DRINKING WATER FLUORIDATION

STATE OF THE DEBATE

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1.0 Executive Summary

This "white paper" presents SGM's summary of the current state of the drinking water fluoridation debate. Key takeaways include:

- Drinking water fluoridation has been practiced in the U.S. for 70 years on the basis of proven dental health benefits for which the evidence appears strong.
    - Benefits of drinking water fluoridation are biggest for children and lower-income populations
    - Benefits to dental health appear to exist even in today's world of high availability and use of fluoridated dental care products
- Even though the number of U.S. water systems artificially adjusting the fluoride level of their source water has been slowly declining, the percentage of the U.S. population receiving fluoridated drinking water has been steadily rising for more than 20 years.
- While water fluoridation is practiced in a number of other countries, only a small percentage of the world's population and that of western Europe, in particular, receives fluoridated water.
- To counteract the rising incidence of dental fluorosis in the U.S. population, likely due to increased overall exposure to fluoride, the U.S. Public Health Service recently lowered its recommended fluoride level for those systems choosing to fluoridate their water, to 0.7 mg/L from a range of 0.7 to 1.2 mg/L.
- A recent review by the independent, and well-qualified, National Research Council of the National Academy of Science found:
    - EPA should lower its Maximum Contaminant Level Goal of 4 mg/L to provide added protection against severe dental fluorosis, bone fractures, and skeletal fluorosis.
    - The Secondary Maximum Contaminant Level of 2 mg/L does not completely prevent the occurrence of moderate dental fluorosis.
    - The links between water fluoridation and other health effects, based on current scientific data, are weak/inconclusive. Additional research is warranted.
    - Subpopulations with renal disease are particularly sensitive to drinking water fluoride concentrations due to an increased tendency for fluoride to accumulate in their bones.
- There does not appear to be any credible scientific evidence that impurities in drinking water fluoridation chemicals or the inherent nature of those chemicals pose a significant health threat to drinking water consumers.
- Water utilities need to weigh overall pros (well-demonstrated dental benefits) and cons (chemical handling hazards for utility staff members and the potential for future discovery of clear negative health consequences beyond those known today of fluoride in drinking water) and other local political, economic, technical, and demographic factors to make well-informed, best-fit decisions regarding the addition of fluoride to their water supplies.

2.0 Introduction

2.1 Document Purpose

The purpose of this document is to provide unbiased information on drinking water fluoridation to SGM clients to assist them in making objective, well-informed decisions regarding fluoridation of community drinking water supplies. The hope is that the communities in which SGM works will reach best-fit decisions based on their specific circumstances and values. SGM does not believe there is a one-size-fits-all answer regarding drinking water fluoridation. In providing this information, we endeavor to equip drinking water utility policy-makers, managers, and operations staff with a base-level understanding of drinking water fluoridation-related science and the on-going fluoridation debate.

2.2 Analysis Context, Limitations and Approach

The volume of technical and scientific information on drinking water fluoridation, and fluoride, in general, is enormous. The same is true of the amount of information and arguments, pro and con, put forth by drinking water fluoridation proponents and opponents. The fluoridation debate is probably the longest-running, most emotionally- and politically-charged debates in the drinking water industry. Also, in many aspects of the drinking water fluoridation debate, the arguments by proponents and opponents center on the validity and details of the scientific process used by specific researchers. While it may be of value to our clients to have been able to provide an in-depth, comprehensive analysis of the individual primary research papers on this topic in order to "get to the bottom of" these fundamental research arguments, this has been largely beyond the scope of our current effort. Unfortunately, such an evaluation would require, it appears, devotion of the resources associated with development of a master's thesis or doctoral dissertation.

In light of the above, our analysis approach has tried to:

- present facts, where they exist
- shed light on what clearly seem to be poor pro/con arguments that we believe should not be given much, if any, weight in the local decision-making process
- give significant weight to findings of the most unbiased and well-documented sources
- offer summary information, and interpretation, where appropriate, on other elements of the debate
- provide our audience with a listing of resources, which they can review on their own in order to inform their own decision-making processes; we strongly encourage decision-makers to undertake their own research on this topic, and to listen to what those on both sides of the debate have to offer.

2.3 Document Format

As with many websites of fluoridation proponents and opponents, we have organized the content of this white paper into a set of questions and answers. We have attempted to pick the questions that are the most pertinent in the decision-making process.

3.0 Drinking Water Fluoridation Q&A

3.1 What is fluoride?

Fluoride is the monovalent anionic form (i.e. the ionic form with an electric charge of -1) of the atomic element fluorine. It is also a generic name used to refer to chemical compounds containing fluoride, such as naturally-occurring minerals and the natural and manufactured salts used in drinking water fluoridation. Fluorine is the 14th most common element in the Earth's crust (Wolfram Research, Inc. Staff, 2015), comprising roughly 0.065% of the crust's mass. The most common fluoride mineral is fluorite, a compound of calcium and fluorine (Withers, 2012).

3.2 Does fluoride exist naturally in drinking water sources?

Yes. Fluoride can, and does, occur naturally in public water systems as a result of runoff from the weathering of fluoride-containing rocks and soils and leaching from subsurface geological formations into groundwater.

In many western Colorado surface waters with which SGM is familiar, fluoride occurs in concentrations in the 0.1 to 0.4 mg/L range, which is less than the 0.7-mg/L level recommended by federal and state health organizations for tooth decay reduction purposes. Concentrations in groundwaters tend to vary more widely from place to place due to the extended contact of the groundwater with subsurface geological formations whose fluoride content varies. There are a number of water utilities in Colorado that need to remove fluoride in order to comply with federal and state limits.

Naturally-occurring fluoride sources are typically minerals, such as fluorite, as opposed to the manufactured silico-fluoride salts used in most drinking water fluoridation processes. Sodium fluoride can be a source of naturally-occurring fluoride and is also a commonly-used drinking water fluoridation salt. Fluoride can also enter water supplies via atmospheric deposition from fluoride-containing emissions from coal-fired power plants and other industrial sources.

3.3 What is drinking water fluoridation?

Drinking water fluoridation is the process of deliberately adding fluoride to the public drinking water supply to provide increased public health protection from dental caries, while minimizing increases in dental fluorosis. The practice typically involves fluoride addition at a water treatment facility in a quantity sufficient to bring the naturally-occurring fluoride concentration in the source water up to a target finished water fluoride value or range set by the water utility. The target is commonly established based on recommended levels from federal and state governmental health organizations.

3.4 What are the origins of drinking water fluoridation?

The research behind drinking water fluoridation had its origins in Colorado. In 1901, Dr. Fredrick S. McKay established a dental practice in Colorado Springs (Center of Disease Control (CDC) Staff, 1999). He found many people had brown stains on their teeth, called the Colorado Brown Stain by locals. He also found the discolored tooth enamel was more resistant to decay. It was found that the teeth of inhabitants of numerous other towns exhibited similar tooth discoloration including the Aluminum Company of America's company town Bauxite, Arkansas (National Institute of Dental and Craniofacial Research Staff, 2014). McKay had determined the cause of the brown stain was in the town's drinking water. In 1931, H. V. Churchill, a chief chemist at the Aluminum Company of America, found that the water from Bauxite contained fluoride. Churchill contacted McKay for water samples from the other towns, and the two men confirmed that high fluoride levels in drinking water led to the discoloration of teeth.

In the 1930s, Dr. H. Trendley Dean conducted a nation-wide investigation of drinking water fluoride levels and the incidence and degree of tooth decay and dental fluorosis. Dean discovered fluoride levels up to 1.0 ppm (mg/L) reduced dental decay, but did not cause dental fluorosis in most people.

In 1945, Grand Rapids, Michigan became the first city to deliberately fluoridate drinking water to improve dental health. After 11 years of fluoridation, it was discovered that dental caries rate had dropped more than 60 percent in the children born after Grand Rapids started adding fluoride to the drinking water supply; soon thereafter, many towns started water fluoridation (National Institute of Dental and Craniofacial Research Staff, 2014).

3.5 What is the current prevalence of drinking water fluoridation in the U.S.? What are the trends in the practice?

As of December 31, 2012, according to the CDC's Water Fluoridation Reporting System, which uses data provided by the states and U.S. Census Bureau population estimates:

- 211 million people in the U.S received fluoridated water through a community water system (CWS); this accounted for roughly two-thirds of the total U.S. population.
- 74.6% of all people in the U.S. served by CWSs received fluoridated drinking water.
  - Colorado's percentage was at 72.4%, ranking it 28th out of 50 states.
- 35.0% of the total number (52,734) of U.S. CWSs practiced fluoridation.

SGM analyzed trends in water fluoridation as reported by the CDC. Table 3-1 presents national data for a recent 20-year period. Table 3-2 presents Colorado data for a recent 12-year period. These results indicate:

- The fraction of the U.S. population receiving fluoridated water (i.e. water that is naturally or artificially fluoridated to levels at or above targets recommended by federal and state public health organizations) steadily rose through the period. This is true also for the fraction of the CWS-served population in the U.S.
- The same is true for the fraction of the total number of CWSs providing fluoridated water.
- The fraction (as well as the total number) of U.S. CWSs that were actively adjusting fluoride levels declined during the period and hovered in the 11% to 12% range in recent years.
- There was not a strong trend, either up or down, in the fraction of the CWS-served population in Colorado receiving fluoridated water. As a result, Colorado's percentage in that category has generally fallen lower in rankings among those of all states.

SGM offers the following hypothesis regarding contributing factors for the observed trends:

- Nationally, and world-wide, the percentage of people living in cities continues to rise.
- Utilities serving large cities are more likely to choose to fluoridate their supplies.

- Small systems make up the vast majority of the total number of CWSs nationally. Small systems typically have fewer resources to effectively manage fluoride and typically serve rural populations with more conservative political views.
- Therefore, while the fraction of total CWSs choosing to adjust fluoride levels is slowly falling as a result of slightly more smaller utilities electing to cease fluoridation than to begin it, the overall population and the population fraction receiving fluoridated water is increasing as a result of rapid growth in urban populations served by utilities who have chosen to continue fluoridating.

Table 3-1 U.S. Drinking Water Fluoridation Prevalence (1992-2012)

Year	% of Total US Population Served by Fluoridated Community Water Systems (CWSs)	% of US CWS-Served Population Receiving Fluoridated Water	% of All CWSs Serving Fluoridated Water	% of All CWSs Adjusting Fluoride Levels
1992	56%	62%	18%	14.5%
2000	57%	65%	No data reported.	
2002	60%	67%		
2004	62%	69%		
2006	61%	70%	31%	11.9%
2008	64%	72%	31%	11.1%
2010	66%	74%	34%	11.1%
2012	67%	75%	35%	11.4%

Table 3-2 Colorado Drinking Water Fluoridation Prevalence (2000-2002)

Year	% of Colorado CWS-Served Population Receiving Fluoridated Water	National Rank
2000	73.0%	25
2002	75.3%	25
2004	73.4%	27
2006	73.6%	26
2008	70.6%	30
2010	70.1%	31
2012	72.4%	28

3.6 What is the current prevalence of drinking water fluoridation outside the U.S.?

The total number of people receiving fluoridated water outside of the U.S. is similar to the total number receiving fluoridated water within U.S. borders. There are far more countries where drinking water fluoridation is not practiced than where it is. This is true even for developed nations with the resources to effectively implement drinking water fluoridation. Among the notable observations (Fluoride Action Network, 2012) related to global drinking water fluoridation and fluoridation, in general, are:

- Approximately 3% of the population of western Europe receives fluoridated water.
- Approximately 5% of the world's population receives fluoridated water.

- Countries outside the U.S. with significant populations to whom fluoridated drinking water is delivered are shown in Table 3-3, which also includes a list of notable countries where drinking water fluoridation is not practiced.

Table 3-3 Drinking Water Fluoridation Practices Outside the U.S.

Countries with Water Fluoridation (% of Population Receiving Fluoridated Water)	Countries without Water Fluoridation
United Kingdom (11%)	Austria (has salt fluoridation)
Spain (11%)	Belgium
Canada (44%)	Denmark
Australia (80%)	Finland
Brazil (41%)	France (has salt fluoridation)
Chile (70%)	Germany (has salt fluoridation)
Irish Republic (73%)	Greece
Israel (70%)	Iceland
New Zealand (62%)	Italy
Argentina (19%)	Luxembourg
Malaysia (75%)	Netherlands
Singapore (100%)	Northern Ireland
Hong Kong (100%)	Norway
South Korea (6%)	Portugal
Guatemala (13%)	Scotland
Guayana (62%)	Sweden
Panama (15%)	Switzerland (has salt fluoridation)
Papua New Guinea (6%)	India (high natural levels)
Peru (2%)	Japan
Serbia (3%)	China
Vietnam (4%)	
Brunei (95%)	
Libya (22%)	

- Fluoridation proponents note that no European country prohibits fluoridation, some areas in Europe have sufficiently high naturally-occurring fluoride levels, and a number of European countries have not pursued drinking water fluoridation due to the technical, legal, financial, or political reasons (American Dental Association Staff, 2005).
- Proponents also note that salt and/or milk fluoridation is practiced in a number of European and Latin American countries as an alternative to drinking water fluoridation (National Center for Chronic Disease Prevention and Health Promotion Staff, 2015).
- Fluoridation opponents indicate that many countries have forbidden or avoided drinking water fluoridation due to stated concerns regarding infringement on the right of personal choice, the addition of a “toxic” chemical to the water supply, and the difficulty in achieving an appropriate dose.

3.7 Does drinking water fluoridation provide public health benefits, especially in the U.S. today?

Based on the findings of many peer-reviewed scientific studies over a long period of time, there is overwhelming consensus within the U.S. public health community that drinking water fluoridation currently reduces tooth decay. This view is held by all, or nearly all, U.S. public health organizations, including both trade organizations and government agencies. An often-cited number is that fluoridation of drinking water reduces the incidence of dental caries by about 30%. There are also a number of controlled scientific studies conducted over the past 15 years that demonstrate water fluoridation's dental health benefits.

Fluoride reportedly achieves this effect by helping re-mineralize teeth by absorbing onto the tooth surface, then attracting calcium present in saliva. Fluoride also creates an acid resistant crystal surface on the tooth using calcium and phosphate. Fluoridated water also reduces cavity-causing bacteria's ability to produce tooth mineral dissolving acid (Center of Disease Control (CDC) Staff, 1999).

Fluoridated water makes teeth more resistant to decay by strengthening children's developing teeth before the teeth erupt (Wisconsin Dental Association Staff, 2012). Fluoridated water helps maintain erupted teeth by preventing decay, reversing the early stages of decay, and re-mineralizing teeth.

Fluoride opponents cite data that question the dental health benefits of drinking water fluoridation. Unfortunately, these data tend to be from efforts that did not generate publication of peer-reviewed results in scientific journals. One example includes an evaluation of World Health Organization data, which indicate that reductions in the rates of incidence of dental caries in recent decades in countries without salt or drinking water fluoridation have occurred at similar rates to those observed in the U.S. While this observation raises a question as to drinking water fluoridation's benefits, it does not stem from a controlled scientific study that accounts for other factors. Another example includes the results of a re-evaluation of the data from a large U.S. study of tooth decay in communities served fluoridated and non-fluoridated water. The re-evaluation of the data indicate that there was no difference in tooth decay rates among communities receiving fluoridated, non-fluoridated, or partially-fluoridated water. It is not clear why the work did was not published in a peer-reviewed scientific journal.

3.8 Does fluoride in drinking water provide benefits above and beyond the use of fluoridated toothpastes and rinses?

While fluoridated toothpastes are effective, at least one study found that fluoridated water reduced tooth decay by about 29 percent even when subjects used fluoridated toothpaste (Campaign for Dental Health Staff, 2014).

Fluoridated drinking water is considered the least expensive option for receiving recommended levels of fluoride and works to protect teeth topically and systemically (Fluoride Information Network). Fluoridated toothpastes expose teeth to fluoride topically, but since toothpaste is spit out, it does not work systemically. Furthermore, fluoridated toothpastes and mouth rinses are not typically used regularly throughout the day.

Alternatives to fluoridated water are fluoride tablets, fluoride mouth rinse, and topically applied high dose fluoride. Fluoride tablets and fluoride mouth rinses are expensive, require high doses, and topical exposure of fluoride to teeth is limited. Topically-applied high dose fluoride has to be performed by a medical or dental professional.

Fluoride is also beneficial to bones up to a point; however, the optimum levels for bone are higher than the levels for teeth (Linus Pauling Institiute Staff, 2012).

3.9 Whom does drinking water fluoridation benefit the most?

While fluoridated drinking water has been demonstrated to provide dental health benefits across many demographic categories, it appears to provide the most benefits to children and lower-income populations. The benefits to children are due to the effects of fluoride incorporation into teeth and their enamel during the period of maximum growth. Lower income populations tend to have less ability to access regular dental care and products. Fluoridating water to prevent cavities costs about 50 cents per cavity (Fluoride Information Network). Before insurance, a filling for a cavity costs from $110 to over $200 (Braces Info Staff, 2014).

Based on these considerations, a stronger case for drinking water fluoridation can be made in communities with significant numbers of children and lower-income families.

3.10 What is the U.S. government's recommended "optimal" level for fluoride in drinking water?

As of 2015, the U.S. Public Health Service (PHS) recommends an optimal fluoride concentration of 0.7 mg/L (U.S. Department of Health and Human Services Federal Panel on Community Water Fluoridation Staff, 2015) for communities that choose to fluoridate. In this context, one milligram per liter (mg/L) is equal to approximately one part per million by weight. This fluoride concentration is the optimum level for dental health (American Dental Association Staff, 2005). PHS describes the 0.7-mg/L target as providing an optimal balance in protection from dental caries while limiting the risk of dental fluorosis.

Prior to 2015, PHS recommended an optimal range of 0.7 to 1.2 mg/L. This range was established in 1962 with different fluoride targets for different regions of the country based on mean air temperature. It was assumed at the time that average water consumption would vary with air temperature. However, this did not turn out to be the case. Furthermore, overall fluoride exposure has increased since the original recommendations were made. Importantly, the target was revised downward due to observed upward trends in the incidence and severity of dental fluorosis in the U.S.

Fluoride opponents point-out that the concept of a recommended uniform fluoride concentration in drinking water is flawed because:

- fluoride doses for humans are most meaningful when expressed in terms of mass of fluoride consumed per day per unit body mass
- even on that basis the levels of fluoride consumption that yield positive and negative health outcomes differ for different individuals
- different individuals drink different amounts of water on a daily basis
- therefore, achieving an optimal fluoride consumption dose for individuals cannot be achieved through uniformly-fluoridated water

3.11 What are the well-established health risks of excessive fluoride ingestion from drinking water?

Although the rate varies from person to person, roughly fifty percent of fluoride ingested by adults is ultimately incorporated into bone, including teeth. Furthermore, a drinking water fluoride concentration of 2 mg/L contributes 57% to 90% of the total fluoride exposure of the average U.S. adult. Drinking water therefore represents the largest source of fluoride exposure to the U.S. population. Other sources of fluoride ingestion include, in descending order of importance: food sources, beverages other than tap water (which are often made with tap water), dental products/toothpaste, pesticide residues, pharmaceuticals and consumer products. The known health risks of fluoride ingestion are:

- Dental (or "enamel") fluorosis: This dose-related mottling of enamel that can range from mild discoloration of the tooth surface to severe staining and pitting is the most common negative impact from fluoride exposure via drinking water. The condition is permanent when it develops in children during tooth formation, a period ranging from birth until about the age of 8. Excessive fluoride exposure between the ages of 6 months and 3 years has the most pronounced effect. In its mildest form, enamel fluorosis can be present as thin, white streaks, detectable only under close dental examination by health professionals. In its severest form, it is characterized by dark yellow to brown staining and discrete and confluent pitting, constituting enamel loss. Its mild and moderate forms are generally considered only aesthetic, not true health impacts. Severe cases, due to the compromises in the protective function of the enamel as well as the negative psychological effects from a degradation in personal appearance, have been considered to have truly negative health consequences. Drinking water fluoride levels less than 1.5 to 2.0 mg/L are associated with very limited incidence and severity of dental fluorosis.

- Skeletal fluorosis: a bone and joint condition associated with prolonged exposure to high fluoride intake, typically in excess of 20 mg/day for 20 years, or more [note that 20 mg/day would require daily consumption of 2 liters of water containing 10 mg/L of fluoride]. Fluoride increases bone density and appears to exacerbate the growth of bone spurs in the bone and joints, resulting in joint stiffness and pain. The condition is categorized into one of four stages: a pre-clinical stage and three clinical stages that increase in severity. The most severe stage (clinical stage III) is referred to as the "crippling" stage. Few clinical cases of skeletal fluorosis in healthy U.S. populations have been reported in recent decades.

- Bone Fractures: although not as well-established as dental and skeletal fluorosis, the link between excessive fluoride consumption and an increased risk of bone fractures appears to be evident. There are biologically-plausible mechanisms by which fluoride can weaken bone and both observational studies of human populations and animal studies that support this link. This effect is particularly strong for populations (i.e. those with renal disease) prone to accumulate fluoride into their bones at an increased rate.

3.12 What other health concerns have been raised with fluoride ingestion from drinking water?

The strong, one-sided viewpoints of fluoridation advocates and detractors alike makes the truth in this area difficult to discern. For this reason, this summary relies heavily on the findings of the National Research Council of the National Academy of Sciences, which in 2006 issued a report documenting its review of the suitability of federal drinking water fluoride limits to protect public health against negative health outcomes from drinking water fluoride exposure. The NRC performed a comprehensive review of all the science executed since its previous review of the fluoride standards in 1993. SGM believes the 2006 NRC review to be the most objective analysis available to-date of the science of fluoride health effects. **Table 3-4** summarizes the committee's finding related to health outcomes other than dental and skeletal fluorosis and bone fractures.

Table 3-4 Summary of Outcomes of 2006 NRC Review

POTENTIAL ADVERSE HEALTH IMPACT	SUMMARY OF NATIONAL RESEARCH COUNCIL'S REVIEW FINDINGS
Reproductive and Developmental Effects	Many studies on animals have been conducted. Results from these indicate only "very high" fluoride concentrations might lead to adverse outcomes. Only a few human studies available, which suggest that "high" concentrations of fluoride might be associated with alterations in reproductive hormones, fertility, and developmental outcomes; however, but studies are insufficient for risk evaluation.
Neurotoxicity and Neurobehavioral Effects	Animal studies have shown deficits in motor coordination and species-typical behaviors due to fluoride exposure. Chinese epidemiological studies of populations exposed to 2.5 to 4.0-mg/L in drinking water have reported IQ deficit effects. However, the studies lacked sufficient detail and suffered from experimental design flaws to allow for extrapolation to US populations. Studies on molecular, cellular and anatomical changes in the nervous system due to fluoride exposure suggest that functional effects could occur, maybe under certain physiological or environmental conditions. Further research on IQ effects and brain chemistry/function is warranted.
Endocrine Effects	Numerous endocrine effects of fluoride exposure are possible. Some could be possible with drinking water at 4 mg/L, or less, especially for young children and high water intake individuals. Many of the effects could be sub-clinical (i.e., no adverse health effects). However, there is the possibility that adverse effects could be observed due to relatively minor hormonal imbalances. Further research is needed.
Other Organ System Effects	Other Organ System Effects – for drinking water with 4 mg/L of fluoride, or less, there is unlikely to be a risk to gastrointenstinal, kidney, liver and immune systems. Subpopulations with renal impairments (kidney diseases), who tend to retain more fluoride than healthy individuals, could have increased risk of gastrointestinal irritation, renal tissue effects, and altered hepatic and immunological impacts.
Genotoxicity and Carcinogenicity	Based on the committee's collective consideration of data from humans, genotoxicity assays, and studies of mechanisms of action in cell systems (e.g., bone cells in vitro), the evidence on the potential of fluoride to initiate or promote cancers, particularly of the bone, is tentative and mixed. Assessing whether fluoride constitutes a risk factor for osteosarcoma is complicated by the rarity of the disease and the difficulty of characterizing biologic dose because of the

	ubiquity of population exposure to fluoride and the difficulty of acquiring bone samples in non-affected individuals.

Table 3-4 indicates that the evidence to-date for links between human health impacts and exposure to fluoride in drinking water are weak to mixed and insufficient for performing the risk assessments upon which sound public policy should be based. However, the NRC did not reach the conclusion that none of these potential health impacts could exist, and more often than not, it indicated that more scientific research using improved methods is warranted and would benefit future reviews of the federal standards. This runs counter to the position that many fluoride advocates make that more research on potential negative health impacts is unnecessary. That said, it is important to note that the NRC was charged with reviewing these potential health impacts in an evaluation of the federal standards for fluoride in drinking water, which currently are set at 2 mg/L and 4 mg/L. Thus, a review of science related to the potential negative health outcomes associated with drinking water at fluoride concentrations near the recommended level of 0.7 mg/L is even less likely to yield findings that implicate water fluoridation as a source of significant risk in these areas.

3.13 Does drinking water fluoridation increase the rate lead leaching from pipes into drinking water?

Concerns have been raised about fluoride leaching lead from pipes into drinking water. Dr. Roger Masters published studies in 1999 and 2000 claiming water fluoridated with silicofluorides leach lead from pipes into water (American Dental Association Staff, 2005). The EPA reviewed Master's study and found the chemical assumptions made and statistical methods used were scientifically unjustified, the research was inconsistent with accepted scientific knowledge and Masters failed to acknowledge the inconsistencies. The EPA concluded that there was no credible evidence showing fluoridation leached lead into the drinking water.

3.14 What are the state and federal limits for fluoride drinking water?

The following are EPA's federal standards for fluoride in drinking water:

- Secondary Maximum Contaminant Level (SMCL): 2 mg/L (non-enforceable)
- Maximum Contaminant Level (MCL): 4 mg/L (enforceable)
- Maximum Contaminant Level Goal (MCLG): 4 mg/L

The State of Colorado has adopted the SMCL and the MCL. The MCLG is the goal EPA sets without consideration given to technical and economic factors. Because these factors have not been considered to be a significant impediment to reducing high source water fluoride concentrations, EPA has set the enforceable MCL equal to the MCLG. EPA set the SMCL and the MCLG/MCL in 1986 on the following basis:

- SMCL of 2 mg/L: to limit the incidence of severe dental fluorosis to near-zero levels and to control the incidence of moderate dental fluorosis to 15% or less.
- MCLG/MCL of 4 mg/L: to limit the risk of crippling skeletal fluorosis.

EPA is currently re-evaluating its fluoride limits as part of a regular Safe Drinking Water Act (SDWA)-mandated 6-year review of drinking water standards. This review was also supported by the 2006 findings of the NRC, which EPA asked to evaluate the adequacy of its current MCLG and SMCL for fluoride to protect public health. The NRC conducted this evaluation and made the following recommendations:

- Regarding the MCLG: "The MCLG should be lowered in light of the collective evidence on various health end points and total exposure to fluoride. Lowering the MCLG will prevent children from developing severe dental fluorosis and will reduce the lifetime accumulation of fluoride into bone that the majority of the committee concludes is likely to put individuals at increased risk of bone fracture and skeletal fluorosis, which are particular concerns for sub-populations prone to accumulating fluoride in their bones."

  "To develop an MCLG that is protective against severe dental fluorosis, clinical stage II skeletal fluorosis and bone fractures, EPA should update the risk assessment of fluoride to include new data on health risks and better estimates of total exposure (relative source contribution) for individuals. EPA should use current approaches for quantifying risk, considering susceptible subpopulations, and characterizing uncertainties and variability."

- Regarding the SMCL: "The prevalence of severe enamel fluorosis is very low (near zero) at fluoride concentrations below 2 mg/L. From a cosmetic standpoint, the SMCL does not completely prevent the occurrence of moderate enamel fluorosis. EPA has indicated that the SMCL was intended to reduce the severity and occurrence of the condition to 15% or less of the exposed population. The available data indicate that fewer than 15% of children will experience moderate enamel fluorosis of aesthetic concern (discoloration of the front teeth) at that concentration. However, the degree to which moderate enamel fluorosis might go beyond a cosmetic effect to create an adverse psychological effect or an adverse effect on social functioning is not known.

SGM recently contacted the Regulatory Affairs Coordinator of the American Water Works Association for an update on EPA's fluoride standards review process. As of May 2015, EPA is currently working on the risk assessments. A projected completion date is unknown at this time.

3.15 What are the most common chemicals used for drinking water fluoridation?

The most common chemicals used for drinking water fluoridation are listed in Table 3-5 along with selected data.

Table 3-5 Common Drinking Water Fluoridation Chemicals

Parameter	Sodium Fluoride	Sodium Fluorosilicate	Fluorosilicic acid
Chemical formula	NaF	Na2SiF6	H2SiF6
Physical form	Dry, coarse, granular crystalline solid	Dry, fine granular solid	Liquid
Typical Purity	97 to 99%	>98%	20 to 23%
Typical Impurities	Water, acids/alkalis, sodium fluorosilicate, sulfites, iron, trace others	Chlorides, water, colloidal silica	water
Production Method		Manufactured from fluorosilicic acid	Manufactured from phosphate-containing

			rock as a byproduct of phosphate fertilizer production. Rock is mixed with sulfuric acid to produce F-containing gasses, which are passed through scrubbers, reacting with
Relative Cost	Highest	Middle	Least Expensive

3.16 Do drinking water fluoridation chemicals present important health concerns?

Water treatment plant staff members must exercise great care and take the proper precautions when working with the concentrated forms of drinking water fluoridation chemicals that are used in the water treatment process. This is true for many drinking water treatment chemicals, including various forms of chlorine, such as chlorine gas and bulk sodium hypochlorite, and common oxidants, such as potassium and sodium permanganate, ozone and chlorine dioxide. Operators are trained in proper handling methods, the use of personal protective equipment, and emergency response protocols in order to safely handle the many different types of chemicals used in water treatment.

Fluoridation opponents regularly point to the fact that fluoridation chemicals arriving in bulk form at the water treatment plant are “toxic” or “hazardous.” It is important to note that any substance can be considered toxic or hazardous – it all depends on the concentration and/or total amount of the substance being contacted or ingested. Pure water can be toxic to humans if consumed in excessive quantities. Many water treatment chemicals are considered toxic and/or hazardous. The concentration of the chemical as present in drinking water, and the associated health benefits and negative consequences at that concentration, are what is relevant. There is little debate regarding the benefits of drinking water chlorination despite the fact that chlorine gas and concentrated bleach are understood to be toxic and/or hazardous in their bulk form.

As with any water treatment chemical, impurities are introduced to sodium fluoride, sodium fluorosilicate, and fluorosilicic acid during their respective production processes. However, the State of Colorado requires that all chemicals introduced to the drinking water supply meet the requirements of NSF/ANSI Standard 60, “Drinking Water Chemicals – Health Effects.” This standard establishes strict limits for maximum allowable concentrations of impurities based on health risk assessments. It also requires annual third-party testing of the composition of certified chemicals and unannounced inspections of production and distribution facilities to ensure proper formulation, packaging and transport safe guards to protect against potential contamination. NSF fluoridation product testing results indicate very low levels of impurities of concern exist in water fluoridation chemicals. In fact, the majority of fluoridation products as a class, based on NSF test results, do not contribute even measurable amounts of arsenic, lead, other heavy metals or radionuclides to drinking water.

3.17 How much does drinking water fluoridation cost?

The cost of community fluoridation depends on the size of the community, number of fluoride injection points, amount and type of fluoridation equipment, type of fluoride used, and expertise of water plant personnel (American Dental Association Staff, 2005). The American Dental Association estimates, “For most cities, every $1 invested in water fluoridation saves $38 in dental treatment costs.” Fluoride Information Network states the cost of fluoridating Arcata Water is 50 cents per year per person.

3.18 What are the environmental impacts of water fluoridation?

Studies by the European Union’s SCHER (Scientific Committee on Health and Environmental Risks) found marine invertebrates – the most sensitive aquatic organism – felt adverse effects at or above 2.9 mg/L of fluoride (European Union Staff, 2010).

Fluorosilicic acid and sodium fluorosilicate are created by passing the gases created during the manufacture of phosphate fertilizers through scrubbers. The phosphate fertilizer plants use scrubbers to prevent and control air emissions (International Finance Corporation Staff, 2007).

3.19 Is water fluoridation a form of mass medicine?

Fluoride is a mineral that strengthens teeth. Pro-fluoridation groups often compare water fluoridation to adding vitamin D to orange juice, iodide to table salt, or folic acid to breakfast cereal. However, individuals have many relatively inexpensive options for consuming orange juice, salt and cereal without these additives. It is much more difficult and expensive for an individual living in a fluoridated area to consume ufluoridated water. Therefore, whether or not water fluoridation is deemed “mass medication,” it does reduce one’s freedom of choice from a practical perspective.

3.20 Is water fluoridation legal under the U.S. Constitution?

The legality of water fluoridation has been challenged in the U.S. court system multiple times since 1952. Cases were generally brought based on:

- Constitutional rights infringement (1st, 10th, and 15th amendments)
- Violation of religious freedom
- Violation of pure food acts
- Abuse of municipal authority
- Unreasonable and/or unnecessary measure
- Wasteful or illegal use of public funds
- Unsafe measure or nuisance
- Availability of alternatives (sources of F)
- Breach of contract
- Class litigation (only children benefit)
- Deprivation of fundamental liberties

Fluoridation was upheld by the courts in all cases, including in the highest courts in 12 states. States in 25 states have affirmed the legality of water fluoridation. The U.S. Supreme Court has refused to hear water fluoridation cases eight different times on the basis that “no constitutional question was involved.”

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