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Performance Evaluation of Existing Aerated Lagoon System at Bixby, Oklahoma

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March 1979

PERFORMANCE EVALUATION OF EXISTING AERATED LAGOON SYSTEM AT BIXBY, OKLAHOMA

by

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. The complexity of the environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

As part of these activities, this case history report was prepared to make available to the sanitary engineering community a full year of operating and measured performance data for a two-celled, aerated wastewater treatment lagoon system.

Francis T. Mayo, Director
Municipal Environmental Research Laboratory

ABSTRACT

The University of Oklahoma School of Civil Engineering and Environmental Science research group in collaboration with INCOG & BIXBY, have studied a well designed, well operated two cell aerated wastewater treatment lagoon system. The study involved four seasons and nineteen study parameters. The data was treated to statistical analysis, using a SPSS multiple regression, and to normative analytical expression.

The lagoon exhibited an overall BOD_5 removal efficiency of 92%, but was only totally in compliance for 7 months of the year. The use of several kinetic models and regression models were not very satisfactory though the temperature coefficient (Θ) were in substantial agreement with Adams and Eckenfelder and other reputed values.

This report was submitted in fulfillment of Grant No. R803-916 by the University of Oklahoma under the partial sponsorship of the U.S. Environmental Protection Agency. This report covers the Bixby lagoon operating period of January 1976 through December 1976.

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SECTION 1

INTRODUCTION

BACKGROUND

Biological waste treatment by means of waste stabilization lagoon system can be considered as a major wastewater treatment alternative for small communities (especially those with less than 50,000 population) and rural areas and some industries. Waste stabilization lagoon system are chosen not only for the reason of low initial capital cost, but also because of their relative stability and simplicity, as well as minimum cost of operation and maintenance. The low initial capital cost is particularly true in the rural areas where more openland is available and at lower costs. For these reasons, today there are thousands of wastewater treatment lagoons in use for domestic wastewater treatment in the United States.

The use of lagoon systems to treat wastewater is wide-spread and there are great variations in the design of these systems: from simple anaerobic, facultative, aerobic and maturation lagoons to modified lagoons of various designs (for example - the use of aeration systems or devices to maintain aerobic conditions), from single to multiple cell systems, and so forth. Although a large number of these different systems of lagoons have been studied, there is a common lack of carefully collected data in sufficient depth -- in terms of realistic, long-term performance data which would be indispensible for producing sound design criteria for future use. Partly this is due to very little on-site capability and facility to determine operational test results.

SIGNIFICANCE OF PROJECT

In the October of 1972, Congress passed the Federal Water Pollution Control Act Amendments. The Act has three major targets:

(a) All municipal treatment facilities must achieve secondary treatment effluent limitations, and all industries must implement the Best Practicable Treatment technology

(BPT) for treatment of the wastewater discharged into all surface waters. The Act requires that these effluent criteria be met by 1977. The Environmental Protection Agency (EPA) has defined municipal secondary treatment standards and also Best Practicable Treatment technology effluent standards for each category of industry and type of manufacturing process used.

(b) By 1983, municipalities must achieve BPT in their treatment facilities. (BPT has been defined by EPA as secondary treatment for municipalities). Industries will have to implement Best Available Technology (BAT), as defined by EPA by 1983, for each kind of industry class.

(c) By 1985, all pollutional discharges must be eliminated from the nation's waters.

The Congress mandated that these steps be taken to enable the water quality goals of fishable and swimmable waters to be achieved by 1983. The spirit and overall purpose of the Act is to restore and maintain the chemical, physical and biological integrity of the nation's waters.

The law also established the National Pollution Discharge Elimination System (NPDES). Under NPDES, all point source (municipal and industrial) are issued permits specifyin the nature and quality of pollution they may discharge. These permits, at a minimum, reflect the appropriate technology based BPT or BAT standards.

The secondary treatment effluent limitations or the minimum performance requirements for publicly owned treatment works as established in the Act of 1972 specify that the BOD_5 and suspended solids arithmetic mean values of the effluent samples for 30 days consecutive sampling shall not exceed 30 milligrams per liter or 45 milligrams per liter for samples collected in seven consecutive days. They further specify that the arithmetic mean values for the 30 day consecutive sampling shall not exceed 15% of arithmetic mean of the influent samples collected at approximately the same time during the same period. Finally, they specify that the geometric mean of the fecal coliform bacteria and the effluents shall not exceed 200 for the 30 day period or 400 for the seven consecutive day period.*

These regulations and EPA's definition of secondary treatment seems to emphasize the installation of activated sludge units.

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*This has been deleted. See new standards at end of this section.

On the other hand, it is precisely because small communities cannot afford the high costs involved in the construction, operation and maintenance of activated sludge or other sophisticated units that they had to resort to treatment by means of lagoons. There also exists a strong possibility that many of the present operating lagoon will not meet EPA secondary treatment effluent standards without modifications. (2,3,4) Thus, in order to meet treatment standards, many of the presently operating lagoons would have to be modified or upgraded.

Among the numerous alternatives for upgrading lagoon treatment, functionally serialized lagoons (anaerobic, facultative and maturation) present a possible solution. Other possible solutions for upgrading the treatment are addition of air, recycling, controlled discharge, possibility of final sedimentation, filtration, and even the possibility of harvesting algae through natural methods such as culturing carp or milk-fish, or passing through a natural aquatic habitat. However, before a decision can be made on what methods of upgrading are sufficient in improving effluent quality to meet the standards, it becomes necessary to gather additional pertinent data on existing lagoon systems. At the present, there are very limited published data on performance of lagoons on a seasonal basis for the most important water quality parameters (including nutrients). It is most important to have such data in order to do a rigorous performance evaluation. Therefore, it is important to determine how an existing well-designed aerated lagoon treats wastewater. Well designed, well operated lagoon must have been operated sufficiently long and at different climatic conditions to be able to ascertain their performance in order to determine whether there are existing continuous discharge aerated lagoons that can meet the 1977 secondary treatment standards. This project will document and evaluate carefully collected operating performance data from one such lagoon system.

* Since the beginning of this project, the federal Secondary Treatment Effluent Standards have been amended. As published in the July 26, 1976 Federal Register, the limitations on fecal coliform bacteria were deleted in the 1976 revision of the standard. It is now felt that it is environmentally sound to establish disinfection requirements for domestic wastewater discharges in accordance with water quality standards promulgated pursuant to Section 302 and 303 of the Act and associated public health needs. On October 7, 1977, suspended solids limitations were amended to permit less stringent limitations for publicly owned wastewater treatment ponds with a design capacity of two million gallons per

day or less. Either the Regional EPA Adminstrator or the State Director for Environmental Control, subjected to EPA approval, may establish less stringent limitations based on the actual performance of waste stabilization ponds in the geographic area which are meeting effluent quality limitations for biochemical oxygen demand.

SECTION 2

CONCLUSIONS

Although the Bixby lagoon system exhibits an overall BOD_5 removal efficiency of 92%, it is only in compliance with EPA's BOD_5 standard for about 7 months out of the year. Winter and early Spring months are the non-complying months.

Total suspended solid levels in the effluent remained fairly high for 11 months of the year. The average TSS level for those months was 52 mg/l, which may be attributed to algal growth.

Fecal coliform density in the wastewater entering the Bixby lagoon system was high, in the order of 10^5/100 ml. Even if the lagoon system had coliform removal efficiency as high as 98%, it still would not be able to reduce the coliform bacteria to less than 200/100 ml. Additional treatment would be necessary if there were a bacterial limitation for the receiving stream.

The use of linear regressions to characterize the influent, mid-point and effluent parameter and correlate lagoon efficiencies all fall short of being satisfactory. Additional parameters not clear at the present will have to be included in the regression analysis for it to be meaninful.

The attempt to depict the performance of Bixby lagoon system in terms of kinetic models was unsuccessful. The wide variations in experimental data which were being fitted to the models could not be satisfactorily explained. One possible explanation was that it may be due to algal growths which affected the fraction of the biologically active volatile suspended solids.

SECTION 3

RECOMMENDATIONS

For the numerous small communities and rural areas, wastewater treatment by means of lagoons is a significant and economically feasible alternative. However, few existing lagoons were able to perform to more desirable treatment levels as that obtained from conventional secondary treatment systems. It is obvious that lagoons as a viable means of wastewater treatment need to be further studied and monitored so that from such actions meaningful knowledge may be acquired and better design criteria may be formulated.

At the present, lagoon effluent standards are less strigent as a result of subsequent revisions of the 1972 Act. However, should a need arise in the future for the improvement of the Bixby lagoon system the addition of one or a combination of the followings is recommended: anaerobic lagoon for pretreatment, maturation lagoon for polishing and/or chlorination prior to discharge. However, feasibility study should be conducted prior to any such action.

The effect of the relative abundance of algae on the biologically active portion of the volatile suspended solids should be investigated.

The retention time in each lagoon at Bixby based on plug flow is 40 days. A method of accounting for this time lag in the correlation and regression analysis should be developed.

SECTION 4

APPROACH

PRIMARY OBJECTIVE

The primary objective of this project was to generate reliable year round performance data for a typical multi-cell aerated lagoon waste disposal system. Bixby, Oklahoma is a case in point. This lagoon system, which consists of two cells in series using an Air Aqua* system, is located in the town of Bixby, Oklahoma, which is part of the INCOG Multi-County Planning System. This aerated lagoon was selected for study by EPA with the concurrence of others.

SECONDARY OBJECTIVE

The secondary objective was to utilize these data to evaluate the effectiveness of the multi-cell lagoon system to perform in accordance with its design criteria and its ability to meet the secondary treatment standards as established by the Federal Water Pollution Control Act Amendments of 1972.

Data generated and evaluated in this lagoon system were to be similar to data from other types and locations of well-designed well-operated multi-cell aerated or a combined aerated and facultative lagoon system. These data could be used not only to assist design engineers and regulatory officials, but also assist EPA in its stated objective of defining lagoon capabilities and lagoon grading needs. A great number of parameters were studied in considerable depth. Out of the parameter study two significantly useful things were sought: 1) the more meaningful parameters conceivably could be used as routine operational tests, and 2) the parameters could be interrelated to provide predictive equations for future design.

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*Tradename of Hinde Engineering aeration system.

SCOPE

From the existing Bixby lagoon system at Bixby, Oklahoma, one full year of lagoon performance data were collected. Within this period, data collection was divided into four temporal phases coinciding with the four seasons: Spring, Summer, Fall and Winter. In each period, data were collected daily for one month while samples of one week (7 consecutive days) per month were taken during the remaining two months.

Sampling was done with a flow proportional type compositing device, and sampling points were the influent (before entering the lagoon system), the mid-point (exit of first cell) and the effluent (exit from the lagoon system). Nineteen parameters were attempted: flow data, pH, temperature, dissolved oxygen, alkalinity, total BOD_5, soluble BOD_5, total suspended solids, volatile suspended solids, total COD, soluble COD, phosphorus (dissolved orthophosphate), total Kjeldahl nitrogen, ammonia nitrogen, nitrate and nitrite nitrogen, fecal and total coliform. Nitrate and nitrite nitrogen tests were subsequently discarded after tests performed at the start of project consistently showed near zero values. The remaining parameters were measured in depth with the exception of algal determination which was performed qualitatively only. Table 1 is a sampling and analytical guide.

Four tests were performed at the site, namely: pH, temperature, alkalinity and dissolved oxygen. Total suspended solids, volatile suspended solids, total and soluble COD, total and soluble BOD_5 tests were performed at the University of Oklahoma's mobile laboratory parked by the lagoon. Remaining tests were conducted by Laboratory Services, Division of the Tulsa City County Health Department.

This report in addition to containing the tabulation of the performance data, detailed information concerning the lagoon design, operational parameters, inlet and outlet configurations and flow pattern, also included an interpretation of the data as to its significance in relation to the objectives of the project. Statistically, data were analysed in the form of correlation matrices to assist in the identification of appropriate and redundent tests, and hopefully to develop through regression analysis technique and equations representing the performance of this type of lagoon. These equations, if developed, would be useful in design and evaluation of performance, including both efficiency and cost of treatment.

TABLE 1. SAMPLING AND ANALYTICAL GUIDE

PARAMETER	INFLUENT	SAMPLING POINTS MID-POINT	EFFLUENT
WW Flow	X		
pH	X	X	X
WW Temperature		X	X
Dissolved Oxygen		X	X
Alkalinity	X	X	X
Total BOD_5	X	X	X
Soluble BOD_5	X	X	X
Total Suspended Solids	X	X	X
Volatile Suspended Solids	X	X	X
Total COD	X	X	X
Soluble COD	X	X	X
Phosphorus*	X	X	X
Total Kjeldahl Nitrogen	X		X
Ammonia Nitrogen	X		X
Nitrate Nitrogen+	X		X
Nitrite Nitrogen+	X		X
Fecal Coliform	X	X	X
Total Coliform		X	X
Algal Determination		X	X

*Actual test performed was dissolved ortho-phosphate. For convenience, dissolved ortho-phosphate was identified by phosphorus.
+Nitrate and nitrite tests were discontinued after numerous tests performed at the start of the project yield zero or near zero values consistently.

SECTION 5

PROJECT DESCRIPTION

DESCRIPTION OF THE CITY OF BIXBY AND ITS LAGOON SYSTEM

The site selected for this segment of the oxygen-supplied multiple lagoon system was that of the city of Bixby, Oklahoma. The city of Bixby is situated in the Indian Nation Council of governments (INCOG) and is adjacent to south Tulsa City. The current population of Bixby is 3,000 and is projected to grow to 6,000 in the year 2,000. The present population prodces an effluent BOD_5 averaging 350 milligram per liter. Currently, Bixby has no manufacturing or process industries discharging industrial waste into the sanitary sewers. This greatly increased the desirability of the Bixby lagoon system as a site for intensive study because the wastewater concentration entering the lagoon system will be relatively stable and practically free of toxic substances which may disrupt treatment continuity. All variabilities in the wastewater which enters the Bixby lagoon system can thus be attributed to normal small town domestic and commercial sources.

Bixby Lagoon System

Bixby lagoon system is a dual-cell system, with total surface area of $23.5\text{x}10^{-3}$ km^2, an average depth of 3.2 m, and an overall volume of $5.6\text{x}10^4$ m^3. Each cell is 167 m long and 38 m wide. The cells are not cemented and are supported on the sides by a dike of slope 3:1. It has 20 h.p., 9.8 m^3/min., Hinde/Air-Aqua system with 84 laterals in the primary and 48 laterals in the secondary, designed to supply all the oxygen requirements for loading of 276 kg of BOD_5 per day, a population of 4,500 people and o.4 MGD (1 GPD = o.oo3785 m^3/d). The present plant is operating at about 90% efficiency, and a retention time of about 67.5 days. The flow is continuous, the inlet and outlet system is designed against short-circuiting. The plant is well operated, and is always acessible. It does not have final clarification nor does it have chlorination, nor are there available long-term records. These data are summarized in Table 2 and a sketch of the

TABLE 2. PROCESS DATA

Two Lagoons -	$5.6x10^4$ m^3 volume $23.5x10^{-3}$ km^2 surface area 3.2 m depth designed for either serial or parallel operation. (See sketch, Figure 1)
Aeration -	20 h.p.- Air Aqua System/Hinde Engineering 84 laterals in primary 48 laterals in secondary % oxygen demand supplied - 100%
Design -	Q = 0.45 MGD (1 GPD = 0.003785 m^3/d) Population = 4,500 BOD_5/DAY = 335 kg Retention Time = 31.6 days BOD_5/100 m^3 = 0.6 kg BOD_5/HPH = 0.7 kg BOD_5/m^2/DAY = 0.015 kg
Actual -	Q = 0.21 $\pm$ 0.04 MGD (1 GPD = 0.003785 m^3/d) Population = 3,000 Influent BOD_5 = 240 (200 - 350) mg/l Effluent BOD_5 = 11 mg/l Efficiency = 90.5% BOD_5/m^2/DAY = 0.008 kg Retention Time = 67.5 days
Operation -	Continuous flow Off set inlet, air lift, over under baffle No Cl_2 Effluent V notch weir No cover, cell depth constant Maintenance good, always acessible
Other -	Built in 1970 Engineering - HTD (Tulsa/Okla. City) Operator - Fred Keas

facility in Figure 1.

DESCRIPTION OF THE EXPERIMENTAL INVESTIGATION

Sampling was simplified with the use of automatic-samplers which were setup at the lagoon influent, the mid-point and the lagoon effluent. The sampler set at the mid-point allowed analysis of each cell's performance individually.

Each sampler collected 50 ml of sample every fifteen minutes and approximately 4 liters of sample was collected in a 24 hour period.

The samples were stored in ice boxes at 4 degrees Celsius. This inhibited biological activity in the composite samples. All the experimental parameters used in the correlation were measured within 1 day of sample collection. pH, temperature, dissolved oxygen and alkalinity tests were conducted on-site immediately after samples were collected.

In the experimental analysis, 462 samples were collected and analyzed between January and December 1976. January, April, July and November were months of intensive testing and approximately 75 samples were analyzed in each of these months. This close study of the behavior of the lagoons was essential to get data to predict the seasonal variation of the performance of the lagoons. During each of the remaining months, testing was not equally rigorous and about 21 daily samples were analyzed in each month.

DESCRIPTION OF EXPERIMENTAL ANALYSIS AND PROCEDURES

All analysis were performed in accord to either the 13th Edition of Standard Methods for the Examination of Water and Wastewater (7) or EPA's Manual of Methods for Chemical Analysis of Water and Wastes (17). In the following, they will be abbreviated as Standard Method and EPA Manual respectively. The analytical procedures chosen for the parameters included in this project are briefly outlined as follows:

Tests conducted on-site:

pH - direct measurement by pH meter.
Temperature - measured by thermometer in Celsius.
Dissolved Oxygen - measured by D.O. probe.
Aklalinity - titrimetrically determined by mixed bromcresol green - methyl red double indicator method.

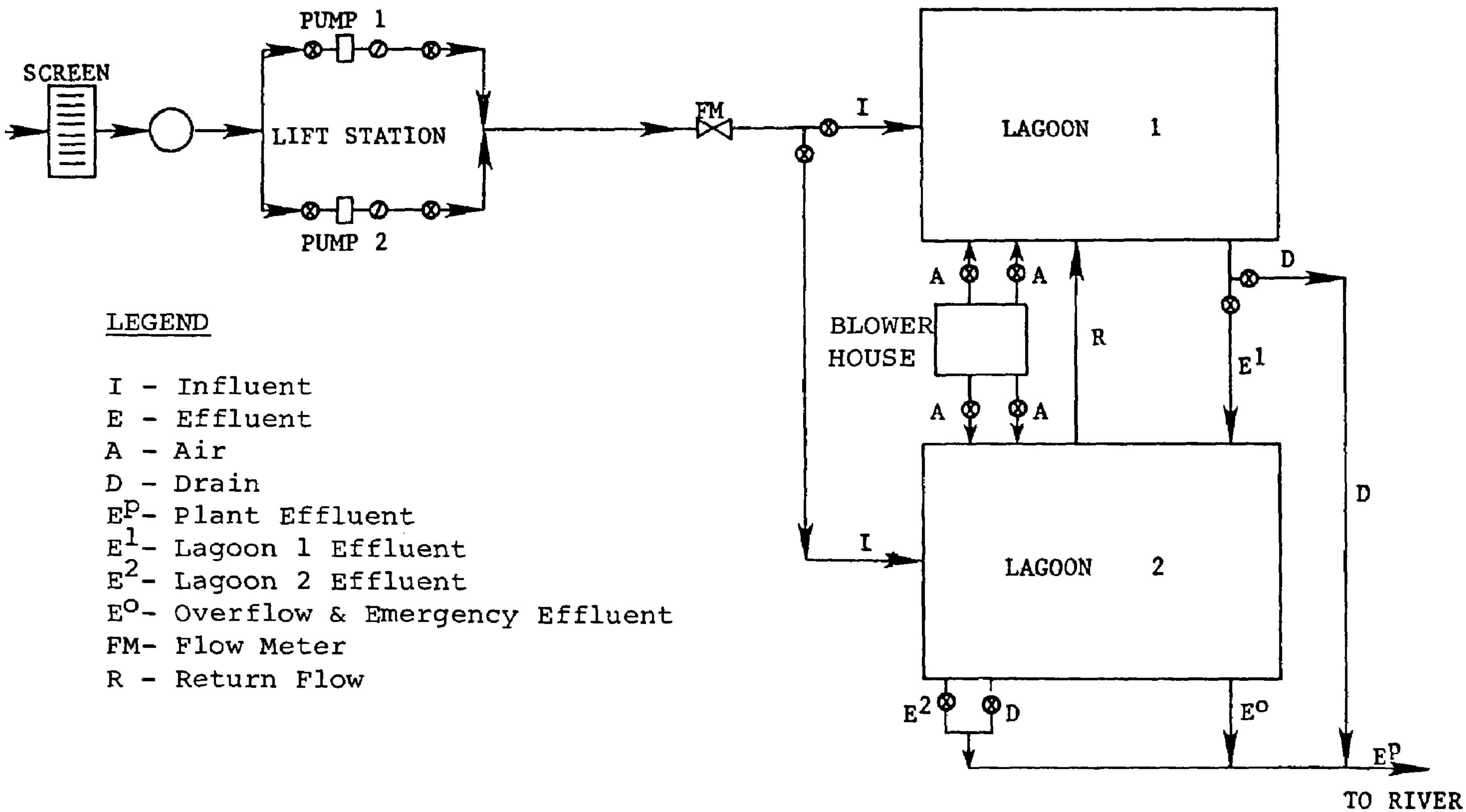

Figure 1. Flow schematic of Bixby lagoon system.

(Standard Method)

Tests conducted in laboratories*:

Phosphorus - determined in terms of dissolved ortho-phosphate by direct colorimetric analysis procedure. (EPA Manual, storet no. 00671)

Ammonia Nitrogen - determined by Automated Colorimetric Phenate Method using Technicon Autoanalyser Unit AAII. (EPA Manual, storet no. 00610)

Total Kjeldahl Nitrogen - determined by titration of ammonia after distillation. (EPA Manual, storet no. 00625)

Nitrate Nitrogen - measured by spectrophotometer. (EPA Manual, storet no. 00630)

Nitrite Nitrogen - measured by spectrophotometer. (EPA Manual, sotret no. 00615)

Total BOD_5 - determined by Azide Modification of the Winkler Method. (Standard Method)

Soluble BOD_5 - samples were first filtered through 0.45 μ filter with subsequent determination by the Azide Modification of the Winkler Method. (Standard Method)

Total COD - determined by titrimetric method after reflux. (EPA Manual, storet no. 00335, Low Level)

Soluble COD - samples were first filtered through 0.45 μ filter with subsequent determination by titrimetric method after reflux. (EPA Manual, storet no. 00335, Low Level)

Total Suspended Solids - complete evaporation of the water portion with residue dried at oven temperature of 103 ^{o}C. Determined by weight difference. (Standard Method)

Volatile Suspended Solids - complete evaporation and ashed at 550 ^{o}C. Determined by weight difference. (Standard Method)

Total Coliform - determined by membrane filter technique. (Standard Method)

Fecal Coliform - determined by membrane filter technique. (Standard Method)

Flow Rate - determined by measurement of water level over weir with a portable water level recorder.

Algal determination - qualitatively determined.

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*Six tests were performed in O.U. Mobile Laboratory. See page 8.

DESCRIPTION OF STATISTICAL ANALYSIS TECHNIQUES

Because of the extremely large amount of performance data collected over the project period, statistical analysis would be impractical as well as not feasible without the use of high-speed computers. All the analysis conducted in this project were done with the use of a "canned" statistical analysis package -SPSS. (6) SPSS is a highly flexible, user oriented tool with output data printed out in very neat and readable manner.

Analysis of experimental data to obtain continuous variable descriptive statistics such as maximum, minimum, mean values, and standard deviation, etc. was executed with the use of a sub-program in the SPSS.

For studies related to characterization of wastewater entering the facility, efficiency correlations and design method verification, the principal tool used was multiple regression analysis.

In all correlation work, where all the variable interdependencies are not immediately obvious, stepwise regression analysis is probably the most useful and versatile tool (6).

Stepwise regression enables the identification of the most significant variables, which "explain" a given dependent variable, in the relative order of their importance. The initial task, therefore, is to identify all possible independent variables which may be related to a given dependent variable. The stepwise regression procedure introduces each variable, in order of its importance, into the regression equation and shows the effect of this introduction on the overall correlation coefficient (r^2), the F ratio, the standard error, and the beta weights for each variable in the equation. No variables would be added to the regression equation if the addition of a variable does not increase the r^2 value.

Once the pertinent variables are identified by the stepwise regression, a very close examination of all the possible underlying theoretical explanations is necessary. This is simply to avoid the problems caused by an exclusive reliance on statistical analysis. There are, sometimes, unexpected indications of variable interdependencies. These need very careful substantiation. Alternatively, variables thought to be extremely significant may not appear in the final equation resulting from the stepwise procedure. This can happen easily especially when there is considerable scatter in the original data for that variable because of low experimental reproducibility (7). This problem occurs often in biochemical tests.

One common decision whenever this problem arises is to force the excluded variable(s) into the regression equation by abandoning the stepwise procedure. This also enables dropping of non-significant variables from the equation with a corresponding increase in the total number of valid cases. The final regression then, shows the best relationship between the independent variables and the dependent variables.

The output from such a final regression includes a tabulation of all regression parameters, a case by case listing of observed versus predicted values for the dependent variable, and a plot of the standardized error in predicted variable values. An analysis of such a plot can reveal whether or not there is reason to suspect systematic violations of the assumption that the regression is linear. In such cases, non-linear transformations of the independent variables may be indicated and the entire regression exercise repeated. However, the regression statistics produced after such variable transformations cannot be compared against the original statistics except in a very general, qualitative way. This is especially true if logarithmic transformations are used.

The fitting of observed lagoon data to a general design equation can be done by rearrangement of the design equation, identification of "synthetic" new variables and regression of these variables using least squares methods. Should it be necessary to force such regressions through a fixed point (for theoretical reasons), the usual unconstrained regression procedure is no longer useful. A similar situation would arise, for example, if a particular regression coefficient were to be held fixed. Such problems are best handled by a basic reformulation of the least squares technique which forces such constraints to be met at the beginning. Examples of such modifications are discussed later in the report.

SECTION 6

PROJECT GENERATED DATA

The primary objective of this report on Bixby lagoon system was to generate the much needed performance data for a typical multi-cell aerated lagoon waste disposal system on a year-round basis. For this reason, Section 6 is entirely devoted to the tabulation and presentation of data generated during the course of this project. For clarity purpose, data are organized into three levels: year-round, seasonal, and monthly.

DATA GENERATED ON A YEAR-ROUND BASIS

Data generated in this group is an attempt to create an overall view of the parameter characteristics measured at the Bixby lagoon system. Tables 3 to 5 are statistical descriptions of the water quality parameters at the influent, mid-point and effluent of the Bixby lagoon system. Table 6 summarizes lagoon efficiency of individual cells and the lagoon system as a whole.

DATA GENERATED ON A SEASONAL BASIS

Seasonal average water quality of wastewater at various treatment stages of the Bixby lagoon are computed and tabulated in Table 7. Data generated in this manner allow observation and comparison of wastewater treatment efficiency on a seasonal basis. Figure 2 to 8 are computer interpretations of parameter level vs time (these parameters are the ones involved in the kinetic modelling.)

DATA GENERATED ON A MONTHLY BASIS

Tables 8 to 10 contain data computed to monthly averages. Their significance lie in the fact that they revealed the trend of parameter level variation throughout the year when data were collected. Figure 9 to 20 are graphical presentations of data so computed. These graphs besides visually showing trends of parameter variation, also permit comparison of treatment efficiencies

TABLE 3. STATISTICAL DESCRIPTION OF INFLUENT WATER QUALITY AT BIXBY LAGOON, 1976

TEST	AVE. VALUE+	MIN.	MAX.	STD. DEV.
pH		4.3	7.6	
Alkalinity*	154.0	94.0	198.0	18.9
Total BOD_5	368	210	740	90
Soluble BOD_5	154	53	350	56
Total S.S.	268	92	772	138
Volatile S.S.	201	40	631	116
Total COD	641	233	1,148	147
Soluble COD	262	115	545	69
TKN	45.7	21.0	115.0	11.8
Ammonia-N	29.3	9.0	48.9	6.7
Flow, GPD**	1.4×10^5	617	17.6×10^5	1.8×10^5

+All values were computed from one year period data. Unless indicated, all units are mg/l except for pH.
*As $CaCO_3$
**1 GPD = 0.003785 m^3/d

TABLE 4. STATISTICAL DESCRIPTION OF MID-POINT WATER QUALITY AT BIXBY LAGOON, 1976

TEST	AVE. VALUE+	MIN.	MAX.	STD. DEV.
pH		5.5	8.0	
Alkalinity*	85.7	26.0	194.0	41.7
Temperature,^oC	17.8	1.0	30.0	8.6
DO	7.6	2.2	13.6	2.6
Total BOD_5	84	26	183	37
Soluble BOD_5	25	3	132	28
Total S.S.	90	19	232	46
Volatile S.S.	70	12	196	39
Total COD	195	88	498	67
Soluble COD	71	17	246	35

+All values were computed from one year period data. Unless indicated, all units are mg/l except for pH.
*As $CaCO_3$

TABLE 5. STATISTICAL DESCRIPTION OF EFFLUENT WATER QUALITY AT BIXBY LAGOON, 1976

TEST	AVE. VALUE+	MIN.	MAX.	STD. DEV.
pH		6.3	9.8	
Alkalinity*	74.4	24.0	180.0	24.1
Temperature, ^{o}C	17.3	1.0	31.0	9.1
DO	8.8	2.0	19.0	4.0
Total BOD_5	30	7	131	21
Soluble BOD_5	16	1	128	19
Total S.S.	56	11	186	33
Volatile S.S.	35	4	146	23
Total COD	103	20	330	45
Soluble COD	55	6	250	32
TKN	7.8	1.0	23.0	4.7
Ammonia-N	3.3	0.1	23.8	4.6

+All values were computed from one year period data. Unless indicated, all units are mg/l except for pH.

*As $CaCO_3$

TABLE 6. SUMMARY OF BIXBY LAGOON EFFICIENCIES, 1976

TEST	AVE. VALUE+	MIN.	MAX.	STD. DEV.
BOD_5 Cell 1	77	48	94	9
BOD_5 Cell 2	61	-17*	92	24
BOD_5 Overall	92	68	97	5
Total S.S. Cell 1	61	-22	93	24
Total S.S. Cell 2	16	-392	94	76
Total S.S. Overall	76	29	96	14
COD Cell 1	69	18	89	12
COD Cell 2	45	-15	95	21
COD Overall	84	55	97	7
TKN Overall	83	34	98	10

+All values were computed from one year period data. Values are removal efficiencies in percentages.

*Negative sign indicates increase in waste concentration.

TABLE 7. SEASONAL AVERAGE INFLUENT, MID-POINT, AND EFFLUENT WATER QUALITY AT BIXBY LAGOON, 1976

	SPRING			SUMMER			AUTUMN			WINTER		
TESTS	INF.	MID.	EFF.	INF.	MID.	EFF.	INF.	MID.	EFF.	INF.	MID.	EFF.
pH	6.5	6.8	7.2	6.2	6.7	6.8	6.2	6.2	7.6	6.7	6.9	7.9
Alkalinity*	160	109	85	151	78	72	149	71	60	157	113	79
Temperature, °C	-	19.3	19.1	-	28.0	28.4	-	12.7	11.8	-	6.6	5.7
DO	-	6.6	7.1	-	6.4	5.2	-	8.2	11.6	-	9.8	13.2
Total BOD_5	394	88	35	355	64	20	366	111	25	357	80	40
Soluble BOD_5	148	24	16	129	13	9	144	7	10	199	52	28
Total S.S.	301	79	58	258	72	66	258	133	52	253	78	46
Volatile S.S.	221	61	41	214	58	33	192	108	35	178	52	28
Total COD	606	206	131	594	156	84	757	263	102	630	165	94
Soluble COD	240	77	74	248	62	49	257	67	47	302	78	46
Phosphorus**	37.7	44.0	48.2	-	-	38.0	-	-	-	36.9	40.7	32.0
TKN	49.1	-	10.4	43.5	-	4.7	46.9	-	5.3	43.6	-	10.1
Ammonia-N	24.1	-	5.0	31.1	-	0.8	33.9	-	0.1	29.8	-	6.1
Fecal Coli.+	199	147	73	-	-	-	-	-	-	-	-	-
Total Coli.+	-	303	166	-	-	-	-	-	-	-	-	-
Flow, x10^3 gpd#	150	-	-	151	-	-	132	-	-	118	-	-

Unless otherwise indicated, all units are mg/l except for pH.

*Alkalinity as $CaCO_3$.

**Actual tests performed were dissolved ortho-phosphate. For convenience, dissolved ortho-phosphate was identified as phosphorus.

+Values are x100/100ml.

#1 gpd = 0.003785 m^3/d.

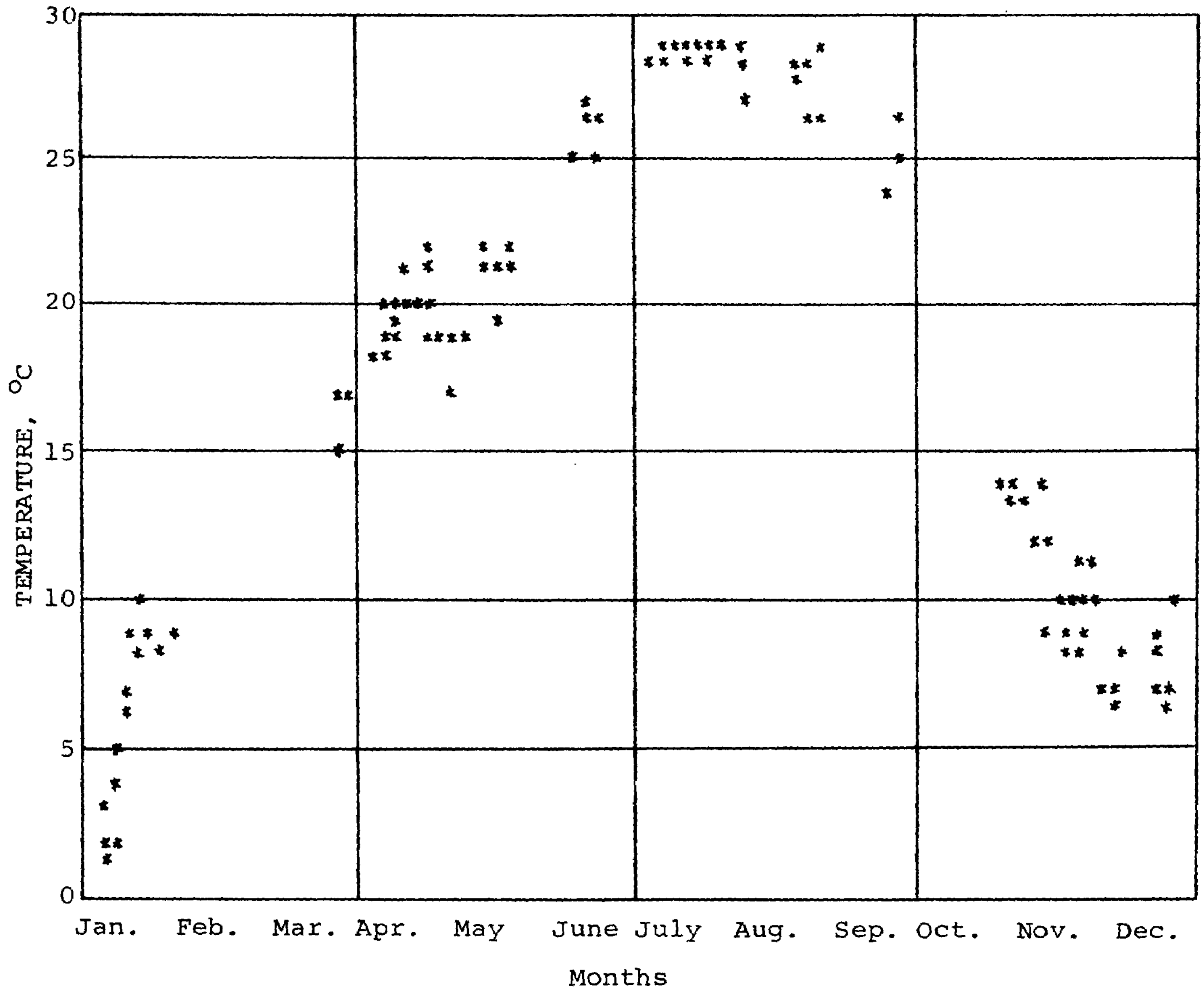

Figure 2. Seasonal mid-point water temperature change at Bixby lagoon, 1976

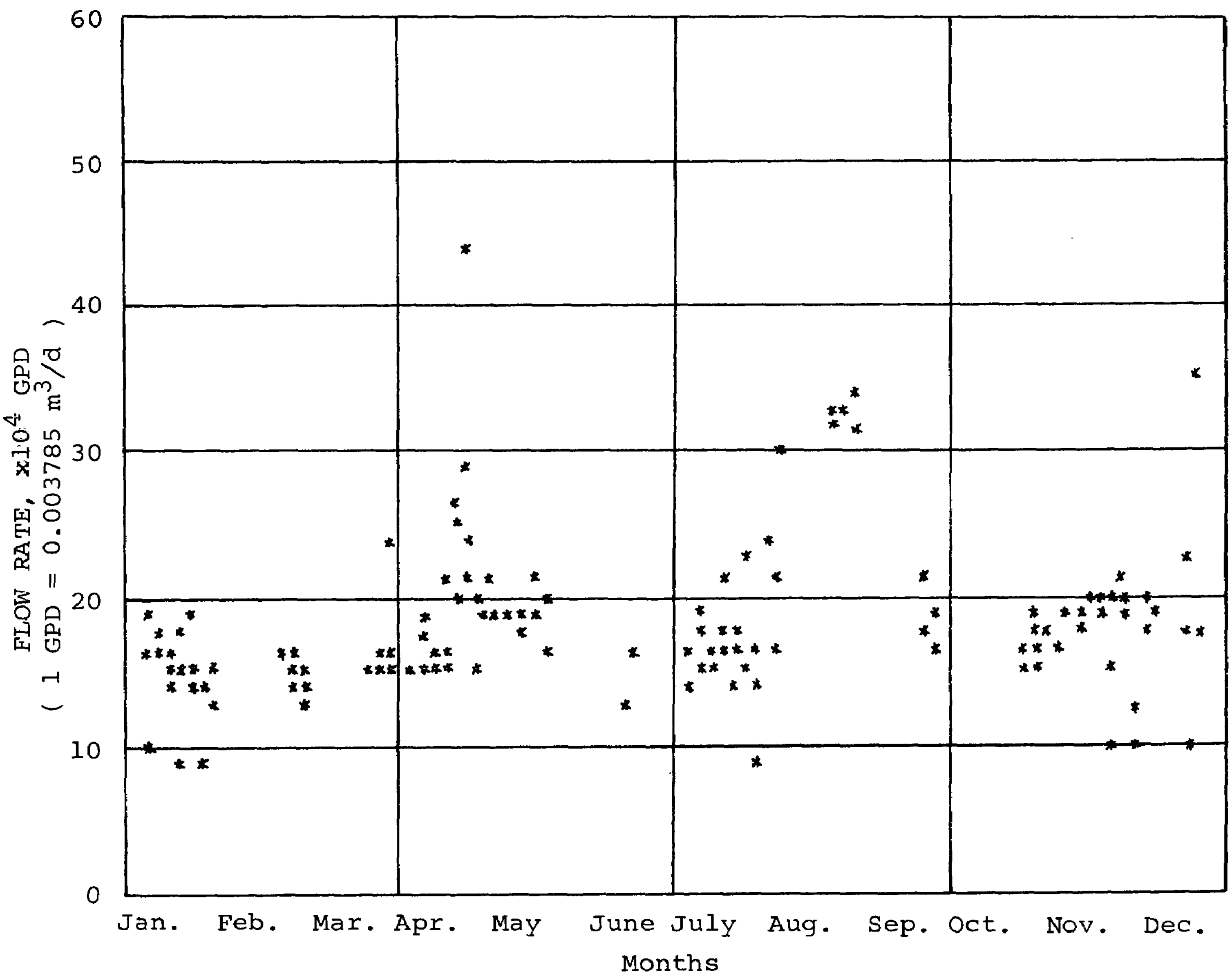

Figure 3. Seasonal influent flow rate change at Bixby lagoon, 1976

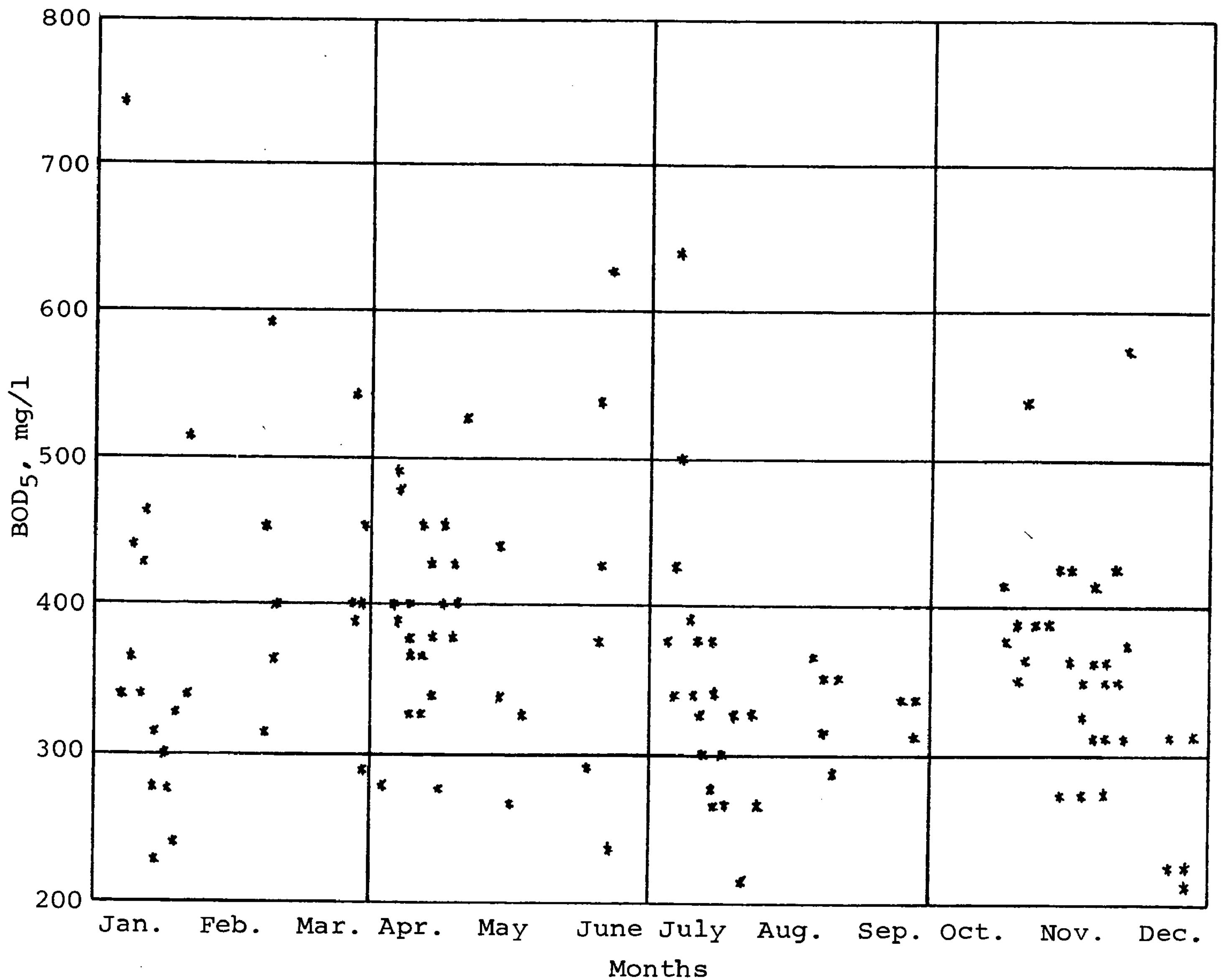

Figure 4. Seasonal influent BOD_5 change at Bixby lagoon, 1976

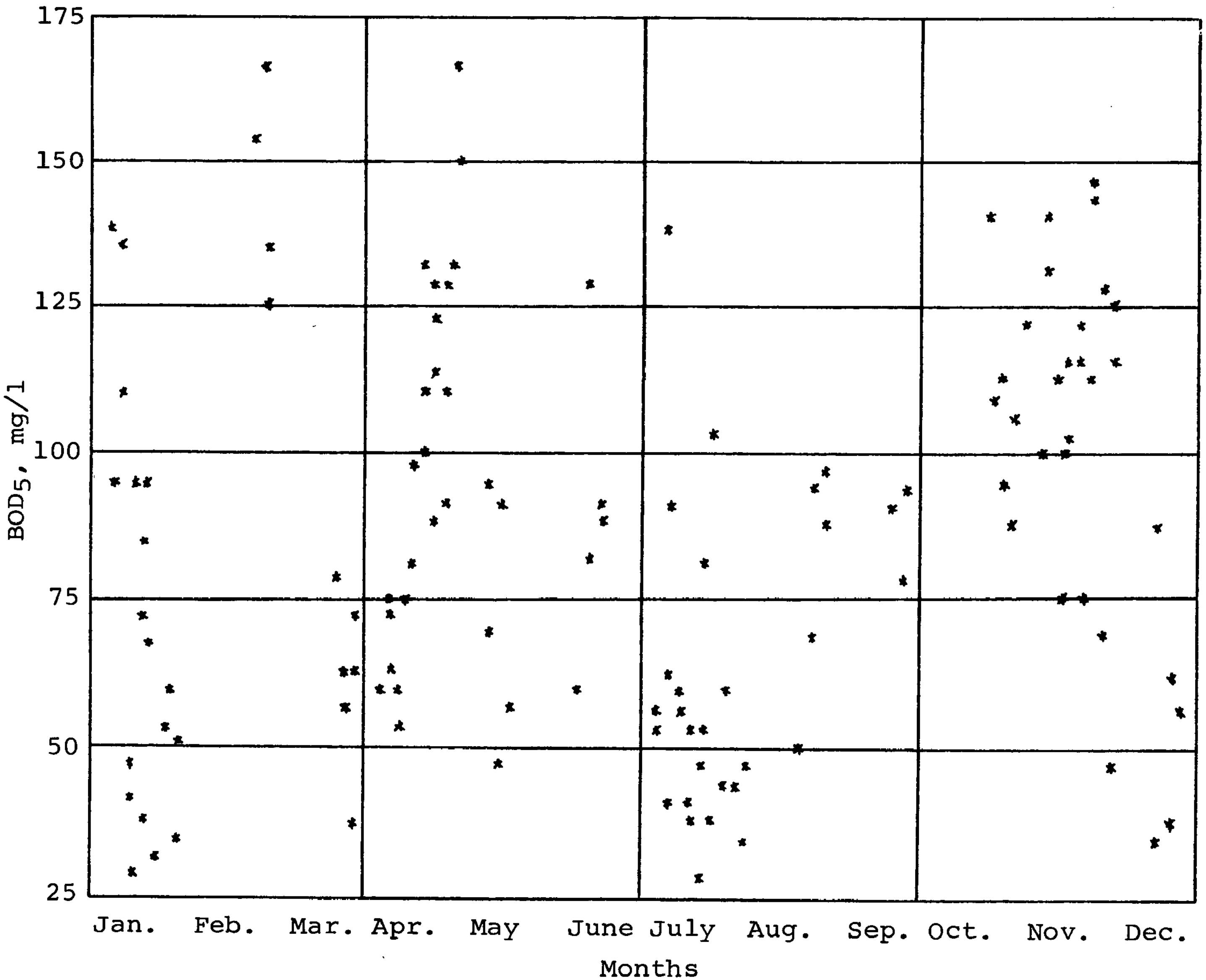

Figure 5. Seasonal mid-point BOD_5 change at Bixby lagoon, 1976

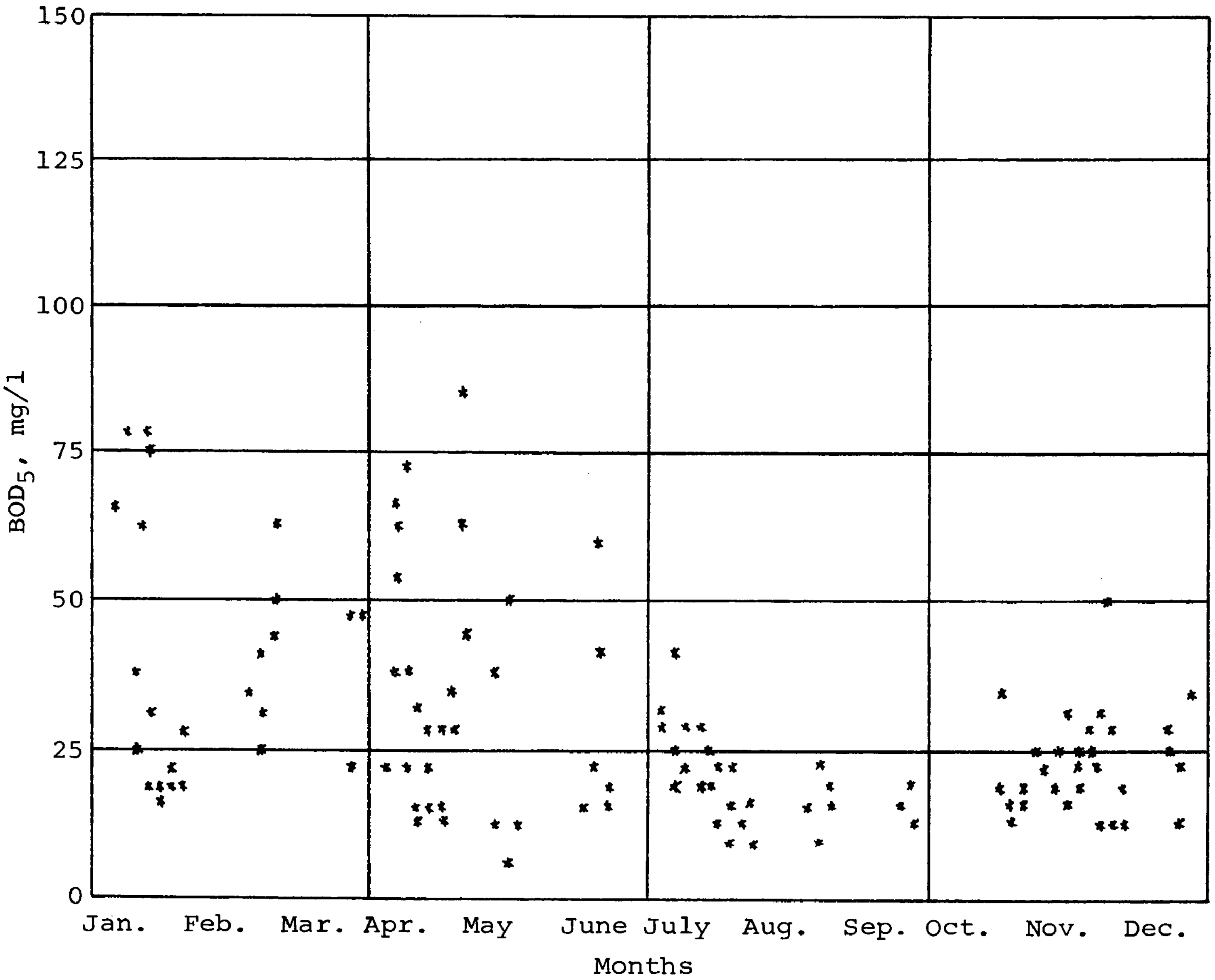

Figure 6. Seasonal effluent BOD_5 change at Bixby lagoon, 1976

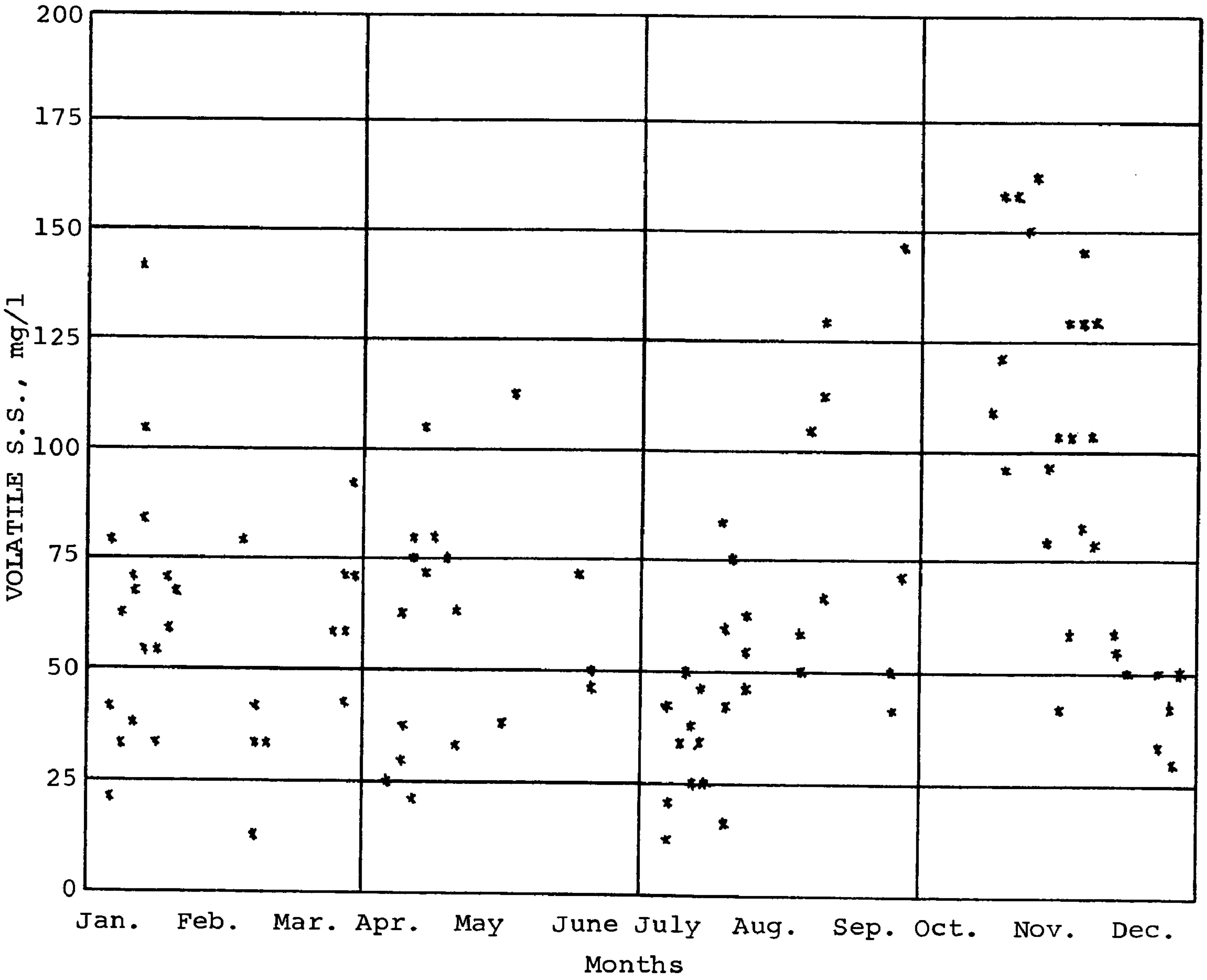

Figure 7. Seasonal change of mid-point volatile suspended solids at Bixby lagoon, 1976

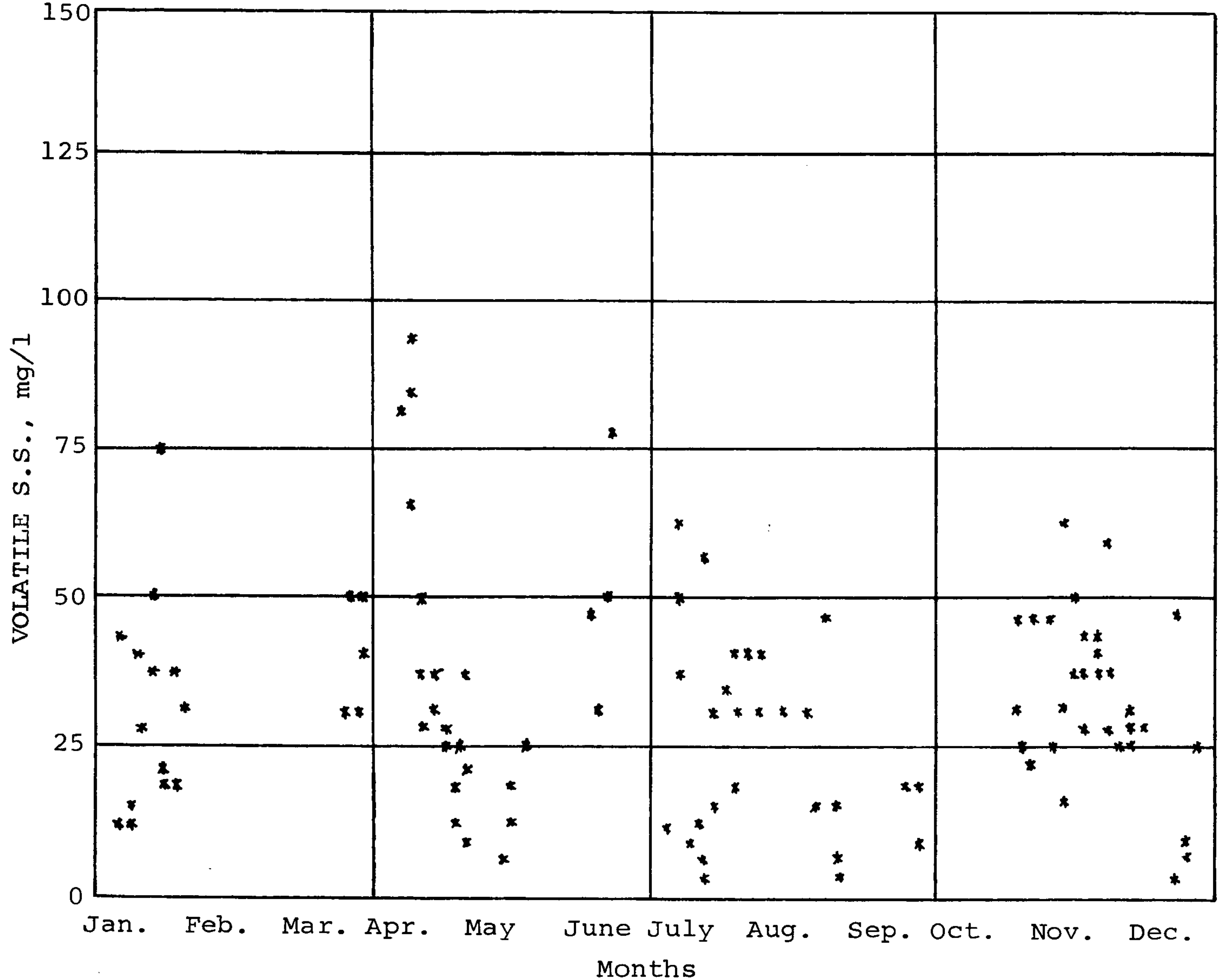

Figure 8. Seasonal change of effluent volatile suspended solids at Bixby lagoon, 1976

TABLE 8. MONTHLY AVERAGE INFLUENT WATER QUALITY AT BIXBY LAGOON, 1976

TESTS	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
pH	6.9	-	7.1	6.7	6.5	6.5	6.1	6.4	6.2	6.3	6.5	6.3
Alkalinity*	165	-	162	169	159	157	152	144	142	163	154	143
Total BOD_5	368	422	414	430	379	413	355	213	330	388	383	283
Soluble BOD_5	222	244	227	132	136	122	140	105	142	136	156	119
Total S.S.	323	228	236	347	271	230	253	282	213	230	289	134
Volatile S.S.	230	177	107	288	207	187	200	255	82	180	229	96
Total COD	664	523	671	619	552	606	594	589	646	773	815	619
Soluble COD	312	368	319	225	240	267	254	223	259	278	262	224
Phosphorus**	36.5	-	37.3	-	-	-	-	-	-	-	-	-
TKN	42.9	44.4	63.6	42.3	40.2	40.8	47.5	36.3	44.2	47.1	50.2	44.3
Ammonia-N	31.0	27.9	25.1	24.7	24.4	26.5	36.3	22.3	33.5	40.4	32.6	28.5
Fecal Coli., x100/100 ml	-	-	133	225	-	-	-	-	-	-	-	-
Flow, $x10^3$ gpd#	111	109	123	168	141	111	124	222	140	124	148	148

Unless otherwise indicated, all units are mg/l except for pH.
*Alkalinity as $CaCO_3$.
**Actual tests performed were dissolved ortho-phosphate. For convenience, dissolved ortho-phosphate was identified as phosphorus.
#1 gpd = 0.003785 m^3/d.

TABLE 9. MONTHLY AVERAGE MID-POINT WATER QUALITY AT BIXBY LAGOON, 1976

TESTS	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
pH	7.3	-	7.7	6.8	6.6	6.5	6.6	6.8	6.7	6.4	6.6	6.4
Alkalinity*	142	-	157	111	72	71	81	74	52	45	38	74
Temperature, ^{o}C	5.7	-	16.6	19.3	21.0	25.9	28.7	27.4	25.0	14.0	9.5	7.4
DO	10.6	-	6.7	7.3	4.4	3.5	6.9	7.7	7.1	8.4	8.4	7.9
Total BOD_5	68	150	60	99	71	87	56	79	87	105	110	52
Soluble BOD_5	55	87	40	37	9	13	14	8	5	8	9	12
Total S.S.	93	63	101	73	80	61	66	102	109	166	120	51
Volatile S.S.	64	40	63	59	74	53	50	87	78	140	98	40
Total COD	147	186	191	216	183	175	139	204	185	268	248	173
Soluble COD	65	133	111	84	64	104	53	69	68	57	68	66
Phosphorus**	38.6	-	43.6	-	-	-	-	-	-	-	-	-
Fecal Coli., x100/100 ml	-	-	113	162	-	-	-	-	-	-	-	-
Total Coli., x100/100 ml	-	-	213	328	-	-	-	-	-	-	-	-

Unless otherwise indicated, all units are mg/l except for pH.
*Alkalinity as $CaCO_3$.
**Actual tests performed were dissolved ortho-phosphate. For convenience, dissolved ortho-phosphate was identified as phosphorus.

TABLE 10. MONTHLY AVERAGE EFFLUENT WATER QUALITY AT BIXBY LAGOON, 1976

TESTS	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
pH	7.6	-	9.2	6.9	6.9	6.7	6.7	7.1	8.1	7.7	7.1	6.7
Alkalinity*	91	-	149	80	59	69	75	69	63	62	59	49
Temperature, ^{o}C	5.2	-	16.0	19.2	20.3	26.1	29.3	28.2	24.3	12.8	8.6	6.6
DO	13.5	-	9.0	5.7	8.3	3.9	4.3	6.4	9.5	10.6	11.7	11.5
Total BOD_5	48	41	39	36	27	26	20	14	40	19	24	21
Soluble BOD_5	36	32	36	13	6	9	10	5	4	6	7	5
Total S.S.	51	-	59	67	44	97	71	38	28	51	56	36
Volatile S.S.	31	-	43	41	39	52	33	25	16	34	39	21
Total COD	85	-	154	128	119	146	75	60	61	85	116	110
Soluble COD	41	-	107	70	59	60	48	44	30	39	52	55
Phosphorus**	32.9	-	39.9	-	104	-	38	-	-	-	-	-
TKN	7.7	19.2	22.2	7.5	5.6	6.3	5.0	2.7	3.9	4.3	5.9	8.4
Ammonia-N	4.6	13.9	14.8	3.0	1.2	1.3	0.6	0.5	0.1	0.2	0.1	1.0
Fecal Coli., x100/100 ml	-	-	53	80	-	-	-	-	-	-	-	-
Total Coli., x100/100 ml	-	-	129	178	-	-	-	-	-	-	-	-

Unless otherwise indicated, all units are mg/l except for pH.
*Alkalinity as $CaCO_3$.
**Actual tests performed were dissolved ortho-phosphate. For convenience, dissolved ortho-phosphate was identified as phosphorus.

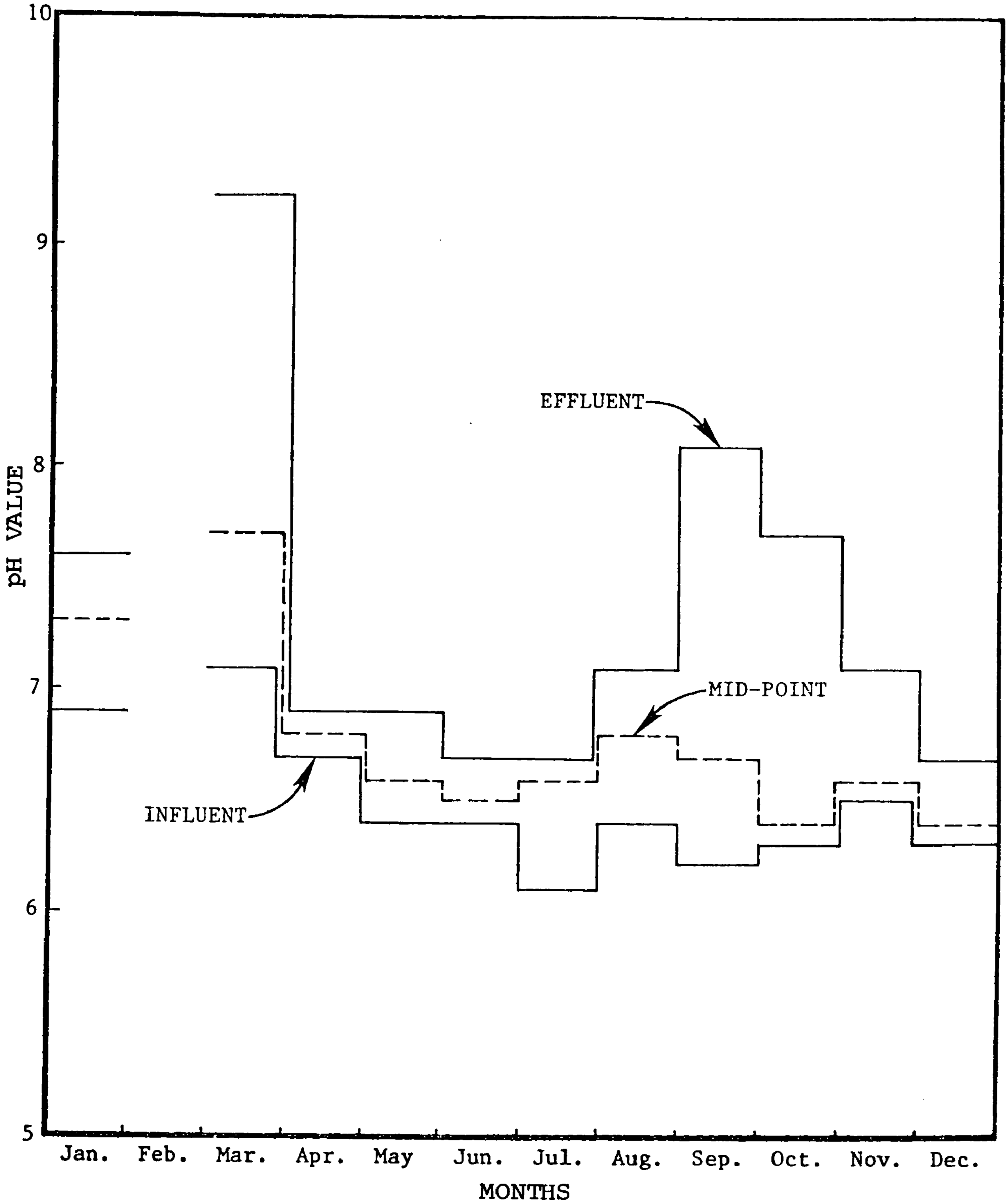

Figure 9. Monthly average pH value at Bixby lagoon, 1976.

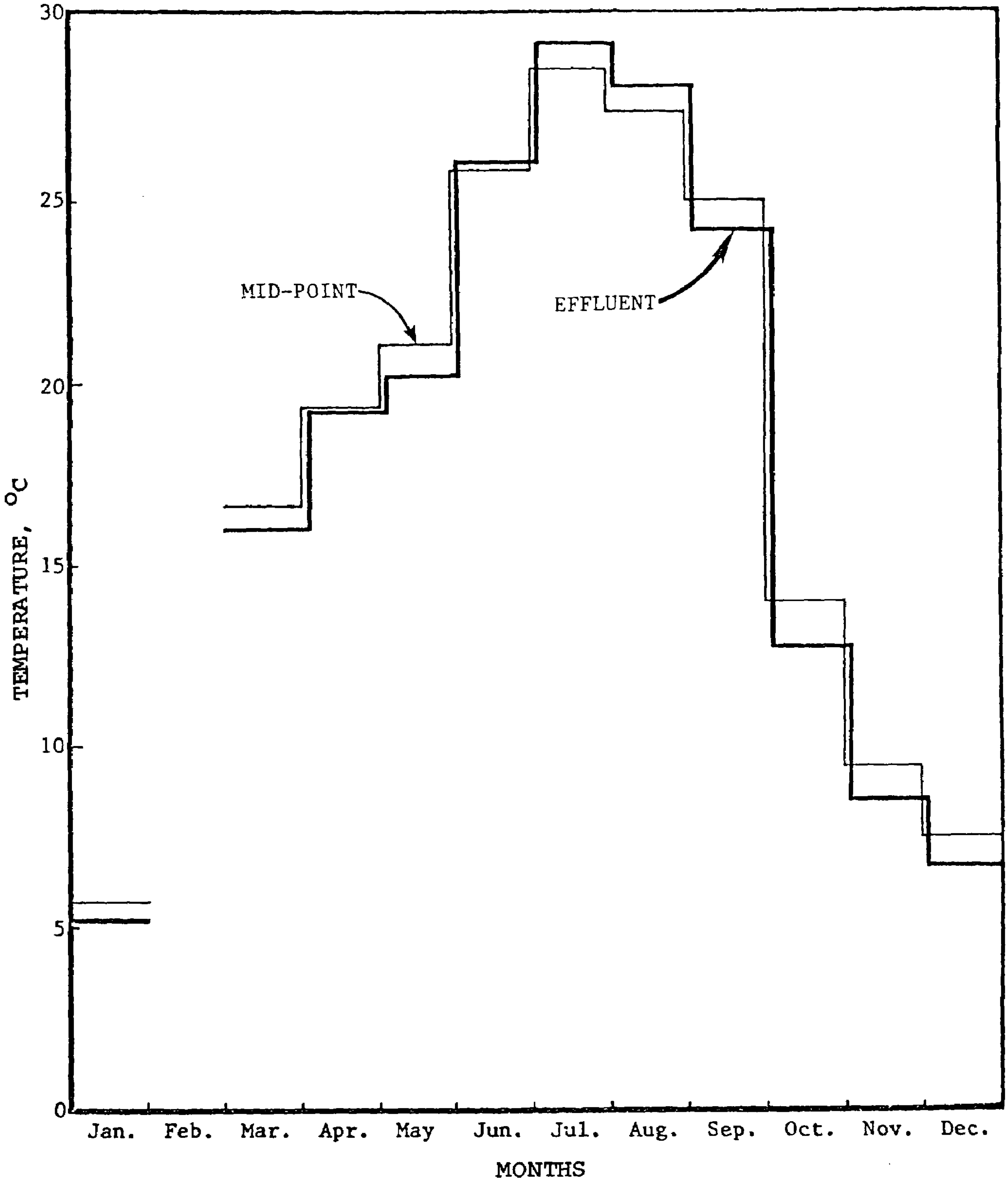

Figure 10. Monthly average water temperature at Bixby lagoon, 1976.

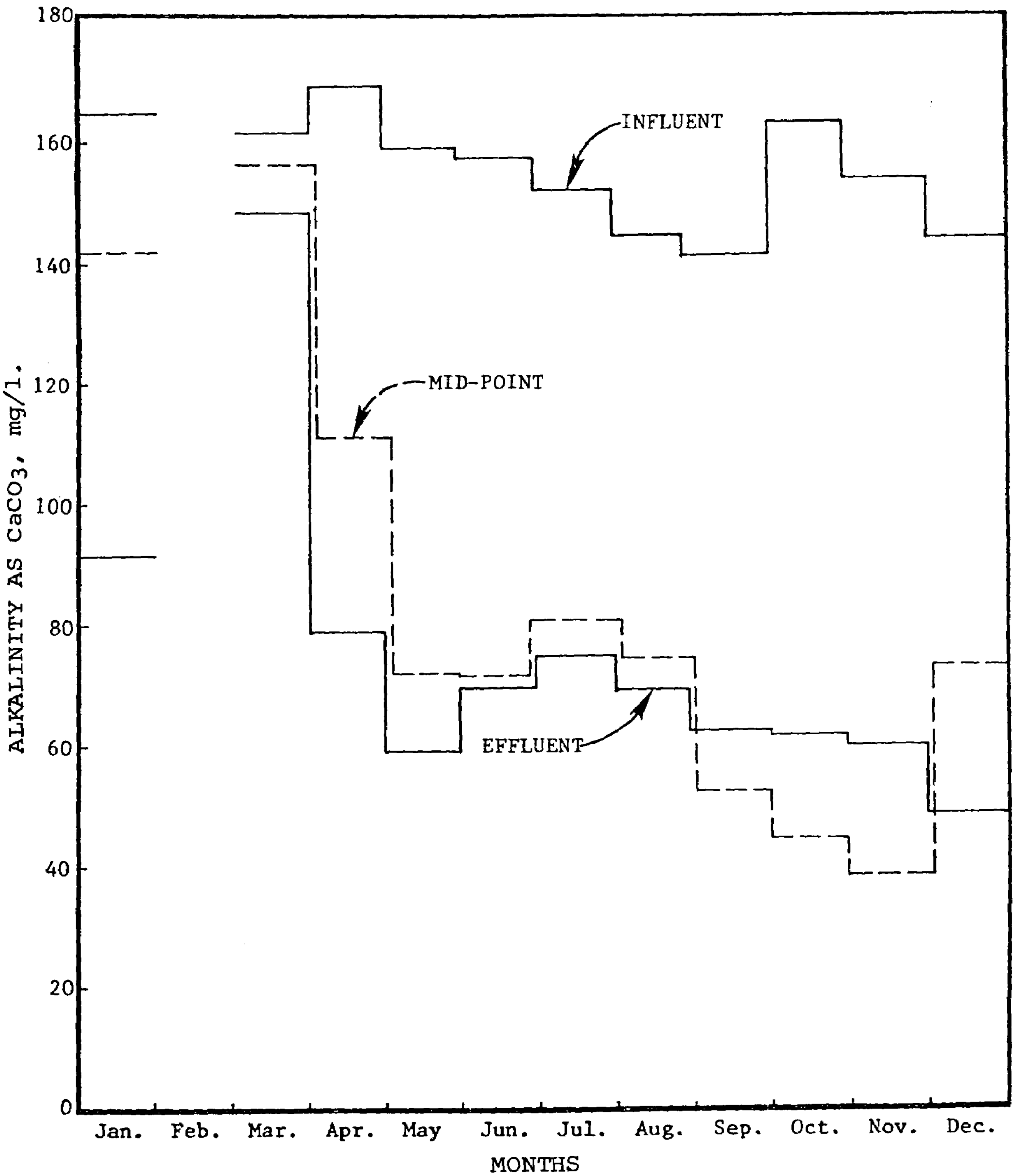

Figure 11. Monthly average alkalinity at Bixby lagoon, 1976.

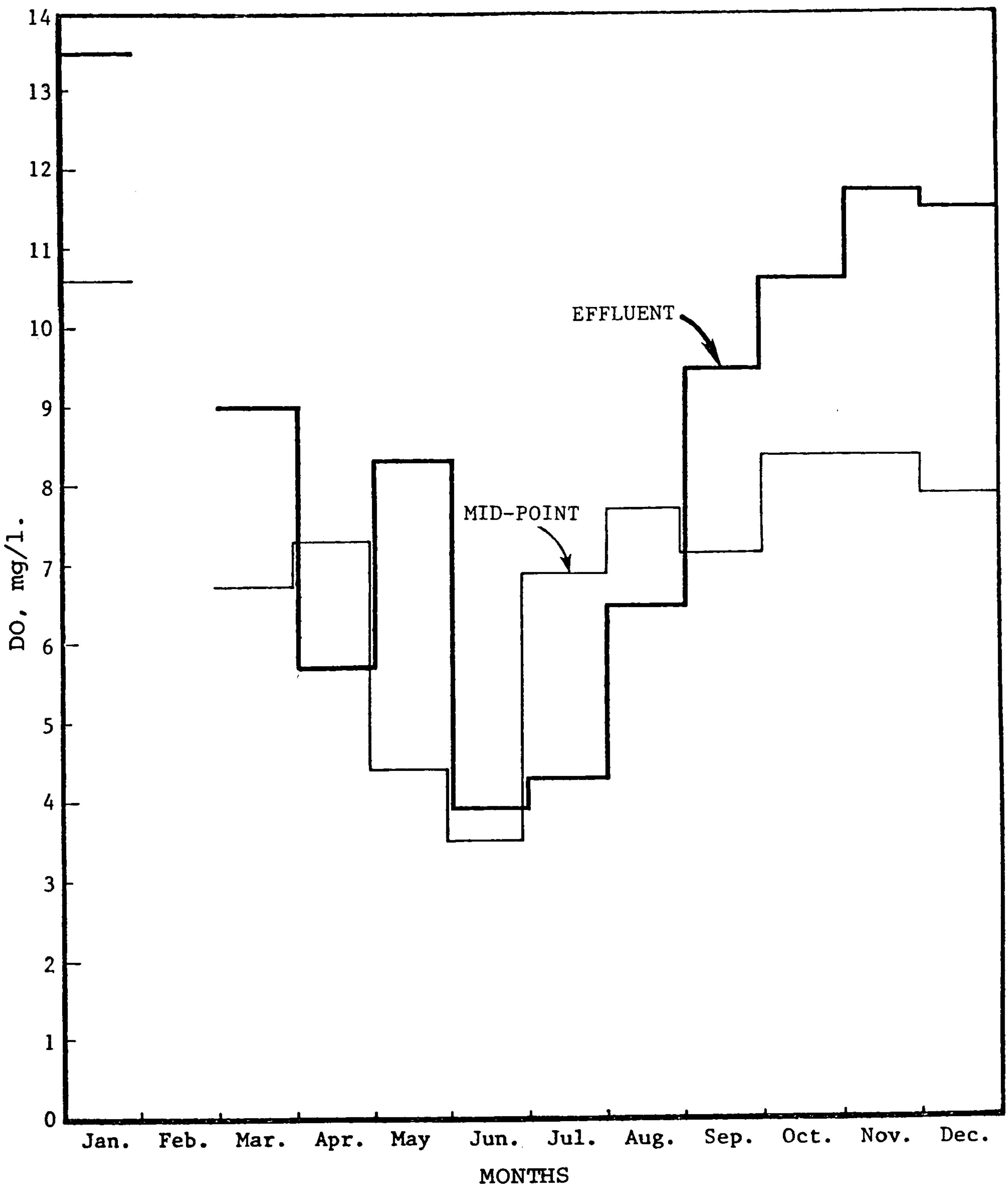

Figure 12. Monthly average dissolved oxygen at Bixby lagoon, 1976.

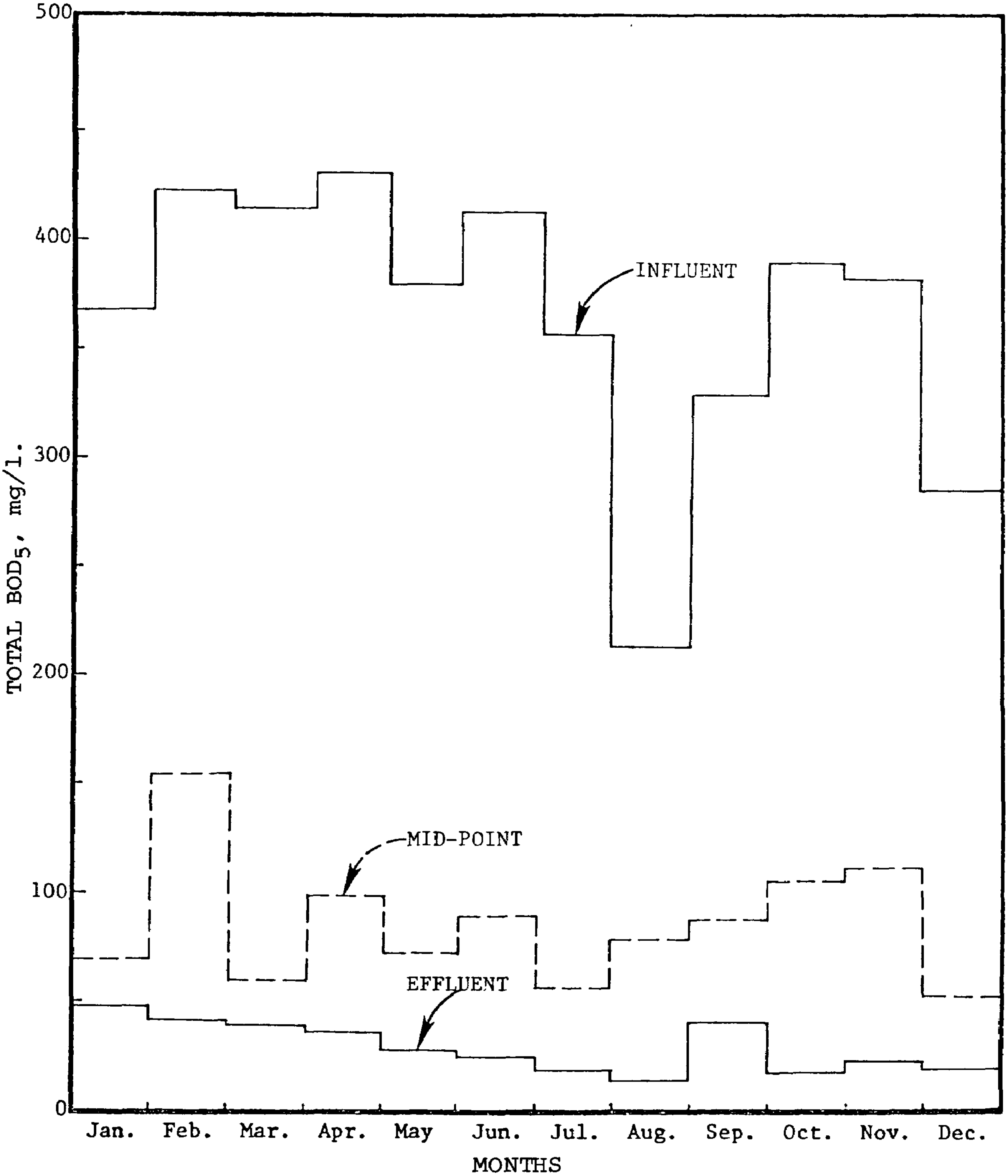

Figure 13. Monthly average total BOD_5 at Bixby lagoon, 1976.

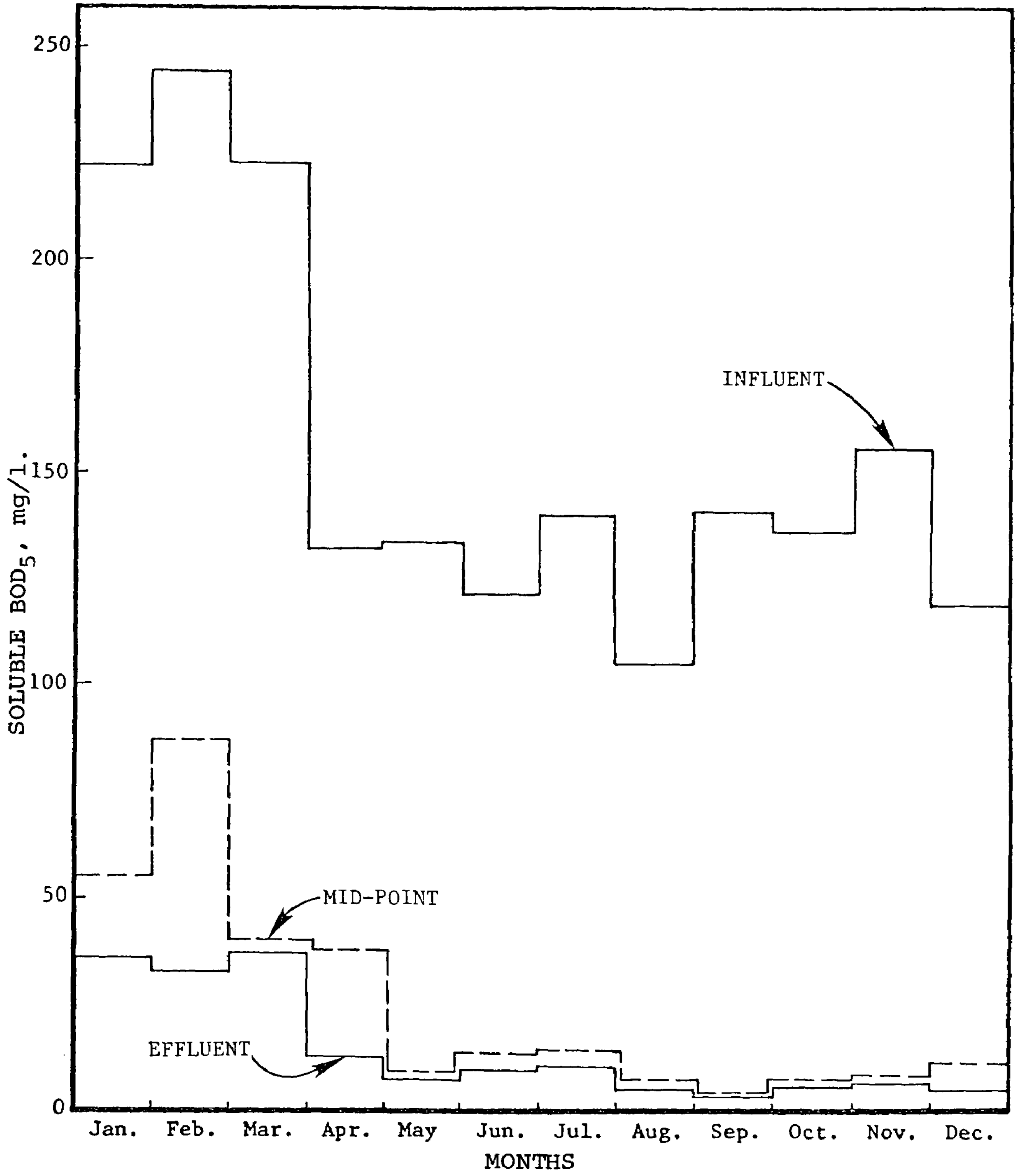

Figure 14. Monthly average soluble BOD_5 at Bixby lagoon, 1976.

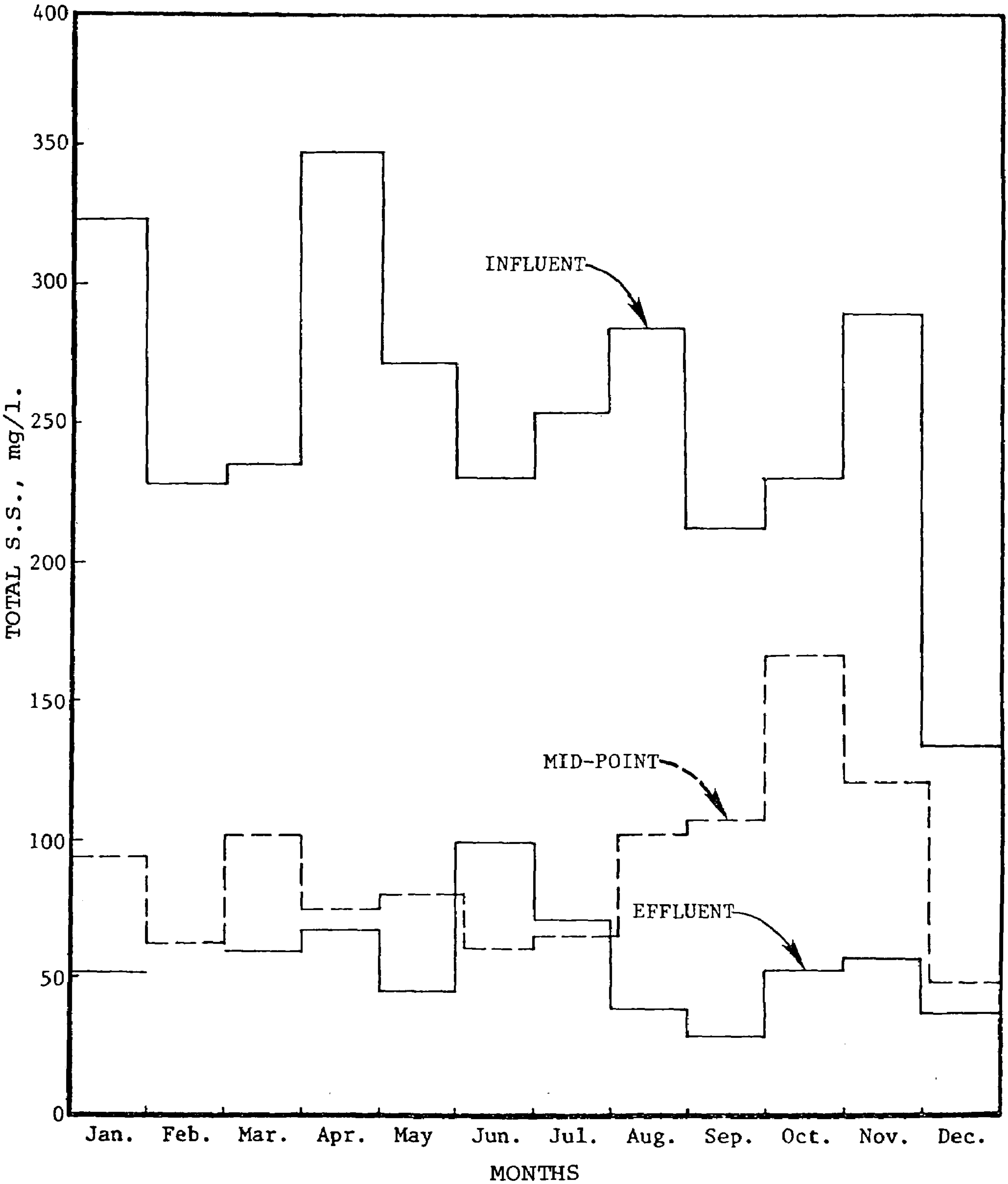

Figure 15. Monthly average total suspended solids at Bixby lagoon, 1976.

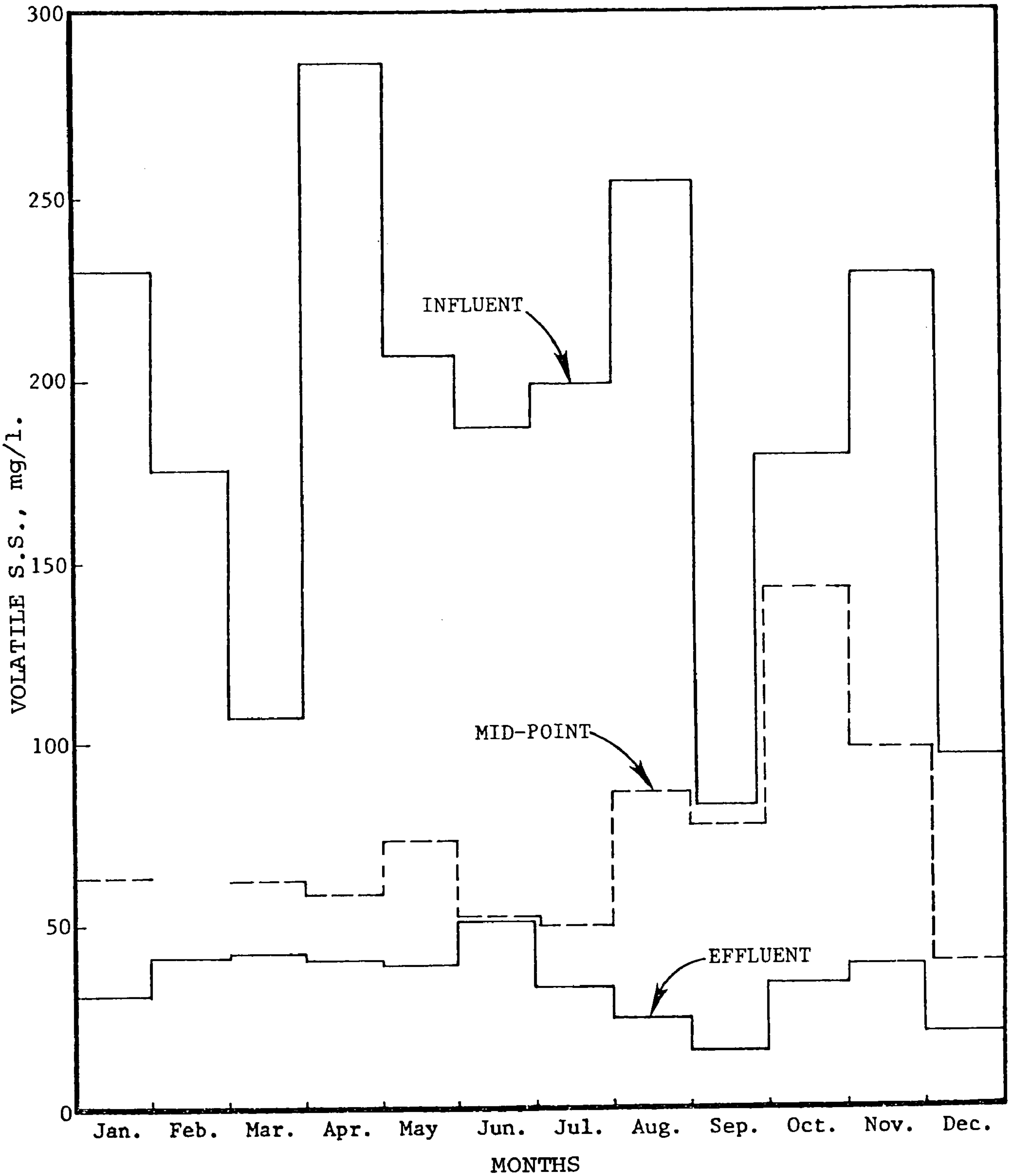

Figure 16. Monthly average volatile suspended solids at Bixby lagoon, 1976.

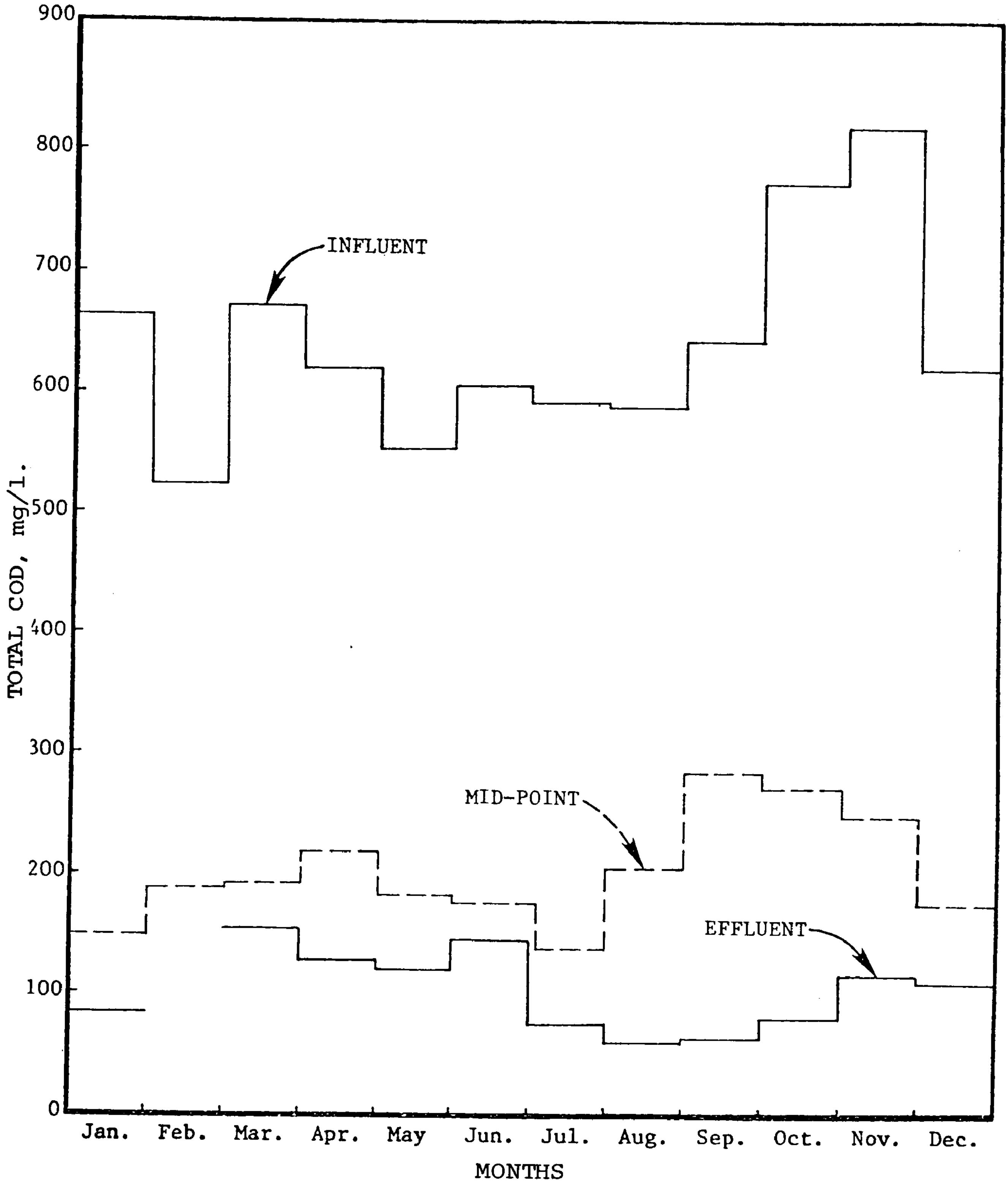

Figure 17. Monthly average total COD at Bixby lagoon, 1976.

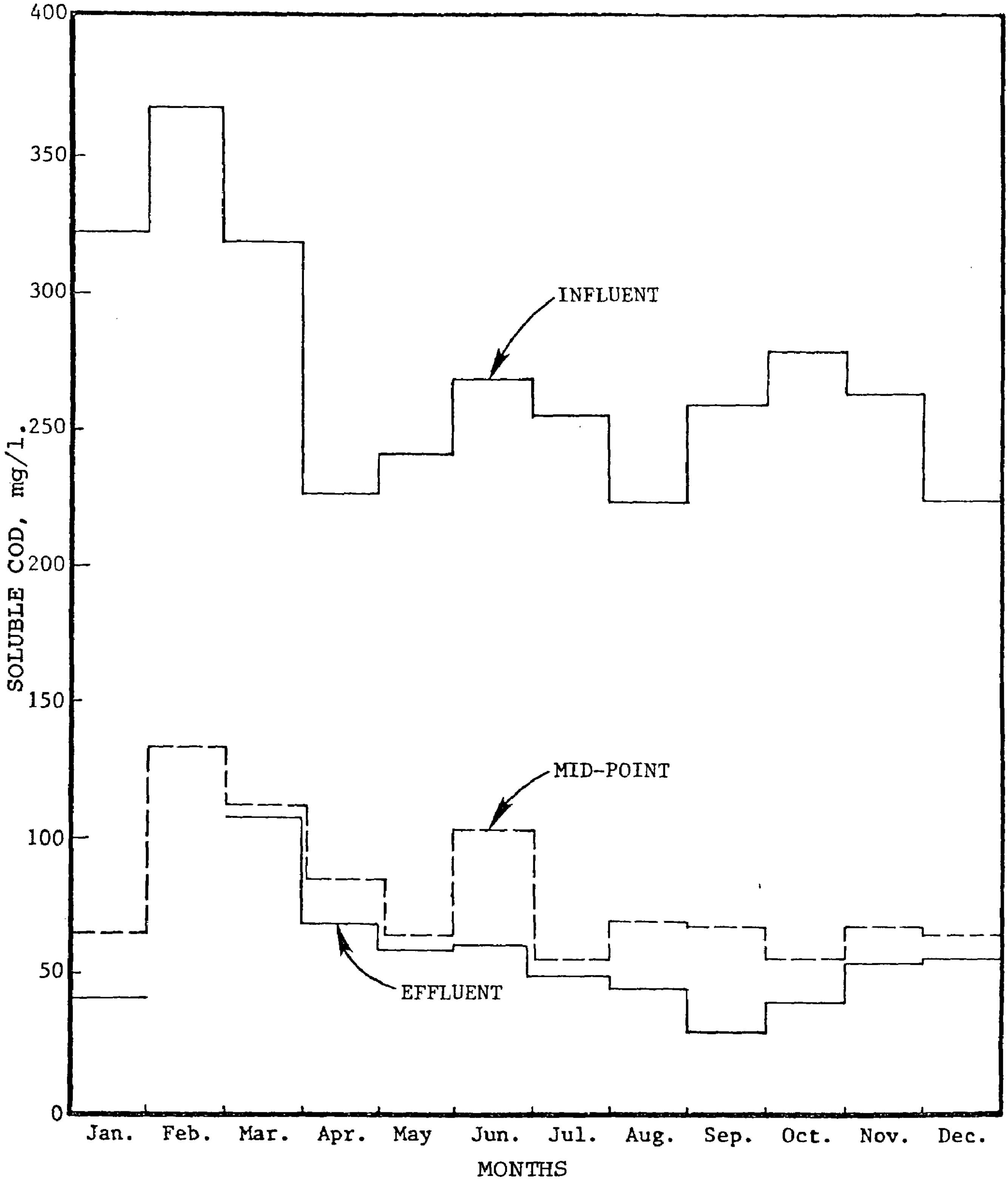

Figure 18. Monthly average soluble COD at Bixby Lagoon, 1976.

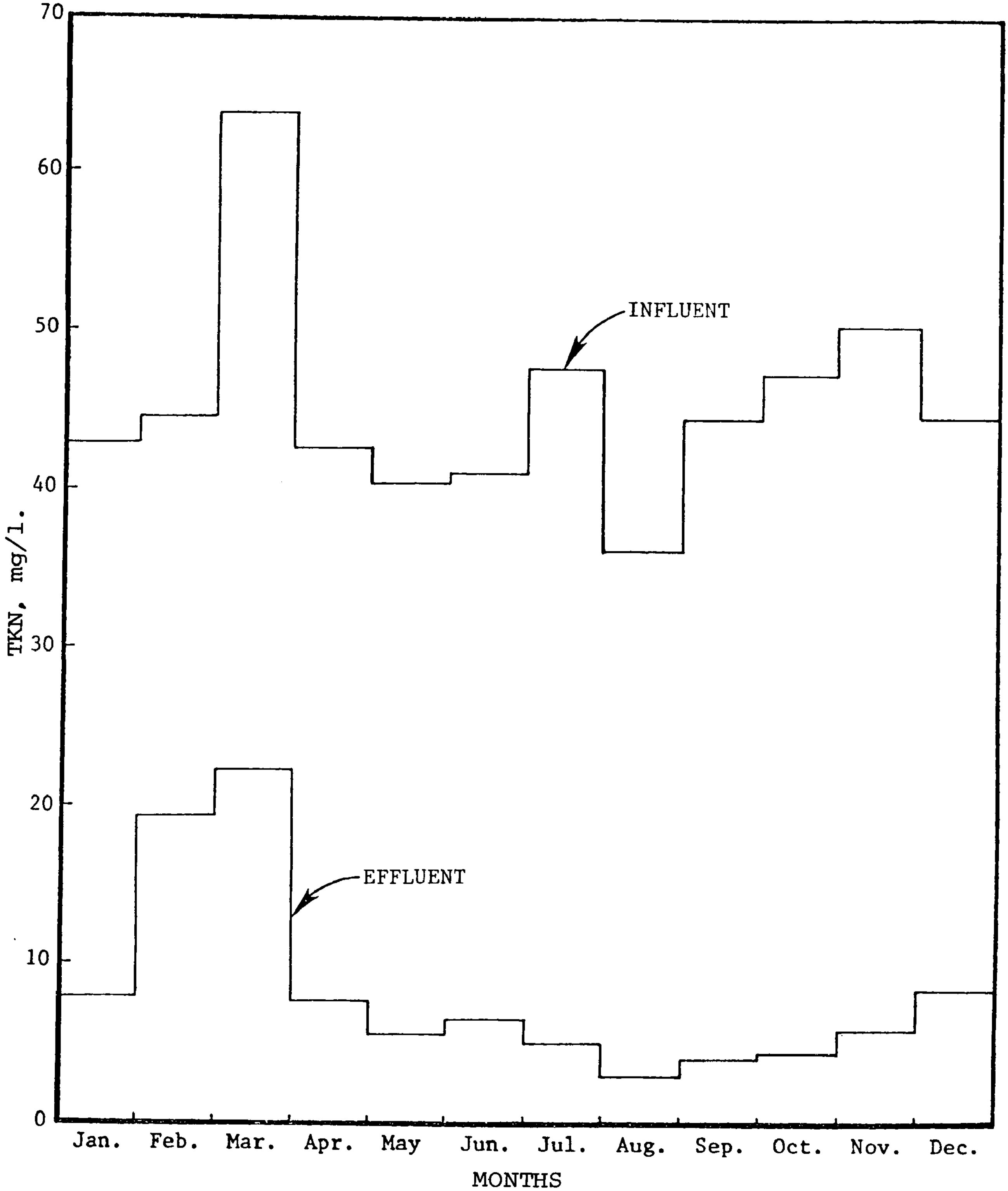

Figure 19. Monthly average total Kjeldahl nitrogen at Bixby lagoon, 1976

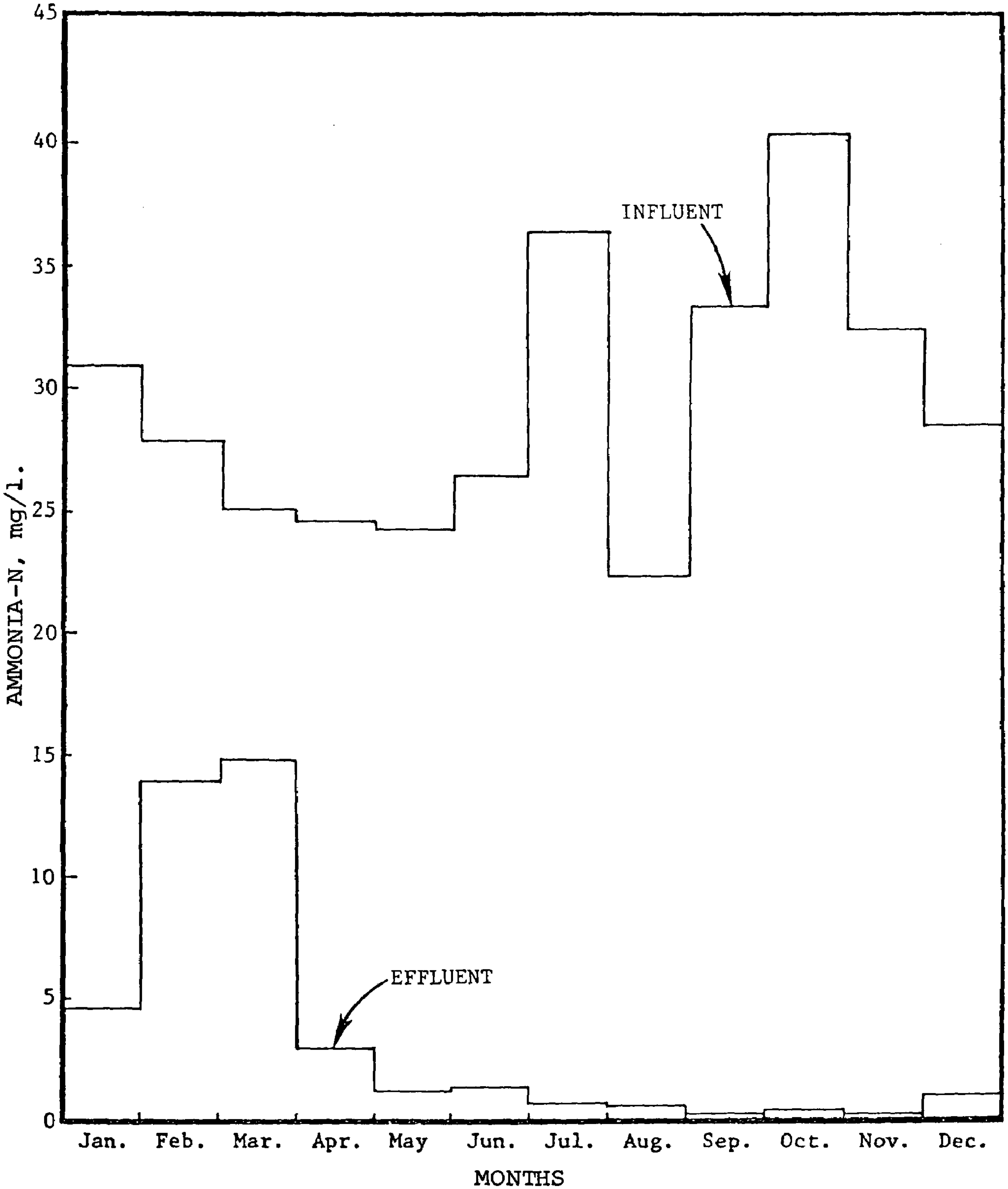

Figure 20. Monthly average ammonia nitrogen at Bixby lagoon, 1976.

at any month of the year.

The analysis of algae was performed qualitatively only and analysis was made to the genus level. Based on comparative observation, the population density of the different algae are referred to as very abundant (VA) or rare (R). Algal analysis performed at the Bixby lagoon are tabulated in Table 11.

TABLE 11. ALGAL GENUS IDENTIFIED* AT BIXBY LAGOON

ALGAL GENUS	POPULATION DENSITY
(From mid-point of lagoon system)	
Ankistrodesmus	VA
Euglena	R
Golenkinia	R
Oocystis	R
Scenedesmas	R
(From effluent of lagoon system)	
Ankistrodesmus	VA
Chlorella	R
Euglena	R
Golenkinia	R
Pediastrum	R

*Identification was performed by Bill Cox, Pollution Control Section, Tulsa City-County Health Dept., Tulsa, Oklahoma; on single sample.

SECTION 7

PROJECT DATA EVALUATION AND ANALYSIS

The stated secondary objective in the proposal is to utilize the generated data to evaluate the effectiveness of the multi-system lagoon to perform in accordance with its design criteria and the ability to meet the secondary treatment standards as established by the Federal Water Pollution Control Act Amendments of 1972.

This section of the report will discuss, in relation to the stated secondary objectives, the results of analysis of data collected. However, before the discussion of the results, a brief literature review will perhaps be helpful to readers who are unfamiliar with the modelling aspects of biological waste treatment.

BRIEF LITERATURE REVIEW IN BIOLOGICAL WASTE TREATMENT MODELLING

Literatures reviewed indicated that there exists a proliferation of design methods for biological treatment facilities. There are, however, precious few articles on the analysis of existing biological treatment facilities. A study of operational parameters in facultative lagoons is essential if one is to compare the performance efficiencies against design values.

Horsfall (8) points out that little is understood of the biochemical reactions that take place in facultative lagoons. Enzymatic processes do not necessarily occur in the same environment as the bulk of water. Also, if cells encounter food sources at low concentration, they develop a mechanism for concentrating food around the cell in a separate layer. These cells are thus able to consume food that cannot be transported directly through the cell walls. The cells excrete enzymes that break up the food, thereby enabling transport across the cell wall.

A variety of life forms degrade organic wastes. It is impossible to predict which of the several steps these organisms use to consume the waste is rate-controlling. The problem is complicated by the fact that domestic and industrial wastes are practically impossible to classify at a level of detail essential for theoretical biochemical degradation studies. Horsfall suggests that lagoon design procedures are simplistic and that the fact that biochemical facilities operate efficiently is surprising in view of the uncertainties in design methods.

Shastri, Fan and Erickson (9) have developed a non-linear least squares method for estimating the parameters in a nine parameter stream water quality model. However, as Brown and Berthouex (10) have pointed out, the model is not convincing because the fundamental premises on which the model is built are themselves questionable. They argue that using highly non-linear kinetic models for BOD removal studies is questionable if numerous parameters are arbitrarily hypothesized as being revelant. In fact, practically any data set could be forced to fit a nine-parameter, non-linear model. Therefore, a mere parameter estimation exercise does not validate the model per se. This is simply because innumerable "counter-models" could be proposed and shown to fit the same data equally well, regardless of the theoretical validity of the models themselves. This issue lies at the heart of the question of model calibration versus model testing and validation against observed data which was not included in model calibration originally. As a result, complex models require very extensive field data collection. A corollary of this statement would be that, in the absence of extensive field data, models should be constructed to be as simple as possible. The real problem therefore, is not the lack of theoretical models but rather the shortage of consistent and reliable experimental data drawn from long term water quality monitoring studies of operating facilities. In fact, an even more fundamental problem often is the lack of good waste characterization studies.

Viraraghavan (11) attempted such a waste characterization study between BOD_5, COD and TOC for a raw sewage, septic tank effluent and polluted groundwater. Viraraghavan made the following conclusions:

(a) For raw sewage the correlation coefficients between BOD_5, COD and soluble organic carbon were not significant at the 5 percent level.

(b) For polluted groundwater the correlation coefficient between COD and soluble organic carbon was significant at the 1 percent level.

However, these conclusions may be entirely premature since

Viraraghavan used only ten raw sewage, 20 septic tank effluent and 28 polluted groundwater samples in the statistical analysis. Besides, other essential parameters such as suspended, dissolved, settleable, and total solids as well as nutrients and their degradation by-products were completely ignored in the characterization. A final point in such an exercise is simply that there is no logical necessity for different waste waters and surface or groundwaters to have similar statistical profiles for various pollutants. It is obvious that each kind of wastewater has unique characteristics and that any extrapolation to other kinds of wastewater is not logical.

Thus, studies which report field data for the major water quality constituents on a seasonal basis are useful. They make it possible to confirm or deny the reliability of the design procedure which was used to build the facility in the first place. In a stream water quality modeling effort, field data would be similarly essential to enable model calibration. Additional data, not used in the model calibration, would be necessary for model validation exercises.

This study shows in the succeeding sections that influent characterization, treatment process efficiency correlations, and effluent characterization and correlation against influent data are all possible using simple multi-parameter linear models.

A final effort in the study addresses the important problem of attempting to derive characteristic design parameters from operational information. The complications caused by seasonal temperature variations are, specifically, addressed in an attempt to see how well the standard lagoon design method formulas fit observed performance data.

RESULTS AND ANALYSES

The discussion on results and analyses, will be divided into seven sections as follows: (results from regression analysis are summarized in Appendix B).

(i) Computing statistical averages and standard deviations.

(ii) Characterization of the wastewater entering the lagoon system (influent).

(iii) Calculation of removal efficiencies for pollutants listed on the NPDES permit and also for other parameters. (These removal efficiencies were computed for each cell as well as for the total system). Correlation of pollutant removal efficiencies against influent properties and parameters for each cell and for the total system.

(iv) Correlation of lagoon mid-point properties (between cell 1 and cell 2) with influent properties.

(v) Correlation of effluent parameters with influent parameters.

(vi) Fitting the standard aerated lagoon design equations to actual performance data for biochemical oxygen demand (BOD), with temperature dependency of the reaction rate constant included.

(vii) Fitting the CSTR and Plug Flow Models for different rate mechanism to a set of data which has a constant temperature.

(i) Computing statistical averages and standard deviations:

Descriptive statistics of the experimentally determined parameters are summarized in Tables 3-5. The statistics of the parameters at the influent are presented in Table 3, the mid-point and effluent statistics are presented in Tables 4 and 5, respectively.

Examination of these tables indicate the wide variation of the experimentally determined water quality data.

As shown in Table 3, the average value of the influent BOD_5 is 368 mg/l and has a standard deviation of 90. The volatile suspended solids have an average value of 201 mg/l and a standard deviation of 116. At the outset, a close study of these standard deviations indicates that a waste characterization attempt would have dubious success. This hypothesis is confirmed in subsequent sections.

Tables 4 and 5 indicate similar wide variations. For instance, the effluent BOD_5 has an average value of 30 mg/l and a standard deviation of 21. An attempt to predict the mid-point and effluent parameters was ambiguous at best. In the linear regression equations the constant term was always high, indicating that the correlating parameters only partially "explain" the dependent variable.

(ii) Characterization of wastewater entering the lagoon system:

Raw wastewater properties dictate the lagoon performance. Influent wastewater properties at a lagoon system can vary on an hourly, daily, monthly and seasonal basis. Hourly fluctuations can be very different because total flow and pollutant loadings are particularly high after morning and evening hours. Mid-afternoon and night-time conditions are usually less severe. In the Bixby study, it was decided to take samples composited throughout the day so that the effect of hourly fluctuations could be smoothened out.

Despite such daily averaging, there remains a high degree of variation in raw wastewater properties by season. This, along with climatic considerations, causes the performance to vary considerably between the seasons.

The federal NPDES permit does not specifically require raw wastewater analysis. The apparent emphasis in the permit system is on the quality of the treated wastewater. Due to this, some communities do not feel that influent monitoring is necessary on a routine basis. However, for design calculations, or for performance grading studies, influent characteristics data are equally important as those of the effluent.

An examination of Tables B-1 to B-6 (in Appendix B) shows the several significant correlations attempted between various influent parameters for different seasons. Table B-1 shows the stepwise regression which led to the identification of significant variables for explaining selected dependent variables. The low correlation coefficients indicate that the regression equations are a poor substitute for experimental data, and most likely are excluding significant parameters from variables considered in the regression analysis.

(iii) Correlation of pollutant removal efficiencies:

As may be expected, the lagoon efficiencies for BOD removal are consistently high except possibly during winter. From the one year data period of this project, the overall BOD removal efficiency averaged about 92%. This, in conjunction with the annual average effluent BOD_5 concentration of 29 mg/l, shows the Bixby lagoon to be substantially in compliance with the federal requirements of secondary treatment for BOD_5.

The overall removal efficiency for BOD was found to correlate primarily only with the temperature of the wastewater. on a monthly basis, effluent BOD_5 concentration was below 30 mg/l in seven months out of the year. Low BOD values seemed to coincide with the warm temperature of summer months while lagging into the late autumn months. Further explanation is difficult because of the uncertainties involved in the experimental determination of influent BOD caused by flocular dispersion of organic material.

BOD removal efficiency correlation for cell 2 is quite good with BOD at the end of cell 1. This reinforces the suspicion that raw influent BOD fluctuations are quite large; the high standard deviation of 89 mg/l again pointe in the same direction.

Total suspended solids (TSS) removal efficiency averaged at 76%, while the average effluent TSS was 54 mg/l on an annual basis. This shows that the lagoon fails to meet federal secondary treatment limitations for suspended solids. Examination of the monthly average effluent water quality (see Table 10) revealed that for TSS only one month out of the year did the effluent TSS level meet the standard.

The fecal coliform density data of raw wastewater at the Bixby lagoon system are in the range of 10^5/100 ml. With this concentration of coliform bacteria in the wastewater, even a reduction efficiency as high as 98% may still result in an effluent with fecal coliform exceeding the 200/100 ml secondary effluent standard. Data of effluent total and fecal coliform collected at Bixby are in the range of 10^4 and 10^3/100 ml respectively, indicating non-compliance with the federal secondary treatment requirement. In view of this inadequacy in bacteriological treatment, it is suggested here that perhaps a maturation pond added will greatly improve the bacterial removal efficiency of the Bixby lagoon system or disinfection should be used if the water quality standards required meeting effluent numbers less than 200/100 ml.

(iv) <u>Correlation of lagoon mid-point properties</u>:

At the mid-point of the lagoon (between cell 1 and cell 2) system, the annual average BOD_5 and TSS were found to be 84 mg/l and 89 mg/l respectively. This shows that the bulk of the BOD and TSS removal occurred in cell 1. This is in keeping with theoretical considerations which predict a BOD removal rate proportional to the average concentration of BOD in the cell. Similarly, the bulk of the TSS in the influent settle down rather quickly in cell 1. Cell 1 is also more vigorously aerated than cell 2 and this surely complicated the analysis. Above all, the growth of algae in cell 2 also contributed significantly to TSS.

(v) <u>Correlation of effluent properties with influent properties</u>:

As discussed under (ii) above, the Bixby lagoon meets the EPA criteria for BOD_5 but not for TSS, or fecal coliform density.

Correlations were attempted for total and soluble BOD_5 and COD, total and volatile suspended solids and total Kjeldahl nitrogen in the lagoon effluent. In general, it was not found feasible to correlate effluent properties with influent data with any high degree of reliability, for in cases where correlation did exist, they were found to be erratic in nature. This is perhaps partly because of the inscrutable random scattering in the influent and effluent peoperties and the fact that the effect of algae has not been considered.

A further complication is the fact that the lagoons' average residence time (based on plug flow) is nearly eighty-two days. This time lag is very significant and an attempt to correlate influent and effluent properties has proved this to be true. On the other hand, an attempt to correlate influent and effluent data taken eighty-two days apart would ignore the effect of intervening parameters like climatic and other cumulative factors during those eighty-two days. It can be said, therefore, that at this time there is no satisfactory method for correlating effluent parameters with influent values for a high retention time aerated lagoon unless during the entire retention period all intervening factors could be controlled. This fact also casts some doubt on ones ability to accurately compare the design calculations against actual operating data. Ignoring the time lag or considering the average values seems to be the only viable alternatives at the moment.

(vi) <u>Curve-fitting of design equation to operating data</u>: The standard design equation for aerated lagoons (11) is:

$$(S_o-S_e)/(X_v t) = k\ S_e \quad \text{--------------------------------} (1)$$

S_o = influent BOD_5 concentration, mg/l.
S_e = effluent BOD_5 concentration, mg/l.
X_v = average or equilibrium concentration of volatile solids (active bio-mass) in lagoon, mg/l.
t = detention time = V/Q, days.
k = specific organic removal rate coefficient 1/mg-day.

In the above design equation it is a normal practice to plot $(S_o-S_e)/t$ versus S_e. A linear regression is then carried out to obtain the slope (kX_v). The reason why k and X_v are lumped together in most studies is that prediction of X_v in an aerated lagoon which has zero recycle is often impossible. The intercept from this plot (which theoretically should be zero) is labeled as a "residual term". The alternative to having a residual is forcing the line through the origin and decreasing the degrees of freedom of the regression equation for y by 1.

The real problem with the above mentioned plot is that the term, S_e, appears in the numerator of both the x and the y-axis term. This, as discussed by Sherwood and Reed (12), is a cardinal error since highly erroneous values of S_e would be disguised under such a plot.

The correct procedure for plotting the design equation is really:

$$(S_o - S_e)/S_e = k\, X_v t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

and to do a least squares fit which forces the line to pass through the origin. Such a plot of $(S_o/S_e - 1)$ versus t would show two independent variables on either axis and would not suffer from the above mentioned deficiencies.

Before such a plot is made the temperature effect on the specific organic removal rate constant must be considered. The standard approach (9) is:

$$k = k_o\ \Theta(T-20) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where

k_o = specific organic removal rate at 20°C; 1/mg-day.
Θ = temperature coefficient (dimensionless)
T = temperature of the waste °C

Substituting (3) in (1) and taking logarithms yields ln $((S_o - S_e)/S_e)$ =

$$\ln (k_o X_v\ V) - 20(\ln \Theta) + (T \ln \Theta - \ln Q) \quad \ldots\ldots\ldots\ldots (4)$$

a plot of these synthesized variables ln $((S_o - S_e)/S_e)$ versus $(T \ln \Theta - \ln Q)$ should be forced through a slope of 1.0. The intercept is then $\ln(k_o X_v V)$.

There is no really definitive recommendation in the literature as to whether or not one should treat X_v as an independent design parameter in aerated lagoon design. For this reason, an attempt was made in this study to determine whether extensive operating data gathered over a period of one year could be used to elucidate the problem.

The methodology used to segregate the effect of X_v, assuming it to be statistically significant, was to rewrite equation (4) as:

$$\ln((S_o - S_e)/S_o) = \ln (k_o V) - 20 (\ln \theta) + (T \ln \theta - \ln Q + \ln X_v) \quad \text{----------(5)}$$

where X_v has been combined with the synthetic independent variable term.

It should be recognized that X_v reduced very rapidly from the entrance to the first cell to the exit of the first cell. The variation in the second cell is not so marked because of the rapid growth of algae which interfere with the measurement of the volatile suspended solids (VSS). In other words, the fraction of the VSS which is biologically active, x, varies inversely with the relative abundance of algae. There was no attempt to isolate the value of x from the measured VSS value in this study. Such a determination would have to be based on extensive pilot plant experiments in which all other operating conditions could be carefully controlled. Such control was not possible in the Bixby lagoon system.

The X_v term, as used in the above equations, therefore should be thought to include the multiplier x. The net effect of using X_v without x in the regression exercise would be to bias the value of the intercept term ($\ln k_o V - 20 \ln \theta$) in equation (5).

If the basic data variables in equation (5) were "noisy", this could easily conceal the true significance of x in the regression. The Bixby study has shown that these data items do in fact contain a great deal of random spread and hence the error involved in ignoring x is probably not significant.

Equation (5) was regressed for two alternatives:

(a) Cell 1, with S_o measured at raw influent, S_e, T, X_v measured at cell 1 exit.

(b) Cell 2, with S_o measured at cell 1 exit, S_e, T, X_v measured at cell 2 exit (i.e. at lagoon system exit).

Eckenfelder reported the temperature coefficient, θ for a pulp and paper mill waste and for a board-mill waste to be varying from 1.07 to 1.09 for filtered and settled samples. (13) Herman and Gloyna using municipal wastewater for a temperature range of 25°C to 35°C found the optimum rate constant K_{35} to be 0.60, with θ value equal to 1.085. (14) Mancini and Barnhart reported that for aerated lagoons, θ varies from 1.06 to 1.18. (15)

Because the value of the temperature coefficient θ is not known with certainty, it would have to be varied until the best least squares lines could be obtained. Seventeen values of θ between 1.0 and 1.2 were attempted in each of the two alternatives. The value of θ which gave the best fit in terms of the lowest residual sum of squares of the errors and/or the best correlation coefficient (r) was chosen.

The regression exercise was repeated for equation (4) which, as explained earlier, helped produce an average value for the product $k_o X_v$ rather than k_o alone.

Results of these regression exercises for both equation (4) and (5) are tabulated in Table 12. All regressions were found to have F values which were statistically insignificant at the confidence level of 95%. Correlation coefficients were also found to be rather low, probably due to noisy data and ignoring of the effect of algae.

The most impressive result obtained from these regressions was that the temperature coefficient values θ were 1.01 and 1.035 for equation (4) and 1.05 and 1.035 for equation (5) for cell 1 and cell 2 reapectively. This is in strong agreement with Adams and Eckenfelder's (16) reported general value of 1.035.

TABLE 12. EVALUATION OF TEMPERATURE COEFFICIENT

CELL	REACTOR MODEL	X_v VARIABLE?	SS_r	SS_y	r^2	VALID CASES	θ
1	CSTR	Yes	49.42	22.4	0.062	72	1.050
1	CSTR	No	16.74	22.4	0.269	72	1.035
1	Plug Flow	No	6.02	5.9	0.239	72	1.020
2	CSTR	Yes	130.70	62.2	0.068	75	1.035
2	CSTR	No	76.20	62.2	0.072	75	1.010
2	CSTR	No	38.20	27.6	0.062	75	1.000

(vii) <u>Fitting the CSTR and Plug Flow Models for different rate mechanisms to a set of data which has a constant temperature</u>:

As can be observed from data tabulated previously, the temperature of the wastewater remained fairly constant for the months June through September. Average temperature was 28 °C, with a standard deviation of 1.2. Since the average retention time in each of the two cells is 40 days (based on plug flow), it is necessary to choose data for model fitting which has the same temperature over an extended period of time. Accordingly, the data for July to September were used in the following models.

The basic design equations for a plug flow reactor and a CSTR under steady state conditions are respectively:

$$\int_{o}^{V} dv/Q = \int_{S_o}^{S_e} ds/(-r) \qquad \text{and} \qquad Q(S_o - S_e)/V = -r$$

In the above equations: V = volume of reactor (m^3)
Q = flow rate (m^3/day)
S = concentration of BOD_5 mg/l.
r = rate of reaction mg/l/day.

Both these design equations represent ideal extremes between which the lagoons perform. Different kinetic models for the rate of reaction were substituted in these design equations. These equations were simplifies and linearized by taking logarithms. The possibility of treating the volatile suspended solids as a variable was also considered.

Table 13 summarizes the results for cell 1 and Table 14 for cell 2. In these tables the first column represents the reactor model, the second column the rate equation that was used. The third column, SS_r, is the residual sum of the squares - a measure of the deviation of the observed values from the values predicted by the regression equation. Column 4, SS_y, is a measure of the deviation of the observed value from the average value of the dependent variable.

An examination of Tables 13 & 14 show that none of the models are "better" than just predicting an average value for the lagoon performance, that is, none of the models explain the data sufficiently. This can be explained partly because the kinetic models do not account for algae growth. Actually, the poor results in this modeling exercise are in keeping with Horsfall's (8) contention that existing design equations are simplistic and do not reflect the complexity of the biochemical reactions.

TABLE 13. SUMMARY OF MODEL TESTING, BIXBY CELL 1

REACTOR MODEL	RATE EQUATION	SS_r	SS_y	r^2
Plug Flow	$r = K$	2.14	0.75	0.159
Plug Flow	$r = K\ S$	2.18	0.89	0.159
Plug Flow	$r = (K\ S)/S_o$	3.30	1.39	0.023
CSTR	$r = K$	2.14	0.75	0.159
CSTR	$r = K\ S$	3.95	3.86	0.150
CSTR	$r = (K\ S)/S_o$	4.08	4.61	0.198
CSTR	$r = k\ X_v$	6.41	0.75	0.019
CSTR	$r = k\ X_v\ S$	12.55	3.86	0.163
CSTR	$r = (k\ X_v\ S)/S_o$	13.20	4.62	0.128

$K = k\ X_v$
25 DATA POINTS, AVE. TEMP. = 28 °C, STD. DEV. = 1.8

TABLE 14. SUMMARY OF MODEL TESTING, BIXBY CELL 2

REACTOR MODEL	RATE EQUATION	SS_r	SS_y	r^2
Plug Flow	$r = K$	12.11	7.36	0.068
Plug Flow	$r = K\ S$	10.05	5.59	0.067
Plug Flow	$r = (K\ S)/S_o$	7.23	5.94	0.015
CSTR	$r = K$	12.11	7.36	0.068
CSTR	$r = K\ S$	20.32	14.53	0.073
CSTR	$r = (K\ S)/S_o$	31.74	24.78	0.080
CSTR	$r = k\ X_v$	26.72	7.36	0.052
CSTR	$r = k\ X_v\ S$	31.95	14.53	0.092
CSTR	$r = (k\ X_v\ S)/S_o$	46.39	24.78	0.034

$K = k\ X_v$
25 DATA POINTS, AVE. TEMP. = 28 °C, STD. DEV. = 1.5

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APPENDIX A

SUMMARY OF A COMPARATIVE STUDY OF PARAMETERS USED FOR MEASURING WASTE TREATMENT LAGOON PERFORMANCE

Appendix A is a summary of the determination of meaningful parameters that the author proposed to be used as routine operational tests. Table A-1 is a tabulation of the parameters that were measured at five lagoon systems. Panama Lagoons are U.S. Army lagoons in the Canal Zone. (5) Austin Lagoons are experimental lagoons. (18) Fayette and South Dakota lagoons are both municipal lagoons. (19, 20)

Table A-2 is the result of determination of tests necessary for the evaluation of performance of the various type of lagoons. This table is developed as a result of information gathered from other lagoon studies and this project. In Table A-2, the most important test as indicated are also the tests proposed to be used as routine operational tests. These tests are important to both design evaluation and routine operational control. The second group of tests, rated as important are pertinent to design evaluation considerations. The third group or the less important tests are the ones that are not apparent in their effect on design evaluation, but their overall important should not be entirely neglected.

In Table A-2, the noticeable absence of the nutrient tests among the important tests is due to the fact that in waste treatment lagoons treating primarily domestic waste, nutrients are not limiting factors in regard to lagoon performance. The exclusion of the dissolved oxygen test from the most important test group is that dissolved oxygen is usually at a reasonably high level and therefore it is not necessary to test it routinely.

TABLE A-1. COMPARISON OF PARAMETERS MEASURED AT FIVE LAGOON SYSTEMS

PARAMETERS	BIXBY LAGOON	PANAMA LAGOON	AUSTIN LAGOON	FAYETTE LAGOON	SO. DAKOTA LAGOON
pH	X	X	X	X	X
Acidity		X*			
Alkalinity	X	X		X	X
Temperature	X	X	X	X	X
DO	X	X	X	X	X
Total BOD_5	X	X	X	X	X
Soluble BOD_5	X				
Total S.S.	X	X*	X		X
Volatile S.S.	X	X*			
Settleable S.		X*			
Total COD	X	X	X		
Soluble COD	X				
Phosphorus	X	X		X	X
TKN	X				
Ammonia-N	X	X		X	X
Nitrate-N	X*	X		X	
Nitrite-N	X*	X*		X	X
Organic-N		X		X	
Algal Count		X			
Fecal Coli.	X	X	X		
Total Coli.	X	X	X	X	X
Flow, Influent	X				X
Flow, Effluent					
Other	a		TOC	b	c

*Tests were discontinued later.
a - Algal determination.
b - Chloride, detergent.
c - Turbidity, chloride, sulfide.

TABLE A-2. PRELIMINARY IDENTIFICATION OF TESTS NECESSARY FOR THE PERFORMANCE EVALUATION OF EACH TYPE OF LAGOON.

TESTS	NON-AERATED LAGOONS				AERATED LAGOONS		
	ANAEROBIC	AEROBIC	FACULTATIVE	MATURATION	AEROBIC	FACULTATIVE	EXT-AERATION
pH	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ
Acidity	*	*	*		*	*	*
Alkalinity		*	*		*	*	*
Temperature	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ
DO, Effluent		X	X	*	*	*	*
Total BOD_5	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ
Soluble BOD_5	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ
Total S.S.	*	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ
Volatile S.S.	*	X	X		X	X	X
Total COD		X	X		X	X	X
Soluble COD		X	X		X	X	X
Phosphorus			X				
Ammonia-N							
TKN							
Nitrate-N							
Nitrite-N							
TOC							
Sulfide	X		*				
Turbidity			*	*			
Algal Count		X	X		X	X	X
Fecal Coli.		*	*	*	*	*	*
Total Coli.		Ӿ	Ӿ	Ӿ	Ӿ	Ӿ	Ӿ
Flow		X	X	X	X	X	X
Odor	X						

Unless indicated, tests should be performed at both influent and effluent points.
Ӿ - Most important tests. X - Important tests. * - Less important tests.

APPENDIX B

RESULTS OF REGRESSION ANALYSIS

TABLE B-1. SUMMARY OF PRELIMINARY REGRESSION DATA, JAN.-DEC. 1976.

Characterization of Waste

Dependent Variable	Variables Attempted In Regression	Variables Selected In Regression	1	2	F.value	Confidence Level	Standard Error
V011, COD IN	V007 TKN IN V009 TOTAL BOD IN V010 SOL BOD IN V013 TSS IN V015 FLOW;GPD	V013 TSS IN V009 TOTAL BOD IN V007 TKN IN	3	74	6.75979	99.95	121.88
V013 TSS IN	V007 TKN IN V009 TOTAL BOD IN V015 FLOW;GPD	V007 TKN IN	1	76	2.80299	90.18	139.3
V014 VSS IN	V013 TSS IN	V013 TSS IN	1	76	213.6694	99.99	54.67
V007 TKN IN	V006 AMMONIA IN	V006 AMMONIA IN	1	76	4.73048	96.72	10.77
V007 TKN IN	V009 TOTAL BOD IN V013 TSS IN V015 FLOW;GPD	V015 FLOW;GPD	1	76	4.46520	96.21	10.79

TABLE B-2. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JAN.-DEC. 1976.

Characterization of Waste

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V011 TOTAL COD IN	V007 TKN IN V009 TOTAL BOD IN V013 TSS IN	2.371184 0.2984597 0.3044201 356.9879	99.99	0.204	125.70
V013 TSS IN	V007 TKN IN	2.750073 143.9223	98.18	0.046	139.34
V011 TOTAL COD IN	V009 TOTAL BOD IN	0.2992710 545.3842	95.65	0.033	140.23
V007 TKN	V015 FLOW GPD	-7.6671401E-05 56.58597	99.98	0.102	11.5
V014 VSS IN	V013 TSS IN	0.7334903 -2.488477	99.99	0.777	55.45
V007 TKN IN	V006 AMMONIA IN	0.4309353 33.3799	99.37	0.061	11.97
V010 SOL BOD IN	V009 TOTAL BOD IN	0.2463666 63.27534	99.99	0.155	52.04
V012 SOL COD IN	V011 TOTAL COD IN	0.1488168 166.5253	99.97	0.094	67.02

TABLE B-3. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JAN., FEB., DEC. 1976

<u>Characterization of Waste</u>

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V011 TOTAL COD IN	V007 TKN IN V009 TOTAL BOD IN V013 TSS IN	2.493559 3.613323E-02 0.5352311 388.1805	64.02	0.145	144.99
V013 TSS IN	V007 TKN IN	1.719844 178.1662	32.51	0.006	131.1
V011 TOTAL COD IN	V009 TOTAL BOD IN	---------------NO	CORRELATION-------------------		
V007 TKN IN	V015 FLOW; GPD	---------------NO	CORRELATION-------------------		
V014 VSS IN	V013 TSS IN	0.7976157 -21.15965	99.99	0.888	37.88
V007 TKN IN	V006 AMMONIA IN	0.3753874 32.51137	85.24	0.061	5.97
V010 SOL BOD IN	V009 TOTAL BOD IN	0.2987844 91.34779	99.74	0.280	55.67
V012 SOL COD IN	V011 TOTAL COD IN	7.9981E-02 253.0131	68.78	0.03	71.74

TABLE B-4. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, MARCH-MAY 1976.

Characterization of Waste

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V011 TOTAL COD IN	V007 TKN IN	0.3534145	97.8	0.361	100.21
	V009 TOTAL BOD IN	-1.9700766E-02			
	V013 TSS IN	0.4801225			
		469.8646			
V013 TSS IN	V007 TKN IN	2.106279	86.7	0.076	136.1
		210.7788			
V011 TOTAL COD IN	V009 TOTAL BOD IN	-0.5635178	92.83	0.104	119.5
		852.4			
V007 TKN IN	V015 FLOW;GPD	-1.1796518E-04	98.6	0.162	18.1
		67.06766			
V014 VSS IN	V013 TSS IN	0.6834089	99.99	0.666	68.9
		0.8095333			
V007 TKN IN	V006 AMMONIA IN	0.9821723	90.2	0.083	19.66
		25.34194			
V010 SOL BOD IN	V009 TOTAL BOD IN	0.2342563	91.32	0.098	50.09
		59.14523			
V012 SOL COD IN	V011 TOTAL COD IN	0.2247983	98.78	0.162	72.63
		102.9625			

TABLE B-5. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JUNE-AUG. 1976.

Characterization of Waste

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V011 TOTAL COD IN	V007 TKN IN	-0.2361691	99.29	0.377	80.53
	V009 TOTAL BOD IN	0.6596316			
	V013 TSS IN	0.1671231			
		334.56			
V013 TSS IN	V007 TKN IN	-1.534388	34.9	0.007	149.37
		323.6429			
V011 TOTAL COD IN	V009 TOTAL BOD IN	0.7103718	99.97	0.351	85.23
		349.699			
VC07 TKN IN	V015 FLOW;GPD	-8.72784E-05	99.96	0.352	6.63
		57.06159			
V014 VSS IN	V013 TSS IN	0.8745831	99.99	0.884	46.43
		-30.27953			
V007 TKN IN	V006 AMMONIA IN	0.8588041	99.98	0.465	6.37
		17.36009			
V010 SOL BOD IN	V009 TOTAL BOD IN	0.2835594	99.97	0.327	39.76
		28.11254			
V012 SOL COD IN	V011 TOTAL COD IN	0.3404716	99.92	0.284	55.62
		45.43303			

TABLE B-6. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, SEPT.-NOV. 1976.

Characterization of Waste

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V011 TOTAL COD IN	V007 TKN IN V009 TOTAL BOD IN V013 TSS IN	10.23053 0.5929619 0.2321051 10.07128	99.99	0.778	72.21
V013 TSS IN	V007 TKN IN	13.85392 -398.6944	99.91	0.376	119.2
V011 TOTAL COD IN	V009 TOTAL BOD IN	1.698052 147.4821	99.99	0.573	92.1
V007 TKN IN	V015 FLOW;GPD	-9.51804E-05 59.70244	91.53	0.114	6.45
V014 VSS IN	V013 TSS IN	0.5878145 40.49858	99.99	0.674	57.96
V007 TKN IN	V006 AMMONIA IN	0.6176733 26.20884	99.87	0.355	5.59
V010 SOL BOD IN	V009 TOTAL BOD IN	9.628862E-02 109.1254	77.85	0.055	28.07
V012 SOL COD IN	V011 TOTAL COD IN	9.641165E-02 184.2956	95.31	0.144	30.22

TABLE B-7. SUMMARY OF STEPWISE REGRESSION DATA, JAN.-DEC. 1976

Lagoon Efficiensies

Dependent Variable	Variables Attempted In Regression	Variables Selected In Regression	1	2	F.value	Confidence Level	Standard Error
V046 BOD EFFIECIENCY CELL 1	V019 TEMP MP V009 TOTAL BOD IN V013 TSS IN	V019 TEMP MP V009 TOTAL BOD IN V011 TOTAL COD IN	3	64	3.61696	98.2	8.1
V047 BOD EFFICIENCY CELL 2	V025 TSS MP V031 TEMP EFF V023 TOTAL COD MP V021 TOTAL BOD MP	V025 TSS MP V031 TEMP EFF V023 TOTAL COD MP V021 TOTAL BOD MP	4	63	9.81592	99.99	20.45
V048 BOD EFFICIENCY TOTAL	V009 TOTAL BOD IN V019 TEMP MP V011 TOTAL COD V031 TEMP EFF	V031 TEMP EFF V011 TOTAL COD IN V009 TOTAL BOD IN	3	64	3.05528	96.53	5.05
V049 COD EFFICIENCY CELL 1	V011 TOTAL COD IN V009 TOTAL BOD IN V019 TEMP MP V013 TSS IN	V011 TOTAL COD IN	1	66	2.54154	88.43	10.35
V050 COD EFFICIENCY CELL 2	V025 TSS MP V023 TOTAL COD MP V031 TEMP EFF V021 TOTAL BOD MP	V025 TSS MP V023 TOTAL COD MP	2	65	7.23842	99.85	20.11

TABLE B-7. Cont'd.

<u>Lagoon Efficiencies</u>

Dependent Variable	Variables Attempted In Regression	Variables Selected In Regression	1	2	F.value	Confidence Level	Standard Error
V051 COD EFFICIENCY TOTAL	V013 TSS IN V011 TOTAL COD IN V019 TEMP MP V031 TEMP EFF V009 TOTAL BOD IN	V013 TSS IN	1	66	1.19143	72.09	7.04
V052 TSS EFFICIENCY CELL 1	V013 TSS IN V011 TOTAL COD IN V009 TOTAL BOD IN V019 TEMP MP	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN	3	64	15.01452	99.99	18.66
V053 TSS EFFICIENCY CELL 2	V025 TSS MP V031 TEMP EFF V023 TOTAL COD MP V021 TOTAL BOD MP	V023 TOTAL COD MP V031 TEMP EFF V025 TSS MP	3	64	13.09213	99.99	69.67
V054 TSS EFFICIENCY TOTAL	V013 TSS IN V031 TEMP EFF V011 TOTAL COD IN V019 TEMP MP V009 TOTAL BOD IN	V013 TSS IN V031 TEMP EFF V011 TOTAL COD IN	3	64	9.39776	99.99	11.76
V055 TKN EFFICIENCY TOTAL	V019 TEMP MP V011 TOTAL COD IN V009 TOTAL BOD IN V013 TSS IN V007 TKN IN	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V019 TEMP MP	4	63	4.97705	99.85	5.31

TABLE B-8. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JAN.-DEC. 1976.

Lagoon Efficiencies

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V046 BOD EFFICIENCY CELL 1	V019 TEMP MP V057 AMT. BOD IN	0.3096749 -6.367396E-08 75.04213	98.94	0.085	9.04
V047 BOD EFFICIENCY CELL 2	V031 TEMP EFF V063 AMT BOD MP V067 AMT TSS MP	0.3956547 4.723689E-07 1.0786696E-06 37.13798	99.96	0.192	21.77
V048 BOD EFFICIENCY TOTAL	V031 TEMP EFF	0.1714976 89.1727	99.79	0.089	4.93
V050 COD EFFICIENCY CELL 2	V065 AMT COD MP V067 AMT TSS MP V031 TEMP EFF	6.239130E-07 2.880887E-07 0.23101231 22.23239	99.99	0.198	19.40
V052 TSS EFFICIENCY CELL 1	V057 AMT BOD IN V061 AMT TSS IN V019 TEMP MP	-2.123962E-07 4.116586E-07 0.6153472 44.33618	99.99	0.235	21.90
V053 TSS EFFICIENCY CELL 2	V065 AMT COD IN V067 AMT TSS MP V031 TEMP EFF	3.19013E-08 5.131307E-06 -2.895973 -0.4622752	99.99	0.366	64.41

TABLE B-8. Cont'd.

Lagoon Efficiencies

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V054 TSS EFFICIENCY TOTAL	V031 TEMP EFF	-0.2610138	99.99	0.217	11.914
	V061 AMT TSS IN	2.30723E-07			
	V059 AMT COD IN	-4.51608E-09			
		72.50847			
V055 TKN EFFICIENCY TOTAL	V019 TEMP MP	0.2649953	97.36	0.094	7.719
	V057 AMT BOD IN	-6.801801E-08			
	V056 AMT TKN IN	2.844735E-07			
		81.26784			

TABLE B-9. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JAN., FEB., DEC. 1976

Lagoon Efficiencies

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V046 BOD EFFICIENCY CELL 1	V019 TEMP MP	1.804974	87.93	0.232	8.05
	V057 AMT BOD IN	1.1025123E-07			
		63.10404			
V047 BOD EFFICIENCY CELL 2	V031 TEMP EFF	14.01739	96.44	0.560	18.83
	V063 AMT BOD MP	3.0296144E-06			
	V067 AMT TSS MP	9.103946E-07			
		-66.25088			
V048 BOD EFFICIENCY TOTAL	V031 TEMP EFF	0.5952108	69.36	0.055	7.40
		85.31143			
V050 COD EFFICIENCY CELL 2	V065 AMT COD MP	8.2201986E-07	97.57	0.456	9.91
	V067 AMT TSS MP	1.1222128E-06			
	V031 TEMP EFF	-1.238537			
		19.16636			
V052 TSS EFFICIENCY CELL 1	V057 AMT BOD IN	-2.28154E-07	70.41	0.324	14.76
	V061 AMT TSS IN	5.0686795E-07			
	V019 TEMP MP	-3.336686			
		81.92313			
V053 TSS EFFICIENCY CELL 2	V065 AMT COD MP	------------------NO CORRELATION---------------			
V054 TSS EFFICIENCY TOTAL	V031 TEMP EFF	-.6839095	97.7	0.483	7.88
	V061 AMT TSS IN	3.565298E-07			
	V059 AMT COD IN	-5.358666E-08			
		75.07638			

TABLE B-9. Cont'd.

<u>Lagoon Efficiencies</u>

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V055 TKN EFFICIENCY TOTAL	V019 TEMP MP	-0.721412	93.6	0.395	5.44
	V057 AMT BOD IN	4.394689E-08			
	V056 AMT TKN IN	-1.449E-06			
		91.88497			

TABLE B-10. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, MARCH-MAY 1976.

Lagoon Efficiencies

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V046 BOD EFFICIENCY CELL 1	V019 TEMP MP	-1.521782	99.16	0.289	6.08
	V057 AMT BOD IN	-1.42388E-07			
		115.2151			
V047 BOD EFFICIENCY CELL 2	V031 TEMP EFF	4.286493	99.10	0.377	21.95
	V063 AMT BOD MP	3.7664E-07			
	V067 AMT TSS MP	2.14875E-06			
		-52.31941			
V048 BOD EFFICIENCY TOTAL	V031 TEMP EFF	1.388996	98.99	0.221	3.87
		65.21324			
V050 COD EFFICIENCY CELL 2	V065 AMT COD MP	7.691299E-07	51.28	0.098	22.22
	V067 AMT TSS MP	-5.05891E-07			
	V031 TEMP EFF	-0.239462			
		25.29951			
V052 TSS EFFICIENCY CELL 1	V057 AMT BOD IN	-3.86296E-07	99.62	0.450	13.66
	V061 AMT TSS IN	4.993186E-07			
	V019 TEMP MP	2.306771			
		26.59588			
V053 TSS EFFICIENCY CELL 2	V065 AMT COD MP	-2.403267E-07	76.68	0.267	14.49
	V067 AMT TSS MP	1.53379E-06			
	V031 TEMP EFF	2.756489			
		-11.84721			

TABLE B-10. Cont'd.

Lagoon Efficiencies

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V054 TSS EFFICIENCY TOTAL	V031 TEMP EFF	0.931586	88.01	0.205	13.97
	V061 AMT TSS IN	2.738169E-07			
	V059 AMT COD IN	-5.508731E-09			
		48.461			
V055 TKN EFFICIENCY TOTAL	V019 TEMP MP	3.829024	99.99	0.553	6.59
	V057 AMT BOD IN	-1.2462157E-07			
	V056 AMT TKN IN	1.154889E-06			
		3.188585			

TABLE B-11. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JUNE-AUG. 1976.

Lagoon Efficiencies

Dependent Variable	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V046 BOD EFFICIENCY CELL 1	V019 TEMP MP	3.088944	98.21	0.250	6.88
	V057 AMT BOD IN	-5.1052676E-08			
		-3.332165			
V047 BOD EFFICIENCY CELL 2	V031 TEMP EFF	2.961521	94.7	0.301	11.86
	V063 AMT BOD MP	1.561813E-06			
	V067 AMT TSS MP	-30.45803			
V048 BOD EFFICIENCY TOTAL	V031 TEMP EFF	0.2634126	69.51	0.038	1.99
		86.67577			
V050 COD EFFICIENCY CELL 2	V065 AMT COD MP	8.776925E-07	98.17	0.348	17.5
	V067 AMT TSS MP	-1.046776E-07			
	V031 TEMP EFF	3.98633			
		-85.51623			
V052 TSS EFFICIENCY CELL 1	V057 AMT BOD IN	-4.82136E-08	62.11	0.128	20.47
	V061 AMT TSS IN	1.803818E-07			
	V019 TEMP MP	-3.558946			
		165.5479			
V053 TSS EFFICIENTY CELL 2	V065 AMT COD MP	-3.37821E-07	99.47	0.741	17.61
	V067 AMT TSS MP	2.252324E-06			
	V031 TEMP EFF	-18.84411			
		549.2112			

TABLE B-11. Cont'd.

<u>Lagoon Efficiencies</u>

Dependent Variable	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V054 TSS EFFICIENCY TOTAL	V031 TEMP EFF	-2.323927	96.80	0.336	13.54
	V061 AMT TSS IN	7.79934E-08			
	V059 AMT COD IN	1.476833E-07			
		123.4936			
V055 TKN EFFICIENCY TOTAL	V019 TEMP MP	0.3588631	96.21	0.282	1.88
	V057 AMT BOD IN	7.952106E-09			
	V056 AMT TKN IN	6.066973E-07			
		75.50454			

TABLE B-12. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, SEPT.-NOV. 1976.

Lagoon Efficiencies

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V046 BOD EFFICIENCY CELL 1	V019 TEMP MP V057 AMT BOD IN	0.2872387 2.56492E-07 52.57227	84.0	0.160	8.85
V047 BOD EFFICIENCY CELL 2	V031 TEMP EFF V063 AMT BOD MP B067 AMT TSS MP	-------------------NO CORRELATION------------------			
V048 BOD EFFICIENCY TOTAL	V031 TEMP EFF	-0.3122703 96.53475	88.93	0.107	4.85
V050 COD EFFICIENCY CELL 2	V065 AMT COD MP V067 AMT TSS MP V031 TEMP EFF	5.844505E-07 -4.5638265E-07 1.262185 31.74012	99.99	0.709	7.54
V052 TSS EFFICIENCY CELL 1	V051 AMT BOD IN V061 AMT TSS IN V019 TEMP MP	-1.007704E-06 9.188986E-07 -0.4569783 63.36416	99.62	0.517	16.39
V053 TSS EFFICIENCY CELL 2	V065 AMT COD MP V067 AMT TSS MP V031 TEMP EFF	8.667412E-08 6.226111E-07 0.7175017 37.84197	82.81	0.226	15.60

TABLE B-12. Cont'd.

Lagoon Efficiencies

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V054 TSS EFFICIENCY TOTAL	V031 TEMP EFF	9.849385E-03	99.96	0.623	6.84
	V061 AMT TSS IN	5.643188E-07			
	V059 AMT COD IN	-4.011315E-07			
		98.28307			
V055 TKN EFFICIENCY TOTAL	V019 TEMP MP	0.1740435	68.45	0.183	2.40
	V057 AMT BOD IN	-1.292232E-08			
	V056 AMT TKN IN	3.34404E-07			
		84.82043			

TABLE B-13. SUMMARY OF STEPWISE REGRESSION DATA, JAN.-DEC. 1976

Predicting Mid-Point Properties

Dependent Variable	Variables Attempted In Regression	Variables Selected In Regression	1	2	F.value	Confidence Level	Standard Error
V021 TOTAL BOD MP	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V019 TEMP MP	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN	3	56	8.18624	99.98	30.35
V023 TOTAL COD MP	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V019 TEMP MP	V011 TOTAL COD IN	1	58	4.56314	96.31	73.07
V025 TSS MP	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V019 TEMP MP	V011 TOTAL COD IN V019 TEMP MP	2	57	6.60485	99.73	43.74
V022 SOL BOD MP	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V014 VSS IN V019 TEMP MP	V009 TOTAL BOD IN V011 TOTAL COD IN V019 TEMP MP V013 TSS IN	4	55	12.84829	99.99	18.89
V024 SOL COD MP	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V014 VSS IN V019 TEMP MP	V009 TOTAL BOD IN	1	58	1.11408	70.44	41.3

TABLE B-14. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JAN.-DEC. 1976.

Predicting Mid-point Properties

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V021 TOTAL BOD MP	V061 AMT TSS IN	-2.431649E-07	99.99	0.305	29.67
	V057 AMT BOD IN	9.5585035E-07			
	V019 TEMP MP	-1.479171			
		69.74489			
V023 TOTAL COD MP	V061 AMT TSS IN	-4.88751E-07	98.70	0.073	67.46
	V059 AMT COD IN	7.7177165E-07			
		149.7909			
V025 TSS MP	V019 TEMP MP	-2.177494	99.96	0.220	41.47
	V059 AMT COD IN	4.681205E-07			
	V058 AMT SOL BOD IN	-9.369269E-07			
	V061 AMT TSS IN	6.6979104E-08			
		101.0664			
V022 SOL BOD MP	V019 TEMP MP	-0.7011226	99.99	0.308	20.67
	V058 AMT SOL BOD IN	1.55455E-06			
		2.16999			
V024 SOL COD MP	V060 AMT SOL COD IN	4.882489E-07	90.89	0.024	33.61
		51.99619			

TABLE B-15. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JAN., FEB., DEC. 1976.

Predicting Mid-point Properties

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V021 TOTAL BOD MP	V061 AMT TSS IN	-9.40834E-07	99.5	0.707	24.8
	V057 AMT BOD IN	6.278336E-07			
	V019 TEMP MP	-11.27744			
		149.7123			
V023 TOTAL COD MP	V061 AMT TSS IN				
	V059 AMT COD IN	----------NO CORRELATION----------			
V025 TSS MP	V019 TEMP MP	5.253647	92.0	0.610	24.23
	V059 AMT COD IN	-2.828018E-07			
	V058 AMT SOL BOD IN	-1.082674E-06			
	V061 AMT TSS IN	1.8908713E-06			
		38.67576			
V022 SOL BOD MP	V019 TEMP MP	-7.858441	99.99	0.717	21.71
	V058 AMT SOL BOD IN	2.230613E-06			
		45.75013			
V024 SOL COD MP	V060 AMT SOL COD IN	9.633473E-07	94.15	0.107	27.65
		42.25974			

TABLE B-16. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, MARCH-MAY 1976.

Predicting Mid-point properties

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V021 TOTAL BOD MP	V061 AMT TSS IN	-2.679179E-07	99.54	0.426	25.23
	V057 AMT BOD IN	9.8079974E-07			
	V019 TEMP MP	7.244122			
		-96.22798			
V023 TOTAL COD MP	V061 AMT TSS IN	-4.1396E-07	23.3	0.025	59.60
	V059 AMT COD IN	4.450183E-07			
		189.0472			
V025 TSS MP	V019 TEMP MP				
	V059 AMT COD IN				
	V058 AMT SOL BOD IN	----------------NO CORRELATION----------------			
	V061 AMT TSS IN				
V022 SOL BOD MP	V019 TEMP MP	-3.470565	97.74	0.253	16.01
	V058 AMT SOL BOD IN	8.7329E-07			
		73.15219			
V024 SOL COD MP	V060 AMT SOL COD IN	----------------NO CORRELATION----------------			

TABLE B-17. RESULTS OF REGRESSION VARIABLES SELECTED AFTER STEPWISE REGRESSION, JUNE-AUG. 1976.

Predicting Mid-point Properties

Dependent Variable	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V021 TOTAL BOD MP	V061 AMT TSS IN	-8.867321E-08	99.68	0.419	20.06
	V057 AMT BOD IN	4.688706E-07			
	V019 TEMP MP	-10.35434			
		333.7117			
V023 TOTAL COD MP	V061 AMT TSS IN	-6.804419E-08	99.04	0.291	38.7
	V059 AMT COD IN	6.89286E-07			
		96.34911			
V025 TSS MP	V019 TEMP MP	2.851196	77.87	0.229	31.39
	V059 AMT COD IN	5.24489E-08			
	V058 AMT SOL BOD IN	9.819212E-07			
	V061 AMT TSS IN	2.515837E-07			
		-48.87567			
V022 SOL BOD MP	V019 TEMP MP	0.3077798	73.74	0.105	11.69
	V058 AMT SOL BOD IN	5.2027359E-07			
		-5.515419			
V024 SOL COD MP	V060 AMT SOL COD IN	4.8975877E-07	99.26	0.229	12.87
		38.53497			

TABLE B-18. RESULTS OF REGRESSION VARIABLES SELECTED AFTER STEPWISE REGRESSION, SEPT.-NOV. 1976.

Predicting Mid-point Properties

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V021 TOTAL BOD MP	V061 AMT TSS IN				
	V057 AMT BOD IN	---------------NO CORRELATION---------------------------			
	V019 TEMP MP				
V023 TOTAL COD MP	V061 AMT TSS IN				
	V059 AMT COD IN	---------------NO CORRELATION---------------------------			
V025 TSS MP	V019 TEMP MP	1.121863	99.21	0.592	33.28
	V059 AMT COD IN	1.386452E-06			
	V058 AMT SOL BOD IN	-4.707157E-06			
	V061 AMT TSS IN	9.352955E-07			
		45.16838			
V022 SOL BOD MP	V019 TEMP MP	4.5705377E-02	67.33	0.130	3.31
	V058 AMT SOL BOD IN	2.30846E-07			
		0.8368860			
V024 SOL COD MP	V060 AMT SOL COD IN	---------------NO CORRELATION---------------------------			

TABLE B-19. SUMMARY OF STEPWISE REGRESSION DATA, JAN.-DEC. 1976.

Predicting Effluent Properties

Dependent Variable	Variables Attempted In Regression	Variables Selected In Regression	1	2	F. value	Confidence Level	Standard Error
V037 TOTAL BOD EFF	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V019 TEMP MP V031 TEMP EFF	V009 TOTAL BOD IN V019 TEMP MP	2	48	8.96151	99.95	21.49
V038 SOL BOD EFF	V010 SOL BOD IN V012 SOL COD IN V014 VSS IN V019 TEMP MP V031 TEMP EFF	V010 SOL BOD IN	1	49	27.85733	99.99	19.83
V039 TOTAL COD EFF	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V019 TEMP MP V031 TEMP EFF	V011 TOTAL COD IN	1	49	2.75074	89.64	48.62
V040 SOL COD EFF	V010 SOL BOD IN V012 SOL COD IN V014 VSS IN V019 TEMP MP V031 TEMP EFF	V010 SOL BOD IN V012 SOL COD IN V019 TEMP MP V031 TEMP EFF	4	46	4.39372	99.15	28.57

TABLE B-19. Cont'd.

Predicting Effluent Properties

Dependent Variable	Variables Attempted In Regression	Variables Selected In Regression	1	2	F. value	Confidence Level	Standard Error
V041 TSS EFF	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V019 TEMP MP V031 TEMP EFF	V013 TSS IN	1	49	5.69229	97.91	29.55
V042 VSS EFF	V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V014 VSS IN	V011 TOTAL COD IN V014 VSS IN	2	48	6.57962	99.7	15.93
V035 TKN EFF	V007 TKN IN V009 TOTAL BOD IN V011 TOTAL COD IN V013 TSS IN V019 TEMP MP V031 TEMP EFF	V007 TKN IN V009 TOTAL BOD IN V011 TOTAL COD IN V019 TEMP MP	4	46	8.34508	99.99	2.58

TABLE B-20. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JAN.-DEC. 1976.

Predicting Effluent Properties

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V037 TOTAL BOD EFFLUENT	V019 TEMP MP	-0.6373126	98.36	0.113	20.3
	V057 AMT BOD IN	3.0022921E-07			
	V061 AMT TSS IN	-1.0223558E-08			
		27.60717			
V038 SOL. BOD EFFLUENT	V019 TEMP MP	-0.1601284	99.99	0.274	18.03
	V058 AMT SOL BOD IN	1.4907674E-06			
	V062 AMT VSS IN	-1.58528E-07			
		-8.426982			
V041 TSS EFFLUENT	V019 TEMP MP	0.2934921	99.35	0.137	29.97
	V057 AMT BOD IN	-6.75198E-07			
	V061 AMT TSS IN	3.69532E-07			
		69.96406			

NO CONFIDENCE IN PREDICTING EFFLUENT COD'S AND VSS.

TABLE B-21. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JAN., FEB., DEC. 1976.

Predicting Effluent Properties

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V037 TOTAL BOD EFFLUENT	V019 TEMP MP	-15.19848	99.85	0.772	20.89
	V057 AMT BOD IN	-3.177845E-08			
	V061 AMT TSS IN	6.432184E-08			
		147.6917			
V038 SOL BOD EFFLUENT	V019 TEMP MP	-9.064955	99.99	0.869	16.44
	V058 AMT SOL BOD IN	2.341592E-06			
	V062 AMT VSS IN	-2.0301668E-07			
		44.96168			
V040 SOL COD EFFLUENT	V031 TEMP EFF				
	V060 AMT SOL COD IN	---NO CORRELATION---			
	V062 AMT VSS IN				
V041 TSS EFFLUENT	V019 TEMP MP	-1.733782	49.98	0.221	21.37
	V057 AMT BOD IN	-7.007306E-07			
	V061 AMT TSS IN	5.268625E-07			
		74.12917			
V042 VSS EFFLUENT	V062 AMT VSS IN	2.4052816E-07	60.38	0.098	15.53
	V059 AMT COD IN	1.098939E-07			
		14.66022			
V035 TKN EFFLUENT	V019 TEMP MP	0.4897082	99.95	0.685	1.83
	V056 AMT TKN IN	9.46846E-07			
	V061 AMT TSS IN	3.23372E-08			
		-1.645129			

TABLE B-22. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, MARCH-MAY 1976.

Predicting Effluent Properties

Dependent Variables	Independent Variables	Coefficient In Regression Equation	Cofindence Level	r^2	Standard Error
V037 TOTAL BOD EFFLUENT	V019 TEMP MP	-5.0066	71.1	0.160	17.67
	V057 AMT BOD IN	-1.4400566E-07			
	V061 AMT TSS IN	8.4209674E-08			
		134.0367			
V038 SOL BOD EFFLUENT	V019 TEMP MP	-5.571941	99.62	0.515	8.78
	V058 AMT SOL BOD IN	1.045895E-08			
	V062 AMT VSS IN	-6.901865E-08			
		125.1794			
V040 SOL COD EFFLUENT	V031 TEMP EFF	-3.680056	75.48	0.223	41.74
	V060 AMT SOL COD IN	1.41637E-06			
	V062 ANT VSS IN	-6.485565E-07			
		126.06			
V041 TSS EFFLUENT	V019 TEMP MP	-4.181593	90.06	0.234	34.8
	V057 AMT BOD IN	-1.08493E-06			
	V061 AMT TSS IN	5.7175E-07			
		176.1793			
V042 VSS EFFLUENT	V062 AMT VSS IN	6.708066E-07	70.86	0.135	30.62
	V059 AMT COD IN	-4.754626E-07			
		68.58951			
V035 TKN EFFLUENT	V019 TEMP MP	-2.640331	99.99	0.734	2.80
	V056 AMT TKN IN	7.37957E-07			
	V061 AMT TSS IN	-3.9730322E-08			
		58.83446			

TABLE B-23. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, JUNE-AUG. 1976.

Predicting Effluent Properties

Dependent Variable	Independent Variables	Coefficient In Regression Equation	Condifence Level	r^2	Standard Error
V037 TOTAL BOD EFFLUENT	V019 TEMP MP	-1.129164	53.55	0.103	9.86
	V057 AMT BOD IN	7.621986E-08			
	V061 AMT TSS IN	-8.121767E-08			
		51.02819			
V038 SOL BOD EFFLUENT	V019 TEMP MP	-0.9311389	88.43	0.251	8.82
	V058 AMT SOL BOD IN	5.251931E-07			
	V062 AMT VSS IN	-1.1085798E-07			
		29.93009			
V040 SOL COD EFFLUENT	V031 TEMP EFF	-4.839794	57.06	0.146	24.43
	V060 AMT SOL COD IN	2.76011E-07			
	V062 AMT VSS IN	-2.149446E-07			
		188.377			
V041 TSS EFFLUENT	V019 TEMP MP	3.524894	86.99	0.222	34.65
	V057 AMT BOD IN	-9.85267E-07			
	V061 AMT TSS IN	2.857604E-07			
		-2.68606			
V042 VSS EFFLUENT	V062 AMT VSS IN	-2.1265245E-07	70.4	0.120	26.38
	V059 AMT COD IN	3.6231892E-07			
		6.616256			
V035 TKN EFFLUENT	V019 TEMP MP	0.150057	95.79	0.275	1.031
	V056 AMT TKN IN	-1.2929168E-07			
	V061 AMT TSS IN	-1.168428E-08			
		1.25442			

TABLE B-24. RESULTS OF REGRESSION OF VARIABLES SELECTED AFTER STEPWISE REGRESSION, SEPT.-NOV. 1976.

Predicting Effluent Properties

Dependent Variable	Independent Variables	Coefficient In Regression Equation	Confidence Level	r^2	Standard Error
V037 TOTAL BOD EFFLUENT	V019 TEMP MP	1.170972	91.7	0.290	14.32
	V057 AMT BOD IN	-4.832518E-08			
	V061 AMT TSS IN	-4.97638E-07			
		26.07699			
V038 SOL BOD EFFLUENT	V019 TEMP MP	2.003566	98.52	0.472	13.72
	V058 AMT SOL BOD IN	1.55971E-06			
	V062 AMT VSS IN	-4.129796E-07			
		-37.4667			
V040 SOL COD EFFLUENT	V031 TEMP EFF	-1.03349	75.28	0.183	16.92
	V060 AMT SOL COD IN	-1.098727E-07			
	V062 AMT VSS IN	3.1701628E-07			
		55.64379			
V041 TSS EFFLUENT	V019 TEMP MP	-1.836766	99.22	0.475	15.66
	V057 AMT BOD IN	3.67628E-07			
	V061 AMT TSS IN	2.343345E-07			
		46.46516			
V042 VSS EFFLUENT	V062 AMT VSS IN				
	V059 AMT COD IN	----NO CORRELATION----			
V035 TKN EFFLUENT	V019 TEMP MP	-.133172	98.70	0.442	1.00
	V056 AMT TKN IN	1.035E-07			
	V061 AMT TSS IN	-4.2646E-09			
		6.564393			

APPENDIX C

OPERATIONAL PROBLEMS

During the study, several operational problems became evident. The two major problems associated with the lagoon system itself were loss of one of the dikes due to burrowing by muskrats and plugging of the air diffuser system. In one month muskrats completely drained cell number two and one other time the cell level was dropped significantly by someone who inadvertently turned on the irrigation pump used for applying the effluent to adjacent lands. The aerators were not functioning properly for a significant portion of the time. Based on periodic site visits approximately twenty-five percent of the system was not functioning properly about fifty percent of the time. The problems were usually associated with plugging of the aeration tubes.

Other problems associated with the project include:

a) Freezing of the samplers.
b) Loss of power to the mobile laboratory and concomitant freezing and breaking of important glassware and loss of chemicals.

APPENDIX D

DAILY DATA

TABLE D-1. INFLUENT TEST DATA OF BIXBY LAGOON, 1976.

S.NO	DATA YR	MO	DT	PH	ALKALINITY	TOTAL PHOSPHOROUS	AMMONIA NITROGEN	KJELDHAL NITROGEN	BOD TOTAL	BOD SOL.	COD TOTAL	COD SOL.	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	FLOW RATE GPD	FECAL COLI
A01	76	1	6	7.5	178	31	27.5	48.9	0	0	552	348	694	631	120400	0
A02	76	1	7	6.5	197	37	33.7	48.8	0	0	374	305	181	157	125600	0
A03	76	1	8	.0	155	31	32.3	48.5	740	282	846	439	392	278	140500	0
A04	76	1	9	6.4	163	35	30.0	44.5	337	253	586	259	0	0	76300	0
A05	76	1	10	6.4	166	33	31.0	42.6	440	253	563	341	0	0	120600	0
A06	76	1	11	6.8	140	38	24.5	43.0	0	0	652	308	234	176	126600	0
A07	76	1	12	7.6	136	30	33.3	45.8	357	288	442	244	157	121	130800	0
A08	76	1	13	6.5	189	35	33.1	46.2	421	229	603	324	304	240	105000	0
A09	76	1	14	6.5	162	33	33.3	35.1	463	233	547	265	0	0	105000	0
A10	76	1	15	6.6	153	34	27.6	43.9	420	260	852	471	190	90	116000	0
A11	76	1	16	.0	0	41	33.0	48.4	338	228	619	332	380	208	121100	0
A13	76	1	17	7.6	181	36	43.8	55.4	315	220	528	318	0	0	132600	0
A14	76	1	18	.0	0	34	33.5	48.0	315	170	632	265	357	159	61700	0
A15	76	1	19	.0	0	39	32.5	37.9	270	265	955	271	404	278	110400	0
A16	76	1	20	7.1	160	35	31.2	39.9	225	175	817	311	420	308	133200	0
A17	76	1	21	.0	0	42	32.3	42.3	277	173	760	302	387	265	115000	0
A18	76	1	22	6.9	180	36	29.5	40.7	300	194	657	338	185	121	103000	0
A19	76	1	23	7.2	0	41	.0	.0	0	0	0	0	0	0	138100	0
A20	76	1	24	.0	0	45	.0	.0	0	0	0	0	0	0	65600	0
A21	76	1	25	.0	0	40	.0	.0	0	0	0	0	0	0	106800	0
A22	76	1	26	7.3	150	40	25.5	33.7	320	238	516	244	285	230	98900	0
A23	76	1	27	6.8	146	34	24.2	33.7	240	156	512	413	275	190	106600	0
A24	76	1	28	6.9	186	40	29.0	30.7	510	189	530	313	328	230	94200	0
A25	76	1	29	6.8	158	0	.0	.0	342	252	567	333	0	0	109000	0
B01	76	2	22	.0	0	0	23.9	46.8	0	0	542	374	336	220	123600	0
B02	76	2	23	.0	0	0	27.2	42.9	445	282	645	450	210	142	109700	0
B03	76	2	24	.0	0	0	34.0	41.8	315	237	543	357	232	208	121600	0
B04	76	2	25	.0	0	0	29.0	32.0	592	185	489	364	156	136	98600	0
B05	76	2	26	.0	0	0	30.5	42.0	0	0	0	0	0	0	95600	0
B06	76	2	27	.0	0	0	26.6	54.0	363	255	415	347	208	0	105200	0
B07	76	2	28	.0	0	0	24.4	51.0	397	262	500	314	0	0	100600	0
C01	76	3	22	.0	0	36	23.1	97.0	0	0	736	339	357	80	109400	4000
C02	76	3	24	7.1	132	40	27.7	.0	390	273	616	275	119	90	114400	9000
C03	76	3	25	7.2	164	43	24.7	56.5	405	245	636	302	273	140	108000	13000
C04	76	3	26	7.3	192	38	.0	58.5	540	295	617	466	290	170	120700	19000
C05	76	3	27	6.9	158	25	23.1	.0	293	224	718	197	240	160	110300	25000
C06	76	3	28	.0	0	49	26.9	56.0	455	165	0	323	180	90	121600	18000
C07	76	3	29	.0	0	30	24.9	56.0	400	161	700	328	190	120	175200	5000

Data except for pH, Flow Rate and Fecal Coliform are in mg/l. Fecal Coliform count as /100 ml.
Alkalinity as $CaCO_3$. Total Phosphorus is measured in terms of Dissolved Ortho-phosphate.
For Flow Rate, 1 GPD = 0.003785 m^3/d.

TABLE D-1. Cont'd.

S.NO	DATA YR	MO	DT	PH	ALKALINITY	TOTAL PHOSPHOROUS	AMMONIA NITROGEN	KJELDHAL NITROGEN	BOD TOTAL	BOD SOL.	COD TOTAL	COD SOL.	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	FLOW RATE GPD	FECAL COLI
D01	76	4	5	6.7	122	0	31.0	61.3	280	0	797	0	0	0	116200	4000
C02	76	4	6	6.8	162	0	.0	53.0	390	162	433	119	288	262	126700	21000
C03	76	4	7	6.5	142	0	23.0	59.0	400	127	654	294	546	490	139500	16000
D04	76	4	8	6.5	154	0	24.0	48.0	480	172	763	348	308	0	109600	18000
C05	76	4	9	6.5	190	0	27.0	03.0	490	206	565	247	0	0	107900	0
D06	76	4	10	7.0	0	0	36.0	45.0	400	154	740	0	580	232	114900	18000
C07	76	4	11	.0	0	0	28.0	56.0	330	135	568	279	598	378	116700	15000
C08	76	4	12	6.4	150	0	31.0	56.0	368	139	765	400	274	230	119700	21000
C09	76	4	13	6.4	186	0	27.0	53.0	370	136	815	217	638	530	118900	0
C10	76	4	14	6.3	172	0	31.0	59.0	450	143	557	252	499	352	115800	0
C11	76	4	15	6.5	142	0	41.0	45.0	360	75	685	162	236	228	160400	18000
C12	76	4	16	6.3	130	0	24.0	15.0	330	113	617	201	340	240	122300	33000
C13	76	4	17	6.5	146	0	26.0	40.0	420	112	667	200	272	192	145500	21000
C14	76	4	18	4.3	132	0	18.0	40.0	370	120	727	173	480	348	184400	28000
C15	76	4	19	.0	0	0	16.0	36.0	340	42	653	161	0	0	191700	16000
C16	76	4	20	.0	0	0	9.0	21.0	0	0	233	172	188	140	463700	0
C17	76	4	21	6.4	156	0	15.0	37.0	400	113	583	174	368	212	331500	47000
C18	76	4	22	6.7	198	0	20.0	40.0	280	105	618	115	224	212	212800	15000
C19	76	4	23	6.4	194	0	21.0	48.0	450	150	457	147	140	0	156600	36000
C20	76	4	24	6.7	186	0	17.0	45.3	0	53	475	222	128	0	178500	21000
C21	76	4	25	6.7	184	0	21.0	37.0	370	135	461	131	264	104	116200	0
C22	76	4	26	6.5	182	0	23.0	27.0	420	98	547	333	176	104	141500	0
C23	76	4	27	6.3	158	0	23.0	27.0	400	180	572	238	140	0	146300	30000
C24	76	4	28	6.4	165	0	20.0	35.0	530	140	508	192	0	0	146900	0
C25	76	4	29	6.3	154	0	23.0	35.0	0	105	452	173	0	0	154900	27000
C26	76	5	1	6.3	164	0	23.7	41.0	520	150	548	183	304	0	139300	0
C27	76	5	2	6.2	168	0	.0	.0	0	0	769	288	176	0	143400	0
E01	76	5	11	6.5	124	0	26.5	39.5	440	135	554	300	288	164	142100	0
E02	76	5	12	6.2	170	0	.0	41.6	340	160	585	261	0	0	131600	0
E03	76	5	13	6.5	128	0	23.6	36.8	0	150	436	227	204	64	162200	0
E04	74	5	14	6.5	162	0	24.7	.0	0	0	472	263	0	0	141300	0
E05	76	5	16	6.3	152	0	21.7	39.5	265	160	654	236	252	220	136900	0
E06	76	5	17	6.7	182	0	25.0	43.0	330	60	477	139	328	268	146200	0
E07	76	5	18	6.5	178	0	25.7	40.0	0	0	477	216	348	320	125700	0
F01	76	6	10	6.7	142	0	28.4	44.0	290	120	559	237	452	408	0	0
F02	76	6	11	6.2	143	0	24.4	37.9	370	130	456	207	144	124	0	0
F03	76	6	12	6.4	166	0	26.6	43.7	535	100	674	358	220	152	97800	0
F04	76	6	13	6.5	166	0	26.6	41.1	420	150	758	327	140	120	0	0
F05	76	6	15	6.4	148	0	.0	39.8	0	0	579	232	288	232	0	0
F06	76	6	16	6.6	158	0	.0	38.3	240	90	568	242	136	88	123300	0
F07	76	6	17	6.3	180	0	.0	.0	620	140	0	0	0	0	0	0

TABLE D-1. Cont'd.

S.NO	DATA YR	MO	DT	PH	ALKALINITY	TOTAL PHOSPHOROUS	AMMONIA NITROGEN	KJELDHAL NITROGEN	BOD TOTAL	BOD SOL.	COD TOTAL	COD SOL.	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	FLOW RATE GPD	FECAL COLI
G01	76	7	5	6.1	144	0	48.0	47.0	380	150	475	188	0	0	103500	0
G02	76	7	6	6.1	150	0	34.5	40.5	330	190	555	222	216	48	123000	0
G03	76	7	7	6.1	140	0	.0	39.5	430	140	651	208	196	120	140200	0
G04	76	7	8	5.9	160	0	.0	38.3	500	170	848	545	0	0	126700	0
G05	76	7	9	5.8	134	0	.0	41.0	640	350	657	314	228	88	109300	0
G06	76	7	10	6.0	138	0	.0	40.5	340	90	539	250	95	0	115900	0
G07	76	7	12	5.8	140	0	.0	43.4	340	140	510	270	132	0	105900	0
G08	76	7	13	6.0	164	0	.0	42.0	390	140	680	267	568	532	123100	0
G09	76	7	14	5.9	152	0	.0	55.0	380	150	574	228	184	135	125700	0
G10	76	7	15	6.1	175	0	28.8	46.0	380	110	653	243	268	216	118700	0
G11	76	7	16	6.1	152	0	29.0	55.0	320	60	612	194	464	316	159000	0
G12	76	7	17	6.2	152	0	42.0	57.0	300	130	486	264	328	168	127700	0
G13	76	7	18	6.1	150	0	33.0	45.0	260	120	480	235	107	40	125800	0
G14	76	7	19	5.7	180	0	38.0	61.0	340	130	617	264	184	0	107300	0
G15	76	7	20	6.4	154	0	35.4	.0	280	180	519	245	215	128	129500	0
G16	76	7	21	6.3	152	0	35.0	54.0	370	110	623	264	234	220	122400	0
G17	76	7	22	6.2	160	0	35.3	57.0	300	130	0	250	208	200	116100	0
G18	76	7	24	6.2	150	0	36.0	49.0	260	140	537	236	192	188	170900	0
G19	76	7	25	6.3	150	0	44.0	50.0	330	110	636	239	280	224	67100	0
G20	76	7	26	.0	0	0	.0	.0	0	0	0	0	0	0	100400	0
G21	76	7	27	.0	0	0	.0	.0	0	0	0	0	0	0	122600	0
G22	76	7	28	6.8	150	0	36.0	53.0	330	120	545	269	188	168	121900	0
G23	76	7	30	6.6	152	0	33.0	35.0	210	80	478	139	488	412	174800	0
G24	76	8	2	6.6	154	0	23.0	.0	260	90	546	188	332	188	227700	0
G25	76	8	3	6.0	168	0	24.0	36.0	260	130	435	220	160	116	158200	0
G26	76	8	4	6.4	172	0	27.0	42.0	320	90	655	188	215	215	124000	0
H01	76	8	22	6.3	122	0	.0	38.3	0	0	614	223	240	168	238400	0
H02	76	8	23	6.2	164	0	27.4	39.8	360	100	727	242	304	296	238800	0
H03	76	8	24	6.2	130	0	24.9	33.9	310	100	686	233	772	628	246700	0
H04	76	8	26	6.3	120	0	24.6	32.4	350	120	665	252	328	283	247500	0
H05	76	8	27	6.6	140	0	23.9	30.2	290	120	466	214	224	189	250400	0
H06	76	8	28	6.3	130	0	23.7	36.1	350	90	602	242	96	32	254800	0
H07	76	8	29	6.7	138	0	27.1	38.3	0	0	485	232	148	24	234400	0
I01	76	9	20	6.5	150	0	29.1	48.0	0	0	707	226	156	48	126900	0
I02	76	9	21	6.3	132	0	31.6	43.4	340	140	603	0	124	100	163300	0
I03	76	9	22	6.0	140	0	35.0	45.0	340	170	570	309	92	60	126100	0
I04	76	9	23	6.1	144	0	38.1	40.4	310	115	703	241	480	120	143400	0

TABLE D-1. Cont'd.

S.NO	DATA YR	MO	DT	PH	ALKALINITY	TOTAL PHOSPHOROUS	AMMONIA NITROGEN	KJELDHAL NITROGEN	BOD TOTAL	BOD SOL.	COD TOTAL	COD SOL.	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	FLOW RATE GPD	FECAL COLI
J01	76	10	23	.0	0	0	.0	38.1	410	170	704	268	0	0	116100	0
J02	76	10	24	.0	0	0	36.4	45.7	370	145	815	260	280	239	118800	0
J03	76	10	25	6.4	162	0	.0	48.7	385	155	833	274	155	93	123500	0
J04	76	10	26	6.2	156	0	37.3	44.9	350	140	717	307	208	153	137400	0
J05	76	10	27	6.2	172	0	38.8	50.4	305	150	771	264	178	138	112200	0
J06	76	10	28	6.3	175	0	48.9	54.9	360	60	797	288	232	216	128500	0
J07	76	10	29	6.2	150	0	.0	.0	535	135	0	285	327	239	132900	0
K01	76	11	4	6.2	178	0	.0	.0	390	140	730	275	197	183	122400	0
K02	76	11	5	6.3	156	0	33.2	.0	390	140	855	244	277	213	139000	0
K03	76	11	8	6.5	144	0	24.8	39.6	300	110	632	169	181	171	0	0
K04	76	11	9	6.2	150	0	39.4	47.4	430	120	735	225	243	219	142600	0
K05	76	11	11	6.1	134	0	41.6	44.6	270	120	664	284	246	205	133100	0
K06	76	11	12	.6	0	0	40.2	50.8	430	130	0	221	561	462	150900	0
K07	76	11	13	6.5	162	0	45.0	54.1	360	160	789	284	177	138	146600	0
K08	76	11	16	6.1	156	0	30.7	44.1	330	150	664	260	160	147	148700	0
K09	76	11	17	6.2	190	0	36.5	45.3	330	130	840	269	146	124	136800	0
K10	76	11	18	6.0	164	0	.0	.0	280	150	553	220	170	117	148700	0
K11	76	11	19	.0	0	0	28.1	43.2	310	140	666	236	186	152	152100	0
K12	76	11	20	6.2	0	0	27.5	42.5	360	150	772	241	197	132	153200	0
K13	76	11	21	6.1	94	0	26.7	45.3	0	0	872	242	258	206	108300	0
K14	76	11	22	6.0	112	0	34.0	55.6	410	170	1038	272	327	257	75700	0
K15	76	11	23	6.3	142	0	29.1	44.6	350	140	724	238	184	161	150400	0
K16	76	11	24	6.2	140	0	31.1	48.0	310	180	758	249	272	230	145100	0
K17	76	11	25	5.8	156	0	23.4	35.7	360	160	662	267	134	113	163300	0
K18	76	11	26	5.5	116	0	25.7	38.4	280	190	644	205	0	0	144100	0
K19	76	11	28	6.0	160	0	40.9	59.7	430	0	1040	0	564	456	92700	0
K20	76	11	29	6.1	144	0	31.0	49.4	350	110	700	260	364	344	72000	0
K21	76	11	30	5.8	168	0	38.1	66.6	580	210	1148	314	651	321	151600	0
K22	76	12	2	6.1	106	0	26.8	46.5	310	110	651	232	118	89	134800	0
K23	76	12	3	6.0	156	0	28.1	41.2	380	140	867	241	124	112	134400	0
K24	76	12	5	6.0	148	0	.0	38.4	0	0	430	207	119	88	141000	0
L01	76	12	16	6.5	140	0	27.7	43.9	310	135	542	236	130	88	132700	0
L02	76	12	17	6.5	146	0	32.9	55.5	230	110	742	233	163	112	78300	0
L03	76	12	18	6.2	136	0	32.8	40.5	0	0	633	207	118	88	171900	0
L04	76	12	19	6.4	146	0	25.1	50.0	230	90	584	194	206	161	259900	0
L05	76	12	20	6.4	136	0	27.0	44.6	210	60	507	225	132	58	0	0
L06	76	12	21	6.3	126	0	26.9	43.2	0	230	0	268	74	88	134500	0
L07	76	12	22	6.4	150	0	29.3	45.3	310	80	614	196	152	80	0	0

TABLE D-2. MID-POINT TEST DATA OF BIXBY LAGOON, 1976.
(Effluent Cell 1)

S.NO	DATE YR	MO	DT	ALKALINITY	PH	TEMP. DEG C	DISS. OXYGEN	BOD TOTAL	BOD SOLUBLE	COD TOTAL	COD SOLUBLE	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	TOTAL PHOSPHOROUS	FECAL COLI	TOTAL COLI
A01	76	66	6	132	6.9	2.0	10.7	0	0	150	85	101	79	40	0	0
A02	76	66	7	132	7.0	1.0	13.6	0	0	164	36	63	19	42	0	0
A03	76	66	8	132	.0	1.0	12.6	138	132	190	88	69	42	42	0	0
A04	76	66	9	129	6.9	3.0	11.5	95	83	128	75	0	0	41	0	0
A05	76	66	10	132	6.8	2.0	12.8	110	88	121	75	0	0	40	0	0
A06	76	66	11	132	6.9	4.0	11.1	0	0	243	95	97	63	39	0	0
A07	76	66	12	136	7.5	5.0	12.2	135	115	143	65	38	34	40	0	0
A08	76	66	13	136	7.0	7.0	8.2	40	86	108	58	84	69	40	0	0
A09	76	66	14	125	7.0	9.0	10.4	29	50	112	50	0	0	41	0	0
A10	76	66	15	137	7.3	6.0	11.3	93	47	161	80	50	38	41	0	0
A11	76	66	16	0	.0	.0	.0	48	31	117	63	96	68	41	0	0
A13	76	66	17	140	7.2	10.3	10.3	72	39	103	72	0	53	41	0	0
A14	76	66	18	0	.0	.0	.0	95	77	121	27	122	82	41	0	0
A15	76	66	19	0	.0	.0	.0	85	69	142	62	122	142	43	0	0
A16	76	66	20	156	7.4	8.0	8.3	37	31	155	67	124	106	42	0	0
A17	76	66	21	0	.0	.0	.0	26	18	138	62	109	54	43	0	0
A18	76	66	22	156	7.5	9.0	11.9	31	24	147	76	66	35	37	0	0
A19	76	66	23	0	7.7	9.0	10.4	0	0	0	0	0	0	39	0	0
A20	76	66	24	0	.0	.0	.0	0	0	0	0	0	0	39	0	0
A21	76	66	25	0	.0	.0	.0	0	0	0	0	0	0	39	0	0
A22	76	66	26	158	8.0	8.0	8.0	58	41	280	58	140	72	39	0	0
A23	76	66	27	158	7.7	8.0	9.9	52	23	159	79	85	58	38	0	0
A24	76	66	28	164	7.8	9.0	9.1	35	14	151	99	126	68	39	0	0
A25	76	66	29	154	7.5	9.0	8.9	49	27	115	60	0	0	0	0	0
B01	76	66	22	0	.0	.0	.0	174	48	332	145	140	80	0	0	0
B02	76	66	23	0	.0	.0	.0	153	68	172	141	32	14	0	0	0
B03	76	66	24	0	.0	.0	.0	0	0	148	118	42	34	0	0	0
B04	76	66	25	0	.0	.0	.0	0	112	132	124	56	40	0	0	0
B05	76	66	26	0	.0	.0	.0	165	117	171	117	42	34	0	0	0
B06	76	66	27	0	.0	.0	.0	135	104	142	0	64	0	0	0	0
B07	76	66	28	0	.0	.0	.0	125	72	208	150	0	0	0	0	0
C01	76	66	22	0	.0	.0	.0	77	0	176	120	168	60	46	3000	16000
C02	76	66	24	188	7.9	17.0	6.1	58	47	165	0	62	40	48	11000	21000
C03	76	66	25	194	7.6	15.0	6.0	61	62	198	138	146	60	47	10000	30000
C04	76	66	26	172	7.6	17.0	6.4	55	41	171	0	78	70	40	19000	25000
C05	76	66	27	72	7.5	17.0	6.3	71	25	231	82	55	70	44	19000	0
C06	76	66	28	0	.0	17.0	9.8	38	17	174	65	127	50	36	11000	22000
C07	76	66	29	0	.0	.0	.0	63	47	232	0	53	90	44	6000	14000

TABLE D-2. Cont'd.

S.NO	DATE YR MO DT	ALKALINITY	PH	TEMP. DEG C	DISS. OXYGEN	BOD TOTAL	BOD SOLUBLE	COD TOTAL	COD SOLUBLE	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	TOTAL PHOSPHOROUS	FECAL COLI	TOTAL COLI
D01	76 66 5	182	7.5	18.0	8.6	60	0	236	38	0	0	0	7000	18000
D02	76 66 6	98	7.3	19.0	9.5	74	53	262	0	44	0	0	14000	26000
D03	76 66 7	144	7.5	18.0	9.1	63	51	246	76	44	0	0	9000	21000
D04	76 66 8	160	7.2	20.0	9.0	74	38	174	34	24	0	0	11000	21000
D05	76 66 9	160	7.4	19.0	8.3	72	60	157	35	52	24	0	19000	0
D06	76 66 10	0	7.0	19.2	9.2	76	34	327	0	48	28	0	11000	21000
D07	76 66 11	0	.0	20.0	7.7	58	24	250	154	81	63	0	9000	19000
D08	76 66 12	158	7.1	19.0	8.2	58	24	283	246	40	0	0	9000	19000
D09	76 66 13	172	6.9	20.0	4.4	54	21	153	0	47	37	0	0	0
D10	76 66 14	160	6.9	21.0	4.9	150	6	204	66	119	74	0	9000	17000
D11	76 66 15	160	6.8	20.0	4.7	82	15	182	0	67	22	0	15000	23000
D12	76 66 16	66	7.0	20.0	6.5	96	22	228	61	103	81	0	29000	0
D13	76 66 17	140	6.9	20.0	2.2	132	6	153	0	111	69	0	0	57000
D14	76 66 18	130	6.9	20.0	5.4	110	6	207	60	76	0	0	18000	36000
D15	76 66 19	0	.0	.0	.0	99	10	212	59	91	69	0	0	54000
D16	76 66 20	0	.0	.0	.0	0	0	190	52	110	104	0	0	0
D17	76 66 21	130	6.5	19.0	4.9	128	0	183	44	66	78	0	29000	56000
D18	76 66 22	88	6.7	21.0	8.1	88	36	217	0	88	0	0	10000	19000
D19	76 66 23	90	6.5	22.0	7.3	123	8	138	0	0	0	0	40000	52000
D20	76 66 24	72	6.4	20.0	6.3	111	0	214	60	56	0	0	16000	41000
D21	76 66 25	54	6.7	19.0	2.9	90	27	148	0	118	74	0	20000	52000
D22	76 66 26	70	6.4	19.0	7.2	129	6	393	145	84	0	0	20000	46000
D23	76 66 27	74	6.4	19.0	8.6	108	24	172	67	70	0	0	11000	40000
D24	76 66 28	60	6.2	17.0	4.8	150	3	144	58	70	64	0	9000	19000
D25	76 66 29	60	6.4	17.0	6.8	165	6	173	0	78	34	0	17000	32000
D26	76 66 1	54	6.3	18.5	13.6	132	0	212	115	26	0	0	0	0
D27	76 66 2	55	6.3	19.0	11.2	0	0	327	39	92	0	0	0	0
E01	76 66 11	80	6.7	22.0	4.5	93	0	163	54	72	0	0	0	0
E02	76 66 12	72	6.4	21.0	4.0	69	6	252	54	0	0	0	0	0
E03	76 66 13	76	6.5	21.0	5.5	90	15	163	0	92	0	0	0	0
E04	76 66 14	64	6.6	21.0	4.5	0	0	154	13	0	0	0	0	0
E05	76 66 16	74	6.6	19.5	2.4	47	9	245	45	39	36	0	0	0
E06	76 66 17	70	6.6	21.0	4.5	57	6	162	0	68	0	0	0	0
E07	76 66 18	66	6.6	22.0	5.2	0	0	144	99	128	112	0	0	0
F01	76 66 10	72	6.8	25.0	4.8	60	9	161	118	76	71	0	0	0
F02	76 66 11	66	6.5	26.0	4.2	75	9	107	33	70	50	0	0	0
F03	76 66 12	70	6.4	26.5	4.2	128	12	274	0	44	44	0	0	0
F04	76 66 13	70	6.6	27.0	3.5	86	21	232	200	52	46	0	0	0
F05	76 66 15	80	6.7	26.0	2.4	0	0	126	63	88	0	0	0	0
F06	76 66 16	74	6.6	25.0	2.4	87	15	151	0	36	0	0	0	0
F07	76 66 17	68	6.2	26.0	3.1	90	12	0	0	0	0	0	0	0

TABLE D-2. Cont'd.

S.NO	DATE YR MO DT	ALKALINITY	PH	TEMP. DEG C	DISS. OXYGEN	BOD TOTAL	BOD SOLUBLE	COD TOTAL	COD SOLUBLE	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	TOTAL PHOSPHOROUS	FECAL COLI	TOTAL COLI
G01	76 66 5	70	6.7	28.0	8.0	54	21	89	40	0	0	0	0	0
G02	76 66 6	72	6.7	28.0	5.6	57	24	101	0	150	102	0	0	0
G03	76 66 7	73	6.7	28.0	5.5	90	15	208	59	61	41	0	0	0
G04	76 66 8	74	6.4	29.0	4.1	138	57	192	69	0	0	0	0	0
G05	76 66 9	83	6.4	29.0	4.1	63	39	98	59	32	12	0	0	0
G06	76 66 10	56	6.4	28.5	3.7	42	15	88	60	19	19	0	0	0
G07	76 66 12	86	6.3	29.0	6.6	60	3	140	50	65	51	0	0	0
G08	76 66 13	90	6.8	29.0	4.1	57	0	150	50	42	35	0	0	0
G09	76 66 14	82	6.8	30.0	5.5	36	9	129	40	0	0	0	0	0
G10	76 66 15	96	6.7	28.0	3.2	54	0	136	39	54	38	0	0	0
G11	76 66 16	108	6.7	28.0	4.8	42	9	107	29	51	39	0	0	0
G12	76 66 17	110	7.2	28.5	8.6	39	18	127	78	40	23	0	0	0
G13	76 66 18	104	7.0	28.5	9.0	48	9	127	69	40	24	0	0	0
G14	76 66 19	100	7.6	29.0	9.2	27	6	147	50	80	23	0	0	0
G15	76 66 20	100	7.4	29.0	7.0	54	3	127	75	44	33	0	0	0
G16	76 66 21	80	6.9	29.0	7.9	81	3	160	56	61	44	0	0	0
G17	76 66 22	74	6.7	29.0	9.1	39	0	139	46	200	190	0	0	0
G18	76 66 24	60	6.4	28.0	5.9	102	9	167	64	0	0	0	0	0
G19	76 66 25	62	6.4	28.5	5.7	51	3	145	55	48	40	0	0	0
G20	76 66 26	58	7.3	30.0	9.9	60	9	165	45	84	84	0	0	0
G21	76 66 27	66	7.2	30.0	10.9	51	15	151	57	28	16	0	0	0
G22	76 66 28	69	6.7	30.0	12.1	45	3	167	56	74	57	0	0	0
G23	76 66 30	70	6.7	30.0	12.4	46	15	181	48	102	74	0	0	0
G24	76 66 2	70	6.9	29.0	3.6	33	0	120	17	62	62	0	0	0
G25	76 66 3	72	6.6	28.0	6.4	33	9	106	63	64	56	0	0	0
G26	76 66 4	70	6.6	27.0	5.9	46	9	145	55	46	46	0	0	0
H01	76 66 22	70	6.6	27.5	7.2	0	0	173	68	62	60	0	0	0
H02	76 66 23	72	7.0	28.0	10.4	51	3	183	72	50	50	0	0	0
H03	76 66 24	72	6.8	28.0	8.0	69	6	224	62	126	104	0	0	0
H04	76 66 26	76	6.6	26.5	6.5	93	9	204	78	64	0	0	0	0
H05	76 66 27	82	6.9	29.0	8.7	87	12	214	71	138	112	0	0	0
H06	76 66 28	74	6.4	26.0	5.2	96	9	224	71	96	66	0	0	0
H07	76 66 29	74	6.7	26.5	7.6	0	0	202	61	180	128	0	0	0
I01	76 66 20	52	7.0	24.0	4.3	0	0	245	75	66	52	0	0	0
I02	76 66 21	52	6.5	24.0	6.8	90	0	151	0	70	42	0	0	0
I03	76 66 22	54	6.7	26.0	6.2	78	6	400	82	70	70	0	0	0
I04	76 66 23	50	6.6	25.0	9.1	93	3	345	46	230	146	0	0	0

TABLE D-2. Cont'd.

S.NO	DATE YR MO DT	ALKALINITY	PH	TEMP. DEG C	DISS. OXYGEN	BOD TOTAL	BOD SOLUBLE	COD TOTAL	COD SOLUBLE	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	TOTAL PHOSPHOROUS	FECAL COLI	TOTAL COLI
J01	76 66 23	0	.0	.0	.0	141	11	261	38	138	110	0	0	0
J02	76 56 24	0	.0	.0	.0	108	11	310	59	232	196	0	0	0
J03	76 66 25	48	6.4	14.0	6.8	111	6	299	65	180	160	0	0	0
J04	76 66 26	44	6.5	14.0	9.6	95	8	250	67	136	120	0	0	0
J05	76 56 27	42	6.3	14.0	8.9	95	9	252	34	108	96	0	0	0
J06	76 56 28	42	6.4	14.0	9.7	105	6	257	72	200	160	0	0	0
J07	76 66 29	50	6.3	13.0	7.2	86	6	250	65	0	0	0	0	0
K01	76 56 4	46	6.4	13.0	9.8	123	0	281	71	183	150	0	0	0
K02	76 56 5	56	6.5	12.0	11.1	183	6	498	229	204	161	0	0	0
K03	76 56 8	42	6.5	12.0	9.7	99	12	218	85	107	79	0	0	0
K04	76 56 9	26	6.2	14.0	8.8	141	9	276	57	114	0	0	0	0
K05	76 66 11	42	6.1	9.0	8.6	132	0	386	85	126	95	0	0	0
K06	76 56 12	0	.0	.0	.0	75	3	238	62	46	43	0	0	0
K07	76 56 13	33	6.2	10.0	7.2	111	3	246	48	144	104	0	0	0
K08	76 56 15	38	5.9	9.0	7.2	117	6	244	72	143	130	0	0	0
K09	76 55 17	44	6.1	8.0	8.6	102	3	244	63	114	103	0	0	0
K10	76 56 18	44	6.2	10.0	8.8	99	3	217	59	113	58	0	0	0
K11	76 66 19	0	.0	.0	.0	117	12	263	64	154	146	0	0	0
K12	76 56 20	0	5.9	11.0	7.2	75	0	243	53	127	84	0	0	0
K13	76 66 21	34	5.8	10.0	8.0	0	0	244	42	122	100	0	0	0
K14	76 56 22	44	5.9	8.0	8.4	123	3	239	56	137	130	0	0	0
K15	76 55 23	32	6.1	9.0	8.4	114	3	224	52	113	103	0	0	0
K16	76 56 24	42	6.2	10.0	8.2	0	6	230	56	111	106	0	0	0
K17	76 55 25	34	5.6	10.0	5.1	144	3	230	74	109	80	0	0	0
K18	76 56 26	30	5.6	11.5	4.6	147	15	300	46	140	130	0	0	0
K19	76 55 28	30	5.8	7.0	6.5	69	0	236	96	80	0	0	0	0
K20	76 56 29	32	5.8	7.0	11.8	129	0	163	57	68	0	0	0	0
K21	76 55 30	30	5.9	6.0	10.9	117	12	151	57	218	56	0	0	0
K22	76 56 2	46	5.9	7.0	8.9	48	3	180	65	92	0	0	0	0
K23	76 66 3	36	5.8	7.0	9.3	126	3	186	70	64	59	0	0	0
K24	76 66 5	40	6.3	8.0	8.4	0	0	204	70	60	51	0	0	0
L01	76 56 16	72	6.6	8.0	8.9	89	20	145	73	51	48	0	0	0
L02	76 66 17	70	6.6	9.0	7.2	33	6	171	70	68	0	0	0	0
L03	76 56 18	70	6.4	7.0	7.4	0	0	229	63	49	32	0	0	0
L04	76 65 19	72	6.3	10.0	6.1	36	0	174	45	0	0	0	0	0
L05	76 56 20	78	6.3	6.0	7.9	63	9	168	80	0	43	0	0	0
L06	76 55 21	80	6.3	7.0	9.8	36	12	170	67	33	28	0	0	0
L07	76 65 22	76	6.5	5.0	8.1	57	0	157	63	53	48	0	0	0

TABLE D-3. EFFLUENT TEST DATA OF BIXBY LAGOON, 1976.
(Effluent Cell 2)

S.NO	DATE YR	DATE MO	DATE DT	PH	TEMP. DEG C	ALKALINITY	DISS. OXYGEN	AMMONIA NITROGEN	KJELDAHL NITROGEN	BOD TOTAL	BOD SOL.	COD TOTAL	COD SOL	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	PHOSPHOROUS	FECAL COLI	TOTAL COLI
A01	76	1	6	6.7	2.4	93	12	2.0	6.9	0	0	85	52	52	45	32	0	0
A02	76	1	7	6.6	1.0	95	14	11.3	6.9	0	0	98	26	39	14	33	0	0
A03	76	1	8	.0	1.0	83	15	2.4	6.4	131	128	98	65	33	13	33	0	0
A04	76	1	9	7.3	2.0	91	14	2.5	7.1	65	50	82	52	0	0	31	0	0
A05	76	1	10	7.3	1.0	87	15	2.5	7.4	78	58	79	49	0	0	32	0	0
A06	76	1	11	7.5	2.0	91	13	2.6	7.8	0	0	111	79	42	12	32	0	0
A07	76	1	12	8.2	3.5	91	14	5.5	7.3	115	110	73	36	20	17	31	0	0
A08	76	1	13	7.8	5.0	83	11	3.8	7.0	25	23	72	23	48	29	31	0	0
A09	76	1	14	7.9	6.0	95	15	3.8	5.3	26	45	67	12	0	0	32	0	0
A10	76	1	15	8.2	3.0	85	13	3.9	9.1	62	33	94	40	45	40	32	0	0
A11	76	1	16	.0	.0	0	0	5.2	10.5	39	24	76	27	42	27	32	0	0
A13	76	1	17	8.0	14.2	79	14	4.6	11.3	75	34	85	20	0	49	32	0	0
A14	76	1	18	.0	.0	0	0	4.5	7.8	77	23	54	5	68	37	33	0	0
A15	76	1	19	.0	.0	0	0	5.1	7.1	31	27	75	44	74	75	33	0	0
A16	76	1	20	8.5	7.0	104	11	4.7	6.8	19	13	93	35	66	37	34	0	0
A17	76	1	21	.0	.0	0	0	4.3	7.5	19	10	44	31	43	19	34	0	0
A18	76	1	22	8.6	8.0	110	15	6.5	8.0	15	9	93	36	43	22	29	0	0
A19	76	1	23	9.0	8.0	0	14	.0	.0	0	0	0	0	0	0	30	0	0
A20	76	1	24	.0	.0	0	0	.0	.0	0	0	0	0	0	0	30	0	0
A21	76	1	25	.0	.0	0	0	.0	.0	0	0	0	0	0	0	31	0	0
A22	76	1	26	9.2	7.0	106	13	5.5	8.4	20	15	111	36	104	36	30	0	0
A23	76	1	27	9.3	7.0	108	13	5.8	9.0	21	13	111	64	42	18	28	0	0
A24	76	1	28	9.4	7.0	114	14	5.3	7.1	18	10	103	87	57	32	29	0	0
A25	76	1	29	9.8	8.0	118	13	.0	.0	27	14	71	32	0	0	0	0	0
B01	76	2	22	.0	.0	0	0	13.2	20.9	35	41	0	0	0	0	0	0	0
B02	76	2	23	.0	.0	0	0	14.1	20.7	25	20	0	0	0	0	0	0	0
B03	76	2	24	.0	.0	0	0	13.4	20.7	32	10	0	0	0	0	0	0	0
B04	76	2	25	.0	.0	0	0	13.5	21.0	41	0	0	0	0	0	0	0	0
B05	76	2	26	.0	.0	0	0	14.7	21.8	61	38	0	0	0	0	0	0	0
B06	76	2	27	.0	.0	0	0	14.8	16.3	44	34	0	0	0	0	0	0	0
B07	76	2	28	.0	.0	0	0	13.4	14.0	49	37	0	0	0	0	0	0	0
C01	76	3	22	.0	.0	0	0	14.7	22.5	0	47	132	66	0	30	46	3000	11000
C02	76	3	24	9.4	17.0	146	7	23.8	.0	47	46	134	110	63	30	44	6000	14000
C03	76	3	25	9.3	14.0	160	8	14.7	23.0	0	0	141	91	0	50	43	8000	15000
C04	76	3	26	9.1	17.0	144	7	14.0	22.3	22	23	151	124	67	50	45	3000	8000
C05	76	3	27	8.9	16.0	144	10	11.6	.0	47	42	228	126	60	50	24	8000	18000
C06	76	3	28	.0	.0	0	13	12.0	22.5	0	12	129	0	70	50	40	7000	16000
C07	76	3	29	.0	.0	0	0	11.9	20.7	0	48	0	0	37	40	37	2000	8000

TABLE D-3. Cont'd.

S.NO	DATE YR	MO	DT	PH	TEMP. DEG C	ALKAL-INITY	DISS. OXYGEN	AMMONIA NITROGEN	KJELDAHL NITROGEN	BOD TOTAL	BOD SOL.	COD TOTAL	COD SOL	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	PHOSPHOROUS	FECAL COLI	TOTAL COLI
D01	76	4	6	7.1	18.0	62	8	.0	10.6	23	0	0	34	0	0	0	2000	7000
D02	76	4	6	7.5	18.0	180	9	.0	9.6	66	32	52	28	76	0	0	4000	9000
D03	76	4	7	7.4	19.0	79	8	.0	12.0	53	26	161	47	62	0	0	7000	17000
D04	76	4	8	7.5	19.0	56	9	1.3	9.0	64	24	150	19	118	0	0	6000	12000
D05	76	4	9	7.5	19.0	64	8	.0	11.0	39	22	149	25	82	80	0	8000	18000
D06	76	4	10	7.5	19.2	0	10	.2	12.0	71	19	269	250	150	84	0	2000	7000
D07	76	4	11	.0	20.0	0	7	.3	19.0	37	15	250	106	90	0	0	2000	7000
D08	76	4	12	6.8	20.0	64	5	.3	11.0	36	12	330	217	120	94	0	3000	7000
D09	76	4	13	6.6	20.0	68	3	1.0	9.6	21	8	96	0	78	66	0	0	0
D10	76	4	14	6.5	20.0	66	3	1.0	10.0	30	5	163	75	142	36	0	6000	8000
D11	76	4	15	6.7	21.0	80	5	1.3	8.0	16	5	81	34	40	28	0	9000	11000
D12	76	4	16	6.4	20.0	145	3	2.3	16.0	13	13	121	50	63	50	0	10000	21000
D13	76	4	17	7.3	20.0	68	2	2.7	8.5	15	6	113	60	39	39	0	19000	30000
D14	76	4	18	6.5	20.0	80	2	3.3	10.0	21	14	107	66	29	0	0	17000	25000
D15	76	4	19	.0	.0	0	0	3.3	.0	28	4	127	65	48	31	0	16000	26000
D16	76	4	20	.0	.0	0	0	4.3	7.0	0	0	104	52	67	31	0	11000	0
D17	76	4	21	6.9	13.0	110	5	4.7	9.6	27	3	113	69	29	26	0	7000	29000
D18	76	4	22	6.9	20.0	84	5	5.0	7.5	13	11	115	83	29	0	0	6000	17000
D19	76	4	23	6.7	21.0	90	5	5.0	8.0	16	4	43	0	24	0	0	5000	28000
D20	76	4	24	6.6	20.0	82	6	4.0	7.0	0	0	128	77	33	29	0	7000	13000
D21	76	4	25	6.7	19.0	92	5	5.0	9.0	29	18	61	0	63	14	0	4000	8000
D22	76	4	26	6.7	18.0	76	5	6.0	10.0	35	11	0	0	47	25	0	2000	9000
D23	76	4	27	6.7	18.0	82	6	4.0	10.0	27	13	67	67	23	18	0	3000	19000
D24	76	4	28	6.6	17.0	72	6	4.3	6.9	63	6	58	48	21	8	0	27000	54000
D25	76	4	29	6.7	17.0	82	6	4.0	5.3	83	9	87	29	42	37	0	6000	27000
D26	76	5	1	6.5	18.0	66	5	3.6	8.1	45	0	82	67	26	23	0	0	0
D27	76	5	2	6.4	19.0	64	19	.0	.0	0	0	154	32	52	0	0	0	0
E01	76	5	11	6.8	22.0	56	9	.0	4.3	39	3	0	36	23	0	0	0	0
E02	76	5	12	7.1	21.0	58	6	.5	4.2	12	6	81	84	60	7	0	0	0
E03	76	5	13	7.2	21.0	56	7	.5	7.5	49	8	145	54	145	0	0	0	0
E04	76	5	14	7.1	21.0	54	8	.1	7.9	0	0	163	45	21	14	0	0	0
E05	76	5	16	6.8	19.0	59	6	.3	4.3	7	7	63	54	20	20	0	0	0
E06	76	5	17	7.0	21.0	60	8	1.5	7.6	12	8	144	99	27	25	0	0	0
E07	76	5	18	.0	21.0	58	7	2.1	1.0	0	0	0	81	36	146	104	0	0
F01	76	6	10	6.9	26.0	64	4	1.1	5.8	15	9	144	43	62	48	0	0	0
F02	76	6	11	6.6	26.0	66	4	1.3	6.8	21	9	91	33	48	0	0	0	0
F03	76	6	12	6.7	27.0	72	4	.8	6.2	59	11	232	116	83	30	0	0	0
F04	76	6	13	6.6	27.0	74	4	1.3	6.9	42	9	221	63	100	50	0	0	0
F05	76	6	15	6.7	26.0	68	4	2.0	7.5	0	0	116	53	186	78	0	0	0
F06	76	6	16	6.5	25.0	68	4	.0	5.7	16	11	74	53	0	0	0	0	0
F07	76	6	17	6.3	26.0	74	3	1.1	.0	20	6	0	0	0	0	0	0	0

TABLE D-3. Cont'd.

S.NO	DATE YR	MO	DT	PH	TEMP. DEG C	ALKAL-INITY	DISS. OXYGEN	AMMONIA NITROGEN	KJELDAHL NITROGEN	BOD TOTAL	BCD SOL.	COD TOTAL	CCD SCL	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	PHOSPHOROUS	FECAL COLI	TOTAL COLI
G01	76	7	5	6.7	28.0	100	3	1.6	5.0	27	10	89	30	0	0	0	0	0
G02	76	7	6	6.5	28.0	69	4	1.1	4.7	31	9	91	30	20	14	0	0	0
G03	76	7	7	6.8	28.0	66	4	.0	5.3	0	43	5	59	59	128	38	0	0
G04	76	7	8	6.6	29.0	70	5	.0	4.6	24	10	101	0	0	0	0	0	0
G05	76	7	9	6.4	29.0	64	4	.0	4.6	0	35	25	58	39	64	0	0	0
G06	76	7	10	6.6	29.0	48	3	.0	4.6	20	6	78	0	58	50	0	0	0
G07	76	7	12	6.5	29.0	70	4	1.1	4.3	21	10	100	60	80	0	0	0	0
G08	76	7	13	6.7	.0	64	5	.9	3.8	27	8	100	20	30	10	0	0	0
G09	76	7	14	6.8	30.0	64	5	.0	3.4	27	8	79	0	28	14	0	0	0
G10	76	7	15	6.7	28.0	70	5	.9	4.3	20	8	58	39	42	6	0	0	0
G11	76	7	16	6.7	28.0	88	5	1.3	6.2	20	8	87	39	152	56	0	0	0
G12	76	7	17	6.4	28.5	64	4	1.0	6.0	15	9	98	49	62	4	0	0	0
G13	76	7	18	6.6	29.0	70	4	.5	5.2	20	8	78	59	34	16	0	0	0
G14	76	7	19	6.4	.0	90	5	.8	5.9	18	5	88	50	18	0	0	0	0
G15	76	7	20	6.6	29.0	72	4	.7	5.0	24	8	78	66	96	16	0	0	0
G16	76	7	21	6.8	30.0	80	5	.3	4.9	18	0	85	28	116	30	0	0	0
G17	76	7	22	6.6	29.0	124	5	1.0	5.4	21	6	74	37	114	34	0	0	0
G18	76	7	24	7.5	.0	70	4	.6	3.8	12	6	65	45	0	0	0	0	0
G19	76	7	25	6.5	30.0	72	3	.4	4.4	16	3	64	37	68	18	0	0	0
G20	76	7	26	7.3	31.0	78	4	.3	.0	9	2	73	41	108	30	0	0	0
G21	76	7	27	7.1	31.0	70	6	.3	.0	21	6	57	49	84	40	0	0	0
G22	76	7	28	6.8	31.0	72	5	.4	4.7	9	5	73	44	88	30	0	0	0
G23	76	7	30	6.7	31.0	82	5	1.7	4.9	12	8	72	40	118	42	0	0	0
G24	76	8	2	.0	29.0	62	6	1.0	.0	15	1	60	20	82	42	0	0	0
G25	76	8	3	6.8	29.0	76	6	.5	3.4	9	8	27	0	54	32	0	0	0
G26	76	8	4	6.7	28.0	68	5	.2	3.2	9	6	71	51	32	32	0	0	0
F01	76	8	22	7.1	28.0	70	6	.7	4.1	0	0	51	43	32	16	0	0	0
F02	76	8	23	7.4	29.0	70	4	.4	2.8	15	2	72	47	0	30	0	0	0
F03	76	8	24	7.3	28.0	66	7	.6	2.6	9	3	58	47	46	46	0	0	0
F04	76	8	26	7.0	27.0	70	6	.6	2.9	23	9	0	0	25	0	0	0	0
F05	76	8	27	7.5	29.0	68	8	.0	2.7	16	6	78	51	26	16	0	0	0
F06	76	8	28	7.0	27.0	70	6	.2	3.2	18	3	51	0	11	9	0	0	0
F07	76	8	29	7.3	28.0	72	6	.4	2.9	0	0	61	51	36	4	0	0	0
I01	76	9	20	8.4	24.0	64	9	.1	3.5	0	0	57	38	0	0	0	0	0
I02	76	9	21	7.7	24.0	64	10	.2	3.8	17	0	57	0	42	20	0	0	0
I03	76	9	22	8.0	25.0	62	10	.0	4.1	91	82	20	6	21	19	0	0	0
I04	76	9	23	8.2	24.0	60	9	.2	4.1	12	3	109	46	21	10	0	0	0

TABLE D-3. Cont'd.

S.NO	DATE YR	DATE MO	DATE DT	PH	TEMP. DEG C	ALKAL-INITY	DISS. OXYGEN	AMMONIA NITROGEN	KJELDAHL NITROGEN	BOD TOTAL	BOD SOL.	COD TOTAL	COD SOL	TOTAL SUSPENDED SOLIDS	VOLATILE SUSPENDED SOLIDS	PHOSPHOROUS	FECAL COLI	TOTAL COLI
J01	76	10	23	.0	.0	0	0	.0	4.3	35	8	105	24	126	0	0	0	0
J02	76	10	24	.0	.0	0	0	.2	3.9	20	7	58	42	14	0	0	0	0
J03	76	10	25	7.5	13.0	64	10	.2	4.3	17	9	80	62	56	46	0	0	0
J04	76	10	26	7.5	13.0	64	10	.4	4.8	16	4	86	35	38	25	0	0	0
J05	76	10	27	7.5	13.0	65	11	.1	4.4	14	5	98	11	34	31	0	0	0
J06	76	10	28	7.6	13.0	62	11	.2	4.8	18	0	69	53	51	47	0	0	0
J07	76	10	29	7.7	12.0	60	11	.0	.0	15	3	98	46	35	23	0	0	0
K01	76	11	4	7.7	12.0	64	12	.0	.0	24	4	95	21	50	48	0	0	0
K02	76	11	5	7.6	11.0	70	12	.2	.0	23	3	134	73	0	25	0	0	0
K03	75	11	8	7.5	12.0	24	12	.1	5.2	19	11	113	63	0	30	0	0	0
K04	75	11	9	7.7	12.0	68	12	.1	6.6	25	8	118	57	37	15	0	0	0
K05	75	11	11	8.2	9.0	65	12	.1	5.8	24	2	121	74	68	62	0	0	0
K06	76	11	12	.0	.0	0	0	.1	4.9	17	9	131	51	60	38	0	0	0
K07	76	11	13	7.2	9.0	66	9	.0	9.1	32	4	123	40	93	49	0	0	0
K08	76	11	16	7.4	7.0	56	12	.1	5.6	25	11	104	48	40	37	0	0	0
K09	75	11	17	7.6	8.0	64	12	.1	5.1	20	5	108	51	56	44	0	0	0
K10	76	11	18	7.7	9.0	62	12	.1	6.9	21	1	107	47	47	28	0	0	0
K11	76	11	19	.0	.0	0	0	.1	5.6	27	14	110	56	52	42	0	0	0
K12	76	11	20	7.3	10.0	0	12	.0	5.2	25	8	120	49	56	44	0	0	0
K13	75	11	21	7.2	8.0	60	12	.0	5.9	0	0	109	76	56	38	0	0	0
K14	76	11	22	7.4	7.0	64	12	.1	4.7	24	6	125	49	44	0	0	0	0
K15	76	11	23	7.7	10.0	56	11	.1	6.9	30	6	116	52	46	38	0	0	0
K16	76	11	24	7.6	10.0	62	11	.0	6.8	11	8	108	66	62	58	0	0	0
K17	76	11	25	7.1	8.5	58	10	.0	5.6	23	5	130	59	36	26	0	0	0
K18	76	11	26	7.3	11.0	62	9	.0	5.9	50	14	130	46	66	58	0	0	0
K19	76	11	28	7.1	5.0	60	15	.0	7.3	27	0	125	0	0	0	0	0	0
K20	75	11	29	7.3	6.0	50	13	.0	5.2	11	0	99	34	36	24	0	0	0
K21	76	11	30	7.8	9.0	66	12	.0	5.4	0	12	102	42	104	28	0	0	0
K22	76	12	2	7.8	6.0	39	12	.0	5.4	15	5	103	46	42	30	0	0	0
K23	75	12	3	7.8	6.0	52	13	.0	5.4	12	3	106	67	0	24	0	0	0
K24	76	12	5	7.5	8.0	56	10	.0	5.4	0	0	89	52	30	27	0	0	0
L01	76	12	16	7.3	6.0	56	13	.4	7.4	24	16	130	51	36	4	0	0	0
L02	76	12	17	7.4	7.0	48	13	.0	7.8	29	5	116	19	44	0	0	0	0
L03	76	12	18	7.1	6.0	40	10	.0	7.3	0	0	120	41	52	46	0	0	0
L04	76	12	19	7.0	9.5	46	11	.9	19.3	14	2	89	45	26	0	0	0	0
L05	76	12	20	7.4	7.0	54	12	1.0	8.8	21	2	108	80	36	10	0	0	0
L06	76	12	21	7.4	7.0	56	9	1.4	8.2	11	0	127	75	14	6	0	0	0
L07	76	12	22	7.4	5.0	44	12	1.2	8.1	35	2	110	51	40	24	0	0	0

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-79-014 / 2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE PERFORMANCE EVALUATION OF EXISTING AERATED LAGOON SYSTEM AT BIXBY, OKLAHOMA	5. REPORT DATE March 1979 (Issuing Date)
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) George W. Reid, Leale Streebin	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of Oklahoma, Bureau of Water and Environmental Resources Research, Norman, Oklahoma 73019	10. PROGRAM ELEMENT NO. 1BC822 SOS #3 Task D-1/26
	11. CONTRACT/GRANT NO. R-803916
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory--Cin.,OH, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268	13. TYPE OF REPORT AND PERIOD COVERED Final 1/6/76-12/22/76
	14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES
Project Officer: Ronald F. Lewis, (513) 684-7644

16. ABSTRACT

The University of Oklahoma School of Civil Engineering and Environmental Science research group in collaboration with INCOG & BIXBY, have studied a well designed, well operated two cell aerated wastewater treatment lagoon system. The study involved four seasons and nineteen study parameters. The data was treated to statistical analysis, using a SPSS multiple regression, and to normative analytical expression. This report covers the BIXBY lagoon system operation period of January 1976 through December 1976.

The lagoon exhibited an overall BOD_5 removal efficiency of 92%, but was only totally in compliance for 7 months of the year. The use of several kinetic models and regression models were not very satisfactory though the temperature coefficient were in substantial agreement with Adams and Eckenfelders and other reputed values.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Waste treatment *Lagoons (ponds) *Performance evaluation *Design criteria Chemical analysis Physical tests	Aerated	13B

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