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WATER RELATED UTILITIES FOR SMALL COMMUNITIES IN RURAL ALASKA

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WATER-RELATED UTILITIES FOR SMALL COMMUNITIES IN RURAL ALASKA

by

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ABSTRACT

The "Alaska Village Demonstration Projects" (AVDP) were authorized by Section 113, P. L. 92-500 (86 STAT 816), for the purpose of demonstrating methods to improve sanitary conditions in native villages of Alaska. Central community facilities have been constructed in the native villages of Emmonak and Wainwright to provide a safe water supply; toilets, bathing and laundry facilities; and sewage and waste disposal.

The idea of coming to a community center to secure water, to do the laundry, and to bathe has proven acceptable to the people of Wainwright and Emmonak. However, Alaskan native villages generally can not pay, through service charges, the full cost of routine operation and maintenance of water-related utilities, especially where complex treatment is required to meet waste treatment standards.

The physical-chemical wastewater treatment provided required considerable modification and detailed operator attention to provide consistent secondary treatment. There is no single best method of constructing water-related utility facilities in rural Alaska. A limited number of standard designs can not be expected to meet the wide range of local conditions.

The U. S. Public Health Service and the Alaska Department of Environmental Conservation are the two agencies with primary responsibility to establish and improve water-related utility services in rural Alaska. Appropriate institutions do exist for providing native villages with the technical, logistic and administrative support they need to operate and maintain basic utilities. Funding for operation and maintenance and the level of waste treatment required remain as issues for resolution.

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Unless otherwise stated, the views, conclusions and recommendations are those of the Alaska Village Demonstration Project staff and the U.S. Environmental Protection Agency. Wherever substantial differences of opinion occurred, they are so indicated in the text.

SECTION I

INTRODUCTION

BACKGROUND

The Alaska Village Demonstration Projects (AVDP) serve 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 water is seldom obtainable and where adequate waste disposal is often impossible without facilities for special treatment. Typical sources of drinking water are streams, ponds, 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 discarded fuel drums at home.

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

The difficulties of arriving at satisfactory, 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 or the severe climate. Water is in the frozen state 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 normal weather conditions. These considerations substantially increase associated health hazards. Basic health and environmental standards can be achieved only through new service concepts such as reuse of water and through application of unconventional technology.

These are some of the pressing problems which stimulated legislation to conceive, construct, and install prototype facilities which demonstrate methods of providing basic utility services in Alaskan native villages.

SCOPE AND PURPOSE

The Federal Water Pollution Control Act Amendments of 1972, Section 113, "Alaska Village Demonstration Projects," required that the Environmental Protection Agency report to Congress on the results of

the projects by July 1973. The interim report submitted at that time described the work accomplished in the villages of Emmonak and Wainwright and presented preliminary results. No specific recommendations relating to the establishment of a statewide program were included. After an adequate period of facility operation and evaluation, another report was planned for July 1975 to present technical, economic and social findings in less tentative terms. Unfortunately, the Alaska Village Demonstration Project suffered a major setback in November 1973 when the Wainwright facility was destroyed by fire. Loss of the Wainwright project, subsequent efforts to replace it, and work required to make the Emmonak facility operational resulted in postponement of the second interim report.

Despite these difficulties, substantial progress has been made, valuable technical information has been acquired and important policy issues have been identified. The purpose of the present report is (1) to provide an evaluation of the implementation and operation of the project, and (2) to describe other Federal and State programs for providing water-related utility services in rural Alaska.

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 at a central community facility as opposed to the more conventional approach of extending full-scale water and sewage service to all homes. A secondary consideration was that the facilities be of modular design to permit easy transport and quick installation. It was felt that this approach could reduce the construction costs and permit facility relocation if the village, at some future date, 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 2 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 and appropriated 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.

SECTION II

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. However, they can fill this essential role only if they receive State or Federal financial support. Federal support could be furnished under provisions of the Indian Self-Determination and Education Assistance Act (P.L. 93-638).

OPERATION AND MAINTENANCE COSTS

With rare exception, Alaska native villages can not pay, through service charges, the full cost of routine operation and maintenance of water-related utilities, especially where complex treatment is required to meet established waste treatment 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 resources are available, these installations contribute to the economic well-being 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.

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 of raw wastes and should be designed as simply as possible to meet standards. The physical-chemical wastewater treatment package plants furnished with the original facilities at Wainwright and Emmonak required considerable modification and detailed operator attention to consistently provide secondary treatment.

OTHER STATEWIDE PROGRAMS

The U. S. Public Health Service and the State of Alaska Department of Environmental Conservation are the two agencies with primary responsibility to establish and improve water-related utility services in rural Alaska. Although their approach to meeting these basic needs is different, both appear to be a viable mechanism for accomplishing a statewide program.

FUTURE DIRECTION

The U. S. Environmental Protection Agency (EPA) can continue to make important contributions in improving utility services in Alaskan villages through its cold climate research capability at the Arctic Environmental Research Station (AERS) in College, Alaska. By developing certain innovative features and modifying existing technology in facilities constructed by other agencies, and through evaluation and process optimization, the EPA can attain desired environmental objectives. Such applied research is necessary, not only in relation to water and waste problems in villages, but in reference to electric power generation and conservation of energy.

SECTION III

RECOMMENDATIONS

Upon completion of the facilities at Emmonak and Wainwright, direct involvement by EPA in the construction of village facilities should be concluded. It is recommended that the Agency shift its emphasis towards an applied research program in the Arctic to meet the unique technological needs for environmental protection in this rapidly developing region.

SECTION IV

PROJECT IMPLEMENTATION

The July 1973 Report to Congress described in detail the early stages of project implementation. Therefore, only subsequent considerations and events will be discussed here.

OPERATION AND MAINTENANCE CONTRACTS

During the initial months of facility construction and operation, two men from each village were temporarily hired by EPA to be trained and introduced to the job of operating and maintaining the facilities. Materials and supplies required for facility operation were initially furnished by EPA; overall supervision was provided by EPA's AVDP staff.

In mid-1973, as a first step in transferring management responsibility to the villages, and as a way to accomplish facility completion, evaluation and modification, cost-sharing contracts were negotiated with the City Councils of Emmonak and Wainwright. Under these contracts the operators originally hired by EPA became City employees with EPA project engineers providing the necessary technical guidance. Facility income was applied against costs, with EPA paying the balance. Both contracts became effective in November 1973.

Transfer of ownership of the Emmonak facility to the community is currently being discussed with the City Council. After transfer of ownership, the community will continue to need some financial assistance to operate and maintain the facility. It is envisioned that EPA and the City of Emmonak will agree to a short-term (2-3 years) fixed price contract. This contract arrangement will require more management responsibility by the City Council and will give them time to properly plan for long-term operation. In return, EPA will continue to receive the detailed financial and operating data necessary to prepare the final Report to Congress.

COMPLETION OF THE EMMONAK FACILITY

Bionomics Control Corporation (a subsidiary of Maurice P. Foley Company in Washington, D. C.), the contractor responsible for the design and construction of the central community facility at Emmonak, performed unsatisfactorily. In mid-1973 he declared inability to finish the job, leaving EPA with an incomplete, poorly constructed facility which required modification and upgrading in a number of critical areas.

Major structural difficulties resulted from the contractor's decision to install sumps and drains below the floor of the building and to keep these from freezing by skirting the foundation. Since the foundation had been designed to remain exposed to the ambient air, the ground below the foundation was subject to differential freezing, causing

severe heaving of the perimeter and shifting of the building modules. To correct this problem extensive modifications were required.

The original facility design called for a prototype molten salt catalytic combustor for sludge disposal and primary heat. After the contractor experienced developmental problems with the catalytic combustor, a conventional incinerator was used as a replacement. Since insufficient space had been alloted for this equipment in the original building, an annex had to be constructed.

In December 1973, a safety inspection by EPA's Safety Management Staff identified 33 inadequacies with recommendations for correction. These ranged from minor tasks such as installing exit signs, emergency lights and vacuum relief valves, to major modifications such as providing external fire fighting capability, installing an auxiliary generator, upgrading and extending the fire sprinkler system and relocating the fuel storage tanks.

Since the original contractor had failed to supply adequate facility plans and design information, and due to the piece-meal, remedial nature of the remaining work, only a few of the facility completion tasks could be performed under contract. Therefore, progress in making the facility fully functional was slow and was accomplished essentially through inhouse efforts. By March 1975, all major systems were complete and in operation. (Figures 1 & 2).

The services provided to the community of Emmonak (pop. 450) are varied but limited. The villagers' needs for bathing and laundering have been met. Institutions such as the Bureau of Indian Affairs (BIA) school, the hotel-restaurant-office complex called for the community center, and the new high school are connected via short utiliducts. These institutions get potable water. Their graywater (laundry, shower and sink wastewater) and blackwater (toilet wastewater) are treated on a routine basis.

Most drinking water used in the homes is hand-carried from the facility or transported by snowmobiles and sleds. This is not fully satisfactory because the water could be contaminated in transit; also, some of the more distant households use water from the facility only intermittently.

Disposal of human wastes from homes is accomplished by honey bucket. A receiving station for honey buckets has been constructed at the facility. Whether villagers will find it possible to individually transport honey buckets to the treatment plant for disposal remains to be seen.

To evaluate alternative delivery systems, two vehicles with trailers are available to deliver water and collect wastes. One is a small, 18-horse power, tracked vehicle, the Ranger V, manufactured by N. P. Arnold Company, Inc.; the other is a 1-ton, four-wheel drive Dodge pickup with oversized tires and a snowplow. So far, neither vehicle has served effectively, partly because higher priority work has demanded the operators' attention, but also because of the very difficult driving conditions at Emmonak.

Figure 1. Emmonak Laundry Area

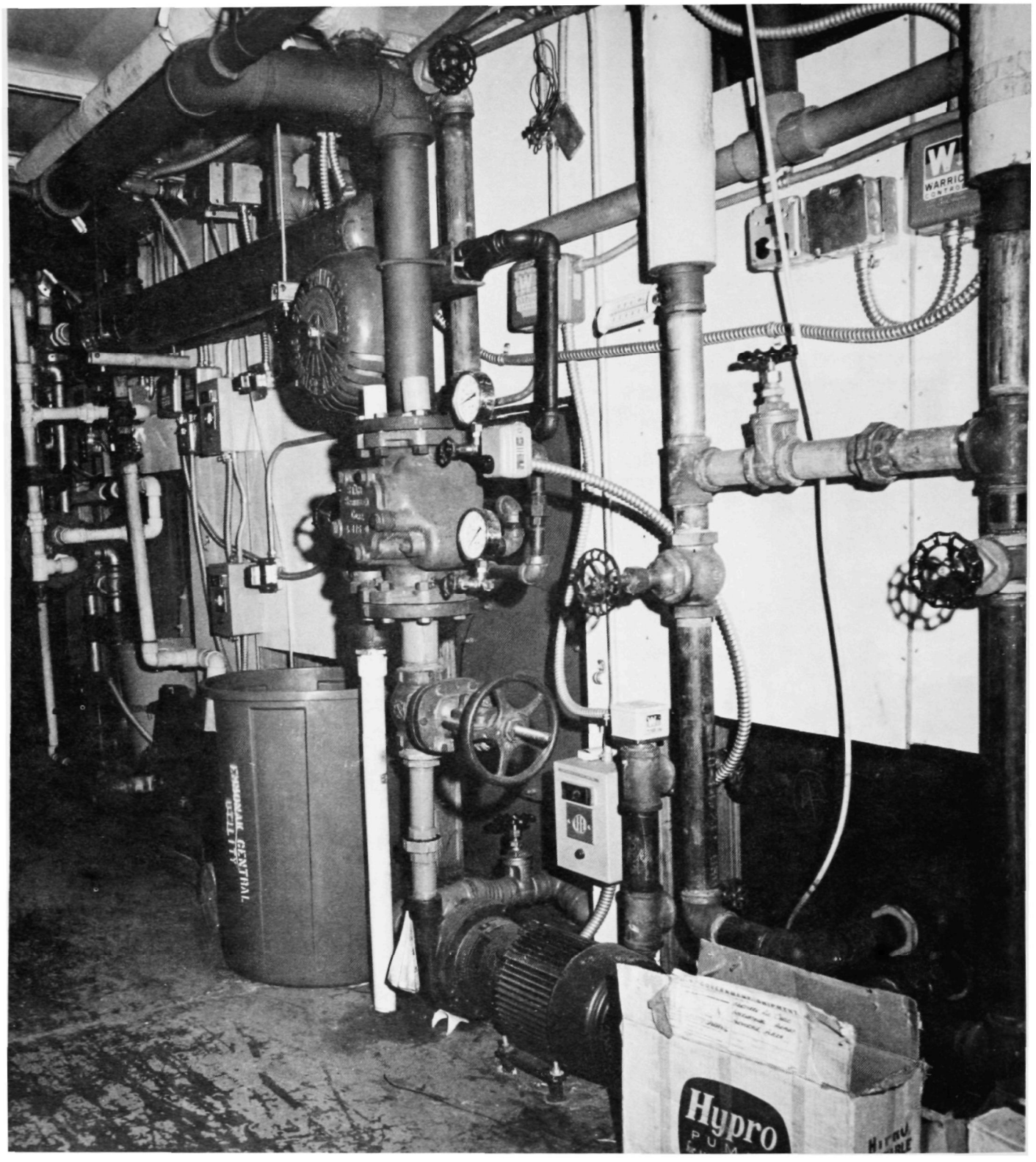

Figure 2. Emmonak Water and Wastewater Treatment Systems.

Improvements in the maintenance and the performance of the two vehicles can and will be made, providing additional useful information. However, to provide Emmonak homes with full scale delivery and pickup service and a satisfactory method of solid waste disposal will require a comprehensive program involving drainage, road improvement, holding tanks and fixtures in homes, a vehicle maintenance facility, several large tanker trucks and perhaps a small tractor. Such a project is considered beyond the scope of work authorized by the AVDP legislation.

WAINWRIGHT FIRE

The Wainwright facility was essentially complete and its various systems in full operation at the time of the fire. (Figure 3). A comprehensive technical evaluation of the facility was under way. Two trained, competent village residents were in charge of the operation and maintenance of the facility under the EPA contract with the City of Wainwright.

On Saturday, November 24, 1973, at approximately 8:30 p.m., a fire was reported in the central facility. The operators had checked the building at 7:30 p.m., found nothing out of order and had secured it for the night. The weather was relatively warm (0 to 10°F) but very windy.

The fire, when discovered, was confined to the attic. One of the facility operators and a companion entered the attic area and observed flames on the heat exchanger and stack enclosure. They fought the fire with hand extinguishers with little effect. Thick smoke forced both men to retreat and they were unable to reenter the attic. Several volunteers climbed onto the roof and unsuccessfully attempted to extinguish the fire around the stack with hand extinguishers. By 9:30 p.m., the facility was completely destroyed. (Figure 4)

The central facility was unoccupied at the time of the fire and no one was injured. Adjacent structures and equipment such as the water storage tank, generator building, utiliduct and fuel storage tanks were not damaged

The investigation into the cause of the fire concluded that the fire did originate on the heat exchanger enclosure located in the attic space. The enclosure consisted of a 4-inch cavity wall with the interior plywood surface treated with fire retardant paint. The cavity was filled with fiberglass insulation and the outside wall finished with plywood.

The fire is presumed to have been caused by heat which escaped from a flange at one end of the heat exchanger and passed through the inside wall of the enclosure, charring then igniting the combustible wall material on the attic side. What caused the heat exchanger to overheat or to fail has not been determined. The AVDP staff did inspect and partially dismantle the heat exchanger after the fire. However, without

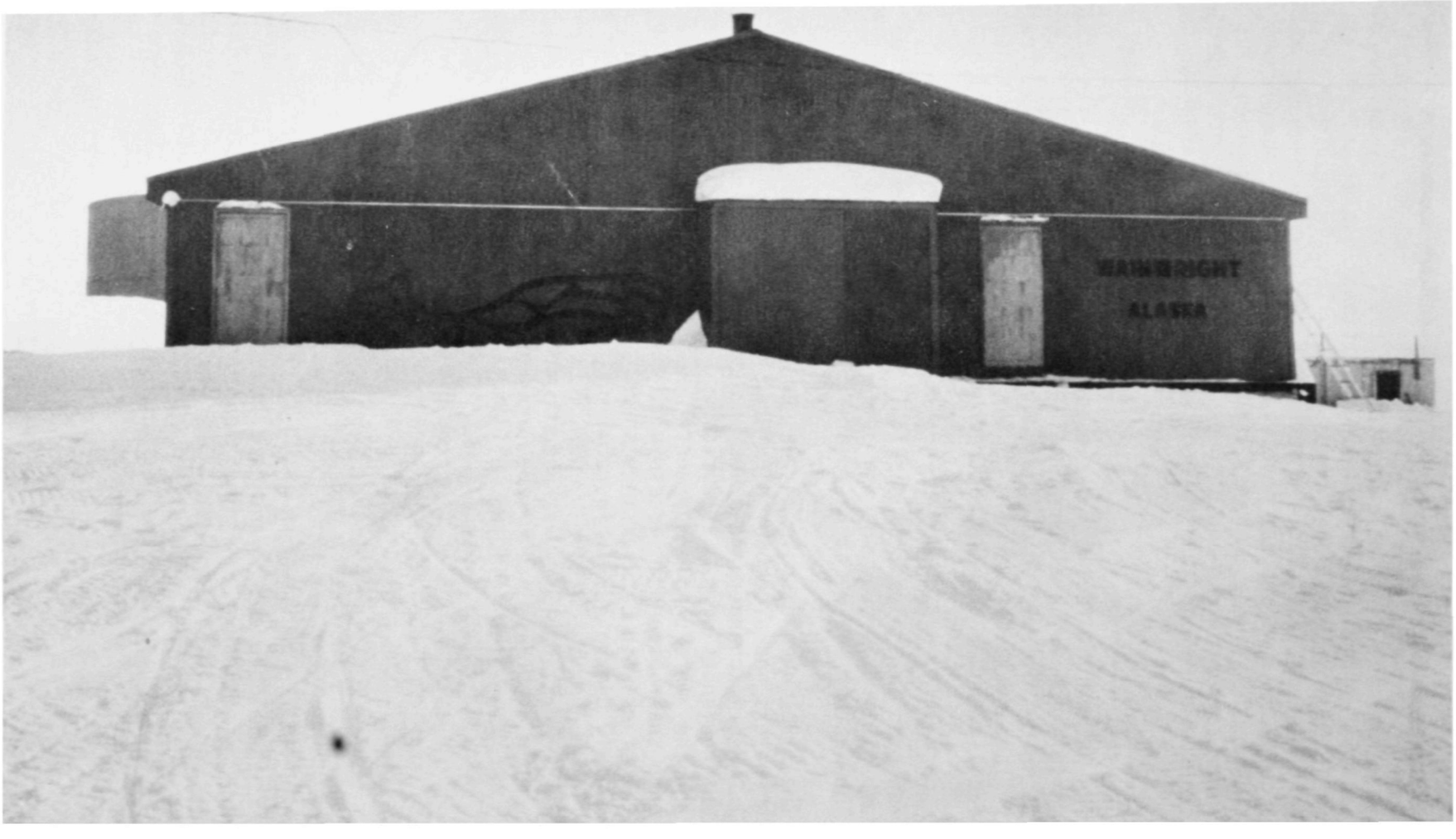

Figure 3. Wainwright I - Before Fire.

Figure 4. Wainwright I - Completely Destroyed by Fire

special tools and equipment they were unable to completely dismantle the unit for detailed examination.

The facility was equipped with a "Halon 1301" fire suppression system which was designed to protect the high hazard areas of the building, including the heat exchanger enclosure. However, the Halon system was set up to flood the heat exchanger space from the inside. The system was not designed to protect the outside of the enclosure or the attic space. At what time during the fire the Halon System discharged is not known. A rate of rise detector was located inside the heat exchanger enclosure.

Regardless of the precise cause of the fire, one fact is obvious. The facility did not have an adequate fire suppression system, nor was there a well defined fire fighting plan for the village.

Immediately after the fire, the AVDP staff took action to protect the remaining components of the facility complex and to provide the village with potable water throughout the winter. A temporary building was erected adjacent to the 1-million-gallon, insulated, raw water storage tank which had originally been provided by the Indian Health Service. A small boiler and other equipment was installed to protect the water storage tank from freezing and to dispense water to the village. The Indian Health Service supplied two tracked Bombardier Musket Carrier vehicles to haul water for delivery to the BIA school and to individual homes. A location was selected for disposal of school sanitary wastes and of fire debris. After spring breakup the facility site was cleared of debris in preparation for rebuilding. In 1974, the Indian Health Service constructed a vehicle shelter and maintenance building, as a first major step in replacing the former facility.

SECOND GENERATION FACILITY - WAINWRIGHT II

In February 1974, EPA decided to move ahead as rapidly as possible to replace the destroyed facility. Total cost was estimated at $650,000. To provide initial financing, funds earlier earmarked for construction of a third facility, at a yet undesignated location, were reprogrammed for reconstruction of the Wainwright Center.

Design

In replacing the Wainwright facility, several changes were made in the original procedures and design. Experience with the project had identified the important desirable features of a central community facility. On the basis of these features, design and technical specifications were prepared under a conventional Architectural and Engineering (A&E) contract by the CH_2M/Hill Corporation in Anchorage, Alaska. Construction is being accomplished under a firm price contract.

The unqualified acceptance by Wainwright residents of the central community facility concept indicated that the replacement plant should be permanent. Experience with interfacing the individually transportable

building modules of the former facility and the one at Emmonak showed that to provide for the possibility of relocating this type of facility was not a good project criterion. The second generation plant, therefore, is housed in a larger, prefabricated metal building with 21 ft. eaves. The additional space makes possible the use of gravity drains, improves access for equipment maintenance and provides the public greater comfort in the laundromat and bathing areas. All treatment equipment is on the first floor and the public area is located in a mezzanine. Figures 5 and 6 show floor plans.

Additional emphasis was placed on fire safety in the new facility. A sprinkler system will protect the entire structure. External fire fighting capability will be provided. All wood above the foundation will be fire retardant treated, and walls will be of type X gypsum or asbestos millboard.

In the absence of large amounts of water under pressure, providing a sprinkler system that fully meets code was expensive. Two alternatives were presented. One was a large diesel-driven pump which would start automatically upon release of a sprinkler head. The other was a 5000-gallon steel vessel in which water is kept under pressure by a heavy duty compressor. The latter system, considered more reliable and economical, was selected.

Since the quality of raw water at Wainwright is uniformly high, it was decided that potable water treatment could be accomplished without coagulation. Potable water, therefore, will be produced by carbon adsorption, filtration, and disinfection with sodium hypochlorite. Plant capacity has been increased to 12,000 gallons per day (gal/day) and storage capacity for potable water will be 5,000 gallons. A schematic diagram of the potable water plant is shown in Figure 7.

Wainwright has no year-round source of liquid water. A 1-million-gallon insulated storage tank, provided by the Indian Health Service, limits the amount of raw water available to the community in a year. Therefore, as in the original facility, reuse of graywater for laundering is planned. Graywater treatment at Wainwright II, however, will substitute powdered carbon for granular carbon. This change was made to avoid innoculation of the recycle water system with microorganisms which seem to thrive in carbon columns. In the potable water system this problem will not be significant because the raw water contains very few bacteria and it will be filtered and disinfected after passing through the adsorption unit.

The size of the graywater treatment system was increased to 25,000 gal/day so that more water would be available in the laundry. Also, the storage capacity for raw graywater was increased from 1,200 gallons to 5,000 gallons so that laundry and shower water would cool down before treatment. This should reduce the thermal shock loading which caused difficulties in the floculation/sedimentation chamber of the original plant. Schematics of the graywater treatment systems are shown in Figures 8 and 9.

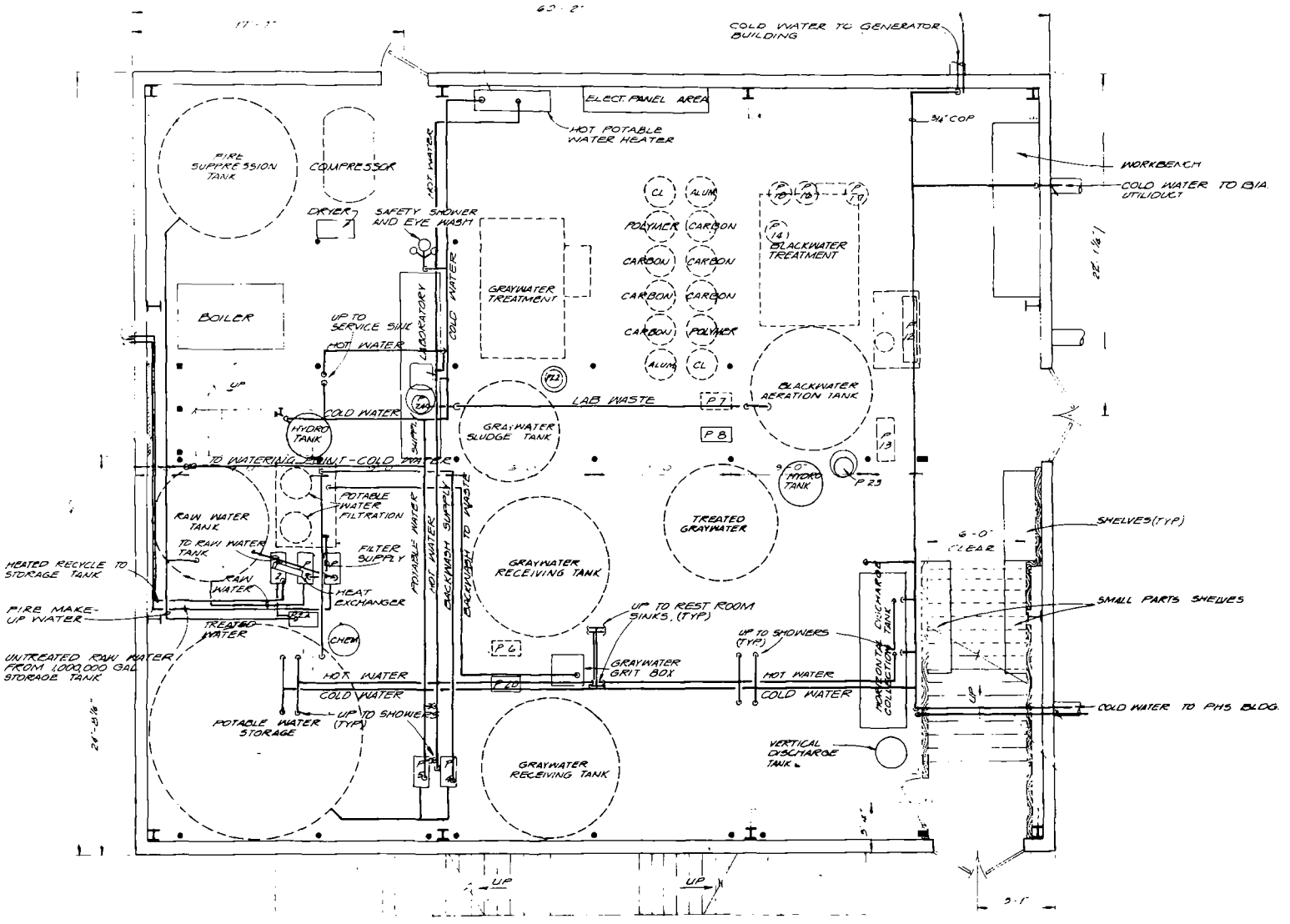

Figure 5. Wainwright II - First Level Floor Plan

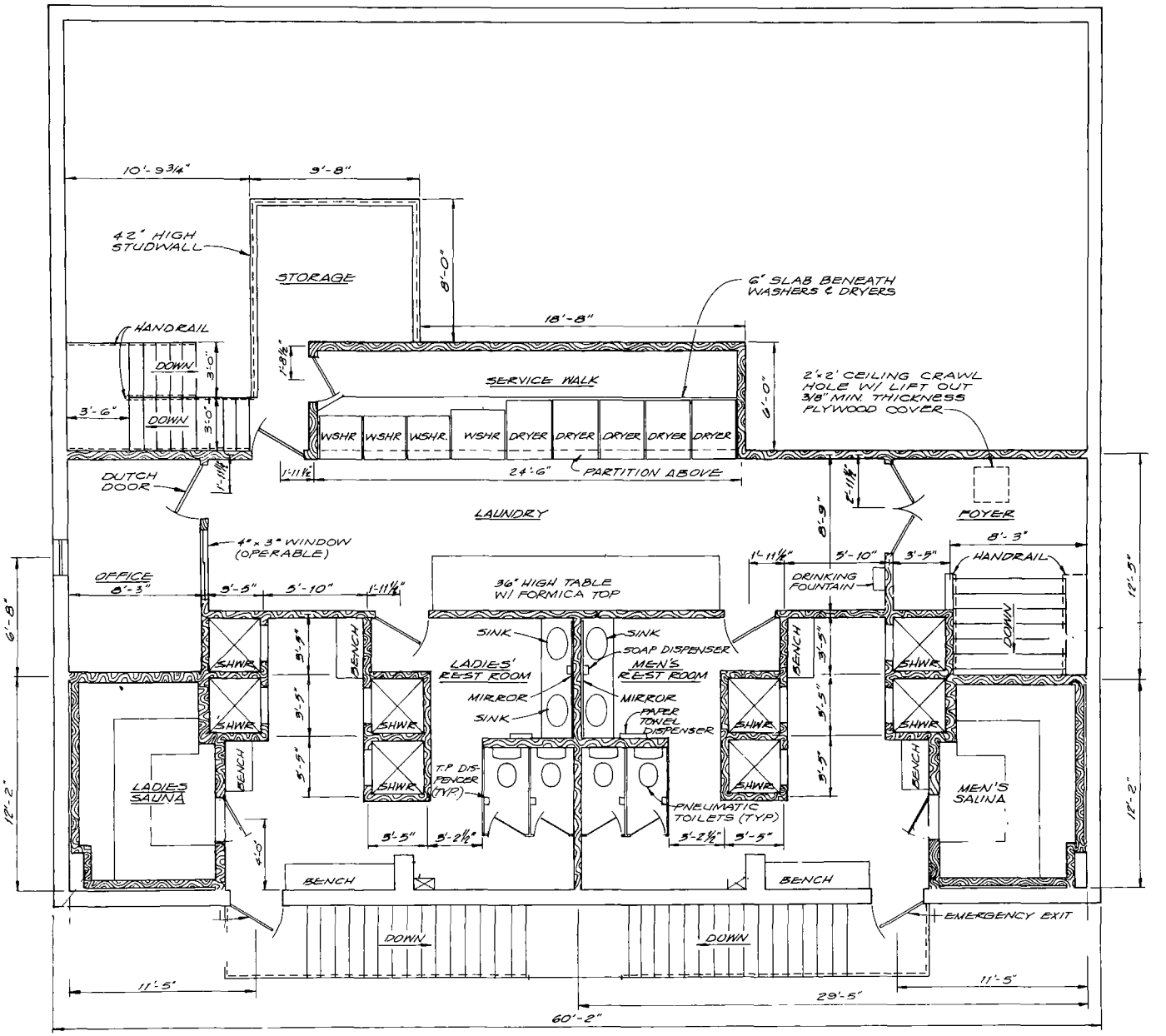

Figure 6. Wainwright II - Second Level Floor Plan

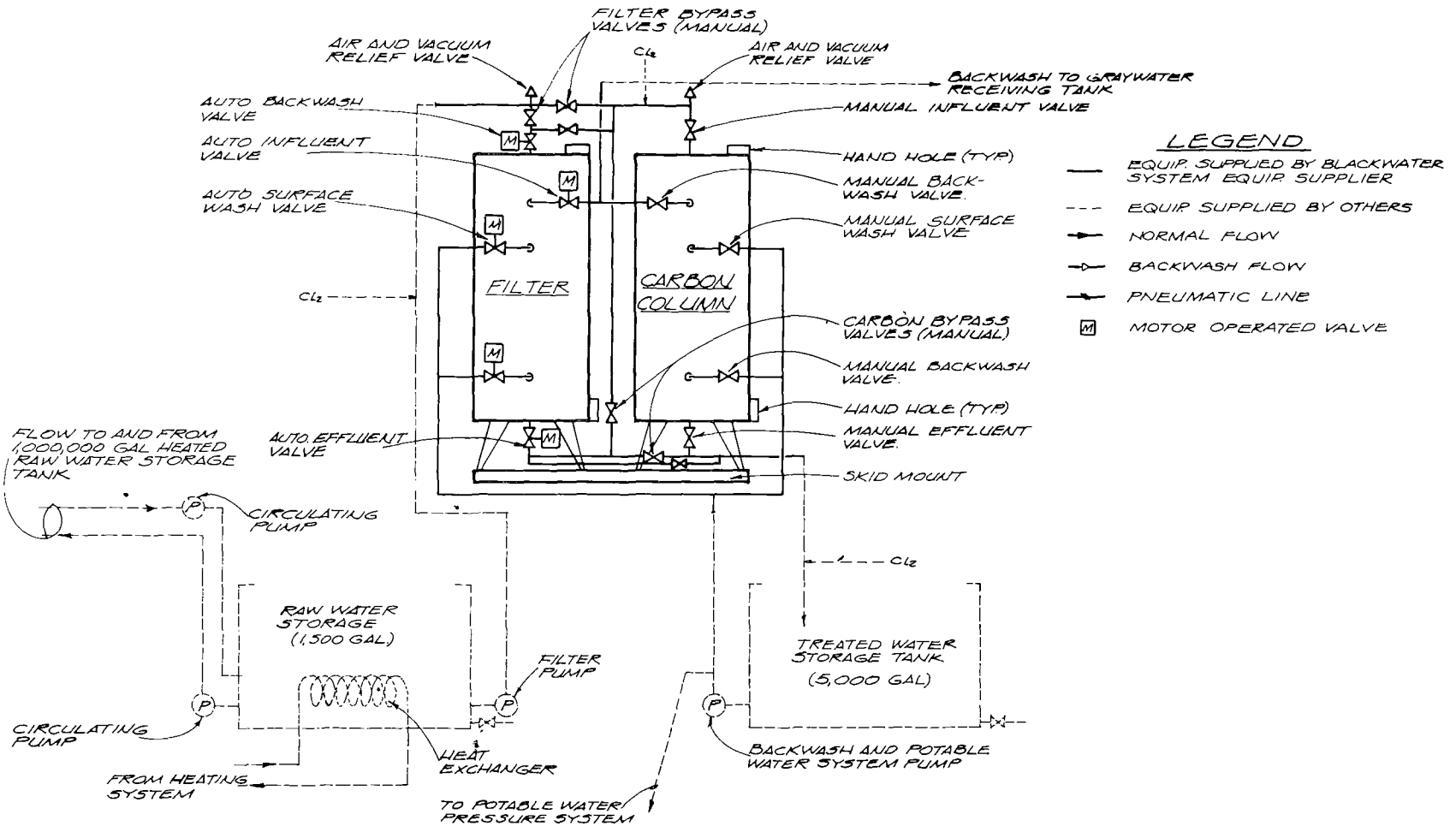

Figure 7. Wainwright II - Potable Water Treatment Plant

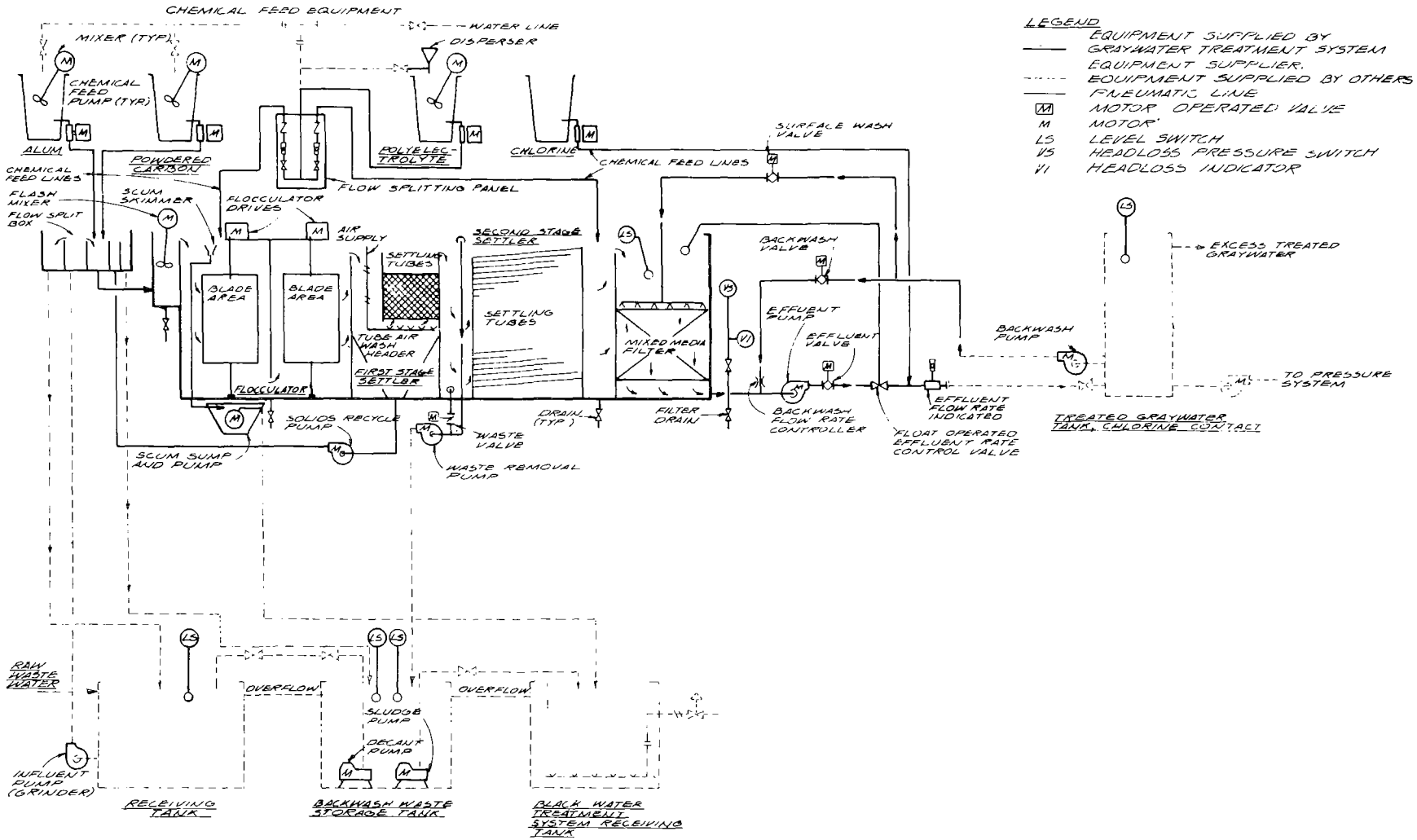

Figure 8. Wainwright II - Graywater Treatment Plant

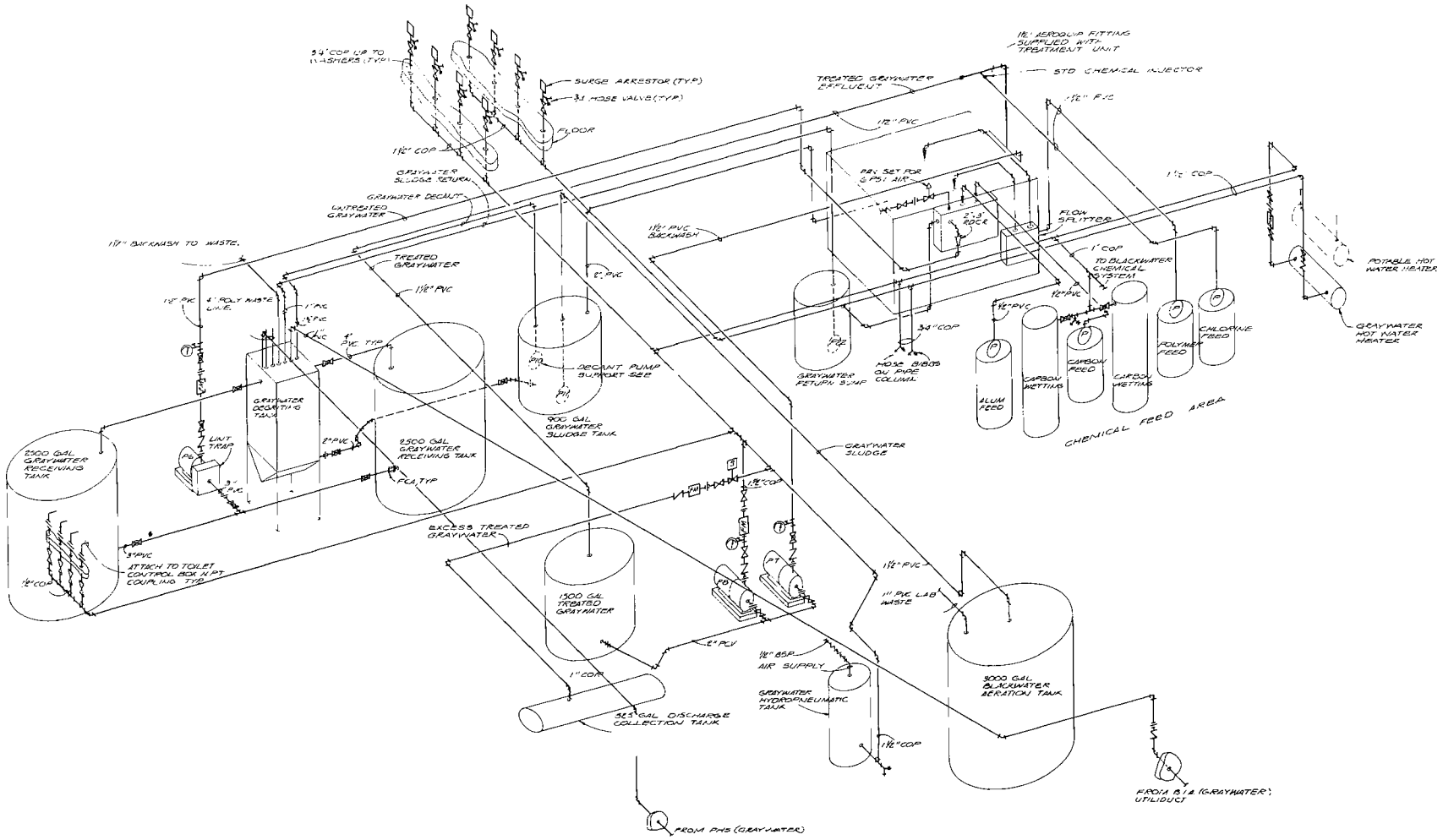

Figure 9. Wainwright II - Graywater System Piping Diagram

Blackwater will be treated in a package plant similar to that provided for graywater treatment, but smaller. The plant will receive human wastes and process sludge supernatant from graywater treatment. This will be held in an aerated tank and treated on a batch basis. Accumulated solids will be allowed to settle and then be removed, disinfected by lime treatment to pH 11 or higher and then disposed on land at a designated site away from the village. Together with excess treated graywater, the final effluent will be disinfected and discharged to the ocean.

Because of the high energy cost of incineration, regardless of heat recovery devices, no incinerator will be provided by the project. The North Slope Borough administration is investigating the use of local coal to generate power in a plant to be constructed adjacent to the central community facility. This plan has the potential for creating an efficient, well-integrated utility complex at Wainwright. Incineration could be accomplished more economically in the power plant, and large quantities of waste heat would be available for heating the adjacent public building. In anticipation of this development, Wainwright II was designed to permit easy interface with future power generation to recover waste heat. Until such time as power can be furnished reliably by a central power plant, electricity required in the central community facility will come from a 50 KVA diesel generator. A heat recovery silencer will be installed to extract exhaust heat for other process uses.

Construction

Upon completion of the revised design for Wainwright, in October 1974, it became clear that the reconstruction work could not be done with what funds remained of the $2 million authorized for the projects by Congress. In the course of the year, the massive amount of Trans-Alaskan Pipeline work and inflation had caused construction costs in Alaska to rise sharply. Total cost of Wainwright II was now estimated at $1,100,000. In November 1974, the Alaska Congressional Delegation sponsored identical bills in the Senate and the House to increase the amount to $3,500,000. After Congress reconvened in early 1975, the legislation was resubmitted as H. R. 3813 and S. 1151.

To reestablish beneficial occupancy at the earliest date, major equipment items and materials were identified early in the design process and purchased by EPA. This permitted the project to take advantage of funds available in FY-1974, and especially to save time and money by shipping via the annual arctic summer sealift.

A plan to have the building erected before onset of winter was unsuccessful. Invitations for bid resulted in a single response at an extreme price of $193,045 which was rejected. It was decided to secure the materials and equipment already at Wainwright under surplus tents and tarps for the winter and to erect the building during summer 1975 when more time would be available to do the job. Sufficient funds remained under the original authorization to do this.

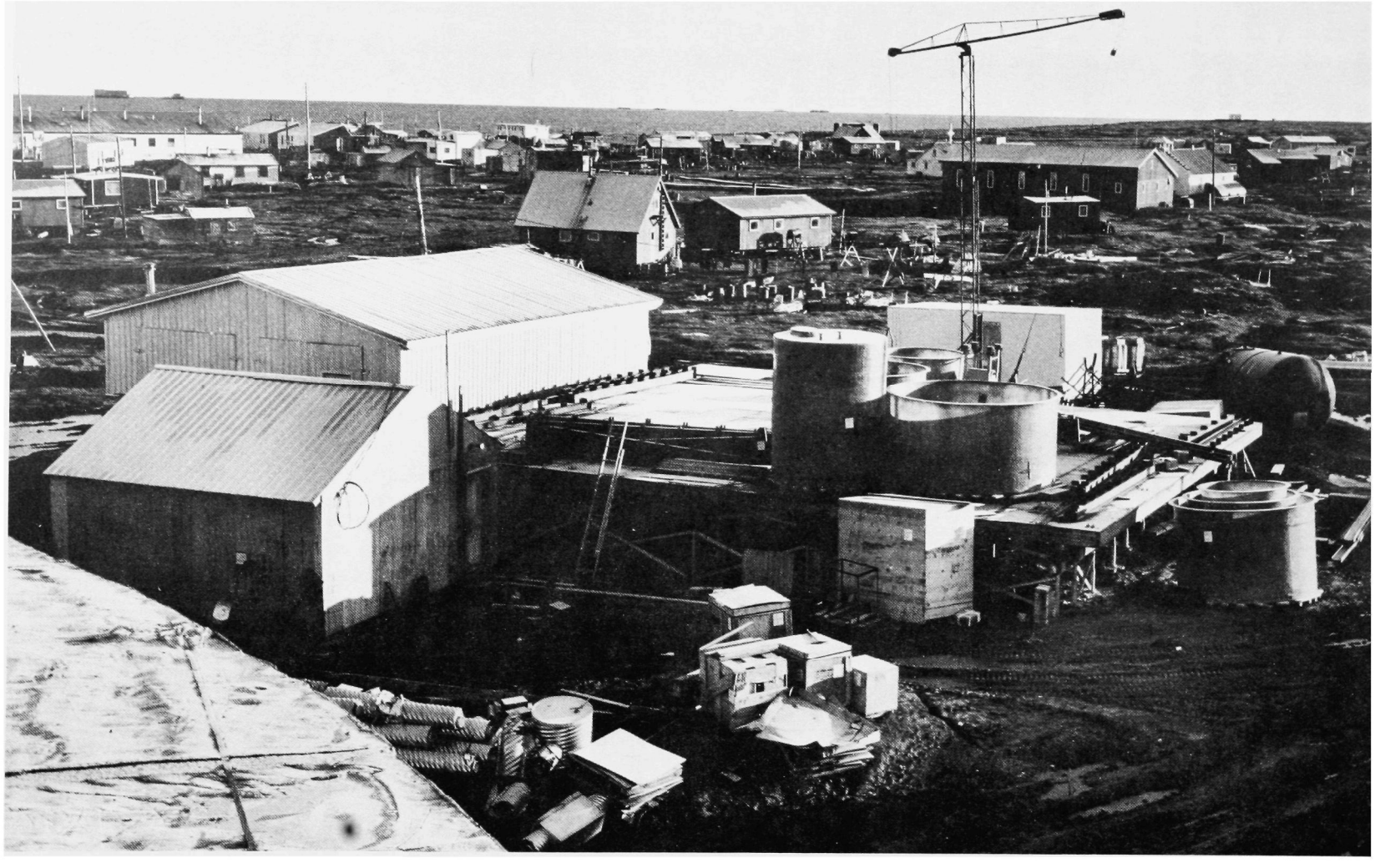

Figure 10. Wainwright II - Under Construction

A firm price contract for two phases of work was awarded to the Rudy Simone Construction Company, Inc., in Bellevue, Washington, in February 1975. This company was the low bidder among four. Phase I, at the cost of $579,454 to be completed by November 1, 1975, called for the erection of the building and procurement of the remaining equipment and materials needed to finish the job. Equipment installation and facility completion was to be accomplished under the second phase of the contract at a firm price of $494,839, to be awarded on or before August 28, 1975. An extension of the acceptance period for Phase II work until November 15 was negotiated with the contractor at a cost of $84,942. Work is underway now which should lead to completion of the facility by August 1976. Figure 10.

MODULAR INTEGRATED UTILITY SYSTEM AT WAINWRIGHT

The community of Wainwright, like most Alaskan villages, is in urgent need, not only of basic water-related utility services which are the prime concern of the AVDP, but also of a more reliable and efficient electric power generation and distribution system. The several small diesel generators at Wainwright (located at the local school, the city power plant and at the AVDP facility) provide power with poorly regulated voltage and interupted service and at great fuel expense. Through better integration of power generation with water and waste treatment, substantial energy savings could be realized.

Recently the North Slope Borough administration decided to construct a new power plant for the City of Wainwright. Timing dictated that the system employ diesel powered generators. The system which has been designed will provide electricity for the schools, the AVDP and the village and will include a significantly upgraded distribution system.

Integration of the power generation system through the use of heat recovery will be accomplished. A new high school which is currently under design will be heated with "waste" heat from the power plant and "waste" heat will also be piped to the AVDP facility for use in heating the water storage tank and the building.

The unique opportunity to demonstrate a well-integrated arctic village utility system at Wainwright has been recognized by the U.S. Department of Housing and Urban Development (HUD). An $86,000 contribution to the AVDP program provided for design and equipment in the new Wainwright central community facility which will permit utilization of excess heat from the central power plant. An additional HUD contribution will be used to complete the inter-tie between the new power plant and the AVDP facility.

Similar approaches to the energy problem have been applied in both industrial and municipal situations in other parts of the United States but none has had the ultimate effect of increasing the individual standard of living as significantly as is anticipated in the

case of Wainwright or other communities in the Alaskan bush. Successful demonstration of the integrated utility system concept in Alaska may mark the beginning of a new way of life for the people in rural communities.

DESIGN FOR SMALLER VILLAGES

With the decision to replace the Wainwright facility, plans for building a third central community facility at a smaller Interior Alaskan village were suspended.

In April 1972, work on a design for such a third facility was begun under a research and development contract with Stefano and Associates in Anchorage, Alaska. This contract has been inactive since 1973, when the funds programmed for the work ($60,233) had been used up. The design concept incorporates some important features of a total integrated utility system. Over the past year, the Agency has been engaged in negotiations with Stefano and Associates to conclude the work by furnishing additional drawings, a listing of equipment and a facility description. Full technical and bid specifications can then be developed at some future time.

SECTION V

OPERATIONAL EVALUATION - WAINWRIGHT

The Wainwright facility served a community of about 360 people. It had been well constructed and its performance met most expectations. It was in operation for 8 months prior to the fire. Operational data in existence for that period consists of accurate facility use records and periodic performance evaluations conducted in the process of fine tuning the potable water plant and during the modifications in optimizing performance of the graywater treatment components.

POTABLE WATER TREATMENT

Because of the relative high quality of the raw water, only minor adjustments of the potable water treatment plant were required. It was concluded that chemical addition for purposes of coagulation was probably superfluous. This finding was taken into account in the design of the replacement plant which will produce potable water by means of filtration, carbon adsorption and chlorination only.

GRAYWATER TREATMENT

Performance of the graywater plant proved sensitive to influent temperature fluctuations. Plant upsets occurred at regular intervals of about 6 weeks. Occasionally, graywater production from washers and showers exceeded the combined capacity of the treatment unit and of the graywater storage tank (1,200 gals.) and thereby caused service to the public to be interrupted.

Plant upsets due to biological growth and decomposition in accumulated sludges occurred in spite of disinfectants applied to the system. Wastewater entering the graywater holding tank was dosed with a quaternary ammonium compound, known by the name of "Roccal," at about 60 mg/l. This compound was rated as a very efficient disinfectant. Lime used in the upflow clarifier during operation to achieve pH $\leq$11 was also considered to be an effective disinfectant. Finally, chlorine was applied to the product water at about 10 mg/l to maintain a chlorine residual $<$1.0 mg/l after 1 hour contact in the treated water holding tank. Despite such routine disinfection measures, the system would occasionally foster biological growths, and the only procedure to correct the upset was to start over with clean water and clean tanks.

From the very beginning, the upflow clarifier failed to perform adequately. Performance was characterized by massive floc carryover into the recarbonization chamber and other downstream tanks. An extremely wide range of chemical dosages was tested in an attempt to achieve good performance of the upflow clarifier. At all dosages, large quantities of sludge carried over into downstream vessels.

To prevent further upset due to upflow clarifier or recarbonization chamber sludge accumulation, plumbing was arranged to completely bypass the upflow clarifier and the recarbonization chamber which were then left dewatered.

Concurrent with sludge carryover from the upflow clarifier, sludge buildup in the chemical mixing chambers of the "Clearflow" unit was observed. The problem could be remedied temporarily by pumping out all five sections on a regular and frequent basis but this proved to be difficult and unsatisfactory. Because of "Clearflow" construction, it was impossible to remove all the accumulated sludge which eventually became septic and infected downstream tanks and processes.

A more satisfactory solution to the "Clearflow" sludge accumulation problem was obtained by bypassing the chemical mixing chambers and using the influent pipe as combination mixing chamber and distribution header. After a period of operation, however, sludge still accumulated in the chemical mixing chambers due to hydraulic pressure and again became septic, resulting in plant upset.

In October 1973, the wastewater treatment system was revised in the field for greater ease of operation and better performance. The baffle plate between the sedimentation tank and chemical mixing chambers was removed entirely. This permitted withdrawal of sludge from the entire area subject to accumulation and was expected to prevent future upsets attributable to sludge accumulation.

Mixing in the influent pipe seemed to improve the system. By using different polyelectrolytes, performance was further enhanced. The modified system, however, was not without problems. The upflow clarifier and recarbonization chambers had previously acted as thermal buffers to absorb some of the shock of hot wastewater from the laundry and showers which was now applied directly to the "Clearflow." Convection currents in the sedimentation/floculation chamber were observed to reduce the clarification efficiency of the "Clearflow."

The hydrasieve never performed according to expectations. Its primary value would have been in its ability to remove relatively large suspended particles from normal sewage. Since the facility did not process sewage per se, this advantage was not realized. Because all of the graywater was pumped to the graywater storage tank, most of the lint and hair was incidentally removed by becoming lodged in pump impellers prior to graywater tank. Other solids, such as silt and sand, were too small to be retained on the hydrasieve. Process sludge was too weak to be retained on the screen and was automatically reintroduced into the system.

To avoid the several problems connected with the hydrasieve, a pump with a basket-type strainer was installed at the laundry sump. The strainer of this pump was very effective in removing laundry lint and preventing pump impeller clogging and lint collection in the graywater tank. Process sludge was withdrawn continuously from the sedimentation hopper of the "Clearflow" unit by a pump and fed to the centrifuge. This procedure proved to be much superior to the former arrangement.

Figures 11 and 12 permit comparison of the graywater treatment system before and after modification.

Between May and October 1973, data were collected at five different times at the end of field trips when the plant was operating properly. The results, as summarized in Table 1, do not reflect the effect of plant upsets.

Coliform bacteria were detected in the effluent following periodic plant upsets. It is felt, however, that no personal contamination from this source resulted since the laundry used predominately hot water which destroys coliforms.

Bacterial contamination was the primary threat to the validity of the water reuse concept. Very low numbers of coliforms by themselves are not significant, but accompanied by background growth of unidentified types and perhaps by viruses, these microorganisms could become a health problem. Besides careful disinfection, regular monitoring of coliforms has been identified as a definite requirement of any water reuse system. Recycle water use records were destroyed in the fire. However, computations based on the number of loads washed, showers taken, etc., indicate that water was reused in the laundry about 2-1/2 times before final treatment and discharge.

BLACKWATER AND SLUDGE INCINERATION

In the absence of a vehicular blackwater collection system, the only toilet wastes available for incineration were from the six recirculating chemical toilets in the public section of the plant. Mixed with water treatment sludges, these were vacuum collected and fed into the incinerator via a positive displacement pump. Liquid-solids separation caused some clogging of the feed pipe. Fuel required to incinerate the blackwater-sludge mixture was about 1 gallon per 4 gallons treated.

HEATING SYSTEM

To conserve fuel, the incinerator had been designed to serve as the main source of heat. This was accomplished by incorporating a large heat exchanger in the exhaust system. A 400,000 BTU/hr liquid phase heater (Singer VaPower) served as an auxiliary unit. As a result of the initial limited demand for the incinerator, the Singer VaPower unit became the prime source of heat. Once numerous startup difficulties had been overcome (caused mainly by high moisture of the fuel atomizing air), the unit performed excellently.

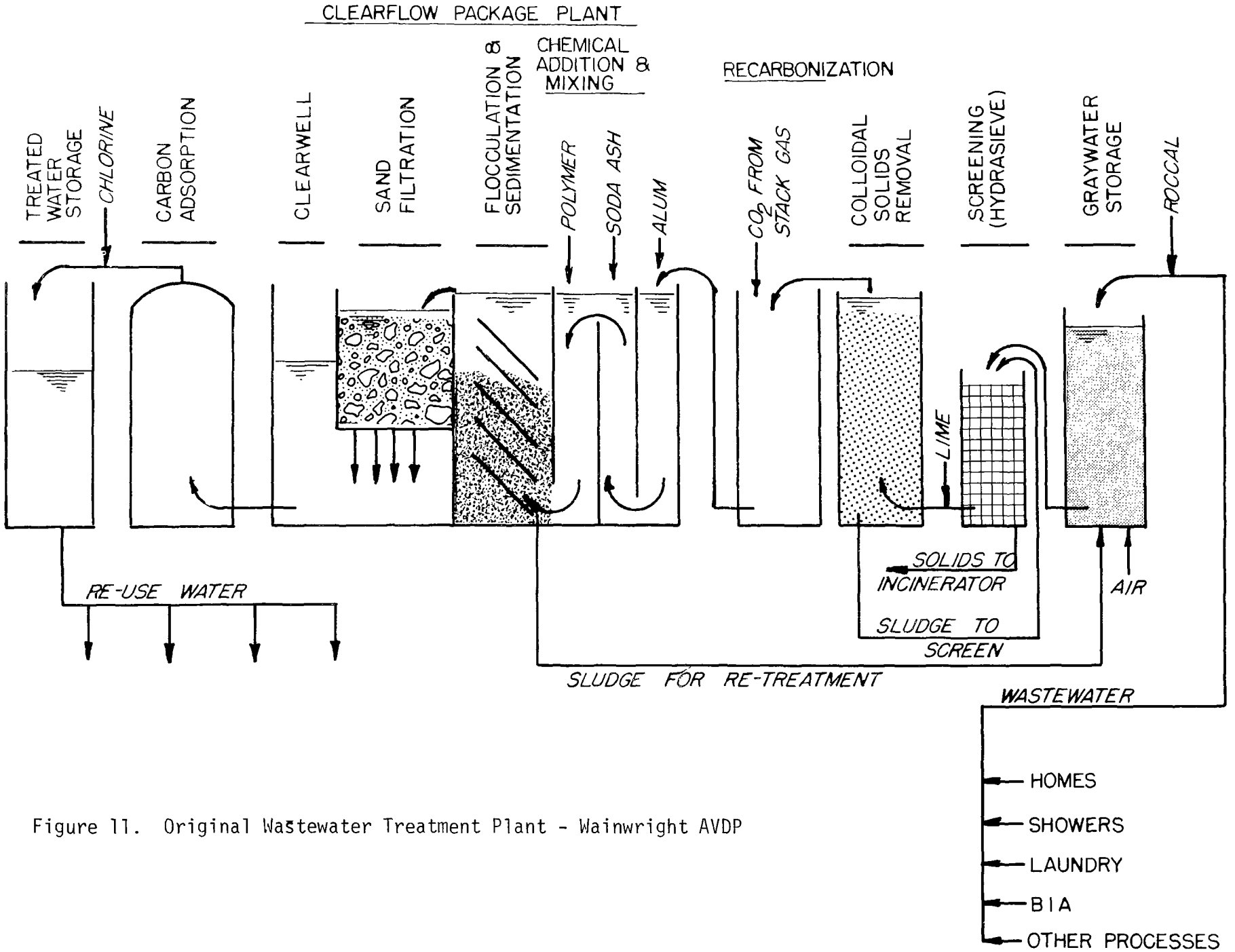

Figure 11. Original Wastewater Treatment Plant - Wainwright AVDP

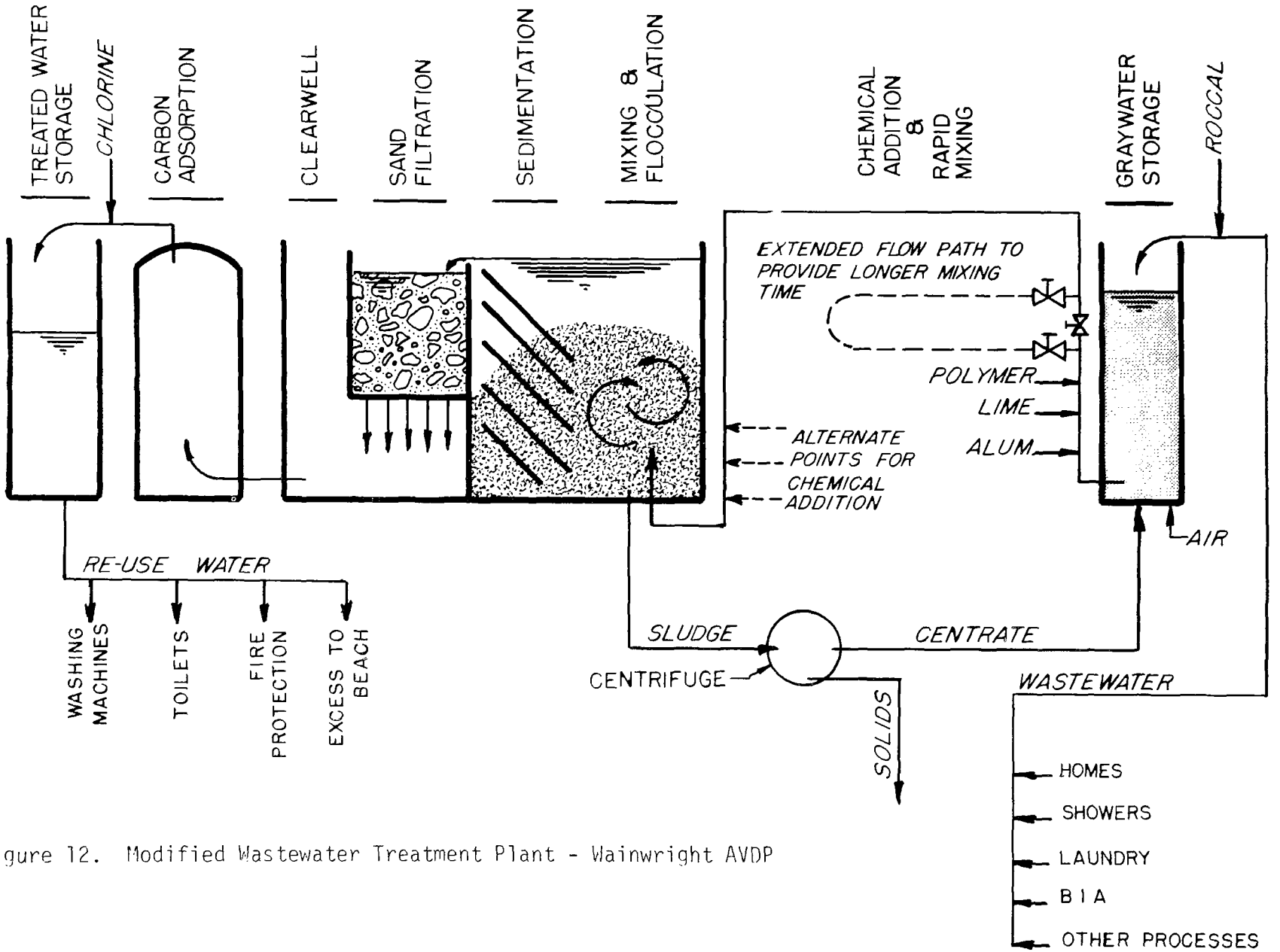

Figure 12. Modified Wastewater Treatment Plant - Wainwright AVDP

TABLE 1

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

	Raw Gray-Water	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

Heat for the dryers and public areas in the facility was provided by circulating "Therminol 55" heat transfer medium in welded piping. However, small leaks existed in the piping which prevented operation of the heating system at optimum temperature of about 350°F. Above 230°F, oil from leaks vaporized, causing bothersome and possibly hazardous contamination of in-plant air. Some of the leaks were too inaccessible to reach. Others came from the few threaded fittings in the system, which, despite repeated efforts, could not be made tight.

FACILITY MANAGEMENT AND USE

The washers performed without problems. Due to the limitations of the heating system referred to above, the dryers operated below optimum temperature. Therefore, during periods of peak demand, backlogs of wet laundry accumulated. The pneumatically operated Monogram toilets (Model 160M-PA) proved to be difficult to operate and maintain.

During the 8 months of facility operation (March-October 1973), people in Wainwright took 4650 showers or about 2 showers per person per month. 4370 loads of laundry were washed and dried representing about 2 loads of laundry per household per week. 25,000 gallons of water were sold at the plant and individually transported to most of the 65 homes.

Service charges were as follows:

Shower, 2 minutes	25 cents
Load of wash	50 cents
Dryer, unit time	10 cents
Drinking water, per gal.	3 cents
Sauna	Free

Plant income for the period was $5,700

After the fire, village water consumption climbed steadily, despite a City Council decision in February 1974, to raise water prices from 3 cents to 6 cents per gallon for water sold at the tank. The charge for water delivered to homes via the Bombardier all-terrain tanker vehicles, which became available in mid-February 1974, was set at 8 cents per gallon. In May 1975, the price of water delivered to institutions such as the school and businesses was increased to 6 cents per gallon, on the assumption that these institutions could better afford to pay closer to the real cost of the service than the average householder at Wainwright.

Consumption of water appears to have been unaffected by these changes in cost. It has risen steadily, taking a quantum jump when the tanker vehicle began to make deliveries in February 1974. Peak demand in the homes occurs during the months of June through September. This may be due to some households continuing to obtain some of their water from ice during the winter. The history of water sales at Wainwright is graphically shown in Figure 13.

Since November 1973, the facility has been operated by the City Council under the cost-reimbursable contract referred to in Section IV. During the first 22 months of the contract period, total expenditures have been $77,000. This figure does not include fuel which has been shipped via the Alaska Air Command COOL Barge. Income was $29,000 for the same period; $21,700 from sale of water and $7,300 for hauling wastewater from the school.

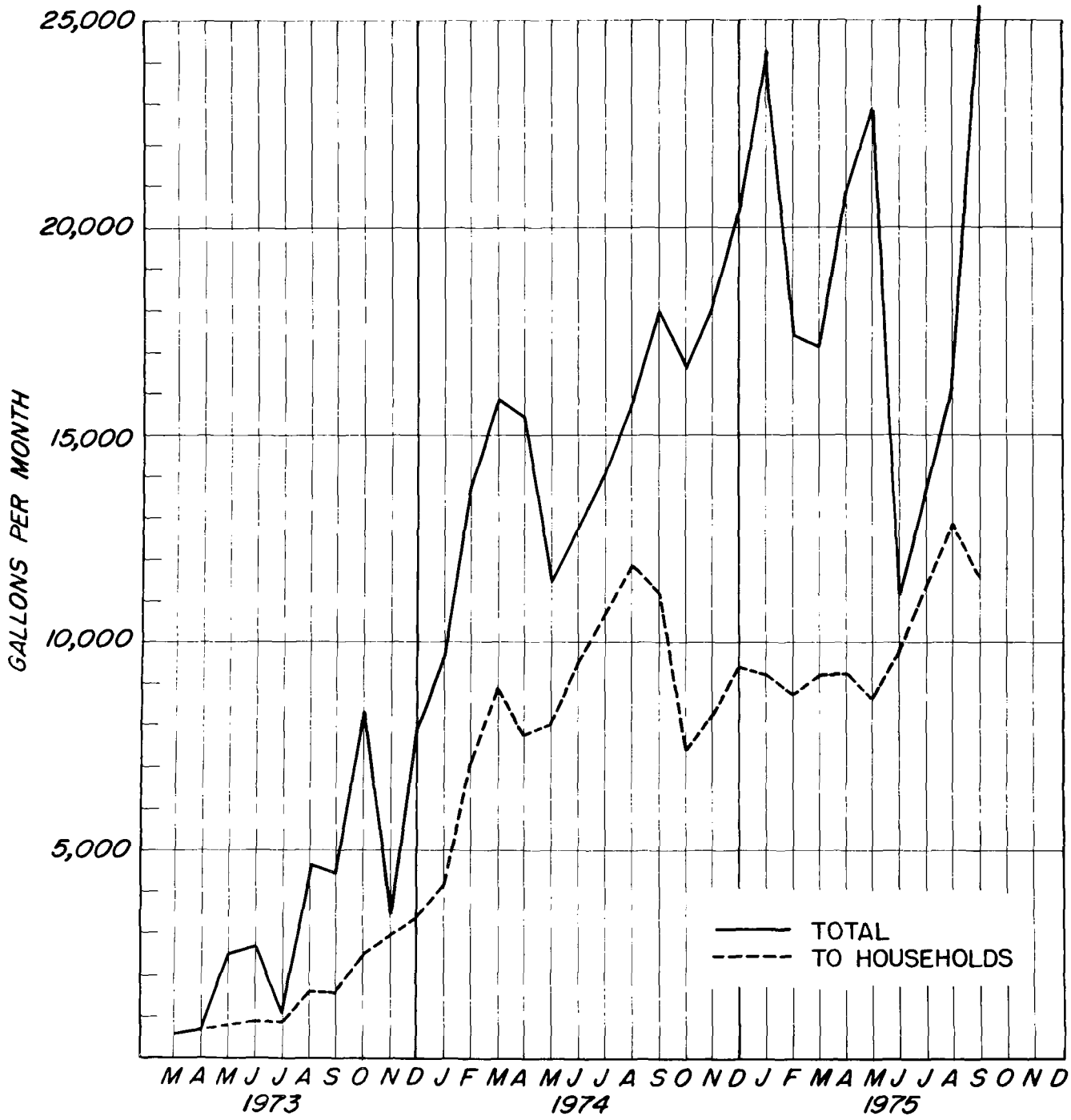

Figure 13. Water Sales at Wainwright

SECTION VI

OPERATIONAL EVALUATION - EMMONAK

Equipment and operational problems have been frequent at Emmonak. These problems stemmed from deficiencies in the original contractor's performance and from the need to maintain basic services while trying to modify systems and bring the facility to completion. By March 1975, work had sufficiently progressed to permit facility performance monitoring to begin.

Instrumentation installed for data collection included:

Hour meters on pump and process equipment motors to obtain operating time and energy requirements;

Flow meters and temperature indicators on heating system lines to obtain heat requirement information;

Watt hour meter on blackwater system for energy requirements;

Water meters to obtain total water production, hot water requirements, etc.

Readings from the above are routinely recorded by the operators on a weekly operations summary form. Laundry and shower use and water sales are also shown on the form.

Sampling for performance monitoring was done by the AVDP staff. Field chemistry, including analysis for hardness, alkalinity, conductivity, and turbidity, was accomplished on site the same day the samples were collected. For solids analysis a procedure was followed whereby dishes and filters were pre-weighed at the Arctic Environmental Research Station laboratory before shipment to Emmonak. Samples for analysis of solids were then filtered and dryed and held in a dry state for return to the AERS laboratory for final drying and weighing. This procedure provided minimum degradating of the samples and eliminated the need to maintain delicate laboratory equipment at Emmonak.

Because of the remoteness of the village, grab samples were collected daily during those periods when AVDP staff were on site. On the day of collection those portions of samples intended for COD and nutrient analysis were frozen, solids samples were filtered and dryed, and color samples were cooled. These samples were held at the site for periods up to a week before return to the AERS laboratory for analysis. A limited number of BOD analyses were done on graywater samples collected on the days before returning to the AERS laboratory.

POTABLE WATER TREATMENT

The water supply system is shown schematically in Figure 14. 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 of somewhat makeshift nature, 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 7-1/2 gpm.

During the period March-October 1972, an average of 4,400 gallons of water was produced per day. Production peaks of 8,700 gal/day and 7,400 gal/day have been registered over 1-week periods. Water required for filter backwash amounts to about 4-1/2 percent of the total product and is not included in this figure. As presently operated, the plant has a capacity of 10,000 gal/day if 2 hours are allowed for down time.

Chlorine residual and pH are monitored by the operators on a daily basis and membrane filter tests for total coliforms are conducted on a monthly basis. Chlorine residuals in the distribution system (within the facility) are normally maintained at 0.1 mg/l. Coliform tests on potable water within the facility have been negative.

The results of raw water and potable water sampling are summarized in Table 2. The variation between winter and summer raw water quality has had very little effect on treatment plant performance. The high summer silt load requires that the raw water holding tank be cleaned each fall. Approximately 6-8 inches of silt collects in the flat bottom tank throughout the summer. The high summer silt load also necessitates cleaning of the treatment plant clearwell on a weekly or biweekly basis, compared to a monthly cleaning during the winter.

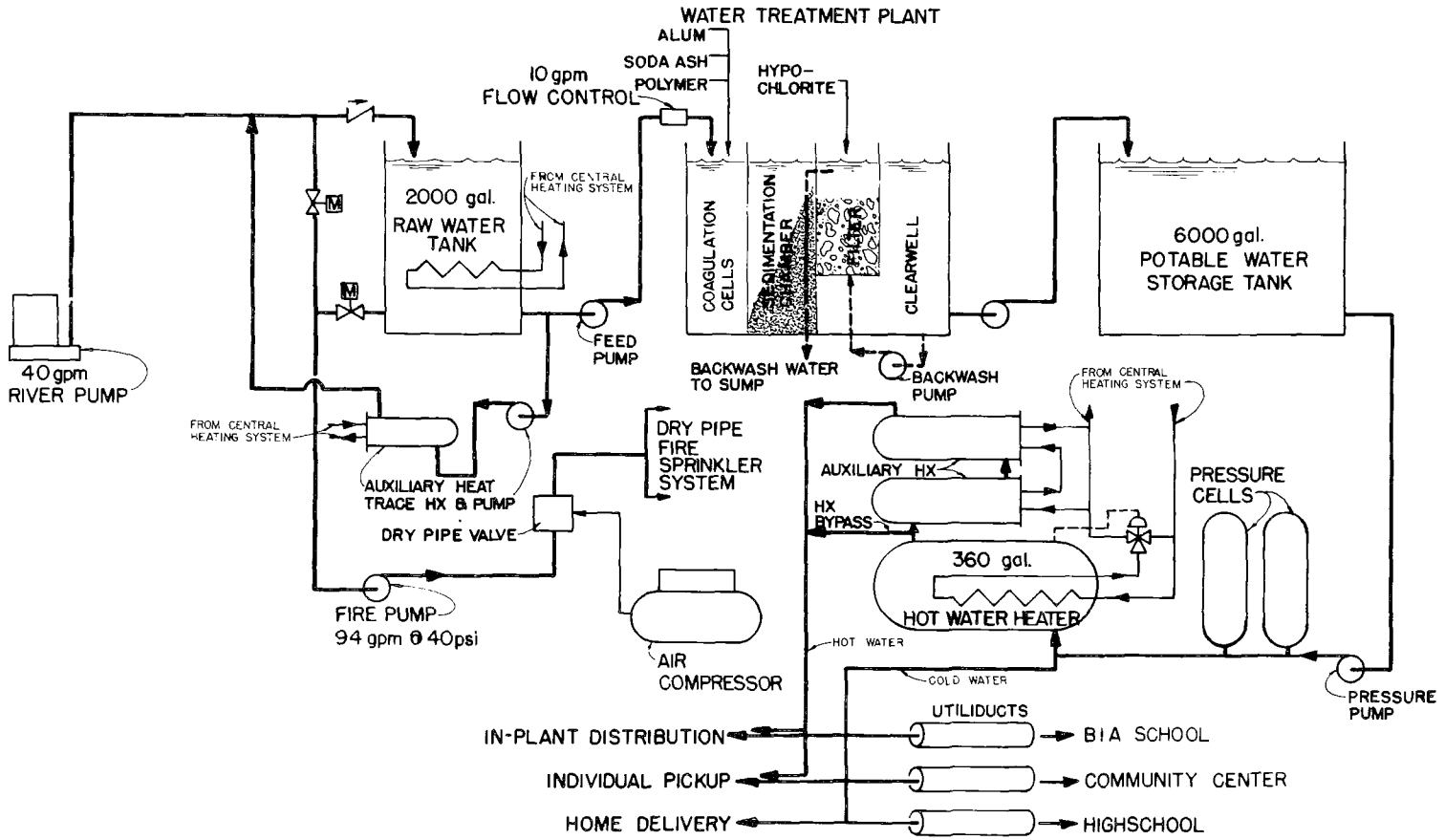

Figure 14. Water System at Emmonak.

TABLE 2

RAW WATER AND POTABLE WATER CHARACTERISTICS AT EMMONAK[1]

Winter Sampling Period	Raw Water	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	Potable Water
# Samples	9	9
pH	7.3-8.5	6.8-8.2
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

Chemical use in the production of 860,000 gallons of water, plus backwash water, during the monitoring period (March-October 1975) has been as follows:

Alum	540 pounds
Soda Ash	265 pounds
Polymer	45 pounds
Sodium Hypochlorite	23 gallons

Energy consumption per gallon of water produced is estimated as follows:

	Watt Hours/Gallon
Raw Water Pump	0.5
Potable Water Treatment	2.0
Pressure Distribution	3.8
Total	6.3

The potable water treatment value includes power required to operate the feed pump, chemical mixers and feed pumps, backwash pump and the treatment plant effluent pump.

Tempering of the water and maintaining it above freezing temperatures in the utiliduct requires much higher levels of energy. These have been calculated in BTU's/gallon of potable water produced and translated into equivalent watt hours/gallon:

	BTU/Gallon	Watt Hour/Gallon
Winter		
Tempering	217	52
Utiliduct Heating	143	42
Summer		
Tempering	25	6
Utiliduct Heating	---	--

The values shown for tempering are based on raising the river water temperature to 58°F which has been found to be the year-round temperature of water in the distribution system. The utiliduct heating value was obtained by using one-half the BTU heating requirement to maintain the utiliduct above freezing.

GRAYWATER TREATMENT

The graywater treatment plant is also a package unit manufactured by Keystone Engineering, Inc. (Figure 15). Treatment consists of alum coagulation, powdered activated carbon (PAC) adsorption, clarification, multi-media filtration and chlorination. Chemicals and PAC are fed along with the waste to four coagulation cells where mixing takes place. The cells are connected in series by a pipe attached to the bottom of one cell and rising on the inside of the next cell to about two-thirds of the height of that cell.

Waste flows from the fourth cell into the clarification chamber where the chemical solids settle out. The waste then flows over a multi-media filter, which removes the remaining solids, and is pumped from the bottom of the filter into the clearwell and then pumped to the river. Sodium hypochlorite is fed to the waste over the filter, with the clearwell serving as a disinfection contact chamber.

Chemical sludge is pumped by an air operated diaphragm pump from the bottom of the clarification chamber over the moving bed filter which dewaters the sludge. Filtrate from the moving bed filter is returned to the graywater holding tank and the sludge is removed to a landfill or incinerated.

Backwash of the multi-media filter is performed manually once each day with backwash water returned to the graywater holding tank.

The graywater consists of laundry, shower and sink waste from within the facility as well as shower and sink waste from the community center, and laundry, shower and kitchen of the BIA school. Also, whenever blackwater is being treated, blackwater centrate from the centrifuge is added to the graywater tank. In the future, laundry, shower and kitchen wastes will be collected from the new high school, and kitchen wastes will be collected from a restaurant at the community center.

The graywater treatment plant was not operated continuously during the monitoring period due to certain operational problems. Powdered activated carbon has not been used in the graywater treatment process to date, nor has pH adjustment been provided, but are planned in the future.

Design capacity of the plant is 10 gpm. During the periods of continuous operation, the plant averaged approximately 7.5 gpm. A daily average of 3,400 gallons were treated during the monitoring period which represents about 8 hours of daily operation at 7.5 gpm. Limited capacity for storage of graywater and plant shutdowns for maintenance result in about 8 hours of enforced idle time per day. Therefore, the plant was operating at approximately 50 percent of full capacity (7,000 gal/day). A peak load of approximately 6,000 gal/day occurred during one weekly reporting period with the next highest peak load being 4,000 gal/day.

Laundry and shower waste samples were collected in the facility for characterization (Table 3). The flow rate of laundry waste was

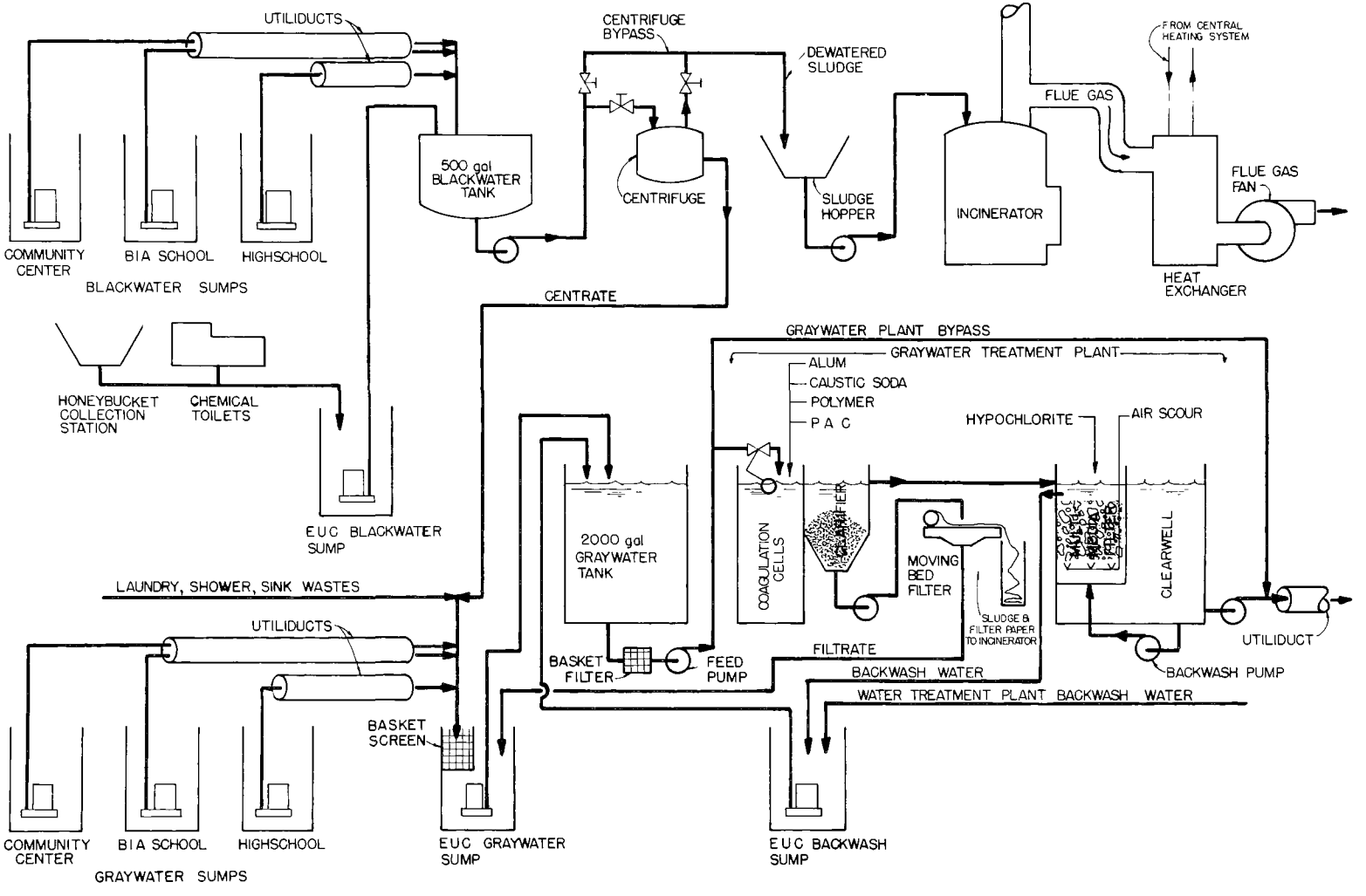

Figure 15. Graywater and Blackwater System at Emmonak.

TABLE 3

GRAYWATER AND TREATED GRAYWATER CHARACTERISTICS AT EMMONAK (1)

	Number of Samples(2)	Temp. °C	pH(3)	Conductivity UMHO	Turbidity JTU	Total Solids mg/l	Total Volatile Solids mg/l	Suspended Solids mg/l	Volatile Suspended Solids mg/l	COD mg/l	COD Soluble mg/l	TPO_4P mg/l	OPO_4P MG/l	NH_3N mg/l	Alkalinity mg/l
Laundry	13	31	6.6-8.7	1360	96	1770	550	240	138	960	---	30.5	23.1	6. 2	248
		(6)	---	(690)	(32)	(830)	(280)	(163)	(88)	(520)	---	(25.1)	(20.7)	(7.0)	(108)
Shower	9	25	5.6-7.3	670	85	810	280	160	121	500	---	2.5	1.2	6.8	156
		(4)	---	(300)	(27)	(367)	(170)	(74)	(73)	(369)	---	(3.3)	(2.1)	(8.6)	(46)
Graywater Composite	26	27	5.3-8.9	1440	109	2640	990	1680	660	1510	300	11.7	7.7	14.3	260
		(3)	---	(1380)	(53)	(2785)	(1190)	(2930)	(1170)	(2480)	(370)	(11.9)	(8.2)	(36.8)	(355)
Treated Graywater Composite	24	23	3.0-7.2	1330	47	1630	520	330	150	300	160	4.4	2.6	7.6	125
		(4)	---	(500)	(33)	(1045)	(480)	(750)	(320)	(250)	(130)	(6.7)	(4.6)	(5.7)	(90)
Percent Removal		---	---	8	57	38	47	80	77	80	47	62	66	47	52
Graywater Adjusted	19	28	5.3-8.4	1035	104	1285	440	400	210	690	190	10.2	6.9	6.5	148
		(3)	---	(380)	(49)	(450)	(210)	(210)	(110)	(345)	(85)	(8.0)	(5.5)	(4.3)	(82)
Treated Graywater Adjusted	18	24	3.0-7.4	1280	51	1330	395	48	33	205	120	2.1	1.1	6.8	115
		(3)	---	(450)	(35)	(610)	(260)	(35)	(35)	(100)	(57)	(1.2)	(0.7)	(4.0)	(52)
Percent Removal		---	---	+24	51	+4	10	88	84	70	37	79	84	---	22

1. Mean with standard deviation in parenthesis.
2. In a limited number of cases, actual numbers of analysis for a given parameter may be 1 or 2 less than the number of samples shown.
3. Range of values.

obtained by multiplying the number of washer loads by the gallons of water required per load. Shower flow rates were obtained by multiplying the number of showers by a factor of 20. The respective rates are as follows:

	Average Gal/Day	Peak Gal/Day
Laundry	800	1670
Shower	780	1330

One problem encountered in operating the graywater plant was the extreme variability of raw waste. Two factors accounted for the variability: (1) the highly concentrated centrate from the centrifuge flowing into the graywater holding tank while processing blackwater, and (2) a buildup of chemical solids in the graywater holding tank from the filter backwash and the passage of solids through the moving bed filter with the filtrate. These two factors tended to upset the plant performance and drastically lowered the effluent quality.

Because of these influences, the performance data are presented in two sets (Table 3). The composite values show the overall performance of the plant, and in this case, no attempt was made to adjust the data because of inconsistencies, etc. A second set of adjusted values was obtained by first plotting the raw graywater total solids analysis on probability paper. The plot distinctly indicated that two groups of data were present. The adjusted graywater and adjusted treated graywater data summary was then obtained from samples taken on the dates corresponding to the set of the low total solids data on the graywater probability plot. This procedure was followed in order to screen out the effects of the blackwater centrate and high chemical solids in the graywater feed on plant performance.

The variability of the composite data is reduced considerably by the removal of the centrate and high solids influence. Although the percentage removals of the composite and adjusted data are similar, the quality of the effluent is increased considerably and the variability reduced for the adjusted data. The adjusted data shows that the plant does not yet meet secondary standards.

The addition of PAC to the process should aid in attaining that goal. Meeting secondary standards in the treatment of the graywater-centrate combination will also require that the dilution factor be increased by metering the centrate at lower rates, that pH be accurately controlled, and that plant upsets be prevented. All of this will require constant operator attention.

Results of sludge analysis were as follows:

	No. of Samples	Percent Solids	Percent Volatile Solids	Thermal Value BTU/lb.
Chemical Sludge	6	1.2	43	4620 (Avg. of 2 samples)
Filter Sludge	3	7.0	45	4430 (1 sample)
Filtrate	1	1	44	---

Since only one sample of filtrate was obtained, definite conclusions on the performance of the moving bed filter cannot be made. The result agrees with the observations that a large amount of sludge was passing through the filter and back into the graywater system.

A limited number of Biochemical Oxygen Demand (BOD) analyses were performed on the graywater samples. Although the BOD test is held in low regard by many people in the sanitary field and has little value in monitoring a chemical treatment process, it was felt some BOD information would be useful. The graywater BOD values could be useful in the design of biological treatment processes and, when considered in conjunction with other parameters such as COD and solids, BOD values permit a much more comprehensive description of the waste. The treated graywater BOD is very helpful in determining the effects a waste will have on the receiving water since it is the only measure of biodegradeability available. Following are the COD/BOD ratios for those samples which were tested for BOD:

Waste	No. of Samples	COD/BOD
Graywater	6	1.8
Treated Graywater	5	2.2

Total coliform counts of six treated graywater samples averaged 2,000/100 ml and ranged from 0 to 5,000/100 ml. These results indicated that disinfection of treated graywater will be effective once stable operation of the plant is achieved.

Operation and maintenance time cannot be estimated accurately because of problems with the plant, continuing modifications and an inability of the operators to spend the necessary time with the plant. The plant will probably require twice the time it takes to look after the water plant, or approximately 40 hours per week.

Chemical use in the treatment of 145,000 gallons of graywater during the monitoring period was as follows:

Alum	872 pounds
Polymer	13 pounds
Sodium Hypochlorite	30 gallons

The power needed to operate the graywater plant is estimated at 4.3 watt hours per gallon. This figure includes power requirements for the graywater sump pump, treatment, and pumping the effluent back to the river.

Operation and maintenance problems included:

A buildup of solids in the graywater holding tank of up to 12 inches which requires cleaning twice each year. The tank has a flat bottom.

Clogging of the coagulation cells which requires draining the clarifier before cleaning.

A rolling action which occurs in the clarifier and upsets the solids settling process. This action is induced by temperature differences between the incoming waste and the liquid in the clarifier and by the configuration of the clarifier inlet.

Rapid buildup of solids in the clarifier when processing high strength wastes, resulting in a carryover and ultimate failure of the filter.

Buildup of gumballs (balls formed by the agglomeration of solid material by the polymer) in the filter media.

Lack of operator time available to give the plant the almost constant attention it requires.

Numerous remedies and modifications have been attempted; others are planned:

A centrifugal pump to transfer chemical sludge from the bottom of the clarifier to the moving bed filter was originally furnished. Because of clogging problems the pump was replaced with a gravity overflow arrangement. The gravity overflow proved difficult to control and was in turn replaced with an air operated diaphragm pump which has been very satisfactory.

A basket screen has been placed in the graywater sump to prevent objects such as socks, washrags, etc., from clogging the sump pump or entering the holding tank. A screen was not originally provided.

An air scour was added to the multi-media filter for use during backwash to aid in breaking up and preventing formation of the gumballs. The efficiency of the air scour has not yet been determined.

Plant piping was modified to allow use of the clearwell as a disinfection chamber. Originally, the clearwell was used for storage of backwash water only. A contact chamber for disinfection of treated graywater was not provided with the original plant.

A new container for collection of moving bed filter paper and sludge has been provided. The container originally provided was very bulky, required two people to handle it, and made it practically impossible to get material into the incinerator.

During processing of blackwater, a very strong odor emanates from the graywater sump. The odor is from the chemicals (used in the chemical toilets) present in the centrifuge centrate. An exhaust blower will be installed to control the odor.

Additional space has been provided for mixing and handling graywater chemicals. Dust control equipment is being installed in the new space. The plant will be operated using PAC and pH adjustment.

Control of centrate concentration in the graywater feed will be attempted.

The discharge configuration from the coagulation cells to the clarifier will be modified in an attempt to improve the clarifier performance.

Aeration mixing will be installed in the graywater holding tank to prevent sludge buildup.

BLACKWATER DEWATERING AND SLUDGE INCINERATION

A schematic of the blackwater system is included in Figure 10. The blackwater is collected in a 500-gallon fiberglass tank with a dished bottom. A Moyno positive displacement pump (Model 1L4-CDQ), with a 1-hp DC variable speed drive, feeds the centrifuge. The bowl-type centrifuge (Model 125 by Leon J. Barrett Company) has a manual scoop, is powered by a 2-hp motor, and has a maximum capacity of 45 gpm. From the centrifuge, sludge is transferred to the incinerator by a second Moyno pump (Model 1M3-CDQ) which is powered by a 1/2-hp AC motor with variable speed drive. The incinerator, a Type IV by Northeast Burnzol, Inc., is oil fired with a gas pilot and rated 60 pounds of sludge per hour.

The sludge feed consists of a 3/8-inch pipe stub placed over the flame area. The burner has a modulating control with a maximum fuel consumption of 12 gallons per hour.

The heat exchanger for recovery of waste heat from the incinerator flue gas is a Maxim Model MFT-140-4 by Riley Beaird. A Model 142-3 blower

by the New York Blower Company serves as an induced draft fan for the heat exchanger.

Current sources of blackwater are the BIA school, the community center and the toilets within the plant. At this time, the blackwater consists of chemical toilet wastes and, in the case of the community center, flush urinal waste. Future sources of blackwater will be from homes through a honey bucket receiving station and the high school which will be sending blackwater to the facility through a utiliduct.

Blackwater collection rates have been as follow:

BIA School	26 gpd
Community Center	26 gpd
In-Plant	15 gpd

The collection rates for the BIA school and community center are preliminary since they are based on information during startup of the systems when problems unrelated to the utility center collection and treatment processes were occurring.

Grab samples were taken from the blackwater holding tank at random times during blackwater processing and analyzed. The results from seven samples were as follows:

pH, range	6.6-8.9
Total Solids, mg/l	8,550
Total Volatile Solids, mg/l	6,000
Chemical Oxygen Demand, mg/l	8,350

This information must also be considered preliminary since extensive settling takes place in the holding tank and no mixing is provided.

Observations made in connection with performance of the centrifuge illustrate the extent to which settling occurs (Table 4). Blackwater had been collected on August 6, 1975, the day before the centrifuge operation began, which permitted solids to settle overnight. The centrifuge operated for a short period on August 7, 1975, and was started up again on August 8, 1975. Additional solids settled overnight as indicated in the table. Blackwater was not collected during that period.

Obviously, a major portion of the solids, including those which could be removed by the centrifuge, are settling to the bottom of the holding tank. The liquid is then channelling through the sludge until the level of the liquid reaches the sludge level and suspended solids begin flowing out of the tank with the liquid.

The centrifuge removed a negligible portion of the soilds in the upper liquid levels in spite of the low feed rate. At the lower liquid levels

TABLE 4

RESULTS OF CENTRIFUGE OPERATION IN TREATMENT OF BLACKWATER AT EMMONAK

Date	8/7/75	8/8/75	8/8/75	8/8/75
Holding Tank Liquid Level,	20	15	6.5	4.5
Centrifuge Feed Rate, gpm	2	2	1	1
Total Solids, Blackwater, mg/l	6,400	5,300	33,000	41,000
Total Solids, Centrate, mg/l	6,200	5,300	12,000	25,000
Percent Removal	3	0	64	39
Suspended Solids, Blackwater mg/l	2,800	2,200	25,000	26,000
Suspended Solids, Centrate, mg/l	2,600	2,300	7,400	14,000
Percent Removal	7	0	70	46
Chemical Oxygen Demand, Blackwater, mg/l	8,000	6,200	39,000	62,000
Chemical Oxygen Demand, Centrate, mg/l	6,300	6,100	25,000	59,000
Percent Removal	21	2	36	5

the high concentration of solids in the feed appeared to reduce centrifuge efficiency. The data indicates that a feed rate of less than 1 gpm is required at very high solids concentrations.

A sludge sample was taken from the sludge collection hopper near the end of the operation. Results of the analysis were as follows:

Percent Solids	13
Percent Volatile Solids	71
Thermal Value, BTU/lb dried material	6800

It has been observed that the intervals between desludging of the centrifuge must not be too long. Otherwise the bowl packs too tight and

difficulties occur in transferring the dry sludge to the incinerator via the hopper, the Moyno pump and the piping.

Since the blackwater flow to the holding tank is still low enough to permit processing the day after collection, the current procedure is to hold the blackwater overnight, which allows solids to settle. On the next day, the upper layer of blackwater is pumped directly to the graywater sump, by passing the centrifuge, until the level in the holding tank is down to about 10 inches. About once a week the sludge which builds up in the bottom of the holding tank is dewatered by using the centrifuge. Towards the end of this process, when the remainder of the sludge in the tank is so concentrated that use of the centrifuge becomes impractical, this thick material is then pumped directly to the sludge hopper, and from there to the incinerator. This procedure has reduced centrifuge operating time substantially.

Power and fuel oil requirements for treatment of blackwater by this method have been calculated as follows:

> 43 watt hours per gallon blackwater
>
> 30 gallons blackwater treated per gallon of fuel consumed in the incinerator.

These figures are based on 500 gallons of blackwater per week. As the amount of blackwater increases, the process will become more economical.

The heat exchanger associated with the incinerator is connected to the heating system in series with the boiler so that heat recovered from the incinerator flue gas is transferred to the circulating hot water. The system is valved so that boiler water is circulated through the heat exchanger only when the incinerator and flue gas fan are in operation. The circulating hot water is split into two loops before entering the heat exchanger. One loop is connected to a heat exchanger in the raw water tank which provides additional cooling of the circulating water while tempering the raw water. The additional cooling of the circulating water increases efficiency of the heat exchanger.

A preliminary evaluation of the heat recovery system has been completed. The results indicate that approximately 25 percent of the net heat input to the incinerator can be recovered and that the heat exchanger recovered 96 percent of the heat in the flue gas that was drawn through it. The heat exchanger and flue gas fan were designed for installation with a different incinerator than was furnished and therefore are undersized. By installing a larger capacity fan it is estimated that heat recovery could be increased to 50 percent with the existing unit.

Some equipment defects and operational problems have complicated the use of the heat exchanger and incinerator. Because the flue gas fan is very noisy, it was installed outside of the building. A heated enclosure has become necessary to keep the fan belts from stiffening.

At low temperatures they place an excessive load on the motor. In the incinerator the bottom refractory material has developed cracks which allow liquid to seep through. Attempts at patching have not remedied the situation. Carbon steel pans to hold the sludge puddle are currently being evaluated.

The equipment provided for blackwater treatment at Emmonak is obviously expensive, and the operating costs are high. At locations where sanitary landfills are feasible, the blackwater treatment process could be simplified considerably. Blackwater solids separation, for instance, could take place in a settling tank. The liquid could be decanted and the sludge disinfected by mixing with lime in the same tank or another holding tank which is emptied to the landfill. Where a shredding process is used for other garbage, the sludge could be mixed with the shredded material. This would eliminate much costly equipment, and be a less energy intensive method of accomplishing the job.

Future plans in reference to blackwater and solid waste processing at Emmonak include the following:

> To collect trash and garbage for incineration. Evaluation will include a determination of garbage and trash characteristics, amounts generated and heat recovery possibilities during incineration of the material.
>
> To install and evaluate a trash compactor.
>
> Attempts will be made to improve the performance of the heat recovery system including improvement of the flue gas fan operation.
>
> Additional information will be collected on blackwater quantities and characteristics.

HEATING SYSTEM

Sources of heat in the Emmonak facility are a boiler of 472,000 BTU/hr gross output, two sauna burners, and the incinerator. A primary hot water circulating system furnishes heat to the dryers, the hot water tank, three unit heaters located beneath the building, a heating and ventilating system within the building and heat exchangers for tempering raw water and heating ethylene glycol for the utiliduct heat trace. The incinerator is connected to the circulating hot water system through the flue gas heat exchanger discussed previously.

Fuel is stored in a 20,000-gallon tank which is filled annually. Fuel consumption during the past year has been 22,260 gallons, distributed as follows:

Unit	Gallons	Percent of Total
Boiler	18,480	83
Men's Sauna	1,745	7.8
Women's Sauna	1,420	6.4
Incinerator	615	2.8

Fuel consumption in the boiler ranged from 490 gallons per week during the winter to 220 gallons per week in the summer. The boiler burner operated about 75 percent of the time in winter and 57 percent in summer. Peak demands have kept the boiler running for 90 percent of the time for short periods.

The saunas are operated about 8 hours per day. Little change in fuel consumption was noted between summer and winter. The men's sauna thermostat is normally set at around 250°F compared to the women's thermostat setting of 170°F, which accounts for the higher men's sauna fuel consumption. The sauna stoves are undersized for the burners. This has resulted in a somewhat greater fuel consumption than necessary. The incinerator was operated for a relatively short period of time during the evaluation which accounts for the small percentage of fuel consumption. This figure will rise considerably in the future.

Assuming the fuel has a heating value of 19,000 BTU/lb, and the operating efficiencies of the boiler and sauna stoves are 70 percent and 60 percent respectively, daily heat requirements have been computed as follows:

Function	Winter BTU/Day	Summer BTU/Day
Hot Water Heater	613,000	613,000
Cold Water Tempering	451,000	52,000
Utiliduct Heat Trace	1,260,000	---
Dryers	833,000	833,000
Space Heating	3,826,000	1,637,000
Saunas	692,000	692,000
Total	7,675,000	3,827,000

Heat recovery during incinerator operation has not been included in the above computation. As the use of the incinerator is increased, the load on the boiler will be reduced. Overall fuel consumption is expected to increase, however, because the heat recovery system is only 25 percent efficient.

Cold water temperatures in the distribution system are about 58°F throughout the year. The heat requirements calculated for cold water tempering are based on heating the incoming raw water to 58°F. This is not done directly but occurs as the water picks up heat after entering the building.

The source of heat for the dryers is the boiler water which flows through a coil at the dryer air intake. The moisture laden air from the dryers is then exhausted from the building.

The space heating figures given in the above table were obtained by subtracting the values of the other functions (excluding the saunas) from the total. The values include heat given up by heat exchangers, etc.

Several methods of heating the utiliduct have been tried. Originally, the utiliduct was provided with electric heat tapes. A number of freezeups occurred during the first winter because these heat tapes malfunctioned.

An effective interim method of keeping the utiliduct warm and the river intake from freezing was to bleed tempered raw water back through the intake line.

Bleeding tempered raw water back to the river was quite wasteful of heat and, therefore, an ethylene glycol heat trace was installed. The ethylene glycol is pumped through a heat exchanger in the facility, which raises the glycol temperature to 125°F, and then through a pipe which is looped through the utiliduct. At first, this trace consisted of 1/2-inch polypropylene plastic which is inexpensive and easily installed. Because of breakage problems at the joints, the polypropylene was subsequently replaced with PVC which is believed to be more reliable and allows the glycol to circulate at a higher temperature. This trace remains to be extended through the section of the utiliduct leading from the river bank to the intake on the ice. Therefore, some bleeding of tempered water is still necessary; hence, the amount of heat used in the utiliduct now may be reduced by half after the heat trace is completed.

ELECTRICITY

Electrical power at Emmonak is supplied by the Alaska Village Electric Cooperative, Inc. (AVEC) which serves numerous villages in Western Alaska. Generators are provided in each village. Power available in Emmonak is 120 volts, single phase and 208 volts three phase.

Because of limited resources available at AVEC and the remoteness of the village, electric power has not been dependable. A number of motors within the AVDP facility have required repair or replacement because of fluctuating voltages. In one instance, a break in one leg of the three phase power lines leading to the facility apparently resulted in a surge of high voltage in the other legs. A number of transformers were damaged which resulted in the loss of the heating system as well as other process equipment until repairs could be made.

As a result of these experiences and because of the potential for damage that exists should a prolonged power outage occur during cold weather, two major modifications were made. A standby generator and a low voltage protection service entrance panel was installed. The generator is a 55 KW unit which was made available by the Bureau of Indian Affairs. The new panel is rated at 400 amps and has low voltage protection with a time delay to prevent tripping from momentary low voltages. The panel also has single phase protection to guard against loss of power in just one leg of the feeder lines.

Electric power consumption by the facility has increased from a monthly average of 6,740 KWH during the first year of operation to 9,630 KWH during the past year. The average winter load from December through March was 12,930 KWH/month and the average summer load from June through August was 5700 KWH/month. The higher power consumption during the past year is attributed to increased facility use and the completion of the blackwater treatment room, startup of the incinerator and the initiation of blackwater treatment.

FIRE PROTECTION

Interior fire protection includes an alarm system, a dry pipe sprinkler system and fire extinguishers placed throughout the building. The alarm system consists of bells located at various points to warn people in the building in case of a fire and a siren on the roof to alert nearby residents during hours when the building is unoccupied. The bells and siren may be activated by manual pull stations or heat detectors.

Because of the small capacity of the raw water tank and the impracticality of providing enough water storage to meet fire protection requirements, a special fire pump-raw water pump connection has been provided (Figure 9). The fire pump and the dry valve are connected by a motorized valve to the raw water tank. Opening of a sprinkler head and release of compressed air from the sprinkler piping activates the fire pump. Initially, this pump draws water from raw water storage. As the water level in the raw water tank drops, a level switch activates the river pump which begins to pump into the raw water tank. This clears the intake line of air. After the raw water level drops further, a second level switch simultaneously activates two motorized valves so that the river pump and the fire pump are now pumping in series.

A test of this system indicated the output of the fire pump was increased slightly when pumping in series with the river pump compared to pumping directly from the tank.

The exterior fire protection equipment is shown schematically in Figure 16. The pump is stored in a warm shelter near the river. If a fire occurs, the pump is taken down to the river and the suction hose connected to the pump. In the winter, the suction hose may be inserted through the ice at the raw water intake or a new hole must be cut in the ice. The fire hose is stored on hose carts in an unheated enclosure, also near the

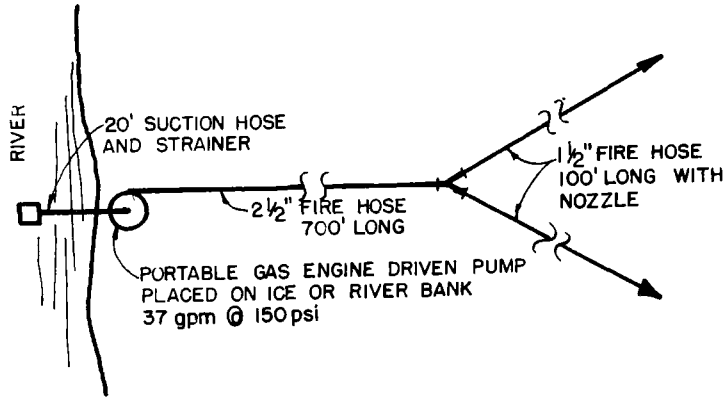

Figure 16. Exterior Fire Protection at Emmonak

river. The fire hose is unreeled from the hose carts between the river and the fire and connected to the pump. Two nozzles were supplied so that a fire can be attacked from two angles. The system has been tested successfully in the summer but has not undergone a winter test.

STRUCTURE AND FOUNDATION

The original building at Emmonak consisted of six prefabricated modules whose interior dimensions are about 7 feet high, 8 feet wide, and 36 feet long. They were placed on a wooden pad foundation and elevated 4 feet above the ground level by steel supports to avoid damage from flooding. Drains and sumps were installed beneath the floor of the modules, and the support structure was skirted to keep these from freezing. This arrangement has several very undesirable aspects, which, together with remedial measures taken, should be mentioned.

Primary among the problems experienced was differential frost heaving under the foundation. The ground at the periphery of the building, beneath the outside edges of the foundation pads, rose 6 to 8 inches above the unfrozen ground under the center of the building. Breaks in the piping occurred and considerable jacking and leveling became necessary to relieve the strain.

This difficulty has been corrected by shifting the foundation pads 30 inches from the periphery towards the center of the building. The steel support structure was modified to accomodate the relocation of the pads. To reduce heat losses, skirting of higher insulating value was installed in such a manner to accomodate ground movements by sliding against the side of the building.

Prefabricated building modules had been selected, in part, because they would permit installation of mechanical and electrical components at the factory, which appeared to be a major opportunity for

TABLE 5

EMMONAK FACILITY USE AND INCOME

Category	March 73-March 74	March 74-March 75	April-September 1975	Total
1. Washers, loads	4,761	6, 131	3,920	14,812
2. Dryers, time units	12,117	13,065	9,022	34,204
3. Baths, men	6,435	6,643	4,353	17,431
4. Baths, ladies	3,543	4,551	3,248	11,342
5. Income from all services, including sale of water:				
a. To village residents	$15,136	$19,632	$17,476	$52,244
b. To institutions	$ 1,954	$12,791	$11,385	$26,130
c. Total	$17,080	$32,423	$28,861	$78,374

reducing total facility costs. In practice, this was offset somewhat by the fact that equipment such as heat exchangers came loose during the shipment and much repiping was required after arrival on site.

The small size and compactness of the building modules complicated operation and maintenance. Eventually, several annexes and additional structures had to be provided to accommodate all necessary functions.

In future facilities of this nature, floor construction requires more careful attention. The floors consisted of 2 x 4 joists resting on two steel "I" beams running the length of the building, with plywood on top of the joists. The floor covering is steel or linoleum. After 3 years of operation, the floors in the shower areas, the treatment module and the mechanical room have begun to rot because of exposure to moisture. In the treatment module, the floor had to be reinforced to prevent failure.

In the laundry, substantial modifications of the floor structure were required in mounting a 25-pound capacity washer-extractor. This type of equipment is especially suitable for cleaning sleeping bags, quilts, and bulky clothing, and, therefore, highly popular in the village. Because the clothes drum of this unit rotates on a horizontal axis, the machine vibrated the building to such an extent that it could not be operated. Eventually, a solution was devised by hanging a heavy weight under the building in the area beneath the machine.

FACILITY MANAGEMENT AND USE

The central community facility at Emmonak has become an institution of importance to the people of Emmonak. They hold in high regard the men who run the plant and place considerable value on the services it provides. The villagers have demonstrated this by their willingness to pay for these services at rates which are equal to, and in reference to some categories, vastly exceed the price paid by Americans elsewhere for their basic water-related needs.

In the eyes of the villagers, the most important services provided by the facility are the suanas and showers, and the laundry. The saunas appear to have met a very strong, locally-felt need. In fact, their inclusion can be considered to have been a major ingredient in the success of the project at Emmonak. Despite routine maintenance, the men's sauna has already received such heavy use as to require renovation. From the onset, the City Council recognized that income from the saunas could be substantial and had the potential of carrying some of the other costs of operating the utilities center. Initially, the fee for adults was set at $1.00. In September 1974, this was raised over 60 percent of all payments by villagers for services at the center (Table 5).

Designs of any future central community facilities for villages in the Lower Yukon-Kuskokwim areas should take into account this experience

at Emmonak. Additional space for dressing and resting should be provided. Sauna heaters should be sized to maintain temperatures of 230°F without problem, and the sauna furnishings, wall panels and floors need more carefully be selected so as to withstand the continuous exposure to high temperature and the wide fluctuations in moisture.

Drinking water has been available from the facility since February 1973. During the 2-1/2 years of operation since then, water sales to village households have ranged from 4,000 gallons to 17,000 gallons per month. Total sales, which include water furnished to the community center and the schools, have reached a maximum of 53,000 gallons per month.

The average daily water use looks about as follows:

Customer		Gal/Day (Avg.)
BIA School		660
Community Center		120*
High School Construction Camp		380
Village Homes		360
In-Plant Use		2880
Cold Water	2080	
Hot Water	800	

*Because of water meter malfunction, this number was inferred from other data

The pattern of seasonal fluctuations in sales of water to households at Emmonak is the reverse of that observed at Wainwright, with peaks regularly occurring in mid-winter and lows reached between July and September (Figure 17). In summer, largely because of the fishing, villagers tend to be too busy for any but the most essential household chores, and water is available from rain. In the absence of a full-scale delivery system and with intra-village travel particularly difficult because of the standing water and mud, those households located some distance from the plant obtain some of their water from more convenient sources.

Whereas the history of water sales to homes has shown only seasonal trends, use of the laundry and baths has steadily increased. The sharpest income increase has occurred in the use of the bath by women (Table 5).

Service charges were initially set by the City Council as follows:

Shower, adult	$ .50
Shower, youth	.25

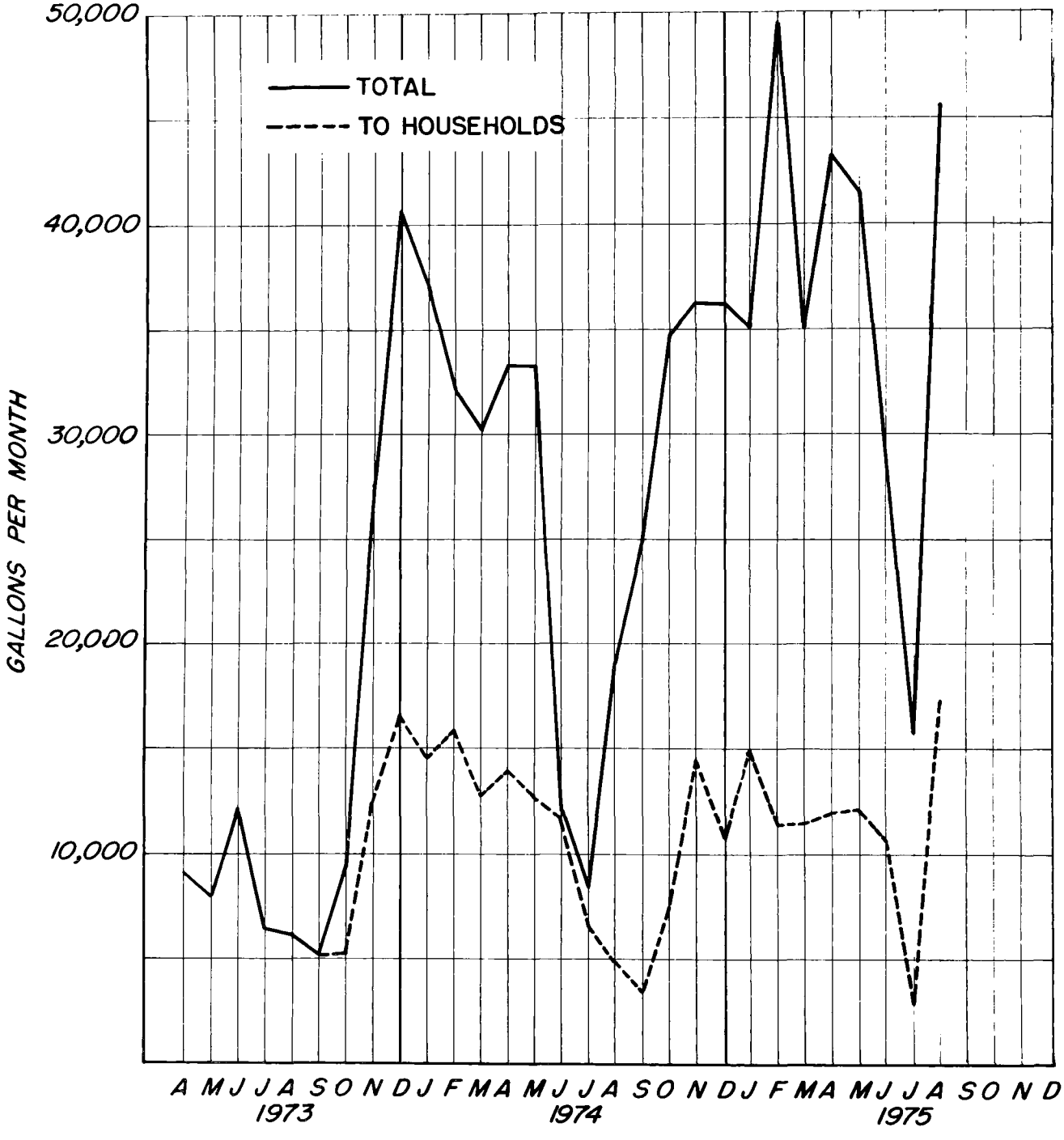

Figure 17. Water Sales at Emmonak.

Sauna/Shower, adult	1.00
Sauna/Shower, youth	.35
Washing Machine, small	.50
Washer-Extractor	.75
Dryer, unit time	.10
Drinking Water, self-service	.02/gal.
Drinking Water, delivered	.03/gal.

In September 1974, responding to increases in staff costs, the rate schedule was revised upward. Two service categories were established: one for commercial users and public institutions, the other for village residents and homes. The rate for drinking water to residents was intentionally kept low, without regard to costs, so as not to discourage its use. In case of the rates established for service to businesses and public institutions the rates were meant to reflect real costs.

Current schedule of rates charged at Emmonak:

1. Services to village residents and houses

Sauna and/or shower, adult	$1.75
Sauna and/or shower, youth, age 12-15	.50
Washing machine, small	.75
Washer-Extractor	1.50
Dryer, half cycle	.10
Drinking water, self-service	.02/gal.
Drinking water, delivered	.04/gal.

2. Service to Commercial Users and Public Institutions

(BIA School, High School, Community Center and businesses)

Drinking Water, via utiliduct or delivered	$ .07/gal.
Graywater treatment, via utiliduct	.05/gal.
Blackwater treatment, via utiliduct	.18/gal.

Since November 1973, the Emmonak facility has been locally managed as the "Emmonak Utilities Center" under the cost sharing contract with the City

of Emmonak. Because the City did not have enough operating capital to finance the contract and since banks would not extend a loan, an advance payment in the amount of $10,000, later increased to $17,000, was made by EPA to the City.

Under the contract, the City Council, in consultation with the EPA Project Officer, sets policy. Responsibility for management and maintenance of the facility and for day-to-day operation rests with a chief operator. He supervises an assistant operator, two public attendants, a driver/mechanic, and one or more skilled or general laborers as the situation may require. The assistant operator acts as deputy. Because the facility is open on weekends and nights, work schedules are staggered.

The chief operator's current pay is $7.90 per hour, with a raise contemplated in the near future. The assistant gets $5.97 per hour, the attendants are paid $3.25, and skilled laborers get $9.68. The relatively high wage of the chief operator is commensurate with his responsibilities. He has been with the project from its inception, is highly competent and has provided the kind of continuity which is essential. The City Council is considering making the chief operator position a salaried one.

Since March 1973, when the facility began to provide services regularly, operation and maintenance costs have averaged $6,300 per month. About 55 percent of this covers the wages of employees, 30 percent is for fuel and electricity, and the remainder goes for supplies, spare parts, and other overhead items. As the result of the need for higher wages, increases in the price of fuel and electricity, and because the blackwater and graywater systems will now be treating wastes from the two schools and the community center on a continuous basis, monthly expenditures and income are expected to increase.

Financial records are being kept by the City Clerk. This job pays relatively little and has been held by four different individuals in 2 years, some with very little experience or training. It appears that the clerks have been performing their duties in good faith and that contract funds are responsibly handled. However, because each of the clerks has had his/her own system and because the clerks succeeded each other without a formal closing and transfer of accounts, it is possible that the requirements of a formal audit at some future date can not fully be met.

SECTION VII

PROJECT COSTS

Since 1970, several changes in accounting points and accounting procedures have occurred in EPA. Therefore, the project costs shown are based on project office records which may 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.

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
Estimated Total	$779,600

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 (1975-1976)

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)
Estimated Total	$1,627,200	
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

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 the 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 comparable with that of the AVDP 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 $1,026,754, 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.

SECTION VIII

OTHER STATEWIDE PROGRAMS

Among efforts to establish and improve water-related utility services in rural Alaska, EPA's AVDP program is the smallest in size. Any assessment of how the job should be done must take into account the experience, program emphasis, and scope of work of two agencies who have the primary responsibility of meeting this need. The organizations concerned are (1) the Office of Environmental Health; Indian Health Service; U. S. Public Health Service; Department of Health, Education and Welfare; and (2) the State of Alaska Department of Environmental Conservation.

INDIAN HEALTH SERVICE

Since 1960, under authority of Section 5, P. L. 86-121, the Alaska Area Office of Environmental Health, Indian Health Service (IHS) has assisted 43 Alaskan villages with the construction of water and sanitation facilities. About 2500 homes have been furnished with running water. Projects currently underway will serve an additional 16 villages and 530 homes. Thirty-three villages have been provided with a watering point from which water can be hauled, as an interim measure, until complete facilities can be provided. About 50 percent of the rural Alaskan natives have been served with running water. Not all the water systems, however, are fully functional. Over 100 villages are still without satisfactory arrangements.

The improvement and safeguarding of people's health is the primary mission of the IHS. Within that context, an assured supply of safe water in the home and sanitary removal of wastes from the home are considered to be first requirements. Control of pollution in reference to the larger environment is a secondary objective. It is accomplished where relatively simple treatment methods will do the job, but is felt to be an unjustifiably expensive luxury in those cases where advanced methods of waste treatment would have to be applied to fully meet formal environmental protection standards.

Because most Alaskan villages lack the economic base to support complex utility systems, a primary IHS design consideration is low operation and maintenance cost, even if this requires high capital investment. IHS concludes that in Alaska, the EPA requirement for secondary sewage treatment, and especially for the best possible treatment by 1980, may very well make the difference in whether or not a village can afford to operate and maintain a facility. Both from a public health and environmental viewpoint, secondary treatment is considered unnecessary at most locations. Faculative sewage lagoons are used wherever possible because of their high reliability and low operating and maintenance cost.

Extended aeration package treatment plants have been installed in a few villages. Their operating history, whether for lack of funds, skill or

attention, has been poor; in almost all cases, the quality of treatment actually attained being less than from facultative lagoons.

Concern has been expressed over the practicality of meeting the provisions of the recent Safe Drinking Water Act. IHS expects the Safe Drinking Water Act to complicate methods of water treatment and quality monitoring unduly, and to have a major adverse effect on the operation and maintenance cost of small rural water treatment and distribution systems.

Projects are initiated by application from villages. Communities are selected for participation on the basis of:

1. Urgency of health need.

2. Economic and engineering feasibility.

3. Ability of the village to participate in and to contribute to the project.

4. Ability and willingness of the village to assume the responsibility for operating and maintenance of the facilities to be provided.

5. Enactment of applicable local ordinances to aid in utilization of the project to improve the health of the village people.

Since 1967, emphasis has been placed on serving those communities receiving new housing under Department of Housing and Urban Development and Bureau of Indian Affairs programs.

Village Councils participate in deciding on the type of project best suited to their community and must agree to assume ownership and full operation and maintenance responsibility for completed facilities after an initial 1 year period of operation. In the course of construction, villages are expected to make contributions in labor or in kind. The force account method of construction is preferred because it reduces cost and allows best utilization of local labor. Training for local operators is provided. Field engineers are available to help with technical problems when requested and limited funds are available on emergency basis, in the case of major malfunction or breakdown of a sanitation system (2).

In conjunction with the construction of sanitation facilities, the Office of Environmental Health also conducts a comprehensive environmental health program in the villages. A team of 20 sanitarians and sanitarian technicians, 18 thereof stationed in the field, engage in epidemological investigations, provide instruction in vector control, food handling and accident prevention, and consult with householders on matters of health within the home.

Funds made available for IHS sanitation facilities construction in Alaska have varied widely, as shown below:

Fiscal Year	Amount
1960	$ 19,000
1961	112,000
1962	240,000
1963	1,058,000
1964	1,281,000
1965	456,000
1966	476,000
1967	442,000
1968	1,246,000
1969	4,804,000
1970	3,933,000
1971	3,737,000
1972	9,882,000
1973	10,300,000
1974	11,198,000
1975	10,810,000
1976	15,000,000

The 1974 amount includes $6 million for water service development at Barrow. The figure shown for 1976 is the requested amount. Additionally, about 10 percent of the funds spent in construction are required for administration. The office has a current engineering, sanitarian and administrative support staff of 53.

Senate and House Bills for the Indian Health Care Improvement Act (94th Congress, 1st Session, S.522 and H.R. 2525) are expected to be passed soon. They would establish as national policy "to provide the highest possible health status to Indians and to provide existing Indian health services with all resources to effect that policy." If fully funded, the Indian Health Care Improvement Act would make available, among other things, $378 million over a 5-year period to supply unmet needs for safe water and sanitary waste disposal facilities, thereby substantially boosting the IHS sanitation facility construction program in Alaska.

The Indian Self-Determination and Education Assistance Act, P.L. 93-638, which was signed into law on January 4, 1975, will change the administration of the IHS sanitation facility construction program. The Act directs the Secretary of the Department of Health, Education and Welfare, upon request of any Indian tribe, to enter into contracts with tribal organizations to carry out any or all of his functions, authorities, and responsibilities which, in reference to such a tribe, he may have.

In Alaska, native communities and organizations are much preoccupied with problems in getting the Alaska Native Claims Act implemented and this time and are likely, therefore, to prefer not to assume too many additional responsibilities immediately. In the course of the next 5 years, however, this situation can be expected to change.

STATE OF ALASKA

In 1970, following the lead set by Congress, the Alaska State Legislature passed the Village Safe Water (VSW) Act (AS 46.07) to provide "safe water and hygienic sewage disposal facilities in villages in the state." The Act stipulates that a VSW facility be built only with assurance from the village governing body that it will accept ownership and responsibility for the operating and maintenance upon completion of the facility. Acknowledging, however, that villages often lack sufficient financial resources to meet this obligation, the Act also allows the State to make grants to the governing body of a village to enable it to do the job.

To provide capital funds for construction, voters approved bond issues for a total of $4 million in 1970 and 1972. Insufficient staff and an initial lack of money for administering the project delayed startup of a program until October 1972. Also, no fund had been established for operation and maintenance subsidies. Without assurance of sufficient resources for this purpose, the Department of Environmental Conservation (ADEC) was reluctant to proceed with construction.

In December 1972, 32 villages were identified as being most in need of the sanitation services intended under the VSW Act. The villages of Northway and Chevak wanted to expand watering points earlier established under the IHS P.L. 86-121 program into simple central facilities, and therefore assistance was provided in completing these. In 1973, with a decision by the Alaska Department of Education (ADOE) to construct high schools at Alakanuk, Selawik and Nulato, it appeared that in these three communities the uncertainty over operation and maintenance could be resolved. ADEC agreed to build VSW facilities as adjuncts to the schools, serving both the institution and the village, if ADOE would pick up the tab for the operation. Design and construction of the schools and utility centers were administered by the Division of Buildings, Department of Public Works. The Nulato plant has been operational since early 1975 and the other two facilities are now nearing completion.

The ADEC has been disappointed in the results. It had been assumed that, by constructing both the school and the VSW facility under a single contract at each location, costs could be reduced. ADEC feels that this has not at all been the case and has decided that future projects shall be financed through grants to the village and be accomplished via construction management contracts instead. Cost of the three projects at Alakanuk, Selavik and Nulato has been over $3 million, and in the case of the Nulato facility, ADEC feels the results have been poor. Further complications resulted from shifts of control over rural school construction from the ADOE to the Alaska State Operated School System (ASOSS). ASOSS was reluctant to accept the responsibility for operation and maintenance which ADOE had previously accepted. Recently, ASOSS agreed to fund part of that cost by paying $6,000 per month for water and waste service at two of the three schools.

ADEC plans to continue the VSW program by constructing central community facilities of simpler scope at the small villages of Beaver, Koyukuk and

Pitkas Point. Kongiganak, Eek, and perhaps Anvik are considered as additional sites. Currently, $800,000 remain available for construction.

In FY-76, funds were approved for the preparation of a long-range plan for the VSW program. This plan is expected (1) to identify those villages where VSW facilities should be installed, (2) to determine what services should be provided by each facility to be built and (3) to establish a schedule for project construction. Capital spending needs will be identified.

In its FY-1976 budget, the ADEC also requested and received $289,000 to assist the first eight villages with the operation and maintenance of their VSW facilities. These funds are looked upon as an interim solution until State policy concerning operation and maintenance for VSW facilities can more clearly be established. As a first step, the Commissioner of the Department of Environmental Conservation submitted a comprehensive report on the Village Safe Water program to the Governor on September 12, 1975.

This report describes the program in detail, airs a number of internal administrative problems and raises the matter of operation and maintenance support as a major issue (3).

> Construction of any utility system, especially in the relatively harsh environment of rural Alaska, is money wasted unless provisions are made for the system to be properly operated and maintained. Most if not all villages qualifying for VSW projects lack the necessary resources to administer, manage, operate and maintain even a minimum VSW facility (or any other utility system) without continuing outside assistance...
>
> To date the State does not have a firm policy position on how to provide for VSW operation and maintenance. Some of the options to be explored...have already become apparent in the few years the VSW program has been in existence...
>
> Some alternatives to consider are: (1) a grant program to subsidize rural water and waste utility service, (2) a system of State owned and operated facilities to provide water and waste service in remote areas, (3) a utility system owned and operated by native organizations either as a service or a profit making venture (perhaps subsidized by the State), or (4) a public utility managed by private organization perhaps controlled and subsidized by the State.
>
> A program for operation and maintenance of VSW facilities should perhaps not be considered independent of the need for a system to insure proper operation and maintenance of rural sanitation facilities in general. In fact it might be well to consider the possibility of an operation and maintenance system for all rural utilities (4).

The Report to the Governor goes on to analyze annual facility operating costs. In 1974 dollars, these were estimated to range from $25,000 to over $100,000 per village, not including amortization. The Report concludes that less than half of these amounts can be expected to be raised from individual users and public health clinics. The rest would have to come from schools or from the State or Federal governments directly.

In formulating the long-range plan mentioned above, the VSW program staff plan to consult closely with IHS and AVDP personnel. June 1976 is set as the target date for plan completion.

SECTION IX

ISSUES

Two major, related issues have been identified which must be resolved before a statewide village sanitation facility construction progam can fully succeed. One is in reference to operation and maintenance support. The other is in reference to the degree of waste treatment required.

OPERATION AND MAINTENANCE SUPPORT

With rare exception, Alaska native villages cannot pay for the full cost of routine operation and maintenance of water-related utilities, especially where complex treatment is required to meet established standards. This finding has openly been acknowledged by the Alaska Department of Environmental Conservation and is tacitly agreed to by the Alaska Area Office of the Indian Health Service. The Alaska Department of Environmental Conservation has suggested that it might be best to postpone further major construction until the problems in financing operation and maintenance of village facilities have been resolved.

In authorizing rural sanitation facility construction and Indian programs, legislatures have dealt with the matter of operation and maintenance support in a variety of ways, mainly by skirting the issue. The Surgeon General was authorized in 1959, under the Indian Sanitation Facilities Program, "...to make such arrangements and agreements... regarding...responsibilities for maintenance...as in his judgement are equitable and will best assure the future maintenance of facilities in an effective and operating condition." (Section 7.a.3., P.L. 86-121) Since no funds for maintenance were authorized, the IHS has interpreted this to mean that operation and maintenance was to remain a local responsibility. The mandate of best assuring effective operation would have to be met by selecting the more viable communities where simple systems would do the job. Lowest possible operation and maintenance cost became a foremost design criterion, even if this required unusually high investments in construction. With the easier locations now served, and with stringent treatment requirements imposed in the meanwhile, the task of providing for reliable functioning of newer facilities, without subsidizing the operation, is becoming increasingly hard. There have been numerous system failures.

A bill sponsored by Senators Stevens and Kennedy for "Alaska Safe Water Facilities," in 1969 (S.7, 91st Congress, 1st Session), and presumably a precursor of the AVDP legislation, recognized the need for financial operation and maintenance support and proposed that such be authorized. In its final form, however, all reference to operation and maintenance had been deleted from the AVDP legislation.

The recent Indian Self-Determination and Education Assistance Act (P.L. 93-638) enables the Secretary of the Interior and the Secretary of Health, Education and Welfare to provide Alaska native villages with grants for "maintenance...or operation of tribal facilities...of adequate health facilities or services." (Section 104, a.1. and b.1.) Monies for such grants, however, must come from funds appropriated for other existing programs.

So far, the only substantive provision which addresses the operation and maintenance need was made by the State in the Village Safe Water Act. In 1975, an initial sum of $289,000 was made available to support the operation of facilities constructed under the Village Safe Water program.

EFFLUENT STANDARDS

The cost of operating and maintaining water-related utilities in rural Alaska is directly related to the level of waste treatment provided. Operation and maintenance costs for the waste treatment phase at Emmonak are estimated to be at least three to four times greater than similar costs for treating the same waste in a lagoon.

The current waste treatment requirements established under P.L. 92-500 are often more stringent than necessary to avoid environmental degradation in rural Alaska. A high degree of environmental protection can be attained at substantially less cost if such factors as community size, distance between communities, character of receiving waters, climatic conditions, geology, good engineering design, etc., determined the level of treatment. Effluent standards formulated in terms of waste units per effluent volume discourage conservative water use. Safe potable water is a scarce and expensive commodity in rural Alaska and will not, therefore, be commonly used as a conveyance for sewage. Thus, the problem of treating highly concentrated wastes to the level required to meet current effluent standards compounds the already serious problems of maintaining water-related utilities in rural Alaska.

Current and proposed standards will require treatment facilities which are technically sophisticated and mechanically complex, and which are costly to build and to operate. In rural Alaska, such installations are unusually vulnerable, even when substantial resources are spent in providing safeguards against failure. The electric power supply is always tenuous. Losses from freezeups are a major threat. When replacement parts are required, it can take a month to get them to the site. For these practical reasons, the argument for simplicity in facilities designed to serve rural Alaska remains very strong.

SECTION X

INSTITUTIONAL CONSIDERATIONS

Because the villages are mostly small and at scattered, isolated locations, institutions are needed at regional levels to provide technical, logistical and administrative support to these communities in operating and maintaining basic utilities. This need was discussed at length in the 1973 Report to Congress. Since then, significant developments towards the establishment of such institutions have occurred.

In the case of the North Slope Borough, a solution has been worked out through transfer of all municipal powers relating to utilities from member communities to the borough. In the so-called Unorganized Borough, in which most villages are located, the Regional Native Housing authorities were recently given authority by the State to enter into agreements with villages for the construction, operation and maintenance of village utilities, including generation and distribution of electric power (AS 18.55.995-996 and AS 18.57.101-110).

The Regional Native Associations, under whose auspices the Housing Authorities are formed, will require financial support if they are to take advantage of this enabling legislation. They would appear to be eligible for Federal assistance from the Indian Health Service and the Bureau of Indian Affairs under provisions of the Indian Self-Determination and Education Assistance Act. However, because existing programs contain no funds for such a purpose, monies would need to be specifically appropriated.

One critically important ingredient of any undertaking like the Alaska Village Demonstration Project are the local people charged with management and operation. At Emmonak and Wainwright there is no lack of people of sufficient general competence for all aspects of the job. Specific training, guidance and support are essential. This should commence at the design stage and, depending on the community, be furnished for 1 or more years after facility completion. Also, with the fierce competition for skilled people in much of rural Alaska, wages commensurate with the job and the responsibilities must be paid to insure continuity of operation.

The above observations are made only on the basis of the AVDP experience in the two Eskimo villages of Emmonak and Wainwright. They can not simply be extrapolated to apply to all of rural Alaska. The IHS, with its far broader experience throughout the state, reports instances where communities appear to have shown little inclination of supporting a project after it was constructed and where competent operators have not been found.

The Alaska Department of Environmental Conservation feels that the AVDP experience with operators at Emmonak and Wainwright could indeed apply throughout rural Alaska, given a sincere and sympathetic effort to develop, motivate and sustain the local operations and if resources for this purpose were furnished for the life of a facility rather than just an initial period (5).

SECTION XI

REFERENCES

1. Letter from C. P. Falls, ARCO Environmental Conservation Manager, to H. J. Coutts, EPA Arctic Environmental Research Laboratory, dated December 9, 1974. Also letter from C. H. Dunaway, Jr., ARCO to H. J. Coutts, dated December 15, 1975.

2. Letter from Dr. William Ryan, Chief, Sanitation Facilities Construction Branch, Indian Health Service, to Bertold Puchtler, EPA, Arctic Environmental Research Laboratory, dated January 8, 1976.

3. Alaska Department of Environmental Conservation, The Village Safe Water Program: A Briefing for Governor Hammond, Juneau, Alaska, August 1975.

4. Ibid, p.p. 9-14.

5. Letter from J. W. Sargent, Alaska Department of Environmental Conservation to Bertold Puchtler, EPA, Arctic Environmental Research Laboratory, dated January 23, 1976.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

The "Alaska Village Demonstration Projects" (AVDP) were authorized by Section 113, P.O. 92-500 (86 STAT 816), for the purpose of demonstrating methods to improve sanitary conditions in native villages of Alaska. Central community facilities have been constructed in the native villages of Emmonak and Wainwright to provide a safe water supply; toilets, bathing and laundry facilities; and sewage and waste disposal.

The idea of coming to a community center to secure water, to do the laundry, and to bathe has proven acceptable to the people of Wainwright and Emmonak. However, Alaskan native villages generally can not pay, through service charges, the full cost of routine operation and maintenance of water-related utilities, especially where complex treatment is required to meet waste treatment standards.

The physical-chemical wastewater treatment provided required considerable modification and detailed operator attention to provide consistent secondary treatment. There is no single best method of constructing water-related utility facilities in rural Alaska.

17. KEY WORDS AND DOCUMENT ANALYSIS

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