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Treatment of Cheese Processing Wastewaters In Aerated Lagoons

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TREATMENT OF CHEESE PROCESSING WASTEWATERS

IN AERATED LAGOONS

By

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Project 12060 EKQ
Program Element 1BB037
Roap/Task 21 BAD 26

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ABSTRACT

The treatment of cheese processing wastewaters in two-stage aerated lagoons was evaluated over a one year period. Aeration was provided by Polcon Corporation subsurface aerators (Helixors). The aeration system provided an average standard transfer rate of 4.0 lbs oxygen per kilowatt-hour at 20°C and 0.0 dissolved oxygen in tap water. Oxygen dispersion throughout the primary lagoon was normally adequate at a power input of 8.5 horsepower per million gallons. During the spring, however, dissolved oxygen concentrations in the primary lagoon were zero probably due to the solubilization of benthal deposits accumulated but not stabilized during the winter months. There was not sufficient power, however, to prevent suspended solids deposition. Horizontal velocity components varied from 1.0 fps within the central portion of the lagoon to less than 0.1 fps in the sloped peripheral zones. Over the one year period of this study, sludge accumulations ranged from 0 to 2 inches depending upon location.

The lagoon system performance during the one year period was correlated with temperature. The average total BOD removal was 97 percent producing an effluent BOD concentration of 52 mg/l. During the summer months secondary lagoon effluents were less than 20 mg/l, 70 percent of the time. Approximately 50 percent of the total effluent BOD was soluble. Effluent suspended solids were high, averaging 108 mg/l. Greater than 90 percent of the suspended solids were volatile. Total and fecal coliform reductions were normally greater than 99.9 percent throughout the study period.

During the early spring primary lagoon dissolved oxygen concentrations dropped to zero and remained below 0.1 mg/l until mid July. Benthal deposits, accumulated during the winter period, were believed to account for the unusually high oxygen demands during this period. Demands in excess of three times greater than predicted by the BOD load to the lagoon were noted.

Costs for lagoon operation, maintenance, and amortization were estimated to be $13,377 per year, $2.15 per 1000 gallons, $0.14 per lb of BOD applied, and $0.0033 per lb cheese produced.

This report was submitted in fulfillment of project 12060EKQ under the partial sponsorship of the Environmental Protection Agency.

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SECTION I

CONCLUSIONS

The conclusions summarized below were the result of the analysis of data collected over a one year period from the two-stage aerated lagoons treating cheese processing wastewaters for the Kent Cheese Company.

Each of the two lagoons were of equal volume and provided detention times of from 50 to 82 days each during the first year of study. The average flow to the lagoons was approximately 17,000 gpd, ranging from 7,300 gpd to 35,500 gpd. Raw influent BOD loading averaged 285 lbs/d ranging from less than 15 lb/d to 554 lb/d resulting in a primary lagoon loading of from 0.117 to 4.34 lb BOD/1000 cu ft/d.

1. Aerator Performance

    a. The oxygen transfer efficiency of the Polcon Corporation Helixors in the primary lagoon was 4.0 lbs oxygen/kw-hr or 3.0 lbs oxygen/hp-hr, for standard conditions (20°C, tap water, zero dissolved oxygen) at an air flow rate of 14.8 scfm per unit.

    b. An increase of the air flow rate by a factor of two per unit substantially reduced the oxygen transfer efficiency.

    c. The dispersion of oxygen in the primary lagoon at a power input of 8.5 hp/MG was nearly uniform.

    d. At the power input of 8.5 hp/MG, there was a tendency for suspended solids to accumulate in the peripheral regions where horizontal velocity components were normally less than 0.1 fps. The one year study was not long enough to evaluate the rate of solids accumulation within the lagoon.

    e. The relative oxygen transfer coefficient in the primary lagoon was approximately 81 percent of that expected in tap water. The oxygen saturation value in the primary lagoon content was approximately 98 percent of that in pure water.

2. Lagoon Performance

    a. An average of 97 percent removal of BOD was achieved in the two stage aerated lagoon system with the poorest performance (95 percent) occurring during the winter season. The average final effluent BOD concentration was 52 mg/l of which 27 mg/l was soluble. Probability distributions for treatment performance were prepared for the one year study.

b. Temperature had an important effect on lagoon performance.

c. Suspended solids removals in the primary lagoon were sporadic. The overall average removal of suspended solids in the lagoon system was 82 percent with an average concentration of 108 mg/l in the final effluent. Over 90 percent of the suspended solids were volatile.

d. Approximately 29% of the volatile suspended solids in the final effluent contributed to the effluent BOD. A similar relationship for the primary effluent suspended solids indicated that 46 percent of the volatile suspended solids contributed to the BOD .

e. High oxygen uptake rates occurring in the early spring resulted in zero D.O. concentrations in the primary lagoon. These high uptake rates are likely due to the solubilization of solids deposited during the winter months. The cycling of sludge accumulation during the cold periods and active biological stabilization of the benthal deposits during the warmer months will result in dynamic fluctuations in oxygen requirements and sludge deposits. Aerator sizing to account for these fluctuations must be provided. In this study oxygen demands in excess of three times the influent BOD were measured during the early spring.

f. The staging of the wastewater treatment lagoons provided considerable attenuation of the fluctuating BOD and solids concentrations in the primary lagoon effluent.

g. Total and fecal coliform reductions exceeded 99.9 percent in the two stage lagoon system without disinfection.

h. Nitrogen concentrations in the raw wastewater were low with respect to carbon. The BOD to Nitrogen ratio was 100:0.7 indiçating a substantial deficiency in nitrogen. Phosphorus concentrations were high resulting in a BOD:P ratio of 100:2.2.

i. Total phosphorus removals of 52 percent observed during the one year study may be misleading insofar as a steady state with respect to phosphorus transformations has probably not been established. Total organic nitrogen removal of 47 percent were observed. Nitrate concentrations in the final effluent were highest during the warm summer months but were less than 0.4 mg/l during the rest of the year.

3. Costs

The cost for wastewater treatment including operation, maintenance, & capital cost amortization during the first year of operation was $2.15 per 1000 gal., $0.14 per lb BOD applied, and $0.0033 per lb of cheese produced.

SECTION II

RECOMMENDATIONS

Based on the operation of the two stage cheese processing wastewater lagoons at Kent, Illinois, the following recommendations have been proposed:

1. Efforts should be made to further reduce the settleable solids input to the lagoons. These solids cause clogging problems at the inverted siphon, interfere with flow measurement and sampling at the primary lagoon, and result in increased BOD loading to the primary lagoon. Insofar as solubilization of settleable solids during the warm months has resulted in severe depressions in dissolved oxygen concentrations in the primary lagoon, every measure taken to reduce influent settleable solids will help to alleviate that problem. It is suggested that a settling tank or imhoff tank be provided ahead of the primary lagoon for this purpose.

2. The high air pressures observed during dual compressor operation suggests that the air headers and inlet orifices are undersized for the increased air flow rates. Since oxygen uptake rates during the spring and early summer exceed current oxygen transfer rates, it is recommended that investigations be made to determine the necessity for enlarging existing air piping or providing additional Helixors in the primary lagoon.

3. The increased oxygen uptake rates in facultative aerated lagoons during the spring have been reported by a number of investigators. Further investigation should be conducted to provide a quantitative estimate of this increased demand. Such a study would require data collection over a number of years at the existing aerated lagoon site.

4. Nitrogen deficiencies in the raw wastewater will normally result in poorer performance of the biological system. It is recommended that additional nitrogen be added as ammonia or urea to more closely approximate the BOD to Nitrogen ratio of 100 to 5. Comparisons in lagoon performance should be noted during this period (at least one full year) so as to evaluate the value of this supplimentation.

5. The secondary lagoon effluent structure consists of only an upturned 4 inch cast iron pipe elbow. It is recommended that this effluent structure be modified so as to provide some baffling to eliminate gross solids and scum entrainment.

SECTION III

INTRODUCTION

The evaluations and findings reported herein were supported by EPA Project No. 12060 EKQ for post-construction studies over a 12-month period to demonstrate and evaluate the use of aerated lagoons for the treatment of cheese wastes. Initially the objectives of the study included the evaluation and demonstration of the effectiveness of reverse osmosis for the reduction of BOD of cheese whey wastes. The decision was made that the reverse osmosis method would not be included in this study.

The authors of this report were not engaged to design or size the system employed, select equipment utilized or were consulted regarding the process flowsheet applicable to this wastewater treatment scheme. The authors were retained to conduct the post construction study, direct frequency of sampling, recommend analyses to be performed, and evaluate and present findings of the performance of the aerated lagoon systems for the wastes received at the treatment site under the limitations of the existing budget.

The principal objectives of this study were to demonstrate the performance of a staged aerated lagoon treatment plant utilizing the Helixor* type of submerged aeration system treating cheese processing wastes over a 12 month period of operation. Part of the evaluation was directed to the performance of the aeration equipment employed wherein mixing effectiveness in terms of liquid velocities produced, uniformity of dissolved oxygen levels and sludge accumulations could be ascertained under the conditions of operation and geometric configuration of the lagoons employed. In addition the oxygen transfer efficiency of the aeration system employed was evaluated under field conditions. A major part of this study was to determine the BOD removal rate functions for each stage of aerated lagoon treatment noting the influence of BOD loadings, temperature and seasonal variations in loading and performance obtained for this type of biological treatment. The theoretical and applied concepts of biological treatment related to low-solids aerated lagoon systems were employed to evaluate the treatment system. Lastly, the performance of this type of treatment was evaluated in terms of costs associated with the wastewater characteristics and the pounds of cheese produced.

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*subsurface aeration unit manufactured by Polcon Corporation, Montreal, Canada

SECTION IV

EXPERIMENTAL SYSTEM

The wastewater treatment system consisted of two equal volume aerated lagoons with a staged flowsheet wherein the effluent from Lagoon No. 1 is passed to Lagoon No. 2 before final discharge of the treated effluent. The lagoons had earth embankments with side slopes of 3 horizontal to 1 vertical, a water depth of 12 feet at the lowest central portion of the lagoon, and a length-width measurement of 157 feet by 123 feet at the water line for a volume of 955,000 gallons each (Figure 1). The first lagoon was provided with thirteen 6 foot long 18 inch diameter Helixors arranged in a pattern of 2 rows of 4 units equally spaced along the intersection of the flat bottom and side slopes of the long dimension of the lagoon. Five additional units were added to this lagoon between the 2 rows of four units such that 4 of the five units were equally spaced in 2 rows between the 1st and 2nd and 2nd and 3rd aeration units. The fifth additional aerator was equally spaced between the third and fourth unit of the initial eight unit arrangement (Figure 1). The second lagoon was provided with three aeration units arranged in a triangular pattern close to the inlet end of the lagoon in the lowest central section of the lagoon.

A separate blower building with two rated 240 cfm Gardner Denver rotary blowers (one standby), Model 3CDL5, provided the air supply to both lagoons. Usual operating conditions required only one compressor to be operative and it was assumed that the air flow was distributed between the two aerated ponds with an estimated 80% of the airflow supplied to Lagoon No. 1 and the remainder to Lagoon No. 2. The air flow regulation and distribution was effected by the number and size of air orifices providing air directly to each Helixor. The air header piping and valving was arranged to permit the control of air to a pair of aeration units in most instances; however, several aeration headers supplied air to a single unit. The valving in the aeration headers were used only for fully open or closed conditions wherein the inlet orifices controlled the distribution of air flow.

It appeared that the recommendation of the Polcon Corporation Specifications on concrete weights for holding down the air lines and Helixors was inadequate. An inspection of the air lines and Helixors after the initial start up period was performed in the spring of 1970 by a scuba diver determining the location of the air lines, Helixors, and concrete weights in reference to the bottom of the lagoon. It was noted that not all of the Helixors were positioned on the bottom of the lagoon. Rather, some were 18" - 24" above the bottom. Approximately 500 pounds of extra concrete weights were added to each individual lateral.

KENT CHEESE WASTEWATER LAGOONS

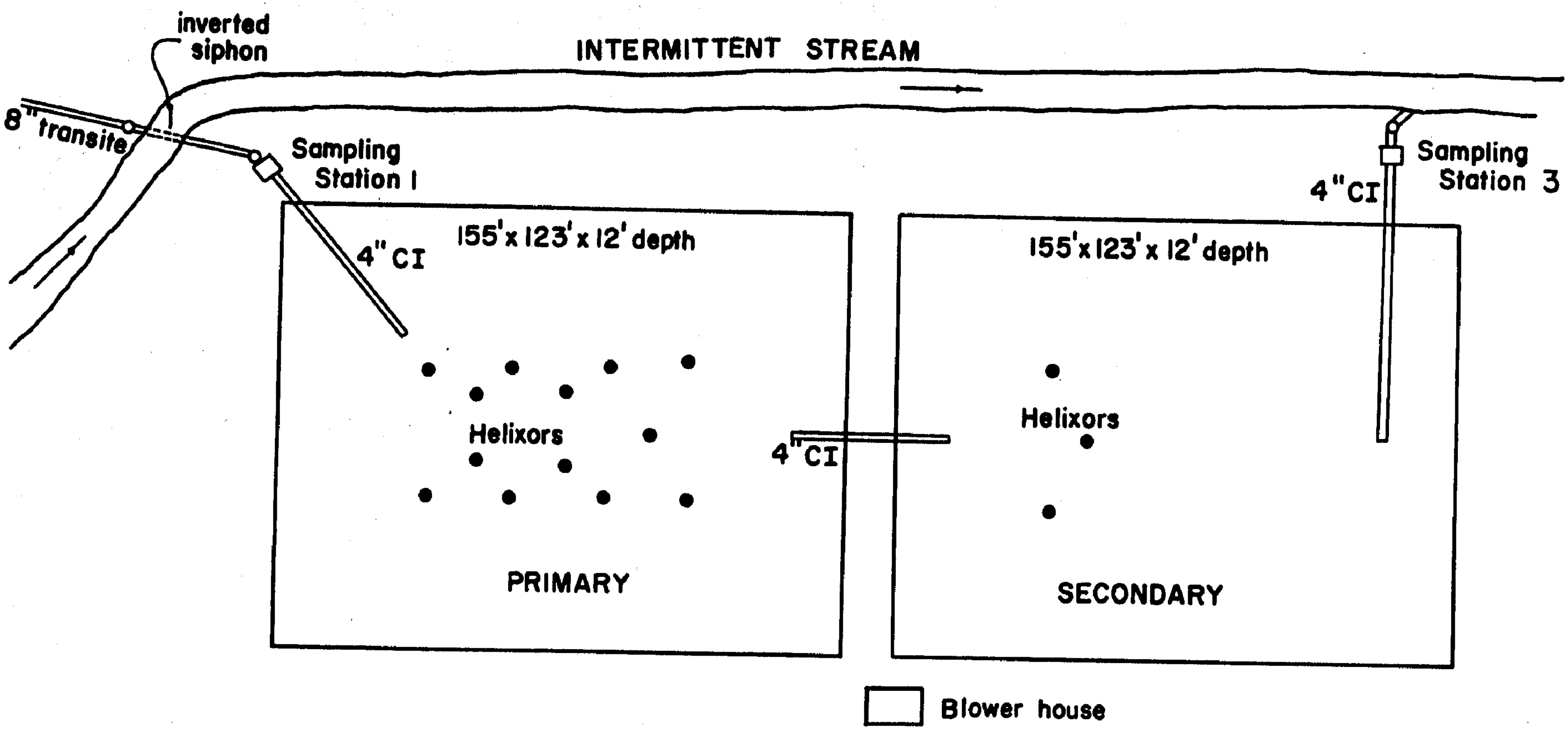


FIGURE 1

Six additional Helixors were installed as per Polcon Corporation specifications utilizing 250 pound concrete weights under each additional Helixor . These six Helixors and lines remained in their original positions.

The wastewater was conveyed to the treatment lagoons through about 3000 ft. of 8 inch transite pipe, passes through a 4 inch inverted siphon to a Snyder-Teague sampling station and thence is discharged through a 4" cast iron pipe to a point of entry to Lagoon No. 1 at approximately mid-depth. The effluent from Lagoon No. 1 passed through a submerged 4 inch cast iron pipe to the secondary lagoon. The water surface elevation in both lagoons was controlled by the placement of 4 inch cast iron riser pipe with the inlet to this pipe, or overflow from the lagoons, at a fixed elevation to maintain the 12 foot water depth. The effluent from the secondary lagoon passed through another Snyder-Teague sampling station.

The sampling stations provided flow measurements and flow composited samples for the raw waste water and treated effluents. Serious operating difficulties resulted in the raw waste sampling station due to the accumulation of cheese solids upstream from the flow measuring control section. The sampling device operated on the basis of taking a fixed volume aliquot on the discharge side of the flow measuring weir. The sampling device was activated by the water depth on the upstream side of the flow measuring weir; consequently, when the upstream float was supported by accumulated solids in the absence of influent flow, the sampling device was activated but no wastewater aliquot could be collected for the composite sample at these times. Thus, the composited sample for quality determination was considered to be reliable, whereas the flow measurements required correction.

The accumulation of solids resulted in inaccurate flow measurements. The control section was modified somewhat but proved to present difficulties throughout the period of the study. In order to obtain reliable measurements of flow, it was necessary to meter water use at the cheese processing plant and to determine boiler feedwater requirements and the extent of infiltration of the conveying sewerage system for reliable flow information. Routine measurements of water pumped at the cheese processing plant were made throughout the post construction study. The well pumps were calibrated and clocks were employed to record total water used. Boiler feed water was also monitored routinely. Only after considerable effort had been exerted to correct the installed flowmeters at the lagoon site was it determined that corrected water use data would have to be employed for flow estimates to the lagoons. At that time infiltration studies were conducted over two weekends, Dec. 4-5 and Dec. 18-19, 1971, to provide an estimate of this flow contribution. During these two periods infiltration rates of approximately 690 and 900 gal/d were measured. The pipeline conveying the cheese process waters to the lagoon system was constructed in 1969 and employed a 12 inch diameter Armco truss pipe with chemical band joint. The manufacturer estimates a maximum infiltration rate with this type of construction of 100 gal/inch diameter/day. This would result in a value of 875 gal/day based on 3,860 ft of 12 inch pipe. An average of 800 gal/d correction was employed to all water use data recognizing that this value would undoubtedly fluctuate with season. The corrections that were employed are tabulated in Appendix C.

A sampling station was not provided between the primary and secondary lagoons; thus, grab samples of the primary lagoon contents were taken near the effluent discharge pipe. Because of the long detention times experienced in each lagoon, 45-75 days, this procedure was deemed acceptable.

An aerial photograph of the wastewater treatment system appears in Figure 2.

FIGURE 2

AERIAL PHOTOGRAPH OF LAGOON SYSTEM

SECTION V

PROCEDURES

The treatment system handled the wastewater from a cheese making industry specializing principally in products of Ricotta, Parmesan, Romano, and Mozzarella cheese. The sources of wastewater were primarily from rinses and washes associated with the storage of milk, transmission lines, vats and pasteurizer with a limited amount of wastes of domestic origin. The by-product whey was collected and transported to another site for recovery and only whey wastes associated with washing and rinsing were discharged to this treatment system. The sources of wastewater treated by the aerated lagoon system are shown in Figure 3. The quantity or quality of rinsewater from each operation was not determined in this study, but rather the collective properties of the total discharge to the lagoon system were determined.

Certain measurements were made daily for operation of the treatment works such as D.O., pH, alkalinity, settleable solids, temperature, and flow quantity whereas more detailed analyses for evaluating the performance of the treatment system were obtained for raw wastewater influent, primary lagoon contents near effluent structure, and secondary lagoon effluent on an eight day sampling frequency. This permitted each day of the weekly operation to be sampled every 56 days throughout the one year study commencing on January 14, 1971. A sampling schedule is outlined in Table 1. All the analyses indicated in Table 1 were performed by Corning Laboratories, Inc., Cedar Falls, Iowa. After sample collection, appropriate volumes of well mixed sample were placed in separate sample bottles for coliform determination, for nitrogen and phosphorus analysis, and for BOD and solids analysis. Nitrogen and phosphorus samples were preserved with mercuric chlorides as prescribed by Methods of Chemical Analyses (1). Samples were shipped immediately after collection to the Corning Laboratories, Inc. where analyses were initiated no more than 10 to 12 hours after collection. The lagoon system had been in operation approximately eight months prior to initiating the sampling program; thus, the data presented does not represent start-up conditions, but there were indications that the performance did not reach steady state in all respects particularly regarding seasonal variations.

FIGURE 3

SOURCES OF CHEESE PLANT WASTEWATER

R-W-R — 3-tanks; 2- 37,000 over the road tankers

R-W-R — 2" S.S. CIP Lines and pump

R-W-R — 2 - 6,000 Gallon / 1 - 10,000 Gallon Storage tanks

R-W-R — 2" S.S. CIP Lines and pump

R-W-R — Pasteurizer - Clarifier pump

R-W-R — 2" S.S. CIP Lines

R-W-R — 5 - 12,000 Pound vats; 3 - 6,000 Pound vats

Cheese

RWR — Ricotta, Romano, Mozzarella, Parmesan

RWR — Hoops-Press

RWR — Whey collection tanks

RWR — Cheese drainage tables

RWR — Packaging tables

RWR — Plant floor

RWR — Cooler Floor

Whey

RWR — 2" S.S. CIP trans lines

HW — Separator

HW — 2" S.S. lines

RWR & HW — Storage Tanks

RWR — 2" S.S. CIP lines

O/R tankers to whey processing plant

RWR = Rinse - Wash - Rinse
HW = Hand Wash
CIP = Cleaned - in - Place
O/R = Over the road tanker
Water Supply = 1/2" diameter hose
60 psi Pressure
Hot Water = Supply provided by steam/water
mixers - air flow 25 GPM

Domestic Waste
20 employees

Company Residents

TABLE 1

SAMPLING SCHEDULE*

Sampling Frequency	Parameter or Determination	Sampling Points: Raw	Primary Effluent	Secondary Effluent
8 days	BOD 5 day 20°C Total	X	X	X
8 days	BOD 5 day 20° Soluble**	X	X	X
8 days	Total Suspended Solids	X	X	X
8 days	Total Volatile Suspended Solids	X	X	X
8 days	Total Coliforms	X		X
8 days	Fecal Coliforms	X		X
30 days	Total Phosphorus	X		X
30 days	Total Kjeldahl Nitrogen	X		X
30 days	Nitrate Nitrogen	X		X

*Analyses performed according to Methods of Chemical Analysis (1)

**Analysis performed on sample filtrates (Whatman #42 filter paper)

Additional operating and performance evaluations were performed during the experimental period including the following items:

1. D.O. measurements with respect to horizontal and vertical control in the primary lagoon,
2. measurements of velocity in the horizontal plane at various locations and depths within the primary lagoon,
3. measurement of oxygen uptake of the treatment lagoon contents,
4. determination of the oxygen transfer coefficients of α and β to enable the evaluation of the aeration system employed.

Various other operating conditions and observations were recorded on a routine basis to assist in the overall evaluation of the performance of this treatment system (Appendix C).

Special measurement techniques employed for the purpose of evaluating the aeration system employed a grid established in the primary lagoon above the water surface to provide a measuring base for horizontal control. At the time oxygen transfer was evaluated, it was necessary to have a measureable D.O. in the lagoon and evidence that the D.O. was maintained at a uniform or steady state condition. The oxygen uptake or demand of the lagoon contents were determined by taking a number of representative samples of the mixture under aeration and placing them in bottles capable of excluding further oxygen transfer from the atmosphere and wherein the decrease in D.O. concentration was measured with respect to time with a Yellow Springs Instrument D.O. probe. In order to evaluate the influence of photosynthetic plankton on the oxygen transfer in the lagoon, oxygen uptake measurements were made both on rates observed under light and dark conditions. There was no discernible difference in the rates observed which indicated that oxygen transfer or supply from this source was negligible during the test periods.

Aerator efficiency was determined on the basis of line to water for the complete aeration system wherein power input was metered in each instance for amperage and voltage drawn. The results were presented in terms of pounds oxygen transferred per kw-hr. Thus, the reported efficiency included oxygen transferred from the atmosphere as well as oxygen transferred by virtue of the aeration system employed.

Aeration efficiencies were corrected to standard conditions of zero dissolved oxygen and 20°C with appropriate corrections for α and β. Representative samples of the lagoon contents were tested in Madison laboratories in a simulated diffused air system to compare transfer capacities (α) for the waste mixture against tap water for two replicate samples. The value α was obtained as an average of the ratio of the transfer rates in the wastewater and tap water. The value β was determined on the basis of the highest D.O. obtained in the aerated lagoon contents for a given temperature, checked by the Winkler D.O. method, against the D.O. at saturation for tap water at the same temperature.

The velocity profiles in the aerated lagoon were made with the use of a Gurley Current Meter which was fixed in the horizontal plane by attachment to a vertical rod. The current meter was rotated in the horizontal plane at a predetermined depth and the maximum velocity and direction were noted to obtain a vectorial representation of the water movement in the lagoon. The velocity was observed in four directions parallel to the sides of the lagoon in the central portion of the aerated lagoon where a single maximum velocity component was not observed due to the highly undirected flow patterns evident within the area bounded by the aeration devices. An attempt was made to measure the vertical velocity component immediately above the discharge of the aeration device but the variation in fluid density as a result of high levels of air entrainment caused on the measurements to be somewhat erratic. Measurements were made one foot below the surface, mid-depth and one foot from the bottom.

SECTION VI

RESULTS AND DISCUSSION

Aerator Performance

The performance of the Polcon Corporation subsurface aerators (Helixors) was evaluated over the one year period in the primary lagoon only. As indicated earlier, the lagoon was sampled at a number of points on a grid (Figure 4) at selected depths to determine the oxygen uptake rates, dissolved oxygen concentration, and temperature. Tests were repeated five times over the grant period in order to evaluate performance under different waste loading and environmental conditions.

Oxygen Uptake Rates - The average oxygen uptake rates recorded in the primary lagoon over the one year study period are presented in Table 2. The values reported represent the average uptake measured at a number of selected points within the lagoon (see Appendix A). Normally, the uptake rates measured on any given day were within 10 percent of each other. The uptake rates reported were not converted to specific uptake rates (mg O_2/gVSS/day) since the volatile solids fraction measured in this lagoon was not well correlated with the active biomass during the study period. Large amounts of suspended volatile matter non-biological in origin associated with the wastewater contributed significantly to the total volatile fraction measured. The influence of algal cells on the oxygen uptake rates in the primary lagoon were negligible as measured by both dark and light bottle uptake rates.

Examination of the uptake rates presented in Table 2 suggest that the biological activity in the primary lagoon was comparable to other aerated lagoon systems (2). The analysis obtained in May, 1971, occurred during the anaerobic period and indicates that the lagoon was extremely active. As discussed later, this high rate of oxygen consumption was believed to be due to the rapid solubilization of organic matter and synthesized cells which had settled in the lagoon and had subsequently been stored over the cold winter months.

Oxygen Transfer Capacity - The values of the oxygen transfer capacity of the primary lagoon contents, as measured by the ratio of the oxygen transfer coefficients in the waste to that in tap water, are reported in Table 3 as alpha. These values represent the average values obtained from several points within the lagoon. Alpha appeared to fluctuate seasonally being highest during the summer months. There was not sufficient data to establish any reliable correlations between alpha and lagoon BOD solids or temperature, but it is reasonable to assume that changes in the metabolic activity within the lagoon would result in changes in the oxygen transfer relationships.

PRIMARY LAGOON GRID

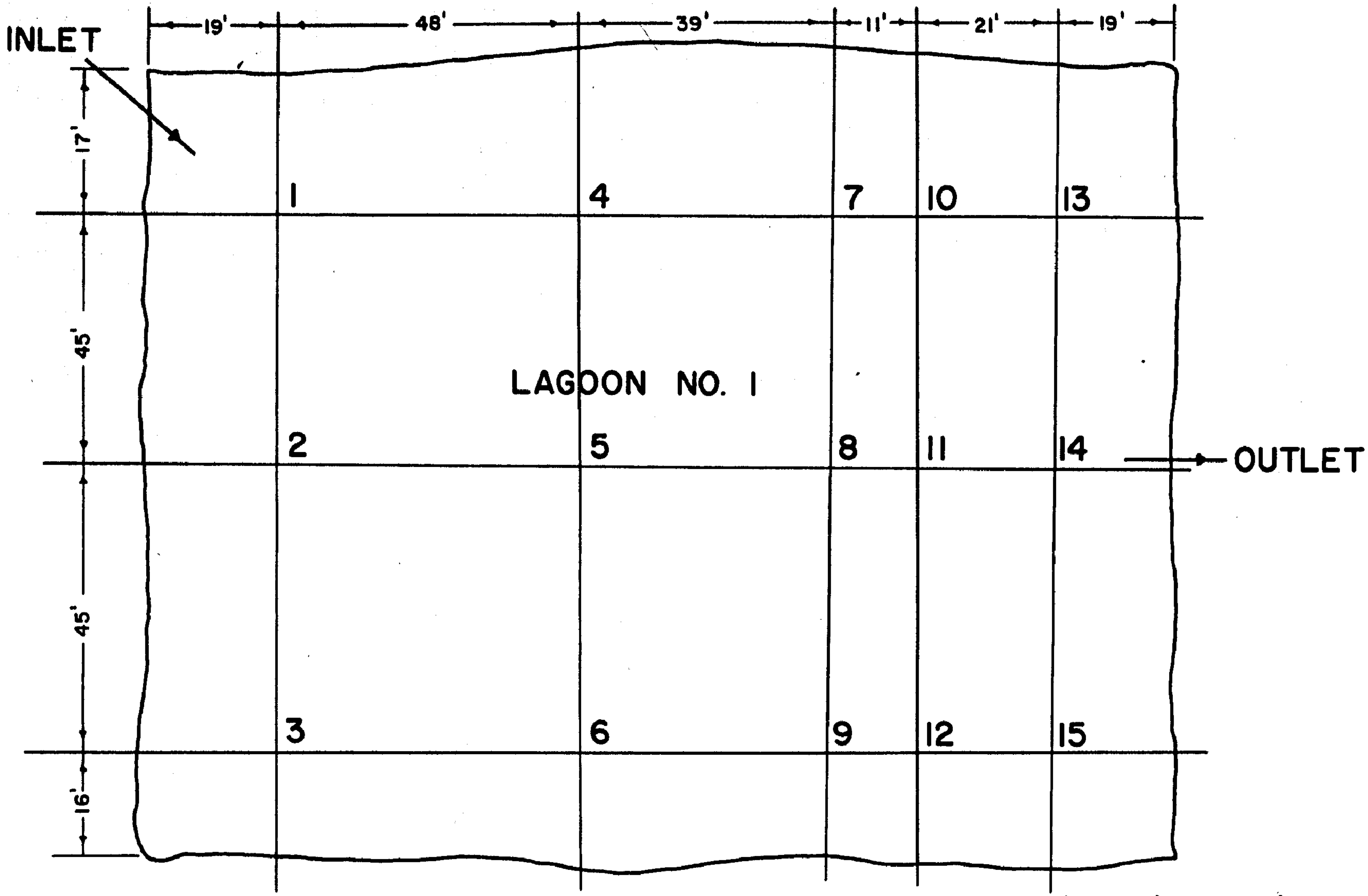


FIGURE 4

1-station numbers

TABLE 2

OXYGEN UPTAKE RATES

PRIMARY LAGOON

(Average Values)

DATE	TEMP. °C	D.O. mg/l	UPTAKE RATE mg/l/hr	lb/hr
11-19-70	6.3	2.8(43)	2.1 (5)	16.7
5-23-71	17.0	0.0(43)	5.6 (5)	44.6
7-21-71	24.0	4.4(39)	1.2 (4)	9.55
8-26-71	23.5	4.4(27)	0.8 (4)	6.4
10-7-71	16.5	2.3(41)	1.5 (3)	12.0

( ) - Number of samples analyzed (see Appendix A & Table 4)

TABLE 3

OXYGEN TRANSFER DATA

PRIMARY LAGOON

DATE	TEMP. °C	D.O. mg/l	α	β	STD. TRANSFER[1] lb/kw-hr	lb/hp-hr
11-19-70	6.3	2.8	0.75	0.96	5.25	3.91
5-23-71	17.0	0.0	0.88	0.96	----	----
7-21-71	24.0	4.4	0.90	0.98	3.18	2.47
8-26-71	23.5	4.4	0.94	0.98	0.98	0.73
10-7-71	16.5	2.3	0.70	0.98	3.45	2.59
Overall Average[2]			0.81	0.97	3.96	2.98

1 - 20°C, D.O. = 0.0, Tap water - see Appendix B

2 - Excluding 8-26-71 data for reason on page 19.

The solubility of oxygen was only slightly affected by the wastewater characteristics within the primary lagoon. Normally values of beta in long detention-type processes such as the one studied here approach 1.0.

Aeration Efficiency - The aeration efficiency of the Polcon Corporation Helixors are presented in Table 3 for five test days. The aeration efficiencies were computed by employing the measured oxygen uptake rates, dissolved oxygen concentration, alpha, beta, and temperature. Power was metered during the test period. The value of the aeration efficiency was corrected to standard conditions of 20°C, tap water (alpha and beta equal 1.0), and a dissolved oxygen concentration of 0.0 mg/l. The approximate saturation value for oxygen for the 12 foot lagoon depth was estimated by using the relationship given by Oldshue(3):

$$C_s = C\left\{\frac{P_b}{20.4} + \frac{O_t}{42}\right\} \qquad (1)$$

where C_s is the oxygen saturation value corresponding to the average partial pressure of oxygen in the gas stream entering and leaving the aerator, C is the oxygen saturation value of water at atmospheric pressure, P_b is the absolute pressure in psi at depth, d and O_t is the percent concentration of oxygen in the air leaving the lagoon. A sample calculation appears in Appendix B.

The overall aeration efficiencies in the primary lagoon were estimated by assuming that 80% of the air provided by the blower was directed to the primary lagoon, since 13 of the 16 helixors were located in the primary lagoon. During August 26, 1971, test, both blowers were in operation resulting in a doubling of the power input to the aerators. Yet the actual measureable oxygen transfer rate was not appreciably higher than for other test periods. It has been well documented in the literature (4,5) that aeration efficiency decreases with increased air flow rates and this analysis tends to verify that fact. In addition, however, it was determined that, during the operation of both compressors, the line pressures increased very significantly requiring the bleeding of air from one of the headers. This was practiced by the use of a "blow-off" or "by-pass" Helixor in the secondary lagoon. Thus, the poor transfer rates for August 26 were not included in the overall average for aeration efficiency.

The measured transfer efficiencies of the Helixor units were lower than the expected performance claimed by the manufacturer (6). Whether this was due to undersizing of the air headers, the geometry of the Helixor-basin configuration, or was, in fact, the actual field expectation for these units has not been determined but it suggests that caution must be exercised in sizing aerators for lagoon systems. An additional factor to be considered was the oxygen uptake occurring in the benthal deposit. No effort was made to ascertain what this contribution was, but significant uptake from this source would substantially increase the aeration efficiencies reported herein.

Oxygen Dispersion - An important function of aeration devices in biological processes is the dispersion of oxygen throughout the basin contents. Normally, rule of thumb criteria recommend that at least 6 to 10 horsepower per million gallons (hp/MG) be supplied to insure adequate oxygen dispersion (7). For the primary lagoon, 8.5 hp/MG were provided during the single blower operation. The results of dissolved oxygen analyses in the primary lagoon for the five field surveys are presented in Table 4. Examination of this data indicates that oxygen was well dispersed throughout the primary lagoon.

Mixing and Solids Suspension - The D.O. parameter is indicative of the dispersion of substances in the dissolved state such as soluble B.O.D. However, the distribution of particulate matter such as biological floc would be a function of the velocity distribution and the velocities necessary to keep the particulate matter in suspension. Normally in aeration tanks in wastewater treatment, velocities along the bottoms of these units would range from 1.0 to 2.0 fps depending upon the geometry of the aeration system employed. Velocity measurements within the lagoon can serve only to show flow regimes developed within the lagoon with the given aeration equipment for the placement arrangements employed and the geometry of the lagoon. Effectiveness of the system in terms of keeping particulate solids in suspension can be evaluated in a qualitative way by determining the location and extent of solids deposition on bottom surfaces of the lagoon.

The maximum velocities observed in the primary lagoon at the various depths are reported in Table 5 for one blower, 192 cfm, and two blowers, 384 cfm. These airflow rates correspond to 2.3 cfm per lineal foot and 4.6 cfm per lineal foot respectively along the longest bottom dimension of the lagoon. The vectorial representations of the resulting surface velocities are shown in Figures 5 and 6 for the single and dual blower operation.

An estimated surface wind of less than 5 mph as indicated on the diagram may have influenced the resulting velocity measurements. Because of the upward vertical velocity components in the immediate vicinity of the inlet and outlet of the Helixors and the necessary compensating downward movement of water between adjacent aeration units, no definitive flow pattern is discernible. However, in zones peripheral to the aeration section, where the bottom of the lagoon is sloped to intersect the water surface, horizontal velocities were measured near the water surface indicating a general circulation pattern towards the periphery of the aerated lagoon with velocities ranging from less than 0.1 to 0.8 fps. Likewise, to compensate for the outward movement of water toward the periphery of the lagoon near the surface, water movement must be in the opposite direction near the bottom of the lagoon, the measurements and magnitude of which was less discernible. Thus, a circulatory pattern of flow developed, in the outer prism shaped sections similar to that which is depicted in Figure 7.

TABLE 4
DISSOLVED OXYGEN CONCENTRATIONS*
PRIMARY LAGOON

Station Number

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11/19/70	2.7	2.9	2.9	2.7	3.1	2.9	3.0	2.8	2.8	2.8	2.8	2.7	2.8	2.7	2.6
1 blower	2.7	2.8	2.9	2.7	3.0	2.9	2.9	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.5
	--	2.8	2.7	2.7	3.0	2.9	2.9	2.8	2.7	2.8	2.7	2.7	2.6	2.7	--
5/14/71	0.1	0.1	0	0	0.3	0.1	0	0.3	0.1	0.1	0.3	0	0	0.1	0.1
1 blower	0.1	0.1	0	0	0.2	0.1	0	0.2	0.1	0.1	0.3	0	0	0.1	0
	--	0.1	0	0	0.2	0	0	0.1	0	--	0.3	0	0	0.1	0
7/21/71	4.4	4.4	4.4	4.3	4.3	4.4	4.6	4.7	4.2	4.8	4.4	4.3	4.9	4.7	4.4
1 blower	4.3	4.2	4.3	4.3	4.3	4.3	4.7	4.7	4.2	4.7	4.4	4.2	4.8	4.7	4.4
	--	4.2	--	3.0	4.3	4.2	4.7	4.5	4.2	4.7	4.3	--	--	--	--
8/26/71	4.1	4.3	4.7	4.3	4.4	4.7	--	4.7	--	--	4.4	--	4.4	4.5	4.5
2 blowers	3.9	4.6	--	4.3	4.4	4.7	--	4.6	--	--	4.4	--	4.4	4.5	--
	--	3.0	--	4.4	4.5	4.7	--	4.6	--	--	4.5	--	--	4.5	--
10/7/71	2.2	2.2	2.7	2.3	2.3	2.4	2.3	2.4	2.3	2.3	2.1	2.3	2.4	3.0	--
1 blower	2.0	2.1	2.7	2.4	2.3	2.4	2.3	2.2	2.3	2.3	2.1	2.3	2.3	2.6	--
	2.1	2.0	--	2.3	2.3	2.4	2.3	2.2	2.3	2.3	2.1	2.3	2.3	2.5	--

*D.O. values in mg/l at 1 ft
3 ft
5 ft below water surface

TABLE 5

VELOCITY DISTRIBUTIONS IN PRIMARY LAGOON

November 7, 1971

Station	One Compressor			Two Compressors		
	Surface*	Mid Depth	Bottom**	Surface*	Mid Depth	Bottom**
1	0.1	0.0	0.0	0.0-0.2	0.0-0.2	0.0
2	0.1-0.2	0.0	0.0	0.1-0.2	0.0-0.1	0.1-0.2
3	0.0-0.1	0.0-0.1	0.0	0.2-0.3	0.2-0.3	0.0-0.1
4	0.4	0.1	0.0	0.6-0.8	0.3-0.4	0.1-0.2
5	0.2-0.5	0.2-0.3	0.1	0.2-0.6	0.2-0.3	0.0-0.2
6	0.1	0.0	0.0	0.0-0.2	0.0-0.2	0.0-0.1
7	0.2	0.0	0.0	0.4-0.5	0.0-0.2	0.0-0.1
8	0.5-0.8	0.2	0.2	0.8	0.2	0.2
9	0.1	0.0	0.1	0.2	0.1	0.1
10	0.0	0.2	0.0	0.4-0.5	0.0-0.1	0.0
11	0.3	0.2	0.1	0.3	0.2	0.1-0.2
12	0.1	0.0	0.1	0.1	0.1	0.0
13	0.2	0.0	0.0	0.2	0.0	0.0
14	0.2	0.1	0.0	0.2	0.0	0.1
15	0.0	0.0	0.0	0.1	0.0	0.0

All values of velocity in ft/sec.

* One foot below
**One foot above

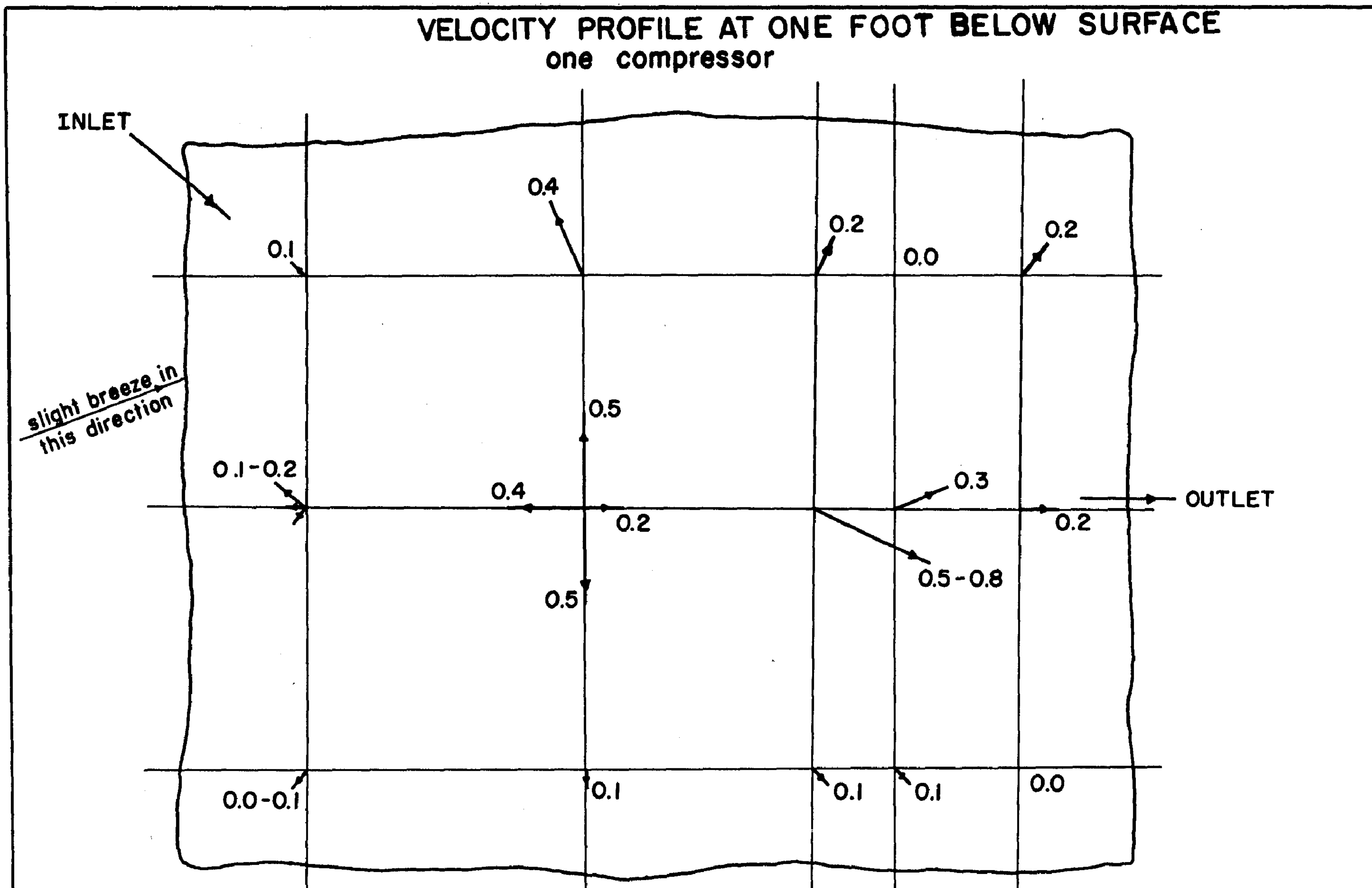

VELOCITY PROFILE AT ONE FOOT BELOW SURFACE
one compressor
INLET
slight breeze in this direction
OUTLET
0.1
0.4
0.2
0.0
0.2
0.5
0.1-0.2
0.4
0.2
0.3
0.2
0.5-0.8
0.5
0.0-0.1
0.1
0.1
0.1
0.0
0.1 fps = 1/8" of vector
Date Nov. 7, 1971

FIGURE 5

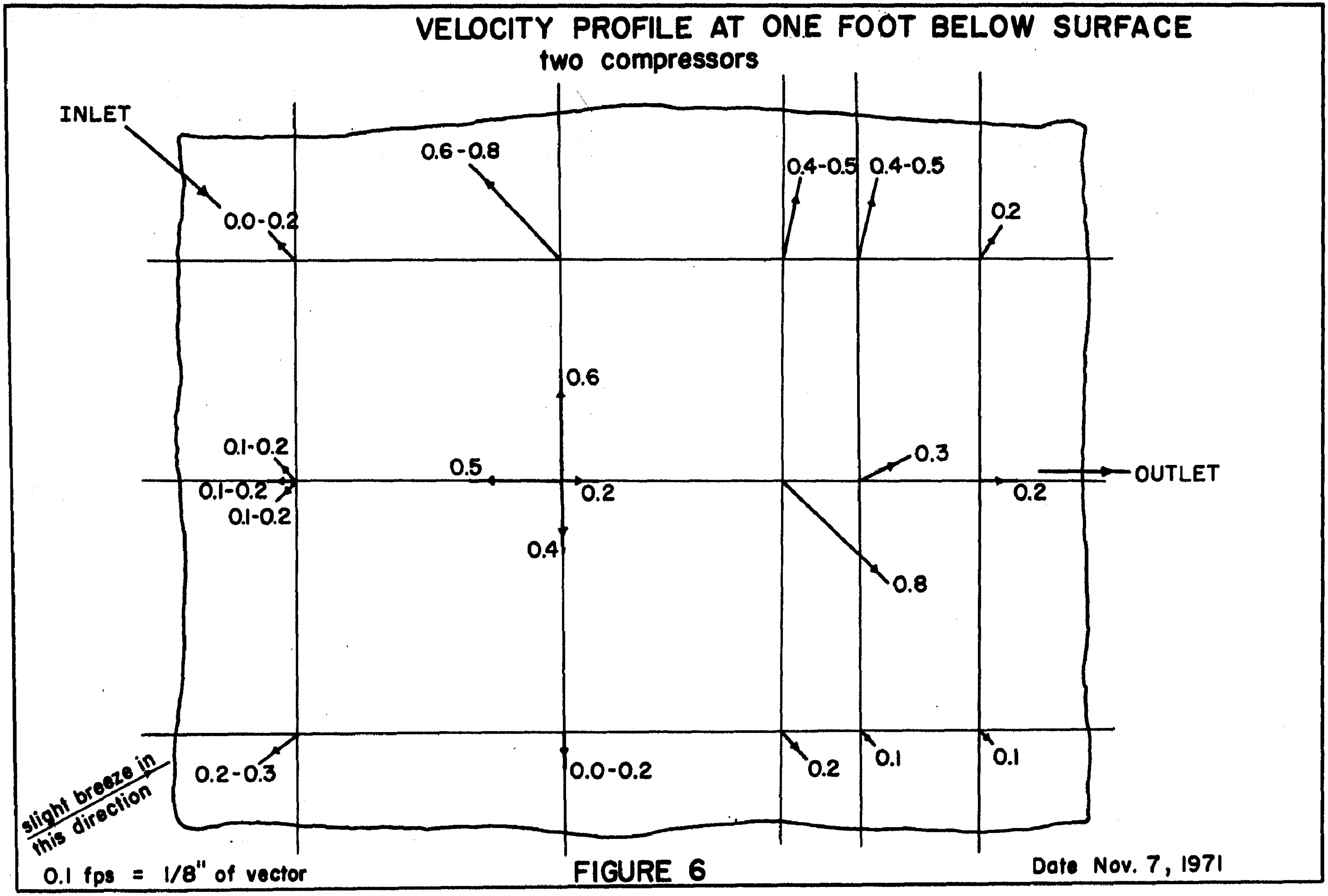

VELOCITY PROFILE AT ONE FOOT BELOW SURFACE
two compressors
INLET
0.0-0.2
0.6-0.8
0.4-0.5
0.4-0.5
0.2
0.6
0.1-0.2
0.1-0.2
0.1-0.2
0.5
0.2
0.4
0.3
OUTLET
0.2
0.8
0.2-0.3
0.0-0.2
0.2
0.1
0.1
slight breeze in this direction
0.1 fps = 1/8" of vector
Date Nov. 7, 1971

FIGURE 6

AERATED LAGOON NO. 1 - SOLIDS DEPOSITION

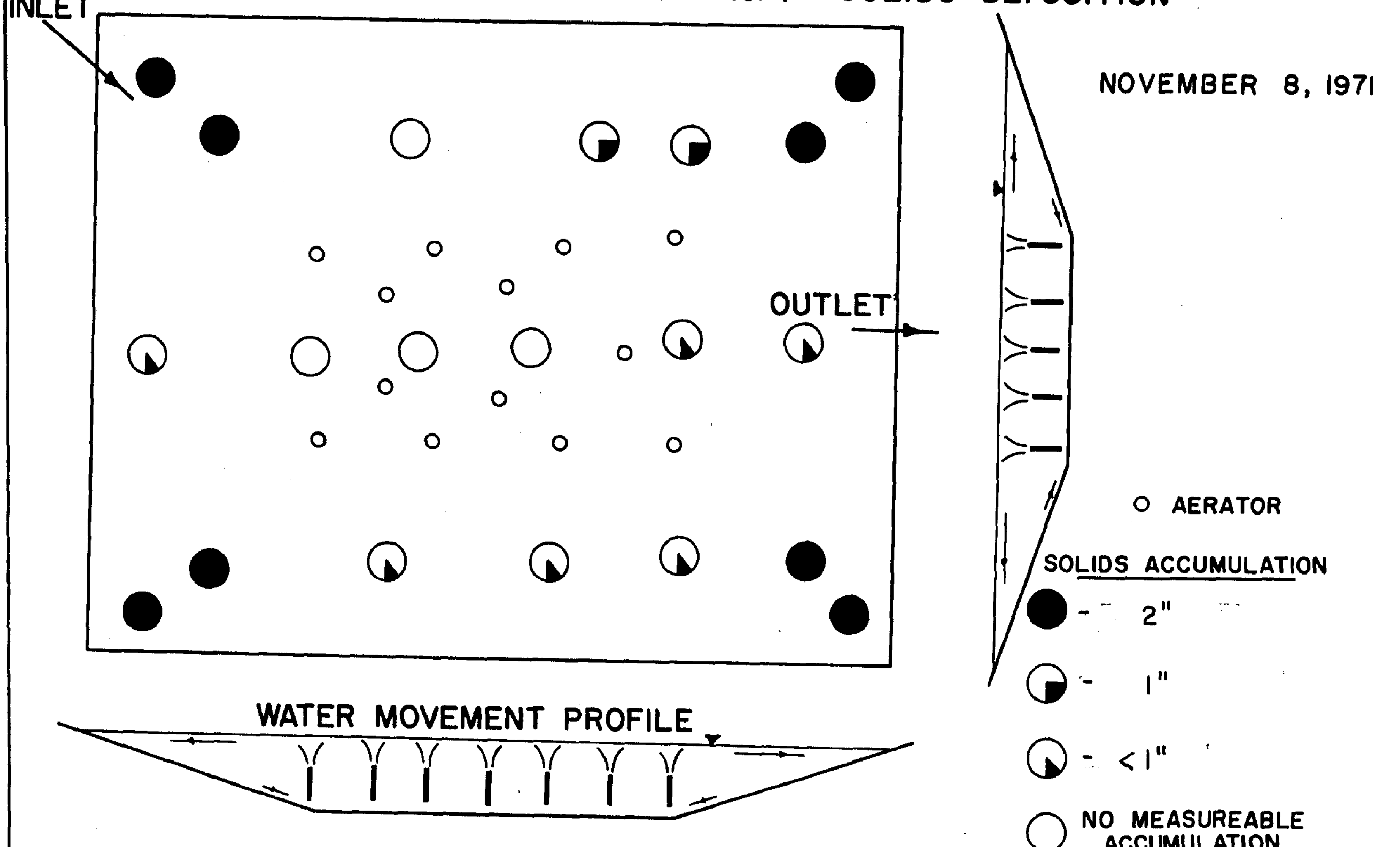


FIGURE 7

Perhaps a more meaningful observation that was made to ascertain the ability of the aeration system to keep solids in suspension was to estimate the accumulation of solids on the lagoon bottom. Utilizing a D.O. probe, a crude estimate of the sludge accumulation was made by lowering the probe to an elevation where the D.O. decreased to zero. This elevation was compared with that where a weight would come to rest, a point which was presumed to be at the bottom of the lagoon. The results were plotted qualitatively by the graphical representations for deposit as shown in Figure 7. It is noted that the greatest accumulation reported on November 8, 1971, almost two years after lagoon operation, occurred in the non-aerated zones of the lagoon corresponding to the tapered prism sections representing sloped sections of the lagoon nearest the intersection of the two adjacent sloped bottom sections. The least discernible deposits of solids occurred in the central aeration zone which may be due either to the higher levels of fluid turbulence to keep the solids in suspension or due to the greater diffusion of oxygen in the lighter accumulations of sludge at these points. For longer periods of treatment plant operation, it is likely that greater accumulations will occur. However, at the time the determinations were made, it would appear that the accumulation of solids would not present a serious problem for this system.

Aeration System Operation - Maintenance of low ambient temperature in the compressor building during the months of July and August required the installation of a fan to maintain an equilibrium temperature between the inside and the outside of the building. During the extreme cold months of the winter, when the temperature of the water drops to approximately 4 degrees Centigrade, the brake horsepower of the fifteen horsepower motor climbed to 18-19 brake horsepower. This problem was corrected by utilizing the six extra Helixors that were initially installed to discharge the air whenever two compressors were required to be in operation in order to maintain residual dissolved oxygen in the springtime. This problem of increased brake power could also be handled by replacing the fifteen horsepower motors with twenty horsepower motors in this particular situation.

The recommendations of Polcon Corporation for stainless steel clamps with the ends bent over has proven to be inadequate. Since January, 1971, three Helixors have floated to the top because of the stainless steel clamp vibrating loose. A type of bolt-nut clamp with the threads damaged after the connections have been made would prevent the nuts from vibrating off the bolts.

Lagoon Performance

The performance of the staged lagoon system was interpreted in terms of several measured parameters: BOD (total and soluble), suspended solids, nitrogen, phosphorus, coliforms (total and fecal). The results reported herein are subdivided in accordance with these parameters. Tabulated results of lagoon performance appear in Appendix C.

The loading to the lagoon system is summarized for the one year study in Figure 8. It is apparent from this figure that flow and organic load to the lagoon is quite variable over the one year period. Hourly flows over a typical 24 hour period are presented in Figure 9 for two days, January 24 and 25, 1972. Analysis of this data indicates that the ratio of maximum to average flow for the day was 1.9. The average flow rate over the 12 month study was approximately 17,000 gallons per day including Sundays.

The apparent cyclic variation in BOD and solids loading to the lagoons (Figure 8) are due to the sampling schedule employed. As noted in Table 1, samples were collected every 8 days in order to obtain data over the entire week. The flows and pollutant loads noted, therefore, represent weekly cycles. Therefore, a trend line was difficult to describe. Average BOD loading over the 12 month study was 285 lb/day and suspended solids loading was 85 lb/day. An average of 13,000 lb cheese were produced per day (excluding Sunday) requiring approximately 1.3 gallons of water per lb of cheese and resulting in 22 lbs of BOD and 6.5 lb of suspended solids per 1000 lb of cheese produced.

Biochemical Oxygen Demand - The performance of the lagoon system in removing biodegradable organic matter was measured by the five day BOD determination. Both total and filtered analyses were performed in order to reflect the influence of the pond system on actual biochemical stabilization as compared with physical separation of particulate organic matter. No long-term ultimate BOD analyses were performed nor were COD or Total Carbon Analyses; thus, the interpretation of the data in terms of mass balances of oxygen demanding materials through the system was limited.

Although the BOD load to the lagoons varied widely over the one year period of study, the most apparent influence on lagoon performance was temperature. In Figure 10, BOD load and temperature are plotted along with the primary lagoon dissolved oxygen (D.O.) concentrations. It is immediately apparent that D.O. rapidly disappeared in the spring along with rising temperatures. In fact, D.O. reached 0.0 on April 10 and did not reappear until July 19. During the remainder of July, six of thirteen days the lagoon was devoid of oxygen. Also, 11 of 31 days in August, 15 of 30 days in September, 19 of 31 days in October, 6 of 30 days in November, and 2 of 31 days in December D.O. values were less than 1.0 mg/l.

CHEESE PROCESS WASTEWATER LAGOONS

JAN 1971 - 1972

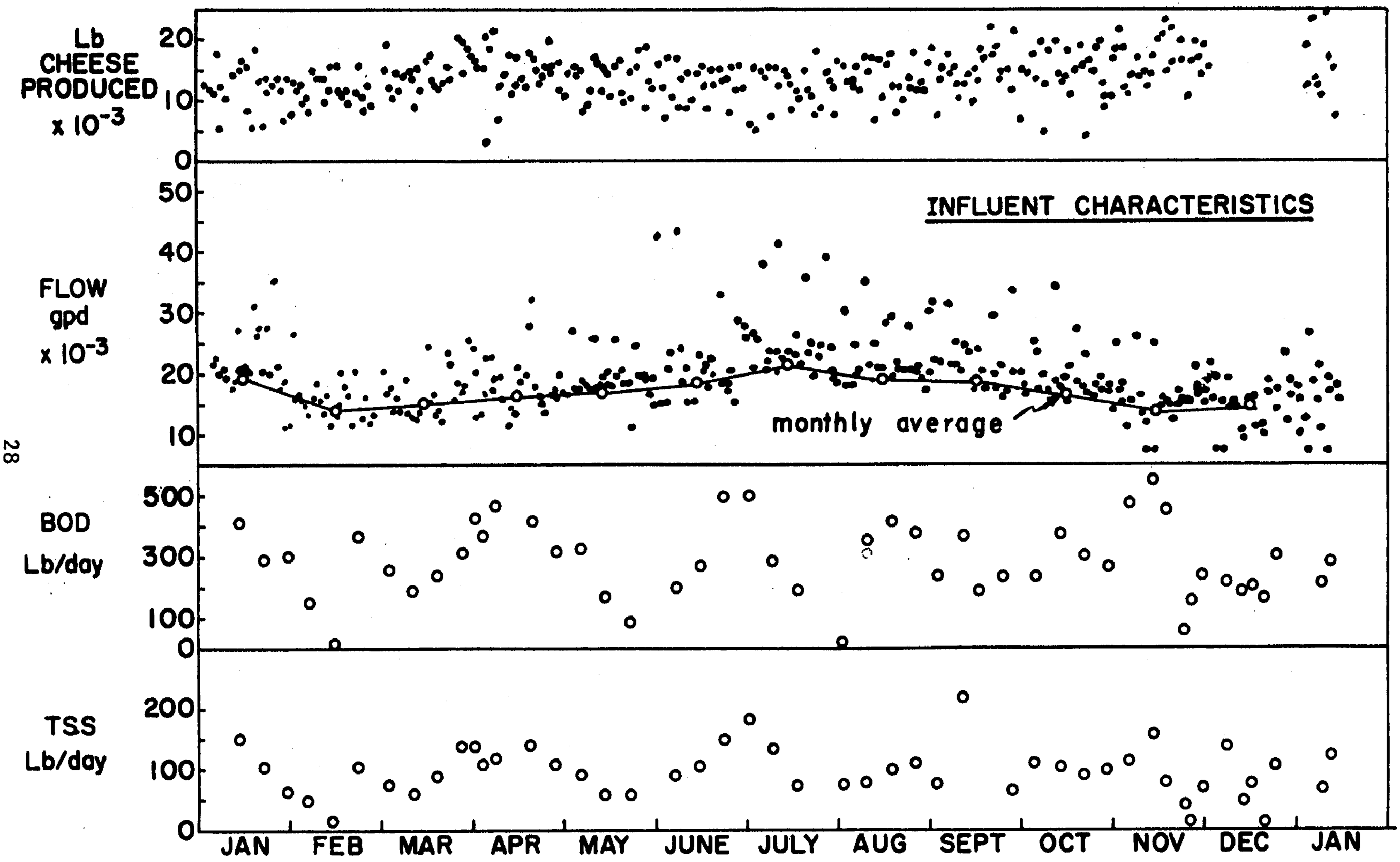


FIGURE 8

CHEESE PROCESS WASTEWATER FLOWS

JAN 1972

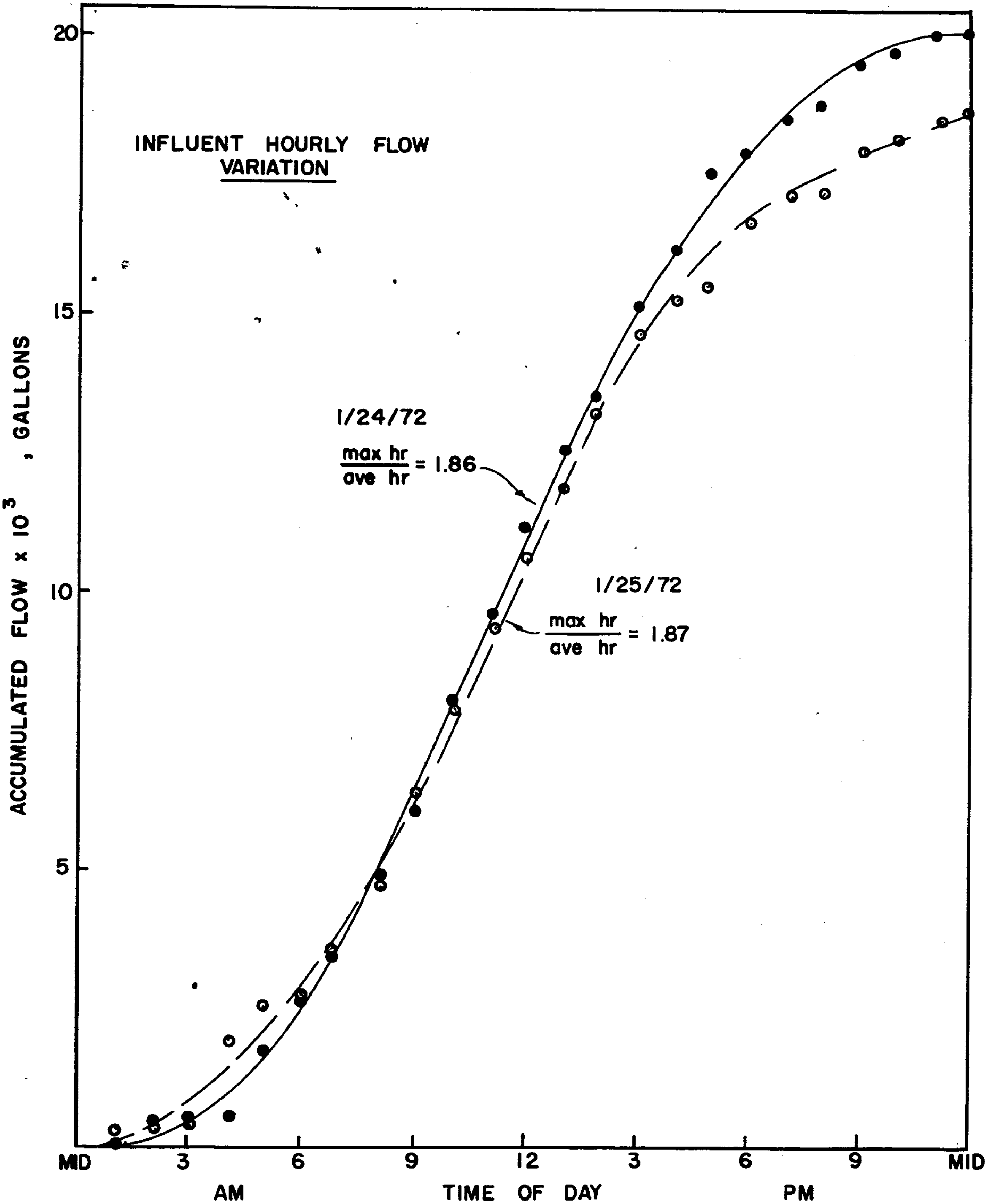


FIGURE 9

CHEESE PROCESS WASTEWATER LAGOONS

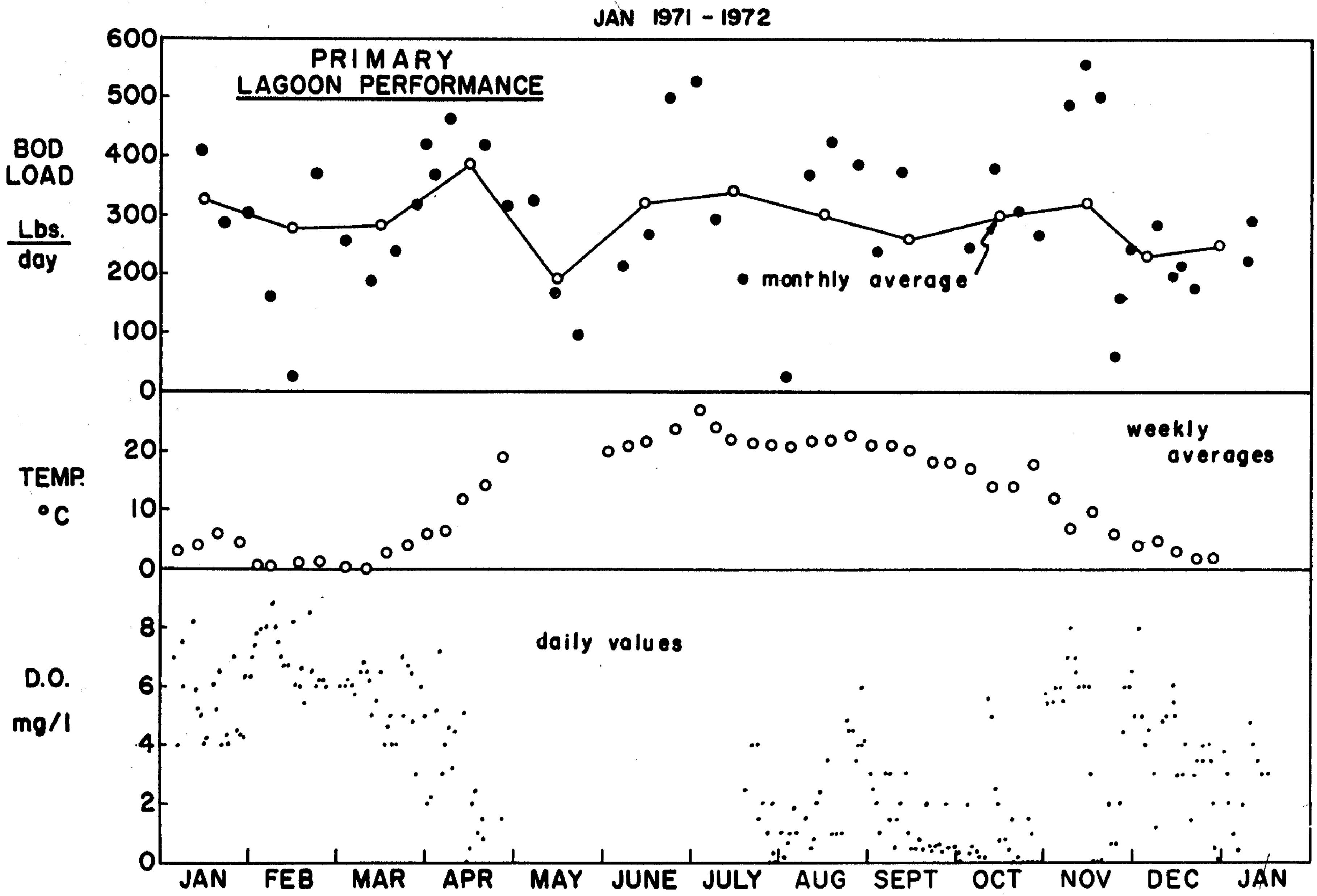


FIGURE 10

It might be assumed that this increased demand for oxygen during the spring was due to the increased biological activities brought about by the warmer temperatures. However, examination of the BOD load just preceding this period would indicate that the demands measured during this period could not be accounted for by the applied load.

For example, if one assumes that the ultimate oxygen demand is 1.47 times the 5 day value (deoxygenation constant, $k_1 = 0.1/\text{day}$), the oxygen demand for a 5 day BOD load of 285 lb/day would be 419 lb/day. The oxygen demand measured in May, during the oxygen deficient period, was 1165 lbs/day, 746 lbs in excess of that predicted above. Furthermore, if one computes the oxygen supplied during this period based on a standard transfer rate of 4.0 lbs O_2 per Kw hr., approximately 600 lbs of oxygen are transferred per day by this system at 20°C and zero D.O.

Therefore, it is reasonable to assume that significant amounts of biodegradable organics are being solubilized from the benthal deposits. During the cold months, anaerobic decomposition of the settled organic matter slows down resulting in accumulations of this material. As the temperature increases, biological activity also increases and solubilization of the benthal deposits begin to appreciably contribute to the organic load of the lagoon. This solubilization increases to a maximum value and then remains constant over the summer months. It may be assumed that this cyclic effect will continue, stabilizing the settled organic solids during the warmer periods and continue to produce both gas and soluble organic compounds.

The high oxygen demands occurring during the spring in waste stabilization lagoons has been attributed to benthal digestion by a number of investigators. Marais and Capri (8) have attempted to estimate the benthal demand in aerated lagoons. In a dynamic simulation of data collected for domestic wastewater lagoons, they showed that the rate of benthal decomposition was highly temperature dependent with an estimated value of the temperature coefficient theta of 1.35. They found that approximately 40 percent of the settled organic matter was resolubilized for the domestic waste.

The one year period of this study was insufficient to adequately quantify the benthal contribution to the lagoon organic load. The study period was too brief to evaluate the effectiveness of the anaerobic digestion in reducing accumulated sludge deposits. Steady state (or rather a quasi-steady state) may occur only after a number of years. Yet, based on this and other studies (2,8,9), it is reasonable to report that oxygen demands during the spring may exceed three times the applied BOD load.

Dissolved oxygen concentrations in the secondary lagoon were normally greater than 2.0 mg/l even during the April-July period of anaerobiosis in the primary lagoon. Only during two weeks in late June did dissolved oxygen levels drop below 2.0 mg/l and there was never a time when a value of zero D.O. was recorded. Dissolved oxygen concentrations were highest during the winter months, decreasing as oxygen uptakes increased in the spring and summer months.

The results of BOD analyses in the two lagoons appear in Figure 11 and average BOD-analyses by quarter are presented in Table 6. The removal of BOD was strongly correlated with lagoon temperatures and concomitant biological activity reaching a maximum late in the summer and early fall. Average BOD removal through both lagoons was 97.3 percent with the poorest performance occurring in the winter quarter with a value of 94.5 percent. During the 4 1/2 month period, July 1 through November 15, the effluent soluble BOD did not exceed 30 mg/l and was $\leq$20 mg/l 70 percent of the time. Examination of the probability plots for total and soluble BOD in the primary and secondary lagoon effluents (Figures 12 and 13) indicates that the distributions of effluent BOD are skewed, being bounded at the lower end by the presence of organic matter relatively resistant to biological degradation. Considerable scatter of effluent BOD is demonstrated above the 50 percentile suggesting that, even with very long detention times, the reliability of the system to produce effluent BOD concentration less than 25 mg/l at all times is very improbable.

It is of interest to note that the soluble fraction of the effluent BOD represents on an average 50 percent of the total, with the highest values occurring during the spring and summer quarters.

Lagoon Modelling for BOD Removal - The mathematical modelling of biological wastewater treatment systems has become a popular method for compacting design data into a simple and useable form. Unfortunately, the biochemical, chemical, and physical reactions taking place in biological waste treatment processes are only poorly understood and the techniques of mathematical modelling normally become curve fitting processes (10). Most popular models currently in use for biological systems include the Monod equation (11, 12, 13, 14) and first order reaction models (15, 16).

Defining the appropriate model parameters for these mathematical models requires careful experimental design in order to examine the model over a rather broad range of the independent variables. In addition, the modeler must be aware of all independent variables which will influence the outcome of the reaction.

The study conducted and reported herein was not designed to provide this kind of information. The lagoons were designed to accept the flow and pollutant load that occurred and little or no control was available. Furthermore, funds were inadequate to make meaningful measurements of both dependent and independent variables. Therefore, it would seem inappropriate to try to develop any type of sophisticated model for this system. Furthermore, until one is able to define with considerable confidence, the independent variables which will provide a model with sufficient rigor to extrapolate process performance from one system to another, there is considerable hazard in presenting any type of mathematical expression which might be used in an effort to describe another system. Thus, by use of dynamic modelling, one may employ the data appearing in Appendix C to write a model for the experimental system described herein. Yet, use of this model to describe performance of any other similar

CHEESE PROCESS WASTEWATER LAGOONS

JAN 1971 - 1972

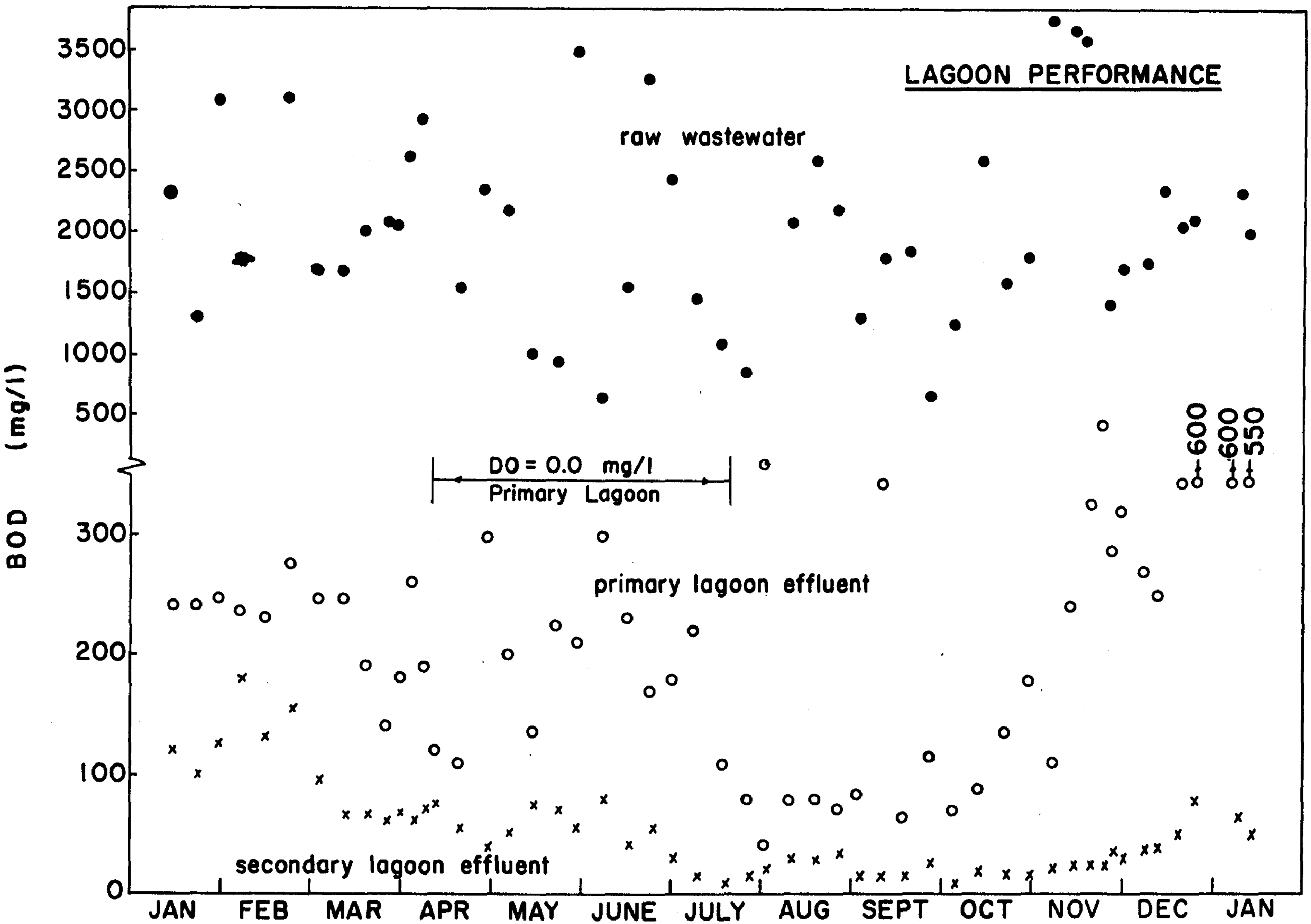


FIGURE 11

TABLE 6

AVERAGE BOD ANALYSES

Quarter 1971	Influent		Primary Effluent			Secondary Effluent		
	Total	Soluble	Total	Soluble	% R.* (Total)	Total	Soluble	% Overall R.* (Total)
Jan-Mar	1940	1060	224	49	88.5	106	51	94.5
Apr-June	2040	1110	204	45	90.0	61	32	97.0
July-Sept.	1530	870	122	37	92.0	21	13	98.5
Oct-Dec.	2100	1420	274	42	87.0	31	14	98.5
Avg.	1910	1140	209	43	89.0	52	27	97.3

All values of BOD in mg/l

*BOD Removal based on total BOD

CHEESE PROCESS WASTEWATER LAGOONS

JAN 1971 - 1972

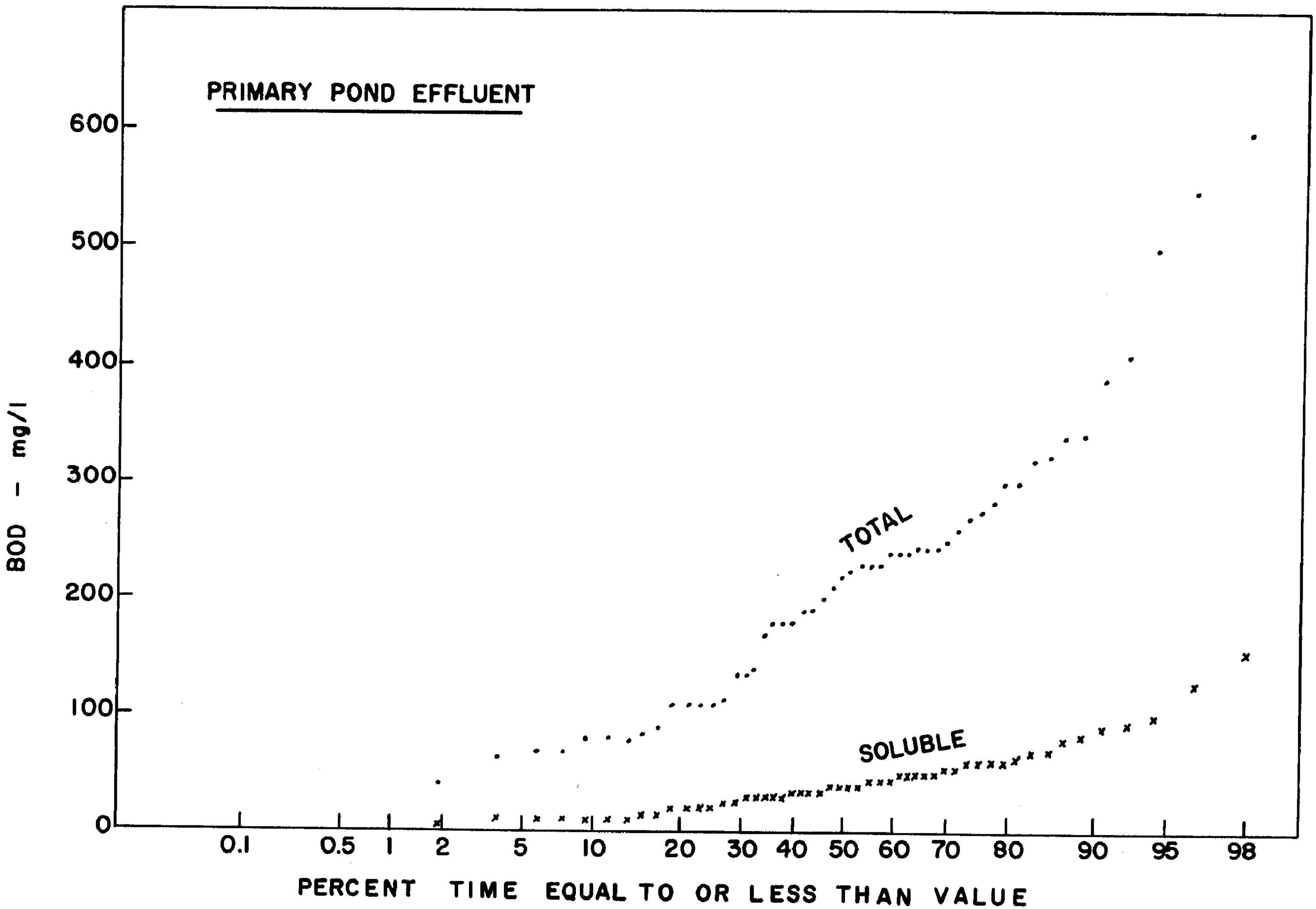
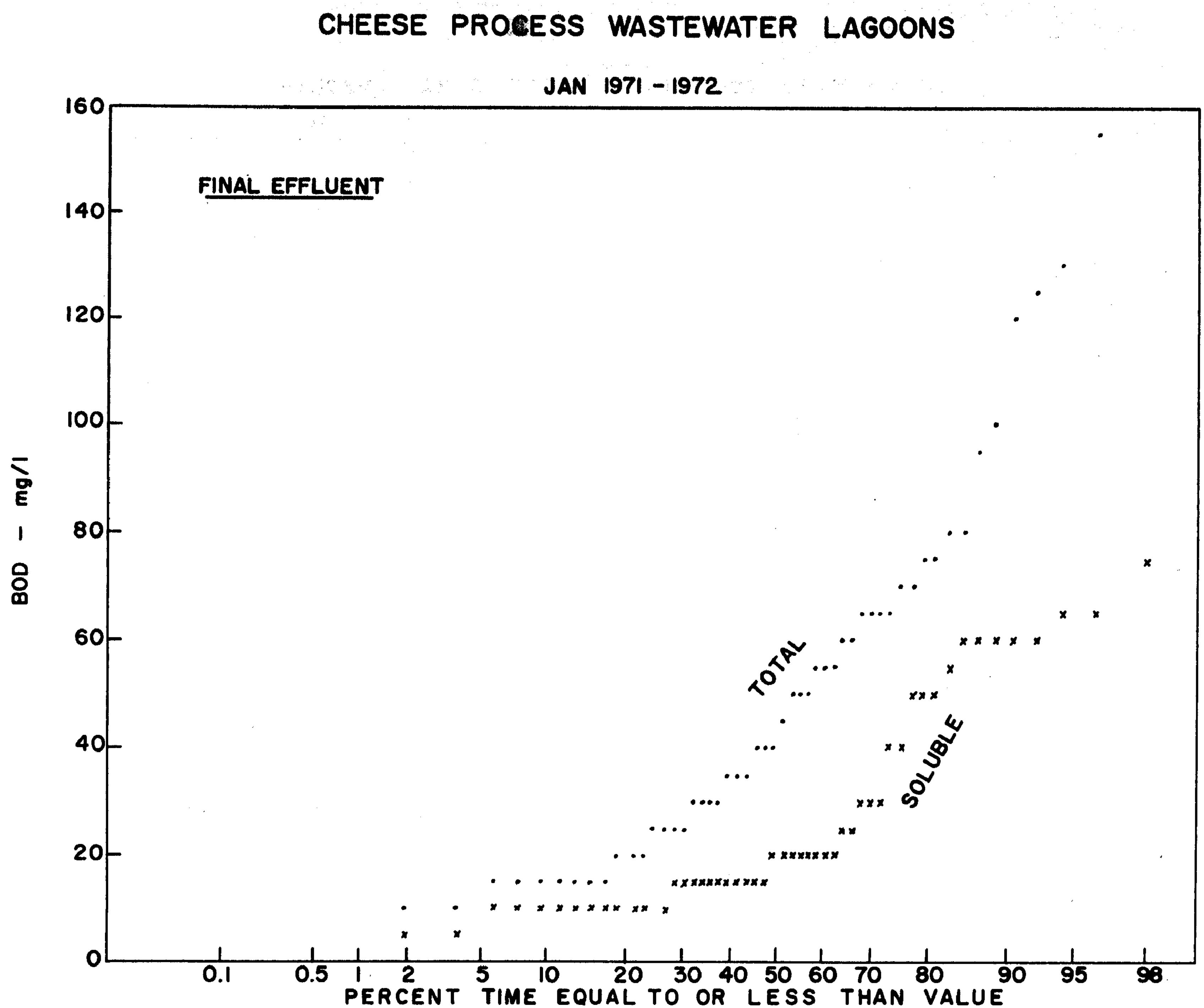


FIGURE 12



CHEESE PROCESS WASTEWATER LAGOONS
JAN 1971 - 1972
FINAL EFFLUENT
TOTAL
SOLUBLE
BOD - mg/l
160
140
120
100
80
60
40
20
0
0.1
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
PERCENT TIME EQUAL TO OR LESS THAN VALUE

FIGURE 13

system may be inappropriate unless the significant independent variables have been described.

The design parameters most often used for aerated lagoon design include BOD loading per unit volume, detention time, and BOD removal rate (usually expressed as a zero or first order kinetic parameter). For reasons stated above, a simplistic analysis of design parameters is provided. Table 7 summarizes by quarter the three design parameters most often associated with aerated lagoons.

Examination of Tables 6 and 7 suggests that BOD loadings, although increasing slightly during the summer months, are relatively uniform based on quarterly analysis. Day to day variations are of little importance in overall lagoon performance owing to the long detention periods. Note the significant increase in flow during the third quarter (July-Sept) resulting in a reduction in detention time of approximately 15 percent from the average.

The estimation of the first-order removal rate constant is of academic interest only. The assumption of completely-stirred conditions is probably reasonable for the soluble BOD fraction based on oxygen dispersion measurements, but total BOD undoubtedly is greatly influenced by the mixing patterns in the lagoon. No measurements were made to ascertain quantitatively the mixing properties of the lagoon system. A first-order reaction is also assumed, although there was no measurement made in this study to confirm it. First-order kinetics are commonly applied to lagoon systems (8,9,16). The magnitude of the removal rate constants are reasonable for this type of system. The seasonal influence on these rates are difficult to separate from the effects of increased flow rates. In any event, a temperature coefficient θ_t, defined by the relationship

$$k_{T_1} = k_{T_2} \theta_t^{T_1 - T_2} \qquad (2)$$

was estimated for the primary lagoon employing the quarterly data presented in Table 7. By solving equation (2) for θ_t, an average value for θ_t for soluble BOD in the primary lagoon was 1.015 whereas a similar value for the total BOD was 1.012. These values are substantially lower than those normally reported for aerated lagoon systems (2, 16). Efforts to calculate θ_t for the secondary lagoon were unsuccessful owing to the variation of the first-order rates calculated. It is important to note that the influence of temperature on biological processes is related primarily to changes in biochemical reaction rates. This can normally be detected through analysis of oxygen uptake rates, dehydrogenose activity, and other biochemical analyses. As stated earlier, volatile solids measurements in this study were meaningless indicators of biological activity owing to the high volatile solids of an inert nature occurring in the raw wastewater.

TABLE 7

LAGOON LOADING PARAMETERS SUMMARY*

Quarter	Flow	BOD Loading (Total/Soluble) Inf.	Prim. Eff.	Sec. Eff.	Volumetric Load Prim.	Sec.	Hydraulic Detention Time Prim.	Sec.	First-Order** BOD Removal Rate Prim.	Sec.	Temp. Prim.	Sec.
1971	(gal/day)	(lb/day)			(lb/d/1000ft^3)		(Days)		(Days^{-1})		(°C)	
Jan-Mar	14,900	270/143	31.2/6.7	14.2/7.2	2.12/1.12	0.24/0.05	64	64	0.12/0.30	0.019/-	2.2	1.0
Apr-June	17,300	285/159	35.9/7.2	10.7/5.2	2.24/1.25	0.28/0.06	55	55	0.13/0.39	0.042/0.007	17.8+	17.8+
July-Sept	20,000	300/169	26.9/8.4	4.6/2.8	2.35/1.33	0.21/0.07	48	48	0.21/0.40	0.100/0.041	21.7	21.7
Oct-Dec	15,200	284/191	35.7/8.5	4.2/8.3	2.22/1.50	0.28/0.07	63	63	0.11/0.34	0.119/0.0003	9.5	9.5
Ave.	16,900	285/166	32.4/7.7	8.4/5.9	2.24/1.30	0.25/0.06	57	57	0.14/0.36	0.05/0.005	--	--

*all values averaged from Appendix C

**$k = \frac{Lo-Le}{Le\theta}$, based on BOD assuming first-order kinetics, CSTR.

+Estimated, based on estimated temperature for May of 20°C

Suspended Solids - The performance of the lagoon system with respect to suspended solids is considerably more difficult to quantify than BOD. Influent suspended solids were high (Table 8) and contained a large fraction of organic matter. Adequate data was not available on the settling properties of the influent solids and it is apparent from Figure 14 that suspended solids removals in the primary lagoon were very sporadic. During the oxygen deficient period, primary effluent solids often exceeded the influent solids level.

Again the advantage of staged lagoon operation is evident in Figure 14 where it is noted that final effluent suspended solids were considerably more attenuated. The probability plots (Figures 15 and 16) indicate that the effluent suspended solids are not distributed normally, being rather widely scattered at the high end of the distribution. The lowest values of final effluent suspended solids occurred during the period July 1 through September 19. In this period, suspended solids concentrations were less than 50 mg/l, 60 percent of the time. The average suspended solids concentration in the final effluent was 108 mg/l of which 91% was volatile matter (Table 8). It is interesting to note that the solids discharged were predominately volatile, especially during the July through December period. Furthermore, lowest effluent solids occurred during the period when greatest algal growth was evident.

The effluent discharge structure, as noted previously, was a vertical standpipe with no baffling. This discharge pipe was used to control lagoon elevation. Although no data was available, it is reasonable to assume that baffles may more significantly reduce suspended solids discharges.

Solids Contributions to Effluent BOD - The data presented above suggests that suspended solids play a significant role in the bio-degradable organic matter discharged from the lagoons. A simple mathematical expression for this contribution is:

$$L_e(\text{total}) = L_e(\text{soluble}) + C_v S_e, \qquad (3)$$

where S_e is the concentration of volatile suspended solids in mg/l, and L_e is the total or soluble BOD in mg/l and C_v is the fraction of the volatile solids contributing to the BOD (total).

Plots of effluent insoluble BOD versus volatile suspended solids (VSS) for both primary and secondary lagoons are presented in Figures 17 and 18. Although not well correlated, there is an indication that approximately 46 percent of the VSS contribute to the total BOD in the primary lagoon. This value is high indicating that the primary lagoon solids are not well stabilized. The contribution of VSS to the final effluent BOD is also quite variable, the average value of C_v being 0.29.

TABLE 8

AVERAGE SUSPENDED SOLIDS ANALYSES

Quarter	Influent Total	Influent Volatile	Primary Effluent Total	Primary Effluent Volatile	Primary Effluent % * (Total)	Secondary Effluent Total	Secondary Effluent Volatile	Secondary Effluent % Overall* (Total)
Jan-Mar	658	614	403	335	38.6	155	143	73.4
Apr-June	600	569	477	390	20.5	119	103	80.1
July-Sept	547	520	239	197	56.3	43	43	92.1
Oct-Dec	595	565	445	377	25.2	111	110	81.3
Average	602	567	395	328	34.4	108	98	82.0

All values of suspended solids in mg/l

*Percent removal based on total suspended solids

CHEESE PROCESS WASTEWATER LAGOONS

JAN 1971 – 1972

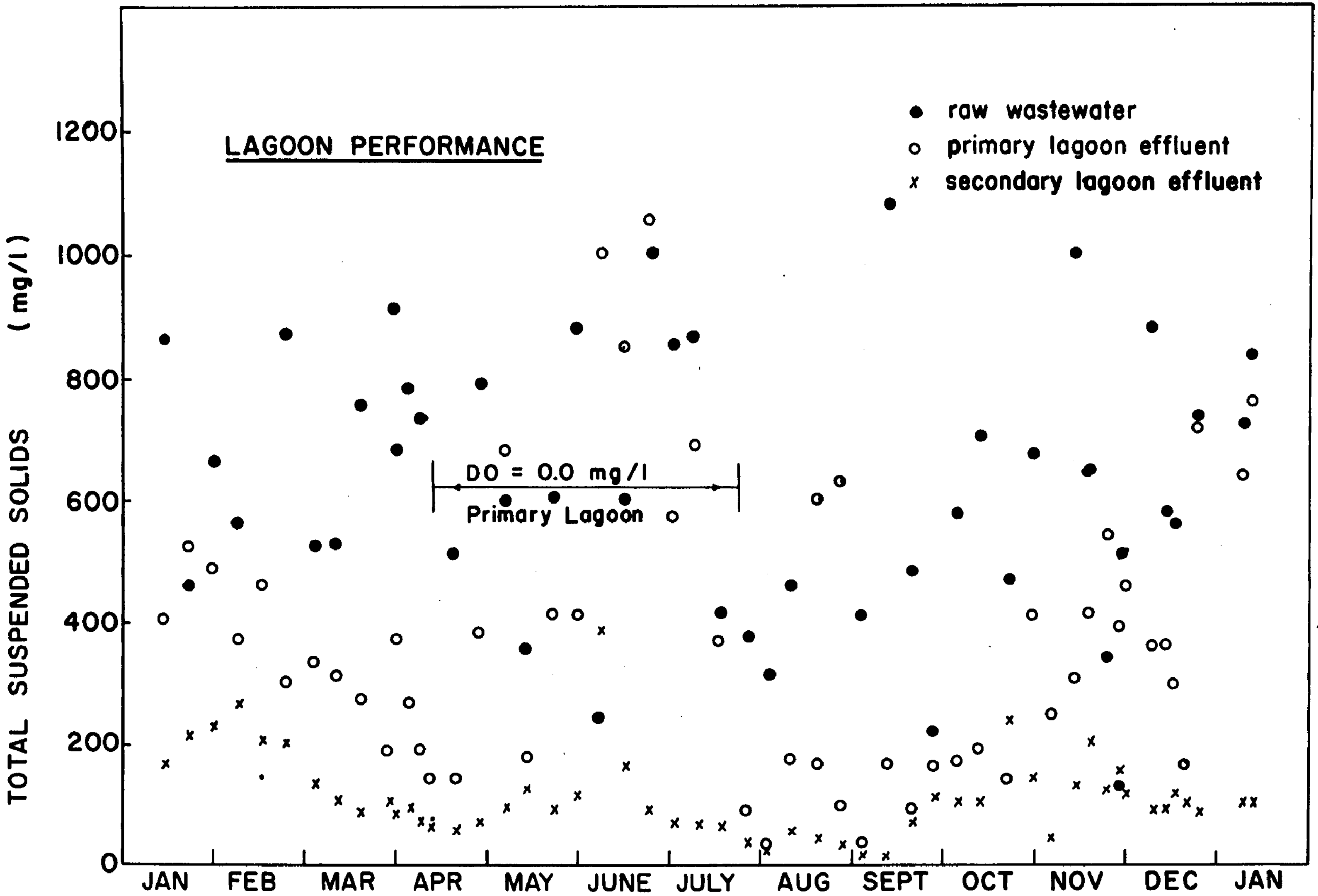


FIGURE 14

CHEESE PROCESS WASTEWATER LAGOONS

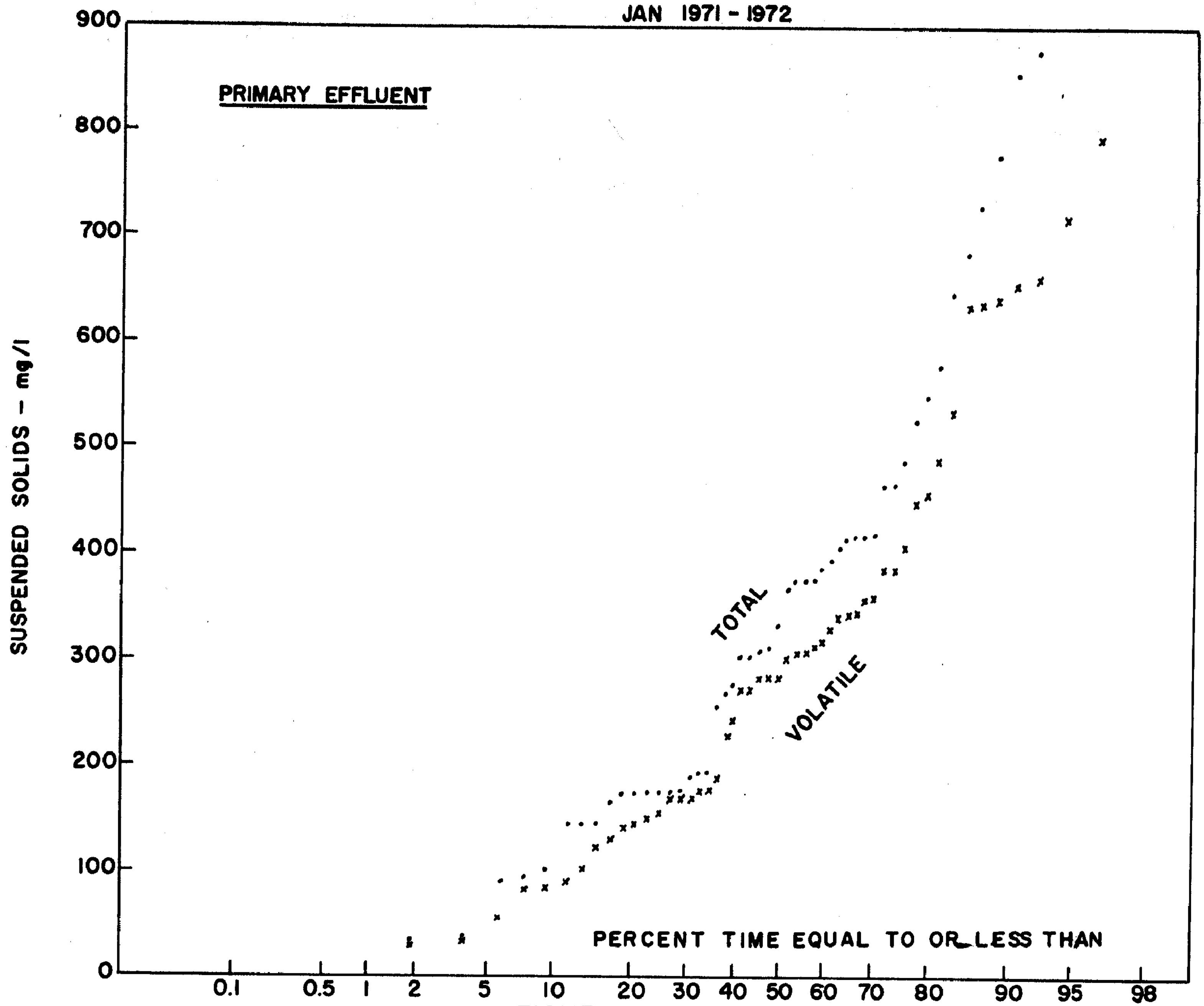


FIGURE 15

CHEESE PROCESS WASTEWATER LAGOONS

JAN 1971 - 1972

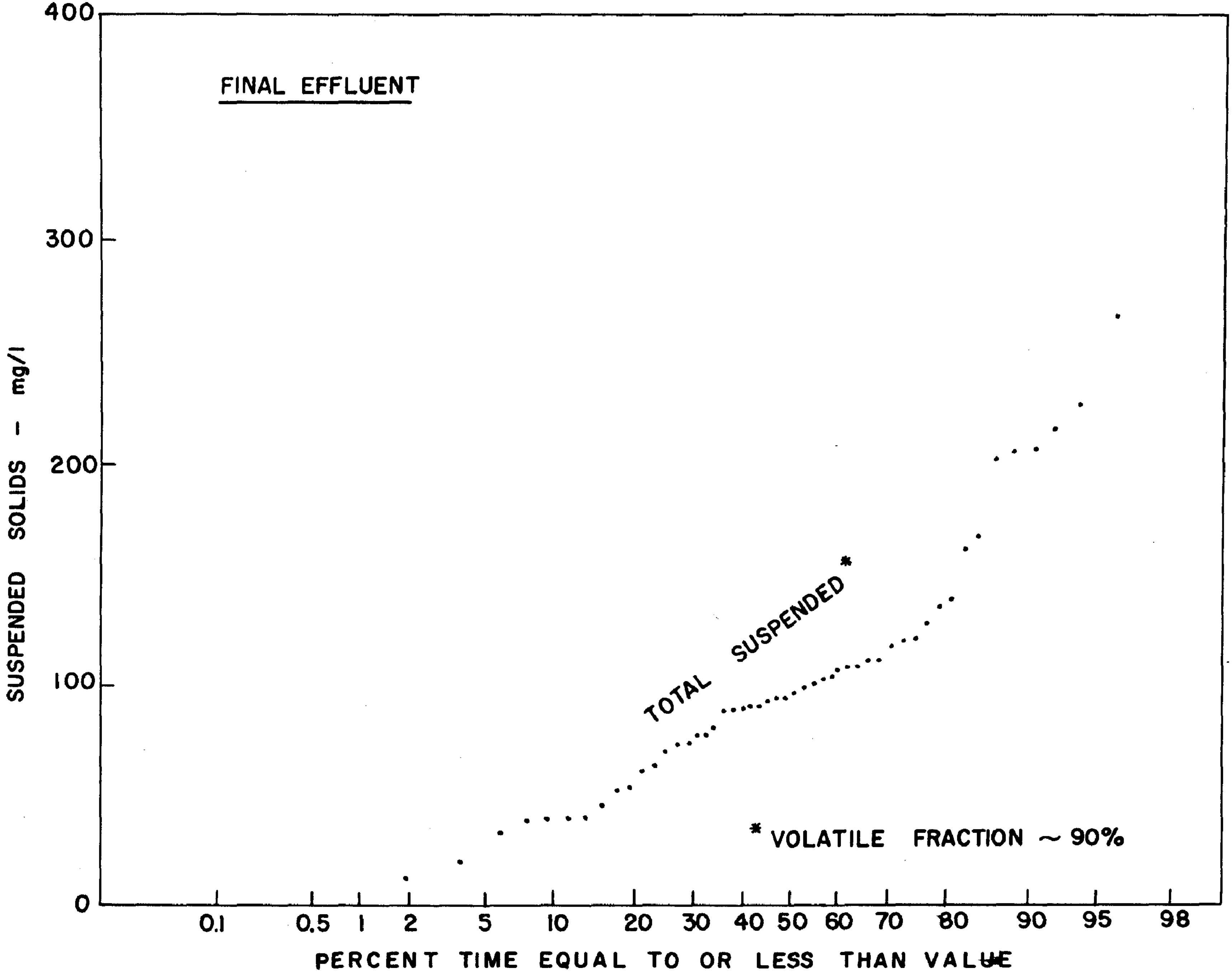
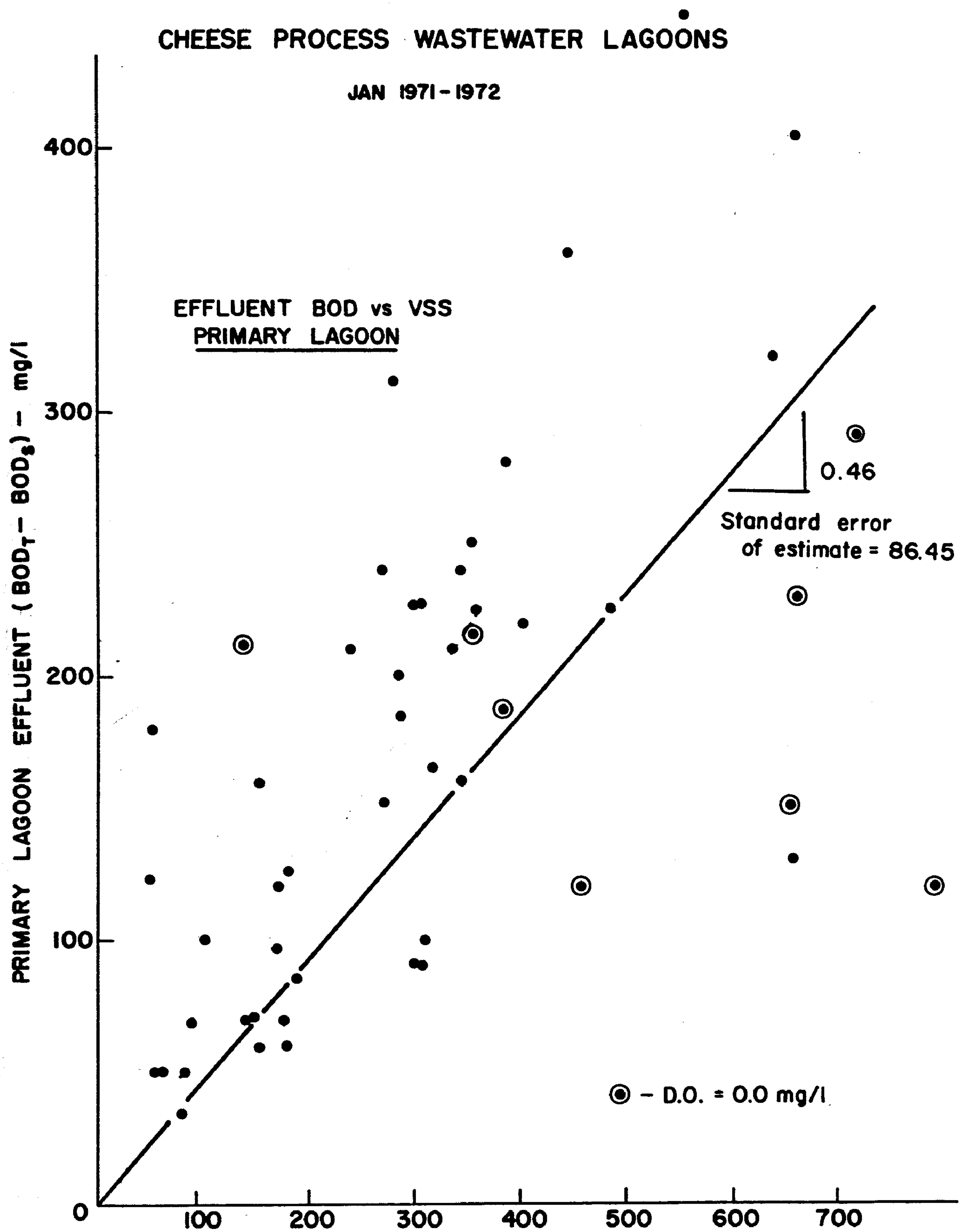


FIGURE 16



CHEESE PROCESS WASTEWATER LAGOONS
JAN 1971-1972
EFFLUENT BOD vs VSS
PRIMARY LAGOON
0.46
Standard error
of estimate = 86.45
- D.O. = 0.0 mg/l
PRIMARY LAGOON EFFLUENT (BOD$_T$ - BOD$_S$) - mg/l
PRIMARY LAGOON EFFLUENT VSS - mg/l
0
100
200
300
400
500
600
700

FIGURE 17

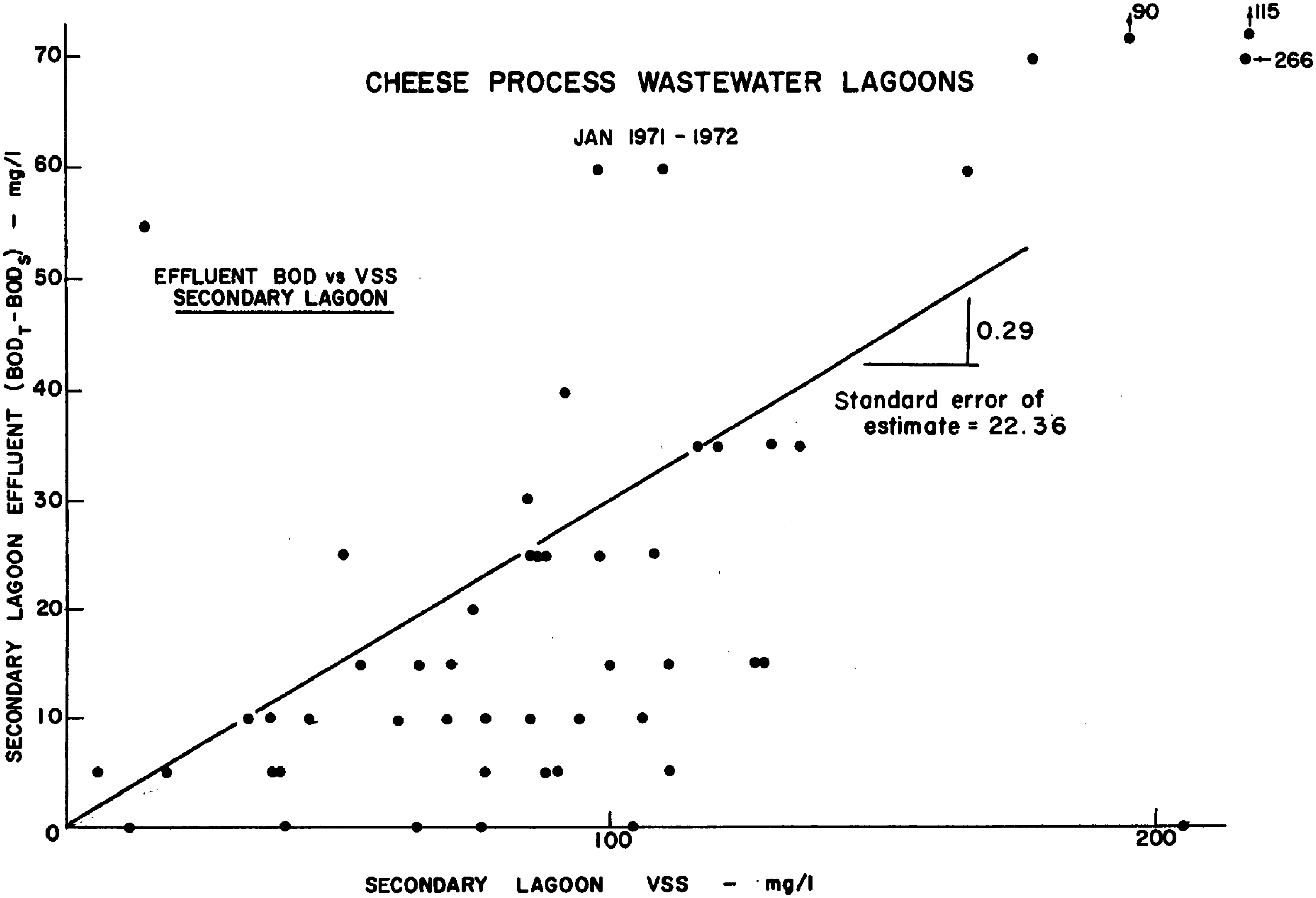

CHEESE PROCESS WASTEWATER LAGOONS
JAN 1971 - 1972
EFFLUENT BOD vs VSS
SECONDARY LAGOON
0.29
Standard error of estimate = 22.36
90
115
266
SECONDARY LAGOON EFFLUENT (BOD_T-BOD_S) - mg/l
SECONDARY LAGOON VSS - mg/l
0
10
20
30
40
50
60
70
100
200

FIGURE 18

Nutrient Levels - The nutrients, nitrogen and phosphorus were determined monthly on 24 hour composite samples collected from the raw wastewater stream and the secondary lagoon. The results of these analyses appear in Table 9. Examination of Table 8 indicates that total phosphorus levels are high owing to the use of phosphate base cleaners. A substantial amount of phosphorus was removed in the pond system. It should be emphasized, however, that removal is the result of sedimentation of the phosphorus and that eventually substantial amounts of phosphorus may be resolubulized and be discharged in the final effluent. Thus, during the one year period, it is doubtful that a steady state with respect to phosphorus transformations has been achieved and, likely, effluent levels may rise significantly over those presently reported.

No data was available on the ammonia nitrogen levels in the system, but it is apparent that total Kjeldahl nitrogen is very low with respect to carbon. The BOD to Nitrogen ratio for the raw wastewater averaged 100:0.7, well below that normally required for adequate biological growth (100:5). The substantial removals of total Kjeldahl nitrogen through the pond system is indicative of both cell synthesis and sedimentation. It is expected that nitrogen recycle would play an important role in the biological system in these lagoons. Nitrate nitrogen in the final effluent was normally low, but warmer temperatures did result in significant nitrification between May and September. An examination of lagoon temperature during these months (Figure 10) indicate that when temperatures exceeded 20°C the rates of nitrification did increase.

Coliform and Fecal Coliform - The sanitary wastewaters from the cheese processing plant were discharged to the process sewers, thereby requiring the installation of chlorination equipment for disinfection of the final effluent. Both total and fecal coliforms were determined from 24 hour flow composited samples of the raw wastewater and final effluent preceding disinfection. Results of these analyses appear in Figures 19 and 20. During this study, no chlorination of the effluent was practiced.

Examination of Figures 19 and 20 indicate that better than 99.9 percent removal of the total coliforms and fecal coliforms was achieved in the lagoons. Temperature did not appear to significantly influence coliform disappearance in the lagoons during the survey period, although there was considerable variation in effluent coliform numbers.

Other Measurements - Values of pH and alkalinity were measured routinely throughout the one year study (Appendix C). Raw wastewater pH values were highest during January through May, averaging approximately 6.5, and then decreasing and leveling off to 6.2 for the remainder of the study. Similarly alkalinities of the raw wastewater averaged 330 mg/l during the January through April period and then continuously decreased to approximately 230 mg/l in September. It is possible that process changes or raw water quality accounted for these changes.

TABLE 9

NITROGEN AND PHOSPHORUS

		Primary Lagoon Influent						Secondary Lagoon Effluent				
Date 1971	Day	Total Phosphorus		Total Kjeldahl Nitrogen		Nitrate Nitrogen	BOD:N:P**	Total Phosphorus		Total Kjel-dahl Nitrogen		Nitrate Nitrogen
		mg/l	lb/d*	mg/l	lb/d*	mg/l		mg/l	lb/d*	mg/l	lb/d*	mg/l
1-22	F	37.0	8.5	7.5	1.7	0.1	100:0.6:0.3	35.0	8.0	4.0	0.9	0.3
2-23	Tu	35.0	4.1	9.2	1.1	1.0	100:0.3:1.1	27.5	3.3	5.9	0.7	0.5
3-19	F	41.3	4.9	10.8	1.3	0.1	100:0.5:2.1	26.4	3.1	5.5	0.7	0.2
4-12	M	7.4	0.7	10.2	1.0	0.4	100:6.8:4.9	28.0	2.8	6.0	0.6	0.4
5-14	F	32.5	5.4	5.3	0.9	0.4	100:0.5:3.2	26.8	4.5	10.6	1.8	1.9
6-15	Tu	76.9	13.2	16.0	2.7	4.4	100:1.0:5.0	10.7	1.8	4.2	0.7	24.4
7-9	F	15.5	3.1	12.2	2.4	0.1	100:0.8:1.0	14.8	2.9	1.5	0.3	3.4
8-10	Tu	33.0	5.8	3.6	0.6	0.1	100:0.2:1.6	11.6	2.0	1.0	0.2	4.0
9-11	Sa	68.4	14.0	12.1	2.5	0.1	100:0.7:3.8	8.4	1.7	1.1	0.2	1.4
10-13	W	55.7	8.2	2.0	0.3	0.1	100:1.1:2.2	14.8	2.2	0.2	0.0	0.4
11-14	Su	04.6	14.4	26.2	3.9	0.1	100:0.7:2.6	23.1	3.5	1.8	0.3	0.4
12-16	Th	42.6	5.7	7.7	1.0	2.7	100:0.5:2.7	31.6	4.3	4.2	0.6	0.2
Avg.		45.0	7.3	10.2	1.6	--	100:0.7:2.2	21.6	3.3	3.8	0.6	--

*lb/d - Calculated by using flow rates on day parameter was measured

** BOD:N:P - ratio of weights (or concentrations) of each component on day of analysis

CHEESE PROCESS WASTEWATER LAGOONS

JAN 1971 - 1972

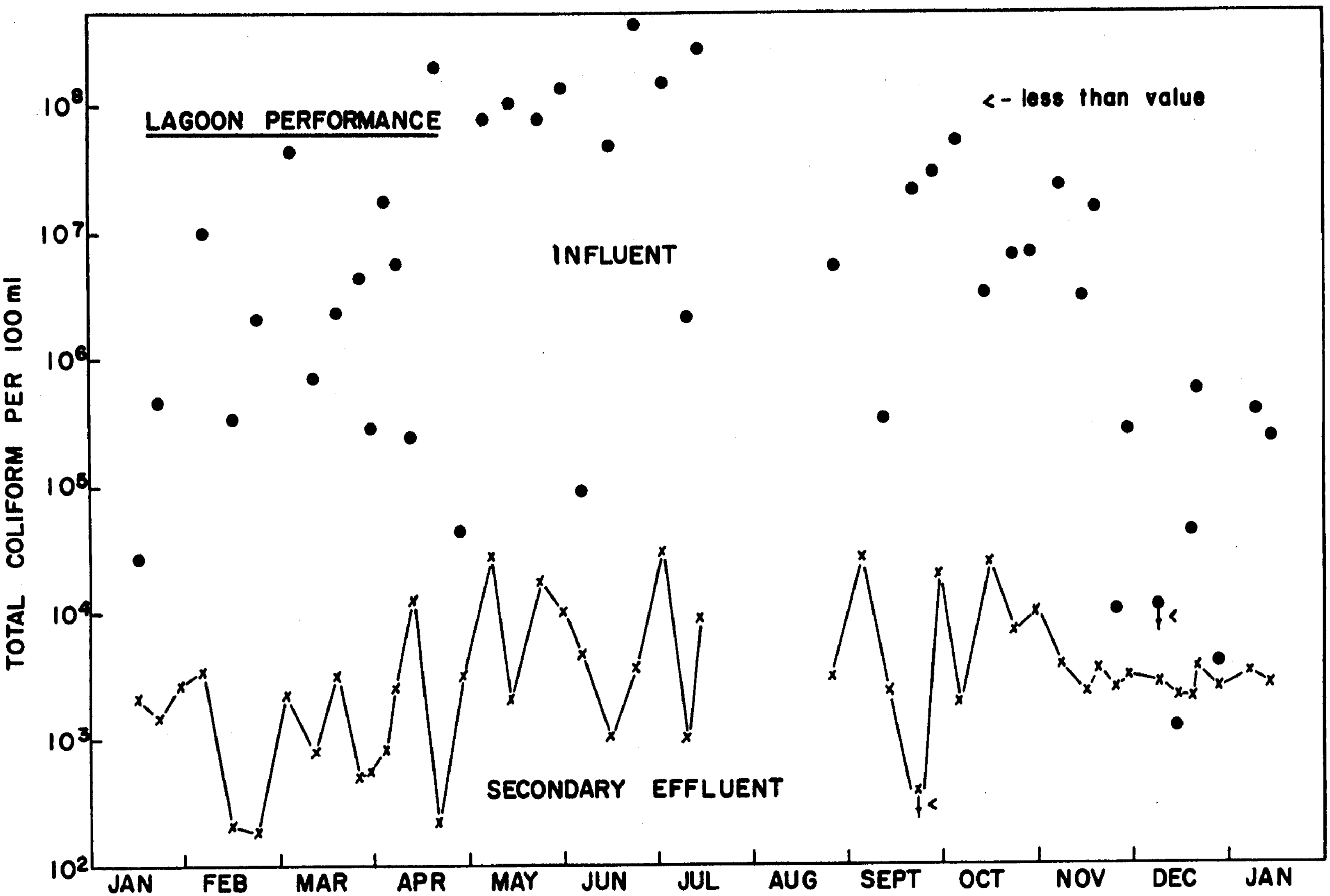


FIGURE 19

CHEESE PROCESS WASTEWATER LAGOONS

JAN 1971 - 1972

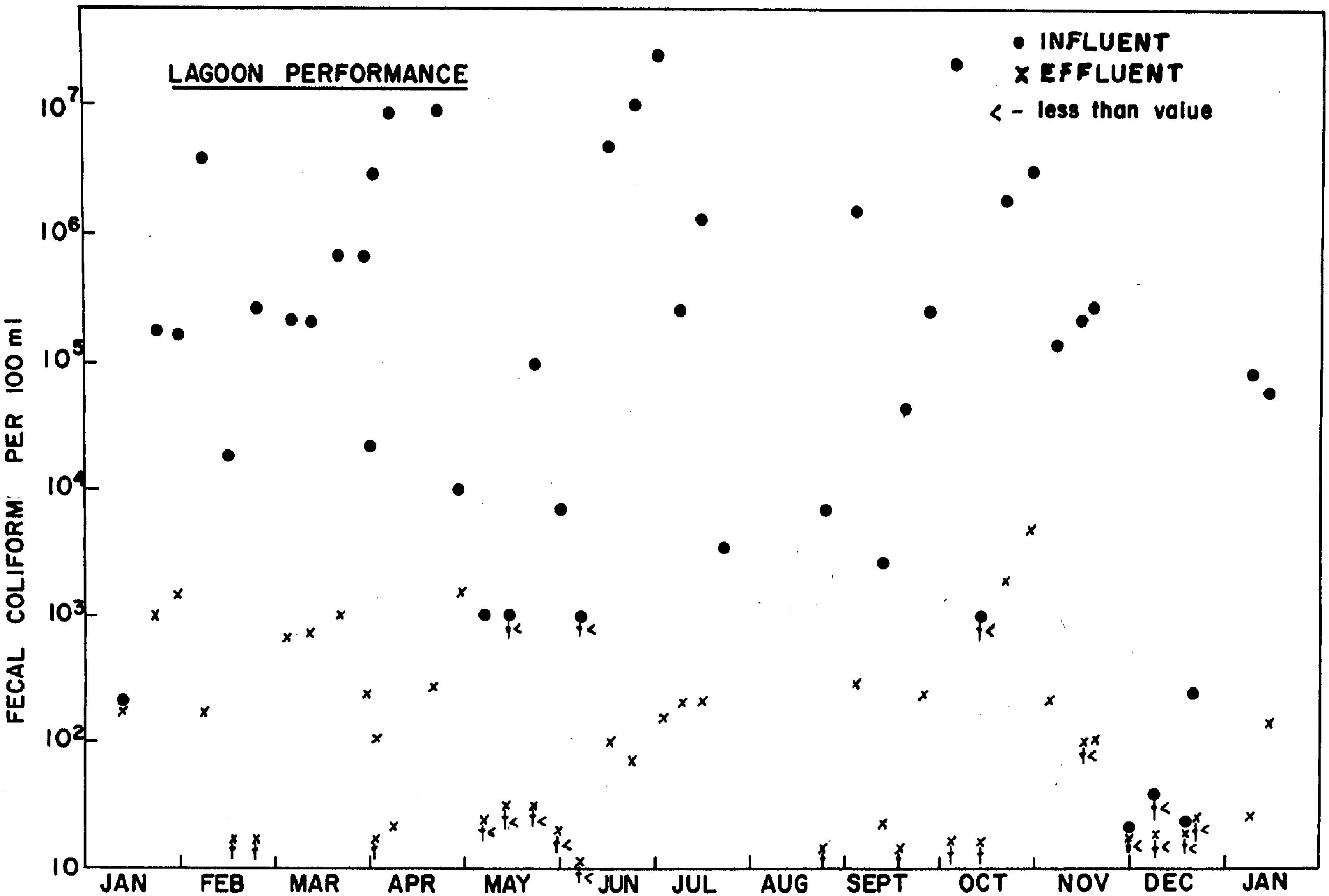


FIGURE 20

The lagoons exhibited pH values of approximately 7.4 during the first one half of the year (January through June), which then sharply decreased to a value of about 7.2 for the remainder of the study. Alkalinities ranged from about 310 mg/l to as high as 540 mg/l during the year. No correlation was noted between pH and measured alkalinity and there was no particular trend in alkalinity values during the year. No correlation was noted between pH and measured alkalinity and there was no particular trend in alkalinity values during the year. It is assumed that changes in algal activities and microorganism respiration influenced these variations, but no data was available on algal activities to document these variations.

Settleable solids were monitored daily on the raw wastewater and on the primary and secondary lagoon effluents (Appendix C). Settleable solids in the raw wastewater ranged between 0.1 and 5 ml/liter during the one year study, normally being less than 1.0. Secondary lagoon effluents never demonstrated significant amounts of settleable solids, but the primary lagoon effluent was high in settleable solids from mid-May through mid-July. Values as high as 120 ml/liter were recorded during this period when dissolved oxygen concentrations were zero. Floating mats of solids and rising sludge was noted throughout this period. Once dissolved oxygen was maintained in this lagoon, the settleable solids decreased to an immeasureable amount.

Costs

The estimated annual capital costs for wastewater treatment at Kent Cheese Co. are based on an interest rate of 7 1/2 percent for mechanical and equipment amortized over a five year period and costs for lagoon construction over a 30 year period. Whereas the estimated annual costs for operation and maintenance are based on costs associated with operating labor, electric power, repairs and replacements, supplies and administration. The annual costs presented do not include those costs associated with the post construction studies that are not representative of normal operating expenses. A summary of the costs related to annual operation for the period January 18, 1971,to January 17, 1972, of these treatment facilities are presented below.

Construction Costs

		Annual Costs
Contract	29,097.42	
Engineering		
Preconstruction Report	500.00	
Preparation of Plans	3,387.14	
Construction Supervision	916.00	
sub total	$33,900.56	
(i = 7.5% 30 yr)		$ 2,870.40
Mechanical Equipment	15,592.82	
(i = 7.5% 5 yr)		3,853.99
sub total		$ 6,724.39
Operating and Maintenance Costs		
Operator labor	$ 1,364.83	
Electric Power (2.676¢/kwm x 92575 kwhr)	2,477.71	
Repairs and Replacement	1,725.43	
Supplies (expendable)	347.47	
Administration	144.62	
sub total	6,060.06	$ 6,060.06
Total Annual Costs		$12,784.45

The estimated costs associated with the treatment of wastewaters for the period January 18, 1971, through January 17, 1972, are based on the interest rates and amortization periods selected for fixed costs, whereas the operating and maintenance costs are those costs actually incurred for the period of operation indicated. One item in the Repairs and Replacement costs category; that is the replacement of a single blower with associated costs, accounted for all but $134.55 of the $1,725.43 indicated in this category. Normally one would expect a longer period of performance for this type of equipment.

The costs prorated to pounds of BOD applied or 1000 gallons of wastewater treated are $0.134 per pound of BOD and $2.05 per 1000 gallons respectively. Based on cheese produced, the estimated cost is $0.0032 per pound.

SECTION VII

ACKNOWLEDGMENTS

This study was supported by the United States Environmental Protection Agency, Office of Research and Monitoring, and Kent Cheese Company, Inc., Kent, Illinois.

William C. Boyle, Ph.D., and Lawrence B. Polkowski, Ph.D., were contracted as research consultants and authors after the treatment plant was in operation and thereafter were responsible for the interpretation of data collected during the post-construction studies and for writing this report.

Lorne Gramms, Ph.D., Tom Jensen, E.I.T., and Jack Quigley, P.E., were employed as part-time assistants to the project.

Mr. Allen Fehr, P.E., Freeport, Illinois, designed and supervised construction of the treatment plant.

E.P.A. Representatives included William J. Lacy, H. G. Keeler, Robert Burm, and Max Cochrane.

Laboratory analysis were performed by Robert Corning, Chief Chemist, and Mrs. Susan Kelly, Laboratory Supervisor, Corning Laboratories, Cedar Falls, Iowa.

The Assistant Operator, plant operator, was Michael Green, Kent Cheese Company, Kent, Illinois.

Mrs. Kathy Watson and Mrs. Barbara Daul, Lena, Illinois, served as administrative assistants.

SECTION VIII

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SECTION IX

GLOSSARY OF TERMS

Alpha, α	Ratio of overall oxygen mass transfer coefficients in waste to tap water
Beta, β	Ratio of oxygen saturation value in waste to tap water
BOD	Biochemical Oxygen Demand, Five-day, 20°C
C	Oxygen concentration in water, mg/1
C_s	Oxygen saturation concentration in water, mg/1
C_v	Fraction of VSS contributing to BOD
CIP	Clean-in-place
cu ft	Cubic foot
d	Day
DO	Dissolved oxygen concentration
ft	Feet
fps	Feet per second
gal	Gallon
gpd	Gallons per day
hp	Horsepower
k	First order removal rate of BOD, 1/days
k_1	BOD deoxygenation constant
kw	Kilowatt
kw-hr	Kilowatt-hour
L_o	Five-day 20°C BOD of influent, mg/1
L_e	Five-day 20°C BOD of effluent, mg/1

lb	pound
MG	Million gallons
mg/l	Milligrams per liter
N	Nitrogen
N_f	Field oxygen transfer efficiency, $\frac{lb\ O_2}{kw\text{-}hr}$
N_s	Standard oxygen transfer efficiency at 20°C, zero D.O. in tap water, $\frac{lb\ O_2}{kw\text{-}hr}$
O/R	Over-the-road trucking
O_t	Percent concentration of oxygen in air leaving lagoon, %
P	Phosphorus
P_b	Absolute pressure at point of air release, lb/in^2
Q	Flow rate, MGD
R	Percent removal of pollutional constituent
S_e	VSS Concentration
SS	Suspended solids
Sec	Second
Scfm	Standard cubic foot per minute
θ	Detention time, V/Q, days
θ_t	Temperature correction coefficient
T	Temperature, °C
v	Volts
V	Volume
VSS	Volatile suspended solids

SECTION X

APPENDICES

APPENDIX A

OXYGEN UPTAKE RATES
Primary Lagoon

Date	Station (Figure 4)	Depth from water surface (ft)	Temp °C	Uptake Rate (mg/l/hr)
11-19-70	1	5	6.3	1.9
	3	5	6.3	2.3
	5	5	6.2	2.1
	13	5	6.2	2.0
	14	5	6.3	1.9
5-23-71	1	1	17.1	5.0
	1	5	17.1	5.8
	5	1	17.1	6.3
	5	6	17.0	6.0
	14	2	17.1	4.9
7-21-71	1	6	24.0	1.2
	5	6	24.1	1.2
	8	6	24.0	1.3
	13	6	24.0	1.1
8-26-71	3	6	23.5	0.9
	5	6	--	1.0
	12	6	23.5	0.8
	14	6	23.5	0.6
10-7-71	1	2	16.5	1.6
	14	6	16.5	1.4
	8	6	16.5	1.6

Calculation of Oxygen Transfer Rate

November 19, 1970

Lagoon No. 1 (Primary Lagoon)

Average Oxygen Uptake Rate = 2.1 mg/1/hr = 16.7 lb/hr
Lagoon Temp. = 6.3°C
Dissolved Oxygen = 2.9 mg/1
1 compressor - 30 amps at 220 v = 6.6 kw
Air Distribution to Primary Lagoon - 80% estimated

Field Transfer: (17, 18)

$$N_f = \frac{16.7\ \text{lb/hr}}{6.6\ \text{kw} \times 0.8} = 3.16\ \text{lb/kw-hr}$$

Standard Transfer:

$$N_s = N_f \frac{C_s}{(C_s - C)\ \theta}\ T\text{-}20$$

$$C_s \text{ at } 20°\text{C} = 9.2\left(\frac{P_b}{(29.4} + \frac{O_t}{42}\right)$$

$$= 9.2\left(\frac{14.7 + 12/2.3}{29.4} + \frac{18.3}{42}\right)^*$$

$$C_{s_{20°}} = 9.2\ (0.68 + 0.5)$$

$$= 10.8\ \text{mg/1}$$

$$C_{s_{6.3°C}} = 14.8\ \text{mg/1} \quad @\ 12'\ \text{depth}$$

$$\alpha = 0.75,\ \beta = 0.96,\ \theta = 1.02$$ (19)

$$N_s = 3.16\left[\frac{10.8}{0.75(0.96 \times 14.8 - 2.8)\ 1.02^{6.3-20}}\right]$$

$$N_s = 5.25\ \text{lb/kw-hr}$$

$$N_s = 3.91\ \text{lb/hp-hr}$$

*where depth = 12' and estimated transfer efficiency is estimated at 10%

APPENDIX C

Lagoon Data

WEEKLY DATA

DATE	DAY	LAGOON INFLUENT (GPD)	BOD$_5$ (TOTAL/SOLUBLE) S.P. 1 MG/L	S.P. 1 LB/D	S.P. 2 MG/L	S.P. 2 LB/D	S.P. 3 MG/L	S.P. 3 LB/D	TOTAL SUSPENDED SOLIDS S.P. 1 MG/L	S.P. 1 LB/D	S.P. 2 MG/L	S.P. 2 LB/D	S.P. 3 MG/L	S.P. 3 LB/D	VOLATILE SUSPENDED SOLIDS S.P. 1 MG/L	S.P. 1 LB/D	S.P. 2 MG/L	S.P. 2 LB/D	S.P. 3 MG/L	S.P. 3 LB/D	TOTAL COLIFORMS S.P. 1 NO./100 ML	TOTAL COLIFORMS S.P. 3 NO./100 ML	FECAL COLIFORMS S.P. 1 NO./100 ML	FECAL COLIFORMS S.P. 3 NO./100 ML
1-14	TH	21,000	2340/1140	410/200	240/30	42.0/5.25	120/60	21.0/19.5	864	151	405	71	167	29.2	846	148	340	57.5	167	29.2	280	200	47,000	2400
1-22	F	27,500	1260/330	288/75.5	240/20	55/4.58	100/30	22.9/6.87	460	105	525	120	216	49.5	434	99.5	405	92.7	178	40.9	280,000	1000	120,000	1333
1-30	S	11,800	3060/1860	301/183	245/20	24.1/1.97	125/30	12.3/2.95	672	66.1	488	48.0	226	22.2	664	65.3	488	48.0	218	21.5	210,000	1500	$<10^6$	3100
2-7	SUN	10,300	1800/1200	155/103	230/15	19.8/1.29	180/15	15.5/1.29	569	48.9	372	32.0	266	22.8	540	46.4	359	30.8	266	22.8	5,400,000	200	10,400,000	5000
2-15	M	13,200	190/105	20.9/11.6	230/50	25.3/5.50	130/75	14.3/8.25	146	16.1	462	50.8	205	22.6	24	2.64	56	6.16	15	1.65	17,000	NONE	450,000	280
2-23	T	14,200	3120/1430	368/169	275/50	32.5/5.90	155/65	18.3/7.67	878	104	301	35.5	202	23.8	854	101	301	35.5	197	23.2	305,000	0.53	4,200,000	200
3-3	W	17,500	1730/1260	253/184	245/45	35.8/6.57	95/60	13.9/8.76	523	76.4	334	48.8	135	19.7	498	72.7	286	41.8	135	19.7	350,000	750	53,000,000	3,250
3-11	TH	13,300	1680/1185	186/131	245/155	27.2/17.2	65/65	7.2/7.2	529	58.7	309	34.3	104	11.5	490	54.4	309	34.3	104	11.5	330,000	275	840,000	830
3-19	F	14,300	2000/1035	238/123	190/40	22.7/4.8	65/60	7.8/7.2	754	89.9	273	32.6	89	10.6	705	84.1	273	32.6	89	10.6	800,000	1000	2,400,000	4000
3-27	S	18,000	2100/930	315/140	140/55	21.0/8.3	60/50	9.0/7.5	915	137.4	190	28.5	106	15.9	768	115.3	190	28.0	106	15.9	800,000	330	6,600,000	670
3-31	W	25,000	2080/1230	433.7/256.5	180/60	37.5/12.5	65/55	13.6/11.5	680	141.8	172	35.9	89	18.6	614	128.0	172	35.9	85	17.7	30,000	100	330,000	566
4-4	SUN	16,700	2640/1500	367.7/208.9	260/50	36.2/7.0	60/50	8.4/7.0	784	109.2	269	37.4	90	12.5	673	93.7	244	34.0	77	10.7	4,300,000	NONE	21,000,000	825
4-8	TH	19,300	2900/1630	466.8/262.4	190/65	30.6/10.5	70/60	11.3/9.7	739	119.0	194	31.2	70	11.3	698	112.4	171	27.5	70	11.3	9,300,000	20	8,600,000	4000
4-12	M	11,800	<150/<150	<14.8/<14.8	110/50	10.8/4.9	75/60	7.4/5.9	85	8.4	144	14.2	73	7.2	75	7.4	130	12.8	65	6.4	NONE	NONE	290,000	1200
4-20	T	32,500	1550/850	420.1/230.4	110/60	29.8/16.3	55/40	14.9/10.8	513	139.0	143	38.8	54	14.6	485	131.5	123	33.3	54	14.6	9,600,000	330	116×10^6	200
4-28	W	16,200	2350/1200	317.5/162.1	300/60	40.5/8.1	40/20	5.4/2.7	797	107.7	386	52.2	74	10.0	782	105.7	348	47.0	74	10.0	10,000	1700	56,000	4000
5-6	TH	17,500	2200/1220	320.6/181.1	200/70	29.7/10.4	50/25	7.4/3.7	598	88.8	681	101.1	97	14.4	578	85.8	632	93.8	85	12.6	1000	<33	71,000,000	37,000
5-14	F	20,000	1000/560	166.8/93.4	135/40	22.5/6.7	75/15	12.5/2.5	353	58.9	178	29.7	121	20.2	347	57.9	173	28.9	110	18.3	<1000	<50	84,000,000	2200
5-22	S	11,600	930/100	90.0/9.7	225/35	21.8/3.4	70/30	6.8/2.9	608	58.8	415	40.1	92	8.9	586	56.7	388	37.5	92	8.9	<100,000	<33	80,000,000	18,000
5-30	SUN	—	3580/1770		210/45		55/20		880		411		117		854		318		117		1000	<20	128×10^6	<10,000
6-7	M	43,100	570/225	204.9/80.9	300/10	107.8/3.6	80/10	28.8/3.6	244	87.7	1007	362.0	390	140.2	197	70.8	717	257.7	266	95.6	<1000	<7	94,000	6,000
6-15	T	20,600	1550/1150	266.3/197.6	230/5	39.5/0.9	40/5	6.9/0.9	605	103.9	857	147.2	163	28.0	569	97.8	636	109.3	130	22.3	7,000,000	100	75,000,000	1000
6-23	W	18,400	3250/2040	498.7/313.1	170/50	26.1/7.7	55/50	8.4/7.7	1003	153.9	1062	163.0	90	13.8	981	150.5	795	122	90	13.8	10,000,000	80	640×10^6	6000
7-1	TH	25,900	2430/1860	524.9/401.8	180/60	38.9/13.0	30/5	6.5/1.1	860	185.8	576	124.4	69	14.9	833	179.9	456	98.5	51	11.0	28×10^6	110	170×10^6	47,000
7-9	F	23,600	1470/550	289.3/108.3	220/70	43.3/13.8	15/15	3.0/3.0	691	136	879	173	67	13.2	527	103.7	653	128.5	40	7.9	400,000	200	2,600,000	1000
7-17	S	21,700	1080/780	195.5/141.2	110/10	19.9/1.8	10/10	1.8/1.8	419	75.8	372	67.3	64	11.6	392	70.9	312	56.5	64	11.6	1,500,000	200	430×10^6	8600
7-25	SUN	—	830/450		80/15		15/10		375		90		39		369		90		39		—	—	—	—
8-2	M	30,000	100/75	25.0/18.8	40/10	10.0/2.5	20/10	5.0/2.5	313	78.3	33	8.3	33	8.3	304	76.1	33	8.3	33	8.3	—	—	—	—
8-10	T	21,100	2070/1140	364.3/200.6	80/10	14.1/1.8	30/20	5.3/3.9	463	81.5	179	31.5	61	10.7	456	80.2	179	31.5	61	10.7	—	—	—	—
8-18	W	19,700	2560/1490	420.6/244.8	80/10	13.1/1.6	30/20	4.9/3.3	601	98.7	171	28.1	45	7.4	601	98.7	150	24.6	45	7.4	—	—	—	—
8-26	TH	21,000	2190/1290	383.6/225.9	70/20	12.3/3.5	35/25	6.1/4.4	634	111.0	100	17.5	37	6.5	604	105.8	83	14.5	37	6.5	7000	5	7,300,000	3000
9-3	F	21,800	1300/390	236.4/70.9	85/35	15.5/6.4	15/10	2.7/1.8	413	75.1	38	6.9	19	3.5	413	75.1	38	6.9	19	3.5	1,330,000	435	1280×10^6	29,800
9-11	S	24,600	1800/800	369.3/164.1	340/130	69.8/26.7	15/15	3.1/3.1	1089	223.4	177	36.3	15	3.1	1061	217.7	147	30.2	11	2.3	4300	35	160,000	4000
9-19	SUN	—	1850/1260		65/30		15/10		489		93		73		457		81		39		61,000	≤5	21×10^6	≤2
9-27	M	33,900	675/400	190.8/113.1	115/45	32.5/12.7	25/10	7.1/2.8	227	64.2	167	47.2	113	31.9	210	59.4	142	40.1	81	22.9	380,000	240	30×10^6	21,000
10-5	T	23,400	1250/650	243.9/126.9	70/10	13.7/2.0	10/10	2.0/2.0	581	113.4	178	34.7	108	21.1	550	107.3	154	30.1	76	14.8	16×10^6	≤4	57,000,000	1500
10-13	W	17,700	2580/1360	380.9/[illegible]	90/30	13.3/4.4	20/15	3.0/2.2	711	105	195	28.8	109	16.1	691	102.0	180	26.6	77	11.4	≤1000	≤4	45×10^6	34,000

WEEKLY DATA

DATE	DAY	LAGOON INFLUENT (GPD)	BOD5 (TOTAL/SOLUBLE) S.R 1 MG/L	BOD5 S.R 1 LB/D	BOD5 S.R 2 MG/L	BOD5 S.R 2 LB/D	BOD5 S.R 3 MG/L	BOD5 S.R 3 LB/D	TOTAL SUSPENDED SOLIDS S.R 1 MG/L	TSS S.R 1 LB/D	TSS S.P. 2 MG/L	TSS S.P. 2 LB/D	TSS S.R 3 MG/L	TSS S.R 3 LB/D	VOLATILE SUSPENDED SOLIDS S.R 1 MG/L	VSS S.R 1 LB/D	VSS S.P. 2 MG/L	VSS S.P. 2 LP	VSS S.P. 3 MG/L	VSS S.P. 3 LB/D	TOTAL COLIFORMS S.R 1 NO./100 ML	TOTAL COLIFORMS S.R 3 NO./100 ML	FECAL COLIFORMS S.R 1 NO./100 ML	FECAL COLIFORMS S.R 3 NO./100 ML
10-21	TH	23,200	1600 / 1000	309.6 / 193.5	135 / 35	26.1 / 6.8	15 / 15	2.9 / 2.9	471	91.1	146	28.2	246	47.6	449	86.9	102	19.7	206	39.9	1.2 x 10^6	3200	7.3 x 10^6	7600
10-29	F	17,900	1800 / 930	268.7 / 138.8	180 / 20	26.9 / 3.0	15 / 10	2.2 / 1.5	678	101.2	415	62.0	149	22.2	654	97.6	345	51.5	111	16.6	3.1 x 10^6	6200	8 x 10^6	10,000
11-6	S	15,400	3760 / 2100	482.9 / 269.7	110 / 25	14.1 / 3.2	20 / 15	2.6 / 1.9	900	115.6	252	32.4	44	5.7	874	112.3	229	29.4	6	0.8	125,000	200	22 x 10^6	5,000
11-14	SUN	18,200	3650 / 2580	554 / 391.6	240 / 55	36.4 / 8.3	25 / 10	3.8 / 1.5	1011	153.5	311	47.2	131	19.9	986	149.7	281	42.7	111	16.8	170,000	<100	4.9 x 10^6	1600
11-18	TH	15,015	3600 / 2400	450.8 / 300.5	325 / 85	40.7 / 10.6	25 / 10	3.1 / 1.3	659	82.5	418	52.3	206	25.8	634	79.4	271	33.9	128	16.0	290,000	<100	13 x 10^6	5400
11-24	W	15,700	450 / 300	58.9 / 39.3	390 / 30	51.1 / 3.9	25 / 15	3.3 / 2.0	348	45.6	548	71.8	128	16.8	190	24.9	448	58.7	94	12.3	<200	<100	10,000	2300
11-26	F	14,200	1400 / 1200	165.8 / 142.1	285 / 35	33.8 / 4.1	35 / 20	4.1 / 2.4	132	15.6	394	46.7	156	18.5	124	14.7	330	39.1	138	16.3	<100	130	<100	2700
11-30	T	17,000	1700 / 1550	241.0 / 219.8	320 / 40	45.4 / 5.7	30 / 15	4.3 / 2.1	524	74.3	466	66.1	122	17.3	502	71.2	388	55.0	100	14.2	<20	<20	270,000	4000
12-8	W	19,310	1750 / 990	218.8 / 159.4	270 / 40	43.5 / 6.4	35 / 10	5.6 / 1.6	884	142.4	368	59.3	96	15.5	874	140.8	306	49.3	88	14.2	<50	<20	<50	4400
12-13	M	9,675	2350 / 1850	189.6 / 149.3	250 / 25	20.2 / 2.0	40 / 15	3.2 / 1.2	582	47.0	376	30.3	94	7.6	560	45.2	360	29.0	88	7.1	<10	<10	1200	2100
12-16	TH	16,155	1560 / 1275	210.2 / 171.8	340 / 30	45.8 / 4.0	50 / 15	6.7 / 2.0	556	74.9	302	40.7	120	16.2	516	69.5	284	38.3	120	16.2	<10	<10	66,000	2,200
12-20	M	10,325	2050 / 1770	176.5 / 152.4	600 / 80	51.7 / 6.9	45 / 20	3.9 / 1.7	176	15.2	1580	136.1	108	9.3	176	15.2	1320	113.7	108	9.3	175	<20	600,000	6,500
12-24	F	17,405	2110 / 1480	306.3 / 206.1	500 / 95	72.6 / 13.8	80 / 20	11.6 / 2.9	726	105.4	728	105.7	98	14.2	708	102.8	660	95.8	98	14.2	<20	<20	5700	3933
1-9	SUN	11,130	2300 / 1700	213.5 / 157.8	550 / 100	51.1 / 9.3	65 / 40	6.0 / 3.7	730	67.8	644	59.8	102	9.5	730	67.8	532	49.4	92	8.5	85,000	40	300,000	4200
1-12	W	17,415	2000 / 1700	290.5 / 246.9	410 / 90	59.5 / 13.1	50 / 20	7.3 / 2.9	846	122.9	772	112.1	108	15.7	816	118.5	640	93.0	84	12.2	54,000	120	200,000	3500

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments	DATE	DAY	PLANT PROCESS Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.)* GPD	POWER Kw-Hr.	OPER. Man-Hr.	SETTLEABLE SOLIDS Samples 1 ml/1	2 ml/1	3 ml/1	pH Samples 1	2	3	ALKALINITY Samples 1 mg/1	2 mg/1	3 mg/1	Cl lb/D	LAGOON 1 DO mg/1	Tem. °F	LAGOON 2 DO mg/1	Tem. °F	WEATHER Rain-fall	Wind	Temp.
JANUARY 1971	1																									
NO SETTLEABLE	2	S		12540																						
SOLIDS ACCUM-	3	S																								
ULATION WITH NO	4	M		11,119																						
RICOTTA PRODUCTION.	5	T		10,704	23,300	2400	21,700																			
OVERNITE -15°F	6	W		17,756	24,100	2100	22,800			2	.1	—	6.65	7.2	7.5	380	460	440		7	37	15	35			
-10°F	7	T		5,702	21,500	2100	20,200			2	.1	—	6.65	7.2	7.4	380	454	440		4	37	11	35			
2nd Cell FROZEN OVER	8	F		12,319	21,900	1800	20900			1	.1	—	7.0	7.1	7.4	370	444	470		7.5	36	9.3	34			
	9	S		10,132	20,600	2100	19,300			2	.1	—	7.0	7.2	7.5	376	446	470		6.0	36	9.0	34			
	10	S			**																					
	11	M		14,508	19,100	2100	17,800			—	—	—	7.0	7.3	7.55	300	430	464		8.2	38	9.0	34			
	12	T		14,700	20,400	2400	18,800			1	—	—	6.95	7.3	7.5	360	444	464		5.8	40	9.1	35			
D.O. CHECKED FOR	13	W		16,307	28,500	2100	27,200			1	—	—	6.8	7.35	7.6	376	430	466		5.2	40	1.0	35			
REPEATABILITY - OK	14	T		5,461	22,300	2100	21,000			1.5	—	—	6.8	7.2	7.55	376	430	466		5.0	40	7.7	35			
	15	F		15,980	22,600	1800	21,600			1	—	—	6.9	7.1	7.55	374	430	466		4.0	40	7.6	35			
	16	S		8,176	21,900	2100	20,600			1	—	—	6.9	7.2	7.4	376	440	464		4.2	40	6.1	35			
	17	S			**																					
	18	M		13,108	32,400	2100	31,100			.1	—	—	6.8	7.4	7.5	344	440	460		6.0	40	7.0	35			
	19	T		18,516	28,000	2400	26,400			1	—	—	6.7	7.2	7.5	330	440	470		5.2	40	6.5	35			
	20	W		13,468	28,500	2100	27,200			.8	1.5	—	6.75	7.45	7.6	280	444	486		6.5	42	6.3	35			
	21	T		5,868	21,500	2100	20,200			.5	—	—	6.5	7.4	7.4	300	440	470		4.0	44	6.0	37			
THAW EXISTED	22	F		13,776	28,500	1800	27,500			.3	—	—	6.4	7.3	7.4	320	430	466		4.3	44	5.9	37			
	23	S		11,606	21,200	2100	19,900			2.5	—	—	6.3	7.4	7.5	320	436	466		4.0	43	6.0	37			
	24	S			**																					
	25	M		12,734	36,800	2100	35,500			.3	—	—	6.4	7.3	7.4	280	430	470		7.0	42	6.5	37			
	26	T		13404	22,800	2400	21,200			.5	—	—	6.6	7.4	7.4	242	430	486		4.5	40	6.5	37			
	27	W		11,938	18,800	2100	17,500			.3	—	—	6.5	7.4	7.5	286	436	484		4.4	40	6.5	37			
THAWING EXISTED	28	T		6,351	20,000	2100	18700			.2	—	—	6.4	7.3	7.4	300	444	484		4.3	40	6.5	37			
LOW SOLIDS - NO	29	F		13,565	12,300	1800	11,300			.2	—	—	6.8	7.5	7.4	326	440	484		6.3	40	7.0	37			
RICOTTA PRODUCTION	30	S		7,806	15,100	2100	11,800			1	—	—	6.7	7.4	7.5	330	444	484		6.3	40	7.1	37			
ICE ON 2nd CELL	31	S			**																					
21 INCHES DEEP	Total			297,544	532,100	48,300	509200			20.2	1.9	—	147.5	1606	1644	7326	9666	9836		119.9	879	162	785			
	Avg.			11,902	17,165	1558	16,135			.96	.4	—	6.7	7.3	7.5	333	439	447		5.4	40	7.4	36			
	Max.			18,516	36,800	2400	35,500			2.5	1.5	—	7.0	7.5	7.6	380	460	486		6.2	44	15	37			
	Min.			5,461	12,300	1800	11,300			.2	.1	—	6.3	7.1	7.4	242	430	440		4.0	36	1.0	34			

*(WELL-BOILER + 800 GPD INFILT.)

**(SUNDAY FLOW INCL. IN MONDAY'S)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments	Date	Day	Plant Process: Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.)* GPD	Power	Hours	Oper. Hours	Settleable Solids Sample 1 ml/l	Settleable Solids Sample 2 ml/l	Settleable Solids Sample 3 ml/l	pH Sample 1	pH Sample 2	pH Sample 3	Alkalinity Sample 1 mg/l	Alkalinity Sample 2 mg/l	Alkalinity Sample 3 mg/l		Lagoon 1 a	Lagoon 1 b	Lagoon 2 a	Lagoon 2 b	Weather: Rainfall	Wind	Temp.
FEBRUARY 1971	1	M		13,062	28,000	2100	26,700				1	—	—	6.7	7.4	7.5	300	444	484		7.0	32	8.0	32			°F
DILUTION FACTOR	2	T		11,883	17,500	2400	15,900				1	—	—	6.6	7.4	7.4	310	440	500		7.4	32	8.5	32			-20
2:1 ON EFFLUENT	3	W		12,443	18,000	2100	16,700				3	—	—	6.7	7.3	7.4	270	444	490		7.8	32	8.5	32			+20
OF 2nd CELL	4	T		9,730	17,100	2100	15,800				2	—	—	6.6	7.4	7.4	296	440	496		7.9	32	8.0	32			-5
	5	F		10,502	15,900	1800	14,900				1	—	—	6.7	7.4	7.5	296	440	480		8.0	32	[illegible]	32			-10
	6	S		8,381	14,600	2100	13,300				1	—	—	6.6	7.4	7.5	300	444	484		8.0	32	8.5	32			+15
	7	S			**																						-10
	8	M		15,078	17,500	2100	16,200				.2	—	—	7.4	7.6	7.6	310	476	502		8.4	32	8.0	32			+18
	9	T		13,355	20,100	2400	18,500				2	—	—	6.7	7.5	7.6	300	470	484		8.0	32	7.9	32			+6
	10	W		13,380	16,600	2100	15,300				2	—	—	6.35	7.6	7.65	286	444	490		7.5	32	7.5	32			+10
	11	T		9,438	14,900	2100	13,600				4.5	—	—	5.95	7.4	7.4	310	450	500		7.0	32	7.0	32			+20
	12	F		13,831	17,500	1800	16,500				.3	—	—	6.2	7.4	7.45	300	444	496		6.7	34	7.0	32			+22
	13	S		11,606	12,700	2100	11,400				.7	—	—	6.4	7.5	7.5	300	446	494		6.7	32	7.0	32			-6
	14	S			**																						+10
	15	M		15,614	14,500	2100	13,200				—	—	—	6.3	7.4	7.45	310	440	480		8.2	32	6.5	32			+20
	16	T		15,974	16,600	2400	15,000				.2	—	—	6.6	7.5	7.45	315	450	476		6.0	32	6.5	32			+26
	17	W		11,222	21,500	2100	20,200				1	—	—	6.5	7.4	7.5	310	446	480		6.0	34	6.5	32			+31
	18	T		11,035	19,300	2100	18,000				1	—	—	6.5	7.4	7.4	356	444	500		6.6	34	6.6	32			+35
	19	F		11,663	17,600	1800	16,600							6.3	7.4	7.4	320	446	486		6.0	34	6.5	32			+38
	20	S		9,475	13,100	2100	11,800				—	—	—	6.4	7.5	7.5	310	436	470		5.4	34	5.0	32			32
	21	S			**																						
	22	M		11,478	22,800	2100	21,500				—	—	—	6.3	7.4	7.4	300	380	414		8.5	36	4.5	32			30
	23	T		15,878	15,800	2400	14,200				1.5	—	—	6.9	7.45	7.5	290	362	416		6.5	34	4.0	32			24
	24	W		10,454	14,000	2100	12,700				1	—	—	6.3	7.4	7.45	300	386	396		6.0	34	4.0	32			
	25	T		8,119	17,500	2100	16,200				1	—	—	6.6	7.4	7.35	300	380	394		6.2	34	4.1	32			
	26	F		12,632	13,100	1800	12,100				1	—	—	6.4	7.4	7.4	296	386	396		6.2	34	4.0	32			
EXCESSIVE THAWING	27	S		9,107	14,500	2100	13,200				5	—	—				300	386	390		6.0	36	3.9	32			
	28	S			**																						
	29																										
	30																										
	31																										
	Total			285,340	410,700	50,400	379,500				30.4	—	—	149.5	171.	191.7	7457	10,324	11156		168	794	156	768			223
	Avg.			11,889	14,668	1800	13,553				1.5	—	—	6.2	7.1	7.2	298	413	446		6.7	33	6.2	32			10.6
	Max.			15,974	28,000	2400	26,700				5	—	—	7.4	7.6	7.65	356	476	500		8.5	36	8.5	32			+38
	Min.			8,119	12,700	1800	11,400				.2	—	—	5.95	7.3	7.35	270	362	390		5.4	32	3.9	32			-20

*(WELL-BOILER + 800 GPD INFILT)

**(SUNDAY FLOW INCL. IN MONDAY'S)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments	Date	Day	Plant Process Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon INF. (CALC)* GPD	Power Kw-Hr.	Oper. Man-Hr.	Settleable Solids Samples 1 ml/l	2 ml/l	3 ml/l	pH Samples 1	2	3	Alkalinity Samples 1 mg/l	2 mg/l	3 mg/l	D.O.	Lagoon 1 DO mg/l	Lagoon 1 Temp. °F	Lagoon 2 DO mg/l	Lagoon 2 Temp. °F	Weather Rainfall	Wind	Temp.
MARCH 1971	1	M		15,193	21,500	2100	20,300			—	—	—	6.6	7.45	7.5	300	370	386		6.0	36	7.0	32		20	
	2	T		19,481	18,400	2400	16,800			.6	—	—	6.65	7.5	7.5	320	356	374		6.0	34	8	32		14	
	3	W		12,038	18,800	2100	17,500			1.5	—	—	6.5	7.4	7.5	316	364	380		6.1	32	6.0	32		8	
	4	T		10,513	15,300	2100	14,000			1	—	—	6.7	7.45	7.60	300	352	380		6.0	32	6.0	32		0	
THAWING ICE	5	F		14,731	17,100	1800	16,100			.2	—	—	6.7	7.5	7.5	300	360	380		6.0	32	6.0	32		30	
" "	6	S		11,774	15,300	2100	14,000			2	—	—	6.6	7.4	7.5	296	302	384		5.7	32	6.1	32		30	
	7	S			* *																					
THAWING ICE	8	M		14,181	20,600	2100	19,300			.1	—	—	6.5	7.4	7.5	290	374	390		6.5	32	6.5	32		10	
" "	9	T		14,804	15,300	2400	13,700			1	—	—	6.4	7.5	7.45	300	370	386		6.8	32	6.5	32		15	
" "	10	W		13,929	14,700	2100	13,400			1	—	—	6.3	7.5	7.5	300	370	388		6.5	32	6.3	32		25	
" "	11	T		8,747	14,600	2100	13,300			.6	—	—	6.4	7.45	7.5	296	370	390		6.1	32	6.3	32		30	
" "	12	F		15,297	14,500	1800	13,500			1	—	—	6.4	7.5	7.4	294	374	390		5.0	32	5.8	32		30	
THAWING ICE	13	S		11,404	15,800	2100	14,500			2	—	—	6.5	7.4	7.4	300	370	390		5.5	32	6.0	32		34	
	14	S			* *																					
THAWING ICE	15	M		16,640	25,800	2100	24,300			—	—	—	6.4	7.45	7.5	290	374	370		6.5	34	6.8	32		45	
" "	16	T		17,336	17,100	2400	15,500			1.5	—	—	6.4	7.4	7.5	298	370	366		4.0	36	5.5	32		24	
" "	17	W		13,313	17,500	2100	16,200			1	—	—	6.3	7.45	7.5	305	370	360		4.6	37	5.4	32		18	
	18	T		12,337	14,500	2100	13,200			1.3	—	—	6.7	7.35	7.4	320	370	380		5.0	39	6.0	32		36	
HEAVY SNOW	19	F		11,560	15,300	1800	14,300			1	—	—	6.6	7.4	7.4	310	374	380		4.0	39	6.0	34		30	
	20	S		12,514	13,600	2100	12,300			1.2	—	—	6.5	7.4	7.5	315	372	376		4.0	39	6.0	34		30	
THAWING COND.	21	S			* *																					
BRIGHT YELLOW	22	M		15,243	24,500	2100	23,200			—	—	—	6.7	7.55	7.5	350	380	376		7	39	7.1	36		30	
SKUM APPEARED	23	T		17,458	23,200	2400	21,600			1.3	—	—	6.6	7.7	7.5	320	364	360		5	41	6.0	34		15	
ON SURFACE	24	W		15,723	17,100	2100	15,800			2	—	—	6.6	7.6	7.5	310	366	360		6.7	41	5.8	34		10	
	25	T		20,592	19,700	2100	18,400			1.6	—	—	6.5	7.5	7.5	340	380	360		6.5	37	5.2	32		20	
3:00 PM D.O. CHECK ON CELL I	26	F		19,848	18,000	1800	17,000			1.5	—	—	6.6	7.5	7.5	330	376	370		4.8	37	6.2	32		30	
" " " "	27	S		14,396	19,300	2100	18,000			2.0	—	—	6.5	7.4	7.45	316	376	380		3.0	39	5.5	34		30	
APPROX. 1" ICE ON	28	S			* *																					
LAST ½ OF 2nd CELL	29	M		18,309	26,700	2100	25,400			.3	—	—	6.5	7.5	7.4	330	388	376		6.0	41	6.0	36		30	
	30	T		17,416	20,600	2400	19,000			2.2	—	—	6.6	7.45	7.55	380	390	374		5.0	41	8.2	36		30	
	31	W		16,354	26,300	2100	25,000			2.0	—	—	6.7	7.65	7.7	368	388	346		4.2	43	9.8	37		45	
	Total			537,931	501,100	57,000	465,600			29.9	—	—	176.1	201.8	202.2	8494	10,030	10,152		148	973	172	890		669	
	Avg.			19,923	16,165	1839	15,019			1.2	—	—	6.5	7.5	7.5	315	371	376		5.5	36	6.4	33		25	
	Max.			20,592	26,700	2400	25,400			2.2	—	—	6.7	7.7	7.7	380	390	390		7.0	43	9.8	37		45	
	Min.			8,747	13,600	1800	12,300			.1	—	—	6.3	7.35	7.4	290	352	346		3.0	32	5.2	32		0	

*(WELL-BOILER + 800 GPD INFILT.)

**(SUNDAY FLOW INCL. IN MONDAY'S)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments	Date	Day	Plant Process Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.)* GPD	Power Meter	Oper.	Settleable Solids Samples 1 ml/l	2 ml/l	3 ml/l	pH Samples 1	2	3	Alkalinity Samples 1 mg/l	2 mg/l	3 mg/l		Lagoon 1		Lagoon 2		Weather Rainfall	Wind	Temp.
APRIL 1971	1	T		16,361	21,500	2100	20,200			2	—	—	6.6	7.6	7.6	360	386	360		2	40	9.5	39			60
	2	F		15,714	14,000	1800	13,000			2	—	—	6.7	7.6	7.8	400	386	340		2.1	46	9.3	37			28
	3	S		15,113	14,500	2100	13,200			1.5	—	—	6.6	7.6	7.6	400	400	340		5.2	37	11	39			18
	4	S		2,968	18,000	2100	16,700																			
D.O. at 3:30 pm - 4 pm	5	M		20,025	24,100	2100	22,800			3.0	—	—	6.4	7.5	7.6	380	400	344		7.2	37	10.8	39			20
" 2 pm	6	T		18,734	23,700	2400	22,100			2.0	—	—	6.5	7.5	7.55	444	414	350		3	37	10	39			25
" 1 pm	7	W		21,398	18,400	2100	17,300			3	—	—	6.5	7.5	7.75	442	416	346		4	43	10	39			40
	8	T		6,649	20,600	2100	19,300			2.5	—	—	6.45	7.65	7.85	440	416	344		4.3	46	9	43			42
CHANGED WEIR	9	F		12,008	20,600	1800	19,600			2	—	—	6.5	7.7	7.8	388	412	360		3.6	50	9	50			50
	10	S		14,291	17,500	2100	16,200			2	—	—	6.5	7.6	7.75	386	412	360		4.5	52	10	52			34
	11	S			**																					
	12	M		17,449	13,100	2100	11,800			—	—	—	6.4	7.65	7.6	300	412	360		5.1	54	7.2	54			48
	13	T		11,812	16,200	2400	14,600			1.5	—	—	6.5	7.5	7.6	420	412	360		0	55	7	54			45
	14	W		17,401	15,400	2100	14,100			1	—	—	6.5	7.4	7.5	440	436	364		.5	54	7	54			30
	15	T		12,140	22,800	2100	21,500			1.5	—	—	6.5	7.4	7.5	438	440	366		2	54	7.6	54			35
	16	F		13,874	20,100	1800	18,800			1	—	—	6.4	7.5	7.45	420	434	370		2.2	54	7.8	54			45
	17	S		12,251	20,400	2100	20,100			2	—	—	6.4	7.4	7.5	412	440	370		1	55	8.0	55			60
RAIN	18	S			**																					
RAIN	19	M		17,685	29,200	2100	27,900						6.5	7.5	7.5	390	430	365		1.5	55	6	55			35
RAIN	20	T		17,000	32,500	2400	32,500			1.0	—	—	6.5	7.5	7.5	380	410	374		.8	57	4.0	57			65
	21	W		14,818	19,000	2100	17,700						6.5	7.5	7.5	324	464	384		0	57	5.6	57			68
	22	T		12,802	17,500	2100	16,200						6.5	7.4	7.5	330	464	384		0	57	5.7	57			60
	23	F		13,961	16,400	1800	15,400						6.4	7.45	7.5	336	460	386		0	59	5.5	57			66
	24	S		15,242	14,900	2100	13,600						6.45	7.5	7.5	330	464	380		0	59	6.0	57			65
	25	S		-	**															1.5	59	5.5	59			70
	26	M		14,702	17,500	2100	16,200			—	—	—	6.5	7.5	7.4	250	450	370		0	64	5.6	64			40
RAIN	27	T		15,444	18,800	2400	17,200			2	—	—	6.5	7.45	7.5	320	448	370		0	64	4.8	64			40
RAIN	28	W		15,913	17,500	2100	16,200			1.5	—	—	6.4	7.5	7.5	354	444	376		0	66	4.5	64			45
	29	T		11,489	21,500	2100	20,200			1	—	—	7.2	7.55	7.46	370	440	380		0	64	4.5	64			45
	30	F		10,288	17,500	1800	16,500			1.8	—	—	7.0	7.5	7.6	370	440	396		0	64	8.0	64			40
	31																									
	Total			387,562	522,900	54,300	490,900			32.3	—	—	169.9	195.4	197.1	9824	11130	9499		50.5	1447	199	1420			1217
	Avg.			14,354	17,430	1810	16,363			1.70	—	—	6.5	7.5	7.6	378	428	365		1.9	53.5	7.4	52.5			45
	Max.			21,398	32,500	2400	32,500			3.0	—	—	7.2	7.7	7.85	444	464	396		7.2	66	11	64			70
	Min.			2,968	14,000	1800	11,800			1	—	—	6.4	7.4	7.4	300	386	340		0	37	4	37			18

*(WELL - BOILER + 800 GPD INFILT.)

**(SUNDAY FLOW INCL. W MONDAY'S)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments	Date	Day	Plant Process Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.)* GPD	Power Kw-Hr.	Oper. Man-Hr.	Settleable Solids Samples 1 ml/l	2 ml/l	3 ml/l	pH Samples 1	2	3	Alkalinity Samples 1 mg/l	2 mg/l	3 mg/l	Cl_2 mg/l	Lagoon 1 D.O. mg/l	Lagoon 1 Temp. °F	Lagoon 2 D.O. mg/l	Lagoon 2 Temp. °F	Weather Rainfall	Wind	Temp.
MAY 1971	1	S		14007	17,500	2100	16,200			1.5	—	—	6.9	7.5	7.55	370	440	396		0	18	8.5	18			
	2	S			**					—	—	—														
	3	M		15044	28,000	2100	26,700			.5	—	—	6.9	7.4	7.5	340	446	380		1	55	8.6	53			
	4	T		14,487	19,300	2400	17,700			1.5	—	—	7	7.7	7.4	340	344	380		0		8.2				
	5	W		14,589	18,800	2100	17,500			2	—	—	7	7.6	7.5	336	460	406		0		8.2				
	6	T		8,141	19,800	2100	18,500			1.8	—	—	6.7	7.6	7.7	340	460	400		0		7.9				
	7	F		8654	18,800	1800	17,800			2	—	—	6.6	7.0	7.6	340	460	400		0		8				
	8	S		11,709	19,000	2100	17,700			1.5	—	—	6.5	7.5	7.7	336	446	400		0		7				
	9	S			**					—	—	—														
	10	M		16,785	26,900	2100	25,600			—	—	—	6.6	7.4	7.6	326	476	408		.5		5.8				
	11	T		15,958	19,300	2400	17,700			1.6	—	—	6.6	7.5	7.6	340	470	400		0		5.8				
	12	W		15,457	19,300	2100	18,000			1.5	—	—	6.5	7.4	7.6	280	480	402		0		6				
	13	T		11,087	21,000	2100	19,700			1	—	—	6.4	7.5	7.65	296	480	400		0		5				
	14	F		14,456	21,000	1800	20,000			.8	—	—	6.5	7.45	7.7	290	476	400		0		5				
	15	S		10,774	19,300	2100	18,000			1.8	—	—	6.6	7.5	7.6	286	476	400		0		5.7				
	16	S			**					—	—	—														
	17	M		15,533	26,700	2100	25,400			—	—	—	6.2	7.4	6.9	262	500	410		0		2.3				
	18	T		16,573	21,000	2400	19,400			1	34	—	6.4	7.5	7.0	266	536	400		0		2.2				
RAIN	19	W		11,231	21,900	2100	20,600			1.5	40	—	6.4	7.4	7.2	228	524	400		0		2.2				
	20	T		9,853	19,700	2100	18,400			2	40	—	6.3	7.2	7.3	240	530	400		0		3				
	21	F		14,691	19,500	1800	18,500			3	40	—	6.3	7.2	7.3	300	534	410		0		3.5				
	22	S		10402	12,900	2100	11,600			2.5	75	—	6.4	7.2	7.3	280	530	405		0		3				
	23	S			**					—	—	—														
	24	M		15,699	28,500	2100	27,200			1	80	—	6.3	7.3	7.3	260	500	400		0		3.8				
	25	T		18,377	21,000	2400	19,400			1.5	85	—	6.4	7.4	7.5	300	512	400		0		2				
	26	W		18,718	20,700	2100	19,400			1	90	—	6.6	7.5	7.5	320	540	380		0		2				
	27	T		8,854	20,400	2100	19,100			1.8	95	—	6.6	7.5	7.5	326	514	368		0		2.5				
	28	F		13,084	17,500	1800	16,500			1	80	—	6.5	7.4	7.5	314	510	370		0		4.2				
	29	S		12,051	20,400	2100	19,100			1	70	—	6.4	7.4	7.4	320	512	376		0		3.8				
	30	S			**					—	—	—														
	31	M		9,789	43,800	2100	42,500			—	75	—	6.3	7.4	7.5	280	516	370		0		4				
	Total			346,003	562,000	54,600	528,200			34.8	804	—	169.9	192.8	193.9	7916	12672	10261		1.5	73	128	71			
	Avg.			13,308	18,129	1761	17,039			1.5	67	—	6.5	7.4	7.5	305	487	395		.75	36.5	4.9	35.5			
	Max.			18,718	43,800	2400	27,200			3	95	—	7	7.7	7.7	370	540	410		1	55	8.6	53			
	Min.			8,141	12900	1800	11,600			.5	34	—	6.2	7.0	6.9	228	344	368		0	18	2	18			

*(WELL – BOILER + 800 GPD INFLT)

**(SUNDAY FLOW INC. IN MONDAY'S)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments	Date	Day	Plant Process: Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.) GPD	Power	Kw-Hr.	Oper.	Settleable Solids Samples 1 ml/l	2 ml/l	3 ml/l	pH Samples 1	2	3	Alkalinity Samples 1 mg/l	2 mg/l	3 mg/l	D.O.	Lagoon 1	Lagoon 1	Lagoon 2	Lagoon 2	Weather Rainfall	Wind	Temp.
JUNE 1971	1	T		16,013	16,700	2400	15,100				2	75	—	6.5	7.3	7.4	260	520	376		0	68	3	66			
RAIN	2	W		12,043	16,800	2100	15,500				2	80	—	6.4	7.4	7.4	270	520	356		0	66	4.1	66			
	3	T		7,129	16,700	2100	15,400				2.3	85	—	6.3	7.4	7.5	300	516	366		0	67	4.0	67			
	4	F		16,888	21,900	1800	20,900				1	80	—	6.2	7.4	7.4	260	526	420		0	68	4.5	67			
WEST BLOWER OUT OF ORDER THIS A.M.	5	S		11,658	24,800	2100	23,500				1	95	—	6.3	7.4	7.5	300	540	430		0	68	2	68			
HIGH AMPERAGE AND TEMPERATURE	6	S			* *																						
RAIN	7	M		16,782	44,400	2100	43,100				—	130	—	6.4	7.5	7.6	200	540	420		0	70	3	68			
	8	T		8792	20,600	2400	19,000				2	140	—	6.4	7.4	7.6	180	530	370		0	70	3.5	70			
	9	W		13,571	19,700	2100	18,400				1.5	130	—	6.3	7.5	7.5	186	536	376		0	70	4.8	70			
	10	T		8,691	21,900	2100	20,600				2	140	—	6.3	7.5	7.5	260	540	370		0	71	5.2	71			
	11	F		14,755	16,700	1800	15,700				1.5	130	—	6.3	7.5	7.5	240	540	370		0	71	5.4	71			
	12	S		10,083	16,700	2100	15,400				1	130	—	6.3	7.4	7.6	200	536	370		0	70	5.4	71			
	13	S			* *																						
WE ARE HAVING PROBLEMS WITH HIGH	14	M		14,645	24,500	2100	23,200				—	110	—	6.4	7.4	7.5	180	530	376		0	71	4	72			
AMPERAGES ON OUR COMPRESSORS.	15	T		15,520	22,200	2400	20,600				15	130	—	6.3	7.4	7.4	206	536	374		0	71	3.8	73			
THEY ARE BLEEDING OF O_2 INTO THE	16	W		12,301	23,200	2100	21,900				2	135	—	6.3	7.4	7.5	260	526	392		0	71	3	73			
AIR TO LOWER AMPERAGES.	17	T		8,584	18,800	2100	17,500				1.5	130	—	6.3	7.5	7.6	240	530	396		0	72	2	72			
	18	F		14,984	23,700	1800	22,700				.2	135	—	6.3	7.4	7.6	190	526	390		0	72	2	74			
	19	S		12,404	20,600	2100	19,300				1.2	130	—	6.2	7.5	7.5	210	526	390		0	71	2	75			
	20	S			* *																						
RAIN	21	M		14,986	34,200	2100	32,900				—	120	—	6.3	7.6	7.6	140	500	380		0	72	.5	75			
	22	T		13,270	20,100	2400	18,500				1.5	120	—	6.3	7.5	7.6	280	530	412		0	74	1	76			
	23	W		13,486	19,700	2100	18,400				1.5	120	—	6.2	7.5	7.6	260	526	410		0	75	.8	76			
	24	T		8,055	18,800	2100	17,500				1	120	—	6.3	7.6	7.5	260	530	416		0	76	.5	77			
RAIN	25	F		15,152	21,500	1800	20,500				.5	120	—	6.3	7.5	7.6	200	530	416		0	76	.5	77			
	26	S		11,750	16,700	2100	15,400				1.5	120	—	6.2	7.5	7.5	212	530	420		0	76	.3	78			
	27	S			* *																						
	28	M		15,563	29,800	2100	28,500				—	120	—	6.3	7.6	7.6	180	426	416		0	73	1	80			
	29	T		11,883	29,300	2400	27,700				1.5	120	—	6.3	7.0	7.4	200	460	380		0	80	1.5	80			
	30	W		11,852	27,200	2100	25,900				2	120	—	6.3	7.3	7.5	216	460	310		0	81	0	81			
	31																										
	Total			330 840	587200	54900	553 100				32.4	3065	—	164	193.4	195.5	5890	13,510	10,102		0	1876	61.8	1894			
	Ave.			12,725	19,573	1830	18,437				1.5	118	—	6.3	7.4	7.5	227	520	389		0	72	2.6	73			
	Max.			16,888	44,400	2400	43,100				2.3	140	—	6.5	7.6	7.6	300	540	430		0	81	5.4	81			
	Min.			7,129	16,700	1800	15,100				.2	75	—	6.2	7.0	7.4	140	426	310		0	66	0	66			

*(WELL-BOILER + 800 GPD INFLT.)

**(SUNDAY FLOW INCL. IN MONDAY'S)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments	Date	Day	Plant Process: Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.)* GPD	Power Kw-Hr.	Oper. Man-Hr.	Settleable Solids Samples 1 ml/1	2 ml/1	3 ml/1	pH Samples 1	2	3	Alkalinity Samples 1 mg/1	2 mg/1	3 mg/1	Cl lb/D	Lagoon 1 DO mg/1	Lagoon 1 Temp. °F	Lagoon 2 DO mg/1	Lagoon 2 Temp. °F	Weather Rainfall	Wind	Temp.
JULY 1971	1	T		6,175	27,200	2100	25,900			1.2	100	—	6.3	7.4	7.5	240	500	460		0	80	.5	80			
	2	F		15,180	21,500	1900	20,400			1	120	—	6.2	7.4	7.5	220	536	440		0	75	1.5	74			
	3	S		5,075	27,200	2300	25,700			1.3	120	—	6.3	7.4	7.5	226	520	444		0	74	1.5	75			
	4	S			**																					
	5	M		14,863	39,400	1900	38,300			—	120	—	6.2	7.5	7.5	180	516	410		0	77	1.8	75			
	6	T		13,628	23,200	2400	21,600			2	100	—	6.3	7.4	7.6	200	500	420		0	74	2.8	74			
	7	W		15,148	23,600	2100	22,300			2	50	—	6.3	7.4	7.6	230	506	416		0	74	3.0	75			
RAIN	8	T		7,517	25,000	2,200	23,600			2	50	—	6.2	7.4	7.5	226	500	400		0	75	3.0	75			
	9	F		15,234	24,500	1700	23,600			2	50	—	6.3	7.4	7.5	220	500	360		0	73	2.0	75			
	10	S		12,773	21,900	2100	20,600			1.5	40	—	6.2	7.4	7.5	250	500	330		0	72	1.6	74			
	11	S			**																					
	12	M		14,477	42,500	2200	41,100			—	50	—	6.3	7.3	7.4	160	486	400		0	72	2.5	72			
	13	T		14,186	25,000	3300	22,500			.8	50	—	6.3	7.15	7.1	210	490	410		0	72	1.5	72			
	14	W		12,569	25,000	2100	23,700			.6	50	—	6.3	7.2	7.2	216	496	400		0	72	2.5	73			
	15	T		8,588	24,100	1800	23,100			.5	50	—	6.3	7.2	7.2	266	480	420		0	72	3.7	73			
	16	F		11,553	27,200	1800	26,200			.2	50	—	6.3	7.2	7.2	240	480	420		0	73	3.5	74			
	17	S		10,173	22,800	1900	21,700			0	50	—	6.2	7.2	7.2	200	490	420		0	72	3.5	73			
	18	S			**																					
	19	M		14,777	36,400	2100	35,100			—	—	—	6.3	7.2	7.3	260	520	404		2.5	72	2.7	70			
	20	T		11,574	25,000	2300	23,500			—	—	—	6.2	7.3	7.4	240	510	416		4.0	70	3.5	70			
	21	W		10,333	25,800	1700	24,900			—	—	—	6.2	7.1	7.2	230	520	424		4.0	71	3.7	71			
	22	T		7,706	20,600	1500	19,900			.2	—	—	6.2	7.1	7.1	240	516	416		4.0	71	3.5	72			
	23	F		17,949	24,100	1900	23,000			.2	—	—	6.3	7.2	7.2	200	520	420		1.5	71	3.0	72			
	24	S		8,775	26,300	2400	24,700			1.5	—	—	6.2	7.1	7.2	280	512	410		2	70	3.5	71			
RAIN	25	S			**																					
	26	M		14,340	40,300	1500	39,600			—	—	—	6.2	7.1	7.2	160	500	416		1.0	69	3.0	70			
	27	T		13,236	25,800	2800	23,800			1.2	—	—	6.2	7.2	7.2	240	500	412		0	69	5.0	70			
	28	W		12,386	21,500	2100	20,200			1	—	—	6.3	7.1	7.2	260	506	410		.2	69	5.7	71			
	29	T		7,590	20,600	1800	19,600			.6	—	—	6.2	7.1	7.2	260	500	412		.2	70	6.0	71			
	30	F		16,743	20,600	2100	19,300			.2	—	—	6.1	7.2	7.1	260	510	416		0	70	5.5	71			
	31	S		12,549	19,700	2100	18,400			1.5	—	—	6.2	7.2	7.2	280	500	412		.5	69	5.0	70			
	Total			311,435	706,800	56,100	672,300			21.5	1050	—	168.6	195.8	197.5	6194	13614	11,148		19.9	[illegible]	85	[illegible]			
	Avg.			11,535	22,800	1810	21,687			1.0	70	—	6.2	7.3	7.3	229	504	413		.7	72	3.1	73			
	Max.			17,949	42,500	3300	41,100			2	120	—	6.3	7.5	7.6	280	536	460		4	80	6	80			
	Min.			5,075	19,700	1500	18,400			0	40	—	6.1	7.1	7.1	160	480	330		0	69	.5	70			

*(WELL–BOILER + 800 GPD INFILT.)

**(SUNDAY FLOW INCL. IN MONDAY'S)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments AUGUST 1971	Date	Day	Plant Process Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.)* GPD	Power	Kw.-hr.	Oper. Hours	Settleable Solids Samples 1 ml/l	2 ml/l	3 ml/l	pH Samples 1	2	3	Alkalinity Samples 1 mg/l	2 mg/l	3 mg/l	D.O. mg/l	Lagoon 1 D.O. mg/l	Lagoon 1 Temp. °F	Lagoon 2 D.O. mg/l	Lagoon 2 Temp. °F	Weather Rainfall	Wind	Temp.
	1	S																									
	2	M		16,828	31,500	2300	30,000				—	—	—	6.2	7.1	7.2	170	512	416		1.0	70	5.0	71	✓		
	3	T		12,815	20,100	2400	18,500				1	—	—	6.3	7.2	7.2	260	500	412		.2	70	4.5	71			
	4	W		12,831	19,700	2200	18,300				1.8	—	—	6.2	7.3	7.2	180	500	420		.7	70	4.5	71			
	5	T		12,472	25,800	1900	24,700				1.5	—	—	6.2	7.3	7.2	180	500	416		1.0	69	5.0	70			
	6	F		15,525	20,600	2000	19,400				.2	—	—	6.2	7.3	7.3	200	506	412		1.8	69	4.0	70			
	7	S		11,545	22,300	2500	20,600				1	—	—	6.3	7.2	7.3	190	512	412		1.0	69	4.0	70			
	8	S			**																						
STARTED STANDBY	9	M		17,065	36,300	1900	35,200				—	—	—	6.3	7.2	7.2	160	516	400		1.5	70	4.5	70			
compressor, 4 AM	10	T		17,041	22,800	2500	21,200				1.5	—	—	6.3	7.2	7.3	190	512	406		1.0	70	5.0	71			
RAIN	11	W		14,810	20,100	2200	18,700				1.3	—	—	6.3	7.2	7.2	160	500	420		.5	72	4.5	72			
	12	T		6,797	26,300	2200	24,900				1	—	—	6.2	7.2	7.2	170	500	416		.8	73	4.5	74			
	13	F		16,561	21,900	1700	21,000				.2	—	—	6.2	7.1	7.2	160	506	416		2	73	4.2	74			
	14	S		10,421	21,900	1700	21,000				.8	—	—	6.3	7.2	7.2	180	512	412		2.4	72	4.2	73			
	15	S			**																						
	16	M		15,614	30,300	2300	28,800				—	—	—	6.3	7.2	7.2	140	500	400		3.5	71	4.2	72			
	17	T		17,517	31,100	2700	29,200				2.5	—	—	6.3	7.2	7.2	280	488	380		1	71	4.8	72			
	18	W		11,756	21,400	2500	19,700				1	—	—	6.3	7.1	7.2	260	490	400		1	71	4.5	72			
	19	T		7,754	22,800	2000	21,600				.5	—	—	6.2	7.1	6.2	240	480	400		1	71	4.5	72			
	20	F		11,936	21,900	1900	20,800				.8	—	—	6.2	7.1	6.2	246	476	412		1	72	4.5	73			
	21	S		9,945	21,900	2100	20,600				.8	—	—	6.2	7.1	6.2	200	440	412		1	72	4.3	73			
	22	S			**																						
	23	M		13,426	28,900	2000	27,700				—	—	—	6.1	7.2	7.3	140	420	400		4.8	72	4.5	73			
	24	T		11,955	22,300	2400	20,700				.8	—	—	6.2	7.2	7.2	200	400	400		4.5	72	4.5	73			
	25	W		17,299	21,900	2100	20,600				.2	—	—	6.2	7.2	7.2	180	412	400		4.5	72	4.5	73			
	26	T		11,742	22,800	2600	21,000				.8	—	—	6.2	7.3	7.2	200	400	406		3.5	71	4.5	72			
METER REPLACED	27	F		12,511	20,600	2100	19,300				.2	—	—	6.1	7.2	7.2	180	400	400		4.0	71	4.5	71			
ON POLE	28	S		11,639	18,800	2300	17,300				.5	—	—	6.2	7.1	7.5	190	412	400		4.0	70	3.8	71			
	29	S			**																						
	30	M		16,004	32,000	2500	30,300				—	—	—	6.1	7.1	7.3	160	436	420		6.0	70	6.0	70			
	31	T		12,086	21,900	2600	20,100				.5	—	—	6.2	7.1	7.2	200	430	416		4.1	70	5.6	70			
	Total			345,895	627,900	57,600	591,100				18.9	—	—	161.8	186.7	185	5016	12,260	10,604		56	1903	[illegible]	[illegible]			
	Ave.			13,304	20,255	1858	19,068				.9	—	—	6.2	7.2	7.1	193	472	408		2.2	73	4.6	72			
	Max.			17,517	36,300	2700	35,200				2.5	—	—	6.3	7.3	7.3	280	516	420		6.	73	6.	74			
	Min.			6,797	18,800	1700	17,300				.2	—	—	6.1	7.1	6.2	140	400	380		.2	69	3.8	70			
	*(WELL-BOILER + 800 GPD INFIL.)						**(SUNDAY FLOW INCL. IN MONDAY'S)																				

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments	Date	Day	Plant Process: Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.)* GPD	Power Kw-Hr.	Oper. Man-Hr.	Settleable Solids Samples 1 ml/l	2 ml/l	3 ml/l	pH Samples 1	2	3	Alkalinity Samples 1 mg/l	2 mg/l	3 mg/l	Cl lb/D	Lagoon 1 DO mg/l	Lagoon 1 Temp. °F	Lagoon 2 DO mg/l	Lagoon 2 Temp. °F	Weather Rainfall	Wind	Temp.
SEPTEMBER 1971	1	W		18,379	33,300	2300	31,800			.5	—	—	6.2	7.1	7.2	200	426	416		3.0	70	5.6	71			
	2	T		7,541	24,000	2700	22,100			.8	—	—	6.2	7.2	7.3	240	416	400		2.5	70	4.3	71			
	3	F		13,626	22,800	1800	21,800			.2	—	—	6.3	7.2	7.3	190	412	406		2.0	70	4.0	71			
	4	S		4963	22,800	2200	21,400			.2	—	—	6.3	7.2	7.2	190	420	400		1.0	70	3.0	71			
	5	S			**																					
	6	M		17,527	33,100	2200	31,700			—	—	—	6.3	7.2	7.2	160	420	422		3	70	5.0	71			
	7	T		14,303	23,400	2600	21,600			.5	—	—	6.2	7.3	7.3	280	436	436		3	70	5.0	71			
	8	W		15,129	22,800	2100	21,500			.6	—	—	6.2	7.3	7.2	240	450	440		1.5	70	5.0	71			
	9	T		12,773	26,300	2200	24,900			.5	—	—	6.3	7.2	7.1	216	450	436		.5	70	5.0	71			
	10	F		10,279	21,500	2000	20,300			.5	—	—	6.2	7.2	7.2	224	444	440		1.5	70	5.0	71			
	11	S		12,695	26,300	2500	24,600			.4	—	—	6.2	7.2	7.2	240	440	436		2.0	70	5.0	71			
	12	S			**																					
	13	M		14,699	24,500	2000	23,300			–	—	—	6.2	7.2	7.2	160	460	424		3.0	70	4.5	71			
	14	T		9,939	20,600	2400	19,000			.5	—	—	6.2	7.2	7.3	190	460	450		1	70	5	71			
	15	W		15,952	18,800	2200	17,400			.8	—	—	6.2	7.2	7.3	240	460	470		.5	69	5.0	70			
	16	T		13,120	25,400	2000	24,200			.5	—	—	6.2	7.2	7.3	240	456	450		.5	69	5.0	69			
	17	F		18,032	21,500	1900	20,400			.2	—	—	6.2	7.2	7.2	220	456	430		.8	65	5.0	67			
	18	S		16,604	19,300	2400	17,700			.8	—	—	6.2	7.2	7.2	240	456	440		.5	65	5.0	67			
	19	S			**																					
	20	M		21,939	31,100	2600	29,300			—	—	—	6.2	7.1	7.3	200	460	436		2.0	65	6.0	64			
	21	T		17,408	21,900	2800	19,900			.8	—	—	6.2	7.1	7.2	240	460	446		.3	65	8.3	64			
	22	W		18,566	18,800	2100	17,500			.8	—	—	6.2	7.1	7.2	240	460	436		.2	65	5.9	65			
	23	T		12,784	23,200	2300	21,700			1.5	—	—	6.3	7.1	7.2	240	466	420		.5	65	7.3	65			
	24	F		14,644	17,100	1700	16,200			.6	—	—	6.2	7.1	7.3	226	460	424		.5	64	7.0	64			
	25	S		14,964	18,800	2300	17,300			.8	—	—	6.2	7.1	7.25	230	460	420		.2	64	7.0	63			
	26	S			**																					
	27	M		11,870	35,000	1900	33900			.1	—	—	6.3	7.2	7.3	190	466	430		2	65	7.5	64			
	28	T		21,067	21,500	2000	20,300			.6	—	—	6.2	7.2	7.2	240	476	430		.5	65	6.8	65			
	29	W		13,313	18,800	1900	17,700			.5	—	—	6.2	7.3	7.2	240	480	436		.3	65	6.5	65			
	30	T		6,537	21,500	1900	20,400			.5	--	—	6.2	7.2	7.3	240	480	440		.3	66	6.5	65			
	31																									
	Total			378,653	614,100	57,000	577,900			13.2	—	—	162	186.8	188.2	5756	11,730	11,214		33.1	1757	145	1789			
	Avg.			14,564	20,470	1900	19,263			.6	—	—	6.2	7.2	7.2	221	451	431		1.3	68	5.6	68			
	Max.			21,939	35,000	2800	33,900			1.5	—	—	6.3	7.3	7.3	280	480	470		3.	70	8.3	71			
	Min.			4963	17,100	1700	16,200			.1	—	—	6.2	7.1	7.1	160	412	400		.2	64	3.0	63			

*(WELL-BOILER + 800 GPD INFILT.)

**(SUNDAY FLOW INCL. IN MONDAY'S)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments	Date	Day	Plant Process Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc)* GPD	Power Kw-Hr.	Oper. Man-Hr.	Settleable Solids Samples 1 ml/l	2 ml/l	3 ml/l	pH Samples 1	2	3	Alkalinity Samples 1 mg/l	2 mg/l	3 mg/l	DO mg/l	Lagoon 1 DO mg/l	Lagoon 1 Temp	Lagoon 2 DO mg/l	Lagoon 2 Temp	Weather Rainfall	Wind	Temp.
OCTOBER 1971	1	F		14,927	15,800	1400	15,200			.2	—	—	6.2	7.1	7.2	200	460	444		.2	68	6.7	65			
	2	S		14,306	18,000	2000	16,800			.6	—	—	6.2	7.1	7.2	226	480	436		0	70	6.2	69			
	3	S			**																					
	4	M		17,573	26,300	2000	25,100			.2	—	—	6.2	7.2	7.2	190	476	440		2.0	67	6.5	66			
	5	T		12,617	25000	2400	23,400			.5	—	—	6.2	7.2	7.3	240	474	440		.4	67	6.5	66			
	6	W		19,635	18,400	2100	17,100			.5	—	—	6.2	7.3	7.2	260	480	436		.6	62	7.5	64			
	7	T		4848	21,000	1900	19,900			.4	—	—	6.1	7.2	7.2	240	476	440		.4	61	7.3	63			
	8	F		12,366	14,900	1200	14,500			.2	—	—	6.2	7.2	7.3	210	476	440		.2	61	7.5	63			
	9	S		17,873	18,400	2200	17,000			.5	—	—	6.2	7.2	7.2	240	480	440		.2	61	7.5	62			
	10	S			**																					
	11	M		19,867	35,900	2300	34,400			—	—	—	6.2	7.1	7.2	180	480	436		5.6	60	9.0	61			
	12	T		14,446	20,100	2300	18,600			.6	—	—	6.2	7.2	7.2	240	476	440		4.0	59	8.0	60			
	13	W		12,833	18,800	1900	17,700			.4	—	—	6.2	7.2	7.1	240	480	440		2.5	59	7.5	60			
	14	T		13,439	21,000	2000	19,800			.5	—	—	6.2	7.2	7.2	240	480	444		2.0	57	7.0	59			
	15	F		18,064	16,400	1600	15,600			.2	—	—	6.2	7.2	7.2	226	480	440		.8	57	6.5	59			
	16	S		11,844	22,600	2200	21,200			.4	—	—	6.1	7.2	7.3	240	476	436		.8	57	6.5	59			
	17	S			**																					
	18	M		15,137	28,500	2200	27,100			—	—	—	6.2	7.2	7.1	180	480	440		.5	52	7.0	60			
	19	T		18,819	20,100	2000	18,900			.5	—	—	6.2	7.2	7.2	240	476	444		1.5	56	7.0	61			
	20	W		15,819	19,300	2300	17,900			.3	—	—	6.2	7.2	7.2	240	474	444		0	58	6.0	60			
	21	T		4,136	24,500	2100	23,200			.5	—	—	6.2	7.2	7.2	246	480	442		.2	58	6.2	62			
	22	F		16,796	18,000	1900	16,900			.3	—	—	6.3	7.2	7.1	230	476	440		0	60	6.0	62			
	23	S		14,534	17,500	1800	16,500			.3	—	—	6.3	7.2	7.1	226	470	436		0	62	5.8	64			
	24	S			**																					
D.O. AT 1PM :	25	M		19,085	19,000	2000	17,800			—	—	—	6.2	7.2	7.2	186	470	444		1.5	65	6.5	65			
1ST CELL 0 2ND CELL 8	26	T		19,474	21,000	2200	19,600			.4	—	—	6.1	7.2	7.2	236	480	436		0	66	7.0	67			
	27	W		12,596	18,800	2100	17,500			.3	—	—	6.2	7.2	7.1	240	480	430		1	64	8.0	66			
	28	T		10,380	18,400	1900	17,300			.5	—	—	6.2	7.2	7.1	240	476	444		0	61	7.5	60			
	29	F		10,535	18,800	1700	17,900			.4	—	—	6.3	7.2	7.2	240	470	444		0	58	8.0	57			
	30	S		16,925	15,800	2000	14,600			.5	—	—	6.3	7.2	7.0	236	474	440		1	65	8.0	63			
	31	S			**																					
	Total			378,874	535,300	51,600	504,500			9.2	—	—	161.3	187	194	5912	12,380	11,436		25.4	1591	183	1559			
	Avg.			14,572	17,268	1665	16,274			.4	—	—	6.2	7.2	7.5	227	476	440		1	61	7.0	60			
	Max.			19,867	35,900	2400	34,400			.6	—	—	6.3	7.3	7.3	260	480	444		.2	70	9.	69			
	Min.			4,136	14,900	1200	14,500			.2	—	—	6.1	7.1	7.0	180	460	430		0	52	5.8	57			

*(WELL - BOILER + 800 GPD INFILT.) **(SUNDAY FLOW INCL IN MONDAY'S)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments	Date	Day	Plant Process Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.)* GPD	Power Kw-Hr.	Oper. Man-Hr.	Settleable Solids Samples 1 ml/l	2 ml/l	3 ml/l	pH Samples 1	2	3	Alkalinity Samples 1 mg/l	2 mg/l	3 mg/l	DO mg/l	Lagoon 1 DO mg/l	Lagoon 1 Temp.	Lagoon 2 DO mg/l	Lagoon 2 Temp.	Weather Rain-fall	Wind	Temp.
NOVEMBER 1971	1	M		17,799	26,700	2300	25,200			.2	—	—	6.2	7.2	7.2	180	484	452		5.8	54	8.0	52			
RAIN	2	T		21,800	18,800	2300	17,300			.4	—	—	6.2	7.3	7.2	230	480	454		5.5	58	8.8	58			
	3	W		17,681	16,600	2000	15,400			.5	—	—	6.2	7.2	7.1	240	480	448		5.5	55	10	54			
	4	T		12,122	20,100	2300	18,600			.4	—	—	6.2	7.2	7.2	240	480	444		6.0	50	10	54			
	5	F		11,204	11,800	1300	11,300			.2	—	—	6.2	7.2	7.1	236	484	440		6.0	52	10	52			
	6	S		14,623	16,600	1000	15,400			.5	—	—	6.2	7.2	7.2	240	480	436		5.5	47	10	49			
	7	S			**																					
	8	M		11,071	28000	2800	26,000			.1	—	—	6.2	7.1	7.1	180	484	444		7.0	45	10	46			
	9	T		13,165	18,900	3300	16,400			.5	—	—	6.3	7.2	7.2	240	480	446		8.0	45	12	40			
	10	W		14,815	14,600	2000	13,400			.5	—	—	6.2	7.2	7.2	240	476	440		7.0	45	12	40			
	11	T		12,225	13,400	2000	12,200			.4	—	—	6.2	7.2	7.2	230	478	440		6.5	44	12	40			
	12	F		14,703	8,600	1700	7,700			.3	—	—	6.2	7.3	7.3	236	480	444		6.0	47	12	43			
	13	S		17,154	9,000	1800	8,000			.4	—	—	6.2	7.2	7.2	240	484	440		6.0	47	12	43			
	14	S			**																					
	15	M		20,313	26,000	2000	24,800			—	—	—	6.2	7.2	7.2	180	480	436		6.0	45	12.5	44			
	16	T		20,656	16,400	2500	14,700			.4	—	—	6.3	7.2	7.2	240	486	440		3.0	46	9	45			
	17	W		23,264	18,150	2300	16,450			.5	—	--	6.2	7.1	7.1	240	484	440		0	54	8.5	48			
	18	T		14963	16,643	2100	15,343			.4	—	—	6.1	7.2	7.2	236	484	444		0	52	8	48			
	19	F		21,943	16,215	2000	15,015			.8	—	-	6.2	7.2	7.2	240	476	440		0	50	8.5	48			
	20	S		16,073	12,877	1300	12,377			.5	—	-	6.3	7.2	7.2	240	470	440		0	46	9	44			
	21	S			19000	2600	17,200																			
	22	M		19,897	16,788	2500	15,088			—	—	—	6.2	7.2	7.2	180	474	444		2	41	10.6	40			
	23	T		16,470	16,442	1800	15,442			.5	--	—	6.2	7.2	7.2	240	480	436		.7	42	10	40			
	24	W		10,174	16,000	1100	15,700			.4	..	—	6.2	7.3	7.3	240	484	436		.7	43	10	40			
	25	T			17,100	2300	15,600			.3	—	—	6.2	7.2	7.2	240	484	440		2	43	10	41			
	26	F		16,394						—	—	—	6.2	7.2	7.2	200	480	440		4.5	42	11	40			
SNOW	27	S		19,315	22,875	2100	21,575			.6	—	—	6.2	7.2	7.2	240	484	440		6.0	41	11.3	40			
	28	S			19,925	2800	17,925																			
SNOW	29	M		14,430	17,500	1800	16,500			—	—	—	6.2	7.1	7.2	180	480	444		6.0	40	12	40			
	30	T		19,092	18,000	1800	17,000			.5	—	—	6.3	7.2	7.2	240	484	444		6.5	40	12	40			
	31	W																								
	Total			416,845	473,000	56,800	437,600			9.3	—	—	161.5	187.2	187	5868	12,500	11,492		112.2	[illegible]	[illegible]	[illegible]			
	Avg.			15,439	15,767	1893	14,587			.4	—	—	6.2	7.2	7.2	226	481	442		4.3	47	10.4	45			
	Max.			23,264	28,000	3300	26,000			.8	—	—	6.3	7.3	7.3	240	486	454		8.	58	12.5	58			
	Min.			10,174	8,600	1100	7,700			.1	—	—	6.1	7.1	7.1	180	470	436		0	40	8	40			

*(WELL-BOILER + 800 GPD INFLT.)

**(SUNDAY FLOW INCL IN MONDAY'S)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments DECEMBER 1971	Date	Day	Plant Process Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.)* GPD	Power	Kw-hr.	Oper.	Settleable Solids Samples 1 ml/l	2 ml/l	3 ml/l	pH Samples 1	2	3	Alkalinity Samples 1 mg/l	2 mg/l	3 mg/l		Lagoon 1 a	Lagoon 1 b	Lagoon 2 a	Lagoon 2 b	Weather Rainfall	Wind	Temp.
	1	W			16,695	2300	15,195				.5	—	–	6.2	7.2	7.2	240	490	456		5	37	12.5	38			
CHECKED CALIBRATION	2	T			23,305	2400	21,505				.3	—	—	6.2	7.2	7.2	236	520	460		8	35	11.5	35			
OF EFF.	3	F			17,245	2300	15,745				.2	–	—	6.2	7.2	7.2	236	520	462		5	39	11	36			
" "	4	S			21,750	2800	19,750				.5	—	—	6.2	7.2	7.2	240	520	468		4	40	11	38			
INFILTRATION TEST	5	S			9,825	1700	8,925				—	—	—														
ON SEWER LINE	6	M			9,155	1000	8,955				—	–	—	6.3	7.2	7.2	180	520	480		4.5	40	11.5	39			
CHECK CALIBRATION	7	T			17,540	2900	15,440				.4	–	—	6.3	7.2	7.2	240	520	480		3	41	11.5	41			
OF EFF. RAIN	8	W			21,210	2700	19,310				.5	–	—	6.2	7.2	7.1	240	522	480		1.2	41	11.6	41			
RAIN	9	T			15,565	2000	14,365				.3	–	—	6.2	7.2	7.2	240	520	476		4.0	44	12	43			
RAIN	10	F			16,765	2300	15,265				.5	–	—	6.3	7.2	7.2	240	530	436		4.8	45	12.5	43			
CHECKED CALIBRATION OF EFF.	11	S			15,980	2300	14,480				.5	..	...				236	516	480		5	44	12.5	43			
EARLIER SNOWFALL	12	S			11,450	1600	10,650				—	-	—	6.3	7.1	7.2											
HAS MELTED (8")	13	M			9,875	1000	9,675				—	—	—	6.2	7.2	7.2	194	520	480		6.0	35	13	35			
	14	T			17,805	2800	15,805				.5	—	—	6.2	7.2	7.2	190	520	460		5.5	40	14	41			
RAIN (2")	15	W			17,540	2700	15,640				.8	—	—	6.2	7.2	7.2	230	516	460		5.0	40	14	41			
	16	T			17,855	2500	16,155				.4	–	—	6.2	7.3	7.2	220	520	464		3.0	41	14	41			
	17	F			15,835	2400	14,235				.3	–	—	6.2	7.3	7.2	220	500	440		3.0	34	14	34			
	18	S			13,270	2300	11,770				.4	—	—				226	500	444		4.0	33	15	34			
INFILTRATION TEST ON	19	S			13095	2000	11,895				—	—	—	6.2	7.3	7.2											
SEWER LINE	20	M			11,125	1600	10,325				.1	–	—	6.2	7.2	7.2	200	500	456		1.5	37	10	35			
CHECKED CAL. OF	21	T			20,640	2500	18,940				.5	—	—	6.3	7.2	7.2	240	500	460		3.0	35	11	35			
EFF.	22	W			18,570	2400	16,970				.5	–	—	6.3	7.2	7.2	240	480	490		3.5	35	11.2	35			
	23	T			15,995	2200	14,595				.5	—	—	6.3	7.2	7.2	230	484	480		3.5	37	11	35			
	24	F			19,105	2500	17,405				.5	—	—	6.3	7.2	7.2	240	490	484		4.0	36	11	35			
	25	S																									
	26	S			25,185	2500	23,485				.2	—	—	6.2	7.2	7.3	200	484	470		4.0	36	12	36			
	27	M			13,215	1500	12,515				.5	—	—	6.2	7.2	7.2	236	484	476		3.5	37	11	36			
CHECKED CAL. OF	28	T			18,800	3000	16,600				.5	—	—	6.2	7.2	7.2	240	490	480		2.0	37	10	36			
EFF.	29	W			20,955	3000	18,755				.4	–	—	6.3	7.2	7.2	230	490	484		.5	36	9	36			
	30	T			20,435	3100	18,135				.5	—	—	6.2	7.2	7.2	240	492	484		.2	36	9	36			
	31	F			20,120	2400	18,520				.4	—	—	6.2	7.2	7.2	230	490	484		3	36	9	36			
	Total				505,905	68,900	461,000				10.7	—	—	168.3	194.6	194.4	6134	13,628	12,714		99.7	1092	346	1104			
	Avg.				16,320	2223	14,811				.4	—	–	6.2	7.2	7.2	227	505	471		3.7	38	11.9	37.6			
	Max.				25,185	3100	23,485				.8	—	–	6.3	7.3	7.3	240	522	490		8.	45	15	43			
	Min.				9,155	1000	8,925				.1	—	—	6.2	7.1	7.1	180	480	440		.2	33	9	34			

*(WELL-BOILER + 800 GPD INFILT.)

To: C. W. Klassen, Director
Environmental Protection Agency
Bureau of Water Pollution Control
525 W. Jefferson St.
Springfield, Illinois

MONTHLY OPERATION REPORT

Comments JANUARY 1972	DATE	DAY	PLANT PROCESS Milk Prdts. lbs.	Cheese Prdts. lbs.	Plant Well (GPD)	Boiler Flow GPD	Lagoon Inf. (Calc.)* GPD	POWER Kw-Hr.	OPER. Man-Hr.	SETTLEABLE SOLIDS Samples 1 ml/1	2 ml/1	3 ml/1	pH Samples 1	2	3	ALKALINITY Samples 1 mg/1	2 mg/1	3 mg/1	Cl lb/D	LAGOON 1 DO mg/1	Temp. °F	LAGOON 2 DO mg/1	Temp. °F	WEATHER Rain-fall	Wind	Temp.
	1	S			17,295	2200	15,895																			
ICE OVER 90%	2	S			12,000	2100	10,700																			
OF 2ND CELL,	3	M		12,371	13,465	1500	12,765			.2	—	—	6.2	7.2	7.2	180	490	480		3.8	40	11	38			
75% OF 1ST CELL.	4	T		19,108	9,325	2500	7,625			.5	—	—	6.2	7.2	7.3	230	480	484		3.0	34	11	34			
	5	W		23,534	28,595	3000	26,395			.3	—	—	6.3	7.2	7.2	210	484	480		2.0	35	11	34			
	6	T		13,534	20,400	2300	18,900			.3	—	—	6.2	7.2	7.2	220	470	484		1.0	35	10	34			
	7	F		12,289	17,790	2800	15,790			.5	—	—	6.3	7.2	7.2	236	474	480		.5	35	10	34			
	8	S		10,418	23,060	2700	21,160			.4	—	—	6.2	7.2	7.2	240	478	484		2	36	10	35			
	9	S			12,330	2000	11,130																			
MELTING ICE	10	M		24,352	7,635	1100	7,335			—	—	—	6.2	7.3	7.2	200	508	490.		4.8	40	11.2	41			
" "	11	T		16,843	21,080	2700	19,180			.6	—	—	6.2	7.3	7.2	238	500	500		4.0	39	11.5	37			
" "	12	W		15,080	19,415	2800	17,415			.4	—	—	6.2	7.2	7.2	200	526	500		3.5	38	12	37			
MELTING ICE	13	T		7,431	19,708	2500	18,008			.5	—	—	6.2	7.2	7.2	210	516	500		3.0	36	12	36			
	14	F			17,417	2200	16,017			.4	—	—	6.2	7.2	7.2	210	520	500		3.0	35	12	35			
	15																									
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	30																									
	31																									
	Total																									
	Avg.																									
	Max.																									
	Min.																									

*(WELL-BOILER + 800 GPD INFLT.)

APPENDIX D

Cost Estimates

Annuity whose present value is 1

$$A^{-1}_{\overline{n}|i} = i \Big/ (1-v^n) = S^{-1}_{\overline{n}|\,i} + i$$

Mechanical Equipment - \$15,592.82

n = 5yr i = 0.075 (7 1/2%) 0.24716472 x \$15,592.82 = 3853.99

Construction - \$33,900.56

n = 30 yr i = 0.075 (7 1/2%) 0.08467124 x 33,900.56 = 2870.40

where

$A_{\overline{n}|i}$ present value of annuity for unit periodic payment at interest rate i

i = rate of interest

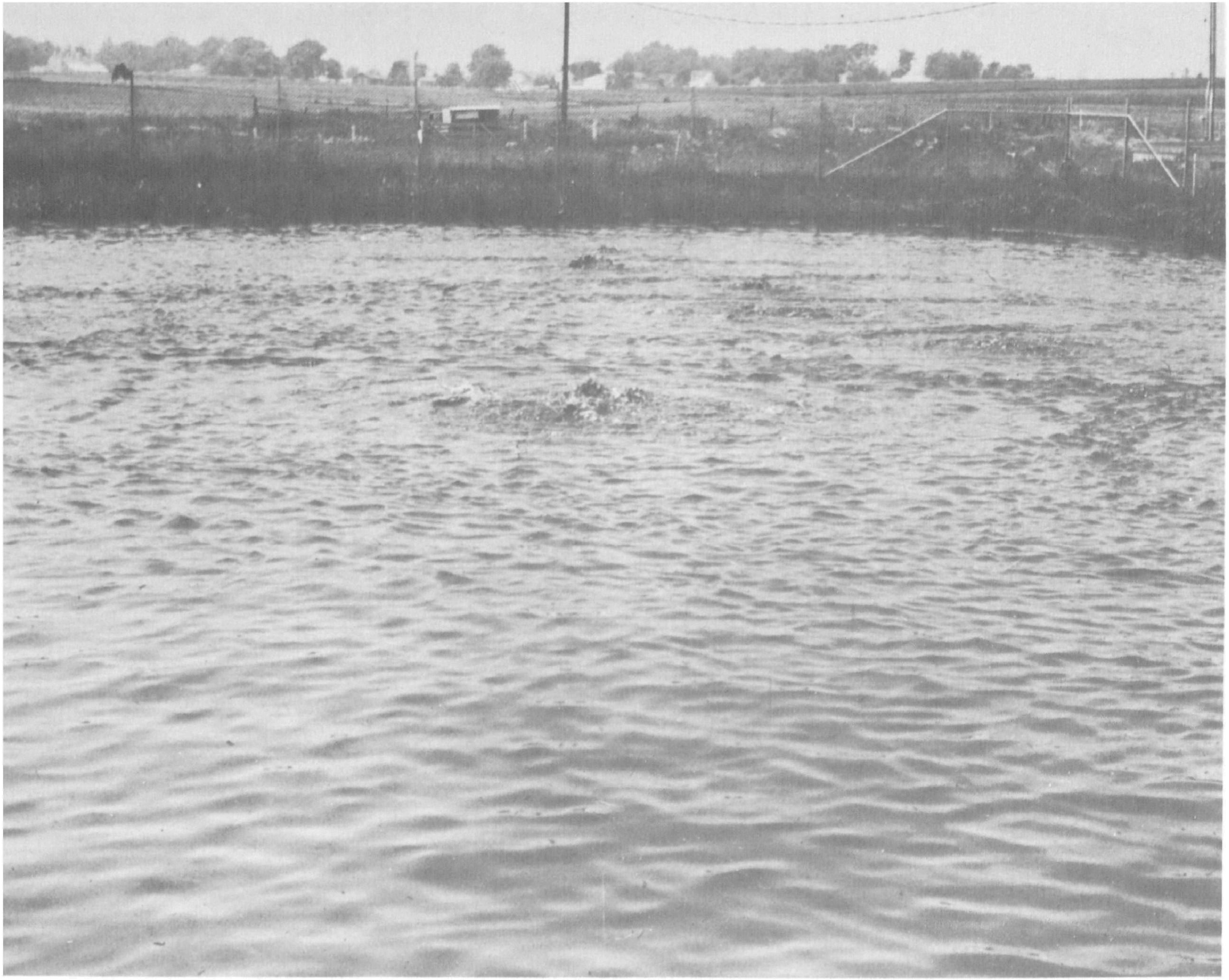
n = number of conversion periods

v = present value (at compound interest) for unit principal, $= (1 + i)^{-1}$

S = Amount (at compound interest) for unit principal = $(1 + i)^n$

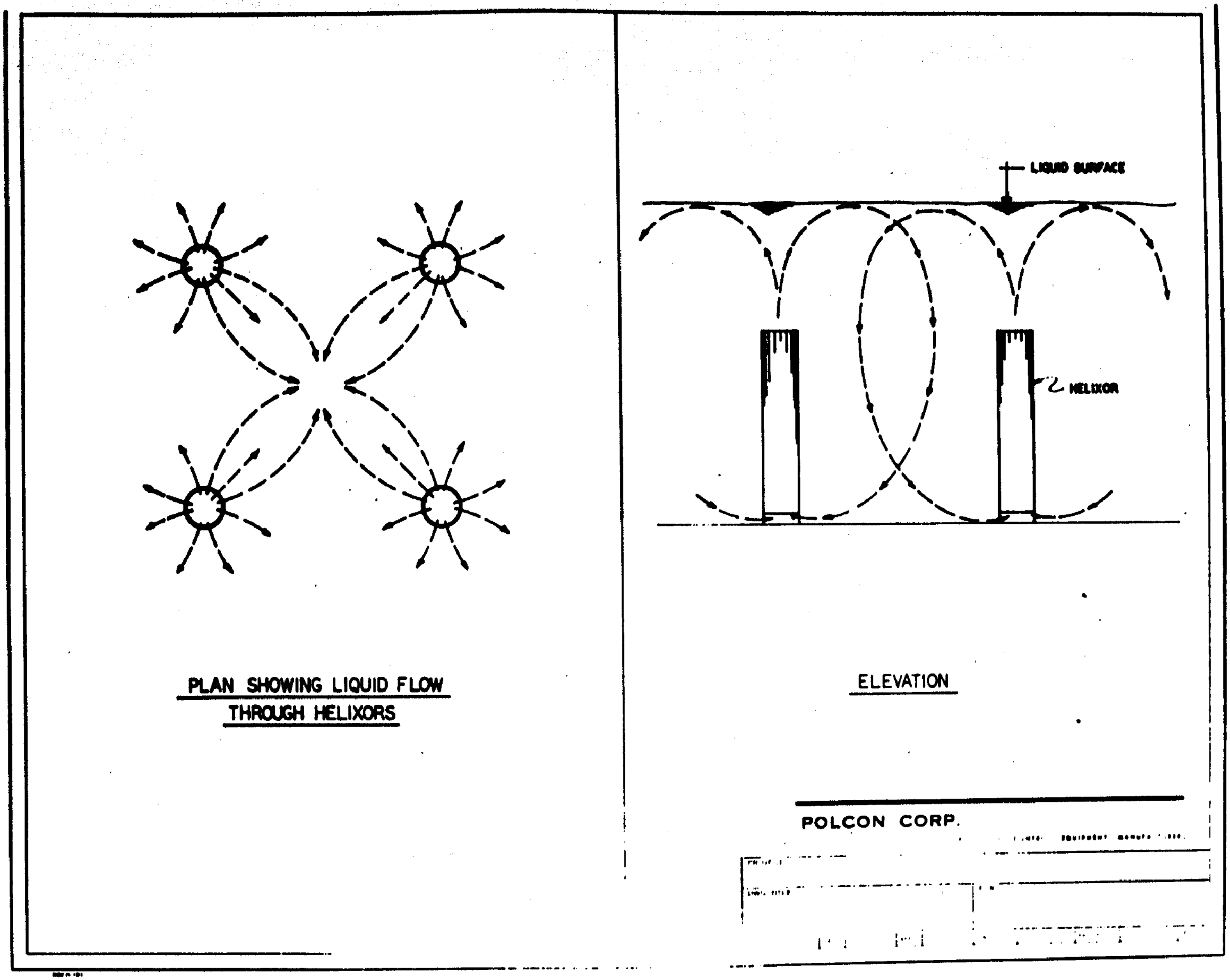
APPENDIX E

Pictures

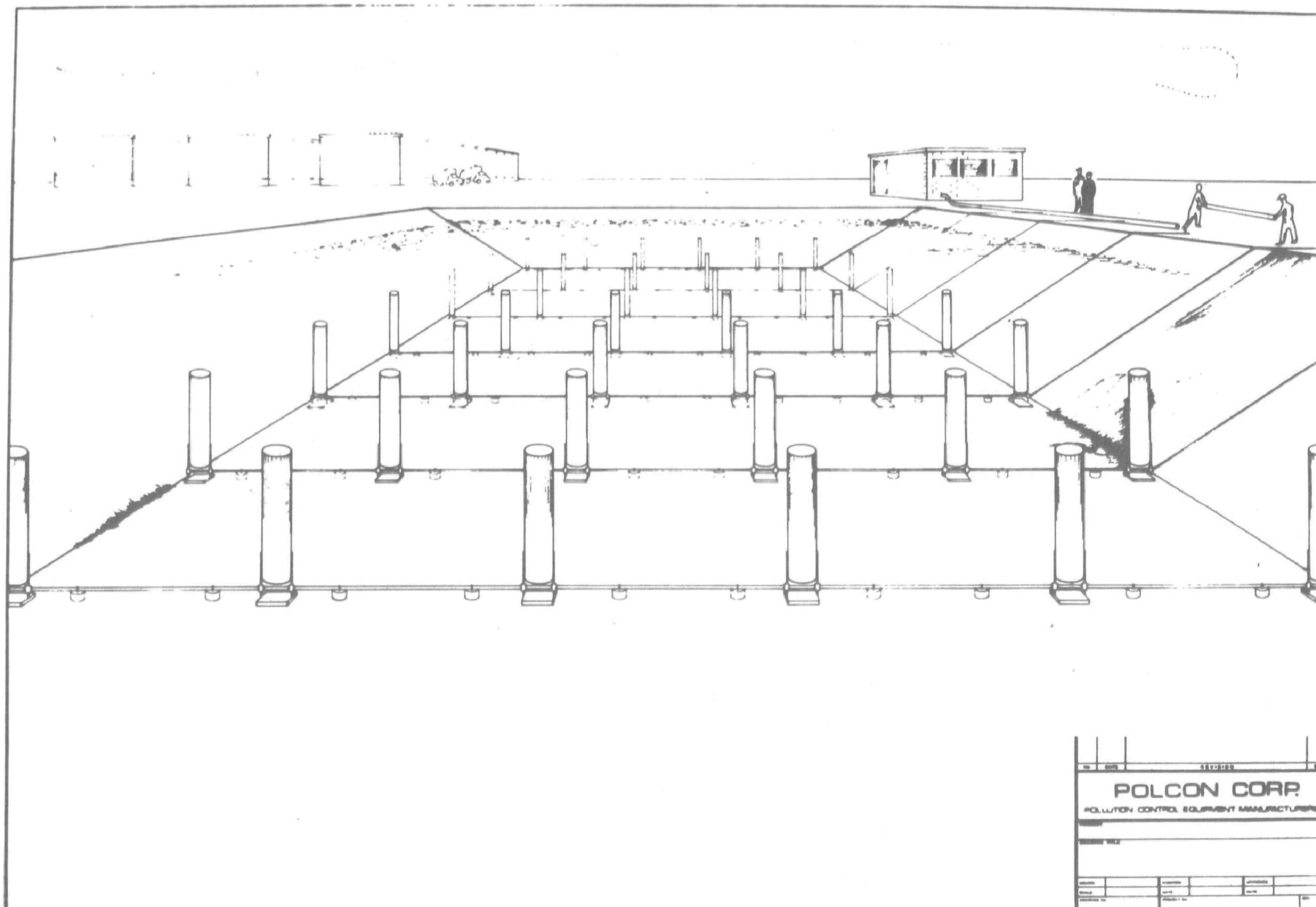


Primary Lagoon - Summer

Primary Lagoon - Winter



Polcon Helixor - Flow Diagram



Polcon Helixor - Perspective

SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

1. Report No.

2.

3. Accession No.
W

4. Title: Treatment of Cheese Processing Wastewaters in Aerated Lagoons

5. Report Date

6.

7. Author(s): Francis R. Daul, Grant Director contracted w ritingof final report to William C. Boyle Phd & Lawrence Polkowski Phd ~~with no publishing rights for Boyle & Polkowski~~

8. Performing Organization Report No.

9. Organization: Kent Cheese Co.
Kent, Illinois 61044

10. Project No.
12060 EKQ

11. Contract/Grant No.

12. Sponsoring Organization: Environmental Protection Agency

13. Type of Report and Period Covered
July 1969
January 1972

15. Supplementary Notes
Environmental Protection Agency report number, EPA-660/2-74-012, May 1974.

16. Abstract: A full-scale treatment of wastewater from a cheese processing operation was conducted over a one year period. A two-stage aerated lagoon system provided an average BOD removal of 97 percent at BOD loadings ranging from 0.117 to 4.34 lb/1000cu ft/day. Hydraulic detention time varied from 50 to 82 days per lagoon. Temperature had the single greatest influence on process efficiency. Costs for lagoon operation, maintenance and amortization were estimated to be $2.15 per 1000 gallons or $0.14 per pound BOD applied.

This report was submitted in fulfillment of Project No. 12060EKQ by the Kent Cheese Co. under the partial sponsorship of the Environmental Protection Agency. Work was completed as of January 30, 1972.

17a. Descriptors: *Aerated Lagoons, *Industrial Wastes, *Biological Treatment, Evaluation, *Aeration, Treatment Costs.

17b. Identifiers: cheese processing wastewaters

17c. COWRR Field & Group

18. Availability

19. Security Class. (Report)

20. Security Class. (Page)

21. No. of Pages: 79

22. Price

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WASHINGTON, D. C. 20240

Abstractor: F.R.Daul

Institution

WRSIC 102 (REV JUNE 1971)

GPO 913.261