal). They do this by setting aside studies showing a higher NOAEL. In each case, they have provided a reason for setting aside these studies, but they have not included a systematic assessment in which they show the strengths and weaknesses of all studies. Both the studies included and those rejected have strengths and weaknesses. The document does not provide a weighting of the studies, with a clear explanation of the weight assigned to a particular study. Instead, an argument is developed to reject a particular study, without fully explaining why the remaining studies (particularly those of Lawrence at al and Greer et al that form the basis of the NOAEL) cannot also be rejected by similar criteria. The document would be improved greatly by considering all studies, assigning weights to the results of each study, and developing a NOAEL and PHG based on these weights. The result would be a higher PHG, and the resulting use of data would be more consistent with federal EPA guidelines on using all data in a weight of evidence determination.

The 8 steps of reasoning I outlined, while somewhat qualitative, each have a reasonable root in what we know of the role of the thyroid in controlling development and functioning of organs. Still, more work clearly is needed to determine which of the two curves in the figure above applies, and the implications of this for a NOAEL focused on adverse effects rather than alterations in iodine uptake, T3, T4 or TSH. In fact, the data on which both the OEHHA and federal EPA studies are based cannot strictly yield a NOEAL. They more properly yield a NOEL (No Observed Effects Level); only through the 8 steps of reasoning can the authors conclude that this NOEL is equivalent to a NOAEL. It is more common to base the NOAEL on direct observation of an effect judged to be adverse, rather than (as in the present case) on effects that are believed to have the *potential* of resulting in adverse effects. As described previously, the data provided in the OEHHA report suggest that a NOAEL based on direct observation of adverse effects would be up to a factor of 10 higher than one based on changes in iodine uptake or T3/T4/TSH concentration, but probably not more than a factor of 10.

The claim of OEHHA that sensitive subpopulations are likely to exist is reasonable. The particular subpopulations they identify are correct: (i) pregnant women with marginal or deficient iodine amounts, (ii) infants and small children with marginal or deficient iodine amounts, (iii) fetuses of mothers in category (i), and (iv) individuals with hypothyrodism, which might include individuals in categories (i) and (ii). It even is likely that some smaller set within these groups will display adverse effects at low concentrations of perchlorate at the thyroid. What has not been established to date is how large this fraction of the population is or how severe any adverse effect might be. Still, there is legitimate scientific and public health concern here, and so a PHG based on demonstrated changes in iodine uptake, T3, T4 and/or TSH might be reasonable, at least after all studies are weighted into the assessment as mentioned above.

Specific and Modifying Comments

While I generally find the OEHHA assessment well presented, and am confident that a PHG of 6 ppb will be protective of public health with a good margin of safety, there are several issues I want to raise that indicate some remaining weaknesses in the existing data and/or their interpretation. I stress that these weaknesses will in general cause the OEHHA PGH to be more protective of health, rather than less, so the net effect of new data that might become available should be to increase the PHG, not decrease it.

1. OEHHA has used the fraction of people with low urinary iodide as an indicator of the fraction of people with iodine deficiencies. There are two reasons for a low urinary iodine concentration, however. The first is that the individual really is iodine deficient, the other is that the iodine is being sequestered more than in the average person. As a result, the fraction of iodine deficient individuals mentioned in the report (on the order of 10%) may be significantly smaller. This is supported by the observation by Lawrence et al, shown in Table 11 of the OEHHA report, that while urinary iodine is affected by perchlorate, serum iodine is not. Changes in urinary iodine, therefore, may not be predictive of changes in serum iodine or iodine available to the thyroid.

2. Since the homeostatic system can to some degree compensate for decreases in T3 and T4, but requires time to do so, it is essential that assessments be based only on data in which the time between perchlorate administration and measurement of T3 and T4 or iodine uptake rate allow sufficient time for the feedback system to operate. This appears to have been accomplished in the case of the studies cited (principally those of Lawrence et al and Greer at al), where the time to measurement was sufficient to allow the feedback system to produce any compensation it may have been capable of producing. As a result, any decreases in T3, T4 and/or TSH that might have been found in such studies (Note: none were found) probably would have been significant for health. There is not, however, a full understanding of the necessary time until measurement, and so there remains the possibility that measurements were made too soon after administration of the daily dose. It is important to note, however, that no alteration in T3 or T4 was found in the human studies, despite the fact that sufficient time was provided to allow compensation to occur. This may indicate that alterations in iodine uptake are compensated for by feedback systems in humans. Another explanation, however, is that the thyroids of these individuals may simply have been using stored iodine and would have eventually depleted that iodine if the experiments had run for a sufficient length of time. This evidently is the assumption underlying the OEHHA assessment, and is reasonable if not fully proven.

3. There is a more scientifically troubling aspect of timing that might lead to a significant underestimate of the LOAEL or NOAEL, and hence a lower-than-necessary PHG. To see this,

consider the fact that iodine crosses the membrane into a cell by a transport process. This can be imagined as carriers on the surface of the cells that "grab" the iodine and bring it across. Perchlorate seems to reduce iodine uptake by also binding to these carriers, taking up "spots" that normally would be occupied by iodine. If dose of perchlorate is given (as in the oral experiments conducted by Lawrence et al and Greer et al), followed by an acute dose of iodine to measure iodine uptake, the acute dose of iodine can saturate the sites that are not occupied by perchlorate. This will leave many iodine atoms without a site, resulting in that iodine being excreted before it can be taken up by the thyroid. If the iodine instead is taken in slowly (as in daily life), the amount of iodine in the bloodstream competing with perchlorate for absorption sites at any one moment will be much smaller, and the number of sites available for transporting iodine will be larger. The result will be less of an effect on iodine uptake than was the case following a large and acute dose of iodine (as in the experiments). This implies that the NOAEL or LOAEL may be higher under conditions of chronic iodine uptake than indicated by the Lawrence et al and the Greer et al studies.

4. The total uncertainty factor of 30 adopted by OEHHA is reasonable, and better than the larger value of 300 (actually 270, but rounded to 300) adopted by the federal EPA. There does appear a rationale for using an uncertainty factor of 10 to account for possible differences in sensitivity between humans, and an additional factor of 3 is reasonable to account for the 14-day length of the studies (rather than a lifetime). Given the argument in item 4 above, it is not necessary to use a factor of 10 for database quality, since the blockage of iodine by perchlorate would not be expected to grow after 14 days given the half-life of perchlorate in the body (rapid excretion) and the mechanism of action (blocking transport of iodine). By using the human data, OEHHA were able to establish a NOAEL of 0.01 mg/kg-day, whereas the federal EPA use of the animal data allowed only establishment of a LOAEL at 0.01 mg/kg-day. It is for this reason that the federal EPA total uncertainty factor was a factor of 10 larger (a total of 300) than was the value used by OEHHA (i.e. the federal EPA uncertainty includes an additional 10x factor for extrapolation from a LOAEL to a LOAEL). The OEHHA approach appears to me more justified because it avoids this extrapolation.

5. OEHHA argues, as does the federal EPA, that protection against alterations in iodine uptake should also protect against cancer. While the exact mechanism by which perchlorate might induce cancer is unknown, the evidence presented supports the claim that it is not genotoxic and probably acts by altering the hypothalamus-pituitary-thyroid system operation in the same way as the non-cancer effects. It is reasonable to expect, therefore, that the PHG will be protective against cancer effects, since it will protect against the blockage of iodine.

Summary Judgment

I close with a summary statement of my review of the OEHHA document, and the implication of the PHG for protection of public health. Water utilities should feel free to use it as needed.

The study by the OEHHA entitled "Draft: Public Health Goal for Perchlorate in Drinking Water" recommends a PHG of 6 ppb. The study is based on a reasonable review of existing scientific information. Where the data could not completely establish the risk from perchlorate, assumptions were introduced that will tend to be protective of public health rather than underestimate the risk. There is, therefore, high confidence that a PHG of 6 ppb will be protective of public health even if the assumptions used in the assessment prove incorrect. It is likely that the true risk is somewhat less than that stated in the OEHHA assessment, and that a PHG higher than 6 ppb could be adopted without loss of protection. The scientific data at the moment do not, however, allow a reliable determination as to how much higher the PHG might reasonably be set. In the interim, it is my opinion that (i) a PHG of 6 ppb is appropriate, (ii) that it is protective of public health with a reasonable margin of safety, (iii) that further scientific *studies should be conducted to determine whether the PHG might be raised, and (iv) that it is equally as effective at protecting public health as the proposed federal EPA standard of 1 ppb, as the latter is based on animal data while the PHG is established on the basis of human studies and appropriate margins of safety that are precautionary in nature.*

Appendix No. 2
Perchlorate Treatment Technology Review

Physicochemical treatment processes such as granular activated carbon (GAC) adsorption, ion exchange, membrane separation, and biological processes such as anaerobic treatment have been identified as treatment technologies that are potentially applicable for the removal of perchlorate from drinking water. Because perchlorate is highly oxidized and does not absorb radiation in the ultraviolet light spectrum, neither oxidation technologies (e.g., ozone or UV/hydrogen peroxide) nor ultraviolet irradiation (e.g., low pressure, medium pressure, or pulsed UV) reduce perchlorate.

Physicochemical processes.
Brown and Snoeyink (1999) indicated that perchlorate removal up to 5,800 bed volumes (BV) in the GAC columns was the result of adsorption. This result indicates that perchlorate is difficult and expensive to remove using the GAC adsorption process because of high solubility of perchlorate in water. However, GAC may be pre-treated to enhance perchlorate removal and on-site GAC reactivation technologies are under investigation by Pennsylvania State University at a groundwater well field in the City of Redlands. Najm and co-workers (1999) demonstrated effective perchlorate removal using anion-exchange resin in a laboratory study. This study showed that the resin had a stronger affinity for perchlorate than for nitrate. However, other common groundwater ions such as sulfate will interfere with perchlorate adsorption by the resin. Additionally, the ion exchange resin is regenerated with brine (usually sodium chloride), and high perchlorate concentrations in regeneration brine present a disposal or treatment problem. Liang and co-workers (1998) demonstrated that both reverse osmosis and nanofiltration membranes consistently removed more than 80 percent of the applied perchlorate (50 to 300 µg/L). In addition, recycling 50 percent of the brine had no significant effect on overall perchlorate rejection. Malaiyandi and Sastri (1981) reported that 94 percent of magnesium perchlorate was removed from a mining waste stream by the reverse osmosis (cellulose acetate) membrane process at the then normal operating pressures of 300 pounds per square inch (operating pressures are now much lower.) Similar to the ion exchange process, perchlorate is not treated but merely conveyed to perchlorate-containing waste brine in significant volume.

Biological Treatment.
Perchlorate is thermodynamically unstable and can be reduced to chloride. This reduction has a large energy barrier that keeps it from taking place in the absence of a catalyst. Microbial reduction of perchlorate has been recognized and applied for more than 50 years for high waste-stream concentrations (Malaiyandi and co-workers, 1999). Perchlorate-reducing microorganisms obtain their energy for metabolism by catalyzing a variety of oxidation-reduction reactions. Perchlorate can serve as an electron acceptor for perchlorate-reducing microorganisms and can be degraded under anoxic conditions. In 1996, a 30 gallons-per-minute, skid-mounted pilot plant was installed at the Aerojet facility in Sacramento, California (Harding Lawson Associates, 1997). The pilot plant simulated a fluidized-bed GAC bioreactor with upstream addition of organic carbon (ethanol) and nutrients (nitrogen and phosphorus). Effluent perchlorate concentrations from the bioreactor were consistently non detected (less than 400 µg/L, the reporting limit at the time). Coppola and co-workers (1998) studied the reduction of perchlorate with anaerobic microorganisms. Pilot-scale bioreactors (700 and 1,600 gal.) were operated to treat up to few thousand gallons of perchlorate wastewater per day. According to the study, the perchlorate concentrations up to 10,000 mg/L were reduced to below a few hundred micrograms per liter with residence time of 3 to 30 hours.

Other biological treatment using different microorganisms have been studied at the low levels of perchlorate currently found in some drinking water supplies. Miller and Logan (2000) conducted bench-scale laboratory experiments in a hydrogen gas-phase reactor system at the hydraulic retention times of 1.1 – 1.3 minutes to achieve sustained perchlorate degradation of 38 percent from a lower perchlorate influent concentration of 740 µg/L. Brown and co-workers (2000) showed that perchlorate can be degraded from 50 µg/L to below the detection limit (2 µg/L) with a 15 minute contact time in a biological active carbon (BAC) filter. Rittmann and co-workers (2002) developed a hollow-fiber membrane biofilm reactor and demonstrated its potential effectiveness for biological reduction of perchlorate from 100 µg/L to below 4 µg/L.

Conclusions.

In summary, pre-treated GAC, ion exchange, and membrane methods have been identified as treatment technologies that are potentially applicable to the removal of perchlorate from drinking water. However, membrane process such as reverse osmosis and nanofiltration are costly. Furthermore, these techniques only remove the chemical from the influent stream and convert it to a waste concentrate, which may pose a disposal challenge. Some proprietary thermal/catalytic destruction processes offer promise for reducing the perchlorate from membrane or ion exchange brine. Most attention to date has been focused on developing a biological treatment, whereby microbes are used to convert perchlorate to a less toxic or innocuous form. However, the biological treatment is focused primarily on high level perchlorate contaminated wastewater and groundwater remediation. It is not clear whether bioreactors would produce potable drinking water on the low levels of perchlorate currently found in drinking water supplies.

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Appendix No. 3

Metropolitan's Comments to OEHHA on the Draft Perchlorate Public Health Goal Report

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

May 2, 2002

Dr. Yi Wang
Pesticide and Environmental Toxicology Section
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency
1515 Clay Street, 16th Floor
Oakland, CA 94612
Attention: PHG Project

Dear Dr. Wang:

Comments on the Proposed Public Health Goal for Perchlorate in Drinking Water

Metropolitan Water District of Southern California (Metropolitan) appreciates the opportunity to provide comments on the Office of Environmental Health Hazard Assessment's (OEHHA) Draft Public Health Goal for Perchlorate in Drinking Water. Metropolitan, through its 26 member agencies, provides nearly half of the water used in Southern California. Approximately 60% of our supply is from the Colorado River which contains low levels of perchlorate.

The Public Health Goal (PHG) report is the foundation for developing a drinking water Maximum Contaminant Level (MCL) for perchlorate in California. Conventional treatment does not effectively remove this contaminant, and technologies that are effective are very costly. Therefore, it is critical that the PHG is set at a level that properly considers the best available data so that regulatory standards have a scientifically credible basis and financial resources are expended to protect against real risks to human health.

Because of the importance of a perchlorate PHG, Metropolitan has asked Dr. Douglas Crawford-Brown, Professor of Environmental Science and Public Policy and Chair of the Environmental Science and Studies Curriculum at the University of North Carolina, to assist in the review of the OEHHA report. Metropolitan's comments are largely based on Dr. Crawford-Brown's review.

General Comments

Metropolitan commends OEHHA for its comprehensive review of toxicological studies of the effects of perchlorate exposure in humans and animals. We find that the draft PHG report is based on a reasonable review of existing scientific information. Where the data could not completely establish the risk from perchlorate, assumptions were introduced that will tend to be protective of public health rather than underestimate the risk. There is, therefore, high confidence that a PHG of 6 ppb will be protective of public health, even if the assumptions used in the assessment prove incorrect. It is likely that the true risk is somewhat less than that stated in the OEHHA assessment, and that a PHG higher than 6 ppb could be adopted without loss of protection, although it is unlikely that the PHG would be above 60 ppb if the additional data were collected.

While Metropolitan agrees that (1) it is appropriate to base the PHG on human health studies (i.e., Lawrence *et al.*, 2000, 2001 and Greer *et al.*, 2000, 2002), (2) perchlorate is not genotoxic and the PHG is protective against cancer, and (3) the total uncertainty factor of 30 is reasonable in light of the human studies used, we note the following:

- OEHHA has based the PHG on a precursor event: the inhibition of the thyroid's uptake of iodine. The assumption underlying the use of a precursor in establishing a PHG is that the threshold for adverse effect is the same as the threshold for change in the precursor. As a result, the argument depends critically on a demonstration that there is at least a non-zero probability that the precursor leads to the end point of concern at low-levels of exposure to the contaminant. The draft PHG report does not explicitly demonstrate this linkage.
- The high acute iodine dosage in the Greer and Lawrence studies may have resulted in a lower No Observed Adverse Effects Level (NOAEL) and Lowest Observed Adverse Effects Level (LOAEL) than would have been the case had the iodine been administered in smaller doses throughout the day, and any PHG based on these studies may be overly conservative.
- The fraction of the population with iodine deficiencies may be overestimated, and so the size of the sensitive sub-populations may be overstated.
- The relative source contribution (RSC) of perchlorate from drinking water is based on extremely limited data and further research is necessary to refine the RSC assumption.
- The widespread use of bottled water and home filtration devices and more recent data from EPA on drinking water consumption suggests that the drinking water consumption assumption of 2 L per day may overstate actual consumption.

We urge OEHHA to address these issues and refine the PHG, if necessary. Our detailed comments follow.

Specific Comments

<u>Use of human health studies</u>

OEHHA wisely relies on available human studies, rather than on the animal studies that formed the primary basis of the federal EPA's recent assessment in Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization (NCEA-1-0503; 2002). It is well established that humans generally are less sensitive than test animals to the effect of thyroid-active agents such as perchlorate. his is why the federal EPA did not feel it necessary to apply a 10x Uncertainty Factor for interspecies extrapolation when using the animal data to estimate a Reference Dose (RfD) for humans. Still, there remains a possibility that humans might be more sensitive in some cases. As a result, the use of data directly obtained in humans is likely to be more protective of public health, in the sense of providing a more accurate understanding of acceptable levels of exposure, than would extrapolation from animal data. The OEHHA analysis should, therefore, provide a sounder basis for public health protection than the federal EPA analysis.

<u>Genotoxicity and cancer effects</u>

OEHHA argues, as does the federal EPA, that protection against alterations in iodine uptake should also protect against cancer. While the exact mechanism by which perchlorate might induce cancer is unknown, the evidence presented supports the claim that it is not genotoxic and probably acts by altering the hypothalamus-pituitary-thyroid system operation in the same way as the non-cancer effects. It is reasonable to expect, therefore, that the PHG will be protective against cancer effects, since it will protect against blockage of iodine.

Uncertainty factor

The total uncertainty factor of 30 is reasonable in light of the human studies used. The total uncertainty factor of 30 adopted by OEHHA is reasonable, and better than the larger value of 300 (actually 270, but rounded to 300) adopted by the federal EPA. There appears a rationale for using an uncertainty factor of 10 to account for possible differences in sensitivity between humans, and an additional factor of 3 is reasonable to account for the 14-day length of the studies (rather than a lifetime). It is not necessary to use a factor of 10 for database quality (as was used by the federal EPA), since the blockage of iodine by perchlorate would not be expected to grow after 14 days given the half-life of perchlorate in the body (due to rapid excretion) and the mechanism of action (blocking transport of iodine). By using the human data, OEHHA were able to establish a NOAEL of 0.01 mg/kg-day, whereas the federal EPA use of the animal data allowed only establishment of a LOAEL at 0.01 mg/kg-day. It is for this reason that the federal EPA total uncertainty factor was of 10 times higher (a total of 300) than was the value used by OEHHA (i.e. the federal EPA uncertainty includes an additional 10x factor for extrapolation for a LOAEL to a NOAEL). The OEHHA approach appears to be more justified because it avoids this extrapolation.

Linkage between adverse health effects and perchlorate at environmental exposures

The OEHHA assessment relies primarily on measured changes in iodine uptake into the thyroid following exposure to perchlorate. A measured decrease in iodine uptake after giving a person perchlorate is not necessarily an indication that an adverse effect will take place. This is an essential distinction because public health protection focuses on protection against *adverse effects*, and not simply protection against *effects*. This is the distinction drawn at the federal and Cal EPA between a quantity such as a No Observed Effects Level (NOEL) and a No Observed Adverse Effects Level (NOAEL). The NOAEL will be at a concentration equal to or higher than the NOEL, since there can be low concentrations at which an effect is seen but the effect is not adverse to health (or even noticeable). It is important, therefore, to determine whether the effects observed in the human studies cited by OEHHA are adverse, or simply are effects with no adverse consequences.

OEHHA notes properly (i) that changes in iodine uptake could result in changes in T3 and T4 in the bloodstream; (ii) that decreases in T3 and T4 could result in adverse effects in some highly sensitive people; (iii) justifies item (ii) somewhat convincingly by invoking data on developmental effects associated with exposure to perchlorate; and (iv) that there exists a subpopulation of sensitive individuals whose homeostatic mechanisms and/or dietary intake of iodine are inadequate to compensate for significant changes in the amount of iodine able to be taken up into the thyroid, and hence might display adverse health effects. There is no direct evidence provided as to the shape of the dose-"adverse health effects" response curve at low concentrations of perchlorate (i.e., near the concentrations of regulatory interest), despite the fact that this is crucial in determining whether the NOAEL for an adverse effect is significantly above that for alterations in iodine uptake, T3, T4 and TSH. Thus, the concentration identified as a NOAEL may, in fact, be a NOEL and the PHG may be overly conservative.

Acute iodine dosage

There is a more scientifically troubling aspect of timing that might lead to a significant underestimate of the LOAEL or NOAEL, and hence a lower-than-necessary PHG. To see this, consider the fact that iodine crosses the membrane into a cell by a transport process. This can be imagined as carriers on the surface of the cells that "grab" the iodine and bring it across. Perchlorate seems to reduce iodine uptake by also binding to these carriers, taking up "spots" that normally would be occupied by iodine. If the dose of perchlorate is given (as in the oral experiments conducted by Lawrence *et al*. and Greer *et al*.), followed by an acute dose of iodine to measure iodine uptake, the acute dose of iodine can saturate the sites that are not occupied by perchlorate. This will leave many iodine atoms without a site, resulting in that iodine being excreted before it can be taken up by the thyroid. If the iodine instead is taken in slowly (as in daily life), the amount of iodine in the bloodstream competing with perchlorate for absorption sites at any one moment will be much smaller, and the number of sites available for transporting iodine will be larger. The result will be less of an effect on iodine uptake than was the case following a large and acute dose of iodine (as in the experiments). This implies that the NOAEL or LOAEL may be higher under conditions of chronic iodine uptake than indicated by the Lawrence et al and the Greer *et* al studies.

<u>Size of the sensitive sub-populations</u>

OEHHA has used the fraction of people with low urinary iodide as an indicator of the fraction of people with iodine deficiencies. There are two reasons for a low urinary iodine concentration, i.e. generally predisposed however. The first is that the individual really is iodine deficient, the other is that the iodine is being sequestered more than in the average person. As a result, the fraction of iodine deficient individuals mentioned in the report (on the order of 10%) may be significantly smaller. This is supported by the observation by Lawrence et al, shown in Table 11 of the OEHHA report, that while urinary iodine is affected by perchlorate, serum iodine is not. Changes in urinary iodine, therefore, may not be predictive of changes in serum iodine or iodine available to the thyroid.

<u>Relative source contribution</u>

OEHHA has assumed a relative source contribution of perchlorate in drinking water of 60%. The RSC is based on the results of a study that showed perchlorate bioaccumulated in laboratory-grown lettuce irrigated with water containing 10,000 ppb/L perchlorate. The RSC assumes the transfer ratio of perchlorate in water to lettuce is the same at low concentrations as it is at high concentrations. However, OEHHA notes that results obtained in laboratory conditions "cannot be directly extrapolated to edible agricultural produce". Further research is necessary to refine the RSC assumption.

<u>Usage of bottled water and home filtration devices</u>

The PHG assumes that a pregnant woman weighing 65 kg ingests 2 L of water/day. This assumption significantly overstates daily average ingestion. EPA[1], based on data collected by the U.S. Department of Agriculture in its 1994-96 Continuing Survey of Food Intakes by Individuals, found that pregnant women ingested, on average, 1.3 L of water per day while lactating women, on average, ingested 1.5 L/day. Although ingestion exceeded 2.3 L/day and 3.0 L/day at the 90th percentile for pregnant and lactating women, respectively, the sample sizes at these percentiles were considered too small to meet minimum reporting requirements.

The ingestion of water needs to be further adjusted to take into account the water source and whether the water is filtered. Many consumers drink bottled water and perchlorate levels in bottled water are likely different than perchlorate levels in unfiltered tap water. Individuals who have a home treatment device

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[1] U.S. EPA. Office of Water. Estimated Per Capita Water Ingestion in the United States. EPA-822-00-008, April 2000.

such as ones that utilize reverse osmosis would have lower exposure to perchlorate than individuals without such a device, even if the sources of tap water contained the same perchlorate levels. In Southern California, 38% of consumers report they drink bottled water only and 34% report that they have home filtration devices.

If you have any questions on our comments, please feel free to call Marcia Torobin of my staff at (213) 217-7830.

Sincerely,

/S/ Mic Stewart

Mic Stewart, Ph.D.
Manager, Water Quality Section

Appendix No. 4

Metropolitan's Comment Letter to U.S. EPA on the Draft Perchlorate Risk Assessment

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Ms. Annie Jarabek
Special Assistant to the Associate Director for Health
National Center for Environmental Assessment
U.S. EPA (MD 52)
USEPA Mailroom
Research Triangle Park, NC 27711

April 5, 2002

Eastern Research Group
Attn: Meetings
110 Hartwell Avenue
Lexington, MA 02421

RE: Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization, External Review Draft, January 16, 2002

Dear Ms. Jarabek

Metropolitan Water District of Southern California (Metropolitan) appreciates the opportunity to provide comments on the U.S. Environmental Protection Agency's (EPA) draft *Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization* (Draft Perchlorate Report). Metropolitan is a wholesale water supplier who, through its 26 member agencies, provides approximately half of the water used by 17 million consumers in a six-county region of Southern California. Our sources of supply are imported via aqueduct from surface waters in Northern California and the Colorado River. Perchlorate is found in low levels in our Colorado River supplies, although efforts are currently underway to remove this contaminant from the source.

The perchlorate reference dose (RfD) is the foundation for any future federal Maximum Contaminant Level (MCL), and Metropolitan is interested in ensuring that the best available scientific information is utilized in developing the RfD and subsequent regulatory standards. In order to achieve this end, we strongly urge EPA to fully consider the issues raised by the external peer review panel at the March 5-6 meeting in Sacramento which Metropolitan staff attended. More recently, California's Office of Environmental Health Hazard Assessment (OEHHA) published a draft Public Health Goal (PHG) of 6 ppb. EPA's draft RfD, when placed on a Drinking Water Equivalent Level basis and adjusted for a relative source contribution of 60%, is an order of magnitude lower than OEHHA's draft PHG. We request that EPA closely review the assumptions which lead to differences in the RfD and PHG since both were based on essentially the same underlying health endpoints. Lastly, we ask that EPA ensure that requirements for the cleanup of sites contaminated by perchlorate and Clean Water Act requirements for ambient water quality are consistent with the RfD and any future drinking water standards. Perchlorate is not effectively removed by conventional treatment, effective technologies such as ion exchange and membranes are very expensive, and therefore source water protection through the cleanup of contaminated sites is critical to ensuring a safe water supply. Cleanup requirements and water quality criteria must be at levels that are protective of public health.

Our specific recommendations are discussed below.

Relationship between small changes in hormone levels and adverse health effects.
EPA has set the perchlorate RfD to prevent the precursors (i.e., decreases in thyroxine (T4) and triiodyothyronine (T3) and increases in thyroid stimulating hormone (TSH)) to neurodevelopmental deficits and neoplasia. The focus on precursors has merit if they are easier to monitor and measure than the adverse end point itself, and if it is established that they are, in fact, precursors to the chain of events leading to the adverse effects at doses of environmental interest. The assumption underlying the use of such precursors in establishing an RfD is that the threshold for adverse effect is the same as the threshold for changes in the precursor. As a result, the argument depends critically on a demonstration that there is at least a non-zero probability that the precursor leads to the end point of concern at low-levels of exposure to the contaminant. In the case of perchlorate where the negative feedback mechanism of the hypothalamic-pituitary-thyroid axis acts to maintain hormone homeostasis, internal regulatory mechanisms could theoretically mitigate any adverse health outcomes at low levels of exposure. As noted by some of the peer reviewers, the Draft Perchlorate Report does not clearly demonstrate the relationship between the small changes in T4, T3 and TSH and the adverse health effects of concern. We urge EPA to clearly present the data supporting this relationship. If this cannot be demonstrated, then we ask EPA to reconsider the basis for developing the RfD.

Human health data.
Several peer reviewers as well as most of the public commenters urged EPA to more fully consider the human health data and the quality of these studies. EPA has based the draft RfD on animal data and only utilized the findings from one of the human health studies to confirm that the human health data would have resulted in a consistent RfD.

We ask that EPA conduct a revaluation of the human health studies, particularly those published since 1998, and the uncertainty factors used to adjust from the point of departure. We note that the composite uncertainty factor used by OEHHA is only one-third the uncertainty factor used by EPA (30 versus 100) even though both agencies utilized the same NOAEL for the point of departure and relied on the same human health study for determining the NOAEL (Greer et al., 2000). As noted by the peer reviewers, the EPA traditionally has relied on human data where these are available and are of similar quality as the animal data, using the animal data to bolster (but not replace) conclusions drawn on the basis of human data. We urge the EPA to consider this approach for the case of perchlorate, rather than basing the NOAEL on the animal data and then using the human data as supporting evidence.

Uncertainty factors used to adjust animal data.
Various peer reviewers also questioned the uncertainty factors that were applied to the animal data. These include the factors for insufficiency of the immunotox database, duration, and interspecies variability. The concern is that the EPA originally identified gaps in the database (the kinds of gaps that normally require application of uncertainty factors), and then conducted what appear to us to be a well designed series of experiments to reduce these gaps. In the end, however, these new data do not appear to have significantly reduced the uncertainty factors applied, despite the fact that the data significantly improved understanding of the issues that underlie application of uncertainty factors. The sole exception is the use of pharmacokinetic data to reduce the interspecies extrapolation uncertainty factor. In general,

the recommendations from the peer reviewers were in a direction that would reduce the overall uncertainty factor. Because of the significant impact that the uncertainty factors have on the RfD, these assumptions warrant reconsideration.

Dietary contribution.
Limited data were presented on the dietary contribution of perchlorate from sources other than the ingestion of water. Additional information is necessary in order to determine the relative source contribution from drinking water and for the eventual development of drinking water standards. We ask that EPA undertake the studies necessary to properly assess dietary exposures.

Consistency among EPA programs.
Cost-effective protection of public health from the ingestion of perchlorate requires protection of water supplies from contamination at their source. This, in turn, requires coordination and consistency among EPA programs. Clean Water Act human health criteria and requirements for the cleanup of contaminated sites must be developed on the same basis as any future drinking water standards for perchlorate. The RfD is central to these requirements.

Again we appreciate the opportunity to comment. If you have any questions on our comments, please feel free to contact Marcia Torobin of my staff at (213) 217-7830.

Sincerely,

/S/ Mic Stewart

Mic Stewart, Ph.D.
Water Quality Section Manager

Appendix No. 5

Setting Health-Based Drinking Water Standards[2]

FEDERAL STANDARD-SETTING PROCESS

How does U.S. EPA set drinking water standards?
The 1996 Amendments to Safe Drinking Water Act require U.S. EPA to go through several steps to determine, first, whether setting a standard is appropriate for a particular contaminant, and if so, what the standard should be. Peer-reviewed science and data support an intensive technological evaluation, which includes many factors: occurrence in the environment; human exposure and risks of adverse health effects in the general population and sensitive subpopulations; analytical methods of detection; technical feasibility; and impacts of regulation on water systems, the economy and public health. Considering public input throughout the process, U.S. EPA must (1) identify drinking water problems; (2) establish priorities; and (3) set standards.

(1) Identify drinking water problems.
U.S. EPA must first make determinations about which contaminants to regulate. These determinations are based on health risks and the likelihood that the contaminant occurs in public water systems at levels of concern. The National Drinking Water Contaminant Candidate List (CCL), published March 2, 1998, lists contaminants that: (1) are not already regulated under SDWA; (2) may have adverse health effects; (3) are known or anticipated to occur in public water systems; and (4) may require regulations under SDWA.

(2) Establish priorities.
Contaminants on the CCL are divided into priorities for regulation, health research and occurrence data collection. In 2002, U.S. EPA will select five or more contaminants from the regulatory priorities on the CCL and determine whether to regulate them. To support these decisions, the Agency must determine that regulating the contaminants would present a meaningful opportunity to reduce health risk. If U.S. EPA determines regulations are necessary, the Agency must propose and finalize them, a process which can take several years.

The Agency will also select up to 30 unregulated contaminants from the CCL for monitoring by public water systems serving at least 100,000 people. Currently, most of the unregulated contaminants with potential of occurring in drinking water are pesticides and microbes. Every five years, U.S. EPA will repeat the cycle of revising the CCL, making regulatory determinations for five contaminants and identifying up to 30 contaminants for unregulated monitoring. In addition, every six years, U.S. EPA will re-evaluate existing regulations to determine if modifications are necessary.

(3) Propose and finalize a National Primary Drinking Water Regulation.
After reviewing health effects studies, U.S. EPA sets a **Maximum Contaminant Level Goal (MCLG),** the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. MCLGs are non-enforceable public health goals. Since MCLGs consider only public health and not the limits of detection and treatment technology, sometimes they are set at a level which water systems cannot meet. When determining an MCLG, U.S. EPA considers the risk to sensitive subpopulations (infants, children,

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[2] Sources: U.S. EPA and OEHHA's web sites.

the elderly, and those with compromised immune systems) of experiencing a variety of adverse health effects.

- **Non-Carcinogens (not including microbial contaminants)**: For chemicals that can cause adverse non-cancer health effects, the MCLG is based on the reference dose. A **reference dose** (RFD) is an estimate of the amount of a chemical that a person can be exposed to on a daily basis that is not anticipated to cause adverse health effects over a person's lifetime. In RFD calculations, sensitive subgroups are included, and uncertainty may span an order of magnitude. The RFD is multiplied by typical adult body weight (70 kg) and divided by daily water consumption (2 liters) to provide a Drinking Water Equivalent Level (DWEL). The DWEL is multiplied by a percentage of the total daily exposure contributed by drinking water (often 20 percent) to determine the MCLG.
- **Chemical Contaminants -- Carcinogens:** If there is evidence that a chemical may cause cancer, and there is no dose below which the chemical is considered safe, the MCLG is set at zero. If a chemical is carcinogenic and a safe dose can be determined, the MCLG is set at a level above zero that is safe.
- **Microbial Contaminants:** For microbial contaminants that may present public health risk, the MCLG is set at zero because ingesting one protozoa, virus, or bacterium may cause adverse health effects. U.S. EPA is conducting studies to determine whether there is a safe level above zero for some microbial contaminants. So far, however, this has not been established.

Once the MCLG is determined, U.S. EPA sets an enforceable standard. In most cases, the standard is a **Maximum Contaminant Level (MCL)**, the maximum permissible level of a contaminant in water which is delivered to any user of a public water system.

The MCL is set as close to the MCLG as feasible, which the Safe Drinking Water Act defines as the level that may be achieved with the use of the best available technology, treatment techniques, and other means which EPA finds are available (after examination for efficiency under field conditions and not solely under laboratory conditions), taking cost into consideration.

When there is no reliable method that is economically and technically feasible to measure a contaminant at particularly low concentrations, a **Treatment Technique (TT)** is set rather than an MCL. A treatment technique is an enforceable procedure or level of technological performance which public water systems must follow to ensure control of a contaminant. Examples of Treatment Technique rules are the Surface Water Treatment Rule (disinfection and filtration) and the Lead and Copper Rule (optimized corrosion control).

After determining a MCL or TT based on affordable technology for large systems, U.S. EPA must complete an economic analysis to determine whether the benefits of that standard justify the costs. If not, U.S. EPA may adjust the MCL for a particular class or group of systems to a level that "maximizes health risk reduction benefits at a cost that is justified by the benefits". U.S. EPA may not adjust the MCL if the benefits justify the costs to large systems, and small systems unlikely to receive variances.

When must public water systems comply with new primary standards?

Primary standards go into effect three years after they are finalized. If capital improvements are required, EPA's Administrator or a state may allow this period to be extended up to two additional years.

CALIFORNIA STANDARD-SETTING PROCESS

How does CDHS set drinking water standards?
In California, the regulatory process begins with the determination that a particular contaminate should be regulated. Contaminants are identified as a result of public health concerns (e.g., aluminum), new federal regulations (e.g., surface water treatment rule) or statutory requirements (e.g., MTBE).

Next, California's Office of Environmental Health Hazard Assessment (OEHHA) performs a risk assessment and publishes a **Public Health Goal (PHG)**. The PHG for an acutely toxic substance is the concentration in drinking water at which there is no known or anticipated adverse effects with an adequate margin of safety. For a carcinogen or other substance that can cause chronic disease, the PHG is the concentration that does not pose a significant risk to health. The PHG is a non-mandatory goal based solely on health considerations. It does not take into account economics or technical feasibility.

California's Department of Health Services (CDHS) then develops an MCL. The MCL is set as close as possible to the PHG, taking into account costs and technical feasibility. If the contaminant is already regulated at the federal level, the MCL must be at least as stringent as the federal one.

How is the PHG determined?
The PHG is determined through a risk assessment that examines information about the contaminant including, occurrence, fate and transport in the environment, physicochemical characteristics, mode of action, and human health and animal studies. The level at which the PHG is set depends on whether the contaminant is a carcinogen or not.

If the contaminant is not a carcinogen, (i.e., it is acutely toxic) the PHG is set at a level at which there is no known or expected risk, with an adequate margin of safety. For acutely toxic substances it is believed that the body can protect itself against low level toxic "insults" but above a certain level, the body's defense mechanisms may be overwhelmed.

The "no risk" level is determined by reviewing available animal and human health studies (focusing on those that meet the highest scientific standards) and identifying the highest dose at which there is no observed adverse effect (NOAEL). If no acceptable study exists, then the lowest dose at which an adverse effect is observed (LOAEL) is selected and the dose is divided by 10 to establish an estimated NOAEL.

The NOAEL may then be further adjusted (i.e., reduced). Additional adjustments may be made if (1) the NOAEL is based on animal data rather than human studies, (2) there are subpopulations that may be significantly more sensitive to the contaminant, (3) the database is of sub-optimal quality, or for other reasons. These adjustments can cumulatively be as high as 1,000.

Until relatively recently, it was thought that even the smallest amounts of a carcinogen had a non-zero probability of causing cancer. If the "no-risk" criterion were applied to carcinogens, this would mean the PHG would be zero. Since this is not realistic, the criterion for carcinogens is that the PHG must be set at a level at which there is no "significant" risk to health. By convention, the "no significant risk" level is the concentration of a contaminant at which the lifetime probability of cancer is no greater than one in one million.

Whether the PHG is for a toxic substance or carcinogen, it must take into account whether there are sources of exposure other than drinking water. If there are, then the PHG will be lower than what it would have been had all of the exposure come from drinking water. OEHHA then publishes a draft PHG report and provides a 45-day public comment period. Any revisions must be available to the public for a 30-day comment period.

How is the MCL established?

The California Health and Safety Code (§ 116365) requires that health-based MCLs (primary drinking water standards) shall be as close as feasible to the corresponding public health goals, to the extent technologically and economically feasible. In no case, however, may the MCL be less stringent than the national primary drinking water standard adopted by U.S. EPA, if any.

Proposed regulations have a 45-day public comment period. "Post-hearing" changes made in response to comments have a subsequent 15-day public comment period. Once CDHS completes the regulatory process, it submits the regulation package, including responses to public comments, to the Office of Administrative Law (OAL). OAL has 30 working days to review the regulation and approve or reject it. If approved by OAL, it is filed with the Secretary of State and becomes effective in 30 calendar days. An emergency regulation has a 10-day review by OAL; if approved, it becomes effective immediately, and its public comment period occurs after the regulation is effective. CDHS is required to review primary drinking water standards at least once every five years after their adoption.

Appendix No. 6
Summary of Terminology Used in Setting Drinking Water Standards and Goals

Terminology	Abbrevia-tion	Enforceable (Y/N)?	Federal or California Terminology	Definition	Similar to:
Reference Dose	**RfD**	N	Federal	An **RfD** is an estimate of the amount of a chemical that a person can be exposed to on a daily basis that is not anticipated to cause adverse health effects over a person's lifetime. In RfD calculations, sensitive subgroups are included, and uncertainty may span an order of magnitude.	NA
Drinking water equivalent level	**DWEL**	N	Federal	The **DWEL** is the concentration of a contaminant in drinking water that a person can be exposed to on a daily basis that is not anticipated to cause adverse health effects over a person's lifetime, assuming that the only exposure to the contaminant is from drinking water. It is determined by multiplying the RFD by the typical adult body weight (70 kg) and divided by daily water consumption (2 liters).	NA
Maximum Contaminant Level Goal	**MCLG**	N	Federal	The **MCLG** is the DWEL multiplied by a percentage of the total daily exposure contributed by drinking water (often 20 percent). For *possible* human carcinogens, a safety factor is included. For *known* or *probable* human carcinogens, the MCLG is usually set at zero.	California PHG except the MCLG is usually "0" for known or probable carcinogens.
Public Health Goal	**PHG**	N	California	The **PHG** is the level of a 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. For acutely toxic substances, the PHG is set at	Federal MCLG except PHG for carcinogens is usually set at

Appendix No. 6
Summary of Terminology Used in Setting Drinking Water Standards and Goals

Terminology	**Abbrevia-tion**	**Enforceable (Y/N)?**	**Federal or California Terminology**	**Definition**	**Similar to:**
				the level at which no known or anticipated adverse effect of health occur, with an adequate margin of safety. For carcinogens or other substances that may cause chronic disease, the PHG is set at the level that does not pose any significant risk to health.	a lifetime risk of cancer of 1 in 1 million.
Action Level	**AL**	N	California	The **AL** is the level of a contaminant in drinking water at which there is no significant risk to persons ingesting water on a daily basis. However, the AL can take into account detection limits for the contaminant.	PHG except that the AL can consider "detectability"
Maximum Contaminant Level	**MCL**	Y	Federal	The Federal **MCL** is set as close to the MCLG as feasible, which the Safe Drinking Water Act defines as the level that may be achieved with the use of the best available technology, treatment techniques, and other means which EPA finds are available (after examination for efficiency under field conditions and not solely under laboratory conditions) are available, taking cost into consideration.	California MCL except the Federal MCL is based on the MCLG
Maximum Contaminant Level	**MCL**	Y	California	The California **MCL** is set as close as feasible to the PHG as is technologically and economically feasible, but in no case at a level lower than the Federal MCL, if any.	Federal MCL except the California MCL is based on the PHG

CHRONOLOGY OF METROPOLITAN'S ACTIONS

1950s

	Ammonium perchlorate manufacturing begins at the BMI complex near Henderson, Nevada

1997

February	Perchlorate is detected in drinking water wells in northern California adjacent to an Aerojet rocket testing and manufacturing facility.
February	For the next three months the State of California Department of Health Services (CDHS) requires testing of drinking water wells in northern California for perchlorate.
March	An expert review panel concludes that the available toxicological data is insufficient to develop a credible reference dose (RfD). Eight toxicological studies were subsequently recommended to address data gaps.
April	CDHS begins sampling of drinking water systems in southern California using a new analytical method that was capable of measuring perchlorate at 4 ppb. Perchlorate was subsequently found in many wells in the Los Angeles, Riverside and San Bernardino Counties.
May 28	CDHS notifies Metropolitan of perchlorate detection in the state, and its intention to have press release. Subsequently, CDHS adopts an Action Level of 18 ppb.
May	Metropolitan issues a fact sheet and regulatory alert on perchlorate to Member Agencies.
June 2 - 9	Metropolitan's Water Quality Laboratory collects initial samples from State project water and Colorado River water (CRW). Perchlorate was detected only in the CRW.
June 11	CDHS issues a press release on perchlorate detection in southern California groundwater wells.
June 12	Initial discussion on detection of perchlorate in CRW and other groundwater supplies in southern California takes place during Metropolitan's Member Agency Water Quality Managers meeting.
June 24	Metropolitan staff provides the Board, through the Water Quality, Desalination and Environmental Compliance Committee, its initial information report on perchlorate as an emerging contamination issue.
July 16	The U.S. Bureau of Reclamation and Park Service collects water quality samples at Lake Mead and at upstream locations near Glen Canyon Dam and Crystal Dam.

July 17	The initial meeting of the Raymond Basin Task force takes place that included participation from U.S. EPA, CDHS, the National Aeronautics and Space Administration/Jet Propulsion Laboratory, and local water utilities.
July 22	Metropolitan staff convenes a management briefing to provide an update on perchlorate occurrence in groundwater and surface water
July 23	The Raymond Basin Task Force meets to establish a perchlorate action plan with stakeholder participation.
July 23 - 24	Metropolitan collects perchlorate samples from all areas of Lake Mead to characterize perchlorate occurrence.
July 28	Metropolitan's Board of Directors adopts a "Support for Perchlorate Research" position allowing staff to support federal funding activities including $2 million in the fiscal 1998 appropriations for U.S. EPA perchlorate research.
August 1	Metropolitan collects samples throughout Lake Mead with emphasis on Las Vegas Wash, Las Vegas Bay and Boulder Basin.
August 13	Metropolitan gives Member Agency Water Quality Managers an update on perchlorate occurrence.
August 15	Metropolitan gives Member Agency Managers an update on perchlorate occurrence.
October	Metropolitan initiates monthly perchlorate monitoring of source and treated waters, including select distribution sites in the central pool area.
October	Metropolitan staff initiates pilot plant studies to investigate treatment options. Enhanced coagulation, oxidation with ozone and PEROXONE (hydrogen peroxide combined with ozone), oxidation followed by Granular Activated Carbon treatment and membrane processes were evaluated.
December	Metropolitan begins quarterly perchlorate monitoring of Lake Mead at Hoover Dam outlet.
December 1	Metropolitan staff inspects the Las Vegas Wash area in Henderson, Nevada where perchlorate contamination originated.

1998

January 22	Metropolitan's Board of Directors adopts a "Support if Amended" position on SB 1003 (Sher - Palo Alto) to require a primary drinking water standard for perchlorate to be based on good science.
January 27	Metropolitan staff meets with staff from USEPA Region IX to discuss perchlorate remediation status near the Las Vegas Wash area.

February	The American Water Works Association Research Foundation (AWWARF) issues a Request for Proposal for eight perchlorate treatment studies through a $2 million congressional earmark.
February	Metropolitan staff meets with staff from Southern Nevada Water Authority in Las Vegas to discuss perchlorate contamination.
March 2	U.S. EPA includes perchlorate in the Drinking Water Contaminant Candidate List as a contaminant that needed additional information on toxicity, occurrence, treatment technologies and analytical methodologies.
May	AWWARF awards Metropolitan the following grants: • Treatability of Perchlorate-containing Waters by Reverse-Osmosis and Nanofiltration, • Removal of Bromate and Perchlorate in Conventional Ozone/GAC Systems, • National Assessment of Perchlorate Contamination Occurrence
December 31	USEPA issues a draft toxicological report summarizing the results of the eight toxicity studies that were initiated in 1997. This document recommends a revised RfD of 0.0009 mg/kg-day, or the equivalent of 32 ppb for drinking water action level.

1999

January 7	CDHS adopts perchlorate as an unregulated chemical for which monitoring is required.
February 10 - 11	U.S. EPA conducts an external peer review workshop in San Bernardino, California for the U.S. EPA 1998 toxicological report.
February 22	Metropolitan's Board of Directors votes to support language developed for Metropolitan sponsored legislation on perchlorate contamination consistent with Board-adopted legislative policy principles.
September	Kerr-McGee submits a work plan to cover the long-term remedial alternative for capture and treatment of perchlorate-impacted groundwater to NDEP. The plan includes construction of a biodegradation process for perchlorate removal.
September 17	U.S. EPA includes perchlorate in the Unregulated Contaminant Monitoring Regulation (UCMR) as a contaminant that requires monitoring.
November	The USEPA approves Method 314.0 for perchlorate monitoring under the federal UCMR.
November 13	Kerr-McGee Chemical LLC and Nevada Division of Environmental Protection (NDEP) initiates clean up of the Las Vegas Wash utilizing an ion exchange process to remove perchlorate from water captured from underground streams.

2000

January 31	In a letter to Southern Nevada Water Authority General Manager, Metropolitan expresses positive participation in the perchlorate clean up effort of the Colorado River.
September	Biothane Corporation and Applied Research Associates Engineering completes design, cost estimate, and schedule for the long-term system at the Kerr-McGee site is complete. Construction drawings are expected in early October.
December	Kerr-McGee decides not to use biological treatment for their long-term system, but rather use ion exchange. This will not effect their operational time line.
January - December	Metropolitan continues to collect perchlorate samples throughout its conveyance, treatment and distribution system.

2001

January - December	Metropolitan initiates its third year of monitoring for perchlorate in its system. Monitoring data is available on an annual average along with a range for each year.
October	Kerr-McGee enters into an Administrative Order on Consent with NDEP to begin operation of the large-scale unit by February 2002.
November	Metropolitan submits its draft final report on "National Assessment of Perchlorate Contamination Occurrence" to AWWARF.

2002

January 18	USEPA releases toxicological report, 2002 external peer review draft. This document recommends a revised RfD of 0.00003 mg/kg-day, which corresponds to a "drinking water equivalent level" of 1 ppb.
January 18	CDHS reduces its Action Level for perchlorate from 18 ppb to 4 ppb.
January 18	Metropolitan's chief executive officer issues a perchlorate alert to the Member Agency managers advising them of the adoption of a revised action level by CDHS.
January 24	Metropolitan's Water Quality laboratory manager provides historical perchlorate monitoring data to member agencies.
February 5	Metropolitan meets with CDHS to discuss actions required of Metropolitan as a result of the revised Action Level.
February 6	Metropolitan's Water Quality Laboratory assists Southern California Water Company

in providing quality assurance of their monitoring data by performing split sample analysis.

February 11	Staff presentation to Metropolitan's Board of Directors indicates changes to State's drinking water regulation on perchlorate. The staff also updates the Board on perchlorate levels in Metropolitan's source water, treatment plants and distribution system.
February 14	In a letter to CDHS, Metropolitan reiterates its agreement of how Metropolitan's observance with the revised perchlorate Action Level will be determined. Metropolitan commits to continued monthly monitoring and reporting with expanded distribution system locations.
February 20	Staff participates in meeting with CDHS and Association of California Water Agencies on drinking water Action Levels including perchlorate.
February 22	Metropolitan staff makes a presentation on perchlorate to the Member Agency managers.
February 25	Metropolitan staff participates in a conference call with the American Water Works Association discussing comments on the draft 2002 USEPA perchlorate risk assessment report.
February 26	A letter along with Metropolitan's updated monitoring data is sent to the member agencies to clarify staff actions following the CDHS adoption of a revised perchlorate action level. This letter also communicated Metropolitan's commitment to expanded perchlorate monitoring program and sharing of these data with the member agencies in a timely manner.
February 27	CDHS changes monitoring and notification requirement for contaminants with action levels. The local government notification when action levels are exceeded is required for groundwater wells only.
March 1	Metropolitan staff meets with the NDEP and Southern Nevada Water Authority and received briefing on perchlorate cleanup efforts at Kerr McGee site.
March 5 - 6	Metropolitan staff attends the external peer review workshop in Sacramento, California for the draft USEPA risk assessment documentation.
March 11	The California Office of Environmental Health Hazard Assessment (OEHHA) releases a draft PHG report on perchlorate. A PHG of 6 ppb was proposed based on the results of human health studies.
March 11 - 12	At the March Water Planning, Quality and Resources Committee meeting, staff presents the Board with a perchlorate update.

March 14	Metropolitan staff makes a combined presentation with CDHS on perchlorate at the Member Agency Water Quality Managers' Meeting.
March 20	Metropolitan staff made a combined presentation with CDHS on the current status of perchlorate at the San Gabriel Perchlorate/Emerging Contaminating Coordinating Team.
March 26 - April 16	Metropolitan staff contacts member agencies to compile questions on the perchlorate issue for the CDHS to address.
March 28	Metropolitan staff makes a combined presentation on perchlorate with CDHS to the Southern California Water Utilities Association presentation.
February 19 - April 3	Metropolitan staff compiles information from member agencies to determine extent of perchlorate contamination in their systems, potential additional demand for MWD water, and treatment options, if any for their impacted supplies.
April 5	Metropolitan provides comments on USEPA's draft Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization.
April 5	Metropolitan retains the services of Dr. Douglas Crawford-Brown of the University of North Carolina to review and provide comments on OEHHA's draft Perchlorate PHG Report and other related issues.
April 29	Metropolitan staff attends OEHHA Workshop to discuss the proposed PHG for perchlorate.
April 29	Metropolitan submits comments on OEHHA's Draft Public Health Goal for Perchlorate in Drinking Water.
May 16	Metropolitan sends a letter to the Southern Nevada Water Authority requesting Metropolitan's participation in evaluating the effectiveness of Kerr-McGee's cleanup program and development of joint recommendations on further actions to benefit the downstream users of Colorado River Water.