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Alaska Village Demonstration Projects Final Report

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ALASKA VILLAGE DEMONSTRATION PROJECTS

Final Report

by

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FOREWORD

Effective regulatory and enforcement actions by the Environmental Protection Agency would be virtually impossible without sound scientific data on pollutants and their impact on environmental stability and human health. Responsibility for building this data base has been assigned to EPA's Office of Research and Development and its 15 major field installations, one of which is the Corvallis Environmental Research Laboratory (CERL).

The primary mission of the Corvallis Laboratory is research on the effects of environmental pollutants on terrestrial, freshwater, and marine ecosystems; the behavior, effects and control of pollutants in lakes and streams; and the development of predictive models on the movement of pollutants in the biosphere.

The Corvallis Laboratory also has responsibility for EPA's Cold Climate Research Program. This report summarizes work accomplished in Alaska as a part of the Cold Climate Program which studies the cold climate aspects of all environmental problems including ecological effects, health effects and control technology. The experience gained in the demonstration projects covered by this report should provide guidance to future utility projects in Alaska.

Thomas A. Murphy, Director
Corvallis Environmental Research Laboratory

ABSTRACT

Two demonstration projects were built as authorized by Section 113 of PL 92-500. Modular construction was used to provide central utility systems which included water supply, laundry, bathing, saunas, and wastewater treatment. Service to homes was by vehicular delivery. Fire destroyed the facility at Wainwright in 1973 and the project was subsequently rebuilt. Energy conservation measures were employed to minimize costs of operation. Equipment performed satisfactorily, but operator preparedness was lacking, thus, many breakdowns occurred. Overall cost of operation and maintenance of the facilities was transferred to the local government by the EPA. The AVDP was paralleled by projects built by the Alaska Department of Environmental Conservation (ADEC) at 11 locations. Small communities need outside support for operation and maintenance of utility systems. Time and training will be required to prepare local residents to assume managerial responsibilities for these projects.

This report covers a period from 1970 to 1979 and work was completed as of January 1980.

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SECTION 1

INTRODUCTION

BACKGROUND

The Alaska Village Demonstration Projects (AVDP) established by the U.S. Environmental Protection Agency were intended to demonstrate methods of improving environmental health conditions in rural Alaska. The need for such improvements is great. Seventy percent of Alaska's natives live in small villages where safe drinking water is not readily obtainable and where adequate waste disposal is often impossible without facilities for special treatment. Typical sources of drinking water are streams, shallow lakes, or rain during the summer. Many of these ponds and streams are stagnant and contaminated. In areas underlain by permafrost, wells are generally unproductive. During the winter, villagers cut ice and melt it in clean fuel drums at home.

Simple methods of waste disposal are often not possible because of unfavorable terrain and soil conditions.[1,2] Many villages are subject to annual flooding. Wastes from latrines and dumps re-emerge during flood periods and are spread throughout the town. During the short summer, the stench can be annoying and pervasive. Communities along the Arctic Ocean store domestic waste from "honey buckets" in empty fuel drums some distance from the home. In early spring, the drums are hauled out onto the ocean ice for disposal. The public health hazard associated with this practice is serious.

The difficulties of arriving at practical solutions to water supply and waste disposal problems in such locations are as great as the need. Successful application of many conventional approaches is ruled out by high costs and/or the severe climate. Water is frozen most of the year. The processes by which wastes naturally tend to decompose are interrupted and seriously retarded by the long winters. The cold also tends to preserve pathogens for longer periods than under temperate weather conditions.[3] These considerations substantially increase associated health hazards. Health and environmental standards can be achieved through new service concepts such as renovation and reuse of water for other than potable purposes and through application of unconventional or innovative technology.

These problems stimulated the legislation designed to conceive, construct, install and evaluate cost and performance of prototype facilities to demonstrate alternative methods of providing basic utility services in Alaskan native villages.

SCOPE AND PURPOSE

The Alaska Village Demonstration Projects (AVDP) were authorized by Section 113 of the Water Pollution Control Act (PL 92-500) in 1970. Subsequent amendments were made to this section and are contained in PL 95-217 which extended the demonstration period for the AVDP and authorized additional expenditures (see Appendix).

LEGISLATIVE INTENT

The Alaska Village Demonstration Projects called for the design and construction of one or more central community facilities to demonstrate methods which "provide for safe water and the elimination or control of water pollution in those native villages in Alaska without such facilities." Provisions for bathing and laundering were to be included. Health and hygiene related educational and training programs were authorized. Also, the projects were to result in the development of preliminary plans to provide safe water and control environmental pollution in all Alaskan native villages.

The intent of the legislation was to demonstrate methods of meeting the water-related service needs of a village by means of a central community facility as opposed to the more conventional approach of extending full-scale water and sewerage service to all homes. A secondary consideration was that the facilities were to be of modular design to permit easy transport and quick installation and to be relocatable if necessary. It was felt that this approach could reduce the construction costs and permit facility relocation if, at some future date, the village was moved to a different site. In 1969-1970, village relocation was a legitimate consideration. Before enactment of the Alaska Native Claims Settlement Act of 1971, the long-term existence of many smaller villages was uncertain.

Hope was expressed that the demonstration project would be completed in two years, that several prototype designs would be available to meet the requirements of most Alaska villages, and that the initial authorization of $1 million would be sufficient for four or five installations. Early in the project it became apparent that these expectations were not realistic. It was found that additional funds would be required to complete just two installations. In 1972, another $1 million was authorized to continue the work.

The legislation did not address two pertinent questions. First, who would own the completed facility, and second, how the facilities would be operated and maintained in communities without sufficient resources to pay the cost.

AVDP HISTORY

The AVDP was administered by EPA through the Arctic Environmental Research Station in Fairbanks, Alaska. A staff of four full-time employees administered contracts and grants and collected and evaluated data relating to the projects. Several reports were published by the AVDP staff dealing with technical, social and economic aspects of the projects. These are listed in the references.[4,5,6,7]

Project sites were selected at Emmonak on the Yukon River delta near the Bering Sea and Wainwright on the coast of the Chuckchi Sea southwest of Barrow (Figure 1). These locations were chosen after consultation with the U.S.

Public Health Service, the Bureau of Indian Affairs, the Alaska Department of Environmental Conservation, the Association of Village Council Presidents and the North Slope Native Association.

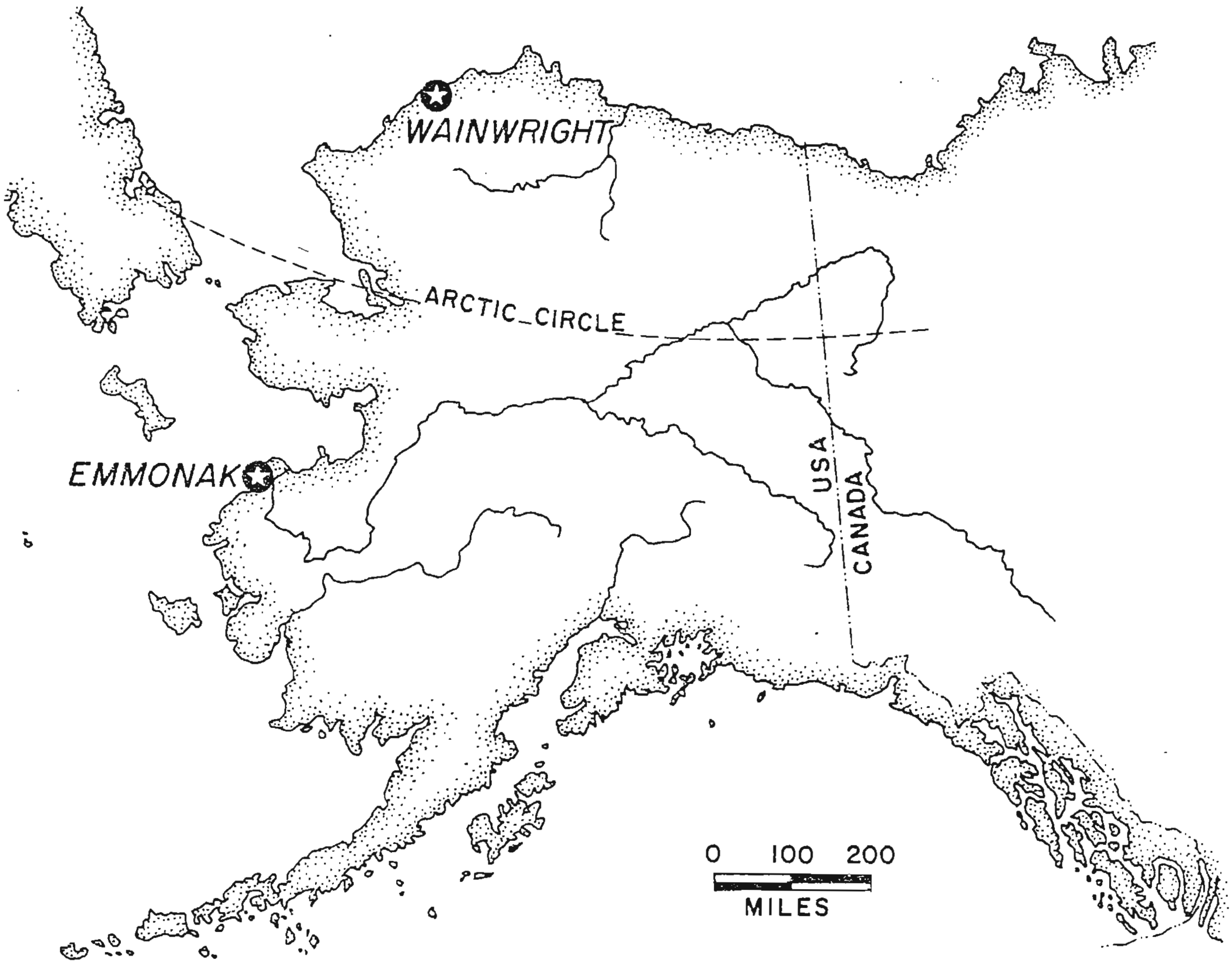

Figure 1. AVDP locations.

After the sites were chosen meetings were held in the selected villages to describe the project concept and to receive public comments. EPA emphasized from the beginning that it was not planning long term operation and maintenance of the facilities and would grant ownership to the village(s) upon completion of the demonstrations. In the interim, native operators were selected by the village leadership (with the advice of project staff) to be trained for facility operation, maintenance and management. Wages were paid directly or indirectly by EPA to the operators.

Facilities were designed and installed at both villages after selecting optimum design concepts from several proposals received under public invitation to bid. Most proposals were based upon modular structure of very conservative size to house the various treatment facilities and personal services. As much as practical, processes were interfaced to recover "waste" energy and thereby minimize operating costs. A schematic diagram of the processes at Wainwright is presented in Figure 2. Electric power generation was beyond the scope of the original projects so designs were based upon the use of power from the existing village system in both cases. However, standby power was ultimately provided.

Construction of the facility for Emmonak was done at several locations in the "Lower 48" and the completed modules shipped to the site for final placement. A similar scheme was used for the Wainwright Project.

Field assembly of the systems and start-up took place from September 1972 to February 1973. Records were kept after opening the facilities to assist in evaluating costs and efficiencies as well as documenting use patterns.

In November 1973 fire destroyed the Wainwright facility before sufficient operation and use information had been collected and evaluated. EPA decided to redesign and rebuild the facility in order to complete the evaluation. Design was accomplished by contract with an engineering firm, which workea within the concept and scope prescribed by the EPA project engineer. Construction was accomplished by fixed cost contract with a construction firm with Alaskan experience. The method of funding the contracts by EPA led to cost overruns. Delays ensued and as a result of insufficient inspection by EPA and poor quality work by the construction contractor, flaws in the structure caused further delays and required extensive repairs. Agency reorganization and program priorities led to elimination of EPA's staff on the AVDP. Subsequent operation and maintenance of the projects was carried out with grants and contracts.

In 1977, ownership of the Emmonak facility was transferred to the village after EPA made repairs and modifications to optimize the system. Simultaneously, a grant was made to the village to aid in obtaining operation, maintenance and management training and technical assistance and support no longer available directly from EPA. A final report of performance and service provided to the village by those activities was prepared by the contractor. The grant expired on December 31, 1978; since then full responsibility for the facility is with the City of Emmonak.

Negotiations were held in December 1978 with the North Slope Borough (Alaska) to assume ownership of the Wainwright facility. The Borough government has legal utility authority for all cities within its boundaries. Ownership of the Wainwright facility and full responsibility for its operation and maintenance and management was transferred to the Borough in March 1979.

In addition to the projects built at Wainwright and Emmonak, a third design was prepared for a much smaller community. This design was based upon a hypothetical community and an actual site was never selected. The fire at Wainwright necessitated the use of funds for replacement at that facility, precluding a third project.

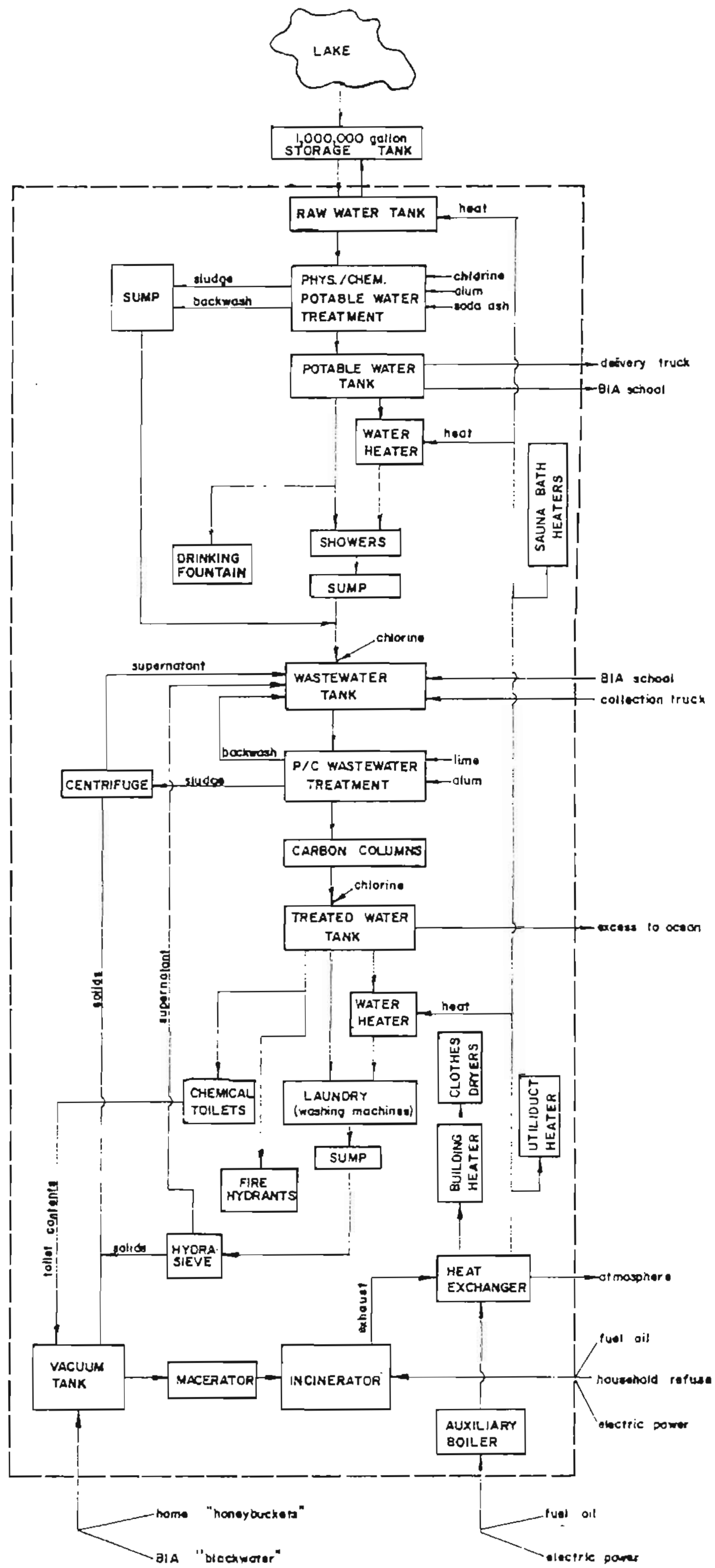

Figure 2. Schematic diagram of project at Wainwright.

The EPA retains responsibility for Section 113(e) of PL 92-500 (as amended) which requires development of a comprehensive program for achieving adequate sanitation services in Alaskan villages in cooperation with the State of Alaska. Finally, the EPA is required to submit recommendations for actions, procedures and legislation necessary to implement the recommendations of the comprehensive study. These activities and responsibilities are beyond the scope of this report and will be reported at a later date.

PROJECT REPORTS

Two comprehensive status reports on the AVDP have been published. The first "Report to the Congress, Alaska Village Demonstration Projects"[6] was published in July 1973 and covered progress to that date. In September 1976, a second report "Water Related Utilities for Small Communities in Rural Alaska"[7] was released. These publications dealt in detail with the conduct of the AVDP, interim conclusions and tentative recommendations. Other reports and publications were also prepared to address problem areas of the projects.[2,4,5] This report summarizes the conduct and results of the AVDP. It is the final report for the projects and contains conclusions and recommendations resulting from nearly eight years of effort. The results of the specific effort to integrate utility functions, including energy aspects as requested and financed by the Department of Housing and Urban Development (HUD), are contained in the section on Energy and Cost Conservation.

SECTION 2

CONCLUSIONS

CENTRAL COMMUNITY FACILITY CONCEPT

The idea of coming to a community center to secure water, to do the laundry, and to bathe (instead of performing these functions in the individual homes) has proven acceptable to the people of Wainwright and Emmonak. In communities where piped distribution and collection systems would be extraordinarily difficult to install, or where water is especially scarce, the central community facility concept has been demonstrated as a viable method to meet basic water-related needs of Alaskan native villages. Combined with a vehicular distribution and collection system, the concept can serve as more than an interim solution.

INSTITUTIONAL NEEDS

Regional native health or housing authorities appear to be the appropriate institutions for providing native villages with the technical, logistic and administrative support they need to operate and maintain basic utilities. At present, the village and/or regional authorities do not have the financial and technical base for this support. An alternative to conventional financing, training and management concepts is needed if facilities of this type are to succeed on a viable wide-use basis.

OPERATION AND MAINTENANCE COSTS

With rare exception, Alaska native villages cannot pay, through service charges, the full cost of routine operation and maintenance of water-related utilities, especially where complex treatment is required to meet technology-based or receiving water quality standards.

INTEGRATION OF UTILITIES

The electric power available in most Alaskan villages is of poor quality and furnished by inefficient installations which waste large amounts of useable heat. Through integration of the several village utility components, reliability could be increased, personnel costs reduced, and substantial energy savings accomplished.

EMPLOYMENT AND ECONOMIC DEVELOPMENT

The utility service centers sponsored under the AVDP program are labor intensive. In regions of very high unemployment and low incomes they add from four to six full-time jobs for local people. Thus, when operation and maintenance funds are available, these installations contribute to the economic well-being as well as the improved sanitary conditions of the villages.

METHOD OF CONSTRUCTING FACILITIES

There is no single best method of constructing water-related utility facilities in rural Alaska. Local conditions, accessibility, etc., are so varied that a limited number of standard designs could not be expected to effectively meet the wide range of conditions. Therefore, designs and construction techniques will vary with the individual situation.

FIRE PROTECTION

Providing full fire protection for public facilities in rural Alaska is unusually difficult and expensive. However, since fire is a major threat to facilities in cold climate regions, a decision not to provide this protection requires careful consideration of resources available for replacement. Insurance is generally not available except at very high premiums.

EQUIPMENT AND PROCESSES

Treatment processes for rural Alaska must be able to accommodate extreme variability in the composition of raw wastes and should be designed as simply as possible to meet requirements.

MANAGEMENT SKILLS

The management of utility systems requires skills and understanding which are generally not well developed in Alaskan natives living in remote villages. Managers will have to be "imported" or recruited locally and given extensive training if utilities are to operate reliably and economically.

SECTION 3

CENTRAL UTILITY SYSTEMS

The concept of the central utility system may be unique to Northern environments. The extreme climate of the north and the high cost of construction of water-related utilities makes the concept particularly attractive because the need for and costs of extensive distribution systems are eliminated. Central systems may vary in nature with nearly as much difference between one central utility system and another, as there is between the conventional system and the central system.

Some central systems include distribution or combination of distribution systems to certain locations within the community. Others make no provision for distribution of water or collection of wastes. Some provide only a source of pure water, while others include the provision for laundry and bathing needs.

The number of people required to operate a central utility system varies depending upon factors such as the type of distribution system, the hours of operation, and if other services are provided. At least one full-time skilled operator is normally required to operate water and wastewater treatment equipment and maintain the heating system, water storage facilities, standby generators and other equipment. If a vehicular distribution system is provided at least one driver will be required to deliver water to homes and other water customers. If sewage is collected by vehicle, a second driver probably will be required to make wastewater collections. The water distribution vehicle for Wainwright is shown in Figure 3 while a typical "utiliduct" cross-section is shown in Figure 4. Depending upon the size of the piped delivery system, additional full-time maintenance people will be required. In addition, a general manager will be needed and one or more clerks to maintain records and billings if these duties cannot be combined with those of other employees.

Hours of operation will further dictate the personnel requirements for a central utility system. A system which operates for only a limited number of hours per week can be operated reliably by a single full-time person. However, valuable utility equipment must be protected through the care of skilled personnel on a regular basis including weekends and holidays. An attempt to operate any utility system with a single operator will undoubtedly result in the overworking of the person and eventual decline of performance and subsequent system failure.

Comparing the number of personnel required to operate a central utility system with requirements of a conventional system in a similar community is difficult. Only very limited experience has been gained with either concept in small rural Alaskan communities. Limited experience with piped delivery and collection systems in Alaska indicates that system reliability is lower,

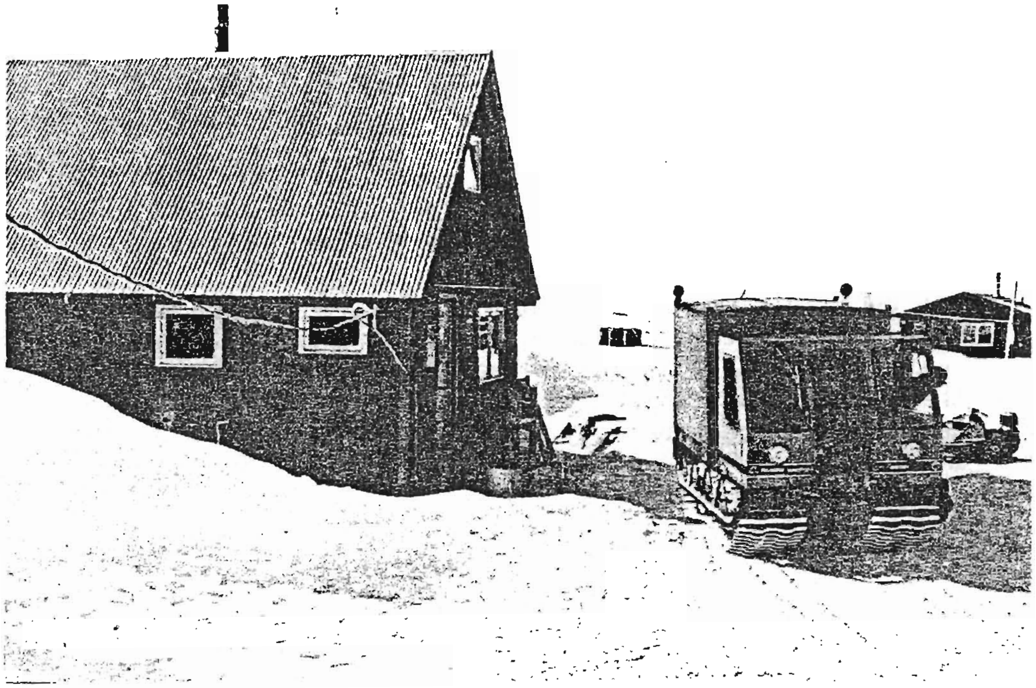

Figure 3. Water distribution vehicle used at Wainwright.

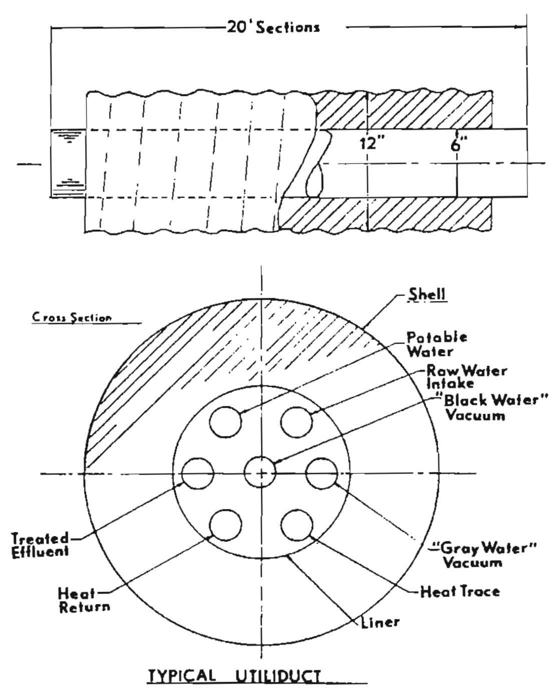

Figure 4. Typical cross-section of a utiliduct used in the AVDP.

and maintenance costs are much higher than for piped systems in temperate areas. The capital cost of pipe delivery and collection systems in small remote Arctic communities is extremely high and has generally precluded the application of such systems. Cameron et al.[9] stated that capital costs for piped delivery systems range from $200 to $350 per foot. Because of high construction and/or maintenance costs of piped systems, even many of the larger communities in the Canadian Arctic include a combination of delivery techniques, ranging from self service to fully piped distribution systems. Documentation of the personnel requirements and costs for operation and maintenance for the various types of utility systems is not available. Cameron and associates[9] showed that in the Northwest Territories labor accounts for 50 percent of the nine cents per gallon water delivery/sewage collection cost.

Decisions to provide fully piped distribution, vehicular, or self service water-related utility service are based on politics which in turn is based upon economics and other social and cultural conditions. It is relatively simple to project the cost of construction, operation, and maintenance of a utility delivery system of a given kind, and to compare these costs. However, such comparisons must be made for each community and should not be generalized.

INSTITUTIONAL SUPPORT

To be successful, projects such as the AVDP must have support from institutions outside of the community, including technical, managerial and financial resources. Obviously, not all communities will require all of these ingredients. Indeed, some communities may require a much lower level of support than others.

In Wainwright, the facility has reverted to ownership of the Borough government. That entity has taxation authority and the means to operate and maintain the facility. That is, the Borough has the financial ability to obtain technical expertise and managerial talent for efficient and effective utility system operation. The Borough government will become the supporting institution relieving the city of those responsibilities.

The Emmonak situation is much different. Emmonak is a community in The Unorganized Borough and does not have the benefit of a large governmental body, other than the State and Federal governments, to support its utility functions. Its tax base is limited to the city. Only by very skillful management will the City of Emmonak be able to operate the utility system without subsidy. Technical and management assistance from outside the city will be required from time to time. User rates at Emmonak will play a much more important role than at Wainwright where some costs can be subsidized by the larger governmental institution.

Technical and managerial assistance is the greatest need of rural cold climate communities. Because of the long lines of communication, and the logistics of supply, the supporting institution will have to provide those services for many communities. Similarly, because of the lack of managerial expertise it will be necessary for the supporting institution to assist in the training of potential managers and to foster attitudes which will lead to career position for qualified people.

SECTION 4

PROJECT IMPLEMENTATION

WAINWRIGHT

Wainwright is a relatively old community on the Arctic coast. The choice of the village site appears to have been dictated by the conditions of the sea ice and the need for a good landing site when materials for construction of a school were delivered by boat in 1904.[15] When the AVDP was initiated, Wainwright had a population of 330 and the community seemed to be stable. A broad range of skills is represented by the residents, but there is no local industry. Therefore, workers travel away from home for (usually) seasonal employment. In 1970, the single school included kindergarten through grade 8 with an average attendance of about 100 pupils. Recently (1978), a high school was built to prove education to grade 12. Total school enrollment in Wainwright is about 135 now (1979). There are no paved roads and only a few wheeled vehicles. Transportation is by "snow machine" in the winter and foot in the summer. There were about 60 houses in Wainwright in 1970, but the North Slope Borough has pursued a housing construction program so today there are nearly 100 homes.

Following the fire in November 1973, which destroyed the original Wainwright AVDP, designs were prepared and contracts let which led to construction of a second project in Wainwright which was accepted from the contractor in October 1976. Figure 5 shows the new structure. The new facility incorporated several changes from the original in an effort to improve the design. Different contracting procedures were used in the construction process to give more project office control and provide a basis for comparison with the previous method. However, budget cutbacks and manpower shortages required the elimination of a full-time on-site EPA inspector. As a result, deficiencies occurred in the construction which required repair later.

During the first winter of operation after reconstruction, defects in the structure were found. The primary defect was a faulty vapor barrier which allowed moisture to penetrate insulating material resulting in poor insulation and contributing to high fuel consumption and marginal comfort in the building. The importance of an effective vapor barrier, especially in severely cold climates, is explained by Rice[11] and Carlson.[12]

Alaska Department of Environmental Conservation (ADEC) personnel were consulted for an evaluation of the new facility. In addition to correcting the insulation defects, they recommended that blackwater (wastewater containing body waste) treatment be modified to a biological rather than a physical/chemical process. Many other small units throughout the state employ biological treatment. This would tend to standardize and simplify the provision of assistance by ADEC personnel if that becomes necessary in the future.

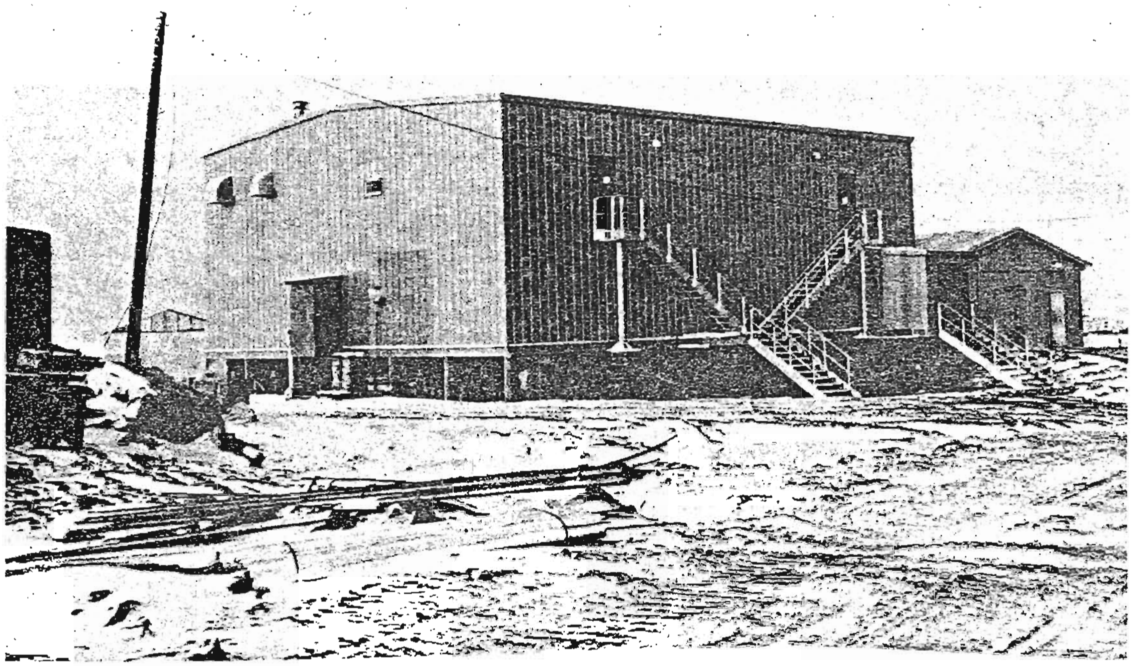

Figure 5. Exterior of process and vehicle storage Buildings for Wainwright AVDP.

AVDP project staff was reduced by attrition and changing EPA priorities so that by the spring of 1977 only one EPA person was available to work on the AVDP. As a result the operation, maintenance, training, and necessary modifications had to be provided by non-EPA personnel. A grant was made to the City of Wainwright as an expedient way to provide funds for operation and maintenance of the facility and to obtain management training for the operators. Subsequently the city contracted with an experienced engineering firm to provide operation and maintenance (O & M) guidance and to design and implement modifications and repair to make the facility fully operational and efficient.

To repair damaged insulation and install vapor barriers where the construction contractor had failed to do so, it was necessary to remove the exterior "skin" of the building, install the vapor barrier, replace insulation and reinstall the "skin". This work was accomplished late in the 1978 construction season.

Changes to the blackwater treatment plant were designed and subcontracts for equipment manufacture were let in 1978. Due to manufacture delay and delivery schedule problems, installation was not completed until June 1979.

To improve reliability and system capability, other subsystems which had not initially been provided or which had deteriorated were installed or repaired. These subsystems included: a backup boiler for the heating system, repair of the utiliduct which serves the elementary school and overhaul of the electrical generation equipment.

The contractor to the City of Wainwright provided technical help to the plant operators as necessary. Management guidance and instruction was also provided by the contractor under the terms of the grant.

During the period between September 1977 and February 1979 significant personnel problems arose which seriously hampered O & M and made management of the project virtually impossible. The principal plant operator who had been associated with the project from the beginning lost interest in the job and retired in the spring of 1978. Personnel turnover left the plant without a deputy operator. The new plant operator became overworked and discouraged. Many essential tasks simply were not done because of lack of time or interest on the part of the operator.

One important task which was left undone was that of seeing that the water storage tank was filled prior to the onset of winter. When the fact was discovered it was too cold to successfully pump water from the lake to the tank. As a result the entire community was placed on a water rationing program. A further complication resulting from this was the lack of facility income from the sale of water and the use of showers and laundry. Moreover, public reliance upon the facility as a dependable source of potable water and a place for bathing and laundering is now questionable and will take a long time to reestablish.

Another error on the part of the operator led to one of the electrical generators being allowed to operate without lubricating oil resulting in siezed bearing and ruined crankshaft. Previously, the generator engine block had cracked because the operators had failed to put antifreeze solution in the engine cooling system.

Other problems occurred because the operators failed to re-order spare parts when existing spares were used for repair or replacement.

Failures to meet expectations are as much the result of inexperienced judgement on the part of EPA and project personnel as from inexperienced managers and mechanics in the villages. McGarry[10] stated there is a tendency for agencies which lack firsthand experience in rural villages to attempt innovation of technologicl solutions to what they feel are the highest priority problems of the community. Being hurried to meet artificial deadlines with inadequate preparation is difficult for both the EPA and the village. Appropriate technology should consist not only of the hardware, but also of intangibles such as organization, education, extension services, supportative institutions and surrounding economic considerations.

In fairness, it should be pointed out that the operator(s) are basically competent. They do understand the processes and they have operated the facilities under some very adverse conditions. They have put in long hours, days and months on end and never feel as though any job is completed.

Communications are a problem between the "bush" and the center for O & M and management support. Facilities for voice communication to and from the "bush" are minimal, overcrowed and unreliable. Written communication is slow and ineffective. Shipment of supplies and repair parts is often slowed by irregular flight schedules and bad weather.

Pelto[8] summarized this phenomenon in the following statement:

> The sudden growth in technical and economic complexity produces economic specialization in such things as mechanics, electronics, retail and wholesale sales. Most often "southerners" are needed to fill these roles. Increased costs of imported energy sources raises the cost of living as well as local definitions of an acceptable standard of living, resulting in the out-migration of young people.

This implies also that potential management skills in the younger generation are not developed or available in rural Alaskan communities.

As pointed out in earlier reports, native operators have demonstrated an ability to improvise in the face of adversity and keep machinery operating. Their mechanical aptitude is high. However, it is becoming clear that management of sophisticated systems involves attitudes which have been alien to the culture of Alaskan natives. In all probability, it will require a period of some years for adjustment, acceptance and understanding of the notions which are necessary for management of modern community service enterprise to pervade the native culture. In the interim, management of systems in the bush communities will be tedious, expensive and plagued with higher failure rate than would normally be expected.

Following the reconstruction of the Wainwright AVDP, the Borough School System, in an unrelated action, planned for a high school facility to be built in Wainwrigt. Design of the high school began in 1976 and AVDP project staff advised both Borough personnel and the architect of the need to conserve water. However, the high school was designed and built with a water requirement more than 5 times that which could be assured by the AVDP. As a result, the AVDP is unable to meet the demand for water at the new school.

In similar fashion the Borough Government has begun building houses and multiplex dwellings. Again, although advised of the absolute limit on the amount of water available, the housing units incorporate plumbing fixtures and appliances with water demands which cannot be met by the AVDP facility.

Since these actions were taken with full knowledge that the existing water supply will not meet demands, there must be plans for a supplementary supply in the future. Two options exist for supplementing the existing facilities. The first is to provide additional water storage tanks. This would permit increased water use since available water is the problem more than treatment plant capacity. Existing treatment capacity is adequate for 3-5 times the existing storage capacity. The second option is to develop an entirely new source of water supply, and a new treatment and delivery system. It is not yet known how the local government plans to eliminate the apparent conflict between available supply and requirement.

Electrical Power

As noted in previous reports, electric power at many, if not most, remote Alaskan villages is unreliable, expensive and of questionable quality. However, electrical power is essential in providing water related utilities and the maximum reliability of those services can only approach the reliability of the electrical service. Similarly, the cost of electrical service is reflected in the cost of other services which depend upon it. Low quality electricity, that is electricity with variable and undependable voltage or frequency, will further increase the cost of other functions which depend upon it because of motor damage, more rapid light burn out, and the like.

Electrical power at Wainwright is no exception to this rule. Difficulties in maintaining engine generators has been significant. Both frequency and voltage fluctuations have caused extensive and repeated damage to AVDP equipment. Motors, capacitors, relays, and magnetic starters have been ruined.

The major problem with the local electrical utility is identical to the major problem of the AVDP, i.e., poor management. Operators are basically able to care for machinery but are not supervised by higher management and do not have sufficient technical knowledge to recognize their own limitations. Occasionally, problems are amplified by the need to improvise short range solutions to problems which over a longer time can lead to more serious equipment damage. The need to improvise is caused by the failure to seek outside support or assistance.

An example of this type of problem would be with motor capacitors. Because of over-voltage surges a capacitor may be destroyed. If replacement is made with an incorrect capacitor the motor may be damaged and if the motor drives a critical piece of equipment then a whole process or the entire project may be jeopardized. The remedy to this is simply to maintain an inventory of spare parts and to reorder them as they are used. Native operators and managers have not yet been thoroughly convinced of the importance of this type of activity.

Transfer of Ownership

The North Slope Borough is the municipal authority with utility responsibility for the City of Wainwright. As such, the Borough codes clearly state an intent to provide utility services where none exist and to acquire ownership where they presently do exist. Under Alaska Statutes as 43.18.010-045, State Air to Local Governments Municipal Services Revenue Sharing Program, the borough is entitled to and has received from the State $2 per capita for the Wainwright sewer area for O & M of air and water pollution control.

The EPA demonstration at Wainwright has been completed and it was in the best interests of the Agency and the Borough to transfer ownership to local authority. Consequently, negotiations were held with Borough authorities in December 1978 to arrange for transfer of ownership of the facility to the Borough. Formal transfer to local ownership was completed in March 1979.

Energy and Cost Conservation Efforts

AVDP staff recognized that life cycle cost for the projects was of extreme importance. Capital costs in rural Alaska are extremely high because of remoteness, communication, transportation and lack of a local skilled labor pool. Operation costs for utilities in Alaska are high because of the cold environment and the high cost of fuel. It was recognized that the cost of operation and maintenance would have a greater impact upon a village that the capital costs which are borne by or shared by State and Federal governments.

The major costs for O & M are for fuel and labor. Prudent design can minimize both. Designs for the projects incorporated energy and labor conservation where feasible.

An energy cascade is used to recover heat where possible. For example, exhaust heat from diesel-electric generators is recovered to be used in building and utiliduct heating. Also, heat exhausted from clothes dryers is recovered for building heating. Utiliducts employ counterflow heat transfer by placing cold water pipes and warm distribution and wastewater pipes in the same protective conduit.

Throughout much of Alaska low grade coal is available although the means of extracting and transporting it is not. A brief examination of coal sources and systems for efficiently and economically using them was made for Wainwright. It was determined that a coal-fired system to provide central power and heat in addition to water and wastewater treatment is feasible, but beyond the scope of the AVDP.

The modular integrated utility system (MIUS) promoted by the Department of Housing and Urban Development (HUD) was employed in the AVDP. At Wainwright HUD contributed to the expense of providing interface between the VDP and a new high school and power plant complex in the village. The MIUS involves interfacing as many of the unit processes as possible in such a manner as to maximize overall system efficiency.

For example, the raw water tank which must be heated to prevent freezing requires 141,000 BTU/hr. If that heat must be produced by an oil-fired heater of 70% efficiency about 35.8 gal/day of fuel is required. However, the 50 kw generator exhausts about 170,000 BTU/hr in exhaust gases and an exhaust gas heater exchanger of 70% efficiency recovers 119,000 BTU/hr. By using the heat exchanger to interface and integrate the two functions a saving of 30.2 gal of fuel/day is realized and overall thermal efficiency of the system is raised 13% by this single interface. Similarly, the clothes dryers exhaust enough heat through an air-to-air heat exchanger to heat the building when the dryers are in operation. A number of such possiblities exist in utility systems. The energy source is not important to the MIUS concept except that as the cost of the energy increases the value of the MIUS investment is increased.

Specific components of the Wainwright system which were added by use of HUD funds were:

1. Design, procurement and installation of exhaust gas heat exchanger for 50 kva diesel generator.

2. Design of utilidor and heat lines for transmission of "waste" heat from city power plant.

3. Design of heat exchangers and pumps to permit use of excess waste heat from city power plant in VDP building and tanks.

4. Design and procurement of air-to-air heat exchanger to recover heat from building exhaust air and clothes dryers.

Although the designed facilities have been installed, they have not been formally evaluated. The heating and ventilation flow diagrams for the project are shown in Figure 6 which appears as a fold out at the back of this publication.

One of the primary ingredients of successful application of the MIUS concept must be integration of operations. This mutual interdependence of one utility upon another allows significant overall increases in efficiency, but demands coordination between the subsystems and a higher level of skill and understanding for the operators.

For example, a city generator plant may have an output of 300 kw with a fuel input of 24 gallons per hour (3.07 x 10^6 BTUh), (subsystem efficiency is approximately 33%). In the same city the water related utility has a heating requirement of 750,000 BTUh which is equivalent to about 8 gallons of fuel per hour if the heater is 70% efficient. However, if the electrical generators are equipped with heat scavanger on cooling systems and exhaust gas systems at least 1,000,000 BTUh (assuming 50% heat recovery) will be available for water utility heating purposes. The integrated system has a total fuel requirement of 24 gallons per hour whereas individual subsystems have a combined fuel requirement of 32 gallons per hour. The efficiency of the combined subsystems is:

$$\frac{750{,}000 \text{ BTUh} + 1{,}024{,}000 \text{ BTUh}}{1{,}014{,}000 \text{ BTUh} + 3{,}070{,}000 \text{ BTUh}} \times 100 = 43\%$$

The efficiency of the integrated system is:

$$\frac{750{,}000 \text{ BTUn} + 1{,}024{,}000 \text{ BTUh}}{3{,}070{,}000 \text{ BTUh}} \times 100 = 58\%$$

Coordination is demanded because, in order to recover heat from the generators, the engine radiators have been replaced with heat exchangers. If the engine heat is not carried away, the engine will be damaged. Similarly, unless engines are running, there is no heat for other uses and no electricity.

Coordination of facilities in the design phase is difficult. Coordination during operation may be more difficult. In typical remote communities, a workforce with a pool of management skills is not currently available to coordinate the activities of MIUS projects. If such projects are to succeed, the managers will have to be "imported" until local skills can be developed.[8]

To date there has been little incentive for people in remote communities to acquire skills in management. Hardware has been the emphasis of most public projects and the intangible facets of project operation and maintenance have been overlooked. Wages for construction workers are typically higher than for people in other occupations which has also tended to discourage the development of managers. Also, there has not yet been a significant demand for a long enough time to attract capable young people to management in village utilities.

Another condition which contributes to instability of the labor and management force at public utilities in native communities is the absence of the concept of career employment to the native culture. People are generally willing to learn to do new jobs, but do not seem interested in pursuing those jobs in career fashion. This is not peculiar to utility employees, but is true of all municipal employees such as city clerk, police, airfield maintenance in addition to utility operators and managers.

The MIUS concept provides efficiency not only in energy, but in personnel use as well. In a typical remote Alaskan community one might expect to find several electrical generating plants which would provide electrical power for school, public building, homes, and commercial enterprises. Using the MIUS concept, the several generating stations would be combined to a single station, and rather than having a number of individuals responsible for operation, maintenance, and management of electrical power generation, a single team would have that responsibility. This may involve an equal number of operational personnel overall, but the necessity to duplicate support personnel would no longer exist and thereby reduce personnel costs and the number of trained personnel required.

The concept also lends itself to more efficient coordination of the various aspects of the MIUS concept. For example, to integrate the energy system within a village which is not totally involved in the MIUS system it is necessary to integrate the individual systems at the school, the public buildings and the village at large, whereas with an overall MIUS concept it is necessary only to coordinate the integration of systems with a single management team. This can also lead to greater reliability since one authority holds responsibility for management of the utility system.

Potable Water

Potable water at Wainwright is provided by treatment of surface water stored in a 1 million gallon heated tank. This volume of water was established as adequate based upon the foreseeable future at the time of original design in 1971.[6] The quantities agreed to by project and village personnel are presented in Table 1.

TABLE 1. DAILY WATER REQUIREMENTS

Personal Home Use	5	gpcd	(1875)
Showers (2/showers/person/week)	3	gpcd	(125)
Laundry (2 loads/family/week)	1.5	gpcd	(565)
School	1000 gals/day		

Figure 7 shows the actual amount of water used in Wainwright for individual home use and for the school. It can be seen that water use in the home is increasing steadily. Water use was ½ gpcd in January 1974 and was about 1.8 gpcd in May 1979.

Water treatment at Wainwright is in the form of filtration, organics removal and disinfection using sodium hypochlorite. A schematic of the water treatment equipment is presented in Figure 8.

Wastewater Treatment

The limited water supply at Wainwright makes conservation and water renovation and re-use attractive. Graywater (water from laundry and showers) is treated by a physical/chemical system (Figure 9) and re-used in the laundry. To minimize the buildup of impurities and reduce the load on the treatment system, the first exchange of soapy water from the washers is discharged to the blackwater treatment system. Subsequent exchanges of water during the wash cycle are returned to the graywater system for retreatment and re-use.

Table 2 presents results of tests on the physical/chemical treatment of graywater at the original Wainwright community utility center. Similar tests have not been conducted since reconstruction of the system, but it is felt that plant modifications will simplify achievement of similar results.

TABLE 2. RESULTS OF PHYSICAL-CHEMICAL TREATMENT OF GRAYWATER AT THE ORIGINAL WAINWRIGHT UTILITIES CENTER

	Raw Graywater	P-C Plant Effluent	Carbon Column Effluent	Reduction Percentage
Color, PCU	35	25	5	86
Turbidity, JTU	200	16	10	95
COD, mg/l	840	284	25	97
Total Solids, mg/l	1910	1670	1240	35
Suspended Solids, mg/l	503	25	10	98
Total Volatile Solids, mg/l	624	304	162	74
Volatile Susp. Solids, mg/l	281	16	4	99

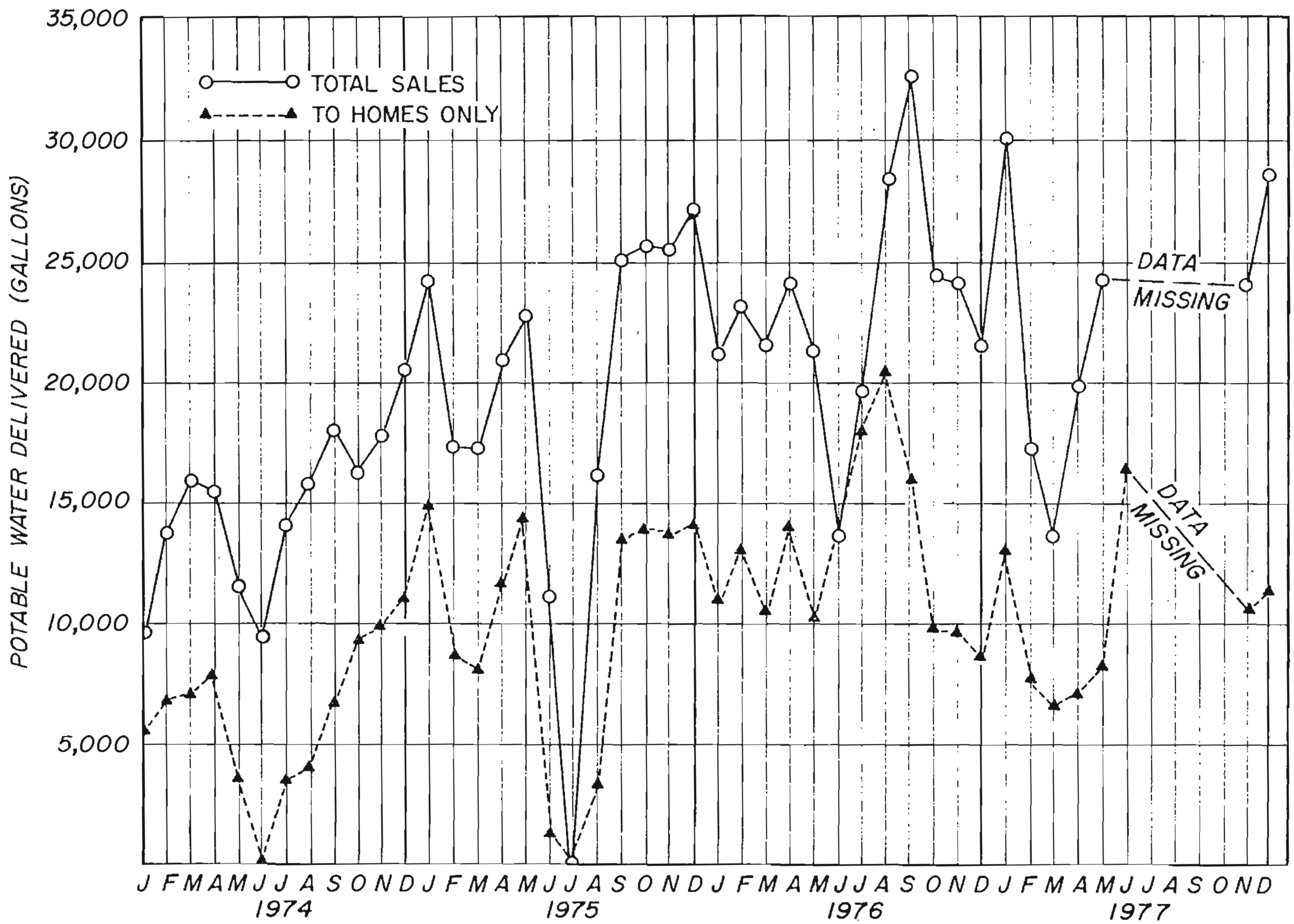

Figure 7. Water sales at Wainwright.

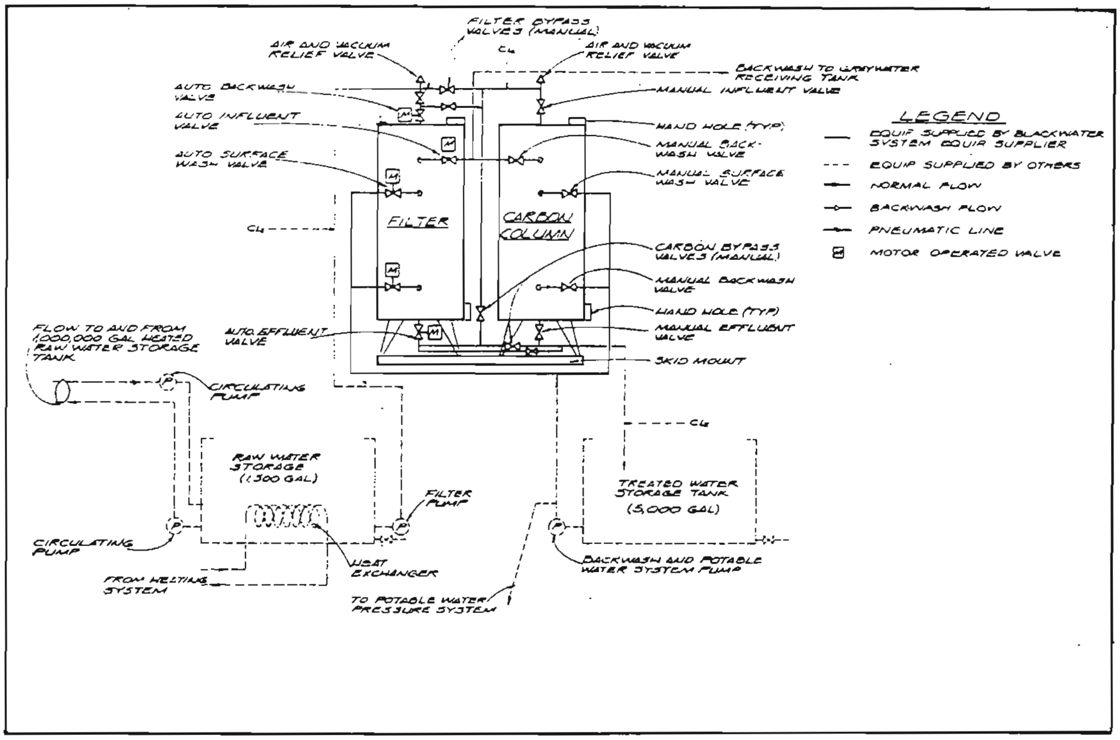

Figure 8. Schematic of water treatment process at Wainwright.

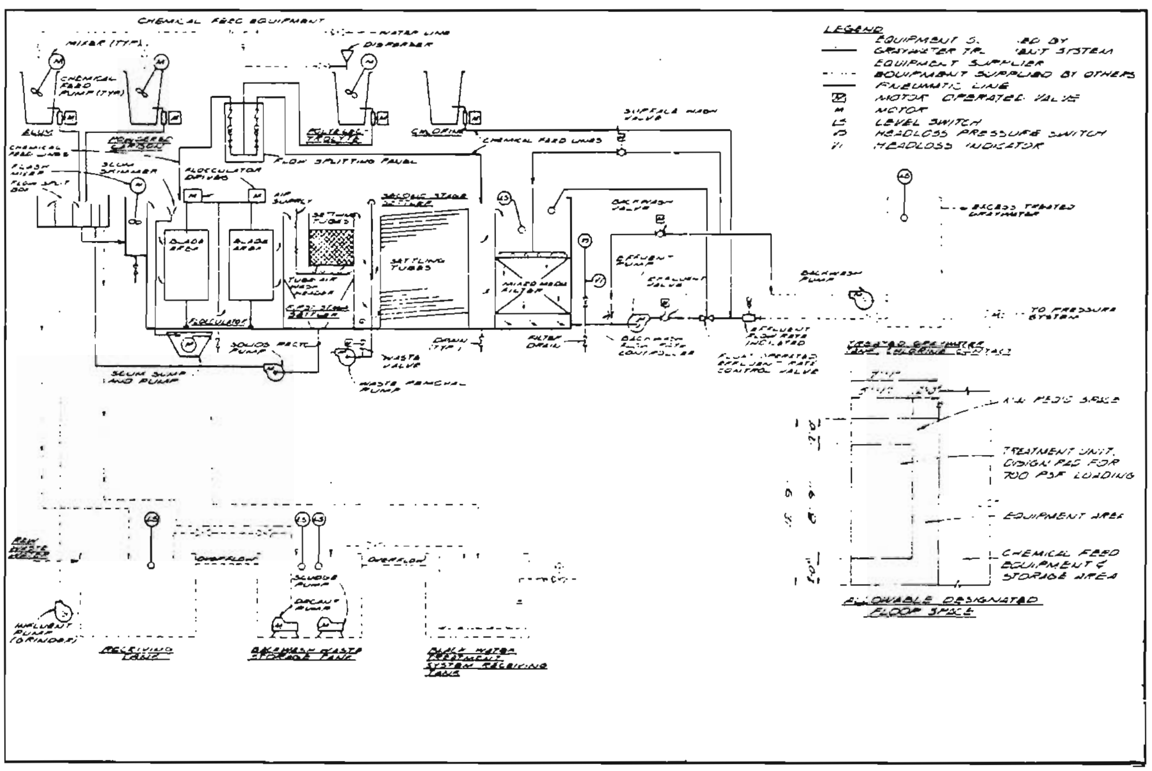

Figure 9. Schematic of graywater treatment process at Wainwright.

Facility Layout

Figures 10 and 11 show the arrangement of the public area and the process area respectively. Experience to date has been satisfactory with this arrangement. Adequate room for equipment maintenance has been provided to help encourage regular inspection and prevention maintenance.

EMMONAK

Emmonak is a recently established community which settled at its present location during the last 30 years. The population of the community at the outset of the AVDP was about 440 and it was recognized that because of the availability of work in the salmon fishing industry the population would probably grow. A locally owned co-op freezes salmon caught by local fishermen. There was a single grade school in Emmonak when the AVDP was built, but today there is also a State operated high school. Emmonak is located on a slough of the Yukon River near its mouth and is subject to occasional flooding. As in Wainwright, there are few wheeled vehicles and no paved roads. Access is by air from the outside world with occasional shipments of heavy materials by river or ocean vessels.

Following the fire at the Wainwright project, a thorough safety inspection of the Emmonak facility disclosed the need for improvements both for safety and routine repair and improvement.

The Emmonak AVDP was designed for a modular building consisting of six modules each approximately 9 feet wide by 9 feet high by 38 feet long. Three modules housed the public use facilities such as laundromats, showers, and sauna. The other three provided space for tankage, treatment processes and building maintenance functions such as heating and ventilation. A lean-to garage attached to the rear of this structure, provided space for maintenance and storage of the delivery vehicle. This layout is shown in Figure 12.

Conditions at Emmonak required construction on a matt foundation and maintenance of the soil beneath the structure in a thawed condition. Preliminary site investigations had determined that permafrost did not exist at this building site and to prevent frost-heave, the ground must be kept unfrozen.

The facilities contained in the Emmonak project included four washing machines, three dryers, four showers each for men and women, and sauna baths for men and women. The treatment processes included were potable water treatment, wastewater treatment, and solid waste and sludge disposal by incineration. The potable water treatment process is a typical "package" treatment plant which user coagulation, sedimentation and filtration to produce potable water, which is then disinfected prior to use by the people of Emmonak. The first wastewater treatment process was a physical/chemical treatment system which used powdered activated carbon, coagulation sedimentation, filtration and disinfection before disposal in the Yukon River.

The original incinerator designed for the Emmonak project could not be produced in time for installation. The contractor was required to provide an alternative type incinerator which is used to dispose of sludge from the

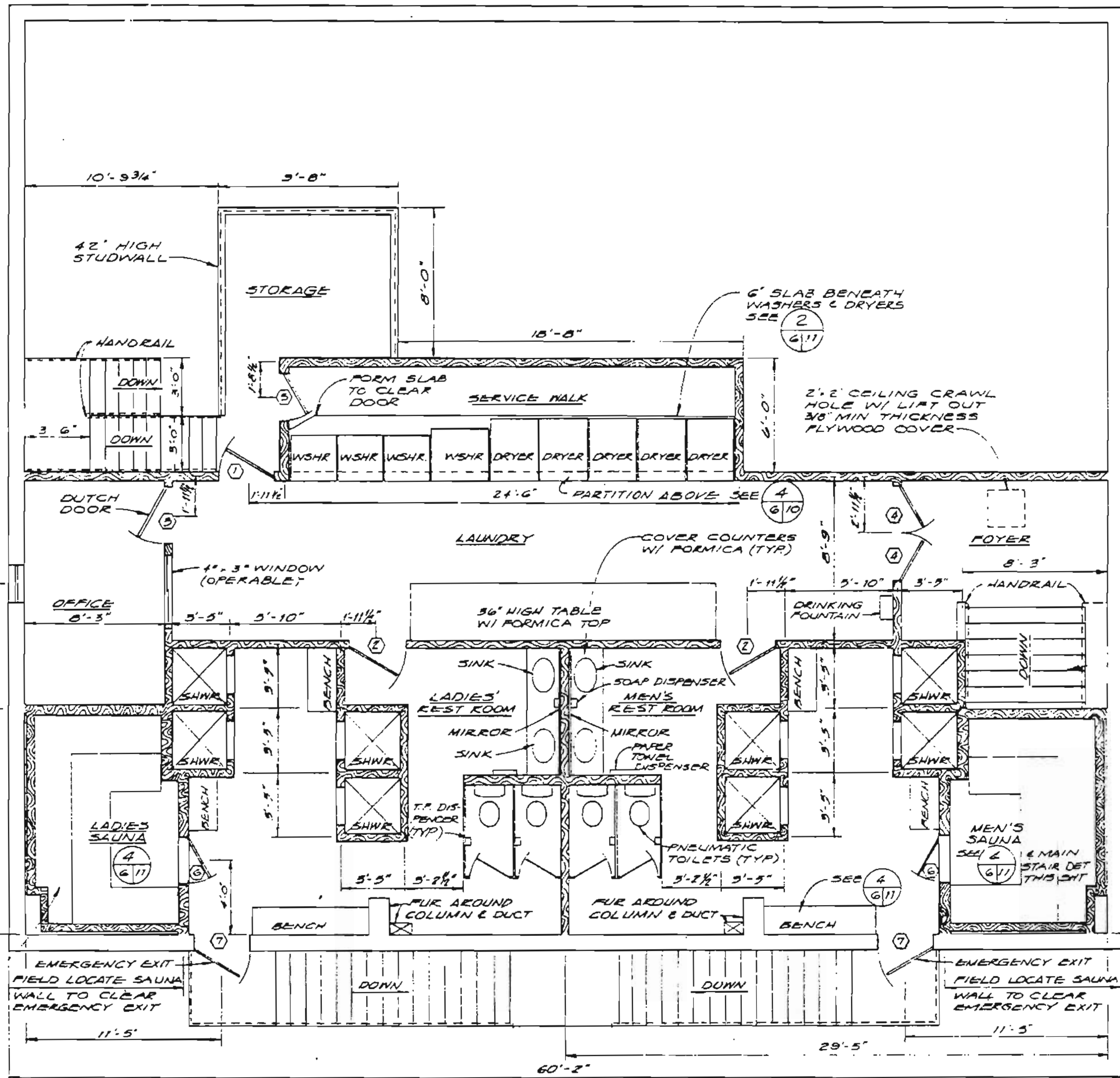

Figure 10. Layout of laundry and shower area at Wainwright.

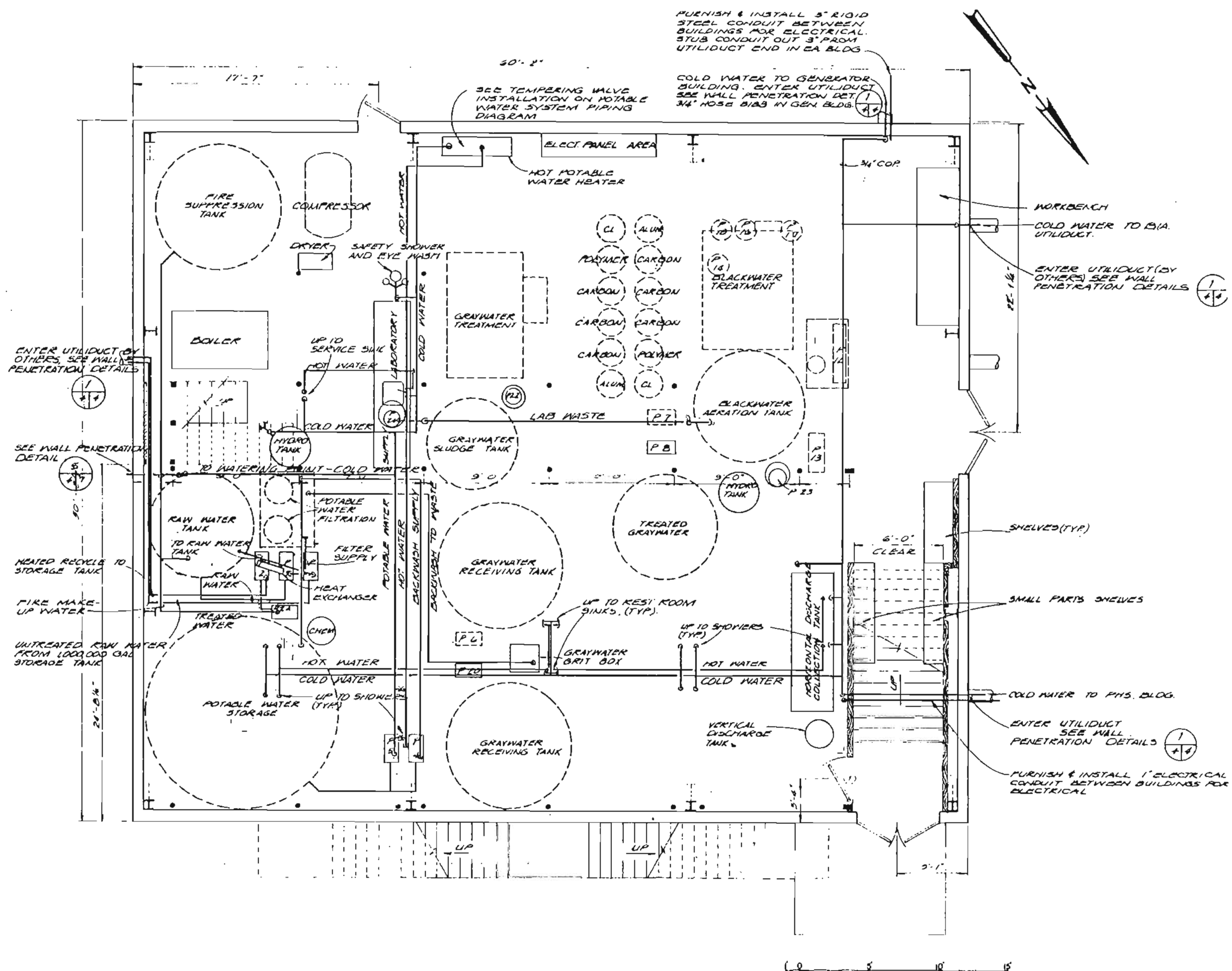

Figure 11. Arrangement of process area.

treatment plants and the small amounts of solid waste materials generated in the community center facility. Heat recovery equipment has been attached to the incinerator in an attempt to recover as much usable heat as possible and thereby reduce operating costs for the incineration process. However, because of the high rate of fuel consumption the operators are reluctant to use the incineratory any more than is absolutely necessary.

The Emmonak project has been in continual use since it was opened to the public in early 1973. Local acceptance and use of the facility has grown so that at this time the demand on the facility is nearly equal that of the design figures estimated in 1972. This high use emphasizes the need in future projects of this nature to modify design to allow for greatly increasing demands for water and laundry and shower facilities. It is also advisable to provide more than the minimally required space in order to make these public buildings less austere and more plesant. Also, the provision of adequate space for treatment processes in necessary in order to achieve proper operation and maintenance of facilities. In the case of Emmonak, processes were crowded into spaces which under many conditions would be termed totally inadequate, resulting in extreme difficulty in the maintenance of equipment. Perhaps 10-20% additional cost for structure is easily justified by the improvement in attitude and performance of operational personnel.

Although the original concept for the Emmonak project included a vehicular distribution system to provide potable water to the homes, the system has never operated successfully. Townspeople do not appear to desire such a service and operational personnel are reluctant to provide such a service under any circumstances. Each household assumes responsibility for obtaining its own water. Containers of water are hauled on sleds, wheelbarrows, and other such means. The costs for a delivery system significantly increased the cost of providing water to the homes. This aspect will be discussed in the cost section of this report.

The showers and saunas are the real heart of the Emmonak AVDP. The sauna bath has become nearly as popular as the Bingo Hall as a social gathering place for men of the town. Saunas were provided as a water conservation device whereby bathing is accomplished with minimal water. The social aspects of the sauna popularized it in Emmonak. Records show that more than 10,000 uses of the sanua/shower facilities were made in 1978.

The laundry facilities at Emmonak are also extremely popular. Records show that each family on the average washed 70 loads of clothes during 1978 or approximately 1½ loads per family per week.

The economic foundation for the Emmonak project comes from the contract to provide potable water for the elementary and high schools in the city and subsequently to provide wastewater treatment after that water has been used. The charges for water and wastewater treatment are greater than the actual cost of those processes and thus provide a subsidy for the other services provided by the utility system. Water is delivered to the schools through a "utiliduct" and wastewater is returned through a similar duct. The quantities involved make vehicular distribution to the schools impractical. Moreover, the labor costs for a vehicular distribution system would far exceed the maintenance costs of the utiliduct.

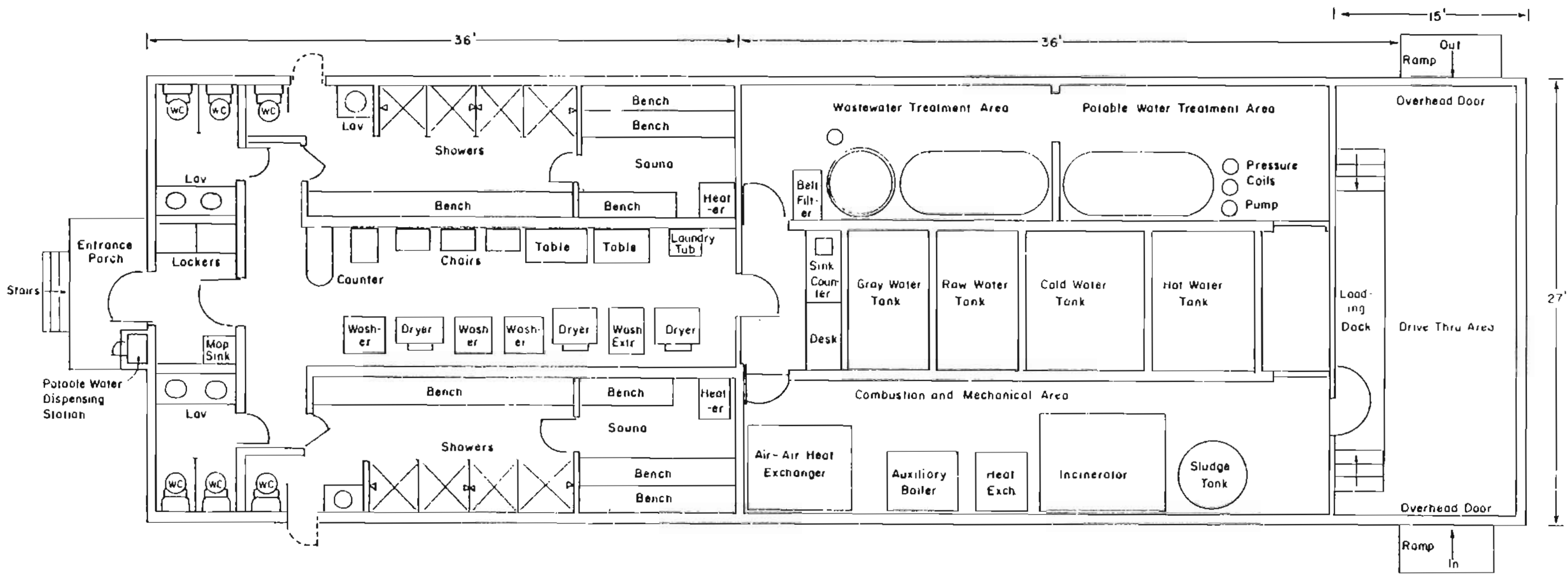

Figure 12. Layout of Emmonak project.

The operators and managers of the Emmonak project have been successful in learning and carrying out their jobs. However, significant training has been required to achieve that mark. It has been observed both by EPA personnel and by contractors that enough time is rarely alloted for job training. Training should cover an extended period of time in years and be relatively low key. In many places the people are not thoroughly convinced of the need for projects of this type. The people of the community must believe in the need for the service before the operators will be receptive to training. The need for training cannot be overemphasized. Skills available in rural Alaskan communities simply are not adequate to manage and maintain projects such as these without assistance, training and continual reinforcement. People are a part of the technology employed in a project such as this and it is wrong to assume that they as an intangible aspect of technology, are immediately and continuously available without training and support. In fact, experience has shown that poor success with projects in the "bush" is more a result of failure to develop and support people than a direct failure of hardware.

Potable Water Treatment

The water supply system is shown in Figure 13. Raw water is pumped from the Yukon River by a 1-hp submersible pump. In summer the pump is suspended from a raft and in winter it is suspended through a hole in the ice and covered with a heated enclosure.

The submersible pump replaced two centrifugal pumps which originally had been installed in a small heated hut on the bank above the river. For a variety of reasons, these pumps would not hold prime. The present arrangement, although somewhat makeshift, has the desirable aspect of avoiding placement of permanent obstructions in the river bed or the bank and has performed satisfactorily.

The choice of the Yukon River as the source of raw water was made after reviewing available information regarding ground water at Emmonak. Wells constructed by the Bureau of Indian Affairs produced water of high organic content and saltwater beyond a certain depth. The river water has been relatively easy to treat.

Potable water treatment is accomplished with a package unit manufactured by Keystone Engineering, Inc. of Seattle, Washington. The plant has been in operation since November 1972 and has functioned well with a minimum of operator attention. Treatment consists of alum coagulation, multi-media filtration and chlorination. The rated capacity of the plant is 10 gallons per minute (gpm). Actual capacity has been about 7½ gpm.

Table 3 presents the raw water and potable water characteristics at Emmonak.

Figure 14 presents a record of the potable water consumption in Emmonak since the beginning of record keeping in 1973. There has been no significant increase in the amount of water for personal home use, but an obvious trend exists toward an increasing amount of water used by schools and other institutions in Emmonak.

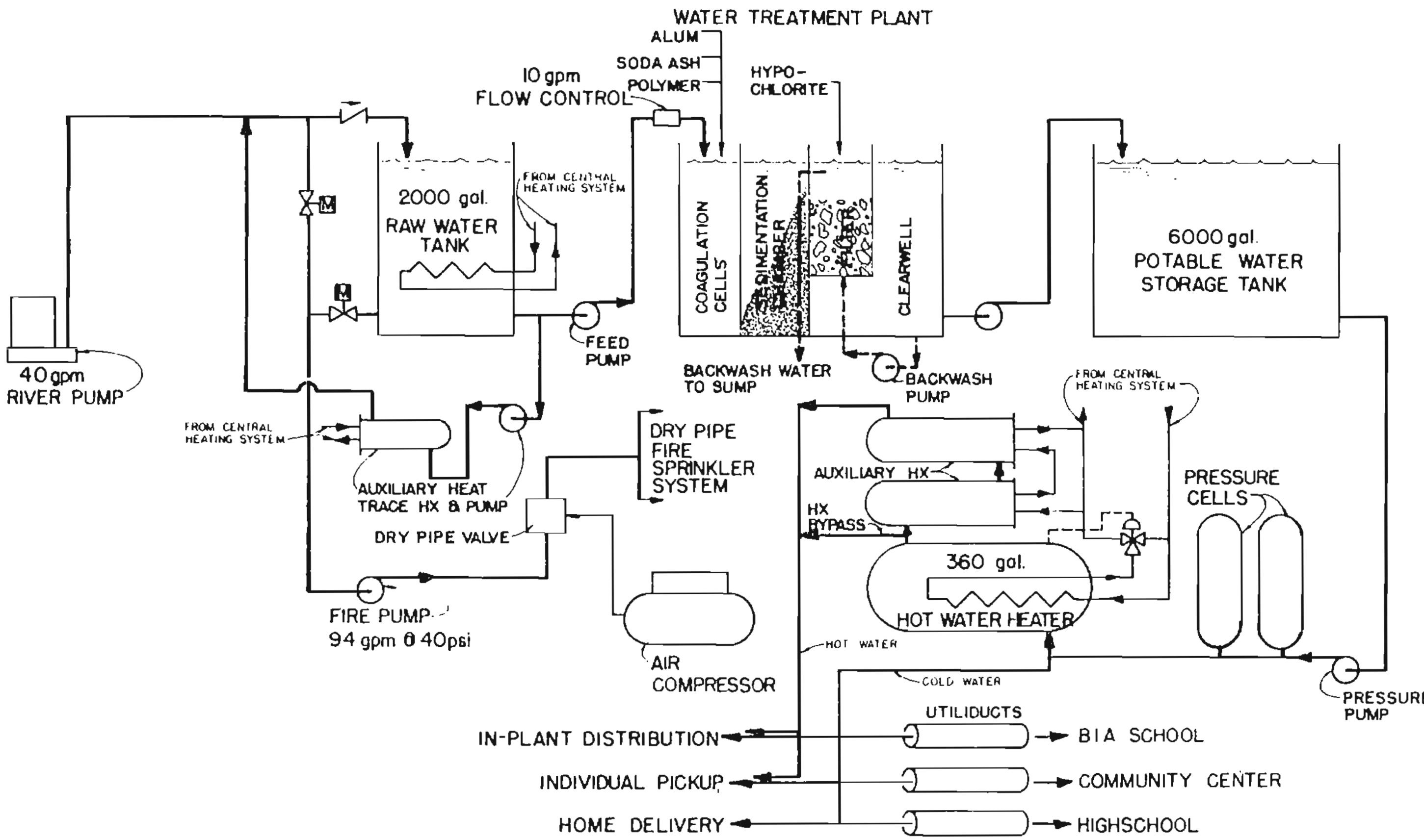

Figure 13. Schematic of water treatment system at Emmonak.

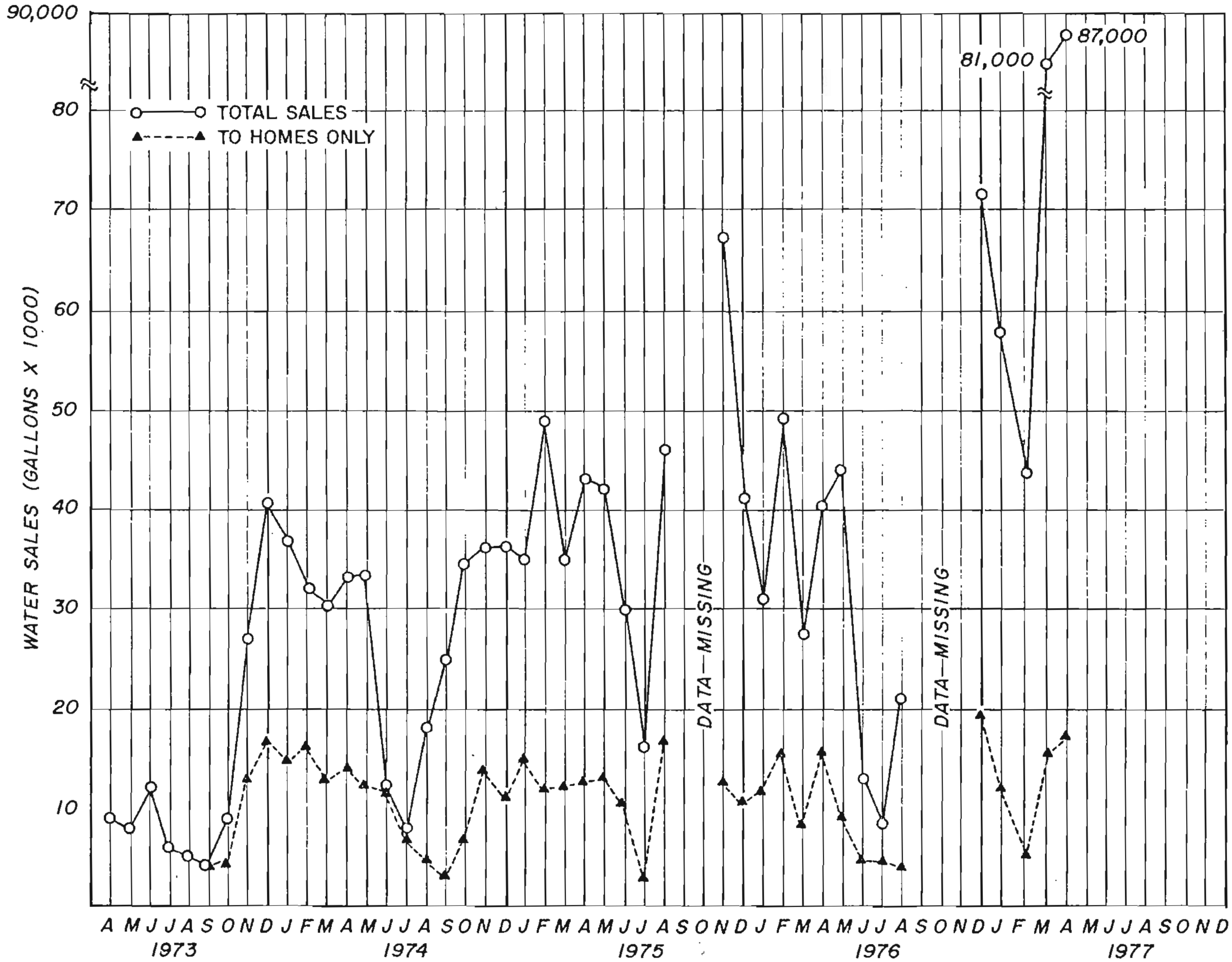

Figure 14. Water sales at Emmonak.

TABLE 3. RAW WATER AND POTABLE WATER CHARACTERISTICS AT EMMONAK[1]

	Winter Sampling Period Raw Water	Finished Potable Water
# Samples	24	25
pH[2]	5.9 - 7.8	6.0 - 7.6
Conductivity, UMHO	350 (56)	430 (86)
Turbidity, JTU	16 (13)	2.8 (1.7)[3]
Suspended Solids, mg/l	3.5 (2)	3 (2.7)[3]
Hardness, mg/l, $CaCO_3$	168 (17)	168 (20)
Color, PCU	4 (2)	0 (0)

	Summer Sampling Period Raw Water	Finished Potable Water
# Samples	9	9
pH	7.3 - 8.5	6.2 - 8.2
Conductivity	190 (13)	290 (29)
Turbidity, JTU	118 (42)	3.0 (2.5)[3]
Total Solids, mg/l	275 (42)	197 (35)
Suspended Solids, mg/l	148 (21)	4.3 (3.9)[2]
Hardness, mg/l CaCO	110 (22)	131 (35)
Color, PCU	36 (5)	4.0 (1.0)[3]

[1] Mean value with standard deviation in parenthesis.
[2] Range of values.
[3] Mean and standard deviation obtained from probability plot.

Blackwater/Graywater System

At the outset of the original Alaska Village Demonstration Project at Emmonak, treatment of graywater was in a conventional packaged physical/chemical (P/C) type treatment plant. As time passed, the process was modified in many attempts to improve the system.

During this period, the collection, grinding, settling, dewatering, disinfection of sewage soilds and incineration of sludges of blackwater from the AVDP Building and the Bureau of Indian Affairs School was identified by the operators as unsatisfactory because the incineration of sludge required a large amount of fuel to dispose of a relatively small amount of sludge.

An attempt to use waste heat from incineration to preheat boiler feed water proved ineffective and of no marked economical advantage. Eventually, the incineration process was abandoned and for a period of time the blackwater generated was collected, stored, macerated, disinfected, mixed with disinfected graywater and discharged through the outfall some distance downstream in the Yukon River.

As a segment of the O & M portion of the contract a new attempt to solve the gray and blackwater treatment problem was attempted. Using most of the equipment already installed, contractors designed a system that:

- collected graywater as before.
- collected blackwater as before.
- allowed the blackwater sludges to settle, while keeping the supernatant moving.
- overflowed blackwater supernatant so that it could be transferred to the graywater collecting/holding tank.
- provided continuous aeration of the graywater holding tank.
- added a carbon contact step in graywater physical/chemical treatment. This improved the reduction of BODs, color and odor, in the mixed collected waters.
- provided for addition of a concentrated lime solution of the blackwater collection/settling tank to raise pH to a level of 11.5 to 12.0 as a means of disinfection.
- pumped off the settled, disinfected sludge with a solids grinding, progressive cavity pump to a centrifuge for dewatering.
- transfered dewaterd sludge to a tank trailer and supernatant to the graywater collection/holding tank.
- provided a landfill for the disinfected sludges.

This system was built and installed using funds provided by the U.S. Public Health Service. In start-up, a number of difficulties became apparent:

- The addition of lime to the blackwater collection/settling tank provided the disinfection required; however, the pH of the supernatant was too high to be neutralized by mixing with graywater and flocculation was inhibited as a result.

- The amount of sludge collected created a hardship on disposal during the wet season because landfill areas were inaccessible due to mud.

After evaluating the overall processing and disposal problem, additional modifications were made utilizing the same equipment, plumbing and most materials.

Since the powdered carbon did not reduce BOD loadings, color and odor to anticipated levels and because the real cost of the material in the future would create an economic burden on the facility; and probably shorten the life of the mixed media filter bed, it was removed from the process.

The blackwater disinfection with lime at the collection/settling tank was discontinued. The supernatant continued to be transferred to the graywater collection/holding tank, was aerated as before, treated by flocculation, filteration and disinfection as the P/C process had done previously, and discharged to the Yukon River.

Disinfection by concentrated lime addition was done at the point of transfer/grinding of the sludges to the centrifuge. The centrate from the centrifuge that was transferred to the graywater collection/holding tank was not of sufficient volume of high pH waters to upset the normal P/C process.

The dewatered sludge (approximately 25% solids) was then transferred by progressive cavity pump into the graywater discharge line to the river.

At the time the utility center was turned over to the local operators, the plant was operating within limits required by the existing discharge permit requirements.

Figure 15 shows the present relationship of treatment processes at Emmonak.

Transfer of Ownership

The City of Emmonak agreed to accept ownership of the AVDP facilities providing the needed repairs and improvements were made at no cost to the city. Consequently, EPA negotiated with the city to assume ownership while repair and improvement work was in progress. Subsequently, a grant was made to the city to assist in operation and maintenance of the facility and to provide management training and technical support for personnel.

Support and training was obtained by the city through contract with the same engineering firm as the City of Wainwright.

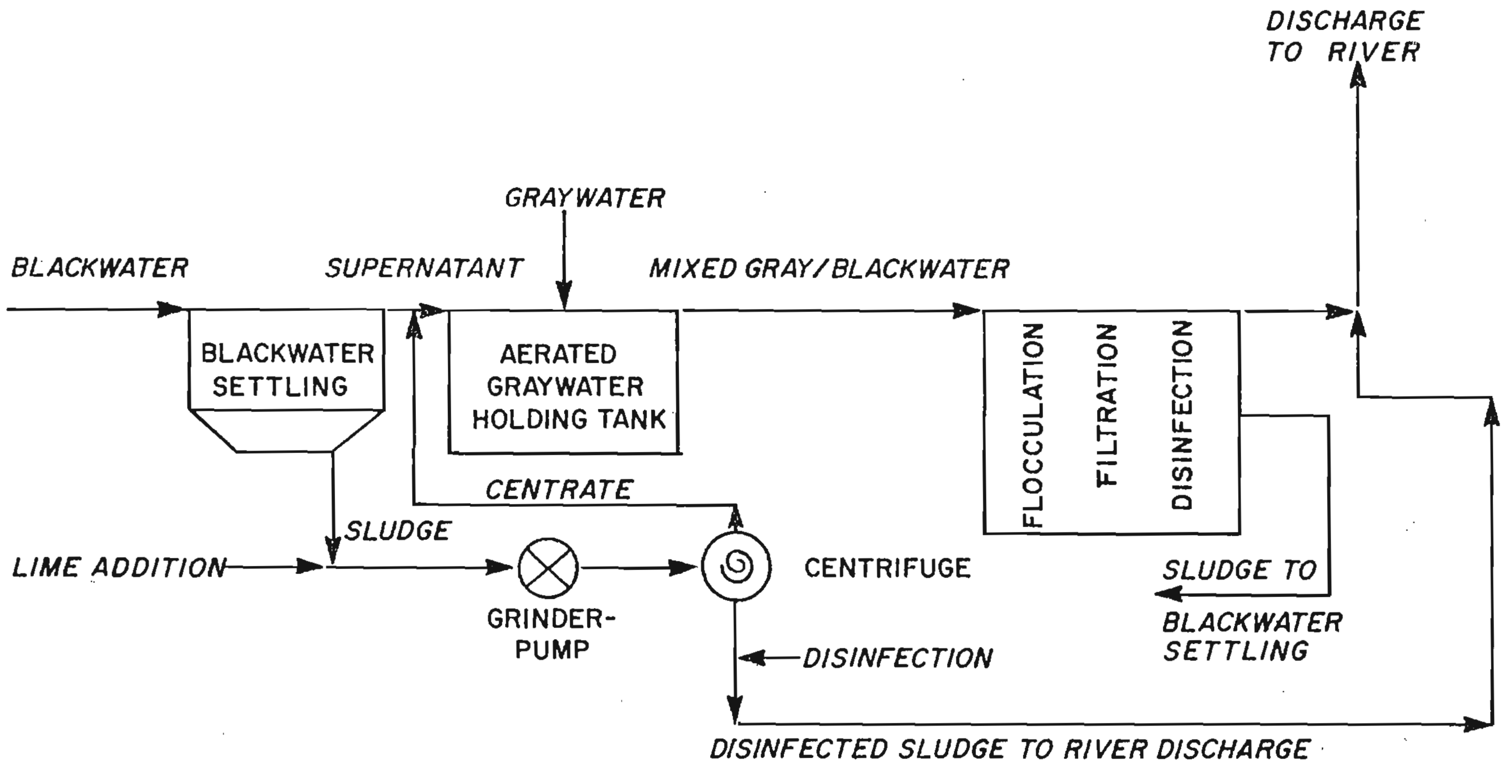

Figure 15. Schematic diagram of modified wastewater treatment system at Emmonak.

The utility system in Emmonak seems to be somewhat more successful than in Wainwright. System management is fraught with problems, but they appear to be of lesser magnitude and shorter duration than at Wainwright. Emmonak is not experiencing the same pressures from outside sources as the North Slope communities and has begun to develop a degree of dependence upon local initiative to establish an economic base. People involved in the fishing industry which provides significant cash and subsistance support in the area seem to have a better grasp of the importance of management.

The chief operator obtained assistance in establishing a parts inventory control system and has been able to do a reasonable job of maintaining the system. There is still some scavanging from one system to support another, but not to a critical extent. Orderly parts storage has yet to be organized and maintained, but the system in use seems to be acceptable for the operators.

EVALUATION AND PROJECT COSTS

Previous reports [6,7] provide technical evaluations of the various subsystems in each project. Modifications were made where necessary to upgrade process performance to achieve required results. It has been demonstrated that equipment which is readily available can be used and achieves the same degree of performance in rural Alaskan villages as in any other location. However, it has been explained that reliability of these systems is lower in isolated villages because of the increased logistics problems and lack of attention to proper operation, maintenance and management given by the operators under conditions which would be considered hardship elsewhere.

As in most communities, system performance is directly proportional to the value placed on the product by the community and the operators. Water treatment is generally quite reliable and the product is generally excellent because the operators and the community value that commodity highly. However, wastewater treatment is of limited quality because operators feel that this is relatively unimportant. In Wainwright where graywater is treated and reused for laundry, it carries a slightly higher priority than it might elsewhere.

Reliability is related to a number of items such as:

1. equipment.
2. reliability of electricity.
3. operator attitude.
4. dependence upon and importance to other processes.

Of these, operator attitude and reliability/quality of electricity are most important.

Cost effectiveness is a difficult subject when related to remote Alaskan communities (or any Alaskan communities for that matter). Costs are higher for all aspects of production. However, charges made for products and services are higher and tend to balance production costs. A projection for income and expenses for Emmonak are given in Table 4 as an example of balancing production and product/service costs.

It will be noted that some services or products seem to provide financial support for others. Water, for example at $0.07 per gallon is as much as 125 times as expensive as water in metropolitan areas of the "lower 48" and is further supported somewhat by saunas/showers. The integrated system both allows and requires a certain amount of give-and-take between process costs since some aspects such as operator time and building heat and light are shared.

Table 5 presents the projected operating budget for Wainwright as proposed by the City Council. The unbalanced budget is based upon the presumed ability of the Borough Government to subsidize the system. The Borough policy is to adhere to a wage scale which keeps the salary cost for the project very high. There is also unwritten policy that the cost for utility services to the community should be limited. An additional factor in the high operating costs for the Wainwright system is the electric power cost of 31¢ per kilowatt hour.

Previously, it was reported[7] that sludge incineration is very expensive. Alternative solutions are not much more attractive either from economic, sanitation or operation aspects. Alternative sludge disposal methods considered were disinfection with lime coupled with land disposal at the town dump, or, simple land disposal. Neither alternative is without the risk of incurring operating difficulties.

Although the operational costs of the project at Emmonak appear to be balanced by the income, one very important consideration, amortization of construction costs, has been omitted since the facilities were provided to the villages at no capital cost. Using the $1 million cost and assuming a life of 25 years, revenue of about $94,000 per year would be required to amortize an 8% loan. This is in addition to all other operating expenses. The Wainwright facilities which cost about $1.6 millicn represent the need for about $150,000 per year for amortization of the capital cost at 8% in 25 years. Capital costs must be a major consideration in developing a comprehensive statewide program.

Cost effectiveness must be related to some benefit level which is not yet clearly established in Alaska. The alternatives to the central utility concept range from no service at all to fully piped systems for water distribution and sewers for collction. Moreover, the services provided must be needed and acceptable to the community they serve. Most communities would prefer the fully piped system, but the AVDP has shown that central facilities are highly acceptable as an alternative means of providing sanitation facilities.

In the Northwest Territories (NWT) of Canada, policy has been developed which overrides cost effectiveness. The Canadians have determined that a certain level of service is essential and affordable by all households and will be provided at fixed cost. Above that cost, customers pay the going economic rate. In locations where delivery is by vehicle the customer pays $5 per month for the first 800 gallons of water, $5 per month for the next 400 gallons and the economic rate for all additional service. Collection of wastewater is at the same rate. Where piped systems exist, $15 per dwelling per month provides up to 40 (Imperial) gallons per person per day. No additional charge is made for sewerage.

TABLE 4. OPERATING BUDGET -- EMMONAK

Source	Income	
Washers	$ 8,400	(4800 loads @ 1.75)
Dryers	5,800	(9667 loads @ .60)
Sauna/shower	34,125	(17,500 users @ 1.95)
Misc.	105	
Home Water	2,520	(36,000 gal @ .07)
School Water Contract	50,000	
	$100,950	

Expense	Amount
Salaries	$ 62,000
Fuel	22,000
Power	6,200
Supplies and Materials	4,200
Equipment Repair	4,200
Misc.	2,350
	$100,950

TABLE 5. OPERATING BUDGET -- WAINWRIGHT

Source	Income	
Laundry (wash and dry)	$ 12,000	(3000 loads @ 1.50)
Showers/sauna	35,000	(17,500 users @ 2.00)
Home Water	48,000	
School Water Contract	9,800	
	$176,800	

Expense	Amount
Salaries	$164,800
Fuel	43,200
Power	70,000
Supplies and Materials	16,000
Equipment Repair and Replacement	15,000
Misc.	5,000
	$314,000

NWT policy also prescribes the extent of service to be provided based upon the population of the community.

Population	Service
0 - 50	none
50 - 150	trucked delivery and sewage pickup
150 - 700	partially piped system
over 700	completely piped water and sewerage system

EPA personnel participated in the preparation of a design manual for utilities in cold climate regions.[13] This text has been cooperatively published by the Environmental Protection Service of Canada and EPA. Technical information is now available under a single cover that, when combined with engineering experience gained in other regions, will allow design of technically successful utility projects in cold climates. Clearly, this guidance does not apply to the social and economic aspects, the intangible segments of technology. Policy is needed to guide the designers of hardware. Village projects are very expensive, but they are extravagant only if the capital costs are not supported by O & M funding and appropriate support for the people involved in O & M.

Since 1970, several changes in accounting procedures have occurred in EPA. The project costs shown are based on project office records which may, in fact, reflect small errors.

As previously noted, IHS and HUD contributed to the facility at Wainwright. Non-EPA contributions are indicated by asterisks on the individual item and are included unidentified in the totals. Entries are rounded to the nearest $100.

All these costs are substantial, and the question arises whether such Federally sponsored central community facilities are costing more than they should. The recent establishment of commercially sponsored communities at Prudhoe Bay makes possible some comparisons. Atlantic Richfield Company (ARCO) and Exxon have made available capital and operating cost information for sewage treatment and water treatment plants in their joint operations center on the North Slope.[1] Before mid-1975, the design size of these plants was similar to that of the ADVP facilities. They served a population of 300 to 400 people in a boarding house type arrangement.

As of December 1, 1974, gross investment in the ARCO-Exxon Operations Center water and sewage treatment plants was $1,173,021 and $1,025,754, respectively, making a total of $2,199,775. Building plumbing fixture costs are not included. Yearly gross operating costs are reported as follows:

	1972	1973	1974
Water Treatment	$131,000	$162,400	$147,200
Sewage Treatment	74,900	121,000	120,500

Neither property taxes nor prorated Anchorage office administrative support costs are included. Average monthly operating costs thus come to $12,240 for water treatment and $8,790 for treatment of sewage. The total average monthly cost of operating the Emmonak AVDP facility ($6,300) compares favorably with the above. AVDP capital costs have also generally been lower.

In a study prepared for the U.S. Public Health Service and the North Slope Borough of Alaska[14] the cost for an underground utilidor system for Barrow, Alaska was estimated at $1000 per lineal foot. The project to provide service to 168 points would have a capital cost of $52 million and an annual O & M cost of $990,000. This estimate was for the utilidor system alone and did not include the construction and operation of the treatment systems.

These examples are cited to demonstrate the generally high cost of providing and maintaining utility service in Alaska. It is necessary to design systems of appropriate technology for each place where utility systems are to be installed. A fixed policy may tend to stifle individuality, but it may also provide the foundation for establishment of appropriate technology.

CAPITAL INVESTMENTS

Emmonak Facility (1972-1976)		
Design	$ 63,700	
Construction	514,300	
Safety Modifications and Facility (Completion to date)	181,600	
Additional Work Required, est.	25,000	
Grant for Repair (Operation and Maintenance)	127,068	
Estimated Total	$906,668	
Wainwright I Facility (1972)		
Design	$ 52,900	
Construction Contract	508,600	
Misc. Direct Support	15,000	
Water Storage Tank (IHS)	335,000*	
Total	$911,500	
Wainwright II Facility (1975-1979)		
Design and Inspection	$ 49,500	
EPA Procurements	210,500	
Construction Contracts:		
Phase I	529,500	
Phase I (HUD contribution)	50,000*	
Phase II	495,000	
Extension of Award Period	85,000	
Contract Modifications, est.	10,000	
Shipping of Equipment and Materials	75,700	
Force Account Work	10,000	
Generator Shelter	8,000	
Vehicle Shelter (IHS)	50,000*	(1974)
Vehicles and Trailers (IHS)	54,000*	(1972, FOB Anchorage)
Grant for Repair (Operation and Maintenance)	887,000	
Estimated Total	$2,514,200	
Design for Smaller Villages	$60,233	

OPERATING EXPENSES

Village Personnel Training	$33,000	
Operation and Maintenance - Emmonak (April 1, 1973 to October 1, 1975)		
Revenues	$ 78,400*	
EPA Support	110,800	
Total	189,200	
Operation and Maintenance - Wainwright (April 11, 1973 to October 1, 1975)		
Revenues	$ 34,700*	
IHS Support	2,000*	
EPA Support	79,500	
Total	$116,200	
EPA Administration (1971 through FY 1975)		
Personnel	$497,600	
Travel	144,700	
Miscellaneous	51,400	
Total	$693,700	
Grand Total	$5,424,701	

SECTION 5

STATE OF ALASKA PROJECTS

Since 1970, the State of Alaska has had a rather ambitious program to provide sanitation facilities for rural villages. References 16 and 17 have very briefly documented the early progress of this program. The State is actively pursuing the accelerating this activity to improve village sanitation conditions.

THE VILLAGE SAFE WATER ACT

The Village Safe Water Act of 1970 was passed for the purpose of providing "safe water and hygienic sewage disposal facilities in villages in the State", and to assure that there will be at least one facility for safe water and hygienic sewage disposal, and bathing and laundry services. A village is defined as "an unincorporated community which has between 25 and 6000 people residing within a two-mile radius; or a second class city". The VSW act is administered by the Alaska Department of Environmental Conservation (ADEC).

A village receiving a VSW project is not required to contribute toward costs of construction. The State may "provide for construction by contract or through grants to public agencies or private non-profit organizations, or otherwise".

When a VSW facility is completed the recipient village must be given title to it. The village must agree to accept ownership of the facility and be responsible for its operation and maintenance. The State at the discretion of the Commissioner may assist a village with operation and maintenance expenses when the local governing body lacks sufficient financial resources.

VSW CONSTRUCTION EXPERIENCES

By the end of fiscal year 1979, Village Safe Water sanitation facilities will have been constructed in 11 Alaskan villages. Table 6 lists these villages along with data concerning population, location, climate, costs and year of construction. All VSW projects are central facilities. Figure 16 shows VSW project locations.

Northway and Chevak

In late 1972 and early 1973 the villages of Northway and Chevak requested assistance under the VSW program in finishing central facilities they had begun to construct on their own initiative. Since Northway and Chevak had committed their own resources and thus demonstrated a sincere desire to improve sanitation in the villages, they were granted VSW assistance.

TABLE 6. VILLAGE SAFE WATER PROJECT DATA

Village	Location N. Lat.	Location W. Long.	Population	Mean Jan. Temp °F	Mean Annual Temp °F	Constr. Cost X1000	Operating Cost X1000	Year of Initial Operation
Northway	62°58'	141°56'	40	-24	+22	60	28	1972
Chevak	61°32'	165°35'	447	+2	+29	75	37.5	1972
Nulato	64°43'	158°06'	330	-16	+25	860	109	1974
Selawik	66°36'	160°00'	521	-16	+22	1100	109	1975
Alakanuk	62°41'	164°34'	512	-3	+28	1000	109	1975
Pitkas Point	62°02'	163°17'	85	-3	+28	350	38	1976
Koyukuk	64°53'	157°42'	124	-16	+25	440	25	1976
Beaver	66°22'	147°24'	101	-20	+30	450	25	1976
Kongiganak	59°52'	163°02'	200	+2	+30	1100		1979
Tanana	65°10'	152°04'	350	-20	+23	1400		1979
Council	64°40'	163°40'		-8	+24	118		1979

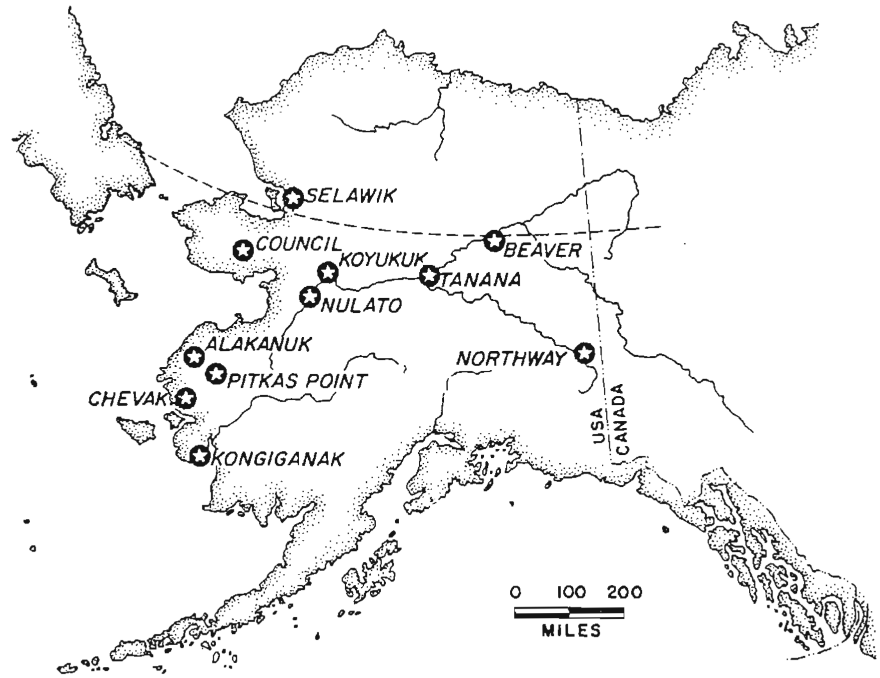

Figure 16. Location of Village Safe Water Projects built by the Alaska Department of Environmental Conservation.

Before the VSW project began, Northway had a one-story wood frame building of about 700 square feet situated over a well. The building housed a one-room health clinic, a watering point for the village and a room for community gatherings. The VSW project consisted of improving the watering point, and adding laundry equipment and showers. Wastewater from the facility (containing no toilet waste) is discharged to a small natural pond. Chemical toilets used in the facility are emptied into a Federal Aviation Administration sewage treatment facility several miles away.

<u>Nulato, Selawik and Alakanuk</u>

In early 1973 the Alaska Department of Education, lacking funds to provide water and sewer services for new schools scheduled for construction in Nulato, Selawik and Alakanuk, asked ADEC to install VSW facilities in those villages. The VSW facilities were to provide sanitation services for both the new schools and the villages. ADEC agreed to this arrangement in return for promised operation and maintenance support from the schools.

In each village the school and VSW facility were designed and constructed under joint contracts administered by the Alaska Department of Public Works. All three VSW facilities were patterned after the AVDP projects in Emmonak and Wainwright. They are two story structures approximately 55 feet square and built on piles. The facilities contain washers and dryers, showers, saunas, rest rooms, solid waste disposal bins, honey bucket dumps and a watering point.

Nulato

At Nulato the water source is a well, water from which contains more than 28 mg/l iron and 5 mg/l manganese. Water treatment is pre-chlorination followed by alum and lime coagulation/flocculation, rapid sand filtration, and post-chlorination. The water treatment plant is a standard Met-Pro physical/chemical package plant with 14,000 gpd capacity.

The sewage treatment plant is also a 14,000 gpd Met-Pro physical/chemical package plant, in which the unit processes are alum and lime coagulation/flocculation, carbon sorption, rapid sand filtration, and chlorination. Treated effluent is discharged to the land surface through an elevated, insulated and heated conduit.

Sludge from both the water and sewage treatment plants is dewatered by centrifugation and then hauled to a landfill. Originally the plant had an incinerator with a heat exchange unit, but operating problems caused this to be discarded.

Although the treatment plants have had problems, they are now performing adequately. Sludge build-up has been a problem in both plants.

A hot water boiler is the heat source, and a hot air furnace is the secondary source of building heat in case the boiler fails or is inadequate. The boiler and hot air furnace are interconnected through a complex control system which has been very difficult to keep operating properly.

Selawik and Alakanuk

The water and sewage treatment plants at Selawik and Alakanuk are the same as the plants at Nulato -- Met-Pro physical/chemical package plants with 14,000 gpd capacity. For these villages, however, the water is obtained from surface sources, and product water has been of good quality since the facilities were completed (Selawik in October, 1975, and Alakanuk in December, 1975). The sewage treatment plants also seem to be operating well. Treated effluent is discharged to the land surface.

The floor plans, mechanical systems, and methods of providing sanitation services in the Selawik and Alakanuk facilities are very nearly the same as in the Nulato facility.

All three of these plants require constant operator attention.

Pitkas Point

The Pitkas Point VSW facility was completed in February, 1976. It is a wood frame structure of about 1300 square feet resting on a post and pad foundation and containing a watering point, honey bucket dump, washers and dryers, rest rooms, showers and saunas. The water source is a collection gallery in the bed of a creek. Water treatment is rapid sand filtration and carbon sorption on an as-needed basis, followed by chlorination and fluoridation. Sewage is treated in a secondary biological system which consists of four 1000 gpd extended aeration package plants interconnected through a splitter box. The backage plants are Multi-Flo units with an aeration chamber, and solids separation through a filter membrane. Treated effluent is discharged to an underground leach field. The Pitkas Point school will be plumbed into the VSW facility to receive water supply and sewage disposal services.

Koyukuk

Design of the Koyukuk VSW facility was completed in February, 1976 and the well intended for its water source was drilled in September of 1975. This facility is similar in size and configuration to the one in Pitkas Point except that it contains no saunas and has a pile foundation system. The low capacity well (6 gpm) produces good quality water, so water treatment is only chlorination and fluoridation. Treated sewage effluent from three 1500 gpd (Multi-Flow) plants is discharged into a stream channel which has intermittent flow. The new school to be constructed in Koyukuk will receive water supply and waste disposal services from the VSW facility.

Beaver

This facility provides the same services as the one in Pitkas Point, including service for the village school. The water source is two wells in the thaw bulb of the Yukon River. Sewage treatment is extended aeration in a 5000 gpd Bio-Pure package plant. Treated effluent is discharged to a subsurface leach field in the thaw bulb of the Yukon.

Kongiganak

The facility is basically similar to the ones in Pitkas Point, Koyukuk, and Beaver; and it also serves the village school.

The water supply is the river, with a roof catchment system serving as a back-up source for the summer months. Kongiganak is located close to the coast and storms back up salt water into the river for 3-4 days at a stretch. 25,000 gallons of water storage is provided in order to provide water throughout these periods. A second problem is the varying water quality in the river. The late summer shows turbidities over 200 and color over 500. In the winter, the color and turbidity go down, but the iron content goes up as high as 15 mg/l. This necessitated installing a bank of multi-media, greensand and carbon filters, which sequence of use is varied throughout the year.

Wastewater treatment is accomplished by aeration with discharge to a salt water lake adjacent to the village.

Waste heat from the school generators is utilized to heat the building.

Council

Council has a watering point. Electricity for the well pump is provided by a wind generator which charges a bank of storage batteries. The electricity is used to run a submersible pump which feeds 1000 gallons of storage. The watering point is designed to operate for 2 weeks with no wind. A back-up generator is provided.

Tanana

Tanana uses a well in the thaw bulb of the Yukon River for its water supply. Chlorination and floridation are provided. The waste disposal is to an aerated lagoon which then discharges to a leach field. The lagoon also serves as the wastewater treatment facility for a hospital, school, and FAA facility located at Tanana.

COSTS

Table 6 contains a summary of capital construction costs for the VSW projects. The costs shown include both design and construction. The table also lists the estimated annual operating budgets for VSW facilities. The figures exclude amortization of capital costs.

Sources of revenue in the villages are limited. Individuals who use the VSW facilities pay fees, but fees cannot be so high people no longer can afford to use the facilities. One to two thousand dollars per month might be raised through users' fees in larger villages (400 to 500 residents) and proportionately less in smaller towns. Public health clinics, some owned by the U.S. Public Health Service and some owned by the villages, might receive water supply and waste disposal services from VSW facilities and thus become sources of revenue, but not more than a few hundred dollars per month. Fees paid for school water and sewer services represent a third source of revenue which could routinely amount to about 25 percent of the VSW facility operating budget. Hence as a general rule, more than half of the money needed to operate VSW facilities will have to come from outside the villages.

CONTINUING PROGRAM

ADEC has a continuing responsibility for VSW projects. Not only does ADEC assist in the design and construction of new facilities, but in the operation and maintenance of existing facilities. Because of the complex problems faced by VSW and all other organizations involved in building and maintaining sanitation services in the bush, a comprehensive Statewide planning effort was initiated. It was hypothesized that by bringing the major participants together, workable solutions to common problems like operation and maintenance could be developed, thereby increasing the effectiveness of existing programs and improving sanitation conditions in the villages. However, after nearly two years of intense effort, VSW staff concluded that this statewide comprehensive approach was not feasible. As a result, the plan of study was recently revised to focus solely on the VSW program. When completed, this planning effort would:

1) Prescribe a future role for VSW in relation to the other rural sanitation programs like the Public Health Service;

2) Recommend a rate at which new VSW facilities should be built, estimate funding levels and describe a method for setting construction priorities;

3) Recommend a strategy for operating and maintaining VSW facilities, estimate what it will cost and suggest how this support should be provided.

Hopefully, this revised approach will provide State policy makers with a strategy for dealing with two key issues: 1) the rate of capital construction; and 2) whether or not the State should continue to subsidize operation and maintenance of sanitation facilities.

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APPENDIX

PL 92-500 Section 113 as amended by PL 95-217

ALASKA VILLAGE DEMONSTRATION PROJECTS

Sec. 113.(a) The Administrator is authorized to enter into agreements with the State of Alaska to carry out one or more projects to demonstrate methods to provide for central community facilities for safe water and elimination or control of pollution in those native villages of Alaska without such facilities. Such project shall include provisions for community safe water supply systems, toilets, bathing and laundry facilities, sewage disposal facilities, and other similar facilities, and educational and informational facilities and programs relating to health and hygiene. Such demonstration projects shall be for the further purpose of developing preliminary plans for providing such safe water and such elimination or control of pollution for all native villages in such State.

(b) In carrying out this section the Administrator shall cooperate with the Secretary of Health, Education, and Welfare for the purpose of utilizing such of the personnel and vacilities of that Department as may be appropriate.

(c) The Administrator shall report to Congress not later than July 1, 1973, the results of the demonstration projects authorized by this section together with his recommendations, including any necessary legislation, relating to the establishment of a statewide program.

(d) There is authorized to be appropriated not to exceed $2,000,000 to carry out this section. In addition, there is authorized to be appropriated to carry out this section not to exceed $200,000 for the fiscal year ending September 30, 1978, and $220,000 for the fiscal year ending September 30, 1979.

(e) The Administrator is authorized to coordinate with the Secretary of the Department of Health, Education, and Welfare, the Secretary of the Department of Housing and Urban Development, the Secretary of the Department of the Interior, the Secreatry of the Department of Agriculture, and the heads of any other departments or agencies he may deem appropriate to conduct a joint study with representatives of the State of Alaska and the appropriate Native organizations (as defined in Public Law 92-203) to develop a comprehensive program for achieving adequate sanitation services in Alaska villages. This study shall be coordinated with the programs and projects authorized by sections 104(q) and 105(e)(2) of this Act. The Administrator shall submit a report of the results of the study, together with appropriate supporting data and such recommendations as he deems desirable, to the Committee on Environment and

Public Works of the Senate and to the Committee on Public Works and Transportation of the House of Representatives not later than December 31, 1979. The Administrator shall also submit recommended administrative actions, procedures, and any proposed legislation necessary to implement the recommendations of the study no later than June 30, 1980.

(f) The Administrator is authorized to provide technical, financial and management assistance for operation and maintenance of the demonstration projects constructed under this section, until such time as the recommendations of subsection (e) are implemented.

(g) For the purpose of this section, the term "village" shall mean an incorporated or unincorporated community with a population of ten to six hundred people living within a two-mile radius. The term "sanitation services" shall mean water supply, sewage disposal, solid waste disposal and other services necessary to maintain generally accepted standards of personal hygiene and public health.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/3-80-039	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Alaska Village Demonstration Projects Final Report		5. REPORT DATE March 1980 issuing date
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Barry H. Reid		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Corvallis Environmental Research Laboratory 200 S.W. 35th Street Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS U.S. EPA Office of Research and Development 401 M Street, S.W. Washington, D.C. 20460		13. TYPE OF REPORT AND PERIOD COVERED inhouse - final
		14. SPONSORING AGENCY CODE EPA/600/02

15. SUPPLEMENTARY NOTES Concludes project descriptions reported in "Report to the Congress Alaska Village Demonstration Projects" (July 1, 1973) and "Water Related Utilities for Small Communities in Rural Alaska" EPA-600/3-76-104.

16. ABSTRACT

Two demonstration projects were built as authorized by Section 113 of PL 92-500. Modular construction was used to provide central utility systems which included water supply, laundry, bathing, saunas, and wastewater treatment. Service to homes was by vehicular delivery. Fire destroyed the facility at Wainwright in 1973 and the project was subsequently rebuilt. Energy conservation measures were employed to minimize costs of operation. Equipment performed satisfactorily, but operator preparedness was lacking, thus, many breakdowns occurred. Overall cost of operation and maintenance of the facilities nearly exceed the financial capacity of the communities. Ownership of the facilities was transferred to the local government by the EPA. The AVDP was paralleled by projects built by the Alaska Department of Environmental Conservation (ADEC) at 11 locations. Small communities need outside support for operation and maintenance of utility systems. Time and training will be required to prepare local residents to assume managerial responsibilities for these projects.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Alaska Water Supply Wastewater Treatment Vehicular Delivery Costs Energy Conservation	AVDP Village Safe Water Program Central Utility Systems		06/F, I 13/B, M

18. DISTRIBUTION STATEMENT Release to public	19. SECURITY CLASS *(This Report)* unclassified	21. NO. OF PAGES 62
	20. SECURITY CLASS *(This page)* unclassified	22. PRICE

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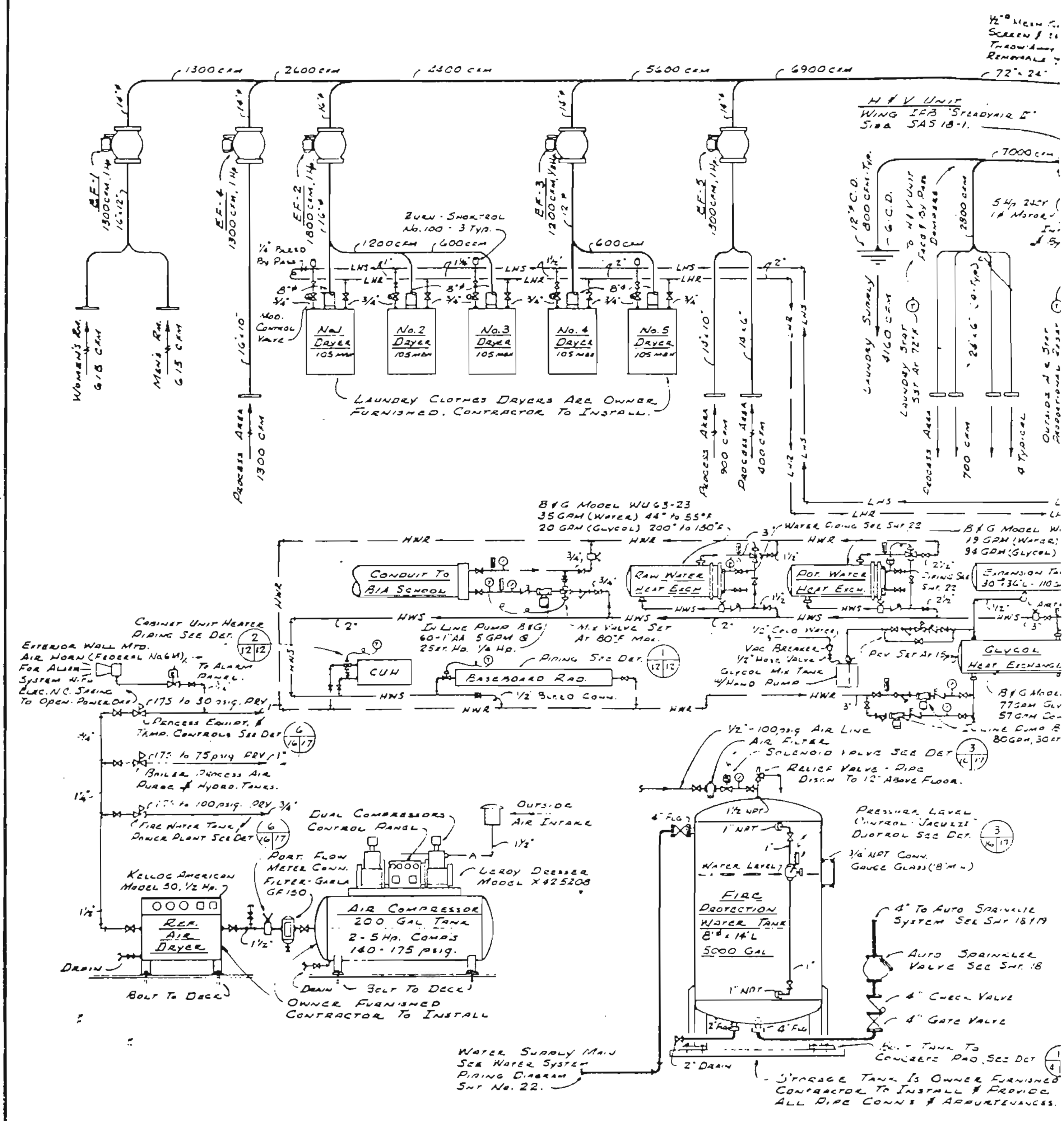

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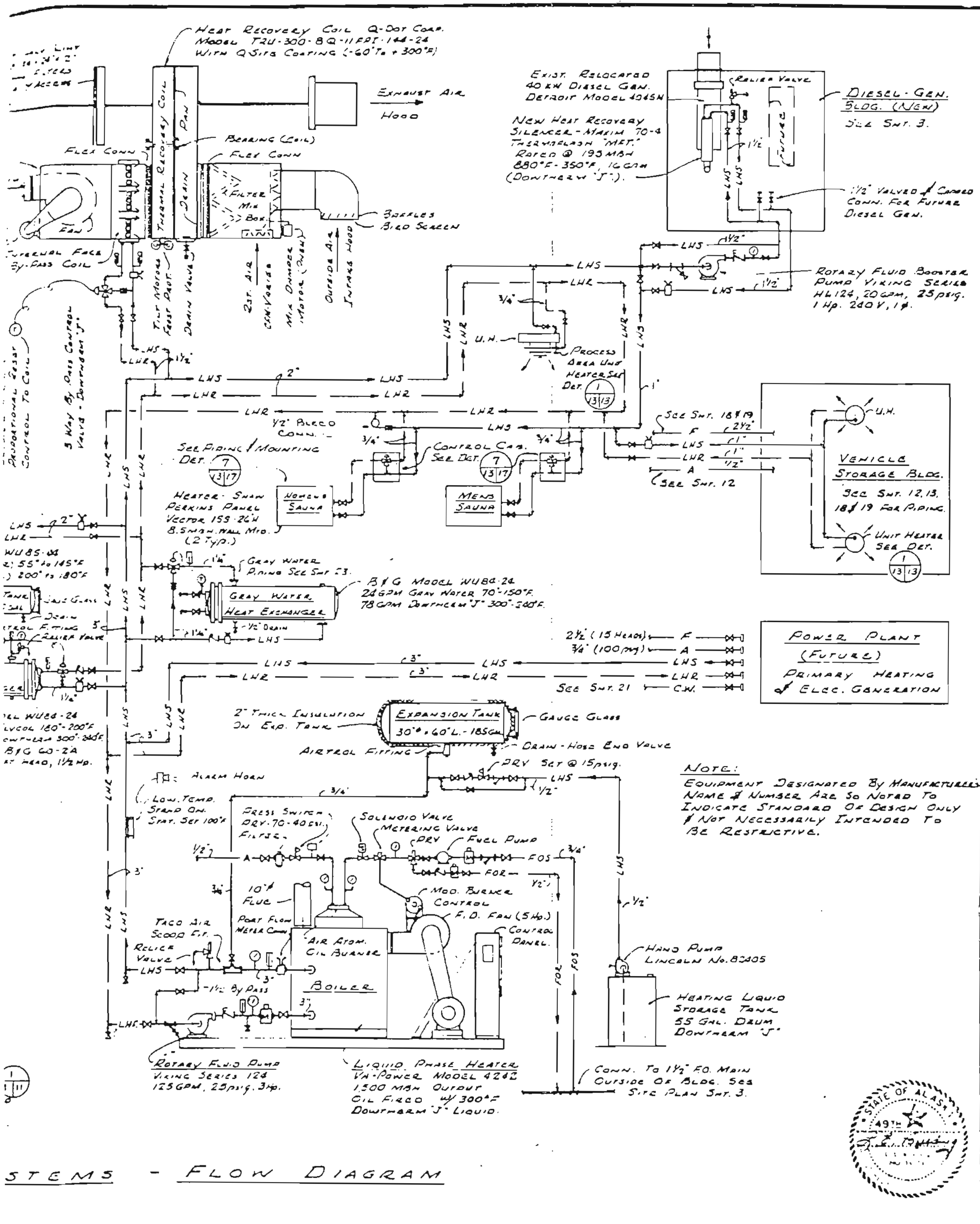

STEMS - FLOW DIAGRAM

Figure 6.

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