San Francisco
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Services of the San Francisco Public Utilities Commission

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Date: November 1, 2011

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Through: Steven R. Ritchie, Assistant General Manager, Water

From: Andrew DeGraca, Water Quality Division Manager

Re: Proposed Approach for Contaminants of Emerging Concern (CECs) in SFPUC's Drinking Water System

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Purpose

The purpose of this memorandum is to summarize a proposed approach for Contaminants of Emerging Concern (CECs) in SFPUC's drinking water system. CECs are those contaminants that are being discovered in water that previously had not been detected or are being detected at levels that may be significantly different than expected. These are often generally referred to as CECs because the risk to human health and the environment associated with their presence, frequency of occurrence, or source may not be known. The SFPUC's proposed approach to CECs is intended to (1) provide a consistent, proactive, and flexible means of organizing and prioritizing CEC work, and (2) enhance stakeholder engagement on CEC issues.

Summary

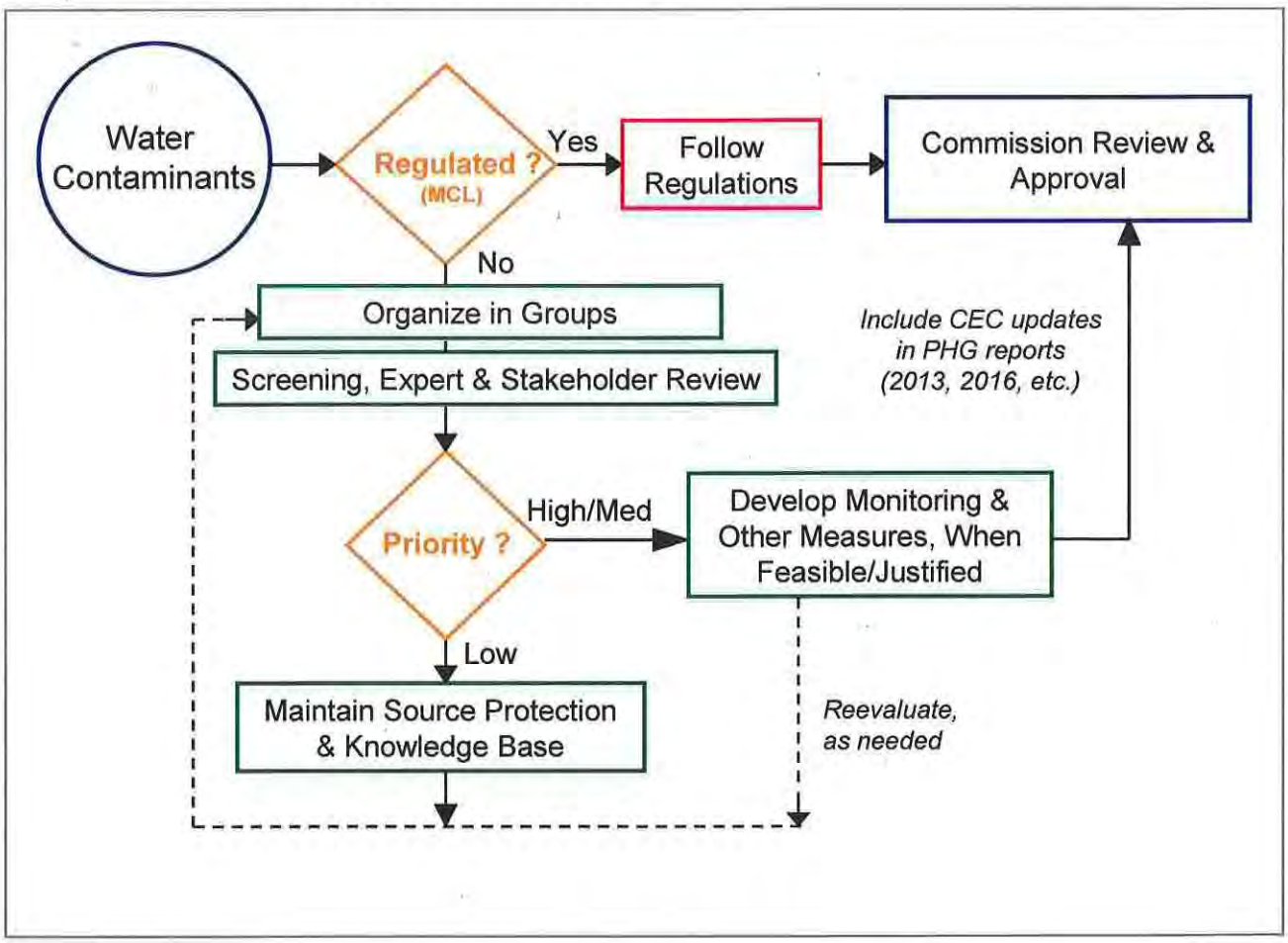
There are less than 100 drinking water contaminants which have gone through a formal process including review of detection methods, occurrence, and health impacts and were eventually regulated. The regulatory process is slow and meticulous.

There are over 100,000 CECs. The list of detectable CECs in drinking water is growing due to improvements in analytical technologies. Public concern about individual CECs can develop very rapidly due to detection, limited health effect information, and rapid communication (i.e., internet). San Francisco's water

system has an excellent source of supply, yet trace detections of some CECs is likely in the future.

In order to ensure limited resources are prioritized on the CECs of greatest concern, the SFPUC needs to develop a more formalized approach. The recommended approach includes the use of staff screening evaluations, expert and stakeholders reviews, and public communication to evaluate SFPUC vulnerability to various CEC groups and then individual CECs as needed. The results of this approach will be presented to the Commission as part of the triennial Public Health Goal (PHG) hearing required under California law. New CEC(s) or information on existing CEC(s) that rapidly emerge will be addressed before the end of the 3-year cycle. The proposed approach is shown in Figure 1.

Figure 1. Flowchart of Proposed CEC Approach



Background

What is a CEC?

As defined by the United States Environmental Protection Agency (USEPA), "[Contaminants] are being discovered in water that previously had not been detected or are being detected at levels that may be significantly different than expected. These are often generally referred to as contaminants of emerging concern (CECs) because the risk to human health and the environment associated with their presence, frequency of occurrence, or source may not be known." (USEPA, 2011)

CECs have become an increasing area of study due, in part, to an increasing number of CECs and advances in analytical detection technology. Approximately 100,000 chemicals have been registered for use in the United States over the past 30 years which include: 82,000 industrial chemicals, 6,000 cosmetics, 3,000 food additives, 1,000 pharmaceuticals, and 1,000 pesticides (COPC et al., 2009). New analytical technologies can detect substances in water in parts per trillion (ppt or nanogram per liter, ng/L, which is one twentieth of a drop of water in an Olympic-sized swimming pool); for most substances, the potential human health impacts at such extremely low concentrations have not been explored. Similarly, when new microorganisms are discovered the health significance of these microbial CECs is not easily determined.

An example of a CEC group is Pharmaceuticals and Personal Care Products (PPCPs). A few individual contaminants within this group include Sulfamethoxazole (an antibiotic), Gemfibrozil (a cholesterol drug), and DEET (an insect repellent) which have been detected in source waters throughout the United States but not in San Francisco's source water to date (NWRI, 2010 and AWWARF, 2008a).

The emergence of PPCPs as a drinking water issue parallels the emergence of chloroform, a by-product of chlorination that was first regulated in 1979 (Pontius, 2008). Chlorine has been used for disinfection in the United States since 1908 and as such, chloroform and other disinfection by-products (DBPs) have been present in disinfected waters for decades. It was not until analytical methods for DBPs were developed 70 years later that the potential health significance of these byproducts could be identified and explored. Recent media coverage of PPCPs is similar to that which occurred when DBPs were first detected in drinking water, in that the public had probably been exposed to these substances for quite some time before the analytical methods were even available to understand the potential for health impacts.

How do regulators address CECs?

USEPA gathers CEC occurrence data through the Unregulated Contaminant Monitoring Regulation (UCMR), which requires utilities to monitor 30 EPA-selected CECs every 5 years. Some individual CECs may become regulated by USEPA after a long screening process that begins with their inclusion on a Contaminant Candidate List (CCL). The most recent list (CCL3) contains 116 individual contaminants, including both chemical and microbial contaminants.

On December 15, 2010, the California State Water Resources Control Board (SWRCB) established its intent to implement recommendations from a State CEC Science Advisory Panel (Drewes, 2010). SWRCB has proposed monitoring requirements for PPCPs and other CECs when a water system recharges an aquifer with recycled water. The list of CECs to monitor was developed by the California Department of Public Health (CDPH) and the Board's CEC Panel. (SWRCB, 2010)

Regulated contaminants vs. CECs

As summarized in Figure 2, there are significant differences between regulated contaminants and CECs. The number of regulated contaminants is large but manageable. There are less than 100 contaminants regulated by maximum contaminant levels (MCLs). Federal and state drinking water regulations establish a clear direction with respect to health targets, monitoring frequency, and communication approaches.

CECs, on the other hand, number in excess of 100,000 chemicals and an unknown number of microorganisms, making their management and understanding untenable on a contaminant-by-contaminant basis. Without regulations or guidance, there is also a lack of direction on health targets, monitoring frequency, or communication approaches. A CEC approach can help fill these voids by providing a systematic method of identifying, organizing, and prioritizing CECs of concern to SFPUC, and providing an approach for communicating with the public.

Finally, while regulatory programs are quantitative (set specific numeric limits for specific parameters), a CEC approach, because of a lack of specific information, must utilize grouping and indicator contaminants and be more qualitative.

Figure 2. Regulated contaminants vs. CECs

Regulations = organized

- Small number (≈ 100 limits)
- Targets (MCLs)
- Treatment techniques
- Monitoring requirements
- Reporting requirements
- Communication requirements

CECs = unorganized

- Large number (≈ 100,000 registered chemicals, plus microbials)
- Analytical, occurrence, health, and treatment research ongoing
- Unknown health effects
- Few and unclear targets
- Few monitoring and communication recommendations

Why develop a SFPUC CEC Approach?
In 2006, SFPUC participated in the American Water Works Research Foundation (AwwaRF) project "Toxicological Relevance of Endocrine Disrupting Compounds (EDCs) and Pharmaceuticals in Drinking Water." This study monitored 62 compounds in source and treated waters of 19 utilities in the United States. Compounds included prescription drugs, over-the-counter drugs, personal care products, and other chemicals with possible endocrine disrupting properties. None of the tested pharmaceuticals or personal care products were detected in SFPUC waters. However, SFPUC had two trace detections of hormones (estrone and progesterone) in the raw water that were believed to be naturally-occurring (from wildlife sources) and were completely removed by treatment. Dr. Shane Snyder, Principal Investigator in the study, commented in his March 2008 interview with the San Francisco Chronicle that SFPUC had the best water tested by their lab.

The 2006 AwwaRF study found trace concentrations of a wide range of pharmaceuticals, personal care products, and endocrine disrupting compounds in other source waters throughout the country. Although levels were far below those anticipated to cause health effects, the detection of these contaminants in the nation's drinking water sources generated national news articles and raised public awareness and concern on CECs. It also highlighted a need for utilities to get organized around the CEC issue.

In 2008, per the Mayor's direction, SFPUC developed a San Francisco Water Quality Protection Plan. An action item from the plan is to "clarify and revise the monitoring framework for emerging contaminants." In 2009, SFPUC's report "Strategic Planning for San Francisco's Water Quality Future" reiterated the need to "develop a policy for addressing emerging contaminants."

Specifically, a CEC approach will:

- Help the SFPUC manage contaminants that are not being covered by existing regulations,
- Help prioritize limited resources on CECs of concern to SFPUC, and
- Provide a framework for involving the Commission, stakeholders and the public in CEC decisions.

Utility Survey by SFPUC (2010)
In 2010, the SFPUC Water Quality Division conducted a survey of 16 large drinking water utilities to determine how they manage CEC issues. All of these utilities were known to be active in this area and participated in research studies on CECs, directly or as project advisory members. SFPUC found that utilities were working on different aspects of CECs but none had developed a comprehensive approach to addressing CECs.

Basic Steps of Proposed Approach

The basic steps of the proposed CEC approach are illustrated in Figure 1 and explained below.

Water Contaminants and Regulatory Question

Starting with any contaminant, the first question is whether or not the contaminant is regulated. If the contaminant is regulated (i.e., has an MCL), then regulations covering limits, monitoring, reporting, and public communications will be strictly followed and the contaminant will not be considered under the CEC approach.

Grouping

If a contaminant is not regulated, it will fall into a group of CECs with similar properties and/or common routes of entry into the water system. Each group is screened to determine its significance to SFPUC using a Screening Evaluation Form (see Appendix A and B for examples of Nitrosamines and PPCPs, respectively).

Screening Evaluation by SFPUC and SFDPH Staff

The first section of the screening evaluation includes general information, such as, CEC description, grouping, indicator parameters, applicable health advisories, and the regulatory development status of the group. If indicators are not detected or at very low levels, it is likely that other parameters in the group would also be non-detect or at very low levels. For example, if the most commonly applied pesticides for a particular watershed are non-detect, it is likely that other pesticides with no or very limited use within the watershed would also be non-detect.

The second section of the screening evaluation covers the context of the review. This section summarizes a statement of goals of any monitoring or investigation, assessment of customer concerns, occurrence data for SFPUC's water sources if available, and an identification of key literature on the group.

The third section of the screening evaluation includes diagnostic questions on health, occurrence, and treatment. This section tries to uncover whether the group is significant to public health in general, if the group is anticipated to occur in SFPUC's source water or distribution system water, and finally, if SFPUC's existing treatment systems will remove the contaminants.

Expert and Stakeholder Review: Priorities and Follow-Up Actions

The next step involves an expert and stakeholder review of the screening evaluations for all groups and the development of priorities based on these evaluations. For top priorities (high and medium priorities), the reviewers will develop monitoring and/or mitigation measures if feasible and justified. For low priorities, the CEC group will not warrant active monitoring, however, the SFPUC should continue its source protection efforts and track new information on the group.

Expert reviews will consist of regulatory agencies (USEPA, CDPH) and consultants. Stakeholders will consist of wholesale customers (SF Wholesale Customer Water Quality Committee), the CAC Water Subcommittee, and other significant groups.

Communication
CEC updates will be provided with the regulatory required Public Health Goal (PHG) reports which are completed every 3 years (2013, 2016, etc.) and formally presented to the Commission for review and approval. PHGs are non-enforceable limits based entirely on human health goals without considering economic or technical feasibility. PHGs only exist for contaminants that have or will have regulatory requirements (i.e., MCLs). The PHG Report does not cover contaminants with MCLs under development (e.g., chromium-6 and N-nitrosodimethylamine, NDMA). In 2010, the SFPUC PHG Report covered arsenic and lead.

In summary, the PHG process is an appropriate mechanism through which to provide updates on CECs because PHGs and CECs are related (neither are enforceable limits) but they do not overlap. PHG Reports cover regulated contaminants (contaminants with MCLs) and CECs cover non-regulated contaminants (contaminants without MCLs).

Output of Proposed Approach

The proposed CEC approach was applied to SFPUC's Regional Water System for surface water. The approach generated 12 CEC groups within 3 general categories: naturally-occurring contaminants, manmade contaminants, and water treatment/distribution byproducts. These CEC groups, with similar properties and routes of entry, are listed in Table 1.

Table 1. Preliminary CEC Groups for SFPUC's Drinking Water System

General Categories	CEC Group
Naturally-Occurring Contaminants	Algal Toxins Inorganics Microbials (e.g., viruses, bacteria, protozoans) Naturally-Occurring Organics (e.g., hormones)
Manmade Contaminants	Fire Retardants Industrial Chemicals (e.g., volatile organic compounds, VOCs) Nanomaterials Pesticides Pharmaceuticals & Personal Care Products
Treatment/Distribution Byproducts	DBPs (nitrosamines) DBPs (other than nitrosamines) Leachate from Materials (liners, gaskets, etc.)

After a review of the 12 CEC groups, microbials and DBPs (nitrosamines) were identified as high priorities, DBPs (other than nitrosamines) and algal toxins were

identified as medium priorities, and the other eight groups were identified as low priorities. The current priorities are summarized in Table 2. Appendix C provides a more detailed summary of the CEC priorities and follow-up actions for each group.

Table 2. Preliminary CEC Priorities for SFPUC's Drinking Water System for Surface Water

Priority	CEC Group
High	Microbials (e.g., viruses, bacteria, protozoans) DBPs (nitrosamines)
Medium	DBPs (other than nitrosamines) Algal Toxins
Low	Pharmaceuticals & Personal Care Products Pesticides Industrial Chemicals (e.g., VOCs) Fire Retardants Nanomaterials Naturally-Occurring Organics (e.g., hormones) Inorganics Leachate from Materials (liners, gaskets, etc.)

New Sources of Supply

The current CEC analysis is based on existing drinking water sources (i.e., the Hetch Hetchy supply and local watershed supplies). Since SFPUC is developing a new source of supply based on San Francisco Peninsula groundwater wells, this new source, though relatively small compared to existing supplies, will need to be folded into the analysis so there is one comprehensive prioritization process. With a groundwater source, some new considerations could include hexavalent chromium (Cr-6) because of the new (non-regulatory) PHG of 0.02 ug/L established on July 27, 2011 and the future (regulatory) MCL for Cr-6 (expected by 2015).

Staff will proceed with the proposed approach unless directed otherwise. If you have any questions, you can reach me at (650) 652-3102.

Appendices

Appendix A – Screening Evaluation for Nitrosamines
Appendix B – Screening Evaluation for Pharmaceuticals and Personal Care Products
Appendix C – Proposed Follow-Up for CEC Groups
Appendix D – Literature Review References

Cc: Manouchehr Boozarpour, Andrzej Wilczak, Gregg Olson **(SFPUC)**
June Weintraub **(SFDPH)**

Appendix A – Screening Evaluation for Nitrosamines

GENERAL INFORMATION ON CEC	
CEC Name	**Nitrosamines**
CEC Description	Nitrosamines include: N-Nitrosodimethylamine (NDMA), N-Nitrosodiethylamine (NDEA), N-Nitrosodi-n-propylamine (NDPA), N-Nitrosodi-n-butylamine (NDBA), N-Nitrosomethylethylamine (NMEA), N-Nitrosomorpholine (NMOR), N-Nitrosopiperidine (NPIP), and N-Nitrosopyrrolidine (NPYR) (Sacher, 2008 and CDPH, 2009). NDMA is a potent carcinogen in experimental animals by several routes of exposure, including ingestion of drinking water (Health Canada, 2010). It is classified by the United States Environmental Protection Agency (USEPA) as B2, probable human carcinogen (USEPA, 1993). The presence of NDMA in drinking water is primarily associated with water treatment additives. It can be formed as a result of chloramination, and to a lesser extent chlorination, as well as the use of some coagulants and anion exchange resins. Consequently, the best approaches to reduce the concentration of NDMA in drinking water are to remove the organic nitrogen precursors, or to modify the disinfection strategy to minimize its formation, without compromising the efficacy of the disinfection process. (Health Canada, 2010)
Grouping Is CEC a group or an individual CEC(s)? If individual CEC, which group is CEC part of? What is the basis for grouping? (USEPA's 4 grouping factors include: (1) similar health effects, (2) common treatment, (3) common analytical method, (4) monitoring/co-occurrence)	Nitrosamines is a group. The universe of studied nitrosamines is relatively small. The AwwaRF study *Strategies for Minimizing Nitrosamine Formation During Disinfection* identifies eight "important nitrosamines" (Sacher, 2008), listed above. USEPA's 2008 Unregulated Contaminant Monitoring Regulation 2 (UCMR2) includes six nitrosamines and USEPA's Contaminant Candidate List 3 (CCL3) includes five nitrosamines. Nitrosamines can be grouped for several reasons. Nitrosamines have similar health effects (carcinogens), common treatment/reduction approaches, such as, polymer management, and a common analytical method (EPA Method 521) (USEPA, 2010). Nitrosamines may also have some co-occurrence properties, i.e., the occurrence of one nitrosamine could be an indicator for other nitrosamines. However, NDMA co-occurrence with other nitrosamines was identified as a data gap at a nitrosamine regulatory workshop in September 2010 (Malcolm Pirnie, 2010).
Indicators What are possible indicator contaminants?	NDMA, NDEA, NDPA NDMA is probably the best indicator for SFPUC, as it is the most commonly detected nitrosamine and it is receiving the most regulatory attention. However, NDMA co-occurrence with other nitrosamines is still a data gap and needs further

	study (Malcolm Pirnie, 2010).
Advisories Does CEC have a USEPA Health Advisory (e.g., DWEL) or California Notification Level?	There are no USEPA Health Advisories for nitrosamines. NDMA, NDEA, and NDPA have California Notification Levels of 10 ng/L (CDPH, 2009).
Regulatory Development Is CEC on USEPA CCL, UCMR list, or California PHG list?	There are five nitrosamines on USEPA's CCL3, including: NDMA, NDEA, NDPA, N-Nitrosodiphenylamine, and NPYR. Six nitrosamines were monitored in 2008 under USEPA's UCMR2, including: NDMA, NDEA, NDPA, NDBA, NMEA, and NPYR. NDMA has a Public Health Goal (PHG) of 3 ng/L. A PHG is a non-enforceable, health-based goal and is the first step in the California regulatory process. California Maximum Contaminant Levels (MCLs) are established as close to the PHG as possible after considering technical and economic feasibility.
CONTEXT OF CEC INVESTIGATION AT SFPUC	
Statement of Goals Why is investigation undertaken?	Low levels of NDMA can be formed during the disinfection process, both by chlorination and chloramination. For NDMA to be formed, reactive chlorine, such as monochloramine or chlorine and ammonia must be present. In addition, organic matter must be present. The most likely precursors of NDMA in SFPUC's water system are the cationic polymers applied at HTWTP and SVWTP for turbidity control. NDMA and other nitrosamines are not currently regulated. However, nitrosamines are likely candidates for future regulations. Therefore, it is important to proactively obtain data on NDMA levels in the SFPUC water system, and, if needed, develop measures to minimize NDMA levels.
Customer Interaction Widespread public concerns? Media coverage?	There is not significant, widespread concern. However, there are some customers who are concerned with chloramination. These customers may be concerned with nitrosamines. NDMA detections have been very low, especially when considering other common sources in most diets (meat, fish, milk, etc.). However, due to a PHG of 3 ng/L and a CA Notification Level of 10 ng/L, NDMA may be discussed in future PHG reports and/or CCRs. In the future, there is a potential for customer questions about NDMA.
Expected Outcomes What are the likely impacts of the investigation to SFPUC and its customers?	The investigation should have beneficial impacts to SFPUC and the customers as SFPUC can gather information supporting possible future regulatory compliance and develop cost-effective methods to minimize NDMA formation prior to an NDMA regulatory program.
Occurrence Data What is available	SFPUC has voluntarily monitored NDMA on a quarterly basis since 2004 (immediately following the conversion from chlorine to chloramine). From 8/2004 to 1/2011, NDMA was detected in 20 of 214 samples (approximately 9 percent of

occurrence information?	the samples). Of the detections, NDMA levels ranged from 2.1 ng/L to 4.6 ng/L, excluding one outlier in May 2010 of 12 ng/L in SVWTP effluent free chlorinated water, collected immediately after plant startup. As shown in the attached table, most of the detections were downstream of HTWTP (i.e., in the College Hill distribution system). This indicates that NDMA levels appear to increase with time/water age. The outlier of 12 ng/L was measured at SVWTP after the plant was off-line for one day. At plant start-up on 5/25/2010, the polymer was inadvertently overdosed by approximately twice the normal dose (a Cat-C dose of 3.3 mg/L versus the normal dose of 1.8 mg/L). No NDMA was detected in the Hetch Hetchy treated water source (85% of SFPUC supply) indicating limited amount of precursor material in this source. In addition to this voluntary NDMA sampling, under UCMR-2 (2008) six nitrosamines (NDMA, NDEA, NDPA, NDBA, NMEA, and NPYR) were monitored at five locations (HTWTP effluent, Irvington Portal, Mocho Shaft, SA3 Baden, and SSL Baden). None of the six nitrosamines were detected during UCMR-2 sampling. There has been one detection of NDEA. An NDEA level of 15 ng/L was measured at SVWTP effluent on 5/25/2010. This NDEA detect occurred during the temporary overdose of polymer, described above. Special sampling was conducted for N-nitrosodiphenylamine, a CCL3 contaminant, in 2003 and 2009. The 2003 data were collected at HTWTP_SED (1 sample) and the 2009 data were collected in response to a complaint (3 samples). These data were ND.
Supporting Information List and attach LIMS occurrence data and key references.	-SFPUC LIMS occurrence data on nitrosamines, 1/2001 to 1/2011 -SFPUC webpage, *Nitrosodimethylamine (NDMA) Information*, April 2007 -CDPH webpage, *NDMA and Other Nitrosamines - Drinking Water Issues*, December 2009 -Health Canada, Guideline Technical Document, *N-nitrosodimethylamine (NDMA) in Drinking Water*, March 2010 -Malcolm Pirnie, *Nitrosamine Regulatory Option Analysis, Key Points from September 27-28, 2010 Workshop*, 2010 -Mitch and Krasner, Water Research Foundation (WRF), *Occurrence and Formation of Nitrogenous Disinfection By-Products*, 2009. -Sacher, et al., AwwaRF, *Strategies for Minimizing Nitrosamine Formation During Disinfection*, 2008 -USEPA Integrated Risk Information System (IRIS), *N-Nitrosodimethylamine (CASRN 62-75-9)*, July 1993 -USEPA presentation (Burneson and Miller), *Potential Approaches for Addressing Groups of Contaminants under the SDWA*, September 21, 2010. -Valentine, et al., AwwaRF, *Factors Affecting the Formation of NDMA in Water and Occurrence*, 2006 -World Health Organization (WHO), *Guidelines for Drinking-Water Quality*, 2008

DIAGNOSTIC QUESTIONS					
WQ Component	**Questions**	**Yes**	**No**	**Unknown**	**Comments (if needed)**
1-Health (SFDPH)	**Is scientific knowledge on CEC health effects well developed?** *- Is scientific literature on health effects available (e.g., animal studies on carcinogenic and/or non-carcinogenic toxicity)?*	X			There has been significant health research on nitrosamines, in both drinking water and food sources. (see Health Canada report on NDMA, 2010)
	Adverse health impacts observed in other DW systems? *- Are public health studies documenting human health impacts (disease or outbreaks) available?*			X	USEPA is considering a national regulation for nitrosamines as a group (USEPA, 2010).
	Existing regulations or guidelines outside of US (e.g., WHO, EU)?	X			For drinking water, WHO has established an NDMA guideline of 100 ng/L (WHO, 2008). Health Canada has proposed an NDMA guideline of 40 ng/L (Health Canada, 2010).
	Existing US health advisories or CA notification levels?	X			NDMA, NDEA, and NDPA have California Notification Levels of 10 ng/L.
	Likely US regulation in the next 10 years? *- Is CEC on a regulatory development list, such as, CCL?* *- Is there a pending regulation or PHG?*	X			There are 5 nitrosamines on USEPA's CCL3. A PHG of 3 ng/L has been established for NDMA. A regulation, an MCL and/or treatment technique, for NDMA and other nitrosamines is likely.
	SIGNIFICANT TO PUBLIC HEALTH IN GENERAL?	**X**			
2-Occurrence (SFPUC)	**Is scientific knowledge on CEC sources/formation well developed?** *- Is scientific literature on sources/formation available?*	X			See references, above. Information is available, especially for NDMA. Information is less developed for other nitrosamines.
	Presence reported in other water supplies? *- Are occurrence studies available?*	X			There have been several occurrence studies by Water Research Foundation (formerly AwwaRF). See references, above.
	CEC present in SFPUC watersheds or source waters?		X		Watersheds are not impacted by

DIAGNOSTIC QUESTIONS					
WQ Component	**Questions**	**Yes**	**No**	**Unknown**	**Comments (if needed)**
	- Are there complex issues involved in managing the CEC in the watersheds (e.g. atmospheric deposition, non-point source pollution versus point source pollution)?				wastewater discharges, industrial pollution, or agricultural runoff. Manmade nitrosamines are not expected in the watersheds.
	Precursor present in SFPUC watersheds or source waters?			X	Natural organic matter (NOM) may be a precursor to nitrosamines formed during and after disinfection. Low levels of NOM (derived from plants, animals, and algal blooms) are naturally present in watersheds. However, the main precursor to nitrosamines appears to be treatment polymers, not NOM.
	Formed or added during current SFPUC treatment? *- Are there complex issues involved with controlling the formation or addition of CEC during treatment?*	X			NDMA is formed during disinfection by chlorination and chloramination. The main precursors in the SFPUC system appear to be the cationic polymers used for coagulation and filtration at SVWTP and HTWTP. NDMA has not been detected in treated Hetch Hetchy water. There are complex issues involved with reducing NDMA levels as the precursors to NDMA (polymers) are needed for coagulation and filtration performance. Operational changes could involve a modification to chemical dosing levels, a modification to the types of coagulant/flocculation chemicals used, and/or measures to reduce water age.
	Formed or added within SFPUC storage or distribution?	X			NDMA and other nitrosamines are disinfection byproducts and are formed during disinfection and distribution.

DIAGNOSTIC QUESTIONS					
WQ Component	**Questions**	**Yes**	**No**	**Unknown**	**Comments (if needed)**
	- Are there complex issues involved with controlling the formation or addition of CEC during storage or distribution?				NDMA levels appear to increase with water age, as College Hill Pressure Zone has consistently recorded higher concentrations than HTWTP effluent.
	POTENTIAL OCCURRENCE IN SOURCE WATER OR DISTRIBUTION SYSTEM?	**X**			
3-Treatment (SFPUC)	**Is scientific knowledge on CEC treatment/removal well developed?** *- Is scientific literature on treatment/removal available?*	X			There have been several treatment/removal studies by Water Research Foundation (formerly AwwaRF), especially for NDMA. See references, above.
	Likely to pass through current treatment for Hetchy Supply? *- Are there complex issues involved with the treatment/removal of CEC?*		X		NDMA has not been detected in treated Hetch Hetchy water. (due to lack of source water occurrence and lack of treatment formation, not due to removal by treatment)
	Likely to pass through current treatment at SVWTP? *- Are there complex issues involved with the treatment/removal of CEC?*	X			Formed during treatment. See Section 2, above.
	Likely to pass through current treatment at HTWTP? *- Are there complex issues involved with the treatment/removal of CEC?*	X			Formed during treatment. See Section 2, above.
	LIKELY TO PASS (NOT REMOVED BY) CURRENT TREATMENT?	**X**			

CURRENT ASSESSMENT	
Could CEC occur in SFPUC water at levels of possible health significance?	**Yes.** NDMA levels have been measured between 2 and 5 ng/L. NDMA has a PHG of 3 ng/L and a CA Notification Level of 10 ng/L.

(SFDPH & SFPUC)	
CEC Prioritization for SFPUC (High, Medium, or Low) (SFDPH & SFPUC)	**High priority.** Nitrosamines are a high priority because they are present in finished water (occasionally above the PHG of 3 ng/L), CA Notification Levels exist for three nitrosamines, and a future MCL is likely. EPA and/or CDPH will probably develop an MCL for NDMA (and other nitrosamines) as EPA has classified NDMA as a Class B2 carcinogen and CDPH has adopted a PHG. It should be noted, however, that despite the regulatory attention, NDMA in drinking water appears to be a minor source of a typical person's overall NDMA exposure/diet. According to one assessment, if only exogenous sources are considered, the relative source contribution from lifetime exposure to drinking water (assuming a mean NDMA concentration of 2.1 ng/L) is approximately 3% (Malcolm Pirnie, 2010)
Recommended Actions (Monitoring and Other Measures) (SFDPH & SFPUC)	Avoid polymer overfeed, provide free chlorine contact time before chloramination, maintain optimized treatment and minimize detention time in the distribution system, monitor quarterly for NDMA systemwide, and follow potential regulatory developments. WQD staff is involved in AWWA and WRF projects on nitrosamines.
Name(s) of Reviewer	SFDPH: June Weintraub SFPUC: Andrew DeGraca, Manouchehr Boozarpour, Andrzej Wilczak, Gregg Olson
Date of Review	March 3, 2011

Appendix B – Screening Evaluation for Pharmaceuticals and Personal Care Products

GENERAL INFORMATION ON CEC	
CEC Name	**Pharmaceuticals and Personal Care Products (PPCPs)**
CEC Description	PPCPs including: prescription and over-the-counter drugs, insect repellents, cosmetics, and soaps. PPCPs enter wastewater collections systems and are not completely removed by conventional wastewater treatment processes. Due to advances in analytical methods, trace PPCP concentrations (ug/L) can be detected in wastewater-impacted rivers. Emerging concerns include ecological and human health issues, with a focus on endocrine disrupting compounds (EDCs).
Grouping Is CEC a group or an individual CEC(s)? If individual CEC, which group is CEC part of? What is the basis for grouping? (USEPA's 4 grouping factors include: (1) similar health effects, (2) common treatment, (3) common analytical method, (4) monitoring/co-occurrence)	PPCPs is a group consisting of thousands of individual chemicals, most without analytical methods. Pharmaceuticals comprise approximately 1,000 compounds while cosmetics and additives comprise about 6,000 compounds. Recently developed and/or published methods based on state-of-the-art instrument technology are limited to approximately 70 to 100 PPCP analytes (OPC, 2009). PPCPs, though sizable and diverse, can be grouped for several reasons: many PPCPs have similar health concerns (endocrine disrupting compounds), PPCPs of concern may have common treatment approaches (e.g., ozonation for trace organics), and finally, PPCPs should have co-occurrence properties as they enter watersheds by the same pathways. For protected watersheds, such as, SFPUC's watersheds, demonstrating the absence of a handful of common PPCPs should provide an indication that other PPCPs (thousands) are also absent.
Indicators What are possible indicator contaminants?	Indicators are available in the Water Research Foundation (formerly AwwaRF) report *Toxicological Relevance of EDCs and Pharmaceuticals in Drinking Water* (Snyder, 2008) and the National Water Research Institute (NWRI) report *CECs in Southern California Water Sources* (Guo, 2010). Some possible indicators are listed, below. **WRF/AwwaRF - 2006** In the AwwaRF study, the most commonly detected pharmaceuticals in the raw water of the 19 water systems (as % of systems detecting chemical) were as follows: o Sulfamethoxazole, antibiotic (89%) o Meprobamate, anti-anxiety drug (84%) o Carbamazepine, anticonvulsant (74%) o Phenytoin, anti-epileptic (68%)

	o Gemfibrozil, cholesterol drug (58%) o Naproxen, pain killer (58%) o Trimethoprim, antibiotic (47%) o Diclofenac, anti-inflammatory (16%) **NWRI – 2008-9** In the NWRI study, the most commonly detected pharmaceuticals in the raw water of State Project Water (as % of detection frequency) were as follows: o Carbamazepine, anticonvulsant (88%) o Sulfamethoxazole, antibiotic (88%) o Primidone, anticonvulsant (70%) o Gemfibrozil, cholesterol drug (53%) o Phenytoin, anti-epileptic (50%) o Acetaminophen, pain reliever (5%) o Ibuprofen, pain reliever (3%) The NWRI study also looked at Colorado River Water and Santa Ana River (see attached table).
Advisories Does CEC have a USEPA Health Advisory (e.g., DWEL) or California Notification Level?	There are no USEPA health advisories or California Notification Levels for PPCPs in drinking water.
Regulatory Development Is CEC on USEPA CCL, UCMR list, or California PHG list?	USEPA's CCL3 includes 12 pharmaceuticals/hormones: 17alpha-estradiol, equilenin, equilin, erythromycin, estradiol (17-beta estradiol), estriol, estrone, ethinyl estradiol (17-alpha ethynyl estradiol), mestranol, nitroglycerin, norethindrone (19-Norethisterone), quinoline USEPA's UCMR3 (monitoring in 2013) will include 7 hormones: 17-alpha-Ethynylestradiol, 17-beta-estradiol, equilin, estriol, estrone, testosterone, and 4-andtrostene-3,17-dione. **PPCPs in Recycled Water** On December 15, 2010, the California State Water Resources Control Board (SWRCB) established its intent to implement recommendations from a CEC Advisory Panel (Drewes, 2010). SWRCB has proposed monitoring requirements for PPCPs (e.g., 17-beta estradiol, gemfibrozil, triclosan, DEET) when a system recharges an aquifer with recycled water. There are also proposed requirements for landscape irrigation with recycled water but these requirements

	focus on traditional parameters (chlorine, coliform, and turbidity). (SWRCB, 2010)
CONTEXT OF CEC INVESTIGATION AT SFPUC	
Statement of Goals Why is investigation undertaken?	PPCPs have been detected at trace levels (ng/L) in numerous water systems throughout the country, especially in source waters under the influence of wastewaters, and are an increasing area of research.
Customer Interaction Widespread public concerns? Media coverage?	Unlikely to impact customer satisfaction as long as SFPUC maintains source water protection. No current media coverage, however, in Spring 2008, the Associated Press (AP) published a series of articles on the 2006 AwwaRF study of 62 endocrine disrupting compounds (EDCs) and pharmaceuticals at 20 drinking water treatment plants in the USA. SFPUC was one of the utilities that participated in the study.
Expected Outcomes What are the likely impacts of the investigation to SFPUC and its customers?	As indicated by the 2006 AwwaRF study, it is unlikely that PPCPs will be detected in SFPUC source waters. Only limited monitoring, such as, monitoring under national surveys, can be justified.
Occurrence Data What is available occurrence information?	SFPUC participated in the 2006 AwwaRF study of 62 endocrine disrupting compounds (EDCs) and pharmaceuticals at 20 drinking water treatment plants in the USA. One round of sampling was conducted at HTWTP_RAW, HTWTP_EFF_POST, and SA#2_SAN_PEDRO. These sites were selected as representative of all SFPUC water sources. All compounds were non-detect except estrone and progesterone (natural hormones) which were detected at HTWTP_RAW at 0.21 ng/L and 2.5 ng/L, respectively. These compounds were not detected in finished water. The project's principal investigator estimated that SFPUC water is one of the most pristine drinking waters in terms of CECs. No other pharmaceutical studies have been conducted on the SFPUC water system. Between April 2008 and April 2009, the National Water Research Institute (NWRI) monitored State Project Water, Colorado River Water, and the Santa Ana River for EDCs and PPCPs. NWRI published a report on this research titled *Source, Fate, and Transport of Endocrine Disruptors, Pharmaceuticals, and Personal Care Products in Drinking Water Sources in California*, May 2010.
Supporting Information List and attach LIMS occurrence data and key references.	-SFPUC benchmark table comparing SFPUC data with other utilities in the 2006 AwwaRF Study -SFPUC benchmark table comparing 2006 SFPUC data with 2008-9 NWRI data -California Ocean Protection Council (OPC) et al., Report from Costa Mesa Workshop (April 28-29, 2009), *Managing Contaminants of Emerging Concern in California*, 2009 -Drewes et al., Recommendations to SWRCB from a Science Advisory Panel, *Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water*, June 25, 2010 -Fono and McDonald, AWWA Journal, *Emerging Compounds: A Concern for Water and Wastewater Utilities*, November 2008

	-Guo et al., NWRI report, *CECs in Southern California Water Sources*, 2010 -Snyder et al., AwwaRF, *Toxicological Relevance of EDCs and Pharmaceuticals in Drinking Water*, 2008a -Snyder et al., AwwaRF, *State of Knowledge of Endocrine Disruptors and Pharmaceuticals in Drinking Water*, 2008b -State Water Resources Control Board (SWRCB), *Staff Report, Constituents of Emerging Concern (CEC), Monitoring for Recycled Water,* November 8, 2010

DIAGNOSTIC QUESTIONS					
WQ Component	**Questions**	**Yes**	**No**	**Unknown**	**Comments (if needed)**
1-Health (SFDPH)	**Is scientific knowledge on CEC health effects well developed?** *- Is scientific literature on health effects available (e.g., animal studies on carcinogenic and/or non-carcinogenic toxicity)?*		X		Research on potential human health impacts is ongoing, especially with respect to endocrine disrupting chemicals (EDCs) and their impacts on vulnerable populations. (Fono and McDonald, 2008)
	Adverse health impacts observed in other DW systems? *- Are public health studies documenting human health impacts (disease or outbreaks) available?*		X		Potential human health impacts from PPCPs are an area of study, but human health impacts have not been identified. The only documented impacts from PPCPs are ecological impacts on aquatic organisms, mainly from endocrine disrupting compounds. (Fono and McDonald, 2008) According to Snyder et al., "The evaluation of toxicological relevance provided here indicates that, although some pharmaceuticals and potential EDCs were detected in U.S. drinking waters, there is no evidence of human health risk from consumption of these waters." (Snyder, 2008a)
	Existing regulations or guidelines outside of US (e.g., WHO, EU)?			X	

DIAGNOSTIC QUESTIONS					
WQ Component	**Questions**	**Yes**	**No**	**Unknown**	**Comments (if needed)**
	Existing US health advisories or CA notification levels?		X		None.
	Likely US regulation in the next 10 years? *- Is CEC on a regulatory development list, such as, CCL?* *- Is there a pending regulation or PHG?*		X		There are no pending regulations and a regulation in the next 10 years is probably unlikely. However, USEPA is studying the issue as the CCL3 includes 12 pharmaceuticals/hormones: 17alpha-estradiol, equilenin, equilin, erythromycin, estradiol (17-beta estradiol), estriol, estrone, ethinyl estradiol (17-alpha ethynyl estradiol), mestranol, nitroglycerin, norethindrone (19-Norethisterone), quinoline
	SIGNIFICANT TO PUBLIC HEALTH IN GENERAL?		**X**		
2-Occurrence (SFPUC)	**Is scientific knowledge on CEC sources/formation well developed?** *- Is scientific literature on sources/formation available?*	X			See Snyder (2008a, 2008b) and Guo (2010), above
	Presence reported in other water supplies? *- Are occurrence studies available?*	X			See Snyder (2008a, 2008b) and Guo (2010), above
	CEC present in SFPUC watersheds or source waters? *- Are there complex issues involved in managing the CEC in the watersheds (e.g. atmospheric deposition, non-point source pollution versus point source pollution)?*		X		Protected watersheds. Source waters are not impacted by wastewater discharges.
	Precursor present in SFPUC watersheds or source waters?		X		
	Formed or added during current SFPUC treatment? *- Are there complex issues involved with controlling the formation or addition of CEC during treatment?*		X		
	Formed or added within SFPUC storage or		X		

DIAGNOSTIC QUESTIONS					
WQ Component	**Questions**	**Yes**	**No**	**Unknown**	**Comments (if needed)**
	distribution? *- Are there complex issues involved with controlling the formation or addition of CEC during storage or distribution?*				
	POTENTIAL OCCURRENCE IN SOURCE WATER OR DISTRIBUTION SYSTEM?		**X**		
3-Treatment (SFPUC)	**Is scientific knowledge on CEC treatment/removal well developed?** *- Is scientific literature on treatment/removal available?*			X	Information is available for some PPCPs but removal efficiencies will vary by CEC (See Table 2, Fono and McDonald, 2008)
	Likely to pass through current treatment for Hetchy Supply? *- Are there complex issues involved with the treatment/removal of CEC?*	X			Hetchy utilizes chlorination as a primary disinfectant, which is not effective at oxidizing pharmaceuticals (with the exception of hormones which are easily oxidized by chlorine). The addition of UV for the Hetchy supply will not enhance trace organic removal.
	Likely to pass through current treatment at SVWTP? *- Are there complex issues involved with the treatment/removal of CEC?*	X			SVWTP utilizes chlorination as a primary disinfectant, which is not effective at oxidizing pharmaceuticals (with the exception of hormones which are easily oxidized by chlorine).
	Likely to pass through current treatment at HTWTP? *- Are there complex issues involved with the treatment/removal of CEC?*		X		HTWTP uses ozone which is effective at oxidizing trace concentrations of pharmaceuticals.
	LIKELY TO PASS (NOT REMOVED BY) CURRENT TREATMENT?	**X**			

CURRENT ASSESSMENT	
Could CEC occur in SFPUC water at levels of possible health significance? (SFDPH & SFPUC)	**No.** Previous monitoring has shown non-detects for PPCPs. The only exception is trace detections of estrone and progesterone in raw water during the 2006 WRF/AwwaRF study. These detections were likely due to naturally-occurring hormones from wildlife and/or vegetation, not pharmaceuticals. All finished water measurements were non-detect. According to Shane Snyder, project lead for the AwwRF study, "…in terms of steroid hormones, this is not a drinking water issue as the concentrations are exceedingly minute and the reaction between phenolic hormones and chlorine is very fast." (EPA Webcast: A New Framework for Addressing Contaminants as a Group, 7/28/2010)
CEC Prioritization for SFPUC (High, Medium, or Low) (SFDPH & SFPUC)	**Low priority**. PPCPs are a low priority because SFPUC has protected watersheds (source waters are not impacted by wastewater discharges).
Recommended Actions (Monitoring and Other Measures) (SFDPH & SFPUC)	Maintain source water protection, benchmark through national or state surveys, and maintain knowledge base. Any future monitoring should have rigorous QA/QC procedures and be part of state or national surveys.
Name(s) of Reviewer	SFDPH: June Weintraub SFPUC: Andrew DeGraca, Manouchehr Boozarpour, Andrzej Wilczak, Gregg Olson
Date of Review	March 9, 2011

Appendix C

Proposed Follow-up for CEC Groups

CEC Group	Priority	Justification	Proposed Follow-up
Microbials (e.g., associated with distribution system intrusion and biofilm regrowth)	High	Treatment and disinfection are optimized for *Giardia*, *Cryptosporidium* and virus inactivation/removal. Distribution system is optimized for Total Coliform Rule (TCR). Detention time in the distribution system is minimized, residual is maintained, and the likelihood of CEC survival and infection is small. However, USEPA and WRF are concerned about intrusion of regulated and unregulated microbial contaminants into distribution systems, and their regrowth. The Distribution System Research and Information Collection Partnership has been formed. Microbial CECs are strategic due to acute nature of pathogenic microbial contaminants and developing knowledge about new pathogenic organisms.	▪ Follow research and regulatory developments for distribution system. ▪ Develop knowledge base for CECs. ▪ Benchmark through national or state CEC surveys when these become available. ▪ Maintain syndromic surveillance with SFDPH. ▪ Optimize distribution system disinfectant maintenance. ▪ Install more mixers in smaller distribution system tanks. ▪ Continue chloramine monitoring. ▪ Complete potable fire hydrant protection project. ▪ Continue cross-connection program. ▪ Improve flushing program.
Nitrosamines	High	Cationic polymer treatment chemical is an NDMA precursor. No significant natural precursors for NDMA or other nitrosamines are likely present, based on SFPUC monitoring since 2004 and UCMR2 monitoring in 2008. Some customers are concerned about chloramine. Nitrosamines will likely be regulated in the future. NDMA has been detected (below CA NL) in the minority of samples. NDEA was detected in one sample.	▪ Maintain optimized treatment and minimize detention time in the distribution system. ▪ Minimize polymer doses. ▪ Continue quarterly monitoring for nitrosamines in plant effluent and distribution system. ▪ Follow regulatory developments.
DBPs (other than nitrosamines)	Medium	Treatment and disinfection are optimized to minimize regulated	▪ Maintain optimized treatment and minimize detention time in the

CEC Group	Priority	Justification	Proposed Follow-up
		DBPs. Detention time in the distribution system is minimized. Bromide and iodide are low in SFPUC source waters. In 2006, SFPUC participated in a USEPA survey of 5 iodoacids and 2 iodo THMs and the results were one of the lowest in the survey. USEPA may regulate additional chlorinated DBPs in the future.	distribution system. ▪ Benchmark through national or state surveys. ▪ Follow research and regulatory developments. ▪ Implement recommendations of treatment chemical quality control project.
Algal Toxins	Medium	Cyanobacteria are present in SFPUC source water reservoirs but the occurrence of algal toxins is minimal. Two rounds of reconnaissance level monitoring were conducted in the Summer/Fall of 2007 and 2010. To date, some algal toxins were detected at very low levels in East Bay reservoirs. No toxins were detected in Hetch Hetchy water or Peninsula reservoirs. Algal blooms may increase in the future due to climate change. Cyanobacteria blooms may coincide with taste and odor episodes, which could lead to customer complaints.	▪ Implement recommendations of Algae Monitoring and Mitigation Plan, July 2011. ▪ Monitor for algal toxins as needed.
Indirect Additives (trace detects from pipe and tank liners)	Low	Very few VOCs and SOCs are detected during soak tests. Detections have been below MCLs, if regulated, and mostly near detection limits. Only NSF 61 approved linings can be installed in SFPUC distribution system. Linings installed improperly and leaching CECs must be removed by the contractor.	▪ Review existing data and update procedures for soak tests. ▪ Conduct inspections, baseline tests and soak tests of new linings. ▪ In cases of detects, follow SFPUC's Manual of Procedures for Disinfection, Dechlorination, & Related Tasks.
Inorganics	Low	Unregulated, naturally-occurring metals (e.g., boron, vanadium) are present in watersheds. Levels are low and not a concern for future regulations.	▪ Maintain source water protection ▪ Monitor if justified
Pesticides (including herbicides, insecticides, fungicides, etc.)	Low	Not likely to be present in SFPUC source waters. Many have been monitored long-term and non-detects can serve as indicators of strong source water protection.	▪ Maintain source water protection ▪ Monitor if justified

CEC Group	Priority	Justification	Proposed Follow-up
Industrial Chemicals (e.g., SOCs & VOCs)	Low	Not likely to be present in SFPUC source waters. Many have been monitored long-term and non-detects serve as indicators of strong source water protection.	▪ Maintain source water protection ▪ Monitor if justified
Pharmaceuticals and Personal Care Products (PPCPs)	Low	Not likely to be present in SFPUC source water. In 2006 SFPUC participated in a WRF national survey of 62 PPCPs and EDCs in raw and finished water. Project investigator estimated that SFPUC water is one of the most pristine drinking waters in terms of PPCPs and EDCs. Non-detects from the survey can serve as indicators of strong source water protection. Customers are concerned about these CECs, which warrants benchmarking when appropriate surveys become available.	▪ Maintain source water protection ▪ Benchmark through national or state surveys ▪ Maintain knowledge base
Naturally Occurring Organics, e.g., Hormones	Low	Levels are unknown but we ingest natural hormones with diet. Monitoring would likely detect low levels (ng/L); e.g., estrone and progesterone that were detected in HTWTP raw water in 2006 WRF national survey. These hormones could have been naturally occurring. Estrone and progesterone were not detected in finished water. Chlorine easily oxidizes natural hormones.	▪ Maintain knowledge base
Fire Retardants	Low	Fire retardants used in materials (furniture, buildings, etc.) and fire extinguishers are not likely to be present in SFPUC source waters. Retardants used for fighting forest fires may end up in water supply, but only in rare situations.	▪ Maintain source water protection ▪ Benchmark through national or state surveys ▪ Investigate types of forest fire retardants and acceptable use areas
Engineered Nanomaterials	Low	Likely environmental pathways for nanomaterials include wastewater discharge and urban runoff, which are not associated with SFPUC's protected watersheds. However, the fate of nanoparticles is not well understood and advances in this field of study should be tracked.	▪ Maintain source water protection ▪ Develop knowledge base. ▪ Benchmark through national or state surveys when these become available

Appendix D – Literature Review References

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