Development of the Flush Tank and Haul™ System
A Case Study

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INTRODUCTION

The climatic and physical conditions in many Arctic communities in the Canadian North and in Alaska are so severe that conventional piped water and sewerage are not feasible. In particular, permafrost conditions preclude simply burying the water and sewer pipes below the frost line. Similarly, septic tanks with leach field disposal of liquid do not function well in permafrost conditions. Piped water and sewage systems can be built, however the cost of construction as well as ongoing operation and maintenance are often too expensive, particularly for small, remote communities. In some other cases, factors such as ground conditions (rock, muskeg, etc.), remoteness and size of the community are such that piped water and sewers are not feasible. Generally, very small and remote communities find it difficult to support piped systems.

The Flush Tank and Haul™ system described in this paper is one of several technologies developed with the objective of providing improved water supply and wastewater disposal service to residents who live in the situations described above. Cowater has developed this system in Alaska since 1990, including the management tools and support required to make it successful.

OVERVIEW (BACKGROUND)

In many Northern communities there are no modern water and sanitation services in homes. Normally the "honeybucket" is used to collect and dispose of human waste. Typically, the honeybucket is lined with a plastic bag and when the bucket is full it is carried by hand to a sewage disposal site that might be a sewage bunker, a sewage lagoon, a honeybucket haul wagon, or the ground somewhere surrounding the home. Because the honeybucket is open, subject to spillage and often carried by children to the dumpsite, it is inherently a health hazard as it exposes people to direct contact with sewage wastes. Fresh water for drinking, cooking, bathing and cleaning is carried to the household in buckets or open containers hauled by ATV's or snow machines. The water source may be a local river or a community well or river ice. Rainwater is also collected and used.

Increasingly, Federal and State Authorities in Alaska are committing themselves to developing and funding alternatives to improve water supply and sanitation systems in rural communities. In studies done by the Alaska Department of Environmental Conservation (ADEC) in 1993/94, out of a total of 230 villages, 103 of these (44%) used honeybuckets, pit toilets and privies for human waste disposal. On average, these villages have approximately 50 homes giving a total of some 5,000 homes in Alaska villages where no improved systems are in use at the present time. In a recently completed study done for Cowater, it is estimated that for approximately 2,500 homes it is not feasible to construct piped water and sewer systems. This then represents the market to which the Flush Tank and Haul ™ system is directed.

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Cowater International Inc. is an international development consulting firm which specialized in community-based, low-cost water supply and sanitation. Since the late 1980s Cowater together with Manus Coffey Associates of Ireland have been developing a patented water and sewage haul system that uses all-terrain vehicles (ATV) and snow machines to pull small water and sewage haul tanks mounted on trailers or sleds. At the home fresh water is stored in an inside tank and sewage is collected and stored in a sewage holding tank. Because of the small size of the haul tanks it is mandatory that the in-house systems use low water-use fixtures, especially the toilet and that the residents use water sparingly in order to keep haul costs within reason. These habits come naturally to residents of these villages who are accustomed to hand carrying water and sewage.

TECHNICAL DEVELOPMENT OF THE FLUSH TANK AND HAUL™ SYSTEM

Initial Studies and the Bladder Systems 1989 to 1992

In the mid-1980s Cowater experimented with methods to provide sanitary collection and disposal of sewage in the homes of Canadian native peoples who lived in remote and small Northern communities. Cowater developed and tested a Flexible Sewage Tank that could be mounted under the floor of a home to collect sewage. The bag was made of a flexible (butyl rubber) material so that it could withstand being frozen solid when and if the home was left vacant during the winter.

Cowater was contacted in 1989 by Village Safe Water in Anchorage and invited to submit a proposal to the City of Mekoryuk for development of a sanitation system for the village. At the same time Manus Coffey Associates Ltd. (MCA) were also invited and Cowater and MCA teamed up to carry out a feasibility study as well as subsequent development work. The Study recommended the construction of the first Flush Tank and Haul ™ system prototype as shown in Figure 1.

The sewage tank consists of a rubber bag set in a wooden box inside the bathroom. A low water use toilet is mounted on the box platform. Water for flushing the toilet is greywater collected under the hand basin and is manually pumped to flush the toilet. Evacuation of the sewage bag is achieved by pressurizing the interior of the bad with a low pressure air blower which expels the sewage up the discharge pipe and out through the wall of the house and into a closed sewage haul tank. The tank is then hauled by ATV or snow machine to the sewage lagoon for dumping. Depending on the size of the household and the wastes disposed of in the tank, the 90 gallon tank would have a holding capacity of from one week to two months. The reuse of greywater from the hand basin for toilet flushing would reduce the total water used.

The study was carried out with a great deal of consultation with the community including public meetings, household visits and surveys and meeting with council.

The Bladder Systems. Following the approval of the feasibility study report five bladder systems were fabricated and installed. The first test unit was installed in the City Office in August 1990 and after successful operation four additional units were installed in private homes in November 1991. The City Office was relocated to the Reindeer Processing Plant in 1992 where it is used intermittently when required. The units were installed by local labor, supervised by the Consultant. All materials and equipment was purchased in advance and transported to the village by air. Training of homeowners, haul operators and City administrative staff was provided by the Consultants. The four household units are still in continuous use by the homeowners.

Evaluation of the Bladder Systems. The demonstrative bladder systems were evaluated in February and again in July of 1992 by the Consultants. By this time numerous technical, social and managerial issues were identified with these units as follows:

- Odors and burping. There was a residual "toilet" smell in the bathrooms and the toilets "burp" when flushed. Recommend placing future sewage holding tanks outside and/or improving sanitation and venting.
- Tanks too high and too big. Recommend placing future tanks outside.
- Operator in house. Operator must enter bathroom to evacuate. Recommend placing tanks outside and designing all functions to be done from outside.
- No full indicator. Recommend future tanks incorporate full indicator.
- Greywater use is unsanitary and smelly. Recommend to use fresh water for toilet flushing and provide a hand basin connected to the system.
- Haul tank problems. The converted honeybucket haul tank was unsuitable. Recommend a new haul tank be developed.
- Water supply system. Recommend that a water haul system be provided including a pressure pump thereby eliminating manual pumping.
- Operation and administration. Recommend that the operator's status be raised with pay increase, clothes, availability of ATV and snow machine and further training of homeowners and City administration staff.

Subsequent Phases 1992 to 1996

The evaluation of the bladder tank systems in 1992 was a turning point in the development of the Flush Tank and Haul ™ system. During the four years from 1992 to 1996 Cowater installed 89 additional units following the new design. A total of 95 units in five villages are now in service, including the original bladder units.

Mekoryuk. A two unit project with outside tanks was installed in 1993 followed by a 23 unit project in 1995. Mekoryuk now has a total of 30 units operating including the original bladder systems.

Napakiak. A total of 39 units were installed in several phases. Other work included construction of a new sewage lagoon and improvement of roads for haul tank operation. A Facility Plan for the whole village was prepared and administration strengthened.

Tununak. Four units were installed in 1994. More units are scheduled.

Public Health Service Yard, Anchorage. In 1995 a transfer tank unit was designed and built for demonstration. This system services buildings built low to the ground.

Nunapitchuk. Six units were installed in 1995 including three transfer tank systems. The work included a social survey, a disposal study and an overall plan.

Nightmute. Four units were installed in 1995 followed by nine units which are presently being installed in new prefabricated homes.

Newtok. One unit demonstration project installed in the Health Clinic in 1996.

Features of the Present System

The latest designs are illustrated in the Figures 2 through 6.

Gravity System. Figure 2 shows a cross section of the gravity system illustrating the super insulated outside holding tank connected to the household plumbing by the sewage discharge pipe. Rubber couplers are used on the discharge pipe to provide some flexibility for differential movement. Heat tape is placed on the pipe as well as around the holding tank to assist in

preventing freezing. The valve shown on the discharge pipe must be closed before evacuation of the tank by blowing air into the air fitting. An outside sewage tank is shown in Figure 3. Note the tie-down cables to prevent movement during flooding or accidental impact. Figure 4 shows a tank being evacuated. Note the sewage hose and air blower hose connected to the tank. After filling, the sewage tank is hauled to the lagoon for dumping.

Transfer Tank System. This is shown in Figure 5 and is designed for buildings too low for the gravity system. In this case the sewage is first collected in a small transfer tank in the platform beneath the toilet. It is transferred to the outside tank by a suction induced by a vacuum blower which is turned on when the transfer tank is full. In this case two valves must be closed before pressurizing the holding tank for evacuation.

Toilet. In all recent installations we have used the Inax one pint per flush toilet. This is a very robust toilet made in Japan and used widely in that country.

Water System. Water is collected from a public watering point (well or washeteria) in a 100 gallon haul tank. At the home it is "pumped" into the inside storage tank by pressurizing the tank with a blower. Many homeowners self-haul water in the traditional manner and fill the storage tank manually. Inside the home a small demand pump delivers water to the connected fixtures. How water heaters are installed where requested.

Fixtures Connected. In all cases the toilet and hand basin are connected. Where existing plumbing exists the kitchen and bath/shower are connected. In older homes without plumbing connections for the kitchen and installation of bath/shower are at the homeowners discretion.

Service Levels

Reasonably accurate records on haul frequencies and sewage generated for the Napakiak project and the Mekoyruk project have now been collected. These results are shown in Table 1. These are average results and include very different household sizes as well as different service levels in homes. Two major points to be noted are:

- The average sewage generated per day is very low at 1.2 and 1.4 gallons per person per day for Napakiak and Mekoryuk respectively. This compares with the design figure of 3.0 gallons per person per day.
- Water haul frequency is lower than sewage haul indicating that people frequently self-hauled water. This was much more pronounced in Mekoryuk and Napakiak and may be because the water quality of Mekoryuk City water was poor and people preferred river water.