ENVIRNONMENTAL STANDARDS FOR NORTHERN REGIONS

Environmental standards for northern regions:
A symposium
Daniel W. Smith
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A SYMPOSIUM

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PREFACE

The environmental standards for water, air, and land are of prime importance to all members of the northern community. Many of the ecological systems are easily disrupted. Some of the systems are extremely stable. Although the volume of scientific and engineering research on various aspects of the total environment is expanding rapidly it appears that those studying the conditions that exist and those setting the standards for these areas seldom, if ever, communicate. Due to the increased attention being paid to the meaning and impact of regulations, the sponsors of this symposium proposed an opportunity for open discussion of the issues. The program was designed to address the full range of environmental situations.

The principal objectives of this symposium were:

1. to review environmental standards and regulations
2. to identify environmental problem areas
3. to examine the adequacy, pertinence, enforcement, and effectiveness of environmental control in the North.

While these objectives could not be completely satisfied by this meeting, doors were opened; participants discussed issues brought forth; and progress was made toward a better understanding of needed environmental standards for northern regions.

ACKNOWLEDGMENT

The success of this symposium should not be judged by the program chairmen. We are, however, appreciative of the large number of participants and of the part they took in the session discussions. This attendance and participation are alone sufficient criteria in our eyes to judge the symposium worthwhile.

The authors of the manuscripts presented herein are sincerely thanked for their diligent effort and participation. Our appreciation is extended to the session moderators: Bob McCollum, Eric Davis, Tim Buzzell and Sid Heidersdorf. A special acknowledgment is due our out-of-state guests including those from Canada and our luncheon and banquet speakers.

The accommodations and service provided by the Holiday Inn, Anchorage, were very much appreciated as, in particular, was the assistance given by Ms. Sue Knudsen, catering secretary.

Alyeska Pipeline Service Company, Atlantic Richfield Company, and British Petroleum Alaska, Inc. are thanked for the flight along the pipeline corridor and fine tour of the Prudhoe Bay facilities. This excursion was the highlight of the symposium for many of our Canadian friends. A special thank you to John Ratterman and Frank R. Fisher of Alyeska, C. Paul Falls of ARCO and Charles B. Towill of BP.

Financial support for this symposium was provided by the University of Alaska - Division of Statewide Services, Program of Environmental Quality Engineering, and the Institute of Water Resources. These organizations are acknowledged for their participation.

The secretarial staff and graduate research assistants of the Institute of Water Resources provided much-needed help, especially Julie Conover, executive secretary of the institute, whose assistance was invaluable.

Lastly, we acknowledge Mayo Murray, editor, Institute of Water Resources, for her unselfish devotion in seeing to it that the proceedings of this symposium became a reality. Her countless hours in working with the manuscripts and the assistance she provided two environmental engineering "editors" are priceless.

Timothy Tilsworth
Daniel W. Smith

SESSION I
NORTHERN RESEARCH GROUPS

Moderator:

ROBERT McCOLLUM

THE UNIVERSITY'S ROLE IN ENVIRONMENTAL STANDARD RESEARCH

Robert F. Carlson*

I want to say a few words today about the role of the university in achieving environmental standards for the north. Rather than present a detailed plan of research action, it will be more useful to discuss the context in which this research will be carried out over the next several years in the north and the activities in which the university can best engage.

As a starting point, I think it would be helpful to define, as a frame of reference, several terms.

First the term *environment* - the dictionary tells us the word means "the total of circumstances surrounding an organism or group of organisms." I assume this includes people. It certainly means more than the natural environment. Adopting this frame of reference makes research a great deal more complex and difficult and certainly conveys the idea that the organisms, people, are a part of the environment in the sense that it is people who are setting the standards. A consideration of people's needs and desires when adopting environmental standards seems quite appropriate.

The word *standard* means "a degree or level of requirement, excellence or attainment." The implication is that some decision must be made to determine exactly what standard is desired and, in the case of an environmental standard, what degree of excellence we are seeking in order to obtain the desired total of circumstances surrounding people.

Next the word *north* - a very difficult concept to define, but which for the most part can be taken to mean cold, a way of life, a lack of people, and remoteness. To some the north can imply a degree of undesirability, as witnessed by the fact that a great deal more people prefer to live in the

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Los Angeles County than in the whole state of Alaska. Nevertheless, for those of us who choose to live in the North, a very desirable way of life is available which can not be enjoyed in Los Angeles County.

Although not mentioned in the symposium announcement, certainly setting an environmental standard will require a certain amount of enforcement. Since not all people generally agree on anything, once a standard is perceived, that is, some agreement achieved as to what level of excellence is required, some type of enforcement will need to be undertaken for those who do not agree.

In view of the above definitions, the task of defining a role for the university, in terms of its research, training and public service functions, would be quite easy if Alaska were Los Angeles County, North Carolina or some other region which has achieved a certain amount of stability in terms of its environment, population and other aspects of living. In the North, however, we face an unprecedented era of resource extraction, change of land ownership and Alaskanization of Alaska.

There are many features of these changes; some are:

1) For the first time, indigenous Alaskans will control much of the states resources.

2) For the first time, sufficient funds will be available for environmental attainment, control, and capital expenditures and with it will come an opportunity to direct expenditure of this money in an efficient manner toward achievement of a certain environmental standard.

3) The coming era will mean an extremely rapid population increase with the attendant environmental conflicts. Alaska very soon will face many of the problems which up till now have been causing concern only in other parts of the country.

4) Probably most important, a greater portion of the population will become permanent residents. For the first time, therefore, decisions will be made by voters, politicians, businessmen and government officials in the certain knowledge that they will need to deal with these decisions for a number of years to come.

This change in Alaska will come at a rapid pace at a time in her history which presents an unprecedented opportunity to control change in order to achieve a long term environmental standard. In the coming years, this means an increase in flow of vital decisions will demand the very best in terms of talent, information, perception, and judgment.

Some of this is already at hand; some will need to be gained through further research and experience. It is critical that the experience and research have intimate communication.

It is very important then, that those who participate in setting environmental standards adopt a northern viewpoint, demand modern, sophisticated tools of understanding which can mean sophisticated mathematical models, modern data acquisition, and expeditious communication of the results of both experience and research to all Alaskans. Also we must demand absolute economy in defining, obtaining, and maintaining an appropriate environmental standard. No longer can we afford to build treatment plants for the sake of building a treatment plant, adopt standards because the federal government says we must, or accept federal money because it is there to be accepted.

What will be the university's role in all this? For a variety of reasons, because of the increasing dependence on Alaskan personnel for Alaska decisions and the increased funds brought about through resource extraction, the university will play an ever-increasing role in achieving an appropriate environmental standard. First, the university - through its research, instruction and other public service roles at all campuses of the university will emphasize a greater role in training at all levels, associate through master degrees.

Second, modern tools of environmental standardizing, which will emphasize adapting the best in techniques, theories and mathematical and computer models, will be developed to suit Alaskan conditions. This is a task which must be carried out by Alaskans, in Alaska, if modern tools are ever to be adopted by environmental practitioners. Third, university training will emphasize equipping Alaskans to manage Alaska's environment. This is an absolute must because of the many peculiar features of Alaska and due to a need to develop a particularly northern way of examining and controlling the environment. No longer should Alaskans have to rely on outside consultants to examine and report on the control of Alaska's environment. This does not infer that use should not be made of expertise, wherever it can be found, but the expertise must be acquired on terms specified by Alaskans. Fourth, there will be an emphasis on studying the effectiveness of environmental control and examining the equipment, procedures, politics, law, and means of achieving a proper environmental standard. This will mean many kinds of research which has not been done before in Alaska, but which offers a great deal of promise in achieving a greater efficiency of expenditure of public funds and talent. Fifth, the university must aid in development of a northern viewpoint or perception of the kind of environment we hope to achieve.

We have it within our power to achieve an environment which is characterized by the Alaska wilderness or one which is characterized by downtown Megalopolis, U.S.A. We have some of both already. Some would want us to move in a rapid pace in one or the other direction. The appropriate choice can be made only through acquistion of as much knowledge as possible and a broad dissemination of this knowledge to the people who must make the decisions.

In summary then, the University of Alaska's research, instructions, and public service, will participate to the fullest in obtaining the appropriate environmental standard for Alaska. This will be brought about in many ways: through training programs, short courses, associate degrees programs, bachelor and master degree programs, large sophisticated research projects, development of mathematical models, the gathering of informational data and use of traditional techniques of analysis and description. The university, however, cannot do this by itself but must work with various state agencies. These agencies cannot play a passive role of accepting whatever the university happens to produce but must adopt an active role in criticizing, suggesting, assisting and using the university's product, whether it be training, research or public service.

It is my hope that in the years to come we can have another seminar which will illustrate, to all who care to attend, a peculiarly Alaskan environmental standard which has been developed by Alaskans for living in Alaska. I also expect that the university, through its research, teaching, and public service roles, will respond and equip the people of Alaska with the necessary tools, understanding and perspective to establish, maintain, and regulate an environmental standard which is appropriate to the state of Alaska.

RESEARCH ACTIVITIES OF U.S. ARMY COLD REGIONS RESEARCH AND ENGINEERING LABORATORY

Timothy Buzzell*

The mission of the Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL) includes performing basic, applied and evaluation type research that addresses engineering and scientific problems caused or aggravated by cold conditions. The main laboratory is located in Hanover, New Hampshire, with an Alaskan Division located in Fairbanks, Alaska. The professional staff includes 53 research scientists, 72 research engineers, and 120 support personnel.

CRREL's involvement in environmental research has been extensive in recent years. Areas of research given consideration include: water supply and purification; wastewater treatment and disposal; utility distribution systems; solid waste disposal; and receiving body water quality.

During 1972-1973 an experimental snow fence was operated in the Barrow Village watershed to demonstrate the feasibility of significantly increasing water yield in those coastal areas of low annual precipitation and runoff. Using an 8-foot-high fence, water storage was increased significantly. Snow melt was delayed about one month. Computer model simulations have also been performed with predicted ground temperatures and snow melt in good agreement with the observed. The impact of a late snow cover on tundra ecology is being monitored in cooperation with University of Colorado ecologists.

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CRREL has, in the past, done research on conventional treatment of cold, high iron content waters in Alaska and has formed a good appreciation of the difficulties involved in making them potable. Rates of chemical additions, coagulation time requirements, and sedimentation time requirements are all affected. This has led to research on other non-conventional treatment techniques. Among these are reverse osmosis and microflotation. Microflotation is a fast and efficient variation of the conventional flotation process in which the liquid surface tension is reduced through the addition of a surfactant thus reducing considerably the bubble size and hence increasing removal efficiency. The process is currently being considered at CRREL as a possible technique for the treatment of the grey water in closed loop recycling systems.

CRREL has in the past done a considerable amount of applied research on biological secondary treatment of wastes at low liquid temperatures and on package biological treatment systems. This work has resulted in the development at CRREL of a single tank extended aeration system utilizing wood stave tankage and a floating tube settler. This system has been shown to have several advantages over conventional package plant design with respect to size, thermal protection, and cost.

CRREL funded a study for Dr. R. S. Murphy, formerly of the University of Alaska, to evaluate the cold season operation of the College Utilities oxidation ditch in College, Alaska. This work resulted in a final report which was accessioned by CRREL. In addition, literature research and on site investigations of winter-time operation of several oxidation ditches were conducted during 1972. This was compiled, together with certain information from Dr. Murphys' report, and consolidated into a CRREL Technical Report.

CRREL has sponsored aerated lagoon research in the past through the Corps of Engineers Alaska District to determine the long term performance of aerated lagoons in an arctic climate both with respect to waste treatability and sludge accumulation. Another lagoon study sponsored by CRREL and conducted by EPA involved investigating alternative aeration devices for non-complete mix aerated lagoons.

Effluent standards suggested by EPA for 1977 would require that secondary treatment provide a product containing less than 30 ppm BOD and suspended solids to include the algal fraction. Generally lagoons in Alaska cannot presently meet these requirements due primarily to high summer-time algal concentrations caused by extended periods of sunlight. CRREL is funded by FY 75 to do investigatory research via literature and on site investigations into the various alternative means of upgrading lagoon effluent quality. In addition, CRREL and the Institute of Water Resources at the University of Alaska intend to conduct a joint project at Eielson Air Force Base this summer (1974) to determine the applicability of land disposal as a viable means of upgrading the algal-laden effluents from Alaskan lagoons during the summer months.

CRREL is the lead laboratory for the Corps of Engineers for management and for conducting land treatment research. The objective of the research is to determine:

a. short and long term responses of the receiving ecosystems to different effluent types,

b. the effect of various application rates and periods

c. influence of seasonal climatic conditions.

A major portion of the work is being conducted in-house in a unique wastewater management research facility recently constructed at CRREL. CRREL also manages Corps-sponsored research conducted at other institutions, civil engineering labs and universities.

CRREL-sponsored research in 1972 (through the former Arctic Health Research Lab in Fairbanks) to investigate the applicability of ozonation for iron removal in the treatment of Alaskan groundwaters. This work, now being done by the Institute of Water Resources at the University of Alaska, has currently been expanded to look at the feasibility of using the ozonation process in conjunction with filtration to achieve desired water purity.

Related to this, CRREL is currently conducting work in-house to determine the disinfection and treatment responses of domestic primary and secondary effluents to ozonation.

At Barrow and Fox, Alaska, experimental crude oil spill studies have been conducted as part of CRREL's effort to evaluate the ecological impact of petroleum spills in cold ecosystems. Observations have been underway since 1970 along the Haines-Fairbanks pipeline route to evaluate long-term ecosystem recovery from petroleum products. Movement of oil vertically and laterally in the organic-rich and water-saturated soils has been monitored.

CRREL is actively participating in a Corps of Engineers program to determine if open-water disposal of dredgings is environmentally sound. Specifically, CRREL is studying the significance that the organic fraction of dredged sediments has on the transport and availability of potential pollutants.

The Caribou-Poker Creeks Research Watershed has been established as a site for long-term investigation of the northern forest environment. Research is initially aimed toward developing an understanding of hydrologic, climatologic and environmental relationships in an undisturbed setting.

There is also a remote sensing group at CRREL interested in use application. This includes both satellite and aircraft imagery and real time data acquisition.

U.S. GEOLOGICAL SURVEY

WATER RESOURCES DIVISION PROGRAMS

Harry Hulsing*

DIVISION FUNCTIONS

The primary function of the Water Resources Division is to determine the source, quantity, quality, distribution, movement, and availability of both surface and ground waters. This work includes investigations of floods and shortages of water supply, their magnitude, frequency, and relation to climatic and physiographic factors; the evaluation of available waters in river basins and ground-water provinces, including water requirements for industrial, domestic, and agricultural purposes; the determination of the chemical and physical quality of water resources and its relationship to various parts of the hydrologic cycle; special hydrologic studies of the interrelations between climate, topography, vegetation, soils, and the water supply; research to improve the scientific basis of investigations and techniques; scientific and technical assistance in hydrologic fields to other Federal agencies and to licensees of the Federal Power Commission. As prescribed by Bureau of the Budget Circular No. A-67, the Division is also to coordinate Federal water-data acquisition activities, which includes designing and operating a national water-data network, organizing the national network of data, maintaining a central catalog of information on water data and acquisition activities, and preparing a Federal plan. The results of these investigations are published in the series of Geological Survey publications.

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PROGRAM OBJECTIVES

The objectives of the National Water Information Program must be directed toward developing information regarding hydrologic systems to such refinement and degree that these systems may be modeled for examination of the hydrologic consequences of alternative actions of man. From the information developed and the methods used to present it, we must be able to predict the changes that will take place in the hydrologic system in response to stresses now being applied or new stresses that will be applied under future development alternatives.

More specifically, the policy of the Water Resources Division is to:

> Provide the knowledge and data concerning the water resources needed for the solution of increasingly complex environmental, land use, and water problems and permit the optimum management and use of these resources.
>
> Develop methods, instrumentation, techniques, and uniform standards for collecting, analyzing, and disseminating data.
>
> Coordinate data-acquisition activities of all water agencies.
>
> Undertake analytical and areal studies to provide information in its most useful form.
>
> Improve the effectiveness and efficiency of the entire system by scheduling fundamental and problem-oriented research as an integral part of the total program.

The Geological Survey is the major collector of water information in the nation. Therefore, its districts are expected to produce needed water data in a timely fashion to the user. The need may be for real-time data, for current data, or for historic data. It is of great importance to know about these needs in advance when possible. A district must have some knowledge of the demand for products and services of non-Federal users, Federal users, and the Geological Survey itself.

The non-Federal cooperative program normally is oriented toward the day-to-day operations of the cooperator and is related to water supply problems, environmental concerns, legal problems, water rights, and management. Much of these data are of interest to the Federal establishment and are of a quite high priority. On the other hand, a large part of the programs with other Federal agencies are routine data collection and reporting. This may seem to be low priority work in many cases, however, the survey has certain responsibilities under OMB Circular A-67 to obtain these data. When considering existing financial and manpower constraints and the fact that the district program must be oriented toward reaching long-range as well as short-range goals, priorities must be set and used in programming.

Present thrusts are concerned with the energy crisis, the environment, Indian-related problems, and land use. We must solve these problems at the same time that we are pushing toward long-range goals. Some long-range goals are:

1. Complete a river-quality assessment of all critical major basins in the nation to: (1) define the existing river quality, (2) present trends in river quality, and (3) project river quality under various alternatives of basin development and river management.

2. Expand water-quality information activities to fully establish a national accounting network which includes measurement of physical, chemical, biologic, and sediment parameters; identify and evaluate baseline concentrations, trends, and behavior of toxic metals and pesticides; and assess and summarize water-quality conditions for major river basins.

3. Establish a national network of streamflow stations parallel to the water-quality accounting network to provide baseline data for national assessments and regional water-resources planning studies.

4. Develop models for major regulated stream systems to adjust histori-

cal data to constant conditions for planning and design, and to evaluate and predict environmental impacts of development.

5. Expand research on the hydrologic principles that control river quality with special emphasis on estuaries, lakes, and reservoirs, to provide technical information for use in understanding the resource and its problems.

6. Provide data and information on substances in solution and in suspension entering estuarine and coastal waters, their movement in these waters, their effect on the environment, and their eventual deposition in the ocean.

7. Complete nation-wide appraisal of regional ground-water supplies and assess subregional ground-water reservoirs.

8. Complete a national inventory of the underground space storage potential and develop the criteria and guidelines required to safeguard the subsurface water and mineral resources.

9. Complete a national appraisal of the nature, extent, and magnitude of current utilization of underground space for the deep-disposal and storage of wastes and for the regulatory storage of water, gaseous, or liquid fuels and chemicals. Also, appraise the extent of potable ground-water contamination.

10. Investigate the nature, distribution, and magnitude of geothermal resources in order for the Department of the Interior to appraise, lease, develop, and manage lands having geothermal potential as required by the 1970 Geothermal Steam Act.

11. Identify the unmet Federal, State, and local needs for water data, and expand and implement the National Water Data System to meet those needs.

12. Collect and analyze hydrologic data with emphasis on urban, coastal, arid, arctic, and lake environments.

13. Develop and operate a system for the collection, processing, storage, and dissemination of water-use data that will provide standardized information: (1) as input to planning decisions at all levels, (2) in the management processes where planning decisions are implemented, (3) for the location and design of structures, and (4) in operations in the daily management of facilities.

14. Provide, in regard to the hydrologic environment, basic interdisciplinary capability for: (1) evaluating long-range effects of man's activities on the hydrologic environment, (2) assessing before the fact the likely hydrologic impact of upcoming developments, (3) providing information on critical environmental problems before they reach crisis proportions, and (4) carrying out immediate environmental evaluations in response to unforeseen needs of agencies in preparing environmental impact statements in the area of hydrology.

THE ALASKA DISTRICT PROGRAM

GENERAL

Alaska, located far to the north and being largely undeveloped, is unique in regard to water data needs and problems. The water data presently being acquired are not adequate to meet either the present or the changing and growing needs of the water data-using community. At the present time the Geological Survey does most of the water data acquisition in Alaska, for both water quantity and water quality, and for both the Federal and the non-Federal sectors.

Agencies in Alsaka require water data for planning the development of the water resources and in managing the use of water and water-related resources in support of activities ranging from flood and pollution control through fish and wildlife management and other water-use projects to research in watershed management. The most frequently cited need for water data is for general-resources information to define streamflow characteristics for use in planning or managing uses of surface waters or water-related resources. Other strong uses for data are in connection with water supply, pollution control, flood control, and public safety.

DISTRICT PROGRAM

Data collection began in Alaska in 1906 mainly because of mining activities in the Yukon-Tanana area, and in 1915 it began in South-eastern Alaska for the development of hydroelectric power. In 1946 the collection of streamflow data in the rest of the State was begun by the Survey. In 1960 the District operated 72 gaging stations of which 10 were non-federally financed. In 1962 a crest-stage program on small streams was started to obtain peak discharge for flood-frequency studies and in 1969 the collection of water data was begun to obtain information on the impacts and hazards along the proposed oil pipeline from the North Slope to Valdez.

The hydrologic-data network in general consists of about 212 gaging stations (including 90 crest-stage gages), 11 observation wells where water-level measurements are made periodically (there are no wells where water quality is determined), 124 sampling sites where chemical quality of waters is determined, 130 sites where water temperature is measured (including 27 continuous recorders), and 59 stations where sediment samples are collected.

Current resources appraisals constitute a substantial part of the District program. The projects are concerned with: (1) water resources studies, (2) glaciological studies, (3) stream erosion studies, (4) bridge site studies, (5) flood-frequency studies, (6) low-flow studies, (7) scour in stream channels, and (8) flood inundation studies.

The Survey obtains some quality of water data at all gaging stations as the opportunity affords. As a result, most streams are sampled once or twice a year for concentrations of individual dissolved constituents and certain other characteristics such as hardness, specific conductance, pH, and temperature. During this past systematic sampling program, the general description of Alaska water has largely been accomplished. Recent review indicates that, in general, the pattern of dissolved mineral concentration throughout the State for most streams can be derived reasonably well from existing data. The emphasis on the Alaska chemical-quality basic-data program is being shifted toward other needs including: (1) determination of turbidity variation, (2) determination of nutrients (mainly various systems containing nitrogen and phosphorus), (3) field investigations including systematic dissolved-oxygen studies, (4) determination of trace mineral constituents in water or water-sediment mixtures, and (5) reconnaissance investigations of lakes.

Suspended-sediment samples have been collected at each visit to about half the continuous record stations. The purpose is to define stage versus suspended sediment curves for estimating sediment discharge at sites and eventually to regionalize these data.

Water temperature, biological, and bacteriological data are being collected at a few locations. The District plans to gradually enlarge this coverage to include most of the State.

The 1974 Fiscal Year budget is approximately $1,700,000 of which about $52,000 is for research.

FUTURE PLANS

The proposed program for streamflow data includes the installation of at least 70 new stations for several purposes: (1) to provide particular information needed at specific sites for current use, (2) to define the statistical flow characteristics for all streams in Alaska, (3) to operate indefinitely a small network of stations for streams that are expected to be free from man-made changes, and (4) to describe the flow and the stream channel in terms that would be valuable in planning the use of the stream for such purposes as recreation, waste disposal, conjunctive surface-water ground-water supply, and (5) guarding against water hazards.

The District is planning to give greater emphasis to exploring the possibilities of extending the utility of streamflow data as requested by several agencies and hope to include a determination of the accuracy requirement of the generalized data needed for planning. Statistical analyses will be a principal tool in transferring data from gaged to ungaged sites. The development of mathematical models of streamflow characteristics by regression methods involving basin and climatological characteristics may provide synthesized data where no streamflow data now exists.

A major portion of the water-quality activity in the near future will shift from the collection of routine inorganic water-quality data to the reduction and analysis of the existing data and to network design. It is anticipated that the end product of this analysis and network design will be a report or series of reports presenting the statistically analyzed and reduced data in the form of charts, graphs, and maps along with recommendations for data networks and program activities.

A systematic effort to classify and evaluate the lakes of the State in terms of regional characterization, existing quality, and pollution potential will be a part of the data-collection effort.

A network of long-term observation wells and springs will be established.

Much more work needs to be done on glaciers, estuaries, and lakes. A few sample-lake studies should be made to set up a pattern for attacking the entire State.

A program of reconnaissance-type programs is needed for environmental data, specific hydrologic problems, flood events, and glacier-dam-lake breakouts.

ARCTIC ENVIRONMENTAL RESEARCH LABORATORY

Richard W. Latimer*

INTRODUCTION

The Arctic Environmental Research Laboratory is located on the Fairbanks campus of the University of Alaska. It is one of many research facilities administered by the Environmental Protection Agency. The mission of the Laboratory is to provide information necessary for environmental protection in cold climate areas. This includes: (a) conducting research on the interrelationships between cold-dominated environments and their indigenous organisms and conducting studies relating to the effects of man on arctic and subarctic ecosystems; (b) conducting research including development and demonstration of technology, necessary for the control of environmental pollution in cold climates.

PAST RESEARCH ACTIVITIES

MUNICIPAL POLLUTION CONTROL

Laboratory researchers have studied for a number of years the operation of pilot plants and full scale treatment plants utilizing different biological processes. Extended aeration has been extensively studied in order to develop design criteria. Two units with exposed aeration basins utilizing submerged aerators were evaluated. One unit had a conventional horizontal flow clarifier while the other had a modified upflow clarifier with tube settlers. Organic loading was the parameter most seriously affected by low temperatures. BOD removals above 80 percent at liquid temperatures less than 7°C can be maintained.

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Several aerated lagoons operating under the low temperatures of the subarctic have also been studied. These lagoons are of the incomplete mix type in which the aeration rate is sufficient to maintain uniform DO levels throughout the lagoon, but is not enough to keep the activated sludge particles in suspension. Approximately 35 to 40 of these lagoons have been constructed or are in the planning stages in the state of Alaska. An analysis of data collected from these lagoons indicate the number of cells provided in series has little effect on performance as long as adequate storage space is provided for incoming solids and short circuiting is held to a minimum. Studies have also shown that coarse bubble diffusion systems can be more economical than fine bubble systems.

In Arctic Alaska there are many transient industrial camps of 10-60 men each. Oil well drilling camps on the North Slope are usually set up at one site for one to three months. Physical-chemical treatment is one process available to achieve secondary and in some cases tertiary treatment. One such plant, a prototype installation, was evaluated. The physical-chemical process performed well, attaining COD removal above 95 percent. However, considerable effort toward proper design, set up, hardware selection and operation needs to be developed if P-C units are to consistently provide a tertiary treatment level in isolated arctic installations.

A 2-year study of treated wastewater disinfection with chlorine at less than 1°C has recently been completed. This laboratory study was conducted in two phases During the first phase, three secondary and one primary effluent were examined using batch treatment. The second phase of this study was conducted in a well-baffled bench scale flow through contact chamber. The configuration of the contact chamber and method of adding chlorine before entering the chamber provided a system comparable to any operating system that might be designed in accordance with current applicable design guidelines. It was concluded that effective wastewater disinfection can be achieved at less than 1°C in the presence of a 1 mg/l or less total chlorine residual, if the effluent receives sufficient contact time and the total chlorine residual is measured by the orthotolidine method.

A research grant with Colorado State University, to study the use of lime in disinfection of treated wastewater at low temperatures, has recently been completed. Batch treatment was used to examine secondary effluent and raw sewage in this bench scale laboratory study. The results indicated that both sewages could be disinfected to a safe level with lime treatment which provided a pH of 11.5 to 12.0, and that the process of disinfection could be completed in no more than 30 minutes, even at 1°C, depending on pH.

ECOLOGICAL EFFECTS

The Laboratory has undertaken a number of studies in the past to understand the natural ecosystems in cold climate areas and the impact that man has made on some of these systems. One of the most important is the low winter dissolved oxygen phenomena that has been identified in Alaskan rivers.

Water samples collected over a 4-year period, from 36 selected Alaskan rivers have been analyzed for dissolved oxygen and other water quality parameters. Severe DO depletion during winter was found in many river systems large and small, and located in a range of latitudes (70°N to 61°N). Data indicate that DO depression begins in October and continues into February. Stations near the mouth of a river were generally depressed more than upper stations. The later trend is exhibited in the Yukon River which contained 10.5 mg/l (73 percent saturation) at the Canadian Border but only 1.9 mg/l (13 percent) near the mouth. The depressed winter DO concentrations and low winter discharge in many Alaskan rivers are more severe and widespread than present literature indicates.

The Tanana River near Fairbanks, Alaska, provides an excellent field laboratory to study the survival of enteric (intestinal) microorganims when the water temperature is essentially 32°F and there is total ice cover. A large amount of domestic wastewater enters the river in the Fairbanks area. The river then flows for more than 200 miles (7 days flow time) without further wastewater addition. Fecal indicator bacteria in this river was examined. Researchers found that these bacteria survived in greater numbers for longer periods than was expected, based on comparable data from more temperate climates.

As a result of this research, it was possible to begin examining the survival relationship between the accepted fecal indicator bacteria and the enteric pathogens under the same environmental conditions. Although the preliminary study suggested a relationship between indicator and pathogenic bacteria survival, more extensive research is necessary to definitely establish the survival relationship. Preparation for this study is now in progress.

Research on natural watersheds in Alaska was initiated a number of years ago when the Caribou-Poker Creek area was designated as a Research Watershed by the Interagency Technical Committee for Alaska as representative of the Tiaga biome. The tiaga is the ecological unit covering most of Interior Alaska. The Caribou Creek unit is to remain undisturbed with no planned management activities other than research studies. The Poker Creek unit is to be the experimental watershed with planned perturbations after a period of basic data gathering. Eleven water quality stations have been established to measure water quality parameters for all streams draining each basin and sub-basin. Intensive summer program gathered biological, chemical and physical data for each station using helicopter transportation. Future research will include the effects of activities as mining, road building, logging, etc., on the water quality of the area.

The Chena River is a subarctic stream flowing westerly from the low mountains of eastern Alaska to the Tanana River near Fairbanks. It is typical of many Interior Alaska rivers with the exception that its lower reaches are highly polluted by domestic and industrial wastes from the Fairbanks area. A 3-year study of the river was undertaken to understand the physical, chemical, and biological limnology of the river system and what effect man's influence--past, present and future--has on the river. Dissolved oxygen was one of the most critical parameters determined. A flood control project is now under construction on the river above the city of Fairbanks. In addition, new waste treatment facilities are being constructed for the Fairbanks area which will eventually eliminate most of the pollution entering the lower river.

Road construction in the developing north is and has been an activity of man with significant environmental impact. In order to minimize the adverse effects of such activity, the Laboratory has published guidelines for road construction in Alaska These guidelines suggest procedures for planning, design, construction, and maintenance that will assure environmental protection during the construction of development roads as well as major roads under cold climate conditions.

Large and frequent fires are not new to the Tiaga of Alaska. But man's attempt to extinguish these fires on a large scale is a relatively recent activity. To help understand the environmental costs and benefits of such activities, the Laboratory has conducted two studies on the effects of forest fires on water quality. In general it was found that unmanned fires had little effect on water quality. However, fire control methods may cause serious, long-lasting damage to the aquatic ecosystem within the burned area.

One of the early studies conducted by the Laboratory was designed to understand the effects of placer mining on water quality. As you might expect, some of these effects can completely disrupt the natural aquatic systems in streams and rivers for many miles With the tremendous increase in the price of gold accelerated placer mining activity is expected in Alaska. This activity will be faced with new waste discharge requirements. A fresh look at the effectiveness of existing control technology is indicated.

The only inhouse studies conducted by Laboratory personnel in the marine environment delt with the effects of pulp mill wastes on two estuarine areas in Southeast Alaska. Ward Cove and Silver Bay are the location of the only pulping operations in Alaska. The effects of sulfite waste liquor and organic bottom deposits combined to reduce the productivity of the areas and significantly reduce populations of indigenous fish and shellfish.

AIR POLLUTION CONTROL

Fairbanks, Alaska was the site last winter for a study of CO and hydrocarbon emissions from vehicles. Vehicles were analyzed at idle and adjustments were made to reduce the emissions. It was found that proper adjustment of in-use vehicles could result in significant reduction of CO and HC produced at idle. Emission levels of propane, gasoline and diesel fueled vehicles were also measured and compared. Most of the pollution control equipment and methods presently in use on motor vehicles are helpful in reducing CO emissions in cold climates. However, they are not always as effective as they would be in warmer climates.

Ice fog, a winter phenomenon typical of inhabited arctic regions, is produced when water vapor is released into ambient air that is too cold to hold the water vapor in solution. In the Fairbanks, Alaska, area, cooling ponds and combustion unit (furnaces, gasoline engines etc.) are the major water vapor emitters. One promising control technique is to use ambient air heat exchange to scrub the water vapor out of the flue gas. Such a device was evaluated and found to be effective in condensing out about 90 percent of the water vapor in the flue gas. Sulfur dioxide removal by the condensation process was also significant. The AERL has also demonstrated that ice fog control on motor vehicles is practicable An exhaust gas heat exchanger has been installed on the undercarriage of a 1/2-ton carryall vehicle and has proved effective.

PRESENT RESEARCH ACTIVITIES

MUNICIPAL POLLUTION CONTROL

The "Alaska Village Demonstration Projects" was authorized by Congress in 1970 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 solid wastes disposal. Physical-chemical processes have provided the basis for treatment systems in the central facilities. Although there has not been enough time to allow full operation and evaluation of these facilities, preliminary results indicate that the technology is available to provide these basic utility services to remote villages. Continued research is planned to provide sound technical and social-economic data upon which an acceptable state-wide program can be developed.

ECOLOGICAL EFFECTS

In 1972, a meander of the Chatanika River, near Fairbanks, was rechannelized by the Alaska Department of Highways to protect the Elliot Highway from being eroded. This project gave the Laboratory an opportunity to assess the effects of this disturbance on suspended sediment, bottom sediment distribution, stream bed, water chemistry and aquatic organisms (primarily benthic macrofauna). Samples were collected both before and after the new channel was constructed, and the river diverted. The data is now being analyzed and should be in report form next year. This information will be extremely valuable as river bottom gravels are used extensively in Alaska; in fact, this is the largest "mining" industry in the state. Little is known of the effects of these disturbances on the aquatic life in high latitude streams.

The planned Trans-Alaska oil pipeline will cross many arctic and subarctic rivers as well as unique terrestrial ecosystems. Oil from the pipeline will undoubtedly be introduced into these ecosystems. Little is known of the behavior of oil discharged into the subarctic environment although, recently, some increased effort has been made to understand this phenomenon. Laboratory researchers have conducted a small experimental oil spill to study the fate of crude oil discharged on a Interior Alaska terrestrial environment underlain with permafrost. The site is located near Fairbanks and was saturated with North Slope crude oil in July 1973. The oil now appears to be distributed in numerous pockets that are characteristic of the irregular surface of the moss-covered forest floor. Core samples from the experimental site are being analyzed to determine compositional changes in the oil, especially over extended periods of time. Sampling will continue through this year. The data will then be analyzed and should be in publication next year.

The Tanana River will once again provide us with a ideal outdoor laboratory this winter when an extensive survival study of indicator and pathogenic bacteria in relationship to enteric virus will be conducted. This study is planned for February and March 1975 and will involve many researchers from several different Federal agencies. The results of this study should be available next summer and will provide excellent data for use in upgrading existing water quality standards.

The Laboratory is continuing its baseline data collection on the experimental watershed near Fairbanks. Continuous recording monitors have been installed on the two major streams in the watershed which should provide us with good water quality data during the winter season. With a year-round record of water quality, we can now begin to plan perturbations in the area and assess their impact on water quality.

Grant and contract work by other research organizations, through funds provided by EPA, complement our ongoing inhouse efforts. The University of Alaska is conducting such a study on a large subarctic lake in Alaska. The biological, chemical, and physical limnology parameters of a lake system that experiences ice and snow cover for more than half of its annual cycle, are essentially unknown. The first thorough investigation of such a lake is entering the second year of a 3-year study. Data from this study of Harding Lake will increase understanding of the progression from oligotrophic to eutrophic lakes in the subarctic and provide guidance for water resource management practices as development pressures increase in Alaska.

A grant to study the effects of crude oil and its components on young Coho and Sockeye salmon was recently completed with the University of Alaska. This was a laboratory study in which the young salmon were exposed to different concentrations of crude oil and components. A typical behavior pattern was exhibited in the presence of crude oil with the behavior pattern intensity and fish mortality decreasing with decreasing oil concentrations. The acute toxicity study found that monocyclic aromatic compounds are generally toxic with the degree of toxicity increasing with increasing saturation. This toxicity apparently results from alteration of cell membrane permeability which in turn destroys the ability to regulate salt balance. The observed symptoms are muscle hypertension, hyperactivity, loss of equilibrium and death.

Another grant project with the University of Alaska, currently in its second year, is an investigation of the effects of crude oil on sediment organisms in Port Valdez. Meiofauna collections have been taken from three primary (tidal flat) areas in Valdez Arm. Two other areas, one near an oil seep from storage tanks destroyed by the 1964 earthquake, have also been sampled. In June 1973, three small containment structures were installed on one study site, one for use as a control and two for experimental purposes. In the experimental structures, the equivalent of 500 mg of "fresh" Prudhoe Bay crude oil per liter of seawater was added and allowed to settle on the sediment as the tide receded. On five subsequent days, the equivalent amounts of oil which had been "weathered" were added. Samples are now being sorted and the data analyzed. A final report of the results should be available next summer.

An interdisciplinary 3-year grant project with the University of Alaska has just been completed. This project was designed to further our knowledge of the baseline conditions in the near shore aquatic environments of Arctic Alaska. Physical, chemical, geological, and biological data have been gathered and are being analyzed so that a firm basis of understanding will exist of the processes active in this environment. Such a knowledge is fundamental to decisions regarding resource development in the regions. The final report should be available this year.

I should mention another study on the North Slope of Alaska that was conducted by Laboratory personnel. A baseline study of the biological, physical, and chemical characteristics of the Sagavanirktok River and five of its tributaries was initiated as oil development activities accelerated in the area. A total of 28 stations were located in the area impacted by the oil industry. The field work is complete and only the final report remains to be written.

In order to complete the survey of ongoing activities, I need to mention two relatively small inhouse projects. Both of these efforts are "state-of-the art" type projects. First, a study that will complete a comprehensive literature review on oil degradation in the freshwater and terrestrial environments with special emphasis on low temperature. A part of this study will be to select and test the appropriate techniques for future oil degradation research at the Laboratory. The second study will assess the environmental effects of log handling and storage on Alaskan waters. This effort will include a review of the current literature, as well as site visits and discussions with interested individuals.

FUTURE RESEARCH ACTIVITIES

The research program at the Arctic Environmental Research Laboratory has in the past been oriented towards meeting immediate waste treatment needs in Alaska and baseline data collection for an understanding of the unique arctic and subarctic ecosystems. The present program has emphasized fate and effect studies of various pollutants from man's activities in cold climates and applied state-of-the-art technology to meet environmental health problems in remote rural communities.

Future research will be heavily oriented towards the environmental impact of resource development (oil, gas, lumber, metals, coal, etc.) in the arctic and subarctic. Ecological research will move into the predictive mode in order to attempt to assess environmental impact before it occurs. Environmental engineering will continue to play an important role in applying technological advancement to cold climate areas. Such control technology problems as Co_2 and ice fog will remain on our priority list.

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Max C. Brewer*

It seems rather obvious that the sponsors organized this symposium because they recognized a need: a need for the development of environmental standards which would fit the northern areas, standards that were practical, that could be recognized for their obvious value to society, that would be accepted by society and that could be applied in guiding man's endeavors in these areas. The implication is that we do not have these standards today or, if we do have them, that they are not being effectively utilized.

Programs in basic research probably reached their period of greatest activity in Alaska during the early 1960's and by 1965 had begun to decline due, in large measure, to a rapid tightening of research funding and to the increased emphasis on applied or more mission-oriented research. Another contributing factor was a lack of the application of the basic research information being obtained to the problems being encountered by governmental units. As a result, today we probably have, in general, less of a research effort underway concerning northern problems in Alaska, particularly environmental problems, than at any time in almost 20 years. At the same time the requirements for environmental and engineering information and know-how in nearly all disciplines are at their greatest in Alaska's history.

The decline in the programs in basic research, unfortunately, has not resulted in any real increase in applied research concerning northern problems. We are still importing methods from the more southerly, temperate climates and then trying to modify these methods or hardware on the jobsite, generally after they have failed to perform as anticipated. Our methods of wastewater treat-

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ment, although an excellent example of this problem are only one of the many examples which could be cited. The handling of oil spills, both on land and in the water, is another. And, even though the hot-oil pipeline construction project has produced some new information and know-how, this can hardly be classed as applied research. That information has been more of a spot-checking nature or a quick grab for information when the need was suddenly thrust upon the operators. Additionally, there are no known plans to even preserve this information or to validate the interpretation of it or its usefulness in any form that could be made available for general use.

In organizing the Department of Environmental Conservation it was recognized that Alaska had some very unique problems, because of its subarctic and Arctic areas, and that the department had been given widely encompassing statutory responsibility for environmental protection and conservation. Thus, the department was organized along more functional lines rather than the disciplinary pattern of organization mandated to the Federal Environmental Protection Agency through enactment of separate laws such as those covering Clean Air (1970), Clean Water (1972), and Noise Pollution (1972). Additionally, since the department's mandate was general with the responsibility for "setting standards for the prevention and abatement of pollution of all water, land, subsurface land and air pollution and other sources or potential sources of pollution," it allowed the flexibility for a functional approach. Such flexibility is somewhat unique, for example the Environmental Protection Agency has the limitation of navigability and can provide remedies for oil or sewage pollution only when such pollution reaches or has the potential of reaching navigable waters concerning which there is no widely accepted single definition. In a like manner, the Alaska Department of Fish and Game, in protecting against the siltation of streams, is limited to enforcement actions in streams identified as being anadromous streams.

The functional approach has allowed the department to look at the overall environment of the state and to concentrate its efforts on the unique problems or potential problems in northern regions rather than always following nationwide standards developed for urbanized temperate regions. Sometimes these standards may not be practical or even applicable for sparsely populated subarctic or Arctic areas. The greater flexibility also provides the opportunity to engineer for solutions to problems rather than trying to obtain solutions through enforcement of inappropriate regulations.

The department has been organized with five divisions: Marine and Coastal Zone Management, Permafrost and Soils Engineering, Land Use and Urban Development, Terrestrial Ecology and Environmental Engineering, and Water and Air Quality Control. From the environmental conservation standpoint, the Marine and Coastal Zone Management and the Permafrost and Soils Engineering divisions are the most important for Alaska. From the environmental health standpoint, the Division of Water and Air Quality Control, including other EPA-type functions such as solid waste disposal, pesticides, noise pollution and radiation, is the most important.

The trans-Alaska oil pipeline project provides an illustration of the validity of these judgments although other examples abound. The permit for the construction of the pipeline, requested in 1969 and early 1970, was delayed because the Department of Interior determined that the pipeline company had demonstrated insufficient understanding concerning the problems to be expected as the pipeline traversed the areas subject to permafrost conditions. After the enactment of the National Environmental Policy Act, the lawsuits filed under the NEPA and that delayed construction of the pipeline were premised on the claim that the pipeline company had not demonstrated that the project would not cause irreparable harm to the environment in the areas where permafrost conditions prevailed, that it would not interfere with caribou migrations, and that it would not entail unacceptable damage to the marine environment of the Prince William Sound area. At no time did the questions of water or air quality, solid waste disposal, noise pollution, use of pesticides, or potential radiation hazards cause any delay in the issuance of the Department of Interior permit.

The Division of Marine and Coastal Zone Management is engaged in both applied and basic research. Although responsible for review and comments concerning all proposed coastal activities of an immediate nature, the division also is monitoring the effects on the coastal zone environment of existing activities such as: encroachment of urbanization on salmon-spawning streams; the effects of log-rafting on the marine environment of bays and coves; the toxicity, including mercury analysis, of pulp mill discharges at Sitka and Ketchikan; the concentration of lead in sea water engendered by the spillage during ore-loading operations at Skagway; siltation and channel modifications caused by offshore borrowing of material and the disposal of spoil material; and the effects of coastal activities on selected marine organisms. Looking to the future, the division has intensively studied Berners Bay, the proposed location of a new pulp mill. This eighteen-month study has not only provided baseline information on water chemistry but also includes current patterns, mapping of the submerged topography, and an estimate of the effects of the potential discharges and sludge deposits from a pulp mill. Oceanographic studies, in cooperation with the Coast Guard, have been conducted in southeastern Alaska, in Cook Inlet, concentrating in the Kachemak Bay and Kamishak Bay areas, and in the Bering Sea in order to obtain baseline information particularly on water chemistry and currents. Intensive investigations also have been conducted on the heavy metals in the marine environment and the occurrence of deep sea manganese nodules, particularly those in the Gulf of Alaska. Publication of some of the work already has occurred.

Some idea of the importance of an understanding of the environmental character of the coastal zone of Alaska can be inferred from a review of statistical information. Alaska has 53 percent of the nation's coastline and 65 percent of the nation's continental shelf abuts this coastline. The majority of Alaska's population lives within the coastal zone area and the state's major industries, fishing, petroleum and natural gas production, and forestry are all located within or almost immediately adjacent to the coastal zone. Recognizing the importance of Alaska's coastal area, the National Oceanic and Atmospheric Administration (NOAA) recently awarded the Division of Marine and Coastal Zone Management a grant of $600,000 for the first year's efforts towards developing a coastal zone management program for the state.

A division of Permafrost and Soils Engineering is unique in a department of environmental conservation. Some could respond that such is true because Alaska, where some 85 percent of the land mass is affected with a permafrost condition, is the only state so afflicted. However, the environmental importance of permafrost becomes more readily apparent with the realization that the permafrost condition of the soils affects most of the road construction in Alaska. It further must be considered and designs modified accordingly in much of the building construction, even along the coast; it heavily impacts all aspects, including the costs, or exploration, development, production, transportation and logistics for petroleum operations on the land areas of the state where the potential for finding petroleum is considered attractive; it is a determining factor on the availability of water supply and distribution throughout much of the state; it influences the collection and disposal of sewage; it inhibits practical disposal of solid wastes; it often controls the location and development of material borrow sites; it influences and sometimes is a determining factor in the location of settlements; it often is a controlling factor in stream bank or coastal erosion; and it impacts heavily on the costs of all engineering projects. In addition, except perhaps for the impact of glacial flour, permafrost is the greatest controlling factor on the quality of surface waters and, without doubt, the controlling factor on the quality of subsurface waters in the state.

Although the Permafrost and Soils Engineering Division was created to provide engineering and plan review assistance to other governmental units and to the remote villages in order to minimize environmental damages from proposed construction projects, the division personnel have been engaged full time in reviewing and commenting on plans for the trans-Alaska hot-oil pipeline. This project, with its requirements for road construction, pipeline construction including stream crossings, camp construction, material borrow and spoil disposal, and problems of erosion, water supply, sewage disposal and solid waste disposal, has all the environmental problems that would be expected to be found in communities throughout most of Alaska. The programs originally intended for this division have been deferred because of the high priority assigned to the pipeline construction and its potential for extensive environmental damage.

The coupling of land use and urban development into one division is recognition not only of the nationally recognized problems concerning the uses of land but also the peculiar problems facing Alaska which, although it is by far the largest of the states has only very limited amounts of land actually usable for intensive human activity. In other states, land-use proponents aim for preservation of lands for recreation, parks, and wilderness purposes. Alaska also has a requirement for identifying and classifying lands for their best use or uses and of attempting to guide the management of the lands so as to minimize damage to the surrounding environment, while at the same time avoiding undue social detriments including excessive taxation. The critical nature of the problem becomes obvious when it is noted that even with maximum development, less than 4 percent of the lands of the state are suitable for intensive agricultural purposes. Additionally, nearly all of the existing communities in the state have one or more of the following physical liabilities: they may be plastered against a mountainside; located in an exposed coastal area subject to rapid erosion; located in a river flood plain subject to frequent flooding; located on a river or glacial outwash plain containing unstable soils; or located in an area having unstable soils and subject to periodic earthquakes of sufficient magnitude to induce material instability or liquifaction in the soils. In addition to these liabilities are the almost universal problems of obtaining sufficient supplies of crushed or natural construction materials, of finding good water supplies, and of developing safe and socially acceptable methods for the disposal of sewage and solid wastes

Land Use Planning in Alaska also suffers from society's natural reluctance to bite the bullet of change- particularly a change which, like zoning, tends to inhibit certain freedoms of action by the individual property owner. This reluctance is magnified in Alaska where the philosophy has always been to maximize local governmental control. Unfortunately, in the case of land use management, as well as in environmental pollution problems, local governmental control has proven to be ineffective largely because the governmental units are large and somewhat unwieldy for a specific type of zoning and because the local governmental bodies usually have been controlled by the business or larger propertied communities which are still strongly imbued with the pioneer spirit of independence in their actions.

An additional problem in the development of land use planning as well as pollution control, is the retention in Federal ownership of the vast majority of the lands in Alaska. This introduces two additional sets of managers: one at the Alaskan level and one at the Washington, D.C. level, neither of whom, with the exception in many instances of the military, is usually very receptive to local suggestions or even to state regulations. At the Washington level there is a great hesitation to agree to any plan that might even suggest infringement on Federal power. At the local level, there is a strong tendency for managers who are frequently rotated to similar management responsibilities in the southern 48 states to manage in much the same way and for the same purposes as they did in those states even though this type of management may not have proven to be overly successful even there.

The Department of Environmental Conservation to date has been able to influence land use management through three mechanisms: through advice to other agencies, through comments on Corps of Engineers permit applications and on environmental impact statements, and indirectly through permit requirements for water and air pollution control. In this regard, it should be noted that the Clean Air Act of 1970 has the potential for becoming the strongest mechanism for land use control that will probably ever be passed by the Congress. The Clean Water Act Amendments of 1972 also provide some mechanisms for land use control although in this instance, the mechanisms are effective only for limited areas, unlike the Clean Air Act which may be used effectively over wider basin areas. The department's research in land-use planning has been limited primarily to evaluating and, on occasion, to obtaining field data prior to commenting on permit applications and environmental impact statements, and before issuing water or air pollution control permits.

Applied research in Terrestrial Ecology and Environmental Engineering has been slow in developing because of a lack of funding. In some respects this work tends to parallel that of the Alaska Department of Fish and Game Habitat group. One major difference is that ADF&G must identify the specific areas to be protected as critical habitats. Once so identified, an area is usually off-limits to most non-fish or non-game activities. The Department of Environmental Conservation does not have such restrictions and can consider environmental problems throughout the state.

To date, reports have been prepared covering off-road vehicles use; recommendations have been made on the rehabilitation of material borrow areas and a set of proposed regulations for control of material borrow areas and their rehabilitation has been developed; recommendations have been provided for the construction of access roads and mining roads; recommendations for improvement in the requirements for permit issuance for geophysical exploration have been provided; and controls for stream-side and lakeside development have been suggested. The department also has obtained agreement from a company to provide erosion control structures and reseeding for an extensive set of trails damaged by a geophysical company on the Kenai Peninsula. It also has a lawsuit pending against another company concerning unwarranted tundra tearup on the North Slope.

The Department's Water and Air Quality Control Division essentially includes all the EPA-oriented environmental health functions. Under the state statutes, this division is largely regulatory and the orientation is thus more towards abatement of pollution although, as mentioned above, the Federal Clean Air Act of 1970 potentially is the strongest land-use bill ever expected to be passed by the Congress. As the regulatory-oriented arm of the department, this division is the one where much of the day-to-day activity regarding water pollution, air pollution, solid waste and oil spill pollution activities are monitored. The very nature of these problems requires that the personnel not only be field-oriented but that they be located in the field where the people activities and the subsequent pollution problems are occurring. Unfortunately, it is a continuous fight to get many of these personnel stationed in the field due to the extreme and excessive amounts of paperwork that must be managed in order to obtain the EPA grant funds, amounting to over 15 million dollars this year, for the construction of sewage treatment facilities, and the modest water and air pollution control grants which fund a portion of the division's salaries. The tight tie of this division to the EPA, through the funding realities of life and standards that often do not fit the Alaskan environment or which were developed without a sufficient data base, is probably the biggest single problem facing the Department.

The most effective tool that the division has for the prevention of either water or air pollution is the statutory requirement for plan review for wastewater dischargers and large air-emitters. Other areas of applied research orientation are related to package sewage treatment plants, which have a tremendously high failure rate in Alaska. These plants, many of which are prototypes, generally are designed for domestic sewage and are not capable of being operated at anything approaching their "designed capacity" in camps in Alaska. The biggest problem, even when the installation is correctly made and the plant is well operated, is that camp sewage, from a predominantly adult male population being fed a high calorie diet rather than being from a family-type clientele, is just "too rich," often averaging three to five times the designed BOD loadings.

The Department has a Village Safe Water program which provides for combination water treatment, sewage treatment, solid wastes disposal and shower facilities at remote villages. To date facilities have been or are being constructed in five villages using state funding. New approaches are being tried by the division under this program which, to be successful, must provide these utilities at a reasonable cost and simplicity of operation if these amenities are ever to be brought to the remote areas of the state. The use of sewage lagoons is being investigated under this program and the division has obtained reluctant agreement from the EPA to allow sewage lagoons to be used in a selected few locations where EPA grant funding is involved.

Studies of water consumption in the major towns and cities of the state have been initiated with a two-fold purpose in mind: to highlight the need for reducing water consumption in those towns where water supply is a problem and where people now leave the taps open to keep the water lines from freezing and, also to reduce the overloads on sewage treatment plants in those areas where such plants are now in existence. Part of the problem, which now shows water usage rates often averaging five to ten times normal consumption, could be alleviated by deeper burial of water lines or the establishment of a circulating domestic water system such as is presently in use in Fairbanks. However, much additional applied research and planning are needed in the fields of water supply and sewage disposal since sufficient funding cannot be expected to provide these facilties using existing conventional methods and hardware.

Probably the most sophisticated research being accomplished by the division is in the field of air pollution control. Carbon monoxide measuring stations have been established in Fairbanks and Anchorage, sulfur oxide and particulate measurements are being obtained in Sitka and Ketchikan, and theoretical studies of potential air pollution are being made for the Valdez area which will be the terminus for the trans-Alaska oil pipeline.

The division has been able to assist with planning and to inspire local agencies to improve their methods of disposing of solid wastes. The most notable successes have been in Fairbanks, where a controlled and well-operated landfill was instituted, and on the Kenai Peninsula, where an areawide solid waste pickup service has been initiated. Field surveys of the solid waste problem have been conducted along most of the primary road system, photographs have been taken, and the worst trouble spots identified. However, the problem of solid waste in Alaska is much more difficult than in most other states for the following reasons: the sparsity and the remoteness of population which often almost causes a severe litter problem rather than a solid waste problem; the very high costs per unit volume of both collection and disposal; a lack of fiscal and equipmental resources to establish landfills, sanitary or otherwise, in the remote and small villages; and the problems of disposal in the permafrost areas over most of the state except in the southeastern region, where landfills are plagued with leachate problems because of the high rainfall.

The climatic factor of an extended winter season and cool summers further retards both the processes of biodegradation and chemical weathering to which archeologists excavating old Eskimo houses can readily attest. In fact, it has been speculated that archeologists excavating in the year 4000 in areas where oil barrels have been used as sewage receptacles, will promptly dub it the scatological drum culture. The additional packing involved in shipments to Alaska and the widespread usage of plastic containers and coverings, which under natural conditions are almost indestructible, add further complications particularly in the villages.

In addition to assisting communities with planning and the improvement of landfill practices, the department has investigated the use of air curtain incinerators for medium-sized communities. In small remote communities, which lack the wherewithal for proper handling of solid wastes, the department has encouraged burning, even at times open burning, of nonputrescibles. Although such open burning can cause minor and temporary violation of the air quality, the trade-off of having a temporary and minor violation is considered to be far superior to having blowing paper and other materials contaminating the environment in perpetuity.

Although the department has many regulatory functions, it does not consider itself to be an environmental policeman. The intent is to be the state's environmental conscience. However, it is well recognized that many regulatory agencies have become little more than paper entities and parasites upon the public purse because they have ignored enforcement of their regulatory responsibilities. The department, therefore, has adopted a policy of trying to work with people to prevent pollution and, should chronic pollution actually be occurring, to give people an opportunity to correct it and clean it up. Should they not be willing to move towards accomplishing this correction by the time of the third contact, legal proceedings, which can bring substantial penalties, are initiated. An exception to this procedure is the handling of oil spills which are considered to be spot pollution, rather than chronic pollution. They are specifically prohibited by statute and administrative or legal proceedings are initiated for each occurrence. In this regard the department has been aware of an average of about 200 oil spills per year occurring within the state and expects that number to more than double with initiation of the construction of the pipeline. In spite of the vigorous oil spill control program, however, the department has tabulated the spillage of approximately 1,300,000 gallons of petroleum products within the state since July 1971.

Protection of the environment is an educational and caring process. Hopefully it will improve over the years but this improvement will require knowledge of the environmental processes, practical and equitable environmental standards, gentle persuasive pressures and, above all, candor and openness with the public.

ACTIVITIES OF THE WATER POLLUTION CONTROL DIRECTORATE

F. G. Hurtubise*

The Environmental Protection Service (EPS) was formed to ensure that the Federal Government's regulations and guidelines concerned with the quality of the environment are approached in a fashion consistent with national policy and enforced under appropriate circumstances. E.P.S. is involved in the development of guidelines and regulations, in the identification and solution of pollution problems, problem surveillance and monitoring, and the development and demonstration of waste control technology.

The Water Pollution Control Directorate (WPCD) is responsible for the identification and solution of pollution problems, the development of guidelines and regulations, and the development and demonstration of new municipal and industrial wastewater treatment technology.

This latter function is carried out by the Technology Development Branch which is also involved in the training and technology transfer activities of the WPCD. The Technology Development Branch is subdivided into 3 divisions by function:

The Training and Technology Transfer Division coordinates and develops training programs for government and industry personnel in the field of wastewater treatment, plans and schedules seminars to provide opportunities for the exchange of information between scientists and engineers in government and industry, and publishes a series of reports covering the activities of the entire Water Pollution Control Directorate.

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The Planning and Coordination Division plans, coordinates and monitors programs undertaken by the W.P.C.D. across Canada for the design and development of new or improved treatment processes, for water pollution control. The main objectives are to increase the efficiency of the EPS Technology Development (Water) program and to prevent duplication of government subsidized projects.

The Technology Development and Demonstration Division is charged with the conception, development and implementation of technology development programs as related to water pollution control for industrial and municipal wastewaters across Canada.

Operating at the Wastewater Technology Centre, of the Canada Centre for Inland Waters (CCIW) the Technology Development and Demonstration Division undertakes bench and pilot scale studies in their laboratories and participates in field demonstration. The Wastewater Technology Centre (WTC) is located in a two-story building at the North end of the CCIW site. The building houses laboratories, and provides 15,000 sq. ft. of working area for a wide variety of modular wastewater and sludge treatment process equipment.

The Wastewater Technology Centre bases its program priorities on the requirements of the Abatement and Compliance Branch of the Water Pollution Control Directorate, plus inputs from the various Regional Branches of EPS and Provincial Environmental organizations.

In August, 1971, the Government of Canada and the Government of the Province of Ontario signed an agreement to ensure that the water quality of the Great Lakes is restored and protected. This "Canada/Ontario Agreement on Great Lakes Water Quality" was signed in response to the recommendations of the International Joint Committee (IJC) in anticipation of the Canada/United States Agreement on Great Lakes Water Quality. Late in 1971, research programs were initiated on chemical removal methods, sludge handling, sludge disposal and other matters related to the process of nutrient removal from sewage. A major portion of the effort of the Wastewater Technology Centre has been directed toward the solution of these nutrient removal problems.

The Wastewater Technology Centre is organized along process lines with units concerning: (1) biological processes; (2) physical processes; (3) chemical processes and (4) soil processes. Analytical back-up required for the projects is provided by the Laboratory Services Section. The Facilities Service Section operates and maintains the various units of equipment at the WTC.

BIOLOGICAL PROCESSES UNIT

This group is responsible for carrying out developmental work on biological processes used to remove components such as BOD, suspended solids and toxicity from municipal and industrial wastewaters. A bioassay group, responsible for determining the fish toxicity of untreated waste streams and treated process effluents, is part of the biological processes unit.

CHEMICAL PROCESS UNIT

This group carries out developmental work using chemical processes for the removal of undesirable and potentially harmful constituents from effluent waste streams. Of immediate concern and involvement is the removal of phosphates by chemical means.

PHYSICAL PROCESSES UNIT

This group carries out research and development work on physiochemical treatment processes for the removal of deleterious and toxic constituents from industrial and municipal waste streams. Active areas of concern include the development of design and operational criteria for the dewatering of municipal waste sludges, investigations of physical-chemical treatment (PCT) processes for small communities and the treatment of wastes from base metal mining and metal plating industries.

SOIL PROCESSES UNIT

The chief area of responsibility of this group is in investigating methods suitable for the disposal of effluents and chemical sludges using soil systems. Areas of concern consist of characterizing the leachate from the sludge soil system and the role different soil systems play in removing various constituents.

The work of the Wastewater Technology Centre is not specifically directed toward Northern Technology or Northern Standards. However, we believe much of it is applicable and more of it is transferable.

In any case, a look at the map of Canada will show you that none of us are very far south. Our national anthem sings of the "true north, strong and free", and one of our early explorers dismissed the whole of Canada as "quelques arpents de neige" - several acres of snow.

THE EXTENT AND COORDINATION OF NORTHERN TECHNOLOGY DEVELOPMENT PROJECTS IN CANADA**

A. R. Townshend*

PROGRAM PLANNING AND COORDINATION DIVISION

It is the responsibility of the Program Planning and Coordination Division of the Technology Development Branch to plan, coordinate and monitor programs undertaken by the Water Pollution Control Directorate across Canada for the design of new or improved wastewater treatment processes, for the development of new Canadian technology and equipment for water pollution control, and for the adaptation of proven foreign technological developments to solve Canadian problems with a knowledge of studies being undertaken by other Government agencies, universities and private sectors in the water pollution control field.

The main objectives are to increase efficiency of the EPS Technology Development Program (Water) and to prevent duplication of Government subsidized projects. The programs within the Branch are coordinated to integrate with the technological needs of the effluent regulations programs, the Canada-US and Canada-Ontario agreements on the Great Lakes, the Canadian North, interdepartmental and international programs. Finally, the Program Planning and Coordination Division identifies technology gaps and suggests plans of action.

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**Excluding those being undertaken by the EPS Northwest Region which are covered in the following pages by Dr. R. Dawson.

NORTHERN ARCTIC TECHNOLOGY PROGRAM

The 1974-75 Northern technology development program includes projects in our Pacific, Northwest and Altantic regions. Problems associated with the collection, treatment and disposal of domestic wastes are being addressed together with problems associated with the storage of industrial wastes from mining and oil drilling operations.

Those projects not being undertaken in the Northwest Territories by our Northwest region by category are:

CATEGORY	PROJECT SUBJECT
Collection	Vacuum Collection Systems
Collection	Buried Pipelines
Collection	Pressure Collection Systems
Treatment	Sludge Dewatering
Treatment	Disinfection
Disposal	Combined Sewage and Garbage Incineration
Industrial	Tailings Dam Stability

Vacuum Sewage Collection Systems

Two existing vacuum sewage collection systems installed in Western Canada will be investigated to determine what modifications, if any, are required to adapt this system to the arctic environment. System designs will be prepared that may be used for a pilot project in fiscal year 1975-76.

Buried Pipelines

Instrumentation of a buried pipeline will be carried out at Farrow, Yukon, to check the calculations for such systems made by our Northwest Region personnel. The calculation technique developed indicates that pipe can be insulated to such an extent as to prevent thawing of the permafrost. A technical paper on these theoretical calculations is presently being prepared for the National Research Council.

Pressure Sewer Systems

Assessment of the potential use of pressure sewer systems may be undertaken if a project proposed in Newfoundland is carried out this year. Although this is not a permafrost site the planned shallow burial should give some indication of cold temperature effects.

Sludge Dewatering

Sludge disposal from secondary treatment plants has been identified as a major concern in the future development of the north. A laboratory freeze-thaw study is to be initiated in conjunction with a review of other sludge dewatering and disposal methods that may be applicable to arctic conditions. A pilot plant installation is envisaged for 1975-76.

Disinfection

Disinfection practices are being examined to determine areas requiring technology development with particular emphasis on chlorinated effluent toxicity and virus inactivation at low temperatures. Although this problem is not unique to the arctic situation it is felt that viral and bacterial studies should be initiated to determine cold temperature effects.

Combined Sewage and Garbage Incineration

Our initial study in this field will be carried out at the Bedford Institute at Halifax, Nova Scotia. This is dictated by the fact that installation of an incinerator for combined sewage and garbage from vessels is nearing completion at this site. A waste characterization study will be carried out in three typical arctic communities. An attempt will then be made to simulate the wastes for incinerator trials at the Bedford Institute.

The objectives of this study are to determine the suitability of this type of incinerator and to obtain data on the best methods of operation as well as to obtain flue gas pollutant emission data.

It is anticipated that the results of this study will indicate what incinerator modifications may be necessary to make this a feasible pilot plant project under arctic conditions in 1975-76.

Stability of Mine Tailings Dams

The instability of tailings dams under permafrost conditions is of major concern. It is therefore planned to study the thermal regimes and pore pressures using thermisters and piezometers installed in the embankment of a mine impoundment dam at Farrow, Yukon.

Data obtained will be studied and interpreted to determine parameters peculiar to the arctic that significantly influence the stability of embankments and to develop design criteria.

NORTHWEST REGION NORTHERN TECHNOLOGY PROGRAMS

R. N. Dawson, Ph.D.*

INTRODUCTION

The Northwest Region of the Environmental Protection Service (EPS) Environment Canada is responsible for activities in the provinces of Alberta, Saskatchewan, Manitoba and the Northwest Territories (N.W.T.). These responsibilities include:

1. Regulatory activities under the Fisheries Act, Clean Air Act, Canada Water Act.
2. The clean-up and prevention of pollution from federal government activities.
3. Co-ordination of environmental emergencies.
4. Advisory services to industry, other federal government departments, provincial and territorial governments and the general public and the Department of Indian and Northern Affairs (DINA) in the administration of the Arctic Waters Pollution Prevention Act and the Northern Inland Waters Act throughout the Northwest Territories.
5. Technology Development.

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TECHNOLOGY DEVELOPMENT

The Region provides an operational role in field projects on a national program of technology development in gaseous emissions, liquid wastes and solid waste treatment technology. Particular emphasis is placed on northern areas because of rapid development, fragility of eco-systems and lack of knowledge. Zone of influence studies are also carried out.

NORTHERN TECHNOLOGY PROGRAMS

Applied research in northern technology in the Northwest Territories was started by J.W. Grainge in the early 1900's under the Department of National Health and Welfare. Efforts were concentrated on developing satisfactory wastewater treatment and collection systems for small northern settlements. Rapid development in the mining, oil and gas, and transportation industries has required an expanded effort to develop waste treatment systems and to determine the effects of pollutants on northern species.

Since the EPS Northwest Region was formed in 1972, the following programs have been carried out.

Wastewater Effluents

Community Wastewater Disposal - Most activity to date has occurred in the development of systems for installation in workcamps associated with the MacKenzie Valley highway and proposed pipeline.

Industrial Wastewater Disposal - This field is gradually developing and includes projects such as gas plant wastewater treatment and drilling mud disposal.

Air Emissions

Community Gaseous Emissions - Little activity has occurred to date with the exception of studies on ice fog and feces incineration.

Industrial Gaseous Emissions - Although not much work has been done in this field to date studies are anticipated on zone of influence effects of SO_2 and heavy metal emissions from gas plants and mining operations.

Solid Wastes

Community Solid Waste Disposal - This has been an area of active development because of the problems encountered in permafrost areas as well as the severe weather conditions.

Industrial Solid Waste Disposal - Projects on mine tailings drilling mud disposal and oil sands disposal are anticipated.

Environmental Emergencies

Industrial Spills - Oil spills and blow-outs in ice covered seas have been investigated. Major studies on background, detection and clean-up techniques of oil spills in the Beaufort Sea have been undertaken.

Hazardous Materials - Only the disposal of drilling mud has been investigated to-date.

Northern Technology Projects

Only the present programs as summarized in Table 2 are reviewed, however, the past projects for which some data and reports are available are shown in Table 1. An insight into the areas in which we anticipate environmental problems and future technology development projects are shown in Table 3.

Wastewater Effluents

Community Wastewater Disposal - Based on the Alaska pipeline experience there will be problems with the treatment of liquid and solid wastes from the large construction camps associated with the proposed Canadian Arctic Gas pipeline along the MacKenzie Valley. Department of Indian and Northern Affairs funded several projects through ALUR (Arctic Land Use Research) to develop solutions for these problems. Projects are underway at workcamps along the MacKenzie Valley Highway, which roughly parallels the pipeline route.

Vacuum Toilets and Incineration - A washcar containing three different toilet types - 2 types of vacuum toilets and a recirculating toilet, was set up approximately one year ago at a workcamp outside of Fort Simpson, N.W.T. Water from showers and washbasins can be utilized for flushing the toilets and the wastes collected from the toilets are incinerated in an oil-fired tangential burner equipped with a mascerating pump. The project is designed to determine water consumption, economics of incineration, operating problems, toilet acceptability, etc. of the system. Analysis of air emission has been carried out to determine the particulate and gaseous emissions. A final report will be prepared at the end of 1974.

Physical-Chemical Treatment - A 7,500 USGPD package physical-chemical treatment system has been set up in Yellowknife, N.W.T. (trailer mounted) including chemical additions, flocculation, tube settling, sand filtration, carbon adsorption and chlorination. The plant operates on domestic sewage from the town sewer system and will be spiked with pump-out-tank sewage to simulate the organic strength of typical workcamp wastes (1,800 mg/L BOD_5). An operating schedule will be developed and equipment modified prior to installation in a workcamp as a demonstration unit for treatment of workcamp wastes. Economics and operating problems will be reported on.

Rotating Biological Discs - A 5-man, 300 IGPD, rotating biological contactor suitable for installation in small camps or isolated residences is being tested in the same trailer unit at Yellowknife, for treatment of workcamp wastes. A student under Dr. G. Heinke, University of Toronto, is participating on the project. A 7,500 USGPD rotating biological contactor has been installed in a heated trailer at an 85-man workcamp in Arctic Red River to treat workcamp wastewater. Dr. E. Davis, University of Saskatoon, is carrying out parallel laboratory studies to model rotating discs to compare with the Arctic Red River disc. University of Toronto will also co-operate on the larger disc efficiency studies. The rotating discs are being tested because they consume little power, can cope with fluctuating hydraulic and organic loads and possess all requirements for successful workcamp utilization. Modified discs based on our experiences to date are being installed at artificial island drilling rigs in the Beaufort Sea.

Stability and Thermal Regime in Oxidation Pond Berms - A steady-state computer model has been prepared to predict subsidence and temperature profiles in lagoon berms in permafrost soils. Our concern is that seepage and heat transfer can make lagoon berms unstable in permafrost areas. Field work is progressing on determining actual temperature profiles in the Inuvik lagoon for comparison with predicted values. A finite difference technique computer model developed for Canadian Arctic Gas is being utilized to predict transient temperature profiles and subsidence. The object is to develop design criteria for permafrost area lagoons.

Concentrated Human Waste Disposal - Little information is available on the fate of human waste contained in "honey bags" disposed of in pits in arctic areas. Dr. G. Heinke is observing the degredation of organics, bacteria and nutrients in a simulated pit at the University of Toronto. He is charged with recommending a suitable system for degrading concentrated human wastes as a pilot project.

Buried Pipeline Studies - Theoretical calculations indicate that adequately insulated lines should not cause thawing of permafrost if buried. Projects are planned to install lines at Happy Valley Subdivision in Inuvik and at Frobisher Bay, N.W.T. These installations will be monitored to determine the reliability of steady state and transient thermal regime and subsidence predictions.

Long Retention Lagoon Studies - High Arctic Islands - lagoon wastewater treatment systems are to be installed and designed by EPS at the High Arctic Weather Stations at Eureka and Mould Bay, N.W.T. These will be monitored following installation to determine their practicability and treatment efficiency in these high latitudes.

Industrial Wastewater Disposal - EPS is involved in evaluating the technology development requirements for liquid processing wastes from tar sands processing plants, currently being installed in Alberta. We are co-operating with DOE Alberta on these evaluations and will participate with the Alberta Government and industry on stimulating contract research.

Drilling Mud Disposal - EPS, Northwest Region, is currently involved in studies characterizing drilling muds and their toxicity to fish life. Component testing of drilling mud mixtures and zone of influence studies are being carried out under the direction of a joint government/industry steering committee, consisting of Department of Indian and Northern Affairs, Arctic Petroleum Operators Association, Environmental Protection Service and Fisheries Service. Preliminary studies have been reported on, the work is continuing and treatment studies have been proposed. The effect of drilling muds is considered significant under ice in the Beaufort Sea at the production drilling stage. Treatment studies are proceeding as a requirement of drilling permits on exploratory wells in the MacKenzie Delta. Contracted studies have produced drilling sump guidelines for northern operations.

Air Emissions

Community Gaseous Emissions - Air emissions from incinerated concentrated wastes are being studied at Fort Simpson.

Industrial Gaseous Emissions - EPS is co-operating with DOE Alberta to evaluate air emission treatment possibilities from tar sands processing plants.

Solid Wastes

Community Solid Wastes Disposal - Solid wastes simulating workcamp wastes are being shredded and applied to land in several plots at Inuvik, N.W.T. The aim of the study is to determine the effect on the thermal regime in a permafrost area of land shredded waste disposal. Also, the effect of insulating the solid wastes from the permafrost with wood chips will be established. The effect on degradation of insulating the shredded material from sunlight will be evaluated. Following the initial shredding feasibility study, determination of wildlife activity at other sites will be carried out.

Baling and Interim Storage - A system for baling solid wastes and storing them in the community has been designed for Baker Lake, N.W.T. A field demonstration study is under development to show the benefits on dump size reduction by baling and storing during severe weather conditions at this location.

Industrial Solid Wastes

In co-operation with DOE Alberta, alternatives for solid wastes disposal of processed Athabasca Tar Sands are being evaluated.

Environmental Emergencies

Northwest Region is co-operating with the Headquarters Centre of Oil Spill Technology on clean-up and detection techniques for oil spills in arctic shore-fast ice conditions. An oil well blow-out or transportation line spill onto or under shore-fast ice in the Beaufort Sea could have the most disastrous environmental effects of any event in the arctic areas. The high geo-pressures and difficulty of drilling in arctic conditions increases the probability of such an event. A feasibility study to theoretically predict oil slicks under ice and to evaluate various electromagnetic spectra phenomena to successfully anticipate oil slicks under ice will be evaluated. The feasibility of intercepting oil spills under shore-fast ice by down-current trenching and flotation of oil; mapping of ice topography and using shaped charges to penetrate the entrapped oil; development of package pumping and storage systems operable on ice; in-trench or in specially designed portable incineration of oil slush ice mixtures are all being evaluated as part of the Beaufort Sea study. Northwest Region will participate in any field studies and evaluation of contracted work. It would seem sensible that drilling in shore-fast ice or infested areas offshore should be delayed until satisfactory detection and clean-up technology has been developed and demonstrated under field conditions.

TABLE I. PAST PROGRAMS

Specific Funded Projects

MAJOR PROGRAM AREA	GENERAL SUB-AREA	PROJECT	FUNDING AGENCY	PROJECT WORKERS
Wastewater Effluents	Community Waste Disposal	Conventional Long Retention Lagoon Efficiency Studies	PHE-NH&W	
		Evaluation of Inexpensive Utilitor Systems	PHE-NH&W	
		Stability & Thermal Regime Oxidation Pond Berms	ALUR	EPS
		Algae Viability - Lagoon Effluents	ALUR	EPS
		Land Disposal - Domestic Wastewater	ALUR	EPS
		Workcamp Wastewater Disposal Vacuum Toilets & Incineration	ALUR & EPS	EPS
		Concentrated Human Waste Disposal	ALUR	Univ. of Toronto
		Workcamp Wastewater Treatment		
		-Vacuum Toilets & Incineration	ALUR & EPS	EPS
		-Physical-Chemical	EPS	EPS
		-Rotating Biological Disc	EPS	EPS
		Long Retention Lagoon Efficiency Studies - Arctic Islands	EPS	EPS
		Buried Pipeline Studies	EPS	EPS

TABLE I (CONT'D) PAST PROGRAMS

Specific Funded Projects

MAJOR PROGRAM AREA	GENERAL SUB-AREA	PROJECT	FUNDING AGENCY	PROJECT WORKERS
Wastewater Effluent	Industrial Wastewater Disposal	Drilling Mud Disposal -Zone of Influence Studies -Toxicity Investigations -Treatment Studies	APOA EPS & DINA	 DOE EPS EPS & IOL
		Athabasca Tar Sands -Wastes from Processing Operations	EPS	EPS
Air Emissions	Community Gaseous Emissions	Workcamp Wastewater Treatment -Vacuum Toilets & Incineration		
	Industrial Gaseous Emissions	Athabasca Tar Sands -Processing Wastes		
Solid Wastes	Community Solid Waste Disposal	Shredding & Application to Land	ALUR & EPS	EPS
		Evaluation of Paper Bag Systems for Collection	ALUR	EPS
		State of Art Reveiw	EPS	3 Consultants
		Baling & Interim Storage	EPS	Stanley & Assoc.
	Industrial Solid Waste Disposal	Drilling Mud Disposal -Sump Design	APOA DINA	Dames & Moore
		Athabasca Tar Sands -Solid Waste Disposal	EPS	EPS
		Utilization of Wood Chips	ALUR	EPS/DPW
Environmental Emergencies	Industrial Spills	Hydrocarbon Storage -Dyke Design	EPS	IOL

TABLE II. PRESENT PROGRAMS (1974-75)

SPECIFIC FUNDED PROJECTS

MAJOR PROGRAM AREA	GENERAL SUB-AREA	PROJECT	FUNDING AGENCY	PROJECT WORKERS
Wastewater Effluents	Community Wastewater Disposal	Workcamp Wastewater Disposal		
		-Vacuum Toilets Incineration	ALUR & EPS	EPS
		-Physical Chemical Treatment	EPS	EPS
		-Rotating Biological Disc	EPS	Univ. Toronto and U/Saskatchewan
		Stability & Thermal Regime Oxidation Pond Berms	EPS	EPS
		Concentrated Human Waste Disposal	ALUR	U/Tornoto
		Buried Pipeline Studies	EPS	EPS
		Long Retention Lagoon Studies Arctic Islands	EPS	EPS
		Land Sewage Disposal	ALUR	
	Industrial Wastewater Disposal	Athabasca Tar Sands -Processing Wastes	EPS	EPS
		Drilling Mud Disposal -Toxicity Studies -Zone of Influence	APOA	EPS
Air Emissions	Community Gaseous Emissions	Incineration of Vacuum Toilet Sewage	ALUR	EPS
	Industrial Gaseous Emissions	Athabasca Tar Sands -Processing Emissions	EPS	EPS
Solid Wastes	Community Solid Waste Disposal	Shredding & Application to Land	ALUR	EPS
		Baling & Interim Storage	EPS	Contract

TABLE II (CONT'D) PRESENT PROGRAMS

SPECIFIC FUNDED PROJECTS

MAJOR PROGRAM AREA	GENERAL SUB-AREA	PROJECT	FUNDING AGENCY	PROJECT WORKERS
	Industrail Solid Wastes	Athabasca Tar Sands -Process Solid Wastes	EPS	EPS
Environmental Emergencies	Industrial Spills	Beaufort Sea -Detection Under Shore-Fast Ice -Cleanup Under Shore Fast Ice -Trenching -Pumping & Storage -Disposal of Recovered Oil	EPS	Contract

TABLE III. FUTURE PROGRAMS

AREAS OF DEVELOPING INTEREST

MAJOR PROGRAM AREA	GENERAL SUB-AREA	PROJECT	PROJECT RELEVANCE
Wastewater Effluents	Community Wastewater Disposal	Concentrated Human Wastes Disposal	Small communities will continue with pump out tanks for some time. Satisfactory disposal systems non-existent.
		Demonstration of Innovative collection systems - vacuum sewers - pressure sewers - buried insulated lines	Rapid development of large urban centres anticipated due to resource development
		Demonstration of efficient economical waste treatment system	Northern communities require development of easily operated and maintained systems
		Virus removal studies	Transmission of viral disease through water route suspected
		Sludge disposal techniques	Freeze thaw concentration
		Land applications of effluents and sludge	
	Industrial Waste Disposal	Mining Waste treatment and zone of influence studies	Effects of mine tailings from base metal operations unknown in arctic areas
		Tailings dam design - Permafrost areas	Thermal regime, subsidence seepage problems in permafrost areas - knowledge gap
		Agricultural Waste Treatment	Diffuse sources from intense fertilization in arid areas of Prairies are rapidly eutrophicating lakes and streams. Feedlot operations are expanding and organic wastes have become a disposal and odor problem.
		Gas Plant liquid waste treatment	Gas plants to be constructed - effect of effluents unknown; reliable treatment methods required

TABLE III (CONT'D) FUTURE PROGRAMS

AREAS OF DEVELOPING INTEREST

MAJOR PROGRAM AREA	GENERAL SUB-AREA	PROJECT	PROJECT RELEVANCE
		Drilling Mud Disposal	Environmental impact of production drilling wastes offshore being evaluated. Treatment technology gap.
		Mine waste toxicity studies on arctic species	
Air Emissions	Community Gaseous Emissions	Control of ice fog	As population density increases, ice fog could directly affect micro-climates.
	Industrial Gaseous Emissions	Emission control from gas plants	Sensitivity of lichens, etc., to SO_2 well documents; zone of influence studies, refinement of tail gas treatment for arctic application required.
		Emission control from smelting operations	As Above
		Emission control from tar sands processing	Density of processing plants will have serious environmental impact on major watershed area
Solid Wastes	Community Wastes Disposal	Combined incineration of solid wastes & concentrated human waste	Waste heat from such an operation could be applied to beneficial use in small community
		Development of Innovative collection and disposal systems	Transportation of solid wastes difficult in small communities; subject to prolonged blizzard conditions
	Industrial Solid Waste Disposal	Mining tailings disposal techniques	Tailings dam failures have been experienced at Yellowknife, N.W.T.

TABLE III (CONT'D) FUTURE PROGRAMS

AREAS OF DEVELOPING INTEREST

MAJOR PROGRAM AREA	GENERAL SUB-AREA	PROJECT	PROJECT RELEVANCE
Environmental Emergencies	Industrial Spills	Technology Innovation for oil and gas well blow out prevention and control	High pressures and frequence of blow outs in arctic drilling indicate that more efficient control mechanisms and more rapid control procedures are required
		Oil spill cleanup, detection and disposal technology in ice infested shore fast ice situations	Increased potential hydrocarbon transportation and production in arctic continental shelf areas and sensitivity of area dictates development of technology to prevent disastrous pollution consequences
		Environmental effects of natural gas leakage from undersea pipelines	

SESSION II

NORTHERN REGION STANDARDS

Moderator:

ROBERT McCOLLUM

ALASKA'S ENVIRONMENTAL STANDARDS

Max C. Brewer*

The Department of Environmental Conservation has the primary responsibility for the promulgation and enforcement of regulations setting standards for the prevention and abatement of all water, land, subsurface land and air pollution, and other sources or potential sources of pollution of the environment, including by way of example only, petroleum and natural gas pipelines. This is a wide-ranging charter and the responsibility is often shared with several other departments and agencies whose statutory obligations may address more specific aspects of the environment. This sharing has both advantages, in that it provides more expertise and more field observers to solve any problems that may arise, and disadvantages, in that it often introduces confusion, on the part of the public and occasionally within the various agencies involved, as to where the responsibilities actually rest. It also leads, because of land ownership problems in Alaska, to a tendency towards development of double or triple or even quadruple standards in the manner in which the environmental standards are applied, particularly as regards Federal lands.

As part of its responsibility the department must develop environmental regulations which, although have the force of law upon adoption, have tended to be used as guidelines for defining the statutes and for the prevention of pollution. It should be emphasized that standards, whether by statute or by regulations, are useless in the protection of the environment unless there is enforcement and the willingness to provide that enforcement, after all other approaches have failed, even though such enforcement is a time-consuming and unpleasant job.

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*Commissioner, Alaska Department of Environmental Conservation, Juneau, Alaska, 99801.

The department has the philosophy that regulations involving environmental standards should be meaningful, environmentally realistic, practical of operation and publicly acceptable. They should state the purpose of the regulations, be short, direct, easy to read and should tell a person exactly what is prohibited, where the edge of violation occurs, and what the penalty for any violation may be. In many cases additional environmental or public health guidelines or engineering suggestions may be desirable, but these should be issued separately and be issued as guidelines for the use of the prudent man but without any force of law. It is virtually impossible to combine legal prohibitions, environmental or health guidelines, and engineering suggestions into a set of regulations and end up with regulations that can be understood or legally enforced in a court of law. However, it is possible for a regulatory agency to assist the public even as it performs its statutory regulatory functions.

The department is well aware of the many very distinct environmental, including climatic, and socio-economic regions in the state and the fact that it is almost impossible to establish specific detailed standards to cover the entire state. Thus, the endeavor has been to try to establish statewide "floors" for standards allowing any local government to establish and enforce its own more strict standards should the local conditions so indicate and the desire to do so prevail. At the same time the department has not favored totally autonomous local environmental control, nor is there persuasive evidence that such autonomy would be accepted by the Environmental Protection Agency, because of the nationwide failure of such autonomous controls in the past.

It is because of public objection to these failures in the past that the National Environmental Policy Act was passed by the Congress. That act, subsequent acts, and the Environmental Protection Agency regulations all tend to reserve control of environmental standards to the Federal government which then allows the governors of the respective states to administer environmental programs, using Federal "floors" for standards and with many strings attached. Unfortunately some of these Federal standards, developed for more temperate climates, do not fit the Alaskan environment and there is no mechanism to provide for needed modifications. Additionally, the department does not agree with the rapidity with which the Federal standards have changed, nor often with the tenuous data upon which some of the standards have been based, believing that this has reduced environmental credibility with the public and that it also has slowed both industry's willingness and even capability to comply.

To date the department has adopted regulations, including standards, for the following environmental subjects:

Air Quality Control	(18 AAC 50)
Solid Waste Management	(18 AAC 60)
Water Quality Standards	(18 AAC 70)
Wastewater Disposal	(18 AAC 72)
Surface Oiling	(18 AAC 75)
Radiation Protection	(18 AAC 85)
Pesticide Control	(18 AAC 90)

Two of these sets of regulations, Air Quality Control and Water Quality Standards, are not approved in their totality by the Environmental Protection Agency. The EPA is dissatisfied with the state's plan, including both the transportation control strategy and the episode plan, submitted for the control of carbon monoxide emissions in the Fairbanks area. As a result the EPA has provided its own plans. These are so totally unacceptable to the local populace and its governing bodies as to be unenforceable in practice. There also is a strong lack of acceptance of some of the data presented as background material for the EPA proposed plans. In the presence of what amounts to a very polarized situation, with many imposed but unenforced deadlines in the plans, the department has been pursuing a policy of trying to get the local community moving in the direction of improving the carbon monoxide situation and of obtaining EPA's agreement to accept such a program for improvement rather than to arbitrarily impose plans and deadlines. This policy has maintained some local credibility which is essential to any solution of the problem.

Alaska's Water Quality Standards are deficient in that the state has not requested state implementation of the Federal National Pollutant Discharge Elimination System permit program. To properly accomplish this program, using the EPA estimates of the number of permits that one person could provide and service per year, it was calculated that an additional 40 personnel would be required in the department. Not only did the department question some of the excessive paperwork requirements for this program, but it also questioned whether or not this would be the most advantageous use of state environmental resources, even if such resources could be obtained from the administration and from the legislature. There also was no prospect that either would agree to provide the necessary fiscal resources.

It also should be noted that the state's Water Quality Standards are receiving water standards, whereas the EPA, since 1972, has approached control of water pollution through standards for effluent discharges. There are advantages and disadvantages from the use of either approach. One of the disadvantages to the use of receiving water standards is that these would allow some pollutants to be discharged into the waters as long as such pollutants did not cause the water quality to fall below the standards adopted for its classified use. A disadvantage in using the effluent discharge standards is that they allow pollutants to be discharged on a parts-per-million or pounds-per-ton or product basis regardless of the ability of the receiving water or the environment to absorb and naturally cleanse itself of the pollutants.

The department has not adopted any regulations or standards in the following environmental areas.

Water Supply
Coastal Zone Management
Land Use Planning
Petroleum and Natural Gas Pipelines
Operator Training
Hazardous Substances
Industrial Waste Disposal
Noise Pollution Control

because candidly it lacks the manpower to develop the regulations and, if they were developed, to enforce them. Certainly Alaska Statute 46.03.200

specifically calls for the development of regulations covering water supply and industrial waste disposal while AS 44.46.020 specifically calls for the development and enforcement of regulations covering petroleum and natural gas pipelines. The other mentioned regulations, although not specifically named in the statutes, are required to fulfill the statutory requirements for prevention and abatement of all water, land, subsurface land and air pollution.

Although the above list is ordered with regard to the critical nature of these areas in order to accomplish the department's mission, the greatest pressure from the municipal groups has come for the development of regulations covering operator training and water supply. Each of these regulations requires considerable expenditures of manpower if they are to become anything other than a paperwork exercise or to be enforceable except on an extremely selective and, frankly, unfair basis.

The problem with adopting regulations for operator training is further complicated by the estimated need for some 700 operators, the fact that only a small percentage of those now operating are even partially trained, and the extremely transient nature of most operators, particularly at this time. Additionally, once regulations are promulgated, a flood of operators will need to be certificated almost overnight. These untrained, partially trained and the few trained operators would then hold paper "grandfather rights" as operators and it would take many years to work them out of the "system." It would seem to be far more meaningful and productive for the state to launch a substantial training program, instead of the existing limited on-and-off-again training programs, build up a supply of trained operators and then to proceed with the adoption of regulations covering the requirement for operator training and certification. However, in fairness, it should be stated that there is a lack of unanimity of agreement in the department concerning this subject.

There are serious problems in the enforcement of environmental standards in Alaska. These problems exist, to varying degrees, in all states but they are particularly difficult for Alaska, surprisingly largely due to the fact that such a large percentage of the lands remain in government ownership: Federal, state and local. Unfortunately, but bluntly, we are caught with four sets of standards for enforcement of environmental regulations: one set for Federal agencies, a second for state and local agencies, a third for individuals and a fourth, and by far the most strict set of standards of enforcement, for industry. The department strongly disagrees with these multiple standards, has fought against them as being unfair to the environment, including the people, and has publicly admitted on numerous occasions that the situation exists and that the department has been able to accomplish only a minor amount in the way of a correction of the situation.

Federal agencies are specifically exempted from many of the Federal environmental laws and from EPA requirements in many instances although, by executive order, they in general are supposed to abide by the environmental laws to the extent that Congress furnishes them with the money to accomplish whatever modifications or rehabilitation of facilities that may be required. The agencies themselves, in their actions, also are exempt from any environmental action on the part of the states, due to sovereignty, although they are supposed to cooperate with the states in the states' efforts toward protection of the environment. Unfortunately, in their extreme desire to protect the issue of sovereignty, numerous of the Federal agencies have been known on occasion to try to hide incidents of environmental pollution and on many occasions have refused to provide reports on the pollution incidents once the incidents are discovered by others. Of the operating Federal agencies in Alaska, the military has been the most cooperative about publicly admitting the occurrence of pollution incidents and in providing both clean-up and follow-up reports.

Once it becomes aware of a pollution incident caused by a Federal agency, the state has the further recourse of contacting the EPA, which can exert some internal pressure on the culprit but is prohibited by Congress from taking any direct action. The state's other recourse is to throw the spotlight of publicity on the incident and the offending agency. In many instances, this often seems to be the only effective mechanism for the prevention of continuing pollution incidents by some agencies.

State and local governmental units are not exempt from the state's pollution statutes and regulations. However, like the Federal agencies, any plant modifications or rehabilitation usually requires an appropriation or bonding authority from the legislature or local governmental unit. This may or may not be provided. In many instances the work also requires matching money from the Federal government which many or may not be available for a number of years.

The procedure for the construction of sewage treatment plants provides a good example of the funding problems in protecting the environment. The same funding problem exists to an even greater degree in Alaskan villages where the local people may never have sufficient resources to enable them to construct or to even operate water treatment, sewage treatment or solid waste facilities.

Like the Federal agencies, the state and local agencies often seem to prefer to cover up incidents of pollution rather than to report them. Often this tendency extends not only to the agencies' own work forces but additionally to their construction contractor's endeavors. Administrative remedies are available in the case of the former; statutory remedies are available in the case of incidents where contractors are involved, once they are caught.

Individuals, in many instances, receive more lenient treatment in the cases of environmental pollution than does industry. Perhaps it is largely because there are so many more of them; their environmental indiscretions individually are generally smaller in magnitude, although not in cumulative total, and thus often escape individual detection, and because they often do not have the resources with which to completely correct the problems actually discovered. In the cases detected the department has insisted that individuals at least make a reasonable attempt to provide correction.

It has been industry which usually has borne the brunt of the environmental statutes and regulations from both the Federal and state levels. Not only has this brought a certain backlash from industry and a heavier public relations campaign on the part of industry, but it has also fostered a polarization and an increase in the environmental credibility gap between industry and the public and between industry and government. Additionally, it has harmed the program for improvement in the protection of the environment by, in effect, removing many of the potential protectors, that is the general public, and assigning nearly the whole chore to industry. For example, we often see the Congress, the governmental agencies and the public insisting on secondary sewage treatment and talking of tertiary treatment for a few scores of people working at an industrial plant while at the same time blithely, or at least quietly, looking the other way while the sewage from nearby municipalities, with populations numbering in the thousands, dumps raw into the waters. The poor fish, occupying the water environment, don't know from whence the sewage is coming, only what is coming and what it does to thier environment when it arrives.

The result of the multiple standards in the enforcement of environmental protection has been that too often, in recent years, industry has sweat blood because of unrealistic standards often based on technology which has not yet been developed and unrealistic deadlines, whereas the public has largely assumed a passive or, at times, advocatory role in environmental protection. This attitude is well evidenced by the public's reluctance to pay sewage assessments even when the Federal and state governments provide seven-eighths of the total costs to pay for sewage plant operational costs and to pay for proper maintenance of solid waste disposal services. The regulatory agencies haven't always helped matters either as they concentrate on their favorite industrial targets, which can't retaliate overtly through the ballot, demanding unrealistic standards with unreasonable deadlines. Politically, it may be tempting but it lacks something as regards environmental honesty.

Environmental standards, to be really effective, must take into consideration the environment absorbing the waste products and its ability to naturally process the waste. The job of protecting the environment also must be shared by both industry and the public with government providing encouragement and acting as a truly honest broker and educator.

EPA REGULATIONS IN ALASKA

Oscar E. Dickason*

The Clean Air Act of 1970 and the Federal Water Pollution Control Act (FWPCA) Amendments of 1972 are the two major pieces of U.S. Federal legislation passed in the environmental area in the past few years. These two bills have had EPA swamped meeting deadlines, preparing regulations, and responding to lawsuits nationally. The effects of these regulations, and lawsuits are being felt in Alaska.

My background in EPA has primarily been in water pollution control thus is the subject upon which I will dwell the most. Fortunately, the program for the symposium appears to be most heavily weighted in this area.

There are so many requirements associated with the 1972 Amendments to the FWPCA bill that it's difficult to pick a place to start or to select which of the many regulations to cover. Therefore, I will just highlight a few points which have particular reference to Alaska.

First, the industrial waste guidelines required by the water bill and how they apply to Alaska. The law requires EPA to prepare effluent guidelines for a number of industry classifications. These guidelines are to describe what we consider to be best practicable treatment to be achieved by July 1, 1977, and best available treatment to be achieved by July 1, 1983. These guidelines, once developed, are to apply nationally with no distinction between a plant located in Alaska and one located in California or Hawaii. This, as you might expect, causes difficulty in Alaska. In one particular case this across-the-board requirement was changed to fit Alaska's requirements. The guidelines for the seafood shellfish processing industry as finally promulgated give recognition to Alaska as a separate sub-group with different requirements for the best practicable treatment required for 1977.

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The guidelines originally called for the screening of waste solids from the effluent followed by dissolved air flotation regardless of the availability of an acceptable means of disposing of the waste solids after screening. As promulgated, only screening will be required at just a few locations in Alaska, and the others will be judged on a case-by-case basis -- as many in Alaska desired in the first place.

Now in this case there has been a relaxation of the National standards for Alaska and a broad base of support existed for this action. There are instances, however, where the national standards for best practicable treatment may be too lenient for Alaska. Many "Interior" streams and rivers which experience low dissolved oxygen concentrations in the winter may require higher levels of treatment for a waste discharge than are required by the guidelines. The case-by-case approach will work in these situations, albeit, at a higher level of treatment. It will be interesting to see how much support exists when these situations arise.

The requirements for municipal waste treatment and monitoring have caused difficulties in Alaska. The National guidelines require municipal effluents on the average to have less than 30 mg/l biochemical oxygen demand, less than 30 mg/l of suspended solids, and less than 200 per 100 ml of fecal coliform. Generally, this effluent quality will not be achieved by an aerated lagoon; and even though the lagoon could perhaps come close, at least in one instance a community was required to go to a more difficult-to-operate activated sludge system before a construction grant was issued to that community. Hindsight may show this to be a mistake, and if so, I am optimistic enough to believe that it will not be repeated. Certainly what has been done in changing the monitoring requirements of municipal effluents in Alaska gives encouragement.

Initially EPA permits prepared for Alaska under the National Pollutant Discharge Elimination System (NPDES), were requiring monitoring on the basis of national regulations, regardless of size or location - from a 10-15 man Coast Guard Station at Massacre Bay on Attu Island to cities the size of

Anchorage. After many letters from the Alaska Department of Environmental Conservation and others, we have issued permits for these smaller facilities calling only for tests that will enable the operator of the treatment plant and EPA to know if the plant is operating correctly. These requirements are scaled upward as the size of the plant increases or the nature of the receiving water indicates the need for more frequent testing. Although not meeting the letter of the guideline, we are meeting the intent and I believe we are doing the job of environmental protection.

Many other issues in water pollution control are still in front of us - primary vs. secondary treatment in Anchorage is one example. The recently adopted oil spill prevention regulations may present problems in the remote areas of Alaska. Considering the increased cost of building waste treatment plants in Alaska, lack of adequate grant monies is a problem, particularly when the State allocation is based on population. If you get financing to construct, where do you get the money and the trained individuals to operate a facility in a small village? This list could go on and on.

The Clean Air Act of 1970 was described as having more deadlines per page than any other legislation passed up to that time. Since 1970, EPA and the State agencies have been under a constant series of requirements which defy description and which have led to many Federal-State-local conflicts. Unfortunately, it's the conflicts that make the headlines. What we should all realize is that it is amazing that the conflicts have been as few as they have.

Briefly, where do the regulations from the air program give us trouble in Alaska and what are we doing about them?

First, the deadlines for achieving compliance, from some source points, were extremely short. They did not consider Alaska's shorter construction seasons, longer delivery times and so forth. Even when these problems are recognized the procedures for allowing final compliance beyond the mandated deadlines are not easy.

Achieving ambient air standards for particulates caused another problem, at least in Fairbanks and Anchorage. The natural airborne dust in these two cities, coupled with dust generated from many unpaved roads, causes violations of the State Ambient Air Quality standards for particulates. We still don't know how to handle this problem. Certainly few in Alaska have failed to hear or read of the problems in developing a transportation control plan for Fairbanks. The problems there are numerous, some related to regulations, some the result of court decisions, and many from the very short, court-mandated, deadlines.

One problem was that in Fairbanks the problem of carbon monoxide was emphasized and for all practical purposes, the other Fairbanks air problem of ice fog was ignored. We were requiring the retrofitting of the older automobiles with devices that had never been tested in the cold Fairbanks winters. Our attention to ice fog is still minimal, but we are now studying the retrofit devices to see if they will work in Fairbanks. The study was included in the final plan promulgated by EPA for Fairbanks.

As in the water regulations, there are also areas in our national regulations which may not be stringent enough for Alaska. This has to do with the control of air pollution from indirect sources. By indirect sources we mean air emissions generated by new highways, airports, shopping centers, parking lots, etc. These regulations require an evaluation of problems caused by parking lots only if they exceed a 1,000 car capacity in Standard Metropolitan Statistical Areas (SMSA). Anchorage is the only SMSA in Alaska. Fairbanks and other cities which are not SMSA's, would come under the regulation if a parking lot exceeded 2,000 cars.

We are still waiting for the EPA regulations which will define how we are to handle the issue of no significant deterioration. These regulations will have a profound effect on Alaska in terms of land-use planning and will influence decisions on where development will and will not occur. It appears that this major issue will be decided by the Courts. Unfortunately this seems to be the trend today for solving environmental problems.

THE ADMINISTRATION OF THE NORTHERN INLAND WATERS ACT IN THE YUKON TERRITORY

Mike Rychlo*

Canada's concern to ensure effective water management in Canada's North has been evidenced by the Northern Inland Waters Act passed by Parliament in February 1970, and Regulations in respect of this Act promulgated by Privy Council Order dated September 14, 1972. The Northern Inland Waters Act established the Yukon Territory Water Board and the Northwest Territories Water Board with the objective: to provide for the conservation, development and utilization of the water resources of the Yukon Territory and the Northwest Territories in a manner that will provide the optimum benefit therefrom for all Canadians and for the residents of the Yukon Territory and the Northwest Territories in particular.

It is the reponsibility of the Department of Indian Affairs and Northern Development to administer this Act, and to do so, two regional offices have been established, one in Whitehorse for the Yukon Territory, and one in Yellowknife in the Northwest Territories. Each office of the Controller of Water Rights carries out the duties related to the Act, and provides technical advice to the respective Water Boards. The staff in the Yukon which, by the way, is a Territory with 207,000 sq. miles and approximately 20,000 people, is now comprised of three professional engineers, a technician and two clerical personnel.

In accordance with the Act, the membership of the Yukon Territory Water Board includes three persons named by the Commissioner in the Council of the Yukon Territory, and at least one nominee of each of the departments of the Government of Canada that are most directly concerned with water resource management of the Territory. There are then representatives from

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each of the following Departments: the Department of National Health and Welfare, the Department of Energy Mines and Resources, Ministry of Transport, the Department of Public Works, Environment Canada, and the Department of Indian Affairs and Northern Development, making a total of nine members. The representative from the Department of Indian Affairs and Northern Development has been designated by the Minister of the Department as Chairman of the Board.

A basic principle of the Northern Inland Waters Act is contained in subsection 3(2) and may be stated as: no person shall alter or divert the flow or storage of waters or otherwise use waters, including both surface and groundwater, without a water-use licence. This stipulation does not apply, however, to the use of any waters for domestic purposes, or for the purpose of extinguishing a fire or, on an emergency basis, controlling or preventing a flood.

The licences, once issued, establish a precedence of use among licensees. When two licensees are authorized to use water for uses of the same priority, the licensee who first filed an application with the Board is entitled to the use of the water.

The Act prohibits the deposit of waste in any waters, except according to the conditions in a licence. If a person deposits wastes without a licence or uses water or deposits wastes contrary to the conditions of the licence, he is guilty of an offence and is liable to a fine of $5,000.00 for each day the offence continues.

The Controller may authorize the use of water without a licence if he is satisfied that the proposed use will meet the appropriate requirements governing issue of licences and:

(a) the proposed use is for Municipal purposes by an unincorporated settlement;

(b) the proposed use will not continue for a period of more than ninety days;

(c) the proposed use consists of the laying, placing, building, or erecting of any structure, device or contrivance in, over, under or upon any waters; or

(d) the quantity of water proposed to be used does not exceed 50,000 gallons per day.

Following the filing of the application, the applicant is required to give notice of the application by publication in the Canadian Gazette and in one or more newspapers. The Board itself shall give notice of a public hearing to be held by it by publication of the hearing details.

The Water Board will hold a public hearing in the Yukon Territory in connection with each application for a licence or for renewal of a licence, or where it has under consideration the amendment or cancellation of a licence. The hearing may later be cancelled if the Board receives no notice that any person intends to appear and the applicant, in turn, consents to the cancellation.

In considering an application, the Board may require the applicant to provide it with such information and studies as will enable the Board to evaluate any qualitative and quantitative affects of the proposed use. A considerable amount of information, including environmental impact studies and archeological surveys and reports was provided to the Board for consideration of the first water-use application received, that of the Aishihik Power Project.

In addition, the Board may require an applicant to furnish security, for the protection of licensees and owners and occupiers of property who, in the opinion of the Board, are liable to be adversely affected as a result of the issuance of a licence to the applicant. The amount of the security deposit is determined by the Board, but the amount will not exceed $100,000 or 10 percent of the estimated capital cost of the work, whichever is the greater.

If the Water Board is satisfied that the applicant is in the position to meet the appropriate requirements, then the Board may, with the approval of the Minister of Indian Affairs and Northern Development, issue a licence for a term not exceeding twenty-five years.

With regard to the licencing of water use within the Yukon Territory, we have received 175 applications as of the end of May, 1974; 4 water-use licences have been issued and an additional 106 authorizations have been granted by the Controller.

The applications include 5 proposals for hydro-electric development. The Aishihik Power Development 100 miles west of Whitehorse, was approved by the Board and granted the first licence under this new legislation.

There have been 17 applications for Municipal water-use for communities throughout the Yukon. Public Hearings have been held on the Whitehorse and Dawson City applications and licences will be issued as soon as details of the sewage treatment works are finalized. The scheduling of public hearings for other Municipalities is forthcoming.

Five major mining operations have applied for water-use licences and two of these have received licences. Licences for the other three are presently in the draft stage. Thirty-five applications for diamond drilling have been received and 27 authorizations granted. Three authorizations for water-use in oil exploration have been granted by the Controller. Sixty-five authorizations for water-use in placer mining have been issued.

In issuing a licence, the Board may attach to it any conditions that it considers appropriate including conditions relating to the manner of use of waters, the quantity and types of waste that may be deposited in the waters.

The Board's staff reviews all information provided by the applicant, as well as hydrologic and precipitation records for the area concerned to establish the flow patterns and availability of water on a year-round basis. The staff also examines all records of water quality data collected by the Board's staff and by other agencies to determine normal background concentrations of substances in the water, the performance of the waste treatment facilities as evidenced by analyses of the waste discharges, and the degree of impairment of the receiving streams and any affects on downstream users. In addition, in the case of a mine, for example, the actual plant processes are studied in order to determine the nature and location of chemical additives and the possibility of in-plant water recirculation. These factors, form the basis of a preliminary draft of a water-use licence, which would reflect the Board's initial judgment on what quantities of water should be used, and the amount and type of waste discharge acceptable. The draft then passes to the various Departments represented by the Board members for input regarding proposed additions, deletions or changes. The draft licence is also provided to the applicant for comments.

The requirements relating to waste discharge for a mining company's water-use licence includes clauses restricting the quantity of waste discharge, as well as limits for specific substances in the waste discharge. A monitoring program is included and it is the licensee's responsibility to carry out the sampling and analyses as required by the monitoring program. Specific limits for receiving water quality are not imposed, as it is the Board's opinion that a substantial amount of information regarding the receiving stream must be compiled and assessed before limits on the constituents of the stream can be justified. Both Water Boards, however, have accepted a proposal presented to them concerning the formation of a working group comprised of personnel from many Government Departments to work towards the development of water quality objectives for the North.

In concluding, emphasis should be placed on the fact that the water resources of the Yukon Territory are extensive and virtually undeveloped. Very little is known about the quantity of this resource, and analytical data and the understanding of the complexities of the water quality are insufficient. The Northern Inland Waters Act, however, has provided the principles for effective water management to the North. The Department had initiated a substantial amount of data collection, research and study in order that proper management decisions can be made with regard to this resource.

ENVIRONMENTAL REGULATION IN CANADA'S NORTHERN TERRITORIES WITH PARTICULAR REFERENCE TO THE TERRITORIAL LAND USE REGULATIONS

Donald W. Hersak*

INTRODUCTION

During this decade the focus of attention has been and no doubt will continue to be on the north - one of the last areas in this "Global Environment" of untapped resources, of rugged individuals, of pristine surroundings. This scenario, I am sure applies equally to the Alaskan frontier and to the Yukon territory as it does to the Northwest Territories the jurisdiction to which my presentation today will be directed. I may add that legislation, governmental administration and field operations are either identical or similar to those within the Yukon Territory. I hope to cover the management of land and its surface resources from the operational side - *i.e.* how we attempt, and hopefully achieve, a balance among three fundamental aims:

1) enhancement of the life qualities of an indigenous population and the preservation of their resource supplies,
2) preservation of the natural environment - both the biotic features and the physical landscape; and
3) encouragement of orderly exploration, development and exploitation of natural resources.

Because of the constraints of time and my own personal experience, I shall concentrate on one regulatory device - the Territorial Land Use Regulations.

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HISTORY

Prior to late 1960's the growth of resource exploitation was gradual with only minor impact on the land surface, only localized disturbances to wildlife populations and minimal social upheaval. The fur traders, then the whalers and later the miners either passed through or were assimilated with rather insignificant effects on their surroundings.

With the discovery of oil in Prudhoe Bay in 1968, the gradual depletion of easily accessible sources of minerals and an imminent world energy shortage, it became evident that a petroleum and minerals exploration boom in the Canadian frontier areas was near at hand. In particular, the eyes of the petroleum industry were on the thick sedimentary sequences and the imposing structures within the MacKenzie Delta and the Sverdrup Basin. The eyes of a concerned public were also directed to these same areas and to the possible effects uncontrolled exploration would have:

- on a fragile, permafrost laden landscape;
- on wildlife populations unaccustomed to man and his machines; and
- on a social fabric based primarily on trapping, fishing and hunting.

The Canadian Government, and especially the Department of Indian and Northern Affairs, set upon the task of designing legislation and an administrative mechanism to regulate activities of northern lands. In order that all points of view (*i.e.* that of the environmentalist/conservationist, that of the industrialist/developer, and that of the local inhabitant) were given consideration, draft guidelines were circulated in 1969, public hearings were held and briefs were invited. A synthesis of the diverse interests culminated in promulgation of the Land Use Regulations in November, 1971.

THE LAND USE REGULATIONS

The Regulations were founded on 3 policy concepts.

1) That at this early stage of development, the concept of multiple land use would prevail throughout northern lands. At the onset of drafting the Regulations it was presumed that all forms of resource activity could proceed in all areas without conflict and that no land use zoning would be initiated.

2) That the Regulations would apply to operations which, by their characteristics or magnitude, could potentially cause environmental harm. The criteria for defining an operation to be placed under regulation (a "land use operation") was outlined in terms that would apply to everyone - government, industry, local entrepreneurs, research groups. (An excerpt from the Regulations defining a "land use operation", appears in Annex 1).

3) Because of widely varying topography, soils, vegetation and climatic features and the diversity of surface activities, one set of inflexible standards could not be effective or meaningful for all types of operation during all seasons and in all areas. Thus the Regulations were divided into two distinct parts. Part one set out general environmental requirements to which all land use operators must adhere. (A few excerpts from Part I of the Regulations appear in Annex 1).

Part two provided the legislative authority and described the administrative procedure for placing specific environmental conditions on individual operations through the issuance of Land Use Permits. (The scope afforded to the administrator of the Regulations or "Engineer" for imposing conditions on an operation is indicated in Annex 1).

Operators must apply for Permits before commencing "land use operations" within 4 zones in the Northwest Territories and 3 zones in the Yukon Territory. These areas, the Land Management Zones, have been set apart for environmental management because of their sensitive or fragile characteristics. The zones include all the areas of detrimental permafrost and most of the significant wildlife habitats and breeding areas. (The Land Management Zones are shown on Annex 2).

ADMINISTRATION OF THE REGULATIONS

In the Northwest Territories the Land Use Regulations are administered by the Superintendent of the Northwest Lands and Forest Service, assisted by a small administrative staff in the Headquarters at Fort Smith and by 30 District Superintendents and Area Resource Management Officers based in field offices throughout the Western Arctic.

Prospective operators in Land Management Zones submit detailed applications to the office of the Superintendent in Fort Smith (or to the Regional Manager, Water, Forests, Land and Environment, Whitehorse for prospective Yukon operators).

The application must detail equipment to be utilized, fuels to be stored, methods of waste disposal and employment opportunities for native people. All proposed excavations, areas to be cleared, and facilities to be installed must be shown on a preliminary plan of an appropriate scale. Within fourteen days the Superintendent (Engineer) may return the application if not completed in accordance with the Regulations. If the application is acceptable it is processed in the Fort Smith office. By processing I mean:

1) the receipting of the application fee and land use fees which are submitted with the application and which are based on the acreage to be subjected to a Land Use Operation;

2) recording of the data indicated on the preliminary plan on compilation maps;

3) distribution of the application to the designated Land Use Inspector in the field, to Settlements in the vicinity of the proposed operation, and to the other governmental agencies which comprise the Land Use Advisory Committee;

4) examination of the land use proposal in conjunction with various maps and checklists, for example:

   (a) Land Use Series Maps (at present, only covering the Mackenzie Valley and Delta) which show on a large scale, areas of environmental and social importance;

   (b) Terrain Sensitivity Maps (covering the Mackenzie Valley and Delta, as well as selected areas in the Arctic Islands where exploration activity is most intense) which describe the characteristics of the soils and geomorphological features, and rate the various terrain types on their susceptibility to disturbance;

   (c) Ecological Series Maps prepared by the Canadian Wildlife Service which show migratory routes, calving, breeding and spawning areas, and seasonal habitats for the more important wildlife species;

   (d) Trapline Maps prepared by the Game Management Branch of the Government of the Northwest Territories, showing the locations of active traplines in the Mackenzie Valley and Delta;

   (e) detailed ecological maps and reports prepared by the Arctic Land Use Research Program and other research, environmental and government agencies.

After processing, the Engineer is given 30 days to react to the application in one of 3 ways:

1) by issuing a Land Use Permit and imposing operating conditions specific to the operation (a sample Land Use Permit, with attached operating conditions, appears in Annex 3);

2) by refusing to issue a Permit;

3) by requesting that an in-depth inspection or study be carried out on the lands in question. The results of this finding are to be made available to the applicant and a decision made on the application within 6 months.

THE LAND USE ADVISORY COMMITTEE

When the Land Use Program was launched in late 1971, a committee or forum of governmental advisors was created to assist the Engineer in reaching a decision on applications and in preparing conditions for inclusion in Land Use Permits. The membership of the Committee includes various Federal and Territorial Government agencies that administer complementary environmental legislation in the Northwest Territories. The committee meets in Yellowknife on a regular basis under the chairmanship of the Engineer. As well as considering individual land use applications, the Committee serves as a forum for airing environmental problems in the North, for co-ordinating research programs and for maintaining uniform environmental standards throughout the Northwest Territories.

SETTLEMENT CONSULTATION

As noted earlier, copies of Land Use Applications are forwarded to settlements located in the vicinity of the intended operation. This consultive mechanism serves three purposes:

1) Settlement councils, Hunters and Trappers Associations, Native Band Councils, and individual residents are kept informed of resource activity in their sphere of interest.

2) Potential conflicts between exploration, developmental activities and local resource users are brought to the attention of the Engineer. For example, locations of active traplines or fishing camps that could be severely disturbed by a seismic survey or a large-scale staging site are recognized before an operation has reached a point of no return.

3) Environmental information derived from first-hand experience by individuals living on and from the land in question is made available to the Engineer.

The terms of reference, within which we must operate, when carrying out this consultive process, are limited to environmental matters only. Since the Land Use Regulations are primarily a vehicle to provide protection for the physical land surface and its biotic features, the Engineer, in his decisions, can only consider input related to the possible effects a proposed activity may have on the environment. When submitting the application to a settlement for recommendation the question of whether or not the operation shall proceed is not being posed - unless, of course, based on local experience, it is revealed that there is an extreme possibility of severe environmental damage and it becomes evident that a Permit should be refused. Rather, settlement consultation is a more positive process where, by negotiation and compromise, the timing, positioning, or conduct of an operation is modified to take into consideration local concerns.

An extension of consultation is the assignment of monitors from the settlement to a particular land use operation. Some very beneficial results have been obtained from this system:

1) Traplines and wildlife habitations, which could only be noticed by a local expert, are avoided during the construction of seismic lines and access routes.

2) Representatives of a settlement are afforded an opportunity to observe, at first-hand, exploration operations; observations which can be relayed to the community to foster their understanding of the developments taking place about them.

3) Monitors have assisted operators in selecting the most advantageous route locations and have passed on valuable knowledge on survival in a very forgiving environment.

ENFORCEMENT AND INSPECTION

The monitoring of on-going operations, enforcement of the Regulations and the implementation of settlement consultation are carried out by Land Use Inspectors located at District and Area Offices throughout the Western Arctic. Most of the Land Use Inspectors are graduates of a technical school, specializing in forestry or in other resource management fields. In addition to their land use inspection duties, they are responsible for forest fire detection and suppression, timber management; and they serve as Crown Land Agents.

The key role in the Land Use Program is assumed by the field inspector whose advice to the applicant and to the Engineer is given prime consideration. His duties commence at the early planning stage of an operation where he provides advice to a prospective applicant on local conditions in his management area and frequently accompanies the applicant on a preliminary inspection of the subject area before the application is submitted. Following the receipt of the application, the inspector submits his recommendations to the Engineer for inclusion in the Permit Operating Conditions.

Following the issuance of a Permit, the inspector is responsible for monitoring the operation. During each onsite visit he completes a report form that indicates to the operator whether he is violating or satisfactorily adhering to the Permit Conditions and the Regulations. The inspector is also expected to point out and advise the operator of developing problem areas, whether they be of an erosional, waste disposal or forest fire protection nature.

After an operation is completed and a final plan, showing the actual areas utilized in the operation, is submitted, the inspector is responsible for conducting a final inspection. During this inspection the accuracy of the final plan is verified for purposes of final land use fee calculation, and any outstanding cleanup or required erosion control measures are noted. When the inspector is satisfied that the land use requirements have been fulfilled, the operator is given a "Letter of Clearance" relieving him of further responsibilities under the Land Use Permit.

Where a violation persists or is of a severe nature, three courses of action are open to the Engineer:

1) The operation may be suspended until an infraction is remedied.
2) If co-operation in remedying an infraction, especially after suspension, is not obtained, a Permit can be cancelled and the operation terminated.
3) A violator of the Regulations or Permit Conditions may be prosecuted and fined a maximum of $5,000.00 per day for each day of an on-going offence.

These actions are seldom required because of the regular on-site inspections and the continual dialogue between the operator and inspector during the progress of an operation. Co-operation from most Land Use Permittees in avoiding environmental problems and initiating corrective measures has been impressive.

MAGNITUDE AND VARIETY OF LAND USE OPERATIONS IN THE NORTHWEST TERRITORIES

Since the inception of the Land Use Program in late 1971, over 850 Land Use Permits have been issued. Over 70 percent of the Permits have been for petroleum exploration activities, primarily seismic surveys and wildcat wells in the Mackenzie Delta and the Arctic Islands. In the Arctic Islands a number of the individual seismic surveys have exceeded 500 line miles.

Permits have also been issued for operations as small as a 1000 cubic yard gravel quarry operation to as extensive an undertaking as the construction of the Mackenize - Dempster Highway System.

The most unique series of Permits issued to date authorize the construction of artificial drilling islands in the shallow waters of Mackenize Bay. Seven proposals have been approved or are under present consideration. Each of the proposals has varied considerably from the original artificial island concept, particularly in method of construction and the component materials. Islands have been or will be constructed of submarine gravels and silts, terrestial gravels and submerged barges - solely or in combination. In conjunction with and because of these projects, extensive studies have been conducted on the ecology of Mackenzie Bay, on the migratory habits of the beluga whale and on the toxicities and treatment of drilling fluids.

PROBLEM AREAS

I will briefly touch on some of the problem areas that we face in the day-to-day operations of the Land Use Program. Progress is being made towards the solution of many of them, others await only inspiration or initiative.

Our major problem is that the distances that must be covered by a handful of inspectors is a logistical and financial nightmare. Some of the more isolated land use operations cannot feasibly be inspected with any degree of frequency.

Because of distances involved in a territory with only a rudimentary transporation and communication system, there are severe handicaps to expedient and efficient administration, particularly when attempting consultation with communities that may only have a monthly mail delivery we are still committed to meet our legislative requirement of a 30 day response to an application.

A very fundamental problem is the lack of base-line environmental information, for all but a few areas. Because of the expense involved in supporting research in the North, studies are often confined to areas of immediate developmental interest and more often than not, only just precede the proposed development or continue in parallel with it. To cite one example, little is known about the migratory patterns and the calving areas of the musk oxen and caribou that inhabit the Arctic Islands though seismic surveys and other land use operations have been carried out in these areas for the past decade.

Though the program has been fully operational for almost 3 years we are still searching for practical solutions to a number of technical problems.

1) The disposal of drilling fluids both at offshore (artificial islands) and onshore locations. Studies have been carried out through a co-operative effort between government (Departments of Indian and Northern Affairs, and Environment) and industry (The Arctic Petroleum Operators Association) to define acceptable toxicity levels, to design acceptable drilling fluid systems, to ascertain methods of treatment and to develop criteria for methods of treatment and to develop criteria for construction and reclamation of land-based mud sumps.

2) Environmentally secure techniques or devices for temporary and semi-permanent fuel storage depots. Our basic requirement

is that fuel storage facilities, particularly those consisting of rubberized fuel bladders, be protected by impermeable barriers. Because of climatic and seasonal change, unavailability of suitable liner materials, prohibitive transportation costs, and a predominance of very permeable soils in our jurisdiction, our requirements are only approached and seldom achieved.

3) Ever-increasing seismic line construction. In an environment where natural revegetation is painfully slow and artificial revegetation is not completely perfected or, in some cases, impractical, the multiplicity and duplication of seismic coverage is an area we are just recognizing and trying to deal with. Our first line of defence is based on attempting to record all previous work, with hopes of guiding prospective operators to existing data or to existing cleared areas. We are also attempting to encourage operators to seek out and develop equipment and techniques that have a more moderate impact on the environment.

4) Summer operations in areas of continuous and sporadic permafrost. We are regularly confronted with proposals to drill exploratory wells, to conduct seismic surveys, or to carry out other operations upon the land, during periods when the terrain is not completely frozen. The choice of which operations can safely proceed and in which areas and under what restrictions is always difficult. We rely heavily on technology advanced and experimentation initiated by both industry and governmental agencies. Problem areas that are presently under investigation are the security of fluid waste disposal sumps, and the acceptable disturbance levels, techniques and vehicles for overland travel.

A subject of current investigation is the handling, removal and/or recycling of the solid waste that is rapidly accumulating at petroleum and mining company base camps and within remote settlements. Government and industry in close co-operation are now designing the logistical plan that should soon see the removal and disposal of unsightly waste materials from Canada's North.

FUTURE DIRECTIONS

In conclusion, I will mention a few areas that we are presently pursuing or will soon be directing our efforts:

1) The development of a form of "land use plan" for exploration, development and recreation activities. Progress has already been made in identifying granular materials, forest resources, lands suitable for agricultural purposes and environmental features. As the process of cataloguing resources proceeds, plans for orderly utilization will be developed. Within our "Land Use Program" which deals with transitory activity we are collecting data on the environment, learned during the past 2-1/2 years. Hopefully, we will soon have a series of maps that will define areas in terms of the acceptable operation types, together with the favorable timing and the stipulations under which they are considered acceptable.

2) A more concentrated effort to guide industry and government operators to improved techniques in the problem areas I have already mentioned. Equally important is the communication to prospective operators of mistakes that have been made in the past and of methods that have worked.

3) The education and involvement of Northern residents in environmental concerns and developmental activities Considerable progress has been made in this area by both industry and various government agencies.

The following examples deserve mention:

1) The Northwest Lands and Forest Service has just recently embarked on a training program for native residents whereby technical training will be given to individuals that already have an innate appreciation for their northern environment. The successful candidates will become our future land use inspectors.

2) The petroleum industry and the Government of the Northwest Territories are currently in the midst of a program of training local residents for technical and administrative postitions in all phases of the petroleum industry - from exploration to refining.

I express my thanks to the symposium committee for giving me this opportunity to address this very prestigious gathering. I hope that those of you facing the same operational problems as we are currently facing in the Northwest Territories can offer suggestions and possible solutions; perhaps there are even some areas where the results of our experiences can be of some assistance to you.

ANNEX 1

SELECTED EXCERPTS FROM THE TERRITORIAL LAND USE REGULATIONS

INTERPRETATION

Section 2

"land use operaton" means any work or activity on territorial lands that involves one or more of the following:

(a) the use of more than 50 pounds of explosives in any one day or more than 300 pounds of explosives in any 30-day period,

(b) the use, except on a public road or trail, of any vehicle that exceeds 20,000 pounds net vehicle weight or the use of any vehicle that exerts pressure on the ground in excess of 5 pounds per square inch,

(c) the use of any self-propelled, power driven machine for moving earth or clearing land,

(d) the use of any stationary power driven machine for hydraulic prospecting, moving earth or clearing land,

(e) the use of any power driven machinery for earth drilling purposes, the operating weight of which exceeds 5,000 pounds, excluding the weight of drill rods or stems, bits, pumps and other ancillary equipment,

(f) the establishment of any campsite that is to be used in excess of 300 man-days,

(g) the leveling, grading, clearing or cutting of any line, trail, or right-of-way exceeding five feet in width;

PART I

EXCAVATION

Section 6

All materials removed by an operator in the course of making an excavation other than rock trenching shall, unless otherwise authorized by an inspector, be replaced and the area of the excavation shall be leveled and compacted.

CAMPSITES AND FUEL STORAGE FACILITIES

Section 12

(1) Every operator shall dispose of all garbage, waste and debris from any campsite used in connection with a land use operation by removal, burning, burial or in such other manner as may be directed by an inspector.

REMOVAL OF BUILDINGS AND EQUIPMENT

Section 14

(1) Subject to subsection (2), an operator shall, upon completion of a land use operation, remove from territorial lands all buildings, machinery, equipment, materials and fuel drums or other storage containers used in the course of the land use operation.

(2) An operator may, with the prior written approval of the Engineer, leave on territorial lands such buildings, equipment, machinery and materials as the operator deems may be required for future land use or other operations in the area, but any equipment, machinery or materials so left must be stored in a manner and at a location approved by the Engineer.

PART II

TERMS AND CONDITIONS OF PERMITS

Section 21

(1) The Engineer may include in any land use permit conditions respecting

(a) the location and the area of lands that the operator may use;

(b) the times at which any work or activity forming part of the land use operation may be carried out;

(c) the type and size of equipment that may be used in the land use operation;

(d) the methods and techniques to be employed by the operator in carrying out the land use operation;

(e) the type, location, capacity and operation of all facilities to be used by the operator in the land use operation;

(f) the methods of controlling or preventing ponding of water, flooding, erosion, slides and subsidences of land;

(g) the use, handling and ultimate disposal of any chemical or toxic materials to be used in the land use operation;

(h) the protection of wildlife habitat;

(i) the protection of objects and places of recreational, scenic, and ecological value;

(j) the deposit of a security deposit, in accordance with section 26; and

(k) such other matters not inconsistent with these Regulations as the Engineer thinks necessary for the protection of the ecological balance or physical characteristics of the land management zone.

OPERATING CONDITIONS

The operator, Dry Hole Exploration and Production Ltd. shall conduct the Well Drilling - YAGO C-25-Icebound Island land use operation authorized by this Land Use Permit in accordance with the following operating conditions:

GENERAL CONDITIONS

1. The operator shall adhere to all conditions stated in Part I (General) of the Territorial Land Use Regulations.

2. The operator's field supervisor shall contact the Yellowknife District Office of the Northwest Lands and Forest Service phone number 873-4431 48 hours prior to the commencement of this Land Use Operation.

3. (a) All machinery and equipment associated with this operation shall operate within those routes or areas designated in the preliminary plan.

   (b) Should deviation from the preliminary plan be required while conducting this operation, the operator must obtain written approval from the engineer.

4. The obligation of the operator with respect to cleanup and restoration of the area of Land Use does not cease until he is in possession of a Letter of clearance from the engineer.

5. Prior to completion, suspension, or abandonment of the well, the Land Use Inspector shall be advised by the operator of the planned schedule for removal of equipment and materials by land from the drilling site and for the final cleanup.

6. The Land Use Permit and Annexed Operating Conditions shall be posted on the site of operations.

EROSION CONTROL AND SURFACE DISTURBANCE

7. (a) In order to minimize surface disturbance, bulldozer blades shall be elevated a minimum of six inches above the ground by employing mushroom type shoes or a similar device,

   (b) The operator may remove these devices for the preparation of the drilling site designated in the preliminary plan.

   (c) During the cleaing of lines, trails or right-of-way in the course of this Land Use Operation, the operator shall adopt such measures to control erosion by surface disturbance as may be required by an inspector.

8. Winter commencement and spring shut-down dates for overland vehicle movement will be determined by the engineer based on local terrain conditions.

9. Movement by land of materials and equipment during this land use operation shall occur while the ground surface is in a frozen state capable of fully supporting the running gear of vehicles and equipment.

10. In order to prevent soil subsidence, the operator shall insulate the ground surface beneath all facilities and structures associated with this Land Use Operation.

11. The winter access road shall be of packed snow construction.

12. The operator shall prescout proposed routes and lines and shall indicate with ground markers the most favorable locations for crossing streams or avoiding terrain obstacles prior to movement of crawler tractors or other heavy vehicles.

POLLUTION PREVENTION

13. The operator shall locate and place fuel storage containers so that any spilled or leaked fuel will be totally contained.

14. Each fuel container or group of fuel containers shall be surrounded by a dyke. The net capacity of the dyked area shall be greater than the volume of the largest container placed therein.

15. The enclosed dyked area including the interior dyke walls shall be lined with impermeable material.

16. All stationary fuel storage facilities shall be clearly marked with flags, posts or similar device so they are plainly visible to local vehicle traffic regardless of snow cover, weather or daylight conditions.

17. Fuel outlets excepting the outlet currently in use, shall be sealed to prevent leakage.

18. (a) All combustible garbage and debris shall be incinerated daily, in a forced-air, fuel-fired incinerator.

(b) The residue and all other noncombustible garbage and debris shall be disposed of by burial beneath a 3-foot layer of compacted soil or by removal to a site approved by the engineer.

19. (a) All waste petroleum products shall be disposed of by incineration daily.

(b) Waste chemicals and waste petroleum products which cannot be incinerated shall be disposed of in the sump or pit areas daily.

STREAM CROSSINGS

20. Fisheries services approval for stream crossings may be obtained through the Land Use Inspector.

21. (a) Stream crossings will be constructed using the natural ice cover or adding to the thickness of that cover by using snow and pumped water to form an ice bridge. For streams flowing during winter, a flow channel will be maintained under the ice bridge.

(b) Where fill is required for the crossing of dry or frozen creeks, snow will be used: dirt fill will not be used, unless otherwise authorized in writing by a fisheries officer in consultation with the Land Use Inspector.

22. Stream approaches shall be constructed with a minimum of disturbance to stream banks by using only snow and ice for construction material.

23. Any obstruction to natural drainage caused during any part of the Land Use Operation shall be removed and conditions restored as much as is possible to the original state.

WILDLIFE

24. The operator shall not use machinery or otherwise conduct the operation so as to harass or unnecessarily disturb wildlife or damage wildlife habitat.

25. The operator shall cooperate at all times with the game officials in regard to the protection of wildlife and wildlife habitat.

26. (a) All firearms shall be under the direct control of supervisory personnel and shall be used only for purposes of protection.

(b) The presence of a wild animal that may potentially create a hazard to persons or property is to be reported immediately to the nearest Game Management Officer or R.C.M.P. detachment.

(c) The feeding of wildlife is prohibited.

27. Prolonged movement by aircraft below elevations of 1500 feet from the ground is to be avoided.

SUMPS AND PITS

28. Sumps and pits connected with any operation on land shall not be constructed within 300 feet of any stream, or water body.

29. All fluid waste associated with this Land Use Operation, except combustible petroleum products, shall be deposited in a pit or sump.

30. Sumps and pits shall be constructed large enough to contain all fluids to a level at least four feet below the lowest elevation of the immediate surrounding ground surface.

31. The operator shall maintain sump or pit wall stability.

32. Sumps or pits shall be constructed in such a manner that the fluids contained therein cannot spread to the surrounding land.

33. Originally excavated material shall be compacted over the entire sump or pit area. This area shall include an over-lap of six feet beyond the existing sump wall.

34. The fluid contained in the sump shall be frozen to the extent that it will support the originally excavated material during placement and compaction over the sump contents.

35. Restoration of the sumps and pits shall be completed prior to the spring shut-down date for overland vehicle movement.

LUNCHEON ADDRESS

PRIMARY vs SECONDARY vs TERTIARY WHICH ONE ?

Speaker:

ROSS E. McKINNEY

PRIMARY vs. SECONDARY vs. TERTIARY TREATMENT, WHICH ONE?

Ross E. McKinney*

Considerable controversy has been raised in recent years concerning wastewater treatment. Unfortunately, inadequate information from various pressure groups and politically oriented individuals has combined to create an erroneous impression in the minds of the public. It has been easy to show the impact of water pollution. TV, magazines and the popular press found water pollution made exciting coverage for a relatively short period of time. The public responded to the flood of pollution rhetoric and demanded that water pollution be stopped. In the United States, the politicians responded by jumping on the pollution bandwagon and passing legislation that was hailed as the solution to the problem once and for all. Instead of producing satisfactory solutions, current water pollution control efforts have tended to create chaos and confusion. Rather than producing a solidified effort, the water pollution legislation has retarded solutions and has alienated large segments of our society. There is absolutely no need for the current chaos and the lack of serious progress in meeting our water pollution control objectives. We have the necessary technology to produce any desired degree of treatment required and we have the economics to apply the required treatment and prevent water pollution. What we currently lack is meaningful leadership to produce the desired results. As long as we continue along the current path, progress will be limited and painful and inefficient. If we are to change directions, we are going to have to make a real effort to educate everyone in our society as to the real needs of water pollution control and its true value.

*Parker Professor of Civil Engineering, Department of Environmental Health Engineering, University of Kansas, Lawrence 66044

DIRECT DISCHARGE

Initially, we discharged wastewaters into nearby streams and rivers without regard to the impact on the environment. Even though the rivers often appeared to absorb the wastes satisfactorily, polluted water was an important method for transmitting enteric diseases. Cholera, typhoid fever and dysentery were all transmitted through human wastes into various water supplies. Approximately 100 years ago we learned how to purify water on a large scale and reduce the potential danger from water-borne diseases. We also learned that wastewater treatment reduced the potential danger for transmitting enteric diseases through water. By combining both water purification and wastewater treatment we reduced the death rate from water-borne typhoid fever in the United States from 35.8 deaths/100,000 population/year in 1900 to zero. Rivers and streams were able to handle most of the organic matter in wastewaters by self-purification until we discharged too much wastewater into those rivers and streams. Overloading our streams and rivers resulted in damaging pollution that killed fish, destroyed useful aquatic vegetation, ruined recreational areas and contaminated one of our most valuable resources. It became apparent that wastewater treatment would have to be improved if water pollution was to be prevented.

PRIMARY TREATMENT

Primary treatment was developed to remove the gross solids that settled easily or floated on the water surface. The effluent from primary treatment could be easily discharged into receiving streams and rivers without creating sludge banks or having observable greasy scum on the water surface. The efficiency of primary treatment depended upon the nature of the wastewaters. Where the wastes were high in suspended solids that were biodegradable, the primary treatment units had a high degree of efficiency. Fresh, domestic sewage treated with 2 hours primary sedimentation can remove 70-75 percent of the suspended solids and 40-45 percent of the BOD_5. As the retention of sewage in the sewer system increases, the sewage undergoes changes with more of the suspended solids being converted to soluble solids which cannot be removed by primary treatment. Normal domestic sewage from a large community will yield 50-65 percent suspended solids reduction and 25-35 percent BOD_5 reduction.

The settled solids removed by primary treatment must be further processed before being returned to the environment. Initially, anaerobic digestion was used to stabilize the organic matter and produce methane gas which could be used as a source of heat or energy. Approximately 60 percent of the volatile solids added to the anaerobic digestor were metabolised to carbon dioxide and methane. The remaining solids represented materials that were essentially nonbiodegradable and easily dewatered. The digested sludge was dewatered initially on sand drying beds but as the production of sewage solids increased, vacuum filtration was used. Currently consideration is being given to centrifugation for dewatering. The liquid from centrifugation or filtration contains considerable ammonia nitrogen and is recycled back to the primary sedimentation tank for ultimate discharge in the treated effluent. The dewatered solids can be incinerated or discharged onto land depending upon local conditions. Even if the sludge is incinerated, ash solids must be discharged back into the land environment.

The settled solids can also be treated directly without anaerobic digestion. Chemical treatment with lime or polyelectrolytes can produce a dewaterable sludge that is normally incinerated with the ash being returned to the land. In a few instances, the sludge has been returned directly to the land for soil stabilization. Health authorities frown on soil stabilization of primary sludge that has been dewatered with polyelectrolytes for fear of spreading disease organisms back into the environment.

In the 1880's chemical precipitation was a popular method for wastewater treatment as it increased suspended solids reductions up to 95-98 percent and with corresponding BOD_5 reductions. Chemical precipitation produces a quality-looking effluent that quickly deteriorates as the soluble organics are metabolised. One of the advantages of chemical precipitation is the reduction in phosphates that is also possible. The major drawback of chemical precipitation is the large quantitites of chemicals that are required on a continuous basis and the large quantity of chemical sludge that is produced. Iron and calcium salts are to be preferred to aluminum salts for precipitation, since iron and calcium can be absorbed more easily back into the environment than aluminum.

SECONDARY TREATMENT

As communities grew in size, the wastewater quantities increased to the point where even more treatment was required than could be provided by primary sedimentation. Biological treatment was developed as secondary treatment to remove the soluble and colloidal organics that remain in the primary effluent. Aerobic biological treatment can produce a very high quality effluent when properly applied to wastewaters. Needless to say, secondary treatment has application only to biodegradable wastes with greatest efficiency being produced in soluble wastes or highly colloidal wastes. Practically speaking, secondary treatment results in the biological conversion of soluble organic matter to insoluble organic solids that can be easily removed by sedimentation.

Trickling filters were first used for secondary treatment because of their simplicity of design and operation. Unfortunately, trickling filters could not handle strong industrial wastes or strong domestic sewage and produce an effluent having little biodegradable organics. Activated sludge was found to be more efficient in removing organics than trickling filters since the microbes, the wastes, and oxygen were more intimately mixed for a longer period of time. Completely mixed activated sludge can treat industrial wastes and domestic sewage of any BOD_5 concentration and produce any desired effluent concentration. CMAS systems have produced 90-99+ percent of BOD_5 reduction with an effluent BOD_5 concentration between 5 and 10 mg/l being possible with good suspended solids separation. The key to good activated sludge operation is a balance between the microorganisms, oxygen, the organic wastes, nutrient elements, trace elements, and time. With domestic sewage only microbes, oxygen, wastes and time are important as excess nutrient elements and trace nutrients are normally present. With some industrial wastes and some domestic sewage, nutrient elements and trace elements are more important and the rate of metabolism can be adversely affected by deficiencies, not only of nitrogen and phosphorous, but also of iron and other trace elements.

Activated sludge can not only reduce the soluble organics, but it also can convert the excess ammonia nitrogen to nitrates, provided adequate oxygen is supplied to the microorganisms. It is even possible to reduce the nitrates to nitrogen gas with an adequate oxygen-demanding potential. Unfortunately, considerable confusion exists as to the design of systems suitable for stabilization of organic matter coupled with nitrification and dentrification. The current recommended systems are far more complex and expensive than necessary and clearly demonstrate the problem of proper design and operation of secondary treatment systems. Technology is available for simpler designs with easier operating characteristics but self-interest often prevents application of the best technology and forces the use of an outmoded technology. Fortunately, a free society generally permits discussion of all processes and eventually results in application of the optimum system in spite of governmental pressures and enlightened self-interest upon the part of favored research and development organizations and equipment manufacturers.

Aerated lagoons and oxidation ponds have been used for secondary treatment of both industrial wastes and domestic sewage. Aerated lagoons are simply dispersed activated sludge systems while oxidation ponds employ both bacteria and algae for their metabolic reactions. Both systems tend to release more microbial solids in the effluent than desired by current EPA regulations, raising serious concern about the future of these treatment systems. When one considers the fact that both aerated lagoons and oxidation ponds stabilize 95-99 percent of the incoming wastewater BOD_5, one wonders what is the real impact of dispersed microbial solids in excess of 30 mg/l as is desired in secondary effluents. The 30 mg/l of suspended solids from an aerated lagoon or an oxidation pond are definitely different than 30 mg/l suspended solids from an activated sludge system or a trickling filter system but this is not recognized by the EPA, at least, not in their standards. Aerated lagoons and oxidation ponds have been used primarily for treating wastewaters from small, rural communities or from small, isolated industrial plants who are willing to provide reasonable wastewater treatment within their limitations. Suddenly, it appears that unless a simple system can be developed to remove the excess dispersed bacteria and algae, aerated lagoons and oxidation ponds will have to be abandoned and replaced by more complex secondary treatment systems having less stable operating characteristics. Small communities and small industries do not have the skills to operate complex biological or chemical treatment systems and will inevitably produce less stable effluents at greater costs and greater efforts. Secondary treatment is not a serious problem for the large communities but when you consider the fact that most of the communities are small, the problem is serious and demonstrates the real lack of leadership in this area at the present time.

One of the newest technical developments in the activated sludge field is the advent of pure oxygen in place of air as a source of oxygen. It is interesting to note the pressures that have been exerted in an effort to use pure oxygen. Technically, pure oxygen systems produce exactly the same results as air-activated sludge systems under identical conditions. It should be recognized that pure oxygen can transfer more oxygen at a faster rate than air simply because of the differences in partial pressures but it does not produce any different biochemical reactions or stimulate any different microorganisms to grow in the activated sludge. With adequate oxygen, an air-activated sludge system and a pure oxygen-activated sludge system produce exactly the same quantitites of excess activated sludge and exactly the same reduction in wastewater organics with the same reaction times. Pure oxygen-activated sludge systems can be operated at shorter aeration times than air-activated sludge systems but will produce effluents containing more BOD_5 unstabilized and will have more excess sludge for disposal. It is regrettable that concern over a new biotreatment system has resulted in distortion of the facts and obvious misrepresentation of fundamentals. For the most part, improper design and improper operation of air-activated sludge systems have created the impression that pure oxygen-activated sludge systems can produce less sludge and better effluent quality than air-activated sludge systems. It is important that this relationship be recognized for what it really is.

TERTIARY TREATMENT

Some communities are located on inland lakes and estuaries that have very limited water for accepting even secondary effluents and require tertiary treatment. Tertiary treatment has been defined as any treatment required after secondary treatment. Tertiary treatment has also been labeled as advanced waste treatment in an effort to create the impression that tertiary treatment represents modern concepts that have not been considered before. This, too, is a fallacy and represents part of the efforts by individuals more concerned with personal prestige and advancement than with solving the practical pollution problems that our society is currently facing. Most of the successful tertiary treatment processes are simply application of well-established chemical concepts to the problem of water pollution.

Phosphate reduction was the first successful tertiary treatment process to be proposed. Phosphate precipitation was first used to treat sewage back in the 1880's but it was not until the 1960's that sufficient concern was raised over phosphate removal to recommend chemical precipitation. Aluminum, iron, and calcium salts can remove phosphates from either the raw wastes, primary effluent, or secondary effluent. The amount of chemicals and systems differ depending upon where the chemicals are to be added. Needless to say, various equipment manufacturers and various chemical suppliers are capable of producing data to prove that their process and location of addition of chemicals is obviously the best system. Careful analysis of the individual treatment system is required to determine the best system. All too often the best system is the least-advertised and least-used system since no one stands to make any profit from using that system. There is no doubt that phosphate reduction can reduce eutrophication in lakes and reservoirs receiving too much phosphorus from domestic or industrial wastewaters. If land runoff contributes the majority of phosphate to the receiving streams, phosphate removal from domestic wastewaters may not produce the desired results and may well create a further split between different segments of the local community. Phosphate reduction is far from being a necessity and should be recommended only after very careful study of all of the factors affecting the particular pollution problem.

Multimedia filtration of secondary effluents has also been advocated as a major tertiary treatment process. There is no doubt that multimedia filtration can remove the suspended solids lost from the secondary sedimentation tanks and produce a higher quality effluent but multimedia filtration is expensive to construct and to operate. Polyelectrolytes are often used to produce a better precipitate for filtration, increasing the complexity of operations. It has been observed that a properly operating activated sludge system will produce a high quality effluent provided the secondary sedimentation tank is properly designed. Too often multimedia filtration is being recommended as a cover for poor design and improper operation. It is time that we stopped advocating more treatment units in lieu of doing the job correctly in the first place. A well-designed secondary sedimentation tank should be capable of producing an effluent with from 5-10 mg/l suspended solids which should not be a problem in any surface water since soil runoff will normally far exceed this level of suspended solids every time it rains.

Activated carbon has been hailed as a major advance for tertiary treatment as well as a replacement for secondary treatment. For some industrial wastes, activated carbon has some value but it has not demonstrated its value with replacing biological treatment of domestic wastewater. In fact, recent studies have shown that the value of activated carbon is prolonged with biological treatment. The complexity of activated carbon systems makes them of limited value except where color compounds must be removed. Activated carbon has been around for years but there has been no real need to produce effluents of such low color since natural runoff from the land produces more color in most locations. Activated carbon is also capable of removing some of the nonbiodegradable organics from wastewaters and has been proposed for this purpose. Since the nonbiodegradable organics remaining in wastewaters have not been shown to be a serious problem to health, their reduction at this time cannot be easily justified. Unfortunately, we are faced with a period of time when certain individuals are quite willing to scare the great majority of the public with stories of unseen dangers that might lurk for those who ingest these compounds. These scare stories are designed to produce more research funds for personal research designed to maintain a definite operation at public expense. Unfortunately, some of these unprofessional research groups have the support of various professional organizations, making it extremely difficult for the public to know how to react.

Nutrification became an interesting tertiary treatment process when it was proposed that excess ammonia nitrogen might kill fish. While the number of documented fish kills from excess ammonia nitrogen in domestic wastewater effluents is extremely limited, there have been plenty of documented fish kills related to excessive concentrations of ammonia nitrogen from feedlot runoff. Once again a scare tactic of what might happen rather than what has happened seems to have stimulated the emphasis on nitrification. Thus far, the emphasis on nitrification has been on a second treatment process after normal secondary treatment to remove the organics. Needless to say, the second treatment units increase the size of the bio-treatment portion of the plant by two, a fact that many engineers find quite profitable. Nitrification increases the cost of aeration quite significantly and will produce a major impact if required extensively. As soon as nitrification became feasible, it was proposed that dentrification be employed to reduce the dangerous nitrates to nitrogen gas. The only problem was the need for a carbon source to create a rapid oxygen demand. It was found that methyl alcohol, wood alcohol, could be used to create the oxgyen demand most easily. The net result was the development of a third stage bio-treatment system in which methyl alcohol was added continuously to create BOD_5 in the last stage so the nitrates could be reduced to nitrogen gas. Once the nitrification-dentrification process was developed, efforts were directed towards establishing a need for the process. This is one of the serious deficiencies of our current technical society. Very few people are seriously concerned with real needs. Most individuals are attempting to create their own empires at the expense of the public with little consideration for professionalism.

There are other tertiary treatment processes availabe where needed. Reverse osmosis, gamma radiation, demineralization, ammonia stripping, hydrogen peroxide, and even distillation have been proposed for tertiary treatment. There is no doubt that we have all the technology we need to completely recycle water any time that we really need to do so. This does not mean that, just because we have the needed technology, further research on water pollution should cease. We should simply recognize that we should not put off facing our water pollution control problems on the premise that we do not know how to solve the problem. We know how to solve the problems but we do not have the resolve to solve them. That is a major difference and it is important that we recognize the real problems and not the contrived problems.

ZERO DISCHARGE

One would be remiss in discussing the current water pollution issues if some mention was not made of the concept of Zero Discharge. There is no doubt that Zero Discharge makes for the kind of glib phrase that our society likes but it simply fails to recognize the basic facts of life. No biological system can exist without the continuous production of waste materials. No community or industry can continue to exist with Zero Discharge. It is possible to reuse all of the liquid portion of our wastewaters since we have a continuous demand for water but we must recognize that even with complete reuse of all of our wastewaters, we would have a continuous discharge of solids that would have to be returned to the environment. Proper return of those solid materials to the environment would pose a greater environmental problem than discharge with the liquids as is currently done. There is no way that we can ever have Zero Discharge and it is important that the public recognize this fact. Recently, the advocates of Zero Discharge have indicated that Zero Discharge simply meant application of the wastewaters to the land rather than having a point source discharge. Where needed, land discharge of wastewaters has merit; but there are many places in the United States that land discharge could not be used efficiently. In fact, most of the large communities produce far more wastewaters than can be applied to their immediate vicinity. Land treatment was applied in England and Europe for years and was found to be wanting as a primary method for wastewater treatment. In the right location, land application has value but it is far from the cure-all that has been proposed by various self-interest groups and it is definitely not Zero Discharge. While we can never have Zero Discharge of wastewaters, we can have Zero Pollution. There is a difference: one is possible and the other is impossible.

ECONOMIC CONSIDERATIONS

In addition to technical consideration, the primary problem with wastewater treatment lies with the economics of wastewater treatment. Economics of water pollution control include the capital costs, operating and maintenance costs, and distribution of those costs. Inflation, Federal grants, and EPA restrictions have all combined to make meaningful economic evaluation all but impossible. It should be recognized that the current confusion with regard to economic considerations is the prime factor retarding wastewater treatment plant development. Cost data have been developed over the years and have been presented in a number of different ways depending upon the objectives of the individuals presenting the data.

Oxidation ponds are the most economical form of wastewater treatment both in terms of capital costs and operating costs as long as land is readily available and periodic discharges of algae are not problems. Primary treatment has a capital cost approximately 200 percent greater than oxidation ponds. Activated sludge systems have a capital cost 66 percent greater than primary treatment but their operating costs are only about 20 percent greater. When we consider the increased efficiency of activated sludge systems over primary treatment units, activated sludge is only half as expensive as primary treatment both in capital cost and operating costs. Trickling filters cost slightly more than activated sludge systems to construct, but the operational costs are closer to the costs of primary treatment plants. Since trickling filters are not as efficient as activated sludge systems, the costs are even greater.

Data are definitely lacking as to the costs for tertiary treatment. The lack of data has not deterred the opponents from presenting pessimistic cost data. The data obtained from Lake Tahoe indicates that tertiary treatment will probably be twice as expensive as conventional treatment. On a pollution-reduction basis, costs will be 10-20 times as great as conventional treatment but it should be remembered that a high quality effluent can be produced that is suitable for reuse.

While it is not possible to present absolute costs, generally speaking, a well-designed activated sludge plant will have capital costs ranging from $30 to $100/capita/year. Industrial costs can be prorated on a population-equivalent basis, with BOD load generally being the controlling factor, but other wastewater characteristics could be overriding. Interestingly enough, local government has maintained for the past 40 years that it could not afford to pay for wastewater treatment systems. The cost of construction and operation of wastewater treatment systems far exceeds the capability of local government in the minds of local politicians. In an effort to develop adequate financing for wastewater treatment plants, the local politicians joined with state politicians to petition the Federal government to pay for wastewater treatment. Needless to say, the Federal government was persuaded to help finance the cost of wastewater treatment. Initially, the Federal share was just a "carrot" to attract greater local support. Unfortunately, the Federal government promised more support than it delivered. Federal politicians thought the water pollution problem was not serious and that the promise of funds was adequate for the solution of a "nonexistent" problem. When the "nonexistent" problem turned out to be a real problem that was being prolonged by Federal promises that never matured, public reaction forced additional political action. The Federal government eventually promised 75 percent of the cost for wastewater treatment plant construction in an effort to get the job done. Local politicians were quite willing to construct wastewater treatment plants as long as they could place full blame for such construction on the Federal government and still claim full credit for obtaining 75 percent Federal aid in constructing the treatment facilities. It seems that everyone has been quite willing to participate in the Federal grant program and still assume full credit at the local level for getting the job done right. Some of the local officials should be ashamed of themselves for trying to play both sides of the street at the same time.

It is not surprising that 75 percent Federal share should result in at least 75 percent Federal control. Local government has abdicated its responsibility for wastewater treatment and state government has not been willing to step in and do the job that is needed. Reluctantly, the Federal government assumed a greater and greater share of the responsibility for wastewater treatment. There has been an increase in paperwork; there have been increases in dictates for financing, dictates for operations, dictates for future treatment and dictates for current treatment. No one is happy with the current set of dictates, least of all the Federal water pollution personnel and the Federal government. No one really wants to accept responsibility for water pollution control but the job must be faced and it must be done. The political atmosphere in the United States over the past two decades has created a real mess. It cannot be defined any better than a "mess." No one is happy and no one believes that the current system is the way to go. But the current system is better than what we were doing and will eventually lead us to a better solution if we would but make an effort to face responsibilities in the area of water pollution.

There is no doubt that one of the big debates lies in financing water pollution control facilities. Who should pay for these treatment plants and how do we get the public to assume its financial responsibility? Unfortunately, too many people look upon Federal grants as "free money" that is supplied by some other segment of our society. If we look at Federal finances, we find that the income taxes are responsible for 64 percent of the current Federal income. Personal income taxes account for 73 percent of the total income tax revenue with corporation income taxes responsible for only 27 percent of the income taxes. The individual is basically responsible for both the personal income taxes and the corporation income taxes. Thus, the Federal share of the 75 percent grants comes out of our own pockets. Some urban people like to think that the rural people are paying a part of the cost of the Federal grants. Examination of the income data indicates that rural incomes are only 5 percent of the total urban-rural income. So we find ourselves paying again for our own messes. For some strange reason we want someone else to pay for treating our wastes. We just refuse to face up to our own problem and we force the Federal government to devise a crazy game that forces us to spend more money for doing a job that we could do cheaper ourselves.

CONCLUSIONS

Currently, the people of the United States have created a complex problem with regard to wastewater treatment. Local government representatives have found that wastewater treatment problems can yield positive benefits by involving the Federal government directly in both the financing and the management of wastewater treatment facilities. Unfortunately, the complexity of the Federal government and the complexity of the water pollution problem have combined to produce real difficulties in solving our water pollution problems. We are stymied by the simple fact that water pollution control is and always will be a local problem which is being attacked at the Federal level as a uniform problem with a single set of solutions. Water pollution control is far from being uniform and requires a diverse set of solutions that meet local needs as well as regional and national needs. Technically we have the ability to meet all of our water pollution control needs but we have not been able to develop the organizational system for handling these problems. We need to develop a tri-partnership with the Federal government establishing basic policy and technical research for new processes in wastewater treatment. The Federal government must act as the overall monitoring system to ensure that progress is being made and that problem areas are being identified for concentrated effort. Federal funding is justified, for the results benefit each and everyone of us. The state government must assume leadership within its jurisdiction. The state must focus upon it objectives within the total Federal system, but must still have full freedom to coordinate the activities of the communities within its jurisdiction. One of our real problems lies in the apparent but needless conflict between the state governments and the Federal government in the area of water pollution control. There simply is too much to be done to quarrel over individual responsibility. The Federal government should be concerned with the big picture and the state government should be concerned with the problems within their boundaries. It is important that the state governments recognize that the ultimate solution to water pollution lies with local efforts. While state government objects to Federal interference in state jurisdiction, local government equally objects to state government interferences in local problems which the state government can not solve and should not try to solve.

The ultimate solution to water pollution problems lies in the proper construction and operation of wastewater treatment plants at the local level. Each municipality, each industry, and each individual must see that his wastes are properly treated prior to return to the environment. The responsibility lies at the individual level with individuals joining into governmental units to produce a better unified effort than individuals can produce alone. We can treat our wastewaters if we want, but we must do it at the local level. We must construct local wastewater treatment plants and we must operate them at the local level. This is our responsibility and our job. No one can do it for us. We can abdicate responsibility for paying for the wastewater treatment plant and we can force both the state government and the Federal government to tax us to pay for the treatment facilities we need and must have. But we must eventually face the problem. Neither the state government nor the Federal government can build our wastewater treatment plants and operate them properly. This is our environment. This is where we live. Only we can make our environment satisfactory for living. All the laws and all the grants will be in vain unless we make them work. The problem is personalities and people.

Primary treatment is too expensive when properly compared to secondary treatment. Tertiary treatment is not only too expensive, it is too complex and unnecessary when compared to properly designed secondary treatment. Unfortunately, some individuals stand to gain more by continuing to create confusion than by trying to create understanding. There is no doubt that in a few locations we will need tertiary treatment but the time for broad scale use of tertiary treatment is still in the future. We must face the fact that activated sludge is currently the best method for wastewater treatment. Properly designed, CMAS systems can produce an effluent with 5-10 mg/l BOD_5 and suspended solids more than one third better than the current EPA standards for secondary treatment. The future lies in front of us all and not behind us. We can meet the standards currently proposed and we can easily eliminate environmental pollution anytime we so desire even though Zero Discharge is fundamentally and practically impossible.

SESSION III
RECEIVING WATERS

Moderator:

ERIC DAVIS

ENVIRONMENTAL REQUIREMENTS FOR FISH

By

Roger Grischkowsky, Ph.D.*

"Disease in wild and cultured populations of aquatic vertebrates and invertebrates may be caused by pathogenic micro-organisms, the effects of toxic materials, or general environmental deterioration. Even subtle physical change in aquatic environments may result in stress leading to an impairment of animal health or deterioration of the quality of tissue for human consumption." That was an overview statement by the National Research Council Subcommittee on Animal Health. Deterioration of the aquatic environment can result from such substances as domestic and industrial sewage, poly-chlorinated biphenyls, pesticides, chlorinated hydrocarbons, fertilizers, silt, petroleum, acids, heavy metals, etc.

Disease is any abnormal condition that is harmful. Fish diseases are a result of intersection of three sets of conditions: host, environment and pathogen. Environment is a predisposing factor which dictates whether the host or the pathogen is favored (see Figure 1).

Three representations of host-environment-pathogen interrelationships are depicted. The intersection of the three specific conditions of host, environment and pathogen creates the disease set. The delicate balance between host and pathogen numbers is mediated by environment as the fulcrum. The triangle of affect shows how a change of one affects the other factors. A partial list of fish diseases mediated by environmental factors is given in Table 1.

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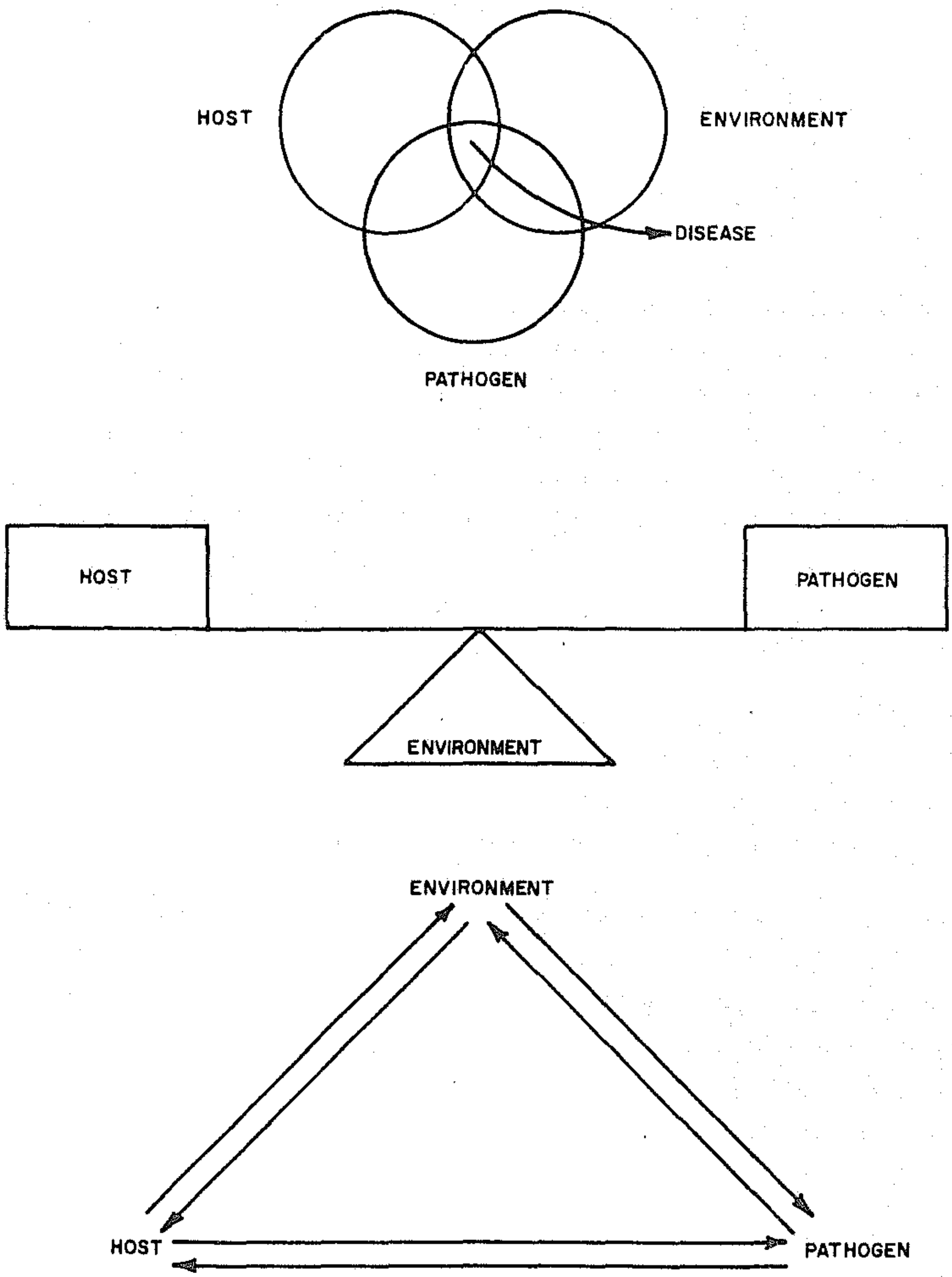

Figure 1: Interrelationship between Host, Environment, and Pathogen.

Table 2 presents water quality criteria which under continuous exposure conditions are conducive to optimum fish health for warm and cold water species.

Water quality standards of Alaska for growth and propagation of fish and other aquatic life are shown in Table 3.

As you can see the set of water conditions which permits fish health is narrow. Multiple use concepts of ground water, industrialization, population increases and natural resource utilization will exert increasing pressure on natural and artificially produced populations of fish.

TABLE 1

DISEASES OF FISHES COMMONLY ASSOCIATED WITH ENVIRONMENTAL FACTORS*

DISEASE	ENVIRONMENTAL FACTORS CONTRIBUTING
Furunculosis (*Aeromonas salmonicida*)	Low D.O., crowding, handling during the presence of the pathogen
Bacterial gill disease	Crowding, chronic low D.O. (4 ppm), elevated NH_3 - N (1 ppm), organic matter
Columnaris (*Chondrococcus columnaris*)	Crowding or handling during warm water (15°C) periods, temperature increases to 20°C if the pathogen is present
Corynebacterial kidney disease	Low total water hardness
Hemorrhagic septicemias (*Aeromonas, Pseudomonas*)	High bacterial loads in water, particulate matter in water, handling, crowding, low oxygen, chronic sublethal heavy metal, pesticide or polychlorinated biphenyl (PCB) exposure
Vibriosis (*Vibrio anguillarum*)	Low D.O. ($\leq$ 66 ppm), high water temperatures, brackish water, high organic loads
Costia, Hexameta	Overcrowding, low D.O.
Fin and tailrot (myxobacterial cold water disease)	Crowding, low temperature, chronic sublethal PCB exposure
Fin and tailrot (*Pseudomonas, Aeromonas Vibrio*)	Domestic and industrial sewage

*After Wedemeyer, in progress

TABLE 2

SUGGESTED WATER QUALITY CRITERIA CONDUCIVE TO OPTIMUM FISH HEALTH; WARM AND COLD WATER SPECIES, CONTINUOUS EXPOSURE.*

WATER CHEMISTRY	LIMITS FOR CONTINUOUS EXPOSURE
Acidity	pH 6 - 9
Alkalinity	at least 20 ppm (as $CaCo_3$)
Ammonia	0.02 ppm
N_2 (gas)	Max total gas pressure 110%
Cadmium	0.0004 ppm in soft water ($\leq$100 ppm alkalinity)
Cadmium	0.003 ppm in hard water ($\geq$100 ppm alkalinity)
Chromium	0.03 ppm
Copper	0.006 ppm in soft water
Copper	0.03 ppm in hard water
Lead	0.03 ppm
Mercury; organic or inorganic	0.2 ppb max., 0.05 ppb average
Hydrogen sulfide	0.002 ppm
Polychlorinated biphenyl (PCB^s)	0.002 ppm
Phthalate esters	0.3 ppb
Total suspended and settleable solids	80 ppm or less

*From Environmental Protection Agency, 1973

TABLE 3

WATER QUALITY CRITERIA FOR WATERS OF THE STATE OF ALASKA.*

Water uses/water quality parameters	Growth and propagation of fish and other aquatic life, including waterfowl and furbearers.
Total coliform organisms	Mean of 5 or more samples in any month may not exceed 1000 per 100 ml, and not more than 20% of samples during one month may exceed 2400 per 100 ml, except ground water shall contain zero per 100 ml.
Dissolved oxygen mg/l or % saturation	Greater than 6 mg/l in salt water and greater than 7 mg/l in fresh water
pH	Between 7.5 and 8.5 for salt water. Between 6.5 and 8.5 for fresh water.
Turbidity, measured in Jackson Turbidity Units (JTU)	Less than 25 JTU when attributed to solids which result from other than natural origin.
Temperature, as measured in degrees Farenheit (°F)	May not exceed natural temp. by more than 2°F for salt water. May not exceed natural temp. by more than 4°F for fresh water. No change shall be permitted for temp. over 60°F. Maximum rate of change permitted is 0.5°F per hour.
Dissolved inorganic substances	Within range to avoid chronic toxicity or significant ecological change.
Residues including oils, floating solids, sludge deposits and other wastes	Residues may not make the receiving water unfit or unsafe for the uses of this classification; nor cause a film or sheen upon, or discoloration of, the surface of the water or adjoining shoreline; nor cause a sludge or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom or upon adjoining shorelines. Residues shall be less than those levels which cause tainting of fish or other organisms and less than acute or chronic problem levels as determined by bioassay.

*Continued on following page

TABLE 3 (continued)

WATER QUALITY CRITERIA FOR WATERS OF THE STATE OF ALASKA.*

Settleable solids Suspended solids (includes sediment and dredge spoil)	No deposition which adversely affects fish and other aquatic life reproduction and habitat.
Toxic or other deleterious substances, pesticides and related organic and inorganic materials	Concentrations shall be less than those levels which cause tainting fish, less than acute or chronic problem levels as revealed by bioassay or other appropriate methods and below concentrations affecting the ecological balance.
Color, as measured in color units	Secchi disc visible at minimum depth of 1 meter.
Aesthetic considerations	May not be impaired by the presence of materials or their effects which are offensive to the sight, smell, taste or touch.

*From Alaska, 1973

As you can see, the set of water conditions which permits fish health is narrow. Multiple use concepts of ground water, industrialization, population increases, and natural resource utilization will exert increasing pressure on natural and artificially produced populations of fish.

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WINTER DISSOLVED OXYGEN PATTERNS IN ARCTIC AND SUBARCTIC RIVERS

E. W. Schallock*

INTRODUCTION

The data presented at this time are part of the Winter Dissolved Oxygen study conducted by Schallock and Lotspeich (1974). The results from this study, presently in press, include additional dissolved oxygen (D.O.) data, other water chemistry data such as pH, alkalinity, and conductivity, and detailed methodology.

Dissolved oxygen has long been recognized as one of the most important components of aquatic systems. It is recognized as a parameter by which the effects of waste discharge on aquatic systems, or receiving waters, are measured. However, it is important because adequate concentrations of this dissolved element are absolutely necessary to meet the physiological demands of critical develomental stages of desirable invertebrates such as stoneflies, mayflies and vertebrates such as arctic grayling, arctic char, and lake trout.

Many studies have been and presently are investigating the effects of dissolved oxygen on temperate aquatic organisms. These studies document effects, both acute and chronic, that often prevent the organisms from following the normal or usual life history pattern. Disrupting the life history pattern may result in the failure of the adults to reproduce viable offspring. If this biological disaster continues for several generations, the population, or in some cases the species, will disappear from the aquatic biological community.

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Dissolved oxygen data were collected from selected streams and rivers located in a range from about 62°N latitude, Prince William Sound, to near 70°N latitude at the Beaufort Sea (Figure 1 and Table 1). These data were collected during the winter season over a period of four years and from 36 rivers. Some of the rivers were sampled only once but specific rivers such as the Chena, Sagavanirktok, and Yukon, were sampled several times to increase the reliability of the data and to enable the development of seasonal and spatial trends.

OBJECTIVES

This presentation is intended to convey some physical-chemical characteristics of some arctic and subarctic streams to provide a basis for sound management decisions that are being and will be made concerning the utilization of these aquatic resources. More specifically, data on dissolved oxygen and surface discharge are developed into seasonal and spatial patterns which are compared to the corresponding patterns of a temperate river system. Discussion is directed to the importance of these patterns and to the differences between the patterns found in temperate climates and Alaskan arctic and subarctic climates. Further discussion emphasizes the management implications of these patterns.

RESULTS AND DISCUSSION

The dissolved oxygen concentration of water at any given time is the net result of a complex interrelationship of meteorological, geological, physical, chemical and biological factors. The importance of each factor varies from system to system and from time to time. For example, the factors affecting the D.O. of the Little Miami in Ohio are significantly different from those of a typical subarctic river in Alaska. Precipitation in March, as rain, may play a significant role in Midwest stream characteristics. In arctic or subarctic Alaska, however, such precipitation would normally be snow and would not significantly affect stream characteristics at that time.

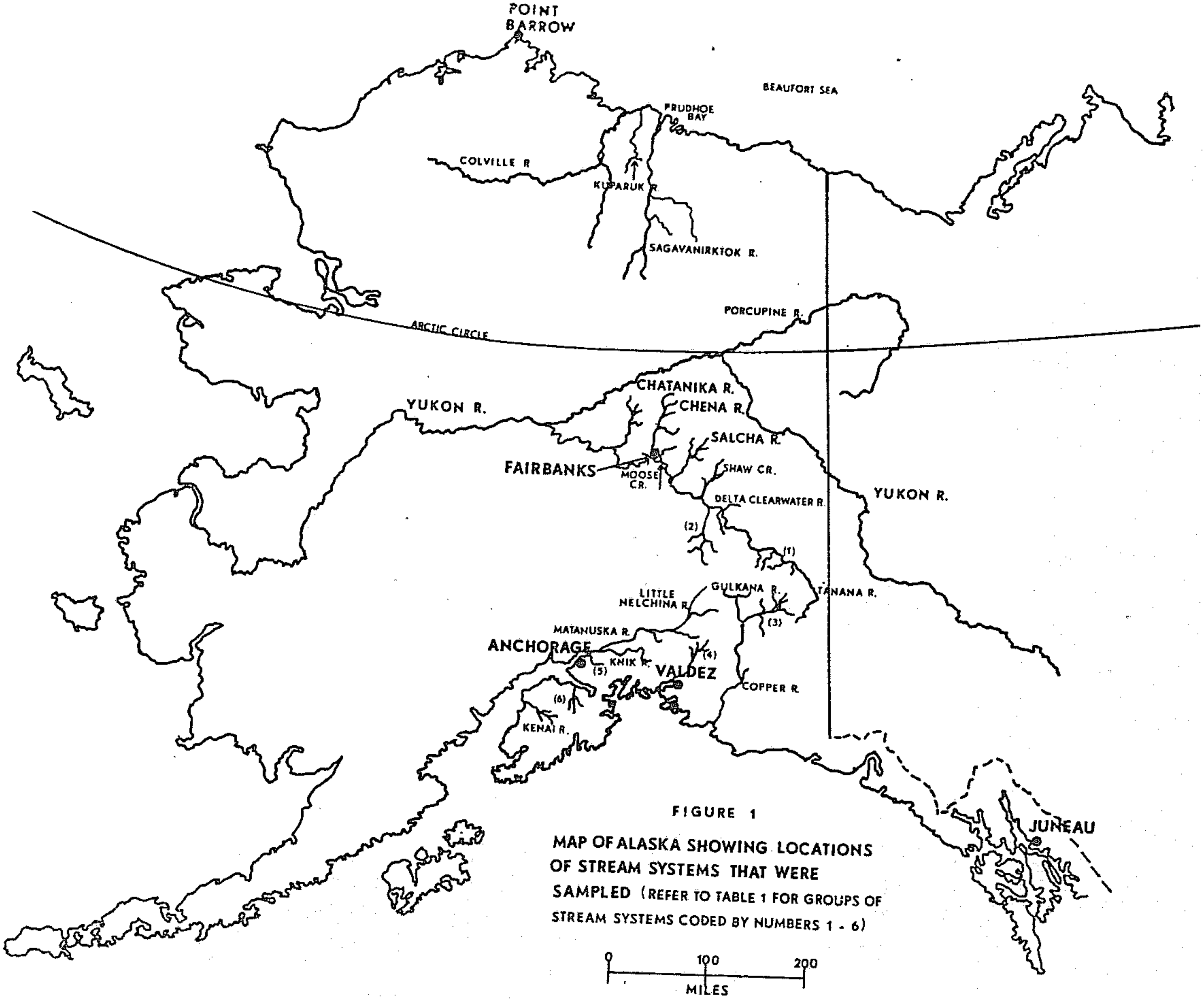


FIGURE 1

MAP OF ALASKA SHOWING LOCATIONS OF STREAM SYSTEMS THAT WERE SAMPLED (REFER TO TABLE 1 FOR GROUPS OF STREAM SYSTEMS CODED BY NUMBERS 1 - 6)

TABLE 1

GROUPS OF STREAM SYSTEMS THAT ARE LOCATED IN CONGESTED AREAS AND CODED BY NUMBERS 1 THROUGH 6 ON THE MAP OF ALASKA (Figure 1)

<u>Area 1 Includes</u>

Gerstle River
Johnson River
Robertson River
Tok River
Chisana River
Gardiner Creek

<u>Area 2 Includes</u>

Donnelly Creek
Ruby Creek
Phelan Creek

<u>Area 3 Includes</u>

Slana River
Chistochina River
Gakona River

<u>Area 4 Includes</u>

Tsina River
Tiekel River

<u>Area 5 Includes</u>

Eagle River

<u>Area 6 Includes</u>

Chickaloon River

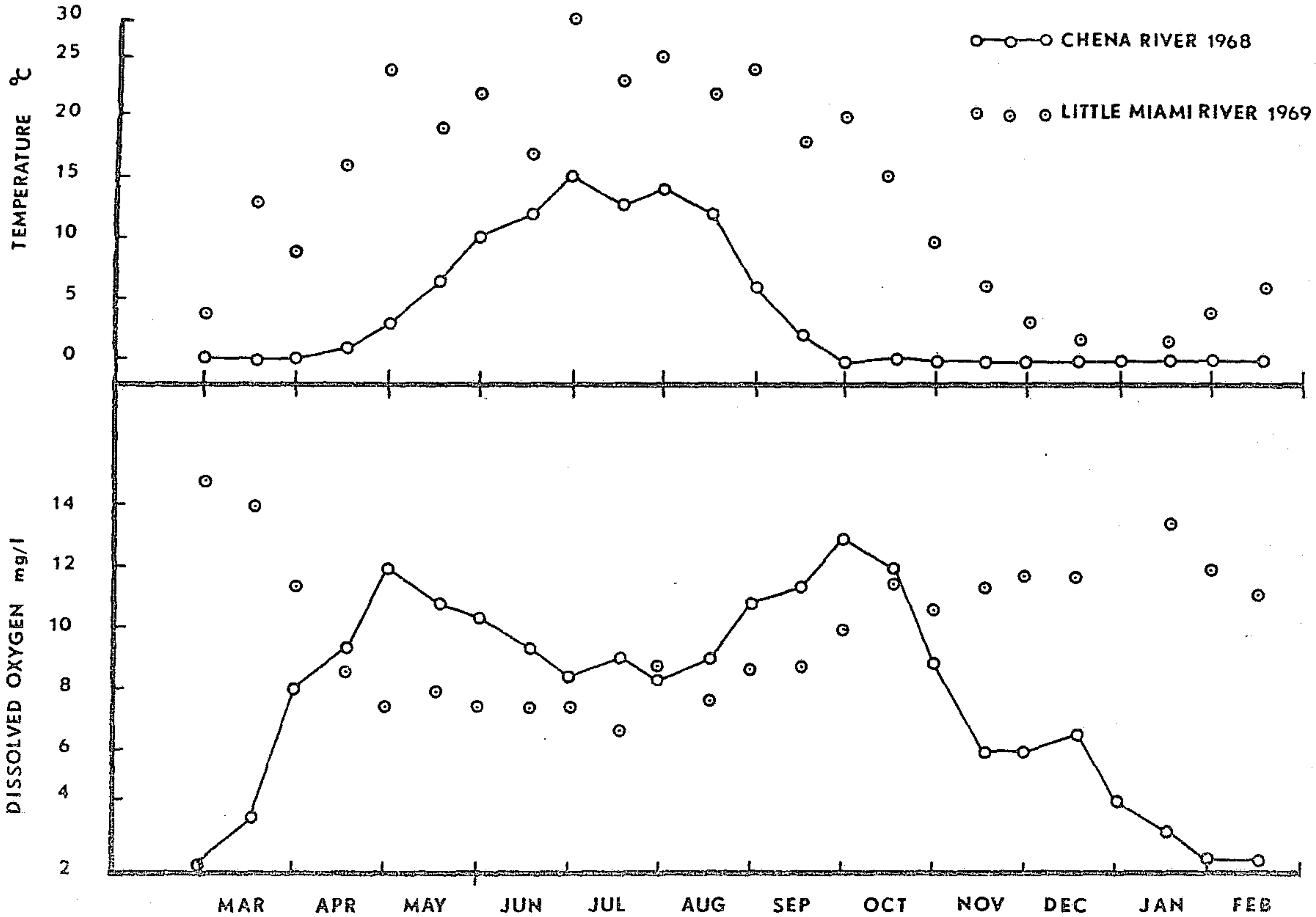
LITTLE MIAMI RIVER NEAR CINCINNATI

To clearly relate differences between the D.O. seasonal patterns of subarctic rivers and temperate rivers, a further comparison is made between the Chena River and the Little Miami River. Mr. A.E. Schwer, Jr. (personal communication, 1972) indicates that, while Little Miami River is within a densely populated area and "man-made pollution" is present, it does not adversely affect dissolved oxygen. The Little Miami River drains a 1713 square mile area and has a 6-year discharge average of 1574 CFS near the mouth (U.S.G.S., 1970). Water temperatures of Little Miami River range from a low of approximately 1°C in January to a high of about 28°C in June (Figure 2). Dissolved oxygen vary sporadically from approximately 14.5 mg/l in March to about 6.5 mg/l in July (Schwer, 1972). Correlation of D.O. with temperature reveals an inverse relationship that has also been described by MacCrimmon and Kelso (1970) in the Grand River in southern Ontario. In both rivers, the D.O. concentrations are at the yearly low during the hot summer months, but increase gradually toward the annual high, near saturation, in winter.

CHENA RIVER

The drainage area and 21-year average discharge of the Chena River are similar to the Little Miami. The Chena drains 1980 square miles and its discharge averages 1520 CFS (U.S.G.S., 1969). Water temperatures in the Chena River range from 0°C in winter to near 17°C in July and dissolved oxygen varies from near 1.5 mg/l (10 percent saturation) to approximately 13 mg/l (90 percent). However, the similarity between the rivers ends when correlations are made between D.O trends and the annual temperature cycle.

Water temperatures and D.O. concentrations were correlated in an inverse relationship throughout the year in the Little Miami River. In the Chena River, this relationship was found only during the summer, as it ended about the first of October when water temperature approached 0°C and the D.O. concentration reached one of two seasonal high values. Shortly thereafter, the long gradual winter D.O. depression began and continued until about March. The second seasonal high D.O. concentration was reached about spring breakup.



TEMPERATURE & DISSOLVED OXYGEN DATA FROM THE LITTLE MIAMI RIVER & THE CHENA RIVER. CHENA DATA FROM FREY ET AL 1970.

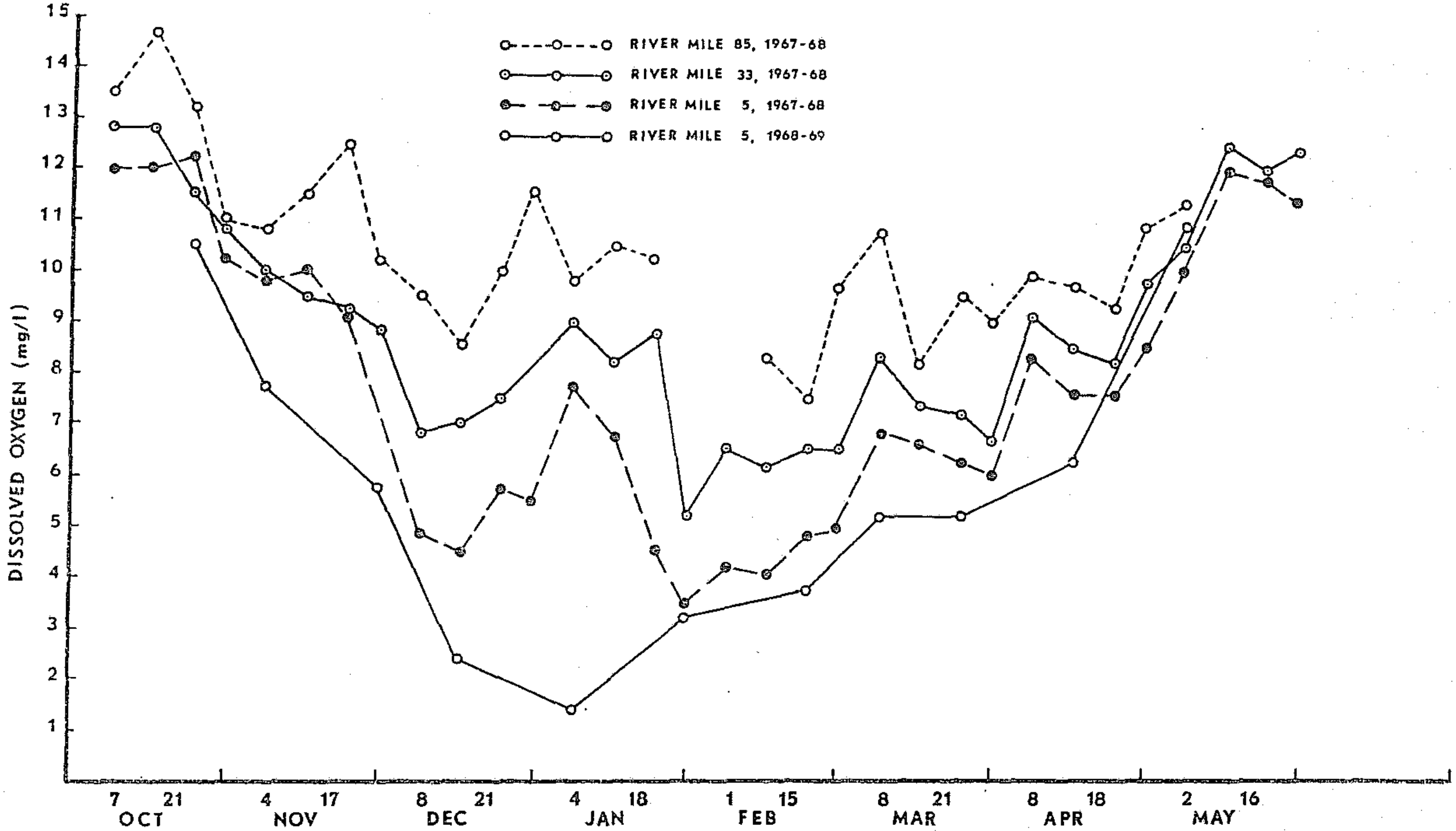
FIGURE 2

The importance of these seasonal trends is twofold: first the lowest D.O. concentrations were recorded during the winter; second, the D.O. depletion was severe. Annual low D.O. concentrations in the Chena River fell below 1.5 mg/l (10 percent saturation) during February and March. These conditions are different in magnitude and timing from the less severe summer and annual low of 6.5 mg/l observed in the Little Miami River.

The Chena River data presented in Figure 2 were collected from a single station near the mouth and revealed seasonal D.O. patterns at that location. Data collected from three stations on the Chena River are plotted (Figure 3) to illustrate changes in D.O. concentrations from station to station along the river. These data reveal that D.O. was found in relatively high concentrations at all stations during "freeze-up" and "breakup," that some D.O. depression is found at all locations during the period between "freeze-up" and "breakup;" and that reaeration took effect at virtually the same time at all stations.

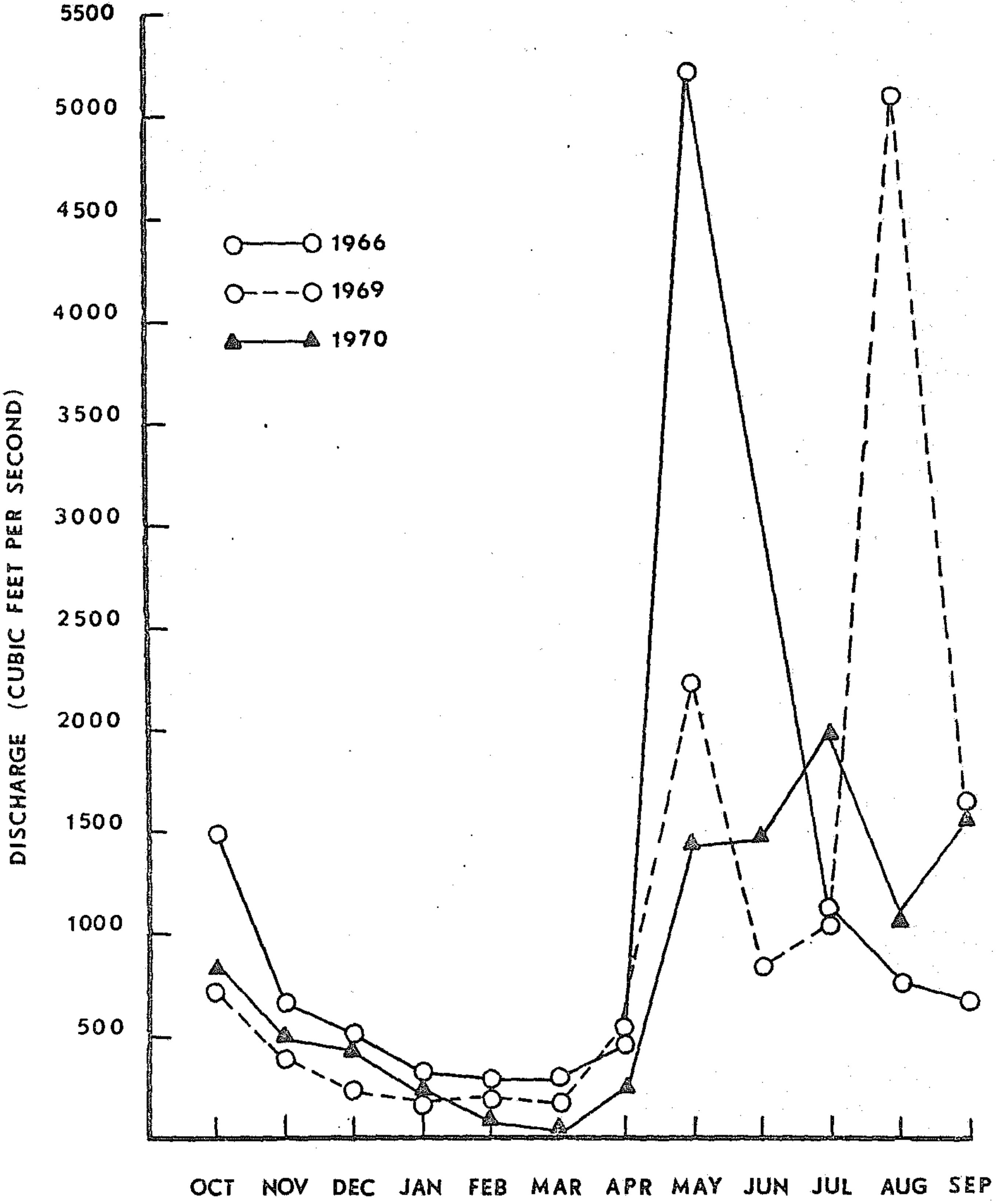
The most important feature of the Chena River data is that D.O. depression is more severe at stations located in lower reaches than those located in upper stations. Data collected at station C-800 located 135 km (85 miles) from the mouth of the Chena, revealed a minimum D.O. of approximately 7.5 mg/l (52 percent), while data collected from C-100, 8 km (5 miles) indicate concentrations as low as 4.5 mg/l (31 percent) in 1967-68. Comparing these 1967-68 data from the 8 km station to 1968-69 data from the same station, reveals that depression is significantly more severe in some years than others.

Also of importance is the timing and magnitude of seasonal discharges of the Chena River (Figure 4). Although yearly variations are found from year to year, the largest discharges are generally found during spring-summer, and the lowest during winter. This generality is also valid for other streams and rivers in the arctic and subarctic. Larger rivers usually "break up" and "freeze up" later than small river systems and those located further north usually "break up" later and "freeze up" earlier.



WINTER DISSOLVED OXYGEN DATA from THREE STATIONS on the CHENA RIVER (DATA FROM FREY ET AL. 1970)

FIGURE 3



CHENA RIVER MEAN MONTHLY DISCHARGE
(DATA FROM U.S.G.S.)

FIGURE 4

SAGAVANIRKTOK RIVER

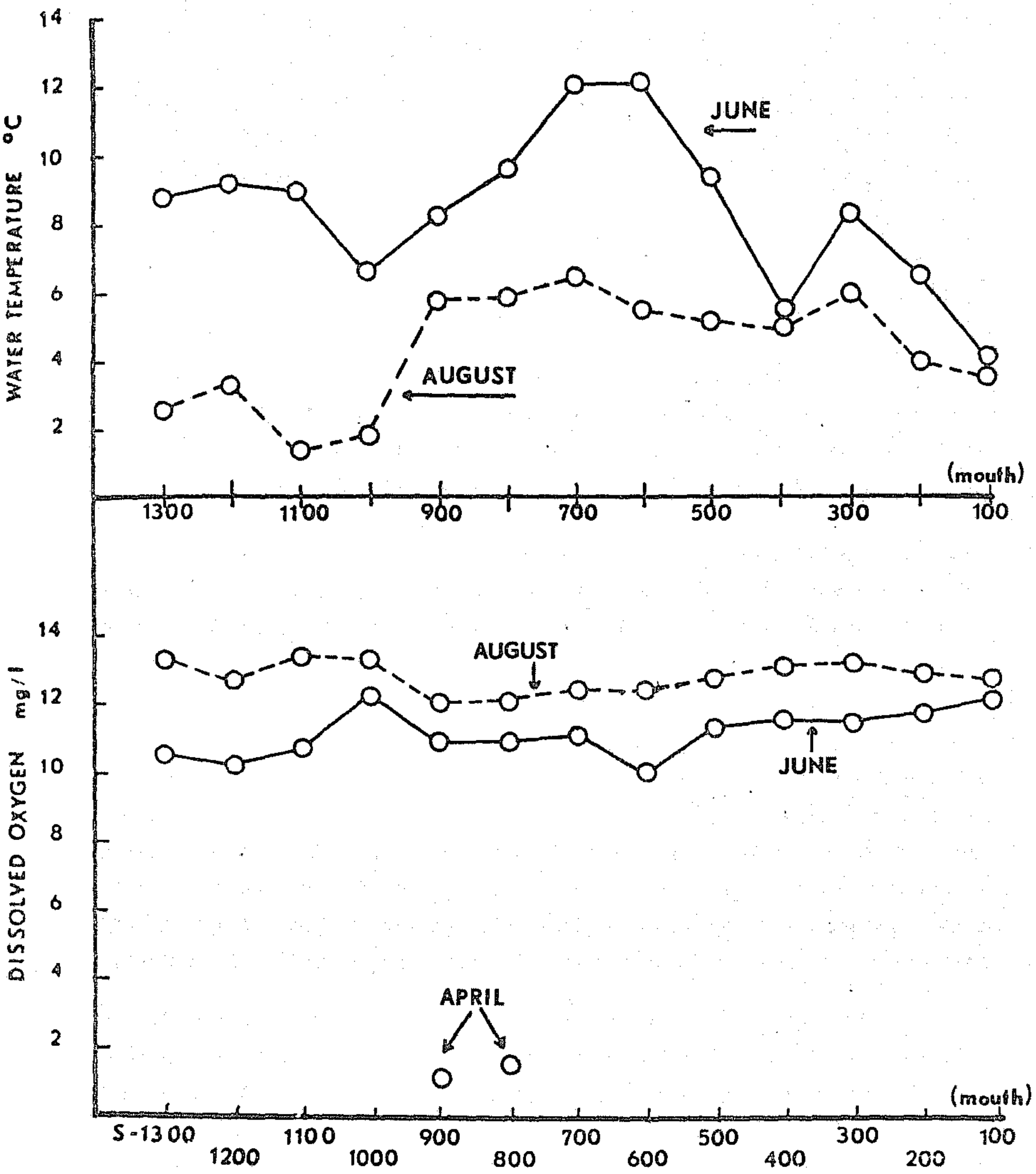
The Sagavanirktok River, located on Alaska's North Slope, and among the most isolated rivers in the State, was chosen for study because of its location, present oil industry activities, and extensive future development. It flows north from the Brooks Range into the Beaufort Sea near Prudhoe Bay and will be transversed by the Trans-Alaska 48-inch pipeline. The Sagavanirktok River ranks second in discharge only to the Colville River of all North Slope river systems. Near Sagwon, discharges ranged from 2800 CFS to 1990 CFS in the August 16 to 21, 1969, interval (U.S.G.S., 1969). These volumes are somewhat larger than the average late summer discharges of the Chena River.

Dissolved oxygen data from the summer reveal high concentrations with small differences along the length of the river (Figure 5). In addition, comparing D.O. data to temperature data from June and August reveals the same, although smaller, inverse relationship between D.O. and temperature than was observed in the Chena River. Further comparison of these summer data to the limited winter data supports the hypothesis that D.O. is severely depressed during the winter in the arctic.

YUKON RIVER

The Yukon River, with its rich historical past, large fishing industry, outstanding waterfowl resource, high annual discharge, and international importance, is one of the most important rivers in North America. The headwaters originate in Canada and the lower 1000 miles traverse the entire state of Alaska from east to west. The Yukon annually discharges a total volume near 124,300,000 acre feet and an average daily volume of 171,600 CFS at Ruby, Alaska (U.S.G.S., 1969). It was therefore important to examine the winter D.O. trends present in this river system.

Two field trips were taken to the Yukon River during March 1971. A total of 14 samples were collected from 12 stations extending over 1664 km (1040 miles) between Eagle, near the Canadian border, and Alakanuk, near the mouth.



DISSOLVED OXYGEN & WATER TEMPERATURE DATA from 13 STATIONS on the SAGAVANIRKTOK RIVER (1969-1970)

Figure 5

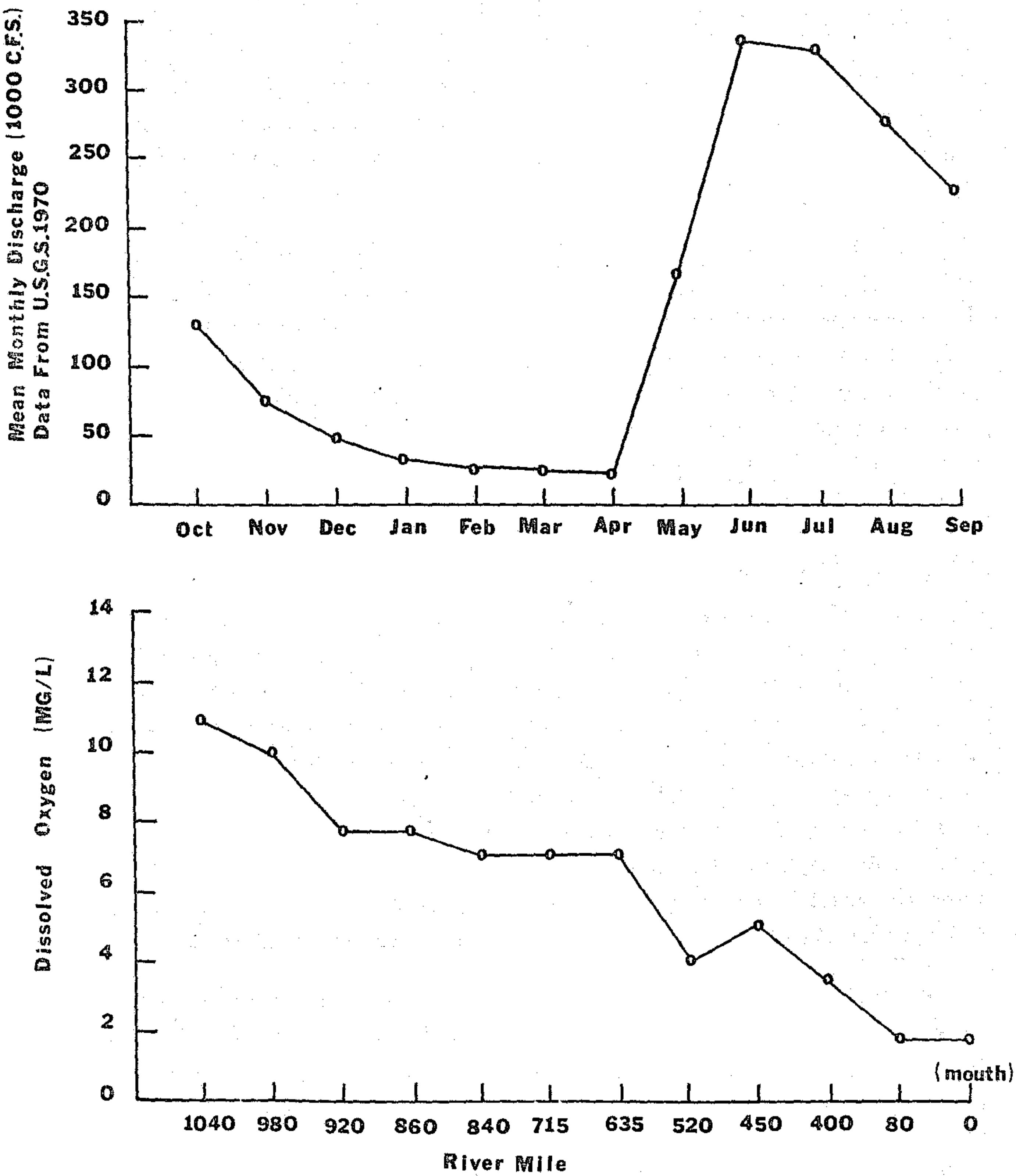
The upper seven stations were sampled in early March and the lower seven stations were sampled in late March; the two intermediate stations near the Ray River, 1044 km (river mile 715), and the village of Tanana, 1016 km (river mile 635) were sampled both trips to provide overlap and continuity.

In the Yukon, as in the other rivers studied, dissolved oxygen concentrations decreased when proceeding downstream (Figure 6). Water collected at the upper-most station at Eagle, 1664 km (river mile 1040) contained 10.5 mg/l (73 percent saturation) while water at Alakanuk near the mouth contained 1.9 mg/l (13 percent saturation). Some minor irregularities exist in the general trend but the only major anomaly was found at Ruby, 832 km (river mile 520). Here the sample was collected from an area of the river where no current could be detected; whereas, all others were collected from areas with detectable current. It is probable that the Yukon River also undergoes gradual D.O. depression during the winter and that the D.O. concentration gradually recovers in spring, in a manner similar to the Chena River.

OTHER ALASKAN RIVERS

Winter dissolved oxygen data from additional rivers in Alaska were collected during field trips timed to coincide with anticipated winter D.O. depression. Sample sties were located where the road crossed the river or where it was convenient and safe to land the aircraft with no concern given to whether the station was close to the mouth or contained open water in the area. Consequently, some sample sites were located on upper or open water reaches of a river where severe depression would not normally be expected.

As anticipated, D.O. concentrations ranged widely from 0.0 mg/l to 15.3 mg/l (Table 2). No pattern is readily apparent from these data since low D.O. was found under a variety of conditions. Data from streams with small discharges (near 20 CFS) such as Moose, Gardiner, and Shaw Creeks, reveal D.O. concentrations of less than 2.0 mg/l. Furthermore, rivers with larger discharges (summer discharges greater than 1000 CFS) such as the Colvilled and Copper Rivers, may contain depressed D.O. concentrations as low as 3.4 mg/l (24 percent saturation).



Mean Monthly Discharge (1970) And Winter Dissolved Oxygen (1971) Data From The Yukon River.

Figure 6

Rivers from different geographic locations such as the North Slope of Alaska flowing north (Sagavanirktok, Colville, Kuparuk), rivers of interior Alaska draining southwest (Yukon, Chena), rivers draining south (Gulkana, Copper), all contain depressed D.O. concentrations (Table 2).

Limited data from some rivers, such as the Kenai, Eagle, Knik, Matanuska, and Chickaloon, located south of the Alaska Range show that rivers near Anchorage contained D.O. concentrations near 13 mg/l (90 percent saturation). The Tiekel and Tsina Rivers near Valdez show similar winter D.O. concentrations. However, these data are not sufficient to conclude that these rivers do not undergo D.O. depression. In summary, many rivers, large and small, located from 70°N to 61°N latitudes, may contain waters with depressed D.O. during winters.

BIOLOGICAL AND MANAGEMENT IMPLICATIONS

Low D.O. may affect large populations of endemic and anadromous fish whether occurring in large or small drainages. For example, drainages as small as Shaw Creek, located near Fairbanks, support sizable populations of grayling, and larger watersheds such as the Chena harbor significant populations of grayling, chum and king salmon, with potential for even larger runs of anadromous fish. The Gulkana-Copper River system supports populations of grayling throughout the year, as well as salmon in various stages of development. These particular lotic systems are not unique in Alaska; other less known but equally important rivers support large populations of aquatic biota and contribute substantially to the total aquatic resources of Alaska.

Severely depressed D.O. has the potential of affecting large numbers of several species of fish and other organisms that are directly or indirectly economically important. It is possible that lethal or other less apparent but nevertheless significant effects may already be limiting these populations. Doudoroff and Warren (1957) discuss the importance of adequate concentrations of D.O. necessary for survival of fishes. The influence of different oxygen concentrations on the growth rate of juvenile large mouth bass is described

TABLE 2

Winter Dissolved Oxygen from Various Rivers in Alaska
(Single Samples During Field Trip)

Stream	March 1969		February 1971	
	Dissolved Oxygen mg/l	% Sat.*	Dissolved Oxygen mg/l	% Sat.*
Tanana-Tetlin Junction	6.7	47	5.7	40
Moose Creek	----	---	----	---
Shaw Creek	1.1	8	1.3	9
Delta Clearwater (Lodge)[1]	11.6	81	10.3	72
Gerstle River	14.0	---	----	---
Johnson River [2]	----	---	13.3	92
Robertson River	13.1	91	----	---
Tok River (Tok Cutoff)	10.8	75	----	---
Chisana River	9.6	67	7.8	54
Gardner Creek[3]	----	---	0.0	0
Gulkana River	----	---	9.0	63
Slana River	8.0	56	7.7	53
Chistochina River[4]	12.4	86	12.9	90
Gakona River	14.0	97	15.3	106
Copper River	4.6	32	2.9	21
Tazlina River	11.4	79	10.9	76
Tsina River	----	---	13.0	90
Tiekel River	----	---	12.6	87
Donnelly Creek	----	---	9.3	65
Ruby Creek	8.5	59	----	---
Phelan Creek	----	---	12.0	83
Little Nelchina River	12.8	89	----	---
Chickaloon River	13.7	95	----	---
Matanuska River, Palmer	13.1	91	----	---
Matanuska River, below Palmer	12.9	90	----	---
Knik River	13.4	93	----	---
Eagle River	12.8	89	----	---
Kenai River	13.2	92	----	---
Porcupine River (near Old Rampart)	10.5	73	----	---
Colville River (4.8km E of Umiat)[5]	3.4	24	----	---
Colville River (at Umiat)	7.5	52	----	---
Kuparuk	8.4	58	8.4	58

*Calculated at 0°C

[1]Spring fed

[2]Overflow water

[3]Sulfurous odor

[4]Overflow water

[5]Under 4 m of ice

by Steward, *et al.* (1967). Other sub-lethal effects, such as the influence of D.O. on the swimming performance of juvenile Pacific salmon, have been discussed by Davis, *et al.*, (1963). Differences in the distribution of two plecopterans are related to dissolved oxygen by Madsen (1968). It can be seen that the effects of D.O. can be manifest in different ways on different organisms. Unfortunately, these and other studies were generally conducted at 10°C-20°C on organisms found in temperate climates.

Ciaccio (1971) reports that low concentrations of D.O. increases the toxicity of many substances. This statement reveals that the concentrations of toxicants established as safe by studies conducted on organisms found in temperate climates, may be toxic to organisms found in subarctic and arctic conditions. For example, the chlorine residuals necessary for disinfection in the subarctic (Gordon, 1973) may be highly toxic to endemic aquatic invertebrates and vertebrates stressed under low D.O. At this time, no cold climate studies have been conducted to determine how low D.O. conditions at low temperatures affect endemic organisms. As a result, a research project that examines these areas has been initiated by the Arctic Environmental Research Laboratory to fill these needs.

The Alaska State Water Quality Standards (1973) currently classify all surface waters of the state for "growth and propagation of fish and other wildlife including waterfowl and fur bearers." The dissolved oxygen criteria established is "greater than 7 mg/l for fresh water." As can be seen from the data gathered in this study, many streams in Alaska under natural conditions fall below these criteria in winter. The Water Quality Standards recognize this natural phenomenon and state that "waters may have natural characteristics which would place them outside the criteria" and that the criteria established "apply to man-made alterations to the waters of the state." The standards also contain a "non-degradation" clause.

The application of the Water Quality Standards and the administration of the National Pollutant Discharge Elimination System during the critical winter period in Alaska will not be easy. All discharges into the waters of the United States are required to be regulated by a permit under the Federal Water Pollution Control Act Amendments of 1972 (ref. PL 92-500). These permits are developed jointly by the principal State water quality control department and the U.S. Environmental Protection Agency, and are reviewed by other State and Federal agencies and the public. The development of these permits must take into consideration Alaska's complex winter stream dissolved oxygen phenomenon. Presently, there are only a limited number of discharges into waters which undergo winter dissolved oxygen depression below the State criteria; however, expected industrial and municipal expansion in the state will result in many more such discharges.

Discharges occurring in the upper reaches of a river system will require careful consideration. The receiving water at the point of discharge may contain ample dissolved oxygen. However, if that river exhibits severe winter D.O. depression, the downstream areas are the most critically affected and may reflect an additional D.O. depression caused by upstream waste discharge.

Discharge permits developed for effluents into streams which exhibit this low dissolved oxygen phenomenon should only be issued after sufficient field studies have been conducted to establish the natural conditions in both summer and winter. This information should include not only dissolved oxygen measurements, but also other water quality parameters and a survey of aquatic organism populations. From these data, the level of waste treatment necessary to protect the water quality of the stream can be defined.

CONCLUSIONS

1. Severe winter D.O. depression may appear in any river located in Arctic-Subarctic Alaska. This winter phenomenon is the net result of a complex interaction of many "natural" factors. Data collected during 4 years of investigation and from geographically widely separated Alaskan rivers revealed that a wide range of D.O. concentrations were found but that many rivers contained severely depressed D.O. concentrations.

2. Rivers of all size drainages and surface discharges may undergo severe natural D.O. depression. Futhermore, rivers located in widely separated localities may show D.O. depression.

3. In rivers exhibiting the depressed D.O. phenomenon, two patterns have been recognized. The D.O. concentration at any one station is gradually depressed from near saturation in October to severe depletion in February or March. Also, the D.O. depletion usually becomes more severe when proceeding from the headwaters toward the south.

4. Annual low D.O. values are usually found during winter in Alaskan streams while annual low D.O. is usually found during summer in temperate areas such as Cincinnati, Ohio.

5. Annual high D.O. values are usually present during the short spring breakup and fall freeze-up period in arctic and subarctic areas, but are usually found during winter in temperate areas.

6. An inverse relationship between D.O. and water temperatures is found only during the warm months of summer in arctic and subarctic areas, but is usually found throughout the year in temperate areas.

RECOMMENDATIONS

This study provides new data that establishes the low winter dissolved oxygen phenomenon as a major consideration in management decisions involving cold climate water resources. Because little information has been available from northern regions, many management decisions in cold climates have been based on extrapolations made from studies conducted in temperate climates. It is recommended that future management decisions in cold regions rely heavily on information generated within these cold-dominated areas rather than on classical information from temperate areas.

Naturally occurring low dissolved oxygen concentrations are found during winter in streams and rivers of all sizes located over widespread geographic areas. From small streams, such as Shaw Creek, to large rivers, such as the Yukon River, many aquatic systems in Alaska exhibit severe D.O. depression. It is recommended that any fresh water aquatic systems proposed as a receiving water be investigated during the winter as well as summer to determine the D.O. characteristics before discharge into the system is allowed.

Natural dissolved oxygen depression generally becomes more severe when progressing downstream. Thus, a waste discharge located in the upper watershed, where the D.O. concentration is high, may not be significantly detrimental at the immediate point of discharge or in the mixing zone. However, even a small reduction of the D.O. concentration in the upper areas could result in further depression in downstream reaches. Bouthillier (1971) points out that under ice cover the oxygen depletion found in the Red Deer River was 2.7 times the BOD--5-20 contained in the waste that was discharged into the river. Therefore, it is recommended that before an effluent discharge into a river system is allowed, all possible adverse effects be considered in the downstream reaches.

Winter discharge volumes for arctic and subarctic rivers are the lowest of the year; this combined with low winter D.O. concentrations, has serious management implications. The least desirable time to discharge waste effluents would be during the winter when both D.O. and stream flow are at annual low levels. The least offensive time would be at spring breakup when D.O. values are high and discharges are usually at the yearly maximum. It is recommended that any effluents discharged into arctic and subarctic rivers with naturally low dissolved oxygen receive the best available treatment as soon as possible and consideration be given to waste discharge timed with both stream discharge and D.O. concentration in mind.

Protection of aquatic resources dictates that the D.O. of a stream be maintained above a specified minimum standard. Currently, the Alaska State-Federal Water Quality Standards specify minimum D.O. concentrations of 7 mg/l in freshwater, but recognized that the natural winter D.O. in some waters falls below this concentration. Under these conditions the standard becomes more difficult to administer. It is recommended that the application of the Water Quality Standards and the administration of the discharge permit system incorporate studies that would evaluate waste discharge effects on streams exhibiting low winter dissolved oxygen.

Most cold climate rivers harbor large populations of economically important fishes. The relationship of these endemic fishes and their prey organisms to low D.O. phenomenon is presently unknown because no cold climate studies on these organisms have been conducted. It is possible that these low D.O. conditions may cause increased toxicity of many substances (Ciaccio, 1971). Addition of a chlorinated effluent to an already stressed aquatic system would not only aggravate the oxygen depletion but would probably cause increased toxicity at extremely low concentrations. It is therefore recommended that these studies be initiated to investigate these possible effects.

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MANDATORY CHLORINATION OF WASTEWATER DISCHARGES

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INTRODUCTION

The stated purpose of the symposium is to discuss the meaning of existing regulations and their impact on the northern environment. In this context, the chlorination of wastewater discharges is a factor of extreme importance.

The title of this paper is perhaps a misnomer and could really be "Mandatory Disinfection" rather than "Mandatory Chlorination." The definition of wastewater disinfection is couched in a variety of words which all have basically the same meaning. That is, disinfection provides an effective barrier against the spread of enteric diseases. Chlorine is the agent used almost exclusively, so disinfection and chlorination have come to be nearly synonymous in usage. However, the addition of chlorine to wastewater does not automatically mean adequate disinfection has been accomplished. As a result, a barrier to the spread of enteric disease is often not provided, while the residual chlorine may be having an intolerable impact on the environment.

Chlorine has had a long history as a disinfectant. According to the report by Collins and Selleck (1972), the first record use in the preparation of potable water was about 1800, with its use in wastewater disinfection beginning in 1893. Extensive studies conducted in the early part of this century . . . "marked the beginning of effective chlorination practice in the United States" (Collins and Selleck, 1972). Intensive study of

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wastewater disinfection with chlorine is still in progress, and the current "State of the Art" from contact chamber design through any environmental impact of the chlorinated effluent has been quite well documented (ASCE, 1970; Brungs, 1973; Chambers, 1971; Collins and Selleck, 1972; Marks, 1972; Morris, 1971; White, 1972, 1974).

However, in actual practice, much of the accumulated knowledge frequently appears to be disregarded.

APPLICABLE GUIDELINES AND REGULATIONS IN NORTHERN REGIONS

The U.S. Environmental Protection Agency (EPA), the Canada Department of the Environment, and the Alaska Department of Environmental Conservation have all established guidelines and/or regulations to minimize the spread of enteric disease by wastewater effluents in northern region receiving waters. Both countries have attempted to establish quality control over the wastewater being discharged as well as the receiving water. The major difference is that EPA and the State of Alaska are applying the same control in all cases, while Canada is making decisions on a case-by-case basis. Along with the efforts to minimize health hazards, each of these regulatory agencies has made provisions for minimizing the toxic effects of chlorine on the biota in the receiving water.

The role of guidelines and regulations is or should be to protect subsequent water uses, and they must be responsive to change as new and better information becomes available. Although it may sometimes be slow, changes do occur for the better, as typified by current efforts to update the EPA disinfection guidelines. Perhaps it should be stipulated in the guidelines that review be conducted on some regular basis to insure timely inclusion of new information. The present interest in the North has stimulated rapid acquisition of new information about the northern environment. As a result of this and other new information, it is suggested that some of the current guidelines and regulations may be inadequate for application in northern regions.

The U.S. Environmental Protection Agency, Region X has directed its efforts toward wastewater effluent quality. Region X established disinfection criteria and design guidelines in 1970 (USEPA, 1970) for application throughout the region, which includes the states of Washington, Oregon and Idaho, as well as Alaska. Possible revisions of this document are currently under review and an updated version should soon be available. If it is assumed that the updated version will be essentially as it appears in draft form, these guidelines will eliminate some of the inadequacies for northern regions that appeared in the original document.[1]

The purposes stated in the introduction to this draft document are that: "All liquid effluent of domestic or animal origin, from wastewater treatment facilities must be adequately disinfected to minimize the health hazards from waterborne diseases and to preserve and enhance the quality of the receiving waters." These guidelines indicate that control over effluent quality will be obtained by limiting construction grants to projects which have ". . . disinfection or other methods to produce substantially complete reduction of micro-organisms." In addition, what is considered to be the best available information is presented in three major sections containing the following points relevant to this discussion.

ADEQUATE DISINFECTION

1. The geometric mean of the fecal coliform numbers shall not exceed 200/100 ml in a 30 consecutive day period, with the number not exceeding 400/100 ml in any seven consecutive days. These numbers are the same as required by the dischargers National Pollutant Discharge Elimination System permit.

2. In the absence of conclusive coliform data at smaller treatment plants, meeting the following three criteria is minimum evidence of adequate disinfection:

A. "Effluent suspended solids less than 30 mg/l."
B. "Adequate contact time."
C. A 1 mg/l total chlorine residual after 60 minutes contact time.

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1 Subsequent to this presentation, it was learned that the Design and Operations portions of the Guidelines will be completely rewritten rather than updating the existing document.

DESIGN

1. Chlorine contact chambers shall provide 60 minutes contact time at design flow, or 20 minutes at peak flow.

2. "Dechlorination of the effluent may be required for discharge to biologically sensitive receiving waters and/or to meet established chlorine receiving water quality criteria."

OPERATION

Either the orthotolidine or the iodometric titration method is acceptable for determining total chlorine residual.

Throughout the document, chlorine was presented as the disinfectant. However, it was stated in each section that equivalent disinfectants may be used.

Prior to October, 1973, the Alaska Administrative Code included regulations which directly specified requirements for wastewater disinfection under Title 7, which was Health and Welfare (State of Alaska, 1959). The responsibility for wastewater disposal and water quality was transferred to the newly established Alaska Department of Environmental Conservation in 1971, and the regulations were subsequently revised and transferred to Title 18, Environmental Conservation: Chapter 70, Water Quality Standards (State of Alaska, 1973a) and Chapter 72, Wastewater Disposal (State of Alsaka, 1973b). No direct reference is made to wastewater disinfection in the October, 1973 revisions of these regulations. However, there is a statement in Chapter 72 (State of Alaska, 1973b) which indicates that ". . .chlorine accident, spill or outage. . ." constitutes an emergency which must be reported to the department. The lack of direct reference to disinfection does not imply that minimizing the health hazard from wastewater effluents has been ignored. However, reference to both chapters is necessary to ascertain that secondary treatment is the minimum for any type of wastewater being discharged into surface waters, and discharge may be prohibited or further treatment required for discharge into sensitive receiving environments or to achieve the water quality criteria. The points applicable to this discussion are:

Chapter 72. Wastewater Disposal

No wastewater can be discharged if it ". . .results in violation of the Water Quality Standards found in Ch. 70 of this title."

Chapter 70. Water Quality Standards

(1) "Waste discharge permits will define a mixing zone outside of which violations of the criteria will be determined. The mixing zone will be limited to a volume of the receiving water that will

> (A) not interfere with biological communities or populations of important species to a degree which is damaging to the ecosystem.

and

> (B) not diminish other beneficial uses disproportionately."

(2) Seven water use classes are defined and encompass all fresh surface waters and ground water, as well as marine and estuarine waters. The sanitary quality of each class is based on the number of total coliform bacteria per 100 ml of sample.

> Class 'A' Water -- "Mean of 5 or more samples in any month may not exceed 50 per 100 ml, except ground water shall contain zero per 100 ml."

> Class 'B' Water -- "Mean of 5 or more samples in any month may not exceed 1000 per 100 ml, and not more than 20% of samples during one month may exceed 2400 per 100 ml, except that ground water shall contain zero per 100 ml."

> Class 'C', 'D', 'F' and 'G' Water -- must comply with Class 'B' coliform numbers.

> Class 'E' Water -- must comply with U.S. Public Health Service Standards for shellfish growing areas.

This chapter also indicates that water having higher quality than the class in which it is placed should be maintained at that higher quality.

In 1973, the Northwest Region of the Environmental Protection Service in the Canadian Department of the Environment established interim guidelines for wastewater disposal in the Yukon and Northwest Territories (Canda, D.E., 1973). These guidelines are currently undergoing internal review and may be modified before being published. It was stated in the foreword of this proposed document that: "It is the intention of the Water Pollution Control Directorate to complete Guidelines for Arctic Wastewater Disposal in the Yukon and Northwest Territories in 1975." In the meantime, these interim guidelines will be used to implement a program of water pollution abatement in the arctic and subarctic regions. These guidelines indicate that disinfection of the wastewater may not be required, but health hazards must be minimized. However, ". . .public health considerations may necessitate effluent disinfection for many communities. Each site must be evaluated for potential casual use of receiving waters, and whenever casual use for internal consumption is determined to be likely, disinfection of sewage effluents shall be required." If disinfection is required, chlorination or ozonation are specified as the alternative methods. In addition, selection of a treatment system shall include:

(A) "Recognition that the receiving water shall remain safe to all casual users."

(B) "Recognition that the receiving water shall remain favourable to the indigenous flora and fauna." This requirement may necessitate the reduction of toxicity in the wastewater.

DO CURRENT REGULATORY CONTROLS PROVIDE ADEQUATE SAFEGUARDS IN NORTHERN REGION RECEIVING WATERS?

The role of regulatory controls is ultimately to protect receiving water quality and water quality standards are the final safeguard. The current concepts of what constitutes an effective barrier to the spread of enteric disease in receiving waters are based entirely on temperate climate information, and are intended to provide a very low calculated disease risk in waters used for primary contact recreation (Mechalas *et al.*, 1972; FWPCA, 1968).

In many states, the measurement of acceptable risk in recreational waters has traditionally been a maximum of 1000 total coliforms/100 ml (Mechalas *et al.*, 1972). There may be some question as to whether this limitation alone provides an adequate measure of acceptable risk since less than 10 to more than 900 of the 1000 total coliforms may be of fecal origin (fecal coliforms) (FWPCA, 1968). It has been suggested that the fecal coliforms should be used as a supplement to total coliforms in determining disease risk (Collins and Selleck, 1972). Even when fecal coliforms are used in conjunction with total coliforms, problems may arise in establishing numbers of these bacteria which indicate an acceptable disease risk downstream from a wastewater discharge. The reasons are that *Salmonella* serotypes have been detected in 27.6 percent of the freshwater samples containing 1-200 fecal coliforms/100 ml (Geldreich and Van Donsel, 1970), and enteric viruses have been found when fecal coliforms were as low as 60/100 ml (Berg, 1973).

Enteric viruses may survive for extended periods and have been isolated from 36 percent of the surface water samples examined throughout the world (Akin, Benton, and Hill, 1971). Only a very few viruses are considered necessary to cause infection (Berg, 1971), and any enteric virus capable of causing infection when consumed orally should be transmissible by water (Mosley, 1966). However, infectious hepatitis is the only viral disease for which documentation has been obtained (Akin, Benton, and Hill, 1971;

Mosley, 1966). The point is that infection and disease are not synonymous which means that a person can be infected with an enteric virus without the disease resulting (Plotkin and Katz, 1966). The infected person may subsequently transmit the virus directly to another person who will develop the disease. This obscures the possibility that water was the source of the original infection (Berg, 1973).

The extensive body of literature indicating that decreasing the water temperature increases the survival of essentially all enteric microorganisms was discussed recently (Gordon, 1972; Van Donsel, Gordon, and Davenport, 1974). This information, coupled with the possible difficulties already encountered in temperate climates in establishing a reliable indicator of disease risk, makes extrapolation of temperate climate standards to northern regions a questionable approach. This may be especially true since northern region waters are usually colder throughout the year than in more temperate regions, and temperatures are generally at or near 0°C for six or more months each year. Two recent studies (Gordon, 1972; Van Donsel, Gordon, and Davenport, 1974) indicated that fecal coliforms survive longer in a subarctic river at 0°C in numbers as much as five times greater than those numbers found in more temperate climate studies (Ballentine and Kittrell, 1968), and that *Salmonella* serotypes can be easily isolated both quantitatively and qualitatively in the presence of no more than 50 fecal coliforms and 300-500 total coliforms. Additional field studies are planned to obtain more definitive correlation between the coliforms and *Salmonella* serotypes at 0°C, and to examine survival of enteric viruses. This information should be a start toward determining an acceptable basis for disease risk in low temperature waters.

Factors which must be considered in establishing safeguards for arctic and subarctic waters are, first of all, that most of these waters are still of unusually high quality in that they are relatively unaffected by man-made pollution. Aside from its being desirable to maintain this quality, many people still fearlessly consume raw water from rivers and lakes on a regular basis. This would suggest either that the receiving water should meet potable water standards without treatment, or that this type of water use should be discouraged.

It is suggested that sufficient information is not available for ascertaining what constitutes adequate safeguards for minimizing disease risk in northern region receiving waters. Until sufficient information is available, the regulatory agencies should continue to: (1) minimize the existing high water quality by vigorously enforcing the Class 'A' or better water quality standard in Alaska, and be equally stringent in the Yukon and Northwest Territories; (2) minimize use of the 1000 fecal coliforms/100 ml water quality standards; and (3) consider employing both total and fecal coliforms as indicators.

WHAT INDICATES ADEQUATE DISINFECTION OF WASTEWATERS IN NORTHERN REGIONS?

In the final analysis, wastewater disinfection is adequate only if it actually destroys the microorganisms which cause enteric disease. The coliform bacteria are the only microorganisms currently being used to indicate disinfection effectiveness. These indicator bacteria have been considered to provide a reliable measure of adequate enteric bacteria removal (Chambers, 1971; Geldreich and Van Donsel, 1970). However, there may be some doubt because the ratio of enteric pathogenic bacteria to total or fecal coliforms may vary considerably (Mechalas *et al.*, 1972). In addition, it is very doubtful that coliforms are adequate for determining the absence of viruses because many enteric viruses are much more resistant to chlorine than are the enteric bacteria (Berg, 1971; Chambers, 1971; Geldreich and Clarke, 1971). When chlorine is added to water, it immediately forms hypochlorous acid (Chambers, 1971; Marks, 1972; White, 1972) which is a very rapid virucide (Berg, 1971), and would be effective in removal of viruses if it could be maintained in wastewater. Normally, however, the ammonia concentration in wastewater is high enough that all of the hypochlorous acid reacts rapidly to form chloramines (Chambers, 1971; Malherb and Strickland-Cholmley, 1966). As a result, some portion of these viruses can be expected to survive the treatment and disinfection processes, and be discharged with the wastewater effluent (Berg, 1971).

As pointed out in the discussion of receiving water quality, there is some question as to what constitutes adequate safeguards for minimizing disease risk in northern region receiving waters. This is equally true in wastewater, particularly since current disinfection practice does not effectively remove enteric viruses. In the original EPA wastewater disinfection criteria (USEPA, 1970), the minimum microbiological evidence of effective disinfection was 1000 total coliforms and 200 fecal coliforms/100 ml. The total coliform standard is being dropped in the revised document. It should be remembered that: (1) fecal coliforms constitute a highly variable portion of the total coliform population (FWPCA, 1968); (2) fecal coliforms tend to be a small portion of the total coliforms (less than 25%) in at least some northern region wastewater effluents (Gordon and Davenport, 1973; Gordon, Davenport, and Reid, 1973); (3) fecal coliforms are more susceptable to chlorine than the non-fecal portion of the total coliform population (Collins and Selleck, 1972; Gordon and Davenport, 1973; Gordon, Davenport, and Reid, 1973) and; (4) there is evidence that several thousand total coliforms per 100 ml can remain when the fecal coliforms have been reduced to substantially fewer than 200/100 ml (Gordon, Davenport, and Reid, 1973). Besides the possibility that adequate disinfection has not been attained if large numbers of total coliforms remain after disinfection, there is the potential for conflict with the Alaska water quality standards. Dilution by the receiving water may well take care of the situation for the present, but as the population of an area increases it becomes more and more precarious to depend on dilution. Perhaps the approach stated by Chambers (1971), that ". . .the bacterial content of the effluent cannot greatly exceed that allowable under the applicable water quality standards. . .if the desired water quality is to be maintained. . .," should be considered for immediate application in northern regions.

The problems stated in this section, as well as in the receiving water section, support the call for research to quantitatively relate coliforms to enteric pathogens if the coliform test is to continue as a useful criterion of disease risk (Gordon, 1972; Mechalas *et al.*, 1972; Van Donsel, Gordon, and Davenport, 1974; FWPCA, 1968).

There are three criteria which, if met in a wastewater, are considered acceptable evidence of adequate disinfection in lieu of conclusive coliform data according to the EPA, Region X, guidelines (USEPA, 1970) and updated version. This evidence is basically correct if it is assumed that adequate disinfection is indicated by 200 fecal coliforms/100 ml, or even 200 fecal coliforms and 1000 total coliforms/100 ml. However, some qualifications are necessary:

1. Suspended solids concentration has been shown to have no effect on disinfection other than to increase the immediate chlorine demand in full scale contact chambers (White, 1974), or in bench scale models (Collins and Selleck, 1972; Gordon and Davenport, 1973; Gordon, Davenport, and Reid, 1973).

2. Adequate contact time must be better described if disinfection is to be attained (for further discussion see CONTACT CHAMBER DESIGN CONSIDERATIONS).

3. The arbitrary chlorine residual: contact time relationship of 1 mg/l after 60 minutes contact time may provide adequate disinfection. However, it should be examined under all operating conditions in each contact chamber (Gordon and Davenport, 1973), and the 1 mg/l chlorine residual must be measured by the orthotolidine method (Gordon, Davenport, and Reid, 1973). This will be discussed under METHODOLOGY PROBLEMS.

CONTACT CHAMBER DESIGN CONSIDERATIONS

In spite of the established need to consider disinfection as a unit process equally as important as other unit processes in wastewater treatment (Canada, D.E., 1973; Gordon, Davenport, and Reid, 1973; White, 1974), it does not appear to have received sufficient attention in actual design practice.

The basic problem was well stated by Collins and Selleck (1972) when they pointed out that ". . .a failure to employ the fundamentals of process design and operation has resulted in poorly conceived wastewater chlorination systems, ill-suited to their purpose." This is not necessarily a problem confined to northern regions, but the impact may well be more severe under the adverse environmental conditions encountered in the North. Chlorine contact chamber design is not within the scope of this presentation, but a few factors which must be considered if maximum efficiency is to be obtained in the wastewater disinfection process include, but are not necessarily limited to: (1) thorough and rapid mixing of the chlorine with the wastewater ahead of the contact chamber; (2) minimizing short-circuiting of the chlorine-wastewater mixture within the contact chamber to such an extent that plug flow is approached; (3) ensuring that there is sufficient contact time for adequate disinfection to occur; and (4) providing an automatic system for continuous chlorine residual monitoring with rapid residual adjustment in response to chlorine demand changes.

It was previously stated (Gordon, Davenport, and Reid, 1973) that the rather scattered literature on chlorine contact chamber design should be consolidated into a "State of the Art" to permit maximum utilization of the information. In the absence of such a work, attention is directed to several recent publications which contain references to much of the relevant literature (Collins and Selleck, 1972; Gordon, Davenport, and Reid, 1973; White, 1972, 1974).

After extensive study of 36 operating systems in California, White (1974) concluded that every molecule of wastewater should receive at least 30 minutes contact time. Similar conclusions were reached in a bench scale study at less than 1°C (Gordon, Davenport, and Reid, 1973). This information suggests that, even if a chlorine contact chamber with perfect plug flow could be designed, it is doubtful that adequate disinfection would be the result if the current design guidelines (USEPA, 1970), permitting 20 minutes contact time at peak flow, were followed. The most probable result of 20 minutes contact time is the discharge of excessive numbers of microorganisms, as well as excessive chlorine, into the receiving water.

METHODOLOGY PROBLEMS

The potential problems in coliform enumeration and chlorine residual determination methodology are not necessarily restricted to northern regions. However, the impact of these problems in northern regions may be severe.

Both the MPN (Most Probable Number) method and the MF (Membrane Filter) method are accepted for total and fecal coliform enumeration (Alaska, 1973a; USEPA, 1970). The MF method has several advantages which make it the preferred method. The most important advantage in determining potential health hazard is that the MF method ". . .provides an actual count of coliform presence in a definite volume of sample. . .," while ". . .the MFN technique is only a statistical estimate of the coliform numbers in a given volume. . ." (Scarpino, 1971). In spite of the obvious advantages of the MF method, the statement was made in Standard Methods (APHA, 1971) that "Experience indicates that the membrane filter technique is applicable to the examination of saline waters, but not chlorinated wastewaters." No reason other than experience was given for this statement. Two recent studies (Lin, 1973; Watkins, 1973) provided some support for this statement by showing an apparent suppression in the number of both total and fecal coliforms obtained from chlorinated wastewater with the MF method as compared to the MPN method. Two other recent reports (Hufham, 1974; Presswood and Brown, 1973) have added more cautions to using the MF method for coliform enumeration.

The intention of this short discussion is only to point out that what are generally considered well-established methods may have inherent problems. More work is necessary to verify the extent of the problems before one method can be recommended over another, or before regulatory agencies require a particular method.

Numerous methods have been described for determining chlorine residual (APHA, 1971; Marks, 1972; White, 1974), but the ones most frequently used in wastewater are the orthotolidine (OT), orthotolidine-arsenite (OTA) and iodometric with either the colorimetric or amperometric endpoint. The OTA method permits the measurement of free chlorine (Marks, 1972), and is recommended when iron and manganese are present (APHA, 1971). Since there is rarely, if ever, free chlorine present during wastewater disinfection, the only advantage of the OTA method over the OT method is if iron or manganese are present.

The OT or OTA methods are much easier to use in chlorine residual measurement than is the iodometric method and, as a result, have been widely used. Recently, it was recommended that the OT method should be abandoned in favor of the iodometric method because the OT method at best gives only a qualitative measure of the chlorine residual (White, 1974). Other sources do not go that far, but do indicate that the iodometric method is much more sensitive than the OT method (APHA, 1971; Gordon, Davenport, and Reid, 1973; Marks, 1972). This difference may be in the range of 2-5 mg/l or more (APHA, 1971; Gordon, Davenport, and Reid, 1973) with the iodometric method indicating the highest residual. Thus, when a specific chlorine residual must be maintained, the measurement method must be specified (APHA, 1971). Although a 1 mg/l total chlorine residual measured by the OT method may be adequate for disinfection, there is evidence that at least a 3-4 mg/l residual measured by the iodometric method will be required for the same wastewater, in either temperate climates (Collins and Selleck, 1972) or in northern regions (Gordon, Davenport, and Reid, 1973).

RESIDUAL CHLORINE IMPACT ON RECEIVING WATERS

The impact of residual chlorine on aquatic life in temperate climate receiving waters has been studied extensively. The results indicated that potentially severe toxicity problems exist (Brungs, 1973; Esvelt, Kaufman and Selleck, 1971), and that toxicity increases propotionally as the residual chlorine concentration increases (Esvelt, Kaufman, and Selleck, 1971). In addition to chloramines, a variety of other chlorinated compounds are, or can be, formed when wastewater is chlorinated, and some of these compounds may be toxic (Brungs, 1973; Glaze *et al.*, 1973). In spite of suggestions to the contrary, recent evidence indicates that the residual chlorine can persist for extended periods (Brungs, 1973), as much as several days (Esvelt, Kaufman, and Selleck, 1971).

The significance of the residual chlorine concentration and the measurement method was pointed out by Brungs in his review (Brungs, 1973). He indicated that the OT method was inadequate for total chlorine residual measurement in the wastewater, and that the iodometric method measured chorine ". . .most closely correlated with biologically active chlorine residuals." He went on to suggest the following receiving water criteria: "In areas receiving wastes treated continuously with chlorine, total residual chlorine should not exceed 0.002 mg/l for the protection of most aquatic organisms." This means that a 1500-fold dilution would be required, for disinfection was only 3 mg/l. No temperature influence was considered in these proposed criteria, and it was pointed out by Gordon *et al.* (1973) that the aquatic organism sensitivity to chlorine in low temperature waters of northern regions is essentially unknown. They suggest that these organisms should be considered at least as sensitive as those in more temperate climates, particularly when ". . .this toxicity is superimposed on the low dissolved oxygen concentrations found in many arctic and subarctic rivers during the winter months. . . ."

Extensive research is necessary in northern regions if the effects of residual chlorine toxicity in the aquatic environment are to be established. In the meantime, there are several methods which can be utilized to minimize or eliminate potential toxicity. Good contact chamber design would reduce toxicity because of the decreased chlorine residual required to achieve disinfection (Esvelt, Kaufman, and Selleck, 1971). Also, automatic chlorine residual monitoring and feedback control systems would prevent high chlorine residuals, reduce toxicity and improve disinfection.

Although good contact chamber design is essential in achieving disinfection, a more effective method of reducing or eliminating residual chlorine toxicity in the aquatic environment is by dechlorinating the wastewater after disinfection (Brungs, 1973). If a slight excess of sodium bisulfite is used as the dechlorinating agent, toxicity caused by residual chlorine will be eliminated (Esvelt, Kaufman, and Selleck, 1971). This methodology was extensively discussed by White (1972).

Probably the most effective method of eliminating chlorine toxicity in the receiving water is to use wastewater disinfectants other than chlorine whenever possible (Brungs, 1973).

ALTERNATE WASTEWATER DISINFECTANTS FOR NORTHERN REGIONS

The inability of chlorine to destroy enteric viruses in wastewater and the potential impact of residual chlorine on the aquatic environment are sufficient reasons for looking to alternate wastewater disinfectants. Another reasons which may ultimately force a change, is that rapidly increasing usage of chlorine, particularly as a disinfectant, is outstripping its production capacity (Ward, 1974).

Several possible methods of wastewater disinfection in northern regions have been discussed in recent years (Chambers, 1973; Chambers and Berg, 1971). These methods include: iodine, bromine, lime ozone, ultraviolet light, pasteurization and gamma radiation. In most cases, insufficient information is available to determine whether these are any better disinfectants or any less toxic than chlorine.

Lime has received some attention for use in northern regions (Morrison, 1973; Morrison, Martin, and Humble, 1973), and may be a better disinfectant than chlorine (Chambers, 1973). However, there are other problems which must be overcome before it would be useful in practical application.

There is an excessive amount of heat wasted in many northern communities. It is possible to recover a large portion of this heat, and it could be used to provide pasteurizing or even higher temperatures in wastewater. Because there would be no potentially toxic chemicals added during the process, this method has considerable merit if efficient disinfection could be provided on a continuous basis.

Ozone has been used for many years as a disinfectant in Europe, and has received the most attention as an alternate disinfectant in the United States. It has been found to be at least as effective as chlorine in all respects (Venosa, 1972), and is a rapid virucide (Berg, 1971; Diaper, 1972; Pavoni *et al.*, 1972). In addition, ozone dissipates rapidly leaving no toxic residual (Sliter, 1974). A compilation of papers published in 1972 discussed current concepts of ozonation (Evans, 1972).

RECAPITULATION

Disinfection should be mandatory for all domestic wastewaters being discharged to northern region receiving waters to protect both the subsequent users and the high water quality. In current practice, chlorination does not generally provide an effective barrier to the spread of enteric disease, and may be toxic to aquatic organisms in the receiving water. Thus, the development of alternate disinfection methods should be accelerated so as to replace chlorination.

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ANCHORAGE WASTEWATER TREATMENT

Calvin E. West*

Unlike the other speakers that have made presentations to you earlier, my goal in environmental standards is a little bit different. As the Director of Public Works for the Greater Anchorage Area Borough, I am responsible in a general way for the administration of a municipal wastewater treatment facility and it is my job, as I see it, to apply what the educators and researchers develop to meet the environmental standards as developed by the regulatory people. To put it in other words - I'm the guy who gets stuck with what all these other people think up.

What I want to try to do today is give a general background of what Anchorage has done in the field of wastewater treatment. Our presentation will be concluded by Dr. Carlson who will present a report that has been done for the borough concerning the receiving waters for our Pt. Woronzof treatment plant. In order to get a feel for what has happened, we need to go back in time a little bit and describe what Anchorage was like prior to the implementation of what we call an areawide wastewater treatment facility. Back in the mid-fifties there were no treatment facilities of any type except for a few isolated small lagoons. There were seven outfalls which discharged raw sewage into the Knik Arm or Turnagain Arm and there were many, many areas that had no collection systems whatsoever. We depended on on-site disposal and since we also depended on ground water for a water supply there were serious problems developing.

Anchorage was a turning point, being the transportation headquarters for almost all the operations in Alaska and with the discovery of oil in the Cook Inlet and the development that was taking place, there was rapid growth in the area which compounded the above-mentioned problems. As always happens when a community faces serious problems of this nature, consultants are hired to make a study to see what can be done to solve the problems. I don't mean

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that in a derogatory sense, but that is precisely what the Anchorage area did. At this time the borough was two years old and was responsible for Area Wide Planning and under that authority a consultant was retained to study the sewerage system requirements for the Anchorage area. The study area included what is commonly called the "Anchorage Bowl" which is the area between Turnagain Arm to the south and west and the military bases to the north and to an elevation of 2,000 feet in the Chugiak Mountains to the east. The purpose of the study was to devise a comprehensive plan that would solve the sewage requirements for the Anchorage community based on the technology at that time. The plan recommended several things and for the sake of time I won't go into a lot of detail. The major points include a primary treatment plant at Point Woronzof to handle all the sewage flow in the Anchorage area and several major pump stations to pump from the drainage basins that could not flow by gravity to Pt. Woronzof. The principle reason that this site was selected for the treatment plant was the hydrological conditions that existed offshore including deep water and high tidal currents which did not exist at any other location. It was determined that dilution ratios of 5,000 to 1 could be obtained under the maximum effluent conditions and minimum flow conditions in the inlet. The report also recommended that the problems of the community be solved on an area-wide basis by one single entity. At that time there were many different agencies that were responsible for operating and maintaining the collection systems that existed. These include several privately owned utilities, a public utility district and the City of Anchorage. After the plan was approved the question of area-wide power was presented to the voters of the borough and was approved by a very slim margin, something less than a hundred votes. After the area-wide powers were assumed by the borough the next step was to begin actual construction. Applications were made for federal assistance and a bond issue was placed before the voters to provide for the local share. The bond issue was voted on in 1967, I believe, and there again passed by a very slim margin, something less than fifty votes. After these events, it took several years to really get going in the construction phase and actual construction didn't begin until late 1969. The sewage treatment plant at Point Woronzof was constructed at the cost of 9.3 million dollars; two major lift stations were constructed at a cost of 3.4 million dollars; and numerous interceptors to divert flow from the existing outfalls to Point Woronzof were built at a cost of 17.5 million dollars. Also we have built 4 million dollars worth of trunks and 5.9 million dollars worth of lateral or main sewers in the period since 1969. This adds up to approximately 40 million dollars in construction from 1969 to date and includes 93.2 miles of new sewer lines. As you can see there has been a considerable effort on the part of the community to solve its wastewater treatment problems. The treatment plant was complete in late December of 1972 but was put on line in July 1972. Completion of the pump station and interceptors allowed total flow to the plant in the Fall of 1973. At this point we were into the sewer utility business but were still faced with many problems especially in the area of financing. Those of you that are aware of the local community know that the sewers in Anchorage are not popular in terms of public acceptance of the system and obtaining the necessary funds to make it go forward.

In the past several years we have had tremendous deficits (in the order of 1.3 million for the last 2 years) in our operating budget. This is because there were insufficient revenues from sewer service charges and other income due to political and public pressures. This has caused a bare bones operational program and with the many problems we have with the collection system, particularly in the older parts of the community (those in existence prior to the earthquake of 1964) we are facing serious problems. In fact, the overall system is in a relatively poor condition due to the reactionary maintenance approach we are forced to take. Of course, this can not continue and the cost for deferring maintenance will eventually be much greater to the community. That, in fact, is what we're faced with today.

Just several weeks ago we had a tremendous scare. The Greater Anchorage Borough Assembly, our legislative body, amended the borough budget to make the sewer utility budget expenses equal to revenues which cut 1.8 million dollars from the total utility budget of 6 million dollars. Since we have almost 4 million dollars in fixed financial costs the cut would have to be absorbed in operations and maintenance. Thus we were faced with closing down the plant or operating illegally in terms of unallocated revenue. Several days later the assembly reversed their action and we are back in business.

The community must now face a tremendous rate increase. Currently our monthly service charge for a single family residence is $3.75, which is somewhat lower than originally proposed due to a reduction by the Public Utilities Commission for Alaska. The rate that we are now considering and will be submitting to the PUC is $7.65. This is, as you can see, an increase in excess of 100%. This is what Anchorage must face in order just to meet the minimum operating requirements. There are no allowances in the $7.65 rate for depreciation funds, covering future replacements, or for any replacements needed in the plant, pumping station or the collection systems.

Beyond the financial problem is another serious problem that this community must face and this is the requirements of the regulatory agencies. I'm sure most of you are aware of or familiar with the requirements of PL 92-500, better known as the 1972 Water Quality Act amendments. For those of you who aren't, I'll state our concern. That law says, among other things, that by 1977 all municipal wastewater treatment facilities must have secondary treatment and by 1983 they must meet what is described as best practicable treatment. With all of our other problems and considering the conditions of the receiving waters which Dr. Carlson will describe, we feel it is unreasonable to ask the Anchorage community to meet these requirements. The expenditures necessary to upgrade our primary plant to a secondary facility, and the resulting additional costs for operations and maintenance are simply not warranted. If this is done, even with the very high percentages of grant assistance that are available from state and federal agencies, we are looking at some tremendous local costs. I'm sure this community will not be willing to bear these costs unless an excellent sales job is made, which could be impossible at this time. Because of this, there has been considerable effort on behalf of the borough to change what we feel is a very unreasonable requirement of the Act, both through efforts directly from the borough and with assistance from our congressional delegation. Senator Ted Stevens of Alaska has introduced amendments to the act which would allow flexibility for the EPA Administration to make determinations that would allow him to waive the secondary and best practical treatment requirements. Also, we have assisted in efforts through the Association of Metropolitan Sewer Agencies, which is a group of many, very large communities that have municipal wastewater authority throughout the United States and Hawaii. AMSA has generated considerable pressures on the various agencies and I think some fruit is beginning to bear. When the act was adopted about a year and a half ago, EPA was adamant about the fact that the law was the law and they were not willing to bend. Recently, Russel Train has made the statement publicly that he thinks that there should be some flexibility on his part concerning the discharge requirement. This was made in Seattle concerning the West Point primary plant that discharges into Puget Sound.

In the next several weeks there will be a seminar sponsored by EPA in Portland, which perhaps some of you people have been invited to attend. A representative from the borough will attend to assist in developing criteria for amendments to the law allowing more flexibility for EPA.

I would like to make it clear that the Greater Anchorage Area Borough is not necessarily opposing secondary treatment. We are only opposing the mandatory requirement. If it is proven that it is environmentally advantageous to upgrade to secondary treatment then we would not be reluctant to do so. In order to determine whether upgrading is necessary, and to evaluate what we are doing to our receiving waters, we commissioned the Institute of Water Resources to make some breakdown studies which they have recently completed. These and other on-going studies will assist in determining the impact of the Point Woronzof discharge on Cook Inlet. Dr. Carlson has been involved in these studies and at this point I would like to turn the presentation over to him.

RECEIVING WATER CHARACTERISTICS OF KNIK ARM

Robert F. Carlson*

I will base my remarks on a study done several years ago in conjunction with the Greater Anchorage Area Borough which was directed toward determining the capacity of Knik Arm for receiving municipal wastewater discharge. The results of this work have been reported in the publication, "Effect of Waste Discharges into a Silt-Laden Estuary" (Murphy, *et al.*, 1972). This paper briefly emphasizes several things about Knik Arm's characteristics as a receiving water.

Knik Arm must be one of the most magnificent bodies of water in the world, especially for waste discharge. It is extremely well mixed, extremely silty, very cold and has a high tidal fluctuation and current. If a water body were to be designed for receiving waste discharge, I find it hard to imagine a better one.

Knik Arm, as many of you know, is usually characterized by its high tidal fluctuations with the coincidental high tidal currents. In addition, it receives a fairly large inflow from numerous rivers. Because of the high tidal phenomena, many people characterize Knik Arm as being one which quickly flushes out injected material. While that characterization is understandable, it is misleading as Knik Arm is better defined as an intense mixing basin created by the oscillating tides moving in both directions twice a day. This means that any waste deposited into the arm will be mixed throughout its waters within a short period of time.

While the mixing or dispersing action of the arm is unusally thorough it is within the ordinary range of engineering experience. We determined values of the diffusion coefficient of 4,700 square feet per second, or 14 square miles per day. This may be compared to a normal high value of 10 square miles per day quoted by many investigators.

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*Director, Institute of Water Resources, University of Alaska, Fairbanks.

A calculation using a very simple theoretical equation for distribution of mass within a mixed body of water indicated an extremely low BOD concentration in Knik Arm as a result of Anchorage's present discharge. The value calculated in the vicinity of the outfall was on the order of 0.004 parts per million, or practically negligible. This low value is caused by the large volume of the inlet and the very low waste discharge compared to fresh water flow down the inlet. The intense mixing causes a nearly equal concentration upstream and downstream which decreases to within 10% of the outflow section concentration 20 miles from the outflow point.

Physical characteristics found in the arm render it an extremely well-suited receiving mechanism for municipal waste discharge. The outstanding physical characteristics are its very low water temperature (-1°C to +12°C), its very high sediment load (300 to 2,000 mg/l), and its very low nutrient load (about 70 percent or less of the nutrient value found in ordinary natural seawater).

Several natural factors cause these values. Low temperature is a consequence of the northern climate; high sediment is caused by the glacial discharge; and the low nutrient values are caused by complete lack of biological life within the arm and the low nutrient load of the input streams.

The study indicated that Knik Arm should be able to accept about 200 million gallons per day of primary treated effluent without any detectable change in the effluent waters. It would seem quite practical to deter any further additional waste treatment capacity for quite a number of years and instead spend the funds for improving other aspects of the Anchorage environment.

REFERENCE

Murphy, R.S.; Carlson, R.F.; Nyquist, D.; and Britch, R. (1972). Effects of waste discharges into a silt-laden estuary: a case study of Cook Inlet, Alaska. IWR Report No. 26. Institute of Water Resources, University of Alaska, Fairbanks.

BANQUET ADDRESS

THE END OF THE BEGINNING

Speaker:

L. EDWIN COATE

THE END OF THE BEGINNING

L. Edwin Coate*

If you've been following the news over the past few months, you might think that it's the beginning of the end for the Environmental Protection Agency (EPA).

Stories have appeared about the Administration sending to Capitol Hill amendments that will relax certain provisions of the Clean Air Act.

Reports have run in the press about how the Office of Management and Budget is trying to get EPA to stop making program operation grants to state pollution control agencies.

Legislation has been introduced in Congress to strip EPA of its regulatory authority over pesticides.

Congressmen are threatening to cut our budget; industry is challenging our regulations; and just about everyone is suing us--including--I might add, the State of Alaska. (Suits, however, are no barometer of impending doom for EPA--just about everybody has been suing EPA since there has been an EPA to sue).

But back to the State of Alaska. Yes, maybe Alaskans wish that sometime or another EPA would just quietly fade away. . .like forever. The rules and regulations, of which EPA seems to have the lion's share, are precisely what many of you came here to avoid. And now EPA is following you. But then consider, without you, the people, we would have no reason to exist.

No, EPA is not dead, nor dying. . .even ever so slowly. Instead of being the beginning of the end, it is for us really just the end of the beginning.

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*Acting Regional Administrator, Region X, U.S. Environmental Protection Agency, Seattle, Washington.

And a great beginning it has been. I will not bore you with lists and lists of individual successes, but I will mention a most significant fact that in the last three-and-a-half years, EPA has created a strong base for programs that will lead to real tangible progress in all areas of environmental protection.

In short, EPA has grown up. It is no longer a knight in shining armor rushing to and fro on a white charger; it is now a solid, professionally-run organization with a well-thought-out, structurally-sound program. It is a program run by an entirely new leadership at headquarters. And, this leadership understands the laws because they helped write them.

Without the 1970 Clean Air Act and the 1972 Water Pollution Control Act Amendments, EPA could not have developed a consistent and effective national pollution control program - although we may have had more friends in Alaska.

Nowhere, has a better beginning been made than in the area of water pollution control. As you know, the Federal Water Pollution Control Act Amendments of 1972 completely revamped our nation's water pollution control effort and, as a result, placed immense responsibilities upon the shoulders of government and industry. With these amendments:

* The federal waste treatment construction grants program was given a new look, and the funding for that program and many others increased measurably. Construction grants for Alaska, for example, were $4,504,000 in 1973, are $6,756,000 in 1974 and will be $15,059,100 in 1975.

* Our planning responsibilities have expanded at all levels of government. Program grants to Alaska have expanded from $39,594 in 1973, to $121,100 in 1974, to available funds in 1975 of $131,039.

* Enforcement has become stronger. Enforcement weakness was a key drawback of the earlier program.

Standards, guidelines, and regulations were created, initiated, and overhauled. . . .but not necessarily in that order.

Congress, in passing this law, insisted on national uniformity. What constitutes water pollution was no longer decided from a time-consuming, case-by-case, stream-by-stream study of the cause and effect of a particular discharge on a particular body of receiving water.

No longer was the legal specification of an industrial discharger's abatement obligations set forth in a vague, general directive such as the requirement to install "secondary treatment or its equivalent." What was "secondary treatment or its equivalent" after all? The answer was anybody's guess because no precise definition existed.

Under the new law, clear standards could be set for pollution control. And, total reliance on the conditions of receiving waters ended. Moreover, each industrial discharge must now meet effluent limitations by applying the best practicable control technology currently available.

Industrial dischargers--uniformly across the country--knew what they had to do and they knew they had to do it by 1977. Similarly, municipal dischargers were told that they must have secondary treatment by 1977. And, again, the law applied uniformly across the country.

The law stresses uniformity, but can it recognize a unique situation? Some of you, here, no doubt feel strongly that the particular conditions of Cook Inlet, with its natural flushing action, constitutes a situation unique enough to justify nullifying the need for secondary treatment of Anchorage's sewage effluent by 1977.

For those of you who feel this way, you are in good company. Dr. Brewer, head of the Alaska Department of Environmental Conservation, not only shares this view but can also justify it in terms of priorities. Dr. Brewer could well argue that secondary treatment for the Point Woronzof Plant would rank pretty low as long as communities in this state are still discharging raw sewage into local receiving waters.

As Dr. Brewer will tell you, only a couple of years ago a "boil water" order was issued in Cordova because domestic water supply was contaminated by septic tank overflows.

From your point of view, it must not seem logical that we have continued to press for secondary treatment for Anchorage. From our point of view, we agree, it is not logical--but to stretch to the breaking point a law that owes its strength to national consistency would be breaking the back of our whole environmental effort. We cannot afford to risk our overall effectiveness and credibility for the sake of unique situations. What, then, can we do about them?

We can recognize certain special conditions which may require--not stretching the law--but rather altering or amending it, and we can give these alterations or amendments our support. Efforts are underway by the City of Anchorage and Seattle Metro to obtain legislative relief from Congress that would exempt the secondary treatment requirement for sewage outfalls in ocean waters for the 1977 deadline. One of these efforts is in the form of a bill submitted to Congress by your Senator Ted Stevens. In essence, this bill requests that ocean outfalls, as exist in Hawaii and Alaska be exempt from the necessity of secondary treatment.

EPA is rapidly reaching the point where it will be presented with a request from Anchorage for the exemption. If we get a request with adequate justification for a bypass of the 1977 date and if the provisions of the Federal Water Pollution Control Act Amendments of 1972 are revised to incorporate such exemptions - when these two conditions are effected, then EPA will be prepared to recommend an exemption for Anchorage. By this recommendation, we would not be saying that the primary ocean outfall will or will not adversely affect the water quality of Cook Inlet, since conclusive studies have not yet been completed, but, at the same time, we can offer responsiveness and flexibility concerning this problem.

As I said before, EPA has grown up. We now have confidence and a strong base of legal support. We are no longer afraid of flexibility; in fact we welcome it. Flexibility in dealing with states and cities with special problems or considerations will strengthen the working relationship between EPA and localities. A stronger and closer working relationship will in turn strengthen the law and make us both realize our objectives sooner with a minimum of pain (hassle).

Our objectives are, in fact, the same. For example, both EPA and Fairbanks want clean air for Fairbanks. It is how fast, that causes our differences. As with Anchorage, EPA is prepared to be flexible on this issue.

As you know, this spring the Administration sent to Capitol Hill a package of amendments to the Clean Air Act of 1970. These amendments are being sought to strengthen the law and make it more workable. We support these amendments, and one of the key provisions of the proposed amendments is greater flexibility in dealing with transportation controls for those areas heavily impacted by motor vehicle pollution.

EPA, in its package of proposed Clean Air Act Amendments, has asked that - in those communities where attainment of ambient air quality standards would cause serious economic and social disruption - EPA be authorized to allow up to five additional years for compliance with air quality standards. EPA would grant this extra time only if all reasonable control measures under existing plans have been or will be instituted. Providing additional time in appropriate cases will enable communities to attain the flexibility they need to develop the long-term transportation system solution necessary to help meet air quality standards.

Los Angeles is, nationally, the example that usually comes to mind as a case where there are no reasonable solutions that could possibly allow the city to meet air quality standards by 1977. To do this, motor vehicle miles travelled would have to be cut by 100%. There is no mass transit system in Los Angeles that would allow people to make the switch from their cars to buses or fixed rail transportation. But that's DeFalco s problem; he's the regional administrator in Region IX. In Region X, we have our own cross to bear and that is Fairbanks.

Fairbanks is another city where EPA would be willing to consider extensions in the deadline for meeting the national ambient air quality standard for carbon monoxide. We have promulgated a transportation control plan for Fairbanks. A plan is needed. Carbon monoxide (CO) levels in this city during the winter frequently far exceed the national standard to protect human health. The maximum 8-hour concentration of CO recorded in Fairbanks last winter, 1973-74; was 35.2 parts per million. This is more than three times the standard of 9 parts per million. Also last winter, the one-hour standard of 35 parts per million was exceeded, with readings higher than 53 parts per million.

A problem is obviously there. As one Alaskan put it, in a recent issue of the University of Alaska's *Northern Engineer*, the automobile and the environment are incompatible in the north, and especially in Fairbanks where the natural terrain creates thermal inversions that trap the CO.

The trouble is, many people in Fairbanks don't seem to acknowledge the problem.

I don't mean to suggest that public relations will solve our environmental problems.

But, if our problems are to be solved, they can only be solved if environmental control programs have public acceptance. Once the public supports environmental goals, then you will begin to see the public take their own initiative in coming up with solutions.

EPA was delighted to see such initiative being taken at the state level right here in Alaska that could go a long way toward cleaning up the carbon monoxide problem. I'm referring to the recent move by the Alaska

Legislature to set aside funds for a public transportation system for Fairbanks. Establishing a public transportation system, there, would help alleviate the serious health and safety problems of ice fog and high carbon monoxide concentrations.

A public transportation system is not the whole answer to meeting national ambient air quality standards, but it is a significant first step. If Alaska and the people in Fairbanks keep the momentum going by setting up public transportation for the city, and instituting other control measures in the EPA plan as traffic controls and parking management, that's the type of progress EPA would regard as qualifying Fairbanks for an extension - beyond the 1977 deadline - in meeting the carbon monoxide standard. The extra time, if granted, could be used by Fairbanks, the State Department of Environmental Conservation and the State legislature to develop other locally generated solutions to solve the CO problem.

Both the Clean Air Act and the Water Pollution Control Act Amendments were intended as a challenge for every level of government and for the private sector to make a real breakthrough in our pollution control effort. We, at EPA, believe in that challenge, and we believe it can be met. From our experience with the Water and Air laws, we are convinced that their goals and purposes can be achieved. Because the laws are demanding, because they reject old patterns and approaches, because they require innovations, and because they express the real needs for environmental control, we believe they will work.

Alaska can do this, and EPA can help. Let's not work together in just a "my way" fashion. Remember that we, in Region X, do not just dictate or force the rule of law, but also can represent you and your special concerns in Washington, D.C. and in Congress. We need not always be your adversary; we can be supportive, too.

Alaska presents a wide range of opportunities -- and not just problems -- for the Environmental Protection Agency. Alaska is a land of opportunity.

Alaska, more so than any other state in the union, has the chance to make sure that the environmental degradation that has occurred in many of her sister states won't happen here.

The reason many people come to Alaska is to escape the pollution caused by the industrialized concentrations in the Lower 48. They came here, seeking the amenities of nature and the outdoors - of clean air and clean water.

Alaska is on the threshold of an industrial boom, at a time when the nation is on the threshold of a new environmental era.

Development and industrialization are inevitable for Alaska. And, with proper planning, by working together, we can insure that Alaska can show the country and the world that growth does not necessarily mean degrading the environment.

For Alaska and for EPA, this is the end of the beginning - the beginning of a new era of economic progress and environmental protection.

SESSION IV
INDUSTRIAL CASE PROBLEMS

Moderator:

TIMOTHY D. BUZZELL

MINING IN ALASKA

Ernest N. Wolff*

> "But besides this, the strongest argument of the detractors is that the fields are devastated by mining operations, for which reason formerly Italians were warned that no one should dig the earth for metals and so injure their very fertile fields, their vineyards, and their olive groves. Also they argue that the woods and groves are cut down, for there is need for an endless amount of wood for timbers, machines, and the smelting of metals. And when the woods and groves are felled, then are exterminated the beasts and birds, very many of which furnish a pleasant and agreeable food for man. Further, when the ores are washed, the water which has been used poisons the brooks and streams, and either destroys fish or drives them away. Therefore the inhabitants of these regions, on account of the devastation of their fields, woods, groves, brooks and rivers, find great difficulty in procuring the necessaries of life, and by reason of destruction of the timber they are forced to greater expense in erecting buildings. Thus it is said, it is clear to all that there is greater detriment from mining than the value of the metals which the mining procures."

The above statement was made by Georgius Agricola and published in 1550 in "De Re Metallica." Agricola, whose real name was straight German: "Georg Bauer", had a great deal to say about mining. We could quote many fascinating observations of his, but since we are here concerned with the environment, we will allow him to rest. We should note, however, that he was one of the Renaissance men, in every sense of the word: a scholar and a genius. He was also a miner, and in writing the first scholarly work on mining, gave the calling some small amount of respectability. It is a measure of the disrespectability of mining that English-speaking people waited three-hundred-and-sixty-one years before another scholar translated the original Latin into English. Herbert Hoover, later to be our 31st President of the United States, working with his wife, translated "De Re Metallica" in 1911.

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It is a peculiar fact, and a peculiar facet of human nature, that men have despised mining and mines throughout history. Although all wealth stems from the application of labor, capital and management of the industries agriculture, forestry, animal husbandry, fishing, and minerals, the world has never romanticized or respected the miner as it has the others at various times. We should therefore, proceed slowly in this day of environmental awareness to believe that we have found a new villain. Anywhere that civilization appeared in the ancient world we can be sure that there were minerals, and of course there were miners. Yet in Greek literature there is hardly a mention of mining; the actual labor was performed by slaves.

> "The Romans, although valuing minerals highly as objects of loot and tribute, disapproved of mining as an occupation in most of the Italian peninsula. This disapproval probably was based largely on the belief that military pursuits were the highest calling for Romans and that those who tilled the soil formed the best source of future soldiers. Some reverence for the sanctity of the soil may have existed that was offended by the extractive methods of mineral exploitation. Pliny the Elder wrote in A.D. 75, 'In abundance of metals of every kind Italy yields to no land whatever: but all search for them has been prohibited by an ancient decree of the Senate, which gives orders thereby that Italy should exempt from such treatment.' Although there is much evidence that prohibitions of this kind, along with sumptuary laws, were indifferently enforced in Rome's later years, nevertheless, it appears that the mineral industry never attained a place of honor among occupations accorded military pursuits, agriculture, or even trade. Most of Rome's mineral wealth came either from looting the accumulations of vanquished peoples or from provincial mines operated on tribute and worked by slaves." (ECONOMICS OF THE MINERAL INDUSTRIES, Seeley W. Mudd Series, Page 8).

The Spaniards destroyed the cultures of Western South and Central America, enslaving the people to work in the mines. They too knew that metals must be obtained, but were able through conquest to buy not only minerals with stolen gold, but almost anything else.

The Russians have for centuries banished undesirables to the mines.

Last year a widely read article in the Readers Digest said "the damage was terrible," and the results of mining in Arizona "makes you sick every time you look at it." The author of this article even picks out one miner by name, Dennis K. Pickers, a vice president of a company mining limestone, and shows the callousness and greed of the miner by quoting him, "That whole mountain will come down if we can sell enough limestone over the coming year."

What are some of the results of this attitude? Some students of Rome believe that the general prohibition or at least discouragement of mining on the Italian peninsula led to its downfall. As a result of the ability of the Spaniards to buy almost anything by following the military profession, their ascendency vanished, for they came to the point where for example, they were a seafaring people who wouldn't even build their own ships and a user of minerals using enslaved people.

I believe that it is evident by now that miners and their professions have been vilified throughout history. For the rest of this discussion, therefore, I would like you to bear in mind that there is a long heritage of buried antagonism that surfaces, like anti-Semitism, in times of stress, and that at such times, appeals to the emotions are extremely effective. Then the harmless or at worst mischievous tommy knocker of the miner becomes the wicked troll of our childhood. Bear in mind also, that like anti-Semitism, this attitude has destroyed peoples and can destroy us. Let us now look at the displeasing effects of mining.

First, we must point out that there are three sets of effects that displease us: pollution of our environment, destruction of economic bases, and affronts to our sense of aesthetics. Regarding this last point, what affronts our sense of aesthetics depends upon what we have been emotionally conditioned to hold aesthetically pleasing. I can think of no other attitude of a human being so completely ruled by emotions as what that human being considers aesthetically pleasing or displeasing. Also, what is economically damaging to us depends and changes with conditions. It would help to clarify the problem, therefore, to identify the subject as pollution, economic, or aesthetic.

Let us start with the worst offender of all; the Eastern United States strip coal mine. This creates straight pollution through water discharges, and the effect is felt in the eastern coal states and areas as far west as Oklahoma. There are basically three types of mine water discharges, Type I) alkaline with little or no iron, Type II) alkaline with iron, and Type III) acid with large amounts of dissolved iron and other metals. The fundamental reactions start with pyrite, water and oxygen:

$$2FeS_2 + 2\ H_2O + 7O2 \rightarrow 2H_2SO_4 + 2FeSO_4$$

There are two conditions that can ameliorate the effects of this reaction. 1) There may not be much pyrite to furnish sulfur, or 2) the acid may be neutralized by limestone. If effective neutralization and oxidation take place, and there is little iron present, we get a harmless alkaline solution, Type I, which can be treated quite inexpensively to bring it within acceptable legal limits. Type II waters, if not treated, may be red, and although not as harmful as acid waters, are objectionable in appearance. It is the true acid water, Type III, that causes the big damage and requires larger amounts of lime to neutralize. All three of the above types are treated by neutralizing with limestone and oxidizing with air.

Unfortunately, the addition of acid continues long after mining stops. Much of the blighted area of the east is the result of mining long since finished, perhaps more than 100 years ago, and it is understandable that the owners are reluctant to treat the effluent waters. The coal was sold for perhaps $1.00 per ton, and it is not fair nor feasible for the present owner to clean up the waters. This then devolves into a state responsibility.

A product of both the neutralization and oxidation processes is $CaSO_4$ - artifical gypsum. This by-product could be used to partially defray the cost, but as with all other situations where new sources are brought into a market, this could have disrupting economic effects. Costs quoted by Consolidation Coal Company for Pennsylvania locations in 1973 range from $0.13/1000 gallons for mildly acid water to $0.72/1000 gallons for highly acid water. Obviously the cost is an important factor, and efforts to seal off the flow of waters have been made. Sealing of old workings, however, has not been effective, since the water gets out somehow, but waters may be channeled with good effects.

Aquatic life cannot be sustained in acid waters although fish can pass through it. Also, stocking of fish in effected streams can be done so that the fish end up in water of tolerable acid levels. The fish and game department of Pennsylvania has had much experience with this.

The foregoing summary should indicate that acid mine waters are produced by the sulfides in the coal or accompanying shale. Alaskan coals, with a few exceptions that will not be mined, do not produce acid. Not much is known of our arctic coals but as of now they appear to be non-sulfide. The same is true of the western coals, and this is in large part behind the drive to develop them.

Coal mines are not the only sources of chemical pollution, and limestone is not the only chemical treating agent. Concentrating plants at mines produce or use dozens of chemicals that may have harmful effects, and these must be contained or neutralized. It is not feasible to discuss all of these, but there are routine applications of many variations of neutralization, both of acids and alkalies, and of oxidation and reduction. Some agents may even be poisonous, *e.g.* cyanide is a common agent in some gold operations. Obviously, acid must not be allowed in contact with cyanide.

Another source of acid pollution that concerns the minerals industry is the metallurgical treatment that follows the concentration. Most metallic ores are sulfides, which are "roasted" to convert them to oxides or sulfates. All roasting and most smelting operations produce SO_2, which forms an acid with water. New emission standards are now causing the industry to reevaluate its smelting methods. Several approaches are being worked upon. One is to leach the ore or concentrate rather than to smelt it; another is to recover the SO_2 before gases are discharged. Here again the by-product, sulfuric acid, could become a drug on the market. The economic effects of the new approaches are quite evident. United States zinc capacity is down drastically and the price has doubled in the last two years.

Metal mines may also be the sources of acid waters although usually not on such a large scale as coal mines. Sometimes water percolating from underground openings contains acid, since the metals occur as sulfides, but ordinarily this is not a problem.

Although I have dwelt on chemical pollution, probably the other two environmental factors, economic and aesthetic, have more of the public's attention. It should be noted here that the mining industry would be overjoyed if economics were seriously considered, for in balance the economic good of minerals far outweighs the economic damage. The economic objections to mining principally involve the disturbance of the surface so that other uses are not possible. In those cases where an open pit encroaches on buildings such as at Butte, Montana; Hibbing, Minnesota, and other cities built around open pit mining, there is nothing to be said. The harm actually belongs under a fourth classification - human, or social - rather than economic, since fair value is paid for the property. In defense of the mining industry, it may be said that highway construction and urban renewal - deliberate policies of our government - cause much more human and social displacement and actual anguish than mining ever has. Another economic effect of especially open pit mining is the creating of excavations where the surface might be put to other uses. Remember what Agricola said? He also said that mines are usually located in areas not well suited to other use. "Moreover, as miners dig almost exclusively in mountains otherwise unproductive, and in valleys invested in gloom, they do either slight damage to the fields or none at all. Lastly, where woods and glades are cut down, they may be sown with grain after they have been cleared from the roots of shrubs and trees. These new fields soon produce rich crops, so that they repair the losses which the inhabitants suffer from increased cost of timber. Moreover, with the metals which are melted from the ore birds without number, edible beasts and fish can be purchased elsewhere and brought to these mountainous regions."

Much disruption of land by coal mining occurred long ago when the surface had little value. Now that it has value, it is reasonable to assume that when that value reaches the cost of restoration, the land will be restored. That day is not far off. Underground mining likewise creates economic damage, notably through subsidence. Differential subsidence causes buildings to fail; the solution, if subsidence cannot be avoided, is to cause the surface to settle uniformly. In Germany the owners of buildings have no legal recourse as long as subsidence is uniform.

Let us now turn to a form of mining that is most noticeable to Alaskans: placer mining. Placer mining is the digging of alluvium, gravel, and running it through a washing device to catch the gold, then stacking the residue. Placer mining got its really black eye in California where hydraulic and dredge tailings covered farming and grazing areas. At least as long ago as 60 years the practice of "resoiling" as it was called, was instituted. This simply means that the surface is smoothed and fines are added to make the land useable again. In Alaska the situation is different. There are about 9,000 acres of dredge tailings in Alaska, or about 0.0024% of Alaska's 375 million acres. Let us bring these 9,000 acres further into perspective. If we consider that the road from Anchorage to Fairbanks is 100 feet wide and 360 miles long, a quick calculation indicates about 4,500 acres are disturbed, or for this one road alone, half the area of our tailings.

These tailings are located mostly in creek bottoms which, to judge from similar valleys that have not been mined, are generally unfit for agriculture. Let us look at the other possible uses.

The undisturbed creek bottoms are, first, useful for wildlife habitat, known as moose pasture to many. The tailings at Fox, near Fairbanks, mined during the thirties, now support birch, up to several inches thick, willow, aspen and alder, and incidentally many moose and waterfowl. The irregular surface apparently does not bother the animals. Another use of the tailings is for homes and commercial buildings. For residences, the rough surface has been utilized, in conjunction with some grading, with good effect. For commercial uses, the surface was smoothed with bulldozers. Some tailings, as at American Creek, Manley area, are indistinguishable from the unmined areas, since they were mined by flume dredge, which mixes fines with coarse material and lays a fairly flat surface of tailings. Finally, the tailings are a very valuable source of gravel.

I believe that in judging the effects of placer mining in Alaska, consideration should be given to alternative treatments of tailings. It is probable, if dredging should be resumed at Fairbanks, that the economics of the situation would indicate smoothing for building sites. However, for most of our tailings, the rough surface will suffice for most uses, and might actually be superior.

Another aspect of placer mining is probably unknown to most people because there is nothing left to see. As much as 100 feet of muck, black muddy material, may have to be stripped, removed by water and allowed to run to major drainage and eventually the ocean. While the stripping is going on, the streams run black and are loaded with suspended solids, an unaesthetic mess if ever there was one. Let us take a closer look. The most intense muck stripping ever undertaken was at Fairbanks. The streams that carried the muck away were the Chatanika, Goldstream, and the Chena River. The first two empty into the Tanana via the Tolovana, but first they must thread their way through the Minto Flats, a maze of low-lying ground and lakes. The net result of this stripping was to possibly silt up a few of the lakes, but its effect on present day fishing and hunting cannot be measured. The muck that went down the Little Chena flowed past Fairbanks, but people either looked away or didn't notice it, because before the Tanana dike was built in 1941, silty water from the Tanana flowed past Fairbanks anyway. The muck from Cripple and Ester Creeks entered the Chena below Fairbanks. During the late forties this muck built up in the Chena to just below the surface, leaving a narrow channel. After three or four years of this inconvenience, it was flushed out and today cannot be seen. What is the temporary effect on wildlife and fish? I am not a biologist, and can only report my observations. I do not believe that there is the slightest evidence in salmon production statistics that the muck affected the catch. When streams near the Yukon were being stripped, the grayling went up in the spring and came down in the fall just as they did before and do now that mining is finished.

Now let me make a few generalizations about our subject. Without mining, most of us will perish. Our population has been pyramided so that we must maintain our technological level to survive. Also, we are feeding much of the world now. In view of this we may as well admit that we are going to have mining. Mining produces a non-renewable resource with many side effects that many find objectionable. One social effect that I have not mentioned stems directly from the non-renewable nature of mining. When the ore is gone the miner and his family must move; he cannot plant a new crop.

This and the other effects, some of which I have mentioned, have distressed mankind since prehistory. There are several things that we can do in the face of this distress; we can prohibit mining as the Romans did, but we must face the facts squarely. If we want to eliminate all effects of mining, (notice that I don't say "undesirable effects" because there is always someone who will find them undesirable), then we must pay, and we should know the cost. A law of our land says that we will have clean water in eleven years, by 1985. The cost of this worthy aim will be either to drastically reduce our technical production or else to direct our whole national effort to the job. Obviously we should find a way to compromise. Perhaps we can put up with some impure waters and clean up others. It is the same with mining. We should certainly bend every effort to eliminate chemical pollution, but perhaps learn to live with irregular tailings and temporary muck stripping. We must learn to ask ourselves, "Is my objection directed toward a dangerous pollutant or is it based upon economic, social or aesthetic values?" If economic, what is the cost, especially if balanced against the economic consequences of mining or not mining? If social, what is the alternative? All social injustices against individuals are justified by the perpetrators; most of us can accept some of these individual injustices if they confer a greater benefit upon society and if the individual is adequately reimbursed economically. Finally, is our displeasure due to aesthetic reasons? Here we must be most careful of all, because as I have already said, aesthetics are based upon emotions, which in turn are to a very large extent conditioned by background. How many of you have seen a "beautiful" mine face, or gone into raptures over a perfect blast? Do we wax indignant over the depredations of a glacier, or the high cut banks caused by lateral stream erosion? Consider the natural groundwater at Fairbanks. To make it useable for the ordinary modern household, it must be treated with 1) aeration, 2) chlorine, 3) some polyphosphate, 4) sodium bisulfite, 5) sodium hydrosulfite, 6) potassium permanganite, 7) manganese greensand, 8) sodium chloride, 9) zeolite, and 10) sand and gravel filters, and this is a fairly simple installation.

I could continue talking about mining and the environment for a long time but I believe it is time to close. I hope that I have given you some insight into not only the environmental problems created by mining but the industry's problems created in trying to cope with these problems. Above all, I hope that you will maintain a sense of perspective so that we can keep the real problems separated from what only appear to be problems.

INDUSTRIAL CASE PROBLEMS - ALASKA SEAFOOD PROCESSORS

Roger DeCamp*

The National Canners Association is a nationwide non-profit trade association with headquarters in Washington, D.C., founded in 1913. Our members pack about 90 percent of the canned goods produced in the U.S. The Association has a number of divisions which handle the usual trade association duties of government-industry relations, public relations, and information collection and distribution, but what makes the Association unique is that we have a Research Laboratory Division with laboratories in Washington, D.C., Berkeley, California, and Seattle. The Laboratory Division acts as technical arm and spokesman for the canning industry. Each laboratory works closely with the industries in its area. In the Seattle Laboratory we are most closely associated with the seafood industry of the Northwest and Alaska. Our work covers a number of areas and we have been working in the waste abatement field since about 1965.

The seafood industry in Alaska, although small in relation to total canning industry in the U.S., is the major State industry. It is characterized by a number of relatively small companies operating plants in small villages and remote areas along the coastline from the Yukon to Southeastern. Present processing waste handling procedures in most cases consist of direct discharge to the marine receiving water. Local conditions, short cyclic seasons, and decreasing profit margins have hampered attempts at more complete treatment. Even simple primary treatment is complicated by the fact that solids disposal is a major problem.

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NCA has worked to determine the characteristics of seafood waste and has funded studies on the effects of direct discharge in the receiving water. We have also studied the use of treatment equipment including dissolved air flotation and screens. The receiving water studies have shown no degradation of water quality resulting from direct discharge in the limited areas examined. Studies on treatment equipment have shown that existing technology from other food areas cannot be transferred directly to seafood waste treatment and each system must be evaluated on a commercial basis before definite conclusions can be drawn.

During the past one-and-a-half years considerable time has been spent working with regulatory agencies on State permit requirements and EPA seafood guidelines. We feel that economics and local conditions must be taken into account in establishing waste treatment levels. In some areas where environmental problems cannot be demonstrated direct discharge of seafood waste should be permitted to allow the material to re-enter the normal food chain. In areas with demonstrable pollution problems, treatment should be required to the level necessary to correct the problem. Hopefully the regulations presently being considered will take all these conditions into account and not require treatment for treatment's sake. Unduly harsh requirements will drive marginal operations out of business and result in increased costs to the consumer.

PULPING OPERATIONS IN ALASKA

Oren A. Mason*

I would like to start off by correcting a misconception. I am listed as representing the Lumber industry and what I know about lumbering could be put on the head of a pin. I am afraid that in this day of specialization, whatever expertise I have developed is in the field of pulp and paper, which true, is a branch of the forest proudcts industry. Within the industry we tend to regard lumbering as the cutting down the tree and processing it for 2x4's and shingles and whatnot, so that we don't really regard ourselves as lumbermen. Referring to some of the other speakers, I was most interested in Dr. McKinney's talk and impressed by the fact that the Environmental Protection Agency apparently is now recognizing that Alaska is different. I am afraid I have a bit of a name for myself with that phrase with Region X, and when I say Alaska is different, Dan Bodien and some of the others in Seattle cringe a little bit, but it is different, and there is no getting around it. Most of our environmental problems today have their root, not so much in the problem itself, as the insistence upon trying to solve it with methods appropriate to the Houston ship canal, Washington, D.C., or the Hudson River. What we really need are methods appropriate to the inside passage in Alaska, or the Tanana River or the North Slope. I tend to divide the problem, if you like, between the natural and the man-made problems. When we come to Alaska we recognize the natural problems. We know things cost more up here. We know that transportation is difficult. We also know that with the intelligent application of technology and technical expertise, they can be solved. The solution is all too frequently hampered, however, by the man-made problems. This can come from several sources. For instance, you get into the situation where solutions and methods are being dictated by people who have no knowledge of what they're talking about. Now, a good

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illustration of that is in the story concerning a senate hearing on the subject of guidance and limitations for the pulp and paper industry. EPA was in attendance and was testifying as to the levels which were appropriate for the various parameters. One senator, who had had a rather tough night the night before, was dozing quietly in the back rows, and about the time when EPA recommended a range of 6.0 to 8.0 for pH, he awoke with a start and decided that he'd better get on the record for the folks back home and he lumbered to his feet. He got up and said, "Now just a minute. I want to protest! We have been entirely too soft on industry for years and I must register my protest and on this parameter I urge that we make it zero." This sort of thing goes on entirely too frequently and does cause rather critical problems for the poor schnook in industry whose job it is to protect the environment, and believe me, we have been working on this for a long time. It was mentioned that I have been working on it steadily since 1960. Not very long, but longer than most people in the audience and I do know about the word ecology. As far as Alaska Lumber and Pulp is concerned I started with them in 1965 and early in 1966 I helped develop a plan, a master plan if you like, which to this day is the blueprint for our environmental program. We are still following it, and in spite of the changes in the regulations, and the changes in the law, if I were to re-write it today I wouldn't change a word of it -- it still fits the situation. Now, when you consider that the Water Pollution Control Act was passed in 1967, the Clean Air Act was amended in 1970, and PL 92-500, was passed in 1972, I think we are fairly timely. Now, in our problems in Alaska and in southeast in particular, the chief natural causes of problems are a lack of energy and a lack of space. When you talk of putting in a secondary treatment plant that may require a three hundred acre lagoon, and you try to find three hundred acres of flat land where you can make a lagoon in the vicinity of Sitka, Alaska, you've got a problem. So basically, we're forced into the use of much more sophisticated and much more expensive treatment. We are currently planning and developing our evaluations of some of these methods by pilot plant; contracts have been signed, and the programs are on the way. Maybe I'm a little naive, probably I am, but I feel that the purpose of treatment should be a means to an end--the end of improving the environment. I get the distinct impression with today's laws, that treatment has become an end in itself. It doesn't matter if you're meeting the water quality standards. It doesn't matter if the winter fishing grounds are within a hundred yards of your outfall. Thou shalt provide secondary treatment, to reach a definite level of BOD in your outfall and it doesn't matter if this costs fifteen to twenty million dollars in capital expenditure and three million dollars a year in operating costs. I just don't think this country can afford this sort of nonsense. I heard one of the speakers yesterday saying that we have to protect the competitive position of industry in the lower 48, so we can't ease off up here. Damnit, we have already, a 1.9 multiplier over Seattle prices for anything we need to built. I think it is pretty nearly time that the industry in Alaska got a break; not at the expense of the environment, but let's not do what is not needed. We can't afford it and you can't afford it - because sooner or later, you're going to pay for it.

Now, I mentioned the National Pollutant Discharge Elimination System (NPDES) program and permit, and I think you have probably gathered by now that, in my opinion, secondary treatment is the main bone of contention. We do have firm indication that with the start up of our new recovery boiler, which is scheduled for this fall (it is now about 80% complete, and incidentally this little gem cost about 20 million), we will be meeting and exceeding all of the standards for water quality of the state of Alaska. Now, NPDES says, thou shalt apply "best practicable" by July 1, 1977. "Best practicable" hasn't been defined yet. As a matter of fact the firm of consultants in Washington, D.C., WAPORA, is currently conducting an investigation as to what constitutes the "best practicable" for sulfite pulping industry. Their report is due in October and I should mention in passing, that even though better than 25% of the dissolving sulfite pulp made in the United States is made in the two Alaska mills, there is absolutely no indication that WAPORA is going to make the trek to Alaska to find out what conditions are here. It would appear that "best practicable" is going to be based upon mills in Florida and possibly one or two in the Pacific Northwest. They still are using guidelines which were set, I believe, in 1969 or 1970, for a completely different purpose, and having nothing to do with practicability or availability, and we must regard them as arbitrary. To me, it seems most inappropriate, and as a matter of fact it has a bit of an Alice in Wonderland characteristic to it, that our company is engaged in a program which, by mid-January, will indicate need and availability of treatment. EPA itself has an on-going program which will come up with a number on October 1, 1974, and yet we received a permit, on September 28, 1973. It is a little bit like sentence first - trial later.

There are other problems involved in the whole business of the permits. Ketchikan Pulp, for instance, has been negotiating with the federal authorities on the basis of treatment plants for their lumber camps, with the literal interpretation requiring installation of package plants for 5-to-10-man camps. I'm not sure; I haven't read all the details on this, but I don't think they require port-a-potties for the men when they go out on the job. ALP (Alaska Lumber and Pulp) does not do any logging. All of our logging is done by contract, and believe me, I am very thankful for that small advantage.

The level of suspended solids is another area which is under some challenge and here is a particularly frustrating area. We have Alaska State Discharge Permit No. 71-1, and that "1" means that we were the first permit issued in the State of Alaska, in 1971. Under this, we were required to install primary treatment, gravity sedimentation. The design criteria on which this was based was attainment of treatment for all streams containing 0.4 tenths of a pound of suspended solids or more, per 1,000 gallons (48 mg/l) and the reduction of suspended solids in the outfall to not more than 0.4 tenths of a pound per 1,000 gallons (48 mg/l). This permit was negotiated, agreed to and signed, and over a period of about a year and a half we installed a 2-1/2 million dollar plant for the removal of suspended solids. The plant went on line in December, 1972 and from that time has been operating continuously and has been exceeding the requirements of our permit. We have been running about 0.3 to 0.35 pounds per 1,000 gallons (36 to 42 mg/l) against a requirement of 0.4, or about 20-25 percent better than required. Now, we get NDPES permit and suddenly the rules change and it appears that our nice new installation, 210-foot diameter clarifier with rim drive, is suddenly obsolete because the new rules say not only are we required to achieve a maximum of 20 pounds of suspended solids discharge per ton, but also we must provide separate treatment for the backwash of our filter plant. Now, we don't treat the water; we just filter a bit of silt out of it, a matter of 200 pounds per day, but one of the shibboleths of our control system is thou shalt not put back anything once you have taken it out, so this 200 pounds must receive separate treatment and then be included in the total outfall load. Configuration of geography of our area is such that, at a guess, I would say in order to remove that 200 pounds of silt that came in with it in the first place, will probably cost in the vicinity of one and one-half to two million dollars. To me this is sinful. Waste of this magnitude is just absolutely inexcusable. I still think, though, that the final insult of the NPDES permit is Clause S11C, and I'll quote this verbatim without comment.

> "Nothing in this permit shall be construed to relieve the permitee from civil or criminal penalties for non-compliance, whether or not such non-compliance is due to factors beyond his control, such as equipment breakdown, electric power failure, accident or natural disaster."

That's enough for NPDES.

Now, I've been sort of sniping away at EPA so far. We do occasionally have some minor problems with the state as well. This is particularly evident in the field of air pollution control. This field of air pollution control, technologically speaking, is in a bit of a primitive state. There is quite a bit of disagreement among the experts as to the proper means of measuring the concentrations of impurities in the air. The Clean Air Act of 1970 is very specific. It addresses itself to the concentration of impurities in ambient air and specifies in some detail the methods to be used in measuring them. It also charges the state with the job of setting emission standards from point sources. These standards are to be set at a level that protects the integrity of the federally set ambient standards. It specifies some, but not all, of the testing methods to be used. It is easy to understand how strict rules are needed to clean up areas of large concentrations of industry. In an area such as southeast Alaska, in my opinion, the occasional column of smoke rising in a wooded area is not all bad. It provides a homing beacon for seaman. As a matter of fact I've gotten in a couple of times myself by boat by picking up the smoke from Sitka. There are even some people who are gauche enough to regard this column of smoke as rather beautiful. When you see a picture of a landscape with trees and hills it is a little bit monotonous; but when you add that little band of smoke coming up, it adds a little humanity and warmth to it. So all of this, of course, brings us to the concept that the beauty is in the eye of the beholder. I know that an awful lot of young ladies need not worry at all about passing a law as to what is ugly and what is beautiful, but there are some of us that would be in rather bad shape. I, for one, would just as soon avoid legislating control of beauty.

Surely, here in Alaska, the requirements are different--they've got to be. They are! And not quite the way you might expect. Back on November 25, 1971, the Federal Register published recommended maxima for emission standards. A comparison of these recommended values with those which became included in the Alaska State Air Quality plan are quite revealing. I've recalculated these things to put them on the same basis, but it does give you a pretty fair idea of what we're up against. Incinerator emission for instance - Federal Register recommended 0.2 of a pound of particulate per 100 pounds of refuse. Alaska State standards - 0.1 of a pound. Fuel burning equipment - 0.3 of a pound particulate per million BTU's and Alaska standard for new facilities - 0.1 of a pound per million BTU's. Existing facilities - 0.2 of a pound per million BTU's and wonder of wonders, on equipment burning wood waste, they allowed the Federal Standard - 0.3 per pound particulate per million BTU's. In the particulate matter from recovery boilers, sulfite pulping, they did not quote in the Federal Register, however, Washington and Oregon have passed federally accepted standards of 4 pounds per air dry ton of production. The state of Alaska, 2 pounds per air dry ton of production. Differences are justified on the basis that, "all emissions standards from the Federal Register are based on source test data that includes both filter and impinger catch from source test trains. The Alaska regulations are based on filter catch only, so these numbers may be increased by 10% to 100%, to compare with the guideline figures." Very interesting! At ALP we ran a number of pilot plant evaluations on air pollution abatement equipment and in the course of one of them we retained a consultant Valentine, Fisher and Tomlinson of Seattle, who have some expertise in the field of emission testing. In a well run test, with equipment in good condition, the difference between the filter catch and the filter plus impinger catch was 7.8 percent on the particulate emissions from a sulfite recovery boiler. This seems hardly justification for cutting the allowable levels in half. Now, one or two footnotes should be added before leaving the subject of air. First, I mentioned that Washington and Oregon originally required both filter and impinger catch. I now believe that Oregon has since dropped the requirement of the impinger section and set the limitations at 4 pounds per ton. Washington has not yet changed. Second, and very important, the lack of road and rail transportation in southeast Alaska, makes salt water transportation of our logs mandatory. As a result, particulate emission from both the recovery and bark boiler consists largely of salt water chemicals of very fine division and the mean diameter of the particles is less than one micron with about 40% of it less than 1/2 micron. This has imposed a further jog on us in that for the first two or three years when we are looking for equipment we'd call a manufacturer and say - "Look, we've got a problem - we want to clean up our air emissions from our sulfite recovery boiler" and they'd say "Oh fine - we have just the thing for you" and they'd want a definition of the size distribution and we'd give it to them and there would be a slight pause at the other end of the phone and they ask if we were sure of those and we'd say "yes, we're quite sure. They are the result of independent tests," and they'd say "Well look, I've got a call on the other line. Do you mind if I call you back?" You know, they never call back and as a result we have been pretty well faced with the necessity for developing our own means of removal of particulate within the framework of power available to us. You can take it out with a high energy scrubber, but the trouble is that the high energy scrubber would probably take 2,000 H.P. to operate and we just don't have it, and no way of getting it.

I've probably given a fairly false impression, one that I don't want to give, and that is that the regulatory agencies are responsible for all of our woes and for all the problems in southeast Alaska - this isn't so. There are many cases where even in spite of complete cooperation between industry and the agencies, a solution isn't available. Here I'll go to the lumbering industry for a concrete example of this - and this is the case of a conical burner at Wrangell. It is a real problem. They are emitting fly ash and the people living around them are most unhappy about it and justifiably so. The town of Wrangell has two saw mills - the Wrangell Lumber Company in the center of town and Alaska Wood Products which is a short distance out. Both mills are under the same management. Both mills manufacture cants for overseas shipment. There are no shavings, very little sawdust in their waste, logs are de-barked and slabs and waste wood are reduced to chips for the manaufacturer of pulp at Sitka. The remaining waste, mainly bark, is burned in conical burners, one at each mill. Shortly after the acceptance of the Alaska State Air Quality plan, the Department of Environmental Conservation quite understandably began pressuring for something to be done. Management of the mill was extremely cooperative. They investigated many suggested changes, they retained consultants. Lance Ingle, the manager, made several trips to the lower 48 to observe equipment in operation. Finally a solution was found; an attachment for the burners which would provide redistribution of the heat and air and promote complete burning of the bark with the elimination of the smoke and fly ash. A plan was developed involving closing one of the burners, the one in town, trucking the waste all to the other one, and burning all of them in the one re-equipped burner. Using only one burner would have the advantage of providing a steady source of fuel so that they wouldn't have to burn it down once a day and this is the time when the problems arose. The manaufacturer of the attachment gave every assurance that the system would work without a hitch. A truck was purchased to haul the waste and the AWP burner was modified and the change was made. It was, and still is, a flop. It seems the equipment had never before had to cope with the wet hemlock bark undiluted with more flammable material, and with the high humidities that are normal in southeast Alaska. The last time I talked with Lance Ingle, the manager of the two mills, he had no idea of what he was going to do. Now, certainly a solution must be found. Otherwise a very lovely, historic town in southeast Alaska, with a slight smoke problem, just won't survive. It is that important! So where do we go from here?

There is some indication that the federal requirements are easing. At a meeting of the Water Pollution Control Federation in March, one of the EPA executives announced that there was a modificattion due in the requirements, particularly for municipalities, and that the requirement of secondary treatment for discharge to saltwater would probably be dropped. I hope it is done in time to save us 15 million dollars. But easing the requirements in specific areas is not going to solve the problem. I think everyone must recognize in this day and age, that our environment is under attack and we must take appropriate action to improve conditions. I think the methods we are using are dead wrong. We don't recognize the need for time. We don't recognize the need for development of technology. All that we want to do is pass a law to make somebody else do something about it and not interfere with our own little non-polluting lives. I would suggest a four-step program, cooperation between industry and authorities, with the general public kept well informed of what was going on. First - investigate the need in each specific area. Second - develop a plan for eliminating the problem, however much time it takes. Third - set up step-wise, attainable goals to bring us from our present position to the position which we desire to reach, and Fourth, and most important, develop a climate in which industry and the authorities stop talking past each other, start accepting the fact that both are working for the same thing, and cooperate.

OIL AND GAS INDUSTRY
STANDARD-SETTING AND COMPLIANCE PROBLEMS

William W. Hopkins*

The problem for the responsible agency is to set standards that are achievable but don't fall so short as to leave environmental benefits on the table. Every conscientious custodian of the public air, land and water, for eight hours or more of every working day, is painfully aware of the awesome difficulty of finding where that line falls. He must probe with all resources available to him for that elusive mark.

If the standards are set so high that the best practicable technology available would not bring industry operations into compliance, the public is not served.

Frequently agencies attempt to establish standards that are too close or even beyond that line. We grant that the conscientious regulator is trying to establish the highest quality level actually achievable. One common source of trouble is standard-setting on the basis of known or claimed performance processes and equipment that may not work--or work consistently--in all situations to which the standard will be applied and enforced. Certainly the claims of the manufacturer or systems developer should not be used as a basis for setting general standards, when the system or equipment:

1. Has been proved out operationally only on a limited scale,
2. Has not performed under all conditions to which the resulting standard will apply,

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3. Is not warranted to maintain performance at the levels set in the standards,
4. Whose cost is not clearly in line with the reasonably demonstrated benefits, and
5. Which entail installation lead times that lag behind the dates established for compliance.

Very much a case in point currently is the subject of EPA adjudicatory hearings on applications by Cook Inlet petroleum platform operators for NPDES discharge permits.

The "state-of-the-art" of effluent and emission systems is a very basic element in the setting of standards. . . quite appropriately, our industry would quickly agree. The law involved requires the use of the "best practicable control technolgoy available," by the compliance date (July, 1977). Unfortunately, the term is not further defined, and interpretations of the regulator and the regulatee tend to vary.

The agency is understandably sometimes too receptive to optimistic news about a system that works in a particular application. The agency is inclined to bear in mind that performance record as it considers the numbers that will go into standards. On the other side of the board, industry experience leads to concern that systems that worked fine for some operations may not do it in another where scale and other conditions differ.

The implications of enforcement are grave, indeed, if the values are set at unrealistic levels.

How far apart can the estimates of "best practicable control technology currently available" be between the agency and the industry? In the Cook Inlet discharge permit case, EPA's final effluent limitations require that the effluent oil be limited to a range of 15 mg/l average and to a range of 5 to 20 mg/l maximum. The platform operators believe these values are unrealistically low. They feel that the U.S. Geological Survey's limits represent what is consistently achievable with available technolgoy. The USGS limits for oil discharge are 100 ppm maximum from equipment designed and maintained for an average of 50 ppm.

Results of an industry status report on the "state-of-the-art" in offshore oil production oil-water separation are cited by the applicants. The study of facilities in the very active Louisiana offshore area entailed a controlled testing problem with many thousands of observations and participation by the EPA. Some of the conclusions referred to experience with water clarifiers, whose optimistic design ratings influence setting of discharge levels for permits. It was found that manufacturers tend to overstate the capabilities of their equipment and that none can provide an acceptable performance guarantee.

Even with the construction of necessary additional platform space and new equipment at exorbitant costs, there is no reasonable expectation that the proposed objectives of the agency can currently be accomplished.

The attempt to raise the quality of water by the setting of currently unachievable standards can actually retard progress toward this end. Installation of available equipment capable of maintaining improved values--but much short of those aimed for by the agency--has been held back while operators try to find equipment that will cut the mustard for their particular operation under the idealistic low numbers sought by the agency. Meanwhile the time for compliance draws closer.

Even in some situations where reliable equipment is available which will consistently meet values set, it may not be in the best public interest to require certain low limits for some kinds of effluents in <u>all</u> receiving waters. For example, Cook Inlet operators argue that the concentrations of phenols involved in their operations are not a problem and therefore that treatment facilities should not be required. Treatment facilities in these instances have little real benefit but would be costly--as much or more costly than in situations elsewhere where they are necessary.

WASTE DISPOSAL FROM NITROGEN FERTILIZER PLANTS IN ALASKA

D. H. Rosenberg* and D. W. Hood**

Alaska has one major nitrogen fertilizer complex. Located in Kenai, Alaska on Cook Inlet (Figure 1), this plant produces approximately 450,000 tons of ammonia per year from which 300,000 tons of pelletized urea are produced. The remaining ammonia is sold as a liquid for use as agricultural fertilizer. This plant which was completed in early 1969 uses natural gas from the Kenai gas field as its source of raw material. In the process of synthesizing the ammonia and urea, wastewater streams are produced. The flow of these effluent streams averages 850,000 gallons per day. Estimates prior to plant start-up were that these streams would contain approximately 7,300 pounds of ammonia nitrogen per day. This would then represent an ammonia nitrogen concentration in the effluent streams of approximately 950 ppm. It was determined by the company that the most acceptable method of disposal of this effluent is through dispersal into Cook Inlet. This then posed the problem as to what effect this effluent would have on the natural environment of Cook Inlet. Questions regarding what would be acceptable levels of ammonia in the immediate region of the outfall, the type and design of diffusion system should be used to reach these levels, and what would be the overall "long-term" fate of the effluent in the inlet were required to be answered.

To answer the question regarding the levels of effluent which would be acceptable into the diffusion zone, toxicity studies of the effluent on marine biota were undertaken. First experiments were designed to determine

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Such action is wasteful of a limited resource: money.

An ethic is developing that says you shalt not waste water. . .or land. . .or air. . .or energy. It is high time for that ethic, for those things have not always been properly valued. Unfortunately, not everyone who endorses that ethic recognizes other related and important values: time, talent and training. In our society, they are values expressable in money as well as in other terms. They can be exchanged for money, and money in turn can be exchanged for them, dirty as that may sound to some who think money and ethics don't mix. Time, talent and training can also be exchanged for clean air, clean water, and the esthetic and material benefits of land. Like water, land and air, time, talent and training should not be wasted--nor should the money for which they are exchangeable.

It makes no long-term sense to squander such assets when they are so needed in the actual enhancement of other values important to our society.

Neither our industry nor any I've dealt with would argue we don't need government standards and enforcement. We do need them; competitive forces rule out consistently effective self-regulation.

Nor do I often hear serious criticism of the professional competency of the agency people who serve in those areas. It is more often policy established by non-technicians that aggravates the differences between industry's technical people and their equally-competent counterparts in the employ of agencies. The managers and technicians on either side must operate in an environment of fragmented and confused public policy.

We need standards that are achievable and whose application benefits the public in the long run--which means in part that the costs of compliance should be commensurate with benefit to the public.

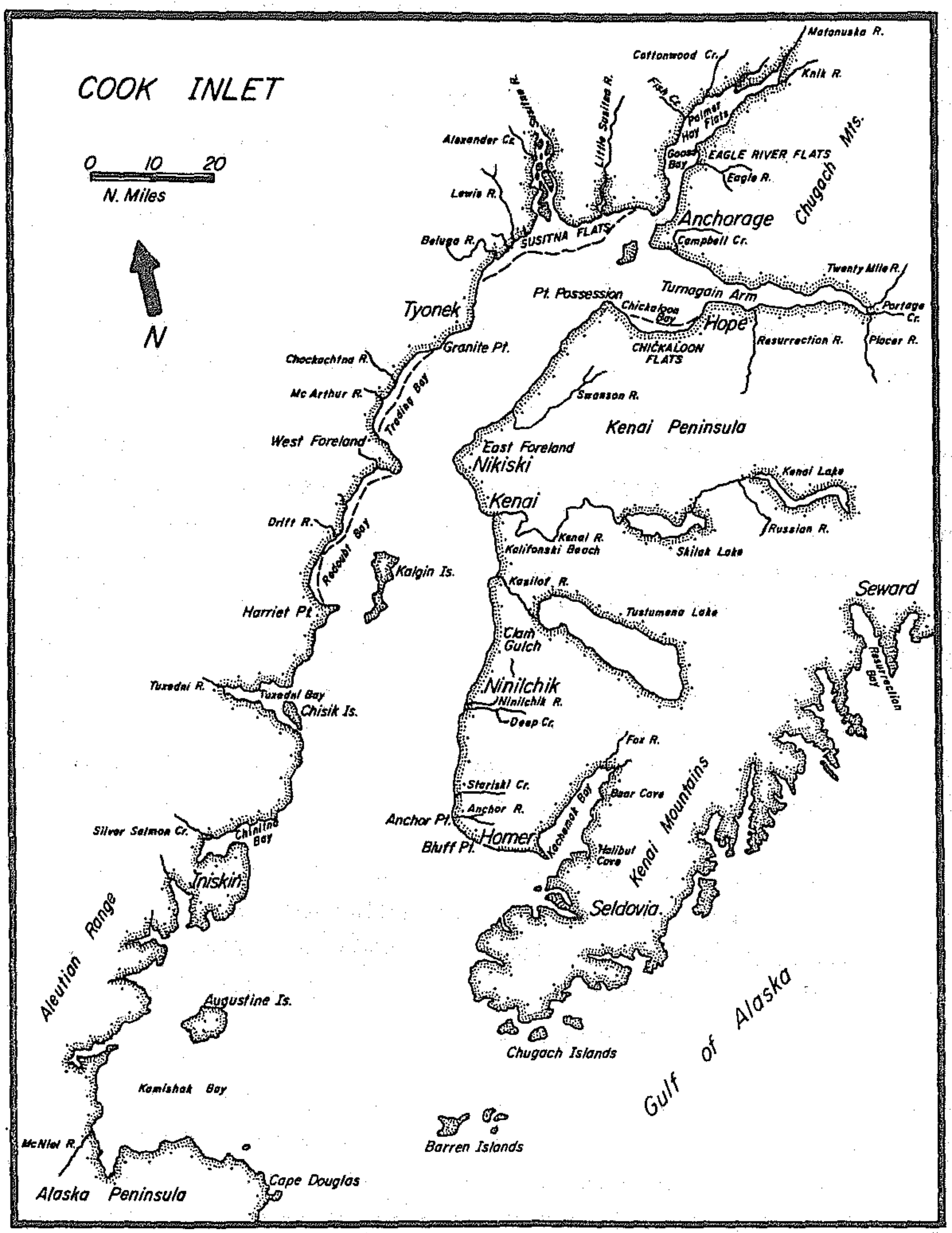

Figure 1: Cook Inlet, Alaska

the concentration of effluent which would not inhibit the vital processes of organisms forming the basis of the marine food web. In most marine systems the organisms responsible for primary production, *i.e.*, fixing carbon by utilization of carbon dioxide, nutrients and sunlight through the process of photosynthesis, are the phytoplankton. The most abundant organisms utilizing this fixed carbon produced by phytoplankton, and are thereby designated secondary producers, are the zooplankton. Most animals of the marine biota have the zooplankton as the basis of their food chain.

In general it is rational to conclude that if the vital processes of the primary and secondary producers of a marine system are protected that the health of the system will not likely be impaired. Exceptions to this arise if excesses are encountered such as over fertilization by sewage effluents in which the composition of the biota changes, excess biological oxygen demand which causes dissolved oxygen depletion in the water, or a specific contaminant affects a vital biochemical process of a high organism which may not be functional in the plankton community. The first two of these effects can be determined by monitoring the species diversity of the system and the oxygen concentrations of the water column. The latter effect is unlikely for a natural component of the nutrient cycle such as ammonia but would be more likely to occur in exotic compounds such as pesticides or polychlorobiphenyls which are strangers to the biological cycle.

Accordingly, the effect of ammonia concentration of the effluent on mixed cultures of phytoplanktonic organisms collected at the outfall site and on laboratory phytoplankton cultures were examined. Also, the effect of the effluent on the respiration of zooplankton was examined and some acute toxicity tests on zooplankton were made.

Indigenous phytoplankton and three laboratory cultures of diatoms were used in experiments examining the effect of various ammonia concentrations on photosynthesis by these organisms. The pH was controlled to levels found in Cook Inlet (7.8 to 8.4) and carbon uptake as measured by incorporation of radioactive carbon-14 (Hood *et al.*, 1960; Rosenberg *et al.*, 1967). The summary results of this experiment indicated that concentrations of effluent containing less than 1 ppm of ammonia would not effect photosynthesis of any of the organisms investigated. A static concentration of about 15 ppm would reduce photosynthesis of organisms to about 50 percent of that of organisms growing in natural Cook Inlet water.

Experiments on the inhibition to respiration and acute toxicity to zooplankton were made by examining the effect of gradient amounts of effluent on the utilization of oxygen by zooplankton organisms collected in net tows from the inlet.

Because of the lack of abundance of zooplankton at the effluent site and other technical problems associated with O_2 utilization techniques these experiments were limited in scope. However, those results which were obtained indicated that an effluent concentration containing as high as 33 ppm ammonium did not influence oxygen utilization of the experimental and control organisms.

In the acute toxicity experiments organisms were examined for mobility after exposure to gradient amounts of effluent for periods of time up to 4 hours. It was found that all the organisms survived an exposure to 50 ppm ammonia for four hours but at concentrations of about 100 ppm the organisms were paralyzed followed by death in an exposure period of 50 minutes.

Based on the above data it was concluded that concentrations of effluent containing ammonia concentrations of less than 30 ppm would not effect the zooplankton organisms adversely.

Since salmon were the major commercially important fish found in the outfall région, studies were also undertaken to determine the acute toxicity of the effluent on them. The data obtained in these studies indicated the coho salmon in sea water would not be affected at concentrations of ammonium salts just below 43 ppm ammonia in water of salinity 29°/oo and a temperature between 15.5°C and 16.0°C.

From these data it was determined that acceptable levels for the concentration of ammonia would be less than 20 ppm within 10 feet of the outfall and less than 2 ppm at a distance of 30 feet from the outfall. It was obvious that to reduce the concentration from 950 ppm in the wastewater system to less than 20 ppm 10 feet from the outfall, a type of diffusor system was necessary.

The actual diffusor design was based on turbulent jet mixing theory (Swansburg, 1967). In order to reduce the concentration of ammonia to less than 20 ppm within 10 feet (65 dilutions), the jet mixing theory requires that the orifice size be 0.59 inches or less. The 0.59 inches was selected as a smaller size offered no particular advantage. A jet velocity of 16.3 feet per second was selected since it was high enough to assure good jet penetration and distribution and yet low enough to avoid undue orifice erosion and pressure drop (Swansburg, 1967). The plant was designed to have a waste flow rate of 1,224 gallons per minute, thus the diffusor system would require a total of 90 orifices.

The plumes from each orifice would be 4 feet in diameter at a distance of 10 feet. In order to prevent overlapping of these plumes within the 10-foot distance, the orifices were placed 49 inches apart. The resulting diffusor was thus required to have a total length of 360 feet. The system is shown in Figure 2. It consists of two pairs of 8-inch pipe, each 45 feet long which are attached to the wharf cassions.

The calculated plume paths in cross section for the minimum and maximum current velocities are shown in Figure 3. This figure was generated by computing the maximum jet velocity along the plume path as a function of distance from the orifice and then adding this velocity to the current velocity by vector addition. From this information the minimum and maximum potential dilution can be calculated. With an effective cross section of 45 feet and the minimum tidal velocity of 1.5 knots (2.54 ft/sec) the potential dilution at 30 feet would be 1,420 times. At the same distance and width the maximum current of 8 knots (13.5 ft/sec) would provide a potential dilution of 4,000

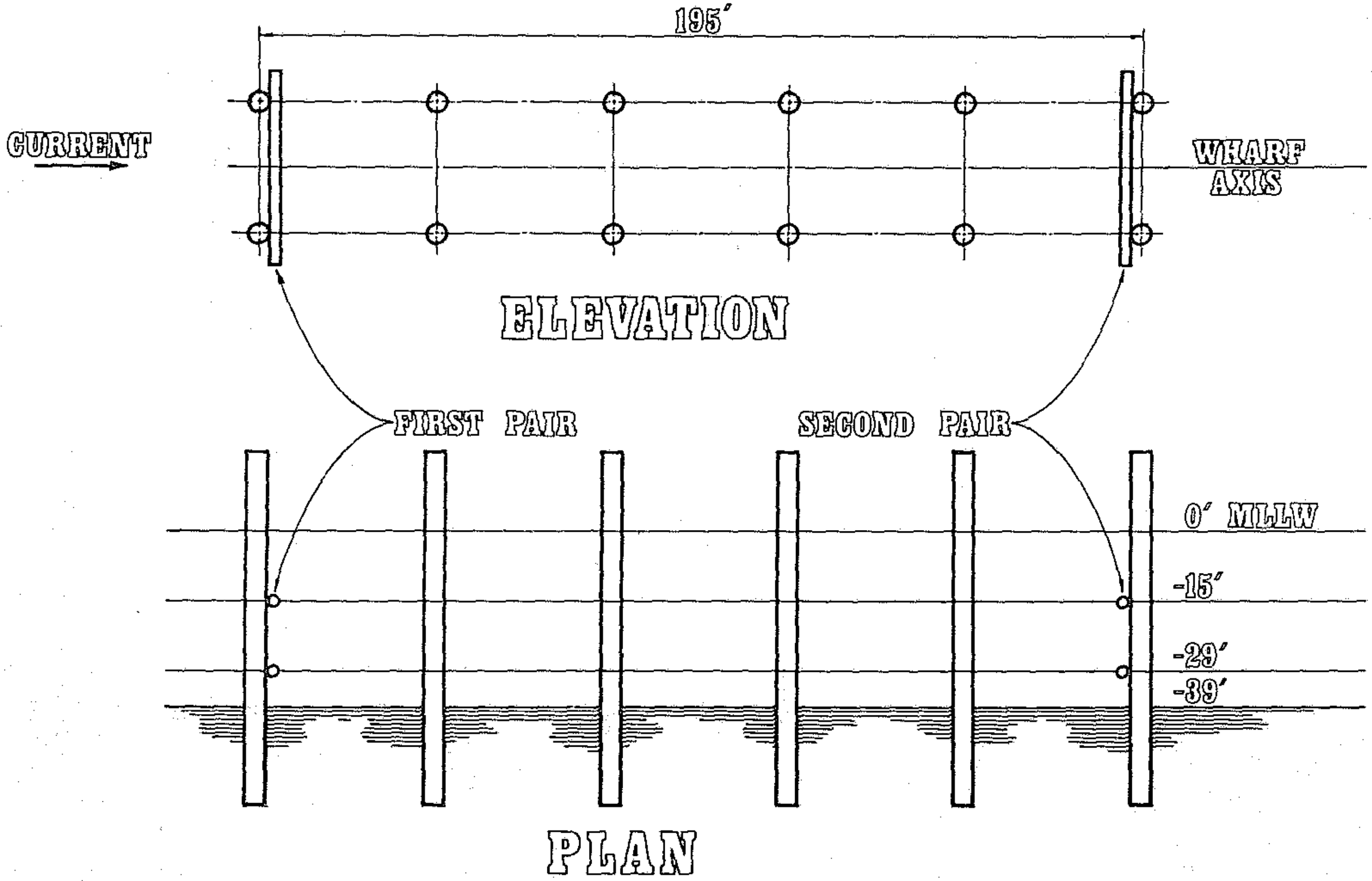

Figure 2: Diffuser system as installed on the Collier Carbon and Chemical Corporation Pier.

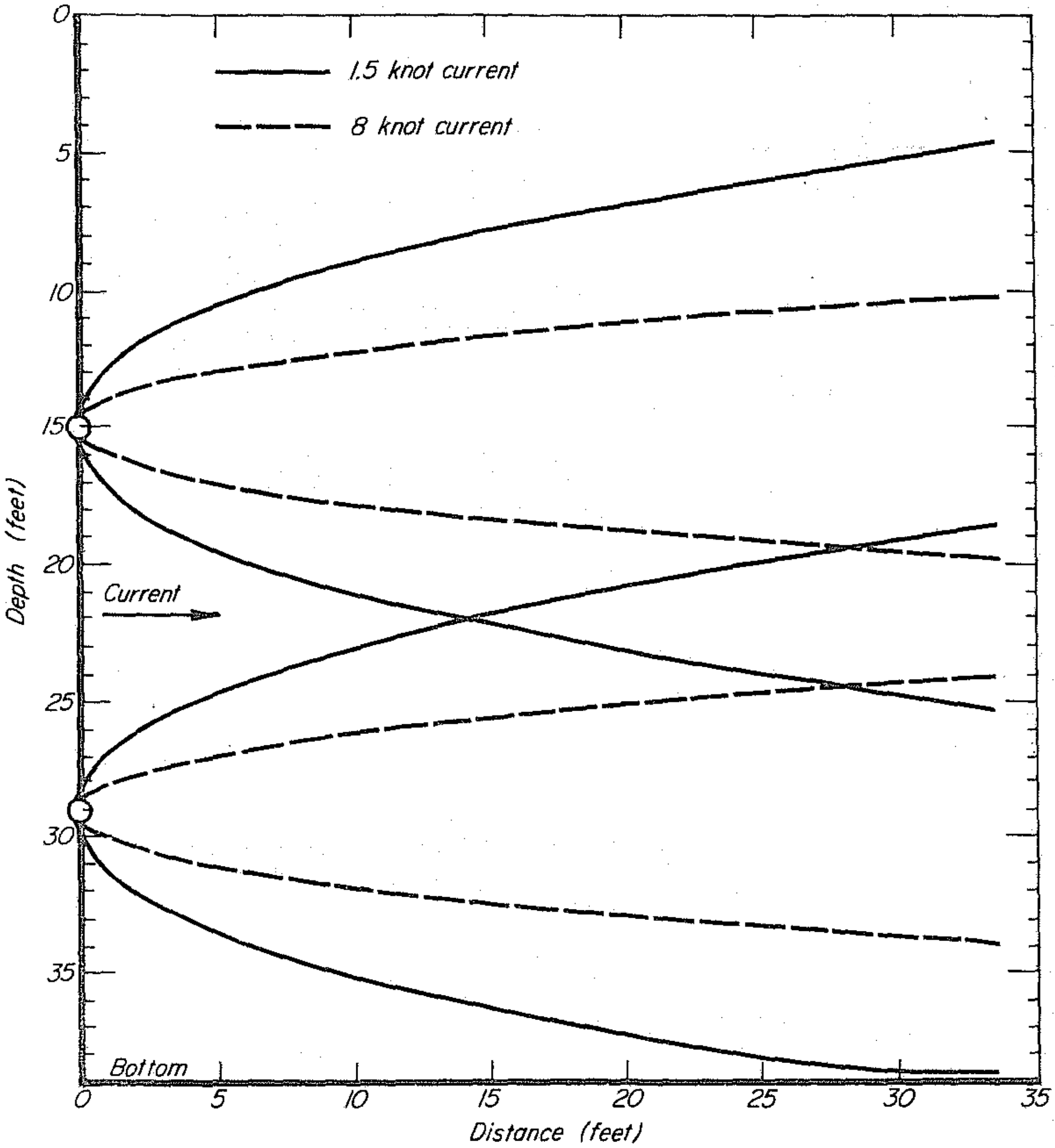

Figure 3: Calculated plume paths in cross-section for minimum and maximum current velocities.

times. It should be noted that the effective cross section was taken to be 45 feet, which make the assumption that effluent from the upstream diffusor passes directly through the downstream diffusor.

Additionally since the flood currents are the strongest (*i.e.*, greater mixing) and to take advantage of the counter-clockwise circulation in the Inlet, it was determined that the effluent should only be released into the inlet on the flood tide.

The performance of the diffusor system was measured under actual operating conditions during May of 1969 (Rosenberg *et. al.*, 1969). Actual dilution measurements were made in the inlet using Rhodamine B dye as a tracer and a servo balancing Turner Fluorometer as a detector. A concentrated solution of dye was pumped at a constant rate directly into the effluent sump located at the effluent retention basins within the plant. The effluent discharge pumps then pumped the labeled effluent into the inlet through the effluent discharge system. The actual concentration of tracer in the effluent was continuously monitored with a second Fluorometer to assure a constant concentration was being maintained in the discharge system. Inlet water downstream from the diffusors was sampled continuously by means of a pumping system which could be raised or lowered to any desired depth. Due to the physical restraints of the pumping system and the pier, measurements could be made only 20 and 75 feet from the diffusor.

Actual measurements of effluent concentration were made on the afternoon of May 9, 1969. This period was selected because the flood tide during this period had a total range of 16.1 feet which is less than the mean tidal range of 17.9 feet. The actual surface currents were measured during this sampling period. They ranged from 2.25 knots to 2.55 knots. Dilution measurements with depth are shown in Figure 4. Dilutions at the 20-foot station were 900 times or greater while at the 75-foot station all dilutions were greater than 10,000.

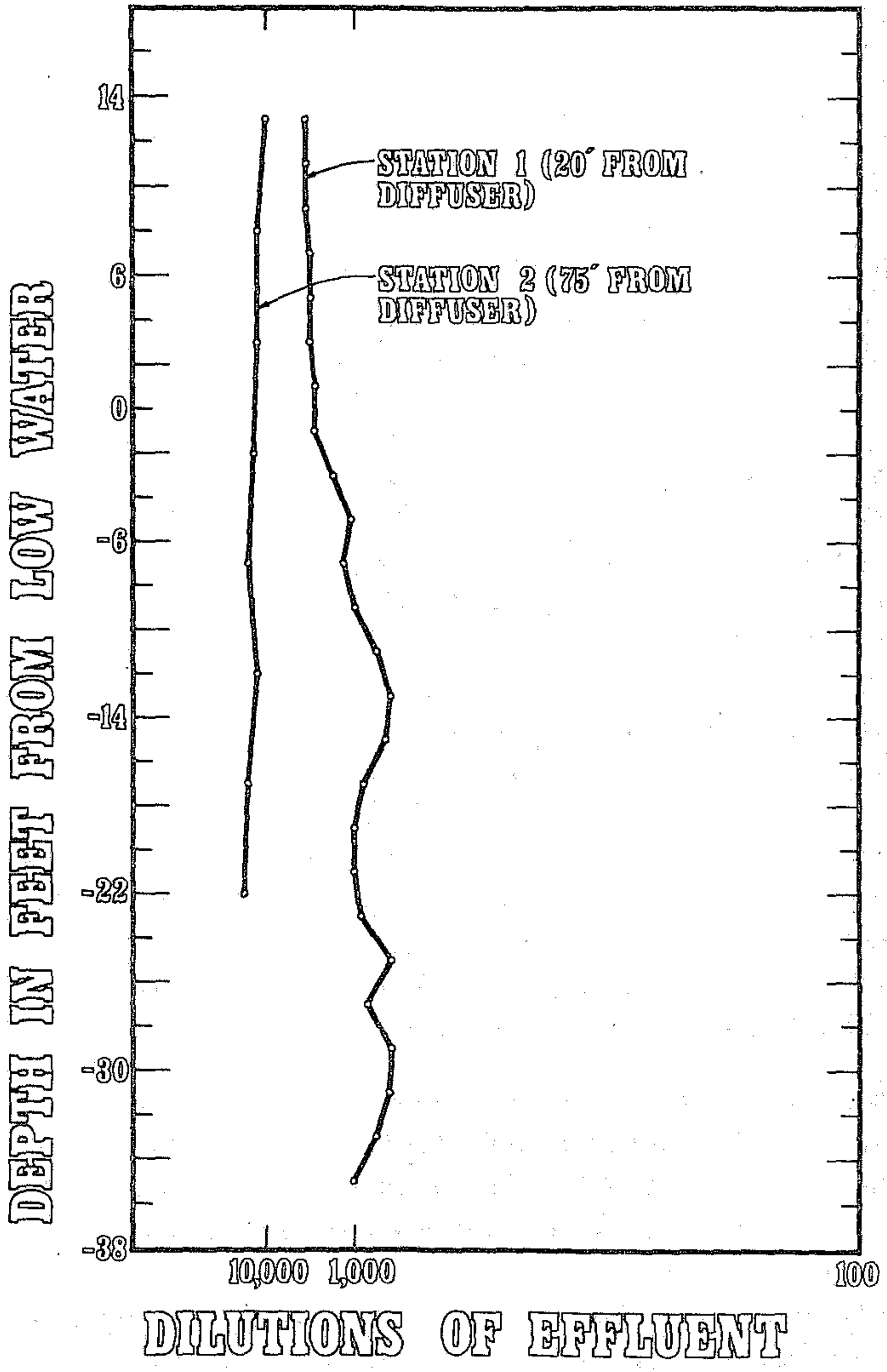

Figure 4: Effluent dilutions measured on the afternoon of May 9, 1969. (Tidal range - 16.1 feet; Current velocity - 2.25 to 2.55 knots)

These data indicate that the diffusor system, as installed, is providing the number of dilutions to meet the required design criteria. The above indicate that the concentration of ammonia at 20 feet would be less than 1.6 ppm and at a distance of 75 feet the concentration of ammonia would be less than .013 ppm.

Actual monitoring of the ammonia levels in the wake of the diffusor has occurred since February 1968. Levels of ammonia at a distance of 300 feet from the diffusor are presented in Figure 5. Here it can be seen that levels of ammonia have at times reached values as high as 0.5 ppm. All of these values are well below the level at which photosynthesis was inhibited.

To understand the long-term fate of the effluent in the inlet, one must understand the nitrogen cycle in marine systems and the oceanography of the Inlet. Figure 6 presents a simplified nitrogen cycle for Cook Inlet. On a mass basis there is about the same amount of nitrogen held in organic matter as there are inorganic nitrogen compounds in the water column. In the sediments most of the nitrogen appears as resistant organic compounds and in the atmosphere most of it is in the form of nitrogen gas. The resistant organic matter in the sediments is lost to the cycle except through long-term geological processes. Nitrogen from the air is brought into the active fixed nitrogen cycle through nitrogen fixation which occurs either by natural biological and chemical processes or by industrial technology.

The organic nitrogen components are essential to the metabolic processes of all living systems on earth. Some form of the inorganic nitrogen ions, nitrate (NO_3-), nitrite (NO_2^-) and ammonium are essential to all plant growth, for it is from these that the complex molecules of living material is derived.

The form of fixed nitrogen utilized by plants is dependent upon the species of organisms and on metabolic and environmental conditions under which growth occurs. By far the greatest influx of nitrogen into the phytoplankton, the community of organisms responsible for over 95% of the photosynthesis of the sea, is in the form of ammonium and nitrate. Nitrate

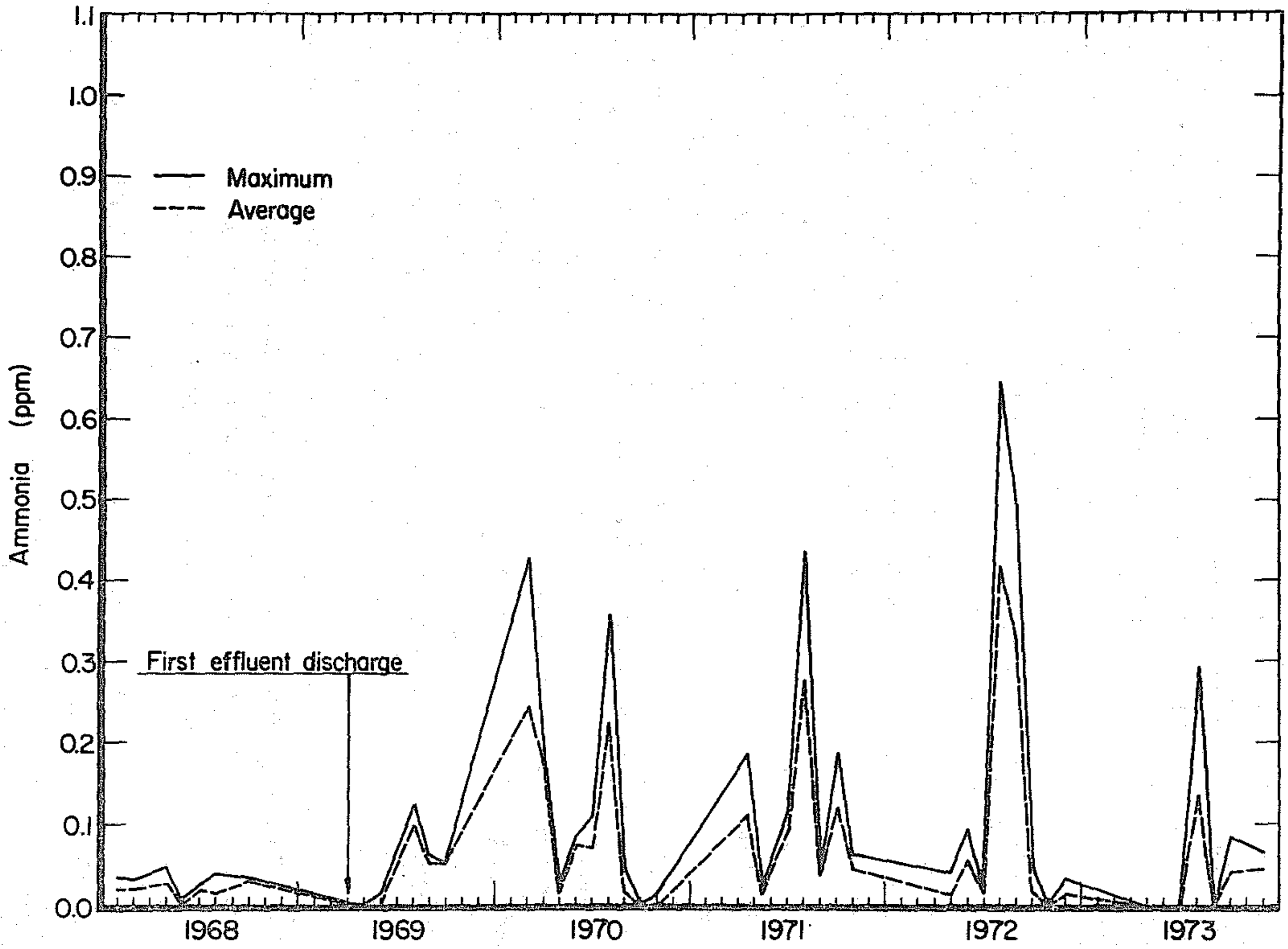

Figure 5: Levels of ammonia at a distance of 300 feet from the diffuser.

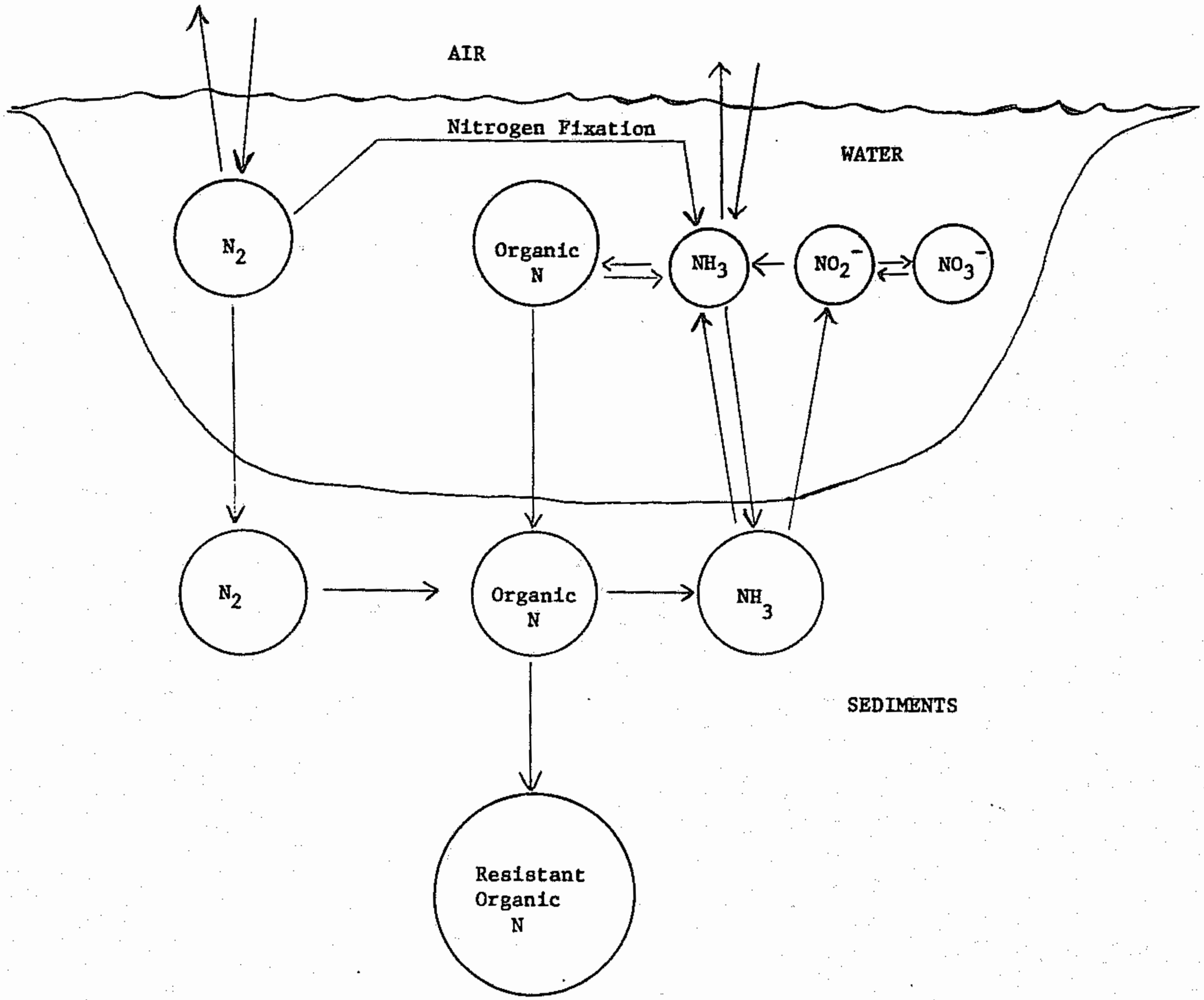

Figure 6: Nitrogen Cycle in Cook Inlet.

tends to be the predominant inorganic nitrogen form under the oxidizing conditions of the sea, but there is substantial evidence that ammonium is the preferred form for assimilation since it is already at the reduction level of organic nitrogen. Nitrate can be used by most plants, however, organisms using nitrate as their source of nitrogen must reduce it to ammonia before incorporating it into cellular materials. In general, however, ammonia and nitrate are easily transferable one to the other by biological systems.

All the forms of fixed nitrogen are interrelated by a series of reactions known collectively as the nitrogen cycle which portrays the flow of nitrogen from inorganic forms in sediments, water and air into living systems and then back into inorganic forms. In Figure 7 a simplified reaction sequence is given. It is clear from this diagram that ammonia plays a central role in nitrogen assimilation by plants and its concentration in natural seawater is usually kept low because as ammonia appears in solution under proper conditions for growth it is quickly assimilated (Reaction 2). Reaction 2 leads to synthesis of amino acids, peptides, purines, and high molecular weight proteins and other complex organic molecules. Upon decay of organic matter urea or ammonia are produced through Reaction 3. In deeper water where utilization is minimal, decomposition or organic matter leads to ammonification (Reaction 3) which is followed by nitrification (Reaction 4). Nitrate is the chemically stable form and nitrite is an intermediate between ammonia and nitrate.

In natural ocean water there is no evidence that ammonium ever reaches concentrations that are toxic to marine organisms. Seldom are values greater than 0.1 to 0.2 ppm found in uncontaminated waters. Thus through natural processes the ammonia released into the Inlet should be used in the growth processes of the marine plants and animals. But what if it were not utilized? What then would be the fate of the effluent?

Oceanographic Cook Inlet is a tidal estuary in many ways not unlike others found throughout the world. For example, the surface salinity distribution as shown on Figure 8 when combined with data on salinity variation with depth shows that Cook Inlet falls into a standard estuary classification. Cook

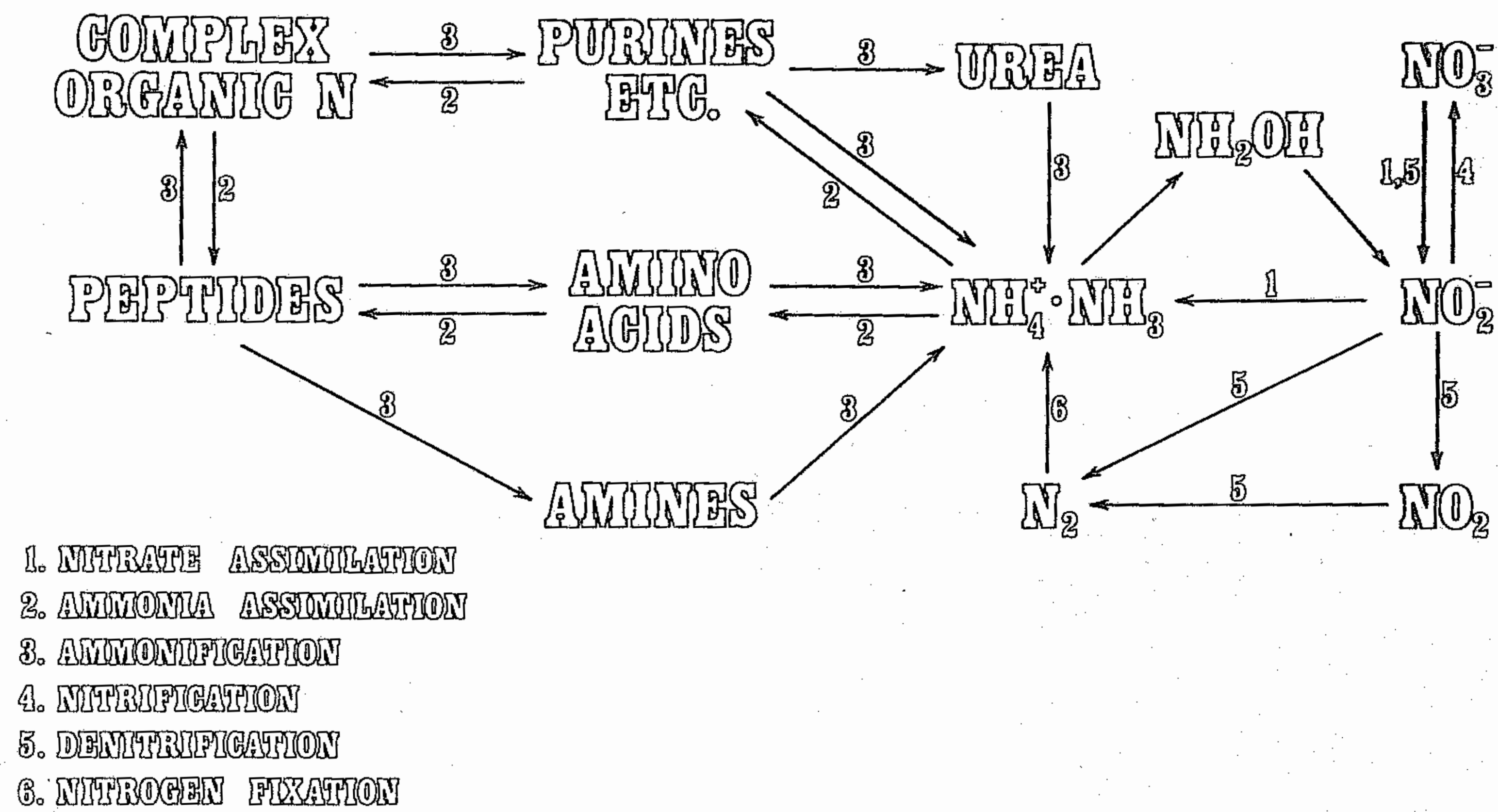

Figure 7: Molecular Nitrogen Cycle in Nature.

Inlet is classified as a two-layered estuary with intense vertical mixing. Further, the inlet north of Kalgin Island, because of the extreme vertical mixing, approaches what is classified as a vertical homogenous estuary with lateral variations due to Coriolis force. As can be seen from Figure 8, the higher salinity waters are located along the eastern shore of the inlet. This salinity pattern is characteristic of an inlet in the northern hemisphere with a net inward flow of water along the right-hand side (looking up the inlet) and a net outward movement of brackish water on the left-hand side. I have generalized this net circulation pattern on Figure 9. The circulation is a result of the tidal currents and associated horizontal and vertical mixing working in conjunction with the forces created by the earth's rotation. Although this circulation pattern has been obtained from the salinity distribution it has recently been confirmed by the suspended sediment patterns observed in data obtained from the ERTS Satellite. Included on Figure 9 are typical suspended sediment loads as observed from the satellite imagery. The outward-flowing high-sediment laden waters are seen to remain along the western shore of the inlet.

It is possible, using the fresh river water which is mixed in the inlet as a tracer to estimate the rate of net inflow of the oceanic waters. This inflow has been found to range from 300,000 to 1,300,000 ft^3/sec. To compensate for this net inflow there is obviously a resultant net outflow which is the sum of the inflow and the contribution to the inlet from the rivers. Since this circulation is driven by the tides and associated mixing it is expected that the rates will remain constant regardless of the time of year. If the volume of the oceanic inflow on a yearly basis is compared to the volume of the yearly contribution of water by the rivers it is found to be approximately ten times larger. This is not unusual for in some estuaries the inflow has been found to be 40 times larger than the river flow.

Using this information it is then possible to determine how long it will take the effluent, assuming it is not used biologically, to reach a steady state concentration in the inlet. That is, to determine how long it will take before the same quantity of effluent is leaving the mouth of the inlet as the

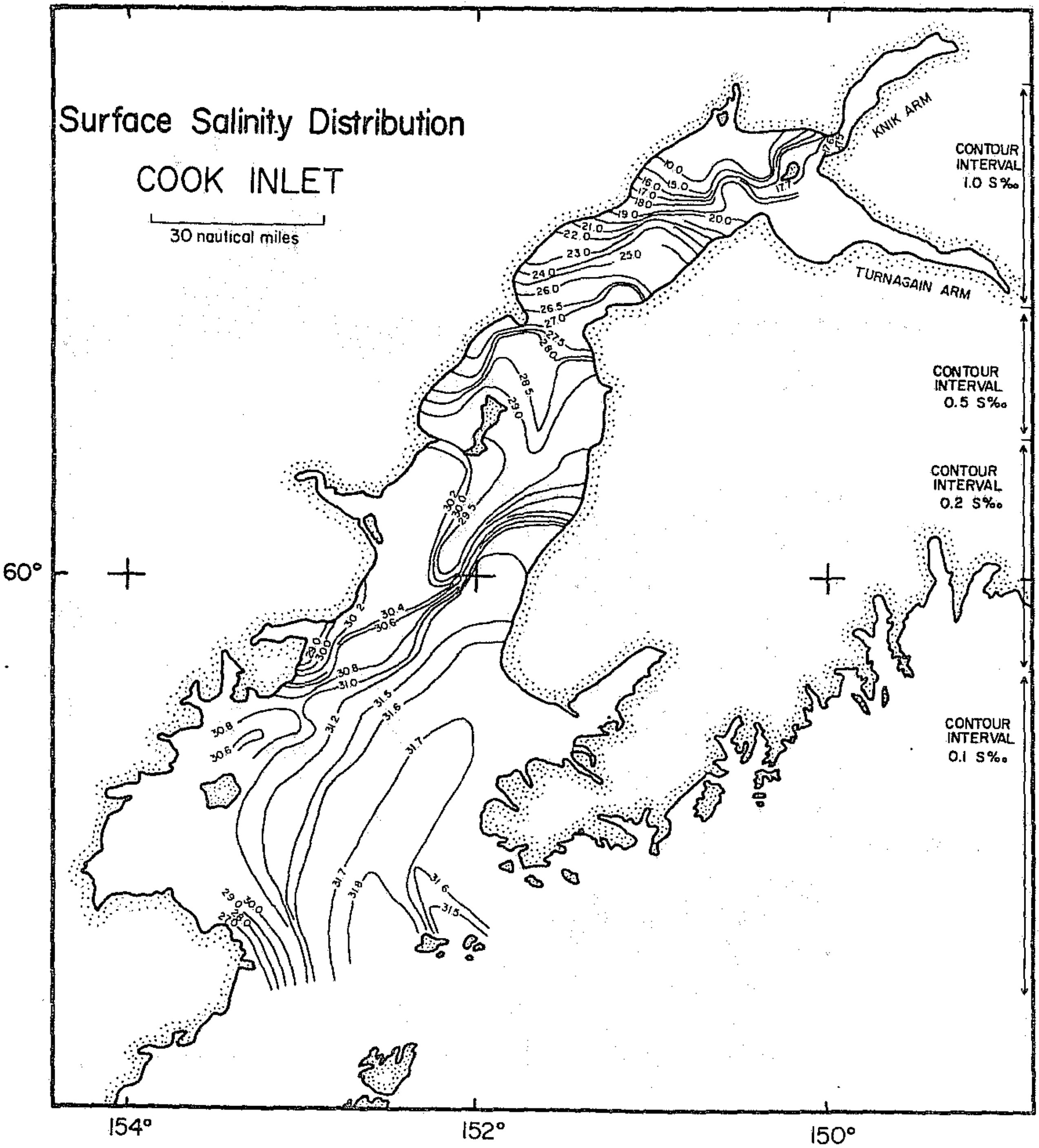

Figure 8: Surface Salinity Distribution, May 21-28, 1968.

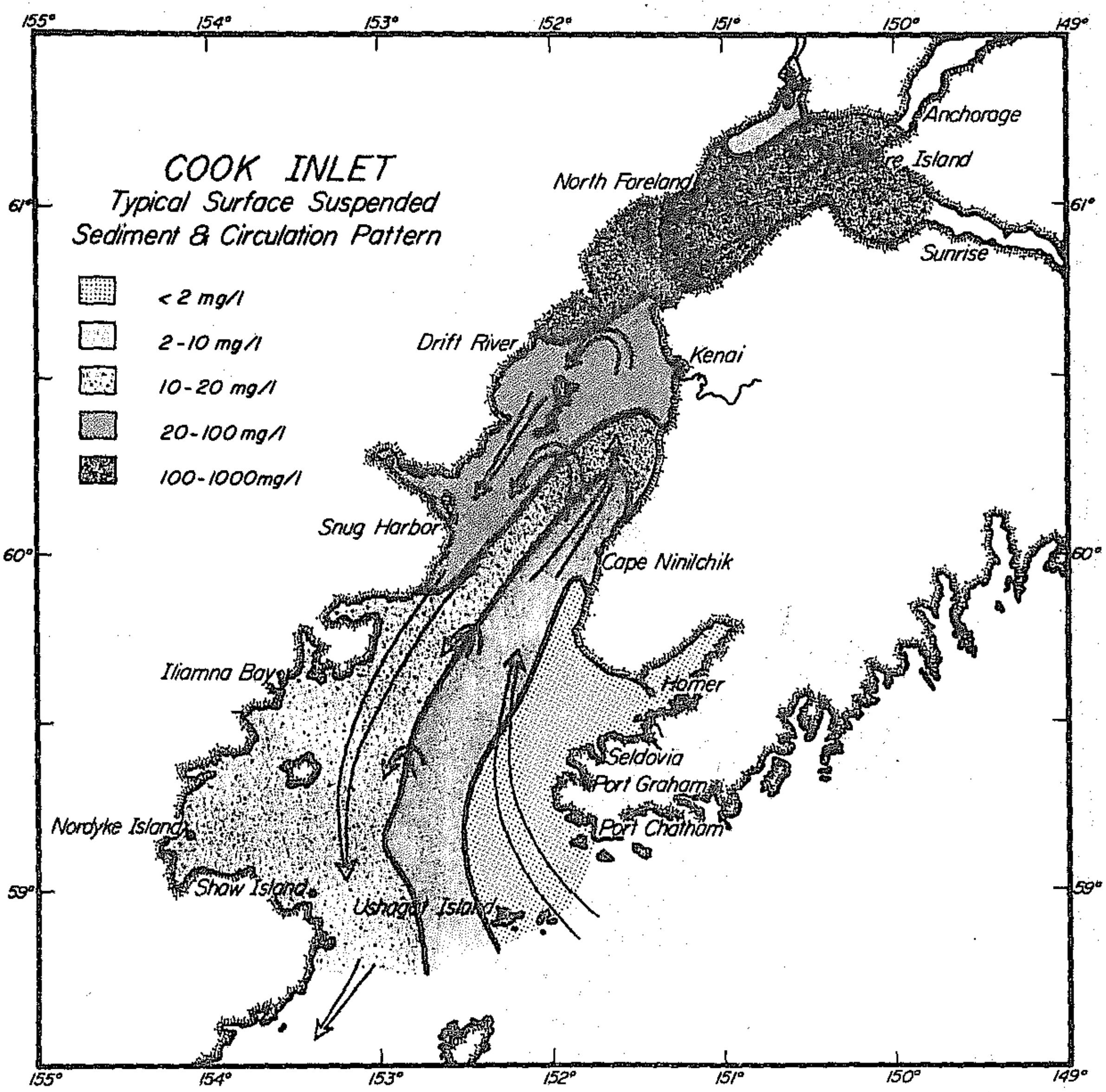

Figure 9: Generalized water circulation and suspended sediment load concentrations for Cook Inlet.

plant is putting into the inlet. This time is calculated to be approximately 12 to 14 months. Based on this time the maximum amount of ammonia that would be present in the inlet would be that released by the plant during approximately 14 months of full operation. The extreme mixing and currents of the inlet will insure that the effluent will be thoroughly mixed throughout the waters of the inlet. This would then represent a maximum increase of 2.8 ppb of ammonia above the natural occurring ammonia levels in the inlet.

It is also of interest to consider the yearly material balance in Cook Inlet of combined ammonia and its companion nitrate when considering the long-term fate of the effluent. The inputs of ammonia components to Cook Inlet are derived both from natural and man-made sources. In Figure 10 these inputs are placed in perspective by the arrows which show the relative amounts coming from the various sources. Input from drainage amounts of 3.2 million pounds of ammonia and 5.5 million pounds of nitrate per year. The estimated input from the 126,000 people in the city of Anchorage is 1.3 million pounds of ammonia and 270,000 pounds of nitrate per year. The plant effluent contains 2.5 million pounds of ammonia equivalent.

The effects of mixing entrainment of ocean water with Cook Inlet water is to carry 61 million pounds of ammonia and 2.3 billion pounds of ammonia equivalents as nitrate into the Inlet.

Precipitation on the Inlet contains about 1.8 million pounds of ammonia and 1 million pounds of nitrate. In addition to the above mentioned sources, nitrogen fixation which has not been measured in Cook Inlet directly, but occurs elsewhere, would be expected to contribute one to ten million pounds of ammonia.

To continue the consideration of ammonia budget, it is now necessary to examine the ammonia sinks. The total entrainment which brings in most of the ammonia components to Cook Inlet replaces water already in the Inlet to maintain hydraulic equilibrium. This water represented by upper Cook Inlet water is much lower in ammonia and contains 9 million pounds of ammonia and 2.4

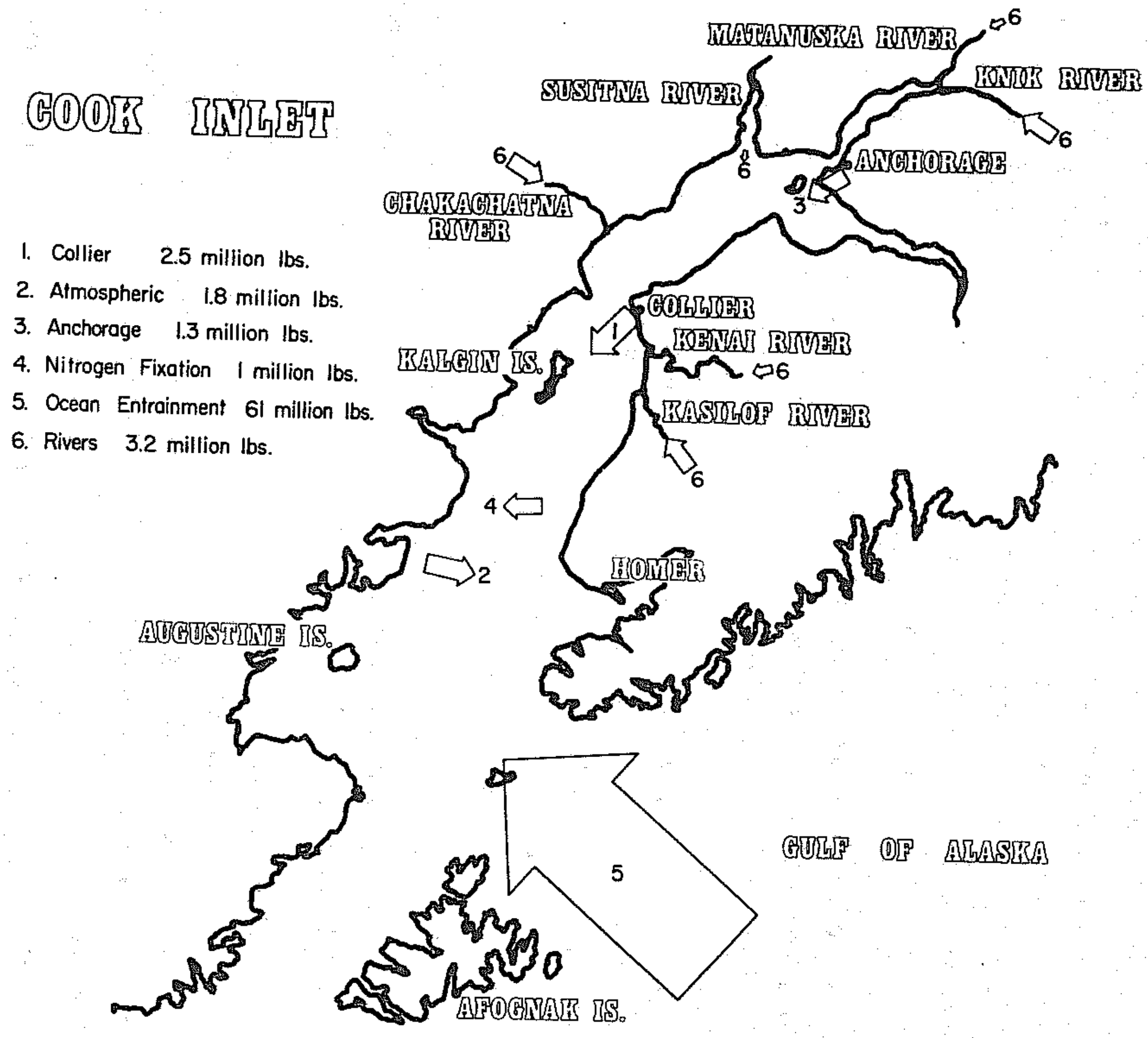

Figure 10: Ammonia Inputs to Cook Inlet.

billion pounds of nitrate. The deficiency in ammonia equivalents is 25 million pounds of fixed nitrogen not including the input from Collier, Anchorage, rivers or atmosphere. Where is this fixed nitrogen going? One area in which fairly good data are available is that of commercial fishing. In 1970, 67.5 million pounds of all species of commercial fish were taken from Cook Inlet. This is equivalent to 1.6 million pounds of ammonia. Other losses from migrating fish, birds, marine mammals exchange to the atmosphere, dentrification and losses to the sediments are not accountable from data available at this time. It is expected, however, that the largest sink is that due to loss of organic nitrogen to the sediments of Cook Inlet.

Ammonia levels in the total inlet have been monitored over the past five years and we find no detectable change in the ammonia balance.

The conclusion can then be made that the system used to dispose of the ammonia effluent into Cook Inlet appears to be satisfactory. From the evidence we have been able to establish it appears that there is no reason for environmental concern for the health of Cook Inlet resulting from the disposal of the fertilizer effluents into this vigorous system. The only other technology that would be preferred is that of direct utilization of these effluents by an aquaculture system which would take direct advantage of the ammonia as a fertilizer for controlled production. The technology required for this type of waste utilization has not yet been fully developed and it will require some years of study before such a process can be recommended for industrial use.

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LUNCHEON ADDRESS

STABILIZATION POND UPGRADING WITH INTERMITTENT SAND FILTERS

Speaker:

E. JOE MIDDLEBROOKS

STABILIZATION POND UPGRADING WITH INTERMITTENT SAND FILTERS

E. Joe Middlebrooks* and Gary R. Marshall**

INTRODUCTION

NATURE OF THE PROBLEM

Water quality and quantity problems in the State of Utah are similar to those in other parts of the country. In Utah, there are many rural communities that are still fortunate to be surrounded by large areas of open and relatively inexpensive land. It was originally due to this reason that many of these communities adopted waste stabilization lagoons as a means of wastewater treatment. Although this treatment scheme requires large tracts of land, the important consideration was that it gave a satisfactory effluent for minimum cost and maintenance. But now Utah, along with the rest of the nation, recognizes that a better quality effluent is necessary. If small cities and towns are to economically produce a higher quality effluent, some form of treatment must be utilized that will continue to take advantage of the large areas of relatively inexpensive land surrounding these communities. One method of treatment that capitalizes on the availability of large land areas is intermittent sand filtration.

In most areas of the country where intermittent sand filtration has been used, the lack of large inexpensive tracts of land was a major factor contributing to a decline in use. Thus, the relatively inexpensive tracts of land available in Utah are a definite asset. Intermittent sand filtration becomes even more economically attractive if filter media are available locally.

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OBJECTIVES

The objective of this study was to evaluate on a laboratory and pilot field scale the performance of the intermittent sand filter as a polishing process that would upgrade existing wastewater treatment facilities. Particular attention was directed toward ascertaining the effectiveness of the intermittent sand filter as a means of removing the highly variable quantities of algae present in stabilization ponds during the warmer months of the year. These results were used to develop design criteria for intermittent sand filters that would consistently produce an effluent of a quality that would meet stringent water quality standards. Details of this study were reported by Marshall and Middlebrooks (1974).

HISTORY OF INTERMITTENT SAND FILTERS

Use of intermittent sewage filtration began in this country in the late nineteenth century. The first intermittent sewage filters were put in use in 1889 in Massachusetts. For many years their use was centered in the New England area. By 1945, approximately 450 intermittent filter plants were in operation in this country. But later reports showed a decrease to 398 in use by 1957. It was also noted (ASCE and FSIWA, 1959) that 94 percent of those still in use by 1957 were serving communities with populations under 10,000.

The intermittent sewage filter has long been known to have the ability to produce effluents of relatively high quality as did the slow sand filter for culinary waters. The decline of intermittent sewage filters was related to the same factors that caused the decline of slow sand filters--an increase in quantity of water to be filtered due to a growing population, and to the rising costs of land. There are other factors that will be mentioned later that compounded the problems that caused the decline.

Intermittent sand filtration, as noted earlier, began in the New England area of this country. Located in Lawrence, Massachusetts, was the Lawrence Experiment Station at which many of the first studies on intermittent sand filtration were accomplished. This region of the country was ideal for the application of such a process as intermittent sand filtration. Many small rural communities were developing to the point that it was necessary to treat their wastewater at a central plant which was economical for the small town. Land to build the filters upon was readily available at reasonable rates and there was also abundant quantities of well graded bank run sand available. These conditions encouraged efforts in research at the Lawrence Experiment Station to improve the intermittent sand filter. As a result of this experimentation and success, the use of intermittent sand filters increased.

Following World War II, many people found the mild climate and sparsely populated land of Florida an ideal place to live following retirement. Large numbers of small residential centers such as isolated tourist courts, motels, trailer parks, drive-in theaters, consolidated schools, and housing developments began to spring up all over Florida. It was soon realized that an economic method of sewage treatment would be necessary for these small communities. Thus, the study of intermittent sand filtration was undertaken at the University of Florida at Gainesville (Calaway *et al.*, 1952; Furman *et al.*, 1949; and Grantham *et al.*, 1949). Much of the modern day knowledge on intermittent sand filters has come out of the studies carried out at Gainesville.

METHODS AND PROCEDURES

EXPERIMENTAL EQUIPMENT

The study consisted of both laboratory (Phase I) and field scale (Phase II) experiments.

Laboratory study

Nine laboratory scale filter columns were erected as shown in Figure 1. Each individual filter column was constructed of 6-inch diameter (15 cm) plexiglass cylinders 6 feet (1.85 m) in length. A flanged coupling was provided in the middle of each column to facilitate the filter cleaning operation.

The filter underdrain material for each laboratory filter consisted of three-inch layers of 1/4, 3/4, and 1-1/2 inch maximum diameter rock supported on stainless steel mesh. A depth of 28 inches (71 cm) of filter sand was then placed upon the quarter-inch diameter rock (6 mm). Sands with effective sizes of 0.17, 0.35, and 0.72 mm and uniformity coefficients of 5.8, 3.8, and 2.6, respectively, were employed.

The 0.17 mm (.0067 inch) effective size sand was the basic sand from which the other two sizes were produced. The sand was a washed bank run sand that was primarily used as fine aggregate in concrete. The 0.35 mm (.0137 inch) sand was produced by sieving the 0.17 mm (.0067 inch) sand through a U.S. series number 50 sieve, the 0.35 mm (.0137 inch) sand being the portion remaining on the sieve. The 0.72 mm (.0283 inch) sand was produced through the use of the U.S. series number 30 sieve.

Logan City, Utah, wastewater stabilization pond effluent was applied once daily to each of the laboratory filters. In order to control the suspended solids concentration in the lagoon effluent applied to the filters, the wastewater effluent was diluted, if necessary, with aerated tap water. Dilution factors were determined on a day-to-day basis by carrying out a daily suspended solids analysis on the filter influent. Also, prior to

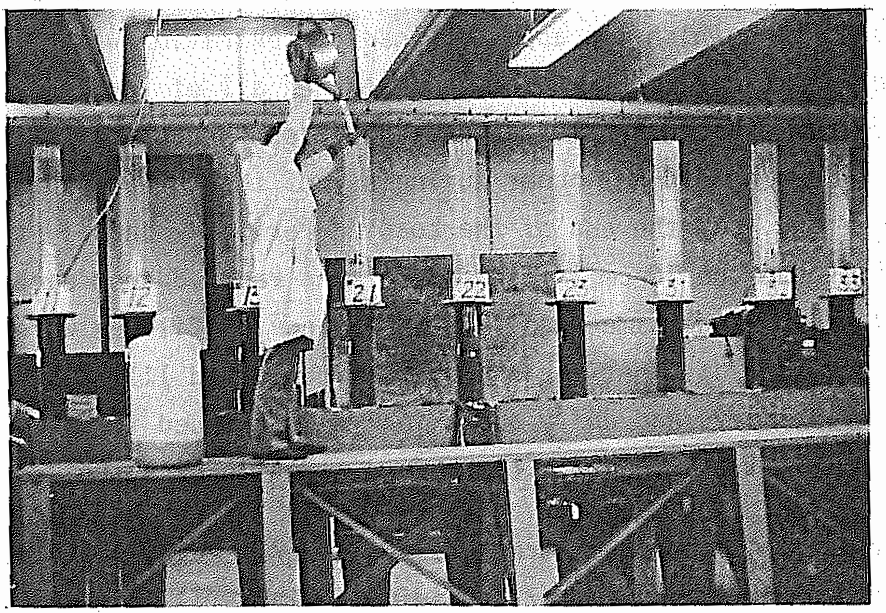

Figure 1: Nine laboratory-scale intermittent sand filters shown during daily loading under laboratory conditions.

dosing, the water temperature was recorded in addition to any other observations noted that day with respect to general filter operation or lagoon performance.

Hydraulic loading rates of 100,000 gpad (153.18 m^3/hectare-day), 200,000 gpad (306.36 m^3/hectare-day), and 300,000 gpad (459.54 m^3/hectare-day) were applied throughout the experiment. Three loading periods of approximately 6 weeks in duration were employed. A loading period constituted a period of operation during which the applied algae concentration was held constant. Plugging is defined as the point in time when all of the specified quantity of wastewater placed on a filter does not pass through the filter in a 24-hour period. Plugging did not occur during any of the three loading periods in the laboratory. At the end of the Loading Periods I and II, the filters were dismantled, the top 10 cm (4 inches) of sand removed from each and replaced with new sand of the same specifications, and the filters were returned to service the same day. At the end of Loading Period III, the top of the sand bed was not removed and daily operation was continued to determine an estimate of the time of operation possible before plugging occurs.

Suspended solids concentrations of 15 mg/l (Loading Period II), 30 mg/l (Loading Period I), and 45 mg/l (Loading Period III) were maintained through each of the loading periods. During the first two loading periods, the wastewater used for filter loading was obtained directly from the Logan City Wastewater Stabilization Ponds. This water was obtained once weekly and stored under refrigeration for use throughout the remainder of the week. During the final loading period, the influent to the filters was obtained from model stabilization ponds operated in the laboratory. These ponds were enriched with inorganic nutrients and were illuminated on a fixed cycle of 16 hours of light and 8 hours of darkness. In addition, when water was removed each day for filter loading, the sample was replaced with tap water and once weekly the sample was replaced with water obtained from the Logan City wastewater stabilization ponds.

Field study

Nine prototype field filters were erected at the discharge point of the Logan City wastewater stabilization ponds and are shown in Figure 2. These units were 4 feet square (1.2 m x 1.2 m) and 6 feet (1.8 m) in height and were constructed of exterior plywood lined with fiberglass and resin. Underdrain construction was the same as the laboratory filters with the exception being that each of the three layers of gravel were 4 inches (10 cm) in depth.

Six filters each were filled with sands of effective sizes of 0.17 and 0.72 mm (.0067 and .0283 inch) to depths of 30 inches (76 cm). The remaining three units were initially filled with 1/4 inch (6 mm) maximum diameter rock to a depth of 60 inches (152 cm). Later in the study the 1/4 inch rock was replaced with sand of 0.17 mm effective size providing six filters with the basic sand.

Lagoon effluent was applied to the filters with three calibrated pumps operated for a specified period of time. During the fourth week of operation, spreading units were installed to assure better distribution of the raw water on the filter bed. A typical spreading unit is shown in Figure 3.

During the first season of operation, the field filters were also loaded once daily at rates of 100,000 gpad (153.18 m^3/hectare-day), 200,000 gpad (306.36 m^3/hectare-day), and 300,000 gpad (459.54 m^3/hectare-day). The hydraulic loading rates applied in the second season are summarized in Table 1. The filter containing 0.17 mm effective size sand loaded at 900,000 gpad (1,378.62 m^3/hectare-day) was operated at this rate for only 28 days because of the lack of adequate freeboard to compensate for changes in percolation rate due to increased head loss.

A daily sample of filter influent was taken for suspended solids and pH analyses. All other influent parameters were measured on a weekly basis with the exception being the bacteriological samples which were taken immediately following the daily dosing with stabilization pond effluent. No attempt was made to maintain a specified suspended solids content in the field experiments.

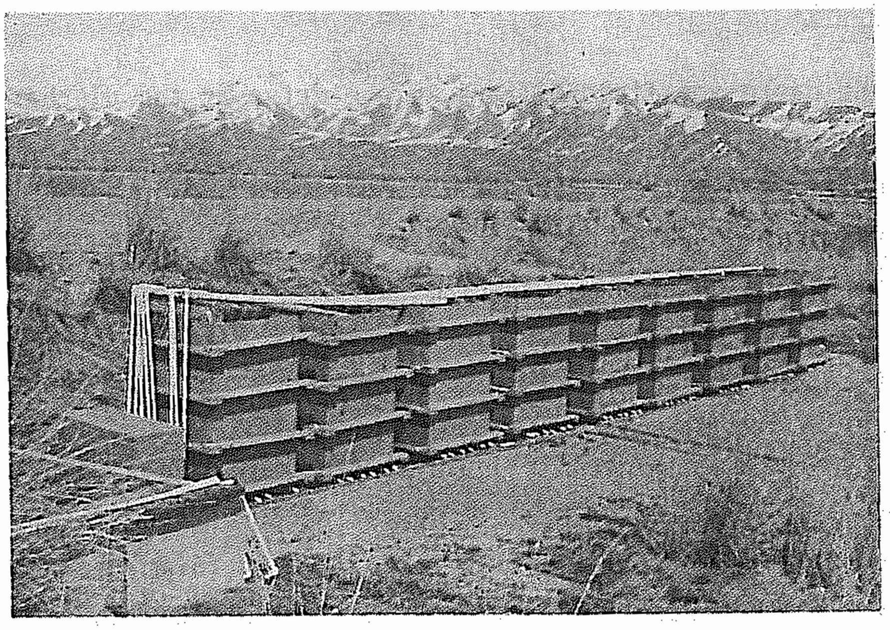

Figure 2: Nine prototype intermittent sand filters located at the point of discharge for the Logan City Wastewater stabilization ponds which were used for study under actual field conditions.

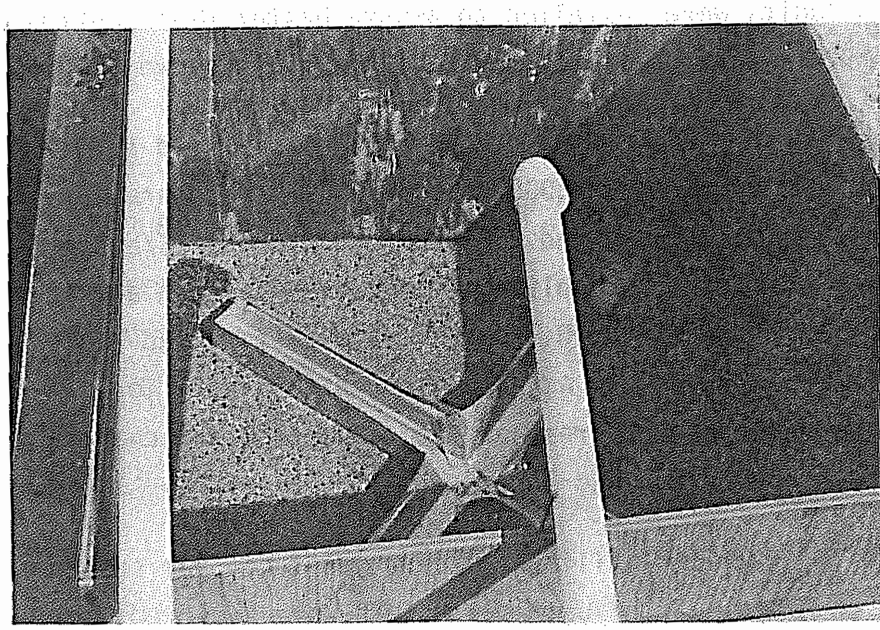

Figure 3: Typical trough used on the field prototype filters to protect the sand bed and to evenly distribute the applied wastewater over the filter bed.

Table 1. Physical characteristics of the filters and the hydraulic loading rates applied to the field filters.

Filter Unit Code	Effective Size of Sand		Filter Depth	Hydraulic Loading Rate	
	mm	inches	in	gpad	m3 /hectare-day
A4	0.17	0.0067	30	400,000	612.72
A5	0.17	0.0067	30	500,000	765.90
A6	0.17	0.0067	30	600,000	919.08
A7	0.17	0.0067	30	700,000	1,072.26
A8	0.17	0.0067	30	800,000	1,225.44
A9[a]	0.17	0.0067	30	900,000[a]	1,378.62
C4	0.72	0.0283	30	400,000	612.72
C5	0.72	0.0283	30	500,000	765.90
C6	0.72	0.0283	30	600,000	919.08

[a]Loaded at this rate for 28 days only.

Sampling

Laboratory filter effluent samples were collected once weekly and composited from 2 days of operation. Filter influent samples were collected for analysis on the days corresponding to the effluent composite sample.

Raw or influent water samples for bacterial analysis were collected just prior to adding the pond effluent to the filters and analyzed for total bacteria and total coliform bacteria. The following day, effluent samples were then taken and analyzed for total bacteria and total coliform bacteria.

Effluent samples from the field filters were collected once a week and the samples were taken immediately following the application of the pond effluent. A filter influent sample was taken daily.

Analyses

Suspended solids, pH, and temperature measurements were performed on filter influent samples on a daily basis for the laboratory and the prototype field filters. Filter influent and effluent samples were analyzed once weekly for biochemical oxygen demand (BOD), ammonia nitrite, nitrate, orthophosphate, total unfiltered phosphorus, suspended solids, and pH. In addition, flask bioassays were performed on the laboratory filter effluents to determine if viable algae cells were in the effluents. Approximately 200 ml of each filter effluent were placed in a 500 ml Erlenmeyer flask and exposed to the lighting pattern described for the laboratory ponds. Growth was measured three to four times weekly in each flask by determining the optical density of the suspension.

Suspended and volatile suspended solids reactive orthophosphate, and reactive nitrite and nitrate were measured by methods outlined in the Practical Handbook of Seawater Analysis (Strickland and Parsons, 1968). Total phosphorus and biochemical oxygen demand analyses were performed in accordance with Standard Methods (1971). Ammonia concentration was determined by methods described in Limnology and Oceanography (Solorzano, 1969). Total plate counts were made in accordance with Standard Methods (1971) with the exception being that all plates were incubated at 20°C for seven days (Calaway *et al.*, 1952). Total coliform were determined by the procedures described in Standard Methods (1971).

Table 2. Algae genera population estimates for the influent and effluent samples from the field filters.

Sample Date	Genera: Influent Sample						Genera: A5 & C5 Effluent Samples			
	Anabaena	Chlamydomonas Vegetative	Chlamydomonas Palmelloid	*Daphnia*	*Diatom*	*Euglena*	*Anabaena*	*Chlamy.*	Debris	Diatom
26 July	0%	25%	70%	Occasional	5%	Occasional	0%	85%(dead)	Mainly	15%
2 Aug	0%	25%	70%	Occasional	5%	Occasional	0%	85%(dead)	Mainly	15%
9 Aug	0%	25%	70%	Occasional	5%	Occasional	0%	85%(dead)	Mainly	15%
15 Aug	Occasional	20%	70%	Occasional	5%	5%	0%	85%(dead)	Mainly	15%
22 Aug	Occasional	5%	85%	Occasional	5%	5%	0%	85%(dead)	Mainly	15%
28 Aug	5%	5%	80%	Occasional	5%	5%	0%	85%(dead)	Mainly	15%
7 Sept	10%	10%	75%	Occasional	5%	Occasional	Occasional	85% (dead)	Mainly	15%
13 Sept	15%	10%	75%	Occasional	Occasional	Occasional	5%	80%(dead)	Mainly	15%
19 Sept	20%	5%	70%	Occasional	5%	0%	10%	75%(dead)	Mainly	15%
27 Sept	10%	Occasional	80%	Occasional	10%	0%	0%	80%(dead)	Mainly	20%

RESULTS AND DISCUSSION

ALGAE GENERA

Laboratory filters

Water applied to the laboratory filters was effluent from domestic wastewater stabilization ponds and many different species of algae were present. *Chlamydomonas sp.* was predominant in both the Logan City and the laboratory stabilization ponds. In most cases, the predominant groups of organisms in the filter effluent were "fusiform diatoms." They appeared at one time or another in all effluent samples studied and were observed quite regularly in the applied water.

There were cases where *Chlamydomonas sp.*, *Scenedesmus sp.*, and diatoms were observed separately and in various combinations in the effluents. There were a few effluent samples in which algae were not observed. This usually occurred in the 0.17 mm (.0067 inch) effective size sand subjected to the lowest loading rate. When the lagoon effluents were applied to the filters, the algae, *Chlamydomonas sp.*, were usually found in a "clumped" or palmelloid state and in the effluent were observed to be single, motile cells in nearly every case. This palmelloid state may have contributed significantly to the removal efficiencies obtained with the filters.

Field Studies

Table 2 summarizes the results of the microscopic analyses for the field filters. As reported for the laboratory filters, *Chlamydomonas sp.* were again predominant in the filter influent during the second year of the field study. A variety of genera was present in the lagoon effluent, but *Chlamydomonas sp.* represented a minimum of 70 percent of the algal population throughout the study.

OXIDATION OF NITROGEN

Laboratory filters

Ammonia concentrations in the influent and effluents were not measured until Loading Period III. As the applied, effluent and removal values show (Table 3), ammonia was present in large quantities and was readily oxidized. This is in agreement with earlier results reported at the University of Florida where settled primary sewage was applied to intermittent sand filters (Furman *et al.*, 1949; and Grantham *et al.*, 1949).

Table 4 shows the relationship between hydraulic loading rate, sand size, and the effluent nitrate concentration for the three algae concentrations applied (Loading Period I, II, III). During Loading Period III, the ammonia concentration, Table 3, was found to be high in the artificially produced wastewater stabilization pond effluent when compared with concentrations that would be expected to exist in a tertiary treated wastewater stabilization pond effluent. Thus, the large increase in nitrification observed during Period III, when compared with that of Periods I and II, was probably caused by the greater amounts of ammonia nitrogen present in the artificially enriched wastewater effluent produced in the laboratory ponds, and was probably not related to the increased applied algae concentrations during Loading Period III.

Filters constructed of sands with smaller effective sizes more readily oxidized ammonia to nitrate (Table 4). This result agrees with the findings of Grantham *et al.* (1949), Furman *et al.* (1949), and Pincince and McKee (1968).

Table 3 shows the changes in ammonia-nitrogen concentrations at the three hydraulic loading rates and filter sand sizes. The 0.72 mm (.0283 inch) effective size sand filter showed a slight decrease in ammonia-nitrogen reduction as the hydraulic loading rate increased. This decrease was probably caused by increased submergence, decreased aeration, and a reduction in the contact time within the filter bed.

Table 3. Mean applied and effluent ammonia nitrogen concentrations obtained during Loading Period III in the laboratory study.

Applied NH_4-N (mg/l)	Effluent NH_4-N Concentration, mg/l — Effective Size of Filter Media: 0.17 mm — Hydraulic Loading Rates, gpad x 10^{-3}			0.35 mm — Hydraulic Loading Rates, gpad x 10^{-3}			0.72 mm — Hydraulic Loading Rates, gpad x 10^{-3}		
	100	200	300	100	200	300	100	200	300
2.13	.006	.004	.006	.006	.014	.017	.043	.146	.217

Table 4. Mean applied and effluent nitrate nitrogen concentrations obtained in the laboratory study.

Loading Period	Applied NO_3-N (mg/l)	Effluent NO_3-N Concentration, mg/l — Effective Size of Filter Media: 0.17 mm — Hydraulic Loading Rates, gpad x 10^{-3}			0.35 mm — Hydraulic Loading Rates, gpad x 10^{-3}			0.72 mm — Hydraulic Loading Rates, gpad x 10^{-3}		
		100	200	300	100	200	300	100	200	300
I	0.034	1.45	1.25	1.20	0.99	1.12	1.63	1.06	1.02	1.09
II	0.110	0.96	0.91	0.91	0.84	0.81	0.74	0.82	0.71	0.76
III	0.165	4.04	3.57	3.89	3.82	3.44	3.03	3.97	3.17	2.81

Field experimental results shown in Tables 5 and 6 were in agreement with the results observed in the laboratory filters. The 0.17 mm (.0067 inch) effective size sand was somewhat more efficient in the oxidation of ammonia-nitrogen than the 0.72 mm (.0283 inch) sand. Ammonia-nitrogen oxidation was not continued in the second year of the field study; however, as the hydraulic loading is increased, a corresponding decrease in oxidation would be expected. The rock filtering media oxidized little of the ammonia-nitrogen to nitrate. This is probably due to the short time required for the liquid to pass through the media.

Table 5. Mean applied and effluent ammonia nitrogen concentrations obtained in the field study during the first year.

Applied NH_4-N (mg/l)	Mean Effluent NH_4-N Concentrations, mg/l		
	.17 mm	.72 mm	6 mm max. dia. rock
1.09	0.013	0.426	1.10

Table 6. Mean applied and effluent nitrate nitrogen concentrations obtained in the field study during the first year.

Applied NO_3-N (mg/l)	Mean Effluent NO_3-N Concentrations, mg/l		
	.17 mm	.72 mm	6 mm max. dia. rock
0.078	0.996	1.11	0.479

BOD REMOVAL

Laboratory filters

As shown in Table 7, the concentrations of BOD_5 in the lagoon effluent applied to the laboratory filters was close to the existing Utah standard of 5 mg/l even before filtration during Loading Periods I and II. This was caused by two factors: the necessity to dilute the effluent to obtain the desired suspended solids concentration applied to the filters, and the high degree of BOD_5 removal produced by the 5-stage Logan lagoon system.

Results of the laboratory study were in good agreement with results obtained by Grantham *et al.* (1949). Examination of Table 8 shows that the loading rates used had little effect on BOD_5 removal. However, the data show a trend toward an increase in the concentration of BOD_5 in the effluent as the loading rate increased. Higher loadings would probably show an even greater increase in effluent BOD_5 concentrations for all sand sizes. With respect to sand size, the effect of loading rate does slightly decrease the filter's ability to remove the applied BOD_5 which agrees with the findings of Grantham *et al.* (1949).

Field filters

At the same hydraulic loading rates as those employed in the laboratory filters, BOD_5 removals obtained during the first year in the field units in general agreed with the laboratory findings with the exception being the lower removal efficiencies obtained with the 0.72 mm (.0283 inch) sand used in the field (Table 9). The differences in performance summarized in Table 8 were probably caused by the 10-20°F greater operating temperature under laboratory conditions. In general, lower air temperatures produce filter effluents with higher BOD_5. This effect was even more pronounced in larger sized sands studied by Grantham *et al.* (1949). Coarser sands allow better aeration which would allow the air temperature to exert a much greater effect on the biological activity.

Table 7. Mean applied and effluent BOD_5 concentrations obtained in the laboratory study.

Loading Period	Applied BOD_5 (mg/l)	Effluent BOD_5 Concentration, mg/l — Effective Size of Filter Media								
		0.17 mm			0.35 mm			0.72 mm		
		Hydraulic Loading Rates, gpad x 10^{-3}			Hydraulic Loading Rates, gpad x 10^{-3}			Hydraulic Loading Rates, gpad x 10^{-3}		
		100	200	300	100	200	300	100	200	300
I	6.71	1.15	1.55	2.31	2.51	2.61	2.97	2.89	3.09	3.01
II	6.34	1.17	1.26	1.96	2.44	2.08	2.41	2.33	2.50	1.93
III	36.5	5.81	5.64	7.14	11.21	10.83	11.53	12.26	12.72	13.25

Table 8. The comparison of BOD_5 removal for the laboratory filters during Loading Period II and the field filters containing 0.72 mm (.0283 inch) size sand.

Hydraulic Loading (gpad)	Percent BOD_5 Removal Under Laboratory Conditions (70°F ave. air)	Percent BOD_5 Removal Under Field Conditions (60°F ave. air)
100,000 (153.4 m^3/hectare-day)	63.2	24.3
200,000 (306.4 m^3/hectare-day)	59.6	17.8
300,000 (459.5 m^3/hectare-day)	69.6	29.6

Table 9. Mean applied and effluent BOD_5 concentrations obtained in the field study during the first year of operation.

Applied mg/l	Average Effluent BOD_5 Concentrations, mg/l		
	0.17 mm	0.72 mm	6 mm max. dia. rock
6.18	1.07	4.70	4.92

The mean monthly influent and effluent BOD_5 concentrations obtained during the second year of field operation at various hydraulic loading rates for the two effective size sands (0.17 and 0.72 mm) are presented in Table 10. The BOD_5 of the influent remained essentially constant during the second year of operation ranging from 10.0 to 24.9 mg/l with an average value of 13.7 mg/l and a median value of 12.5 mg/l. There appears to be little variation in the effluent BOD_5 concentration with hydraulic loading rate for the 0.72 mm effective size sand; whereas, the 0.17 mm effective size sand shows a definite increase in effluent BOD_5 concentration as the hydraulic loading rate was increased. It is very likely that the effluent BOD_5 concentration would also increase for the 0.72 mm sand sizes if the loading were increased to 0.7 and 0.8 mgad.

The mean effluent BOD_5 concentration for the 0.17 mm effective size sand filters loaded at 700,000 and 800,000 gpad (1072.3 and 1225.4 m^3/hectare-day) was twice as high as the values obtained at a hydraulic loading rate of 600,000 gpad (Table 10). A higher effluent concentration was expected, but whether such a large increase would have occurred if all of the filters had operated for an equal time period is unknown. However, based upon the data collected in this study it appears that BOD_5 removal efficiency reaches a limit in the vicinity of a hydraulic loading rate of 600,000 gpad.

BOD_5 reduction with the 0.17 mm effective size sand filters ranged between 38.7 and 97.4 percent with the lower reductions occurring principally at the higer hydraulic loading rates (700,000 and 800,000 gpad). BOD_5

Table 10. Mean influent and effluent BOD_5 concentrations obtained with each sand size and hydraulic loading rate during Phase II under field conditions.

Month	Mean Monthly Influent BOD Concentration (mg/l)	Mean Monthly Effluent BOD_5, mg/l															
		Effective Size, 0.17 mm										Effective Size, 0.72 mm					
		Hydraulic Loading Rates, gpad										Hydraulic Loading Rates, gpad					
		400,000		500,000		600,000		700,000		800,000		400,000		500,000		600,000	
		mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red	mg/l	% Red	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.
June	12.1	0.75	93.8	1.2	90.1	1.3	89.3	-	-	-	-	4.5	62.8	3.6	70.2	3.9	67.8
July	12.6	1.5	88.1	0.87	93.1	1.1	91.3	3.5	72.2	3.3	73.8	5.4	57.1	5.7	54.8	5.9	53.2
Aug.	12.9	2.2	82.9	3.1	76.0	3.1	76.0	4.2	67.4	4.3	66.7	6.2	51.9	5.8	55.0	6.8	47.3
Sept.	16.1	2.0	87.6	1.7	89.4	1.8	88.8	3.4	78.9	4.7	70.8	5.9	63.4	5.1	68.3	5.4	66.5

reductions obtained with the 0.72 mm effective size sand appeared to be independent of the hydraulic loading rate and ranged between 27.0 and 80.7 percent.

Mean BOD_5 reductions for the second season for the 0.17 mm sand ranged from 70.4 percent at a hydraulic loading rate of 800,000 gpad to 88.4 percent for the 400,000 gpad rate. Mean BOD_5 reductions for the 0.72 mm sand were essentially constant for all hydraulic loading rates and ranged from 59.9 to 63.2 percent.

PHOSPHORUS REMOVAL

Phosphorus was initially removed by the intermittent sand filters, but removal was greatly affected by the length of time that the units had operated and the hydraulic loading rate. Because little biological growth occurs on or in the filter as the water passes through, it is unlikely that any significant phosphorus removal was obtained through growth needs. Therefore, the most obvious explanation of the relatively large phosphorus removals obtained at the beginning of the experiments was ion exchange. The sands contained some forms of carbonate which probably served as the exchange medium. Once saturated, there would be no phoshorus removal of any consequence. Phosphorus removals in the field units followed the same pattern observed in the laboratory.

ALGAE REMOVAL

Algae concentrations in the influent were estimated by the suspended solids technique which measures a variety of organisms, inert suspended matter, and a number of various algae species. Effluent algae concentrations were also estimated as volatile suspended solids to overcome the disadvantages of the silts and clays washed from the filters during the early stages of the study.

Laboratory filters

Suspended and volatile suspended solids concentrations applied and in the effluents of the laboratory filters are shown in Tables 11 and 12 for

Table 11. Mean applied and effluent suspended solids concentration obtained in the laboratory study.

Loading Period	Applied Suspended Solids mg/l	Effluent Suspended Solids Concentrations, mg/l								
		Effective Size of Filter Media								
		0.17 mm			0.35 mm			0.72 mm		
		Hydraulic Loading Rates, gpad x 10^{-3}			Hydraulic Loading Rates, gpad x 10^{-3}			Hydraulic Loading Rates, gpad x 10^{-3}		
		100	200	300	100	200	300	100	200	300
I	31.0	5.53	7.93	11.2	10.6	10.9	12.8	13.6	11.9	11.0
II	13.7	3.96	4.80	6.05	9.39	8.19	6.50	11.0	8.15	7.28
III	46.3	1.86	1.93	5.33	9.47	11.9	13.7	16.6	15.9	16.5

Table 12. Mean applied and effluent volatile suspended solids concentrations obtained in the laboratory study.

Loading Period	Applied Volatile Suspended Solids mg/l	Effluent Volatile Suspended Solids Concentration, mg/l								
		Effective Size of Filter Media								
		0.17 mm			0.35 mm			0.72 mm		
		Hydraulic Loading Rates, gpad x 10^{-3}			Hydraulic Loading Rates, gpad x 10^{-3}			Hydraulic Loading Rates, gpad x 10^{-3}		
		100	200	300	100	200	300	100	200	300
II	9.16	1.99	2.14	2.30	3.38	3.33	3.40	3.85	4.00	3.17
III	41.3	1.46	1.70	3.48	7.28	7.14	8.31	10.1	13.1	13.2

the various hydraulic loading rates and sand sizes employed. The suspended and volatile suspended solids removals were independent of the hydraulic loading rates employed. However, after the silt and clay were removed, it appeared that a general trend was developing which indicated an increase in effluent solids concentration as the hydraulic loading was increased, particularly when greater concentrations of suspended solids were applied.

Suspended solids removals were directly related to the effective size of the sands at the higher solids loading rates. At lower loadings the removals obtained on the 0.72 mm (.0283 inch) sand were approximately equal to the removals obtained with the 0.35 mm (.0137 inch) filters.

Some algae passed through the entire depth of the filter bed as verified by microscopic examination of the effluents. Borchart and O'Melia (1961), Ives (1961), and Folkman and Wachs (1970) have reported similar results. Percent removal efficiencies increased with the application of higher algae concentrations, but more algae passed the filter than at the lowest applied concentration. Flask bioassay results are presented later in an attempt to study the ability of those algae present in the effluent to grow.

Field filters

Algal removals by the field filters during the first year of operation are not shown because the silt and clay that was washed from the filters made interpretation of the results impossible. During the second year of operation, algal concentrations were estimated by measuring fluorescence[1] and by determining suspended and volatile suspended solids. Linear regression analyses of the solids and fluorescence measurements produced a linear relationship significant at the 1 percent level.

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[1]G. K. Turner Associates, Palo Alto, California.

Influent and effluent algae concentrations expressed as suspended solids produced by the field filters are summarized in Table 13. Volatile suspended solids concentrations are shown in Table 14. Data for the 0.17 mm effective size sand filter loaded at 900,000 gpad are not presented because of the relatively short period of operation. However, algae removals were similar to those obtained with the 800,000 gpad loading rate.

Figure 4 shows the relationship between the hydraulic loading rates and the suspended and volatile suspended solids concentrations in the filter effluents for the 0.17 and 0.72 mm effective size sands. Algae removal apparently is independent of hydraulic loading rate up to a loading of a approximately 600,000 gpad.

Effluent suspended solids concentrations for the months of May and June 1973 were much greater than the concentrations in the effluents. This was attributed to the washing of fines and clay from the filter sand. Filter media were produced from pit runs sands containing large quantities of fines and clays that were easily washed from the filters. Clean water was not available to prewash the filters; therefore, it was necessary to wash with effluent. Much more material was washed from the 0.17 mm effective size sand because much of the fines were removed when preparing the 0.72 mm sand by screening.

At the 500,000 gpad hydraulic loading rate, monthly mean volatile suspended removals were essentially equal for the 0.17 and 0.72 mm effective size sands. Efficiencies fluctuated considerably from one sand to the other during the study period. But in general the 0.17 mm effective size sand produced a better quality effluent, particularly at the 600,000 gpad loading rate. Volatile suspended solids removal efficiencies appeared to be improving with the age of the filters, which is probably related to the washing of debris from the units (Table 14).

Examination of the effluent suspended solids concentrations at various hydraulic loading rates shown in Figure 4 indicates that the 0.72 mm filters

Table 13. Mean influent and filter effluent algae concentrations measured as suspended solids for each sand size and hydraulic loading rate studied during Phase II under field conditions.

Month	Mean Monthly Influent Algae Conc. as Suspended Solids (mg/l)	Mean Monthly Effluent Suspended Solids Concentrations and Percent Removals															
		Effective Size Sand, .17 mm										Effective Size Sand, .72 mm					
		Hydraulic Loading Rate - gpad										Hydraulic Loading Rate - gpad					
		400,000		500,000		600,000		700,000		800,000		400,000		500,000		600,000	
		mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.
May	5.0	25.1	-	56.0	-	20.9	-	-	-	-	-	31.7	-	7.5	-	15.9	-
June	6.5	15.7	-	38.9	-	14.5	-	-	-	-	-	11.6	-	9.4	-	12.5	-
July	29.8	14.2	52.3	23.9	19.8	20.2	32.2	21.4	28.2	15.4	48.3	17.9	39.9	14.4	51.7	16.9	43.3
Aug	44.2	23.2	47.5	18.8	57.5	30.0	32.1	34.5	21.9	39.1	18.6	33.0	25.3	22.4	49.3	26.9	39.1
Sept	25.2	8.7	65.5	13.6	46.0	8.8	65.1	20.5	18.7	16.5	34.5	12.4	50.8	12.4	50.8	11.4	54.8

Table 14. Mean influent and filter effluent algae concentrations measured as volatile suspended solids for each sand size and hydraulic loading rate studied during Phase II under field conditions.

Month	Mean Monthly Influent Algae Conc. as Suspended Solids (mg/l)	Mean Monthly Effluent Volatile Suspended Solids Concentrations and Percent Removals															
		400,000		500,000		600,000		700,000		800,000		400,000		500,000		600,000	
		mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.	mg/l	% Red.
May	2.2	2.2	-	4.5	-	1.6	27.3	-	-	-	-	3.8	-	1.5	31.8	3.5	-
June	3.6	1.6	55.6	2.4	33.3	1.3	63.9	-	-	-	-	1.9	47.2	1.7	52.8	2.2	38.9
July	23.6	4.5	80.9	6.8	71.2	4.4	81.4	9.8	58.5	5.6	76.3	5.5	76.7	4.9	79.2	6.5	72.5
Aug	34.3	5.1	85.1	4.3	87.5	6.2	81.9	17.8	48.1	13.7	60.1	8.9	74.1	12.1	64.7	9.1	73.5
Sept	22.3	2.7	87.9	5.6	74.9	2.5	88.8	6.6	70.4	8.4	62.3	4.8	78.5	2.1	90.6	4.1	81.6

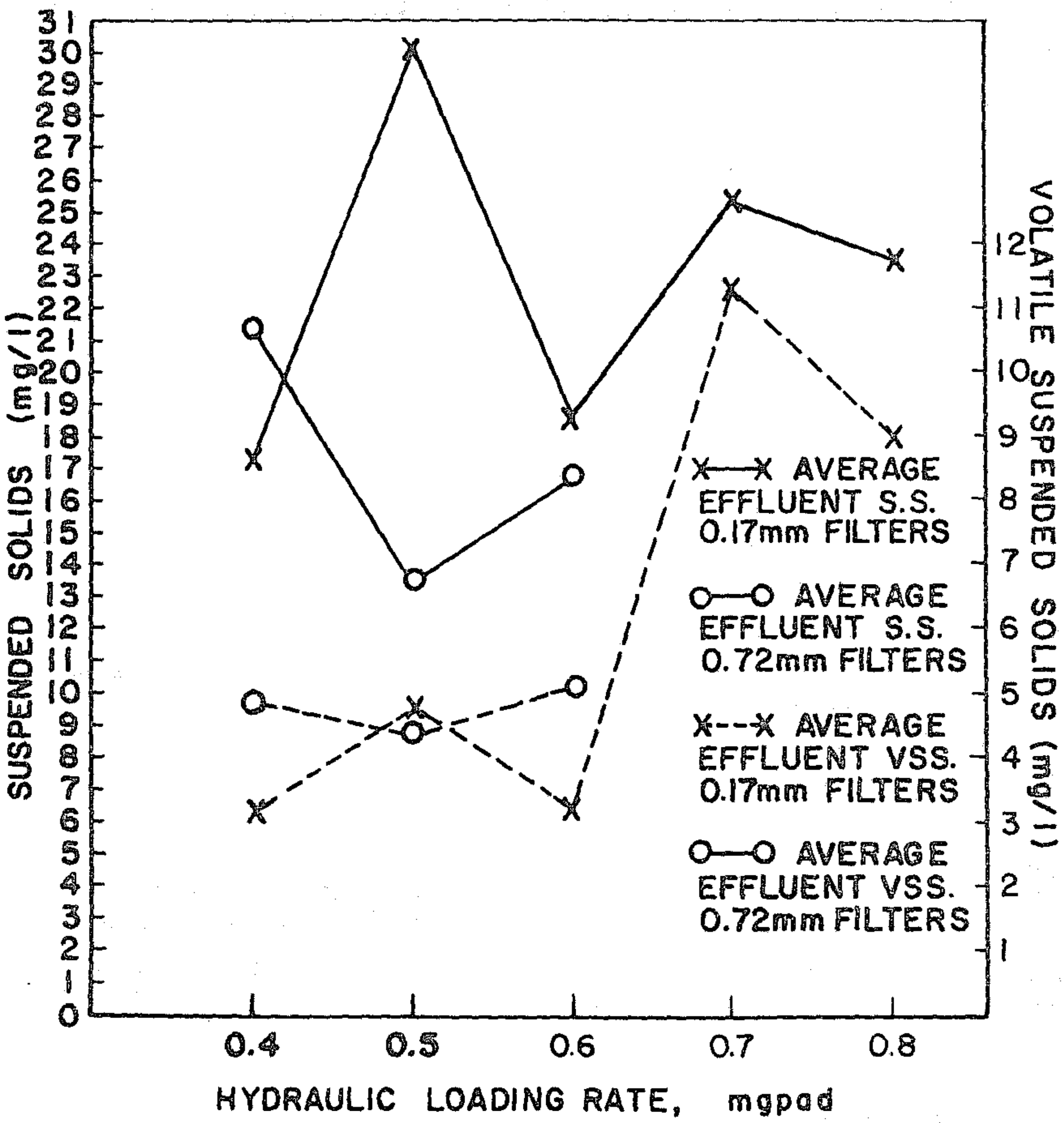

Figure 4. The relationship between the suspended and volatile suspended solids concentrations and the hydraulic loading rates for the field filters.

were more efficient. However, the volatile suspended solids data show just the opposite. Again, this discrepancy is explained by the washing of silt and clay into the effluents.

Laboratory bioassay results indicated that as greater concentrations of algae were applied to the filters more viable cells passed through the 30 inches of sand. As shown in Table 14, during August when the algae concentration was at a maximum, more algae as volatile suspended solids passed the filters.

Although removal efficiencies appeared to improve with the age of the project, noticeable increases in removal efficiencies as the filters approached plugging did not occur. This is counter to the laboratory results and cannot be readily explained except by the variation normally occurring in solids analyses.

BACTERIAL REMOVAL

Stream standards recently adopted by the State of Utah include acceptable levels for both total and fecal coliform organisms. The standards require that a Class "C" water have an arithmetic monthly mean value of total and fecal coliform that does not exceed 5,000 and 2,000 per 100 ml, respectively (Middlebrooks *et al.*, 1972).

Laboratory filters

Total coliform removals of better than 86 percent were obtained with all three sand sizes but due to the high applied counts (610,000 colonies/100 ml) the process was not able to meet the earlier noted standards in this particular application. Even at removals above 95 percent, lesser numbers of applied coliforms would have to be applied in order to meet Class "C" discharge standards. Calaway *et al.* (1952) presented similar results.

As the effective size of the sand was decreased, coliform removals increased, which agrees with the findings of Calaway *et al.* (1952). But, at the hydraulic loading rates employed, total coliform removals with the 0.72 mm (.0283 inch) sand were equal to those obtained in the filters containing 0.35 mm (.0137 inch) sand.

Total coliform removals were independent of the hydraulic loading rates employed, but it is doubted that this would apply at higher loadings. Calaway *et al.* (1952) found that at hydraulic loading rates approximately twice the rates used in this study that bacteria penetrated the bed to much greater depths. Therefore, more bacteria would be expected to pass the filter at higher loading rates. However, at the hydraulic loading rates of 100,000 (153.4 m^3/hectare-day), 200,000 (306.4 m^3/hectare-day), and 300,000 (459.5 m^3/hectare-day) gallons per acre per day, the coliforms removal was independent of loading.

Total plate counts for bacteria showed that the total number of bacteria in the filter influent was essentially unchanged by any of the three sand sizes studied. Also, hydraulic loading rate did not affect the numbers of bacteria present in the effluent.

Field filters

In an attempt to interpret the bacterial removal results obtained with the laboratory filters, total bacterial counts were performed on influent and effluent samples collected from the 0.17 mm and 0.72 mm effective size sands with both loaded at 500,000 gpad (765.90 m^3/hectare-day). After the 0.17 mm filters plugged and were cleaned, total bacterial counts were reduced by 99 percent three days after operation was resumed. But after 18 days of consecutive loading, the same filter effluent contained higher concentrations of bacteria than found in the influent. This increase in effluent concentration with time of operation after cleaning is probably attributable to two factors: 1) the bacterial population in the filter dies off during the drying period before removing the top few inches of sand, and 2) when operation is resumed, the clean sand serves as an efficient filter but as more and more bacteria penetrate the bed and multiply, more are washed into the effluent.

The intermittent sand filter is as much a biological as a physical process and is capable of producing large populations of bacteria within the filter bed. Treatment provided by the intermittent filter when used as a polishing device is accomplished throughout the entire depth of the filter and not limited to the top 12 inches of the bed as implied in other studies.

EFFLUENT ALGAL BIOASSAYS

As mentioned earlier, microscopic examination indicated that algae were passing through the filters. In an attempt to quantify the degree of passage, flask bioassays were employed to assess the number of viable algae in the effluents.

Algae growth, measured by an increase in light absorbency, showed a much greater response in the effluents obtained from the filters when receiving the highest algae concentrations. Microscopic examination also showed higher concentrations of algae in the effluents when the highest concentration of algae was applied.

All of the flask assays exhibited a lag period of approximately three days before any significant growth occurred. This lag or acclimation period required for the algae to respond to a new environment could be advantageous in that it would allow the effluent to be transported considerable distances before an effect could develop. This would allow much of the algae that had passed the filter to settle out or be scavenged before growth could develop. If in the future it becomes necessary to meet more stringent requirements, disinfection would eliminate practically any surviving algal cells.

Microscopic examinations of the field filter effluents yielded similar results, but flask bioassays were not performed on the field filter effluents.

FILTER CONDITIONS AT PLUGGING

Laboratory filters

Plugging did not occur during the three original loading periods used in the laboratory study. To obtain an estimate of the time required for plugging to occur, dosing was continued after Loading Period III without removing any sand from the beds and using algae suspensions from the model stabilization ponds. In order to estimate the plugging time under the most severe conditions evaluated, it was decided to continue loading at the Loading Period III concentrations.

A comparison of the effluent BOD_5 values at the time of plugging with those observed during normal operation showed no noticeable differences. Effluent suspended solids concentrations at the time of plugging were almost equal and near zero. This indicates that break-through does not occur in an intermittent sand filter. This finding is in agreement with the work of Ives (1961) which showed that as the specific deposit increased, the filter coefficient increased. Since the hydraulic head above the sand was not increased to the point that the filter coefficient was forced to decrease, the filters would plug when the filter coefficient was at a maximum. If it were practical to increase the head on intermittent sand filters, breakthrough might occur as in a high rate of pressurized filter.

Possibly the most important polishing mechanisms in intermittent sand filtration is the surface mat or "schmutzdecke" which is composed of suspended matter trapped on the surface of the filter. In this study the mat was composed primarily of algae that had been deposited upon the sand surface.

Following Loading Periods I and II, the filters did not seem to have a predominant surface skin of deposited suspended matter. The top 2 inches (5 cm) of sand seemed to be cemented together by the trapped suspended matter. Below this, the sand particles, although moist, were loose and apparently unaffected by suspended matter. At no time was any of the applied suspended matter detected at depths below the top 2 - 3 inches (5 - 7.5 cm). Sand

2 - 3 inches (5 - 7.5 cm) below the surface mat examined at the end of Loading Periods I and II did not appear to be affected by the applied algal suspensions. Once this sand had become dry, it was hard to tell it from new, clean sand. As the individual filters began to plug under the continued loadings following Loading Period III, a more predominant skin was noted on the sand surface. This skin was, in most cases, approximately one-sixteenth of an inch (1.6 mm) thick and covered the entire filter. During Loading Period III, the 0.17 mm (.0067 inch) and the 0.35 mm (.0137 inch) sands had surface mats that were moist, somewhat porous, and flat or well conformed to the sand surface. But the surface mat for the 0.72 mm (.0283 inch) sand, although moist, was curled and irregular. If a plugged filter is allowed to dry, the surface mat will curl away from the top surface of the sand. This indicates why raking or scraping has been shown to extend the length of filter runs.

Field filters

At the higher hydraulic loading rates employed in the field study, the surface mats for both the 0.17 and 0.72 mm sands followed essentially the same pattern as that observed in the laboratory. The 0.17 mm field filters operated approximately the same period of time before plugging as reported for the laboratory filters (Table 15). At the loading rates employed (400,000 to 600,000 gpad) with the 0.72 mm filters, plugging did not occur during the entire study. Based upon the results of both the laboratory and field studies, it appears that much higher hydraulic loading rates can be employed with the 0.72 mm filters. Higher hydraulic loading rates may result in more efficient solids removal with the 0.72 mm filters because of an increase in thickness of the mat that would accumulate on the surface and serve to trap more of the algae and debris. More detailed economic studies of the operation of the filters needs to be completed, but it appears that the hydraulic loading rate for the 0.17 mm effective size sand filters is limited to approximately 1 mgpad.

Table 15. Operational history of the field filters during the second year.

Filter	Date Began Loading	Date 1st Plug	Ave. SS mg/l Applied	Type Cleaner	Date Loading Resumed	Date 2nd Plug	Ave. SS mg/l Applied	Date Loading Resumed	Type Cleaning	Date of 3rd Plug	Ave. SS mg/l Applied
A4	14 May	10 Aug	20.75	Rake	21 Aug	27 Sept[a]	27.57		-		
A5	14 May	10 Aug	20.75	Rake	21 Aug	27 Sept[a]	27.57		-		
A6	14 May	7 Aug	18.18	Rake	21 Aug	12 Sept	29.58	24 Sept	Rake	27 Sept[a]	24.57
A7	9 July	10 Aug	42.12	Rake	21 Aug	27 Sept[a]	27.57		-		
A8	9 July	10 Aug	42.12	Rake	15 Aug	7 Sept	34.99	7 Sept	Rake	27 Sept[a]	23.82
C4	14 May	27 Sept[a]	25.10								
C5	14 May	27 Sept[a]	25.10								
C6	14 May	27 Sept[a]	25.10								

[a] Project ends.

The 0.17 mm filters were cleaned by raking only which accounts for the relatively short periods of operation between the first and second plugging. If a conventional cleaning by removing the top 2 - 3 inches of sand had been performed, the second period of operation would have matched the initial period. However, because raking is an inexpensive method of extending the period between sand removals, it should be considered part of the routine operating procedure.

TIME OF OPERATION

Laboratory filters

Figure 5 shows the effect of sand size and run time before plugging occurs. It is again evident that the finer sands produce the lowest effluent suspended solids concentrations. But it is also quite apparent that this improved effectiveness was attained at the expense of a reduction in operation time before plugging.

As the operating time increased, an increase in the suspended solids removal efficiency was noted. This is the same as noted by Ives (1961), *i.e.*, as the specific deposit increases, the filter coefficient increases. Knowledge of this situation could prove to be valuable when operating a number of filters. Regular analysis of the effluent for suspended solids would allow one to predict when plugging was likely to occur.

Continued operation eventually caused plugging in all filters. The results show that the 0.72 mm (.0283 inch) filter operated 175 consecutive days before plugging when loaded at a mean algae concentration of 51 mg/l, the 0.17 mm (.0667 inch) sand operated 68 consecutive days at a mean algae concentration of 43 mg/l, and the 0.35 mm (.0137 inch) sand operated 99 consecutive days at an applied algae concentration of 45 mg/l.

Table 16 shows in more detail the operational results for all the filters during the continuation of Loading Period III. Removing the top 4 inches (10 cm) of sand from the filters after plugging, replacing it with new sand,

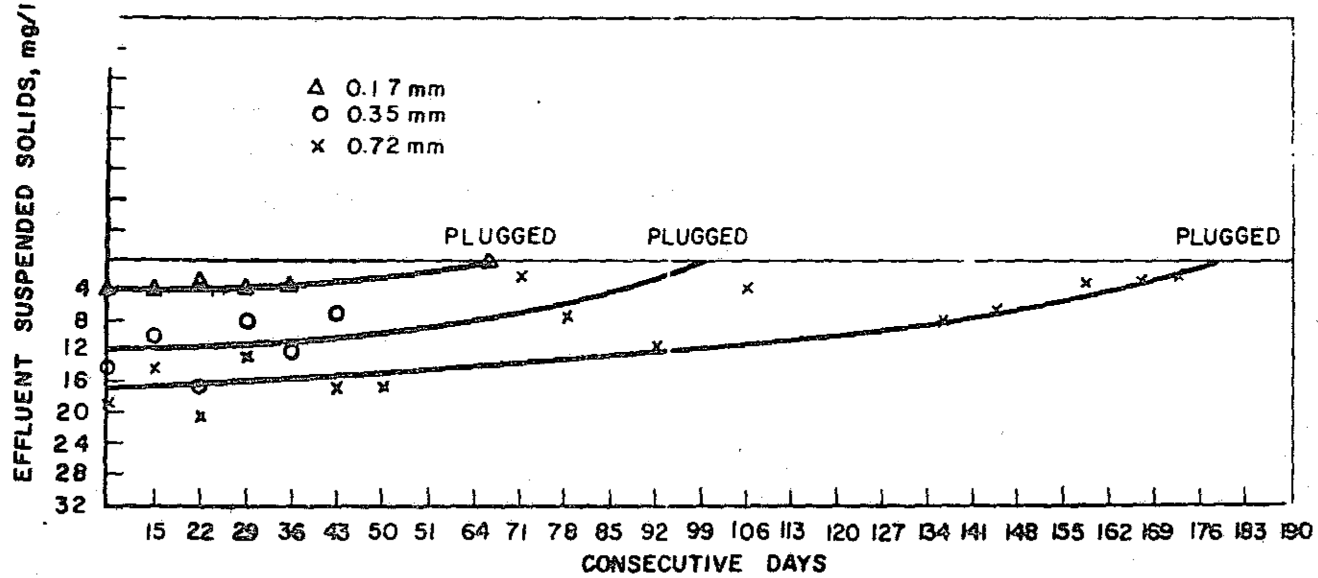

Figure 5. Observed times of operation under approximately 45 mg/l applied algae afforded by each sand size under laboratory conditions and the resulting effect on effluent suspended solids concentration. (Loading Period III plus continuation.)

Table 16. Results of the continuation of Loading Period III showing approximate period of operation by the laboratory filters using two cleaning methods. Loading Period III began 11/1/72 at which time all filters had the top 4 inches (10 cm) of sand removed and replaced with new sand.

Filter	Date First plugging	Mean applied SS to date	Type cleaning	Date put back in use	Date second plugging	Mean applied SS from first plugging	Type cleaning	Date put back in use	Date third plugging
SF 11	4/14	51.46	raking	4/20/73					
SF 12	4/27	51.08	-	-					
SF 13	4/25	51.08	-	-					
SF 21	12/26/72	44.57	scraping	1/10/73	2/6/73	51.76	scraping	2/8/73	
SF 22	12/27/72	44.57	scraping	1/10/73	4/2/73		raking		
SF 23	3/5/73	48.79	raking	3/8/73					
SF 31	12/18/72	46.35	scraping	1/10/73	1/20/73	53.59	scraping	1/30/73	
SF 32	1/28/73	45.19	scraping	1/30/73					
SF 33	1/17/73	44.47	scraping	1/30/73	3/14/73	63.56	raking	3/21/73	4/3/73

and putting the unit back in operation gives second performance periods generally less than the original period. Longer operating periods were expected with the lower hydraulic loading rates; however, the 0.17 mm (.0067 inch) and 0.35 mm (.0137 inch) effective size filters at the lowest loading rate were the first to plug.

Figure 6 shows that the highest hydraulic loading rate studied also allowed greater volumes of applied water to pass the filter bed before plugging occurred. As the figure shows, the result was the same for all the sand sizes studied.

Field filters

As reported for the laboratory filters, the finer sand produced a superior effluent in all categories measured, and again this higher efficiency was attained at the expense of a reduction in operation time before plugging (Table 15).

The increase in suspended solids removal efficiency with increasing operating time was observed for the field filters, but the effluent concentrations appeared to reach a limit and did not continue to drop until plugging occurred. The removal efficiency increase with time of operation in the field filters appeared to be more closely associated with the washing of fines from the filters. However, there is no reason not to expect similar performances between the laboratory and field filters, and it may be that the lack of a decrease in effluent solids concentration is attributable to a continuous washing of fines from the filters up to plugging. After more than one summer of operation, it is likely that a pattern as observed in the laboratory would evolve in the field. Since the 0.72 mm field filters did not plug during the summer of operation, it is possible that the laboratory study results would have been duplicated had the project continued, or had the suspended solids concentrations in the influent been increased.

The 0.72 mm filters operated 137 consecutive days without plugging when loaded at 0.4, 0.5, and 0.6 mgpad with a lagoon effluent containing an average

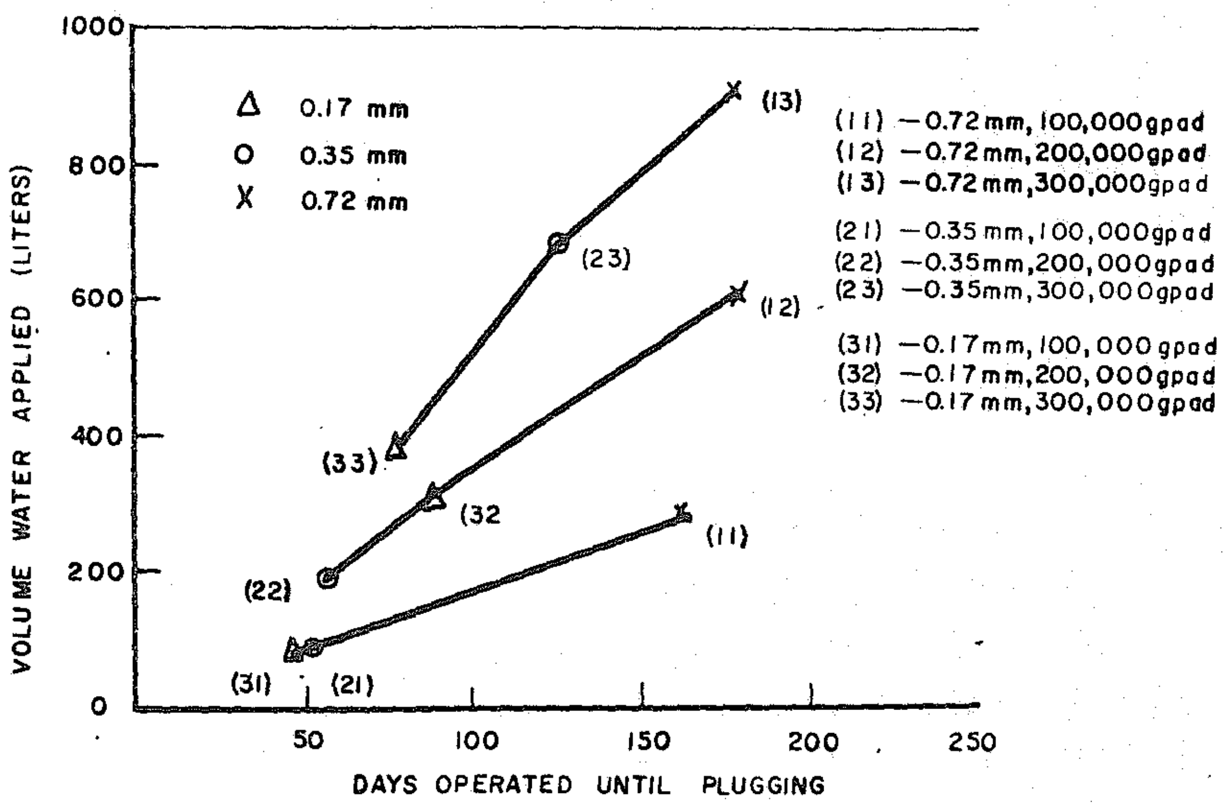

Figure 6. The relationship observed between the volume of water applied until plugging occurred under laboratory conditions.

suspended solids concentration of 25 mg/l. It was not surprising that these units did not plug, because laboratory units with the same sand and a hydraulic loading rate of 0.3 mgpad operated 175 days before plugging and were dosed with a lagoon effluent containing an average suspended solids concentration of 51 mg/l.

The consecutive days of operation for the 0.17 mm filters appear to be directly related to the hydraulic loading rates. Figure 7 shows that up to a loading rate of 0.6 mgpad the filters operated approximately 100 days before plugging when receiving a lagoon effluent containing a mean algae concentration of 20 mg/l. During these 100 days, the filter influent algae concentration ranged from 4 to 51 mg/l. At loading rates of 0.7 and 0.8 mgpad, the 0.17 mm filters operated only 32 consecutive days when receiving a lagoon effluent containing a mean suspended solids concentration of 42 mg/l, and a range of concentrations varying between 30 and 50 mg/l. Because of the large difference in the mean applied suspended solids concentrations, it is impossible to compare the performances at the two hydraulic loading rates or to develop relationships between consecutive days of operation and the hydraulic loading rates.

The results are useful in estimating the number of times during an algae growing season that the filters must be raked and cleaned. During the early spring and summer it is likely that the units will perform effectively for the first 3 months, and removing the top 2 to 4 inches of sand the units should perform a minimum of one month even at very high algae concentrations in the filter influent. It is possible that the consecutive days of operation at the 0.7 and 0.8 mgpad hydraulic loading rates will match those at the 0.4 to 0.6 mgpad rates when receiving equal concentrations of influent algae. Length of operation and the economics of maintenance will be answered in the continuation of the project which will be conducted on a prototype scale.

When the filters plugged, the surface mat and approximately the top 2 inches of sand were raked and broken up and then placed in service again.

Figure 7 shows that there was not a relationship between hydraulic loading rate and consecutive days of operation following the raking. The 0.17 mm filters receiving 0.4, 0.5, and 0.7 mgpad of lagoon effluent had loaded for 38 days and were still operating after the first raking when the project was terminated. The filters receiving 0.6 and 0.8 mgpad plugged within 22 days after the raking. Mean suspended solids concentrations in the lagoon effluent applied to all of the 0.17 mm filters following raking were approximately equal, but the two filters that plugged the second time did receive the highest concentrations of algae, 29.6 mg/l for the 0.6 mgpad loading rate and 35.0 mg/l for the 0.8 mgpad loading rate.

Although direct comparisons of the lengths of performance at the various hydraulic loading rates are difficult, it is obvious that the length of runs for all of the sands and hydraulic loading rates are of adequate length to make intermittent sand filtration competitive with all other processes available to upgrade lagoon effluents to meet new water quality standards.

Figure 8 shows the volume of lagoon effluent applied to the field filters during the 137 days of operation. As reported for the laboratory filters, the greatest volume of water was treated in a given time span by the filters receiving the highest hydraulic loading rates even when plugging occurred and it was necessary to rest the filter and rake the surface before returning it to operation.

OVERALL EVALUATION OF THE PROCESS

Ability to meet present state standards

Intermittent sand filtration was evaluated to assess its capability to produce an effluent that would meet the Utah Class "C" stream standards shown in Table 17 when imposed as discharge standards. In a system such as the Logan City wastewater stabilization ponds, the intermittent sand filter would produce an effluent meeting Class "C" discharge standards 99 percent of the time. The 0.17 mm (.0067 inch) effective size laboratory filters only pro-

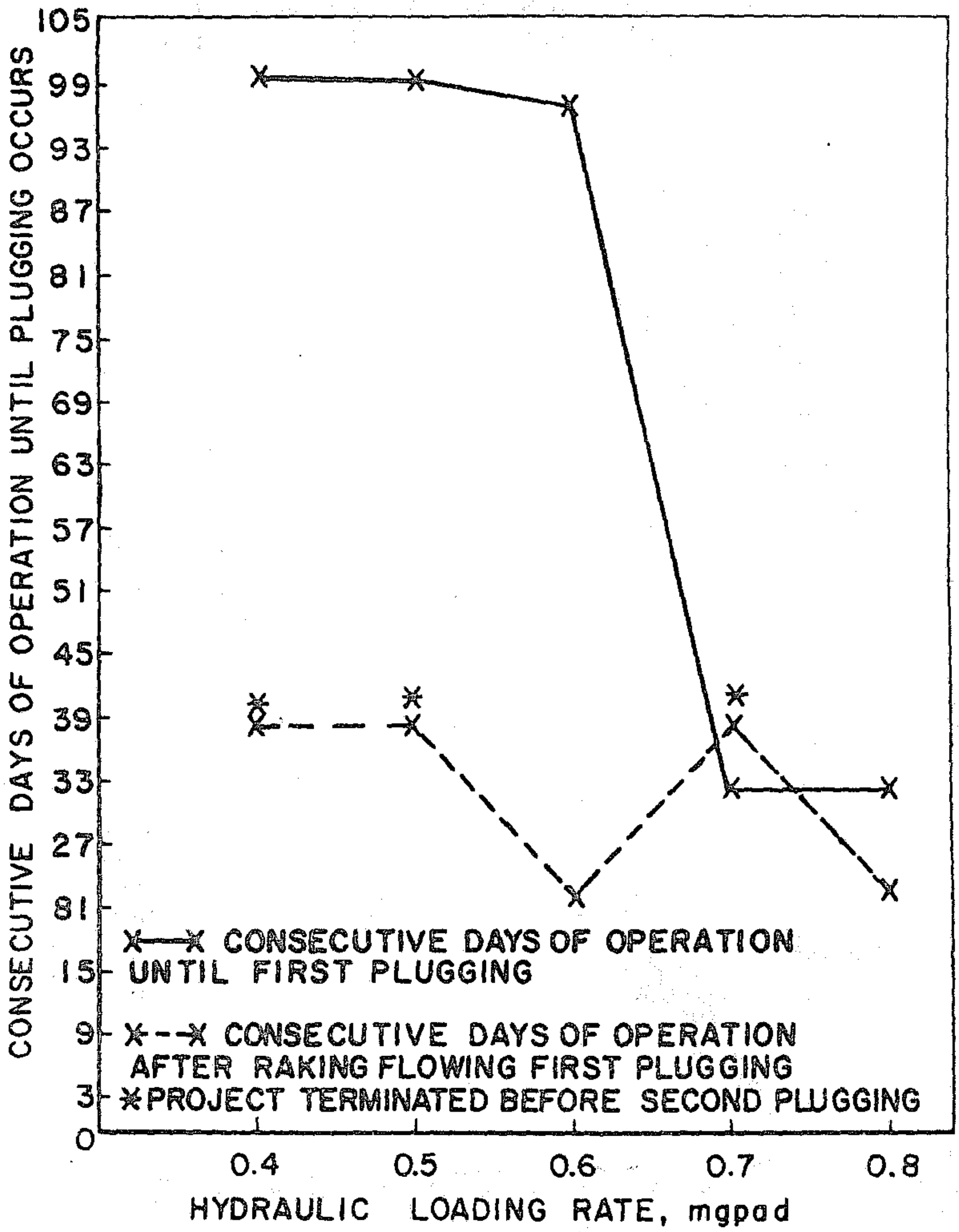

Figure 7. Consecutive days of operation until plugging occurred in the 0.17 mm effective size sand filters at various hydraulic loading rates.

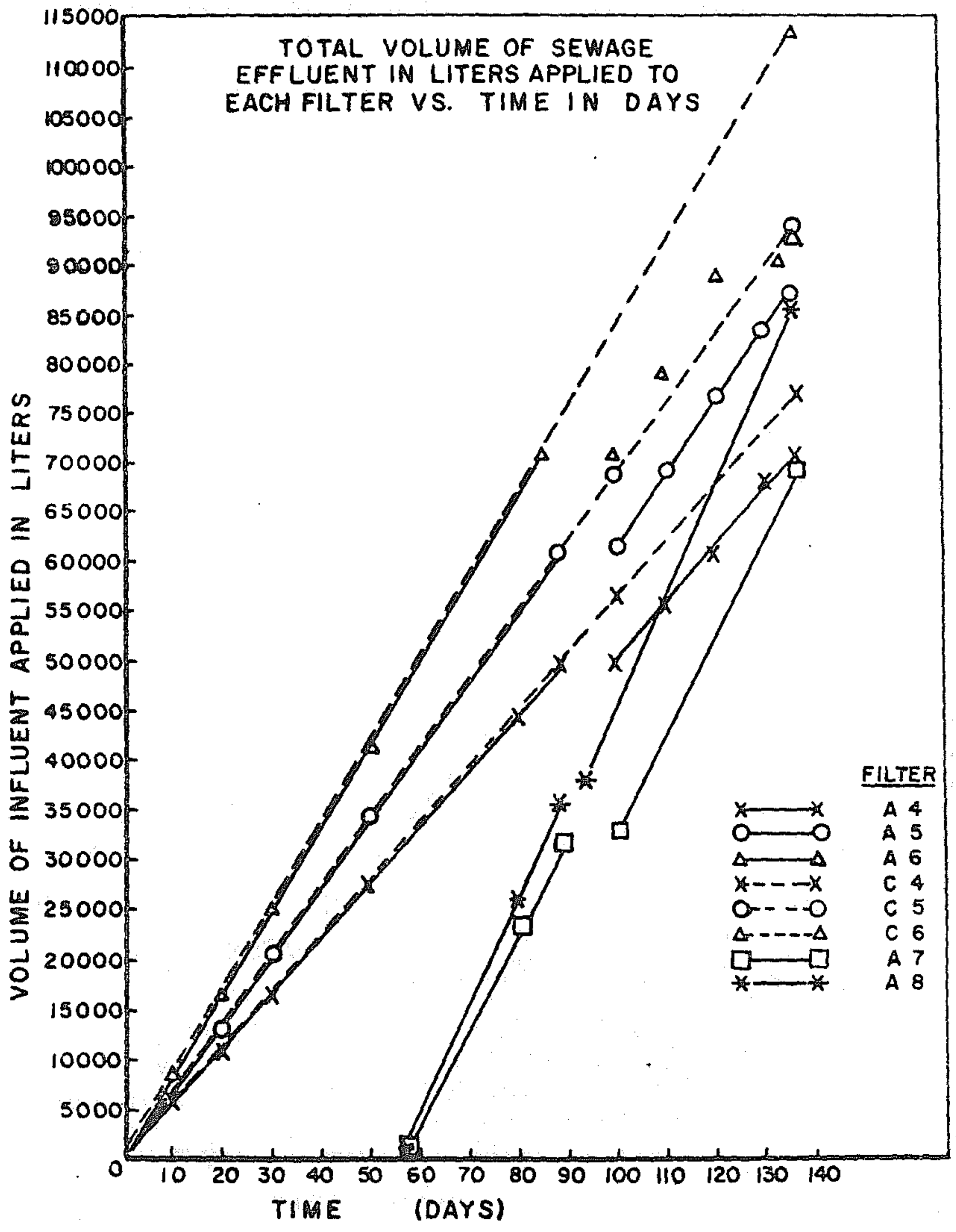

Figure 8. The relationship observed between the volume of water applied until plugging occurred under field conditions. Discontinuity in the lines represents the rest and cleaning period following plugging.

Table 17. Class "C" stream standards for the State of Utah (Middlebrooks et al., 1972).

Parameter	Concentration or Unit
pH	6.5 - 8.5
Total Coliform, Monthly Arithmetic Mean	5,000/100 ml
Fecal Coliform, Monthly Arithmetic Mean	2,000/100 ml
BOD_5, Monthly Arithmetic Mean	5 mg/l
Dissolved Oxygen	> 5.5 mg/l
Chemical and Radiological	PHS Drinking Water Standards

duced an effluent with a mean BOD_5 greater than 5 mg/l (maximum effluent BOD_5 equal 8 mg/l) when loaded at the highest algae concentration and with an influent BOD_5 concentration averaging 36 mg/l. The BOD_5 concentration (36 mg/l) in the influent during Loading Period III was much higher than normally obtained from a well operated secondary wastewater treatment plant. The 0.17 mm field filters produced an effluent with a BOD_5 concentration of less than 5 mg/l on all days of operation when loaded at 0.6 mgpad or less. Effluent BOD_5 concentrations for the filter loaded at 0.7 mgpad exceeded 5 mg/l on only two days out of 67 days of operation and the maximum value in the effluent was 6.7 mg/l. The average BOD_5 in filter A7 effluent was 3.7 mg/l for the entire period of 69 days. A loading of 0.8 mgpad produced an effluent of slightly poorer quality but still reduced the BOD_5 to a mean value of 4.1 mg/l. Thus, most properly operated secondary treatment plants in the state would be able to meet Class "C" discharge standards with the addition of intermittent sand filtration. Even under such heavy BOD_5 loadings as studied during Loading Period III in the laboratory, reductions were greater than 80 percent for the 0.17 mm (.0067 inch) sand at all hydraulic loading rates.

Middlebrooks *et al.* (1972) reported the effluent characteristics of 11 existing wastewater treatment plants in the State of Utah, some of which were heavily overloaded. Seven were trickling filters and five were wastewater stabilization ponds. Assuming that equivalent reductions in BOD_5, suspended solids, and coliform organisms would be obtained by intermittent sand filtration on all types of secondary treatment plant effluents, seven of the eleven plants would be able to meet the BOD_5 standards for Class "C" discharged waters by adding intermittent sand filters. If the overloading were corrected and the plants operated properly, all 11 plants could meet Class "C" discharge standards by installing intermittent filters. Several of these plants were serving metropolitan areas, and it may not be feasible to utilize intermittent filters because of land limitations and economic constraints ususally associated with metropolitan areas.

On the basis of the mean total coliforms per 100 ml reported, five of the eleven Utah wastewater treatment facilities would be able to meet Class "C" discharge standards by the addition of intermittent sand filtration. If the plants were not overloaded, in all probability the coliform requirements could be met in all 11 plants. Again, the addition of a disinfection step would aid materially in meeting coliform removal requirements as well as eliminate the contribution to a downstream algae bloom problem.

Class "C" discharge requirements for pH value and dissolved oxygen are normally easily met by secondary treatment, and the intermittent sand filtration of these effluents further refines effluents. The pH values of the Logan lagoon effluents were approximately equal to a value of 9. When passed through the filters, the pH was reduced to values approximately within the limits imposed. Six to nine mg/l of dissolved oxygen were readily produced by intermittent sand filtration which also meets Class "C" water standards.

COST ESTIMATE

A general approach was taken in the preparation of the cost estimates for an effluent polishing intermittent sand filter process. The estimates shown for initial plant construction outlays are of a higher degree of reliability than the values estimated for operation. Much better estimates of operational expenses will be afforded by the future prototype study.

The in-place total construction cost estimates were prepared through the aid of a local consulting engineering firm. Thus, they are representative of the outlay necessary to construct a typical intermittent sand filter process in the intermountain area during 1973.

The construction and annual operation cost estimate shown for the 15 mgd Logan City facility is not as general in nature as the other estimates. This estimate was based upon two assumptions. One, the process would be located such that pumping of the applied effluent was not necessary. Two, additional cost for land is not necessary as the final one and a half existing tertiary ponds would be drained and the polishing filters would be located within these boundaries. Also, the 15 mgp Logan stabilization pond system is presently the largest existing facility of this type in Utah. A cost estimate for this facility will then provide an expense evaluation for the entire range of stabilization pond systems in Utah.

A large difference was found between locally available filtering media and specially prepared media, so an economic evaluation of the two types of media was made. In this case, the 0.17 mm (.0067 inch) size media was locally available and the 0.35 mm (.0137 inch) and the 0.72 mm (.0283 inch) sizes were specially prepared. The specially prepared media in this area was found to be more than five times more costly than the locally available media. Based on the assumptions that the 0.17 mm (.0067 inch) locally available media was approximately two and one-half times more costly to operate than the 0.72 mm (.0283 inch) media, the 0.17 mm (.0067 inch) media was found to be the economic choice for a 1 mgd and the 15 mgd existing lagoon system.

The construction costs determined in Estimates 1 through 4, Table 18, reflect a paired bed operation designed at 300,000 gpad (459.5 m^3/hectare-day) and 800,000 gpad (1225.4 m^3/hectare-day) and the application of the effluent to the filter in less than 90 minutes. It was assumed that in a municipal construction effort such as this, at least 75 percent of the construction cost would be funded by federal aid. Also, costs without federal assistance are reported.

The construction costs for Estimate 5, Table 18, reflect an optimum design situation for a 1 mgd facility. Conditions considered optimum are minimum bed area operated under scheduled rotation, no pumping required for dosing, locally available media, and plastic bed liners not required. Under these conditions with the aid of federal funds, a filter process designed at 800,000 gpad (1225.4 m^3/hectare-day) for a 1 mgd facility would cost the community $14,500 to construct.

Sand or media expense is approximately 25 percent of the total construction cost. Also, the plastic liner for the bed is approximately 25 percent

Table 18. Estimated cost per million gallons of filtrate produced by various designs of an effluent polishing intermittent sand filter process.

Application conditions	Design flow rate	Design hydraulic loading rate	Effective sand size	Cost with federal assistance $/10^3 gallons	Cost without federal assistance $/10^3 gallons
General (Estimate 1)	1 mgd	0.3 mgad	.17 mm	$47	$115
General (Estimate 2)	1 mgd	0.8 mgad	.17 mm	$33	$ 61
General (Estimate 3)	1 mgd	0.8 mgad	.72 mm	$46	$145
Specific (Estimate 4)	15 mgd	0.6 mgad	.17 mm	$15	$ 48
Optimum (Estimate 5)	1 mgd	0.8 mgad	.17 mm	$16	$ 26

of the total construction cost. Whether or not the liners are a required expense in constructing effluent polishing intermittent sand filters will depend on the specific conditions and regulations governing each location and installation of this process. As shown in Estimate 5, considerable savings are made by not installing the plastic bed liners. In rural areas, land costs for this process are less than 5 percent of the total construction costs.

Costs per million gallons of effluent produced are shown in Table 18 with and without federal assistance. Without federal funds, the costs are greatly increased. The effect of an optimum condition application is noted by the cost of $16 per million gallons (Table 18). Combined effects of larger scale operation and specific application, which in this case held conditions near optimum are noted by the $15 per million gallons cost for the Logan City facility. Finally, for the general applications estimates when a 1 mgd plant constructed with 0.17 mm (.0067 inch) effective size locally available media is compared to one constructed of a specially prepared media. The cost of operation and media using the 0.17 mm (.0067 inch) effective size sand designed for a hydraulic loading rate of 0 3 mgd is essentially equal to the operation and media costs for the coarser 0 72 mm (.0283 inch) effective size specially produced sand. If the 0.72 (0.283 inch) effective size specially prepared sand filter were designed using much higher loading rates and optimum conditions, the cost per million gallons for this particular sand would decrease to the point where it would become economically competitive.

From the present understanding of the operation of effluent polishing intermittent sand filters, a cost ranging between $15 and $47 per million gallons can be assumed to be representative of this process. Table 19 lists alternative methods to meet Class "C" water standards and their estimated costs as reported by Middlebrooks *et al.* (1972). Based on these values, the earlier stated cost for an effluent polishing intermittent sand filter process is quite competitive. There are many avenues of approach that may be taken to produce the same high quality effluent of this process at even lower expense. Coupling this possibility with the fact that a majority of the existing wastewater effluents in Utah can be upgraded to meet Class "C" water standards by the addition of this process, intermittent sand filtration of wastewater effluents has been found to be an economically feasible method of wastewater effluent polishing.

Table 19. Cost of alternative methods of polishing wastewater effluents (Middlebrooks *et al.*, 1972).

Method	Cost per 10^6 gallons
Chemical treatment (solids contact)	$60-130
Grandular or mixed media filtration w/chem	$50
Dissolved air flotation	$110
Electrodialysis	$200
Microstraining	$18

SUMMARY AND CONCLUSIONS

The major objective of this study was to evaluate the performance of the intermittent sand filter and to determine if it was capable of upgrading existing wastewater treatment plants in the State of Utah to meet Class "C" water quality standards.

Hydraulic loading rate was found to have little effect on any of the parameters studied in the laboratory portion of the study. In the field experiments at much higher hydraulic loading rates and varying algae concentrations, suspended and volatile suspended solids removal appeared to decrease with an increase in hydraulic loading. Although significant quantities of applied algae were removed by filtration, cells were found to pass the entire bed depth. Sand size was found to have a general effect on the quality of the effluent produced by filtration. Sand size was also found to be related to the time of operation before plugging occurred. It was concluded that intermittent sand filtration was capable of upgrading a majority of the existing wastewater effluents in Utah to meet Class "C" water standards.

In addition to the above, the following general observations and conclusions were made:

1. Smaller effective size sands better oxidize nitrogen compounds.
2. Hydraulic loading rate has little effect on ability of the sand filter to oxidize nitrogen at the loading rates studied in the laboratory.
3. The nitrogen form which is being oxidized is principally that of ammonia.
4. After establishing equilibrium with the media, intermittent sand filters do not remove a significant quantity of dissolved phosphorus compounds.
5. Hydraulic loading rate has little effect on BOD_5 removal when secondary wastewater effluent is applied to intermittent sand filters with bed depths of 30 inches.

6. BOD removal increased as the effective size of the sand decreased. The 0.17 mm effective size sand filters produced a project low mean effluent BOD_5 concentration of 1.6 mg/l at the 0.4 mgpad loading rate and a high value of 4.1 mg/l at 0.8 mgpad. The project mean effluent BOD_5 concentration for the 0.72 mm effective size sand filters ranged from 5.0 to 5.5 mg/l for the 0.4, 0.5, and 0.6 mgpad hydraulic loading rates.

7. BOD_5 removal was independent of the applied BOD value at the concentrations studied in the laboratory.

8. Viable algal cells passed the entire depth of all the filter sands studied.

9. Hydraulic loading rate did not affect the algae or suspended solids removal efficiency at the 100,000 (153.4 m^3/hectare-day), or 200,000 (153.4 m^3/hectare-day), or 300,000 (454.9 m^3/hectare-day) gallons per acre-day loadings employed in the laboratory study. The effects of hydraulic loading rate on SS removals in the field studies were inconclusive because of the large quantities of fines washed from the filters, but volatile suspended solids removal did indicate a reduction in removal efficiency as the hydraulic loading rate was increased.

10. Smaller effective size sands produced better algal or suspended and volatile suspended solids removal.

11. Sand size was not a significant factor in algae removal at applied algae concentrations of 15 and 30 mg/l, but was significant when the concentration was increased to 45-50 mg/l in both the laboratory and field filters.

12. Intermittent sand filtration produced a 90 percent reduction in the total coliform count in the laboratory filters.

13. Coliform removal was independent of the hydraulic loading rates employed in the laboratory filters.

14. Total bacterial counts as measured by the standard plate count apparently was not reduced by any of the sands studied.

15. Filter plugging causes no decline or improvement in the effluent BOD at or near the time of plugging.

16. Immediately before plugging occurred in the laboratory filter, the filter effluent suspended solids concentrations were approximately zero. As the filter operates with time, the suspended solids removal efficiency increases reaching a maximum point at the time of plugging. This did not occur in the field, but if fines were washed from the filter before placing it in operation, it is likely that a similar pattern would occur

17. At hydraulic loading rates of 0.4 to 0.6 mgpad the 0.17 mm effective size sand filters will operate approximately 100 days before cleaning is required when receiving a lagoon effluent containing a mean suspended solids concentration of 20 mg/l.

18. At loading rates of 0.7 and 0.8 mgpad the 0.17 mm filters will operate 32 consecutive days before requiring cleaning when receiving lagoon effluent containing a mean suspended solids concentration of 42 mg/l.

19. Laboratory filters containing sands of 0.72 mm effective size operated 175 consecutive days before plugging when dosed with a lagoon effluent containing a mean suspended solids concentration of 51 mg/l at a rate of 0.3 mgpad.

20. Field filters containing 0.72 mm effective size sand operated 137 consecutive days before terminating the study without plugging when loaded at 0.4, 0.5, and 0.6 mgpad with a lagoon effluent containing a mean suspended solids concentration of 25 mg/l.

21. If operated and loaded properly, all existing wastewater treatment plants in the State of Utah could be upgraded by intermittent sand filtration to meet Class "C" state standards.

22. Based upon current cost figures it appears that an effluent polishing intermittent sand filter process can be constructed and operated for a cost ranging between $15 to $47 per million gallons of filtrate.

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SESSION V

COMMUNITY CASE PROBLEMS

Moderator:

SIDNEY HEIDERSDORF

VILLAGE SANITARY PROBLEMS

William L. Ryan, Ph.D.*

INTRODUCTION

The Alaska Area Sanitation Facilities Construction Branch of the U.S. Indian Health Service (IHS) has the responsibility of helping to raise the health of the Alaska Natives to the highest possible level through the provision of an adequate source of water and hygienic waste disposal facilities for all Native homes.

There are around 9,000 Aleut, Eskimo, or Indian homes in over 200 villages throughout the state. The majority of these homes do not have safe or adequate sanitary facilities. Onlv about 20% have been serviced with running water since the Indian Health Service program began in 1960. A question that can be asked is: Is running water in each individual home necessary? For the greatest health benefit IHS feels it is. The reasons for this are:

1. People tend to continue using the lake, stream, ice or snow they have always used unless the watering point is closer to their home. It is seldom possible to accomplish this for all the homes within the village.

2. The water often becomes contaminated when it is carried by the individuals to their homes and while stored within the homes.

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3. The quantity of water used within the home has a significant effect on a healthy home environment. When the water is hauled, considerably less is used for bathing, laundry and general clean-up.

4. If haul vehicles are provided to distribute water and collect liquid wastes the village is saddled with large labor and maintenance costs which many cannot afford. ($40 to $50 per month per family versus $20 or $25 for a piped system.) However, engineering considerations in some villages prevent the use of piped facilities and hauling methods must be used.

5. Because of ground conditions during the summer it is impossible to haul water or sewage with a vehicle in many villages. Travel is confined to predestrian traffic on boardwalks.

SEWAGE COLLECTION

Conventional gravity sewage collection systems are used in many villages with several alterations added to reduce freezing problems. All lines and manholes are well insulated and dead ends are constructed so they can be flushed with warm water during periods of low flow. Very little pipe movement can be tolerated with gravity sewers. If soil and drainage conditions indicate frost heaving or settling, other sewage collection systems not relying on gravity must be considered. IHS constructed a pressure sewage collection system in Bethel serving 200 new homes which has worked successfully for the last two years. The sewage is pumped from each cluster of six or so houses through a central pressurized main to a sewage lagoon.

We are also in the final stages of construction on a vacuum operated collection system in Noorvik (near Kotzebue). The toilets flush using only one liter of water. This system will be in operation about August and will serve about 40 houses, a school, and a health clinic.

Both systems will be closely monitored and information will be gathered for future designs. In locations where the sewage collection lines must be installed above ground in utilidors, a pressure or vacuum system approach is very inviting because, if one relies on gravity and the terrain is level, many houses would have to be elevated high off the ground.

SEWAGE TREATMENT

The greatest problem as far as sewage treatment is concerned is to find a simple method which will provide adequate treatment. Operation and maintenance costs must be low. Electricity costs average over 20¢/KWH and oil can cost 80¢ to 90¢ per gallon.

Problems of treating unusually concentrated sewage (BOD's of 1,500 or higher) or unusually diluted sewage are numerous.

Winter water use rates of 800 GPCD and higher are common during the winter in Southeastern Alaska cities and even over 250 GPCD in Anchorage. People leave their water running to reduce the possibility of service lines freezing. This is very wasteful in addition to creating extreme hydraulic overloading at sewage treatment plants. However, even the City of Anchorage recommends it over the radio in the spring.

It must be stopped, but how? Metering of water use is one possibility, but an expensive one for a small community.

Concentrated sewage is generated in many locations such as in small communities, on drilling platforms, and where low water use toilets are used, etc. Because of the nature of these wastes, physical-chemical type plants are usually more efficient than biological plants.

Sewage treatment plants are available to treat sewage produced in the villages to meet EPA effluent requirements. However, the lack of complete operation and maintenance and the logistics and isolation of these sites make it extremely unlikely that the facilities will ever be operated to meet the standards.

A faculative lagoon is our first consideration if local conditions permit. Near most villages in the Arctic, there are small shallow ponds that freeze to the bottom in the winter. In many cases, the outlets of these ponds can be dammed to increase their depth to the point where they can be used as a faculative sewage treatment pond. There can be an odor given off for a short period of time when the ice melts in the spring but with the long periods of sunlight in the summer, treatment efficiency is high. Thus, they should be designed to retain the entire flow during the winter months. Faculative lagoons should be located downwind and at least 1,000 ft. from the nearest dwelling. The lagoons must be designed to prevent the incoming sewage from thawing the permafrost beneath it to the extent the lagoon structure will be jeopardized.

If there is not sufficient area available for a faculative lagoon, an aerated lagoon can be considered. Aeration is usually accomplished with air distribution tubing laid on the floor of the lagoon. In some cases where reindeer processing takes place or other industrial wastes are present only in summer, a surface aerator is used in the village lagoon to temporarily increase the treatment capacity.

The topography of some villages prevents the use of even an aerated lagoon without the requirement of expensive pumping. In many of these places, however, there is room for a small extended aeration plant. These package-type plants should be completely housed in a heated, ventilated building. Two of the disadvantages of these plants are that skilled operators are needed and that they are more expensive to operate and maintain. Physical-chemical package treatment plants have been used by oil exploration camps on the North Slope of Alaska with good results. Because of high operating costs IHS has not used them in the Native villages. Physical-chemical plants require considerable amounts of chemicals during operation and produce sludge that requires disposal. Shipping and storing the chemicals can be expensive.

There is another problem which has been encountered in Southeast Alaska. The standards require chlorination of the effluent, but Fish and Game says there should be no chlorine in the effluent because of damage to small salmon and other fish. Dechlorination is the addition of but another expense and step to an already complicated and expensive facility for a village. In such cases the effluent is discharged to salt water.

SOLID WASTE

IHS recommends using a cut and fill, trench-type landfill operation in the smaller villages because backhoes which are left in the village for water and sewer system maintenance are available and the cost of disposal is much less than for an incinerator. This method is not the most desirable, but it will hopefully stop the practice of dumping the garbage over the bank into the river or out on the ice.

Present incinerators are much too expensive for the smaller villages to operate. Even Barrow, which has a relatively cheap source of fuel, has a population of over 2,000 and has large government installations to help defray the cost to the individual homes, cannot afford to operate their new incinerator.

CONCLUSIONS

The EPA effluent standards could technically be met in rural Alaska but the proper operation and maintenance of the treatment plants would not be possible unless funds were made available to subsidize these costs. Any new treatment methods that would have lower O&M costs and still provide adequate treatment would be a definite help.

I cannot understand why rigid pollution standards that were developed to clean up rivers such as the Ohio and Potomac have to be applied across the board with no exceptions to the Yukon or Bering Sea. In many cases the receiving water would not meet the effluent standards for solids.

IHS feels that providing a reliable method of sewage treatment is more important than providing a high degree of treatment which can and often does break down.

In summation, let's be practical in setting standards. The idea of deciding each case on it's own merits as Canada is proposing seems to be the best way to handle the problem of waste discharges in Alaska.

Reference is made to the appended figure which is the result of data received from a questionnaire submitted to water-producing entities in August, 1973. The questionnaire was a simple one-page questionnaire, which requested the water-supplying entity to fill in sources, treatment, retail population, and production for both average day and maximum day. In essence that constituted the questionnaire so that a quick response would be received. Those results are shown on the appended figure. They are a report by water-supplying entities of actual water used, not a report by a planner or an engineer of what could be used or should be used by the community. The figure is not an erudite presentation in that some of the data may not be strictly comparable for various reasons. The most obvious problem in making a presentation is that seasonal variation is not apparent from the data presented, nor is the very significant industrial use in many of the coastal communities. The bars on the figure report average daily per capita consumption. The per capita consumption for the maximum day is shown in parentheses following the average daily data presented at bar.

The data are presented roughly by latitude in an attempt to see if there were any correlation between latitude and unit water use. The figure starts with Ketchikan, proceeds northerly through the State and terminates at Fairbanks. No readily apparent correlation seems to be obvious from this presentation, except for possibly a decrease in per capita consumption as one leaves the rainy coastal area.

First of all the data presented on the chart are related to the textbook figure of approximately 130 to 150 gallons per capita per day. That textbook figure is for an average municipality and includes commercial and small industrial uses. It does not include high water-using industries, but it should be noted that it does include small industrial water use.

Let me describe briefly a few of the unit water use values for several of the cities. The city of Ketchikan indicated 1,100 gallons per capita per day as average daily use. The maximum daily use is indicated as 1,640 gallons per capita per day. It is significant to note here in the City of Ketchikan there is no high water-using industry so that the extremely high value of per capita consumption is a figure that can be compared directly to the textbook figure. Perhaps the fact that it rains approximately 140 inches per year in Ketchikan has some bearing on the high value shown.

The next four cities shown, Wrangell, Petersburg, Sitka and Juneau are all located in the relatively rainy climate of Southeastern Alaska as is Ketchikan. However, all indicated substantially less unit water use than Ketchikan even though all those cities have some seafood processing industry. This is especially true in the case of Petersburg, whose main industry is predominantly seafood processing.

Skagway, on the other hand, is also located in Southeastern Alaska and has no seafood processing industry, yet the unit water use value for an average day is 750 gallons per capita per day.

The City of Kodiak has the most extensive concentration of seafood processing industry, the high water using industry, in the State. Approximately 15 seafood processors are located in Kodiak. They use approximately 5 million gallons per day, whereas the municipality itself (excluding industry) uses approximately 1 million gallons per day. The average per capita consumption in Kodiak is indicated as 600 gallons per capita per day.

The 1,100 and 2,400 gallons per capita per day value indicated for Seward obviously includes industrial water use. Other data available from inflow/infiltration studies being conducted for the City have subtracted the industrial use from the average daily production. Per capita consumption values for the City of Seward, without industry, range from 1,300 gallons per capita per day during wintertime down to 600 gallons per capita per day during the summer months. It should be apparent that some factor other than wasting water to prevent freezing of service lines is involved in the high unit water use value at Seward during the summer months.

The values that make the whole table realistic and also tend to confirm the validity of the textbook figure are those values for the City of Fairbanks.

The average per capita consumption for Fairbanks is 100 gallons/capita/day with a maximum day of 150 gallons/capita/day. The Fairbanks municipal water system is a heated water system using waste heat from the municipal power plant. In addition the whole distribution system is a loop system and, furthermore, water is physically pumped through the looped mains in the distribution system. Probably most significant in this water distribution system is the fact that the service lines are installed with a pilot tube arrangement, so that the movement of water in the mains forces water through the service lines into the house and out in a return service line back to the mains. The achievement of Fairbanks in restricting per capita consumption to the textbook figure is noteworthy and shows what can be done in a climate colder than in latitudes of Seward or Ketchikan.

At this point one should look into the cause of these extremely high values of unit water use. Probably the single most important cause for the excessive per capita consumption is that of wasting water to the sewer in order to prevent freezing of water distribution service lines. These service lines are the most critical point in a municipal water system subject to freezing temperatures and therefore the most likely to cause the high values of unit water use.

In addition several other reasons can be attributed to these values. Frost heaves break lines in the municipal water distribution system during the winter and then those lines are not repaired until the ground is thawed. The leak is allowed to continue through a good portion of the winter. Another cause is the installation of mains at either too shallow a depth or in a place susceptible to freezing, consequently requiring the municipality to waste water to prevent freezing of the mains. The installation of non-looped distribution systems or non-pumped distribution systems leaves them in a position where wasting water by the municipality to prevent freezing of the mains is necessary. Another reason that should be recognized as being contributary to the excessive values could be called habit. For example in the City of Seward the unit water use for municipal use only during the summer dropped to 600 gallons per capita per day from 1,300 gallons per capita per day during the winter time. This 600 gallons per capita per day value during summer obviously cannot be attributable to any attempt to prevent freezing of service lines. Habit is involved here. That is some of the residents would feel that if the practice were "good enough for Grandpa, then it would be good enough for me." Finally, leaks in the system should be recognized as being a contributor to excessive water use. Perhaps, in the City of Seward and in other places (such as in Dawson) leaks may be a substantial contributing factor to the high value of unit water use.

Now that we have seen what the causes of this problem are it is appropriate to examine the effects. There are several of them and probably the most immediately apparent is the one directly affecting the municipal water system. In general a larger water system is required because of high per capita consumption. This directly affects sizes of pumps, pipes, reservoirs, and water treatment plants. In addition a direct effect is high production of water in a municipal system involving high treatment costs. Generally the pumping costs will be higher because of the need to pump water to a significant portion of a distribution system.

In addition to that obvious affect on the water system, there is a direct effect of high water use on the sewerage system. In general, a larger sewerage system is required meaning larger pumps, pipes, and wastewater treatment plants. In addition to those physically larger facilities, higher treatment costs are involved because of the larger volume. Higher hydraulic loadings are evident as a result and consequently make the concentration of sewage more dilute and more difficult to treat. Because of water wasting into the sewage system, colder sewage is a result. This has the effects of presenting a greater hazard due to incipient freezing in the lines and also an increase in difficulty of sedimentation. Again pumping costs are undoubtedly higher, because in many systems especially those with expanded collection systems, pumping the sewage some place in a sewerage system is usually required.

As a result it should be fairly obvious that the overall consequences of excessive unit water use amounts to a physical and financial leak on a system. It is a drain on the financial resources of municipalities. It should be recognized, though that there is concurrently a beneficial result of high unit water use because there are no frozen lines.

An effect of excessive per capita used that is probably not readily apparent can best be illustrated by an example. In the cities of Kodiak, Cordova and Petersburg, there are concentrations of high water-using industries. These industries, seafood processors, have historically utilized high water-using equipment during the winter time. A typical salmon or crab cannery would use on the order of 0.3 mgd whereas a typical shrimp processing facility would use on the order of 1.5 mgd. These are rough rate figures but give an indication of the relatively high value of water use in shrimp processing. Salmon production is generally restricted to summer months, whereas the production of crab and shrimp is generally a year-round operation. In all three of these cities the municipal water supply is diverted from surface waters. The critical period in these systems is during the winter when precipatation on the watershed falls as snow and remains there and does not flow to the diversion structures. It is an unfortuante circumstance that the highest excessive unit water use occurs in the winter mainly because of the practice of preventing service lines from freezing. These three factors occurring at the same time have caused serious problems in all three of these cities in the last several years. The seafood processors in each of these cities have been closed down sometimes for periods of several months. Therefore the excessive unit water use has to some extent resulted in a direct adverse economic effect on the municipality as a whole. That is to say, not only did all the taxpayers in those municipalities pay for larger water systems and sewerage systems than would be required, but that excessive unit water use periodically caused most of the fishermen, seafood processors, and service industries to suffer a loss of income, partially because of this excessive unit water use.

I have referred to many of the solutions to this problem in this discussion. Probably the most immediate and direct effect would be to insulate the service lines whre the critical problem occurs. That problem most likely constitutes the source of most of the wasted water. The critical point in the service line is either its shallowness or where it rises from the ground into the house, trailer, or whatever facility is being served. Another solution to this problem would be to bury the mains and services deeper to get them below this frost line. A similar solution would be to bury the main generally below the shoulders of roads rather than under roads which are continually cleared of snow during the winter time thereby allowing frost penetration much deeper under the road than under the insulating snow adjacent to the roads.

Another solution which is generally forwarded is to install meters on the services. Several comments are worthy here on meters. When a householder is faced with the alternative costs of several dollars more a month during the winter time because of wasting water to prevent his service line from freezing, he would probably incur such higher costs by wasting water against the probability of paying a much higher cost, on the order of $50-$100, to repair a frozen service line and possible damage that might occur in the house. However, during the summer time when the need to prevent freezing the service line does not exist, the home owner would undoubtedly prevent the wasteage of water in order to save paying for unwanted and unneeded water. Providing meters on high water-using industries, or even the mere suggestion of installing meters on water services to such an industry, usually has a direct and immediate result of inplant conservation practices or a search for alternative sources of water supply. In general in the seafood processing industry salt water is readily available and can be used for some processes previously accomplished using relatively cheap fresh water. In the design of a water distribution system and prevention of stagnating problems in dead ends, a solution would be to loop the distribution system. A further step beyond looping the distribution system would be to physically pump water through the system. Finally, as in the City of Fairbanks, one could install circulating service lines. Again as in the practice at Fairbanks, heating the water either by using waste heat from the municipal power source or using waste oil from a municipality would assist in freeze prevention and therefore reduce the city's need to waste water to prevent freezing.

Finally a partial solution to this problem would be to continue to waste water to prevent freezing the service lines and other water distribution facilities, but not discharge that water to the sewerage system. This will allow the city to maintain the size of their sewerage systems within reason, although that practice would still require a larger than normal water system.

High per capita consumption costs money in several ways, however, it must be pointed out that each solution to this problem also has its associated costs. An economic analysis must be conducted to determine which alternative course of action the city will take.

In summary, excessive values of unit water use is a costly practice for a municipal entity to allow to continue, although as pointed out wasting water to prevent freezing of service lines is a common practice. Although that practice continues and is costly, solutions to the problems are also costly. City managers, or those municipal officials having responsible charge of the municipal water system and municipal sewerage system, should conduct cost effective analyses to determine alternative solutions to the drain on the city's financial resources. Some of these analyses are being conducted at present as a prerequisite to receipt of a grant from EPA for sewerage facility construction, but the practice is by no means as extensive as it should be.

UNIT WATER USE IN ALASKAN MUNICIPAL WATER SUPPLIES

Average Daily Per Capita Consumption*

(in - gallons/capita/day)

City**	0 200 400 600 800 1000 1200
Ketchikan	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx (1640)
Wrangell	xxxxxxxxxxx (1900)
Petersburg	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
Sitka	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx (780)
Juneau	xxxxxxxxxxxxxxxxx(380)
Haines	xxxxxxxxxx (460)
Skagway	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx (920)
Kodiak	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx (900)
Dillingham	xxxxxxxxxxxx (300)
Seldovia	xxxxxx (140)
Homer	xxxxxxxxxxxxxxxxxxxxxx (790)
Seward	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx (2600)
Soldotna	xxxxxxxxxxxxx (770)
Kenai	xxxxx (170)
Cordova	xxxxxxxxxxxxxxxxxxxxxx (900)
Valdez	xxxxxxxxxxxxxxxxx (810)
Anchorage	xxxxxxxxxxxxx (330)
Palmer	xxxxxxxx (240)
North Pole	xxxxxxxxxxx
Fairbanks	xxxxxx (150)
Textbook	xxxxxx

(Data from August 1973 survey)

*Maximum daily per capita consumption shown in parentheses

**Listed roughly by latitude.

SOLID WASTE DISPOSAL IN ALASKA

Joel J. Grundwaldt*, Timothy Tilsworth, Ph.D.**, and Sidney E. Clark***

INTRODUCTION

The preparation of a paper dealing with all aspects of solid waste management in the State of Alaska would be comparable to the presentation of a similar document for all of the "lower 48" - an enormous task. The state-of-the-art of solid waste management in Alaska is not advanced, by any means, but, in general, is keeping pace with developments elsewhere in the United States. Statewide statistics on solid waste are nonexistent in the literature, however, selected publications yield a reasonable picture of the present situation. Most of these publications are contained in the selected bibliography at the end of this paper. Almost no information exists for remote areas of Alaska and thus a major portion of this paper deals with solid waste operations in the Fairbanks North Star Borough and the Greater Anchorage Area Borough.

The State of Alaska had a population of 302,173 in 1970 (U.S. Bureau of Census) and most of this population was located within the city limits of incorporated municipalities. The state contains some 586,400 square miles and is transected by three climatic zones: temperate in southeastern Alaska, subarctic in interior Alaska, and arctic in northern and western Alaska. The state has a broad range of climatic conditions including mean annual precipitation ranging from 4 to 200 inches, mean annual snowfall

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ranging from 20 to 225 inches, mean annual temperatures ranging from less than 10°F to more than 45°F, and temperature extremes of -75°F to +100°F (Hartman and Johnson, 1969). In addition to these extreme climatic conditions, Alaska has a unique soil problem known as permafrost (permanently frozen ground).

The State of Alaska adopted solid waste regulations in October of 1973 which were placed administratively in the Department of Environmental Conservation (Register 47, October 1973, Title 18, Environmental Conservation, Chapter 60, Solid Waste Management, State of Alaska). Three significant aspects of these regulations are (a) incineration shall be considered a viable process alternative in the detailed plan required; (b) the disposal of putrescible waste in areas subject to permafrost or leachate generation is restricted and shall be allowed only in conjunction with special procedures approved by the department; and (c) violation of the regulations is subject to penalties including a possible maximum punishment by a fine of not more than $25,000 or imprisonment for not more than one year or both.

Although the regulations have been helpful in the management of solid waste in Alaska, it has been observed that enforcement of regulations during the past two years has been minimal. Leadership by the State of Alaska has been lacking in regard to solid waste management.

REMOTE AREA SOLID WASTE DISPOSAL

As stated previously, very little definitive information is available for solid waste management in the remote areas of Alaska though limited information is available concerning solid wastes in villages. It has been stated, however, that the sources of the solid waste in the state are, for the most part, imported and very little of the solid waste is exported. This is due primarily to the relatively small industrial base of the state, much of which is located in semiremote areas.

INDUSTRIAL SOLID WASTE

Alaska has a relatively small amount of industry and thus the solid waste problem therefrom is small for such a large state but is huge when considered at the local level. The primary industries of the state are seafood, lumber, and mining. Information is lacking regarding the types and amounts of these industrial wastes. It is known, however, that there is a considerable quantity of these wastes. For example, it is estimated that the processing of one salmon results in about 33% waste. Processing of one crab will result in 70 to 80% waste and waste resulting from shrimp processing amounts to about 80%. The combined weight of fish and shellfish processed during 1970 amounted to almost 605,000,000 pounds. Most of the waste produced from this processing is disposed of in the coastal regions of the state. Recent consideration for resource recovery primarily in the area of animal food production has been directed at the seafood industry. It is obvious that more attention must be paid to the solid waste generated from these industries in the future.

The lumber industry is located primarily in southeastern Alaska and little information is available regarding the amounts and types of waste related to this activity. Several pulp mills are located in southeastern Alaska and the solid waste generated from these industries should be monitored more closely.

Solid waste resulting from the mining industry is essentially that of "spoil" and the tailings remaining from dredging operations.

PIPELINE SOLID WASTE

An additional source of industrial waste for the state is the Trans-Alaska Pipeline. Impact of this construction waste is yet to be determined because of the relative newness of the project. Most of the combustible waste associated with the project is incinerated with little waste deposited in land disposal sites. It is expected that a great deal of industrial solid waste information will be available in the near future due to extensive monitoring operations by the Alaska Pipeline Office (APO-Federal), Alaska State Pipeline Coordinator, Joint State/Federal Fish and Wildlife Advisory Team, and representatives of the conservation societies.

A study conducted in 1974 concerning the feasibility of a Prudhoe Bay/Deadhorse solid waste utility estimated solid waste production in the oil development area of the North Slope to be 6 pounds per capita per day (Arctic Environmental Engineers, 1974). The study recommended a solid waste management process consisting of central collection/transportation and shredding/incineration. Operation costs were projected at $79 per ton for transportation, $145 per ton for disposal and capital costs amounting to $1,748,400. These figures emphasize the high cost of solid waste management in remote areas within Alaska.

RECREATIONAL SOLID WASTE

Recreation is considered a major industry in the State of Alaska. Recent increases in recreational activities have resulted in increased solid waste problems in remote areas. These include maintenance of highway litter control and solid waste resulting in state and federal parks.

The Bureau of Land Management (BLM) of the U.S. Department of Interior, has solid waste responsibility for all Federal lands in the State of Alaska, excluding Pet 4 of the Naval Reserve and the Arctic Wildlife Refuge, both located on the north slope (Jeglum and Stephenson, 1974). BLM solid waste management activities are conducted in the villages if located on federal land and along federal campgrounds near the highways of the state. Litter barrels are provided near the Taylor and Steese Highways in conjunction with two modified landfill operations along the Taylor Highway near the Walker fork of the Forty-Mile River. Modified sanitary landfill operations are also operated on the Steese Highway at miles 66 and 101. The maintenance of the litter barrels on the Steese, Taylor, and Elliot Highways is conducted through an agreement with the Alaska State Highway Department and, during 1974, BLM paid the highway department $7,000 to maintain the operation. BLM actively uses Youth Conservation Corps personnel for assistance with these projects, particularly painting and maintenance. Total cost figures for the campground operations are unknown as are the volume and characteristics of the waste.

The Alaska Division of Parks has an interagency agreement with the State Department of Highways for controlling litter on the highway right-of-way. The Interior District conducts operations in the Delta and Tok areas with some 150 to 200 barrels available for use (Kroll, 1974). Four dumpsters are provided at Harding Lake; two dumpsters are located at the Salcha River campground; and approximately 15 dumpsters are in the Richardson Highway area. Compactor-type trucks are not presently in use at these locations and the solid waste is transported to disposal sites either in open-bed vehicles or in the dumpster units themselves. Problems are expected to increase in the campground maintenance/solid waste disposal operations due to the increased visitation rate and work associated with the pipeline. Solid waste disposal operations include landfill disposal on state property, with the landfills covered twice yearly. Occasional burning occurs for volume reduction and incineration of putrescible wastes. Landfill disposal sites are located off the road and are not visible to the public; however, the sites are not fenced. Some sixty barrels are used as storage containers on the Steese Highway with seventy barrels being used on the Elliot Highway from the Steese Highway intersection to the Yukon crossing. Refuse generally is stored in plastic bags and collected and transported from the Steese Highway intersection in open-bed trucks. An additional problem of the campground solid waste program is the bulk toilet solid waste disposal problem. Bulk toilets in interior Alaska campgrounds are usually of 1,000 gallon capacity and the sewage is collected and hauled to Fairbanks for disposal once yearly.

VILLAGE SOLID WASTE

The Arctic Environmental Research Laboratory (AERL) of the U.S. Environemtnal Protection Agency located in Fairbanks, Alaska, is presently involved with the Alaska Native Village Demonstration project. A part of this project includes solid waste disposal operations at the villages of Wainwright and Emmonak in the State of Alaska (Puchtler and Reid, 1974).

Village solid waste characteristics have not been defined but combustibles are estimated to be a very small fraction of the material. In general, there is a large amount of cans and bottles present as litter in the village area with only small amounts of paper. Litter that occurs in the village areas is generally discarded during the winter with some spring cleanup occurring after breakup. The general disposal pattern in the villages is to dump solid waste on the river banks. This practice is a potential public health and safety hazard because of broken glass and putrescents in addition to being unaesthetic (See Figure 1).

The AERL project at the village of Wainwright utilized a WASTECO California retort pathological hearth incinerator which was designed to include sewage sludge. The burning rate for sludge was about 5 gallons per hour and was reduced to 3 gallons per hour when mixed with refuse. Human wastewater production was estimated to be 3 quarts per capita per day. During late 1973, the demonstration project was razed by fire. The system had been operated three times per week; however, data on the weights and volumes of refuse and sewage sludge are not available. Conclusions derived from monitoring incineration are expected to state that heat recovery was difficult and complex and that incineration, in general, is too expensive for village operations. A new project at Wainwright, proposed by AERL, will

Figure 1: Solid waste at Village of Emmonak. (Photo courtesy Puchtler, AERL, USEPA, 1972)

be a modified landfill with thickened sewage sludge which has been treated with lime and mixed with refuse. The landfill disposal site will be located approximately 5 miles from the village in a permafrost area where a maximum of 14 inches of thaw is noted in the permafrost. Cover material for the landfill will consist of beach sands. Collection of solid waste in the village of Wainwright is by the utilization of plastic bags and barrels at the home, with assistance from a Bombardier track vehicle to which a wire basket is attached.

Solid waste storage and disposal at the village of Emmonak is accomplished primarily through the use of 55-gallon barrels. The refuse is collected with the assistant usage of a trash masher. The demonstration project includes a Northeast Burnsall Incinerator which is provided for disposal of sludge and refuse. The sewage sludge is dewatered by centrifugation prior to disposal through incineration with refuse.

Village residents demonstrate a good level of awareness of solid waste management problems, although the need for public education is evident. Village disposal alternatives include the acute need for a moderately convenient method. Operation of sophisticated disposal facilities is very difficult because of a lack of parts and stock supplies and difficulties encountered in training personnel for maintenance of the equipment.

FAIRBANKS NORTH STAR BOROUGH

The Fairbanks North Star Borough comprises a large area in the interior of Alaska. The 1970 population of the Fairbanks North Star Borough was 45,864 and was estimated to be some 58,000 during 1974 by the Greater Fairbanks Chamber of Commerce. A large portion of the borough population consists of the City of Fairbanks, which had a population estimated at 27,150 during June 1974 (Greater Fairbanks Chamber of Commerce). During 1973, the borough obtained solid waste disposal powers through legislative action but not solid waste collection powers. The Fairbanks North Star Borough operates a modified sanitary landfill disposal site near the City of Fairbanks. Solid waste is hauled to the site individually by residents of the borough living outside the city limits of Fairbanks, whereas the City of Fairbanks maintains its own solid waste collection system consisting of packer trucks.

DISPOSAL

The Fairbanks North Star Borough started operation of the present modified landfill site in 1973. Originally this site was operated by the City of Fairbanks but operation was transferred to the borough in 1973. The City of Fairbanks has a contract arrangement with the borough for use of the disposal operation. The disposal site is located southeast of the city and serves the borough residents with the exception of military operations at Fort Wainwright and Eielson Air Force Base located on the Richardson Highway. The landfill operation has been in existence since the mid-1960's and, during its early years of operation, was maintained by private contractors. Considerable controversy has been associated with this site and its operation and, at one point during 1972, the Department of Environmental Conservation closed the facility because of improper operation. Closure of the facility was prompted because of inadequate and infrequent cover, no vector control program, and solid waste leaching. According to management officials associated with the landfill following the 1967 flood, the City of Fairbanks had been instructed to deposit waste material in the water table itself. Thus the city embarked on a "sanitary landfill operation" in which trenches were constructed that were filled with water and into which solid waste was then deposited. This operation was stopped in the fall of 1972 and shortly thereafter the Fairbanks North Star Borough took over operation of the area. Leachate studies were started by the borough in 1973. As of the summer of 1974, there was little evidence indicating a leachate problem. This may have been due to the fact that contaminants introduced to the groundwater during the period of improper operation had long departed the area. Problems still exist with the operation and the site, in that only a very small amount of cover material is available on location and the suitability of the cover material is questionable. However, a vast improvement has been noted during the past two years. Experimental work utilizing snow as a temporary cover has been considered. Some use is made of the Fairbanks Municipal Utilities System and the University of Alaska fly-ash resulting from the power plant operations. The result of operation of the landfill during the winter is that no cover is applied due to the frozen state of the soil and thus a potential health hazard is present. The solid waste deposited on the ground is frequented by relatively heavy populations of ravens. The site itself is located in an area of discontinuous permafrost and operation during the winter is typified by the extreme climatic conditions, including temperatures approaching -70°F. These low temperatures interfere, in particular, with hydraulic systems of equipment needed to operate the landfill.

Studies conducted by the Environmental Services Department of the Fairbanks North Star Borough during 1973 and 1974 indicated that 212,632 cubic yards of waste were disposed of at the Fairbanks landfill per year. These values, of course, are estimates of volume and the accuracy of these estimates is unknown. Total costs for the disposal of this waste material totalled approximately $210,000 at an approximate unit cost of $1.00 per cubic yard. It is unknown if the volumes were of a compacted nature or were of loose density. Therefore, it is somewhat difficult to estimate the cost per ton of the deposited refuse. However, if one assumes the density of the material, as noted, amounted to 500 pounds per cubic yard, loose, the approximate disposal cost would be $4.00 per ton.

The Fairbanks North Star Borough also operated an experimental landfill near Harding Lake at 41 mile on the Richardson Highway. This landfill is provided for the residents of the borough near the Salcha River area and some 735 cubic yards of waste were disposed of during the 1973-74 period at a total cost of $4,061. Average disposal cost for this operation was $5.53 per cubic yard, or approximately $20 per ton (McKenzie, 1974).

The total solid waste collected within the Fairbanks area was estimated in 1972 to be about 30,800 tons per year, of which 13,800 tons were generated at Fort Wainwright. An average of 4.8 pounds per capita per day was collected in the Fairbanks area, but the average solid waste disposal at the landfill amounted to 6.1 pounds per capita per day. Refuse characteristics for the City of Fairbanks are based on a short-term study conducted by the city during October of 1971. Collected refuse totals were as follows: City of Fairbanks collection service, 76 tons per week; University of Alaska, 45 tons per week; Far North Sanitation Service, 190 tons per week; Drake Sanitation Service, 15 tons per week; and Fort Wainwright, 266 tons per week. A total of 592 tons per week were disposed of in the Fairbanks landfill service area.

COLLECTION

The City of Fairbanks collection service provides for waste generated from approximately 3,000+ households with no direct charge to the individual with the exception of the purchase of the "green bags." However, revenues for the collection/disposal operation are obtained through the city/borough sales and property tax system. The city collection system is facilitated by the use of plastic bags which are 1-1/2 mil thickness and, during 1971, were purchased at a cost of approximately 4.6 cents per bag. Distribution of the bags is provided by the retail establishments in the city at cost to the users. Other private solid waste collectors provide service within the City of Fairbanks for commerical establishments and for both commercial and residential areas in the Fairbanks North Star Borough. Both city and borough collection and disposal problems are expected to increase rapidly in the near future due to the impact of pipeline-associated work.

SPECIAL WASTES

University of Alaska

The University of Alaska operates its own collection system on campus near Fairbanks. The collection system consists of compactor trucks in addition to dumpster-type units. The waste generated from the university consists both of domestic refuse and refuse generated from university-associated activities. Disposal of the material is accomplished at the borough's landfill at no cost to the university. Ashes resulting from the university's power plant operation, which consumes 3,000 tons of coal per year and results in 11% ash, are disposed of at the borough's landfill site and on the campus itself. Characterization studies of the university's solid wastes were conducted during 1971. However, those estimates were based on volume and covered only a three-week period, thus the reliability of the information may not be sound. Some 45 tons per week of solid waste were transported to the borough's landfill site.

Fort Wainwright

A U.S. Army post, Fort Wainwright, is located due east and adjacent to the City of Fairbanks. This installation operates a modified landfill in area near the base of Birch Hill and the Chena River. This military operation has been in progress since the mid-1950s. Prior to 1950 the Fort Wainwright operation consisted of incineration with the resultant ash and residue used as fill as part of a program of reclamation of low-lying areas near the base. At present solid waste is collected on the post, and the majority is transported to the landfill by compactor trucks. During the summer of 1971, 540 tons of solid waste were disposed of weekly. Waste is compacted at the landfill and covered semi-daily using a crawler-type tractor. The cover material is primarily ash resulting from the coal-burning power plant on Fort Wainwright. Local soil is available but only on a limited basis. The present site is generally subject to a high water table with potential leaching problems and discontinuous permafrost conditions.

SUMMARY

Solid waste collection and disposal operations in the Fairbanks North Star Borough have improved radically during the past few years. However, little long-range planning is being done by the borough and it is expected that the present landfill site near the City of Fairbanks will be short-lived. Site-selection controversy is sure to occur prior to 1980. Additionally, because of the "energy crisis," the potential for utilization of refuse as a secondary fuel in interior Alaska appears to hold more promise than in the past. Offsetting the positive aspects of heat recovery is a localized problem of "ice fog". This alternative should be exposed in detail as resource recovery becomes more and more important. Recycling of solid waste from interior Alaska is not feasible at the present time due primarily to small volume and high transportation costs. This bleak picture is complicated by the lack of a nearby market for the recycled material. However, it should be noted that scrap metal from a local junkyard was collected in 1972-73 and shipped to Taiwan. Therefore, all of Alaska's resource recovery potential is not negative. The student chapter of the American Society of Civil Engineers at the University of Alaska is presently engaged in a recycling project which involves collection and transportation of used computer cards to the Seattle/Vancouver area. The status of the project is unclear at this point.

GREATER ANCHORAGE AREA BOROUGH

The Greater Anchorage Area Borough (GAAB) is a political entity of approximately 1,700 square miles which lies at the upper end of Cook Inlet, a large tidal estuary of the Gulf of Alaska. It is the base for important commercial fisheries, a major area of petroleum exploration and production, recreation and other activities as well as the major cargo transport route linking of Alaska with the rest of the world.

Even though the maximum temperature averages 19.4°F during January as in other areas of northern continental United States, the developed area is characterized by permafrost lenses which can cause great economic loss when built upon or very difficult problems with solid waste disposal sites as the permafrost thaws upon filling. Within the area of the GAAB, the mean annual precipitation ranges between 12 and 66 inches, with the larger amounts contributing to a significant leachate problem.

Roughly 85% of the area is mountainous and uninhabitable with numerous peaks ranging from 5,000 to 8,000 feet. Of the remaining area, about half is comprised of lowlands characterized by high ground water levels and thick peat deposits, which leave only about 125 square miles suitable for development. Because of the area's rapid growth rate much of the undesirable lowlands are now being developed, meaning that, in places, up to 30 feet of peat must be excavated and backfilled with suitable material prior to the installation of roads, sewers, storm drains, and other utilities. Additionally, a significant portion of the residential community is now expanding to the mountainsides on 1- to 5-acre tracts where slopes exceeding 25% are common and cause extreme difficulty and high costs in providing road maintenance, sanitary facilities, and solid waste collection service.

PROBLEMS

The function of solid waste collection is currently provided on a mandatory basis to those residents within the City of Anchorage and on the military bases, which collectively represent about 50% of the area's population. The service is also available on a nonmandatory basis to another 49% of the population; however, only about 75% elect to have their wastes collected at the home. The expansion of the residential community into the lowland areas and onto large lots on the hillside areas, both in the area of nonmandatory collection has led to a considerable unit collection cost differential. Based on 1972 data, the collection costs were $32 per ton in the more accessible, higher density area of mandatory collection, whereas, in the area of nonmandatory collection with large lots, the unit costs were $45.10 per ton. Other than the rather high unit costs of which labor costs represent the highest percentage (55%), the collection of wastes functions quite adequately. Probably the most significant problems are those related to the scattering of litter by loose dogs and difficult access to the collection points during heavy snowfalls on unsurfaced, steep roads in the low density hillside areas. The longest distance traveled is approximately 11 miles one way.

Presently solid waste management is administered by the following: the borough government which operates a sanitary landfill, serving a population of 67,500 in Service Area 30 and a modified landfill, serving a population of 8,500 in Service Area 70; the City of Anchorage which operates a sanitary landfill serving a population of 54,500; Fort Richardson and Elmendorf Air Force Base each operating sanitary landfills; and the City of Girdwood which operates a modified landfill and serves a resident population of about 300 plus a weekend recreational population that is estimated to be about 1,500.

Each of the disposal sites has its respective problems in addition to those problems unique to landfill operations in the subarctic. The most significant problem is that of obtaining adequate amounts of cover material during the 5-month period when frost approaches 6 feet in depth. Because of the high land values and scarcity of more suitable landfill areas, which are currently selling for $1.50 to $5.00 per square foot, the more low-lying, often swampy, areas without available cover material, are being utilized as landfill sites. Cover material must be trucked to the disposal operations. With the deep frost penetration, it has proven to be more practical to have cover material delivered to the site on a daily basis rather than stockpiled at the landfill because the material can be excavated from in-place banks which will remain open during winter operations. When obtained from stockpiles, frozen chunks approaching 1 cubic yard in size are common. Cover material costs have ranged between $0 72 and $1.75 per ton over the last few years, with the current price at $1.11 per ton. An additional problem related to climate in the subarctic is a condition commonly called "breakup" which occurs each spring as the top portion of the 5 to 6 feet of frost gradually leaves the ground over a 3- to 4-week period of time. The gradual thawing of frost during the daytime with freezing at night causes the landfills to be nearly inacessible. However, with the application of coarse-grained cover material, the problem can be somewhat alleviated.

Another landfill problem unique to the subarctic has been the limited amount of daylight available from late November through the middle of January when it is limited to the hours of 10 to 3 p.m. Although this doesn't present a particular problem from an operation viewpoint, it has presented a problem with respect to handling safely the large number of private vehicles utilizing a disposal site. The problem has since been minimized with a portable 3-KW diesel-powered generator equipped with two 1000-watt lamps mounted on a telescoping tower which facilitates limited operation during hours of darkness.

For some unknown reason, the landfill operations in the Anchorage community are not plagued by many of vermin so often found in association with land disposal sites. Even though Anchorage is a major port, the community does not have a rat problem. In fact, they are unknown to the Anchorage area, even though they are found in the much colder cities like Fairbanks. The various species of the common fly also are not very abundant. Large numbers of the herring and mew gulls, however, do frequent the area once the frozen lakes begin thawing in late April and remain until freeze-up during October. Of the four municipal land disposal sites located within the Greater Anchorage Area Borough, three are adjacent to airports and therefore the presence of large numbers of seagulls presents a potential safety hazard to aircraft. All attempts to discourage the birds from frequenting the area, including shooting, alarm systems, adequate daily refuse cover, avitrol, and other methods, have failed to alleviate the problem.

The borough, in recognizing that a potential problem could exist with the disposal of refuse in low-lying areas characterized by high ground water levels and in not knowing what happens to refuse where natural ground temperatures rarely exceed 3°C, initiated a groundwater monitoring program at several disposal sites to determine if a potential problem existed in an attempt to develop criteria for the selection of new sites. Two sites were chosen, one of which was underlain by deposits of peat up to 6 feet deep, underlain in turn by well-sorted fine sands with some gravel, and the other of which was underlain by glacial till. The first of the above sites also had a groundwater table within 2 feet of the surface where, in some places, solid wastes were dumped into excavated trenches containing groundwater. The second site had always been dry, with groundwater 9 feet below the disposed refuse. Utilizing a rotary air drill, numerous test wells were installed at various depths in and below the disposed refuse and outside the two sites. These test wells were constructed of 4-inch steel casing, the lower 3 to 5 feet of which were perforated with 8- to 12-inch slots approximately 3/8-inch wide. On the basis of thirty-one parameters selected for testing, it was determined that no detectable leachate was present in the site where refuse had not been placed in the water table. However, in the site characterized by the high groundwater levels, a leachate was found to be present in those areas where the refuse was placed in water as shown in Figure 2 at test wells No. 2, 3, 4 and 5. Even though the landfill has been in operation since 1958 (filling from north to south and from west to east), it does not appear that the leachate is migrating downstream out of the site as indicated by the potentiometic contours. It was not known, however, if the leachate changed with depth because the deepest well, #5, still produced a leachate. An additional deep well, #11, was then installed between wells

No. 4 and 5, using the cable tool method of drilling so as to permit more accurate sampling at selected depths where water could be obtained. It appeared from the previous sampling that specific conductance might be a good field test to detect quickly the presence of leachate. Figure 3 (preceding page) shows how the specific conductance changed with depth. Additional testing has shown that the leachate has not migrated downward below the landfill site.

During Fiscal Year 1972-73 the landfill operational costs for Service Area 30 were as follows:

Personnel	$1.98/Ton
Equipment	3.00/Ton
Utilities	0.09/Ton
Cover	0.72/Ton
Overhead	1.56/Ton
TOTAL	$7.35/Ton

A unique problem to the Anchorage area is the airport incinerator provided to dispose of international air carrier refuse. The incinerator capacity is 1,200 pounds per hour and for the year 1973, 492 tons were processed at an average incineration of 370 lbs/hr. Operational costs during 1973 amounted to $105/ton (Hutson, 1974). Amounts of refuse and costs of operation are expected to increase dramatically in the near future.

PLANNING

The Greater Anchorage Area Borough is a second class borough which, by state statute, provides only the mandatory areawide services of public health, education, planning and zoning, and tax assessment and collection. In 1971, the borough, recognizing the magnitude of the existing and potential problems and cost in providing for solid waste services, applied for and received an E.P.A. Solid Waste Management Planning Grant. This grant was made to finance an investigation of the viable short- and long-range alternatives for providing an optimum solid waste system that was environmentally safe, modern, and efficient. The services, such as solid waste collection and disposal, sewer services, road maintenance, fire protection and other services within a second class borough, are all nonmandatory and must be approved by the voters of a service area prior to their initiation. At the time of the planning grant application, even though 99% of the area's population could receive solid waste collection service through the City of Anchorage's mandatory municipal system or through private firms working the area, only about 85% was doing so. At the same time, only 66% of the area had solid waste disposal authority, which consequently spawned many open, indiscriminate dumping places. Since that time, solid waste disposal authority has been extended to serve more than 99% of the borough's population.

The borough's approach to the planning project has been rather unique with respect to the organization and development of a "master plan". As for organization, the borough utilized a multidisciplinary approach composed of a citizens' advisory committee, consultants having specific expertise on specific functions of solid waste mangement, and a borough staff study team. The forty-five-member citizens' advisory committee is composed of five subcommittees each of which is responsible for developing recommendations on its specific functional topic. These topics include storage, collection and transport of wastes, processing and disposal of wastes, public relations, organization and administration of solid waste systems, and financing and legal aspects. During the development of the studies by consultants, each of the subcommittees acted as a community sounding board on the various alternatives being examined. The borough staff recognized that often a solid waste plan prepared by one consultant leans toward that consultant's preferences or specialities. A complete solid waste plan might not really be considered under these conditions. The borough elected to retain three different firms to examine and recommend alternatives for the functions of storage, collection and transfer; processing and disposal; and organization and administration. Also because the function of collection often approaches 80% of total solid waste handling cost, an attempt was made to reduce costs and build the processing and disposal function around the collection itself. Although there have been some problems with this approach because the multijurisdictional character of the area, it is still felt that this technique has merit. The responsibility and function of the borough study team was to direct and coordinate the activities of the advisory committee and the consultants.

There have been many immediate, short-term direct and indirect effects of the planning activities on managing solid waste within the Greater Anchorage Area Borough. At the City of Anchorage disposal site, the most noteworthy improvements include the installation of groundwater monitoring wells and leachate diversion system, development of a final site plan, construction of an all weather access road, fencing, effective screening, a new entrance gate, and adequate daily cover. At the Service Area 30 disposal facility, the most noteworthy improvements include installation of a groundwater-leachate monitoring system, weighing facilities that categorize solid wastes by type, construction of an all-weather access road, development of a final site plan, and cover material acquisition by contract. The immediate impact of the planning efforts to the Eagle River-Chugiak community (Service Area 70) has been conversion of an existing dump to a landfill by covering it, control of access, presence of attendants when it is open, provision of adequate cover, development of a final site plan, and development of a financial base with which to operate it.

At the present time, an approved long-range "master plan" has not been acted upon. However, the alternatives under consideration include continued upgrading of the existing municipal operations, joint operation of one facility by the two adjacent military bases, relocation of the existing municipal disposal operations to sites where cover material may be obtained on the site rather than having to be hauled in, consolidation of the City of Anchorage Service Area 30, and Turnagain Arm areas into one service area, and joint operation of a regional baling facility with the military bases and the Eagle River-Chugiak Service Area continuing to operate sanitary landfills. Another alternative plan is being considered similar to the above except that the regional processing facility would be a milling plant. Collection and disposal costs of each alternative is presented in Table II.

TABLE II

SOLID WASTE COLLECTION AND DISPOSAL COSTS - GAAB

Alternatives	1974 Annual Cost	1974 Unit Cost	1979 Annual Cost	1979 Unit Cost
UPGRADING EXISTING LANDFILLS				
Collection and Disposal	3,798,500	25.60	6,351,100	31.79
Disposal	1,123,300	7.57	1,679,300	8.41
NEW LANDFILLS AND UPGRADED OPERATIONS				
Collection and Disposal	3,846,900	25.92	6,386,000	31.96
Disposal	957,900	6.45	1,329,800	6.66
CONSOLIDATION AND BALING				
Collection and Disposal	3,677,300	24.78	5,989,100	29.67
Disposal	1,023,000	6.89	521,600	2.61
CONSOLIDATION AND MILLING				
Collection and Disposal	1,023,000	6.89	818,900	4.10
PROJECTED REVENUE AT CURRENT RATES	$2,726,000	$18.37	$3,814,100	$19.09

The cost figures include all projected expenses including overhead. Baling comes out very well because the compaction step is very effectively accomplished under controlled conditions that are not subject to weather extremes.

The regional baling facility has an added attractiveness with its long-range potential for remote site disposal with a resource backhaul using the Alaska Railroad. Outside the metropolitan area, about 30 miles north, sand sites and gravel deposits are abundant. On the return trip, sand and gravel would be backhauled, thereby eliminating an additional problem that is becoming severe in the rapidly developing community. The additional processing costs are more than offset by the retail sale of sand and gravel, the reduced requirements for land and cover material, and the savings resulting from acquiring very expensive lands near the metropolitan area The unit milling costs are also reduced in comparison to the bulk landfilling cost because of smaller cover requirements, and increased densities resulting in smaller land acquisitions. Also, with an ever-changing attitude toward recycling, the adaptability of a milling plant causes that alternative to appear more attractive. However, without a market readily available for reuse of solid waste products in Alaska, Alaskans must weigh very carefully the alternative of resource recovery or processing that has cost disadvantages for sanitary landfill operations.

SUMMARY

Solid waste management is not well-documented in the State of Alaska. Collection and disposal operations are complicated by extreme climatology and operations must be modified to account for severe low-temperature conditions. Unique problems of permafrost and potential generation of "ice fog" present challenges to waste engineers. Although the State of Alaska has existing regulations, it needs to take more positive steps in leadership to ensure that the state does not become an uncontrolled dumping ground for unwanted waste material. The state has thus far provided little more than lip service to the important pollution area of solid waste disposal. Immediate needs to be satisfied in the area of solid waste management include monitoring of solid waste generated throughout the state in municipalities, industries, and villages; research related to the disposal of solid waste in permafrost areas; landfill modification alternatives available to small remote locations such as village operations; and the training programs to ensure proper operation of the disposal facilities including those of landfill and incinerator operations.

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WASTEWATER TREATMENT AND DISPOSAL ALTERNATIVES IN NORTHERN REGIONS

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INTRODUCTION

Wastewater disposal practices at many locations in the North have been dictated by policies and regulations formulated to meet the needs of the more densely populated areas of North America. As a result, some effluents are being improved to a quality far beyond the needs dictated by expected effects in the receiving waters.

This discussion concerns the treatment requirements for discharges of relatively small volumes of wastewater from municipal sources. Demographic, economic and environmental support for a more broadly based policy concerning wastewater treatment will be presented along with a discussion of the basic types of standards which are involved. This will be followed by a discussion of alternative wastewater treatment techniques which warrant more detailed consideration in light of the more flexible guidelines suggested. This discussion is primarily directed at problems faced by small domestic waste discharges although parts of the discussion apply equally well to small industrial waste discharges.

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NORTHERN CONDITIONS

Several conditions in the arctic and subarctic present unique situations which warrant further examination. Three of these are

1) environmental conditions
2) population densities
3) socio-economic constraints of a near-subsistence economy.

Each of these factors should have a substantial modifying effect on the planning and design of wastewater handling and disposal systems.

ENVIRONMENTAL CONDITIONS

Present knowledge of arctic and subarctic river, lake, and estuary systems is very limited. Studies are rapidly filling many of the gaps; however, much is yet to be learned. Some baseline information of the physical and chemical conditions and the ecology of streams and rivers has been gathered. The Chena River, Chatanika River, and Goldstream Creek have been studied in some detail in recent years (Frey, Mueller, and Berry, 1970; Frey, 1969; Schallock, Mueller, and Gordon, 1970; and Peterson, 1973). The effects of waste discharges into the Cook Inlet, Alaska, estuary have been assessed (Murphy, *et al.*, 1972). The annual cycles occurring in subarctic lakes are just now becoming subjects of more interest and study (Alexander, 1970; Tilsworth, 1973).

Not only is information on how aquatic systems function limited, the situation is compounded by extremely varied conditions throughout the state. General characteristics of aquatic systems in relation to wastewater discharges will be discussed briefly with the majority of the discussion centered on stream conditions.

The range of environmental conditions within northern rivers and lakes varies considerably with time of year and location. Winter flow in rivers is negligible while summer flows are high and carry heavy sediment loads. Ice cover is the rule, rather than the exception, with water temperatures at 0°C in the winter, and comparably low during the remainder of the year. During periods of ice cover, the concentration of dissolved oxygen (DO) progressively reduces. Near the mouth of most major rivers in Alaska, natural winter DO levels are well below generally established minimums. The organisms present have adapted to these harsh conditions in various ways by such methods as metabolism reduction and migration. However, tolerance levels, either natural or man-induced, have not been well defined.

Few studies of the effects of wastewater discharges on these waters have been conducted. Gordon (1970) showed in laboratory experiments that indigenous bacteria exert an oxygen demand at low temperatures and that the addition of organic and inorganic nutrients increased the rate of oxygen utilization. Murray and Murphy (1970) also studied the biodegradation of organic substrates at low temperatures. They found that the food-to-microorganisms ratio was more important than temperature in determining the rate of DO depletion.

In another study, the effect of ice cover on the DO content of the Red Deer River in Alberta was measured (Bouthillier and Simpson, 1972). In this river which receives municipal effluent, initial 5 day, 20°C biochemical oxygen demand (BOD) of the river below the outfall and the rate constants established by BOD bottle tests were found to bear little relation to oxygen uptake in the ice-covered, shallow river. Total organic carbon (TOC) closely related to oxygen depletion. It was concluded that biological oxidation under river ice was a complex reaction and the bottom characteristics and benthol demand were very important. The bottom of Red Deer River was mainly gravel and rock allowing a great amount of surface area for the growth of microorganisms.

In evaluating the effect of wastewater discharges from construction camps, Greenwood and Murphy (1972) estimated that a 300-man camp located near the mouth of the Colville River could store wastewater for 9 months, discharge it during a one-month period in June, and increase the stream BOD by only 0.0026 mg/l with proper dilution. This approach, the use of dilution, is a very real alternative which warrants careful consideration.

The results of many of the studies and evaluations differ but are not necessarily contradictory, for each study was conducted under different conditions. There are many gaps in the knowledge of aquatic kinetics yet to be filled before the assimilative capabilities of a northern receiving water can be accurately assessed or predicted.

Assimilative capacities of northern rivers in the winter are undoubtably lower - and perhaps much lower - than rivers of similar physical charactersitics located in temperate zones. Considering the complexity of the ecosystem, the great range of physical characteristics, and the uncomparability to areas where much more research and experience has been documented, it will be quite some time before northern water systems can be accurately modeled. In the interim, the aquatic integrity must be protected by knowledgeable utilization of the limited data coupled with common sense.

Perhaps the lack of knowledge and experience, and the concern for the relatively pristine North has led to defensive guidelines. Perhaps the nationwide application of strong regulations is the sole cause. Whatever the case, the assessment of the effects of wastewater discharges on these waters has generally been by conjecture and extrapolation.

SOCIO-ECONOMIC CONDITIONS

The most significant facts concerning wastewater discharges in the North concern actual population and resultant volumes and strengths of the wastes. As of 1970, the population of Alaska was 302,173 (Evans, 1973). Of these, 71,564 were enumerated as living in areas not considered to be contiguous communities. The remaining 230,609 were distributed throughout the 295 communities of Alaska. Figure 1(a) shows the various communities grouped according to population. Although the mean population is 782, the mode, or most frequently occurring community population, is under 100 persons. As is common to most northern areas, approximately 84% of the communities in Alaska have a population of less than 500 people. From Figure 1(b) it can be seen that nearly one-third of the urban population of the state lives in only three communities. Figure 1(c) shows that only one-fifth of the population lives in the 87% of the communities which have a population of less than 1000 people. Table 1 summarizes population information by community size.

Equivalent information has been developed for the Northwest Territories of Canada (Government of the Northwest Territories, 1973). Table 1 and Figure 2(a) and 2(b) show that the majority of the communities in the Northwest Territories are small and that most people live in the eleven larger communities. In the 1973 study, Northwest Territories' predictions of future community size and number indicated a drastic reduction in the number of smaller communities. A similar reduction in the number of communities and an increase in size can be expected in Alaska.

Many small communities in the North have limited economic bases. In a report by Puchtler (1973) the annual per capita cash incomes of two small Alaskan communities, Emmonak and Wainwright, were examined. These communities are somewhat unique in that they have integrated utilities systems which include water supply and wastewater treatment in one facility. Also, the communities do not have distribution or collection systems.

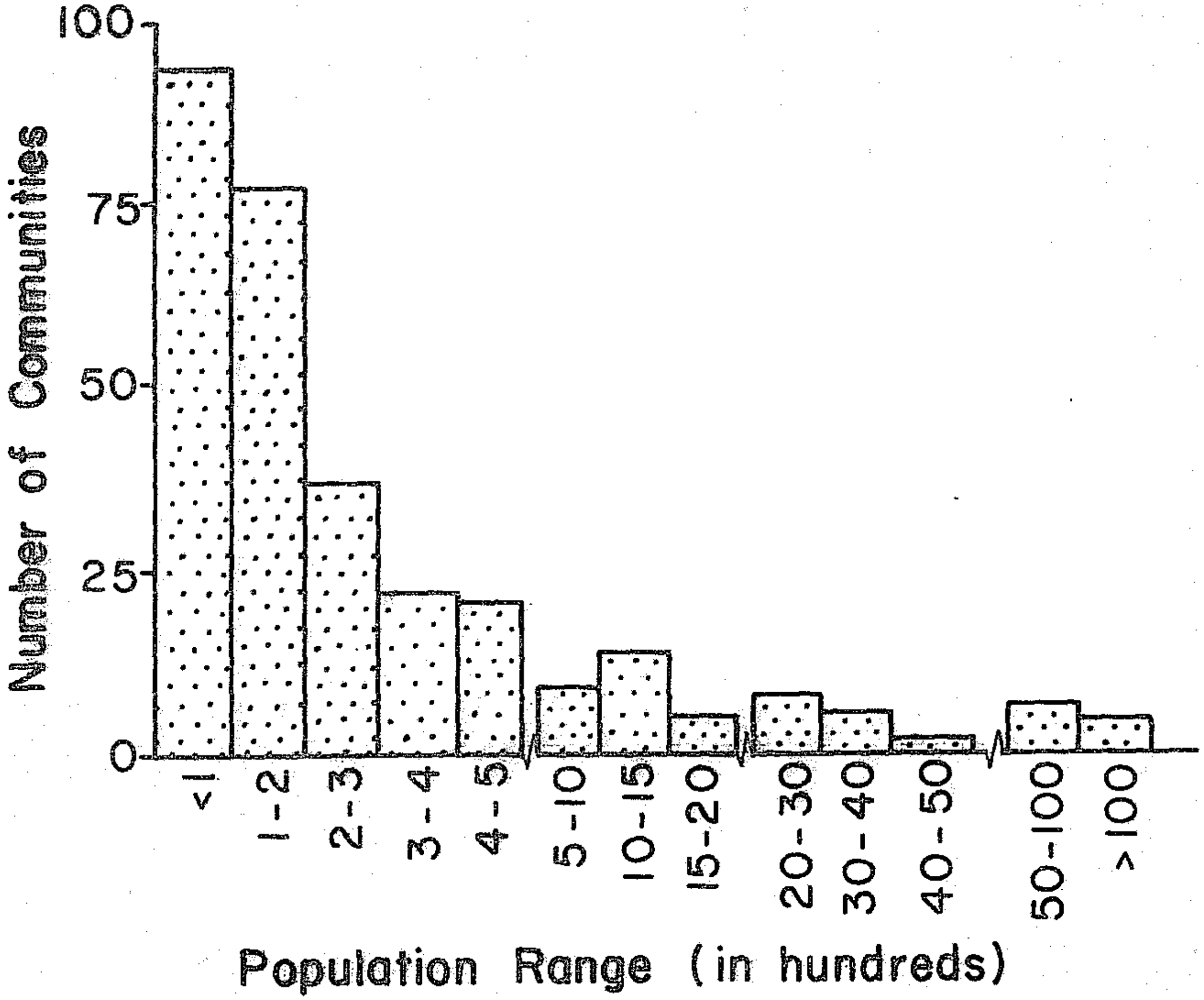

Figure 1A: Summary of Population Information for Alaska

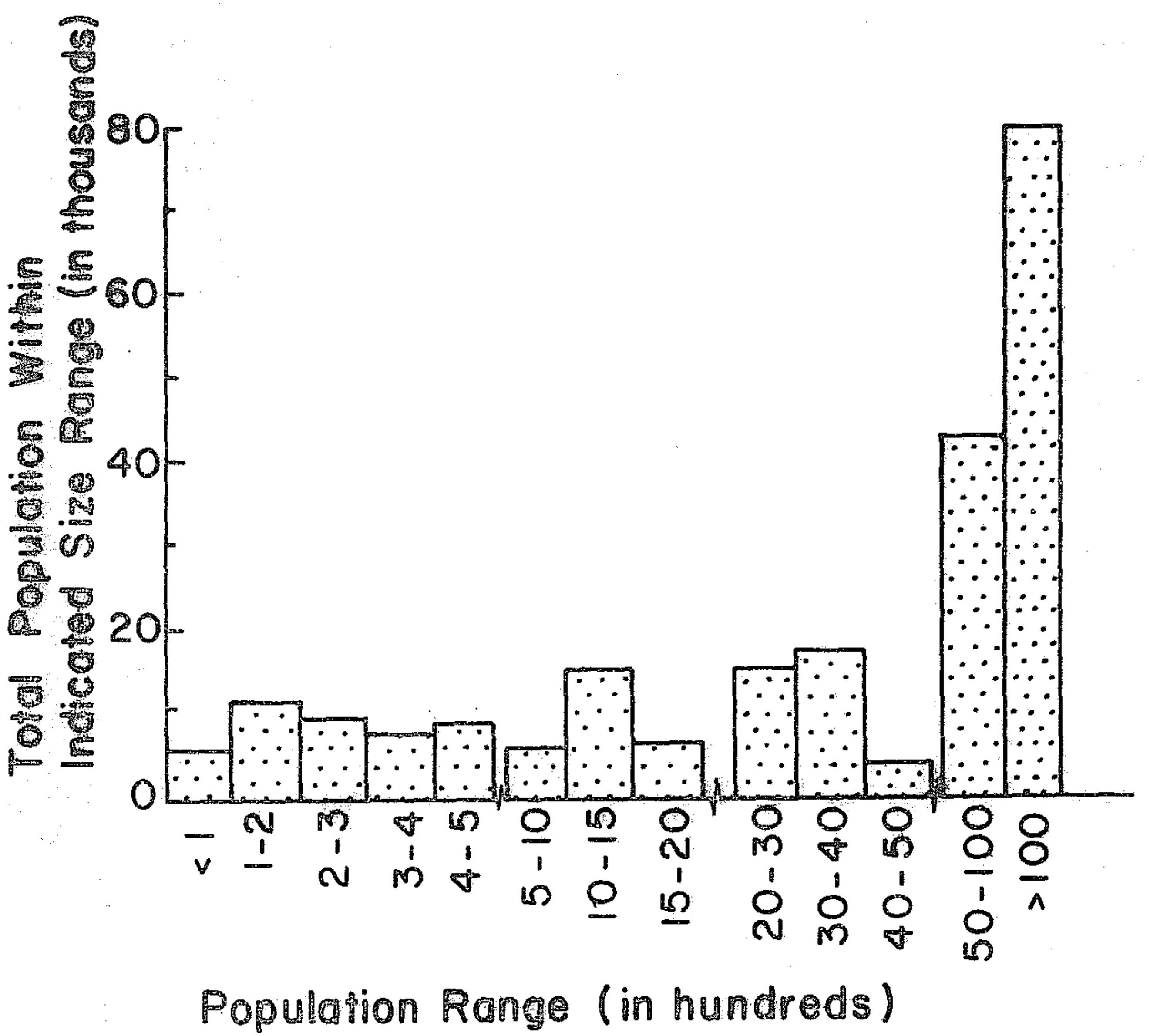

Figure 1B: Total Population within each of the Indicated Population Ranges for Alaska

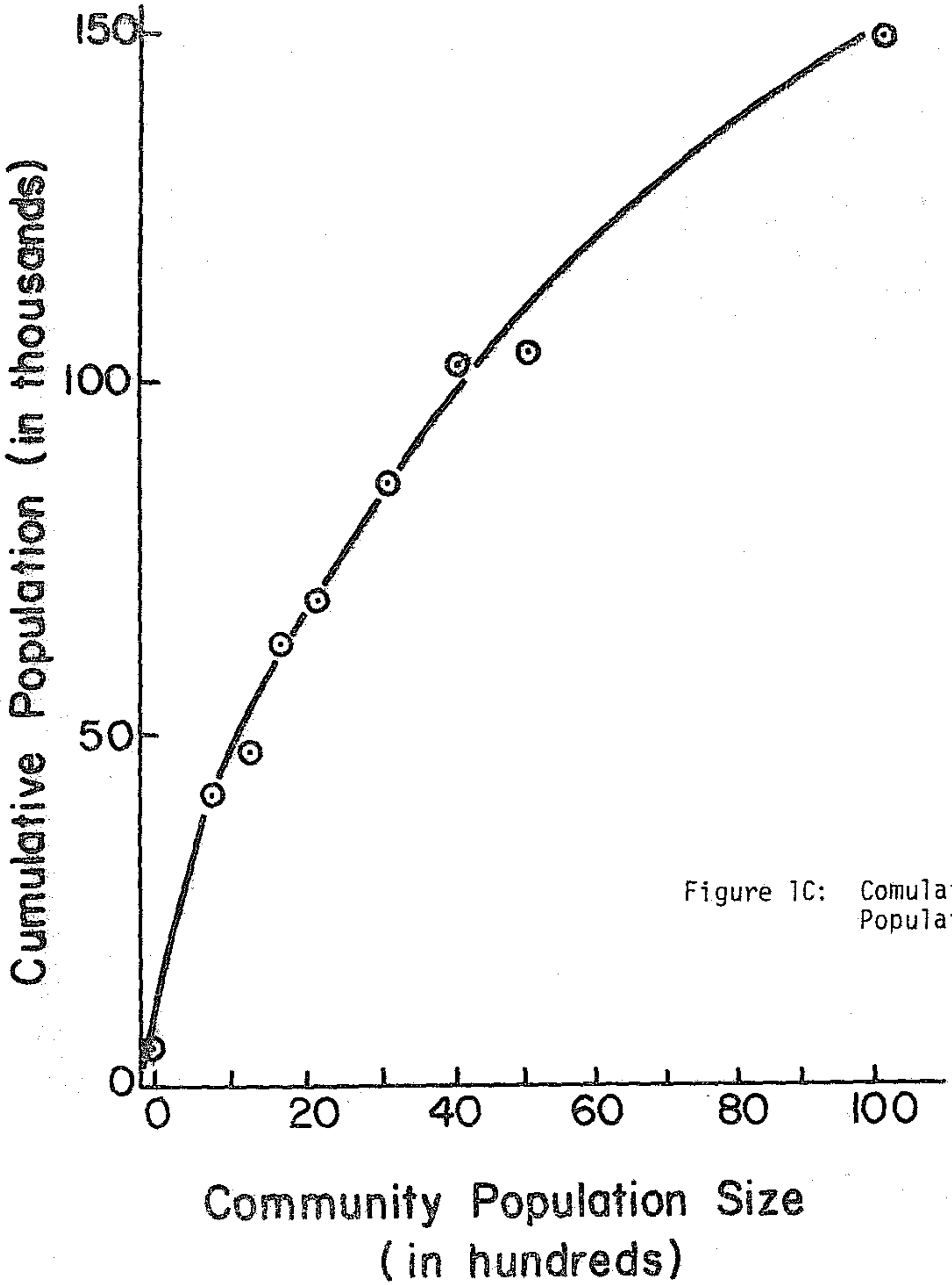

Figure 1C: Comulative Population by Community Population Size for Alaska

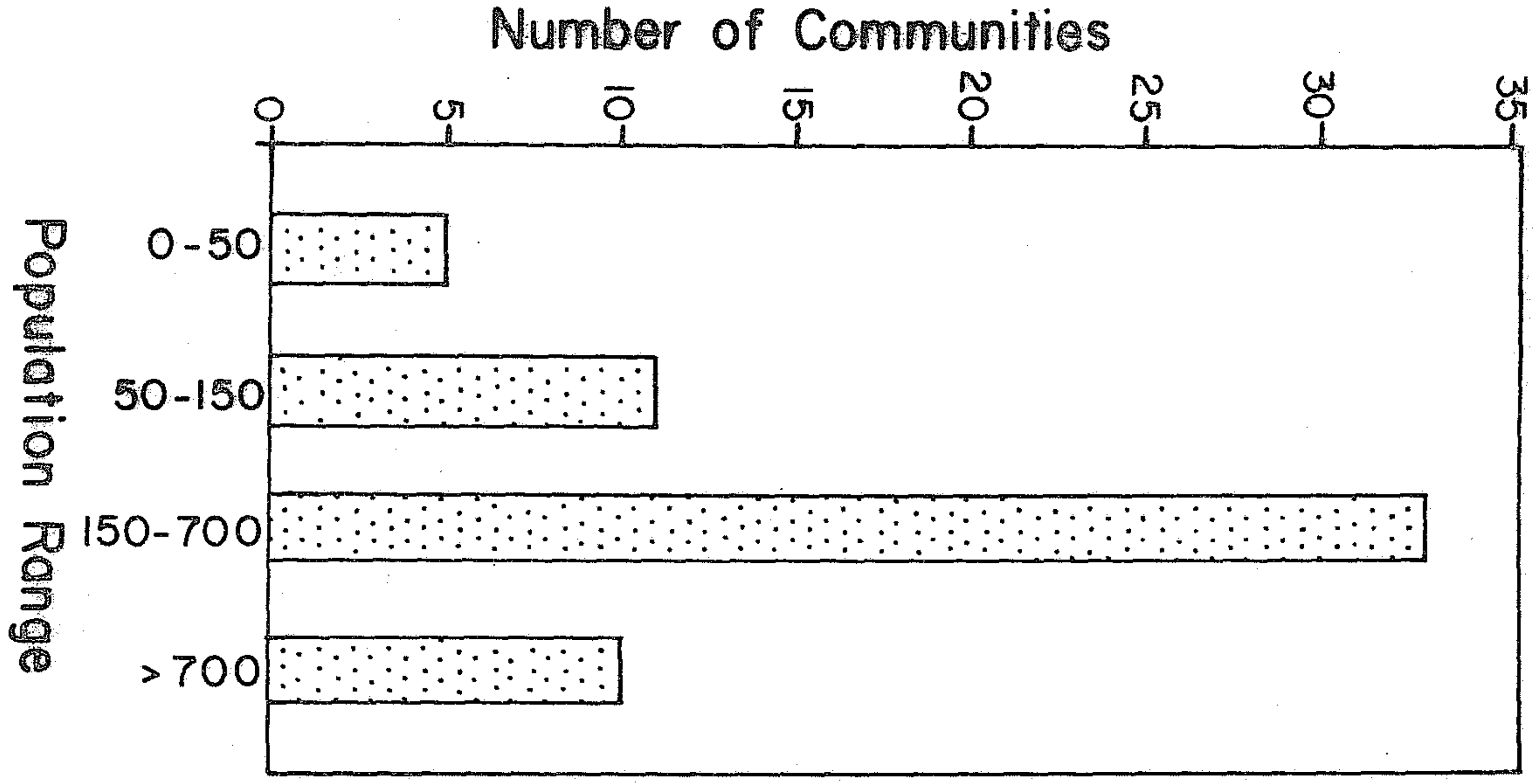

Figure 2A: Number of Communities in Indicated Population Range for Northwest Territories

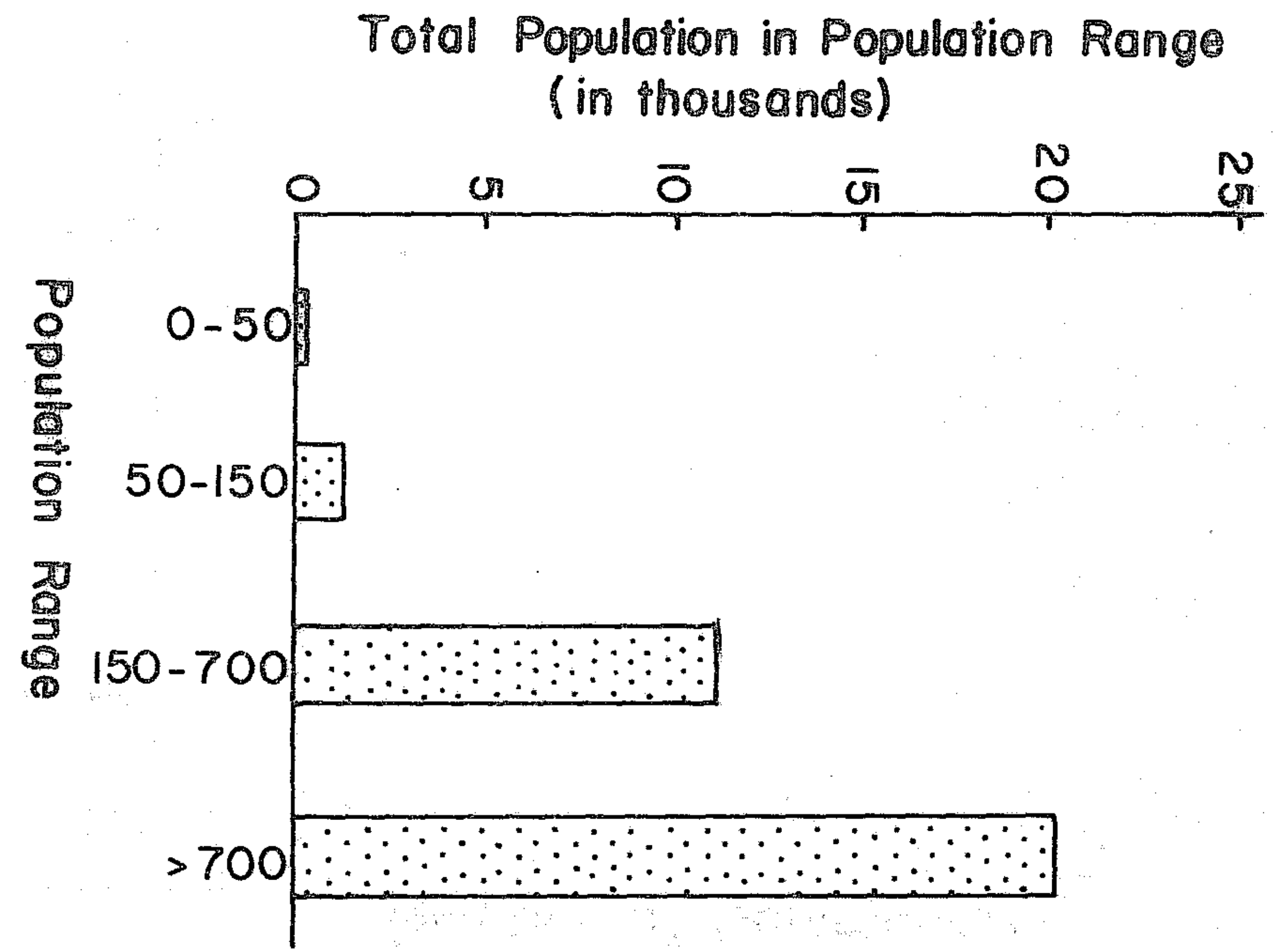

Figure 2B: Total Population in each of the Indicated Population ranges for Northwest Territories

TABLE 1

Population Information for Alaska and Northwest Territories

ALASKA

Population Range of Communities	Number of Communities	Total Population Within Range
100	93	5260
100-200	77	10988
200-300	36	8809
300-400	22	7565
400-500	20	8933
500-1000	8	5689
1000-1500	13	15170
1500-2000	4	6918
2000-3000	7	15765
3000-4000	5	17187
4000-5000	1	4168
5000-10,000	6	43268
10,000	3	80889
TOTALS*	295	230,609

NORTHWEST TERRITORIES **

Population Range of Communities	Number of Communities	Total Population Within Range
50	5	200
50-150	11	1200
150-700	33	12200
700	10	20300
TOTALS	59	33900

* Total Alaska population in 1970 was 302,173 of which 71,564 were not enumerated as residents of established communities.

** Numbers taken from graphs in Department of Local Government (1973). Proposed Water and Sanitation Policy for Communities in the Northwest Territories. Government of the Northwest Territories.

When the incomes were adjusted to Anchorage purchasing equivalents the results were:

TABLE 2

	Actual Cash Income	Adjusted for Subsistence Income
Anchorage	$5,210	
Emmonak	834	$1,034
Wainwright	738	1,288

Adjustments for subsistence food supplies were also made. Puchtler also determined the proportion of per capita income required to meet utilities costs for the communities both before and after adjustment for subsistence food sources. The results are as follows:

TABLE 3

	Percent of Income % Cash Income	Expended for Utilities % Total Proceeds
Anchorage	1.6	1.6
Emmonak	9.2	8.0
Wainwright	14.5	9.8

One should also keep in mind the unequal levels of services that are being compared.

These figures show that northern rural dwellers are presently paying a considerably greater percentage of their income for utilities than are residents of larger cities. This data is important for it indicates that those least able to pay for meeting their utility needs are required to pay the greatest portion of their income.

Other important factors to be considered in evaluating wastewater treatment needs include the recreation and tourist potential of various natural water qualities, the potential agricultural use of the water, use of water systems for subsistence food supplies, and waterway transportation. The relatively natural condition of waters in the less-developed portions of the nation have been of increasing interest to the general public in recent years. The influence of those interested in utilizing wilderness areas for recreational purposes will undoubtedly be felt in certain management decisions. The use of the aquatic system for subsistence food supplies and transportation are also important considerations. Recent reports indicate that agriculture and related water quality changes may increase greatly in the next 10 to 15 years. The major influence of agricultural use on water quality will occur during less critical periods when rivers are free of ice cover and flows are high.

STANDARDS

Generally three types of standards have been employed to protect the ecological, aesthetic and sanitary integrity of the receiving waters. There are

1. standards based solely on receiving water quality
2. standards based on the quality of the effluent discharge
3. standards which combine both of the above in some integrated fashion.

Water Quality Standards

Receiving water quality standards are based on the assimilative capacity of the receiving waters. River basins or stream zones may be classified as to their assimilative capacity and intended use and standards are established for each classification. As an alternative, discharges may be considered on a case-by-case basis with the responsibility for submitting evidence resting with either the discharger or the designated government agency. Dischargers also may be required to maintain certain water quality criteria in the receiving waters.

The advantages of imposing standards derived from such considerations include:

1. effluents can be tailored to the physical and ecological characteristics of the receiving waters to achieve desired quality conditions.

2. flexibility in admistration can be used in adapting to public demands, regional needs and changing stream and effluent conditions

3. innovative engineering and environmental solutions are encouraged

4. uncontrolled discharges such as agricultural, natural occurrences, etc., are accounted for

5. the standards may be used as a land use management tool by establishing zone or basin standards based on priority use.

Disadvantages of this approach are:

1. technical and economic limitations in accurately evaluating the ecological system to establish discharge criteria are experienced

2. legal problems in establishing "scientific" standards and enforcing them are encountered

3. there may not be enough leeway to include room for industrial and population expansion nor a sufficient "safety factor"

4. administrative problems in allocation of the established or estimated "assimilative capacity" among present and future discharges may occur

5. discharges affecting more than one administrative jurisdiction are inherent in many areas.

Effluent Standards

These standards are usually based on a certain allowable discharge in terms of some effluent criteria such as Biochemical Oxygen Demand (BOD) or Suspended Solids (SS) (Many other characteristics may be considered, for example: chemical oxygen demand, toxicity, total dissolved salts, nutrients, etc.) These standards may be based on a specific degree of removal of a polluting constituent, a specified concentration in the effluents, or a specified type of treatment such as "screening," "secondary," etc.

The advantages of basing standards on these criteria include:

1. they are easily administered and enforced, especially in the case of multi-source pollution

2. an equal effort is required by all polluters

3. receiving waters are kept as clean as practical rather than considered as a part of the treatment system.

Disadvantages of these methods may include:

1. actual physical and ecological conditions are not taken into account

2. allowable discharges are usually based on an "average" wastewater effluent and receiving water

3. equal effort may not be equal "economic" effort

4. there may be a lack of flexibility

5. the size of the community is not considered, *i.e.* the pollution loading on a total weight or volume basis.

Combination Standards

A combination standard or compromise standard may include both of the above types of standards to varying degrees. Effluent standards based on some minimum desirable conditions may be supplemented by receiving water criteria. Most standards that have been established are actually a combination of the two, with the major emphasis being placed in one direction.

The origins, merits, and examples of wastewater standards have recently been summarized by Cleary (1974). With respect to the North, some of the advantages and disadvantages of each type of standard are outlined in Tables 3 and 4.

STANDARDS FOR NORTHERN REGIONS

It is ironic that today we are attempting to function under uniform effluent standards similar to those established by the British Royal Commission in 1912 (Cleary, 1974). At that time, the Commission set standards of 20 mg/l BOD and 30 mg/l SS. Today, EPA is suggesting 30 mg/l BOD and 30 MG/l SS in municipal wastewater effluents. This standard requires a properly operated secondary treatment system. It is worth noting at this point that some of the smaller streams and lakes in Alaska could not handle an effluent at even that strength without serious consequences. However, the important fact is that today there is only one substantial community in the interior of Alaska - Fairbanks - and it has plans not only to upgrade its treatment facilities greatly, but also to discharge the highly treated effluent into a river system where the minimum winter dilution at design flow will be over 400 times. (This is assuming a wastewater flow of 6 mgd and a river flow of 4000 cfs.) Other than the Fairbanks area and Delta Junction (1970 populations 33,441 and 703 respectively), all communities in the Yukon River drainage basin have populations of less than 500. Needless to say, the wastewater discharge from all the communities in the basin would be undetectable with respect to BOD if properly dispersed upon discharge.

Physical, ecological, and assimilative capacity characteristics of receiving waters vary considerably as do land use and population density. These variations, together with the economic limitations and social structure, make standards based on a combination of receiving water quality and effluent discharges appear to be most reasonable.

In recently released interim guidelines for the Yukon and Northwest Territories, wastewater treatment requirements were established on a community-by-community basis (Pick, 1973). Decisions of treatment requirements were based on comprehensive studies or expert opinion on public health and environmental needs. Of course, the requirements are subject to modification as community conditions or environmental requirements change or as more information becomes available. Exact treatment techniques were not specified, rather, general effluent quality objectives were established. This appears to be a sound approach to meeting the environmental quality needs of the north.

Presently, the State of Alaska and the Environmental Protection Agency require mandatory secondary treatment with further treatment of the wastewater required if it is to be discharged to sensitive receiving waters. These regulations are, in many cases, absolutely necessary. However, these standards were established on a nationwide basis and do not allow flexibility to meet the needs of small remote communities and camps in the North. This is where the problem lies and this is where continued reworking and modification of our regulations are needed.

Although the need for the reduction of biodegradable organics in municipal wastewaters is not great for many small northern communities at present, the need for proper disinfection does exist. To allow flexibility in engineering and administration, and considering economic and operating constraints in Alaska's many small communities along the coast and major rivers, a minimum treatment of solids reduction and thorough disinfection should be provided. The following discussion addresses methods of meeting the real wastewater treatment needs of these communities.

ALTERNATIVE TREATMENT METHODS

Environmental conditions in northern climates are severe during part of the year and warrant careful evaluations. The foregoing discussion has indicated that the ecology of aquatic systems is not well understood and that the effects of man-caused insults are even less understood.

We have looked at some of the forms of controlling man-created wastewaters. Two general approaches, stream standards and effluent standards, can be used. The contention of the authors is that a position between the two extremes is, at present, the best for northern conditions and for small communities of the North. Many of the communities are struggling for economic independence, a goal which is attainable only if all segments of our system function on a reasonable and realistic basis. In light of this, wastewater treatment systems which warrant consideration under various environmental, health, and socio-economic conditions will be discussed.

For northern communities, wastewater treatment systems can be classified into four categories:

1. disinfection only
2. lagoons
3. aerated systems
4. encapsulated systems

Special consideration and possible modifications with respect to each of these categories will be covered in the following discussion. Again it should be noted that disinfection and simple lagoon systems meet the treatment needs based on the conditions warranting consideration. The need for modified lagoon systems, for aerated outdoor systems, and for encapsulated systems may be dictated in some locations in the north and are only discussed briefly.

DISINFECTION

The importance of wastewater disinfection has been shown by Gordon (1972) in a study of the survival of indicator organisms in a subarctic river. He found that fecal coliform survival was 2.7 to 5.4 times greater than that indicated by winter survival data from more temperate climates. The fact that microorganism survival is inversely related to temperature has been well documented (Velz, 1970). The survival time of viruses is increased as temperature is lowered and is extended to several decades when frozen (Chambers and Berg, 1970). Field evaluation of virus survival in a subarctic stream is now being studied by Gordon (1974a).

In many cases, where small subarctic communities are concerned, a well-designed system providing good disinfection with solids reduction, is all that is needed. BOD quantities discharged from these communities are so low that with a well-designed dispersion system, organics which cause the reduction in the oxygen content of the water would be undetectable.

Direct disinfection methods including the use of chlorine, iodine, bromine, lime, ozone, pasteurization, and ultraviolet light have been summarized by Chambers and Berg (1970). Some of the merits of these techniques will be mentioned briefly.

Chlorine is the most widely used disinfecting agent and is mandatory in most areas. It can usually achieve acceptable results more economically than other disinfectants. However, its effectiveness can be seriously reduced by pH, temperature, and reaction with ammonia to form chloramines. Gordon (1973) investigated the use of chlorine at low temperatures and found a marked reduction in disinfecting ability and although minimal disinfection was not prevented, arbitrary chlorine residuals after a certain contact time could not be considered *prima facie* evidence of satisfactory disinfection. At low temperatures the residual for the same dosage will be higher. This, coupled with the growing concern for the stream ecological damage caused by chlorinated effluents (Gordon, 1974; Brungs, 1973), has led to increased interest in alternative disinfection methods. This ecological problem has not, unfortunately, been reflected in the present regulation (Environmental Protection Agency, 1970).

Iodine on a weight basis has a disinfecting power about four times that of monochloramine for E. coli and a much higher efficiency for reducing virus and cysts (Kruse, *et al.*, 1970). It is less influenced by pH and temperature and is much more stable and easier to handle than chlorine. Lower dosages of iodine are required, therefore low residuals will be discharged with the effluent. This, along with its relatively chemical inactiveness, indicates that less ecological effect would result from effluent treated with iodine. This should be looked into before widespread use. A cost comparison for a North Slope physical-chemical pilot wastewater treatment plant indicated for chemical cost, iodine was 57% more expensive than chlorine (Kreiss, *et al.*, 1970). However, when the other considerations mentioned earlier are included, iodine becomes a viable and more attractive disinfecting agent.

High pH, from excess lime addition as a disinfectant at low temperatures, has been investigated by Morrison *et al.*, (1973). Adequate disinfection of raw and secondary effluent and the precipitated sludge at 5°C, can be obtained at a pH greater than 11.5 with detention times of less than 1 1/2 hours. Temperature was found to be less important than pH. Lime dosage required is very dependent on wastewater alkalinity and hardness, especially to obtain the high pH values required. This will limit the use of lime in areas where it is relatively expensive due to high shipping costs. A lime treatment system will be discussed later in this paper.

Ozone has been shown to be an effective disinfectant at low temperatures by Fetner and Ingols (1959). It holds promise for areas where electricity (energy) costs are comparatively lower than shipping costs. This would include areas close to northern refineries such as Norman Wells, N.W.T., Prudhoe Bay (perhaps Fairbanks, Alaska, in the future) and future hydroelectric sites. Efficiency is high and side benefits such as reduction in COD, BOD and increased dissolved oxygen should be considered.

Disinfection of wastewater by specific disinfection agents or techniques must be considered as a part of the total treatment system, including the discharge method and dilution. Regulations must be adequate to safeguard public health but at the same time versatile so that the most economic and environmentally sound techniques may be encouraged and applied.

All of the following systems provide some reduction of microorganisms. These systems must be considered as part of the total disinfection - organics removal system.

LAGOONS

Lagoons have grown in popularity due to their low initial and operating costs. The relatively large land area requirements, including a buffer zone, reduce their attractiveness for larger communities.

Natural aeration lagoons rely on the bacteria-algae symbiotic relationship to synthesize most of the organic matter to algae (McKinney, Dornbush and Vennes, 1971). Unlike encapsulated, controlled environment, waste treatment processes operating under relatively steady conditions, dynamic methods must be used in lagoon design (Marais, 1970). This is especially true in the north where climatic seasonal amplitude is large and "averaging" is erroneous.

Ice cover reduces the waste treatment lagoon to little more than a sedimentation tank, since the rate of anaerobic degradation will be extremely slow. Wastewater may be stored during this period and discharged during spring flood conditions or retained into the summer until sufficient treatment has occurred (Barsom, 1973). Short circuiting has been found to be the most prominent problem with existing lagoons. Long retention, the use of at least three cells in series and careful design of inflow and overflow piping can greatly alleviate this problem.

To achieve a high quality effluent, algae must be removed from the treated water before discharge. King, *et al.*, (1970) found that a lagoon effluent 5-day BOD at 20°C (55 mg/l) was only 20% of the 26-day BOD at 20°C (290 mg/l) which was approximately equal to the raw wastewater COD (288 mg/l) Without algal removal, the lagoon was not a treatment method with respect to the receiving waters. However, the filtered 5-day BOD at 20°C was only 8 mg/l, which indicates the potential for a high degree of treatment. Algae removal or separation systems such as submerged intakes and rock filters have been discussed by McKinney *et al.* (1971).

Characterisitics of a number of northern lagoons are summarized by Clark, Coutts and Christianson (1970). Grainge, *et al.* (1973) discussed lagoon design, operation, location and construction problems for northern and permafrost regions. The short retention lagoon at Hay River, N.W.T. which discharges into a swampland has been studied. Preliminary reports indicate that in 4,000 meters the effluent creek is comparable to a control creek, both chemically and biologically (Hartland-Rowe, 1973). Extrapolation of these results especially to more northerly locations are cautioned against without more research in this area.

For increased efficiency of lagoon systems in the North, several modifications to natural aeration lagoons can be considered. These are:

1. long retention (reduced shortcircuiting)
2. periodic discharge or cycling systems
3. land disposal (may be periodic)
4. swampland disposal
5. algae removal

Each of these will require study in the North before implemention on large scale.

Aerated Systems

Aerated systems for outdoor use in cold climates are of the extended aeration type. The two systems in use today are the oxidation ditch and the aerated lagoon. The oxidation ditch has been studied extensively and shown to work well under variable climatic conditions (Ranganathan and Murphy, 1972).

The use of aerated lagoons in northern regions has received considerable study because of relatively low operation costs and stable, ease of operation characteristics. Considerable research on aerated lagoon systems occurred between 1968 and 1973 (Christianson and Smith, 1973). In the last year or two, research on aerated lagoons has decreased. However, several projects are still underway by the US Army Corps of Engineers and in Canada.

Encapsulated Systems

Encapsulated systems involve the insertion of a unit designed for temperate climates into a heated environment. This approach to design has worked satisfactorily where time has been the most critical commodity. However, as development proceeds in the North it is imperative that we develop systems which are adapted to the environment we live in. This objective will require creative engineering and the acceptance of a few failures. A first step in this endeavor is a thorough knowledge of past efforts. For now, a few of the key systems of the present and future will be noted.

Extended Aeration

Extended aeration has been in active use for 30 years. The system is good. It requires a low energy input relative to other capsule systems and will probably have a long future in the North. The major problems are the greatly pulsating load seen in small installations and the knowledge and experience required to operate a biological system.

Physical-Chemical

Physical-chemical systems have seen great application in industrial camps. However, the technical expertise required, expensive chemical needed, relatively complicated mechanical gear, high power costs, and sludge disposal problems will inhibit wide use in municipal applications.

Rotating Biological Contactor

The bio-disc has been used in Europe since 1960 and has recently been gaining favor in North America. The system consists of a series of large diameter, lightweight plastic discs, mounted on a horizontal shaft and placed in a semi-circular tank. Rotation of the discs through the wastewater and air build up a microbial mass. The discs, therefore, act as a medium for fixed biological growth. Shearing forces exerted by rotation through the mixed liquor strip off excess biomass. Operation of the bio-disc combines the advantages of activated sludge and trickling filter treatment systems.

This method of wastewater treatment has been used in conjunction with primary treatment to achieve high quality secondary effluent. The hydraulic loading can be adjusted to achieve desirable levels of BOD and ammonia nitrogen removal (Antonie, Kluge and Mielke, 1974). At wastewater temperatures below 50°F lower hydraulic loadings are necessary for a given degree of treatment. Sludge recycle was found to have little effect on system efficiencies. Adjusting disc rotation speed does have an effect although an optimum economic speed should be established for the given conditions (Antonie and Koehler, 1971). The mixed liquor solids settle rapidly and solids concentration of 4 to 5 percent were achieved (Antonie, *et al.*, 1974).

Low maintenance and stability under fluctuating organic and hydraulic loading has been illustrated by Sack and Phillips (1973). These factors along with the low power consumption and the minimal operator skill required make this system suited to package plant application in small and/or remote communities where secondary quality effluent is desired.

Lime Treatment

The addition of lime to raw wastewater has been shown to be capable of achieving adequate disinfection (Morrison, Martin and Humble, 1973). Lime has generally been limited to removing phosphorous and to produce a floc to remove suspended and colloidal matter. There are many papers and reports published on these aspects (Culp and Culp, 1971). The sludge produced can be recovered, recalcined and reused. This process for effluents of different alkalinity was studied by Mulbarger *et al.* (1969). In order to prevent the build-up of inerts sludge must be wasted at a rate that will depend on the effluent characteristics and economics of recalcination versus new lime. Make-up lime amounting to 25% is a reasonable estimate. This can be improved by separating the organic and the chemical sludge by selective centrifugation (Parker, Zadick and Tram, 1973).

Lime as a total system at pH of 11.5 produces a safe sludge and disinfected effluent with approximately 80% removal of BOD, COD, and TOC. Nutrients removal of 96% phosphorous and 30% total nitrogen may be achieved (Bishop, *et al.*, 1973). Comparable organic and nutrient removals may be achieved at a lower pH than that required for disinfection. The incremental cost of lime required for disinfection must be weighed against alternate disinfection methods, keeping in mind the advantages of lime as a partially recycleable coagulant and sludge disposal. Where lime may be available locally or where relatively lower energy to shipping costs reduce recalcination costs, this simple system may have advantages.

Integrated Systems

In Alaska, recent efforts in meeting small community utility needs have taken a different approach. This is the combining of all basic sanitary needs into one central facility in the community. These efforts have seen mixed results to date. A lot has been learned and many improvements have been planned or made. The principle problem with such systems is that they are complicated and require a highly skilled operator for successful operation. This need must be realized from the very beginning and treatment of water and wastewater must be based on the rational health and environmental needs of the location and carefully tempered by economic considerations.

CONCLUSIONS

1. Even though a lower degree of treatment may be obtained, it is economically and practically more efficient to have a properly operating and well-maintained solids removal and disinfection system than a more complicated, expensive to operate and maintain system which may not function properly most of the time.

2. It is imperative that we make use of logic and reason when we begin to apply uniform effluent regulations.

3. It is necessary to look at more than just effluent standards in evaluating municipal wastewater discharges. The health, social, economic and environmental effects of all alternatives should be examined. Health and environmental effects should have controlling influence where it appears that undesirable effects may occur.

4. There is a definite need for a factual cost study to the total design and construction cost of small wastewater systems in the North. Also, the operating and maintenance costs must be clearly and completely evaluated if we are going to proceed on a rational basis.

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