United States Arctic Research Commission
Alaska Rural Water and Sanitation Working Group

Alaskan Water and Sanitation Retrospective

1970–2005

February 2015

Contents

Introduction 1

Methodology 3

Community Case Studies 4
- Community Case Study One: Buckland, Alaska 4
- Community Case Study Two: Mekoryuk, Alaska 7

Summary of Advantages and Disadvantages of Decentralized Water and Sanitation Systems 12
- Water Systems (Delivery/Distribution) 12
- Sewage Disposal Systems 14

Discussion 17

The Future/Ways Forward 21

Appendix A: Interview Questions 22

Acknowledgements

We would like to acknowledge the interviewees that generously donated their time to this project, as well as Emily Menard Autenreith (ANTHC) and Fatima Ochante (ADEC) for their assistance in recording, organizing and preparing this report.

Introduction

Water is needed for many purposes in daily life, including drinking, cooking, cleaning, and personal hygiene. Much of the scientific discourse on water focuses on its quality, but researchers have recently found that water *quantity* is also a factor critical to health in Alaska's rural villages.[1,2,3]

Washing hands with clean water is something most people in the United States and the rest of the developed world take for granted. Little thought is given to the importance of hand washing to remove bacteria, viruses, and other infectious particles that cause disease because it is an automatic act and the water is *just there*. However, for Alaska's rural residents, this is often not the case.

In many rural Alaskan ("bush") communities, where jobs are scarce and household income is low, the cost of water is a significant economic burden that can lead to household water rationing. When people pay for water by the gallon, thought must be given to the quantity used. With respect to hand washing, this type of water conservation often leads to the use of a communal washbasin, in which many people rinse their hands in the same water over the course of a day. These washbasins serve as transmission points for disease and, in some cases, have been measured to contain levels of microbial activity close to that of raw sewage by the time they are emptied. Recent Alaska-based research has shown that people who live in a place with ample clean water for hand washing ("water secure") are likely to be healthier. Conversely, people who live in water insecure locations have a significantly higher risk of "water-washed"[4] diseases, such as pneumococcal disease (e.g., pneumonia, meningitis), respiratory syncytial virus (RSV), and a variety of skin diseases (including boils and infection with methicillin resistant *S. aureus* or MRSA).[1]

Over 4,000 rural homes in Alaska are considered "unserved"[5] at this time.[6] Many of these are considered "non-serviceable"[7] via traditional approaches (i.e., pipe or haul systems) because of the high capital costs associated with their construction. Numerous water and wastewater systems throughout the State of Alaska are failing or are out of regulatory compliance.

Water and sanitation needs are increasing, while available funding is decreasing. Conservatively, it would cost over $700 million to meet existing rural Alaskan water and sanitation needs related to providing first-time service and addressing critical health needs and an additional $200 million for a growing number of minor needs and improvements.[8,9] Operations and maintenance (O&M) funds are not included when funding is appropriated for a new water or sewer system. Many rural communities struggle to afford these O&M costs and, as a result, aging systems are failing prematurely due to improper operation and lack of maintenance. Concurrently, when heating oil and gas prices rise, functioning systems become more expensive to use and maintain. At the same time, climate change is adding a new dimension to an already complex problem, stressing existing systems. Thawing permafrost may increase the amount of solid materials and dissolved organic

---

[1] Hennessy, T.W., T. Ritter, R.C. Holman, D.L. Bruden, K.L. Yorita, L. Bulkow, J.E. Cheek, R.J. Singleton, and J. Smith. 2008. The relationship between in-home water service and the risk of respiratory tract, skin, and gastrointestinal tract infections among rural Alaska natives. *American Journal of Public Health* 98:2,072–2,078, http://dx.doi.org/10.2105/AJPH.2007.115618.

[2] Thomas, T.K., J. Bell, D. Bruden, M. Hawley, and M. Brubaker. 2013. Washeteria closures, infectious disease and community health in rural Alaska: A review of clinical data in Kivalina, Alaska. *International Journal of Circumpolar Health* 72:21233, http://dx.doi.org/10.3402/ijch.v72i0.21233.

[3] Gessner, B.D. 2008. Lack of piped water and sewage services is associated with pediatric lower respiratory tract infection in Alaska. *Journal of Pediatrics* 152(5):666–670, http://dx.doi.org/10.1016/j.jpeds.2007.10.049.

[4] Water washed disease: infection caused by inadequate water availability.

[5] Unserved homes are homes without running water and wastewater service within the home.

[6] W. Griffith, Program Manager of Division of Water Facility Programs, Alaska Department of Environmental Conservation, personal communication, 2013

[7] Non-serviceable homes are homes that do not have running water and wastewater service within home and cannot be provide service even is available within the community for various reasons such as: the home is not structurally sound, does not have a thermostatically controlled heat source, is too far from the community center to feasibly serve, is too small or is not a year round occupied home.

[8] W. Griffith, Program Manager of Division of Water Facility Programs, Alaska Department of Environmental Conservation, personal communication, 2013

[9] Indian Health Service (IHS) Sanitation Deficiency System, IHS Sanitation Facilities Construction Program Annual Report, December 2010, http://www.ihs.gov/dsfc/documents/SFCAnnualReport2010.pdf.

carbon in surface water (which filtration systems typically cannot handle) and variations in the timing of snowpack melt (resulting in a need for altered water storage strategies) are examples of these challenges. Finally, Environmental Protection Agency (EPA) drinking water regulations have become more stringent, resulting in increased water treatment levels, leading to more complex water treatment systems and higher operating costs.

In summary, many existing water and sanitation systems in Alaska are unsustainable over the long-term. Funding to provide adequate service for the more than 4,000 unserved homes in Alaska has not been provided, on a regular basis, by federal or state entities. Health problems are expected to increase with the decrease in hand washing and body hygiene that will follow service declines. *Innovation* is one way to address these issues.

The purpose of this retrospective is to inform the water and sanitation industry and the general public about technologies deployed in rural Alaskan villages between ~1970 and 2005. We indicate, per interviewee input, why the majority failed on a technical level or failed to provide adequate water on an *as-used* basis to improve health outcomes. This retrospective will supplement prior, and often meager, documentation of unsuccessful approaches to water and sanitation in Alaska, as both a cautionary tale and as a benchmark against which progress can be made.

Methodology

This report focuses on the period from ~1970–2005, though some events and technologies described herein fall slightly outside this time range. Twenty-six subject matter "experts" in Alaskan water and sanitation were interviewed using a semi-structured interview guide developed by the Alaska Rural Water and Sanitation Working Group (Appendix A). The interviewees were chosen by the Working Group and are considered leaders in the field of water and sanitation in Alaska over the last three decades (in multiple areas of expertise). Each interview was directed by the same set of questions (Appendix A) and administered by the same interviewer, but discussion was flexible, often digressing as appropriate. A transcript (close to verbatim) of each interview was recorded. These transcripts, along with interviewer notes, constitute the basis of this report. Interviews ranged from 45 minutes to over two hours in length, with ~60 minutes being an average length.

The interview transcriptions became the raw data for inductive analysis. Data were processed using Microsoft Office Excel spreadsheet software, which allowed for the attachment of codes (i.e., labels) to text segments so that they could be stored, sorted, and queried for major themes across, or within interview questions and transcriptions. Participants' responses were examined for key themes. In this phase of the analysis, the qualitative data (interview responses) were summarized across participants to describe general thematic patterns present. Per this method, transcribed data were open-coded and categorized from each interview following a process called "constant comparison," a significant characteristic of the grounded theory approach.[10] Constant comparison involves initial coding of data to capture themes within the transcripts, allowing researchers to become sensitized to similarities and differences within the data.[11] Identified codes are then compared and used to form core categories that attempt to represent the data. Core categories are given conceptual definitions that move them beyond descriptive tools to analytic units.[12] Codes were developed for passages within each transcription and entered into an evolving codebook used for coding subsequent transcriptions systematically. Changes to the coding process were made to reflect the perceptions of the participants. This process continued until each transcription was coded per the most recent codebook.

Data were organized, including illustrative quotations pertinent to each code, within a summary of codes. This summary facilitated the analysis of thematic patterns within and across respondents allowing identification of thematic units present in the data as they related to the questions of interest in this study.

---

[10] Glaser, B.G., and A. Strauss. 1967. *Discovery of Grounded Theory. Strategies for Qualitative Research*. Sociology Press, 271 pp.

[11] Southwell, O., and J. Fox. 2011. Maternal perceptions of overweight and obesity in children: A grounded theory study. *British Journal of Health and Psychology*16:626–641, http://dx.doi.org/10.1348/2044-8287.002002.

[12] Ibid., 631.

Community Case Studies

In addition to the interviews, this report also includes two case studies, from Buckland and Mekoryuk, to help convey the challenges that rural Alaska communities face in the effort to obtain in-home water service. The information included in these case studies came from a variety of sources, including city managers, tribal organizations, and the retrospective interviewees. These case studies are intended to help the reader understand the often steep challenges faced by communities, operators, and engineers when trying to install systems that best fit the physical and social environment encountered in the various villages.

Community Case Study One: Buckland, Alaska

FIGURE 1. Buckland in relationship with the State of Alaska, USA.

This community[13] in the Northwest Arctic Borough, is located on the west bank of the Buckland River, about 75 miles southeast of Kotzebue. The total area of Buckland is 1.2 square miles (3.1 km^2) and it is positioned in the transitional climate zone, characterized by long, cold winters and cool summers. Local temperatures range from −60° to 85°F (−51° to 29°C). Annual precipitation averages 9 inches (23 cm) and annual snowfall 40 inches (1 m). Crosswinds are strong enough to restrict air traffic during the winter.

Based on the 2010 census, the community had 416 members, 98 households, and 74 families. There were a total of 101 housing units, only a small number of which were used seasonally. Residents are predominantly indigenous, with 95% being of Alaska Native and/or American Indian heritage. The median household income is $42,188 while the median family income is $43,393. The per capita income is $9,344, and about 22% of the population lives below the poverty line.

The community's water source is surface water from the Buckland River. Until the 1980s, Buckland was primarily a "honeybucket community,"[14] with infrastructure that consisted of a central watering point connected to the local water treatment plant where residents could do laundry, use toilets, take showers, and transport treated water to their homes. This central watering point facility is referred to as the "washeteria"[15] or laundromat. Buckland's school, built near the watering point, was also served by this water treatment plant.

In 1985, a small wastewater lagoon was constructed in the middle of town, to the northwest of the washeteria as a repository for waste from the clothes washers, showers, toilets, and the water treatment system. The river has frequently impacted this lagoon. In the springtime, ice jams caused floods that washed lagoon

---

[13] The following data were accessed on 10/11/2013 at the State of Alaska's website for community profile information. Retrieved online from http://commerce.alaska.gov/cra/DCRAExternal/community/Details/525f1c5e-cc76-415c-9b62-38721d36914b.

[14] A honeybucket is a bucket used as a toilet that does not use water and has to be emptied manually (used in homes that lack indoor plumbing).

[15] Washeteria in rural Alaska is a public facility that is centrally located and equipped with washers, dryers, showers, and toilets. Typically, a washeteria is combined with a water treatment facility into one building with each facility operated separately from the other. Generally, the washeteria provides a watering point (dispenser or fill station) on the outside of the building.

contents into the community. In 1986, the water system was updated by moving the water intake upstream from the lagoon, to minimize contamination from river flood events. Nevertheless, the next year, the lagoon was damaged by ice and flooding, but was quickly repaired by raising the dikes and armoring the facility with steel retaining walls. These infrastructure improvements also increased the size of the water storage tank (located at the central watering point). Today, Buckland's water is pumped from the river and is stored in a 750,000-gallon raw water tank. Filtered water is stored in a 183,000-gallon tank.[16]

In 1994, the Northwest Inupiat Housing Authority (NIHA) constructed 14 homes in Buckland with a haul system that consisted of a water-holding tank suspended under the building that was constructed on pilings above ground. This arrangement was problematic because the tanks required heating with an electrical heat trace system, which was used to maintain or raise the temperature of pipes to prevent freezing. The heat trace was cost-prohibitive to operate due to the amount of electricity required. In practice, the heat trace was often turned off, resulting in tank freezing and system failure.

In 1995, a composting toilet demonstration project was conducted in the home of a local elder. This composting toilet was later trademarked as the "AlasCan." This single installation of the AlasCan in Buckland was the result of an arrangement directly made between this homeowner and an AlasCan representative. The major limitation of the AlasCan system was that it only partially addressed the human waste problem. It was not designed to process gray water (i.e., water from sinks and showers), nor did it solve the problem of providing flowing water to the home (e.g., for hand washing), thus, it provided few health benefits. Experimental use of the AlasCan in other communities revealed additional disadvantages, such as the inability to leave the system unattended for two weeks or more (i.e., during remote subsistence activities). Additionally, the toilet system did not perform well in colder climates due to the slowed activity of key bacteria that could not function well or died at subzero temperatures. Long-term successful operation of the system often required skills comparable to those of bioengineers and users frequently became frustrated with the "fussy" systems.[17] Therefore, other systems were subsequently explored in Buckland, and the honeybucket was re-embraced as a pragmatic solution, with users finding them easy to operate, empty, and wash out and with some models even boasting comfortable seats and odor-resistant lids.[18]

In 1996, the Indian Health Service (IHS) installed a haul system to serve 51 homes in Buckland. Instead of using a haul system already available on the market (e.g., Cowater's Flush Tank and Haul®), the agency chose to design its own modularized water and sewer systems to serve the fixtures present in the homes. These systems were located in a modular building that was placed adjacent to each home. These small exterior buildings (approx. 8 × 10 ft.) include one tank for treated water, and another, connected to the indoor toilet, for wastewater. The modular systems included a heater to prevent the tanks from freezing, as well as electrical and plumbing connections.

IHS also supplied Buckland with military vehicles, also known as Humvees,[19] to transport water and sewer via a truck-mounted haul tank, and trailer-mounted haul tank, respectively. As part of this project, a new sewage haul lagoon and solid waste site were constructed approximately one mile away from the community.

The initial concept for the customized IHS system was to avoid using much needed space inside the home for water/plumbing tanks but, from an engineering standpoint, this external modular design was not energy efficient. A module detached from the house incurred greater heat loss and higher energy expenses. Buildings had their own heaters, lights, pumps, and other devices. As one such module served each home, it was basically an additional housing unit that residents had to maintain and pay for, therefore, expensive and difficult to maintain from a homeowner/user standpoint.

Additionally, the haul equipment was not appropriate for local conditions. Tight space in small homes, small corridors, and unmaintained roads made maneuvering a giant Humvee and trailer difficult.[20] As snowpack is pervasive in villages, the wheels

---

[16] Information accessed on 10/11/2013 from Buckland's RUBA Community Status Report. Retrieved online from http://commerce.alaska.gov/dca/ruba/report/Ruba_public_report.cfm?rID=720&isRuba=1.

[17] Information from interviews with retrospective interviewees, project managers, and village representatives.

[18] http://www.maydayindustries.com/sanitary_toiletchems.html.

[19] High Mobility Multipurpose Wheeled Vehicle (HMMWV), commonly known as Humvee, a four-wheel-drive military automobile.

[20] There are large standard Humvees and a smaller sports version of the Humvee. The larger version was the one supplied in Buckland (John Warren, ANTHC, personal communication).

of such heavy haul equipment got stuck easily. Additionally, it was unrealistic to think that individuals could easily maintain such specialized equipment. These are unique vehicles with replacement parts that are difficult to find for users in remote villages. When vehicles broke down, finding local repair experts with appropriate, specialized knowledge was just as challenging. Although the Humvees were hard to maintain, the haul system continued to operate using heavy equipment and Honda ATVs to pull the trailers.

In summary, these systems were technically difficult to operate and costly to maintain. Ultimately, whenever haul systems failed or their use was discontinued because homeowners couldn't afford or maintain it, locals resorted to what they were used to doing: self-hauling their honeybuckets.

In 1999, the community engaged in a master planning process assisted by the US Army Corps of Engineers (USACE), and a main challenge was identified: the community was located on a flood plain. In 1992, a sewage haul lagoon and solid waste disposal area were constructed approximately one mile west of the community. Subsequent to this, whenever an ice jam downstream occurred, floodwater flowed through the lagoon and landfill spreading waste into and around the village. The lagoon was abandoned in 2010, and all wastewater and honeybucket waste is now disposed of at a new lagoon located outside of town beyond the landfill and old honeybucket site.

Historically, the community of Nunatchiaq (Buckland's Iñupiaq name) had originally been located on the opposite (northeastern) side of the river, which was not affected by seasonal floods. In the 1950s, however, the residents decided to move to their current location (on the southwestern side of the river) after the local school was built there—a location pre-determined by where the Public Health Service (PHS) barge docked. Unfortunately, a poor location was chosen for the school. With little to no knowledge of local conditions in Buckland, the school was built on the side of the river that regularly flooded. As a result, the community has regularly faced environmental contamination and disease due to the seasonal flooding of their sewage haul lagoon and solid waste site.[21]

The realization that the only high ground that did not flood was located on the other side of the river, where the community had originally existed, led USACE to the idea of building a bridge to allow year-round access to this area, where a sewage lagoon could be located. Therefore, the 1999 Master Plan recommended the construction of a suspension bridge for community access to the other side of the river where an already existing pond could potentially be used as a sewage lagoon (though this would have presented permitting issues).

An Alaskan expert in bridge construction submitted a project and budget proposal to USACE. However, USACE rejected this proposed design in favor of a second, more elaborate plan. Both proposals featured bridges designed to support loaded truck traffic. The former was a low-cost, single-lane suspension bridge. The USACE preference was for a larger bridge that was designed by a non-Alaska-based consultant.

The impasse led to disagreements between different agencies rendering the construction of such a bridge a highly political issue. The bridge was ultimately deemed not feasible after design changes were made and the estimated costs for construction rose from $2.8 million (Alaskan firm proposal) to $24 million (non-Alaskan firm proposal).

Thus far, many of the lessons learned in Buckland point to the need to design inexpensive, suitable infrastructure consisting of a low-tech system that doesn't require complicated maintenance and is inexpensive to operate and mobile.

Funds that were previously awarded for the bridge remained unused after the highly political impasse, and residents were losing patience. In 2003, the village requested USACE to hand management of the project to the State of Alaska's Village Safe Water (VSW) Program.

Haul systems were piloted in Buckland as an inexpensive alternative to piped systems, assuming both approaches could provide health benefits, with the difference being that capital costs for haul systems are substantially lower than those for pipes. However,

---

[21] Information from interviews with retrospective interviewees, project managers, and village representatives

insufficient data and faulty projections that did not account for the operation and maintenance costs of haul systems may have led to erroneous assumptions.

Projections of the costs to the users to operate the water systems that were made prior to construction were underestimated because fuel and operation costs were low in the late 1990s when the projections were made.

The Buckland case raises questions about the long-term expense of haul systems. In this case, despite lower initial capital costs, the haul systems appear to rival the cost of a piped system while potentially failing to offer the same health-related benefits, secondary to water rationing behavior.

A VSW-led project is currently underway to construct a centralized piped system that will deliver water to all homes in Buckland. Out of approximately 90 homes, approximately 70 have already been connected to this system.[22] Residents whose homes are not "on line" yet continue to haul water and use honeybuckets.

In Buckland, the capital cost *per house* for the piped system is ~$500,000. All but eight homes will have service by the end of 2014. However, it is important to note that Buckland's soil is ice-rich. Therefore, the risk of permafrost thawing caused by heated pipes buried underground is high. In order to mitigate this risk, insulated pipes are placed on four inches of foam insulation and the temperature in the water mains is limited to 45°F to keep the ground from thawing. Climate change is a wild card in this situation, as the location is flood-prone. Protecting infrastructure from floods is both difficult and costly. Foundation pads for the water tank and lift stations have been armored with riprap in areas prone to flooding to protect these installations. Erosion occurs along the river bank, and the community would benefit from erosion control projects to protect homes near the river.

In time, the community may face further challenges in trying to operate, repair, and maintain their piped systems without external assistance, as has been the experience of other communities under similar conditions. It remains to be seen how sustainable the service will be in the long run.

Community Case Study Two: Mekoryuk, Alaska

Mekoryuk is located on the north shore of Nunivak Island in the Bering Sea. Mekoryuk[23] has a total area of 7.4 square miles (19 km^2). The local average annual precipitation is 15 inches (38.1 cm) and annual snowfall is an average of 57 inches (1.45 m). Summer highs average 48° to 54 °F (9° to 12 °C), while winter high temperatures range from 37° to 44°F (3° to 7°C). Extremes have been recorded from 76° to –48°F (24° to –44°C).

The 2010 US Census indicated that the community had 191 members, 70 households, and 40 families. There were 86 housing units, 11 of which were vacant on a seasonal basis. The people in Mekoryuk are predominantly indigenous; 97% are Alaska Native and/or of American Indian heritage. The median household income is $26,250, while the median family income is $58,750. The per capita income is $22,233, and about 28% of the population is below the poverty line.

FIGURE 2. The location of the community of Mekoryuk in the State of Alaska, USA.

---

[22] W. Griffith, Program Manager of Division of Water Facility Programs, Alaska Department of Environmental Conservation, personal communication, 2013.

[23] The following data were accessed on 10/11/2013 at State of Alaska's website for community profile information. Retrieved from http://commerce.alaska.gov/cra/DCRAExternal/community/Details/b1df202d-fed0-4f6f-8370-aa0d13299ac8.

Until the 1960s, the community had no formal water and sanitation systems. The first type of water-delivery system that was installed was an underground piped water and sewer system. After working for a few years, the system failed due to winter freeze ups and complications with permafrost.[24] The only portion of the piped system that remains in operation is the sewer line running between the school and the lift station. After the wide-scale failure of the piped system in the 1970s, the community reverted back to self-hauling honeybuckets, collecting rainwater and melting ice for drinking water. In the late 1980s, Mekoryuk received a grant from the Indian Health Service (IHS) for a citywide honeybucket-haul system, but the community refused to work on such a project as it was considered a suboptimal solution to their water and sanitation needs. Community members wanted improved means of sanitation.

At the request of the community, and with their input, the State of Alaska's Village Safe Water (VSW) program solicited designs for a small-scale water and sewage haul system from engineering firms. In 1991, the successful bidder completed an initial demonstration project consisting of a closed haul water and wastewater system. These systems carry tanks on trailers that are hauled by four-wheelers in the summer and by snow machines in the winter (Figures 3 and 6). Water haul tanks hold 100 gallons and wastewater tanks hold 160 gallons. Instead of suctioning material from the sewage holding tanks, these machines pump in air to evacuate the tanks (Figure 4).

After a trial period, the newly designed systems were considered fundamentally successful, and additional units were delivered and installed. The design was similar to what was piloted in Buckland, except that the water holding tank is located within the home. Gradually, the community moved from honeybucket-haul to closed haul systems, with 90% of the homes at the time (1990s) being served by these systems. Currently, approximately 53 homes and four commercial buildings use these systems, while four households use honeybuckets as a result of haul system failure (e.g., freeze-up issues or inability to find replacement parts for outdated systems).[25]

Mekoryuk currently has a 4.3-acre wastewater lagoon located several miles from town and a lined water reservoir (Figure 5) near the treatment plant that has the capacity to hold 7.5 million gallons of water. The reservoir is filled before winter by pumping from an "infiltration gallery"[26] underneath the Mekoryuk River. The river has a tidal influence that sometimes leads to saltwater intrusions into the freshwater. Therefore, to avoid brackish water, the point source for the water (at the infiltration gallery) is located upriver, approximately four miles away from the reservoir. The town water plant draws on the reservoir year round and treats the raw water. After treatment, water is stored in a 125,000-gallon tank.

FIGURE 3 (left). Water haul tank.

FIGURE 4 (above). Flush tank and haul sewage tank, commonly known as "a dog house."

The community has a water treatment plant and a central watering point/washeteria. Residents haul water from the washeteria or have water delivered to them via the community flush tank and haul system (Figure 6). In many cases, showers or baths were installed in houses as part of the flush tank and haul system, but it is difficult to determine how many of these are still operational, as the space they occupy in the home is at a premium and they are often removed or repurposed.[27] Currently, about 50% of homes have washing machines. However, residents often prefer to use washers and

---

[24] Information accessed on 10/11/2013 from Mekoryuk's RUBA Community Status Report. Retrieved online from http://www.commerce.state.ak.us/dca/ruba/report/Ruba_public_report.cfm?rID=645&isRuba=1.

[25] Personal communication, interview with M. Davis (Mekoryuk resident), 9/2014.

[26] A structure including perforated conduits in gravel to expedite transfer of water to or from a soil aquifer.

[27] Author/working group field observations, retrospective interviewee data.

showers provided at the washeteria to cut down costs for water haul service, as these are considered to be "water hungry" appliances. Anecdotally, washeteria operations register high traffic during weekends, as residents are able to do their laundry mostly during non-working days. The limited number of washing machines available often forces residents to do their laundry at home.[28]

Flush tank and haul systems are used in almost every home, but not without challenges. Parts are costly and hard to find. Users report that the ultra-low-flow toilets (one pint per flush) perform poorly and are difficult to maintain, requiring constant scrupulous cleaning. Because these toilets are directly connected to the sewage tank, there is nothing keeping the unpleasant sewage odor from seeping into the interior of homes and offices if the seal on the toilet is not maintained and the toilet no longer holds water. Changes in wind direction and strength can exacerbate this problem. Though it meets code requirements, the toilet portion of this system is considered its main weakness, due to recurring issues with valve failure and poor ventilation.

When homeowners in rural Alaskan villages need repairs, and skilled locals are unable or unavailable to perform them, the community is challenged to find external expertise, especially in light of the challenges of extreme climate, remoteness, and associated high expense. Additionally, much of the flush tank and haul infrastructure that requires attention is found within homes. Remote maintenance workers (RMWs) are authorized to make repairs "up to the meter," adjacent to the home, but not inside private residences. Those repairs are the responsibility of the homeowner or professional service providers hired by the homeowner.

For financially poor communities, with small economic bases, the costs to operate, maintain, and provide transportation for haul systems are relatively high. The expenses to have water delivered to the home and sewage removed are difficult for the majority of the community to afford. Non-senior users are charged $39.65 for haul service and seniors $32.50 per haul (2013 figures). Households with four to six members are usually serviced twice a month at a total cost of $158.60 per month for water and sewage haul. There are six households that have water delivered once every two months. Frequently, residents find themselves forced to limit the use of these systems to sewer pick-up and resort to self-hauling water from the washeteria at a lower cost. Other common money-saving practices include collecting rainwater or melting ice to save money. In some cases, this practice results in contamination of holding tanks as this water comes from non-treated sources. In other villages, instead of releasing sewage at the lagoon via the paid haul system, residents self-haul and empty the buckets they placed under the kitchen sink (which is considered "gray water"[29]) at various points around town. Commonly, the gray water is dumped in a ditch adjacent to the home in potential contact with children and animals, creating an environmental health hazard.

Snowdrifts are common in Mekoryuk, and have historically challenged the operation of the haul vehicles. Renting snow removal equipment from the city is costly for homeowners, often costing as much as $100 per plow out after labor and rental costs. The expense can be higher for homes located farther away from the main road. Yards that are not always fully clear of snow (Figure 7) represent a

FIGURE 5 (below). Lined water reservoir.

FIGURE 6 (right). Haul tank dumping sewage into the lift station building on the right.

---

[28] Personal communication, interview with M. Davis (Mekoryuk resident), 9/2014 and discussion, 2014 Washeteria Workshop, Alaska Rural Water and Sanitation Working Group.

[29] The relatively clean wastewater from baths, sinks, washing machines, and other kitchen appliances is considered "gray water," while sewage from toilets is deemed "black water."

FIGURE 7. A road, cleared of snow, between town and the airport.

challenge for the haul operator[30] to maneuver through the limited space adjacent to the tanks and the typically small homes.

The water plant operator faces particular danger in driving a four-wheeler through the precarious and unsafe trail on swampy tundra (Figures 8 and 9) to arrive at the community's water source on the Mekoryuk River. Attempts to seek financial assistance from funding agencies for trail improvement have been unsuccessful thus far.

Mekoryuk was the first village in Alaska to receive flush tank and haul units. The oldest haul units were prototypes. Finding key replacement parts is, therefore, increasingly problematic. These parts have to be pre-ordered and fabricated outside of the community. Time, labor, and elevated shipping costs are additional factors in what has been described as an often-exasperating endeavor. Mekoryuk's oldest flush tank and haul systems are over 20 years old, and the community administration is concerned with how much longer their haul system will function without a major overhaul. The local saltwater environment causes the infrastructure to age more quickly: sewage tank door hinges corrode to the point of falling off; worn wastewater tanks leak through holes, causing sewage to spill on the ground adjacent to children's play areas. The dilapidated state of some of the infrastructure often defeats its purpose. To lengthen the overall life of these systems, the administration made the assumption that upgrades are needed every five years. However, this task involves costly repairs that homeowners often cannot afford at that frequency.

Lessons learned in Mekoryuk include the fact that the lifespan of closed haul systems depends upon highly involved care on the part of homeowners for repairs, parts replacement, and maintenance. If systems are expensive to operate (requiring repairs/maintenance beyond the capabilities of a typical homeowner) or are technically complex and not serviced accordingly (e.g., due to parts being costly or rare), systems will fail, and local community members are likely to revert to self-hauling their honeybuckets and water for use at home.

Although appreciative of having access to a water and sanitation system, users are not fully satisfied with the performance of flush tank and haul systems. They desire a piped system. Their frustration is evident in statements such as, "We are no different than other human beings, we pay taxes like any other citizen, so we want a piped system to continue improving our community; our younger generations are living in the electronic age, we cannot stay in the dinosaur age with these systems; we need to follow up on health improvements."

FIGURE 8 (above). Conditions of a trail leading to water source, Mekoryuk, Alaska.

FIGURE 9 (left). Traveling by four-wheeler on swampy trail, Mekoryuk, Alaska.

---

[30] It is important to note that Mekoryuk has two types of operators with distinct tasks: a flush tank and haul operator and a water plant operator. One deals with hauling water and sewage and the other with the water source, water plant, and washeteria.

The interest in closed haul systems peaked during the 1990s, but has since waned. Initial capital costs for haul systems are low, compared to piped systems. However, in retrospect, many residents feel that while the haul systems are less expensive to construct and more convenient than self-hauling honeybuckets, the haul systems are costly to operate and maintain from a user standpoint. Additionally, associated health outcome improvements were not necessarily seen.

In the 1990s, providing haul systems was considered comparable with equipping a community with suitable (piped) water and sanitation infrastructure. Therefore, when the village of Mekoryuk accepted the flush tank and haul demonstration project and additional units were constructed, the community was considered to be a "served community." This designation did not sit well with some members of the community who felt that the closed haul systems were only an interim solution until piped water was installed. Ultimately, the community missed the opportunity to obtain funding for a piped system during the era when agencies had the financial capacity to provide this service.

Despite the community's current desire to be considered for funding to construct a piped water and wastewater system, Mekoryuk is not actively pursuing such. Villages with a haul system, like Mekoryuk, are considered a lower funding priority than villages with no system at all. Despite having a long-standing application for funding for pipes, Mekoryuk never scores high enough to be considered. Project costs of pipe infrastructure are exorbitant, and there are now a limited number of rural communities receiving state and federal funding for this type of system. Funding for repairs or replacement of existing systems is rarely available in the current funding environment where communities receiving first-time service are prioritized (though few of these are likely to receive piped systems, given the current budget crisis). There are no clear solutions available to secure the finances necessary to install a piped-water and sewer system in Mekoryuk or many other small, rural, remote Alaska communities.

Summary of Advantages and Disadvantages of Decentralized Water and Sanitation Systems

The following information was collected through in-depth interviews with experts (from state, federal, tribal and private entities) who have decades of direct experience with water and sanitation projects across rural Alaska. The aim of this section is to provide an insightful overview of the type of systems employed in rural Alaska between ~the late 1970s and 2005 as well as an assessment of how these systems have performed, according to the assertions made by interviewees. This section excludes consideration of centralized systems, such as piped infrastructure, in order to focus on less expensive and more basic technologies. ***Wherever possible, we have listed opinions in italics (especially those inconsistent with current assessments).***

Water Systems (Delivery/Distribution)

NAME AND DESCRIPTION	ADVANTAGES	DISADVANTAGES
1. SELF-HAUL FROM UNTREATED SOURCE Residents get their own water from a variety of traditional sources (e.g., rain, spring, creek, or lake, in the form of water or ice).	• Inexpensive • Infrastructure not needed • Homeowner can use preferred water source (may provide benefits in the form of increased palatability)	• Water is not treated and may be unsafe for consumption/below government standards for drinking water. • Contamination of water may occur during hauling, storage, and use. • Homeowner must haul their own water, which is inconvenient, especially for the elderly/incapacitated. • Users tend to conserve water to reduce costs and inconvenience related to water and sewer haul/disposal, thereby decreasing the potential health benefit of having water in the home. • Realistically, self-haul systems are highly unlikely to provide the estimated 15–26 gpppd[31] needed for adequate washing and hygiene in a household with internal fixtures. • In cases of supplemental self-haul, the hauler may contaminate treated water holding tank by adding the untreated self-hauled water (leading to algal/bacterial growth and a need for storage tank sanitization).
2. SELF-HAUL FROM TREATED SOURCE (CENTRAL WATERING POINT) Residents get water from a central (treated) watering point (often a washeteria/laundromat). Water is purchased by the gallon by the homeowner at these sites. The homeowner is responsible for transport to the home.	• Relatively inexpensive • Minimal infrastructure (beyond central facility) needed to make system functional • Can be operated year-round • In combination with haul systems, washeterias provide many of the features, conveniences, and comforts that a piped system does	• Homeowner must haul their own water, which is inconvenient, especially for the elderly/incapacitated. • Users tend to conserve water to reduce costs related to water and sewer haul/disposal, thereby decreasing the potential health benefit of having water in the home. • Realistically, centrally located self-haul systems are highly unlikely to provide the estimated 15–26 gallons per person per day (gpppd) needed for adequate hand washing and hygiene. • *Washeterias (where the central watering points are commonly located) generally operate "in the red" and may need to be subsidized by the community*.

---

[31] The World Health Organization suggests 26.4 gallons gpppd (Howard, G., and J. Bartram. 2003. *Domestic Water Quantity, Service Level and Health*, World Health Organization). The American Society of Civil Engineers recommends 15.9 gpppd (Smith, D.W., ed. 1996. *Cold Regions Utilities Monograph*, 3rd edition, New York, NY).

NAME AND DESCRIPTION	ADVANTAGES	DISADVANTAGES
3. WASHETERIA Generally, a community operated site that provides showers, washers/dryers and bathrooms to communities that are not fully served. Often connected to the water treatment plant, the washeteria also serves as the site for the purchase of treated water by the gallon (see #2, above).	• Provides a central watering point and allows members of the community a place to take showers (in most cases) and wash clothing	• In *small* communities (<250 people), washeterias are less likely to be a self-supporting service. • Unreliable/dwindling/unstable power supply in villages may not be suitable to deliver the high temperature needed for the "kill step" in typical commercial clothes dryers. This is a human health issue, as these facilities may then serve as a transmission point for disease. • Revenues are compromised when consumers use washers but not dryers, as they take wet clothes home to hang dry. This practice allows them to save money and humidify the home during drying process.
4. COMMUNITY HAUL A community-supported operator delivers water to holding tanks in individual homes. "Small haul" generally employs an ATV with a trailer and is geared to traveling on boardwalks (in towns without roads). "Large haul" is truck haul that uses roads to deliver water/remove wastewater (typically in "hub" communities).	• Has the potential to provide adequate amount of water for toilets, sinks, and a shower • Centralized payment collection can remove some of the confrontation about charging people for these services, which to some extent is still a relatively new concept for isolated indigenous communities. By offering community pickup, consumers see a direct benefit and are more likely to pay in exchange for receiving a service that relieves them from the inconvenience associated with self-hauling honeybuckets. • Lower capital costs than pipes and less prone to community-wide catastrophic failure	• *Overall (operating) costs are generally estimated to be lower than a piped system, but in practice it is the opposite.* • O&M needs tend to be inside the home limiting access to technical assistance. • Cost for labor is high. In some cases, operator expands/contracts his hours based on money available for his wage. • Difficulty trying to estimate future O&M costs, thus community can't get accurate information on costs. • *Per several interviewees, system is more expensive than numbers one and two (above), and possibly to piped systems as well, when the long-term costs of haul/maintenance on vehicles, etc. are considered.* • To use it at the level required to provide optimum health (i.e., 15–26 gpppd minimum) is fairly expensive (improving health outcomes requires adequate amounts of water at home, generally thought to be 15–26 gpppd). • Requires the hiring of operators to deliver water (and remove waste). • In-home requirements like holding tanks are a burden on homeowners: they occupy living space and need to be kept warm/unfrozen. Holding tank systems cannot be left/allowed to freeze without winterization. • Consumers often bypass the system to avoid paying for hauled water in (e.g., collect rainwater) impacting public health benefits and the business model. • If the homeowner subsidizes water delivery, issues exist related to keeping water storage tanks sanitary/uncontaminated (e.g., if using roof catchment systems bird droppings commonly found on roofs or contamination of fill lines could contaminate the collected water). • Users tend to conserve and recycle water to reduce costs related to haul/disposal, thereby decreasing the potential health benefit of having water in the home.

OTHER CONSIDERATIONS

- Self-haul is still practiced in some unserved communities, as well as by individuals in served communities who choose to self-haul from untreated water sources, due to palatability preferences.
- Community haul systems exist in several villages in rural Alaska. See **Sewage Disposal Systems** section for additional details. Showers and washing machines are water-hungry devices that tend to cost more and lead to water re-use. There is no good understanding or measure of success for haul systems, as there is no common grading method. The cost analysis of flush tank and haul has not always assumed that some households will collect water at no cost from local natural sources (e.g., rainwater or self-haul) to supplement their water reserves. This practice materially impacts both water quality and cost in addition to contaminating holding tanks. Bypassing the service also impacts the revenue or financial viability of systems, such as washeterias and haul systems. Unlike features of a piped system that are relatively permanent and don't disappear, a haul system can easily come and go, participation is optional, and many other features can "drag the system down." In communities that have a combination of community delivery service for water and a piped sewage collection, users have caused system back-ups by conserving water to the point that not enough wastewater flows into the piped sewage system. This practice causes the sewage system to function improperly.
- Many communities in rural Alaska are currently served by a system consisting of a central watering point and a washeteria. The potential exists to improve service in the non-freezing months of summer, using temporary pipes to bring water closer to homes (i.e., by using several temporary watering points). Power in villages is variable (voltage, frequency); therefore, washeterias with electromechanically simple designs (e.g., that avoid logic circuitry) have fared better. Along the same lines, robust duplex systems performed better, because if one part failed, the other could take over.
- The possibility exists for saunas to bring revenue to washeterias, as steam houses seem to be popular in certain regions of rural Alaska (e.g., Hooper Bay, Emmonak, and other villages in the Yukon Kuskokwim region). It would be necessary, however, to analyze projections of revenues versus expenses, as energy costs could outweigh revenues. The role of the sauna in disease transmission and fire risk needs to be explored, as well.

Sewage Disposal Systems

NAME AND DESCRIPTION	ADVANTAGES	DISADVANTAGES
1. HONEYBUCKETS (SELF-HAUL) Simple and inexpensive means of providing a place for waste to be deposited. Generally consists of a five gallon bucket, fitted with a plastic bag and a toilet seat. Honeybuckets can be used inside or outside the home (in a building similar to an outhouse minus the pit). This alternative is also known, by agencies, as an open-haul system. There are two methods for users to self-haul honeybuckets: i. Self-haul from house door to hoppers (bins) spread around town. Community pick-up service is in charge of collection and transport of hoppers' content to final disposal site (see #3). ii. Self-haul from house door all the way to final disposal site (e.g., honeybucket lagoon) when community pickup service is not available, discontinued, or, if user decides to bypass service.	• Inexpensive to set up • Mobile • Homeowner is responsible for maintaining it (requires little or no community organization/ infrastructure)	• Homeowners must haul their own waste to a disposal site or facility, thereby increasing the possibility of contact with waste. Hauling waste can also be difficult for elderly or incapacitated users and is generally unpleasant for all. • During self-haul, waste is often spilled into the open atmosphere during transport. Sewage may be dumped on boardwalk creating significant hazards. Birds and other animals feed on waste and later distribute it throughout the community. Often, sewage is aberrantly dumped geographically closer to the community over time (especially in winter in places with lagoons/dumping stations located a distance from town) contaminating the environment. • If community-haul operators are not engaged enough, waste will also be spilled when technology is not properly applied (e.g., not securing lids while driving around). • Messy, issues with odor and spilling waste, consumers didn't want it near houses, issues with kids being exposed to raw sewage. • Minimal health outcome improvement. Truly the bottom of the scale with regards to sewage disposal.
2. HONEYBUCKET BUNKER SYSTEM (SELF-HAUL)[32] A sewer bunker is a covered pit in which honeybucket wastes are dumped. They are generally used where residents cannot support the operation of a higher-level disposal system and typically consist of a covered, wood-reinforced pit. Honeybucket wastes are dumped into the ground, and (in theory) the liquid portions of the waste soak into the ground. Sizing of the bunkers depends on use profile and solid drainage. They fill and their use is discontinued over a period ranging from one to several years (e.g., depending on size, use, drainage).	• Low tech • Localized location for sewage disposal, prevents/decreases the incidence of indiscriminate dumping	• One step up from indiscriminate dumping of sewer on ground near home. • Residents are potentially exposed to waste during hauling and dumping (which is a significant health hazard). • Bunkers do not function properly and cannot be installed in permafrost or high moisture soils. • Eventually, bunkers fill up and need to be covered or filled in and made safe for the community. • Sewage bunkers also tend to occupy prime real estate near or in the village (land which could be used for other, more productive things such as housing) and as communities grow, they fill more quickly and need to be capped and replaced. • Replacement often does not match the pace of use. • There has been a particular issue with bunkers being used as trash receptacles, which can significantly shorten their lifespan.[33]
3. HONEYBUCKET HOPPERS Centrally located, mobile containers serving clusters of homes, used for individual honeybucket collection. The community typically provides a service where they haul the hopper to the sewage lagoon.	• More convenient than having individuals haul honeybuckets to the lagoon which, in turn, likely prevents individuals from dumping honeybucket waste on the ground	• Communities have to charge for the service of hauling the hoppers. • There is no way to prevent non-paying residents from using hoppers (locking users out from use is not a feasible solution). • Traditional hoppers are plastic, cost several thousand dollars, and are not commercially available. These hoppers are susceptible to cracking when frozen because they are made of plastic, which gets brittle in cold and must be hammered on in order to remove the frozen sewage.

---

[32] As of 2014, funds are no longer provided to construct honeybucket bunkers.

[33] Sewage disposal alternatives to honeybucket disposal systems, Environmental Health Branch of the AK Area Native Health Service, USPHS, April 1985.

NAME AND DESCRIPTION	ADVANTAGES	DISADVANTAGES
4. OUTHOUSES (SELF-HAUL) Simple and inexpensive means of providing a place for waste to be deposited. Generally consists of a small structure built over a pit, dug into the ground. Lifetime of outhouse depends on depth of hole, amount of water in area, frequency of use, and soil characteristics.	• Inexpensive to construct • Homeowner is responsible for building it/maintaining it (requires little or no community organization/ infrastructure) • No fees incurred for hauling waste • Can be moved to a new pit location when necessary • If small community size and homes are spread out, minimal contamination issues	• Soils have to be able to support an outhouse. Frozen and saturated soils are not compatible with outhouses. • Provides minimal solution to half of the equation, as this technology alone will not provide water in the home. • Outhouses may fill/overflow creating a public health hazard. • They must be placed at an adequate distance from public water sources to avoid contamination. • This approach is not optimal for homes built in close concentrations. • Trash dumping in outhouse pits was mentioned as a specific problem, significantly shortening the lifespan of the chosen site.
5. CLOSED HAUL SYSTEMS (COMMUNITY-HAUL) Consist of a wastewater holding tank located inside or outside the home. Low-water-use toilets and fixtures are used to limit flow into the tank. A vacuum or pressure pump (blower) withdraws the contents of the tank into another tank that is mounted on a trailer or truck. The haul trailer is transported to the disposal site (e.g., lagoon), by truck or an all-terrain-vehicle. Collection service is scheduled on either a routine cycle, or an on-call basis.	• Has the potential to provide adequate removal of waste from the home on a regular basis • Closed-haul systems are generally more sanitary than more basic options as there is less spillage associated with their use • *Centralized (payment) collection may remove some of the confrontation about charging people, especially people that the operator may be related to/friends with in a small village; consumer has to pay to receive service in exchange* • *There is the perception that these systems are less costly than pipes and less prone to catastrophic failure*	• Require a higher level of infrastructure than other non-piped systems and the hiring of operators to remove waste. • In-home requirements like holding tanks are burden on homeowners (take space, cost money to keep thawed). • Consumers bypass the system, impacting the business model, to avoid paying for sewage pickup (e.g., disconnect the drain under sink and put a five gallon bucket or make hole in the floor and let it drain right out below the house). *Gray water disposal is an issue in Alaska that many do not wish to address.* Impact of indiscriminate gray water disposal depends on local drainage conditions. • *These haul systems often operate on extremely small margins. One or two families going on extended hunting trips can push the system from the black into the red.* • In early small-scale haul systems, tanks utilizing lids for covers would get brittle and fail in the cold, fit improperly and often blow away, and then they were not used. This led to spillage of sewage along the haul route (a health hazard). • When infrastructure wears down (e.g., hauling equipment fails or boardwalks deteriorate), consumers dump waste indiscriminately around the community or use unsanitary barrels for carrying water.
6. WATERLESS/COMPOSTING TOILETS These are dry toilets that use a predominantly aerobic processing system that treats human waste, typically with no water or small volumes of flush water, via composting or managed aerobic decomposition.	• Self-contained • Low cost (as compared to many other systems) • Water is not needed in this type of system	• Mini-chemical treatment plant with multiple pumps and valves requires users to be technically savvy and fastidious ("need to be an engineer to run one"). • Not having a hardware store nearby makes repair and maintenance challenging. • Degradation rate is lower due to cold weather. • High electric bills for running heater all the time. • Smell and exhaust problem, system needs improvement. • Cannot easily be left for any period of time, especially in the cold. • Provides minimal solution to half of the equation, as this technology alone will not provide water in the home.
7. INCINERATOR TOILETS An incinerating toilet is a toilet that burns human waste using electrical burners or propane.	• Small quantity of waste (ash) ultimately produced/left to deal with • If not in use, residents can walk away from it	• Ugly, energy-intensive, high-cost, high-maintenance, not a permanent solution. • The units do not meet air quality standards. • Propane is expensive and cannot be shipped on a typical airplane (hazmat). • The cold in Alaska makes operation more challenging than running an incinerator toilet in more temperate areas. • Residents are reluctant to fire their burner up every time because they need to burn a lot of BTUs to do it. Infrequent incineration leads to accumulation of waste, potential hazards, and failure of the systems. • Process for ventilation and filtration is not intuitive for users; vent problems have caused accidents and emergency evacuation.

NAME AND DESCRIPTION	ADVANTAGES	DISADVANTAGES
8. SOLAR OUTHOUSES (COMPOSTING)	• Smell is not bad due to aerobic respiration	• Users overwhelm system by dumping gray water into it. • It can be challenging to make sublimation and evaporation processes work in typical Alaskan (cold) climate.
9. CHEMICAL TOILETS (PORTABLE TOILETS)	• Units are water sparing and their oil-based carrier fluid is recyclable	• Odor. • Chemicals need to be shipped remotely, which is often a challenge/ expensive. • Inappropriate in freezing conditions.
10. BIOLOGICAL REACTOR/ EVAPORATOR	• Addresses the problem of how to remove waste, important for disease control • In-home waste management system • Reduces users' contact with waste • Can be purchased in Alaska (i.e., Sportsman's Warehouse)	• Very complex reactor with air flow and many pumps, not feasible/ workable on a large scale. • Fire (explosion) hazard if smoking nearby due to methane gas production. • Putrid process for the average person (leads to low compliance and rejection of units). • Reactors will fail if used by too many people or if unpleasant maintenance procedures are not followed by users. • Requires household heat to facilitate evaporation and constantly moving air out of the house. • Failures across the board for long-term use.

OTHER CONSIDERATIONS

- Outhouses can be and are used today in parts of Alaska, mainly in sparsely populated areas that have no permafrost and are not prone to flooding. There tends to be a regional preference for outhouses versus honeybuckets.
- Honeybuckets are still the predominant means of sewage disposal in approximately 50 rural communities of Alaska.[34] These are seen as the lowest level solution to the sanitation problem in Alaska and confer the least health benefit. There are concerns about waste transport practices.
- Comminutors (grinders) for honeybucket waste (including bags) failed because residents would overwhelm the system by disposing of household garbage in the comminutor, especially if the grinder was located closer to town than the dump.
- The co-locating of the honeybucket dump and garbage dump results in a serious problem. If gated off, residents tend to dump at the gate. Community commitment is needed to make these levels of sanitation work.
- Issues arise when not everyone in the community participates in haul service. The waste disposal methods of non-participating families might not be the most sanitary and are not always included in estimates. Sewage lagoons have been the lowest-cost option for waste disposal in rural areas. There is no economical mechanism for environmental release of waste material as compared to building a lagoon.
- Incinerator toilets can work but have a high energy cost. They can use both propane and electric, but require great amounts of both (or either).
- Solar outhouses encounter limitations due to the State of Alaska not supporting the separation of gray and black water because regulations do not allow the state to promote solutions that only handle black water (which might encourage users to dump gray water on the ground).
- There is the perception that haul systems are less expensive than piped systems, as capital costs for haul systems are substantially lower than those of pipes. This perception may help explain the shift from piped systems to other alternatives in the 1990s. From a user perspective, however, once built, haul systems are expensive to run due to labor/transportation costs and heating. User fees for haul service are generally higher than fees for operation and maintenance of piped systems, while generally not providing a similar level of health benefits and convenience as that offered by piped service. Envisioning communities that can self-sustain their water and sanitation systems may require a bigger investment on the part of the state, in order to offer a service that is affordable for users to sustain in the long term.

---

[34] Out of the more than 200 rural communities in Alaska, 50 meet the definition of "unserved" (as of 2013). A rural Alaska community is considered "unserved" (still using honeybuckets) if less than 55% of the year round occupied homes in the community are served by a piped or closed-haul system.

Discussion

Historically, in many villages, food preparation was conducted outside the home. As Native groups settled into stationary locations and formed communities with various households (generally in response to laws regarding school enrollment), the food-making process was brought inside, and with it came the need to have water available for a variety of purposes, including drinking, cooking, cleaning, and general hygiene.

Along the same lines, the year-round accumulation of physiological waste became an issue because individuals no longer migrated in groups to different sites according to their seasonal subsistence activities. In 1955, the Indian Health Service (IHS) was created to address severe health disparities between Native and non-Native populations. At the time, life expectancy for Alaska Natives was 40–42 years, while that of Non-Natives was 68–70. The Alaska Native population was suffering the highest rate of tuberculosis ever recorded.[35] Widespread unsanitary conditions, including cramped housing, were a contributing factor. Therefore, IHS started providing primary health care in villages. To address sanitation issues, IHS began building water utilities, recognizing that clean water confers health benefits. However, soon after, the agency came to the realization that many rural residents did not understand the connection between the use of clean water and the transmission of infectious disease. People would, for example, wash diapers in the kitchen sink and then, without properly disinfecting the sink, use it to prepare meals. To educate and engage the communities with respect to sanitary practices, the IHS established a program in 1966 to coordinate and provide training for Public Health Sanitarians as well as provide educational/orientation courses for engineers and tribal crews.[36]

In rural Alaska, however, educational efforts to raise awareness and explicitly establish the link between water use and disease pathways, were either insufficient or not successfully made at the early stages of this process. Thus, while this connection is often self-evident for urban utility users, this is not always the case for rural Alaskan residents. Per interviewees, other than Public Service Announcements (PSAs) that promoted proper hand-washing practices, a wide-scale education program for villages about health-related benefits of treated water use, as it relates to both water quality and quantity, does not appear to have existed. Recorded sanitation failures (e.g., caused by users flushing fish heads down their toilets) also indicate a lack of relevant education at the local level regarding the equipment installed in homes and its proper use. Currently, health education is undertaken to varying degrees, but only in association with project construction. Conducting a formal process for health education in villages could lead to overall health improvements.

During the time frame of this retrospective (~1970–2005), the motivation behind providing water utilities was largely focused on the convenience aspect related to having water in the home, as opposed to the beneficial health effects. Peer-reviewed studies linking the effects of hand washing on respiratory and skin diseases in rural Alaska did not emerge until ~2005.

Recent research has illustrated clear connections between water quantity and health.[37,38,39] However, Alaskan rural residents tend to conserve water to reduce the expense of water delivery and sewer haul. Hence, in remote villages in rural Alaska, the term "water secure" arises, which means "the reliable availability of an acceptable quantity and quality of water for health, livelihoods, and production, coupled with an acceptable level of water-related risks." The ability to afford the service is an important factor in consuming the optimum amount of water. The Environmental Protection Agency estimates that village users are willing to pay

---

[35] Johnson, MW. 1973. Health Service Report. 88(3):247–254.

[36] Public Law 86-121 50th Anniversary Report, page 29. Retrieved online from http://www.ihs.gov/dsfc/index.cfm?module=documents.

[37] Hennessy, T.W., T. Ritter, R.C. Holman, D.L. Bruden, K.L. Yorita, L. Bulkow, J.E. Cheek, R.J. Singleton, and J. Smith. 2008. The relationship between in-home water service and the risk of respiratory tract, skin, and gastrointestinal tract infections among rural Alaska natives. *American Journal of Public Health* 98:2,072–2,078, http://dx.doi.org/10.2105/AJPH.2007.115618.

[38] Thomas, T.K., J. Bell, D. Bruden, M. Hawley, and M. Brubaker. 2013. Washeteria closures, infectious disease and community health in rural Alaska: A review of clinical data in Kivalina, Alaska. *International Journal of Circumpolar Health* 72:21233, http://dx.doi.org/10.3402/ijch.v72i0.21233.

[39] Gessner, B.D. 2008. Lack of piped water and sewage services is associated with pediatric lower respiratory tract infection in Alaska. *Journal of Pediatrics* 152(5):666–670, http://dx.doi.org/10.1016/j.jpeds.2007.10.049.

a maximum of 5% of their median household income for haul service (though this varies and can be as low as 1.6% in certain villages). After this threshold (or possibly before, depending on other factors such as the cost of energy), users start conserving water to the point that health benefits are lost.

Additionally, community members often prefer non-treated sources because of factors such as color, taste, and lack of chlorine, and will use these sources for drinking water, even when they could have their water delivered with a haul system. This practice shows the lack of awareness of health threats associated with non-treated water. Therefore, research is needed to better understand how village residents view disease and health to successfully engage users in more sanitary practices.

Based on the interviews we conducted, it is clear that active efforts to incorporate community feedback into the design of utilities were also lacking (with a few notable exceptions). An official mandate to hold public meetings and to gather local input for master planning processes[40] did not come to fruition until the late 1990s. Prior to this, incorporating local input depended heavily on the personality of the engineer assigned to the community. Even today, the amount of community involvement depends largely on the project engineer or superintendent in charge, as well as on the level of engagement of the local community. An example of the engineer/user mismatch: anecdotally, outhouses, in some cases, ended up becoming smokehouses and storage places for outboard motors, as they did not appropriately fit the intended needs of the users. Through these interviews, we have just scratched the surface of the tasks needed for exploring water and sanitation approaches that are culturally appropriate for Alaska Native communities.

Failure to engage local residents with awareness-raising efforts and an active exchange of feedback on project design and community needs may partially explain the lack of ownership of water and sanitation utilities in communities frequently described by interviewees. The fact that systems have been delivered after construction costs were fully covered by federal and state agencies may represent a barrier to nurturing leadership and creating a sense of ownership over local water and sanitation utilities. More recently, utility assistance programs for rural Alaska have begun to use a greater number of locally hired and trained workers for infrastructure projects. Arguably, this allows community members to work on their own systems and thus create a sense of ownership and investment at a local level. However, the ownership process does not appear to take place automatically after such an approach. If local residents are paid for their work to install a system, they will undoubtedly expect payment to maintain and repair the system. Often the financial incentive for a skilled local resident to provide/exchange labor is lacking in small remote villages, partly due to a small customer base and residents' primary reliance on non-cash subsistence activities. Another way to build a sense of ownership of a water system is for the community to apply for and receive government or small "seed money" loans and then provide labor on a voluntary basis to build low-tech systems. Early in the history of the IHS program, the tribe contributed all labor, at no cost, to the sanitation facilities construction projects. However, this tribal in-kind contribution model was discontinued as dictated by evolving US labor laws.

In rural Alaska, provision of water and sanitation has been mainly an agency-driven effort, with Native communities doing little independently. That is not to disregard the great task that communities face in trying to sustain their utilities (operation and maintenance) with little or no government assistance after the infrastructure has been provided. Nevertheless, if communities do not have a stake in the acquisition of their systems, they may have decreased incentive to treat them with the care they require. This problem is observed particularly in communities where water service has been introduced relatively recently. If residents lose service, they are not greatly frustrated because they have been used to living without water for a long time. In the urban setting, however, users feel highly impacted when service is lost.

In allusion to the complexity of this problem, we have learned from the interviewees that the local technical talent pool in rural Alaska is so small that it is difficult, if not impossible, to sufficiently train back-up personnel to operate and maintain systems should the primary operator depart the community. Turnover sometimes occurs because trained water operators can make more money working for the school than for the city or tribe. They, therefore, leave the water plant and take a better paying job in (for instance) school maintenance. A particular social aspect is noteworthy to further understand turnover. In many Native Alaskan cultures,

---

[40] Funds for conducting the master planning process comes from the State of Alaska, the Environmental Protection Agency, and the US Department of Agriculture, not from the Indian Health Service.

"sharing" is an important cultural value. Hence, the "sharing" (the turnover of a position to another member of the community) of a stable paying position is common as it follows cultural norms for sharing resources, which are accessible through filling a particular position. Thus, in certain places, this social aspect results, to some degree, in augmented turnover.

With respect to in-home system problems for users living in small remote villages, repairs are complicated by many factors. It is impossible to simply go to a hardware store to pick up pieces needed for basic repairs of their systems. Not having a large store like "Lowe's," or even a small hardware store in a village is a major problem. Parts are rarely back-stocked for future emergencies. Interviewees also noted that it is rare for a water plant to carry replacement parts that local users can purchase for common repairs. Evidently, the situation is more complicated than simply having users caring little about their systems or lacking the skill or technical capacity required.

As expressed in interviews, it is relevant to note the legacy of utilities in small rural communities. This legacy approach expects costs to be balanced by revenues, a model that is unlikely to be compatible with most Alaska Native communities that have little to no economic basis for such, given their traditional subsistence lifestyle. In Alaska and on all tribal reservations in the contiguous United States, after receiving the infrastructure at no cost, the local entity is responsible for operating and maintaining water and sanitation utilities with its own financial resources. Although many basic services provided in villages are partially subsidized (e.g., internet, electricity, heating, cell phones), there is no direct financial assistance or subsidy for water and sanitation from state or federal agencies. Municipal subsidies are rare exceptions, with only a few villages having a strong enough economic base for such (i.e., the oil-rich North Slope Borough, Bristol Bay fishing communities, or Southeast villages). Public assistance to sustain these critical systems should be reconsidered. Public funds are currently covering great capital costs but exclude a means to protect and ensure returns from these huge investments in infrastructure that are expected to deliver long-term health benefits. From a private investor perspective, it is not advisable to make a multimillion dollar infrastructure investment and then hope it will be properly operated and maintained by local user fees. As pointed out by several interviewees, this is a trait unique to Alaska's funding system for these types of capital projects.[41] By contrast, elsewhere there are small-size communities in the Canadian Yukon Territory where the Territory's government provides a sort of subsidization by paying the person in charge of maintaining and operating lower-tech systems (e.g., a closed haul system).

By not funding the costs of operation and maintenance, the Alaskan approach enables capital projects that are often not cost-effective in the long-term, particularly from a user perspective. For example, when comparing the up front costs for construction of piped systems versus haul systems, the latter is comparatively inexpensive because operational costs (e.g., for haul-vehicle maintenance) were not always accounted for. In several instances noted by interviewees, a few years after the infrastructure was received, the local administration began to realize that the sum of long-term costs for operation and maintenance of these systems was close to surpassing the cost of acquiring a piped system in the first place.

In addition, the expected health improvements from acquiring haul systems have not been documented (See discussion on advantages vs. disadvantages of haul systems on pages 22 and 29). Long-term health benefits of the various systems are not formally considered in the funding evaluation process.

Hence, villages face challenges after receiving high-end systems that they struggle to self-support with local financial resources, an insufficient economic base, and small populations. Service providers/agencies have loosely identified a cut-off point of between 200 and 300 residents to minimally support a community haul system.[42] If at this point, two families or users discontinue service or payment (e.g., if leaving town seasonally for subsistence hunting/gathering), the solvency of the utility is compromised and figures go from positive to negative cash flow.

Per interview responses, water treatment plants that function properly are those that have an experienced, long-term operator. The city of Noorvik, with a vacuum system that was built in the 1970s, represents the hallmark in successful operator-system stories. The local system has been repaired several times, but it has always worked. The community has had two successive

---

[41] The authors wish to note that similar situations do exist, to some extent, on reservations in the (lower-48) United States.

[42] The break-point depends on local climate, per interviewees. Communities on Kodiak Island or Sitka can support systems with smaller populations for this reason. However, western or southwestern communities need approximately 300 residents. Village size and local geography will determine the scale of water service.

high-quality operators, each with roughly 25-year careers, who have played a key role sustaining the operations of their system.

Nevertheless, after training an individual to be the local operator, it cannot be assumed that operations of the water treatment plant will proceed smoothly or be free of operating/technical issues. In 2011, there was a 30% turnover of water treatment plant operators in rural Alaska. In many cases, after receiving training, operators leave for a better-paying position at a mine or a bigger town. One issue is the part-time nature of the work and pay. At the low end of the spectrum, some operators are paid for only 12 hours a week at a rate of $10/hr. The key ingredient for a local system to work is a well-trained, stable, committed operator. Chances to retain operators in the position increase when they are paid a reasonable living wage and are directed by someone with the technical capacity to do so. Being paid on time at a fair pay rate and for an acceptable number of hours factors positively in retention of workers for this village position. In some cases, frozen pipes are deemed tech failures or lead to blaming the operator. However, it must be acknowledged that it cannot fully be the operator's fault if the community lacked the financial resources to pay for his time/services.

Also identified in interviews was a circular argument related to the provision of utilities in villages with limited local economies. Somehow, villages need to access funds to develop a local economy that can support the critical infrastructure the government has given to them; however, absent amenities (such as flush toilets and running water) represent a hindrance to the economic development of villages. Tourism may be an alternative for communities lacking natural resources to develop a local economy (e.g., oil, mining, fishing) or for villages choosing non-extractive industries. Creative entrepreneurs might be able to forge an industry, but they will be challenged to find tourists willing to visit villages that have no running water or decent water and sanitation services—a classic "catch-22" situation. Herein lies the conundrum related to rural development whenever villages are deemed "unsustainable." To exemplify this point, Emmonak, a coastal community in western Alaska, saw the construction of its first hotels and an increase in its local fishing base after the village received water and sanitation systems and an airline set it as one of its hubs. These events would not have happened if the community continued to haul honeybuckets.

Sustained operation of utilities is further compromised by lacking, or underfunded, technical support programs. Communities with piped systems can seek support from remote maintenance workers (RMWs, ADEC program) or circuit riders (Tanana Chiefs Conference program). However, villages with closed-haul systems are limited with respect to this assistance as RMWs cannot repair "in home" problems, which is where the majority of haul infrastructure is located. RMWs, on the other hand, are overloaded with work and are spread out too thin. In some instances, one RMW is assigned to as many as 15 communities. The RMW program faces current and future funding challenges. As a result, their responses largely address emergencies or catastrophic breakdowns that could be avoided if RMW staff were able to more effectively conduct preventative visits to local operators/systems.

On the other hand, agencies and service providers are challenged by revolving leadership in villages. Interviewees noted what was termed a "spark-plug syndrome." Often, in remarkably small villages, one or two residents carry the institutional knowledge necessary to keep the town afloat. When these individuals leave the position/the village, communities fall into disarray. It is difficult to find an individual willing to step in or a person with the required leadership and organizational skills. Not consistently having a knowledgeable person filling key positions is detrimental to the management of village water and sanitation systems.

The Future/Ways Forward

So what can be done?

Learning from past mistakes is a first step.

In today's funding atmosphere, money is short and need is high. Innovative technologies may be a partial solution to this problem. In this case it may not be *new* inventions that are needed. Instead, *new application* of tried-and-true technologies so that they function well in Arctic and sub-Arctic settings holds promise. An example of this is application of gray water recycling technologies to in-home systems in rural Alaska. To flush a toilet with water previously used during showering or while washing clothes not only saves on the amount of delivered water used (and charged for) but also decreases the amount of wastewater that needs to be hauled away from the home. Low-flow fixtures are another technology widely used in arid regions of the United States, but not extensively employed in Alaska. Investigation into their use and the behaviors surrounding their use is needed. Low-flow fixtures must allow for adequate hand washing and the related improvement in health outcomes.

The State of Alaska is currently promoting an effort to encourage this type of innovation. "The Alaska Water and Sewer Challenge" (http://dec.alaska.gov/water/watersewerchallenge/index.html) is a request for proposals (RFP) intended to spur worldwide research to develop innovative and cost-effective water and sewer systems for individual homes in remote Alaska villages. This endeavor focuses on decentralized water and wastewater treatment, and water recycling with the ultimate goals being a decrease in capital and user costs of in-home running water and sewer in rural Alaska homes and improvements in health outcomes through access to adequate water quality and quantity.

It is also worth noting that, presently, the ADEC is doing a review of preventative maintenance practices—the RMW program has agreed to work with the communities to ensure that villages have current preventative maintenance plans. Additionally, efforts are underway to make it possible to incorporate a "score" that takes into account the communities' preventative maintenance efforts when qualifying for capital improvements funding.

Innovation can also mean funding operation and maintenance of systems in new ways. During the 1990s, the State of Alaska funded a proposal called the Local Utilities Matching Program (LUMP). While achieving what may be considered the #1 worst acronym in the field, it also made significant advances in rural water and sewer management. In the case of LUMP, a $480,000 State appropriation was used to match residential user fees dollar-for-dollar. It was capped at $10,000 per village, per quarter. This program encouraged communities to collect user fees, which increased during the program; promoted trained operator retention, which is a huge problem in rural areas; reduced non-compliance enforcement costs by upping compliance to a startling 100%; and facilitated preventative maintenance programs—a critical need and a great topic for future discussion. So what happened? LUMP was considered successful but the money ran out and the communities lost all progress made under the program. The Alaska Rural Water and Sanitation Workgroup is currently evaluating parts of this pilot program for potential revitalization.

There are a variety of entities in the state working toward improving health outcomes in rural Alaska by providing and improving water services in villages. The US Arctic Research Commission (USARC) is coordinating these groups so that this work is maximally efficient and ideas can be shared across federal, state, tribal, academic and other private and nonprofit groups. The USARC-coordinated Alaska Rural Water and Sanitation Working Group's efforts are directly applicable to the USARC's priority goal of Arctic Human Health. Especially important is the interface between health, engineering, and Alaska Native groups knowledgeable about sociobehavioral practices in their communities. The integration of these ideas allows research on subjects such as hand washing to be more successfully incorporated into planning for new water systems. The workgroup hopes that greater human health improvements can be made more rapidly through this partnering effort.

Please visit our website at **http://www.arctic.gov/water-san** for more information and updates on working group activity.

Appendix A. Interview Questions

1. General info: Name, dates of service to village.

2. Name pilot program(s) that you have been involved in (focus on decentralized systems?)

3. For each program, please respond to the following questions:

    a. Describe the project (in general)

    b. Are you aware of the cost associated with constructing the project (if so, list)?

    c. Are you aware of the homeowner's cost associated with operating the system (if so, list)?

    d. Are you aware of the cost to the utility associated with operating the system (if so, list)?

    e. Benefits conferred by the system (check those that apply)"
        a. In home efficient water/wastewater management
        b. In home water treatment
        c. In home hygiene
        d. In home laundry facilities
        e. Reduced contact with human waste
        f. Other

    f. Please list the deficiencies and limitations identified during pilot testing'
        a. Cannot be left in an unheated house and then resume operations
        b. Operational requirements exceeded local knowledge
        c. Operational costs were prohibitive
        d. Other

    g. Were community needs considered in the inception of this project?

    h. Did you receive community feedback on the effectiveness of the project? (if so, elaborate)

    i. Was energy efficiency considered in the inception of this project?

    j. Was the project successful?
        a. If yes, why?
        b. If no, why did it fail?

Disclaimer: The information presented within this report reflects the views and opinions of those interviewed, not those of the US Arctic Research Commission, the Alaska Rural Water and Sanitation Working Group or any of the organizations affiliated with this working group. The information contained herein is provided as a public service with the understanding that the USARC makes no warranties, either expressed or implied, concerning the accuracy, completeness, reliability, or suitability of the information. USARC Web pages and this report do not endorse any commercial providers or their products.

UNITED STATES ARCTIC RESEARCH COMMISSION

WWW.ARCTIC.GOV

VIRGINIA (WASHINGTON, DC) OFFICE
4350 N. Fairfax Drive, Suite 510
Arlington, Virginia 22203
T-703.525.0111
F-703.525.0114
E-mail: info@arctic.gov

ALASKA OFFICE
420 L Street, Suite 315
Anchorage, Alaska 99501
T-907.271.4577 or 907.271.4576
F-907.271.4578
E-mail: info@arctic.gov

Printed in the United States of America
March 2015