CITY OF AUBURN

Sewer Pipe Blockage and Potential Education Strategies

University of Washington Department of Environmental and Occupational Health Services
Environmental Health 545: Water, Wastewater, and Health

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SEWER PIPE BLOCKAGE AND POTENTIAL EDUCATION STRATEGIES

About Livable City Year 04
About the City of Auburn 05
Executive Summary 06
Introduction 08
Defining the Problem 10
Potential Health and Environmental Concerns 14
Educational Strategies for Behavioral Change 18
Past Programs to Improve Residential FOG Disposal Practices 20
Suggested Approach for FOG Reduction Program 28
Evaluation 36
Conclusion 38
References 40

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ABOUT LIVABLE CITY YEAR

The UW Livable City Year program (LCY) is an initiative that enables local governments to tap into the talents and energy of the University of Washington to address local sustainability and livability goals. LCY links UW courses and students with a Washington city or regional government for an entire academic year, partnering to work on projects identified by the community. LCY helps cities reach their goals for livability in an affordable way while providing opportunities for students to learn through real-life problem solving. LCY has partnered with the City of Auburn for the 2017-2018 academic year, the inaugural year of the program.

The UW's Livable City Year program is led by faculty directors Branden Born with the Department of Urban Design and Planning, and Jennifer Otten with the School of Public Health, in collaboration with UW Sustainability, Urban@UW and the Association of Washington Cities, and with foundational support from the College of Built Environments and Undergraduate Academic Affairs. For more information contact the program at uwlcy@uw.edu.

LIVABLE CITY YEAR: ONE YEAR. ONE CITY. DOZENS OF UW FACULTY AND HUNDREDS OF STUDENTS, WORKING TOGETHER TO CATALYZE LIVABILITY.

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ABOUT THE CITY OF AUBURN

The City of Auburn is well-positioned to take advantage of many of the opportunities in the Puget Sound region. Centrally located between Seattle and Tacoma, Auburn is home to more than 77,000 residents. It is the land of two rivers (White & Green), home to two nations (Muckleshoot Indian Tribe & City of Auburn) and spread across two counties (King & Pierce).

Auburn was founded in 1891 and has retained an historic downtown while also welcoming new, modern development. Known for its family-friendly, small-town feel, Auburn was initially an agricultural community, the city saw growth due to its location on railroad lines and, more recently, became a manufacturing and distribution center. Auburn is situated near the major north-south and east-west regional transportation routes, with two railroads and close proximity to the Ports of Seattle and Tacoma.

Auburn has more than two dozen elementary, middle and high schools, and is also home to Green River College, which is known for its strong international education programs. The city is one hour away from Mt. Rainier, and has many outdoor recreational opportunities.

The mission of the City of Auburn is to preserve and enhance the quality of life for all citizens of Auburn, providing public safety, human services, infrastructure, recreation and cultural services, public information services, planning, and economic development.

WWW.AUBURNWA.GOV

01 EXECUTIVE SUMMARY

The City of Auburn expressed a need to develop techniques to mitigate sewer pipe clogs from Fats, Oils, and Greases (FOG) throughout the city. Our goal is to provide educational strategies for FOG and provide an evaluation plan for the city's effectiveness on decreasing sewer pipe clogs from FOG. In order to develop an effective plan, we reviewed literature related to FOG disposal effects on the environment, behavior-changing education-specifically in regards to environmentally sustainable behaviors, as well as past and current programs for FOG disposal education in other cities in the United States. To do this, students split into two groups: Group 1 focused on the effects of sewer pipe blockages on the city and Group 2 focused on best education practices used by other cities that showed decreases in clogged pipes due to FOG. Group 1 research found two main sources that cause pipe blockage: FOG and personal wipes. Group 2 research found three different approaches that were successful in other cities:

- Picture-based brochures due to a high percentage of non-English speaking homes,
- In-home FOG collection sources for an alternative way to dispose of FOG, and
- Outreach to the community through schools and community events.

02 INTRODUCTION

Many foods contain fats, oils, and grease (FOG), nonpolar molecules that do not dissolve in water (Williams et al. 2012). When the food that contains these substances, or the waste FOG that is left over from cooking them, is deposited into sewer drains, FOG will build up on the walls of sewer pipes, as shown in Figure 1 (Williams et al. 2012).

FIGURE 1

Fats, Oil, and Grease (FOG) clog up sewer pipes .

Credit: https://water.arlingtonva.us/sewer/fog/

This reduces the diameter of the pipes, minimizing water flow, and can even result in complete blockages of the pipes (Ashley et al. 2000). The FOG deposits can grow especially large when other items, such as disposable wipes, floss, and hygiene products become lodged in the grease (Keener et al. 2008). These blockages can cause significant problems with water flow from residential and commercial areas to wastewater treatment facilities, resulting in sewer overflows and additional maintenance for water utilities' employees (Elwell et al. 2016). This places additional stresses on the resources of water utility companies and public officers, who are responsible for safely moving wastewater from point-of-use locations to a wastewater treatment facility (Southerland, 2002).

THESE BLOCKAGES CAN CAUSE SIGNIFICANT PROBLEMS WITH WATER FLOW FROM RESIDENTIAL AND COMMERCIAL AREAS TO WASTEWATER TREATMENT FACILITIES, RESULTING IN SEWER OVERFLOWS AND ADDITIONAL MAINTENANCE (ELWELL ET AL. 2016)

According to Sewer Utility Engineer, Robert Elwell, and Water Distribution Manager, Chad Jordison, the City of Auburn faces increasing accumulation of FOG and cleaning wipes in wet wells relative to previous years (Keener et al. 2008). This problem has resulted in increased time and energy invested in cleaning. The city sewer system consists of 200 miles of collection system piping, 27 pump stations, and serves 18,000 customers. Wet wells are monitored weekly for debris by the Utilities Division and pumped out at least twice annually by a private contractor, depending on FOG accumulation. Although Auburn has established a program to regulate the activities of food service establishments, sewer disposal habits in residential areas have become increasingly problematic (Keener et al. 2008). The best way to address the problematic FOG-related blockages and sewer overflows is to prevent FOG from entering sewers in the first place. Therefore, the City of Auburn is developing a strategy for public education and outreach that will promote proper disposal of FOG and reduce the levels of FOG in sewer pipes.

03 DEFINING THE PROBLEM

In recent decades, there has been an increase in the amount of harmful residential waste entering the environment via sewage or storm runoff (Daughton and Ternes 1999). FOG, pharmaceuticals, and personal care products have been identified as major culprits that pose problems for treatment of municipal wastewater and are the specific categories that we will focus on in this section.

FOG have multiple adverse effects when introduced to a wastewater system. Even under typical conditions, FOG form aggregations in sewer lines and pump stations that impede wastewater flow and hamper inspection activities. Occasionally, when FOG formations entrain floating debris, they may grow sufficiently massive to obstruct or damage sewer mains and contribute to backup and overflow events (EPA 2001). In pump station wet wells, FOG decomposition by both aerobic and anaerobic mechanisms releases unpleasant odors and can attract rodents to pump station sites (Groff 2008). In secondary wastewater treatment, FOG's biochemical oxygen demand has potential to overtax the aerobic digestion process, slowing waste degradation and possibly precipitating the release of incompletely neutralized pathogens in processed effluent (Williams 2012).

FOG in municipal wastewater consist primarily of cooking waste: saturated and unsaturated triglycerides from animal and vegetable sources (Keener 2008. Commercial food preparers in the US are typically required to install grease interceptors to limit their introduction of cooking FOG to the waste stream; these devices, when properly used, are capable of reducing FOG concentrations in effluent to 100mg/L or lower (Dayton 2010). Residential disposal is unregulated however, and US homes dispense an estimated 7.1 liters/person-year of FOG into municipal sewers, though at lower average concentrations of 20-30mg/L (Long 2012). The aggregate contribution is larger, predictably, in areas of higher population density. Petroleum and mineral oil, wax, and grease comprise secondary sources of wastewater FOG, despite prohibitions against toxic discharges into municipal sewers (Keener 2008). Because approximately half of all sanitary sewer overflows (SSO) in the U.S. are thought to result from partial or complete obstruction by FOG aggregations, it is in the public's interest to limit their introduction to wastewater systems (EPA 2015).

Human pharmaceutical drugs are defined as chemicals used for the diagnosis, treatment, and prevention of disease as well as many other health functions (Heberer 2002). The study identifies two major routes in which medicinal products for human use may be introduced to municipal wastewater including excretion mainly from private households and hospitals as well as via waste disposal methods. The medication is metabolized in the human body incompletely and excreted only slightly transformed or unchanged conjugated to polar molecules according to Heberer. Following the introduction of pharmaceuticals to the municipal wastewater, sewage treatment plants (or STPs) are responsible for removing these contaminants but may suffer from ineffective removal due to two factors (Daughton and Ternes 1999). STPs are designed to treat human waste of mainly natural origin primarily via the degradative action of microorganisms in primary, secondary and/or tertiary processes. However, the fate of micro-pollutants originating from pharmaceuticals is less certain and may be degraded by only a small subset of oligotrophic organisms whose presence is more prevalent in receiving waters or sediment. Secondly, there are many classes of drugs introduced to the market each year and may cause a challenge for microbiota in the sewage treatment works to extensively degrade pharmaceuticals never seen before. Research was undertaken to measure the removal efficiency of municipal STPs for 32 drug residues representing six medicinal classes and five metabolites (Ternes 1998). The results showed that due to incomplete removal during the passage through the STPs, over 80% of drug residue were found in STP discharge streams.

FOG IN MUNICIPAL WASTEWATER CONSIST PRIMARILY OF COOKING WASTE: SATURATED AND UNSATURATED TRIGLYCERIDES FROM ANIMAL AND VEGETABLE SOURCES

Another issue contributing to high rates of improper disposal is the relatively recent pervasiveness of pharmaceuticals in the home. The usage rate, defined as percentage of the population actively using some form of prescription, was examined for a local municipality in England and it was found that over 98% of households were in possession of some type of pharmaceutical compound, with 11.5% of the population disposing their unwanted medication down the sink or toilet (Bound and Voulvoulis 2005). There is also some evidence to suggest that people are largely unaware of the proper methods for disposal of pharmaceuticals. One

particular study analyzed and measured the habits of patients receiving medication and found that about a third of patients believed that flushing pharmaceuticals down the toilet was acceptable while another 21% were unsure if flushing them was acceptable or not (Seehusen and Edwards 2006).

Personal care products are products "marketed for direct use by the consumer" and in contrast, to pharmaceutical compounds, are used in significantly larger quantities that can be released into the environment (Daughton and Ternes 1999). Similar to pharmaceuticals, they consist of active ingredients, with biochemical actions that are generally poorly understood and if left untreated, can result in significant environmental hazards as further described in the study. Wet wipes are a specific source of concern for public works which mainly results from improper disposal of the product. After wet wipes are flushed, they enter the municipal sewer system where they are carried to a wastewater treatment plan (Kessler 2016). However, unlike toilet paper, wet wipes fail to disintegrate, which can cause sewer pumps to clog and forces officials to shut down the sewer system in order to remove the wipes manually.

The problem is further exacerbated by the rapid growth and popularity of personal care products in the household. Personal wipes, a major contributor of sewage waste in the personal care sector, are a $6 billion industry with a predicted annual growth of 6% over the next decade (Goodman 2013). According to Goodman, manufacturers of personal care products are contributing to the public's confusion and lack of education regarding their understanding when it comes to disposing of those products properly. In his research, Goodman notes that manufacturers of personal care products consistently state that their products are 100% biodegradable and that they pose no issue after being flushed, as is proven in their extensive in-house testing. However, the conditions and temperatures that these products are exposed to in the sewage system are not favorable for biodegradation and may take months to years before their materials fully degrade (Kessler 2016).

WET WIPES ARE A SPECIFIC SOURCE OF CONCERN FOR PUBLIC WORKS WHICH MAINLY RESULTS FROM IMPROPER DISPOSAL OF THE PRODUCT

The addition of both FOG's and personal wipes to the municipal sewer system is the primary cause of the so-called "fatbergs," which consist of congealed lumps of fats, wet wipes and other non-biodegradable items that can readily clog sewers or restrict flow of sewage (Hunt 2016). Utility companies and organizations such as the Washington Suburban Sanitary Commission have spent millions of dollars on equipment to shred materials clogging the sewers in addition to replacing damaged sewer pumps (Ehrenfreund 2013). Unclogging sewers and replacing damaged equipment can be costly and requires intensive labor.

Many solutions have been proposed and enacted since the epidemic of improper waste disposal was identified. However, a large number of these quick-fix solutions have been ineffective and did not reach the intended audience (Scott et al. 2013).

Without clear cause and effect for homeowners and apartment residents, there is limited motivation to change one's behavior and the target population is not aware of how their individual actions cause larger consequences. The study makes clear that mass communication tactics seeking to educate consumers about proper disposal habits are unlikely to be enough if consumers cannot make the connection between their disposal habits and the effects of such habits.

04 POTENTIAL HEALTH AND ENVIRONMENTAL CONCERNS

The discharge of large quantities of FOG into wastewater systems creates conditions that require surveillance and ongoing maintenance to control; in addition, it may present certain hazards to human health and the environment. Inherent toxicity is not the primary concern, however, as food-grade cooking waste from commercial and residential sources comprises the major FOG sources in municipal wastewater systems. Toxic contributions from automotive and industrial sources, on the other hand, make up only a minor fraction of the total (Garza 2005). The hazard results from FOG's tendency to form glutinous aggregations in sewer lines and pumping station wet wells. If they are not periodically dislodged or extracted, FOG aggregations can reach sufficient size and mass to impede wastewater flow, potentially contributing to sanitary local backups into residences or sanitary sewer overflows (SSO) that release of untreated sewage into the environment (Alkhatib 2016).

FOG exhibit low solubility in water. As reported by He et al., the FOG in municipal wastewater systems is composed primarily of the 20 free fatty acids (FFA) most commonly found in prepared food and cooking oils. They report that the melting points of these molecules vary from -49°C to 71°C, with many of the FFA's derived from animal sources being solid at room temperature. A common form of FOG aggregation results when animal fats, melted and emulsified in hot dishwasher effluent, bypass grease interceptors and continue on to solidify within the wastewater pipeline. This type of FOG formation is soft and greasy in texture and because it is less dense than water, may accumulate to depths of several feet above collected water in pumping station wet wells. A second type of FOG aggregation appears to develop by saponification, or soap formation, in the presence of Ca2+ ions. Masses of this type are quite solid and may require mechanical disruption by high pressure water jets to remove them from waste lines and pump station machinery (He 2011).

The most significant FOG hazard results from blockages solid enough to cause local backups or sanitary sewer overflows (SSO) by physically obstructing wastewater pipes. Sewer blockage can occur when there is a continuous build-up of FOG's in the sewer system according to a study published by Alkhatib, et al. In the US, FOG masses have been found to substantially reduce the effective diameter of typical 8" wastewater pipes, particularly in areas where sewage flow rates are slower. When wastewater discharge rates exceed a system's flow capacity near an obstruction, an overflow occurs upstream of the blockage. Similarly, storm events that feed combined wastewater systems may precipitate SSOs by overwhelming FOG-compromised sewer lines. FOG buildup in wet wells can contribute to pumping station overflows, even under normal discharge conditions, if soft aggregations engulf and disable the floats and ultrasonic level sensors intended to alert sewer managers to rising wastewater above a developing obstruction (Williams 2012).

SSOs occur, according to the EPA, between 23,000 and 75,000 times annually in the United States, and FOG is believed to be a contributing factor in 47% of those events (EPA 2015). The United Kingdom cites a similar figure, estimating that 50% of its SSO's are FOG-related (Williams 2012). The most common adverse health outcome associated with SSOs is E. coli gastroenteritis from accidental ingestion of water contaminated by untreated sewage, according to the EPA. More serious illnesses associated with SSOs include cholera, cryptosporidiosis, and Hepatitis A, though even common enteric pathogens may cause severe infections in sensitive populations such as children and the elderly (EPA 2015). When untreated sewage flows over into natural bodies of water, fish and shellfish may become contaminated with fecal pathogens that can then be spread to consumers. Users of recreational waters, too, are affected by SSOs: outbreaks involving E. coli, Cryptosporidium, and Norovirus have been reported, and beach and waterway closures impact the economic health of waterfront business communities and subsistence fishers (Barwick 2000).

BEACH AND WATERWAY CLOSURES IMPACT THE ECONOMIC HEALTH OF WATERFRONT BUSINESS COMMUNITIES AND SUBSISTENCE FISHERS

SSOs have environmental impacts as well, as untreated wastewater contains pharmaceutical and pesticide residues that have been shown to disrupt endocrine function in amphibians and aquatic animals (Gros 2016). The high nutrient content of sewage can feed algal growth in contaminated waters, leading to hypoxic conditions that are harmful or lethal to fish. Subtler effects of FOG include the generation of unpleasant odors in wet wells, and the potential to attract rodents and insects to pumping station sites. It has also been suggested that the FOGs

contribution of fatty acids may lower the pH of sewage-contaminated waters and suppress the growth of acid-intolerant microbes. Large concentrations of FOG in wastewater can impede biological treatment methods and reduce the purity of effluent from wastewater treatment plants. Finally, oxidative decomposition of FOG in landfills generates greenhouse gases methane and carbon dioxide (Martin-Gonzalez 2010).

The introduction of wet wipes into municipal sewage is a significant issue that can cause damage to aquatic habitats. Wet wipes, as opposed to other personal care products, present a particular danger due to some of the environmentally toxic materials used to produce it as well as its growing popularity within households (Sahu 2012). Wet wipes are mainly composed of water but a large composition of wet wipes is made up of anionic surfactants common of household cleaning products. These surfactants, if not sufficiently removed during the wastewater treatment process and build up in high concentrations, can kill or harm growth of algae or other microorganisms in water and fish are particularly susceptible to absorbing surfactants through their gills (Yuan et al. 2014). Surfactant-containing wastewater discharge leads to a reduction of dissolved oxygen and corresponding deterioration of water bodies.

Pharmaceuticals are also discharged into the environment and cause serious negative effects on the health and viability of small organisms, particularly fish species. Pharmaceuticals, due to their nonpolar property, are able to pass through biological membranes and target specific cells or tissues (Corcoran et al. 2007). The study points to specific pharmaceuticals like the synthetic oestrogen EE2 that has been found in environmentally significant concentrations due to its relatively low solubility and has been shown to induce feminization in aquatic species. The study states that pharmaceuticals are generally designed to have low toxicity effects on mammals but that there is a significant potential for side effects once fish and other aquatic species, that contain a less tolerant physiology and biochemistry, are exposed to the compounds. Another similar concern that the study lists is that the continuous release of pharmaceuticals into the aquatic environment may lead to long-term exposure and increase likelihood of adverse biological effects. While officials tend to know quite a bit about health risks of exposure to a single drug, there is little known about the combined health effects from interactions between pharmaceuticals compounds in wastewater on the human population and the environment (Kim and Aga 2007).

THE STUDY STATES THAT PHARMACEUTICALS ARE GENERALLY DESIGNED TO HAVE LOW TOXICITY EFFECTS ON MAMMALS BUT THAT THERE IS A SIGNIFICANT POTENTIAL FOR SIDE EFFECTS ONCE FISH AND OTHER AQUATIC SPECIES ARE EXPOSED TO THE COMPOUNDS

05 EDUCATIONAL STRATEGIES FOR BEHAVIORAL CHANGE

In the realm of environmental studies, a common topic is how to educate people with the goal of not merely increasing their knowledge about a topic, but also influencing their habits and behaviors, which enables the spread of environmentally-sustainable behaviors. Education strategies have been grouped many different ways. The World Wide Fund for Nature has identified four categories of environmental education: information, communication, education, and capacity building (Monroe et al. 2007).

- The information category focuses on an increase of awareness by using informal education.
- The communication category opens up a dialogue between the educator and the learner to share experiences that enable them to prioritize and plan for the future.
- The education category promotes understanding, an attitude of concern, and motivation to achieve goals.
- The last category, capacity building, promotes support and work in the conservation setting.

Work by Edgar Dale, who established the Cone of Learning, can help evaluate the success of each of these categories. According to his research, after two weeks we remember only 10% of what we read, 20% of what we see, 50% of what we hear and see, and 70% of what we say (Mayer-Mihalski and DeLuca 2009). Because the World Wide Fund for Nature communication category allows the student to communicate with the educator and others about the importance of the topic at hand, this strategy will most likely result in the best long-term knowledge of the topics, and the longest changes. Therefore, it is best to implement an education strategy that falls under the communication group, as this will potentially result in a 70% chance people will remember how to dispose of FOG materials properly.

For effective learning, we need to 1) set a clean curriculum, or plan for presenting required information, 2) set up enablers, or tools that the learner can use, 3) show application, or how learners can use the knowledge, and 4) address media, or present information that addresses different learning styles (Mayer-Mihalski and DeLuca 2009). Furthermore, asking people to make a commitment or set a goal is very helpful in changing behaviors, especially if feedback is continuously given as to how the goal is being met (Abrahamse et al. 2005). Providing rewards for change may also be effective, but studies have not conclusively shown whether the changes in behavior continue after the reward ends (Abrahamse et al. 2005). Most importantly, the educational program to promote correct FOG disposal should not only give information, but also encourage the public to change their behaviors in specific ways.

06 PAST PROGRAMS TO IMPROVE RESIDENTIAL FOG DISPOSAL PRACTICES

Many U.S. county and city public works companies have noticed a large number of FOG-related sewer problems and have responded to these problems with programs designed to decrease the amount of FOG that reaches the sewers in the first place. Most of these programs focus on managing the amount of grease released from food service establishments (FSEs), however some combine these efforts with plans to engage the public and reduce residential FOG disposal as well (City of Atlanta, Vallecitos Water District, and Seattle Public Utilities). In the majority of these programs, the public is educated with informational materials, while some also provide alternative disposal methods for residents or collaborate with schools to engage children and encourage behavioral change.

Informational Materials

Different counties and cities have used a large variety of media types to spread information regarding the proper disposal of FOG. The most common types are paper materials, which are cheap and easy to produce. In Atlanta, Georgia and Los Angeles, California, informational brochures, which explain the problems related to FOG disposal as well as how to properly dispose of FOG, are distributed with water bills (Benne and Sukenik 2006, Mmeje et al. 2004). Information about the extent of brochure distribution (where and to whom the brochures are given) is not available for most programs, however some options are mailing the brochures to all city residents with their water bills and distributing them at community events (Benne and Sukenik 2006, Mmeje et al. 2004). Programs have also designed posters that can be hung in community gathering-places, such as schools, or common areas in apartment complexes (Texas Commission on Environmental Quality 2013). News articles related to FOG disposal are also numerous throughout the country (Coetsee 2012, Michaels 2014, Gregory 2014, and Makin 2015). These can be especially useful when they are properly timed, for example the day before Thanksgiving, when a lot of people will be cooking greasy foods (Michaels 2014, Makin 2015).

Some programs also included educational videos in their strategies for engaging the public, which were displayed either on governmental websites or on the city's private cable channel (Seattle Public Utilities, Bennett and Sukenik 2006, and The William States Lee College of Engineering, 2016). Air-time on television channels can be expensive, so using these materials for spreading education information can significantly raise the cost of the public engagement program (Dulac 2013).

IN THE MAJORITY OF THESE PROGRAMS, THE PUBLIC IS EDUCATED WITH INFORMATIONAL MATERIALS, WHILE SOME ALSO PROVIDE ALTERNATIVE DISPOSAL METHODS FOR RESIDENTS OR COLLABORATE WITH SCHOOLS TO ENGAGE CHILDREN AND ENCOURAGE BEHAVIORAL CHANGE

On the other hand, information displayed on websites is a very cost-effective way to distribute material. Most programs that were developing educational handouts also included the information on the city's website (Vallecitos Water District, Bennett and Sukenik 2006, Seattle Public Utilities). This is an easy way to provide an additional resource for residents who use the city website or who may be searching the internet regarding sewer problems.

The educational materials that have been developed for FOG management programs often include several different types of information. Most mention the types of food that contain FOG, specifically meats, cooking oil, butter, dairy products, baked goods, and food scraps (City of Atlanta, Seattle Public Utilities, and Vallecitos Water District). Some also focus on the fact that FOG does not necessarily build up only on pots and pans used for cooking; it can also be present on trays, plates, utensils, grills, and cooking surfaces (Seattle Public Utilities and Vallecitos Water District). The educational materials often warn against improper FOG disposal by listing some of its negative consequences, such as grease buildup in pipes, pipe clogs and sewer overflows, attraction of insects and animals, pollution of natural waterways, and an increase in sewer bills (City of Atlanta, The William States Lee College of Engineering 2016, Vallecitos Water District, Citizen Energy Group Indianapolis 2013). Some programs have also found it important to address several commonly-accepted myths about grease. These programs explain that warm water, soap and detergents, and garbage disposals are not able to remove grease, but simply move the grease out of the sink into the pipes, where it builds up (Vallecitos Water District, Dallas Water Utilities).

Another important aspect of many educational materials used in FOG disposal programs is the idea of spreading information about the correct ways to get rid of FOG (Vallecitos Water District and Citizens Energy Group Indianapolis 2013). Reminding people who are using proper disposal methods to share their knowledge with others is important, as it will increase the spread of information. In this way, the public can become collaborators with the water utilities in helping other people reduce FOG levels in city sewer pipes.

REMINDING PEOPLE WHO ARE USING PROPER DISPOSAL METHODS TO SHARE THEIR KNOWLEDGE WITH OTHERS IS IMPORTANT

Importantly, these educational materials also mention specific alternatives to pouring grease down the drain. Most suggest placing the oil and grease in a container, letting it cool, and then disposing of it with solid waste (Vallecitos Water District, Citizens Energy Group Indianapolis 2013, Cobb County). Some also include the idea of wiping plates and pots with a dry paper towel before washing them in the sink (Seattle Public Utilities). Another idea that has been encouraged is using sink strainers to prevent food scraps from entering pipes (Seattle Public Utilities). Giving residents clear steps for proper disposal is important in enabling them to change their behavior, so this part of the educational material is typically emphasized.

Providing Alternatives

Many of the programs implemented to reduce FOG disposal into sewers not only educated the public about proper FOG disposal, but also provided easy alternatives to pouring FOG down their drains. The FOG management programs offered two types of alternatives, sometimes in combination: providing containers for in-house FOG collection and providing easily-accessible drop-off sites (Vallecitos Water District, City of Atlanta, Washington Suburban Sanitary Commission 2016). The containers that were provided were either plastic containers with foil-lined bags (Vallecitos Water District), simple plastic containers (City of Atlanta Watershed Management), or plastic lids to cover aluminum cans, which can be reused (Washington Suburban Sanitary Commission 2016). All of these programs required the residents to contact the water utilities in order to request a collection container, and they were given the containers free of charge. When programs provided drop-off sites, they were either at local companies that recycled the oil (Vallecitos Water District) or by sports facilities, in front of stores, and by frequently-used parking lots. These programs also informed residents that their FOG was being reused in sustainable ways, as kitchen oils and grease can be refined into biodiesel or methane for electricity production (Vallecitos Water District). By telling residents that their recycled FOG is going to good use, these programs can emphasize that proper disposal of FOG is a “cool” and sustainable habit, which may be a helpful motivator in encouraging people to change their behaviors.

Working with Schools and Other Community Organizations

Collaborations between city wastewater divisions and schools or other community organizations show a wide range of involvement on the part of the city. While some cities have expended the time and resources to work with schools to develop laboratory units, others have devised quick activities to briefly inform children about proper waste disposal at fairs or other educational events.

Developed in Palo Alto, California in 1998 by San Jose State University professors, the City of Palo Alto, and 13 high school teachers, Sewer Science is a week-long, hands-on curriculum that teaches the fundamentals of wastewater treatment (Hughes, 2002). Often sponsored by regional water quality control plants, the program has spread to various California counties and is now being implemented outside the state (Maya, 2015 and Ludwig, 2014). Throughout the Sewer Science week, students prepare simulated wastewater with food and household products, including dog food, cereal, vegetable oil, ammonia, toilet paper, and baking soda. They then manipulate Plexiglas models of treatment operations, such as the sedimentation tank, aeration tank, and media filters. Quantitative measurements follow, and students learn to measure pH, turbidity, ammonia, and chemical oxygen demand. They then compare their results to EPA effluent standards and add real activated sludge to their aeration tanks to simulate biological treatment of the wastewater. The curriculum includes a workbook that streamlines the lab by providing protocols for all test methods, data tables for results, and lab guidelines for each day (Hughes 2002). By the end of Sewer Science, students understand that chemicals (including FOGs) irremovable via sedimentation, biological treatment, and filtration should not enter the wastewater system in the first place.

THE LOS ANGELES, CALIFORNIA PROGRAM WAS ABLE TO CUT THE NUMBER OF SANITARY SEWER OVERFLOWS BY 40 PERCENT IN TWO YEARS, AND THEY ATTRIBUTE MOST OF THEIR SUCCESS TO THE ACTIVITIES OF THE “GREASE AVENGER,” A SUPERHERO MASCOT WHO SHARED INFORMATION RELATED TO FOG IN PUBLIC SPACES SUCH AS PARKS AND SHOPPING MALLS

Alternatively, more simple outreach strategies also exist. Educational outreach via hands-on activities at schools, apartment management meetings, and community gatherings is one aspect of Dallas's large-scale "Cease the Grease" FOG recycling program. The University of North Carolina-Charlotte's College of Engineering has developed a set of word searches (K-2nd grades), crossword puzzles (3rd-5th grades), and jeopardy questions (5th-7th grades) related to FOGs and wastewater science (Maya 2015). In Gwinnett County, Georgia, kids are invited to join the "FOG Informant Agency" to help Secret Agent H2O combat the Fats Fiend, Oil Offender, and Grease Goblin. Children are encouraged to help prevent improper FOG disposal through keeping an eye on their parents and creating a FOG disposal can (Gwinnett County Government). Rather than involving simulated activities, these programs focus on teaching proper waste disposal concepts to captive audiences, with the hope that this knowledge will eventually end up in household kitchens.

EDUCATIONAL PROGRAMS SHOULD NOT BE LIMITED TO MERELY INFORMATIONAL MATERIALS, BUT ALSO ENGAGE THE PUBLIC IN CHANGING BEHAVIOR

Past Successes Using Combined Approaches

Although there are many grease management programs organized by water utility services, there is very limited information about the success of these programs in reducing the amount of FOG in sewer pipes. There are, however, some programs that are more developed and in larger cities with more resources that have recorded their success. The Los Angeles, California program was able to cut the number of sanitary sewer overflows (SSOs) by 40% percent in two years, and they attribute most of their success to the activities of the "Grease Avenger," a superhero mascot who shared information related to FOG in public spaces such as parks and shopping malls, as well as at community events (Mmeje et al. 2004). The Los Angeles Water Utilities included not only a public outreach campaign, but also more stringent FSE regulations in order to minimize FOG disposal from both residential and commercial sources (Mmeje et al. 2004). Atlanta, Georgia was able to reduce their grease-related SSOs by 50% in 5 years, and their program combined FSE grease control requirements, compliance enforcement, and public outreach (Bennett and Sukenik 2006). The "Dallas, Texas Cease the Grease FOG management program" has the best documented success, with a 95% reduction in grease-related SSOs in 6 years (Dulac 2013). This was also the most extensive program, which combined educational materials, TV broadcasting, website design, competitions, community outreach at schools and other community organizations, as well as more stringent FSE regulations (Dallas Water Utilities).

As these examples make clear, in order for a grease management program to be successful, it should take multiple approaches to reducing FOG disposal into sewer pipes. In addition to addressing FSE regulations, the program should provide a range of public education efforts. Sharing FOG related information in merely one form has not been shown to be successful in reducing sewer problems. Therefore, educational programs should not be limited to merely informational materials, but also engage the public in changing behavior by providing alternative methods of disposal or interacting with the community at community events or schools.

07 SUGGESTED APPROACH FOR FOG REDUCTION PROGRAM IN AUBURN

As discussed with City of Auburn officials, the following plan uses a combined approach and may be limited by the project budget. We suggest that implementation occur first in the Auburn 40 pump station district, as this station has recently yielded large amounts of FOGs during wet well cleanings. Further, the Auburn 40 district is composed of an isolated community of homes, where progress toward decreased FOG accumulation may be evaluated by Utilities employees (Keener et al. 2008). In addition, we have formulated initial drafts of surveys that may be administered to city residents before and after implementation of any FOG reduction measure.

Part I: Improved Brochures

Within the past two years, informative FOG/wipe disposal postcards have been mailed to residents served by select Auburn sewer districts, shown in red boxes in Figure 2 (Keener et al, 2008).

However, no effect on waste disposal behaviors was noticed. The postcards encouraged residents to "Keep FOG Out!" and included a list of common FOGs, as well as tips to keep drains FOG-free (City of Auburn 2015). One weakness of the postcards may have been their limited outreach to English-speaking households. The City of Auburn's Core Comprehensive Plan indicates that 75 percent of the city's population speaks English at home (average data from 2008-2012). Among the remaining 25 percent, over 40 percent does not speak English proficiently.

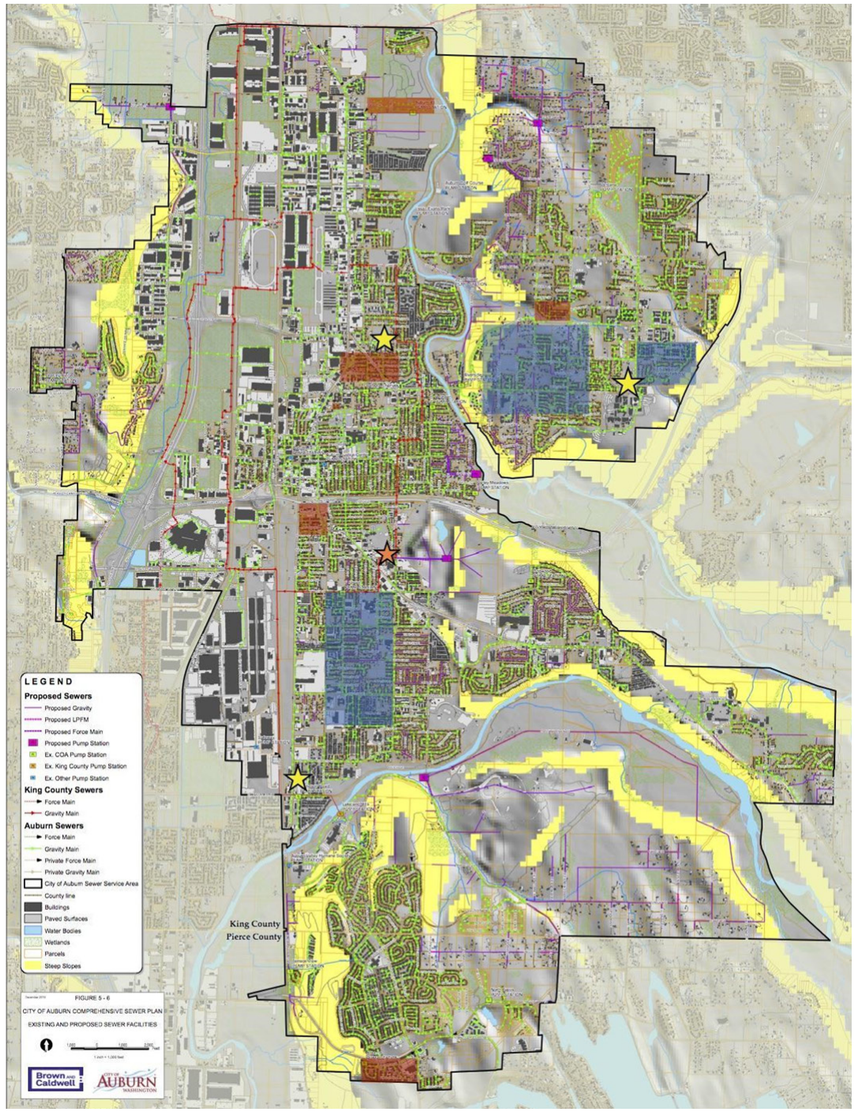


FIGURE 2: MAP OF THE CITY OF AUBURN'S SEWER SYSTEM

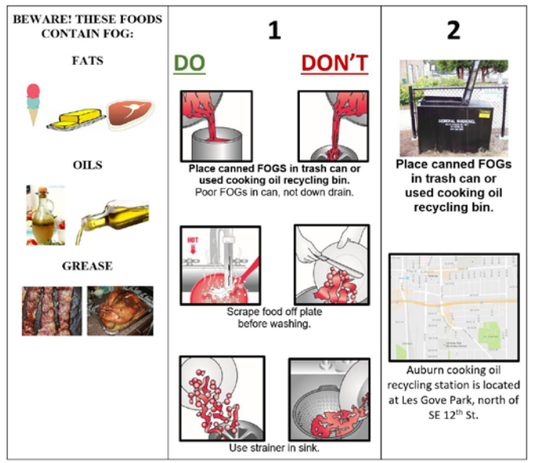
Neighborhoods already contacted with educational postcards are highlighted in red (FOG postcards) and blue (wipes postcards). Pumping stations are displayed as red stars, and potential collection bin sites are shown as yellow stars.

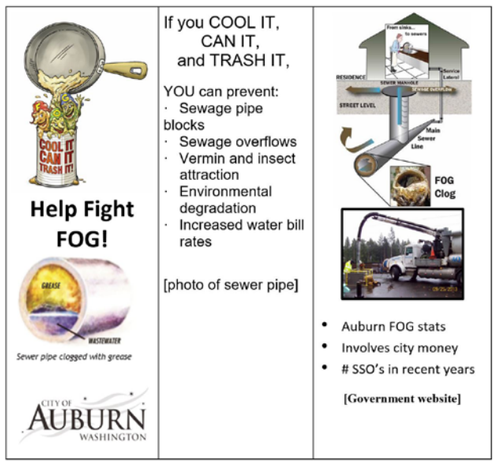
Credit: Figure adapted from 2016 Auburn Comprehensive Sewer Plan.

One third of non-English speaking residents speak Spanish, but the remaining two thirds speak a wide variety of languages (City of Auburn 2015). Therefore, rather than producing translated versions of FOG outreach brochures, we propose an informative outreach effort that uses primarily images to portray appropriate waste disposal behaviors (Gwinnett County Government).

Ideally, this informative outreach strategy should be distributed at major Auburn events, as well as mailed to city residents. Potential outreach events include Auburn Days, the "Water Festival" held for elementary students at Green River College, Boeing's Earth Day activities, Public Works Week, and the Citizen's Academy (Elwell et al. 2016). Information may be presented as a brochure, pamphlet, postcard,

or magnet. Although magnets may be the most expensive approach, they are also most likely to serve as a constant reminder of appropriate waste disposal behaviors. Ideally, a FOG magnet would be accompanied by a more descriptive brochure illustrating the motivation for proper FOG disposal. A basic brochure template is shown in Figures 3 and 4.





Credit: Student Group 2

FIGURES 3 & 4:

Sides A and B of the Proposed Brochure template.

Based on our review of FOG reduction techniques implemented in other cities, the following strategies seem as though they may be most effective among Auburn residents:

Imagery

In order to reach out to Auburn's diverse population, a focus on FOG disposal imagery should be used. Examples that may be incorporated in designing this informative brochure include the Texas Commission on Environmental Quality's poster, entitled "Let's Tackle the Grease in This Kitchen!" (Texas Commission of Environmental Quality 2013). Similar to the poster that targets Auburn's food service establishments, this brochure portrayed the do's and don'ts of FOG disposal without words.

The Process Approach

If Auburn residents better understand the process by which FOGs harm their city's sewer system, they will be less likely to improperly dispose of their wastes. We suggest using an image-based flowchart that ends with images of dirty Auburn wet wells in the last step. For instance, the UNCC Engineering Program's FOG brochure presents a simple 3-step flowchart along with their 1-2-3's of FOG disposal (William States Lee College of Engineering). In addition, residents might be more likely to pay attention if select monetary statistics are included on the handout (e.g. money spent to clean wet wells in 2016).

The "FOGs can harm your sink!" approach

Homeowners and landlords are likely to pay close attention to proper waste disposal when they recognize the potentially harmful consequences to their own drains. As shown through educational efforts by the Washington Suburban Sanitary Commission's "Your Sink Doesn't Get Hungry" campaign, there are a number of food items that both harm garbage disposals and may lead to sewage overflows when put down the sink (Ludwig 2014).

Part II: Household FOG Collection Resources

The City of Auburn currently has one FOG collection bin, located at the south end of Les Gove Park, north of SE 12th Street. One option to further combat FOG in Auburn is the installment of additional bins throughout the city in locations that are often frequented by the public, such as grocery stores, parking lots, and public parks. Placement of these bins will be best determined by Auburn city officials. Suggested locations are the following: Albertson's grocery store, Dick Scobee Elementary School, and the park North of the Green River College Campus. Other potential locations are in the residential community served by the Auburn 40 pumping station, which would be a good start to determine the effectiveness of this strategy, and somewhere in the southern part of Auburn, which is not covered by any of the other suggested locations.

Although collection bins hold potential to result in an ideal form of FOG disposal, residents may be hesitant to utilize them if it means driving to a station. Additionally, residents would have to be made aware of installment of new bins. This would likely involve producing additional pamphlets, or adding a note/map to an already-existing document mailed to residents.

Perhaps installment of household collection bins could be supplemented by distribution of plastic lids to cover aluminum cans (Washington Suburban Sanitary Commission 2016). If funding permits, printing directions for FOG disposal or a map of FOG disposal bins on the lids might increase their effectiveness.

Part III: Cooperation with Local Schools and/or Community Organizations

Because lesson plans for classroom sewer system simulations are not readily available online, we suggest that the City of Auburn directly contact the sources discussed in the preceding section if interested in working with local schools in the long run (Hughes 2002, Maya 2015, Ludwig 2014). Although the Sewer Science program has previously been proven effective in reaching households, this strategy

would require teachers and city officials to invest time toward adopting such a curriculum.

Our initial suggestion for a simple educational outreach strategy is for the City of Auburn is to distribute their plastic lids, fliers, and/or magnets at city events, as well as to other community organizations. Perhaps distribution could be combined with a short, hands-on activity that illustrates the ineffectiveness of pipes clogged with oil and grease and the negative attending consequences on civic infrastructure as well as residents' homes. For example, kids might enjoy decorating FOG cans or becoming members of an organization like the "FOG Informant Agency" (Gwinnett County Government). We suggest that activities organized at City of Auburn booths be targeted toward elementary school students, in order to maximize parental involvement.

08 EVALUATION

Evaluation is a key component of education. To teach a topic effectively, one must assess the before and after to see the change made or the knowledge gained. Analyzing the results of a lesson improves future preparation. An educator must teach to an audience's specific knowledge level, rather than above or below it (Evaluation and Assessment Frameworks for Improving School Outcomes).

Evaluation should help a community work toward specifically identified milestones and goals. In terms of the Auburn FOG disposal effort, evaluation might involve having conversations with residents in the town, sending out surveys, or a combination of these techniques (What is Evaluation).

It is standard practice to use surveys to assess whether outreach programs have resulted in a change in environmental knowledge or behavior. A large collection of literature is available for studies of changes in recycling patterns and solid waste management (Barr et al. 2001, Clark et al. 2003, Corral-Verdugo and Figueredo 1999, Vicente and Reis 2008). The surveys used in these studies are good examples of survey implementation that allows for evaluation of an intervention program.

In order to most effectively collect information, it is important to consider the geographical distribution, timing, and mode of delivery of the survey. The majority of studies that assess change in environmental behavior deliver surveys at households (Clark et al. 2003, Vicente and Reis. 2008, Margai 1997). This allows for classification of the responders into neighborhoods, which may have different access to waste-reducing alternatives (Clark et al. 2003, Margai 1997). These surveys can be mailed with utility bills (Clark et al. 2003), however most often interviewers visit people at their homes in and give the survey orally (Barr et al, 2001, Vicente and Reis 2008, Margai 1997). A more communicative approach enables verbal clarification of the ideas expressed in the survey, so it is less likely for the respondents to misunderstand the questions. When these surveys are being distributed in multilingual neighborhoods, it is important that the interviewers can speak the most common languages of communication (Margai 1997). Additionally, if surveys are given orally, it is possible to conduct the surveys in a public area, such as a grocery store or school (Covey 2016). This can minimize the amount of time and effort needed for the survey.

IN ORDER TO MOST EFFECTIVELY COLLECT INFORMATION, IT IS IMPORTANT TO CONSIDER THE GEOGRAPHICAL DISTRIBUTION, TIMING, AND MODE OF DELIVERY OF THE SURVEY

In order to assess whether an intervention has resulted in better environmental behavior, it is important to gather information both about individuals who have been participants and people who have not participated in the educational outreach. Different studies have done this in different ways, either by interviewing the same people before and after intervention (Margai 1997) or by interviewing both participants and non-participants after the intervention. If the single survey time approach is taken, it is important to carefully classify how much of the educational material respondents have been exposed to, either by including questions about this in the survey (Vicente and Reis 2008) or targeting neighborhoods whose participation in an intervention program is known (Barr et al. 2001, Clark et al. 2003). If the intervention activities are not targeted at specific households or neighborhoods, this last approach is not likely to be effective. Another consideration to take into account is the attrition rate of survey respondents when two surveys are conducted. Some of the initial participants will not be accessible when the second survey is conducted, so not all of the initial surveys will be able to be used for effectiveness analysis. Surveys are further limited by the fact that participants may suffer some degree of recall limitation or recall bias - either they cannot fully recall details of their environmental behavior, or their recollections are not necessarily accurate or complete (Gordis 2014). Thus, while surveys hold potential to assess a community's environmental behavior before and after an intervention, certain limitations are inevitable.

Based on these standards, we suggest that two surveys be performed in Auburn, one before implementation of the educational program and one after implementation. The pre-program survey will provide information about the willingness of residents to change behavior, which can help guide the allocation of resources to different neighborhoods. The first survey will also provide baseline information about current practices related to FOG disposal that can be compared to the post-program survey to assess the effectiveness of the community outreach program, i.e. how many residents have reduced FOG disposal into drains.

If the City of Auburn chooses to initially target the Auburn 40 sewer district in their FOG intervention effort (i.e. through delivering brochures, magnets, and/or FOG can lids to pre-identified homes), then a door-to-door survey method would enable simple comparison of disposal behaviors before and after the intervention (Barr et al. 2001, Vicente and Reis 2008, Margai 1997). Sample size would be limited by the number of residences in the Auburn 40 zone, and behavior change could be assessed within a confined group of people. In addition, to supplement the survey analysis, Utilities employees could monitor the Auburn 40 wet well, which collects wastewater only from the Auburn 40 zone, in order to qualitatively monitor the outcome of the intervention.

Alternatively, if the City of Auburn chooses to implement a city-wide intervention through non-targeted distribution of FOG education materials, we suggest that the surveys be given verbally to visitors at grocery stores, specifically Albertsons and Safeway. By surveying at grocery stores, the surveyors can target individuals who are likely responsible for FOG disposal, as it is probable that the same family member buys food and disposes of food. Additionally, because the distribution of educational materials will not target specific neighborhoods, it is more appropriate to determine respondents' exposure to the intervention by a question in the survey than by assuming exposure based on their home address. In this scenario, in order to maximize the analysis of effectiveness of the program, the post-intervention survey should also include a question about exposure to education about FOG, as this will prevent the second survey from being limited to those people who were contacted during the first survey.

Pre-Intervention Survey

The pre-intervention survey should consist of 3-5 short questions that assess Auburn residents' awareness of the FOG problem, current FOG disposal strategies, and openness toward altering disposal habits. This survey may also provide Auburn city employees with an opportunity to provide brief education on FOG clogs. We suggest that surveys be delivered orally and that shoppers initially be made aware they will only have to answer a few questions. Hiring bilingual surveyors might prove beneficial, as 8% of Auburn's residents speak Spanish as their first language.

Suggested questions are included below:

Introductory Statement: "Would you be willing to answer four quick questions about your household's food waste disposal?"

1. FOG Awareness: "Are you aware that fats, oils, and greases (FOG) can build up in your pipes?" Answer: Yes/No

2. Current FOG Disposal: "What do you currently do with your cooking oil, butter, and bacon grease when you're done cooking or eating?"

   a. Wash it down the sink
   b. Flush it down the toilet
   c. Scrape/pour into the trash once cool
   d. Can and throw away
   e. Place in FOG collection bin

3. Potential for Behavior Change: "If the City of Auburn were to install a cooking oil disposal bin near you, would you be likely to use it?"

Answer: Yes No Additional Info_____

4. Potential for Behavior Change: "Would FOG disposal be easier if the City of Auburn were to distribute FOG cans and lids?"

Answer: Yes No Additional Info _____

5. Geographic Information: If residents are willing to share their address, have them write it on the survey form.

Post-Intervention Survey

The post-intervention survey should determine whether the Auburn FOG intervention program proves effective, perhaps six to eight months following implementation. The survey should be administered in similar fashion to the pre-intervention survey.

Suggested questions are as follows:

Introductory Statement: "Would you be willing to answer a few quick questions about your household's food waste disposal?"

1. FOG Awareness: "Are you aware that fats, oils, and greases (FOG) can build up in your pipes?" Answer: Yes/No

2. Current FOG Disposal: "What do you currently do with your oil, butter, and bacon grease when you're done cooking or eating?"

   a. Wash it down the sink
   b. Flush it down the toilet
   c. Scrape/pour into the trash once cool
   d. Can and throw away
   e. FOG collection bin

3. Do you recall being previously surveyed by the City of Auburn in [month]? Answer: Yes/No

4. Program Evaluation: Have you noticed our effort to improve awareness about proper FOG disposal? Answer: Yes/No

If yes, how have you received information about FOG disposal? [Select all applicable.]

a. Informational brochure/magnet

b. Collection can and lid

c. Poster by collection bin

d. Presentation at public gathering

If yes, did you change your disposal behavior? Answer: Yes/No (Why not?)

5. Geographic Information: If residents are willing to share their address, have them write it on the survey form.

Survey Assessment

The pre- and post-intervention surveys are intended to gather general information about FOG awareness levels, FOG disposal behaviors, and potential for behavior change in the Auburn community. The first two suggested questions are identical on both surveys and can be used to directly compare FOG awareness and disposal behaviors before and after the education intervention, perhaps through using a t-test. Questions 3 and 4 of the pre-intervention survey assess residents' willingness to utilize new options for proper FOG disposal. Prior to installing new disposal containers or distributing FOG can lids, Auburn officials might decide on a percentage of positive response necessary to implement these actions. Questions 4 of the post-intervention survey directly asks residents if they altered their disposal behaviors as a result of the city's FOG education efforts. This will help city officials decide whether further education outreach should implement alternative strategies.

One weakness of our proposed surveys is that they do not account for demographic factors. Age, household size, home ownership, and socioeconomic status have previously been found to be confounding variable in terms of waste reduction behavior and recycling patterns (Margai 1997, Covey 2016, Owens et al. 2000, Lansana 1992). However, the surveys serve as a good start to assessing the FOG problem, and implementation should not involve excessive time or resources on the part of the City of Auburn. Further, in our effort to suggest an effective community-wide FOG outreach program, we have attempted to present distributable materials that target the city's diverse population and minimize the degree of confounding variables.

09 CONCLUSION

As evidenced by increasing amounts of FOGs in Auburn wet wells, the city faces a need to further inform its population regarding proper waste disposal. We reviewed effects of city systems due to FOG and personal care wipes to understand the problem further. We also reviewed education and outreach strategies used by other cities facing FOG accumulation problems and suggested a reduction strategy for the City of Auburn. Combined approaches have proven most effective, and we have presented a three-fold plan consisting of (I) illustrative pamphlets/magnets, (II) distribution of FOG collection resources, and (III) an educational outreach plan. Due to budget limitations, only part of this plan may be implemented. We also reviewed the literature surrounding evaluation of waste reduction programs and suggested surveys that may be implemented before and after Auburn's FOG education intervention.

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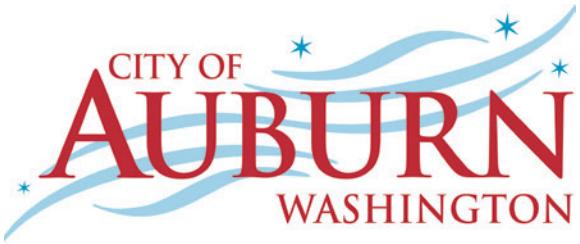

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