UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SUBJECT: Implementation of EPA's Flow Regulation Policies

DATE: March 15, 1973

FROM: David Calkins

TO: All Water Basin Planning Officers

Enclosed herein for your use and information are the EPA guidelines regarding Storage and Release for Water Quality Control in Reservoirs Planned by Federal Agencies (hereafter referred to as Guidelines).

The Guidelines include:

A. A copy of Section 102(b) of the Federal Water Pollution Control Act Amendments of 1972.

B. A description of the six main issues expressed in the Guidelines.

1. Adequate treatment for control at the source.
2. Determination of the need for storage for water quality control.
3. Environmental assessment.
4. Assessment of the value of water quality control storage.
5. Identification of beneficiaries.
6. Assessment of widespread or national benefits.

C. An Appendix which is an Assessment of Adequate Treatment For Implementation of EPA's Flow Regulations Policy.

David L Calkins

EPA Form 1320-6 (Rev. 6-72)

The Appendix provides quantitative information on pollutant reductions of "at source treatment methods," however, it should be noted that the treatment levels apply only to flow regulation studies. Guidelines as they relate to flow regulation for Municipal Wastes Treatment techniques will be published in the near future.

Enclosure

ENVIRONMENTAL PROTECTION AGENCY

REPLY TO
ATTN OF:

DATE: JAN 16 1973

SUBJECT: Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies

TO: All Regional Administrators

1. PURPOSE

To amend EPA policy on determining the need for and value of reservoir storage for water quality control.

2. BACKGROUND

a. Section 102(b) of the Federal Water Pollution Control Act Amendments of 1972 requires, in part, that in the planning of any reservoir by a Federal agency, inclusion of storage for regulation of streamflow shall be considered, except that such storage shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source. The Act also provides for additional coverage over previous legislation in that reservoirs constructed under license granted by the Federal Power Commission are also included. The Act further provides that the need for, value of and impact of storage for water quality control shall be determined by EPA, whereas the need for and value of storage for other stream flow regulation purposes shall be determined by the Federal agency planning the reservoir. To administer this legislation, "adequate treatment or other methods of controlling waste at the source", must first be defined and then the pollutant reductions attainable from application of these measures must be estimated.

b. Over the past several years, advancement in pollution control technology, together with an increasing recognition of the limitations of flow augmentation as a means of enhancing water quality, have indicated that reservoir storage for water quality control is generally a poor substitute for at-source pollution control measures. This points toward the need for a policy requiring provisions for high degrees of pollutant reduction from at-source controls or treatment methods prior to consideration of reservoir storage and releases for water quality control. Such a policy would be consistent with the National goals for water quality and control of pollution sources set forth in Section 101 of the Act.

3. STRUCTURE OF POLICY

The enclosed guidelines and an appendix defining "adequate treatment" supplement the policy statement presented below.

4. POLICY STATEMENT

a. Storage to be included in a reservoir or other impoundment project for regulation of stream flow shall not be used as a substitute for the provision of adequate waste treatment or other methods for controlling waste at the source.

b. As a basic element of this policy, EPA defines "adequate waste treatment or other methods of controlling waste at the source" as the best available pollution control technology economically achievable including advanced waste treatment techniques, land disposal, land management practices, process and procedure innovations, changes in operating methods and other alternatives.

c. Water quality monetary benefits obtainable from streamflow regulation shall be credited only to reservoir storage specifically required for and allocated to water quality control.

d. EPA shall recommend to construction agencies of Federal projects the inclusion of storage for water quality control by flow regulation only where such storage is required as a supplement to application of the best available technology and is in consonance with water quality management plans developed under the Federal Water Pollution Control Act or its amendments. This same provision shall also apply to reservoir projects constructed under license granted by the Federal Power Commission.

e. When EPA recommends provision of storage for water quality control, all the environmental consequences of such provision should be considered, so that EPA will be in a position to comment favorably on the water quality storage aspect of the project when the environmental impact statement on the project is circulated for comment.

f. An EPA recommendation regarding the provision of storage and releases for water quality control shall take into account State laws and policies with respect to such storage.

g. When water quality control storage included within existing reservoirs is no longer needed, such storage should be reallocated to other purposes based upon appropriate studies and after consultation between the construction agencies and EPA. Reservoir operations should be modified as indicated by the study findings.

5. APPLICATION AND IMPLEMENTATION

This policy applies to EPA's evaluation of the need for and value of water quality control storage in reservoirs planned by the Corps of Engineers, Bureau of Reclamation, Soil Conservation Service and other Federal agencies and in reservoirs licensed by the Federal Power Commission. EPA will implement this policy to the extent of its authorities in conducting all program activities including review of reservoir plans under Section 102(b), water quality management planning, interagency water and related land resource planning, and review of environmental statements.

Date: JAN 16 1973

William D. Ruckelshaus
Administrator

Enclosure

GUIDELINES OF THE ENVIRONMENTAL PROTECTION AGENCY REGARDING STORAGE AND RELEASES FOR WATER QUALITY CONTROL IN RESERVOIRS PLANNED BY FEDERAL AGENCIES

INTRODUCTION

These guidelines describe the Environmental Protection Agency's approach in carrying out its responsibilities under Section 102(b) of the Federal Water Pollution Control Act Amendments of 1972. Section 102 (b) states:

> (b)(1) In the survey or planning of any reservoir by the Corps of Engineers, Bureau of Reclamation, or other Federal Agency, consideration shall be given to inclusion of storage for regulation of streamflow, except that any such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source.
>
> (2) The need for and the value of storage for regulation of streamflow (other than for water quality) including but not limited to navigation, salt water intrusion, recreation, esthetics, and fish and wildlife, shall be determined by the Corps of Engineers, Bureau of Reclamation, or other Federal Agencies.
>
> (3) The need for, the value of, and the impact of, storage for water quality control shall be determined by the Administrator, and his views on these matters shall be set forth in any report or presentation to Congress proposing authorization or construction of any reservoir including such storage.
>
> (4) The value of such storage shall be taken into account in determining the economic value of the entire project of which it is a part, and costs shall be allocated to the purpose of regulation of streamflow in a manner which will insure that all project purposes share equitably in the benefits of multiple-purpose construction.
>
> (5) Costs of regulation of streamflow features incorporated in any Federal reservoir or other impoundment under the provisions of this Act shall be determined and the beneficiaries identified and if the benefits are widespread or national in scope, the costs of such features shall be nonreimbursable.
>
> (6) No license granted by the Federal Power Commission for a hydroelectric power project shall include storage for regulation of streamflow for the purpose of water quality

control unless the Administrator shall recommend its inclusion and such reservoir storage capacity shall not exceed such proportion of the total storage required for the water quality control plan as the drainage area of such reservoir bears to the drainage area of the river basin or basins involved in such water quality control plan.

Key elements addressed in these guidelines are: (1) adequate treatment or control at the source; (2) determination of the need for storage for water quality control; (3) environmental assessment; (4) assessment of the value of water quality control storage; (5) identification of beneficiaries; and (6) assessment of widespread or national benefits.

ADEQUATE TREATMENT AND CONTROL AT THE SOURCE

As a basic element of the flow regulation policy, the best available pollution control technology economically achievable, rather than simply minimum pollution control measures, shall be provided prior to provision for water quality storage. The best available technology includes advanced waste treatment techniques, land disposal, land management practices, process and procedure innovations, changes in operating methods and other alternatives. Because of continual progress in pollution control technology, the definition must be time-and-specific-case-related. Since evaluation of storage requirements for flow regulation for water quality control and other purposes normally involves projections for water needs 50 years into the future, it is reasonable to forecast any improvements in pollution control technology that can be expected at least 10-15 years hence. Specific waste treatment and control techniques and pollutant reductions attainable for municipal, agricultural and mining waste are presented in the attached Appendix. Guidance on pollutant reductions attainable for industrial wastes is being developed. The Guidelines and the Appendix will be reviewed periodically and updated as warranted by actual and anticipated advancements in the state-of-the-art of waste treatment and control technology. The municipal waste treatment levels presented in the Appendix apply to flow regulation studies only. Municipal waste treatment guidelines defining secondary treatment and best practicable technology will be published to implement other provisions of the Act. These future guidelines shall apply if more stringent than those presented in the Appendix.

As advances are made in waste treatment and control techniques, it may be possible in time to eliminate the need for flow regulation in the control of man-induced pollution. Thus, in the future, flow regulation may be warranted only for alleviating the effects of natural pollution (i.e., artesian systems of highly mineralized water) which are and may continue to be particularly difficult and expensive to control through other means.

NEED FOR RESERVOIR STORAGE FOR WATER QUALITY CONTROL

Application of the best available technology economically acheivable may not be sufficient, in all instances, to attain the desired water quality. Additionally, pollution from natural or non-point sources may not be amenable to effective control with the techniques that are, or are expected to be, available in the forseeable future. In these instances, the Federal government is authorized to give consideration to providing reservoir storage for water quality control as a means of improving instream water quality.

Flow regulation for water quality control should be used only where it, in combination with the best available pollution control technology, is demonstrated to be the best alternative for achieving water use and quality goals. All alternatives considered must be relevant to all pertinent water resource planning and management activities for the entire river basin. Any viable alternatives to flow regulation should be evaluated as a means of achieving the incremental increase in quality needed over that provided by maximum practical treatment or control at the source. It is recognized, of course, that each of the possible alternatives has distinct advantages and disadvantages and are thus not directly comparable. Nevertheless, meaningful comparisons can be made when the specific objectives to be achieved and conditions to be maintained are clearly presented.

In evaluating waste water management alternatives, the emphasis should be on measurement of quality conditions and benefits for specific periods of time and for particular stretches of stream. Items to be taken into account include the water quality standards and other pertinent environmental factors of water and related land uses, the withdrawals of water and the returns, the consumptive losses; the quality of the returns, land drainage, and the extent of present and probable future stream management. Storage for flow regulation for quality control should be considered only if the water quality is expected to fall below the standards or other specified water quality criteria after the effects of all other reservoir releases and water uses and application of the best available technology have been analyzed. Any reservoir storage required for low flow augmentation to offset mineral water quality deterioration primarily attributable to irrigation (private or public) must be allocated to that purpose rather than water quality control.

The analytical process will facilitate making distinctions between reservoir releases to assure a sufficient quantity of water for municipal and industrial water supply, navigation, recreation, and other purposes and specific releases necessary to assure a quality condition at definite points or stream reaches. Water quality releases must be identified with specific water quality criteria. Criteria contained in State and State-Federal water quality standards must be used where applicable. Where no water quality standards have been formally adopted, water quality goals contained in current approved water quality management plans developed in accordance with the Federal Water Pollution Control Act Amendments of 1972 should be given primary consideration. Where no water quality goals for a given stream have been expressed through water quality standards or water quality management plans, water quality goals should be developed for planning purposes in coordination with local and State pollution control agencies.

When storage for water quality control is justified and a multipurpose impoundment is constructed accordingly, this storage must be used or held for its intended purpose until the need for it is eliminated or changed. When storage needs are eliminated or changed, the storage provided may be reallocated among other beneficial uses.

Operating schedules of reservoirs constructed to include water quality control storage should be reviewed by EPA to ensure that optimal water quality conditions are maintained downstream, especially at drought flows approaching the design low flow. Flow releases from all such federally controlled reservoirs should be checked by EPA as necessary to determine whether or not the operating schedule is being followed during critical flow periods.

Should legal protection of reservoir releases for the purpose of water quality control not be adequately assured, EPA will analyze this problem when determining whether water quality control storage should be provided. Also, there must be assurances that flow releases for quality control will in fact be made by the agency(s) in charge of the proposed reservoir's operation in accordance with operating criteria acceptable to EPA before EPA will recommend inclusion of such storage in the proposed reservoir.

Flow regulation practices that result in lower than natural low flows (i.e., those which would occur in the absence of the impoundment) or release water of less than preimpoundment quality (e.g., zero dissolved oxygen) are considered to be in violation of the anti-degradation clause of the water quality standards. During periods when natural flows equal to or less than the flow values used to design waste treatment facilities located downstream from the site of a proposed impoundment would occur, the rate of discharge past the dam should be at least equal to the rate of inflow above the dam; whether or not water quality storage is provided.

ENVIRONMENTAL ASSESSMENT

The evaluation of the need for water quality control storage for low flow regulation must extend beyond simply calculating the low flow augmentation and corresponding storage needed as a supplement to the best available technology economically achievable with a view toward meeting water quality standards. Federally built or licensed reservoirs generally require the preparation of an environmental impact statement under the National Environmental Policy Act by the lead agency, which must assess all the environmental consequences of the action, both adverse and beneficial. EPA will be in the position of commenting on such statements. When EPA recommends provision of storage for water quality control, all the environmental consequences of such provision should be considered, so that EPA will be in a position to comment favorably on the water quality storage aspect of the project when the environmental statement is circulated for comment.

VALUE OF RESERVOIR STORAGE FOR QUALITY CONTROL

The environmental and economic gains obtainable from meeting water quality standards, or in their absence the selected water quality goals, cannot be fully evaluated in monetary terms. However, such benefits are considered to be at least worth the cost of implementing the best water quality management plan to meet the standards or goals. Where the plan includes flow regulation from incremental water quality storage in a reservoir project as a supplement to "adequate treatment", the value of such storage, particularly downstream economic losses prevented, shall be assessed in monetary terms to the extent practicable. Other environmental values not subject to economic evaluation shall be accounted for and described qualitatively. Water quality monetary benefits shall not be credited to flow regulation storage designated for purposes other than water quality control.

IDENTIFICATION OF BENEFICIARIES

Beneficiaries of flow regulation for water quality enhancement beyond that produced by the employment of the best available pollution control technology are primarily the dischargers of the treated wastes that the augmented flow is intended to assimilate.

Without the augmented flow, higher cost alternatives (e.g., reduction of the waste-producing activities or reconstruction of industrial plants and facilities) would be required to meet the water quality standards. Many beneficiaries should be identifiable from an inventory of point waste sources.

ASSESSMENT OF WIDESPREAD OR NATIONAL BENEFITS

The Act requires that an assessment be made by the agency planning the reservoir, of the extent to which the benefits of flow regulation for water quality control are widespread or national in scope. For this purpose, EPA will provide the planning agency with a list of specific beneficiaries and length of stream reaches improved. Responsibility for the decision as to whether or not the benefits are widespread or national in scope is that of the construction agency.

APPENDIX

ASSESSMENT OF ADEQUATE TREATMENT FOR IMPLEMENTATION OF EPA FLOW REGULATION POLICY

CONTENTS

Contents (Cont'd)

PURPOSE

The purpose of this appendix is to provide quantitative guidelines on degrees of pollutant reduction attainable from "adequate treatment" or other methods of controlling waste at the source to aid in the implementation of the Environmental Protection Agency's policy on flow regulation for water quality control. This appendix presents wastewater treatment processes, other pollution control approaches and the ranges of pollutant reductions obtainable from these various methods. The treatment levels presented herein apply to flow regulation studies only. Municipal waste treatment guidelines to define secondary treatment and best practicable technology will be published to implement other provisions of the Act. These future guidelines shall apply if more stringent than the treatment levels presented herein.

ADEQUATE TREATMENT AND CONTROL

"Adequate treatment or other methods of controlling waste at the source" is interpreted to mean the best available control technology economically achievable. It is expected that the specific degrees of pollutant reduction attainable from such measures will change as we proceed into the future and technological advancements are made. Accordingly, anticipated improvements in the state-of-the-art of pollution control technology must be reflected in the definition employed. For continuity in the application of the flow regulation policy on a national scale, it is important that the definition of "adequate treatment or other methods of controlling waste at the source" be as specific as possible. This is necessary to minimize the individual interpretation required of policy users, thus reducing the variation in treatment or control requirements from river to river regarding flow regulation for quality control. Yet, it is recognized that if "adequate treatment or other methods of controlling waste at the source" is defined too narrowly, the definition may become unrealistic and arbitrary.

The definition must be based on two considerations: technical feasibility and economic feasibility. From a technical basis, it can include only those treatment processes or other means of pollution control considered at any point in time to be dependable based upon full scale operation or extensive pilot scale testing. Pollutant reductions presented in this document are believed to be attainable in most situations at costs that will not be prohibitive. The January 1970 cost data presented herein must be adjusted upward to reflect current price levels. In addition, cost data presented are based on national averages, and must be adjusted to account for regional variations and unusual local conditions.

Municipal Wastes

Present. Standard primary and secondary waste treatment processes have been considered practical for many years. Largely through research and development efforts of EPA and its predecessor agencies, several additional waste treatment processes have shifted from experimental to operation status. Information presented herein on all municipal waste treatment processes was provided by the Advanced Waste Treatment Research Laboratory in Cincinnati, Ohio. The information is based on treatment methods for which the estimated costs are considered sufficiently low to make the treatment methods practical.

No definite cost maximum was used in selecting the various treatment systems. It will be found, however, that all the systems have an operating cost substantially less than $1.00/1,000 gal. at the 10-mgd level.

The removal capability of treatment processes is in most cases difficult to define accurately because of a lack of knowledge about the exact composition of pollutants. Effluent concentrations given in the accompanying tables must be considered, therefore, to be only approximate values based on the average of results obtained to date. Also, these concentrations are based on conscientious operation of the equipment.

Information related to the degree of treatment that can be obtained with a properly designed and operated conventional treatment system is being developed to be issued as regulations required to define secondary treatment under Section 304(d)(1) of the Act. The information contained in these regulations shall be applied in the conduct of flow regulation studies.

The maximum degree of removal of pollutants attainable at this time from the best available technology is shown in Table 2. In constructing this table, six treatment systems were chosen that have either been tested extensively on pilot scale, or that have been operated at plant scale, or for which there is dependable evidence of technical feasibility. These are described at the bottom of the table. The effluent concentrations or percentage removals for appropriate systems are shown for each waste constituent. Obviously, the removals for each system cannot all represent the best removal for each constituent. Generally, System IV, carbon treatment of effluents from System II or System III, would give best results. To limit the table just to System IV, however, would eliminate a number of less expensive systems that could be used where organic removal was not of primary concern.

The total capital and operating costs for the six treatment systems have not been calculated. Costs for the processes making up the systems are shown in Figures 1 through 7 and Tables 3 and 4. The cost for alum addition is approximately 5¢/1,000 gal. and consists mostly of chemical cost. Iron addition may be somewhat cheaper if a cheap supply of chemical, such as from pickle liquor, is available. Capital cost is negligible compared to the capital cost of a conventional treatment plant. In all cases where addition of a chemical is involved, an average dose has been used for cost calculations. For a first estimate of total system treatment costs, effects of variation in chemical dose should not be important. Total capital and operating costs for the various systems can be obtained easily from the included graphs and tables.

There are a few points about Table 2 that should be brought to the reader's attention. The first activated sludge stage of System I can be of a high rate type which would have slightly lower cost than those shown in figures 1 and 2. The cost reduction would probably not exceed 1¢/1,000 gal. System III does not exhibit good nitrogen removal. Nitrogen removal could be improved to the quality of System II by substituting three-stage activated sludge treatment (see Note a of Table 2) for conventional activated sludge. This substitution would increase the cost by the amount shown in Figure 4. The organic removals of System III would then become at least equivalent to, and possibly slightly better than, those of System II. All demineralization processes produce some brine. Disposal of this brine in a way that will not cause further pollution is likely to be a problem. Considerable expense could be involved. No cost for brine disposal has been included.

The most recent treatment and cost data available for land disposal wastewater systems is that developed during the design of the Muskegon County, Michigan system. This large-scaled wastewater management system featuring land disposal of wastewater through spray irrigation is under construction. The overall system, designed to serve a population of 168,000 plus five major industries, will treat a design flow of 43.4 MGD. Table 5 presents the expected pollutant reductions based upon special project research and design studies. The estimated capital cost for the project is $42 million and annual operating costs are estimated at $980,000 for the first year of operation and $1,345,000 for the design year of 1990.

<u>Future</u>. No one can state with assurance what pollution control technology will be like over the next 50 to 100 years. On the other hand, we should not plan multimillion dollar water resource projects with useful lives of 50 to 100 years or more based on the assumption that there will be no further improvement in pollution control technology. This becomes particularly apparent when consideration is given to the amount of research in this area presently underway and the research objectives that will have to be met in order to maintain minimally satisfactory water quality conditions in the future. Estimates of levels of treatment expected to be attainable by 1980 have, therefore, been developed. They are considered to be conservative.

There are many known methods for removing critical pollutants to fairly low levels. Some of these have been identified in Table 2 for use at the present time. Other known methods require additional refinement before they can be considered in the operational category. Major problems associated with these other methods are lack of complete reliability and substantial treatment cost. Current EPA research and development efforts are aimed more at overcoming these problems than at the attainment of higher degrees of removal. An example is the removal of nitrogen. If nitrogen removal could be carried out as ammonia removal with a physical-chemical treatment method, the upsets that can occur with biological nitrification and denitrification would be eliminated. Physical-chemical methods for ammonia removal are known, but they either have problems associated with their operation or, in their present state of development, are more expensive than biological removal.

By 1980, some improvement in the degree of pollutant removal can be expected. The treatment processes and the degree of removal attainable by that date are given in Table 6.

Improvements in organic removal should be obtainable by use of a polishing chemical oxidation treatment. Presently, ozone treatment appears to have most promise. Improvement in removal of all types of pollutants is most likely to occur through application of reverse osmosis. This treatment method is being developed rapidly for a number of applications including treatment of industrial and municipal wastes. Although it has many good features, it has the disadvantage of producing a brine stream which in turn presents an ultimate disposal problem. Also, it has never been operated at a large scale nor for a long period of time.

Costs for ozone treatment and reverse osmosis are very difficult to estimate. The small amount of work completed on ozone treatment suggests that it may cost about the same as carbon treatment when applied to secondary effluent. The application in Table 6 is for polishing carbon treatment effluent. Both capital and operating costs would be expected to be significantly less than costs shown earlier for carbon treatment. Some very rough cost figures for reverse osmosis are included in Table 4. These figures do not include brine disposal.

Storm and Combined Sewer Overflows

To date, very few storm and combined sewer discharges have been subjected to treatment or control. It has only seen since 1967 that significant attention has been given to this problem. EPA's Storm and Combined Sewer Pollution Control Branch (SCSPCB) has, since that time, undertaken a number of studies to evaluate a wide variety of treatment and control techniques under varying hydrological conditions. Much remains to be done in this area, however. The information presented herein on treatment and control techniques applicable to storm and combined sewer discharges was provided by SCSPCB.

Present. The SCSPCB demonstration program has thus far indicated that a great deal of emphasis must be placed on the physical control of combined sewer overflows and/or storm water discharges. Thus, storage, diversion, and flow routing in the system, employing remote sensing and telemetry and computerized decision making, etc. will form a major portion of many metropolitan programs designed to abate pollution from these sources.

The degree of treatment applicable to combined sewer overflows and/or storm water discharges cannot be considered apart from the areawide control system capability. It is anticipated, for example, that any of the treatment methods that now appear applicable for combined sewer overflows or storm water discharges will require that they operate in conjunction with storage in "surge" basins. It is doubtful that an effective treatment process will be developed which alone will be capable of handling the extreme flow rates encountered without this kind of "assist". Evaluation of alternative costs will, therefore, require assessment of the amount of storage or level of "surge" control required to match the treatment methods under consideration.

All overflows can be completely controlled at high cost. If they are completely controlled the degree of treatment feasible would generally be less than the degree feasible for basic wastewater treatment works. When and where they are a problem, the control and treatment of storm water discharges will very likely parallel the processes used for combined sewer overflows.

Presently, the best available technology for reducing pollutants from combined sewer overflow is considered to be complete interception, with use of surge facilities, and treatment utilizing fine screening, dissolved air flotation with chemical flocculant aids, and chlorination. The effectiveness of this treatment system in the removal of key pollutants is given in Table 7.

Information available to date indicates that the capital cost (excluding land) of a screening/flotation system would be in the range of $5,000 to $8,000 per MGD for plants greater than 50 MGD in size. Operation and maintenance costs would be relatively low due to the expected periodic usage when treating combined overflow. They are expected to be less than $20 per MGD, excluding chemical costs. Chemicals would be expected to cost another $20 to $25 per MGD.

Future. Because of the extreme variation in flow rates and generally lower pollution potential of combined sewer overflow relative to the dry weather wastewater flows, it is anticipated that the pollutant reduction attainable from the best available technology for combined sewer overflow will frequently be less than the reduction of pollutants for the dry weather flow. The projected degrees of treatment attainable for combined sewer overflow by the year 1980 is given in Table 8. Where land disposal and extensive surcharge storage is practicable, greater removal of pollutants from stormwater may be achievable by 1980.

The types of treatment processes providing the degrees of treatment indicated in Table 8 would be essentially the same types that would be employed to provide similar levels of treatment of municipal wastes.

Industrial Wastes

Present. The wide variation in manufacturing processes and wastewater characteristics among industrial facilities, even within the same industrial category, produces significant differences in effluent quality and pollution control problems. For issuance of permits, each industrial plant must achieve at least minimum levels of pollution control to meet the effluent limitation requirements of the Act. The precise pollution control requirements applicable to individual plants can only be determined on a case by case basis. As a general standard, however, the minimum requirements represent application of the "best practicable control technology". These effluent limitations, which are defined for each category of industrial sources, reflect recent advances in technological feasibility and assure that maximum efforts are made to control discharges of heavy metals and toxic or hazardous substances.

The treatment lèvels associated with the above general standards are only minimums. In most areas where serious pollution control problems exist, more stringent requirements will be necessary to achieve compliance with applicable water quality standards. Under this policy, the best available technology economically achievable, rather than simply the minimum treatment required for permit issuance, shall be applied prior to provision for reservoir storage for water quality control.

Where guidance on the best available technology is not available, guidance furnished Regional Offices, including quantitative data, covering pollutant reductions obtainable from application of the best practicable control technology to the various types of industrial wastes shall be used until issuance of guidance regarding the best available technology. These data shall then be used. The present guidance represents the best applicable compilation of information on industrial wastes. However, professional judgement must be exercised on a case-by-case basis when estimating the degree of control or treatability of wastes produced by any given industrial facility.

Treatment processes generally considered practical for use in treating most industrial wastes include conventional primary and secondary treatment, chemical precipitation-clarification, single or multimedia filtration, chemical oxidation-reduction, carbon adsorption, ion exchange, conventional disinfection, and such sub unit processes as electrodialysis, reverse osmosis and evaporation. Also, land disposal of industrial wastes may be practical in some cases. The application of best available technology for the treatment of all industrial wastewaters may also include the following in-plant control techniques:

1. By-product recovery even when there is no feasible market or use of the recovered material.

2. Water reuse and recycling.

3. Reuse of wastewater constituent.

4. Multi-purpose operations for the primary purpose of water pollution abatement.

5. Waste stream segregation.

6. Preventative process changes and maintenance.

7. No unessential water use.

8. Water conservation (dry processes)

Future. To prevent excessive water use and control stream pollution, treatment and reuse of industrial wastewater is becoming more and more necessary for continued industrial expansion. The huge present water use and rapid growth of water use by American industry is such that we cannot continue to rely solely on traditional water supply sources. Even in water abundant areas, intake water supplies for industrial use are rapidly becoming restrictive. The trend toward increasing water reuse is already underway. It must be accelerated now in order to provide an adequate base for future industrial expansion.

Current and future environmental standards and requirements concerning discharges of wastewaters are expected to accelerate the move by industry to reduce both the pollution discharge loads and magnitude of effluent volumes, in order to minimize impacts on the environment.

Wastewater reuse is not only a resource conservation measure but also a method of pollution control. It is a step in tune with future demands. Adequate research and development activity in this field of exploration is the key to accelerating the development of extensive wastewater reuse systems, and ultimately the closed-loop water cycle. The latter, which results in a no effluent discharge situation, could comply with any present or foreseeable water quality standards.

Industrial water quality requirements for reuse are less demanding, as a general rule, than the needs for municipal supplies. Accordingly, industrial water reuse may be technically and economically achievable earlier than municipal water reuse systems. By 1983 effluent limitations for all industrial discharges to receiving waters require application of the best available technology economically acheivable. It shall be assumed, for purposes of estimating water quality storage needs in Federal reservoir, that, by the year 1980, closed-loop systems will be feasible for all industrial operations producing toxic wastes and for all new industrial plants. For other industrial operations the 1980 treatment levels shall be assumed at least equal to that now obtainable from the best available technology.

Agricultural Wastes

Present. Pollutants of agricultural origin that find their way into surface waters in significant amounts generally emanate from overland runoff and from overground and underground irrigation return flows. Both of these sources of pollution are amenable to a certain degree of control through improved land management practices. In some situations better land management alone may not be sufficient to adequately control these wastes. In such situations treatment, where practical, will also be required before consideration can be given to flow augmentation.

Pollutants accompanying runoff resulting from rainfall on cropland and pasture include sediment, nutrients, pesticides, and decaying vegetation. This source of pollution can be controlled quite effectively by the application of land management practices directed toward minimizing the amount and velocity of overland flow.

The suspended pollutant load accompanying runoff is proportional to about the fourth power of velocity and the square root of slope length.1/

1/ Amemiya, Minoru, "Land and Water Management for Minimizing Sediment," Proceedings of a Conference Conerning the Role of Agriculture in Clean Water, Nov. 1969, prepared under FWPCA Grant No. 13040 EYX.

Other significant factors pointed out by Amemiya are slope gradient, soil properties, cropping sequence, and rainfall intensity. All except rainfall intensity can be modified to maximize water infiltration and thus minimize overland flow.

Practices that can be employed to minimize runoff include:

1. Mulching-tillage methods that create rough soil-mulch surfaces and increase subsurface storage (can increase infiltration by a factor of eight to fifteen).

2. Contour planting and tillage (can reduce soil loss on slopes of moderate grade and length by 50 percent).

3. Contour strip-cropping, the practice of alternating strips of a close growing meadow or grass crop with strips of grain or row crops across a hillside (the reduction on soil erosion is proportional to the fraction of the slope that is in grass strips).

4. Terracing, the excavation of ridges and channels across the slope to trap water running downslope and the conveyance of the water to suitable surface or subsurface outlets at a nonerosive velocity (this serves to reduce slope length).

Proper tillage along with terracing, alone, would almost eliminate soil loss[1] (and hence, also the suspended pollutant load in runoff) from cropped fields on slopes up to six percent. Since must of the nutrients, except for nitrates, and much of the pesticides contained in runoff are associated with soil particles, a large sediment load should produce a similarly large reduction in the nutrient and pesticide loads.

Pollutants in the dissolved phase are usually reduced in proportion to the reduction in runoff volume. The amount of nutrients contained in the dissolved and colloidal phases can be minimized by applying only that amount of fertilizer actually needed and by ensuring intimate mixture of fertilizer with soil. Pesticide levels in the dissolved and colloidal phases can also be minimized by applying the minimum amount needed for pest control or by using biological controls.

Runoff collected by drains should not be discharged directly to a water-course. Discharge to an area of land where percolation into surface soil can occur or to a pond is preferable. However, care must be taken to avoid possible contamination of groundwater. Soil absorption practices generally do not greatly reduce the total water yield from a watershed. They merely reduce the surface flow component while increasing the subsurface flow component to partially offset the surface

---

1/ Ibid.

flow reduction. Thus, a greater percentage of the water reaching watercourses is first filtered through the soil.

Generally, proper land management, including suitable fertilizer and pesticide application techniques, will provide the best means of controlling pollution from cropland.

Pollution resulting from irrigation return flows can be feasibly controlled to a certain degree by several programs. These programs may involve use of previously described land management practices, improvement of irrigation and drainage practices, or interception and disposal of return flows high in salts and minerals.

Overland irrigation return flow (i.e., tail water) is produced by the excessive use of irrigation water and/or poor land management. It can be essentially eliminated by using appropriate water application rates and employing many of the same land management practices used to control rainfall runoff.

Irrigation return flow in the form of drainage water that has percolated through the soil is much more difficult to handle. It is higher in dissolved solids than the water applied. Those dissolved solids consist primarily of sodium, calcium, magnesium, potassium, boron, chloride bicaronate, and sulfate. Significant amounts of nitrates may also be present. The increase in concentration of those minerals and salts resulting from the irrigation of a soil of a given salinity is a function of size of the area irrigated, distance of drainage water travel through the soil from point of application to stream re-entry, and the amount of water lost through evapotranspiration.

The size of the area irrigated can be minimized by eliminating the unintentional irrigation of non-cropland. The largest single area in this category is that underlying and adjacent to the canals transporting irrigation water to the croplands. Seasonal losses by seepage from unlined canals often range from 13 to 48 percent of the diversions.1/ These losses can be essentially eliminated by lining the canal with impervious materials.

The distance that drainage water must percolate through the soil in returning to the stream can be minimized by installing a network of drains four feet or so beneath the area being irrigated and piping the drainage to the stream or to a sink, whichever is more appropriate. This not only reduces the salt pick-up by the drainage water but also prevents the water table from rising occasionally above the level of the drains and depositing minerals and salts in the root zone. This, in turn, reduces the amount of salt deposited in the root zone and the amount of water that must be applied over the long-term to maintain a salt balance in the crop growing layer of soil.

1/ Houk, Ivan E., "Irrigation Engineering" Agriculture and Hydrological Phases, Vol. I, John Wiley & Sons, Inc., N.Y. 1951.

The loss of large amounts of applied water (an overall average in the order of 40 to 60 percent) through evaporation and transpiration is inevitable. This, of course, has a concentrating effect on the dissolved solids and is the main cause for the increase in salinity of water used for irrigation. Elimination of non-crop vegetation will minimize transpiration. Evaporation from the soil, itself, can be minimized by subsurface application of the irrigation water. This method, used in the past primarily in the East and South, employs a series of open-joint drains laid 15 to 24 inches below the ground surface. The water is applied through this system of piping directly to the root area of the plants. This method requires a comparatively small amount of water, essentially all of which is usefully employed.

At the present time, treatment of drainage water for the removal of minerals and salts is considered infeasible, except in special situations. Special situations are deemed to be where high-value crops are grown in a water-short area and where brine disposal would be relatively inexpensive or where the treatment would be carried out in combination with the production of power or some other process generating large amounts of waste heat.

Those agricultural areas contributing large amounts of nutrients, pesticides, and sediment to surface waters via rainfall runoff can be feasibly controlled to a much greater degree by 1980 through improved land treatment practices.

Advancements in the treatment of irrigation return flows are close at hand. Already, electrodialysis processes are sufficiently well developed to provide generally adequate removal of most of the common ions normally present in irrigation return water in significant amounts. There still appears to be some question regarding the ability of electrodialysis processes to remove boron, however.[1/] Howe, in 1966, investigated the feasibility of using an electrodialysis process to reclaim drainage water in the San Joaquin Valley.[2/] He estimated that desalted drainage water could be produced at about $117 per acre-foot (35.9¢ per 1000 gallons).

1/ Sword, Bryan R., "Desalination of Irrigation Return Waters," published in FWPCA WPC Research Series Project No. 13030ELY, "Collected Papers Regarding Nitrates in Agricultural Waste Water", December, 1969.

2/ Howe, E.D., "Reclamation and Treatment of Irrigation Waste Waters," Proc. Symposium on Agr. Waste Waters, Univ. of California Report No. 10, April, 1966.

The cost can still vary considerably, depending on the degree of treatment needed and the cost of brine disposal. Advances being made in distillation and reverse osmosis technology may ultimately bring the cost of these techniques into the feasible range. Where removal of dissolved solids from irrigation drainage water is not feasible, flow regulation may be considered. However, any storage required for such flow augmentation is chargeable to the irrigation purpose rather than water quality control.

Mine Drainage[1/]

Present. Most methods for handling mine drainage are aimed at controlling rather than treating the volume of discharge. Treatment techniques are employed where controls alone are not sufficient to adequately reduce the volume of discharge. The effectiveness of best available technology varies widely depending on the quality characteristics of the mine, and the hydrology and geology of the area.

Drainage from surface mines, whether active or inactive, is generally easier and less costly to control than drainage from underground mines. Control techniques applicable to surface mines are directed toward minimizing or preventing contact between air and flowing water and the mine's exposed strata, spoils, and other toxic and acid or alkali-forming materials. This is accomplished by diversion of water draining into the mined area, and reclamation of the affected area or flooding of the mine pit in the post-mining period.

Surface mine reclamation includes backfilling, regrading, contouring, and revegetation of the affected landscape. The effectiveness and feasibility of these techniques are dependent on the nature of the surface and overburden, slope of land, and proposed use of the reclaimed land.

Water control structures (e.g., lined diversion ditches) may be used in addition to surface reclamation measures. They serve to divert drainage from the site of an active surface mine and/or prevent erosion at a reclaimed site. Where drainage into an active surface mine cannot be effectively restrained, the collection and immediate removal of water from the mine using pumps can be an effective control. This practice minimizes the contact time between the water and the contaminants and thus limits the amount of water contamination that can occur.

An alternative to post-mining water control and reclamation techniques, where topographic and drainage features are suitable, is the construction of impoundments to submerge acid-forming or other materials that are most troublesome when in direct contact with the atmosphere. This approach also provides some degree of control over flow releases from the area and may augment the local supply of stored water for beneficial uses.

1/ Information contained herein on the control and treatment of mine drainage, unless specified otherwise, was provided by the Pollution Control Analysis Branch, Research Program, EPA.

Drainage from underground mines presents a more complex problem. Routes taken by air and water entering and leaving underground mines are difficult to identify and even more difficult to control. There are, nevertheless, some feasible control techniques that are effective in many situations. They are directed at preventing the exchange of water and, in certain cases, air in the mine. Control techniques for active mines involve drainage diversion and controlled pumping. In addition to these two approaches, mine sealing techniques are also applicable in inactive mines.

Where waters entering an active or inactive underground mine are of surface or localized underground origin, it is usually feasible to divert them away from exterior openings, or seal the seepage areas. This is accomplished by any of a number of approaches utilizing dikes, lined ditches, bulkheads, etc. If water emanates from such diverse sources that it cannot be prevented from entering an underground mine, consideration should be given to its collection and immediate removal through pumping. This approach, which is also applicable to surface mines, has already been described.

Additional alternative controls are available for inactive mines. Most are directed at permanent sealing of a mine to prevent air exchange and/or air contact with acid-forming and other oxidizable materials. The sealant may be water, an inert gas, or trapped air. Another approach is to place internal seals that prevent acid production and/or mine drainage discharge.

If air or another gas is used as the sealant, the first step is to close the mine by constructing bulkheads or seals at all exterior openings. If the sealant is water, only those significant openings below the desired water level to be maintained need be sealed. Water should be maintained at a level sufficient to inundate all acid-forming and other undesirable materials.

Internal seals are designed to cover exposed materials or prevent the movement or air and water deep within the mine. They can be formed by grouting or pouring of concrete.

Pollution can also result from drainage from mining refuse piles and reject tailings ponds. Drainage from these features is often among the most toxic or damaging of all mine drainage. Feasible control methods for these waste sources entail leveling and grading of the refuse or tailings and stabilization with a covering of soil and vegetation, chemicals, compacted fly ash, or other impervious materials. Acid-forming materials in tailings may also be stabilized by permanent flooding. A summary of control methods and their ranges of effectiveness is given in Table 9.

Where at-source controls alone cannot effectively reduce or eliminate sources of contaminated mine drainage, consideration should be given to treatment of the drainage before discharge to a stream. Feasible treatment processes include neutralization, precipitation, sedimentation, and aeration. These processes are effective in the reduction or removal of suspended solids, acidity, alkalinity, and most heavy metals.

Excess acidity, commonly the most troublesome constituent of mine drainage, can be eliminated by neutralization with an alkaline compound. Lime is the compound most commonly used for this purpose. The treatment process generally consists of adding and mixing the alkaline compound with the drainage, aearation of the drainage if ferrous iron is present, and sedimemtation and removal of the resulting sludge in a mechanical facility or earthen settling ponds. Most heavy metals commonly found in acid mine drainage are also precipitated in the process because they are less soluble at neutral or higher pH's than at lower pH's.

Methods of final disposal of the sludge include burial in the settling pond, removal to another location for burial, discharge into abandoned deep mine workings, and use of more sophisticated methods to lessen its volume by dewatering or drying.

The maximum efficiency attainable with neutralization in the treatment of acid mine drainage is 98 to 100 percent removal of acidity and 90 to 100 percent removal of the common metals, iron, aluminum, and manganese.[1/] The amount of alkaline compounds needed to attain this level of removal is dependent primarily on the concentration of acidity and iron in the drainage. The cost of treatment by neutralization is largely dependent on the amount of alkaline compounds used in the process. Plant capacity also has an influence on treatment costs. According to Hill, the cost of treatment by neutralization can vary from $0.05 to $1.10 per 1,000 gallons, depending on the nature of the above influencing factors, primarily the former. At costs above 30 cents per 1,000 gallons, other treatment techniques (e.g., ion exchange and distillation) begin to become competitive. Treatment costs for mine drainage in excess of 35 to 40 cents per 1,000 gallons are usually considered infeasible at this time when large drainage flows are involved or at-source controls may be used. However, providing treatment at costs exceeding 40 cents per 1,000 gallons may be the least costly alternative for meeting treated water demands of industries and municipalities in water short areas.

Future. Research on improved methods for the control and treatment of mine drainage, and their demonstration of feasibility, has only recently received wide attention. In the Federal sector, the Environmental Protection Agency and Bureau of Mines are currently funding work in this area. EPA efforts are being directed toward the development of solutions in the following problem categories: (1) control and treatment of mine

---

1/ Hill, Ronald D., "Mine Drainage Treatment, State of the Art and Researh Needs," December, 1968. Report of the FWPCA Mine Drainage Control Activities, Cincinnati, Ohio.

drainage discharges from active mines; (2) procedures for closing presently operating mines that will result in no discharges; (3) methods for reducing pollution from nonoperating and abandoned mines; and (4) new mining methods that create little or no pollution.

Within the next five to ten years many of the current at-source control techniques applicable to abandoned mines or mines at the termination of mining will be much improved. These include such procedures as soil sealing, grouting, methods for minimizing water percolation through soils, and plugs and barriers for blocking or controlling the flow of water through and out of underground mines. By 1980 it is expected that feasible drainage control techniques can be 50 to 75 percent effective when applied to inactive mines on an area-wide basis.

Where control methods alone will not be adequate, at both active and inactive sites or mining areas, collection and treatment of the drainage will also be required to meet water quality goals. It is expected that, before 1980, feasible treatment methods will be feasible in some situations which should be considered on a case-by-case-basis.

Although much-improved control and treatment technology is needed and will occur over the projected time periods, selective application of presently available technology can be very effective in reducing or eliminating the pollution effects of individual mine drainage sources. Any tendency to generalize mine drainage pollution abatement as an unknown area requiring further research should be avoided. As defined in the discussion of adequate treatment on Page 2, analysis of at-source control and waste treatment employed must be time-and-specific-case-related.

Table 1

Degree of Municipal Waste Treatment Possible with Conventional Activated Sludge and Disinfection

The table originally developed to indicate the degree of municipal waste treatment possible with conventional activated sludge and disinfection will be replaced by the regulation being developed for Section 304(d)(1). This information will be furnished when the regulation is promulgated.

1/2/

Table 2

Degrees of Treatment of Municipal Wastes Attainable in 1971

Waste Constituent	Effluent Concentration (mg/1)	Treatment System
5 Day BOD	5	I (note a)
	2	II (note b)
	5	III (note c)
	2	IV (note d)
COD	20	I
	15	II
	20	III
	8	IV
Dissolved Organic Carbon	8	I
	5	II
	7	III
	3	IV
Total Nitrogen as N	3	I
	2	II
	18	III
TKN	2	I
	1	II
	18	III
Total Phosphorus as P	0.5	I
	0.2	II
	0.2	III
	0.2	IV
Total Dissolved Solids	450 or 40% removal	V (note e)
	75 or 90% removal	VI (note f)
Suspended Solids	10	I
	2	II
	2	III
	1	IV
Bacteria		
Total Coliforms	1000/100 ml	I
	Essentially total removal	II, III, IV

1/This table was prepared by the EPA Advanced Waste Treatment Research Laboratory, Robert A. Taft Research Center, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

2/This table applies to flow regulation studies only. Municipal treatment guidelines to define secondary treatment and best practicable technology will be published to implement other provisions of the Act. These future guidelines shall be applied if more stringent than those presented herein.

Table 2(Continued)

Waste Constituent	Effluent Concentration (mg/l)	Treatment System
Fecal Coliforms	200/100 ml	I
	Essentially total removal	II, III, IV
Enteric Viruses	≤95% removal	I
	Essentially total removal	II, III, IV

Notes:

a. System I = Three-stage activated sludge system with alum or iron salt addition for phosphorus removal + disinfection.

The first stage of the activated sludge system consists of a high rate aerator and a settler for removal of the bulk of the carbonaceous matter. Most or all of the aluminum or iron salt would be added in this aerator. Total mineral dose would be about 1.5 moles per mole of phosphorus. The second stage of the system consists of a nitrifying aerator and a settler. Sludge from the settler is returned only to the nitrifying aerator. The aerator would be sized for a 3-hour residence time. The third stage would consist of a stirred but unaerated basin for carrying out denitrification and a final settler. Detention time of the basin would be two hours. Menthanol would be added as an organic source in a ratio of three parts by weight to each part of nitrate-N. A part of the aluminum or iron salt used for phosphorus removal could be added before this settler. A small amount of polyelectrolyte might also be added for improved turbidity removal.

b. System II = System I + multimedia filtration.

c. System III = Conventional single-stage activated sludge + two-stage lime clarification + multimedia filtration + disinfection.

d. System IV = Either System II or System III + granular carbon treatment.

e. System V = System IV + electrodialysis or ion exchange.

This degree of demineralization is enough to prevent a build-up of minerals if the water were reused.

f. System VI = System IV + ion exchange.

Removal of more than 90% of the minerals from wastewater is possible, but probably not necessary. Costs increase significantly as degree of demineralization exceeds 90%.

Table 3 1/

Cost for Disinfection by Chlorination

	Plant Size (mgd)		
	1.0	10	100
Capital Cost ($)	30,000	80,000	310,000
Total Treatment Cost (¢/1,000 gal.)*	2.3	1.0	0.6

*15 mg/l chlorine dose, 30 minutes contact time
Capital amortized over 25 years at 6%

At $75/ton Cl_2 the effect of changing dose is 0.031¢/1,000 gal. for each mg/l. Doses lower than 15 mg/l would be satisfactory for nitrified waters.

Table 4 1/

Cost for Demineralization*

Process	Plant Size (mgd) 1.0		10	
	Capital cost ($)	Total Treatment cost (¢/1,000 gal.)*	Capital cost ($)	Total Treatment cost (¢/1,000 gal.)*
Electrodialysis**	630,000	25	3,400,000	15
Ion Exchange***	800,000	32	1,400,000	22
Reverse Osmosis***	650,000	50	5,000,000	40

*Does not include cost of brine disposal.

**Costs are for 40% demineralization.

***Costs are for 90% demineralization. Blending of demineralized and undemineralized water with these processes is possible to give the 40% removal obtainable with electrodialysis.

1/ These Tables were prepared in 1971 by the EPA Advanced Waste Treatment Research Laboratory, Robert A. Taft Water Research Center, 4676 Columbia Parkway, Cincinnati, Ohio 45226. They apply only to flow regulation studies.

Table 5

ESTIMATED REDUCTION OF TYPICAL POLLUTANTS BY THE
PROPOSED MUSKEGON COUNTY WASTEWATER MANAGEMENT SYSTEM

Item	RAW WASTEWATER 42 MGD Subsystem	1.4 MGD Subsystem	Irrigation Underdrain Effluent	Effective Removal (%)
BOD-mg/l	250	500	4	98-99
Suspended Solids-mg/l	250	1000	4	98-99
Phosphorus (Total P) mg/l	5	3	0.5	83-90
Nitrogen (Total N) mg/l	20	40		
Ammonia-N-mg/l			0.5	97-98
Nitrate-N-mg/l			5.0	75-87
Coliform Bacteria #/100 ml	$2\text{-}20 \times 10^6$	$2\text{-}20 \times 10^6$	0	100%
Pathogenic Viruses	Known to be present in undefined concentration	Known to be present in undefined concentration	0	100%

Table 6 [1/][2/]

Degrees of Treatment of Municipal Wastes Attainable in 1980

Waste Constituent	Effluent Concentration (mg/l) or Degree of Removal	Treatment System
5 Day BOD	≤1	IV, VII (note a) VIII (note b)
COD	<5	VII, VIII
Dissolved Organic Carbon	<1	VII, VIII
Total Nitrogen as N	85% removal <0.3	VIII IX (note c)
TKN	85% removal <0.2	VIII IX
Total Phosphorus as P	<0.1	VIII
Total Dissolved Solids	≥90% removal	VIII
Suspended Solids	Essentially total removal	VIII
Bacteria	Essentially total removal	VIII
Enteric Viruses	Essentially total removal	VIII

Notes:

a System VII = System IV + ozone polishing.

b System VIII = Reverse osmosis treatment and disinfection of effluent from conventional activated sludge.

c System IX = Reverse osmosis treatment and disinfection of effluent from three-stage activated sludge system including carbonaceous removal, nitrification, and denitrification.

1/ This table was prepared by Flow Regulation Policy Task Force and applies only to flow regulation studies.

2/ This table applies to flow regulation studies only. Municipal treatment guidelines to define secondary treatment and best practicable technology will be published to implement other provisions of the Act. These future guidelines shall be applied if more stringent than those presented herein.

Table 7 1/2/

Degrees of Treatment of Combined Sewer Overflow Attainable in 1971

Waste Constituent	Percent Removal
5 Day BOD	75
Total Phosphorus	85
Suspended Solids	75
Total Coliform	(Effluent Concentration of 1000/100 ml)
Fecal Coliform	(Effluent Concentration of 200/100 ml)
Viruses	80

Treatment System

Surge facilities + fine screening + dissolved air flotation using chemical coagulants + chlorination

1/ This Table was prepared by the EPA Storm and Combined Sewer Pollution Control Branch and applies only to flow regulation studies.

2/ This table applies to flow regulation studies only. Municipal waste treatment guidelines to define secondary treatment and best practicable technology will be published to implement other provisions of the Act. These future guidelines shall be applied if more stringent than those presented herein.

Table 8 1/2/

Degrees of Treatment of Combined Sewer Overflow Attainable in 1980

Waste Constituent	Percent Removal of Waste Constituents 1980
5 Day BOD	85
Total Phosphorus	90
Suspended Solids	85
Total Coliform	(Effluent Concentration of 1000/100 ml)
Fecal Coliform	(Effluent Concentration of 200/100 ml)
Viruses	80

1/ This Table was prepared by the EPA Storm and Combined Sewer Pollution Control Branch and applies only to flow regulation studies.

2/ This table applies to flow regulation studies only. Municipal waste treatment guidelines to define secondary treatment and best practicable technology will be published to implement other provisions of the Act. These future guidelines shall be applied if more stringent than those presented herein.

Table 9 [1/]

Summary of Methods for the Control of Mine Drainage

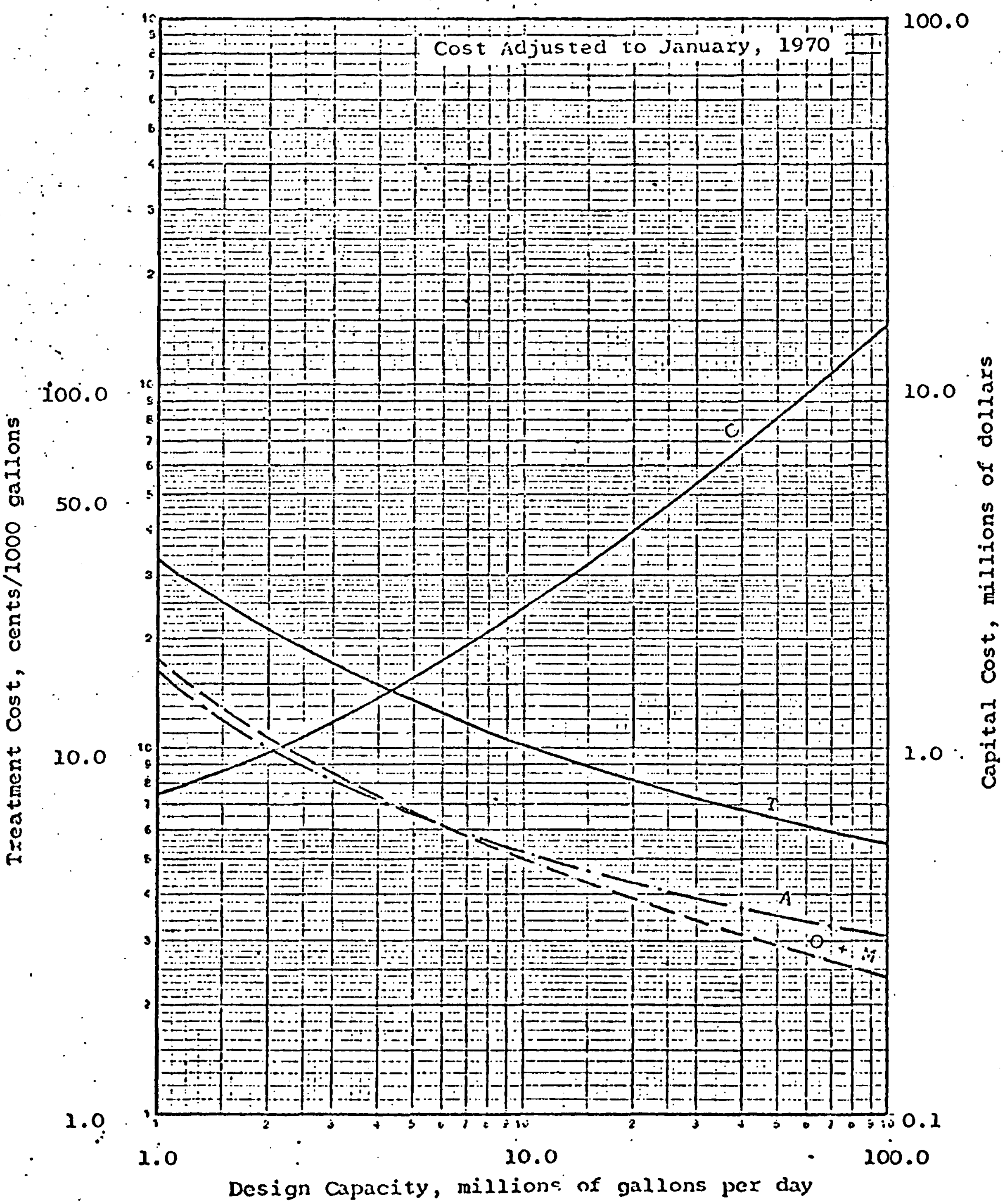
Control Method	Normal Range of Effectiveness(%)	Remarks
Surface Mine Reclamation	25-90	Includes backfilling, grading, contouring, and water control structures
Revegetation	5-25	Used primarily for erosion control
Drainage Diversion	25-75	Surface and underground
Surface Mine Impoundment	50-90	
Mine Sealing (Air)	0-50	Few mines can be air-sealed
Mine Sealing (Flooding)	75-99	Not all mines can be flooded
Mine Sealing (Inert Gas Blanket)	Unknown	Method is considered feasible but has not yet been applied.
Controlled Pumping and Drainage		Primarily active mines
Internal Sealing	Unknown	Method is considered feasible but has not yet been applied.
Refuse Pile Reclamation	25-75	
Reject Tailings Pond Stabilization	25-95	

1/ Information in this table was provided by Pollution Control Analysis Branch, Research Program, EPA. Information on costs of these control methods is contained in "Handbook of Pollution Control Costs in Mine Drainage Management", December 1966, published by FWPCA.

FIGURES

Figure 1. ACTIVATED SLUDGE PLANTS

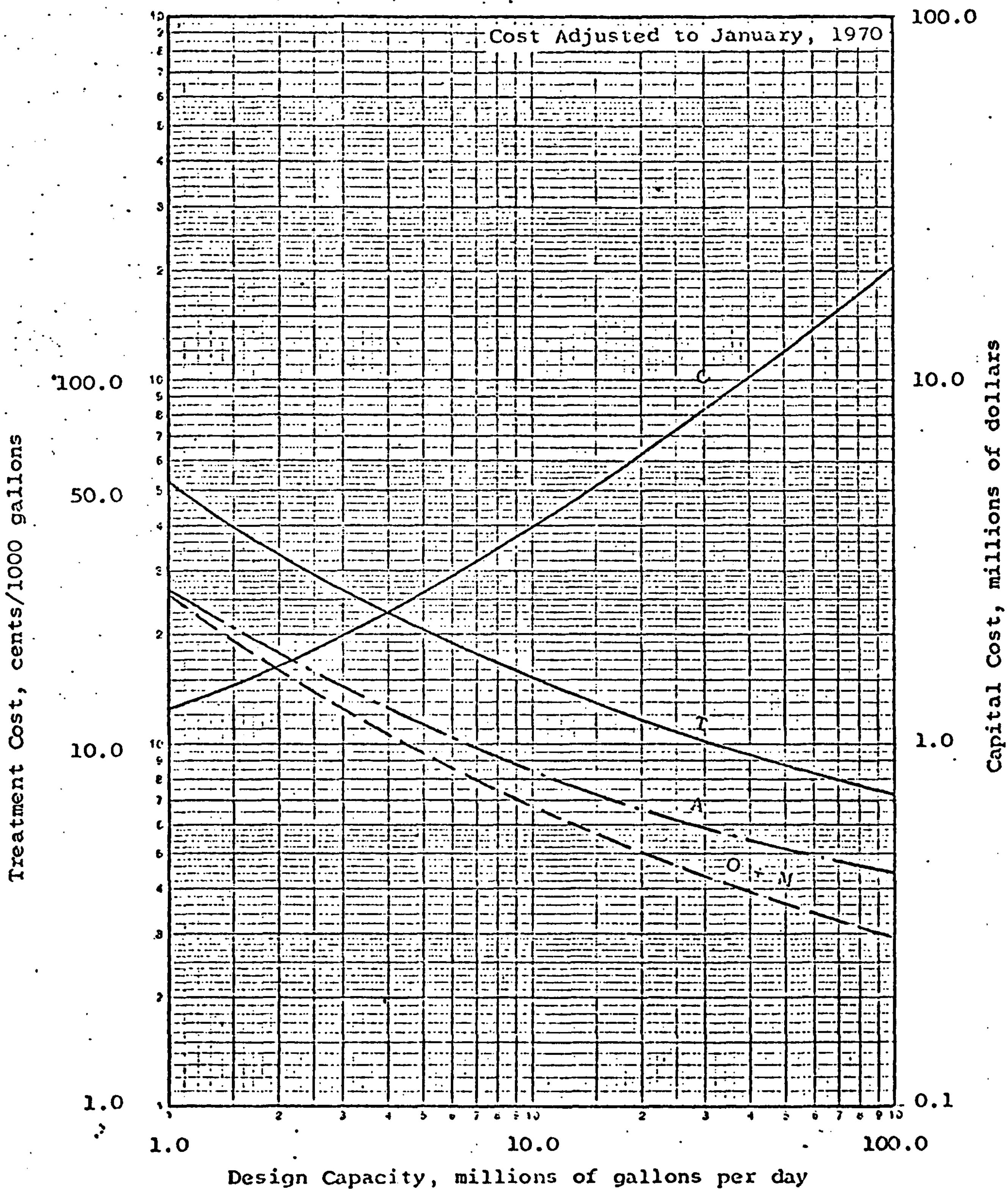
Including: Preliminary Treatment-G+F+S, Primary Sedimentation, Primary Sludge Pumps, Aerators, Diffused Air System, Final Settlers-Multiple, Recirculation Pumps, Sludge Thickener, Anaerobic Digesters, Sludge Drying Beds, Chlorination, Laboratory



C = Capital Cost, millions of dollars
A = Debt Service, cents per 1000 gallons (6% - 25 yr.)
O + M = Operating and Maintenance Cost, cents per 1000 gallons

Figure 2. ACTIVATED SLUDGE PLANTS

Including: Preliminary Treatment-G+F+S, Primary Sedimentation, Primary Sludge Pumps, Aerators, Diffused Air System, Final Settlers-Multiple, Recirculation Pumps, Sludge Thickener, Anaerobic Digesters, Sludge Holding Tanks, Vacuum Filtration, Multiple Hearth Incineration, Chlorination, Laboratory



C = Capital Cost, millions of dollars

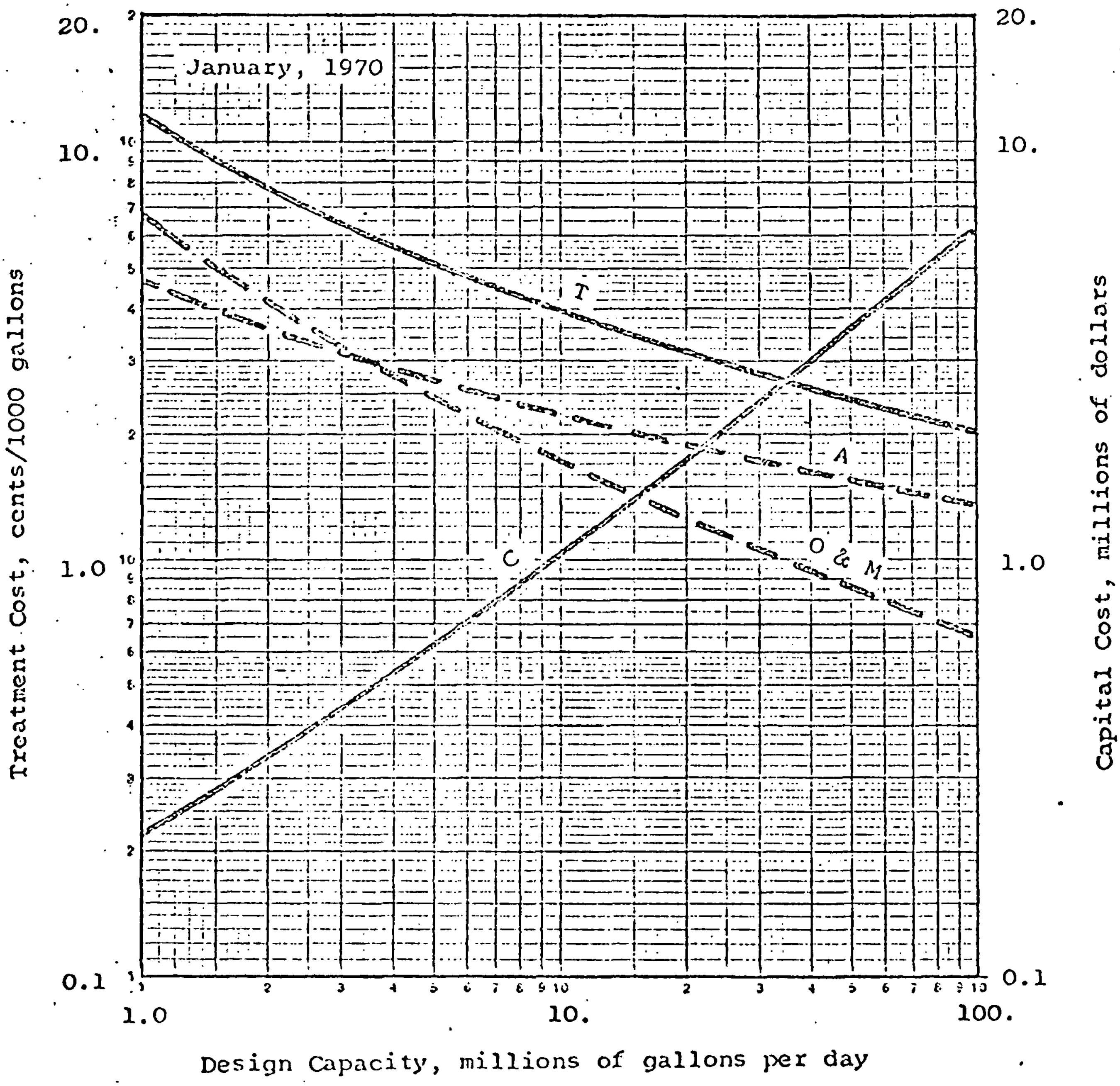
A = Debt Service, cents per 1000 gallons (6% - 25 yr.)

O + M = Operating and Maintenance Cost, cents per 1000 gallons

Figure 3.

NITRIFICATION IN DISPERSED FLOC REACTOR
DOWNSTREAM OF ACTIVATED SLUDGE PROCESS

Capital Cost, Operating & Maintenance Cost, Debt Service
versus
Design Capacity

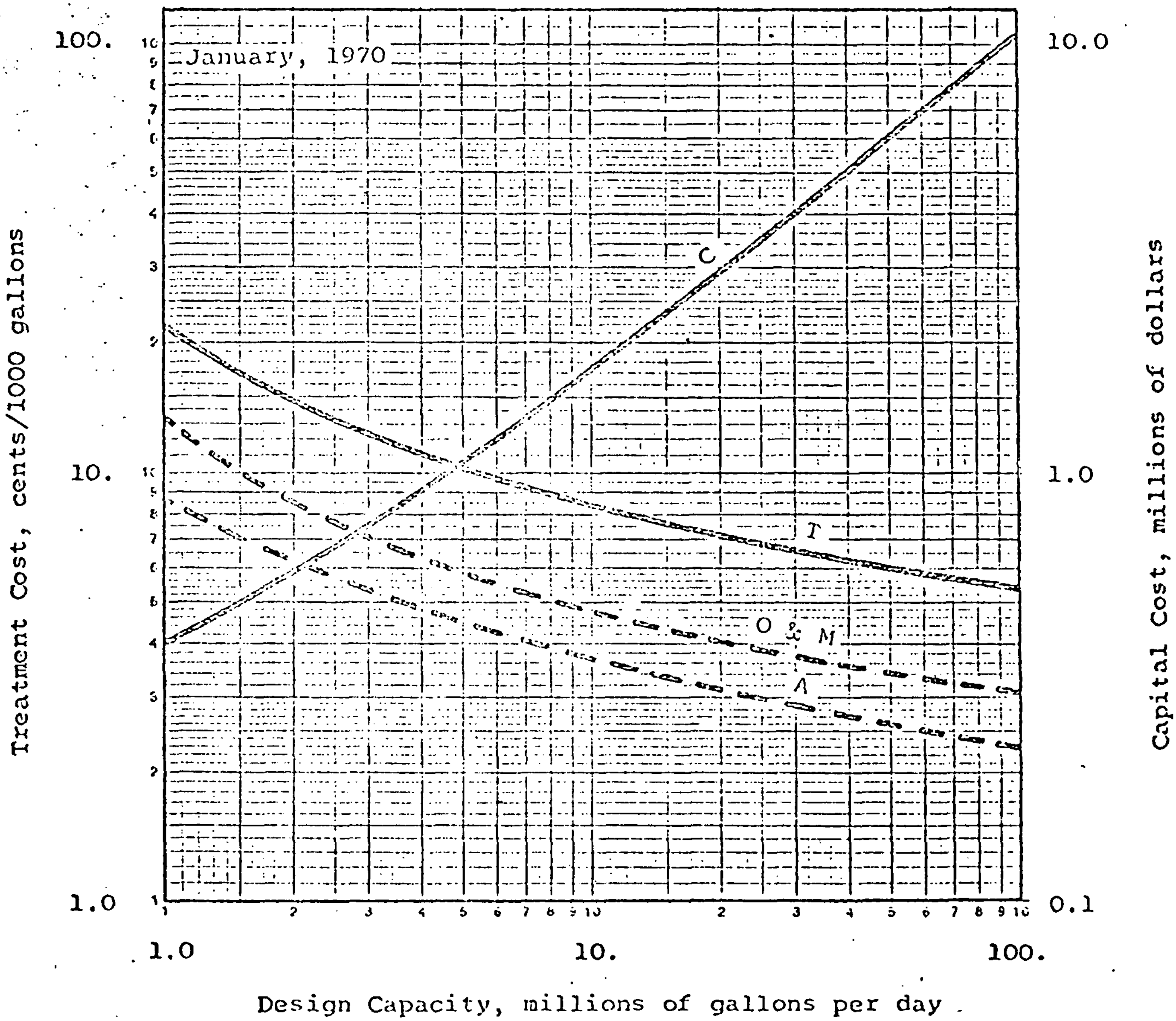


C = Capital Cost, millions of dollars
A = Debt Service, cents per 1000 gallons (6% and 25 yr.)
O & M = Operating and Maintenance Cost, cents per 1000 gallons
T = Total Treatment Cost, cents per 1000 gallons

Figure 4.

NITRIFICATION AND DENITRIFICATION IN DISPERSED FLOC REACTORS

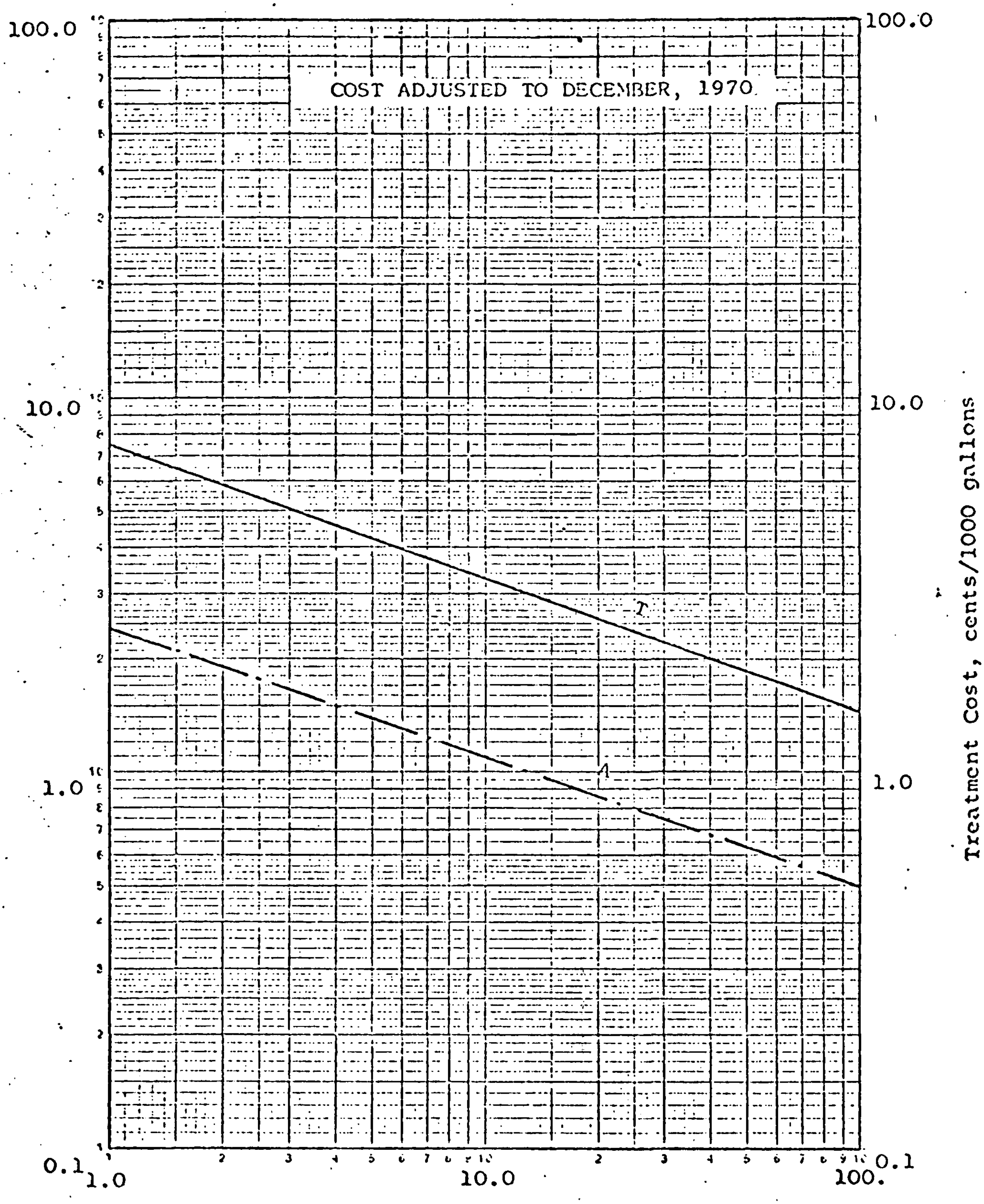
Capital Cost, Operating & Maintenance Cost, Debt Service
versus
Design Capacity



C = Capital Cost, millions of dollars
A = Debt Service, cents per 1000 gallons (6% and 25 yr.)
O & M = Operating and Maintenance Cost, cents per 1000 gallons
T = Total Treatment Cost, cents per 1000 gallons

Figure 5.

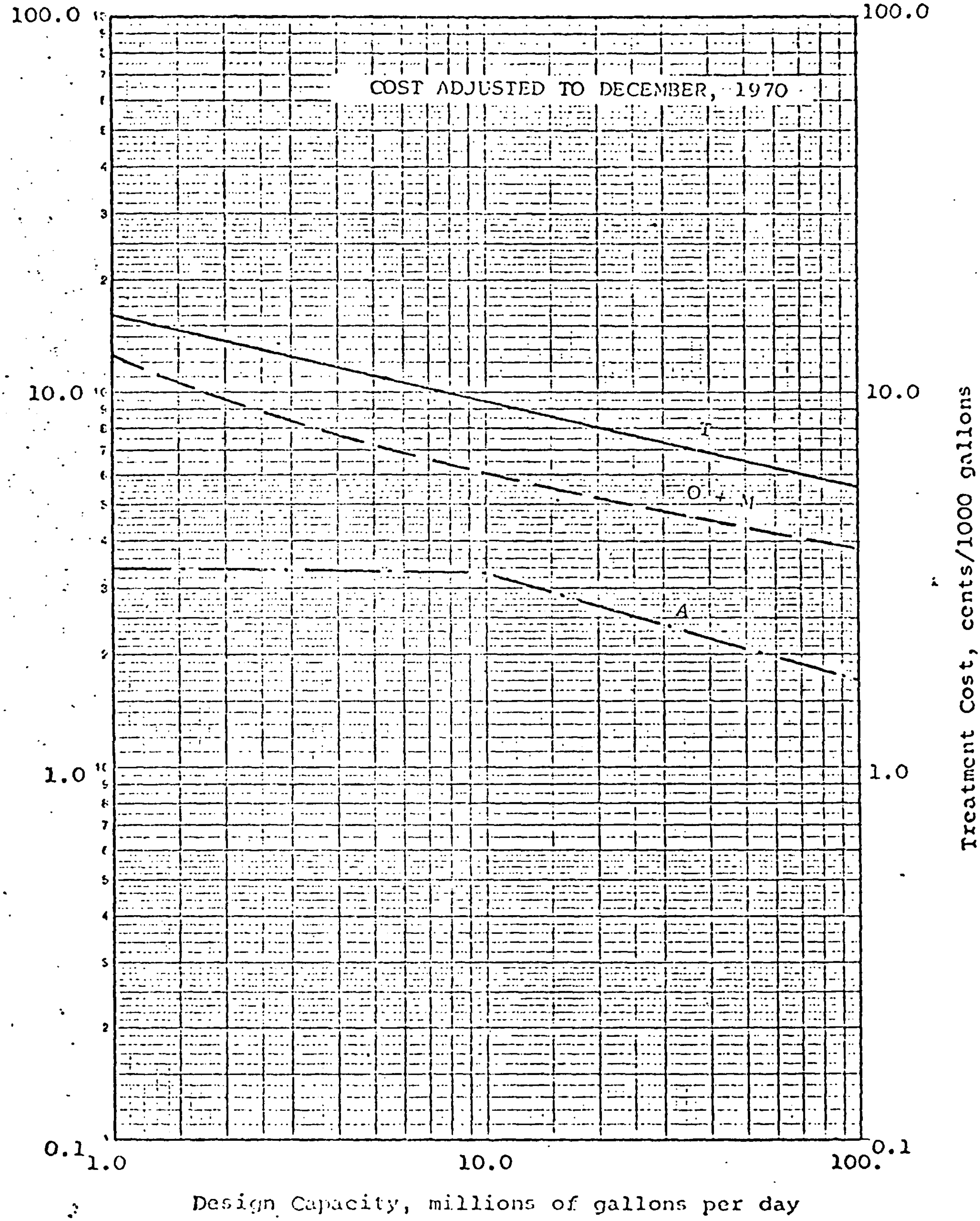
MULTI-MEDIA FILTRATION



A = Debt Service, cents per 1000 gallons (6% - 25 yr.)
T = Total Treatment Cost, cents per 1000 gallons

Figure 6.

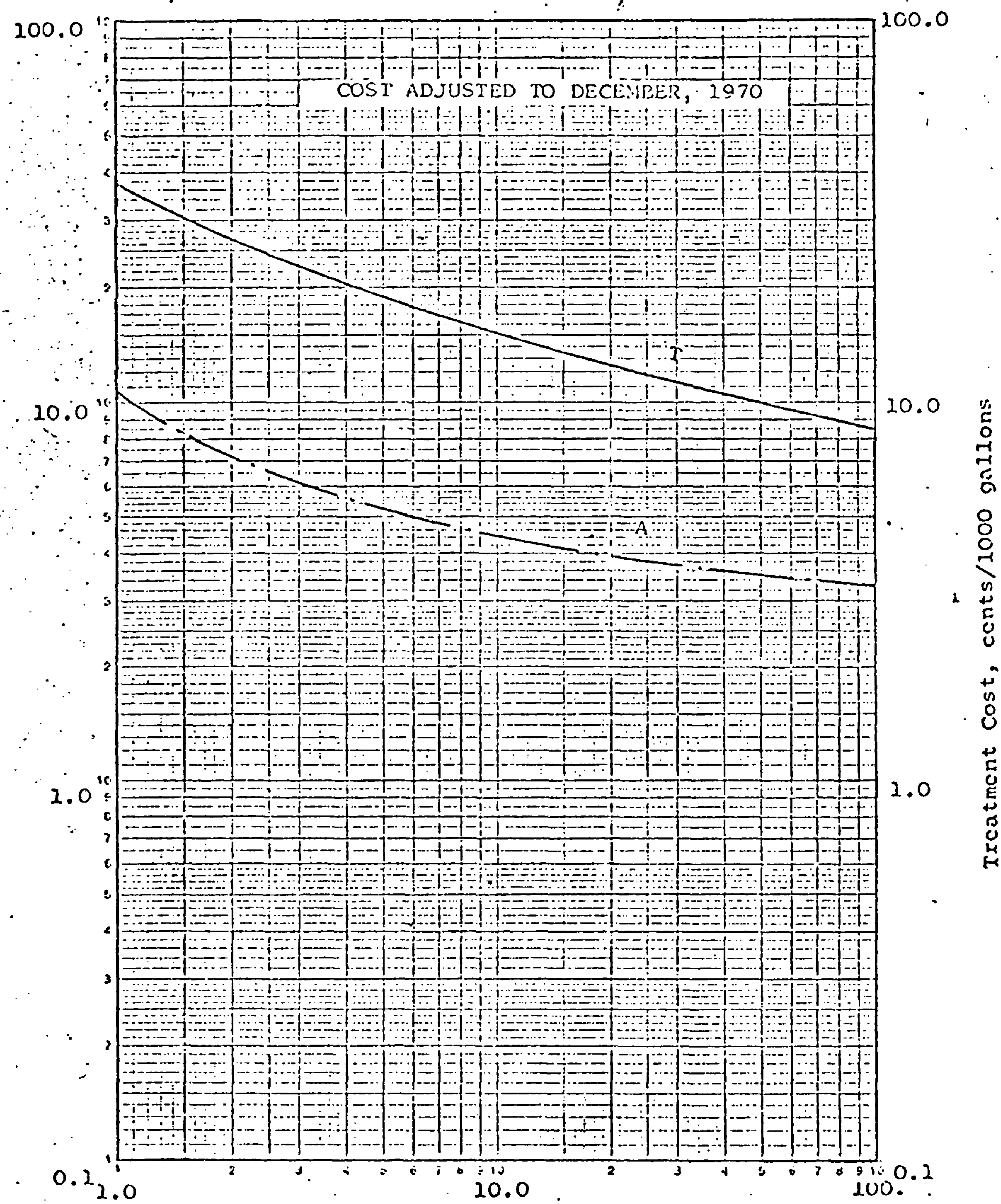
TWO-STAGE LIME CLARIFICATION



A = Debt Service, cents per 1000 gallons (6% - 25 yr.)
T = Total Treatment Cost, cents per 1000 gallons

Figure 7.

GRANULAR CARBON ADSORPTION



A = Debt Service, cents per 1000 gallons (6% - 25 yr.)
T = Total Treatment Cost, cents per 1000 gallons