GIS Analysis of Sheridan Regional Water Transport;

Where Does Your Water Come From?

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Capstone Project Disclosures

This client-based project was completed on behalf of the Institute for Environmental Solutions and supervised by PUAD 5631 Capstone course instructor Jason Machado, Ph.D. and second faculty reader Robyn Mobbs, PhD. This project does not necessarily reflect the views of the School of Public Affairs or the faculty readers. Permissions to include this project in the Auraria Library Digital Repository are found in the final appendix. Questions about this capstone project should be directed to the student author.

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Executive Summary

Contaminants of Emerging Concern (CECs) are a danger lurking in the drinking water that are currently unregulated and untreated. The Institute for Environmental Solutions (IES) is a Colorado-based non-profit organization that is focused on improving the health and safety of out local communities through its Chemical Footprint Project. This project includes a pilot program in Sheridan, CO about CECs and strategies to alleviate their impact. For the educational component, IES needed to understand where the tap water comes from, where it goes when it leaves down the drain, how it is treated, what happens to CECs throughout, and how to best engage with the community using this information. The purpose of this project is to address these questions by creating a map and presentation of water transportation throughout Sheridan as well as distributing a survey.

The main finding of the map and presentation research is that CECs are prevalent in Colorado. Sheridan's drinking water comes from multiple reservoirs owned by Denver Water. CECs are not treated during the drinking water treatment process. The wastewater then goes to two wastewater treatment plants, South Platte Renew and Metro Wastewater Reclamation District. CECs are not treated during this process either, and the water goes back into the South Platte River, continuing downstream.

The findings of the survey showed that people care about their water quality but are unaware of CECs. It shows they are interested in learning more about them, but that online communication versus community workshops are better suited to change their behavior regarding CECs. This may be due to the effects of the COVID-19 pandemic.

The recommendations based on these results are as follows: IES should have an informational presentation about water transportation, quality, and CECs. This presentation has been created and is ready to be used for any IES purpose. IES should also expand its online presence to accommodate the current needs of the community. Lastly, IES should expand its reach outside of Sheridan, starting with Denver.

Introduction

The Issue

Water makes up 71% of the Earth's surface and 60% of our bodies, but this natural resource is often taken for granted (How Much Water is There on Earth?, 2020; The Water in You: Water and the Human Body, 2020). 91% of the world's population has access to improved, but not necessarily clean, drinking water, which still leaves approximately 663 million people without equitable access (Assessing Access to Water & Sanitation, 2020). The U.S. first began routinely disinfecting the community drinking water starting in Jersey City, New Jersey in 1908 (History of Drinking Water Treatment, 2020). This change in how people treated their drinking water caused a dramatic decrease in nationwide diseases including cholera and typhoid fever. Since then, expansive networks of pipelines, treatment plants, and storage facilities have created a system where 86% of the U.S population gets their drinking water (Public Supply Water Use, 2020).

There are two different types of water on Earth: surface water and groundwater. Both come from rain and snow, but surface water accumulates in rivers, streams, and lakes and is then extracted and distributed to water treatment centers. This provides 64% of the water for public water systems, whereas groundwater provides the other 36%, and is stored in natural aquifers

until accessed at a natural spring or pumped out with a well (Drinking Water Distribution Systems | US EPA, 2020). Public water suppliers get water from both sources which then goes through a series of treatment steps including catchment, screening, coagulation and flocculation, and sedimentation and clarification. The catchment is where a series of pumps and pipes connect the water to a treatment plant. The water is then screened to trap large debris like plants, fish, and trash. Afterward, coagulants (chemicals with a positive charge) are added to the water which binds to negatively charged dirt particles and forms an agglomeration of the solids called 'floc'. The floc is then separated from the water and moved to a sedimentation pond. This is the point where water enters the treatment process. All systems must have standard treatment practices in place to meet the EPA's Safe Drinking Water Standards, but which treatments to use are left to each plant to decide. The most common ones are ozonation, filtration, and disinfection. Ozonation kills microbes, removes bad odors, and degrades pesticides, filtration removes particles, and disinfection adds a chlorine compound to kill or inactivate microorganisms. The treated water is then pumped to the top of a storage tank, creating water pressure when it goes back down. Water then flows through the main and service pipes to individual homes and businesses (Drinking Water Distribution Systems | US EPA, 2020).

While it may seem like the water from the tap should be trustworthy after all these steps and being approved by the EPA, there is still a danger that grows every day, lurking in the water. It goes unregulated, untreated, and affects the health of ecosystems and the human population at large. They are called the contaminants of emerging concern (CECs). Their current course will contaminate the water and create a bigger health crisis. In order to change this course, it is important to know what these chemicals are, what they are doing to the water, and how to stop

them. It is then up to the stewards of the public to disseminate this information in an effective way that engages the public and motivates them to take action. More treatment means higher costs for water treatment plants, so they will not be the first to take care of this issue. It must begin with the people. The Institute for Environmental Solutions (IES) recognizes this and has chosen to do something about it.

The Client

IES is a Colorado-based non-profit organization, focused on delivering scientific solutions to improve our health and the environment. Its vision is to create efficient ways of dealing with complex environmental problems. One way it does this is through the Chemical Footprint Project (CFP). The CFP project team works on several initiatives to reduce human exposure to CECs containing in personal care and household products. It does this through outreach, remaining educated on the latest chemical footprint news, and the development and presentation of workshops for kids and adults. Part of their outreach includes educating the community to make them more conscious about the wastewater they create, their chemical footprint, and the environmental improvement they can make by reducing both.

Project Purpose

The goal of this project is to create a map that visualizes where tap water comes from and where wastewater goes for the people in the city of Sheridan, Colorado. This educational aid will strengthen IES's educational outreach by connecting the community members with their water so that the people will be more motivated to prevent pollution from products containing CECs. Other goals of this project are to understand why CECs are important to prevent and why

educating the public about them effectively can initiate change. The key questions that will be answered throughout the paper and supplemental materials are:

- Why are CECs important?
- Will educating the community make a difference?
- Where does water come from in Sheridan, CO?
- Where does wastewater go in Sheridan, CO?
- What policy implications could this have for the City of Sheridan?

The paper will begin with a literature review to answer the first two questions. Next, an analysis of an in-depth survey about community engagement and education. Following will be the methodology to the GIS analysis which will lead to a report of the results from that analysis, answering the following two questions. Last, there will be a discussion about the results and recommendations for IES, including the answer to the final key question.

Literature Review

The environment is facing a new wave of problems. Global temperatures are rising, ice caps are shrinking, sea levels are rising, trash is building up, plastic is filling the oceans, and wildfires are burning land. Unfortunately, humans are the cause of these issues. We are polluting the land and our own water, sometimes without knowing it. Non-profit organizations filled with people passionate about restoring our ecology attempt to tackle these issues. Some organizations work on policy development for environmental protections, some to save animal species, some to save habitats, and others focus on changing the behavior of humankind to reduce their ecological footprint. The ecological footprint is the impact of a person or community on the environment, expressed as the amount of land required to sustain their use of natural resources

(Ecological Footprint, 2020). One part of this is the chemicals we put in the water. The Clean Water Act passed in 1972 by the EPA sets water quality standards, handles enforcement, and helps state and local governments develop their own pollution control plans (Clean Water Act, 2020). Over the past 40 plus years, the water quality practices have only gotten more robust. In 1996, the Safe Drinking Water Act was passed to ensure quality control of any potential drinking water sources (Summary of the Safe Drinking Water Act | US EPA, 2020). However, there are new contaminants of emerging concern that are not currently regulated or treated for.

Contaminants of Emerging Concern (CECs)

CECs are chemicals that we use in our everyday lives including medicines, personal hygiene products, cleaning products, and their chemical additives. They are present in the environment and associated with various sources such as municipal wastewater treatment plants, runoff from agricultural and urban land surfaces, and septic systems. They are produced industrially but are dispersed into the environment through water from household use (USGS, 2017).

The specific chemicals that are considered CECs often vary depending on the organization. More than 40,000 have been identified, but some are hard to detect and many have a significant lack of research on their effects (Diamond et al., 2011). The EPA releases a Contaminant Candidate List (CCL) every few years which is a list of contaminants that are currently not subject to any proposed or promulgated national primary drinking water regulations but are known or anticipated to occur in public water systems. The most recent list published in 2016 contains 97 chemicals/chemical groups and 12 microbial contaminants (Contaminant Candidate List 4-CCL 4 | US EPA, 2020).

Approaches to the research of CECs vary as well depending on the program. Many programs focus on high production volume (HPV) chemicals under the assumption that these chemicals pose the greatest threat since they are the most produced and used. Other programs approach it from the opposite direction, using the persistence, bioaccumulation, and toxicity of organic chemicals (PBT) method. This method puts the chemicals as the greatest threat dependent on the frequency of their occurrence and their toxicity at low levels (Diamond et al., 2011).

Beyond the different approaches, most of the research to date has centered around detecting CECs in certain waterways, and their effects have focused on aquamarine life and farm animals (Kolpin et al., 2002; Vidal-Dorsch et al., 2012; Snyder et al., 2003; Meador et al., 2016). The USGS consistently tests waterways for CECs. It conducted a national study from 1999-2000, testing 39 different streams flowing from intensely urbanized areas, and found that 80% of these streams had prevalent levels of contaminants (Kolpin et al., 2002). Other non-governmental organizations have also tested multiple fisheries, rivers, lakes, and fresh leachate from landfills (Masoner et al., 2014). All have at least one prevalent CEC, usually more. Currently, there is no defining list of CECs, there is no specific standard for detecting CECs, and there is no set approach to categorize the threat of CECs. The knowledge gaps and lack of structure make these chemicals hard to research and almost impossible to potentially regulate.

What is known is that they are becoming more prevalent, due to bioaccumulation. Bioaccumulation is the process by which the concentration of a chemical in an organism becomes higher than its concentration in the air or water around the organism (Blowes et al., 2003). This happens when an organism drinks the water and the chemical attaches to the tissues

within the organism and therefore accumulates, creating a higher concentration (Diamond et al., 2011).

CECs have known effects include causing issues in fertility for fisheries, issues with growth in mussels, increased mortality to other aquatic invertebrates, toxicity to internal organs, developing fetuses, and reproductive systems (Post et al., 2017). Some have even been listed as suspected carcinogens for humans (Per- and Polyfluoroalkyl Substances (PFAS), 2020). Due to the issues and variances in testing the prevalence of CECs, it is even more difficult to determine the exact effects of CECs. Almost all research to date has been done on aquatic ecosystems and some farm-land mammals. Their effects on the human population are very undecided, and the scope of their effect is even more unknown. The EPA has the Integrated Risk Information System of known chemicals and their *possible* effects. However, there is no direct research linking the toxicity of the chemicals in the water to adverse health effects in humans (IRIS | US EPA, 2020; Benson et al., 2017) The unknown is one of the most concerning components of CECs. Their potential effects are almost endless as they include any ingestion effects of pharmaceuticals, cleaning products, beauty products, and pesticides (Bradley et al., 2020; Benson et al., 2017).

Current drinking water and waste treatment plants do not treat for CECs. Part of this is due to the lack of regulation, part of it is due to the fact that there is no current solution to treat CECs. The normal water treatment process includes ozonation, filtration, and disinfection. These processes do not remove or break down CECs, which allows bioaccumulation. Not only do they lack the ability to remove CECs, but these processes can chemically change the property of CECs, creating various mixtures with even more ambiguous detectability and range of effects.

There has been some effort in possible other treatments to deal with CECs, including activated carbon, reverse osmosis, and membrane treatment (Snyder et al., 2003; Kim et al., 2018). However, there are no current treatments that have been proven for more than one CEC, and none that are able to be instituted within a water or waste treatment plant. Solutions have varied, and only been created in a lab environment. Even if there was a standard treatment for the most popular CECs, it would be a large economic cost to be implemented at the treatment plants.

Overall, CECs are known to exist, but not to what extent. They are known to have adverse health effects, but the extent is not completely known. There are possible treatments, but no proven standard. They are unregulated, untreated, and accumulating every day. Right now, the best way to handle CECs is to immediately reduce their chance of getting into the water in the first place. This begins in individual households and local businesses; until more is known and a cost-effective solution is available, it is up to the community members to be knowledgeable of CECs and reduce their use.

Community Education & Engagement

Engaging people to change their behavior is not always easy and has presented a wealth of problems for non-profits. These problems range from motivational differences to perceived capability to lack of resources. Programs that have been implemented in one geographical area and that have been successful will fall short in a different area due to the wide range of differences between these variables in different communities. People can be motivated by money, their own personal values and morals, the possible repercussions, their respect for an authoritative figure, and many other reasons. This causes an issue for program development in community education and engagement. What incentive will work for one person may not work

for another (Ryan & Deci, 2000; Ryan & Deci, 2020). For example, offering 20 cents per aluminum can may incentivize someone who is motivated by money, but not someone who feels most compelled by their own values (which may not include recycling). People's perceived capability can also affect the success of a program. Even if the monetary-motivated person sees a billboard at a bus stop stating 20 cents for each aluminum can but the drop off location is not near a bus stop, that person may feel incapable of dropping off any cans. For the same reasons, a person who is morally motivated to recycle, but is unsure of what items are recyclable, may feel overwhelmed and incapable of recycling correctly and therefore not even attempt to recycle at all. Even when people are properly motivated and feel capable of changing their behavior, a lack of access to resources may prevent them from doing so. Someone who is motivated to lose weight feels capable of sticking to a workout regime but does not have access to a gym or healthy grocery options may not change their behavior (Cecere et al., 2014). This makes choosing the right program hard for many organizations.

One of the most common options is through a mass media campaign. However, these campaigns alone have mixed results (Young et al., 1996; Tilbury & Wortman, 2008; Luepker et al., 1994). The more holistic approaches have better overall success across multiple regions. The mixed-method approach can help appeal to people across the spectrum of motivation and self-efficacy. The most popular methods include focus on empowerment, ownership, education, mass-media, and actionable step-oriented instructions. Using these mixed methods have been proven to reduce the risk of HIV/AIDS, reduce cholesterol and other cardiovascular issues, reduce obesity, reduce smoking-related illnesses, reduce chemical footprint, and increase sustainability practices (Ramires-Valles, 2002; Fortmann et al., 1981; Chawla & Cushing, 2007;

Weisbrod et al., 1992; Sloot et al., 2018). Community engagement and education can therefore help reduce the presence of CECs in waterways, the next question for IES is what is the best way to educate and engage the community of Sheridan and possibly other areas in Colorado?

Methodology

This project required a mixed-methods approach. The research questions that were answered are:

- RQ1: Where does water come from in Sheridan, CO
- RQ2: Where does water go in Sheridan, CO
- RQ3: What are Coloradan's attitudes towards water quality
- RQ4: What knowledge do Coloradans have of CECs
- RQ5: What is the best method to initiate behavioral change regarding CEC containing household products in Colorado

Answering these questions required data collection and analysis through a survey and ArcGIS.

GIS Map

A map was created in ArcGIS to demonstrate the water distribution and treatment process in Sheridan. The map was made into a visual presentation to be used in IES's community workshops to aid the organization in educating the community about CECs and about its water. This portion of the project answers where tap water comes from, where wastewater goes, and what happens to the water throughout the entire process. The data that was used in the map was both secondary and original. Current map layers provided by the City of Sheridan, USGS, and ArcGIS were reviewed. This provided a starting point to include the sanitary districts of

Sheridan, CO as well as the collection reservoirs used by Denver Water. Other layers, including the location of water treatment plants, sewer treatment plants, and final destinations needed original data to be collected by contacting relevant officials and conducting interviews with the City of Sheridan, Denver Water, South Platte Renew, and Metro Wastewater Reclamation District.

Data Collection

A survey was distributed to obtain data on public opinions about water treatment, CECs, and behavioral motivation regarding CECs (Appendix A). The survey was designed, reviewed, and tested among a focus group. The group provided feedback about the survey in order to ensure it is easily understandable and to ensure consistent interpretation of the questions to improve the quality of the responses. After the review and focus group phases were completed, the survey was designed in Qualtrics survey software through UC Denver. It was a web-based survey, posted in two manners - online and posters. The poster included information about the survey, what it was for, a link to take the survey online, and included a QR code that can be scanned (Appendix B). These posters were displayed in various locations in different towns of Colorado, including libraries, rec centers, local shoppes, and community centers. Online, the survey was shared on community and personal social media accounts such as Facebook, Twitter, and NextDoor. Accounts to post about the survey included IES and other community organizations. The survey also included demographic informational questions and where they received news of the survey. This helped track the differences between groups of people, as well as which postings received the most traffic. The survey was available for 30 days, from October 2nd until November 1st, 2020.

Survey Development

There are multiple reasons to use a survey as a means to collect information about a subject. Politicians use it for their campaign strategies, commercial organizations use it for marketing strategies, TV and radio are scheduled based on consumer surveys, and government and non-profit organizations use surveys to determine program effectiveness. Surveys can gather different kinds of information depending on what the research question determines, including descriptive, behavioral, and attitudinal (Rea & Parker, 2014). Descriptive elements can help understand the socioeconomic differences between groups of people, behavioral information can help to understand what does or would motivate people to behave a certain way, and attitudinal focused questions help determine attitudes and knowledge (Rea & Parker, 2014). These types of information are most relevant for this project's survey. The attitudinal information will determine what peoples thoughts and knowledge are about water quality and CECs. The behavioral information will help IES determine the best ways to conduct its community outreach programs. The descriptive data gathered will determine if there are any differences to the previous two questions based on location or other socioeconomic factors.

There are different types of surveys: focus group surveys, paper surveys, in-person surveys, and web surveys (Rea & Parker, 2014). The one best suited for this project is a web-based survey. Web surveys provide their own set of advantages for data collection. Web surveys are low cost, have a quicker response rate time, reduce the amount of human error, reduce time for data entry, have more design flexibility that can increase survey completion, and can reduce social desirability effects (Umbach, 2004; Lazar & Preece, 1999). Designing the survey and writing the survey also affect response rates and quality of data. There are different

methodologies one can use to produce a survey. They can include focus groups with a pilot test, email campaigns, a web-link posting, location of posting, and the look of the survey. Best practices for designing surveys include choosing a specific methodology and running a pilot test in some format. For the look of the survey, it is important to make questions and instructions clear, not use too much color, include a progress timer, divide long surveys into sections, and limit the question length (Lazar & Preece, 1999; Umbach, 2004). Designing the survey questions themselves should also be taken into consideration. Even a simple verb change in a questions can influence how a person responds. Areas to avoid this issue include acronyms, low-frequency terms, dense noun phrases, hypothetical questions. In order to avoid multiple interpretations of the same question, the survey should not use ambiguous wording, double-barreled questions, or leading questions (Robinson & Leonard, 2019). The best designed survey will consider each of these elements so that the survey is easily understandable, easily completed, is not biased, and is not loaded. Creating a survey in this manner will lead to more reliable results.

Data Analysis

The survey was available for 30 days, from October 2nd, 2020 until November 1st, 2020. Data collected from the surveys were analyzed using STATA software to determine mean scores for each question. The data from the knowledge assessment set and the behavior assessment set were compared against the demographic information. STATA was used to calculate Pearson r to determine if there was any correlation between the groups of information (knowledge or behavior) and the demographic data. The analysis was conducted to identify any patterns of knowledge gaps. It also helped identify behavior patterns to assist IES in decisions about its

outreach programs as well as provide information for policy decisions. The last three research questions were answered using the survey. In total, there were 47 respondents.

Results

RQ1: Where does water come from in Sheridan, CO?

To learn about Sheridan's public water transportation system, a variety of people from different organizations were interviewed. The first contact was the current Superintendent of Public Works for the City of Sheridan, Randy Mourning. He was able to provide that the City of Sheridan is a part of four sanitation districts - Sheridan Sanitation District #1, Sheridan Sanitation District #2, Valley Sanitation District, and City of South Englewood Sanitation District (Appendix C). All four of these districts receive water from the same company, Denver Water. Most of their water comes from mountain snowmelt, with the primary sources being the South Platte River, Blue River, Williams Fork River and Fraser River watersheds, but it also uses water from the South Boulder Creek, Ralston Creek and Bear Creek watersheds (Appendix D & E) (Collection System | Denver Water, 2020). The next interview was with Ellen Olsen, the Director of the Denver Water Youth Education Program. She provided information on the next steps in the water process. She provided that from the main sources, the water then goes to one of two water treatment plant locations. For security purposes, she was unable to disclose the exact location, but their approximate spots are shown in relation to Sheridan in Appendix F. The water travels anywhere from 7 - 30 miles from the water treatment plants to reach the various residents of Sheridan, using various water pumps and towers to store and maintain pressure. While the water is now ready and available in homes and buildings, it is still untreated for CECs.

RQ2: Where does water go in Sheridan, CO?

While the water that is received by Sheridan comes from the same locations, it does not immediately go to the same location. Water used in Sheridan Sanitation District #2 goes to the Metro Wastewater Reclamation District. Water used in Sheridan Sanitation District #1, Valley Sanitation District, and City of South Englewood Sanitation District go to South Platte Water Renew (Appendix G & H). To find out about Metro Wastewater Reclamation District's procedures, an interview was conducted with Public Information Specialist, Colleen Miller. All wastewater goes to the Robert W. Hite treatment facility in north Denver. The water then goes through a 7 step process: 1. **Bar screens** remove objects ranging from children's toys to false teeth. 2. **Grit basins** remove larger solid wastes. 3. **Primary clarifiers** remove smaller solid wastes. 4. **Aeration basins** enable millions of microorganisms to digest the organic waste remaining in the water. 5. **Secondary clarifiers** allow the microorganisms to clump together and settle to the bottom. After further processing to kill harmful organisms, these biosolids will go to enrich Colorado farmland. 6. **Chlorination and dechlorination** processes provide final wastewater treatment. 7. **Digestion** involves anaerobic digestion by microbes of solids into biosolids and methane. The methane gas is used for electricity at the facility. The biosolids are applied to the METROGRO Farm (in Deer Trail, Colorado) and privately-owned farms and incorporated into the soil either by tilling or applying them to the soil surface depending on the land's slope or erosion potential (What We Do With Wastewater, 2020; Miller, C., email communication, 2020). The water that is left goes back into the South Platte River (Appendix I). The South Platte Renew facility has a very similar treatment process, with the only differences being small details in the types and amounts of disinfectant and microorganisms. The other difference is the methane produced during anaerobic digestion goes towards heating the water in

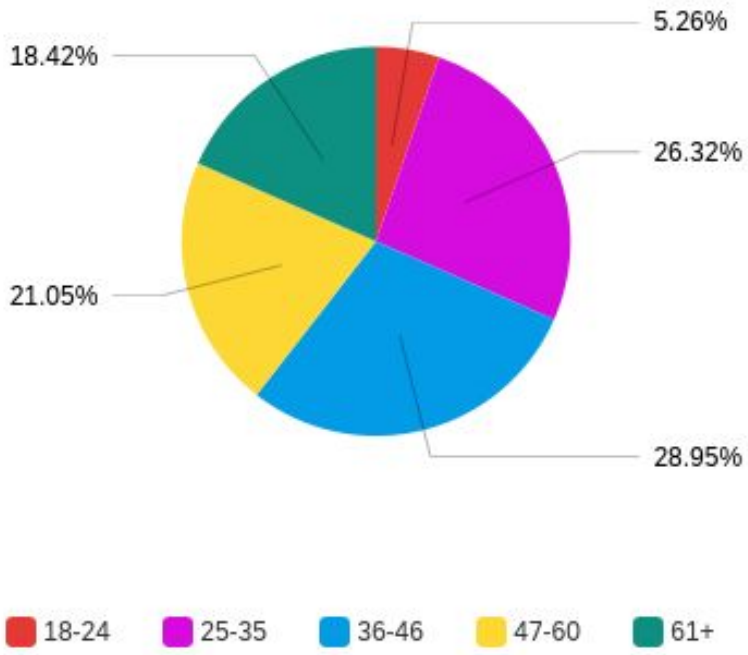
the digesters as well as directly into an Xcel Energy pipeline. The biosolids still go to farms, but at different locations than Metro Wastewater Reclamation District ("Water Renewal Process | South Platte Renew", 2020; Lopez. A, personal communication, 2020).

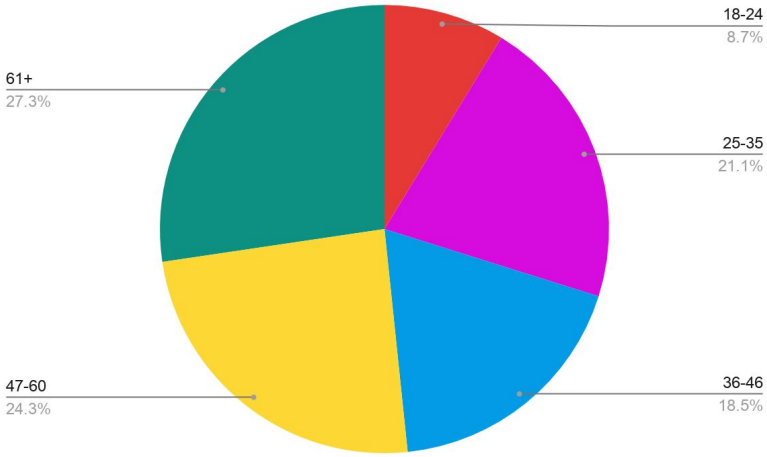
Survey Results

Profile of Participants

The demographic questions included in the survey were not required to complete the survey, but voluntary to answer. Geographically, all respondents resided in Colorado, with 38 of them representing ten cities. Watkins, Littleton, Highlands Ranch, Englewood, and Broomfield each had 1 survey (3%), Kiowa had 2 (5%), and Centennial had 3 (8%). Parker had the third-largest respondent group with 5 (13%). Denver and Aurora had the most respondents with 11 (29%) and 12 (31%) respectively. The age groups varied, the largest was 36-46 year-olds at 28.95%. Subsequently, the 25-35 age group at 26.32%, 47-60 year-olds at 21.05%, 61 and over at 18.42%, and 18-24 year-olds at 5.26%. This breakdown compared to Colorado overall is comparable and can be seen in Figure 1. While the age ranges are comparable, the racial breakdown of survey respondents versus Colorado is not. While Colorado has a diverse racial composition, 94.59% of survey respondents were white, and 5.41% were black or African American. This difference in racial demographics between the survey and Colorado is important to note as it may lack representative views of minority groups (United States Census Bureau, 2020; U.S. Census Bureau QuickFacts: Colorado, 2020).

Figure 1. Age Groups of Survey Respondents & Age Demographics of Colorado



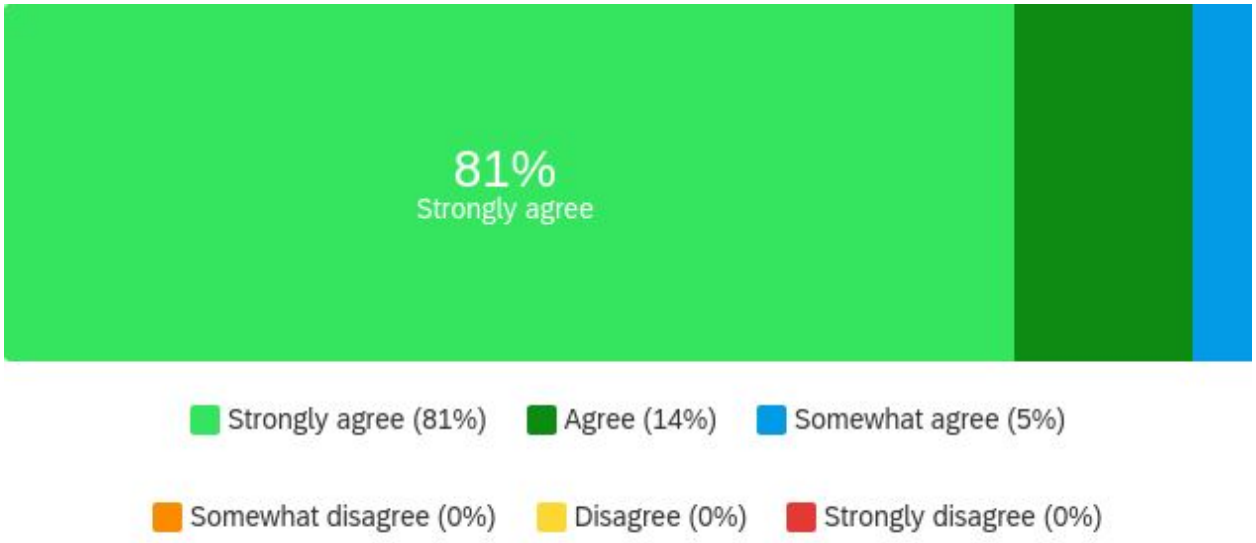


RQ3: What are Coloradan's attitudes towards water quality?

There were two questions on the survey about this. Question 1 - "Water quality is important to me" and Question 2 - "Tap water is sufficiently treated for harmful chemicals".

Both of these were on a 6 point Likert scale from Strongly Disagree to Strongly Agree. Question 1 had an overwhelming response of Strongly Agree at 81%. At 14 % is Agree and the remaining 5% was somewhat agree. No survey respondents chose any type of disagree response (Figure 2).

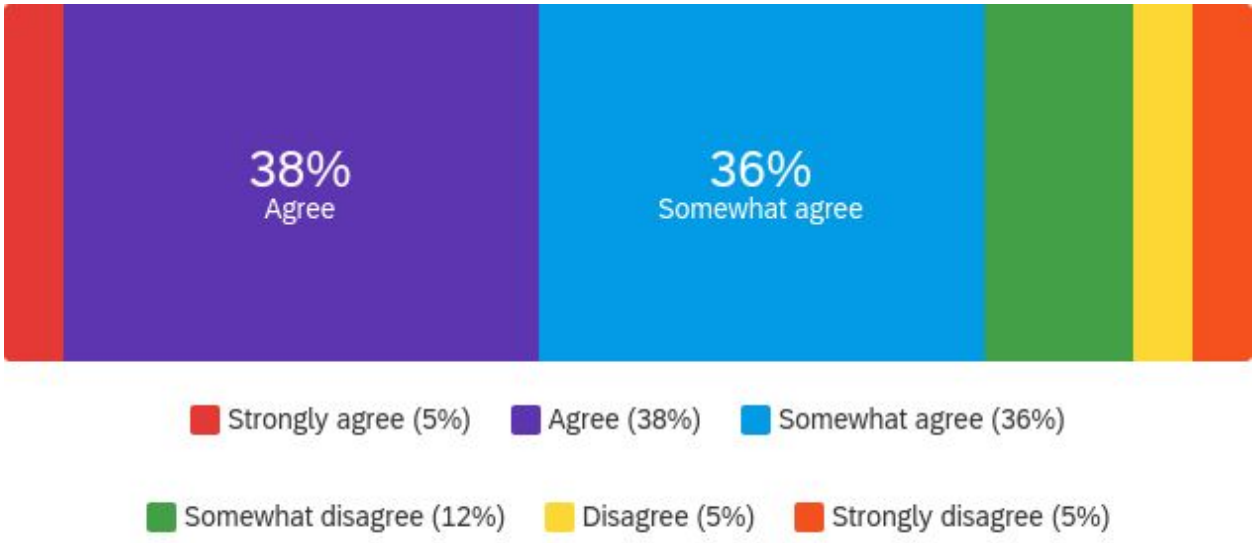
Figure 2. Water Quality Is Important To Me



The results were also tested against age groups and location to determine if there were any significant differences in responses between groups. Using a one-way ANOVA test, the p-values were 0.15 and 0.00. At a confidence level of 95%, alpha = 0.05, which means there is a statistically significant difference between locations. The Tukey post hoc test was run to determine the pairwise comparison of the means and find out which locations were different. The results showed that Watkins was the only difference, and with only one survey response from that location, a possible outlier. When the response was removed and the one-way ANOVA test was performed again, it had a p-value of 0.20, confirming Watkins was an outlier and there are no statistical differences based on location.

Question 2 had a more diverse set of opinions, with responses in each area. However, the majority of people still chose agree responses at a total of 79% while the disagree responses only totaled 21%

Figure 3. Tap Water Is Sufficiently Treated For Harmful Chemicals



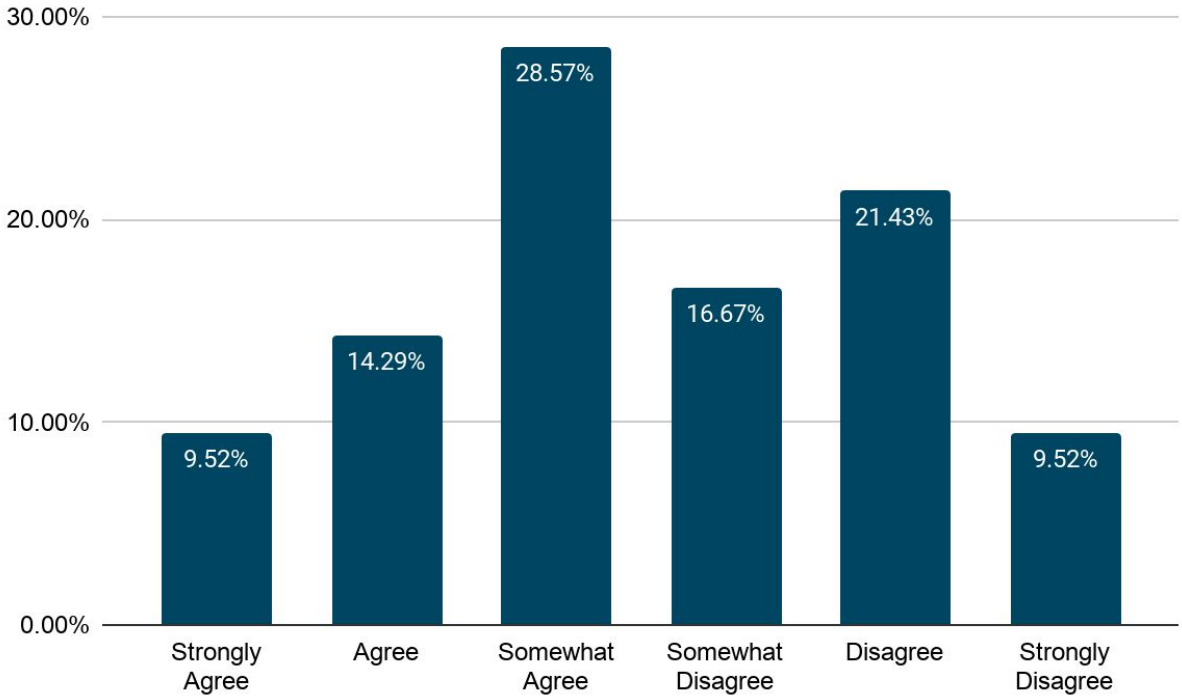
This question was also tested for differences between age groups and location. The p-values were 0.56 and 0.06 and therefore no significant differences between age groups or location.

RQ4: What knowledge do Coloradans have of CECs?

The next two survey questions 3 & 4 were to assess knowledge. Similar to the first two questions, Questions 3 stated "I know exactly where my water comes from and where it goes when it leaves my home" and was accompanied with a 6 point Likert scale from Strongly Disagree to Strongly Agree. The results were split, with a total of 52.38% agreeing to the statement and 47.62% disagreeing. Somewhat Agree and Disagree were the most selected at 28.57% and 21.43%. Only 9.52% Strongly Agreed that they knew exactly where their water came from and where it goes, while another 9.52% selected that they Strongly Disagree and did

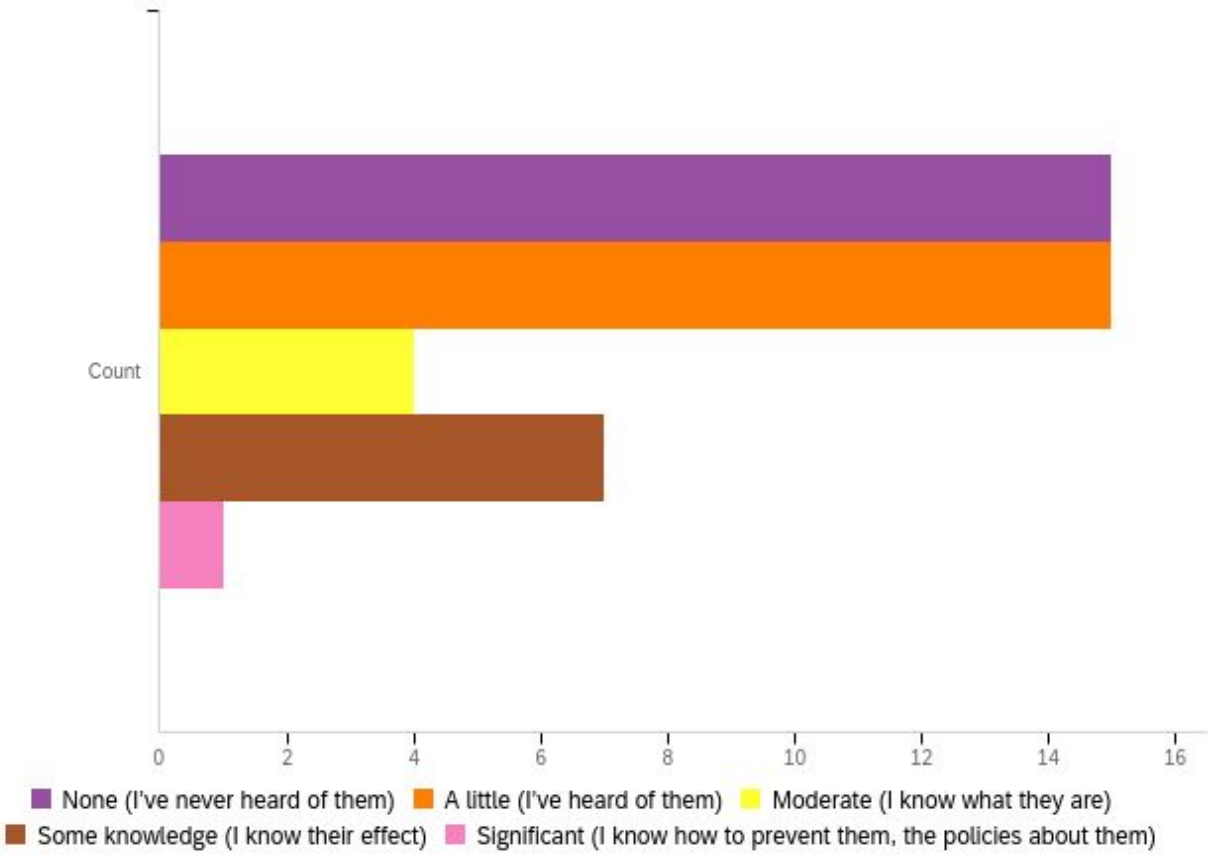
not know at all. In testing for differences among age groups and location, the p-values were 0.44 and 0.20 and therefore no significant differences.

Figure 4. I know exactly where my water comes from and where it goes when it leaves my home



Question 4 asked "How would you rate your knowledge of Contaminants of Emerging Concern?" with a 5 point Likert scale from None - Significant. A large majority said they were fairly unfamiliar with CECs, with 35.71% selecting they had never even heard of them, and another 35.71% selecting they had heard of CECs, but did not know what they were. 9.52% said they knew what CECs are and 16.67% stated they had some knowledge of CECs. Only 2.38% selected that they know a significant amount about CECs.

Figure 5. How would you rate your knowledge of Contaminants of Emerging Concern?



When tested for differences among age groups the p-value was 0.01. After running the Tukey post hoc test, the difference was found between the Over 60 age group and the 36-46 age group (Table 1). Looking at the survey results, the 36-46 age group selected they know none or only a little about CECs while the Over 60 age group reports they have more knowledge about CECs (Table 2).

Table 1. Knowledge vs. Age Stata Results

Q4	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
Q9						
25-35 vs 18-24	-1.2	.8092696	-1.48	0.580	-3.53419	1.13419
36-46 vs 18-24	-1.636364	.8031154	-2.04	0.271	-3.952803	.6800753
47-60 vs 18-24	-.375	.8259574	-0.45	0.991	-2.757322	2.007322
60 plus vs 18-24	-1.71e-15	.8376737	-0.00	1.000	-2.416116	2.416116
36-46 vs 25-35	-.4363636	.4564896	-0.96	0.873	-1.753024	.8802969
47-60 vs 25-35	.825	.4955744	1.66	0.469	-.6043934	2.254393
60 plus vs 25-35	1.2	.5148646	2.33	0.161	-.2850325	2.685033
47-60 vs 36-46	1.261364	.4854596	2.60	0.094	-.1388554	2.661583
60 plus vs 36-46	1.636364	.5051362	3.24	0.021	.179391	3.093336
60 plus vs 47-60	.375	.540716	0.69	0.956	-1.184596	1.934596

Table 2. Knowledge vs. Age Comparison

	Q9: What is your age range?					
	Total	18-24	25-35	36-46	47-60	60+
None (I've never heard of them)	36.8%	0.0%	50.0%	63.6%	25.0%	0.0%
A little (I've heard of them)	36.8%	50.0%	30.0%	36.4%	37.5%	42.9%
Moderate (I know what they are)	5.3%	0.0%	10.0%	0.0%	0.0%	14.3%
Some knowledge (I know their effect)	18.4%	50.0%	10.0%	0.0%	25.0%	42.9%
Significant (I know ...policies about them)	2.6%	0.0%	0.0%	0.0%	12.5%	0.0%

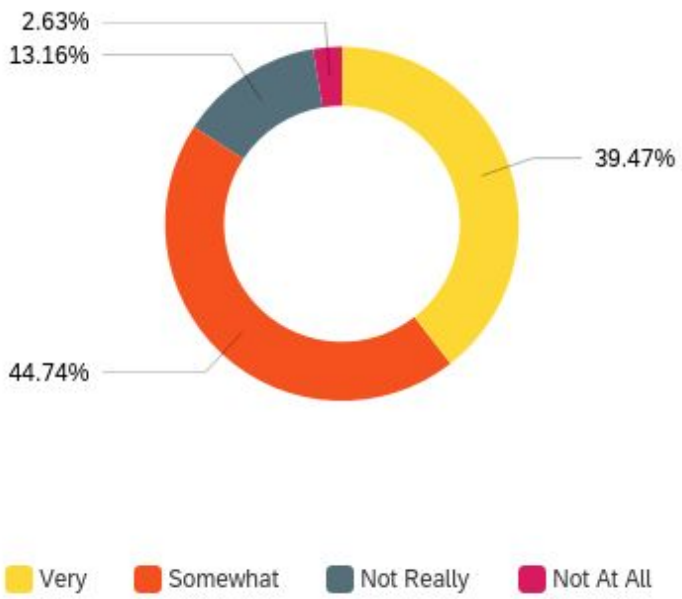
When tested for differences in location, the p-value was 0.01. The Tukey test revealed that Littleton was an outlier. Once removed, the p-value was 0.06, and therefore no statistical difference in knowledge based on location.

RQ5: What is the best method to initiate behavioral change regarding CEC containing household products in Colorado?

The last two main questions of the survey gauge the survey respondent's feelings towards changing their behavior in regards to CECs. Before these questions, there was a short paragraph

explaining what CECs are, where they are found, and why they are considered concerning. Question 5 asked "Are you interested in learning more about CECs?" with a 4 point scale from Not at all to Very. Once informed of the basics of CECs, over 80% said they were at least somewhat interested in learning more about them. The other 20% were not interested with 13.16% in the Not Really category and almost 3% saying they were not at all interested in learning more (Figure 6).

Figure 6. Are you interested in learning more about CECs?



These results were tested for differences in age groups and location and had p values of 0.17 and 0.00 respectively. Since there was no difference in age groups, only the location was run through the Tukey test. The results showed a significant difference between Denver and Aurora, with a p-value of 0.01 (Table 3).

Table 3. Stata Results from Pairwise Comparison of the Means, Tukey test

```
. pwmean Q5, over(Q8) mcompare(tukey) effects

Pairwise comparisons of means with equal variances

over          : Q8
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	Number of Comparisons
Q8	28

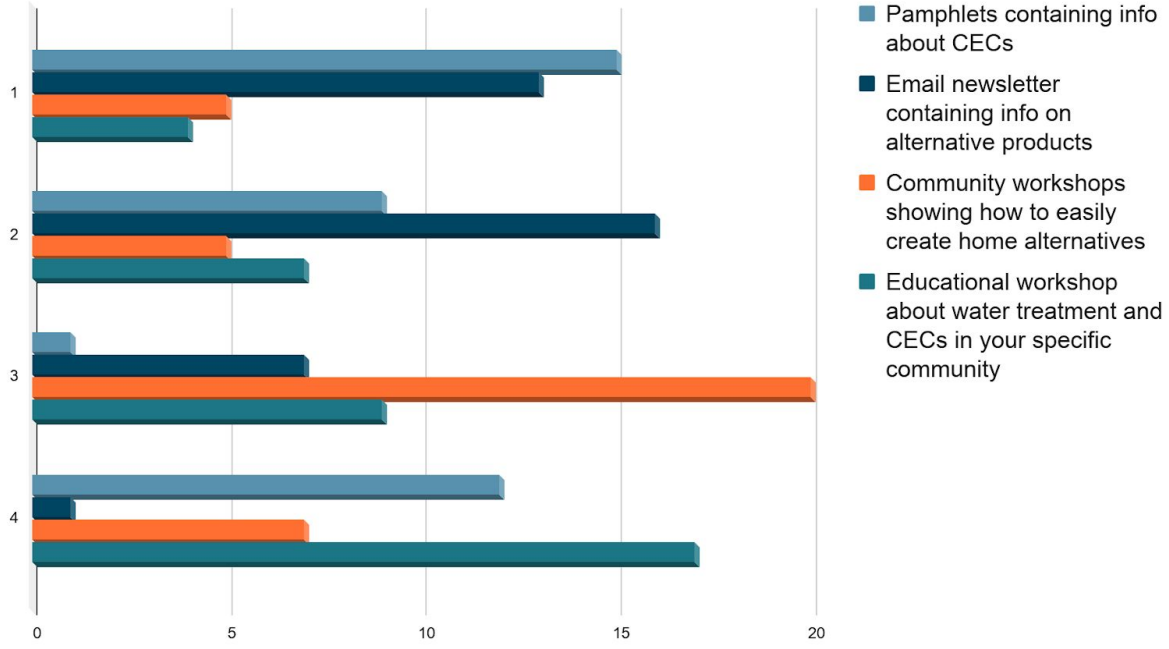
Q5	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
Q8						
Denver vs Aurora	.9090909	.2354586	3.86	0.012	.1390894	1.679092
Parker vs Aurora	5.69e-16	.3002524	0.00	1.000	-.9818915	.9818915
Centennial vs Aurora	5.88e-16	.3641095	0.00	1.000	-1.190718	1.190718
Kiowa vs Aurora	5.14e-16	.4308202	0.00	1.000	-1.408877	1.408877
Englewood vs Aurora	1	.587109	1.70	0.685	-.9199756	2.919976
Littleton vs Aurora	-1	.587109	-1.70	0.685	-2.919976	.9199756
Broomfield vs Aurora	5.70e-16	.587109	0.00	1.000	-1.919976	1.919976

Looking at the survey results, Aurora has more distributed answers and their highest category is "Somewhat" interested in learning more about CECs. However, Denver had an almost unanimous decision with 91% of respondents choosing that they are "Very" interested in learning more (Table 4).

Table 4. CEC Interest	Total	Aurora	Denver
Very	52%	16.5%	91%
Somewhat	39%	67%	9%
Not really	9%	16.5%	0%
Not at all	0%	0%	0%

Question 6 asks the respondents to rank which methods would encourage them to use less CEC containing products. Four methods were available to choose from: Pamphlets containing CEC info, email of alternative uses, community workshop, and an educational workshop. The most chosen for the 1st and 2nd preferred methods were pamphlets containing info about CECs and an email newsletter containing info on alternative products. 3rd most likely was community workshops showing how to easily create home alternatives, and 4th was an educational workshop about water treatment and CECs in your specific community.

Figure 7. Rank which methods would encourage you to use less CEC containing products



Each ranking was run through a one-way ANOVA to test for differences in age groups or location. The p values for age were 0.74, 0.23, 0.12, and 0.43. The p values for location were 0.18, 0.4, 0.54, and 0.06. Therefore there is no statistical difference in responses based on age or location.

Discussion

The survey results show that the people of Colorado are interested in their water, but do not know of the danger of CECs, or even what they are really. 81% said they strongly agreed that water quality is important to them, but only 5% strongly agreed that tap water is sufficiently treated for harmful chemicals. Furthermore, only half (52%) felt they knew where their water came from or where it goes, and almost 80% said they did not know what CECs are. This shows a large knowledge gap for those who care about their water, and throughout the state of Colorado. The age group of Over 60 did report it knew more than those of the 34-46 age group. This difference could be attributed to the fact that both groups are more likely homeowners, but one has had a longer time living there and learning about its water. While age does not have an effect on how interested a person may be to learn more about CECs, their location does. The survey results show that in the largest response areas, Aurora and Denver, Aurora was not as confident they wanted to learn more. Denver, on the other hand, was "very" eager to hear more about this hidden water issue. This implies Denver is an area in Colorado that cares about their water and is searching for more information on it. According to the survey, the best methods to change people's behavior are to send a pamphlet or newsletter about CECs and alternative products. The workshops were not a popular choice to motivate people to change.

Limitations

Due to accessibility and time constraints, there are certain limitations to this survey. While this survey was posted online, it was only posted in the cities of Aurora, Denver, and Parker. Unfortunately, due to the social media regulations of public libraries in Colorado, surveys can only be posted physically at each library, and cannot be posted to their social media. This

influenced the survey to get more respondents from the areas where physical flyers were hung. The survey therefore was conducted with a convenience sample, not a random sample which can limit how accurate the generalizations are of the whole state. Also, no one below the age of 18 was able to take the survey. It should also be noted that at the time the survey was available the COVID-19 pandemic was a major affecting factor in people's daily activities and choices, mostly to avoid gatherings of people. It is very possible that those who chose the workshops as their last choice would change their opinion in the absence of a pandemic.

Policy Implications

The policy implications for this study are as follows:

1. People in Denver are very interested in learning more about CECs, and there may be other communities that are more inclined to learn about them as well. It is an opportunity for IES to expand its reach to other areas that are eager for more.
2. Whether due to COVID-19 or other reasons, the current climate is that in person workshops are not the popular choice. In order to reach more people, it is important that IES expand its online presence and resources.
3. There is a significant difference in knowledge and perceptions of CECs and age. It is important to reach out to those who feel they know less and educate that group. Those in this age group may be first time home buyers, and it would make a bigger impact to connect those people with their water and avoiding CEC containing products.

Recommendation 1:

To address the knowledge gap of where water comes from, where it goes, and the CECs it contains, IES should have a presentation with information on all three of those categories. I have

developed such a presentation based on my research, and it will be given to IES on completion. This presentation can be used for snapshots in newsletters, its workshops, and other ways IES sees fit.

Recommendation 2:

IES should expand its online presence by changing workshops to be recorded or through video meetings. IES should also write more newsletters and create shareable pamphlets about CECs and possible alternatives to better interact with the community.

Recommendation 3:

If IES has the resources, it should expand its reach outside of Sheridan, starting with Denver. That community can receive the same newsletters and also be a part of the same online workshops. This will also be a good resource for IES as expanding its reach also means more donations to the organization.

Conclusion

CECs are a danger to the health and wellness of Colorado residents. Many people are unaware of what they are or why they should be prevented. People in Colorado care about their water quality and are interested to know more about CECs. The best way to reach people with information about CECs is through newsletters and pamphlets. Due to a global pandemic, online communication is key. IES should expand its online presence as well as expand its reach to other communities. By increasing access to the informational presentation as well as increasing the audience that IES impacts, there is a chance to educate the people about CECs, decrease CEC use, and improve the quality of the water for everyone.

Appendix A. Survey Design

I need your opinion. I am a graduate student in the MPA program at CU Denver working on my capstone project. For this project, I am looking for information about water treatment processes and community engagement and education practices. Your honest, careful responses will help non-profits and city governments better serve the people. Please email melissa.mahan@ucdenver.edu with any questions or to request survey results.

Q1. Water quality is important to me. (6pt scale: Strongly Agree, Moderately Agree, Mildly Agree, Mildly Disagree, Moderately Disagree, Strongly Disagree)

Q2. Tap water is sufficiently treated for harmful chemicals. (6pt scale)

Q3. I know exactly where my water comes from and where it goes when it leaves my home. (6pt scale)

Q4. How would you rate your knowledge of Contaminants of Emerging Concern (CECs)? (5pt scale:
None (I've never heard of them), A little (I've heard of them), Moderate (I know what they are), Some knowledge (I know their effect), Significant (I know how to prevent them, the policies about them)

The last two questions ask about your opinion of CECs. CECs include a wide range of chemical compounds used in common household and personal care products such as lotions, soaps, insect repellents, and sunscreens. They are of emerging concern because of the possible risks they present to human health and the environment.

Q5. Are you interested in learning more about CECs? (4pt scale: Not at all, Not really, Somewhat, Very)

Q6. Which method would encourage you to use less CEC containing products the most? (Mult. Choice: Pamphlets containing info about CECs, Email newsletter containing info on alternative products, Community workshops showing how to easily create home alternatives, Educational workshop about water treatment and CECs in your specific community)

Lastly, we need information about you to help us determine the needs of specific groups of people.

Q7. In what state do you currently live? (Mult. Choice)

Q8. In what city do you currently live? (open-ended)

Q9. What is your age range? (Mult. Choice age range)

Q10. What race are you? (Mult. Choice)

Q11. What is your household income? (Mult. Choice ranges)

Q12. How did you hear about this survey? (Open-ended)

Appendix B. Survey Flyer

Denver

MPA Capstone Course

We Need Your Opinion!

Anonymous Survey!

SCAN ME

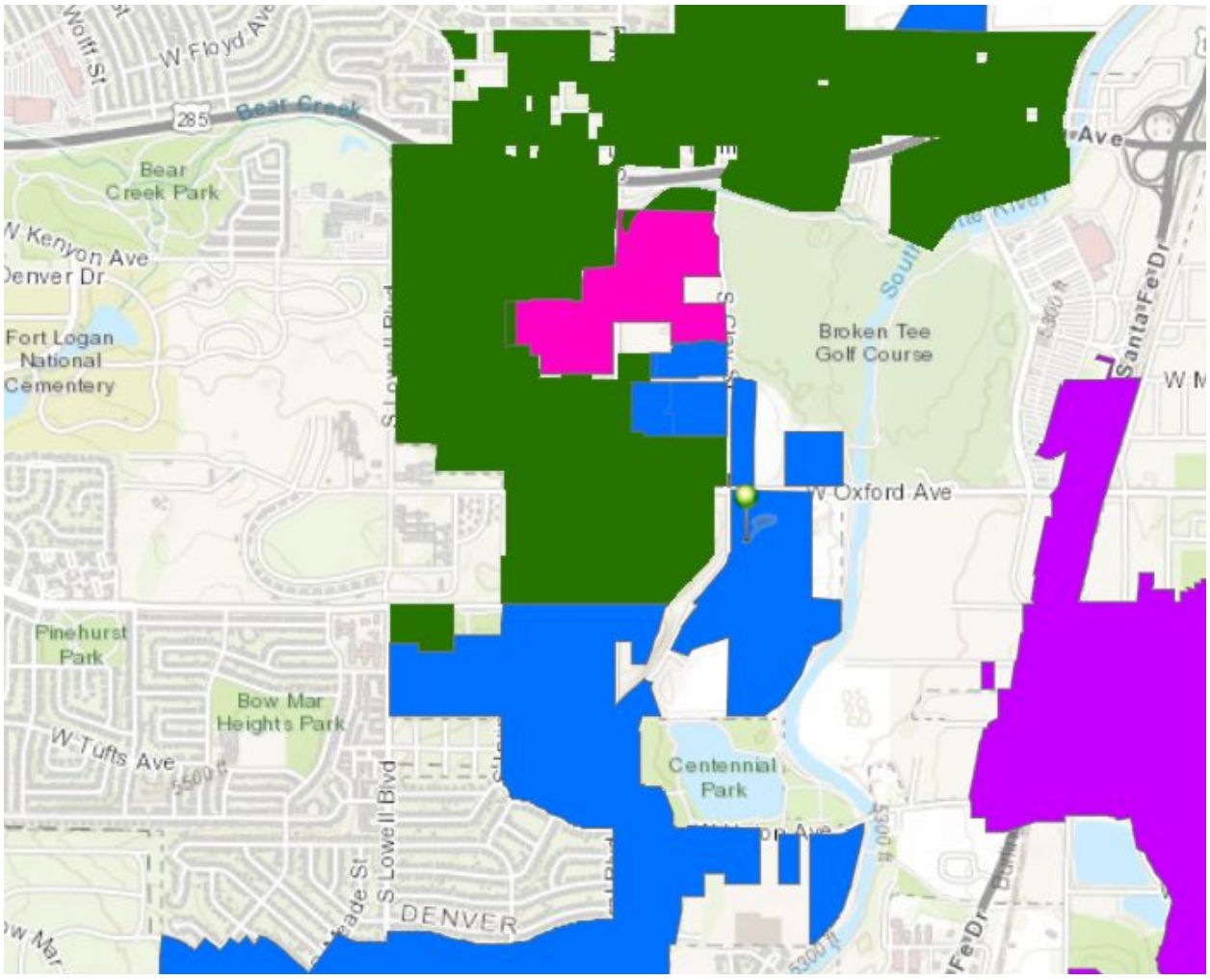
I need your opinion. I am a graduate student in the MPA program at CU Denver working on my capstone project. For this project, I am looking for information about water treatment processes and community engagement and education practices. Your honest, careful responses will help non-profits and city governments better serve the people. Please email melissa.mahan@ucdenver.edu with any questions or to request survey results.

You can take the survey by scanning the QR code to the left or at the link below.

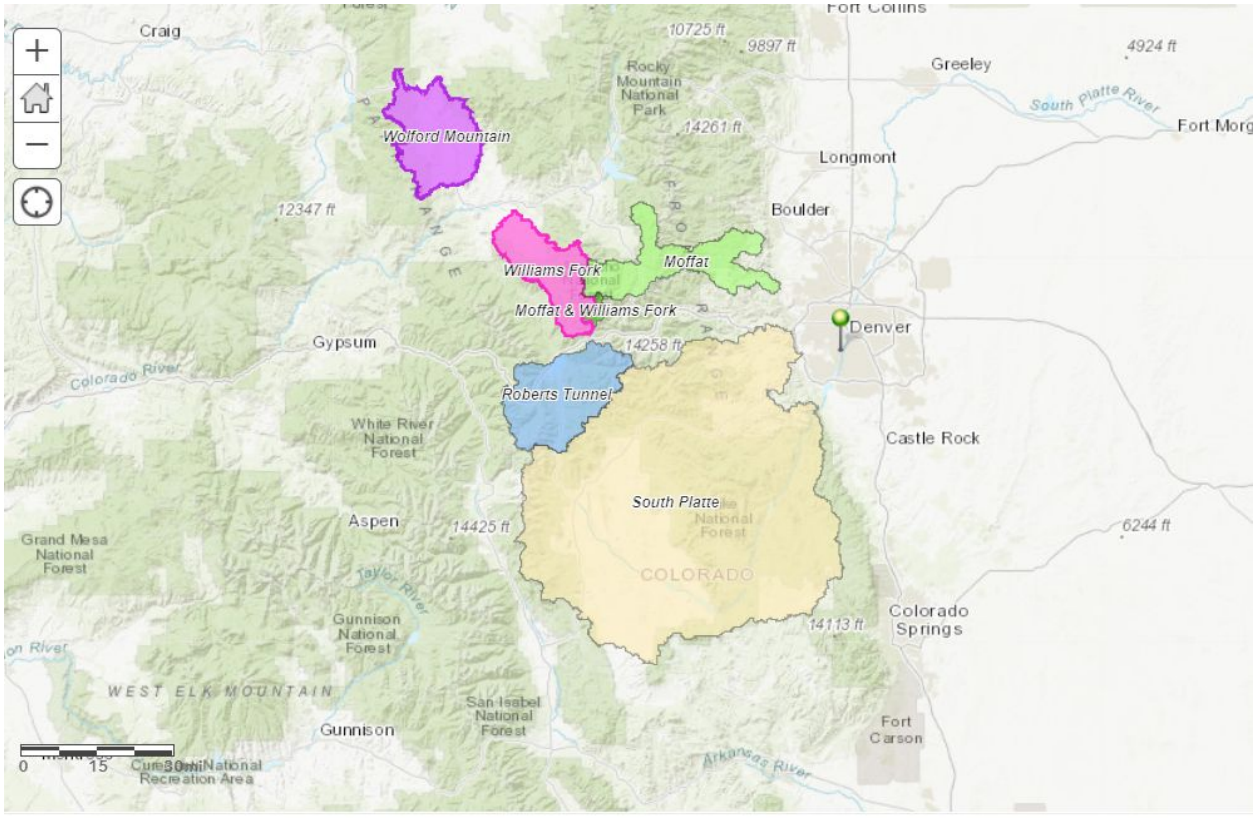
Thank you!

https://ucdenver.co1.qualtrics.com/jfe/form/SV_a9v2iTImxx0dA6V

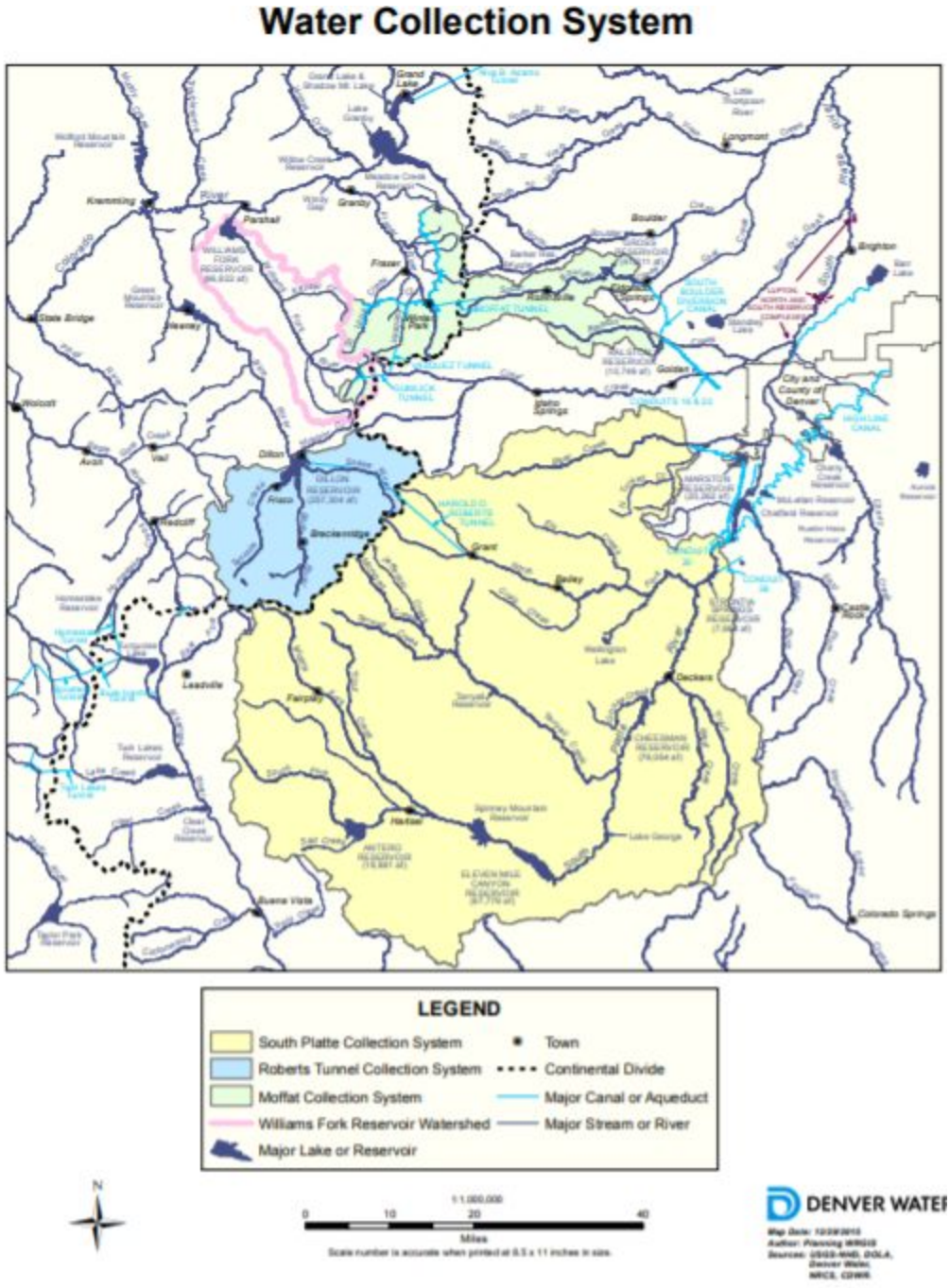
Appendix C. Sanitation Districts of Sheridan, Colorado



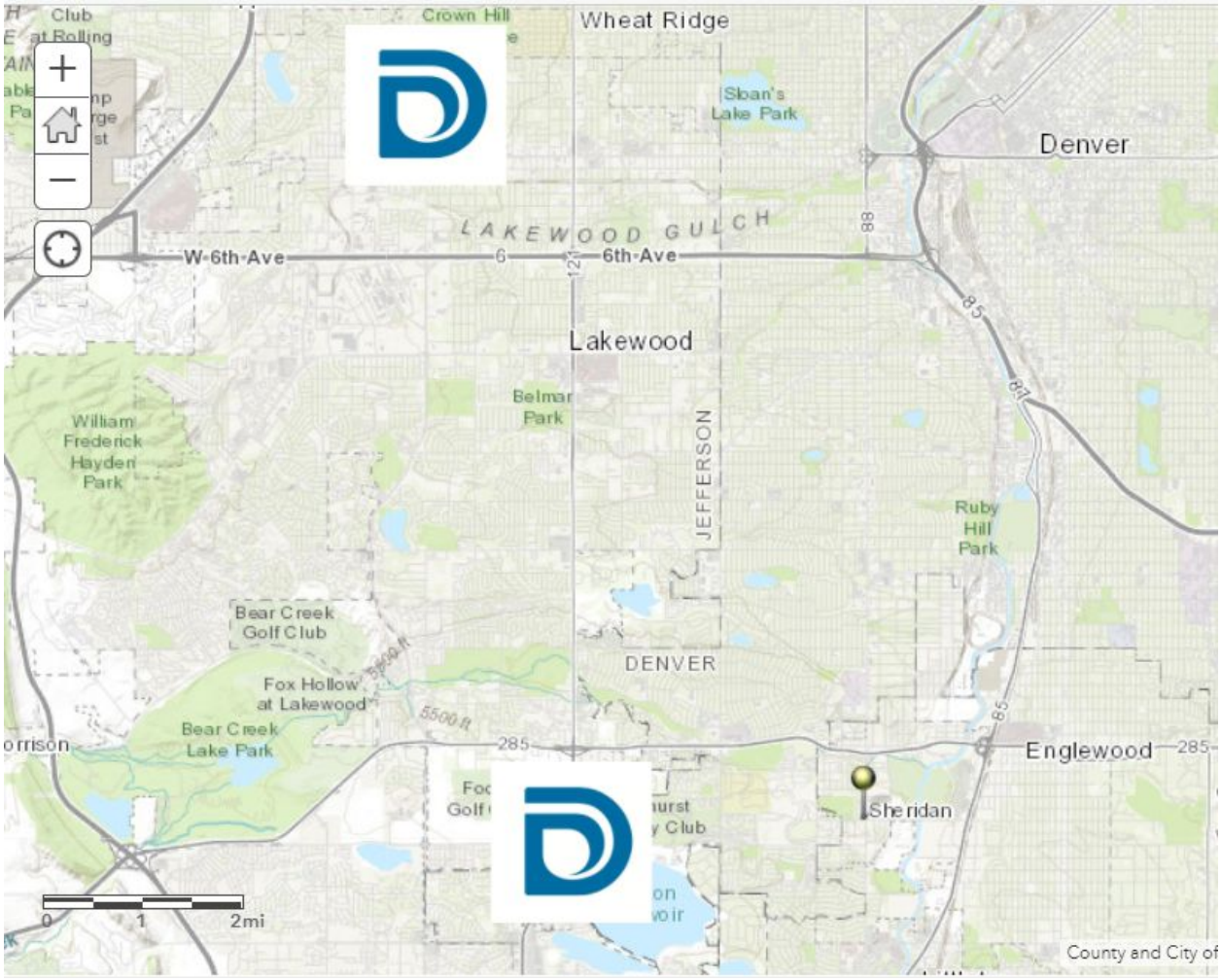
Appendix D. Denver Water Collection System Reservoirs



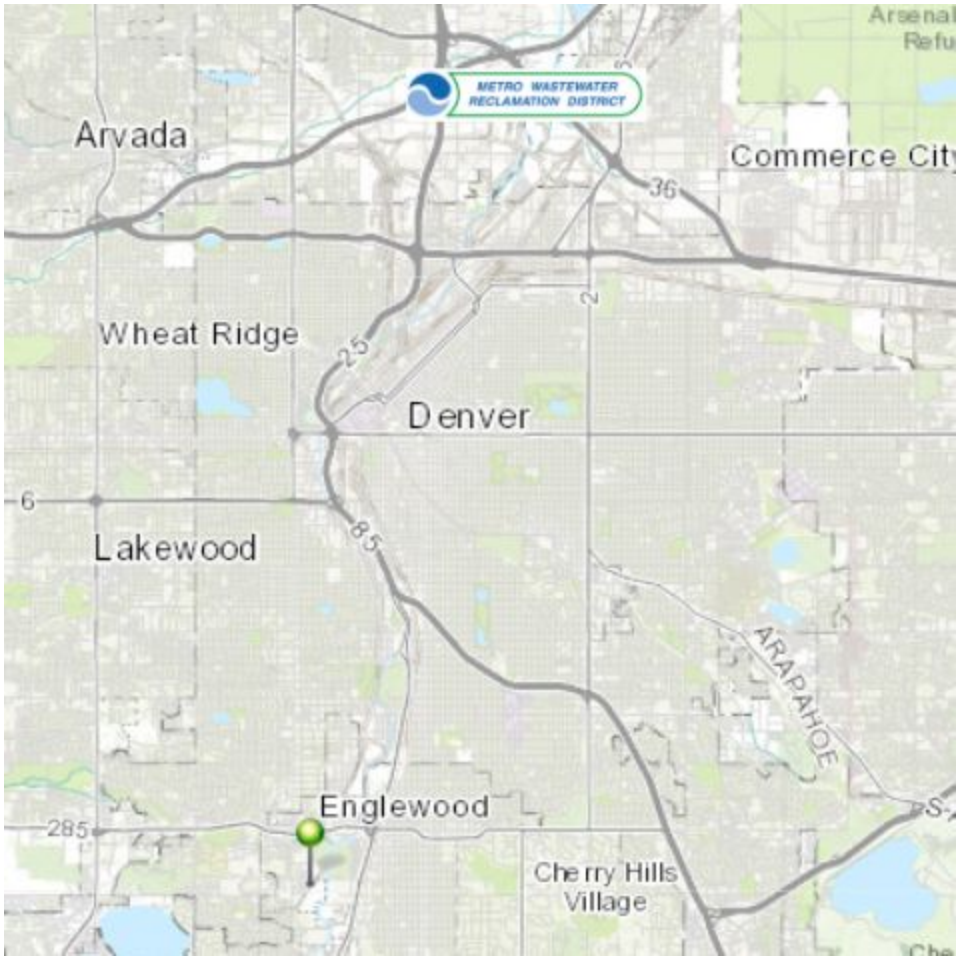
Appendix E. Denver Water Collection System with Major Rivers



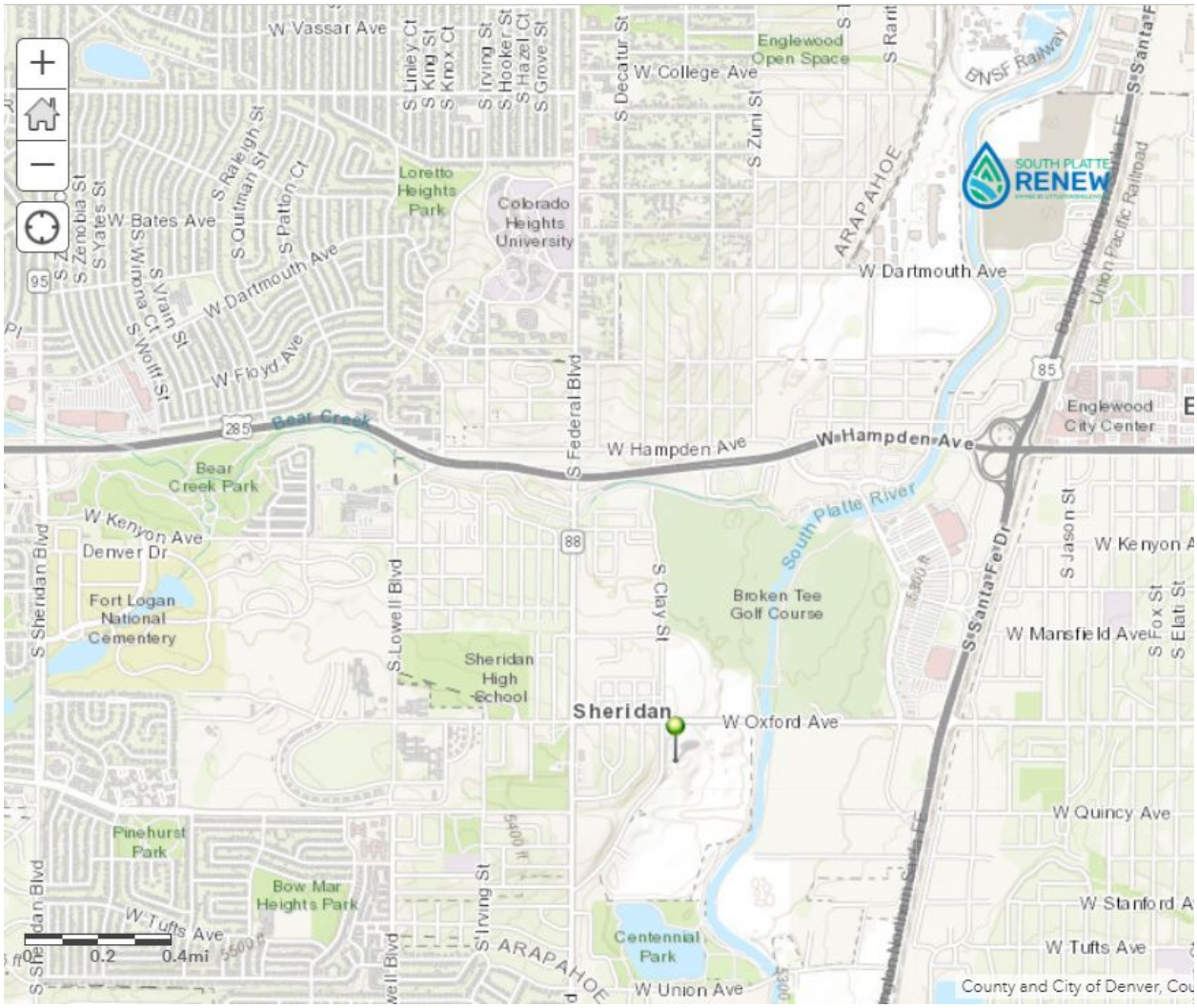
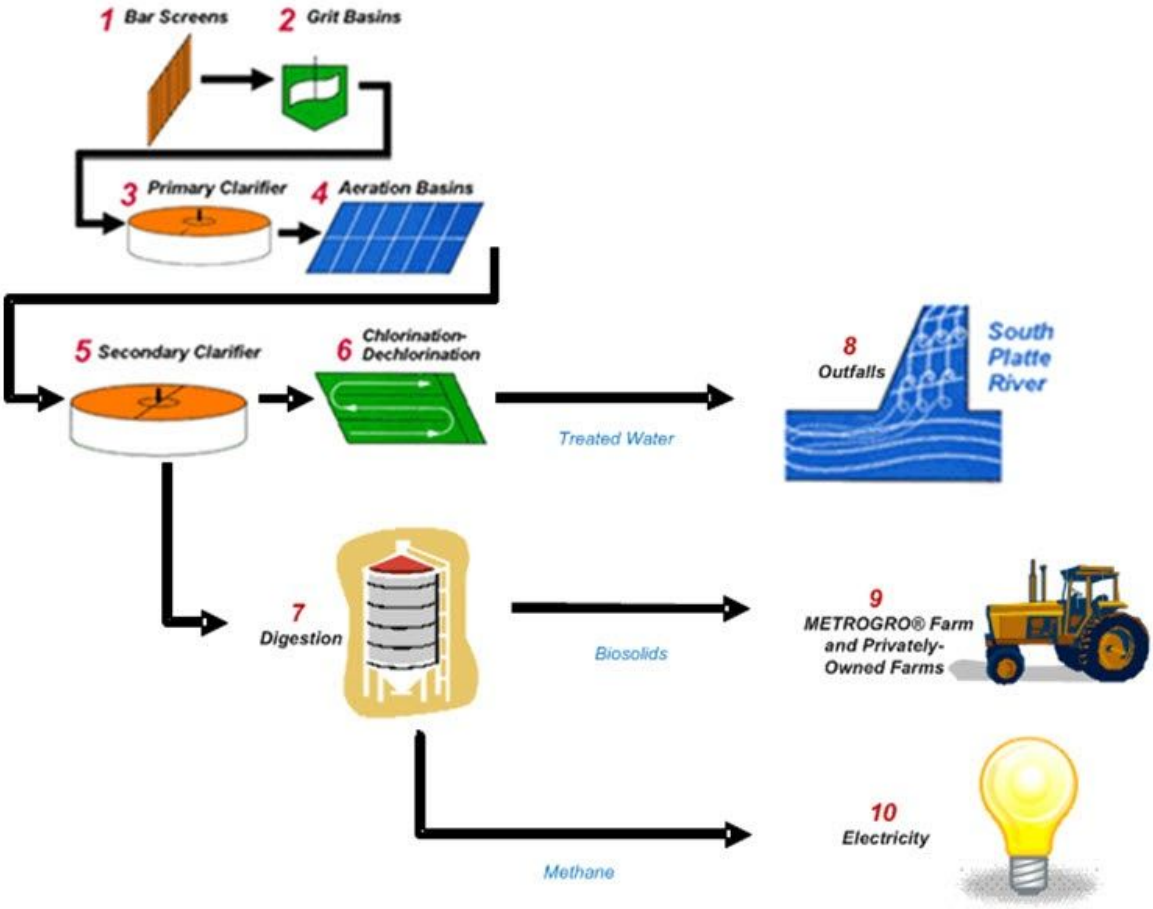
Appendix F. Denver Water Treatment Plants



Appendix G. Denver Metro Waste



Appendix H. South Platte Water Renew



Appendix I. Denver Metro Waste Treatment Process