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Fluoridation in the City of Santa Clara: A Cost Benefit Analysis for the City of Santa Clara Potable Water System

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by

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INTRODUCTION

This paper discusses fluoridation and potable drinking water. The history of fluoridation section discusses when naturally occurring fluoride was first discovered in drinking water and how impacts to dental health brought about the federal regulation relating to fluoridation. The policy analysis section takes a closer look at how the federal regulation impacts the state and local level government. The policy analysis section also discusses two historical health studies, conducted in the mid 20th century, which shaped the future of fluoridation. The policy analysis section also examines how both the public and dental organizations view fluoridation. Lastly, the cost benefit analysis of the paper discusses the City of Santa Clara (City) and the need for additional fluoridation. The main focus of the paper is the estimated cost to fluoridate the potable drinking water system in the City of Santa Clara and the potential public benefit from such fluoridation. The paper also discusses advantages and disadvantages, most importantly it places a quantitative value on whether or not the City of Santa Clara should fluoridate the potable water system.

Cost Benefit Analysis

The City of Santa Clara Water Utility manages four water sources including San Francisco Public Utilities (SFPUC) water (fluoridated water), Santa Clara Valley Water District (no fluoridation), City water wells (no fluoridation) and recycled water (for non-potable uses), serving approximately 111,997 people within the City's service area. (Census, 2009) The City of Santa Clara distributes both fluoridated and non-fluoridated water to the public. Currently, all groundwater wells and imported Santa Clara Valley Water District are non-fluoridated water and make up approximately 80% of the City's total water supply. Based on the added benefits of fluoridated water, and the fact the SFPUC already fluoridates water used by the City of Santa

Clara, this cost benefit analysis was conducted to determine whether the City of Santa Clara should fluoridate the remaining two potable drinking water sources. The analysis and research examined the benefits, impacts and costs associated with implementing a City wide fluoridated drinking water program. Examining how the current state policy would impact the City, including amending current permits, measuring and monitoring fluoridation and capital improvements were also considered. This assessment provided basic answers to the following questions:

- If the City of Santa Clara implemented fluoridation treatment systems at its 28 groundwater wells and the Santa Clara Valley Water District Turnout, what would be the infrastructure (capital) and annual maintenance and operations costs?
- What revenues are needed to finance capital costs and annual operations and maintenance costs and how does that translate into a potential water rate increase?
- What would be the cost benefit ratio of implementing fluoridation throughout the entire potable water system in the City of Santa Clara?
- What would be the general concerns from local citizens and what other concerns or support must be considered from both proponents and those who oppose fluoridation?
- Should the City of Santa Clara fluoridate the drinking water system based on the cost benefit analysis and other supporting information, including public policy, economic factors, and regulations?

The analysis was designed to answer these five questions and provide the Water Utility with valuable information regarding the two remaining non-fluoridated potable water sources in the City. Throughout the years, several utilities in the San Francisco Bay Area have considered implementing fluoridated water in their public water systems. Should the City of Santa Clara decide to, or even consider, implementing fluoridation of potable water, this research provides a valuable analysis describing both anticipated financial and socioeconomic impacts.

LITERATURE REVIEW

History of Fluoridation

The discovery of naturally occurring fluoride in drinking water dates back to 1901, when Dr. Frederick S McKay, a dentist in Colorado Springs, discovered permanent brown staining on his patients teeth, which he called "Colorado brown stain". McKay studied the permanent staining, known as "mottled enamel", and determined it was linked to an agent (fluoride) common in the drinking water. Although the mottled enamel was present, McKay studied his patients and concluded that those with mottled enamel had lower incidence of dental caries (cavities). In 1909, another discovery of naturally occurring fluoride in a drinking water source was discovered by another dentist, Dr. F.L. Robertson, in Bauxite, Arkansas, where the same mottled enamel staining was noticed. The mottled enamel in Bauxite was later attributed to local well water, as a result the drinking water well was abandoned in 1927 by local officials. (Centers of Disease Control and Prevention, 1999)

Both McKay and Robertson were the first to see the effects of fluoridated water on dental health. In 1930 chemist W.R. Churchill analyzed naturally fluoridated water samples sent from McKay. Churchill's investigation included spectrographic analysis of fluoride in both water and soil. Churchill concluded that the samples sent by McKay had high levels of fluoride, between 2.0 - 12.0 parts per million (ppm). Previous work by Churchill found that naturally occurring fluoride is prevalent in water, but in very low concentrations (less than 1.0 ppm). (Centers of Disease Control and Prevention, 1999) Additional studies ensued throughout the 20th century, and it was collectively shown that the ideal range for fluoride in drinking water which prevents caries while suppressing mottled enamel, also known as dental fluorosis, is between 0.7 to 1.2 mg/L. (American Water Works Association, Fluoride, 2009)

Fluoridation Policy

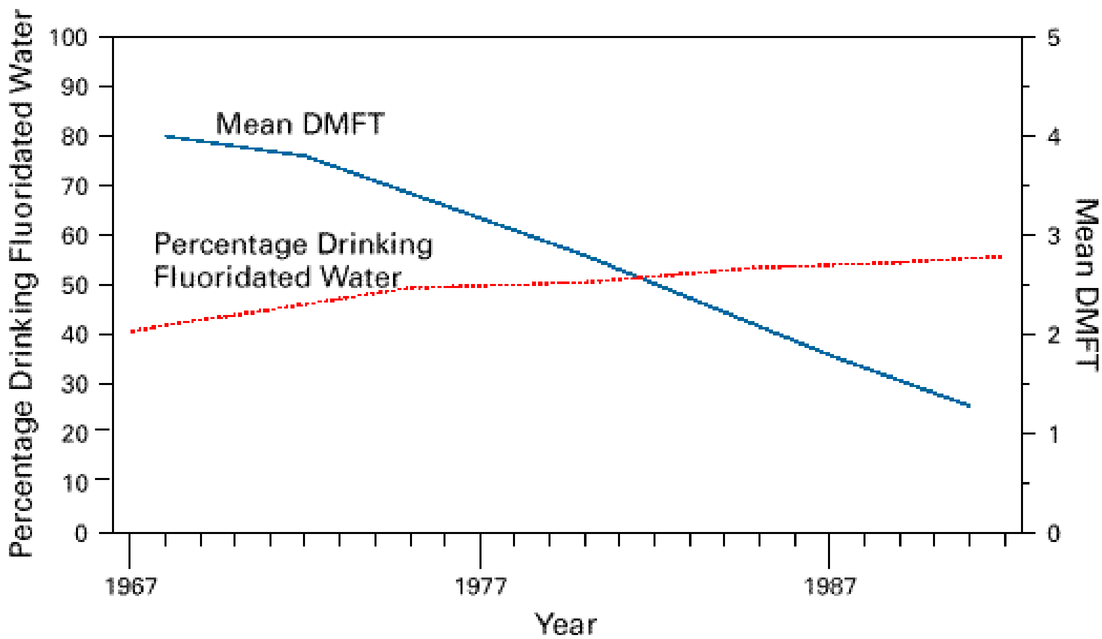
Fluoridation Studies

In 1931, a major epidemiologic study was conducted by Dr. H. Trendley Dean of the Dental Hygiene Unit at the National Institutes of Health. Dean's first investigation was observational epidemiologic surveys throughout the United States where he created the fluorosis index, which categorizes the affects of dental fluorosis. The fluorosis index is as follows: when less than or equal to 25% of tooth surface is impacted it is categorized as very mild fluorosis, 26%-50% of tooth surface impacted is categorized as mild fluorosis, and severe fluorosis is categorized as many brown stains and pitting of the teeth. Dean used the fluorosis index and the data collected in 26 states in the United States in his research. Data collected included the number of decayed, missing or filled teeth (DMFT) in the 26 states. Dean discovered a significant and strong inverse relationship between DMFT and incidence of dental fluorosis. The finding was reaffirmed with a cross-sectional study conducted in Ohio, Indiana, Illinois and Colorado. The cross-sectional study discovered that cavities among children with more fluoride in their water supplies were lower. It was also discovered that, when concentrations of greater than 1.0 ppm of fluoride were used, the association between cavities among children with more fluoride in their water was lower and therefore a weaker association. The study also showed that at 1.0 ppm of fluoride there were fewer and more mild cases of dental fluorosis. (Centers for Disease Control and Prevention, 1999)

A second epidemiologic study conducted in the second half of the 20th century by the Centers for Disease Control and Prevention (CDC), between 1966 to 1994, showed that the

DMFT of children age 12 declined from 4.0 in 1966-1970 to 1.3 in 1998-1970, see Figure 1: Population Percentage with Drinking Water (CDC, 1999) below.

FIGURE 1. Percentage of population residing in areas with fluoridated community water systems and mean number of decayed, missing (because of caries), or filled permanent teeth (DMFT) among children aged 12 years — United States, 1967–1992



This 68% decline in DMFT's was largely seen as the result of community water fluoridation. After this data and evaluation were released several organizations including the World Health Organization, the American Medical Association, and the American Dental Association endorsed water fluoridation. At this time the promotion and introduction of fluoride into other products, such as toothpaste, mouth rinses, tablets, drops and even food, increased. (Centers for Disease Control and Prevention, 1999)

Since the introduction of fluoridation into community water supplies, the positive impacts of fluoridated water have decreased over time. Studies in the 1980's have shown that the DMFT's were 18% lower than those without fluoridation. Studies show the decline occurred due to the introduction of fluoride into bottled water, processed foods, beverages and toothpaste. (Centers for Disease Control and Prevention, 1999) According to the Centers for Disease

Control and Prevention, studies show the number of dental caries, also known as decayed, missing or filled surfaces (DMFS), without fluoridated drinking water is approximately 1.5 DMFS's, whereas the number of DMFS's with fluoridated drinking water is approximately 0.8, for children between the ages of 6 and 13 years old. The difference is 0.7 DMFS's prevented by the introduction of fluoride in public drinking water. (Centers for Disease Control and Prevention, 2001) Although fluoridated water in the 1960's to 1970's made a significant impact on dental health, the impact since the 1980's cannot be attributed solely to fluoridated water supplies. The cumulative impact of fluoride to dental health today can now be attributed to various sources, including both fluoridated water and consumer products.

Dr. Dean's cross-sectional studies from Ohio, and a second epidemiologic study by CDC, have quantified positive impacts to dental health of fluoridation in water supply in amounts between 0.7 to 1.2 ppm, however fluoride concentration over 1.0 ppm can increase the likelihood of dental fluorosis. Additionally, the shift in 1980's to use fluoride in other consumer products adds another level of uncertainty to determining the actual level of fluoride ingested by the consumer. Lastly, medical advancements with dental health, dental awareness and hygiene in recent years would also contribute to the variation in DMFT's.

By 1962 the United States Public Health Services encouraged the addition of fluoride to drinking water in doses between 0.7 to 1.2 mg/L. The fluoride concentration range was developed to include dosage adjustment for climate, where colder regions use a higher fluoride dose assuming consumers ingest less water, and hot climate regions use lower fluoride doses assuming consumers ingest more water. (American Water Works Association, Fluoride, 2009) Nearly a decade later, the United States Environmental Protection Agency (USEPA), promulgated the Safe Drinking Water Act (SDWA) in 1974. The SDWA enabled the USEPA to develop national health standards for potable water contaminants, that are naturally occurring, such as fluoride, and man-made. The drinking water standards are categorized as primary drinking water standards and secondary drinking water standards. Primary drinking water standards are set to protect the health of consumers, whereas secondary drinking water standards are for aesthetics such as taste and odor. The primary and secondary drinking water standards for fluoride are 4 mg/L and 2 mg/L respectively. (SWDA) According to the USEPA, drinking water containing more than 4 mg/L of fluoride could cause bone disease, and drinking water with more than 2 mg/L could cause moderate to severe dental fluorosis. The USEPA also states "Children under nine should not drink water that has more than 2 mg/L of fluoride" (USEPA 2009), since dental fluorosis primarily attacks developing teeth before they break from the gums. Dental fluorosis can result in brown stains and pits in and on the surface of teeth. The USEPA does not require local communities to fluoridate water, however when fluoride is present or is introduced into a potable water source, the USEPA does enforce the primary and secondary drinking water standards for water distribution system owners and operators.

Fluoridation Arguments

Those who support fluoridating drinking water include the CDC and US Surgeon General. The US Surgeon General stated "…community water fluoridation remains one of the great achievements of public health in the twentieth century – an inexpensive means of improving oral health that benefits all residents of a community, young and old, rich and poor alike" (San Francisco Public Utilities Commission, 2008). The CDC also has deemed fluoridation as one of the top ten greatest health achievements from 1900-1999, with nearly 144 million people in the United States consuming fluoridated drinking water. (Centers for Disease Control and Prevention, 1999)

Fluoridating water supplies, unlike water disinfectants, is not required to make water supplies safe to drink. There is concern that fluoridation is a forced “medication” by the water purveyor, which leaves the consumer with no control over what they ingest. The concern over the right to have or not have fluoridation stems from the larger issue that fluoride in larger quantities can adversely impact health, including dental fluorosis, bone disease and neurologic impairment. The consumer of fluoridated water supply is already ingesting fluoridation from other consumer products. Therefore, there exists the possibility of adverse impacts to health due to fluoride increases when water supplies are fluoridated. One major water purveyor and water wholesaler to over 26 bay area communities, the SFPUC, has not had any “known and/or apparent adverse health impacts” due to fluoridated water. The SFPUC has been fluoridating water for approximately 50 years. (San Francisco Public Utilities Commission, 2008)

Both proponents and opponents of fluoridated drinking water have valid arguments. In summary, the incidence of DMFT’s dramatically change with fluoridated water, a positive impact to dental health, whereas the incidence of major general health impacts due to the SFPUC fluoridated drinking water service area is zero. Based on this data, the risk of using fluoridated drinking water administered in proper doses, versus non-fluoridated drinking water, has little or negligible health risk to the consumer, while providing a potential dental health benefit.

Fluoridation Policy

The USEPA does not require fluoride be added to potable drinking water, however the California Department of Public Health (CDPH), which is responsible for the California Drinking Water Program, does require fluoridation of potable drinking water systems. The State requirement applies to public water systems with greater than 10,000 service connections, requiring them to fluoridate their drinking water if funding, indentified by the CDPH and pursuant to Health and Safety Code §116415, is made available. This funding, per 22 CCR §64433, shall be used for capital and associated costs to install system(s) to fluoridate a public water system. A list of public water systems was developed to identify the priority, or order, by which these potable water systems shall receive these funds. The City of Santa Clara is on this priority list and is ranked 140 out of 167 listed public water systems.

CDPH has responsibility to enforce the requirements set forth by the SWDA's primary and secondary standards. Additionally, CDPH inspects, enforces, and permits drinking water distribution systems throughout California. The state further requires fluoridation be controlled, monitored and maintained at prescribed ranges. These ranges are found in the Table 1.

Table 1: Optimal Fluoride Levels (22 CCR §64433.2, Table 64433.2-A)

Average Daily Air Temperature (F°)	Optimal Fluoride Level (ppm)	Control Range (ppm)
50.0 to 53.7	1.2	1.1 to 1.7
53.8 to 58.3	1.1	1.0 to 1.6
58.4 to 63.8	1.0	0.9 to 1.5
63.9 to 70.6	0.9	0.8 to 1.4
70.7 to 79.2	0.8	0.7 to 1.3
79.3 to 90.5	0.7	0.6 to 1.2

In 1988, the State of California adopted these parameters as part of Title 22, which requires distribution systems using fluoridation to maintain optimal fluoride ranges based on temperature. Additionally, CDPH requires fluoridated drinking water purveyors in the state of California to monitor fluoridation levels daily and document fluoridation activities. The water purveyor must complete monthly and annual reporting to CDPH and maintain a permit for fluoridation in the system. (CDPH, 2010)

In the absence of funding identified by the state, a public water system may elect to pursue fluoridation. If a public system has the financial ability to fund public water system fluoridation, the decision on whether or not to implement fluoridation is made by that community and its leaders. This determination is based on public interest, finances, political lobbying, and other possible feasibility issues in implementing fluoridation within that community. The decision is made by the local water purveyor regarding whether or not to fluoridate water, unless funding is provided by CDPH to install and construct necessary infrastructure. For water retailers like the City of Santa Clara, who buys water from a water wholesaler (e.g., SFPUC), they may not have the ability to decide whether or not their imported water receives fluoridated water, since this decision may be made for them by the water wholesaler, as is the case with a portion of the City of Santa Clara.

METHODOLOGY

The methodology used to complete this research was a cost benefit analysis and included information from existing public policy, regulations, fluoridation studies, dental health statistics, fluoridation information from other public agencies and a financial analysis. This research provides background on dental health regarding fluoridation and its benefits. A cost estimate was prepared for the City of Santa Clara to fluoridate the potable water system. This estimate, when compared to the potential benefits, provides a quantitative perspective on system wide fluoridation. This analysis further includes discussion on qualitative program elements, such as compliance with regulations, adherence to existing City policies on fluoridation, optimal dosing required to establish the benefit of implementing water fluoridation, and opposition for and against water fluoridation by the community. Information used to develop this cost benefit analysis has been obtained through the Centers for Disease Control and Prevention, American

Dental Association, Environmental Protection Agency and American Water Works Association. Additional sources are utilized to complete the analysis. The steps to complete the analysis are listed below:

1) American Water Works Association (AWWA) standards (industry standard) as guidance to determine which fluoridation system(s) and chemical(s) are appropriate for use within the City of Santa Clara. AWWA standards are published standards referenced throughout various sections in the State Water Code.
2) Obtain information and data from San Francisco Bay Area water utilities: including the type of fluoridation systems proposed to be used, costs, and other pertinent operational information.
3) Prepare estimates on capital cost necessary to build fluoridation systems at the 28 groundwater wells and Santa Clara Valley Water District (SCVWD) turnout.
4) Prepare estimates of the cost of operation and maintenance (O & M) for the fluoridation system(s).
5) Determine the annual revenues (rate increase) needed to meet the capital and O & M costs of fluoridation treatment system(s).
6) Determine the cost benefit using the annual costs of fluoridating City's water to the number of dental caries prevented in dental treatment dollars saved.
7) Determine, based on cost benefit analysis and other information researched, whether or not the City should consider system wide fluoridation.

These seven steps provide a comprehensive approach to determining the cost versus the benefit of implementing fluoridation treatment systems in the City of Santa Clara. Assumptions are made in order to complete the analysis, however those are noted throughout the paper when information and analysis is completed. This information will be an objective study on whether or not fluoridating the potable water system is in the best interest of the City and its community.

FINDINGS

City of Santa Clara Fluoridation History

City of Santa Clara has not historically fluoridated the potable water system, and it was not until the introduction of AB 733 (Speier) in the 1990's that the Water and Sewer Utilities Department became actively involved in the fluoridation issue. AB 733 (Speier) required the state to adopt regulations mandating public water systems with 10,000 or more service connections to fluoridate potable water systems. On March 15, 1995 the Director of Water and Sewer Utilities requested approval from the City Council to contact local legislators and the League of California Cities regarding the Utility's opposition to AB 733 (Speier). The Agenda Report summarized the assembly bill to Council and explained how the Council's approval would permit the City to express its opposition to the proposed bill. This Agenda Report also provided an economic impact section which described the cost to install fluoridation (through chemical injection at 28 groundwater wells) to be as much as $800,000 annually, which would translate to approximately a 7% rate increase. (Hathorn, Request for Approval to Contact Local Legislators and Others Expressing Opposition to AB 733 (Speier), Mandatory Fluoridation of Drinking Water, 1995)

The Agenda Report from the Utility Director also came with discussion points which included the following concerns:

- If the City fluoridated all of its system water at the state required fluoride dosage, the optimal fluoride dose would not be consumed unless the target consumers drink system water daily and at prescribed amounts

- There are risks in using fluoride operationally, since optimal dosage amount must be maintained to prevent dental fluorosis, while still providing the beneficial amount
- The risk for potential water contamination would increase with 28 new chemical injection locations
- Adding fluoride could start the introduction of other health based additives to potable water systems, leaving the consumer no choice over what health additives they consume

(Hathorn, Request for Approval to Contact Local Legislators and Others Expressing Opposition to AB 733 (Speier), Mandatory Fluoridation of Drinking Water, 1995)

Following the March 1995 Agenda Report, the Office of the Mayor and City Manager sent a letter on April 12, 1995 to Assemblyman Vasconcellos. This letter requested Vasconcellos' opposition to AB 733 (Speier), describing the various concerns regarding fluoridation of public water systems, including the financial impact to ratepayers, the ability to properly dose the drinking water source leaving no way to ensure a consumer received enough fluoride, and the inherent risk in introducing fluoride to 28 injection points within the potable water system. In summary, the letter stated that the assembly bill was flawed, had several disadvantages and was not cost effective, specifically when comparing the additive to the potential health benefit. (Nadler, 1995) Unfortunately, Assemblyman Vasconcellos voted "Aye" both times AB 733 (Speier) reached the assembly floor in both June and September 1995. (Senate, 1995)

On March 15, 1998, the Citizens for Safe Drinking Water, an organization opposing fluoridation in public water systems, sent a letter to the City expressing concern about fluoridation in the City of Santa Clara. The Director of Water and Sewer Utilities provided information to the Director of Citizens for Safe Drinking Water, stating that the City Council's policy position is opposition to the use of fluoridated water within the City's public water system. This response letter to the Citizens for Safe Drinking Water was written after AB 733 (Speier) was passed, however the letter further explains how the City of Santa Clara was listed as number 139 out of 166 systems on the priority list during that time. The priority list is the list the state generated in response to the passage of AB 733, determining the order in which water systems will be required to fluoridate their water when state funds become available. As of June 2010, the state has placed the City of Santa Clara as 140 on the priority list. Since the City of Santa Clara is so far down the priority list, it was explained in the response that it is unlikely that the City of Santa Clara would actually receive state funding for implementing fluoridation in the near future. (Sparacino, 1998)

By September 23, 1998, the Water and Sewer Utilities sent another Agenda Report to Council for action. This Report summarized the Council's previous opposition to AB 733 (Speier) and their continued opposition to fluoridating the water supply in the City. The report summarized a request from the Citizens Advisory Committee (CAC) for the City to further investigate the ability to adopt an ordinance that prohibited city water supply fluoridation, as did another charter City in the region, Santa Cruz. The department staff at the City of Santa Clara further investigated the possible adoption of an ordinance, and requested a formal legal review from the City Attorney's Office. It was found that there are no legal precedents to compare this issue to, and that it is very likely that the state would prevail in requiring cities within the state to fluoridate. In this Agenda Report the City had requested the Council to take no further action on adopting such an ordinance to avoid any legal issues with the state. (Hawthorn, State Requirement to Fluoridate the City's Drinking Water Supply, 1998)

By July 2000, the San Francisco Public Utilities Commission (SFPUC) was evaluating improvement alternatives to fluoridation of its potable water system. One alternative included system-wide fluoridation, resulting in distributing fluoridated water to all its retailers, including the City of Santa Clara. During this time, SFPUC sought input from Bay Area Water Users Association (BAWUA), an association made up of all the SFPUC retailers, which is now known as Bay Area Water Supply and Conservation Agency, on system wide fluoridation. A letter was sent by SFPUC on July 3, 2000 to the City of Santa Clara Mayor, including other BAWUA member agencies, requesting the City of Santa Clara's active participation and written position on receiving fluoridated water. (Klein, 2000)

On August 21, 2000, the City of Santa Clara responded to the SFPUC on its possible system-wide fluoridation alternative in a formal letter to the Water Quality Bureau Manager at SFPUC from the City of Santa Clara City Manager and Director of Water and Sewer Utilities. This letter included the City's concerns with having a blend of fluoridated and non-fluoridated water, with no guidance or state requirements for a blended system. Additionally, the letter included concerns about how the blended system would invite discontent from the public, since some residents would receive fluoridated water while others did not. The City of Santa Clara formally requested that SFPUC not proceed with system wide fluoridation and that the introduction of fluoridated water could also increase City staffing needs for water quality testing and possible monitoring requirements by the State. The letter also explained how extensive public outreach would need to be done if SFPUC proceeded in order to help educate the consumer as to why some consumers within the City would receive fluoridated water and others would not. (Saunders & Sparacino, 2000)

In November 2000, the SFPUC held an informational meeting in the South Bay for the public on SFPUC's Fluoridation Feasibility Study. The City of Santa Clara helped publicize this event through the City's cable channel and by sending the advertisement out to homeowners associations. (SFPUC, Notice of Public Information Meeting on the SFPUC Fluoridation Feasibility Study, 2000) This feasibility study was developed due to existing fluoride facilities which were deteriorating in the SFPUC system and needed upgrades. Due to AB 733 (Speier) SFPUC included the expansion of fluoridated water treatment systems as part of the study, including the evaluation of extending fluoridated treated water to all service areas. Those areas already receiving fluoridated water included San Francisco and communities on the Peninsula north of Redwood City and Belmont. The remaining agencies in the SFPUC service were not receiving fluoridated water, including the City of Santa Clara. (SFPUC, San Francisco Public Utilities Commission System-wide Fluoridation and Public Outreach/Notification, 2005) After completing the feasibility study, SFPUC did proceed to fluoridate system-wide. It was not until 2005 that the significant upgrades to SFPUC's existing infrastructure were completed, introducing fluoride by building the Harry Tracy and Sunol Valley Fluoridation Facilities. By September 2005 the City of Santa Clara and several other BAWUA municipalities received fluoridated drinking water from SFPUC.

As part of SFPUC's system-wide fluoridation, the City of Santa Clara had an extensive public outreach program regarding the partial City fluoridation. This included bill inserts to residences receiving fluoridated water, information provided in "Inside Santa Clara", a local city newspaper for its residents, updating the Annual Water Quality Report regarding fluoridated water, and brochures for customers on fluoridation.

Chemicals used in Fluoridation

Several chemicals used to introduce fluoride into drinking water including ammonium silicofluoride, calcium fluoride (fluorspar), hydrofluoric acid and magnesium silicofluoride. The three major chemicals used in United States for fluoridation are sodium fluoride, sodium fluorosilicate, and fluorosilicic acid. Unlike other fluoride compounds, these three major chemicals each have a specific AWWA written standard for their use in fluoridation: AWWA Standard B701 Sodium Fluoride, AWWA Standard B702 Sodium Fluorosilicate, and AWWA Standard B703 Fluorosilicic Acid. Since these three chemicals have been used for several years throughout the United States and have AWWA standards, selecting these chemical compounds for use in the City would be most practical.

Sodium fluoride, sodium fluorosilicate and fluorosilicic acid each have advantages and disadvantages, therefore three major considerations must be taken into account to determine which chemical would be best. These considerations are chemical solubility for efficient treatment use, disassociation of the parent compound producing a favorable cation or by product, the expense, usability and availability of the compound. (AWWA, 2004) Table 2 below provides a summary of these major considerations for the three major chemical compounds.

Table 2: Major Considerations for Fluoridation Treatment Chemicals

Chemical	**Chemical Solubility (g/100 mL)**	**Disassociated Cation(s) & Compounds**	**Expense, Usability & Availability**
Sodium fluoride (NaF)	4.05	Na^+	Relatively inexpensive, powder/crystal form dissolved into solution, 50-100 lb bags or 125-400 lb drums (bulk)
Sodium Fluorosilicate ($NaSiF_6$)	0.762	Na^+, HF, SiO_2	Relatively inexpensive, powder/fine crystal form dissolved into solution, 50-100 lb bags or 124-140 lb drums (bulk)
Fluorosilicic Acid (H_2SiF_6)	Infinite	HF, H^+, SiO_2	Relatively inexpensive, liquid, 13 gal -55 gal drums, tank cars (bulk), can be difficult to procure from chemical manufacturer

Solubility is an important characteristic of water fluoridation. As seen in Table 2, fluorosilicic acid has optimal solubility, followed by sodium fluoride and sodium fluorosilicate. Fluorosilicic acid has infinite solubility, since it iteratively degrades to hydrofluoric acid which strongly disassociates in water to hydrogen and fluoride ions. Sodium fluoride has a higher solubility, over four times has much as sodium fluorosilicate, making it a more effective chemical then sodium fluorosilicate for adding fluoride (ions) to the water. (AWWA, 2004)

The disassociated cations and compounds are most favorable with sodium fluoride since sodium (Na^+) is least harmful and the only cation available when this chemical is dissolved in solution. The disassociated cations and chemical compounds for both sodium fluorosilicate and fluorosilicic acid generate HF (hydrofluoric acid) and SiO_2 (silicon dioxide, chemical used to make glass). HF compounds when disassociated in water lower the pH of the solution to approximately 1.2. Since HF does continue to degrade to hydrogen and fluoride, the pH of the water can still be lowered slightly by the excess hydrogen ions. In order to utilize fluorosilicic acid and sodium fluorosilicate for fluoridation, total dissolved solids and pH would need to be monitored closely to ensure optimal fluoridation of the water and minimal impacts to pH. (AWWA, 2004)

The last major consideration is expense, usability and availability. A brief summary is provided in Table 2, however several items must be evaluated including storage, use, handling, and quantity of chemical needed based on the type of treatment system used, manual versus automatic feed systems for usability, and the ability to obtain the chemical easily and quickly.

Fluorosilicic acid, also known as “FSA”, undergoes various supply and demand concerns in the chemical manufacturing industry. FSA is a by-product of fertilizer manufacturing and dependent on the production of fertilizer by chemical manufacturers. The manufacturing of fertilizer is based on demand from the agriculture industry, therefore FSA production is not always consistent, making its availability a concern for some municipalities that fluoridate with this chemical. In 2007, Cleveland, Ohio barely received shipments from manufactures in time and had to pay higher than normal chemical costs for FSA. (AWWA, 2007)

Another important consideration not listed in the table above is the safety of these chemical products. The safety includes chemical hazards associated with each chemical compound, chemical by products and disassociated cations. This includes both city employees' safety and public safety including, but is not limited to, possible chemical exposure to employees handling the chemicals, proximity of stored chemicals to the public (including nearby sensitizers in the community), fluoridation system failure causing byproducts or unsafe (partially treated) drinking water into the public water distribution system, transporting the material to the well sites, and storing the material onsite in a residential area.

Fluoridation Treatment Systems

Treatment systems used for fluoridation include acid feed systems, saturator systems, and dry feed systems with either a volumetric or gravimetric feeder. Selecting which fluoridation system to use is dependent on both the population served by the system and the chemical chosen to use. AWWA provides general guidelines on system planning, including the selection of which fluoridation system and chemicals to use based on flow rates and population served. Table 3 below summarizes a few applicable parameters:

Table 3: Fluoridation System Parameters by Population Served

Population Served	System Type	Chemical Used	Feed Rate
Less than 5,000	Manual – Saturator	Fluoride Solution	Less than 500 gpm
Less than 10,000	Automatic- Saturator	Fluoride Solution	Less than 2,000 gpm
More than 10,000	Acid Feed	Fluorosilicic Acid 23-30%	More than 500 gpm
More than 10,000	Dry Feed – Volumetric	Sodium Fluorosilicate	More than 100 gpm
More than 50,000	Dry Feed - Gravimetric	Sodium Fluoride	More than 2 mgd

For smaller systems, such as those serving less than 10,000 people, sodium fluoride or fluorosilicic acid can be used. Although these chemicals are more expensive, when used in smaller lots in a saturator or acid feed system they can be more cost effective. When utilizing smaller saturator or acid feed systems, the injection point for these systems will be in the effluent line of the groundwater well prior to distribution into the potable water system. However, these systems will require water softening, as the fluoride ions in solution will combine with calcium and magnesium ions, thereby making a precipitate that will clog the various system parts including the feeder, injection port, feeder line and saturator bed.

These treatment systems are reliable when operated according to manufacture recommendations, however like any other systems or mechanical parts, systems and parts will need to be repaired or replaced due to long term use and exposure. The life of the systems will not be addressed in this study, however this should be further examined to determine other capital investment or replacement costs, which would be needed by the City should system-wide fluoridation be implemented. The City of Santa Clara’s untreated (non-fluoridated) water, supplies approximately 80% of the City’s water, therefore the City would have several treatment options as shown in Table 3. Each groundwater wells serves less than 10,000 people, however the water from one well has the potential to hydraulically influence and blend with water from other parts of the City’s water distribution system.

Localized versus Centralized Fluoridation Treatment Systems

There are two ways to introduce fluoride into the public water supply, either through numerous localized treatment systems or by introducing fluoride at a centralized larger treatment plant. The City does not have one large treatment plant for its three potable water sources because there are multiple water sources at various locations throughout the City, including twenty-eight groundwater wells, Hetch Hetchy water source introduced through a transmission main at the north side of town, and Santa Clara Valley Water District (SCVWD) water introduced through a turnout at the southwest end of town. Hetch Hetchy surface water is already treated at a large water treatment facility prior to being imported into the City of Santa Clara, which includes the introduction of fluoride. SCVWD also treats its surface water at a large water treatment plant prior to delivering the imported water into the City of Santa Clara, however fluoride is not introduced at this plant. Lastly, the existing water quality for the City's groundwater does not warrant additional treatment, except for one well that has a Manganese Treatment system to remove excess manganese, and at well that requires a disinfectant to minimize bacteria count. This leaves two out of the three potable water sources which would require fluoride treatment, the SCVWD turnout and the City's twenty-eight operating groundwater wells.

Developing a centralized treatment system for the SCVWD source water and the numerous groundwater wells in the City would require extensive water main rehabilitation and extension throughout the City, a designated plant with large enough capacity for the flow, and enough real estate both above and below ground to accommodate a treatment plant and large diameter pipes needed to transmit the water to the plant. Finding a piece of real estate owned by the City which is large enough to build a treatment plant would be difficult. One viable existing

City owned parcel of land, that could be utilized to build a centralized plant, would be the Utility Yard for the Water and Sewer Utilities, located at 1705 Martin Avenue, Santa Clara. This site is centrally located, with a majority of the City owned groundwater wells located south of Highway 101, therefore requiring fewer feet of pipe to construct.

The massive capital improvements needed for the main extensions to transmit the water to a centralized plant would costs millions of dollars to design and construct, and several years to complete. Assuming every linear foot of pipe to design and construct would cost $250.00/foot, a conservative estimate, and a total of approximately 77 miles of new pipe, would cost approximately $100 million (See Appendix A). The extensive networks of pipes needed to transmit the water from the wells to a centralized treatment plant would lead to future maintenance and operations costs and eventually main rehabilitation (repair and replacement). Additional ongoing operations costs would include personnel needed to operate and maintain the treatment system twenty-four hours a day seven days a week, since all the City's groundwater wells and SCVWD water would require transmission through the treatment plant.

Building localized treatment systems at the SCVWD turnout and at all the operating groundwater wells would require several small decentralized fluoride treatment systems. No additional pipe would need to be constructed underground in the public right of way, rather any additional piping would be found on existing City owned land. All treatment systems would be compact and located on the existing well site locations. Since there are several wells in the system, there would be no need for an entire staff or division to run the treatment systems twenty-four hours a day, seven days a week. Instead if there was a malfunction or issue with operating the system, the existing well could be shut down, meanwhile several other wells would continue to run throughout the City to supply enough potable drinking water. Lastly, the time to design and install several smaller fluoride treatment systems would take approximately two to four years.

The City of San Bruno, City of San Jose and City of Mountain View all currently use or have evaluated decentralized fluoride treatment systems dispersed throughout their cities. The most logical, cost effective and easiest treatment system option for the City of Santa Clara would be implementing several decentralized fluoride systems throughout the potable water system at the various groundwater well sites and at the SCVWD turnout. (Kimball, 2010) (Turner, 2010) (San Bruno, 2006)

Fluoridation Expenses

Capital Expenses

The capital expenses for fluoridation in the City of Santa Clara would include the costs necessary to install permanent fluoridation treatment system infrastructure at all 28 groundwater wells and the SCVWD turn out location. If infrastructure at all groundwater well sites and the SCVWD turnout were installed, then the entire water supply would be fluoridated within the City. To provide capital costs for the entire system-wide fluoridation within the City, the cost of one treatment system must be determined. It is assumed that since the engineering design at all well sites is similar, the fluoridation treatment system installation would be the same at all sites.

A cost estimate for one fluoridation treatment system for the City of Santa Clara was generated as detailed in Table 4, based on a model completed by the City of San Bruno. The City of San Bruno provided a similar cost estimate to the California Department of Public Health regarding the potential capital costs to implement fluoridation at its groundwater well sites, which are similar to the City of Santa Clara. It is also assumed that the City of Santa Clara would use a chemical feed system. Table 4 also includes cost estimates from various equipment vendors which are tabulated as line items. (San Bruno, 2006)

Table 4: Capital Cost Estimate for one Fluoridation System in the City of Santa Clara

Description	Quantity	Unit Costs	Total
Chemical Feed System			
Metering Pump (5 gpd)	2	$700	$1400
Pacing Meter	1	$2,500	$2,500
Fluoride Saturator (kit)	1	$1,350	$1,350
Spill/Leak Containment	1	$400	$400
Electronic Level Indicator	1	$2,500	$2,500
Auxiliary Equipment			
Fluoride Analyzer	1	$10,000	$10,000
Backflow Prevention Device (air gap if possible or vacuum breaker)	1	$2,500	$2,500
Injection Quill with check valve	1	$650	$650
Alarms (high/low)	1	$2,000	$2,000
SCADA	1	$10,000	$10,000
Site Improvements & Structures			
Piping	1	$14,000	$14,000
10' x 10' Building	100 ft^2	$250/$ft^2$	$25,000
Security	1	$10,000	$10,000
TOTAL Capital (Material) Costs			$82,300
Engineering / Administration (15%)			$12,345
TOTAL EXPENSES for one fluoridation system			$94,645

Sources: (Hach Company, 2010) (Pollardwater, 2010) (San Bruno, 2006)

The cost estimate above includes the cost for the chemical feed system, auxiliary equipment (including telemetry SCADA – Supervisory Control and Data Acquisition), and site improvements and structures. Beyond the capital materials costs an additional 15% of total costs was added to account for contract administration and engineering support for implementing the site treatment system. This cost needs to be multiplied by the number of well sites in the City to determine the total cost for installing fluoridation systems throughout the rest of the City. Adding the number of well sites and the SCVWD turnout, there are a total of 29 Fluoridation treatment systems needed in the City. The total capital cost to install the 29 systems is found in the table below.

Table 5: Total Capital Costs to Install 29 Fluoridation Treatment Systems in the City

Cost of one Fluoridation Treatment System	# of Fluoridation Treatment Systems needed in Santa Clara	Total Capital Costs
$94,645	29	$2,744,705

Operation and Maintenance Expenses

The operations and maintenance expenses to run 29 fluoridation treatment systems in the City of Santa Clara would include the personnel, materials costs and lab costs necessary to operate all systems during any 24 hour time period. Although not all wells run consecutively throughout the city, the wells are cycled and would run intermittently throughout the year, therefore ensuring that each well is operational during any time of the year that it is necessary. Additional expenses for replacement parts and systems would vary based on frequency of use and years of service, so determining the life of a treatment system would vary for each well site.

The most tangible expenses to capture would be the utility staff time necessary to operate and maintain the system. Using the City of Mountain View as an example, they currently have 0.5 persons budgeted annually to operate nine treatment systems, similar to those which would be used in the City of Santa Clara. An additional 0.5 persons is budgeted annually in the City of Mountain View for regulatory compliance with California Department of Public Health (CDPH). The 0.5 person for regulatory compliance is necessary to maintain water quality data and to complete reporting requirements to the CDPH to legally operate the nine treatment systems in the State of California. Translating Mountain View's 0.5 persons for field operations for every 9 treatment systems is approximately 3.5 persons for City of Santa Clara's 29 treatment systems. Converting Mountain View's 0.5 persons for regulatory operations would yield 3.5 persons annually for compliance purposes. Additionally, the operations staff that could operate the treatment systems would need to be skilled and knowledgeable, therefore the City of Santa Clara would need approximately 3.5 Water Treatment Technicians. The compliance staff responsibilities could be shared by the Water Treatment Technicians to help minimize the number of compliance staff persons to approximately 1.5 persons. This crossover and shared responsibilities could be done by training the Treatment Technicians to fill out basic regulatory data and forms in preparation for developing the information which would need to be completed by Compliance staff. This would also save the utility money in staff time.

Currently the Utility does not have Water Treatment Technician positions filled, however they could budget and recruit for these positions. The operations staff time of $111,450.00 per technician annually is based on Water Treatment Technician annual salary (step 5) of $82,560.00 with an additional 35% added on for budgeted employee benefits. Compliance Staff support time of $118,195.20 is based on Code Enforcement Technician salary (step 5) annual salary of $87,552.00 with an additional 35% added on for budgeted employee benefits. Compliance Manager's annual salary of $166,186.00 is based on Compliance Manager 100% control point annual salary of $124,020.00 with an additional 34% added on for budgeted employee benefits. The 35% and 34% for employee benefits is added for classified and unclassified staff respectively. These percentages were provided by the City's Finance Department for fiscal year 2010/2011 as the estimated employee benefits paid by the City. Other staff time would also be devoted to the daily operations and maintenance of the system, however for the purposes of this assessment only the three major positions are included in the operations and maintenance expenses summarized in the Table 6 below. (Lewis, 2010)

Table 6: Total Operations and Maintenance Annual Personnel Costs

Position	No. of Persons needed	Annual Salary plus benefits	Total Costs
Water Treatment Technician	3.5	$111,456.00	$390,096.00
Code Enforcement Technician	1.25	$118,195.20	$147,744.00
Compliance Manager	0.25	$166,186.00	$41,546.50
TOTAL Personnel Costs			$579,386.50

Part of the operations and maintenance costs include the chemical costs of fluoride. For the City of Santa Clara the chemical chosen to perform the cost estimate on is sodium fluoride. The costs of sodium fluoride can be estimated annually by taking the annual groundwater production and using an optimal fluoride dose of 1.1 ppm. The total annual cost of sodium fluoride, using $0.67 per pound, is approximately $102,095.41 (see appendix C). For the purposes of this assessment, operations and maintenance personnel expenses and chemical costs will be used as total annual operations and maintenance costs. Costs for replacement parts and other supplies will be difficult to determine without actually operating the system and determining the need for additional parts. This underestimate in costs to maintain and operate the system will simply capture the known expenses at this time and all other estimates could be adjusted in sequential budgeting years to include such materials and supplies.

ANALYSIS AND CONCLUSIONS

Financial Requirements

One major consideration for determining whether to implement a fluoridation program is the financial impacts to the City of Santa Clara Water Utility, and its customers. Prior to implementing such a program, and making major investment in fluoridation treatment systems, the utility must conduct financial planning for these expenses. The financial planning includes assessing the utility's current financial condition, estimating both capital and operation and maintenance (O & M) expenses, identifying capital finance options, calculating the revenue needed for both capital and O & M expenses, and rate impact to customers. (AWWA, 1998)

Current Financial Condition of Utility

The Water Utility is a part of a larger department known as the Water and Sewer Utilities (Department). The Water Utility of the City of Santa Clara is an enterprise fund in the City, collecting revenues from customers, residences and businesses for the delivery of safe potable drinking water. These revenues are used for the expense to construct or improve, operate and maintain the potable drinking water system. This includes the maintenance costs, labor costs, and overhead expenses incurred by the utility to operate in the City. The overhead expenses include, but are not limited to, administrative services, equipment, human resources, vehicles and communication equipment. The Utility raises customer rates regularly to generate the funds necessary to run the utility. Recent increases in rates were adopted by council in July 2010 to not only generate funds necessary to run the utility, but to also compensate for the reduction in water sales due to the economic downturn and water conservation. Additionally, the cost of water has increased due to the need to replace aging infrastructure, and the increase in water wholesaler rate to the Utility. (de Groot, 2010)

In previous years, the Water and Sewer Utilities has used both moderate rate increases and costs saving initiatives to minimize the rate increases to customers. In helping minimize rate increases, the department has had to use cash reserves to meet the needed expenditures within the water utility. Using these cash reserves over several consecutive years without replenishing it has lowered the amount of cash reserves currently available. As a result the utility is faced with having to raise utility rates to cover expenditures and replenish cash reserves. Raising any utility rates during this economic condition is a difficult task. Adding any additional expenditures or capital improvements to the utility's expenses in any future fiscal year's budget will only necessitate additional funds (in the form of raising rates) to match the fiscal needs or expenses. One of the City's core values in fiscal responsibility emphasizes the need for City staff to make appropriate fiscal decisions for the community and the City.

Capital Financing

The capital improvements for the fluoridation system would be around $2.74 million, which would need at least one, to possibly multiple, funding sources. Since this is a capital improvement project, funds to build such infrastructure could include, but are not limited to, grant funding and various bonds and or loans. Historically, the City has sought bonds to pay for capital improvement projects, however the City would have some challenges in procuring government bonds. Procuring bonds could include debt capacity limitations, back up credit to ensure sufficient funds, letter of credit and high administrative costs to administer the bond. (AWWA, 1998) Funds available from the state through AB 733 are unlikely to become available for several more years, but at that time could be used to repay the debt incurred for fluoridation construction. No timeline has been provided by the State on when the City could expect to see any state funding. Other state approved sources could be used to implement fluoridation, including funding from non-profit organizations, community groups and various other private sources. Without other outside funding, the City of Santa Clara does not currenlty have enough cash to pay for infrastructure improvements. The City would need to consider captial financing.

For the purposes of the Water Utility it is assumed that debt service is based on bonds or loans issued at 25 year increments with level annual payments of 8.5% of the amount borrowed. (de Groot, Debt Services Projections, 2010) Given this financial information, the annual payment for financing the fluoridation capital improvements of $2,744,705 would be $233,299.93. This annual payment would need to be funded by the utility through raising potable water rates. The rate increase would not apply to just one customer type (e.g. residential, municipal, commercial, industrial etc.), rather all customers would be impacted by the annual payment, rate increase, even though the customers who would benefit the most are children. The utility uses a blended water rate, which incorporates all costs associated with delivering water to its customers including any treatment, operations and maintenance. The costs associated with fluoridating water would be incorporated into water rate increases for all customers alike. Supplementing this annual payment using utility cash reserves would not be in the best interest of the utility. Good public financial management practices indicate that capital improvements within the City should be properly funded and revenues should cover the costs to implement those capital improvements.

Program Expenses

As discussed earlier, two major expenses are incurred to deliver fluoridated water to customers: capital (one-time) expenses, and operation and maintenance expenses. To determine the impact to the utility, translating these two major expenses into dollars per capita and dollars per acre-feet is necessary. Per capita expense will show the expense of fluoridation in the City per person, whereas per acre-feet provides expenses based on water production. The Water Utility currently uses dollars per acre-feet for financial planning and using dollars per capita will provide individual benefit in dollars.

Per capita expenses were determined using to two populations, the entire residential population in the City of Santa Clara and the population of those consumers who benefit most from fluoride. The residential population in the City was determined to be 111,997 using 2009 Census data and by using only permanent residents in the City. All transient population, including those who work or visit the City, were not considered in the population. It is assumed that the transient population is not receiving an optimal or high enough dose of fluoride to benefit from the addition of fluoride in the system. California Department of Education 2009-2010 grade school enrollments for the City of Santa Clara were used for the cost benefit analysis. Those most likely to benefit from drinking fluoridated water on a daily basis are children from approximately age six through thirteen, therefore school enrollment numbers for children from kindergarten through grade eight (K-8) were used for this cost benefit analysis. Since those 6-13 years of age are used in the cost benefit analysis as those who obtain the highest benefit from fluoridated drinking water, we can closely compare this target age group of K-8 (approximate age range of 6-13) as 10,704. (California Department of Education, 2010)

The impacted population, those who benefit most from the addition of fluoride, are those between the ages of 6 to 13 years old. Based on fluoridation studies, the targeted population will have the greatest benefit, more so than adults, in preventing dental caries. Translating per capita costs for the impacted population will provide alternative means to examine program expenses versus program benefit. Table 7 below provides a summary of the per capita expenses for both capital and annual O & M for the fluoride program implementation.

Table 7: Dollar per Capita Expenses

Population	Number of persons	Expense Type	Annual Expense	Dollar Per Capita per Year
Total Population	111,997	Annual Capital Expense	$233,299.93	$2.08
		Annual O & M	$681,481.91	$6.08
		TOTAL (Capital + O&M)	$914,781.84	$8.16
Impacted Population	10,704	Capital	$233,299.93	$21.80
		Annual O & M	$681,481.91	$63.67
		TOTAL (Capital + O&M)	$914,781.84	$85.47

Annual O & M and capital expenses used to calculate dollar per capita in Table 7 are from the cost estimates provided in Table 5 and 6. Neither expense has been adjusted for inflation nor present value estimates are used for program expenses, specifically capital, which may require long term financing. As seen in Table 7, the dollar per capita for impacted population for both annual O& M and capital are about ten times higher.

The cost per acre-feet is calculated using the capital and operations and maintenance costs, found in Table 7, and annual water deliveries in acre feet. The annual water deliveries for the past five years have been used to provide a five year trend in water deliveries and theoretical fluoridation expenses. However, based on recent financial trends and lower water sales for the past five years, it should be noted that the cost per acre-ft will fluctuate depending on the amount of water produced and sold. Efficiencies in fluoridated costs can be seen if the utility delivers more water to customers, however there would also be an increase in amount of fluoride chemicals used and personnel costs to operate fluoridation systems that had higher capacities. Table 8 below provides a summary of cost per acre-feet for both annual O & M and capital.

Table 8: Cost / Acre-ft Fluoridation Expenses

	Cost/Acre-ft (annual)					Cost/ Acre-ft
Type of Expense	FY 04/05	FY 05/06	FY 06/07	FY 07/08	FY 08/09	5 year Average
Annual Capital	$9.97	$9.82	$9.51	$9.70	$10.38	$9.87
Annual O & M	$29.11	$28.68	$27.77	$28.34	$30.32	$28.82
TOTAL (Capital + O & M)	$39.07	$38.50	$37.28	$38.04	$40.70	$38.69

Annual O & M and capital expenses used to calculate dollar per acre-ft in Table 8 are from the cost estimates provided in Tables 7. Neither expense has been adjusted, specifically capital which may require long term financing, for inflation. All values are in present value or present worth. One major reason costs have not been adjusted is due to the uncertainty of the economy and with employee pay and benefits at the City.

Customer Water Rate Increases

As discussed earlier, capital financing and revenues are needed to develop and sustain the implementation of system wide fluoridation. Grants can be used, however cannot be depended on, hence this study considers all capital improvements as financed. Along with 25 year financing for the capital expenses, the operations and maintenance costs must be considered when determining the revenues needed. The revenues will be derived from the collection of customer water rates, which is standard practice for both public and private utilities. The City Water Utility would have to consider the impacts to the customer by examining the cost per unit water (hundred cubic feet). The cost per unit of water for five consecutive fiscal years 2004/2005 to 2008/2009, have been tabulated below for reference. Table 9 also provides a summary of what would be the anticipated rate per unit water if system wide fluoridation were implemented including both capital and operations and maintenance costs.

Table 9: Rate per Unit of Water with and without System Fluoridation

	$ / HCF (Hundred cubic foot)				
Cost of Water	FY 04/05	FY 05/06	FY 06/07	FY 07/08	FY 08/09
Unit Cost of water *(without system Fluoridation)*	$1.743	$1.813	$1.940	$2.115	$2.305
Unit Cost of water *(with system Fluoridation)*	$1.833	$1.901	$2.026	$2.202	$2.398

Source: (Water and Sewer Utilities, 2009)

As seen in this table these rates would have increased by approximately $0.09 dollars per unit of water. Once again these rates are not adjusted for previous years' capital or operations and maintenance cost. To increase rates would require approval by City Council and a justifiable case as to the additional rate increase. The City of Santa Clara is known for having the lowest utility rates in the nine San Francisco Bay Area counties, therefore any increase would certainly be a political concern for the City. Having the lowest utility rates in the Bay Area makes the City of Santa Clara an attractive city for small business, large businesses and residents. Therefore any adjustment to these rates, specifically any additional increases, would need to be carefully considered. Another way to translate these rate increases is by using percentages as seen in Table 10 below.

Table 10: Rate increases in Percentage Projected with and without Fluoridation Costs

	% (Percentage)				%
Rate Increase	FY 05/06	FY 06/07	FY 07/08	FY 08/09	4 year Average
Rate Increase *(without system fluoridation)*	4.0%	7.0%	9.0%	9.0%	7.3%
Rate Increase *(with system Fluoridation)**	9.1%	11.7%	13.5%	13.4%	11.9%
Difference in Rate Increase	5.1%	4.7%	4.5%	4.4%	4.7%

*Rate increase is calculated assuming previous year's rate does not include fluoridation costs

Often times the rates are provided to the City Council as a percentage to demonstrate the anticipated impacted. The rate increases in Table 10 above are calculated assuming the previous year had no system-wide fluoridation. The impact shows that a four year average rate increase would have been about 4.7% higher with fluoridation. This increase is substantial when the rate increases without system-wide fluoridation average 7.3% for the four year period. This means that the City Council approved rate increases would increase by over 50%. The 4% increase would be for the first year only, and each succeeding year would include that 4% as part of the base water rate into the future, however the impact would remain for years to follow, with the customer paying this difference in their water rates.

Cost Benefit Analysis

Completing a cost-benefit analysis on the cost of system-wide fluoridation in the City of Santa Clara and the estimated benefits, as dental cost savings, will assist in the decision making process, specifically whether or not implementing fluoridation throughout the City's potable water system is advantageous for both the City and the community. In order to complete a cost benefit analysis it is necessary to quantify both the costs and the benefits of implementing fluoridation in the potable water system. The costs will include the capital financing estimates and operations and maintenance expenses anticipated to continue operating fluoridation treatment systems within the City, as detailed above. The most tangible and quantifiable benefit, for the purpose of this analysis, is captured by calculating the dental cost savings accomplished by the presence of fluoride in the drinking water.

The dental cost savings can be determined by taking the number of dental caries, also known as decayed, missing or filled surfaces (DMFS), and determining the decrease of dental caries when community fluoridated water is introduced. Then take the difference between the two to determine the DMFS's prevented with community water. For this cost benefit analysis, the number of DMFS's with fluoridated drinking water, number of DMFS's without fluoridated drinking water and the cost for DMFS's is from the CDC. (Center for Disease Control and Prevention, 2001) Once prevented DMFS's are determined, this number is then multiplied by the cost per DMFS, which is estimated to be approximately $101.94 each. For this analysis, the number of DMFSs without fluoridated drinking water is 1.5 DMFSs per child per year, whereas the number of DMFSs with fluoridated drinking water is 0.8 DMFSs per child per year for children between the ages of 6 and 13 years old. The difference is 0.7 DMFSs per child per year prevented by the introduction of fluoride in public drinking water. This difference would need to be estimated to 1.0 DMFSs prevented, since dental cost savings are captured in $101.94 per one DMFS. Therefore, for every child it is estimated that the $101.94 dental cost savings will be accomplished annually with the fluoridated drinking water. (ADA, 2004)

Several assumptions have been made for the cost-benefit calculations. These assumptions are listed below to further clarify what information is assumed and utilized to determine the cost benefit:

- Annual costs to fluoridate include 25 year capital finance costs and annual O & M
- Annual O & M costs only include personnel costs and therefore are underestimated for purposes of this cost benefit analysis
- Current enrollment numbers for children K-8 were used (approximately 6-13 years old), therefore a larger population range is used for DMFS prevented overestimating the actual number of children (6-13 years of age) who have cost savings due to DMFS prevented
- It is assumed that 0.7 DMFS is actually 1.0 DMFS since a child cannot have a partial DMFS without incurring the full cost of 1.0 DMFS.

The cost-benefit information described above and calculations are listed in Table 11 below. When the approximate cost for 1.0 DMFS of $101.94 is multiplied by the impacted population, those enrolled in K-8 (approximately 6-13 years old) as 10,704, a total of $1,091,165.76 in annual dental cost savings is achieved.

Table 11: Cost - Benefit Calculation Annual Costs

Per Capita Costs to fluoridate potable water	$8.16
Population of Santa Clara (2009 census)	111,997
Annual Cost for City to Fluoridate	**$914,781.84**
Number of DMFS per year (6-13 yrs) *without Fluoridated drinking water*	1.5 DMFS / child
Number of DMFS per year (6-13 yrs) *with fluoridated drinking water*	0.8 DMFS / child
DMFS / child / year prevented	**0.7 DMFS**
Approximate cost of 1 DMFS	$101.94
Number of Children in Santa Clara enrolled K-8 (approximately 6-13 years)	10,704
Number of DMFS prevented with fluoridation per child (6-13 years)	1
Annual Dental Cost savings with fluoridated water	**$1,091,165.76**
Cost - Benefit Ratio	= (Cost of Implementation / Savings in Costs of Dental Treatment) = $914,781.84 / $1,091,165.76 **= 0.84:1**

Using the total annual costs of $914,781.84 to fluoridate the public water system in the City of Santa Clara, from Table 7, and the annual dental cost savings of $1,901,165.76, yields a cost-benefit ratio of 0.84:1. This cost-benefit ratio indicates that it would cost the City of Santa Clara $0.84 for every $1.00 of dental benefit acquired by the targeted population (children). This cost by the City of Santa Clara would essentially translate to the additional rate paid by ratepayers (residences and businesses alike), therefore the ratepayers would pay $0.84 for every $1.00 of dental benefit. This cost is lower than the benefit therefore it can be assumed that the consumer would pay less for fluoridated water than the costs which would be incurred for DMFSs.

Additionally the rate would be paid by all citizens, while only 9.6% of the City's population (impacted population) would benefit.

Performing a similar cost benefit calculation, using the impacted population per capita costs to fluoridate water annually at $85.47 and comparing that to the dental cost savings of $101.94 per DMFS is found in Table 13 below

Table 13: Cost - Benefit Calculation – Impacted Population

Per Capita Costs to Fluoridate potable water annually	**$85.47**
Number of DMFS per year (6-13 yrs) *without Fluoridated drinking water*	1.5 DMFS / child
Number of DMFS per year (6-13 yrs) *with fluoridated drinking water*	0.8 DMFS / child
DMFS / child / year prevented	**0.7 DMFS**
Approximate cost of 1 DMFS	$101.94
Number of DMFS per year prevented with fluoridation per child (6-13 years)	1
Per Capita Dental Cost savings with fluoridated water annually	**$101.94**
Cost - Benefit Ratio	= (Cost of Implementation / Savings in Costs of Dental Treatment) = $85.47 / $101.94 **= 0.84:1**

. The cost –benefit calculation for the per capita costs for the target population yields the same cost-benefit ratio of 0.84:1, as would be expected. This is just another way of calculating the cost-benefit ratio. Another way of performing the cost benefit calculations is by translating the cost per capita for all populous in the City and equating the total dental cost savings for the target population to the entire population, which gives an annual per capita dental cost saving (with fluoridated water) of $9.74. This calculation can be seen in table 14, which also has a cost-benefit ratio of 0.84:1.

Table 14: Cost - Benefit Calculation – Total Population

Per Capita Costs to Fluoridate potable water annually		**$8.16**
Number of DMFS per year (6-13 yrs) *without Fluoridated drinking water*		1.5 DMFS / child
Number of DMFS per year (6-13 yrs) *with fluoridated drinking water*		0.8 DMFS / child
DMFS / child / year prevented		**0.7 DMFS**
Approximate cost of 1 DMFS		$101.94
Number of DMFS prevented with fluoridation per child (6-13 years)		1
Total impacted population		10,704
Annual Dental Cost savings with fluoridated water		**$1,091,165.76**
Total Population		111,997
Per Capita Dental Cost savings with fluoridated water annually		**$9.74**
Cost - Benefit Ratio	= (Cost of Implementation / Savings in Costs of Dental Treatment) = $8.16/ $9.74 **= 0.84:1**	

Table 13 and table 14 are two different ways to calculate the cost benefit ratio, both having the same cost ratio as what was originally calculated in table 12.

Although this cost benefit analysis is helpful it should be noted that the analysis is derived from theoretical data and cost estimates which are predicted, not the exact costs and numbers which would result if fluoridation were implemented in the City of Santa Clara's potable water system. Since this information is based on several sources of information, and several assumptions were made to calculate the cost-benefit ratio, it is important to note that this cost-benefit analysis is simply a decision making tool and should be used carefully when making a policy decision based on the cost and benefits. It should not be the only tool used by a decision maker to determine whether or not to fluoridate City supplied water. However, the cost-benefit analysis was based on conservative assumptions for actual costs for implementation, therefore if the costs of the implementation of City wide fluoridation of the public water system were to increase, the cost would increase to the benefit (cost savings) acquired by the consumer. By underestimating these expenses, within reason, the cost benefit ratio is lower than what would be expected.

It is difficult to quantify the actual outcome of benefit since the actual decrease in DMFSs would need to be measured before and after the implementation of fluoridated drinking water within the City. Although this number of DMFSs prevented is obtained from the CDC, the true impact to those individuals with dental benefit from fluoride would need to be tracked and monitored closely before and after fluoride is introduced within the service area impacted.

Public Policy Challenges

Other options exist to increase children’s dental health at a lower cost to the community. The city could provide funding to the schools for an educational outreach program to educate parents about the benefits of fluoride-containing products such as toothpaste and mouthwash. The county dental society might be a partner in such a program, and educational materials might already be available for free or at little cost per student through the dental society, CDC or companies that manufacture such products. Fluoride drops and tablets could be distributed for free through local community service organizations and dentists through an annual subsidy from the city. The cost per child for such treatment is about $100 per year, and the funding would be targeted to those actually benefitting from fluoride administration, while not adding a chemical to water consumed by adults and used in industrial applications, for which it would not be beneficial. It has the added public policy benefit of allowing parents to determine whether and how they want fluoride administered to their children for the prevention of dental caries. Furthermore, it foregoes a major capital project that would require perpetual maintenance at ever increasing costs.

Now that AB 733 has been implemented for a period of time, research could be conducted to determine the actual dental benefits to children in systems with fluoridated water versus children drinking non-fluoridated water. Such data would be useful in determining whether the investment in community-wide fluoridated water is worthwhile.

Such data might also be used to overturn AB 733 in the legislature if the benefits are shown to be minimal, especially in an era of tight budgets. The annual funding for the priority list fluoridation programs could be reprogrammed for other children's health initiatives with a better cost/benefit outcome.

Recommendations

For the City of Santa Clara it is recommended that the City not independently pursue implementing system wide fluoridation. The cost benefit analysis shows the benefits to the consumer, reduction in dental caries in targeted population (children), outweigh the costs associated with capital improvements and operations and maintenance costs. However, for the City and community to arrive at the intended outcome associated with community water fluoridation, several factors must be addressed. These factors include, but are not limited to, the City's ability to financially invest in fluoridating the remainder of the drinking water system, overcoming political challenges, and community buy in. Should the State of California provide the financial means to the City to build fluoridation treatment systems, pursuant to the Health and Safety Code, the City would have the obligation to then build the infrastructure necessary to fluoridate the City's public water system. Based on the current State of California budgetary conditions, it is unlikely that the State will have enough funding to install fluoridation systems in all 140 public water systems in the near future. When and if the State of California does have the financial means to implement fluoridation for the City of Santa Clara, then it is recommended that the City reevaluate the costs associated with system wide fluoridation based on current market prices, which will reflect true costs and inflation.

The cost and long term (infinite) investment to fluoridate would be a permanent operation, with maintenance expense and a minimum of twenty five years' capital financing investment for the Utility and its ratepayers. Since this financial investment is significant, it is recommended that, should the Utility invest in capital investments for infrastructure, the priority be placed on investing in infrastructure which is in poor condition, has the potential to cause public health concerns, create negative environmental impacts, or is considered inadequate to sustain natural disaster impacts. The Utility's mission statement includes providing "a dependable supply of safe, potable water… environmentally-sound, wastewater collection, treatment and disposal…", therefore any infrastructure improvements and financial investment should be in alignment with the Utility's mission statement. (City of Santa Clara, 2010)

One major qualitative program concern that would make system wide fluoridation difficult to implement is the state's policy, outlined in detail and described above, which is contrary to the local (City) public policy decision and stance. When AB 733 (Speier) was introduced, the City was adamantly against the forced fluoridation of public water systems, voicing their concerns through letters to legislators and through Council Agenda Reports during City Council meetings. Although AB 733 (Speier) was passed and SFPUC fluoridated its water supply, inherently affecting some City of Santa Clara consumers, it was still staff's recommendation and Council's acknowledgement to not actively implement system-wide fluoridation throughout the entire City.

Based on this public policy history, and previous decisions by the Council and City staff, it is further recommended that the City and its staff continue to adhere to these same policies, unless, of course, the State can provide funding, in which case State law would override local policy, and a new evaluation would be needed for the City and its staff.

Another major qualitative program element is the ability to ensure proper fluoride dosage is received by those consuming potable water. The optimal fluoride dosage level would be 0.7 to 1.2 mg/l.. These dosage requirements are based on the amount of water consumed by the individual. If someone does not drink enough or drinks more potable water daily than what is assumed, the amount of fluoride consumed would vary. Additionally, other fluoride sources, such as toothpaste, consumer products and foods, also could add to the amount of fluoride an individual may consume. The Utility does not have the ability to control other contributing sources of fluoride and the amount of water consumed by those drinking potable water. The proper dosing requirements are essential to achieve the dental health benefit endorsed by ADA and CDC. Also, the concern about overconsumption of fluoride exists, as it can cause fluorosis and other health concerns, which makes it imperative that the city's water system manage the addition of fluoride in conservative amounts. With this information and risk, the potable water system should not be the only source by which the public receives the recommended doses of fluoride needed to achieve dental benefits, including reduction in DMFSs or DMFTs.

The financial burden of implementing system-wide fluoridation within the City of Santa Clara is also a critical factor for the City and its rate payers. The rate increases modeled from the previous 5 years, indicate an average 4.2% increase in rates for consumers. The City Council's position is to minimize any unnecessary financial burden to its rate payers. Since the utility already has many concerns and difficulties implementing high percentage rate increases, any additional rate increases must be justified and presented as absolutely necessary when asking the City Council for their approval. Implementing fluoridation, without the funding identified by the State, would not be an easy rate increase to approve, since it is not considered a required chemical additive in order to provide safe potable water. Based on the financial condition of the Utility and the City Council's position on minimizing rate increases, it is recommended that rate increases for fluoridation not be considered, unless other funding sources are made available to minimize the rate increase needed to finance capital improvements and offset operations and maintenance expenses.

Should the City implement system-wide fluoridation in the future, it is recommended that smaller localized treatment systems be built rather than one centralized treatment facility. Although a series of small treatment systems is inherently easier to operate than one large facility, having several of these facilities distributed through the City presents logistical concerns, chemical management risks, and requires the specific technical expertise. With these challenges comes additional education, training, costly personnel, and long term financial obligations to ensure that facility management adheres to all requirements, including but not limited to requirements imposed by the California Department of Public Health, environmental, health and safety regulations and other local, state and federal laws.

One other concern is that since the Utility's main purpose is to provide safe potable drinking water, activities beyond that purpose, such as adding chemical additives (fluoride) beyond what is necessary to ensure that the water is safe to drink, will transform the Utility into an entity which imposes health supplements on the City's potable water consumer. Since the Utility is not a public health agency, and is not in the business of promoting or providing such services, the Utility would take on the role of advocating a health supplement. As a Utility, the primary concern is to provide the water necessary for both basic consumption and sanitary purposes. Beyond providing water for these primary purposes, the Utility would be forcing those who do not want to ingest fluoridated water to either consume the water or have to buy their drinking water independently, or install treatment to remove fluoride. This advocacy role not only seems inappropriate for such an agency, but also takes the consumer's right to choose what they ingest out of their hands. This could create public concern and unrest among citizens who do not want fluoride in the water. Therefore, based on these concerns, it is recommended that the Utility not impose on the citizens' right to choose, which is in alignment with the City's current policy to not pursue system-wide fluoridation.

Implementing fluoridation could potentially provide dental health benefit to children, as demonstrated in various dental health studies and captured in the cost benefit analysis. The outcome of the cost-benefit analysis, including long-term and short-term financial impacts, researched policy decisions, proper fluoride dosing levels, the potential for rate increases, the challenges in management of fluoridation treatment systems and the community's right to choose what they consume together provide a clear direction on what the City of Santa Clara must consider, should they be faced with the decision on whether they should implement system-wide fluoridation. If the financial conditions and funds were made available to implement fluoridation, a cost-benefit analysis would have to be recalculated and recommendations be reevaluated, however at this time it is the overall recommendation of this research not to implement system-wide fluoridation in the City of Santa Clara.

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APPENDIX A

CENTRALIZED TREATMENT SYSTEM PIPE CONSTRUCTION COSTS

Zone	Well Number	Pipe to Utility Yard (Miles)
1	2 (02)	2.6
1	3 (02)	1.78
1	4	1.47
1	5 (02)	1.83
2	6	3.48
1	7	2.77
2	8	3.81
2	9 (02)	4.38
2	10	4.08
2	11	3.05
1	12	2.03
1	13-02	1.98
1	14	2.26
2A	15	5.06
1	16-02	1.79
2	17-02	3.86
1	18-02	1.38
1	21	2.39
1	22-02	2.91
2	23	3.41
2	24	3.87
1	25	2.33
1	26	2.11
1	28	0.77
2	29	4.32
1	30	1.05
1	32	2.7
1	34	3.13
Total Pipe Length (in miles)		77
Total Pipe Length (in feet)		404,448
Cost of Pipe / Linear foot		$250.00
Total Costs To Construct Pipe (approximate)		$101,112,000

APPENDIX B

ANNUAL PERSONNEL COSTS

Personnel Calculation Assumptions: *1) Work efficiencies can be accomplished by cross training staff* *2) Current Salaries for each position listed with 34% or 35% benefits* *3)Anticipated increases in CalPERS is not captured*			
Position	No. of Persons needed	Annual Salary plus benefits	Total Costs
Water Treatment Technician	3.5	$111,456.00	$390,096.00
Code Enforcement Technician	1.25	$118,195.20	$147,744.00
Compliance Manager	0.25	$166,186.00	$41,546.50
TOTAL Personnel Costs			$579,386.50

APPENDIX C

ANNUAL CHEMICAL COST CALCULATIONS

Chemical Calculation Assumptions: *1) FY 2009/2010 Water Production used for annual water production* *2) Average annual temperature in Santa Clara is assumed to be approximately 70F (weather.com)* *3) Based Average Annual temperature & Title 22 chart, use 1.1 ppm as Fluoride control point* *4) Per chemical manufacturer two major shipments of chemicals are included (no additional shipment costs)*	
Annual Water Production in million gallons (2009/2010)	6,831
Convert million gallons to gallons	7,514,100,000
Convert Million gallons to lbs (using 8.34)	62,667,594,000
Lbs of Fluoride required	68,934
Lbs of NaF required	152,381
Per lb cost of NaF (per chemical manufacturer Solvay Chemicals)	$0.67
Total Annual NaF (Sodium Fluoride) costs	$102,095.41

APPENDIX D

TOTAL ANNUAL OPERATIONS AND MAINTENANCE COSTS

Total Annual Personnel Costs	$579,386.50
Total Annual Chemical Costs	$102,095.41
Total Annual Operations and Maintenance Costs	$681,481.91

APPENDIX E

ANNUAL COST CALCULATIONS – ACRE FT/YEAR (BASED ON HISTORIC WATER PRODUCTION)

Fiscal Year		FY 04/05	FY 05/06	FY 06/07	FY 07/08	FY 08/09	5 year average
Water Production (acre-ft/yr)		*23,411*	*23,758*	*24,536*	*24,048*	*22,476*	*23,646*
Annual Capital	$233,299.93	$9.97	$9.82	$9.51	$9.70	$10.38	$9.87
Annual O & M	$681,481.91	$29.11	$28.68	$27.77	$28.34	$30.32	$28.82
Total Annual Costs	$914,781.84	$39.07	$38.50	$37.28	$38.04	$40.70	$38.69

APPENDIX F

ANNUAL COSTS CALCULATIONS – PER UNIT WATER (BASED ON HISTORIC WATER PRODUCTION)

Fiscal Year		**FY 04/05**	**FY 05/06**	**FY 06/07**	**FY 07/08**	**FY 08/09**	**5 year average**
Water Production (acre-ft/yr)		*23,411*	*23,758*	*24,536*	*24,048*	*22,476*	*23,646*
Annual Capital	$233,299.93	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
Annual O & M	$681,481.91	$0.07	$0.07	$0.06	$0.07	$0.07	$0.07
Total Annual Costs	$914,781.84	$0.09	$0.09	$0.09	$0.09	$0.09	$0.09

APPENDIX G

RATE INCREASES CALCULATIONS (BASED ON HISTORIC WATER PRODUCTION)

	FY 04/05	FY 05/06	FY 06/07	FY 07/08	FY 08/09	Average Rate Increase
Actual $/HCF	$1.743	$1.813	$1.940	$2.115	$2.305	$1.983
New $/HCF (+Fl costs)	$1.833	$1.901	$2.026	$2.202	$2.398	$2.072
Percent Increase (excluding Fluoride)	N/A	4.0%	7.0%	9.0%	9.0%	7.3%
Percent Increase (including Fluoride)	N/A	9.1%	11.7%	13.5%	13.4%	11.9%
Rate % Difference	N/A	5.1%	4.7%	4.5%	4.4%	4.7%