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PERFORMANCE OF SINGLE FAMILY SEPTIC TANK SYSTEMS IN ALASKA

John L. S. Hickey and David L. Duncan

The rapid increase in population in Anchorage and Fairbanks, Alaska, since 1939 has been accompanied by the installation of a large number of individual sewage disposal systems, chiefly septic tank systems or cesspools. By 1960 health officials became concerned over the indiscriminate use of these systems because of possible pollution of the groundwater strata and because their use encouraged urban sprawl which made planning for eventual public sewerage systems difficult.

The continual pollution of the groundwater is particularly important because of the large number of wells used for private and community water supplies. A water supply survey conducted by the Greater Anchorage Health District in 1962–63 showed coliform contamination in 22 percent of samples from private drilled and driven wells less than 50 ft (15 m) deep (1). The survey report states "in areas where a high water table is prevalent, and individual sewage disposal systems utilized, the rate of contamination is extremely high, especially in the shallow and dug wells. We attribute this to the fact that in many instances, the water supply is being pumped from the same area as that of sewage discharge." The survey also showed that coliform contamination has been detected in some private and semipublic drilled wells more than 150 ft (45 m) deep.

In 1961 the Arctic Health Research Center began a study of individual premise waste disposal systems in the Anchorage and Fairbanks areas with the following objectives: (*a*) to determine the characteristics and construction of the septic tank systems in use; (*b*) to determine the life span of the systems and, in the case of failures, to determine the cause as a basis for improving design; (*c*) to determine whether a septic tank system provides effective treatment in the temperature ranges encountered.

Description of Study Areas

Anchorage and Fairbanks represent a sub-arctic area and and arctic area. Anchorage has no permafrost, and Fairbanks is in a region of discontinuous permafrost (Figure 1). The rapid growth of these two cities, Alaska's largest, has been accompanied by the growth of large suburban populations around each of them. The city of Anchorage proper covers 15 square miles (39 sq km) and its suburban population is dispersed over approximately 35 square miles (91 sq km). The city of Fairbanks covers 4 square miles (10.4 sq km) with the suburban population distributed unevenly within a 5-mile (8-km) radius. Both cities have municipal sanitary sewer systems; however, they generally serve only the population within the city limits.

Table I shows the number of housing units in Anchorage and Fairbanks which were served by individual wells and sewage disposal systems in 1960. Most homes within the city limits are

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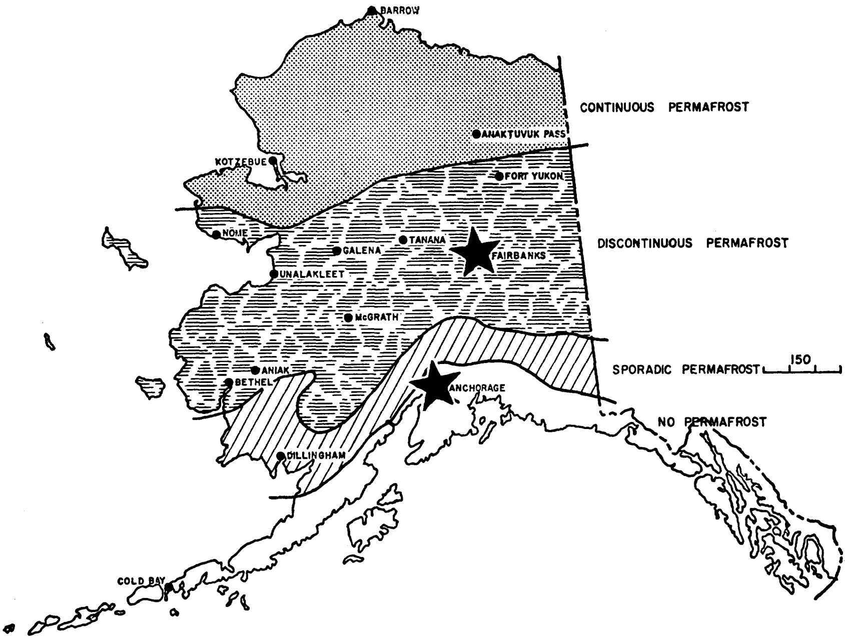

FIGURE 1.—Distribution of permafrost in Alaska.

connected to the sewer systems. Beyond the city limits, however, relatively few homes have access to a sewer system and most homes use individual disposal systems, as indicated by the figures in Table I for Spenard, a suburb of Anchorage. The individual premise disposal systems included in this study are located in residential areas just outside the two cities.

Procedures

In order to insure the validity of the data, the study covered only those systems on which accurate structural data could be obtained. This restricted the study to those disposal systems in residences built through FHA-insured loans, since these were the only houses on which construction details of the disposal systems were available readily. Therefore, only those systems which had been approved by the local health authorities were included since such approval is a prerequisite for FHA-insured loans. Thus, each of the systems studied had been designed in accordance with the FHA Minimum Property Standards current at the time of construction (2) (3).

The study was divided into four parts. First, the FHA applications on file at the local health departments were surveyed to obtain complete information on the systems to be studied.

TABLE I.—Individual Wells and Sewage Disposal Systems in Anchorage and Fairbanks Areas—1960

Parameter	Anchorage	Fairbanks	Spenard*
Population	44,237	13,311	9,074
Housing units	14,538	4,832	2,941
Housing units with individual wells	2,712	1,805	1,438
Housing units with septic tank or cesspool	4,131	658	2,833

* Spenard is a suburb of Anchorage.

Then a selected number of the occupants of the homes in which the systems were installed were interviewed in order to obtain a history of the operation of the system and the causes or symptoms of any failures. The third step was to place temperature-sensing elements at selected points in several systems to determine the actual temperatures of the contents of the septic tanks and secondary treatment units. The fourth step was to perform laboratory studies on the effectiveness of treatment in septic tanks at very low temperatures in order to interpret the results of step three.

Characteristics of Existing Septic Tank Systems

Information was obtained on 1,986 FHA-approved septic tank systems in the Anchorage area and 123 in the Fairbanks area which were installed between 1951 and 1961. Table II correlates the size of tank to the number of bedrooms in the residence and compares these figures to FHA standards. Generally the median sizes of the tanks conform to FHA Minimum Standards current at the time of installation (2) (3), although there are some undersized tanks in most categories. Table II does not include 125 tanks on which the sizes were unknown.

Ninety-five percent of the septic tanks are steel or concrete. Steel tanks predominate, probably because of less weight and lower cost.

Two types of secondary absorption systems are used commonly in Alaska: the conventional drain field and the seepage pit. Seepage pits usually are constructed of logs, as shown in Figure 2, although occasionally they may be built from cement block or rough cut lumber. The roof of the framework ordinarily is covered with roofing paper, and the pit is backfilled and covered with earth. Seepage pits depend on absorption of fluid through the perimeter walls for disposal of septic tank effluent. In the 2,109 systems surveyed, 2,014 had seepage pits for secondary absorption, 88 had drain fields, and on 7 the type of secondary treatment was unknown.

TABLE II.—Size of Septic Tanks vs. Number of Bedrooms Compared to FHA Standards (2) (3)

Parameter	Number of Bedrooms				
	1	2	3	4	5
Anchorage					
Number of homes in group	18	1,144	652	45	7
Size of septic tank (gal)					
Median	500	500	640	750	1,000
Minimum	500	440	470	500	750
Fairbanks					
Number of homes in group	6	46	55	9	2
Size of septic tank (gal)					
Median	825	750	900	1,000	—
Minimum	500	500	500	500	—
FHA Requirements					
Size of septic tank (gal)					
1952–1958*	500	500	600	750	900
After 1958†	750	750	900	1,000	1,250

* 50-percent increase required with garbage grinder.

† No increase required for dishwasher, automatic washer, or garbage grinder.

Note: Gal × 3.79 = l.

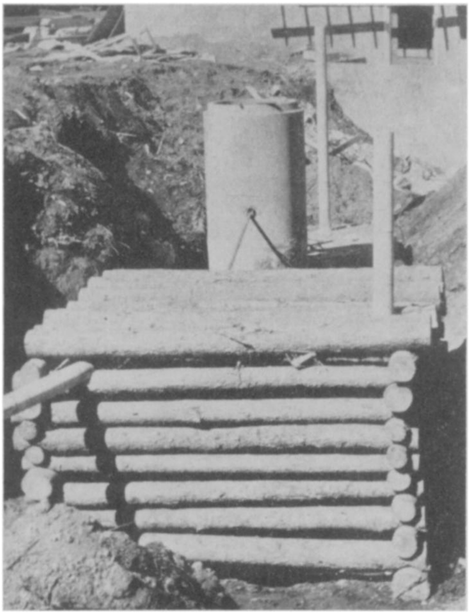

FIGURE 2.—Log seepage pit during construction at Anchorage.

Private Wells

The use of septic tank absorption systems in these areas assumes a greater significance when one considers the large number of homes in both groups which use private shallow wells on the premises as their water supply.

Private water supplies were used by 513 of the homes in the Anchorage group. Records were available for 483 of these. There were 298 drilled wells which ranged in depths from 17 to 436 ft (5.1 to 131 m) with a median depth of 110 ft (33 m). These were generally 6-in. (15.2-cm) diam wells. The remaining 185 wells were bored, dug, or driven wells of which 111 were 20 to 30 ft (6 to 9 m) deep and 17 were less than 20 ft (6 m) deep.

In Fairbanks all but one of the homes studied had a private well, and records were available for 112 of these. There were 21 drilled wells ranging in depth from 17 to 189 ft (5.1 to 57 m) with a median depth of 76 ft (23 m), and 91 driven wells ranging in depth from 18 to 226 ft (5.4 to 68 m) with a median depth of 37 ft (11 m). Of these, 33 were 20 to 30 ft (6 to 9 m) deep and 3 were less than 20 ft (6 m) deep.

Performance of Septic Tank Systems

In this phase of the project, occupants of 57 of the homes in the Fairbanks group and 152 in the Anchorage group were interviewed at length to determine what problems, if any, they had had with their septic tank systems. Adequate information was obtained on 46 homes in Fairbanks and 127 in Anchorage; of these, 23 of the Fairbanks homes and 44 of the Anchorage homes had experienced problems with their sewerage systems. The homes ranged in age from 1 to 10 yr.

The interviews were designed to reveal the cause of failure of the systems. The symptoms reported by the occupants are summarized in Table III. The cases reported include only those instances in which the trouble was believed to be in the disposal system and in which the occupant had taken some corrective action. For example, where occupants complained of "sluggish fixture draining" but had taken no corrective action, the disposal systems were considered to be functioning

TABLE III.—Causes or Symptoms of Septic-Tank System Failures as Reported by Occupant

Cause or Symptom of Malfunction	Fairbanks	Anchorage
Ponding or overflow at secondary absorption unit	5	13
Sluggish draining or backing up of sewage in lines	13	26
Cave-in of seepage pit	4	1
Broken or frozen sewer pipes	1	2
Septic tank failure indicated	0	2
Total malfunctions	23	44
Total interviews	46	127
Homes reporting malfunctions (%)	50	35

properly, since such symptoms could be the result of improper interior drainage or venting.

The main source of trouble was in the secondary absorption systems. Although four of the Fairbanks secondary systems failed by structural collapse, most of the other problems were due essentially to failure of the ground to absorb the septic tank effluent.

The interviews also were designed to secure data from which the survival rate of the systems could be determined. The mortality-type survival curve, shown in Figure 3, relates the number of satisfactorily performing systems to the age of the system. The curves show that in Anchorage, 50 percent of the systems survived about 10 yr without malfunction, while in Fairbanks, 50 percent survived 6.5 yr without malfunction.

The curves in Figure 3 include only systems with seepage pits as secondary units and in which failure was attributed to non-absorption of effluent in the secondary unit, i.e., cases of septic tank failures, structural collapses, and drain fields were omitted. This permits a direct comparison with similar studies on seepage pits. Figure 3 compares the Anchorage and Fairbanks groups to survival rates of seepage pit systems in California and Kentucky. Seepage pit performance in Anchorage is in the range generally observed in other areas, and the performance in Fairbanks is somewhat poorer.

The most significant feature of the comparison is the high rate of early failure in both Anchorage and Fairbanks as compared to the other areas. This characteristic is generally symptomatic of defects in design and construction.

The failures were investigated further by comparing characteristics of households in which the systems failed

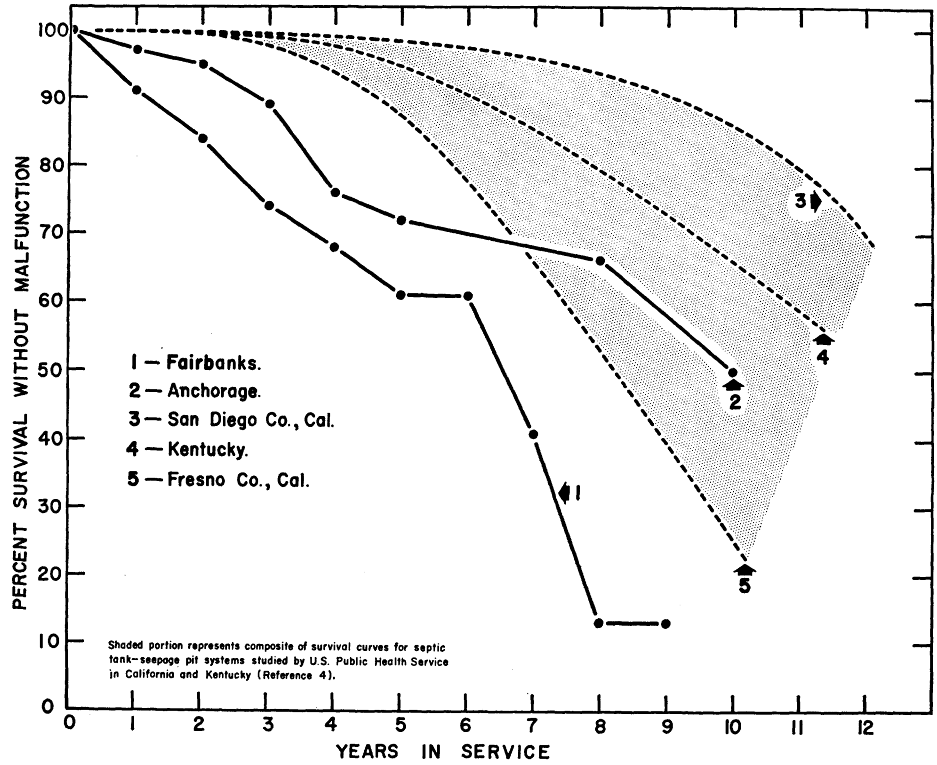

FIGURE 3.—Rate of survival without malfunction of septic-tank seepage pit systems.

TABLE IV.—Comparison of Failed and Non-Failed Septic Tank-Seepage Pit Systems, Anchorage–Fairbanks

Average Values for Systems	Fairbanks		Anchorage	
	Did Fail	Did Not Fail	Did Fail	Did Not Fail
Dwelling				
No. of bedrooms	3.0	3.0	3.0	2.7
No. of persons	4.7	4.1	5.3	4.5
Septic Tank Capacity				
Total (gal)	768	842	718	766
Capacity/person (gal)	164	206	136	171
Seepage Pits				
Wall area (sq ft)	284	265	176	166
Wall area/person (sq ft)	60	65	33	37
Loads washing/wk	7.4	6.4	10.1	8.8
Age of system (yr)	4.8	3.9	6.9	5.4
Age at first failure (yr)	3.7	—	5.2	—
Number of systems*	14	18	38	82

* Due to lack of information on some systems, they are not included in this tabulation; this accounts for the differences in numbers of systems in Tables III and IV.

Note: Gal × 3.79 = l; sq ft × 0.09 = sq m.

to those in which the systems did not fail. This comparison is made in Table IV. Only systems having seepage pits and on which adequate household information was available are included in Table IV. There were too few drainage fields used by the group interviewed to establish similar data for drainage fields.

Table IV shows that the dwellings which experienced no malfunction of the sewage disposal system had greater septic tank capacity and absorption area per person and fewer loads of wash per week. These differences were small, however, and it is difficult to credit success or failure entirely to these differences, even though they were all in the "correct" direction. For example, the systems which malfunctioned had smaller septic tank capacities per person than the systems which functioned well. It is well established that a significant portion of the septic tank volume is intended to provide for sludge storage, and that excessive accumulation of sludge eventually prevents adequate settling of sewage, thus permitting the passage of solids which tend to clog the absorption unit. In this study, however, the failures occurred at a relatively early age (average of 3.7 yr for Fairbanks and 5.2 yr for Anchorage), so over-accumulation of sludge does not appear to be a dominant factor in these failures.

Although the differences in household characteristics undoubtedly had some effect on the survival rate of the systems, it is the authors' conclusion that design and construction practices were more significant factors.

The objectivity of the data presented in this section deserves some discussion. In some of the interviews, the information obtained was vague, and these cases were discarded generally. This weighted the data somewhat in favor of systems which had no history of failure, as few of these had to be eliminated due to lack of specific information. Most omitted cases involved systems which had experienced problems but on which there was not enough specific information for evaluation. Therefore, the number of systems experiencing malfunction is probably greater than the data indicate.

The collapse of several Fairbanks seepage pits deserves some discussion. Four of the 23 failures, or 17 percent, reported in the Fairbanks group were caused by collapse or cave-in of the seepage pits. The exact causes were not known; that is, whether due to too heavy an overburden, excessive settlement, or actual failure of the roof structure. It is interesting to note, however, that all the pits which failed were installed in 1958–59. Prior to 1960 the FHA permitted log seepage pits in Alaska where acceptable to local health authorities. At that time, there was also no FHA requirement that pits be filled with stone (2). Since 1960, FHA standards specify that pits be filled or lined with coarse stone and that reinforced concrete tops be provided (3).

The collapse of the seepage pits in Fairbanks probably would not have occurred if the pits had been filled with stone. In observations on 136 seepage pits in California, 18 percent of 76 pits which were not backfilled with gravel collapsed, while only 1 percent of 60 filled seepage pits collapsed (4).

An alternate pit design which deserves consideration is to construct the seepage pit as a 16-ft by 1-ft (4.8-m by 0.3-m) trench of the proper depth (for example) rather than as an 8-ft by 8-ft (2.4-m by 2.4-m) crib. Proper design is based on wall absorption area, and the trench would provide the same wall area as the crib. The trench could be excavated with a backhoe quickly and with much less disturbance to the surrounding soil than by the method shown in Figure 2. Backfilling the trench would require only one-fourth as much stone and the log cribbing might be eliminated altogether.

Temperatures in Septic Tank Systems

In this phase of the study, temperatures inside 20 septic tank systems in Anchorage and Fairbanks were measured. Twelve systems were instrumented in Anchorage and 8 in Fairbanks as shown in Figure 4. Readings were taken throughout the winter of 1963–64; these are summarized in Figures 5 and 6. Analyses of these data revealed several interesting facts.

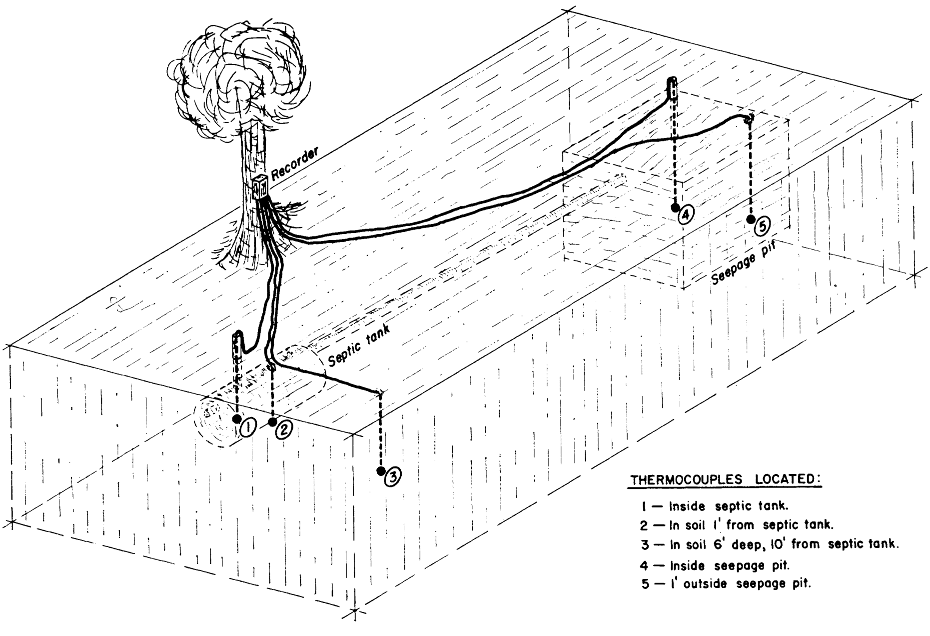

FIGURE 4.—Thermocouple installation.

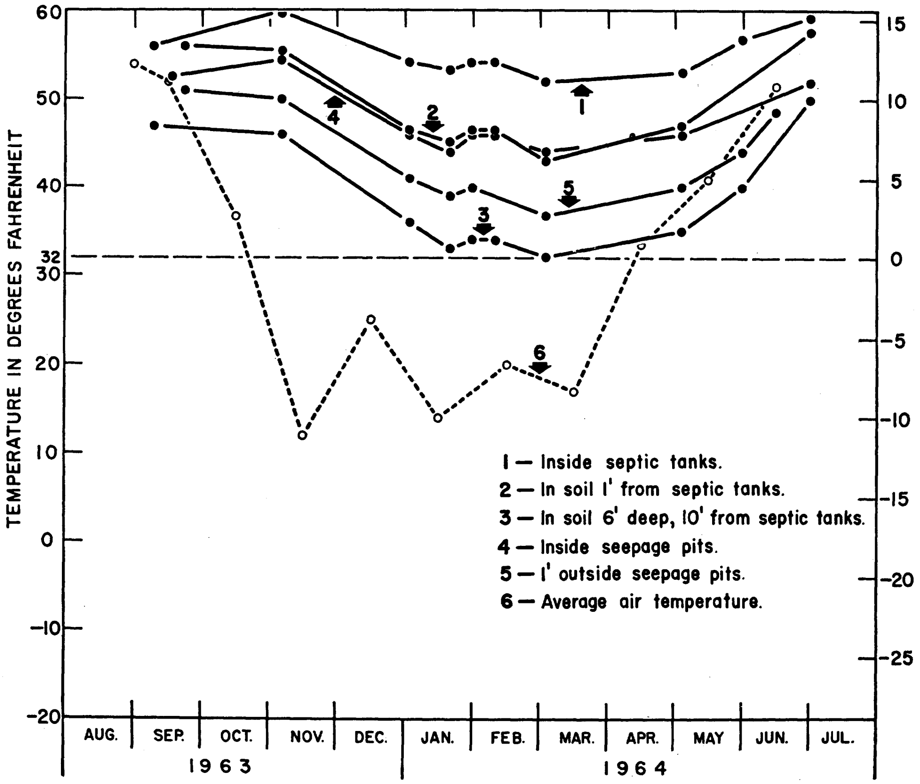

FIGURE 5.—Average temperature in septic tank systems at Anchorage.

The average temperatures of the septic tank contents during the coldest months ranged between 52° and 54°F (11.1° and 12.2°C) for Anchorage and 48° and 50°F (8.9° and 10°C) for Fairbanks. This was true even though the average nearby ground temperature at the same depth remained below 35°F (1.7°C) for several months in both areas.

In Anchorage the concrete tanks apparently provided better insulation than the steel tanks as they were 10.5°F (5.8°C) warmer inside than outside, as opposed to 3.5°F (2.0°C) differential in the steel tanks. The data are summarized in Table V. The concrete walls were generally 4 in. (10.2 cm) thick, compared to 0.25 in. (0.6 cm) thickness for the steel tanks. This temperature difference was not observed among the tanks in the Fairbanks group. The lowest septic tank temperature, 36°F (2.2°C), was recorded in a tank installed 80 ft (24 m) from the dwelling.

In Anchorage the liquid temperature in the seepage pits ranged from 4° to 16°F (2.2° to 9°C) colder than in the septic tanks, with an average difference of 8°F (4.4°C). In Fairbanks, the seepage pit temperatures ranged from 2° to 9°F (1.1° to 5°C) colder than the septic tanks, with an average difference of 6°F (3.3°C). Only two seepage pits reached freezing temperature, one in Anchorage and one in Fairbanks. They reached 31°F (−0.6°C) on two occasions during the year. No apparent difficulties were experienced due to this.

All homes in this phase of the study had pressure water systems and domestic hot water. There is no doubt that the large amounts of relatively warm water contributed to the septic tanks kept the temperatures in the tanks well above that of the surrounding ground.

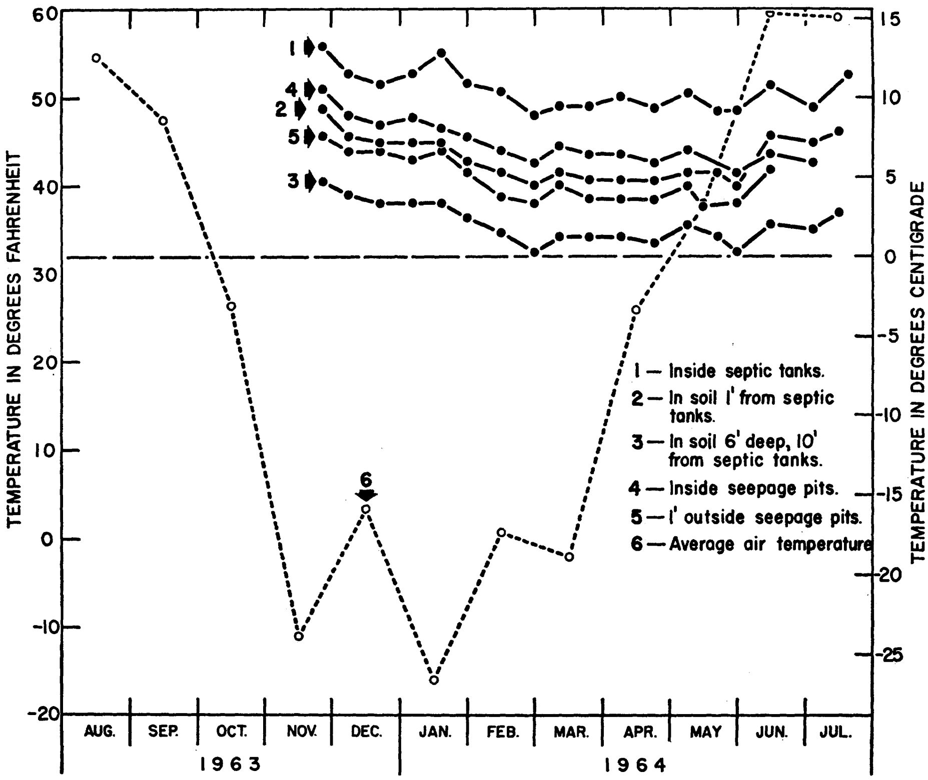

FIGURE 6.—Average temperature in septic tank systems at Fairbanks.

These findings therefore cannot be interpreted to mean that a septic tank would operate properly in a cold climate if it served a home from which it received only small amounts of relatively cold wastewater. In such a situation the tank contents might freeze, particularly if located in a permafrost area.

TABLE V.—Temperature Differential Inside and Outside Septic Tanks Nov. 1963–May 1964

Location	Type of Tank	
	Steel	Concrete
Anchorage		
Number of tanks measured	6	6
Avg. temperature inside tank (°F)	51.3	57.2
Avg. temperature outside tank (°F)	47.8	46.7
Differential		
Average (°F)	3.5	10.5
Range (°F)	0 to 8	−3 to 18
Soil temp. 10 ft from tanks (°F)	35	36.5

Note: (°F—32)0.555 = °C; ft × 0.3 = m.

Treatment Provided by Septic Tanks

Concurrently with the field temperature measurements, laboratory studies were conducted by Washington State University under contract to determine the efficiency of septic tank performance at low temperatures. The following material is excerpted from the final report of this study (5).

The University operated 3 model septic tanks at 59°F (15°C), 40°F (4.4°C), and 33°F (0.6°C) for a period of 20 wk. The models were plastic and each had a capacity of 22.5 gal (85.4 l). Units were covered so that the gas produced could be collected and analyzed. The units were seeded initially with raw sewage from Anchorage.

Five gal (19 l) of raw sewage were fed to each tank daily, resulting in a detention time of 4.5 days. The tanks were fed three times daily; in the morning, at noon, and in the late afternoon. Samples of the effluent from each tank, the accumulated gas, and the raw sewage were analyzed weekly during the 20 wk of operation. Interpretation of data indicated that a steady state of operation was not achieved in the tanks until the seventh week. Data from the last 14 wk were condensed to an average value for each component. Table VI presents these values, which are chemical and physical indices of the degree of treatment accomplished.

The effluents from the 33°- and 40°-F (0.6°- and 4.4°-C) tanks were very similar in all factors tested. The effluent from the 59°-F (15°-C) tank showed similarities to the effluent from the colder tanks in the physical tests, but differed in some of the chemical tests and in the composition of the gas produced. Production of acetic acid was significantly higher in the 59°-F (15°-C) unit, and probably accounts for the lower pH in this unit. Decomposition of organic nitrogen into ammonia nitrogen was somewhat greater in the 59°-F (15°-C) unit. Again, the concentrations of ammonia and organic nitrogen were about the same at the two lower temperatures. Nitrates were absent in all the tank effluents. Trace quantities of nitrites were found at the lower temperatures but were absent in the 59°-F (15°-C) effluent.

The second phase of anaerobic decomposition is that of methane fermentation, with methane (CH_4) and carbon dioxide (CO_2) as the main end-products. The last part of Table VI shows that CO_2 production was greatest in the 59°-F (15°-C) unit, and that CH_4 was produced only in this unit.

These factors (acid and gas production and nitrogen conversion) indicate a higher degree of biological activity in the 59°-F (15°-C) unit. However, the BOD and solids removal are similar for all three tanks.

TABLE VI.—Average Weekly Analyses of Raw Sewage, Accumulated Gas, and Septic-Tank Effluent (Mean ± 95-percent Confidence Limits) (5)

Tests Performed	Effluent from Septic Tank (°F)			Raw Sewage
	59	40	33	
Chemical				
pH	7.26± 0.6	7.75± 0.04	7.62± 0.08	7.87± 0.07
Alkalinity (mg/l as $CaCO_3$)	318.0 ±10.6	308.4 ± 9.7	304.4 ±16.0	279.0 ± 9.5
Conductance (μmhos)	823.0 ±36.5	820.3 ±14.9	808.8 ±31.8	687.0 ± 41.0
BOD (mg/l)	77.6 ± 6.8	83.0 ±17.0	81.5 ±14.1	162.0 ± 25.0
Organic nitrogen (mg/l N)	3.4 ± 0.9	4.9 ± 0.6	5.5 ± 1.2	23.2 ± 4.3
Ammonia nitrogen (mg/l N)	37.0 ± 5.1	31.9 ± 3.9	32.3 ± 3.9	23.8 ± 4.1
Acetic acid (mg/l)	36.4 ±11.2	21.8 ± 6.4	19.5 ± 3.7	6.2 ± 2.6
Propionic acid (mg/l)	3.80± 4.40	2.36± 2.11	1.83± 1.19	1.3 ± 1.1
Butyric acid (mg/l)	0.80± 0.73	0.35± 0.35	0.53± .46	0.50± 0.5
Physical				
Settleable solids (ml/l)	<0.1	<0.1	<0.1	10.9 ± 2.0
Total solids (mg/l)	450.4 ±37.3	455.3 ±46.4	451.2 ±25.0	656.8 ±116.5
Total volatile solids (mg/l)	194.4 ±16.7	183.9 ±28.3	191.5 ±26.2	373.6 ±121.6
Total suspended solids (mg/l)	27.7 ± 6.6	23.2 ± 5.1	29.4 ± 4.5	188.8 ± 57.0
Gas Analysis (%)				
CO_2	2.2 ± 0.3	0.30± 0.01	0.27± 0.05	—
O_2	4.9 ± 1.1	8.9 ± 2.8	5.2 ± 2.2	—
N_2	90.7 ± 1.3	90.6 ± 2.9	95.1 ± 1.8	—
CH_4	2.1 ± 0.7	0	0	—

Note: (°F—32)0.555 = °C.

BOD removal on all 3 tanks is approximately 50 percent. The study attributes 25 percent of this to physical settling at each temperature and the remainder to biological activity.

For all practical purposes, 100 percent of the settleable solids were removed in all three units, and the reductions in volatile, suspended, and total solids were similar in each unit. One of the primary functions of a septic tank is the removal of solids through settling. The septic tanks at all temperatures showed a high degree of efficiency in accomplishing this.

The septic tank also serves as a sludge treatment and storage unit. The sludge was analyzed three times throughout the study. The percent of volatile matter in the sludge was 74.6, 77.4, and 79 percent at temperatures of 59°, 40°, and 33°F (15°, 4.4°, and 0.6°C), respectively. It seems reasonable to presume that the increased biological activity observed in the 59°-F (15°-C) tank reflects more rapid treatment of the sludge, as indicated by the lower volatile solids content of the sludge in this tank. Septic tank temperatures observed in Anchorage and Fairbanks remained above 48°F (8.9°C).

Two parameters were investigated which are of significance in groundwater contamination. They were detergent degradation and coliform reduction. Analysis of the alkyl-benzene-sulfonate content of the influent and effluent of each tank revealed that no degradation occurred in the tanks. The average ABS content of the raw sewage was 3.3 mg/l and that of the effluent, 3.4 mg/l.

The average coliform count of the raw sewage was 24 million per 100 ml. Ninety-seven, 85, and 61 percent reductions were obtained at 59°, 40°, and 33°F (15°, 4.4°, and 0.6°C), respectively. Though these reductions were sizeable, large numbers of coliforms still were present in the tank effluents. The results of the Washington State University laboratory study summarized above may be compared to results of a laboratory study conducted in Cincinnati (6). Removal of solids and BOD in septic tanks is compared in Table VII. Removal of volatile solids and BOD was significantly higher in the Cincinati study. This occurred even though the loading rate in the Cincinnati study was much higher. Several factors may account for this difference. First, in the Cincinnati study, the septic tanks were operated for almost a year, and the high levels of BOD and volatile solids removal were not achieved until after 15-wk operation at summer temperatures. Previous to that time, BOD and solids removal was the same or less than that achieved in the Washington State study.

In the Cincinnati study, the flow rate was reduced during the course of the study from one-day retention to two-day retention. This reduction was accompanied by improvement in BOD and solids removal. The authors at that time attributed the improvement to reduced flow. In later field studies (7), involving 37 septic tanks with flow variations from 30 to 153 gpd (114 to 581 l/day), it was concluded that there was no correlation between water consumption and solids retention in that range. On the basis of this work,

TABLE VII.—Comparison of Solids and BOD Removal in Septic Tanks

Parameter	Removal (%)	
	Washington State University Study (5)	PHS Study, Cincinnati (6)
Total solids	31	31–41
Volatile solids	48–51	59–68
Suspended solids	83–86	68–89 (avg.)
BOD (5 day—20°C)	49–52	70–77
Temperature (°F)	33, 40, 59	40–50
Retention time (days)	4.5	2

Note: (°F—32)0.555 = °C.

the authors felt that the improvement which accompanied flow reduction in the original studies could have been due partly to stabilization of the tank during its initial 10-wk operating period.

The retention time of 4.5 days used in the Washington State study is considered realistic. Assuming an average water use of 40 gpd/cap (152 l/day/cap) (6) and 4.5 persons per home (Table IV), 4.5 days' retention would be provided by a 750-gal (2,850-l) tank, the minimum size now allowed under FHA specifications.

Conclusions

1. On the basis of field and laboratory data from this study, septic tank-soil absorption systems installed according to present FHA standards can be expected to perform satisfactorily over a reasonable life expectancy in the climates of Fairbanks and Anchorage, Alaska.

2. The large amount of heat provided to the septic tank by waste from the residence (primarily because of the domestic hot water system) is believed to be a significant factor in maintaining the disposal system at an operable temperature. Caution should be used in applying this data to a septic tank system which would receive very little warm or hot water.

3. There is evidence from the Washington State University laboratory study that sludge decomposes more slowly at lower temperatures, indicating a need for more frequent cleaning of septic tanks in very cold areas as compared to warm areas. However, in this study, the septic tank temperatures did not go low enough to be considered affected by this factor.

4. The high temperatures found in the septic tanks relative to the surrounding ground indicate that a septic tank placed in permafrost would thaw the ground around the tank. If this ground were not well drained, thawing could result in settling of the tank and rupture of the sewer piping system. The need for proper attention to foundations for septic tanks in permafrost is indicated.

5. A significant cause of failure in the Fairbanks systems studied seems to be inadequate attention to design and construction of the absorption system.

6. Attention should be given to the improvement of design and construction of seepage pits, particularly in the Fairbanks area. One alternate method for obtaining the required wall absorption area in a seepage pit would be to construct the pit as a narrow trench rather than a rectangular pit. The time and materials saving should make this method preferable where soil conditions permit a choice of methods.

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