# Water Source and System Choice in Rural Alaskan Communities: Perspectives from State- and Regional Professionals

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## 1 RESEARCH PROBLEM

While piped water has come to be an expectation in the U.S., thousands of homes in rural Alaska do not have access to water services (Eichelberger, 2014). Alaska contains more than 30 communities where at least 45% of the homes are not served by piped, septic tank and well, or covered haul systems, making Alaska the state with the highest proportion of homes without water and sewer services in the United States (Alaska DEC, 2022; U.S. Arctic Research Commission, 2017). Rural Alaska provides a myriad of challenges when providing safe drinking water including the remoteness of communities, economic constraints, climate change, and harsh climate (Cozzetto et al., 2013; Hickel et al., 2018; Sohns et al., 2021). Many of these impacts disproportionally affect Alaskan Native communities (Brubaker et al., 2011; Cozzetto et al., 2013; McOliver et al., 2015a). The current study advances the understanding of natural and social factors that lead to community or governmental water officials choosing a source (surface water or groundwater) for drinking water infrastructure. By mapping knowledge from experts in the water industry in rural Alaska, the study will identify key factors and create a framework that can be used to choose water sources and infrastructure for future water projects.

## 2 METHODS AND APPROACHES

The data for this research came from interviews with 21 people who work for tribal, federal, and state agencies, private companies and firms, non-profit organizations, and academic institutions. Interviewees were chosen through convenience sampling and snowball sampling and continued until theoretical saturation of the information was met (Ozanne et al., 1992). We performed qualitative thematic analysis on the interview data to understand choices in both water source and infrastructure in rural water projects by both water officials and community members. We then created cognitive maps to represent how factors lead to each water source.

The initial 20 interviews were done to understand their perspectives of water projects in rural Alaska. The initial interview questions were designed to facilitate conversation about successes, failures, and factors of drinking water projects in rural Alaska. After initial analysis, we decided to interview four of the individuals again to go into further depth about choosing a water source. The interviewees for this study are individuals who manage drinking water projects in rural Alaska and often do not reside in the communities in which they work for. The results of this study should be interpreted as knowledge and ideas from individuals in management and not those who are community members directly affected by these projects. This dataset will be supplemented during the second phase of this study which centers on direct community engagement.

The data analysis for this study was done by using NVivo Software to do qualitative coding of the interview transcripts. The analysis consisted of a hybrid content analysis using deductive content analysis with additional inductive coding (Spearing et al., 2022). While the research team used a list of questions to facilitate interviews, a predetermined list of coded categories was not generated to maintain impartiality to all study outcomes. Instead, we allowed themes in the data to emerge throughout the analysis (Saldaña, 2013).

First, we analyzed the semi-structured interviews using deductive content analysis (Fuller et al. 2018; Jayasinghe and Ramachandra 2016; Ragab and Marzouk 2021). To understand how technical water officials and community members make water source choices, we coded the interviews into two categories: groundwater and surface water. After coding the data into water source categories, the researchers analyzed the data with an inductive content analysis to find new and emergent themes (Burla et al., 2008). The inductive coding was used to further categorize and describe the deductive content analysis. Child codes were created as themes emerged for each of the three water sources.

In addition to coding factors that lead to the selection of different water sources, we also coded the relationships between the factors and their water source. Future plans include incorporating these relationships into cognitive systems maps to show the sequential choices leading to each type of water source (Meadows, 2008; Rinaldi et al., 2001). The cognitive maps will be categorized into natural, built, and social categories to organize data and help identify strengths and weaknesses. Frequency tables were made for each of the coded categories to show the prevalence of the category from the perspective of the interviewees. Frequency does not necessarily indicate importance; the frequency of a category's discussion may simply reflect the interviewee's willingness or ability to talk about the subject (Joffe and Yardley, 2004).

# 3 FINDINGS

### 3.1.1 Groundwater

When considering groundwater as a source for drinking water, respondents discussed the impacts of regulations, geography, the influence of surface water, quality variability, and contamination. Respondents familiar with using drinking water regulations in Alaska found the groundwater regulations easier to meet than the regulations for surface water. This often makes using groundwater as a drinking water source the simpler option for rural communities. The use of groundwater becomes more difficult when surface water influences groundwater, because it automatically puts that source under surface water regulations. Five (25%) of the interviewees discussed the concerns of surface water leaking into the groundwater. When discussing how climate change impacts groundwater, one interviewee stated, "*A lot of our subsurface in a lot of places is peat for a long way and peat can be quite frozen in many of these instances and if, as it thaws and creates new pathways to get surface water into groundwater. I think many of our groundwater systems are going to be more and more affected by groundwater under the influence of surface water*." In addition, some geographies in Alaska are more likely to have issues with the groundwater being affected by surface water. For example, interviewees mentioned how in the southeast region it is almost impossible to use groundwater because of their location on the ocean bedrock.

Negative impacts of groundwater include geogenic contamination and quality variability. Fourteen (70%) of the respondents commented on the chemical content of groundwater. For example, one interviewee described some of the elements that impact groundwater, "*we have lots of places with super high manganese, lots of DOC (dissolved organic carbon) in the subsurface, and often the groundwater is far harder to than most people would expect*." Other interviewees noted the chemicals like mercury, iron, and manganese in groundwater near mines. Many communities with high concentrations of chemicals in their groundwater must resort to surface water as one interviewee explains, "*they had groundwater that was very high in arsenic and ended up failing cartridge removal system and have since gone to surface water source largely in part because the operational challenges they've promoted*."

There are also some technical factors to consider when choosing groundwater as a drinking water source. 13 (65%) of the interviewees discussed the technical considerations of groundwater. Transporting a drill well into rural areas in Alaska can be expensive and once it is out there, there is not enough information about the subsurface to know where to drill the well. One respondent explains, "*They may drill a hole and the ground is dry, and then they may go 15 feet another direction and it will be flowing and so that glaciated nature of the subsurface and the unexpected of what is there is quite a challenge*." When groundwater is under the influence of surface water more technical issues arise. In some instances, to avoid groundwater under the influence of surface water, community wells may even go deeper to access water that is less clean, but that can be categorized at groundwater by the regulations. Other technical factors include drilling through hundreds of feet of permafrost, the low temperatures of groundwater, and the unknown chemicals in the groundwater until it is drilled. Despite the challenges of wells, many respondents still reported a preference for groundwater over surface water. For example, one respondent explained, "*I like them (wells) a lot better than surface water generally speaking, because it's more consistent water for treatment. It usually requires a less complex treatment system. And so it's less expensive to operate, and then the operator doesn't require as higher as high level of certification difficult sometimes to get water plant operators who stick around long enough to get a certification level the time that meet the level of the plant permission slaughter plants. Just makes the system a little bit more sustainable I think when they're using well water*."

### 3.1.2 Surface water

Surface water as a drinking water source also has challenges including regulations, quality variability, geography, taste, and storage. Because regulations for surface water are harder to meet, groundwater is often the preferred choice. Still, in some regions, particularly near the coast, it is difficult to find groundwater that has not been influenced by surface water.

Seasons and cold temperatures can have an impact on surface water. One interviewee described how during shoulder seasons (fall and spring) it can be difficult to get water from a surface water source because of the partial ice melt. During these times of the year water needs to be stored in a heated tank, leading to higher costs. Alaska has also suffered from extreme weather events like droughts and floods. A respondent described how during a drought several communities' reservoirs went dry and how during a rainstorm a significant mudslide affected the quality of surface water. An interviewee described the problems faced during cold seasons, "*The surface water freezes for a significant part of the year, so they can only make water one year a year and so they have to make all of their water and store it in big giant storage tanks, and you* *can imagine the subsidence and the shifting of the storage tanks because the water is extremely heavy*."

Seven (35%) of the respondents discussed the technical system considerations of using surface water. A common theme throughout the interviews was the difficulty in training and maintaining operators for the treatment plants. In recent years there has been a 45% percent operator turnover rate, which respondents attributed to be mostly due to the high stress and low payment of the job. Keeping up with the maintenance and treatment takes money and organization because of the remoteness of the communities. The treatment plants for surface water are also much more complex than the groundwater treatment due to the regulations and constantly changing elements in surface water.

## 4 IMPLICATIONS

The unique natural, built, and social factors make rural Alaska a particularly challenging area to provide access to treated drinking water. Climate change makes many of these factors more intense causing access to treated water more difficult. Lack of access to treated water can lead to negative health outcomes. Because of the uniqueness of rural Alaskan communities, it can be difficult to choose which water source and system best fits a communities' needs alongside the natural and social constraints. In this study, we looked at the factors that go into water source choice. By identifying these factors, water officials can better understand how and why different water sources should be chosen for future projects. Results reveal a preference towards groundwater, but climate change's impact leads to groundwater becoming more likely to be under the influence of surface water in many regions. This will lead to groundwater sources to be more tightly regulated, complicating groundwater infrastructure. These implications may lead to governmental consideration to change regulations for groundwater sources under the influence of surface water or providing more resources for communities relying on groundwater and may need more extensive treatment. Further findings show the importance of understanding the communities' water sources year-round and as they take on the impacts of climate change. Climate and seasonal considerations imply a need for innovative and resilient infrastructure solutions.

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