by Timothy D. Buzzell

Community Resource Evaluation in Sewage Treatment Plant Selection

Northern communities need to evaluate what type of waste treatment plant is best suited to their individual needs. Operationally complex plants might produce excellent quality effluent, but without trained personnel, they may be no better than less expensive processes that require little or no operational supervision.

In the past, few people and rustic living conditions in arctic regions made outhouses a practical method of treating and disposing wastes. This situation has changed somewhat in recent years. People who were nomadic only a few years ago are today settled and concentrated in villages throughout the Arctic. These people are now demanding, and rightfully so, the modern conveniences that the rest of this country take for granted. These conveniences include running water, and with it, water carriage of wastes.

However, the wastewater treatment problem becomes greatly magnified once a water supply is available, since waste volume can increase tenfold. Several tangible considerations should be addressed when determining the type of treatment necessary for a given situation, whether it be a single family dwelling or a large modern community. A list of these tangibles may include: (1) the quantity and characteristics of the wastewater to be treated, (2) the susceptibility of the receiving body to environmental damage, (3) the discharge requirements of the various state and federal agencies involved with issuing permits, and (4) the availability and condition of land for receiving a treatment unit.

These have been extensively documented elsewhere. The purpose here is to treat a pair of very important — though frequently overlooked — intangible considerations. These are the ability of a community to fund construction and operation of its chosen treatment process, and the availability of competent, trained personnel in that community to correctly operate the system.

Money May Not Matter

Examples of short-sightedness regarding these two intangibles are numerous. In 1970, for example, the Environmental Protection Agency (EPA) launched an Arctic Native Village Demonstration Project, which established highly sophisticated water and wastewater facilities in the Alaskan communities of Wainwright and Emmonak (see "Village Sanitation," Vol. 4, no. 1 — TNE). Services included showers, laundries, saunas, toilets, and solid waste disposal, all of which were enclosed in one building. Emphasis was placed on recycling of wastes, which required a very complex system of wastewater renovation, solid waste incineration, and so forth. The best technology of the day, with all its massive costs borne by the federal government, was made available to the two villages. The system at Emmonak, however, has for the most part failed. The Wainwright venture, after a brief success, was destroyed by a fire.

To date, the gathered data is vague on why the Emmonak system did not perform well. Perhaps there were design errors involved. More likely, the operators were not able to deal with such a complicated piece of machinery, and realistic results fell far below theoretical expectations. The same may be said about

Wainwright. It is not clear what caused the facility to burn down, but it was due either to an unforeseen design deficiency or to operator incompetence. The result is the same — a million dollar piece of machinery for treating the wastes of 100 to 200 people lasted about one year. The end results of these two demonstrations should be weighed carefully before such grandiose approaches to facilities engineering are taken for the other two hundred native villages in Alaska.

In the future, it may be better to employ treatment facilities such as facultative ponds or aerated lagoons. These, of course, could only be used if the bodies of water which receive effluent could provide a sufficient dilution factor to the discharged wastes. Although the end effluent product of ponds or lagoons may be below what might be achieved with more sophisticated systems, at least it would be predictable and would require little in the way of capital or operational expenditures.

However, there are instances where a sufficient dilution factor cannot be achieved to allow use of ponds or lagoons, and a more efficient treatment form is required. This is the case with most of the northern construction camps along the Alaska oil pipeline route. Many camps are built on the arctic tundra which has little surface water for dilution. Yet significant concentrations of people are, or will be, living in these camps and producing wastes.

Early on, regulatory agencies decided these camps should achieve a high degree of treatment of their wastewaters. The camp owners, quite capable financially of providing the necessary sophisticated equipment, assumed that competent camp personnel could be trained as operators. The camps were provided with extended aeration systems, physical-chemical treatment systems, or a combination of the two. But something went awry. Initial results from these complex and expensive treatment plants were poor — much poorer than could be expected from a simple pond or lagoon system. A special consultant was hired to determine the reasons for the failure, and shortly thereafter the answer surfaced. The men selected as plant operators, though generally mechanically competent, had not been adequately trained in plant operation nor impressed with the vital importance of their tasks.

Successes and Reconsiderations

Paradoxically, the example of system failure for the treatment plants along the pipeline can today be cited as an example of growing success. Although the operators had the potential for competency, they were not properly trained and, as a result, treatment efficiency suffered. Thereafter, pressure was brought by the regulatory agencies to upgrade treatment efficiency, and an operator training program for the camps was initiated. While not a certified program, it stresses the importance of good operation. Soon, most plants along the pipeline were achieving an effluent of significantly higher quality, more in line with expectations for the type of systems involved.

The Canadian government has taken a much more simplistic approach to wastewater treatment than the United States. Wherever possible in their native villages, the Canadians have utilized facultative ponds or aerated lagoons, recognizing the financial limitations of the communities and the general unavailability of experienced operational personnel. The Canadians have also recognized the treatment limitations of these systems and made certain that the final point of discharge is into a water body with a sufficient dilution factor to ensure that that body will not be damaged. These systems have been most reliable.

What System Serves Best?

Traditionally in temperate climates, the credentials of plant operators increase with the size of the community, and implicitly, the size of the treatment system. This should be no different in arctic regions. However, one must also consider in these northern areas the type of community served — its financial limitations and availability of trainable operators. This is necessitated by the wide diversification of community cultures and sources of community income. Examples of the two extremes are the small native villages versus the typical construction camps along the oil pipeline route in Alaska.

The native village may depend almost entirely on fishing as its principal income source. Perhaps revenue from this enterprise is marginal; certainly it is not excessive. The stability of a community with as fragile an economic base as this can be severely disrupted if excessive additional financial burdens are imposed on it. This is to say that if the construction costs for a waste treatment facility equal or surpass the total real estate value of the community, the town may be overly burdened financially. Add to this the fact that the community may be essentially void of technological hardware and that the most complex piece of equipment anyone in the town has ever had to deal with is a snow machine, and one quickly realizes that it may be very difficult, if not impossible, to find people competent and capable of dealing with the more sophisticated wastewater treatment systems. Even if these obstacles are overcome, the sheer cost of salaries of the full time operators required for this machinery may be prohibitive.

Contrast this native village with the modern construction camps along the Alaska pipeline route. These camps are owned and operated by industrial giants whose investment in the North Slope oil and the future revenue that they may potentially recognize from that oil is so tremendous as to be incomprehensible. Almost any wastewater treatment system, regardless of cost, that is necessary for one of these camps would be incidental to the total cost of operating the camp. Further, the owners of these camps would much prefer to absorb the additional cost of a dependable treatment unit capable of producing an effluent that will consistently meet governmental discharge requirements than risk being forced to reduce the population, or worse, shut down the camp completely because the treated effluent does not meet discharge criteria.

Also, consider that these camps have a tremendous reservoir of personnel to draw from, men experienced in the operation of machinery who can be trained to competently operate complex treatment systems. While this labor is not cheap (typical operator costs for a 75,000 gpd treatment plant in a 1000 man camp on the North Slope may run $250,000 per year), again, the camp owners are

financially able and willing to meet the requirements set for effluent discharge.

Selecting the Best Process

Several treatment processes capable of producing secondary quality effluent are in common use today. These include in order of increasing complexity, and consequently, increasing initial and operational cost:

(1) Septic systems
(2) Facultative ponds
(3) Aerated lagoons
(4) The extended aeration variation of the activated sludge process
(5) Conventional activated sludge
(6) Physical-chemical treatment.

The septic system as a treatment device has its limitations in arctic and subarctic regions, though it may act under certain conditions as a reliable disposal method for single-family dwellings. Design of these systems is necessarily different from what is found in more temperate climates. Normally, a leach field is placed within two feet of the ground surface to ensure aerobic biological action. This is not possible in the far North as there is not enough heat in the incoming sewage to keep the field from freezing. This has led most builders to follow their septic tanks with a deep dry well rather than a leach field, and hence the emphasis is on disposal rather than treatment. In areas of shallow permafrost, even this disposal effort may be thwarted. Operation of septic tanks themselves differs in these northern areas from those in the temperate regions in that anaerobic decomposition and reduction of sludge is slowed or nonexistent during many months of the year. The tanks must therefore be pumped more frequently — every 2 to 4 years as compared to 7 to 10 years in more favorable climates.

The facultative pond usually consists simply of a reservoir of sufficient capacity to allow the necessary natural biological action required to stabilize the organic fraction of the waste before it enters and damages the receiving body. No mechanical devices are involved. Air is provided by surface diffusion and through the action of the algal population. This process is therefore relatively simple to maintain and operate. Reduction of the biochemical oxygen demand (BOD) during certain periods of the year may approach 80 to 90 per cent. The fact that it is not always possible to construct large impermeable ponds, especially in permafrost areas, reduces the feasibility of facultative ponds for some locations. Also, the process is criticized for its inefficiency during certain periods of the year. Biochemical oxygen demand reduction suffers during the winter months in northern areas, and algal production during the summer can produce an effluent high in suspended solids.

An aerated lagoon is the logical extension of the facultative lagoon process. External air is mechanically supplied to a pond or series of ponds, thus reducing the pond surface area required for oxygenation, and hence reducing the pond size requirements over the facultative pond considerably. This treatment device requires very little operational time or skill, but, like the facultative pond, effluent quality suffers during certain periods of the year.

The extended aeration process is perhaps the simplest "hardware" type treatment technology. Here, a mixture of influent wastewater and highly concentrated populations of microorganisms are mechanically aerated in either an oval ditch (oxidation ditch) or a tank for 18 to 24 hours. This is followed by a settling phase, during which these microorganisms are separated from the treated effluent and returned to the aeration tank to act as seed organisms for the continuation of the process. The clarified effluent is usually disinfected and then discharged. It is generally accepted engineering practice to encapsulate the smaller of such units (the clarifier — less than 100,000 gpd) in arctic and subarctic regions to prevent freezing. Because of the quiescent conditions, the clarifier is especially susceptible to freezing and even large plants in northern regions encapsulate it. Initial costs of extended aeration units are usually somewhat higher than for aerated lagoons, and operational costs are significantly higher. To produce a quality effluent on a regular basis requires the careful scrutiny of a trained operator.

The conventional activated sludge process, of which extended aeration is a variation, is somewhat more complex. The detention period of the wastewater in the aeration tank is reduced considerably to 2 to 6 hours. This allows for the implementation of much smaller aeration tanks than for a comparable extended aeration unit, but much more sludge is produced, making it necessary to split the return sludge flow from the clarifier. Part of the sludge flow is directed back to the aeration tank and the remainder passes to a point where it receives further treatment. This sludge handling step is what makes the conventional activated sludge process unattractive and expensive for small communities of the North.

Economically, the cutoff point, where extended aeration is no longer competitive with activated sludge, is about one million gallons per day, which represents a population of perhaps 10,000 people. Although the process lends itself to operational manipulation to obtain desired results, it requires highly trained and experienced operators. Operators must also be on duty at all times, rather than for the 2 to 8 hours per day generally required for the simpler processes.

In recent years, a good deal of attention has been given to physical-chemical treatment as a viable wastewater process in northern areas. This has been spurred on by reports that biological systems performed poorly at low liquid temperatures. Physical-chemical treatment generally consists of a coagulation-flocculation stage, usually with alum as a primary coagulant, a polyelectrolyte as a coagulant aid, and lime for pH adjustment. Normally the chemical floc formed by this process is then settled out in a clarifier and the fines are removed as the water passes through a sand filter. The waste then often passes through a column or series of columns containing activated carbon to remove color and the soluble organic fraction. For certain types of wastes, this process can consistently produce a highly polished effluent. However, the disadvantages of the process in cold

Continued on page 41

COMMUNITY RESOURCES
-cont'd. from page 21

regions are numerous. Initial equipment cost is high. The system works best if a consistent quality influent is available, which is not the case in small northern communities. Therefore, large surge tanks must be installed to even out the waste strength. The process normally requires much more operational time and expertise than do the other processes. While no commercial additive is required for biological processes, physical - chemical treatment requires expensive chemicals, especially so when they must be shipped to remote northern areas. Ultimate disposal of the chemical sludges generated by the process can be difficult and costly.

Conclusion

A generalization that applies to the efficiency of these treatment units may be summarized as follows: The simpler the process, the lower the initial cost of the unit will be, the lower the cost of operation will be, and the smaller the operational requirements will be. The more complex the process, the higher the attainable effluent quality will be.

However, what many planners fail to recognize is that while a complex treatment unit may be capable of producing an effluent of excellent quality, it can only be attained consistently when the unit is operated competently. It makes little sense to specify a sophisticated and expensive treatment system for a community where a competent operator is not to be found. The effluent quality from that plant will invariably average out with time to be no better than the quality of the less expensive process that *requires little or no operational supervision*. On the other hand, in the community where capital and competent operational personnel are available, implementation of one of the more complex processes would certainly be likely to produce a high quality effluent on a continued basis.

Mr. Buzzell was a research environmental engineer for the Corps of Engineers Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire for five years. He is presently a project engineer with Dames & Moore in Fairbanks, Alaska.

INTERNATIONAL ASSOCIATION OF HYDRAULIC RESEARCH
COMMITTEE ON ICE PROBLEMS

Ice Symposium

18-21 August 1975
Hanover, New Hampshire

An international symposium on ice problems will be held at Hanover, New Hampshire from the 18th to the 21st of August 1975. The Symposium will be sponsored by the United States Army Cold Regions Research and Engineering Laboratory and will be held on the campus of Dartmouth College. The theme of the Symposium will include:

* Extended season navigation of inland waterways
* Ice jam control
* Effects of sea ice on marine structures

Those participants who would like to contribute a paper must submit an extended abstract of 600 to 800 words, in English, by 15 January 1975. This abstract should outline the content of the paper, detail the conclusions reached, and be of sufficient detail to enable the committee to develop the Symposium program. The extended abstracts will be re-produced and sent to all conference participants before the meeting. The final draft of each paper must be submitted, in English, by 15 July 1975. Papers will be limited to ten pages, including all figures. Sample format, paper size, and illustration requirements will be mailed later.

For more detailed information regarding transportation, housing and registration fees, please write

Mr. G. E. Frankenstein
IAHR Symposium
P. O. Box 282
Hanover, New Hampshire 03755