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Environmental Protection Technology Series

State of the Technology
SEMI-AUTOMATIC CONTROL OF ACTIVATED SLUDGE TREATMENT PLANTS

Municipal Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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State of the Technology

SEMI-AUTOMATIC CONTROL OF ACTIVATED SLUDGE TREATMENT PLANTS

by

Carl A. Nagel
County Sanitation Districts of
Los Angeles County
Whittier, California 90607

Contract No. R803 055-01-0

Project Officer

Robert Smith
Wastewater Research Division
Municipal Environmental Research Laboratory
Cincinnati, Ohio 45268

MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI OHIO 45268

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Fred,

I recommend the following components for the A&I program:

I. Evaluate and demonstrate current technology

   A. Programmable calculators

   B. Desk top computers

   C. Programmable logic controllers

   D. Process controllers

II. Evaluate the need for automated analysis

   A. Sludge settling velocity

   B. Sludge blanket monitor

   C. Wastewater treatability/toxic monitor

   D. Sludge dewaterability

   E. Sludge cake moisture analyzer

   F. D.O. uptake rate

III. Evaluate proposed control strategies

IV. Training operators on instrumentation maintenance

V. A&I program self monitoring

I. Evaluate and Demonstrate Current Technology

This component of the A&I program would evaluate and/or demonstrate the use of devices that have had substantial technology advancement in the past 5 years. These devices would include programmable calculators, desk top computers, programmable logic controllers, and process controllers. The potential use of these devices is outlined as follows:

A. Programmable Calculators

These devices are capable of receiving a number of input valves such as MLVSS, RAD-VS, and sludge blanket level, and computing a given equation such as solids inventory. The device is capable of retaining the program when shut off. Thus, repetitive daily calculations can be performed more timely. Current cost of these devices range from $100 to $500.

B. Desk Top Computer (Home Computers)

The desk top computer would analyze operational data similar to the programmable calculator but have the additional advantage of data storage. This allows the desk top computer to analyze historical data (about one year data volume) for effluent quality vs. operating parameter over a long time period. This would be used by an engineer or class III operator to evaluate the operating parameters of his plant. Current cost of these devices are changing rapidly with the introduction of home computers. Current price ranges from $2,000 to $10,000.

C. Programmable Logic Controllers

These devices are capable of performing relay logic (off/on), timing and counting functions for process control. These functions cover 70 to 90% of all process control functions required at a wastewater treatment plant. Some of these devices can interfere with a common telephone and communicate with a central office. Thus, they can be used for remote monitoring and process control. Current cost of these devices are $5,000 to $10,000.

D. Process Controllers

These devices are capable of performing all the functions of the programmable logic controller plus analog control (flow control and D.O. control). These functions cover all but the most exotic control functions required to operate a conventional wastewater treatment plant. Current cost of these devices range from $5,000 to $20,000.

II. Evaluate the Need for Automated Analysis

This component of the A&I program would evaluate the economic and process reliability benefit of automating aanalysis that currently can only be performed manually. This evaluation would be published to inspire manufacturers to develop these instruments. Potential areas of investigation include the following:

A. Sludge settling velocity (5 min. settling volume)

B. Sludge blanket

C. Wastewater Treatability/Toxic Monitor

D. Sludge dewaterability

E. Sludge cake moisture monitor

F. D.O. Uptake Rate

The method of implementation would be to manually perform the analysis at a high frequency (1 hr.) and evaluate the economic and process reliability benefit.

III. Evaluate Proposed Control Strategies

This component of the A&I program would evaluate control strategies that are proposed in the literature. This can be accomplished at the Test and Evaluation Facility using existing pilot plant equipment. Possible control stratagies that may be evaluated are as follows:

A. Specific oxygen uptake rate.

B. Shifting from conventional activated sludge to contact stabilization as organic load varies.

C. Use of conventional math models in process control.

D. Use of artificial intelligence for process control.

IV. Training Operators on Instrumentation Maintenance

A problem with operation of a wastewater treatment plant through automation is maintaining sensor. In most cases the maintenance requirement of a sensor is simply cleaning the probe. This component of the A&I program would stimulate instrument manufacturers to provide training on installation, operation, maintenance, and application of their devices.

V. A&I Program Self Monitoring

Self monitoring is a vital component of this program. The A&I program will conduct services of wastewater treatment plants to determine the problem areas of automation. This will be accomplished through both inhouse telephone surveys and contract surveys.

FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise, and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The Municipal Environmental Research Laboratory contributes to this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

The County Sanitation Districts of Los Angeles County has been a leader in development of efficient operating and maintenance practices in the field of wastewater treatment. As part of this effort, a number of semi-automatic control schemes have been successfully developed. The purpose of this report is to document the theory and engineering technology needed to apply these new techniques. It is hoped that this report will provide an incentive to encourage application of semi-automatic control schemes in other wastewater treatment plants.

ABSTRACT

This report documents the theory, design and operation of continuous on-line instrumentation currently in use by the County Sanitation Districts of Los Angeles County, California and further describes computer applications which provide daily operational calculations.

Instrumentation sections include Water Level Control of Influent Pumping, Density Control of Primary Sludge Pumping, and Process Air, Return Sludge and Waste Sludge Control in Activated Sludge Plants. Theory, design, operation and maintenance requirements, and results are presented for each system.

A computer application system is described which provides daily operational parameters to the operators and prepares monthly summary of operations reports. A review of other computer applications and a subroutine to compare effluent characteristics with discharge limits is included.

This report was submitted in fulfillment of Contract Number R 803 055-01-0, by the County Sanitation Districts of Los Angeles County, under the sponsorship of the Environmental Protection Agency. Work was completed as of June 1975.

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ACKNOWLEDGMENTS

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SECTION I

CONCLUSIONS

The greater emphasis being placed on protection of the environment has substantially increased the number and complexity of treatment plants. More care in control of various plant processes is necessary to meet present and future discharge standards.

A variety of automatic and semi-automatic instrument control systems have been used successfully for a number of years. These systems aid in stabilizing processes, reduce personnel requirements, and improve the efficiency of treatment plants.

These instrument systems have proven to be reliable and practical. They are suitable for use in plants of any size and require only a reasonable amount of maintenance.

To reduce operator time and improve efficiencies, a computer system, leased or owned, can be used to great advantage. Human errors are largely eliminated and up-to-date information is readily available for review by anyone concerned with the operation.

SECTION II

RECOMMENDATIONS

This program was limited to the description and documentation of five existing instrument control systems. It was not within the scope of this project to present a literature review of all instrument systems commonly used nor to develop or test new systems. It is recommended, however, that development of new systems be supported to further enhance the reliability of treatment processes.

It should be noted that the systems described in this report have been in use for a substantial period of time, their reliability has been proven, and they can be used now in most plants with a minimum of modification being necessary.

SECTION III

INTRODUCTION

GENERAL

Increasing emphasis on efficient treatment and disposal of municipal wastewater has greatly increased the number and complexity of activated sludge treatment plants.

While in most cases the planning and design leading to the construction of new treatment plants have involved extensive engineering work, it is not uncommon that after completion of construction and start-up of the plant the daily operation of the plant is left almost entirely in the hands of the operator. Thus, the responsibility of the plant achieving the design objective rests with the operator.

Most operators, however, have only a limited amount of time they can devote to actually operating the plant. For many, their time is also spent performing maintenance, gardening, laboratory tests, and other miscellaneous functions. Also, the educational backgrounds among operators are quite diverse. Some easily grasp the concepts necessary to operate the plant, others, do not.

For the above reasons it is desirable to have methods to help the operator properly run the plant. Devices that will allow the operator to monitor variable constituents, calculate important operating parameters, set and maintain proper process controls, and activate alarms will help insure proper operation. However, the installation of such equipment does present certain problems. Sophisticated equipment is subject to frequent breakdowns, and maintenance requires highly trained individuals. Also, installation of such equipment can lead the operator to over-rely on the instrument and avoid thinking about the total operation of the plant and the interrelationships existing among the various processes.

LOCATION

This project was conducted by the County Sanitation Districts of Los Angeles County, California. The Districts serve the sewage and refuse disposal needs of nearly 4 million of the over 7 million people in Los Angeles County. There are now a total of twenty-seven Districts, the first established in 1923. They are governed by a Board of Directors made up of the mayors and county supervisors whose jurisdictional areas are involved. The Districts stretch from the eastern border of the City of Los Angeles to Pomona and from Long Beach to Lancaster and include a total of 71 cities. Combining their efforts under a single administration has permitted the development of an expert technical staff capable of attacking wide ranging problems on a regional basis.

At present, the major Districts' facility for treatment of municipal wastewaters is the Joint Water Pollution Control Plant (JWPCP) located in Carson. The plant is currently treating over 1.25×10^6 cu m/day (330 mgd) of wastewater by primary sedimentation and should have secondary treatment facilities added by 1977. The treated wastewaters are discharged through a sophisticated outfall system two miles off Palos Verdes Peninsula. Most of the organic solids removed during treatment are sold as fertilizer base.

In addition to the Joint Water Pollution Control Plant, the Districts also operate and maintain ten smaller secondary plants. Two of these are in the Antelope Valley north of Los Angeles. One plant, operating at about 13,626 cu m/day (3.6 mgd) and serving the community of Lancaster, utilizes oxidation ponds for secondary treatment. There is no percolation to the underground in this area because of the extreme tightness of the alkali soil. A tertiary treatment facility of 1893 cu m/day

(0.5 mgd) capacity was constructed in 1970 to remove nutrients and algae from the oxidation pond water to permit its use in recreational lakes to be operated near Lancaster by the County Department of Recreation and Parks. The other plant, serving the community of Palmdale, treats about 4542 cu m/day (1.2 mgd); the water from the oxidation ponds is sold for irrigation of alfalfa.

An activated sludge plant with a capacity of 18,925 cu m/day (5 mgd) treats the sewage from District No. 26 in the Saugus area. The present flow of about 12,112 cu m/day (3.2 mgd) from this plant is discharged into the Santa Clara River Channel and percolated into the underground to recharge the aquifers.

In nearby Valencia, Sanitation District No. 32 operates a smaller but similar plant to that of District No. 26. The flow of about 4542 cu m/day (1.2 mgd) is also discharged to the Santa Clara River.

District No. 28 operates and maintains a small activated sludge plant in the vicinity of La Canada to treat the sewage from the Angeles Crest Country Club and surrounding residential area. The effluent from this plant makes a substantial portion of the irrigation water for the golf course.

The remaining five Districts' plants are located in the Los Angeles Basin and employ the activated sludge process for secondary treatment. All of the Districts in this geographical area are members of a Joint Outfall Agreement which provides for joint construction, operation, and maintenance of trunk sewers, pumping plants, and treatment works. The maintenance and operation of the joint outfall system, including upkeep and repair costs, are shared jointly by the various districts having ownership. These costs are proportioned according to the amount of flow contributed by each individual District.

Each of the plants in this Los Angeles Basin grouping are situated adjacent to a major trunk of the jointly owned trunk sewer system. None of these plants has solids processing facilities; all waste products, skimmings, primary and waste activated sludges are returned to the trunk sewer for transport and later recovery and processing at the Joint Water Pollution Control Plant.

The Districts' plants involved in this system, with their respective designed capacities are as follows:

1. Pomona Water Renovation Plant,
   36,336 cu m/day (9.6 mgd)
2. San Jose Creek Water Renovation Plant,
   1.4×10^5 cu m/day (37.5 mgd)
3. Whittier Narrows Water Reclamation Plant,
   47,312 cu m/day (12.5 mgd)
4. Los Coyotes Water Renovation Plant,
   1.4×10^5 cu m/day (37.5 mgd)
5. Long Beach Water Renovation Plant,
   47,312 cu m/day (12.5 mgd)

OBJECTIVES

The plants operated by the County Sanitation Districts of Los Angeles County (LACSD) have a variety of control devices which have proven to be useful in properly operating the plants. It is believed that others can benefit from the knowledge gained in this operations experience.

Accordingly, two major objectives have been pursued:

1. Documentation of the theory, design, and operation of continuous on-line instrumentation currently in use by LACSD.
2. Documentation of the computer applications the LACSD has developed to provide daily operational parameters, calculations, and monthly summary of operations reports.

SECTION IV

INFLUENT PUMPING - WATER LEVEL CONTROL

INTRODUCTION

Elevations of all but two of the secondary treatment plants on the LACSD Joint Outfall System are above trunk sewer elevations serving them. This necessitates use of influent pump stations to lift wastewater out of the trunk lines and into the plants. These pump stations are important elements in the treatment process. If they fail, other processes are useless with no flow to treat.

Most of the pumping plants in the LACSD system are designed with variable speed pumps and liquid level control These include 10 treatment plants and 19 sewer lift stations. In general, water surface elevations in the incoming sewers are maintained near normal depth by varying pump speed with depth of flow. Although this proportional relationship between depth and pump speed does not exactly produce normal depth for all flows, it approximates it closely enough to avoid adverse effects caused by excessively high or low velocities in the sewer.

FACILITIES AT THE LONG BEACH WATER RENOVATION PLANT

The Long Beach Water Renovation Plant was the site of data collection to document response of the variable speed pumps to changes in the wet well water level. This station contains four pumping units. Two smaller units each consist of a Fairbanks Morse 25.4 c m (10 inch) centrifugal sewage pump, Watson Flexible shafting, an Ideal Electric motor and magnetic drive, and a liquid level control panel. The two larger units each consist of a Fairbanks Morse 76.2 c m (30 inch) centrifugal sewage pump, Watson flexible shafting, an Ideal Electric motor and magnetic drive, Western Gear right angle gear box, and a Liquid Level Control panel. Currently only the two smaller units are operated since plant flow is not yet sufficient for efficient operation of the larger units.

The Plant is serviced by three influent trunk sewers which discharge into a junction box at the head of the plant. Sewage then flows from the junction box through a 175.26 c m (69 inch) outfall to a wet well where it is pumped into the plant. The influent trunk sewers are of different sizes and slopes and, as such, it is impossible to maintain normal depth in all three under all flow conditions. Thus, the previous statement that pump speed is varied to maintain normal depth in the incoming sewer can only be true when there is a single influent sewer. However, the main purpose of sensing a varying wet well water level is to avoid excessively low or high flow velocities in the sewers. It is not essential to maintain exact normal depth but only to maintain water elevations within reasonable limits.

Pump speed is varied by controlling the output speed of the magnetic drives. This can be accomplished either manually or automatically by use of the liquid level control system. Under manual operation, start and stop of each pump is controlled by the plant operator through use of a sequence selector switch. A pump will start when its corresponding sequence selector switch is set to the "Hand" position. Pump speed is regulated by a manual potentiometer and indicated by a tachometer. Each pump motor has an adjustable (1 to 600 seconds) time delay relay to prevent a successive motor start until the desired time delay on energization of the motor has elapsed. Each variable speed drive also has a time delay relay to allow a sufficient time interval to elapse after the energization of each corresponding motor so that each motor shall start under no load and shall attain full speed before the start of each variable speed drive.

LEVEL CONTROL SYSTEM

The level control system is used to control the influent pumps so that the rate of discharge from the pumping station is approximately equal to the varying rate of sewage inflow. Liquid level in the influent pump wet well is automatically sensed and controlled as described below. Level control in the wet well is initiated by means of proper pump sequencing and by varying the influent pump speed. The system is capable of sequencing pump operation and varying the speed of all pumps as necessary to pump a variable station flow without storage in the wet well.

A schematic diagram of the liquid level control system is shown in Figure 1. Major components of the system are the level sensor and transmitter, liquid level control unit, and the motor/variable speed drive units used to power the pumps.

Primary intelligence for the level control system is obtained from an electronic differential pressure transmitter or transducer. This unit is used to sense the rising and falling liquid level in a stilling well which is directly connected to the influent wet well. Pressure sensed in the stilling well is converted to a 4-20 milliampere direct current control signal, proportional to the stilling well water level.

The liquid level control unit receives the control signal generated by the differential pressure transmitter. This signal is used as a pilot signal for operation of the control equipment. These operations include indication of the liquid level in the wet well, initiation of start and stop functions for all pumps, modulation of pump speed, and actuation of alarms for high and low water levels in the wet well.

Starting and stopping of each pump is initiated by individual current alarms which use the 4-20 ma signal produced by the level transmitter. Current alarms have calibrated hand dials for adjusting the trip setting and deadband setting.

Two time delay relays (adjustable from 1 to 600 seconds) are provided for each pump unit. The first relay is actuated by a motor stop and prevents a successive motor start until the

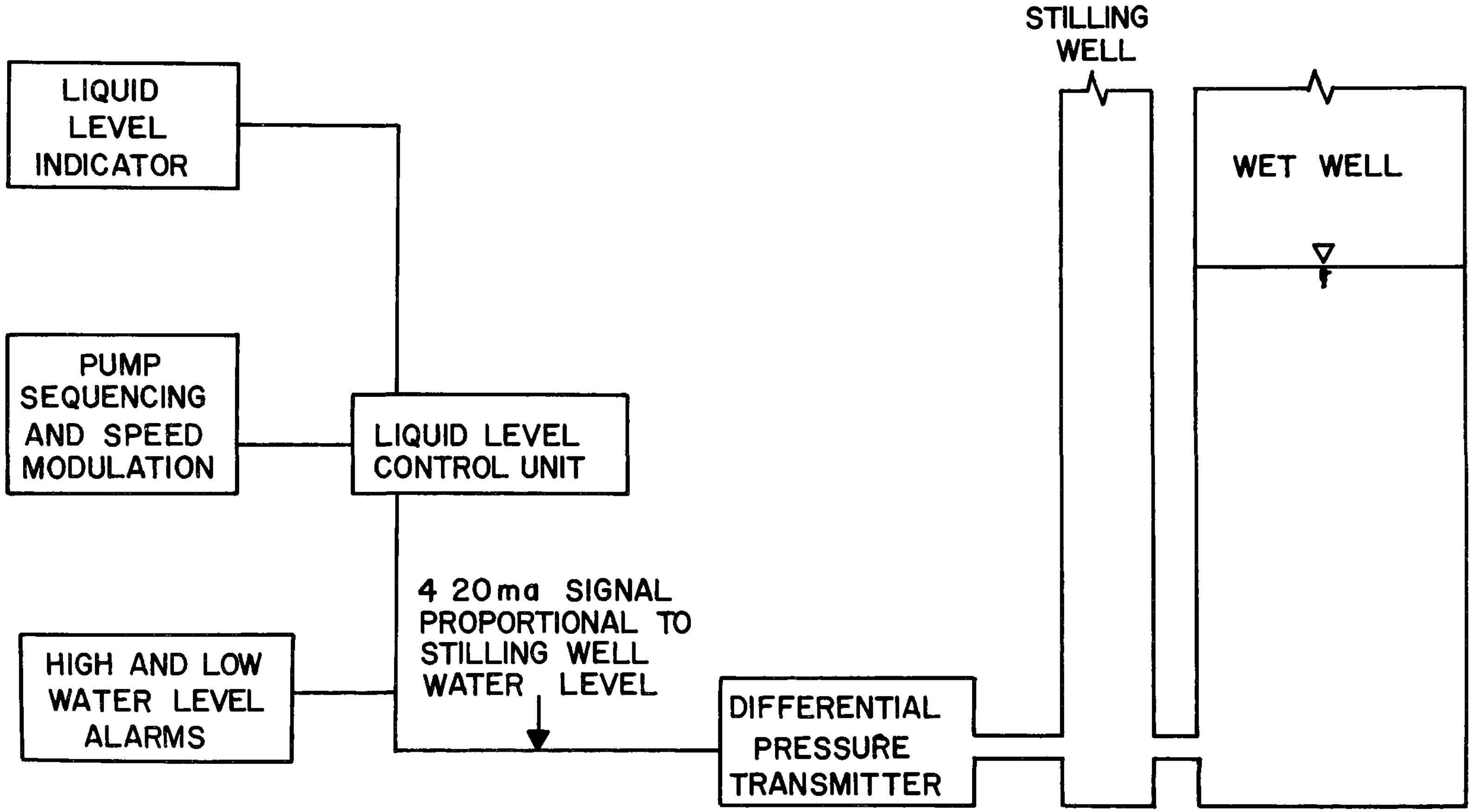

FIGURE 1 SCHEMATIC DIAGRAM OF THE LIQUID LEVEL CONTROL SYSTEM

desired time delay has elapsed. This is designed to prevent rapid starting and stopping of the pump. The second relay is actuated by a motor start and delays energization of the variable speed drive. This allows the motor to attain full speed and start under a no load condition.

AUTOMATIC OPERATION

Pump sequencing and control points levels (based on submergence over pump suction as well as elevations based on plant datum) are shown in Figure 2.

These points are approximate liquid levels at which control functions are initiated together with the level excursions available for control of speed modulation for the various pump combinations throughout the operating ranges. Step numbers in Figure 2 are pump sequencing steps applicable to any of the four pumps which are to be selected by manually positioning the sequence selector switches.

Assume plant flow at zero and the liquid level in the influent pump wet well below the start setting of Step 1. As flow begins and the level rises, the start setting of Step 1 starts the first pump at minimum speed and a rising level causes the pump speed to increase in linear proportion to the rise in level. Operation continues in this manner until the pump is operating at maximum speed.

If the wet well level continues to rise, the start setting of Step 2 starts the second pump and both pumps are adjusted to equal speed so that each will discharge one-half of the station flow. If the level continues to rise, both pumps increase in speed equally in linear proportion to the rise in level until both pumps are operating at maximum speed. Manual selection of the same size pumping units for Steps 1 and 2 is considered normal operation.

Continued increases in wet well water level signal sequential starting of a third and fourth influent pump in the same manner as that described above. At present, however, only two influent

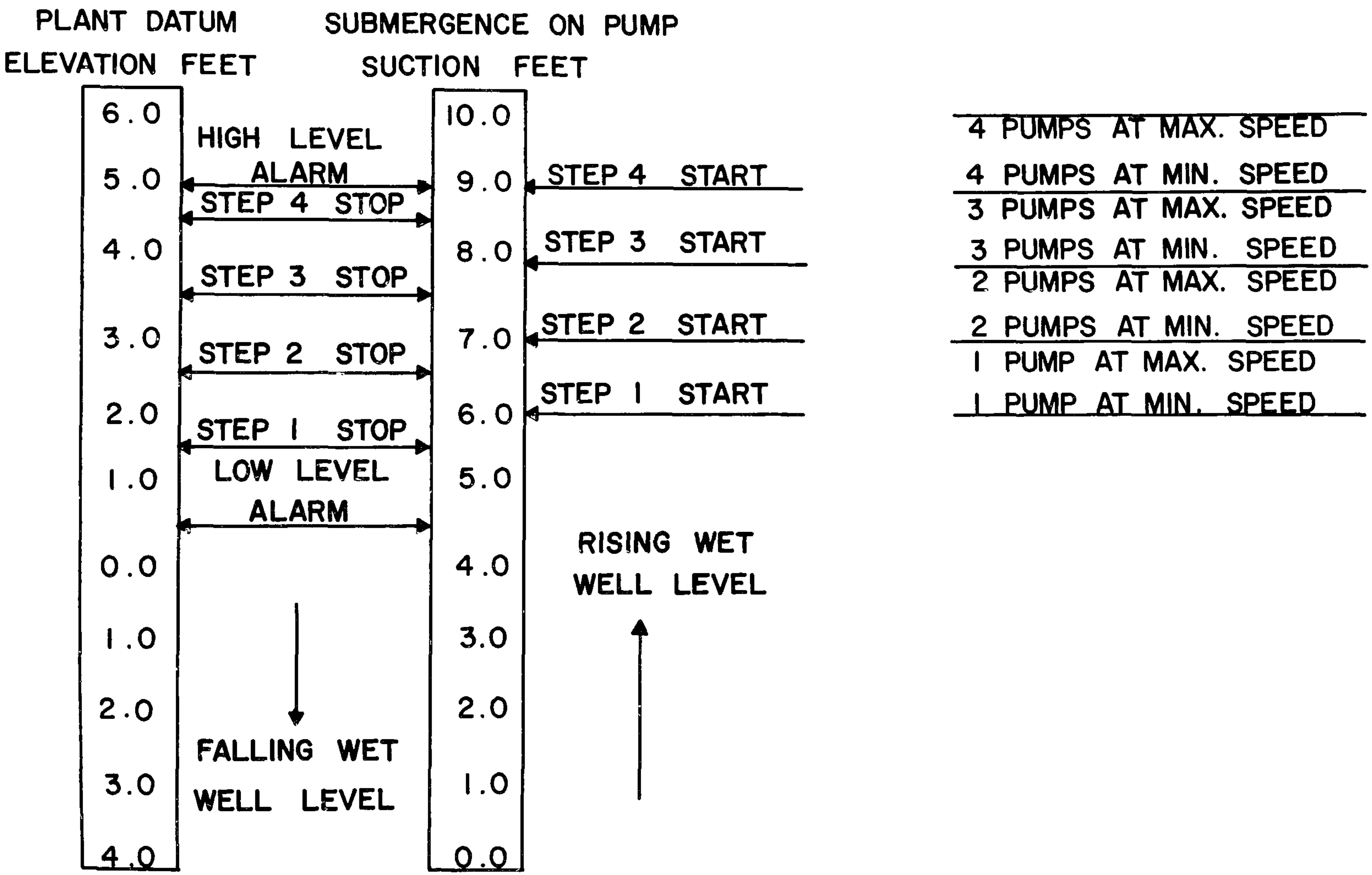

FIGURE 2 PUMP SEQUENCING ELEVATIONS

pumps are required to meet the peak flow rate.

The pumps operate in reverse order when wet well level decreases. The stop settings of Steps 1 through 4 are set so that the level at individual pump stops will be lower than the levels at starts. This is to prevent accidental pump shutdown in response to momentarily lowered water levels experienced following pump starts. The last pump stops and does not operate (except by manual control) when the level falls below the stop setting of Step 1.

EXPERIMENTAL RESULTS

A recorder was placed in the control panel of the influent pump station to continuously record wet well water level. The control signal provided by the differential pressure transducer was used as input to the recorder. This enabled wet well water levels to be correlated with pump sequencing and plant flow rate. Four weeks of data were obtained to document the influent pump control system.

A summary of the experimental findings is presented in Table 1. Incoming sewage flows were sufficient to maintain at least one operating pump at all times, whereas two pumps were required to carry the peak flow. Wet well water levels initiating sequencing of the second influent pump averaged 2.19 meters (7.2 feet) (above pump suction) compared with the desired set point of 2.13 meters (7.0 feet). The actual set points are adjustable and the difference only reflects a slight error in adjustment. Variations in wet well levels initiating pump sequencing were extremely small. The difference between the smallest and largest values observed during the 30-day study period was only 1.52 c m (0.6 inch). Thus, while the set point adjustment was slightly in error the water elevation which initiated the start of the second pump was reproducible, varying insignificantly during the study period.

The same comments apply to the wet well water level used to signal the stop of the second influent pump. While water level

Table 1

SUMMARY OF DATA COLLECTED AT LONG BEACH WATER RENOVATION PLANT INFLUENT PUMP STATION

Variable	Average Value [a]	Standard Deviation	Range [b]
Wet well level at start of second influent pump	7.20	0.022	0.05
Plant flowrate at start of second influent pump	6.10	0.78	2.60
Wet well level at stop of second influent pump	6.95	0.026	0.10
Plant flowrate at stop of second influent pump	7.40	0.50	2.00

a All elevations in feet above pump suction and flowrates in mgd.

b Range is defined as the difference between the smallest and largest value.

initiating pump stop was slightly above the desired set point value (2.21 meters compared with 2.01 meters) (6.95 feet compared with 6.60 feet) the range of values varied by only 3.05 c m (1.2 inch).

While water levels initiating pump sequencing were constant during the study period, corresponding pumped flow rates were not constant. For example, plant flow rate at the start of the second influent pump averaged 23,088 cu m/day (6.1 mgd) but varied from a low of 17,789 cu m/day (4.7 mgd) to a high of 27,630 cu m/day (7.3 mgd). Plant flow rate at the stop of the second influent pump varied in a similar manner.

Variation in pumped flow rate at the time of pump sequencing was due to two causes. First, the proportional controlling system regulates only pump speed and not pump output. Thus, at any particular wet well water level, one value of pump speed is called for. Should wet well water change, pump speed will change in proportion to changing water level. But at any given water level pump speed is constant. There is no reset function in the influent pump control system. Second, at a given rpm, flow rate is determined by the total dynamic head against which the pump works. Dynamic head would normally be a constant value at a given flow rate except for the fact that rags and other debris tend to collect in the volute at the suction side of the impeller. This increases headloss which decreases pump output at a given rpm. Thus, variation in observed flow rates at the time of pump sequencing reflects the degree of ragging at the pump suction.

Routine plant operation calls for deragging of influent pumps whenever the capacity appears to be lower than normal. During the test period, this required deragging on an almost daily basis (21 times during the 30-day study period with a labor expenditure of approximately one-half hour per incident). Not only is this a nuisance as far as a plant operator is concerned, it can affect proper pump sequencing. Following termination of the test period, the practice of routine wet well cleaning was initiated. This is accomplished during the low flow period by manually pumping the wet well to a point below the normal low level point. In this manner, floatables are removed preventing large accumulations of materials which might be drawn into a pump at a later time causing partial stoppages. Since initiation of this procedure on a daily basis, no deragging of the pumps has been necessary during a continuous 90-day period.

Ideally, startup of a second influent pump should not pull down the wet well water level to such an extent that the stopping set point is exceeded. This would result in repeated starting and stopping of the second pump. The time delays, of course, would protect the equipment from too rapid a start and stop. Likewise, stopping of the second influent pump should not cause the wet well level to rise to the point where it again signals for start of the second pump. In other words, one pump at maximum speed should have nearly the same capacity as two pumps at minimum speed.

Plant flow rate and wet well water levels during pump sequencing are shown in Figures 3 and 4. Referring to Figure 3, as flow increased in the morning hours, the wet well level increased to 2.19 meters (7.2 feet) at which time the second pump started. This resulted in a sudden increase in flow rate with corresponding drawdown of the wet well. Lowered wet well levels signalled for reduced pump speed and eventually inflow and outflow from the wet well were matched. During the course of the study the wet well was never drawn down to the point where shutoff of the second pump occurred.

Again referring to Figure 3, as flow decreased in the early morning hours the wet well was eventually drawn down to the point where the second pump stopped. This resulted in a momentary decrease in flow rate and corresponding increase in wet well level. If the remaining pump was free of rags and other debris, it could carry the entire flow and prevent restarting of the second pump. However, if the intake was clogged the single pump would be unable to carry the incoming flow. Wet well level

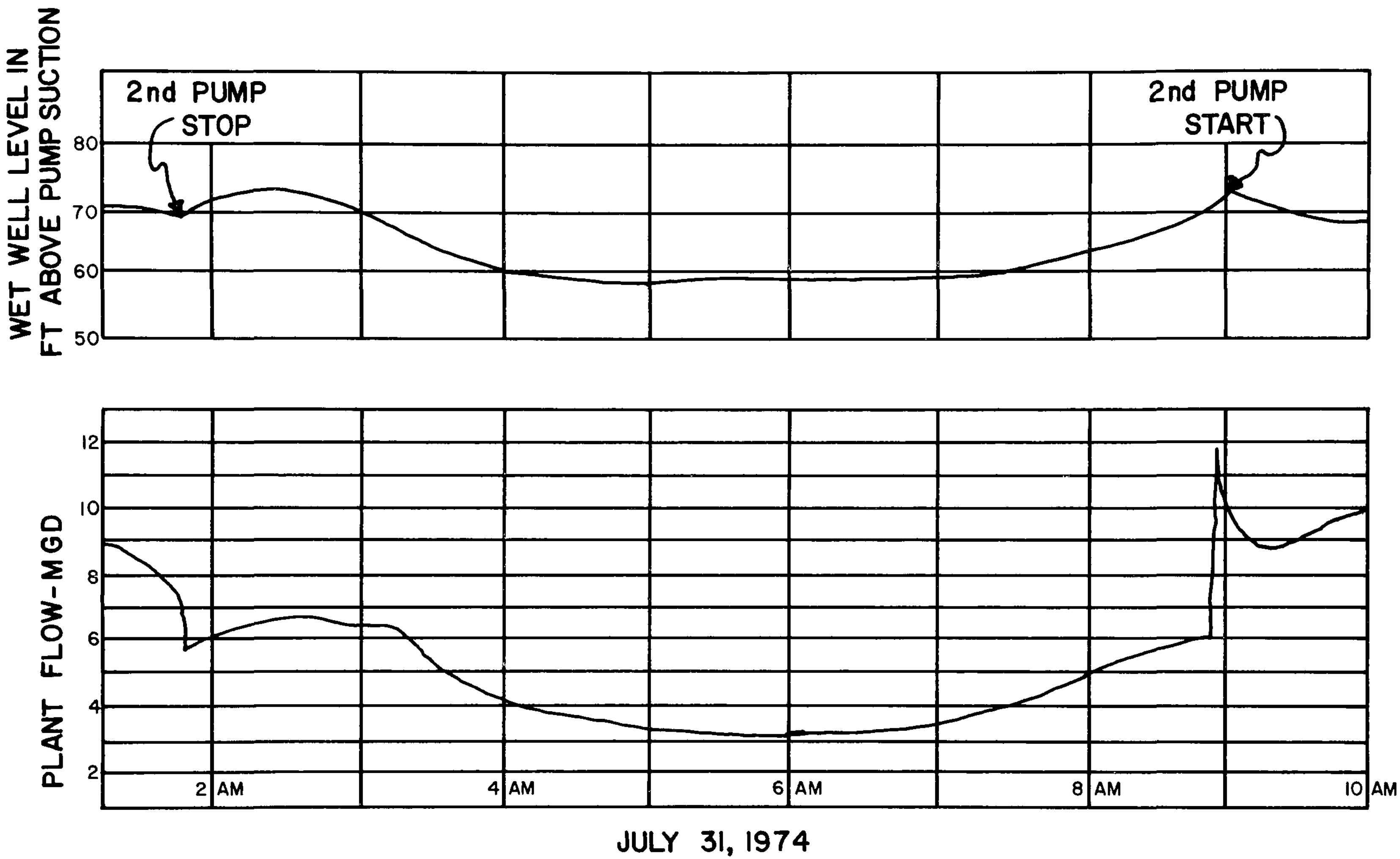

FIGURE 3 WET WELL WATER LEVEL AND PLANT FLOWRATE LONG BEACH WATER RENOVATION PLANT INFLUENT PUMP STATION

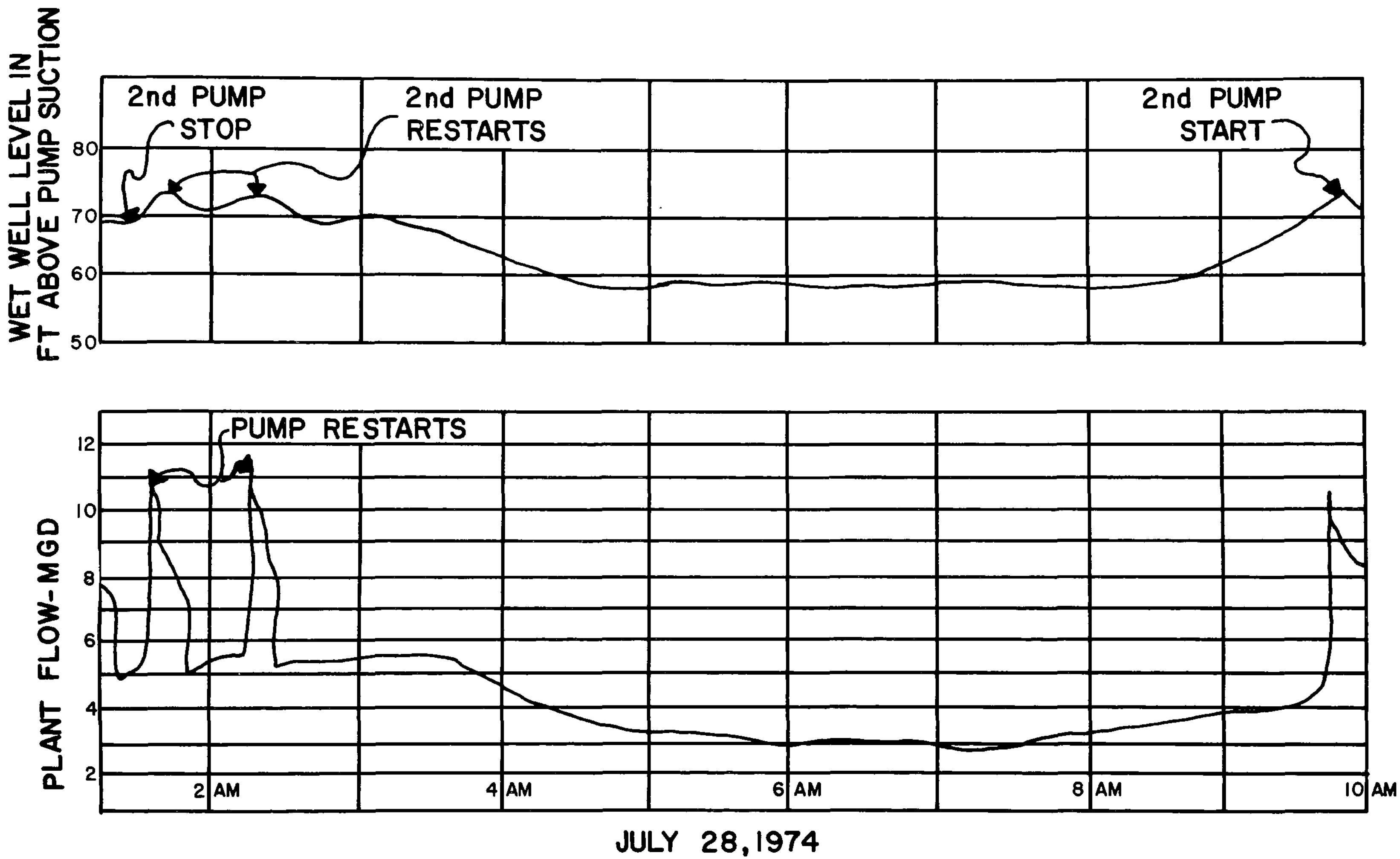

FIGURE 4 WET WELL WATER LEVEL AND PLANT FLOWRATE LONG BEACH WATER RENOVATION PLANT INFLUENT PUMP STATION

would rise to set point level signalling restart of the second pump. The flow rate and wet well levels corresponding to this situation are shown in Figure 4. Restarts occurred approximately 50 percent of the time during the study period. About 10 percent of the time two restarts were required before flow rate was reduced to the point where a single pump was sufficient.

It should be emphasized that pump restarts are not a serious problem in the sense of affecting pump station operation or damaging equipment. Too rapid starting and stopping is prevented by the time delay relays. However, it is probably wise to avoid restarts as much as possible since they waste electrical power and cause a certain amount of equipment wear. Routine cleaning of the wet well or increasing the elevation difference between start and stop set points would avoid the problem.

SECTION V

PRIMARY SLUDGE PUMPING - DENSITY CONTROL

INTRODUCTION

Benefits of Thickening

Sludge thickening occurs naturally in the sludge blanket of a primary sedimentation tank. It is desirable to control this thickening because of the benefits to many sewage treatment plant processes:

1. Fewer gallons are pumped to transfer the same mass of suspended solids.
2. The denser the raw sludge added to the digester, the smaller the digester volume required.
3. The denser the raw sludge, the smaller is the amount of energy required for maintaining digester temperatures.
4. Dewatering filters operate more efficiently when fed by a sludge of high consistency.
5. Material transferred to storage is more concentrated, reducing the storage volume required.

Basis for Intermittent Pumping

Suspended solids settle continuously in a primary clarifier and accumulate in the sludge blanket. The sludge blanket must be maintained at an adequate level to promote proper thickening. This is accomplished by withdrawing the sludge out of the tank's hopper at the same rate that it accumulates, allowing only the thickest sludge from the bottom of the blanket to be pumped.

The following restrictive parameters have evolved from standard practice and from the basic considerations in primary sludge pumping design:

1. "Sludge withdrawal piping generally has a minimum diameter of 15.24 to 20.32 c m (6 to 8 in.)." * Small pipe will become clogged.
2. "Sludge velocities between 1.52 and 2.44 mps (5 and 8 fps) are, in general, found to be satisfactory." The minimum acceptable to prevent settling in the lines is 0.9 mps (3 fps).
3. The rate of flow, tank design, and wastewater characteristics influence the tank efficiency and thus, the rate of accumulation of sludge within the tank. At the JWPCP, the average accumulation rate for a rectangular primary clarifier with a surface area of 502 sq m (5400 sq ft) varies from 1.26 to 2.02 ℓ/s (20 to 32 gpm) (average sludge consistency of 5.5% total solids).

The above restrictive diameter, velocity, and suspended solids removal rate parameters have made intermittent pumping the most practical solution over the years. In this manner, the parameters are fulfilled by pumping the sludge every 20-40 minutes (based on average accumulation rate).

Intermittent pumping may be performed manually but this practice is extremely wasteful of the operator's time and the pumping period may occur at a time when the operator is not at the plant site or is occupied elsewhere. In addition, the results obtained by manual pumping usually are inconsistent and extremely variable depending upon which operator is on duty.

In small treatment facilities where the number of sedimentation basins is limited, reasonable control of sludge pumping can be effected with simple timer controls. In this situation, it is important that timer settings be calculated carefully and that positive displacement collector pumps be employed so that the volume of sludge pumped per unit time remains fairly uniform

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* p 200 - WPCF Manual of Practice No 8 - Sewage Treatment Plant Design, 1959

regardless of sludge density. The timers can control the pumping from one or a series of settling basins.

For larger treatment works, it is more efficient to use larger capacity centrifugal pumps and to use a single pump to serve a series of sedimentation basins. In this application, nuclear density gauges, in conjunction with timer controls, provide an effective method of controlling intermittent sludge pumping. As described later, the timer controls initiate the pumping process and regulate certain segments of the pumping cycle while the density gauge terminates the pumping process and provides a continuous monitoring of the solids concentration allowing the operator to observe density changes as they occur and to adjust the timer settings as required.

Regardless of which of the above two automatic methods of controlling intermittent sludge pumping is used, the basic timer settings depend on the accumulation rate, which is a function of the following variables:

1. Diurnal and seasonal flow. Figure 5 shows the diurnal flow pattern for the Joint Water Pollution Control Plant, a 541 cfs (350 MGD) primary facility operated by the Los Angeles County Sanitation Districts.
2. Diurnal and seasonal influent suspended solids. Figure 6 shows the seasonal variation of influent total solids for the JWPCP in 1973.
3. Diurnal and seasonal sludge settling and thickening characteristics.

The success of timer control <u>alone</u> has been in treatment plants where the timer settings have been carefully calculated and adequate monitoring is provided. Its success also has been in treatment plants where the raw sludge density is unimportant, separate sludge thickening is provided, or where large variations in sludge density can be tolerated.

Density monitoring and control provides a short response time to fluctuations in the diurnal accumulation rate. As a result, the

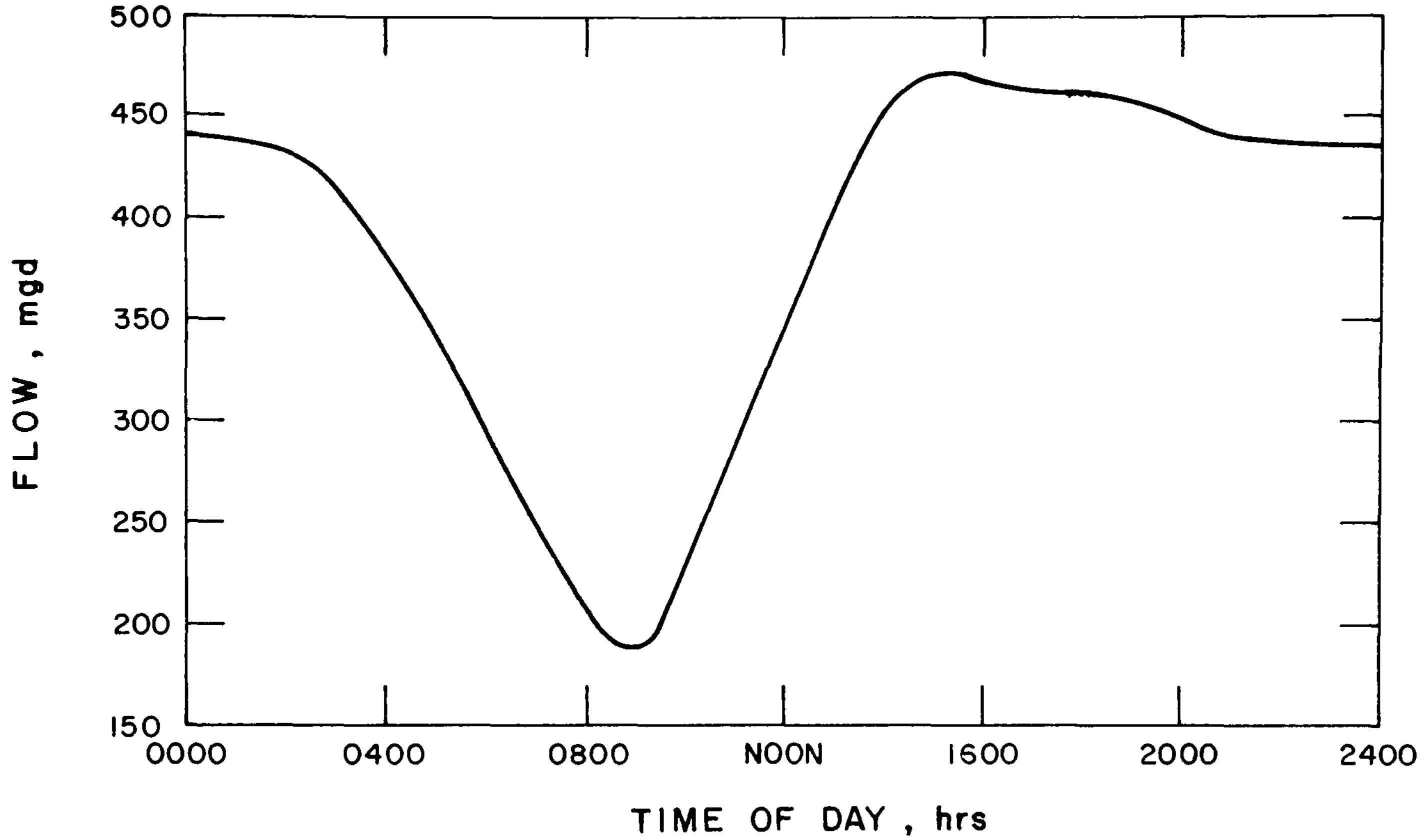


FIGURE 5 TYPICAL DAILY FLOW AT THE JWPCP

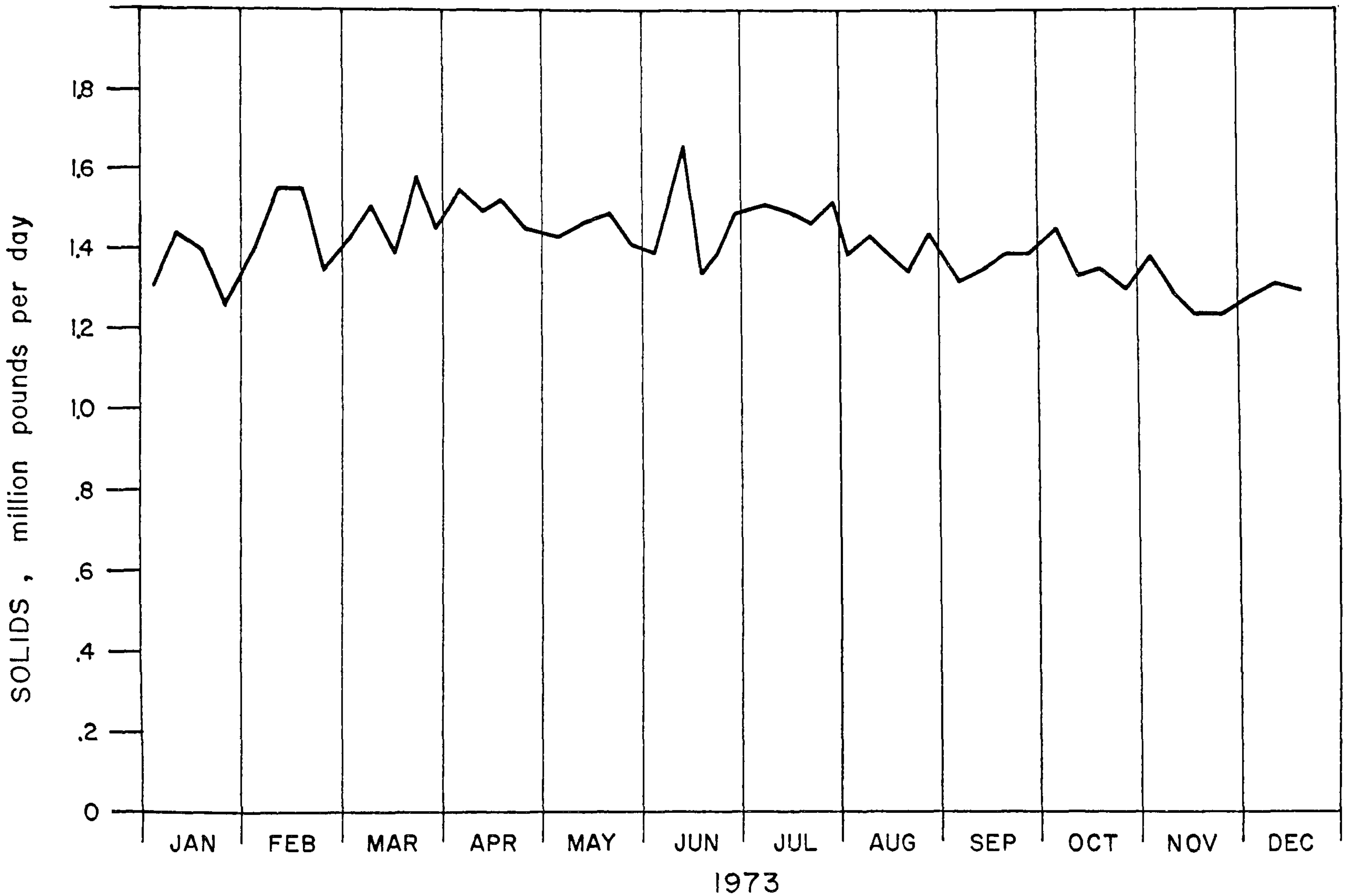


FIGURE 6 SEASONAL VARIATION OF INFLUENT SOLIDS AT THE JWPCP

total volume of sludge pumped is reduced. Its application has been at the JWPCP where large variations in sludge density can not be tolerated in achieving efficient digester capacity utilization. A brief discussion of the digestion system and controls is included at the end of this section.

At the JWPCP, the sludge is pumped from three sedimentation tank batteries to two raw sludge transfer stations. Table 2 summarizes 24-hour composite samples from these two stations during part of 1974. The differences in sludge densities between stations reflect the differences in accumulation rates and thickening characteristics of the sludge.

OPERATION PROCEDURES

Adjusting Timer Settings - Timer Control Only

The timer settings are adjusted to pump a high percent total solids and at the same time to prevent gassing (rising sludge) in a tank.

Indirectly, the operator controls the sludge blanket level by his timer changes. The sludge blanket level that promotes optimum thickening is a variable which depends upon the sludge holding time in the blanket. This holding time must not exceed the minimum time required to produce gassing (rising sludge) in the tank.

Calculations based on suspended solids removals which have been determined on a diurnal pattern can be made to determine the rate at which sludge accumulates in the tank. The timer settings are then adjusted to pump from each tank hopper a volume of sludge of the desired density equal to the volume of sludge that has accumulated in the tank during the same period. With occasional monitoring of the sludge blanket level and visual observation of the tank surface, minor adjustments of the timer settings can be made to correct for lack of sufficient sludge blanket, excessive sludge blanket or sludge bulking which has resulted from gasification.

TABLE 2

MEASURED RAW SLUDGE TOTAL SOLIDS

FROM TRANSFER STATIONS AT THE JWPCP

March-August, 1974

Week Ending	Percent Total Solids		Week Ending	Percent Total Solids	
	Raw Sludge Transfer Station #1	Raw Sludge Transfer Station #2		Raw Sludge Transfer Station #1	Raw Sludge Transfer Station #2
3-15	6.2	5.3	6-7	5.4	5.3
3-22	5.8	5.6	6-14	5.5	5.3
3-29	5.6	5.5	6-21	5.4	5.3
4-5	5.5	5.7	6-28	-	-
4-12	5.8	5.3	7-5	5.6	5.2
4-19	5.6	5.4	7-12	5.3	4.9
4-26	5.5	5.3	7-19	5.4	4.9
5-3	5.7	5.0	7-26	5.4	5.2
5-10	5.5	5.0	8-2	5.4	5.2
5-17	5.6	5.2	8-9	5.5	5.1
5-24	6.0	5.0	8-16	5.5	5.1
5-31	5.6	4.9	8-23	5.7	4.7

For example, if the analyses are made on 4-hour composites, the approximate accumulation rate for each individual period can be determined by the following formula:

Accumulation rate (gal per period)

$$= \frac{\text{Dry suspended solids removed (mg/l)} \times \text{Flow (MGD/Tank)}}{\text{Percent consistency (decimal)} \times 60\ \text{(min/hr)}}$$

$$\times \frac{4\ \text{hrs/period}}{(24\ \text{hrs/day})}$$

The control timers are then set so that the volume pumped during the period equals the volume accumulated during the same period.

Adjusting Timer Settings with Density Controls

With density control, a timer is used to regulate the pump "off" time rather than the pump "on" time. The pump "off" time is set to permit sufficient accumulation of sludge so that density control can be the dominant factor.

At the JWPCP, three separate trunk sewers with different flows and suspended solids concentraions enter the plant. As a result, the accumulation rates in the three sedimentation tank batteries (E1, E2, E3) are different. Shown below are the average 24-hour per day accumulation rates (based on 5.5% total solids) entering JWPCP during the period February - May, 1974.

Average Accumulation Rate (gpm)

Time Period	E1	E2	E3
Feb - May, 1974	22	32	28.5

DESIGN

General

The sludge pumping control system described in this report utilizes nuclear density gauges. Ultrasonic density gauges are also available but the LACSD have no operational experience in their application.

Description of Nuclear Density Gauges

The principle of operation is based upon the fact that gamma radiation is absorbed as it passes through various materials and that this absorption is a function of the density of the material.

The components of a common gauge are shown in Figure 7. A source of gamma radiation (Cesium-137) is placed on one side of the pipe and a measuring cell, or detector, on the opposite side. The measuring cell converts the variable radiation field produced by changes in density directly into an electrical current. This current signal is then amplified and transmitted to a recorder-controller. Figure 8 shows that both the amplifier and recorder-controller are mounted in the same control panel at the JWPCP.

The output of the amplifier is also displayed on its front panel by an indicating meter as shown in Figure 9. In addition, the amplifier has several operating controls located on its front or side panels. Among these are the following (exact names vary between manufacturers):

1. Zero Suppression- This control allows adjusting the beginning point of the measurement. The "residual" current at the reference specific gravity is nullified by a compensating current of opposite polarity.
2. Time Constant - This control permits obtaining a balance between the noise band and the process rate of change. The noise band (pen wipe on a recorder) indicates the random fluctuations of the meter reading and is caused by the statistical variations in the emissions of the radioactive source.
3. Calibration - This control adjusts the full scale sensitivity of the amplifier.
4. Recorder - This control adjusts the amplifier output to the recorder.
5. Check Zero - This control allows adjusting instrument electrical zero.

The recorder is of the two-pen type with set point indicator, as shown in Figure 9. The inner pen records sludge density

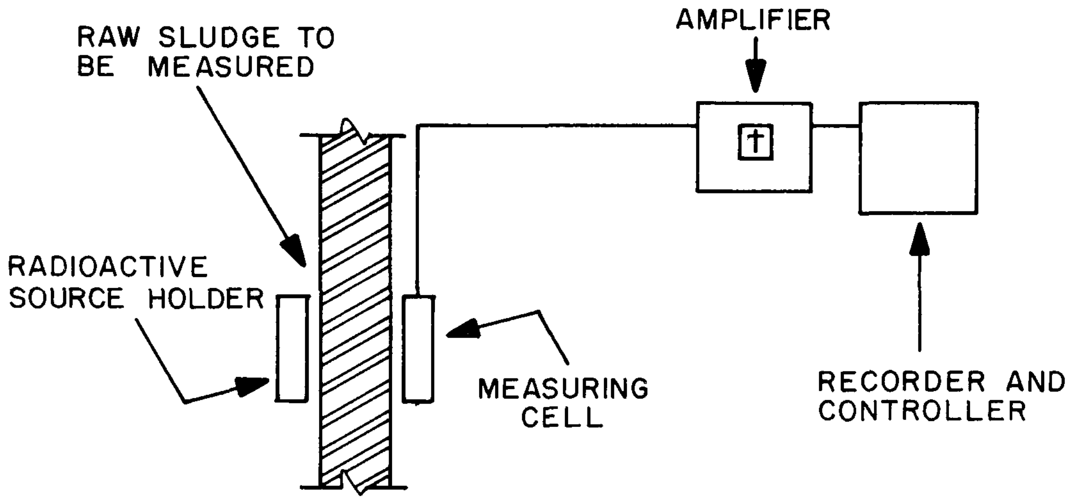


FIGURE 7 COMPONENTS OF A TYPICAL NUCLEAR DENSITY GAUGE

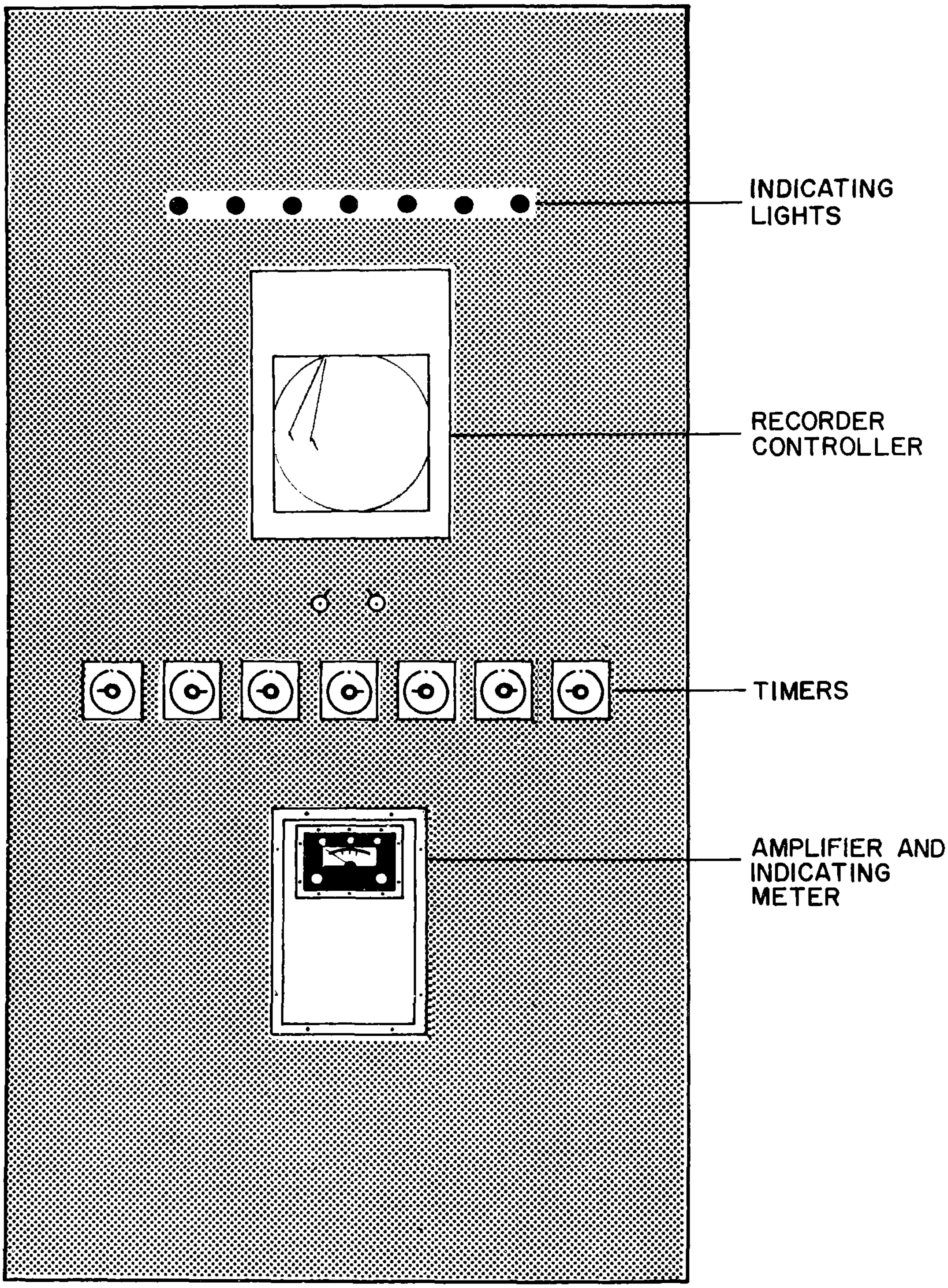
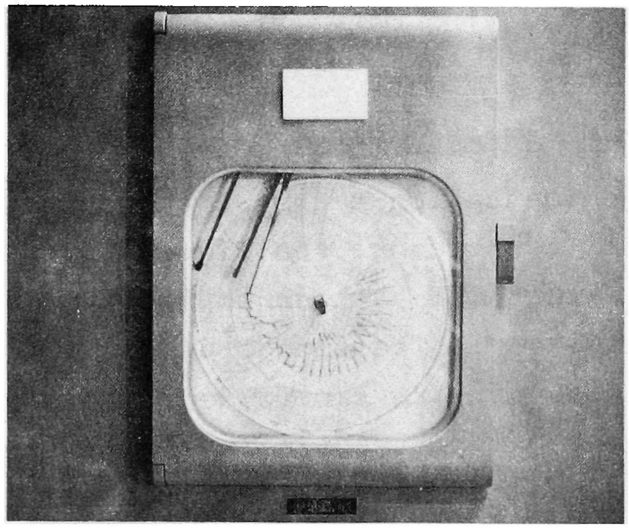


FIGURE 8 TYPICAL SEDIMENTATION UNIT CONTROL PANEL AT THE JWPCP



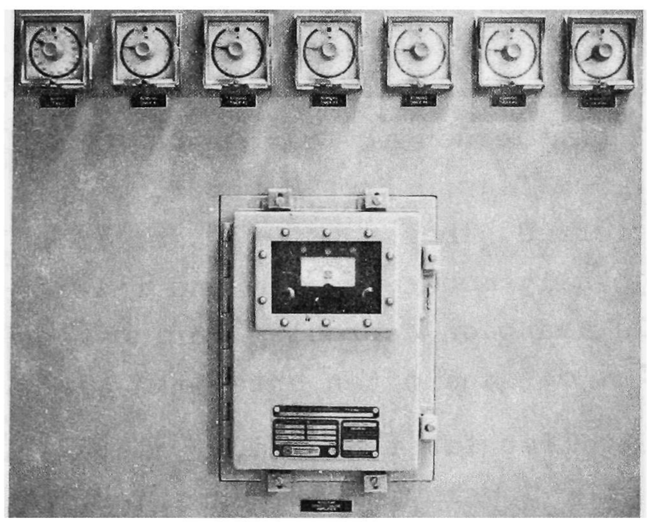


FIGURE 9 CLOSE-UP VIEWS OF RECORDER-CONTROLLER (ABOVE) AND DENSITY GAUGE AMPLIFIER (BELOW)

just as it is displayed on the amplifier indicating meter while the outer pen records collector pump on and off time, see Figure 20. The set point indicator can be set for any density. Both recorder and indicating meter are calibrated in percent total solids (0-10%).

Description of JWPCP Pumping System

The JWPCP has 52 sedimentation tanks arranged into ten pumping units of four to six tanks each, see Figure 10. Each tank is equipped with a draw off valve which consists of a gate valve operated by an air piston. The sludge draw off lines from the individual tanks in a unit are manifolded together and connected to a single collector pump, as shown in Figure 11. Each centrifugal, nonclog pump provides a 6.1-7.6 m (20-25 ft) static lift and has a sludge pumping rate in the range of 47.3-78.86 ℓ/s (750-1250 gpm).

The density gauge for each unit is located below the wet well discharge point and relatively close to the pump itself. This arrangement assures a full pipe. Both horizontal and vertical upflow orientation of the density gauges have provided satisfactory operation, see Figure 12. However, vertical upflow orientation is preferred since sand will settle out on the bottom of a horizontally mounted gauge and falsely indicate a high density. This has been a problem during wet weather periods when huge quantities of sand often enter the plant.

The timers and controller for the sludge valves and pump are mounted just above the density gauge amplifier for each unit and in the same control panel, see Figure 8. Each unit has a master timer (0-120 min) which controls the off time of the pumping sequence. It is this timer which is adjusted to compensate for diurnal and seasonal variations. In addition, each unit has four to six (depending on the number of tanks in the unit) tank timers or delay timers (0-5 min). The primary purpose of the tank timers is to insure that a new supply of raw sludge has reached the density measuring unit and that the control

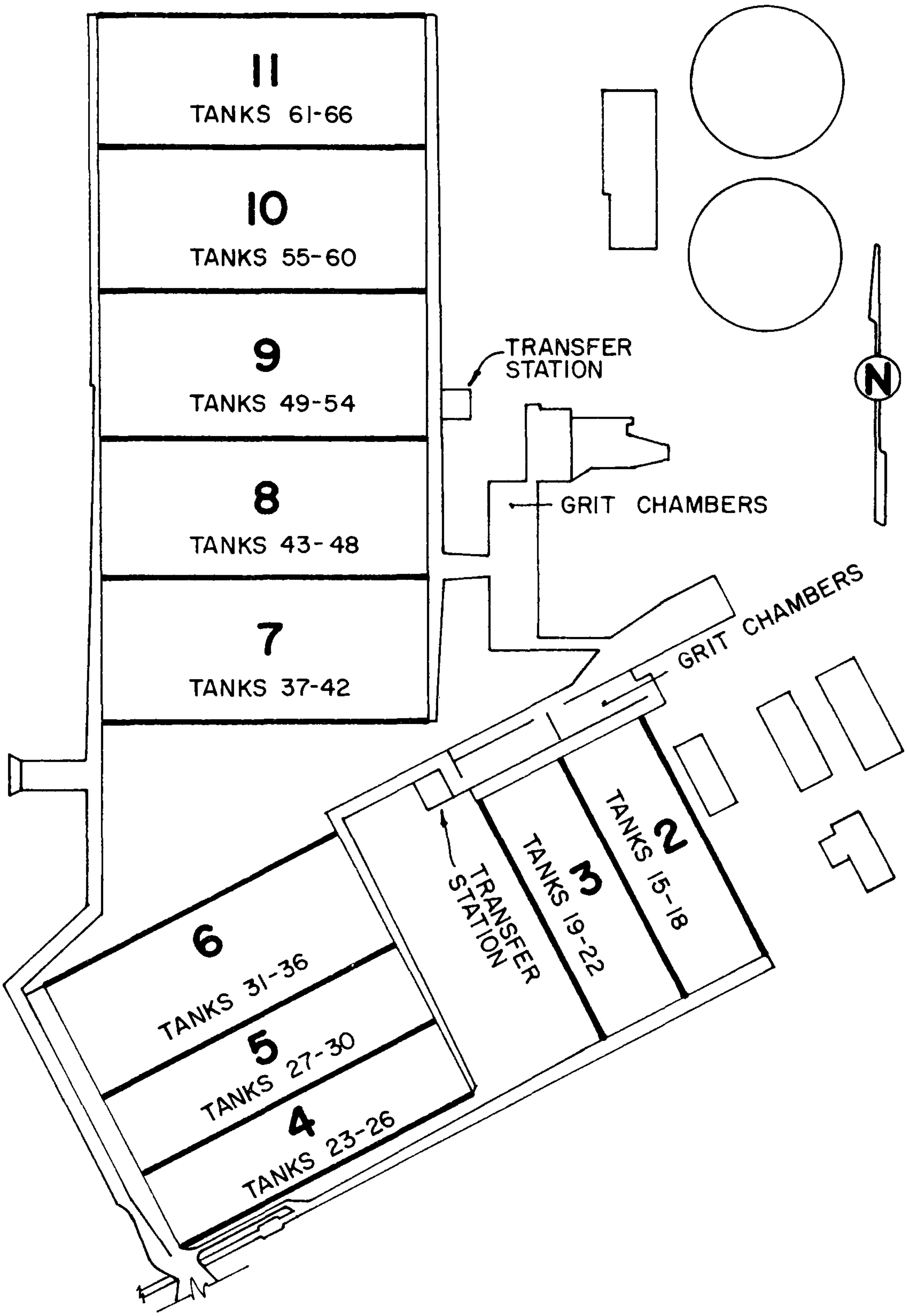


FIGURE 10 LAYOUT OF SEDIMENTATION TANK UNITS AT THE JWPCP

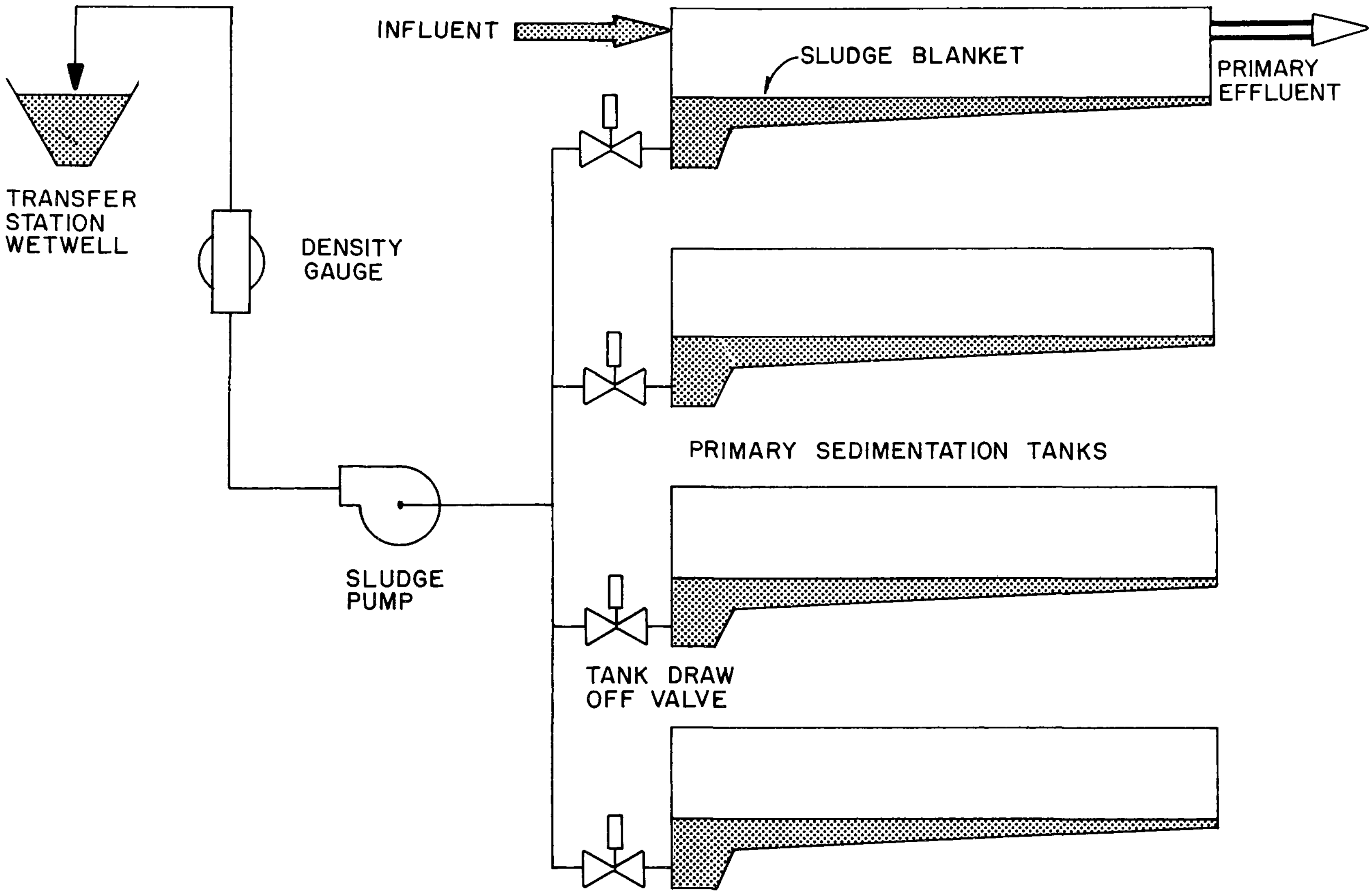
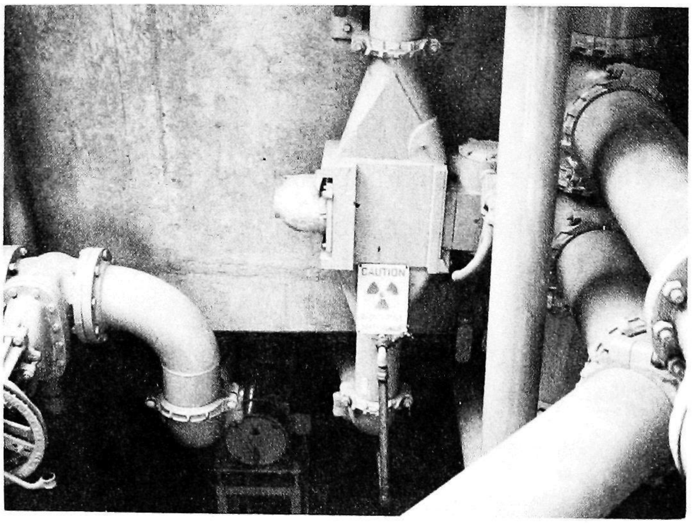


FIGURE 11 SCHEMATIC DIAGRAM OF A SLUDGE PUMPING UNIT



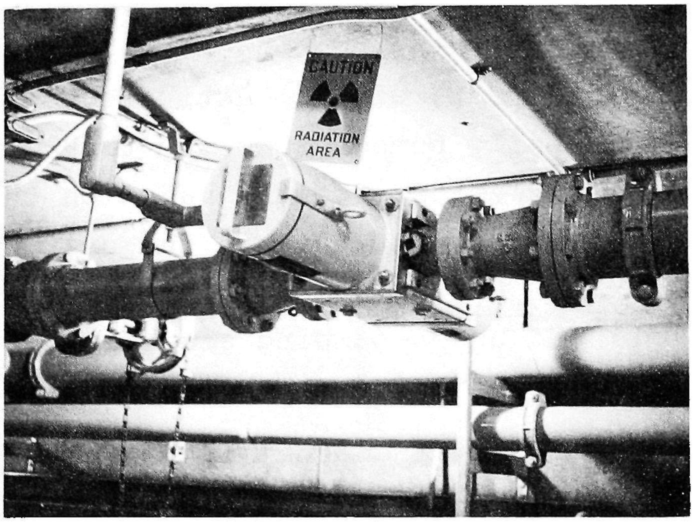


FIGURE 12 VERTICAL (ABOVE) AND HORIZONTAL (BELOW) INSTALLATION OF DENSITY GAUGES

of the pump is not being accomplished by residual sludge in the suction line. These timers are set for the minimum time required to accomplish this purpose (normally 1 min.). In case of malfunction of the density unit however, they can be used to control the pumping cycle. Red lights located above the recorder for each unit correspond to the collector pump and each draw off valve, indicating when the pump is on and when each valve is open.

Sequence of Operation

The following pumping sequence is shown schematically in Figure 13. When the master timer zeros out, the first tank timer is activated; this opens the first draw off valve. At the same time, the collector pump is turned on and sludge is pumped out of the first hopper. If the density of the sludge being pumped is higher than set point when the first tank timer zeros out, the first valve will remain open and the hopper will continue to be pumped until the density drops below set point. At this time, the first valve will close and the second tank timer will be activated, opening the second valve. This sequence will continue until all four (or six) tank hoppers have been pumped, after which the master timer, which has since reset, will be activated again. If the density of the sludge being pumped from any tank is below the set point when its timer zeros out, the valve on that tank will close and the timer for the next tank in the unit will be activated. Thus, both over-pumping (except that caused by excessive tank timer settings) and under-pumping are eliminated because density is the controlling factor.

Timer changes usually follow a diurnal flow cycle, such as Figure 1. In the following discussion, only the off timer setting is changed; the tank timer setting remains constant.

1. 300-900 Hours - The off timer setting is increased during this period since the accumulation rate is decreasing. Often, however, the sludge enters the plant partially digested or septic. As a result, the holding time during this period must be reduced to prevent gassing. The off

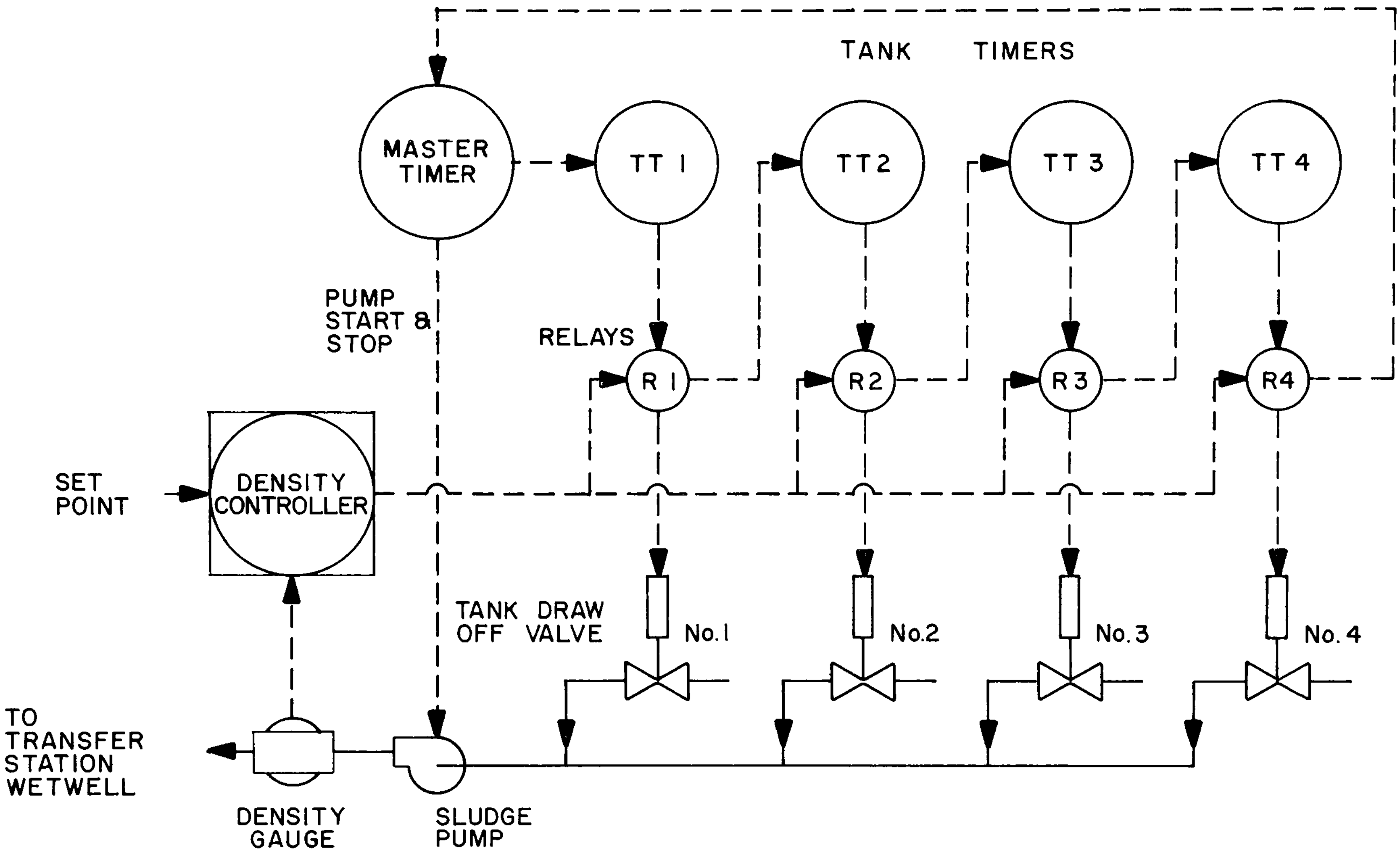


FIGURE 13 SCHEMATIC DIAGRAM OF DENSITY CONTROLLED SLUDGE PUMPING SYSTEM AT JWPCP

timer setting is thus increased but not in direct proportion to the decrease in accumulation rate.

2. 900-1400 Hours - The off timer setting is gradually decreased during this period since the accumulation rate is increasing. However, fresher sludge enters the plant and a higher sludge blanket level can be maintained without gassing. The off timer setting is thus decreased but not in direct proportion to the increase in accumulation rate.
3. 1400-300 Hours - The off timer setting is somewhat constant since the accumulation rate is unchanged.

Adjusting Timer Settings - Density Control

In using density control, only the off timer setting is changed. The tank timer functions as a delay timer that assures the line is clear of sludge remaining from the previous cycle or from the previous tank.

The operator routinely observes the density chart trace and compares it to the set point. Off timer settings are adjusted according to the following procedure.

1. During the daily period of lowest sludge accumulation, the off timer is adjusted to a maximum setting which does not require density control (i.e., the density trace does not exceed the set point at the end of the one minute pumping from each tank). This adjustment is necessary at the JWPCP due to the septic condition of the wastewater during this low flow period. It is impossible to store the sludge in the sedimentation tanks long enough to reach the desired density without gasification occurring. In this case there is the option of lowering the set point rather than adjusting the off timer; however, this is impractical due to the inacessibility of the set point adjustment on some units.
2. During the day, the pumping time from each tank should increase in proportion to the increase in accumulation rate. For example, if the accumulation rate roughly doubles during a day, then the actual pumping from each tank should roughly

double. If the density controlled pumping timer becomes excessive, then the off timer setting should be decreased to increase the frequency of pumping cycles.

Reading Density Charts

Probably the greatest advantage of density gauges is the continuous recording of the sludge density. The recorder trace tells the operator the condition of the sludge and any problems or malfunctions in the pumping system.

The following section discusses the more common recorder traces and what they mean. Interpreting recorder traces is difficult since a single trace can have several causes.

1. Gassing Tanks - Figure 14 shows a recorder trace which indicates under-pumping from the unit tanks (i.e., the off timer setting is too high). Between noon and 2 p.m., the density being pumped is around six percent. However, after the pump stops the trace immediately drops to around four percent and remains at this low level until pumping is again started. This drop indicates separation of the sludge caused by gassing and settling in the gauge. Figure 14 shows that the condition improved after the off timer (OT) setting was decreased from 20 to 10 minutes. An immediate improvement such as this does not always occur. Visually observing the tanks and taking corrective action can usually prevent this problem from developing. An observation of gas bubbles above the collection sump is an indicator of trouble and immediate action should be taken to decrease the setting on the off timer. If only a portion of the tanks in a unit show gassing, corrective action dictates temporarily increasing the delay timers on only the affected tanks. This action causes increased pumping from these tanks without regard to density. The delay timers should be returned to their normal setting after the gassing sludge condition has ceased.

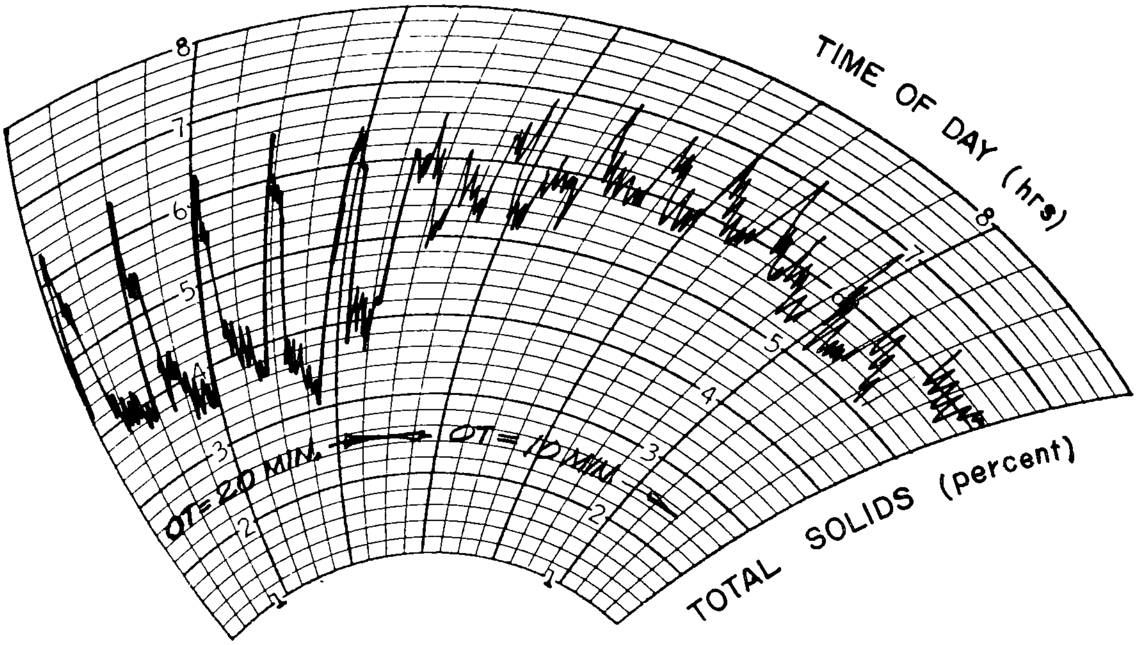


FIGURE 14 SECTION OF DENSITY CHART SHOWING GASING TANKS

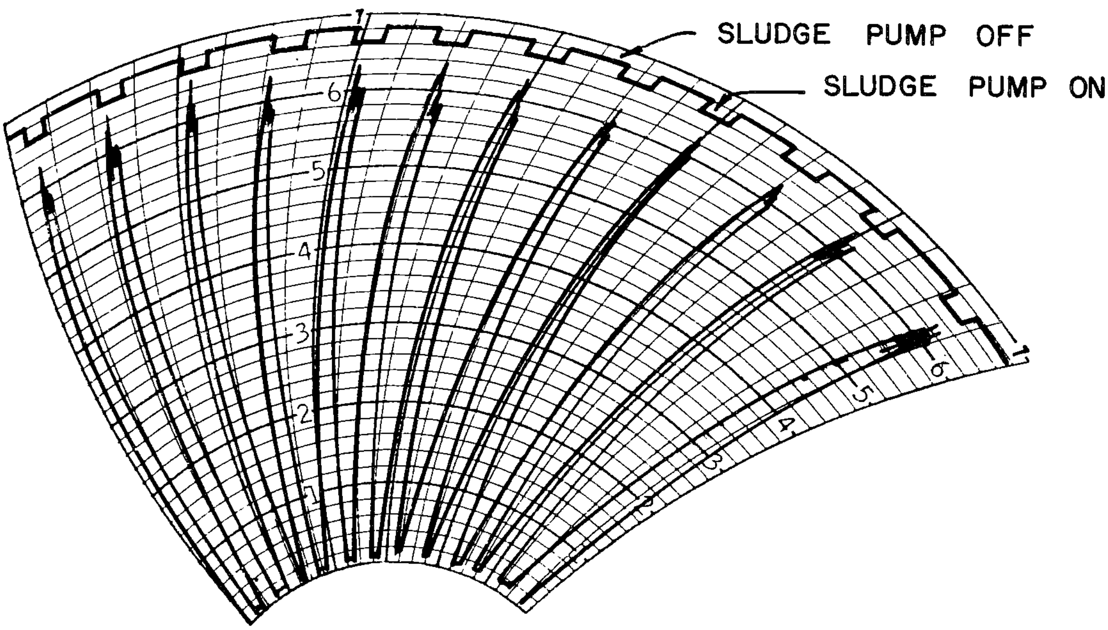


FIGURE 15 SECTION OF DENSITY CHART SHOWING WATER LEAK INTO LINE

2. Water Leak into Line - The recorder trace in Figure 15 indicates a water leak into the sludge piping. During pumping the density is observed to be around six percent. However, after the pump stops the line fills up with water and the trace drops to zero. The leak is usually caused by a faulty solenoid valve on the pump packing gland.
3. Vacuum in Line - Figure 16 shows a sudden drop in the chart trace each time the pump starts. This drop indicates either a vacuum on the line or a very small water leak. A vacuum such as this could be caused by a draw-off valve closing before the pump has shut off.
4. Erratic Charts - An erratic trace such as Figure 17 usually requires visual inspection of the sludge to determine what density is being pumped. Several possible causes exist which include the following: a gross object (such as a block of wood) stuck in the gauge, sand settling in the gauge, or an instrument malfunction. If a unit has less than three tanks in service, an erratic trace which resembles Figure 15 will occur.
5. Density Control - Figure 18 shows the sludge density exceeding the overriding set point on every pumping between 2 p.m. and 6 p.m. As previously described, the pumping continues until the density from each tank drops below set point.

CALIBRATION AND MAINTENANCE

General

The procedures outlined below are described thoroughly in manufacturer equipment manuals such as Ohmart or Chicago-Nuclear. They are presented here to familiarize the reader with the maintenance requirements of nuclear density gauges.

Calibration Procedures

1. Sampling Technique - Every week one calibration sample is taken from each density gauge. Two technicians are

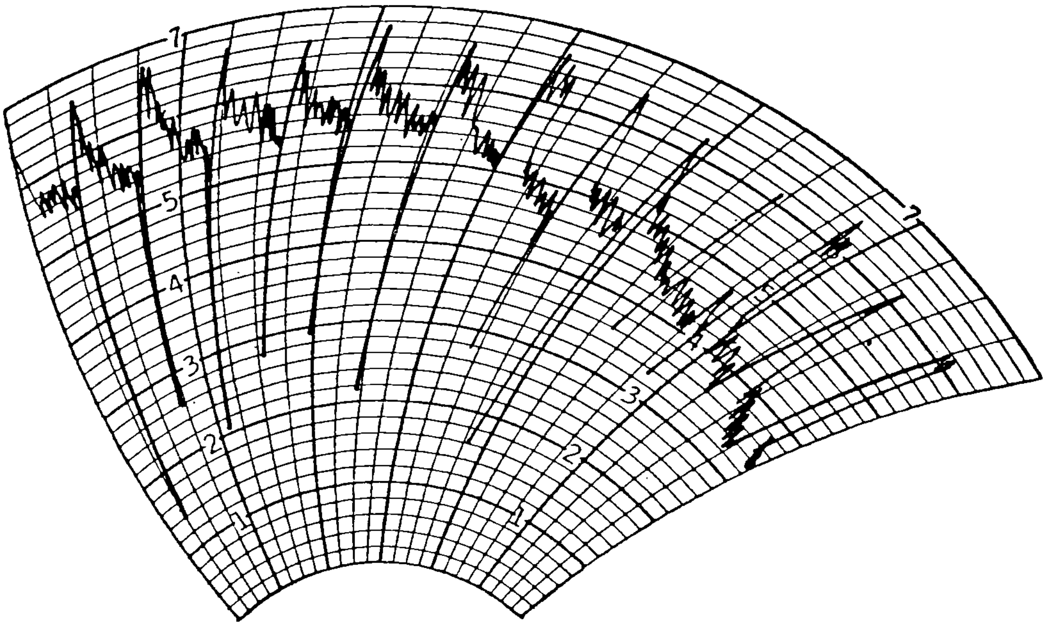


FIGURE 16 SECTION OF DENSITY CHART SHOWING VACUUM IN LINE

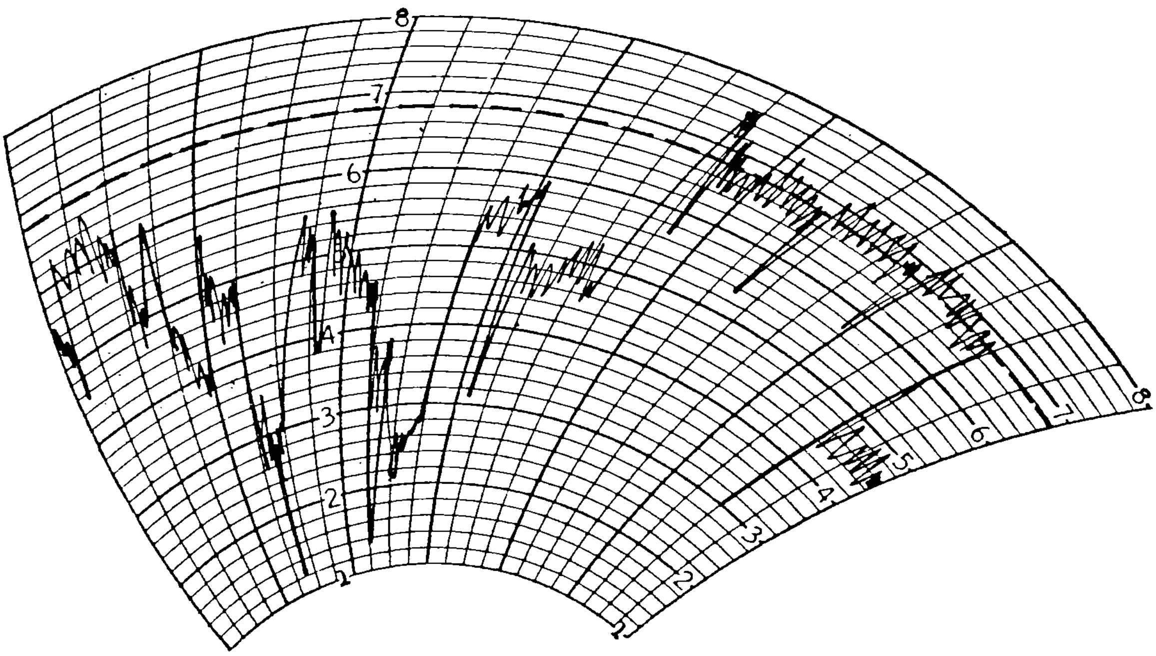


FIGURE 17 SECTION OF DENSITY CHART SHOWING ERRATIC READINGS

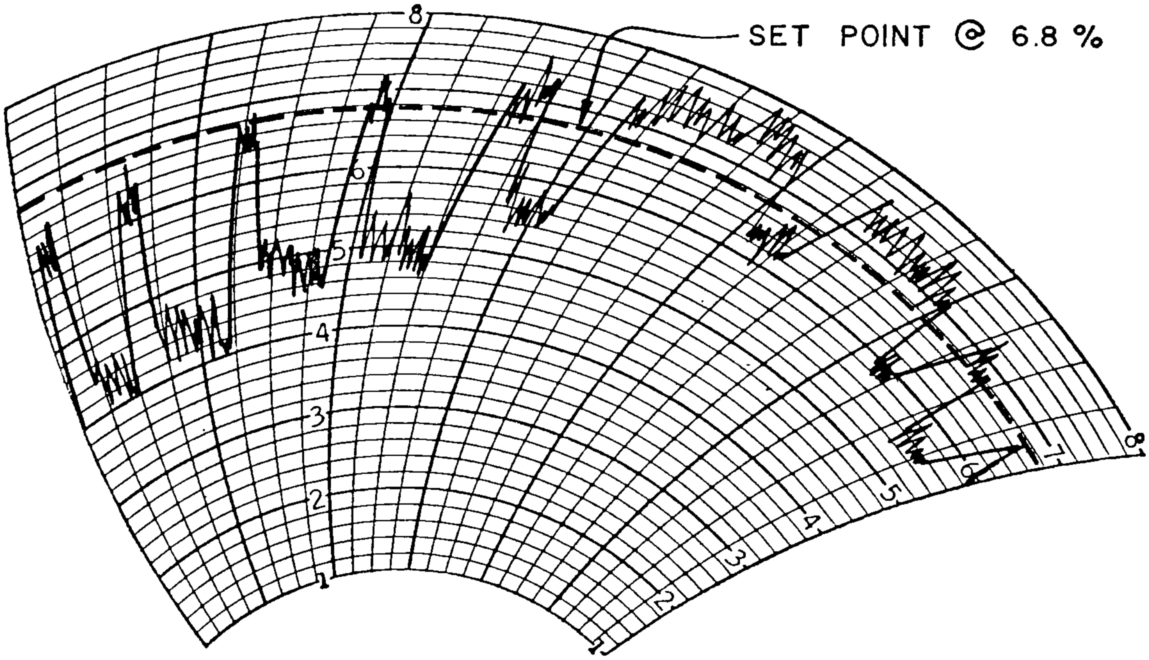


FIGURE 18 SECTION OF DENSITY CHART SHOWING DENSITY CONTROL

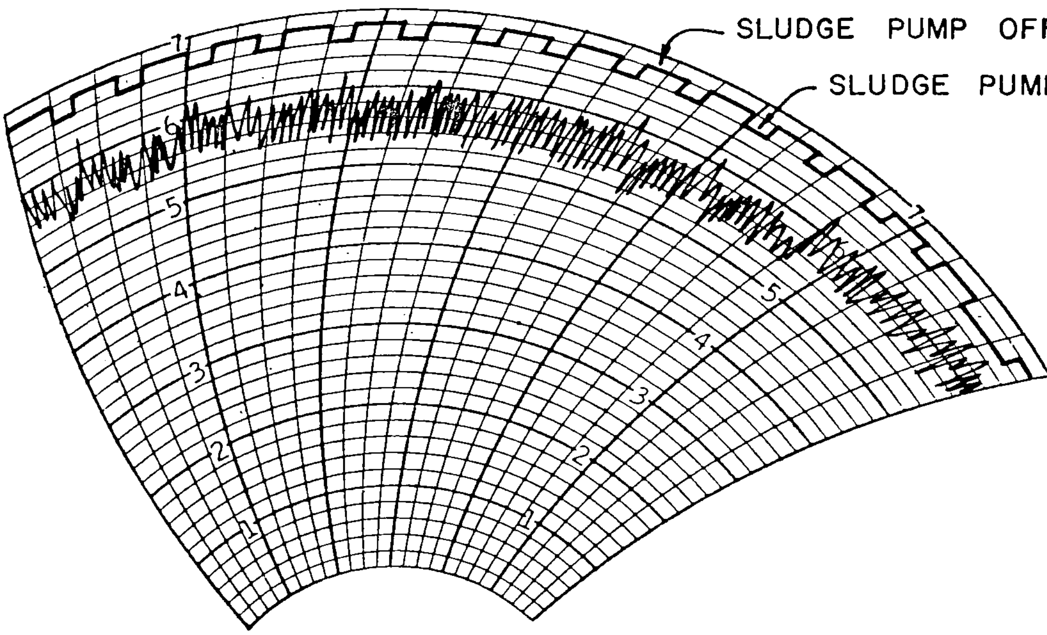


FIGURE 20 SECTION OF DENSITY CHART SHOWING A NORMAL TRACE

are required for the following procedure. After the pump has started and a steady reading is observed, one technician records the density while the other technician obtains a corresponding sample. The samples are delivered to the laboratory for a total solids determination.

At the JWPCP, calibration samples are taken using the "encapsulator" device shown in Figure 19. A one-inch sample line extends from near the density gauge inlet to a nearby sump. The device itself consists of four valves, one of which is a three-way valve. To capture a sample, the valves are first positioned to allow a steady sampling stream to flow into the sump. Valve no. 1 is closed to stop the sample flow and then valve no. 2 is closed to capture the sample, see Figure 19. The captured sample is released into a container by reversing the position of valve no. 3 and opening vacuum breaker valve no. 4.

2. Calibration Adjustment - An instrument technician compares the calibration meter reading to the laboratory analysis of the sample. A calibration correction is required if the two values differ by more than one-half percent. To make this adjustment the process density must again be steady. The adjustment is made using the CALIBRATION control and can be done when the meter is reading any value.
3. Water Zero Adjustment - Once a month, the water zero setting for each density gauge is checked. If a calibration correction is also required, the water zero check is usually made at the same time. The check is made by turning off the collector pump and filling the pipeline with water. This is accomplished by connecting a nonpotable water hose to the sample piping. After a steady reading is obtained, the zero can be ajusted by using the ZERO SUPPRESSION control.

Time Constant Adjustment

Density control of each tank in a unit will not occur unless the

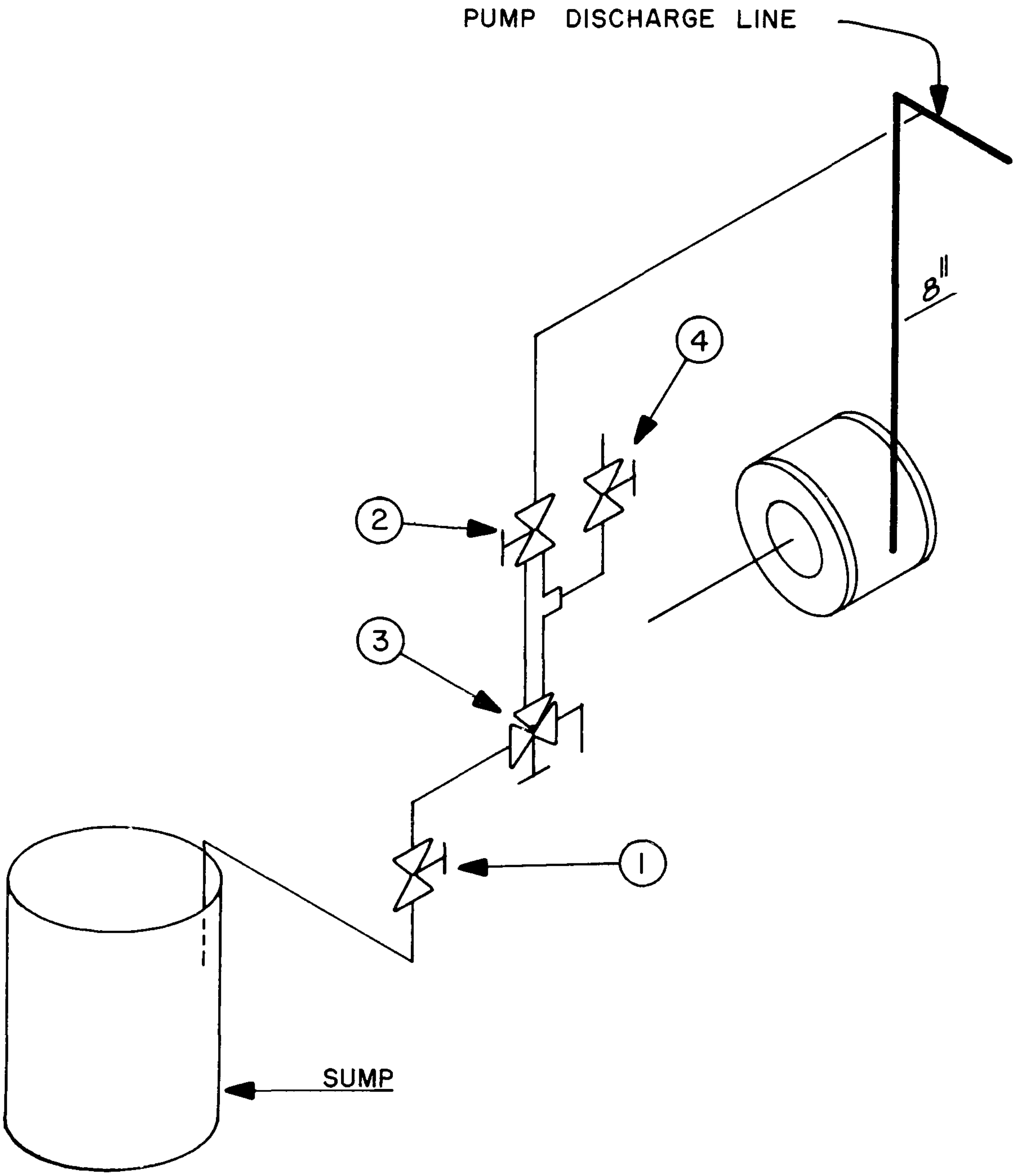


FIGURE 19 SCHEMATIC OF SAMPLE ENCAPSULATOR USED AT THE JWPCP

time constant is properly adjusted. The time constant makes it possible to obtain a balance between the noise band and the process rate of change (or response time).

The time constant is adjusted to read from water zero to process in 30-45 seconds. This is approximately the time required to clear the line of sludge remaining from the previous cycle or from the previous tank. A minimum tank timer setting of one minute gives the controller 15-30 seconds to read the density actually being pumped from each tank.

As described, the response time is first adjusted and then the resulting noise band checked. Figure 20 shows the acceptable noise band limit, approximately 0.4 percent total solids. If the noise band exceeds this amount, it can be reduced by increasing the time constant (i.e., by damping the system).

Maintenance Requirements

1. Daily Checks - This procedure requires approximately ten minutes per instrument per day. The instrument technician checks to make sure of the following:
   a. Chart is inking properly.
   b. Chart time is correct.
   c. Chart reading corresponds to meter reading.
   d. Timers do not stick.
   e. Noise level is not excessive.
   f. Trace is not erratic.
2. Calibration Adjustment - This procedure requires approximately one person-hour per instrument per month.
3. Corrective Maintenance - At the JWPCP corrective maintenance requires approximately one to two person-hours per instrument per month.

ANAEROBIC DIGESTER OPERATION

General

Efficient and proper anaerobic digester operation requires careful control of process variables. Literature on the subject deals primarily with heating and mixing. For the most part, little attention is paid to probably the most important variable of all, the food supply. Various loading parameters have been suggested but little has been published regarding methods to control the loading.

The use of density meters for raw sludge pumping control, coupled with simple digester feed controls, enables anaerobic digestion to be performed efficiently. The control system permits loadings to a series of digesters to be controlled within close limits and allows the loading to each individual digester to be varied as the conditions in each tank warrant.

Description of JWPCP Digester System

The JWPCP has a total of 31 anaerobic digesters arranged in two separate groups; only single-stage digestion is practiced. The first group contains 27 fixed cover, rectangular digesters, each with a capacity of approximately 2832 cu m (100,000 cu ft). The second group is presently composed of four (ultimately 12 or more) fixed cover, circular tanks, each with a capacity of approximately 14,160 cu m (500,000 cu ft). Despite differences in size, configuration, and location the two groups are identical in operation and control. Mixing is provided by gas recirculation, temperature is maintained in the desired range by steam injection, and loadings are controlled by the system described below.

Basis of Loading Control

Loading parameters are generally stated in terms of weight of volatile solids per unit volume of digester capacity. Unfortunately, automation of volatile solids determination has not yet been achieved and laboratory determinations are too time consuming to be of any use during the charging cycle. However, by using density control for raw sludge pumping and by incrementally feeding each digester (5 or 6 times per day), the diurnal variations in sludge density and volatility are evened out.

Weekly and/or monthly averages of density and volatility, determined by laboratory analyses of 24-hour raw sludge composites, provide a satisfactory basis for calculating and controlling loading by volumetric means as per the following formula:

Volume of raw sludge

$$= \frac{\text{Desired loading (weight of volatile solids per unit volume)}}{\text{Avg \% solids (raw sludge)} \times \text{Avg \% volatile (raw sludge)}}$$

x Digester capacity

Control System Elements

The control panel for one group of digesters houses 27 sets of sludge feed controls, one for each digester in that group. Each set contains:

1. 24-hour sludge feed timer - The total number of gallons of sludge to be fed to the digester in one 24-hour period is set on this timer.
2. Incremental sludge feed timer - The number of gallons of sludge to be fed to the digester per feeding is set on this timer. This setting is normally one-fifth or one-sixth of the volume set on the 24-hour timer depending on whether the digester is to be fed five or six times during the 24-hour period.
3. Sludge feed volume totalizer - Displays a running total of the volume of sludge fed to the digester.

The volume of sludge is measured by a Venturi meter in the raw sludge line carrying the flow to the digester group. The resultant pressure differential signal from this meter is converted to a flow signal by an adjacent pneumatic transmitter.

The pneumatic signal is received by a flow recorder in the control panel, recorded on a circular chart and converted to a pulse-time signal. This pulse-time signal is received by both the 24-hour and incremental feed timers. The incremental timer, having been preset for a specific volume of sludge, is clocked out when that volume of sludge has passed the flow gauging venturi (the 24-hour timer is also reduced by this amount).

Sequence of Operation

Pumping to the digestion system is initiated whenever the level in the raw sludge transfer wet well rises to the level probe and starts the pumps. The sludge then passes through the delivery piping and Venturi meter to the first digester in the series.

When the incremental timer clocks out, the feed valve to that digester closes, the flow signal is transferred to the next timer in the series, and the feed valve to that digester opens. Thus, the feed valve to one digester is always in the open position or is opening while the preceding valve is closing.

The control system cycles through every digester, allowing raw sludge to be fed to the digesters in the amount so indicated on their incremental timers. After one complete cycle, the control system switches back to the beginning of the series, again allowing raw sludge to be fed to the digesters in the amount shown on their incremental feed timers. However, if in the previous cycle the amount originally set on the digester total feed counter (24-hour timer) has been satisfied for any particular digester, the control system passes over the satisfied digester to the next digester whose total feed counter has not been satisfied. If a digester is out of service for cleaning or repair, its timers are set to zero, and it is bypassed in the feeding sequence in like manner to a digester whose feeding has been satisfied. An "on-off" selector switch for each tank accomplishes the same objective.

The start of the 24-hour control period is purposely selected to begin late in the afternoon after the laboratory analyses are completed and the condition of each digester can be evaluated. Any loading changes to be made are then "dialed in" on the appropriate timers and the control board is reset by pushing a single reset button. If only a portion of the tanks have been fed on the preceding cycle, the "on-off" selector switches for those tanks which have been fed are turned to the "off" position before the reset button is pushed. Thus, the new 24-hour cycle starts with the tank which would normally be next in line for feeding. After resetting the control board, the selector switches are returned to their normal position.

If the feeding of all of the digesters in the group has been satisfied or if the 24-hour control period expires before manual resetting occurs, the control system automatically resets all timers to the positions they were in at the beginning of the preceding control period. The control system then starts to cycle through the series again as previously described. Changes can still be made in the load settings, but it is more difficult to accomplish than if done before the control board is reset.

Summary

Radioactive density meters have been in operation at the JWPCP since 1959. They have proven to be an effective tool for controlling the intermittent withdrawal of raw sludge from primary sedimentation tanks. By controlling the sludge density within narrow limits, they also permit efficient use of digester capacity and make possible digester loading control by simple volumetric means.

SECTION VI

ACTIVATED SLUDGE - PROCESS AIR CONTROL

INTRODUCTION

Since the activated sludge system is an aerobic process, oxygen must be supplied to sustain metabolism of the microorganisms. Oxygen requirements vary depending primarily on organic strength of the primary effluent, the cell residence time at which the plant is operated, and whether nitrification occurs or not.

Heterotrophic microorganisms in activated sludge use organic compounds contained in sewage both as a source of energy and as a source of carbon for cell synthesis. Oxygen demand is exerted by that portion of organics oxidized to carbon dioxide and water. An additional oxygen demand is exerted when cellular organics are consumed for energy, a process termed endogenous respiration. The extent of endogenous respiration is primarily dependent upon mean cell residence time (MCRT) in the system, increasing with longer cell residence times. However, endogenous respiration is never complete since a fraction of the cellular organics are resistant to degradation and termed refractory. The refractory portion normally represents 10 to 20 percent of the total cell mass. Thus, oxygen consumed may vary from as low as 0.5 lbs O_2/lb COD when endogenous respiration is low to as high as about 0.90 lbs O_2/lb COD when endogenous respiration is complete. In normal plant operation, actual oxygen requirements would fall between these two extremes.

Oxidation of reduced inorganic compounds by autotrophic microorganisms can also exert an oxygen demand in the activated sludge process. Although many reduced inorganics may be present in sewage, only ammonia nitrogen is significant in terms of an oxygen demand. Nitrification is a two-step process in which ammonia is first oxidized to nitrate by the organism Nitrosomonas. Nitrite is then oxidized to nitrate by the organism Nitrobacter.

$$\text{Step 1:} \quad NH_4^+ + \frac{3}{2} O_2 \longrightarrow NO_2^- + 2H^+ + H_2O \qquad (1)$$

$$\text{Step 2:} \quad NO_2^- + \frac{1}{2} O_2 \longrightarrow NO_3^- \qquad (2)$$

$$\text{Overall:} \quad NH_4^+ + 2O_2 \longrightarrow NO_3^- + 2H^+ + H_2O \qquad (3)$$

The above reactions furnish energy for the growth of the nitrifying bacteria, during which some of the nitrogen is assimilated into bacterial protoplasm, with carbon dioxide being used as a source of cell carbon. With an empirical cell formulation of $C_5H_7O_2N$, the assimilation reaction can be written as:

$$5CO_2 + NH_4^+ + 2H_2O \longrightarrow C_5H_7O_2N + 5O_2 + H^+ \qquad (4)$$

Overall oxidation of ammonia to nitrate requires 4.57 mg O_2 per mg of NH_3 -N oxidized. However, some oxygen is produced during cell synthesis and actual oxygen requirements are somewhat less than theoretical. Haug and McCarty,[1] and others,[2,3,4] have shown actual requirements to vary between 3.9 to 4.5 mg O_2 per mg NH_3 -N. The variation is due to the range of reported cellular yields for these organisms.

Since nitrification is an aerobic process, the question arises as to what oxygen tension is required to support the maximum rate of substrate oxidation. Loveless and Painter,[5] showed that for a pure culture of Nitrosomonas the rate of ammonium oxidation was 50 percent of the maximum rate when the oxygen concentration was 0.3 mg/l at $20^{\circ}C$. Boon and Ladelout,[6] showed that for Nitrobacter the rate of nitrite oxidation was 50 percent of maximum when the oxygen concentration was 0.25 mg/l at $18^{\circ}C$ and 0.50 mg/l at $32^{\circ}C$.

Garrett,[7] working with activated sludge concluded that nitrification was independent of the oxygen concentration as long as it was greater than 3 mg/l. This same conclusion was reached by workers at the Water Pollution Research Laboratory in England,[8]. Wuhrmann,[9] studying activated sludge pilot plants, indicated that a dissolved oxygen concentration of 4 mg/l was necessary for rapid nitrification. However, Downing and Hopwood,[10] and Wild, et all,[11] concluded that nitrification in activated sludge is not enhanced by oxygen levels greater than 1 mg/l. This same conclusion has been supported by LACSD evaluations of their nitrifying activated sludge systems. Therefore, it appears that the rate of oxidation is largely independent of dissolved oxygen levels down to concentrations of 1 or 2 mg/l, below which some rate limitation will be observed.

Nitrification in the activated sludge process tends to be an "all or nothing" phenomenon. If the mean cell residence time in the activated sludge process is below the generation time of the organisms, they will be washed from the system and nitrification will cease. Wuhrmann,[12] reported that a MCRT greater than four days was necessary to consistently attain a high degree of nitrification. This corresponds with a value of about four or five days reported by Johnson and Schroepher,[13]. These values are just greater than minimum generation times reported for the nitrifying bacteria. At reduced temperatures, generation time is increased so that a longer MCRT would be required. A design MCRT of ten days for nitrification was recommended by Jenkins and Garrison,[14] and should give sufficient safeguard for most purposes.

From the above discussion, oxygen requirements to stabilize a wastewater can be determined within reasonably narrow limits, depending primarily on influent COD and NH_3-N concentrations and mean cell residence time. However, air quantities required to satisfy the oxygen demand are more variable, depending on the type of oxygen transfer equipment used and efficiencies at which they operate. Also, in all but completely mixed systems, rates of oxygen consumption will vary along the length of the aeration tank. Process air control, is therefore, critical to the stable operation of the activated sludge system. Not only must total air quantity be controlled, the rate at which it is supplied along the aeration tank must also be controlled to provide for stable and efficient treatment.

LACSD FACILITIES

A variety of techniques are used to control process air at activated sludge plants operated by the LACSD. Techniques used can be divided into two basic types: (1) use of a control signal to throttle a centrifugal compressor and, (2) use of preset timers to control the number of on-line positive displacement compressors. Cam programmers, dissolved oxygen probes and plant flow rate are currently used to provide the command signal for the first type of control listed above. Control methods currently used at each treatment plant are shown in Table 3.

Preset Timers

Use of preset timers is relatively straight forward and will be described first. Most treatment plants experience diurnal variations in both flow rate and sewage strength (as measured by COD). In general, as flow rate increases so does sewage strength. This means that process air requirements will vary diurnally as well. 24-hour timers are used at two of the small LACSD treatment plants to control operation of a number of parallel, positive displacement compressors. Thus, with a knowledge of the diurnal variation in oxygen demand, timers can be preset to vary the number of on-line compressors. In this way, oxygen supply can be approximately matched with oxygen demand.

Diurnal variation in plant flow rate, COD loading, and air supply to the aeration system at District 26 WRP is shown in Figure 21. Using data from Figure 21, the pounds of oxygen supplied per pound of COD were determined and plotted in Figure 22. Resulting dissolved oxygen concentrations in the aeration system (measured at the midpoint) are also shown in Figure 22.

One advantage of a timer controlled process air system is that operation is relatively simple and timers can be easily readjusted to change the operation. The system is well suited to small

TABLE 3

LACSD ACTIVATED SLUDGE PROCESS AIR CONTROL SYSTEMS

Treatment Plant	Air to Flow Ratio	D.O. Probe	Cam Programmer	Timers
Whittier Narrows WRP			X	
San Jose Creek WRP		X		
Pomona WRP	X			
Los Coyotes WRP	X			
Long Beach WRP		X		
District 26 WRP				X
District 32 WRP				X

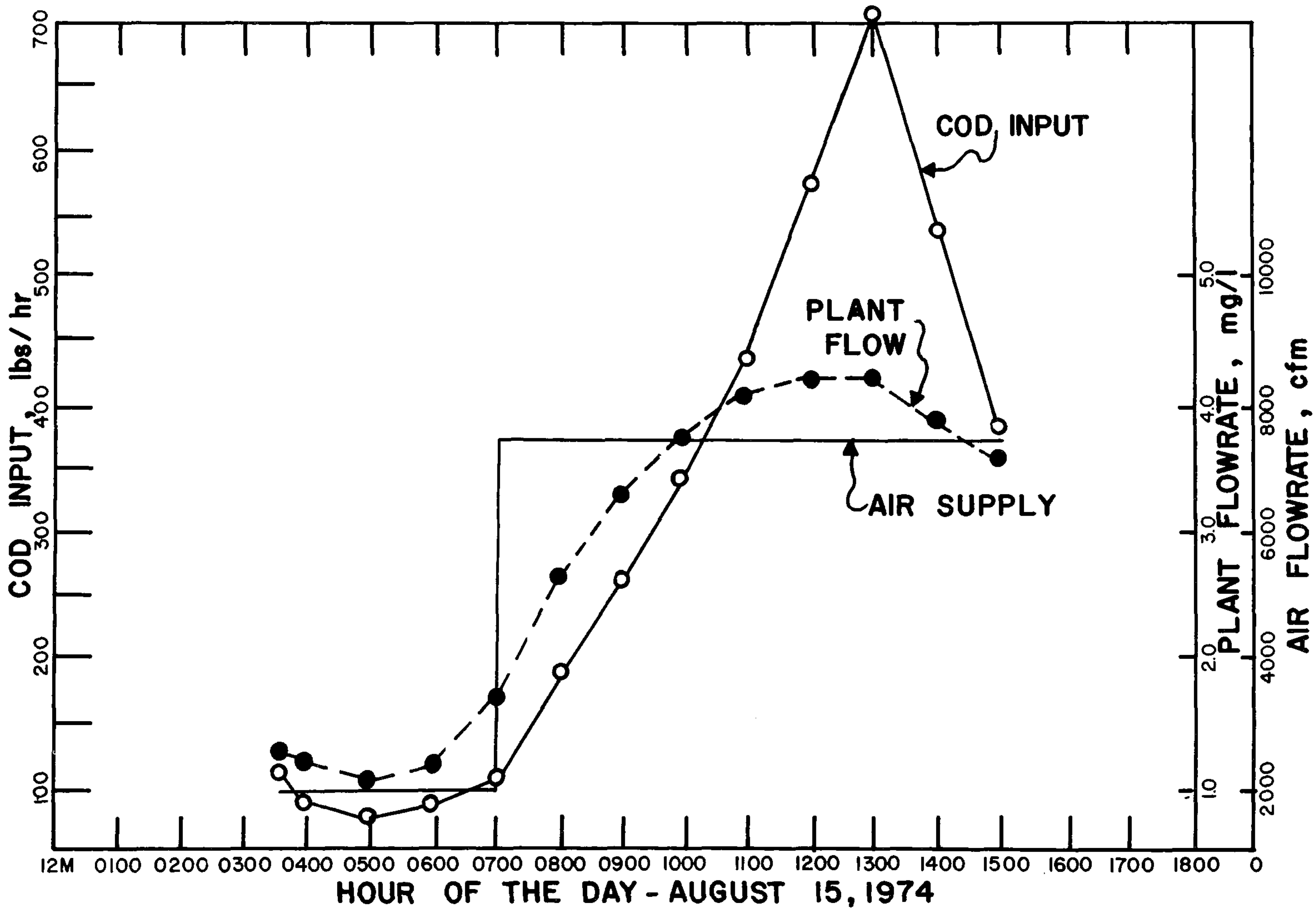


FIGURE 21 ACTIVATED SLUDGE OPERATIONAL PARAMETERS
DISTRICT 26 WATER RENOVATION PLANT

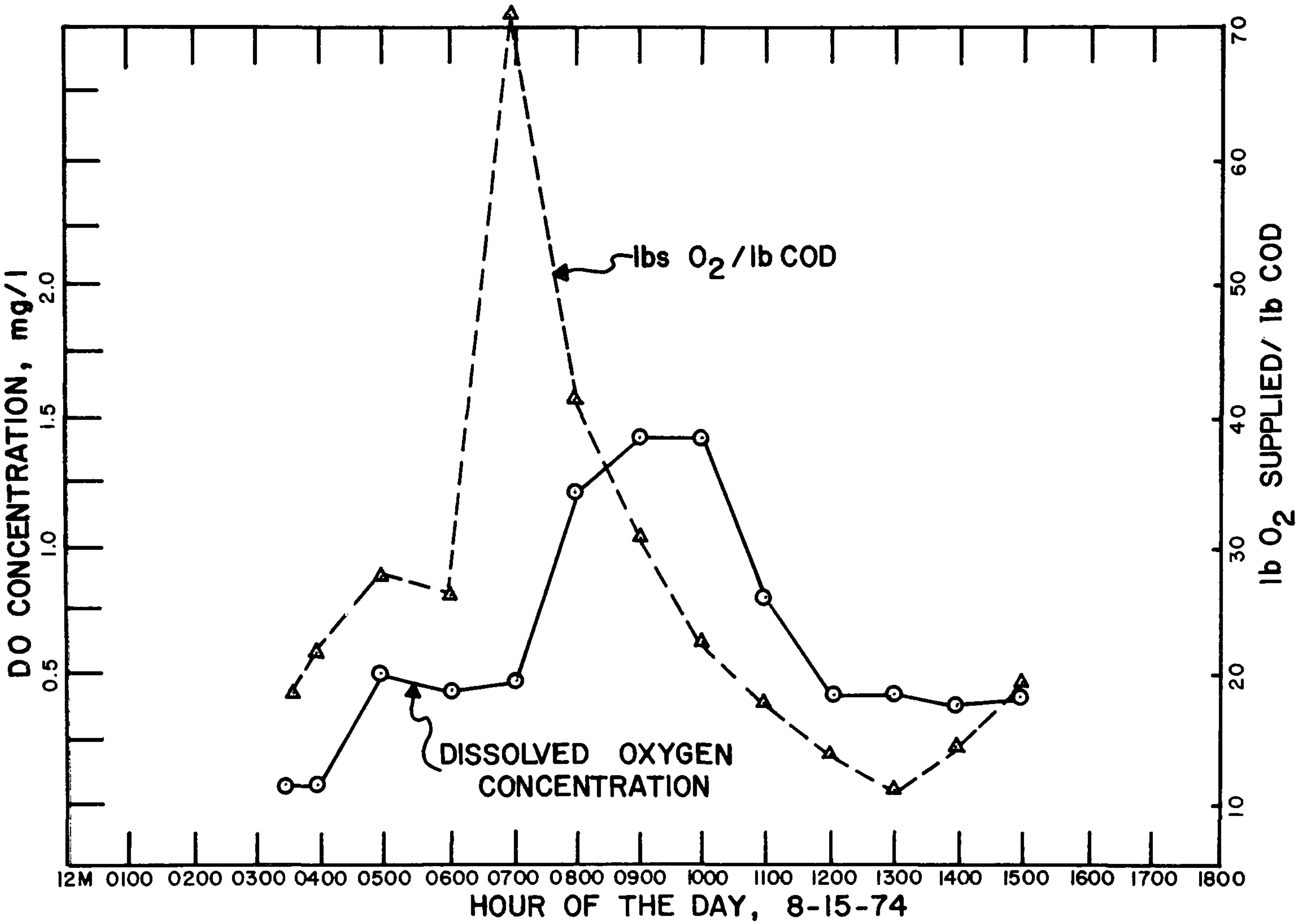


FIGURE 22 ACTIVATED SLUDGE OPERATION PARAMETERS
DISTRICT 26 WATER RENOVATION PLANT

treatment plants where total air requirements are not large. However, preset timer control has some disadvantages which, in general, preclude use in larger treatment plants. Oxygen demand curves can not be exactly matched since oxygen supply can only be incrementally changed. This is evident in Figure 22 where a sudden increase in mixed liquor DO accompanied start-up of the second air compressor. In addition, diurnal patterns of oxygen demand are subject to daily, weekly, and seasonal variations. It is difficult to continually readjust timer settings in anticipation of such changes. As a result, it is likely that most treatment plants would supply an excess of air to compensate for fluctuations in the pattern of diurnal variation.

In summary, timer control of parallel compressors provides an adequate process air control system in small treatment plants where design simplicity is important and excess air can be supplied without significant economic loss.

Cam Programmers

Five of the LACSD activated sludge plants have the flexibility of controlling process air flow by means of cam programmers. A schematic diagram illustrating this mode of operation is shown in Figure 23. A converter transmits a control set point signal which is proportional to the position of a cam follower on the edge of a rotating cam. The transmitted signal is a DC current signal. The cam is driven electrically and completes one revolution in 24 hours.

The converter applies its signal to a ratio controller which changes the set point of the controlling system by a preset adjustable ratio. The controlled variable signal is then transmitted to the air flow controller which compares an input signal (air flow rate) to the set point signal from the ratio controller. The air flow rate signal is generated by a flow tube and differential pressure transmitter. Since the resultant signal is proportional to the square of the air flow rate, a square root extractor is used to produce a signal directly proportional to flow rate. Ratio set

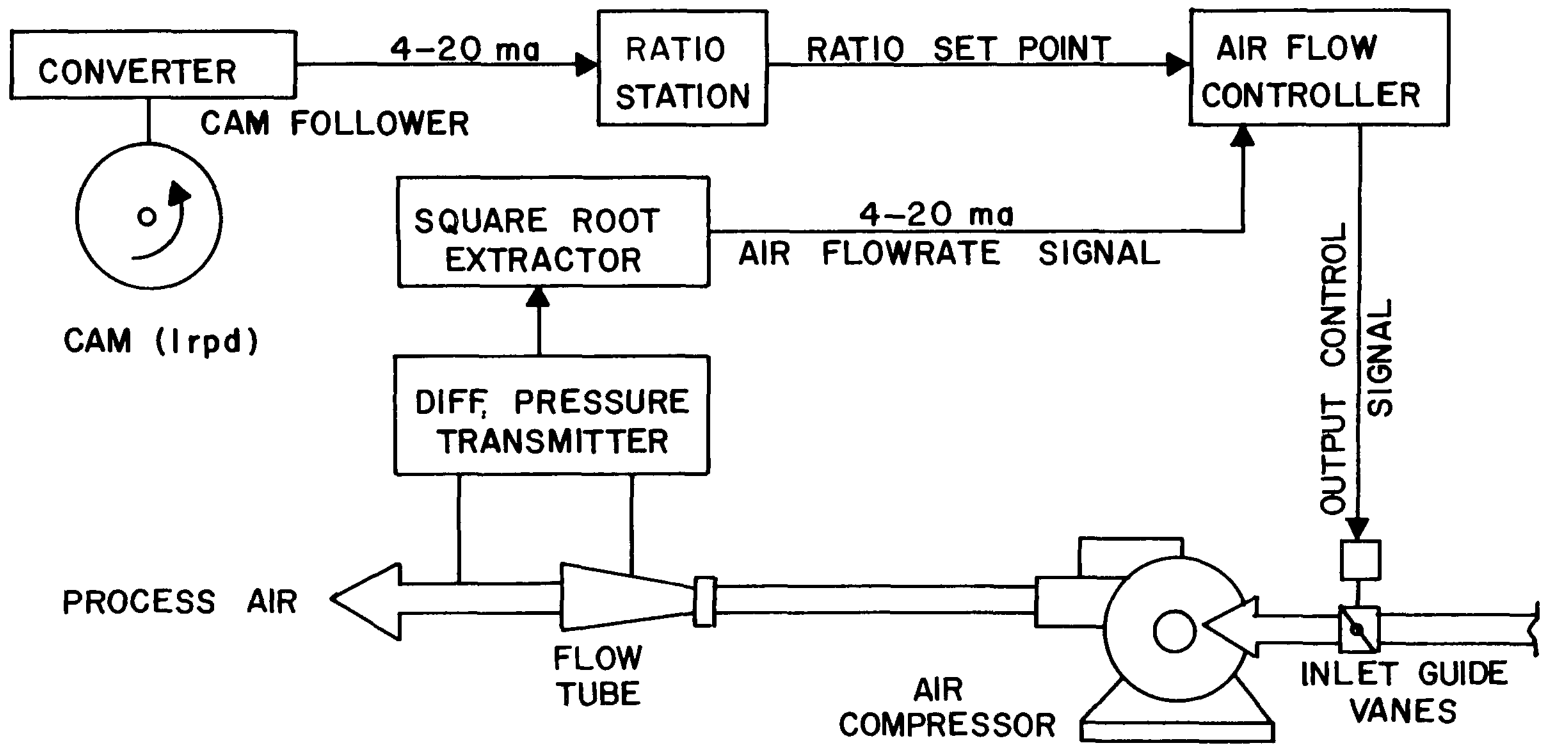


FIGURE 23 SCHEMATIC DIAGRAM OF PROCESS AIR CONTROL USING A CAM PROGRAMMER

point and air flow rate signals are compared in the air flow controller which transmits an output signal to control positioning of compressor inlet guide vanes.

Knowing daily variations in flow rate and sewage stength, as measured by COD and NH_3-N concentrations (if nitrification is desired) the diurnal variation in oxygen demand can be determined. A cam can then be cut to regulate oxygen supply to meet the expected oxygen demand. Should supply not exactly balance demand, a new cam is cut until, by trial and error, supply balances demand. Cam programmers offer an additional advantage over preset timers (described previously) in that compressor operation can vary anywhere from 0 to 100 percent of maximum output.

A modification of cam programmer control is used at the Whittier Narrows WRP. At this plant, it is possible to take as much or as little flow as is desired from the trunk sewer passing the plant. Air flow to the aeration tanks is maintained at a constant rate. To keep oxygen supply and demand in balance, plant influent flow rate is varied by a cam programmer to compensate for changes in sewage strength. The ratio of peak daily to minimum daily flow is about 1.5 under this mode of operation.

While performance of the cam programmer system has, in general, been satisfactory certain disadvantages are inherent in its operation. Daily, weekly, and seasonal fluctuations in diurnal oxygen demand require periodic cam readjustment. Shock loads, either in flow or sewage strength, may upset plant performance since they can not be anticipated when the cams are originally cut. Experience has also indicated that it is difficult to maintain an exact dissolved oxygen content in the aeration tank. For example, if it is desired to maintain 0.5 mg/l at a certain point in the aeration tank, the sensitivity of a cam may not be sufficient to assure that DO at all times.

Air to Flow Ratio

Under this mode of operation process air is automatically maintained at a preset (adjustable) ratio to plant flow. An electrical signal, proportional to flow rate, is generated by the plant influent flow meter and used to regulate the quantity of process air. Actual ratio of process air to plant flow rate is adjustable over the range from 0 to 5 ft^3/gallon. A schematic diagram of this control system is shown in Figure 24.

This process air control system has operated satisfactorily at both the Pomona and Los Coyotes WRP's. An advantage over cam programmer control is offered since changes in diurnal flow rate patterns are automatically sensed and compensated for. Hence, once the desired air to flow ratio is selected, operation is generally automatic. The system will even respond to shock loads resulting from increased flow rate. However, the system will not respond to sudden increases in waste organic strength. This disadvantage may be significant in treatment systems which receive a large proportion of industrial wastes. Another disadvantage lies in the fact that peak flow periods are normally associated with periods of peak organic strength. Thus, if the air/flow ratio is sufficient to maintain adequate DO during the peak flow period, the ratio may be too high during the low flow period when waste organic strength is less. This is partially offset however, as during the lower flow period when waste strength is less, the amount of oxygen consumed by endogenous respiration represents a greater percentage of the total oxygen consumed than it does during peak load periods. Simply stated, if the organic strength had no diurnal variations, a higher air/water ratio would be required during the lower flow periods than during the higher flow periods.

DO Probe Control

Control of process air by dissolved oxygen probes located in the activated sludge tanks is the normal mode of operation at the San Jose Creek and Long Beach Water Renovation Plants. A schematic diagram of the system is shown in Figure 25. In principle, dissolved oxygen probes provide a feedback signal to control operation of the air compressors. This provides a system which

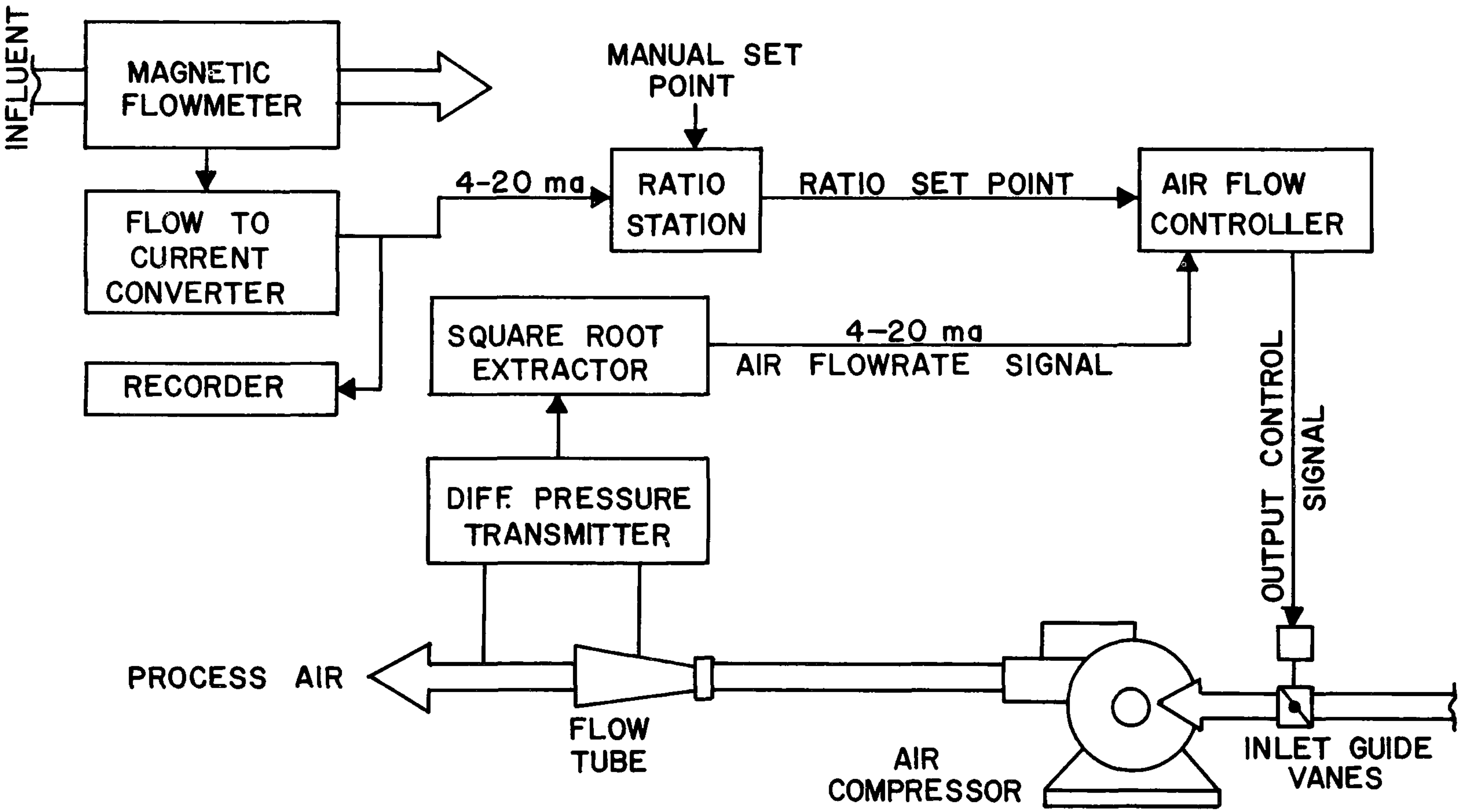


FIGURE 24 SCHEMATIC DIAGRAM OF PROCESS AIR CONTROL USING AIR FLOW RATIO

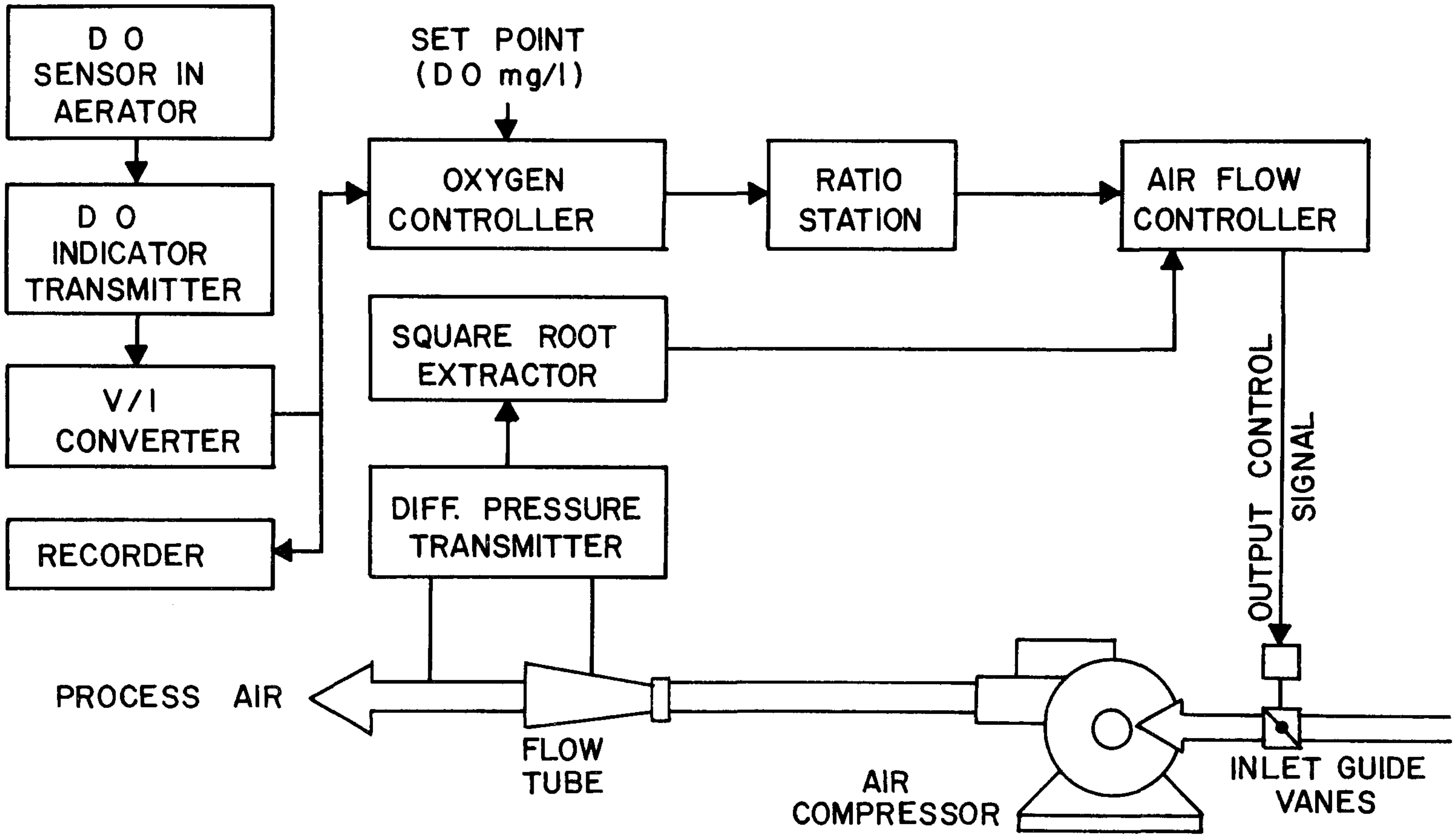


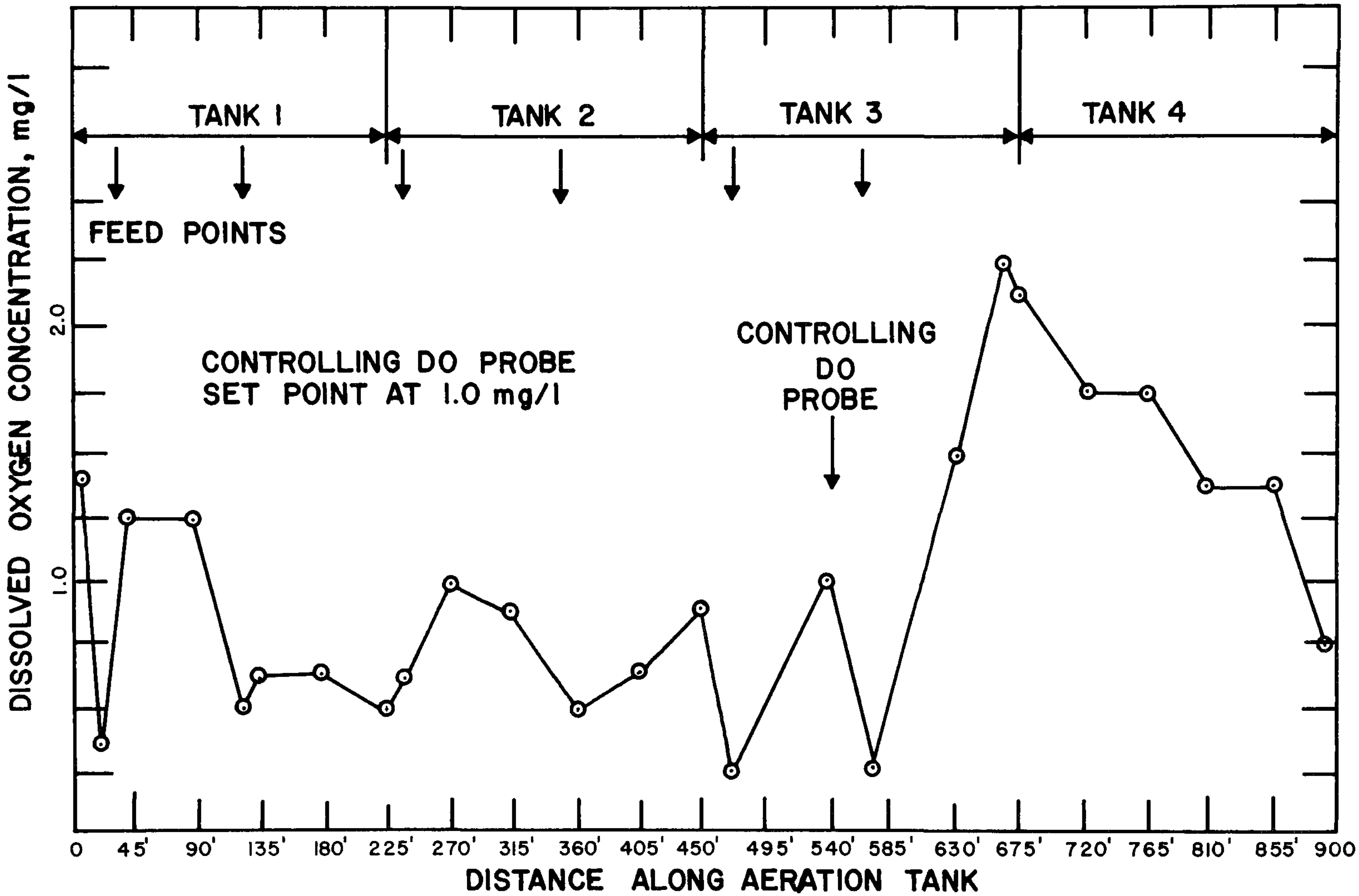
FIGURE 25 SCHEMATIC DIAGRAM OF PROCESS AIR CONTROL USING D O SENSOR PROBES

can respond to any diurnal fluctuation in oxygen demand as well as shock loads whether they be in terms of flowrate or waste strength.

Primary elements for measuring dissolved oxygen are DO probes located in the aeration tanks. Optimum number of probes depends on the type of activated sludge process used. For a completely-mixed aeration tank only one DO sensor would be needed since DO concentrations would be uniform throughout the tank. The San Jose Creek and Long Beach WRP's, which normally use DO sensors for process air control, have nearly plug flow activated sludge systems which employ step feeding (step aeration) of the waste. Hence, DO concentrations vary continuously along the length of the aeration tank as shown in Figure 26. This necessitates use of a number of DO sensors placed strategically along the aeration tanks.

The probes transmit signals proportional to the dissolved oxygen concentration to dissolved oxygen indicating transmitters (refer to Figure 25). The electrical signals are then transmitted to a control panel where they are recorded. One signal is automatically or manually selected to be used as a primary input command signal to the dissolved oxygen controller. Desired DO concentration to be maintained at the controlling probe can be manually set at the oxygen controller. The ratio station receives the output signal from the oxygen controller and applies a ratio set point signal to the air flow controller. This in turn provides an output signal used to control the position of inlet guide vanes on each process air compressor. A signal limiting device is provided in the controller to prevent closure of inlet guide vanes beyond the point that would cause compressor surge.

The reason for controlling process air to the activated sludge system is the necessity of balancing oxygen supply with oxygen demand. Beyond that DO levels should be sufficient to assure that reaction rates are not DO limited. The most straightforward method of accomplishing these objectives is to simply monitor the DO level in the aerator and use that as a feedback signal to



AERATION TANK DO PROFILE AT LONG BEACH WATER RENOVATION PLANT

FIGURE 26 7-1-74 - 1230 - 1430 hours

control compressor operation. Response to changes in diurnal flow pattern as well as to shock loads of either flow rate or waste strength are advantages of this type of system. Experience with DO probe control systems, however, has revealed several operational characteristics which will be noted.

As previously discussed, DO levels below 1 or 2 mg/l will affect nitrification kinetics by imposing a rate limitation. If the MCRT is above 5 or 6 days and the DO set point below about 0.5 mg/l, nitrification may not occur because of the DO rate limitation. However, if the DO set point is increased much above 0.5 mg/l, the rate limitation is removed and nitrification will proceed. This will produce a sharp increase in oxygen demand and process air flow will increase dramatically to try and match the demand. If the operator is not aware of this phenomenon, he may spend many anxious moments pondering the sudden increase in process air flow. If nitrification is not desired, the best operational procedure is to keep the MCRT below about four days. However, this may not produce the best quality effluent in terms of suspended solids. The only other recourse is to maintain DO concentration in the aeration tanks less than 0.5 mg/l which limits flexibility of the process air flow system.

In the DO probe system currently used, only one DO probe can be selected at any time to control process air flow. Experience with the system should indicate the position of the controlling probe that produces the best overall effluent quality. In LACSD experience, the controlling DO probe has usually been located near the midpoint of the aeration tank. A dissolved oxygen profile along the length of the aerator at the LBWRP is shown in Figure 26. The activated sludge system is divided into four tanks arranged in series. Return activated sludge enters at the head end of tank 1 while primary effluent is step fed into the first three tanks as shown in Figure 26. The controlling DO probe was located between the last two inlet gates with the control set to maintain 1.0 mg/l. This DO concentration was maintained at the location of the control probe but varied at other locations in the aeration tank. In general, DO levels decreased at each feed port and increased significantly in Tank 4 which contained no feed ports. If the controlling probe had been located in Tank 4, the same pattern of air supply may have resulted in excessively low DO levels in the first two tanks.

Theoretically, there would be some advantage to locating the DO probe near the beginning of the aeration system in that response to shock loads would not be as delayed. However, experience has indicated that compressor operation is more uniform if the controlling probe is located in the latter half of the aeration system. Flexibility in probe location is recommended in any design. In a more recent LACSD design, each four-pass aeration system has eight possible locations for mounting DO probes, one at each end of each pass. Any four of these locations can be used at one time, with the control system automatically choosing for control, the sensor which is producing the lowest reading. Flexibility also allows any single probe location to be used as the control point.

It should be noted that the DO control system does not regulate the pattern of air flow along the aeration tank. It only regulates total air flow to the aeration tank in order to maintain a set point dissolved oxygen concentration at the site of the controlling probe. The operator must still adjust air flow patterns to assure adequate DO at all points in the aeration tanks. For the DO profile shown in Figure 26, approximately 60 percent of total air flow was supplied to the first two tanks with the remaining 40 percent supplied to the latter two tanks.

Plant flow rate, process air flow rate, and dissolved oxygen concentration at the controlling oxygen probe are plotted in Figure 27 from data collected at the Long Beach WRP. Dissolved oxygen concentrations are seen to oscillate around the set point value of 3 mg/l with amplitude averaging about $\pm$ 0.5 mg/l. Rather large excursions in DO concentration were noted when the compressors were placed on manual control. Upon returning to DO probe control,

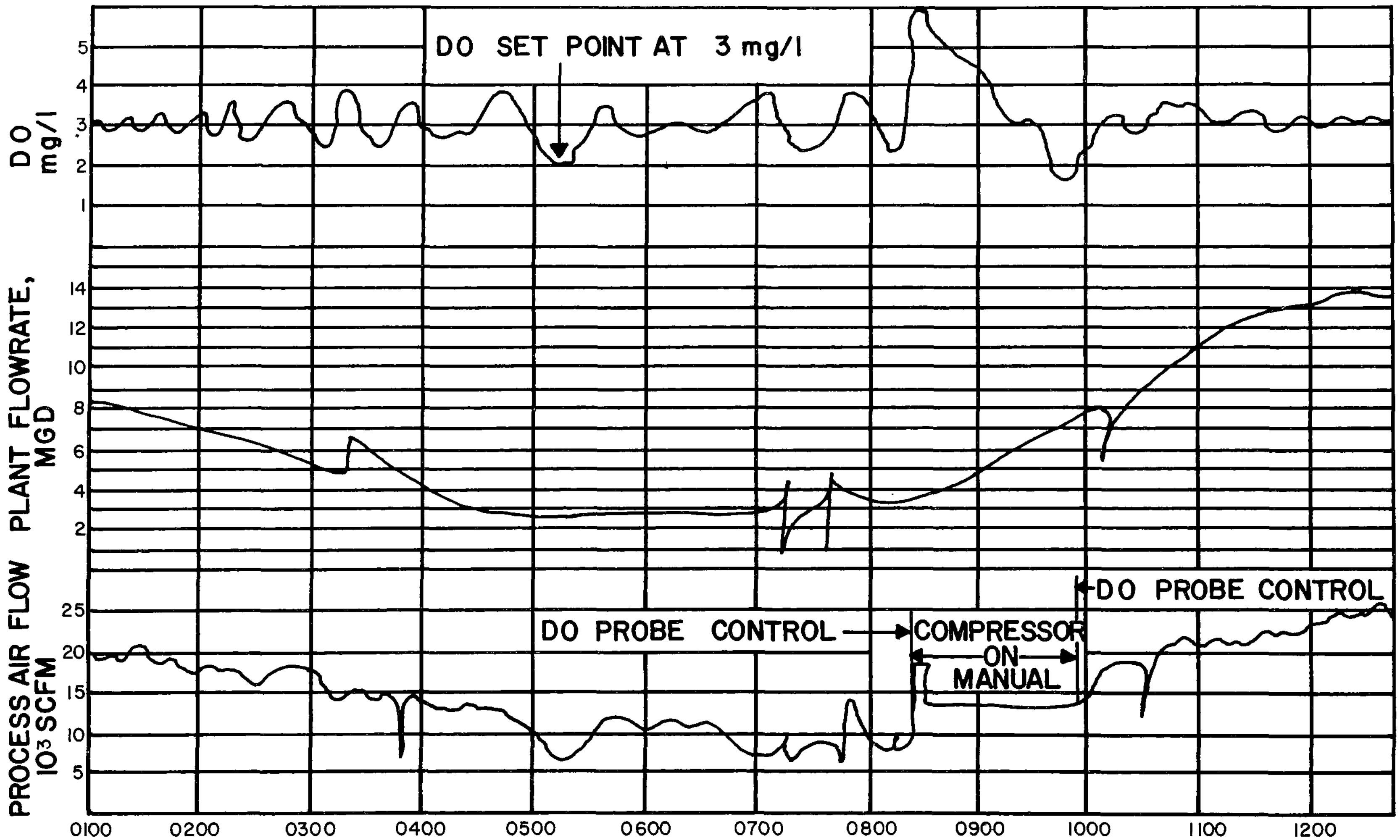


FIGURE 27 CONTINUOUS CHART RECORDINGS OF DO AT CONTROLLING PROBE, PLANT FLOWRATE, AND PROCESS AIR FLOW AT LONG BEACH WATER RENOVATION PLANT-9-22-74

however, oxygen concentrations returned to the set point value. Oscillation of the DO concentration about the set point value as shown in Figure 27 is characteristic of control systems employing proportional band with reset and rate control. The proportional function of the controller provides a signal proportional to difference between the controlled variable (in this case, the DO concentration) and the set point value. Reset action (also known as integral action) produces a corrective signal proportional to the length of time the dissolved oxygen has been away from the set point. Rate action (also known as derivative action) produces a corrective signal proportional to the rate at which the controlled variable changes from set point.

All of the above control functions are adjustable. With regard to proportional action, for example, the amount of deviation of the DO concentration from set point required to move the air compressors through their full operating range is known as the "proportional band" and is adjustable within the controller. This means that each controller must be tuned to the system it is controlling to obtain the proper combination of proportional, reset and rate actions.

Another operational consideration with regard to a DO probe control system is that more routine maintenance is required than with other control techniques previously described. Most additional work centers around maintaining and checking probe calibrations, replacing probe membranes and performing instrumental adjustments. Plant operators, using a portable DO sensor, measure dissolved oxygen concentrations along the aeration tank on a daily basis. If the DO profile is abnormal in any way, the operator may decide to have the controlling probe examined. Instrument maintenance personnel perform in situ calibrations of the DO probes (again using a portable DO meter) on approximately a weekly basis. Membranes are replaced when probe operation becomes erratic or the probe can no longer be calibrated. Examination of log records indicates that instrument personnel performed routine maintenance, adjustments, and calibrations on roughly a weekly basis.

SUMMARY

All of the process air control systems described above offer advantages and disadvantages some of which are described in Table 4. As sophistication increases, so does the accuracy with which oxygen supply and demand can be balanced. But as sophistication increases, so also system costs and maintenance requirements increase. All of these factors must be weighed in assessing the correct design for a given treatment plant. In general, as plant size increases, the benefit/cost ratio of sophisticated instrumentation increases. In addition, many treatment plants are faced with meeting increasingly stringent effluent standards. Under these conditions, the expense of process control instrumentation may be justified provided it offers the promise of better effluent quality.

Latest LACSD designs have incorporated a number of process air control systems to provide a wide range of flexibility in plant operation. For example, the Long Beach Water Renovation Plant has instrumentation for controlling process air by cam programmers, air to flow ratio, and DO probes. In addition, primary effluent turbidity can be used to control process air but this system has never been used. A schematic instrument flow diagram showing the interrelationship of process air control systems at the Long Beach WRP is shown in Figure 28.

TABLE 4

SUMMARY OF RESPONSE OF PROCESS AIR

CONTROL SYSTEMS TO OPERATIONAL VARIABLES

	Process Air Control Systems			
Variable	Preset Timers	Cam Programmers	Air/Flow Ratio	DO Sensor
Response to predictable patterns of flow rate and organic strength	Yes	Yes	Yes	Yes
Response to shock loading in flow rate	No	No	Yes	Yes
Response to shock loading in organic strength	No	No	No	Yes
Ability to balance oxygen supply with demand	Adequate	Good	Good	Best
Sudden increase in air supply if nitrification becomes established	No	No	No	Yes
Maintenance requirements	Minimal	Some	Some	Significant

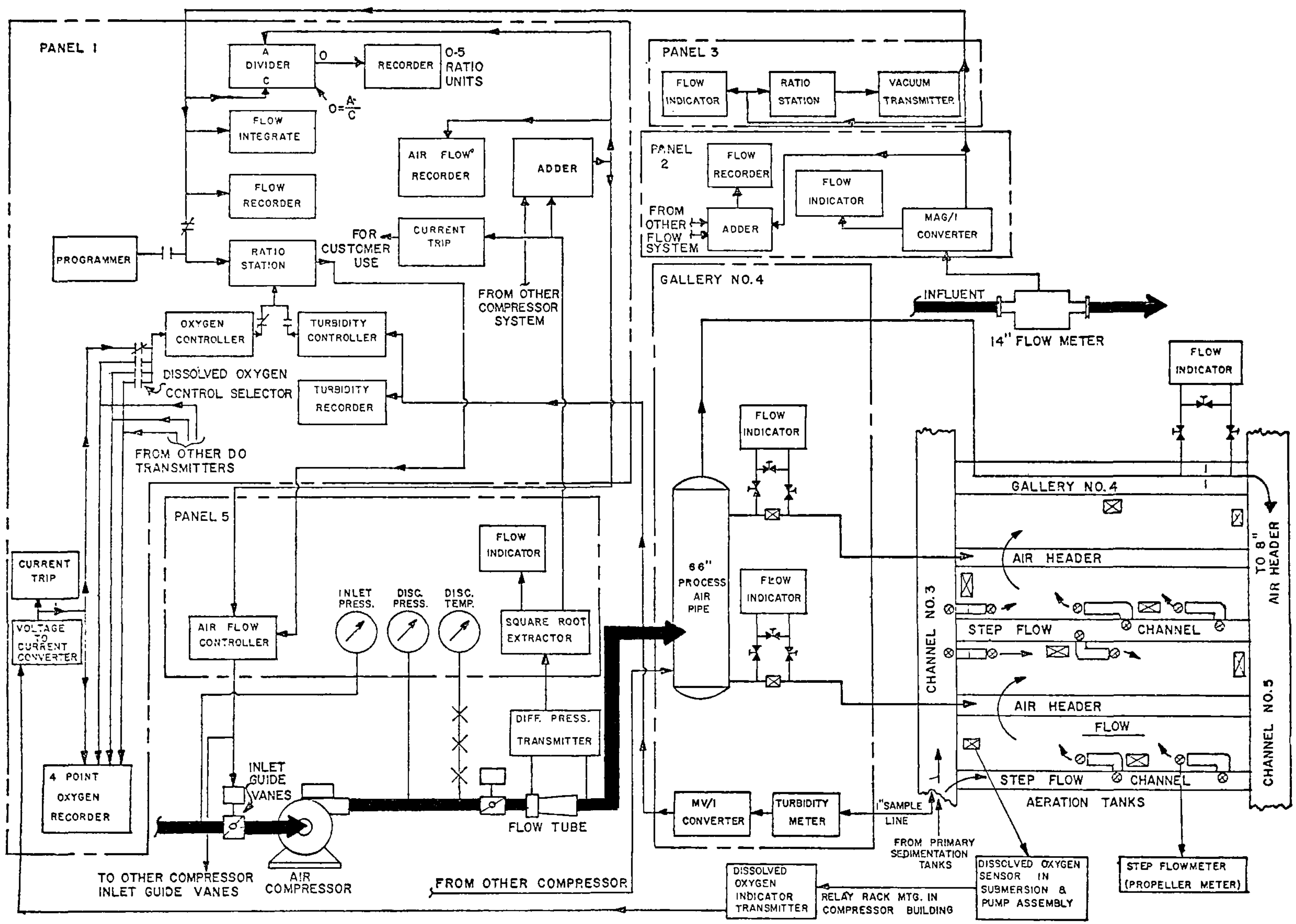


FIGURE 28 SCHEMATIC INSTRUMENT FLOW DIAGRAM

SECTION VI

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SECTION VII

RETURN ACTIVATED SLUDGE - FLOW CONTROL

INTRODUCTION

Mechanisms to control sludge blanket levels in secondary clarifiers have been incorporated in LACSD treatment plant designs since about 1960. Many early designs were unsuccessful and rather unsophisticated compared to today's control technology. Nevertheless, these early attempts at sludge blanket level control led to more effective control techniques incorporated in current designs. It also provided District's personnel with considerable experience in evaluating various control techniques.

Control of sludge blanket level in the final clarifier is desirable for several reasons. If return flow is too great, sludge hoppers will be emptied of sludge particularly during low flow periods when solids loading on the clarifier is low. This results in a low concentration of return sludge. Power requirements are increased as return pumps must convey a greater volume of thin sludge. If anaerobic digestion is used to treat waste activated sludge, excessive digester capacity is used in treating the thin sludge. On the other hand, if return sludge flow rate is too low, sludge blanket levels could conceivably rise to the level of the effluent weirs. This would be somewhat extreme, however, and should never occur with good plant operation.

Maintaining a constant sludge blanket level offers some additional advantages to plants that are hydraulically overloaded. Detention times are determined by total flow through a clarifier, total flow being the sum of plant flow and return sludge flow. Thus, maintaining a more concentrated return sludge minimizes the hydraulic loading on the final clarifiers. Another advantage is that the detention time per pass through the activated sludge system is increased.

Another mode of return sludge control is to return a constant flow rate from the clarifier to the activated sludge unit. Solids are stored in the clarifier hoppers during high flow periods. This control scheme offers several advantages in that operation is straightforward and virtually no control equipment is required. Return sludge is relatively thin during low flow periods however, and this may be undesirable if the treatment plant and/or digesters are overloaded. LACSD upstream treatment plants discharge waste sludges back to the sewer for subsequent treatment at the main treatment facility. Thus, obtaining the thickest possible waste sludge is not a normal operating consideration. Maintaining a constant return rate has proven to be an adequate control technique under these conditions. However, as plant flow rates increase, the incentive to reduce recycle flow rates also increases. This prompted the following study on return sludge flow control techniques.

The Long Beach Water Renovation Plant was the site of a two-month study designed to obtain operational data on the return sludge flow control system. This particular system incorporated latest LACSD thinking with regard to sludge blanket level control. The plant contains six final clarifiers, one of which was used in documenting the return sludge control system. The remaining clarifiers were operated with a constant return rate.

System Description

A schematic diagram of the return sludge control system and associated experimental apparatus is shown in Figure 29. Heart of the system consists of two sludge detector probes installed in the final clarifier above the return sludge hoppers. Probes were model #8100 automatic sludge level detectors manufactured by the Keene Corporation. Each probe contains an infra-red diode light source and a photocell sensor separated by an open gap of approximately two inches. When installed in the final clarifier, the photocell is illuminated by the infra-red diode. Photocell resistance is governed by the amount of light received from the

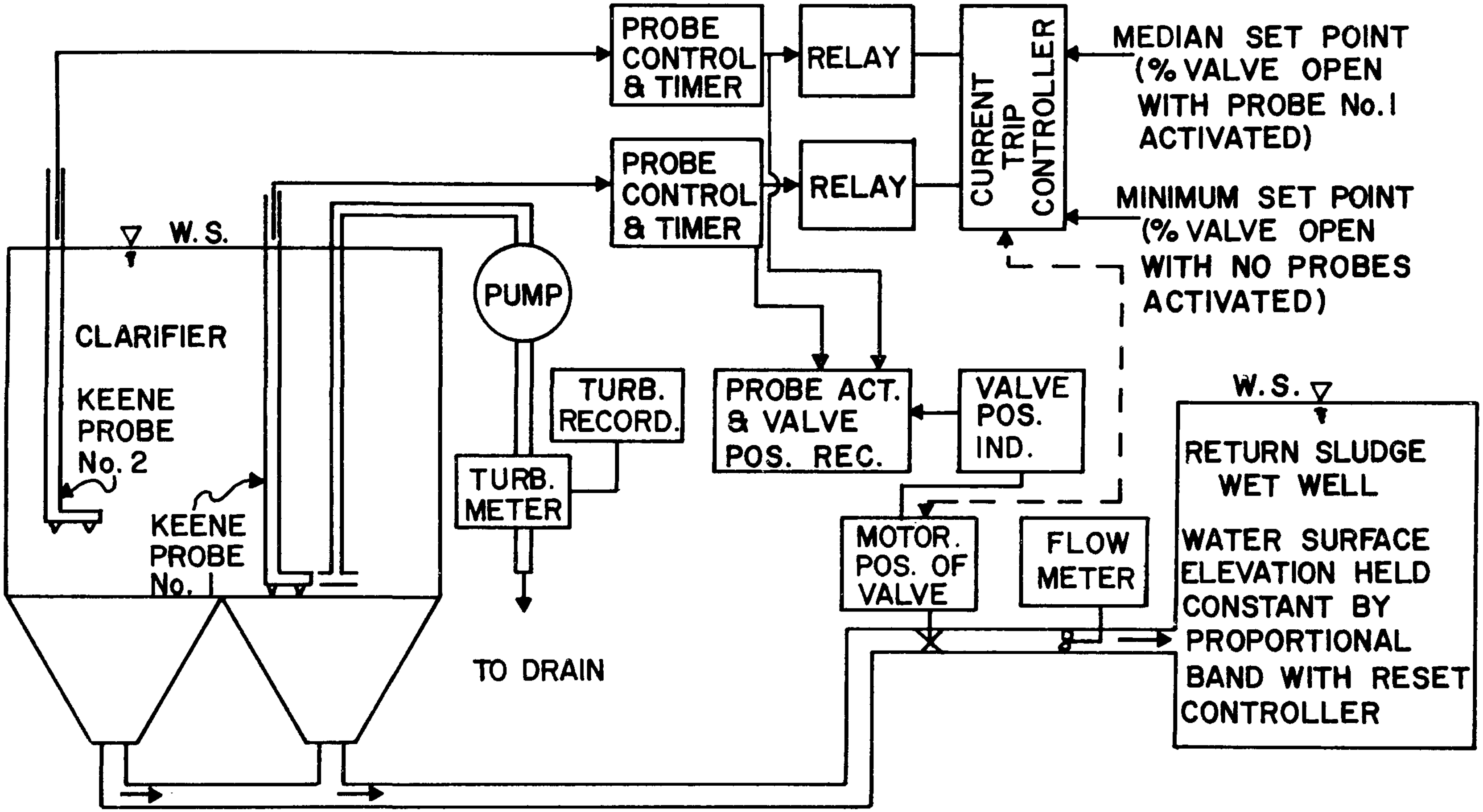

FIGURE 29 SCHEMATIC DIAGRAM OF RETURN SLUDGE CONTROL SYSTEM AND ASSOCIATED EXPERIMENTAL APPARATUS USED IN STUDY

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infra-red diode. Thus, a sludge blanket at the probe will decrease light transmission and the resulting increase in photocell resistance is used as a control signal to regulate the return sludge flow rate.

The controller contains sensitivity adjustments, relays, timing devices, and circuitry necessary to regulate operation of the flow control valve. If a probe senses a sludge blanket, the timer is started which in turn activates the control valves. The valve remains activated until the timer reaches the end of its preset interval. At this point, the valve will remain activated as long as the detector probe continues to sense a sludge blanket. When sludge is no longer sensed, the valve will deactivate. Purpose of the timer circuit is to prevent frequent on-off operation of the valve which would cause undue wear of the mechanical components.

Valve position is determined by a current trip controller with two adjustable set points. One set point controls minimum valve position with no probes activated. The other set point determines median valve position when probe no. 1 (lower probe) is activated. Should probe no. 2 activate, the control valve is positioned to full open.

Under normal conditions, the sludge blanket will be located below the lower Keene probe. During the low flow period, the draw off valve will be at its preset minimum opening. As flow rate increases, solids loading on the clarifier increases and the sludge blanket level rises. As the sludge blanket reaches the lower probe the draw off valve should open to the preset median position. Return flow rate should then be sufficient to lower the blanket level or at least maintain a constant elevation. If, after the preset timer interval, sludge level has dropped below the sensor, the valve will return to minimum open position. If sludge level has not dropped by the end of the interval, the valve will remain at the median open position until sludge level has dropped.

During normal plant operation, sludge blanket levels should never reach probe no. 2 (higher probe). Should the upper sensor be activated, however, draw off valve position will increase to full open. Valve position will remain as such until the preset timer interval expires after which the draw off valve will return to median position as soon as the sludge level falls below probe no. 2.

Several pieces of experimental apparatus were assembled for this study which are not part of the normal control system. These included a two-pen recorder for recording probe actuation and subsequent valve position, a Hach falling stream turbidimeter to measure light transmission, and a light transmission recorder. Samples for the turbidimeter could be obtained from any level in the water column of the clarifier.

<u>Relationship between Plant Operating Parameters and Return Flow Rate</u>

Proper valve settings for controlling sludge blanket level depend upon plant operating parameters and settling characteristics of the activated sludge. A schematic diagram of flow distribution in the secondary portion of an activated sludge treatment plant is shown in Figure 30. Performing a mass balance about the secondary clarifier gives the following:

$$(Q_i + Q_r)X_i = Q_eX_e + (Q_r + Q_w)X_r \quad (1)$$

Where Q_i = primary effluent flow rate

Q_e = secondary effluent flow rate

Q_r = return sludge flow rate

Q_w = waste sludge flow rate

X_i = aerator effluent MLSS concentration

X_e = secondary effluent suspended solids concentration

X_r = return sludge suspended solids concentration

If effluent suspended solids concentrations are within the normally observed range of 5 to 25 mg/l, the mass rate of solids

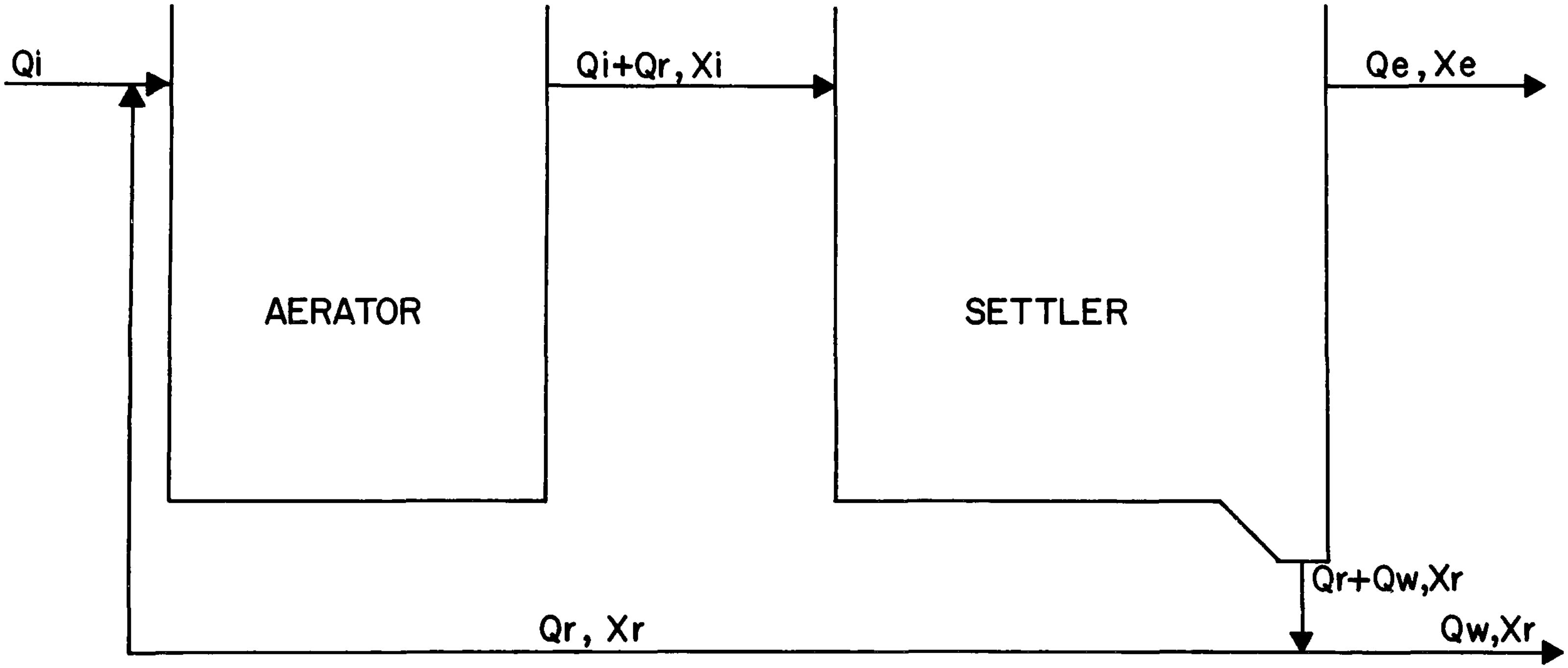


FIGURE 30 FLOW DISTRIBUTION AND SOLIDS BALANCE IN ACTIVATED SLUDGE PROCESS

lost in the effluent can be neglected and equation 1 becomes

$$(Q_i = Q_r)X_i = (Q_r + Q_w)X_r \qquad (2)$$

In normal operation of the activated sludge process waste flow rate, Q_w is usually less than 10 percent of the return flow rate, Q_r. Neglecting this term equation 2 becomes

$$(Q_i + Q_r)X_i = Q_r X_r \qquad (3)$$

Rearranging terms

$$Q_r = \frac{Q_i X_i}{X_r - X_i} \qquad (4)$$

Concentration of return sludge, X_r, is partly a function of return rate, Q_r. As the return rate decreases sludge depth in the final clarifier would increase which should result in a slightly thicker sludge. Magnitude of this effect would be a function of sludge settling characteristics and the particular sedimentation tank design. Q_i, X_i, and X_r can be measured and the values used in equation 4 to predict a return flow rate. Should operation at the predicted return rate result in changes in X_r and X_i, the new values can be used in equation 4 to predict a new return rate and so on.

Another approach to predicting the return sludge concentration involves the settling characteristics of the MLSS as measured by the SVI test. This latter test is performed at least daily in most activated sludge plants. As such, it is a convenient source of information on the settling characteristics of the activated sludge.

Average concentration of solids in the one liter graduate used for the SVI test can be determined as

$$\text{Sludge concentration in mg/l} = 10^6/\text{SVI} \qquad (5)$$

If it assumed that this same concentration can be obtained in the return flow from the secondary clarifier, equation 4 becomes

$$Q_r = \frac{Q_i X_i}{\frac{10^6}{\text{SVI}} - X_i} \qquad (6)$$

Whether equation 5 accurately predicts the return sludge concentration will, again, depend on efficiency of the secondary clarifier.

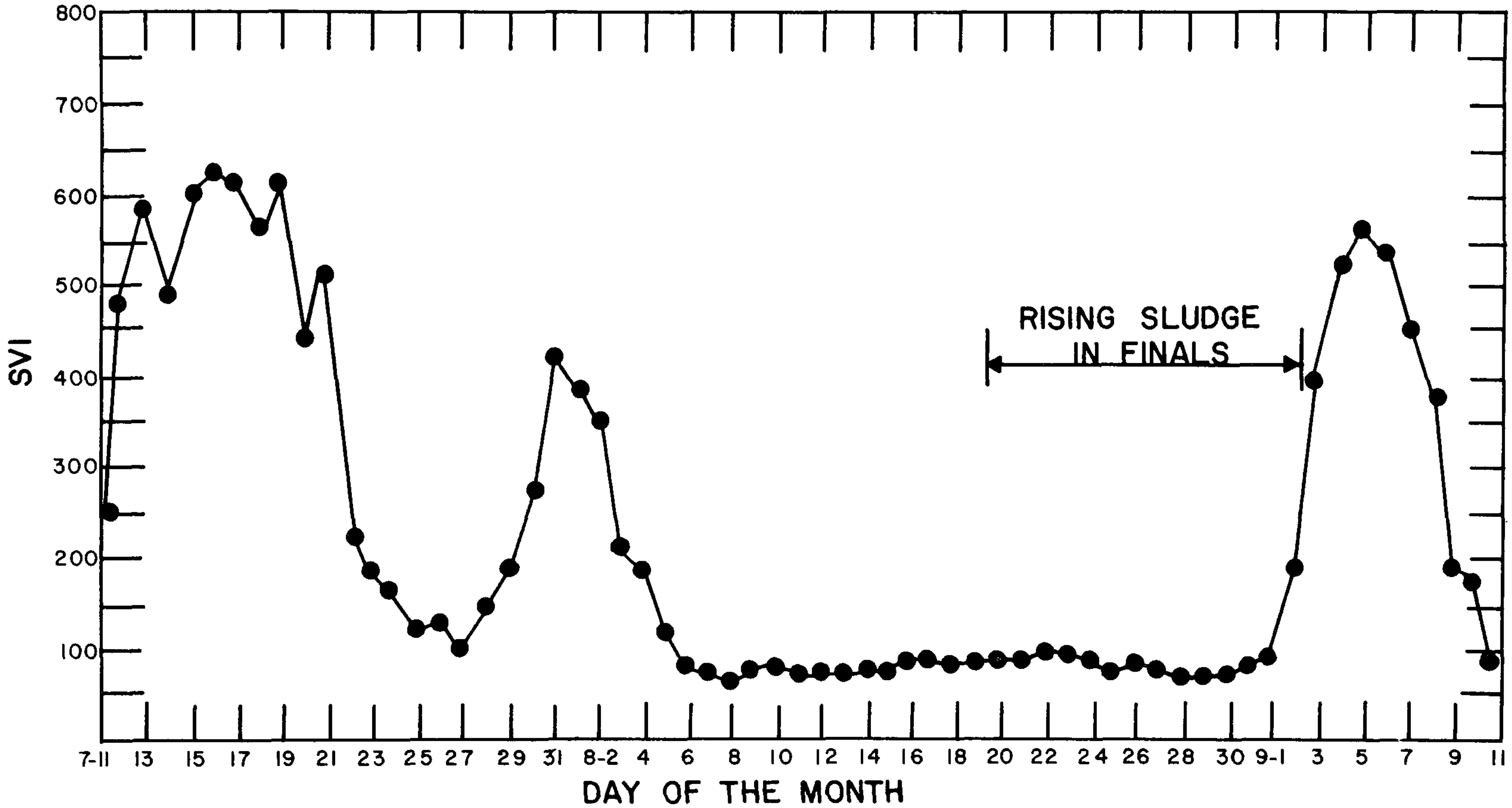
Diurnal variations in plant flow rate and MLSS concentrations must be taken into account when using equations 4 or 6. During the low flow period, the minimum return rate should be sufficient so that the Keene probes rarely, if ever, will actuate. Thus, the proper minimum return rate $Q_{r\ min}$ (both probes deactivated) can be estimated by using minimum flow conditions in either equation 4 or 6.

During peak flow periods, the return sludge rate should be sufficient to maintain a constant sludge blanket level with the lower Keene probe actuated. Thus, the median return rate $Q_{r\ med}$ (lower probe actuated) can be estimated by applying peak flow conditions to equations 4 or 6.

RESULTS

Return sludge flow control equipment described above was operated at the Long Beach WRP for a two-month period from July to September, 1974. The study was designed to answer the following questions: (1) could the control equipment described above maintain a constant sludge blanket level, (2) what operating parameters affected performance of the control equipment, (3) could equations 4 and 6 be used to estimate proper return sludge flow rates, and (4) how much operator time would be needed to maintain the control equipment.

SVI data collected over the period of the study is shown in Figure 31. Each data point represents the average of two daily SVI tests, one conducted in the morning and the other in the afternoon. The plant suffered from severe bulking three times during the study period. In all cases, the bulking was caused by filamentous organisms. Rising sludge also occurred during two weeks of the study period. The plant was being operated to achieve full nitrification and the rising sludge was caused by subsequent denitrification in the final clarifiers. Rising sludge



DAILY SVI DATA ON AERATION TANK DURING STUDY PERIOD

FIGURE 31

was observed in all secondary clarifiers and was not caused by the return sludge control equipment. These problems disrupted normal plant operation but did allow the control equipment to be operated with sludges of varying settling characteristics.

Sampling Techniques

One of the study objectives was to determine whether a constant sludge blanket level could be maintained with the control equipment. Therefore, some method was needed to determine the sludge blanket location in the final clarifier. The first attempt made use of a Kemmerer sampler which could be lowered to a desired depth and then tripped by a messenger. Samples could be collected at increasing depths until the sludge blanket was detected. Two problems arose with this system. First, the Kemmerer sampler caused considerable disturbance in the water column. After the first sample had been collected, there was no assurance that subsequent samples represented the true condition of the water column. Second, the sampler itself was approximately two feet in length and the location of the sludge blanket could not be placed to any greater degree of accuracy. Since the elevation difference between probes no. 1 and 2 was usually two feet, the level of accuracy was not sufficient.

To effect greater accuracy in locating the sludge blanket, a plexiglas tube, one-inch in inside diameter and 16 feet long, was constructed. During sampling, the tube was gently lowered into the water column until the top of the tube was flush with the water surface. The tube was then capped with a stopper and withdrawn. This sampling procedure allowed the entire water column to be visually inspected at one time and also increased accuracy in locating the sludge blanket.

When the SVI was less than about 150, a well-defined sludge-liquid interface existed and sludge blanket levels could be visually determined to within about one foot. However, when the SVI increased much above 300, a definite interface no longer existed in the final clarifier. Instead, a gradual increase in suspended solids was observed at all depths below the water surface. This situation is graphically illustrated in Figures 32 and 33 where suspended solids concentration and light transmission are plotted as a function of depth in the final clarifier. Samples were collected using the Kemmerer sampler and percent transmission was determined with a spectrophotometer at 600 mμ wavelength, 1 cm lightpath. For the data in Figure 32, the SVI was 224 and, using the plexiglas tube, the sludge interface could be visually determined to within two or three feet. Subsequent tests with SVI's near 100 indicated that the sludge interface could be placed to within about one foot of depth. When bulking occurred, however, it was difficult to visually locate the sludge blanket level as indicated by the data presented in Figure 33.

To effect greater accuracy in locating the sludge blanket interface and to avoid the subjective assessments necessary in using the plexiglas sight tube, the monitoring equipment illustrated in Figure 20 was assembled. Components of the monitoring system included an intake manifold, sampling pump, Hach Falling Stream Turbidimeter and a recorder. The intake manifold was a multiple port device designed to minimize approach velocities and avoid pulling up sludge from lower depths. The manifold could be located at any depth in the water column. The Hach Falling Stream Turbidimeter is designed for measuring high turbidities and is commonly used for locating sludge blanket levels. The amount of light transmitted through a sample is measured (as opposed to measuring scattered light) which is similar to the action of the Keene probe.

Light transmission measured by the turbidimeter was correlated with suspended solids concentration in the sludge with the results shown in Figure 34. This correlation applies only to sludge encountered during this study and should not be applied to other types of sludge. Nevertheless, it provides a useful means of estimating suspended solids concentrations from light transmission data.

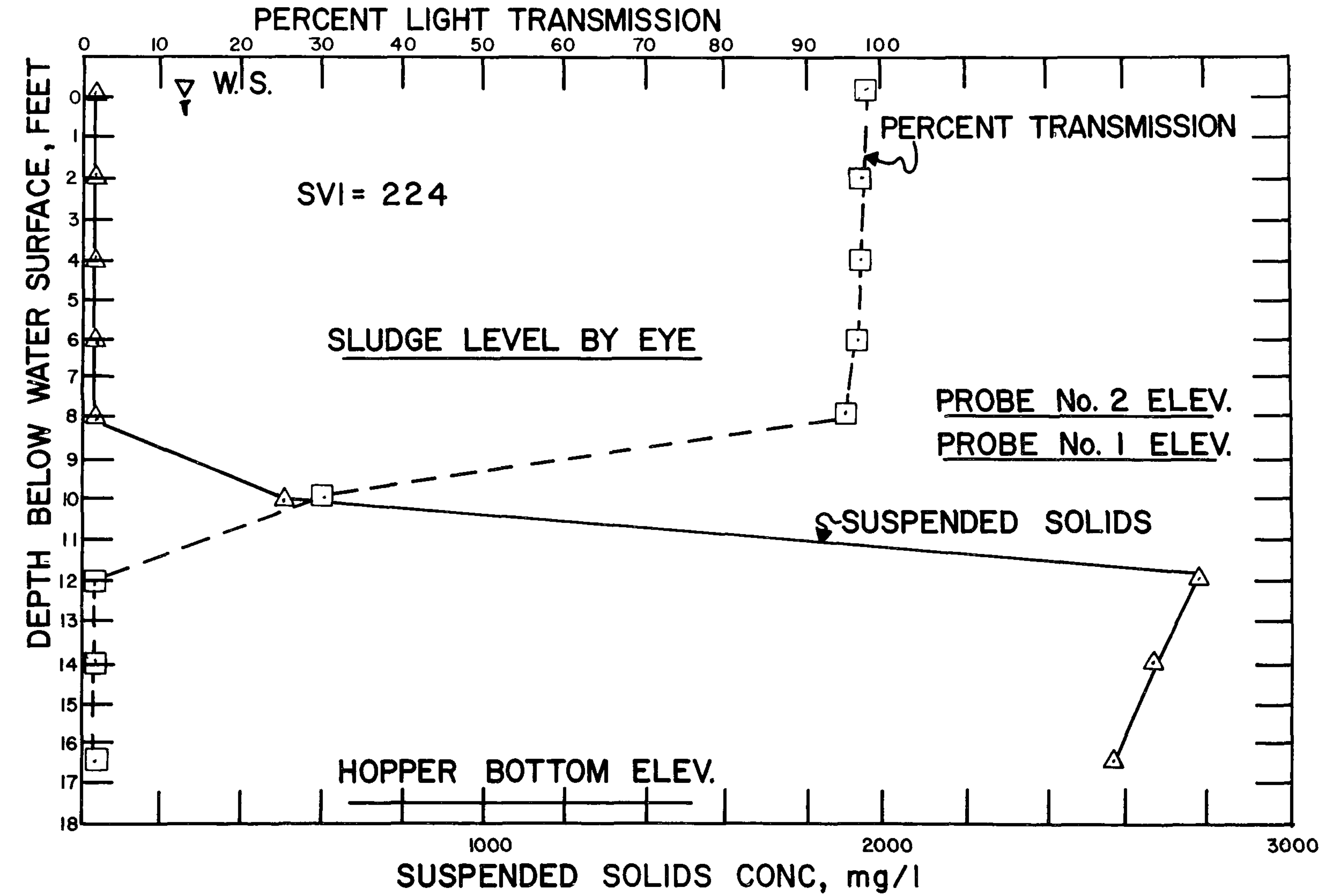


FIGURE 32 SUSPENDED SOLIDS AND LIGHT TRANSMISSION VERSUS DEPTH IN SEDIMENTATION TANK

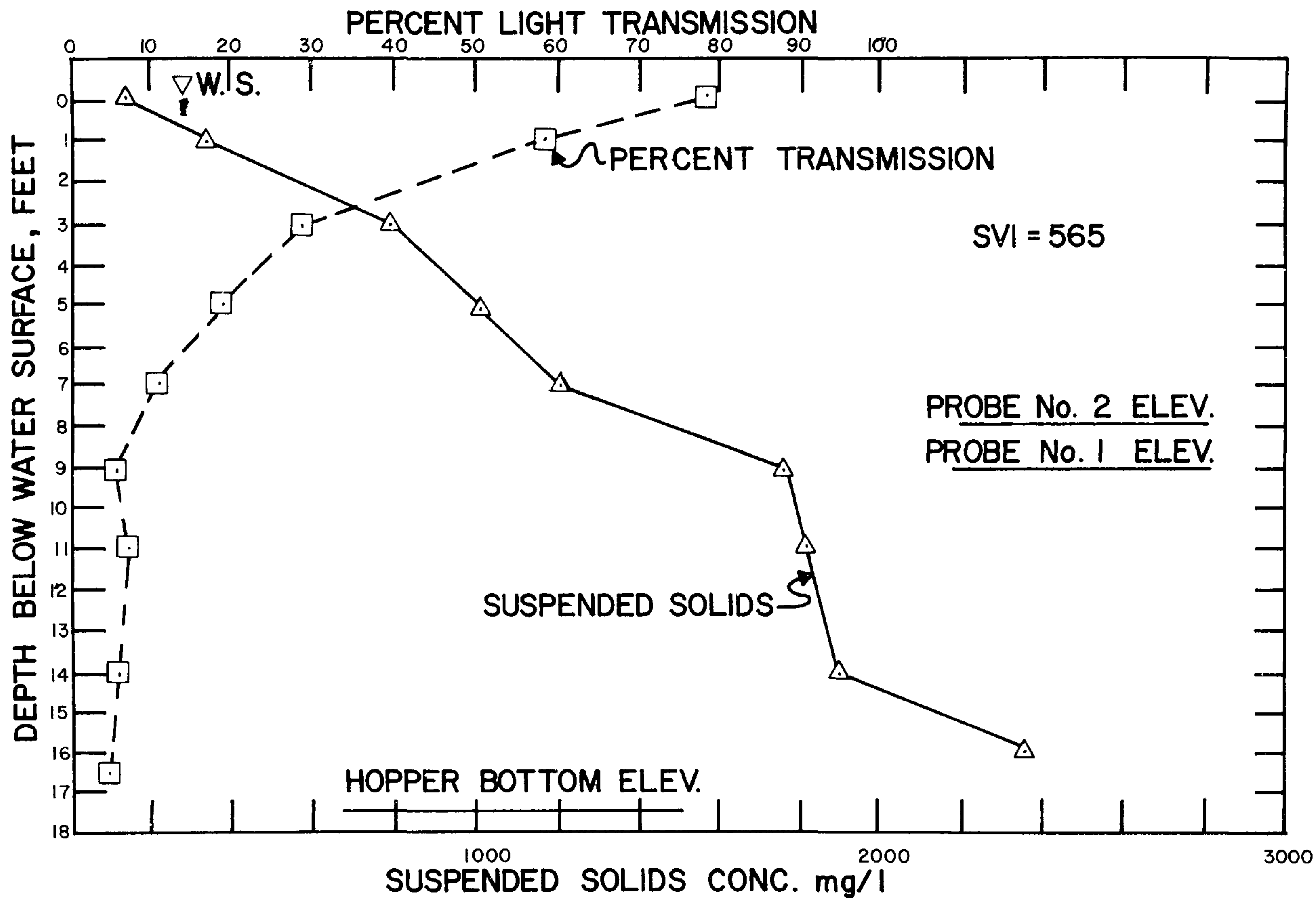


FIGURE 33 SUSPENDED SOLIDS AND LIGHT PENETRATION AS A FUNCTION OF DEPTH IN SEDIMENTATION TANK

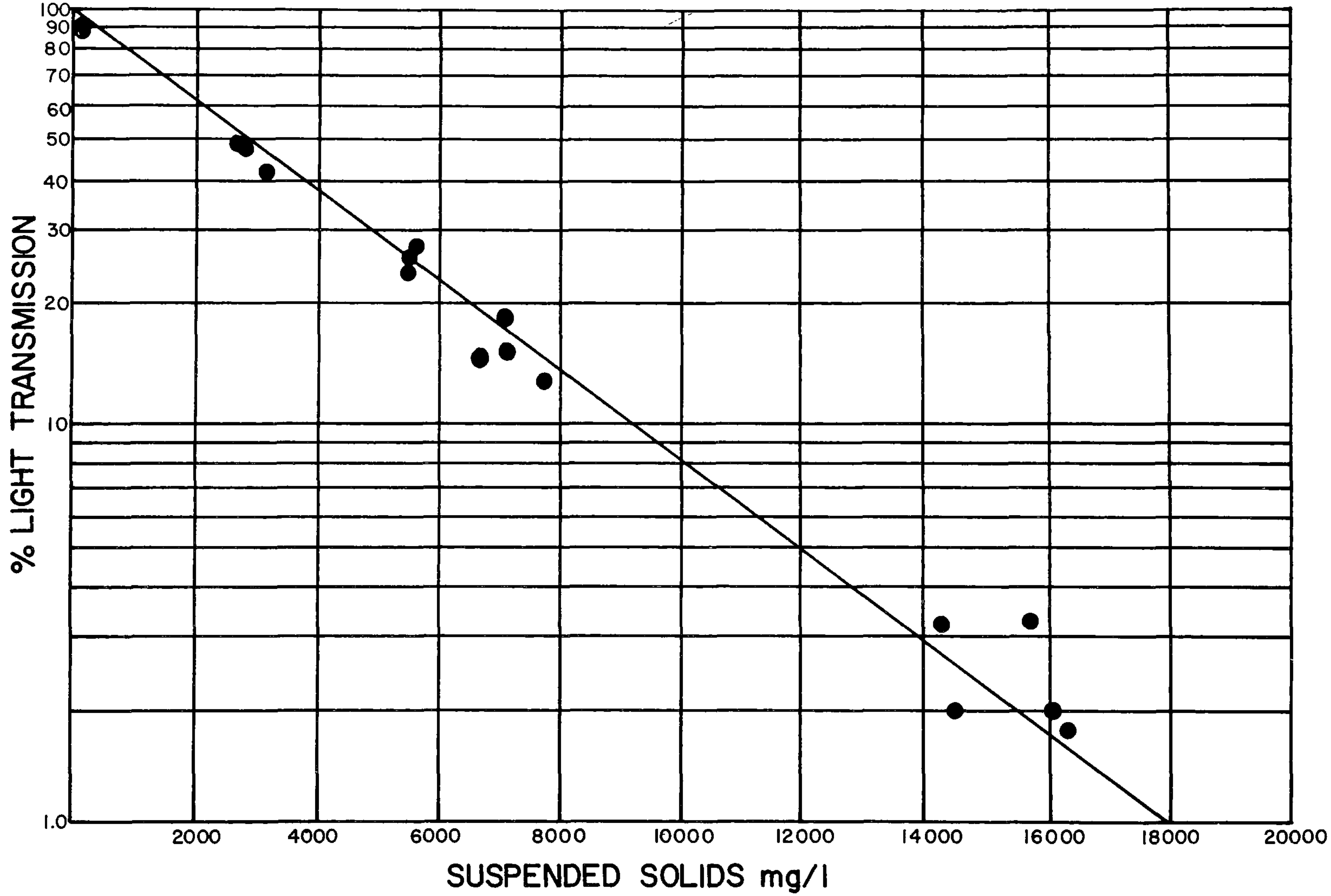


FIGURE 34 PERCENT LIGHT TRANSMISSION VS. RETURN SLUDGE SUSPENDED SOLIDS CONCENTRATION HACH FALLING STREAM TURBIDIMETER 0.25" LIGHT PATH

Sludge Blanket Levels

Average operating parameters at the LBWRP for the month of June, 1974, are presented in Table 5. Using equation 4 with values from Table 5 minimum and median return sludge flow rates per clarifier were estimated to be approximately 0.26 mgd and 1.11 mgd, respectively. The minimum return rate was initially adjusted to 0.3 mgd since flows less than this led to plugging of the control butterfly valve. Since further concentration of the sludge was expected following establishment of a sludge blanket, the median return rate was set at 0.8 mgd. Minor adjustment of these initial return rates were made during the study in response to changing sludge settling characteristics.

During the first week of the study period, it was observed that actuation of probe no. 2 with subsequent full opening of the return control valve caused considerable disruption of the clarifier. With control valve full open, the return rate increased to such an extent that the water surface in the clarifier momentarily fell below the effluent weirs. This was obviously an unwarranted situation and, as a result, probe no. 2 was disconnected from the control circuitry. Actuation of probe no. 2 was still recorded but activation did not affect control valve position. Thus, only two valve positions were used in the remainder of the study, the minimum position with probe no. 1 deactivated and the median position with probe no. 1 activated.

Profiles of percent light transmission in the water column above the return sludge hoppers are plotted in Figures 35 to 38. The Figures are arranged in order of increasing SVI. In Figure 35 mixed liquor SVI was 51 which indicates that the sludge was capable of very dense compaction. Sludge level in the return hoppers was quite low in the early morning low flow period but increased with increasing plant flow. By noon, the sludge interface reached probe no. 1 which caused valve actuation and increased return sludge flow to 0.8 mgd. Timer duration, set to 10 minutes in this test, was too long since the return hopper

TABLE 5

MONTHLY AVERAGE OPERATING PARAMETERS

LONG BEACH WATER RENOVATION PLANT

June, 1974

Minimum daily flow	3.1 mgd
Peak daily flow	13.2 mgd
Average daily flow	9.1 mgd
Mixed liquor suspended solids	1600 mg/l
Return sludge suspended solids	5400 mg/l
Number of final clarifiers in service	5

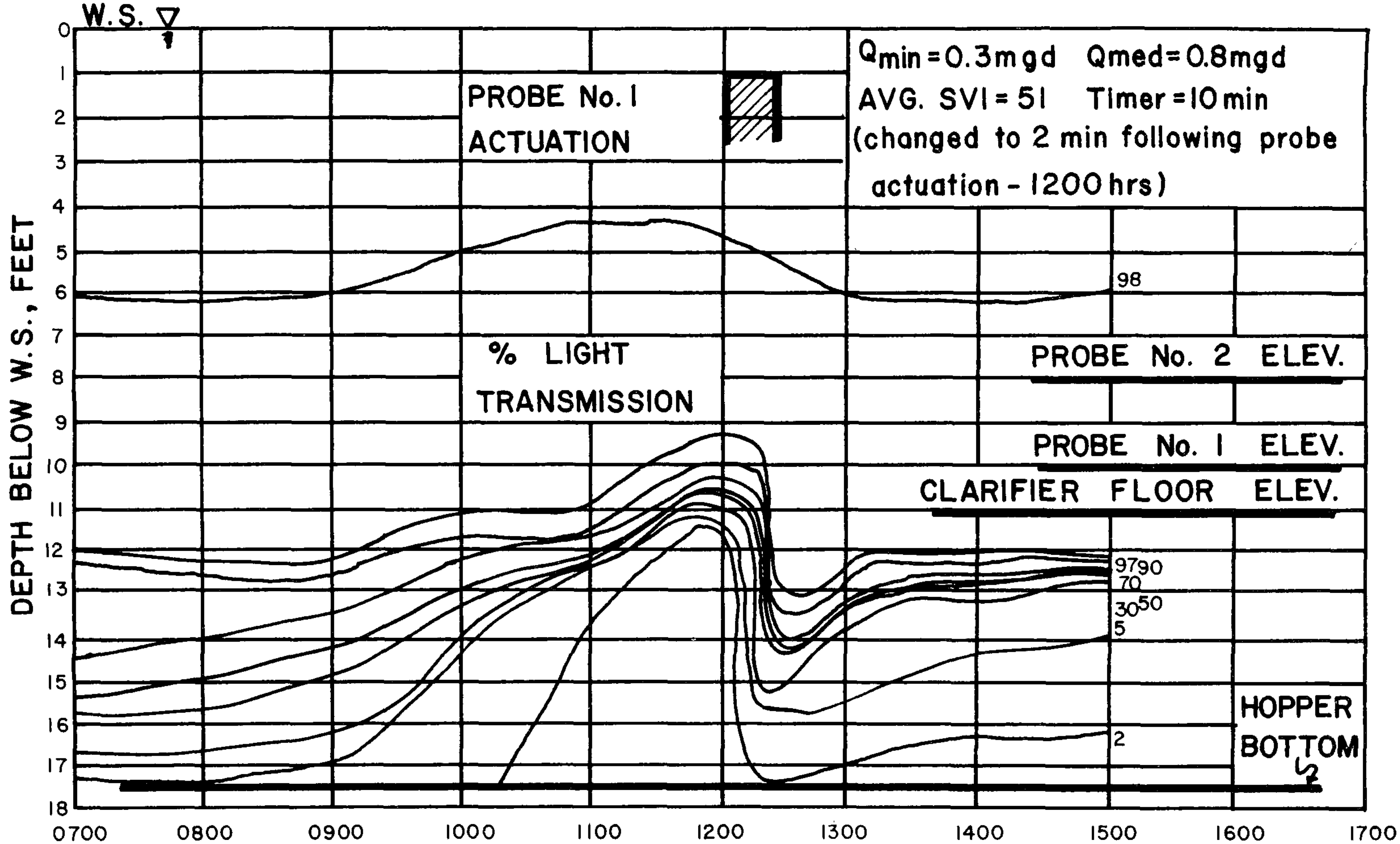


FIGURE 35 PROFILES OF LIGHT TRANSMISSION

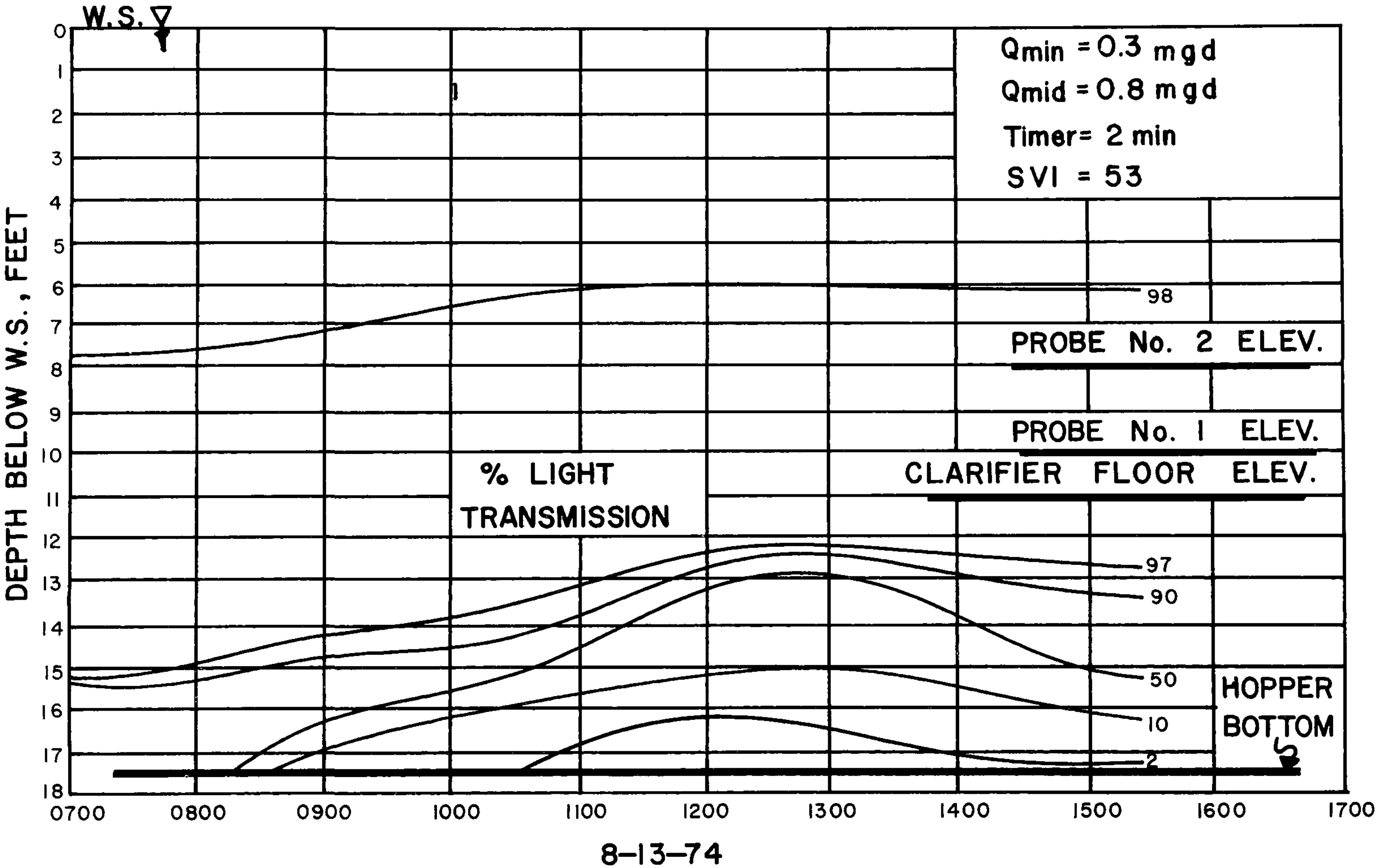


FIGURE 36 PROFILES OF LIGHT TRANSMISSION

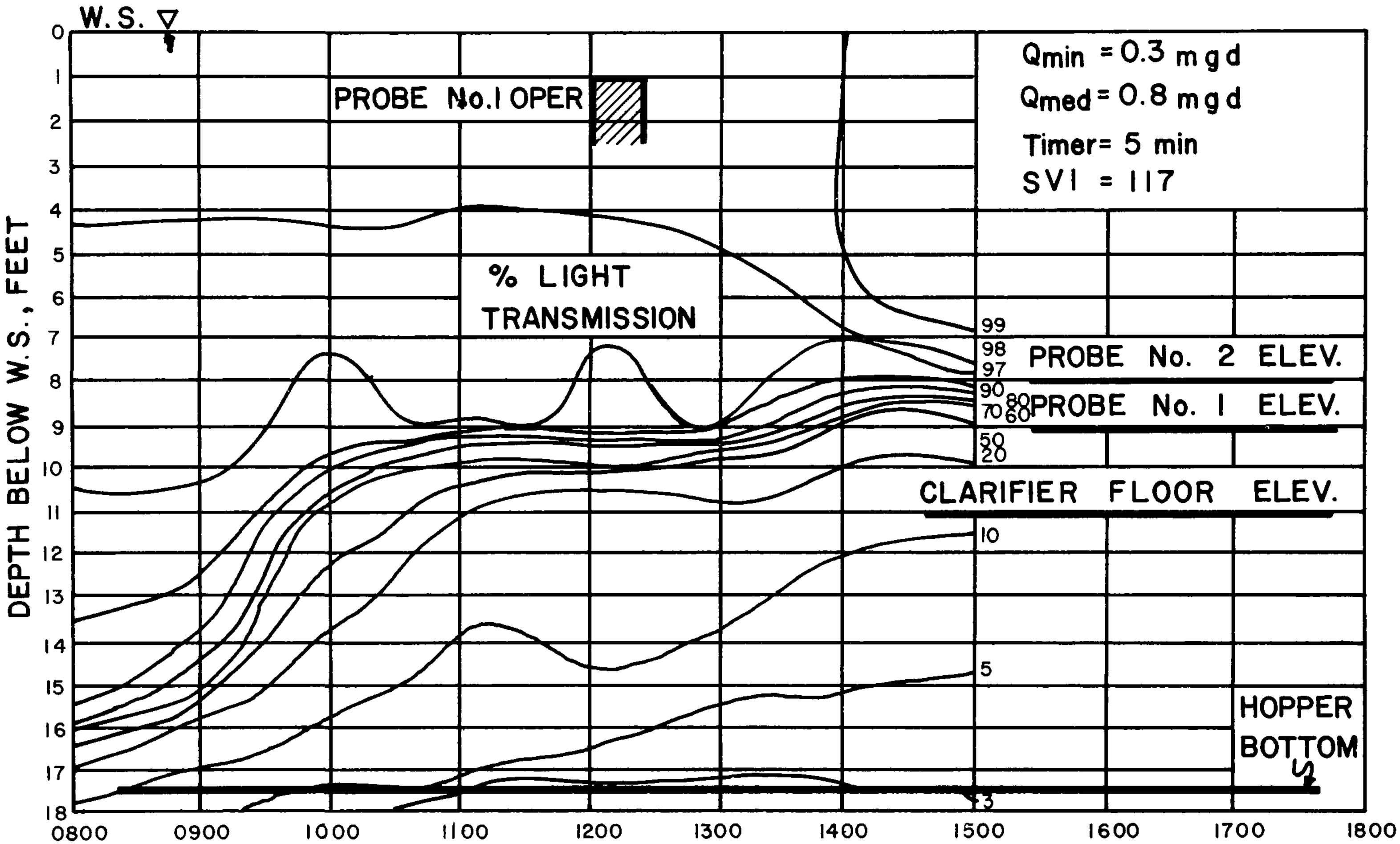


FIGURE 37 PROFILES OF LIGHT TRANSMISSION

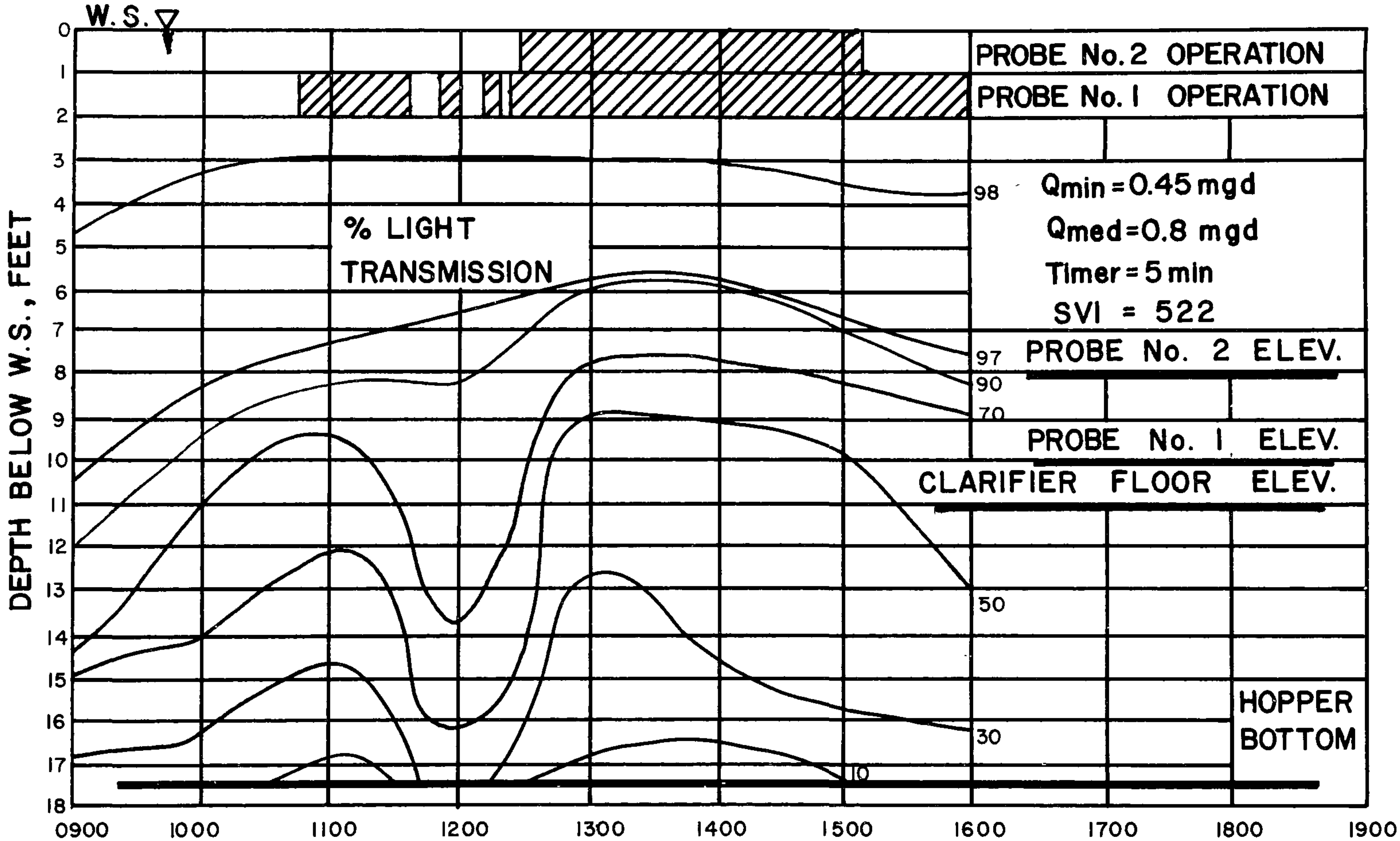


FIGURE 38 PROFILES OF LIGHT TRANSMISSION

was almost emptied of sludge. Interface height subsequently increased but did not reach the level of probe no. 1.

In a subsequent test, timer duration was reduced to two minutes to avoid excessive drawdown of the sludge blanket level. In this case, however, sludge interface never reached the level of probe no. 1 and no valve actuation was noted as shown in Figure 36. SVI was so low and, hence, the sludge blanket so compact that the minimum return flow of 0.3 mgd was more than sufficient to keep the blanket below probe no. 1. Using equation 6 with average monthly parameters from Table 5 and an SVI of 53, the return rate necessary to maintain a constant blanket level under peak flow conditions is estimated to be about 0.24 mgd. The fact that a return rate of 0.3 mgd did not allow a buildup in the sludge blanket seems to substantiate the validity of equation 6.

Constant sludge blanket levels were maintained when the SVI was in a more normal range of 100 to 150 as shown in Figure 37. Even so, the minimum return rate was too large to allow a sludge blanket during the low flow period. This was the general pattern observed throughout the study period. Hopper levels were drawn down during low flow periods but subsequently increased as plant flow rate increased. If the SVI was greater than about 60 or 70, the blanket would eventually reach the level of probe no. 1. Subsequent probe actuation was normally quite effective in maintaining the blanket at or below probe no. 1.

Sludge blanket levels increased above probe no. 1 only during periods of sludge bulking. Light transmission profiles with a mixed liquor SVI greater than 500 are shown in Figure 38. Under these conditions, the sludge interface became very diffuse and would normally reach the level of probe no. 2 causing activation. Recall that activation of probe no. 2 was recorded but caused no change in return flow rate. Return sludge control equipment continued to function in an acceptable manner although the bulking was, at times, quite severe. Generally, the probes would not activate during the low flow period but once activated would stay on continuously until flow rate again decreased.

Strip chart recordings of light transmission at the level of probe no. 1 and probe actuation are presented Figures 39 and 40. For data in Figure 39, SVI was 534 and probe no. 1 was actuated during most of the high flow period between 1000 and 1600 hours and deactivated during the early morning low flow period. Light transmission and probe actuation recordings for an SVI of 183 are shown in Figure 40. Both charts are representative of normal probe operation at their respective SVI levels.

The percentage of time a probe was actuated was found to be a function of mixed liquor SVI. Ranges observed in the time of probe actuation are presented in Table 6. Actuation rarely, if ever, occurred below an SVI of 50. At an SVI of 100, the probe was never actuated more than 10 percent of the time. The length of probe actuation increased rapidly with increasing SVI up to values of about 400 above which probe actuation occurred between 40 and 70 percent of the time.

Probe no. 2 rarely actuated at SVI values below 200 and most of the actuation which did occur was thought to be due to periodic plugging of the probe by biological solids. Above SVI levels of 400, however, probe actuation did occur regular y during the peak flow period.

Scheduled Maintenance

A point of major concern during the study was whether the Keene probes would become fouled with return sludge or other biological growths. If fouling occurred, the probe would react as if it sensed sludge resulting in unnecessary as well as undesired valve operation.

During periods of rising sludge, the probes were observed to actuate even though the turbidimeter showed no decrease in light transmission. The probes rarely actuated for periods longer than the timer interval. This was undoubtedly caused by clumps of rising sludge passing the probe and causing activation. The rising sludge apparently passed by the probe without fouling

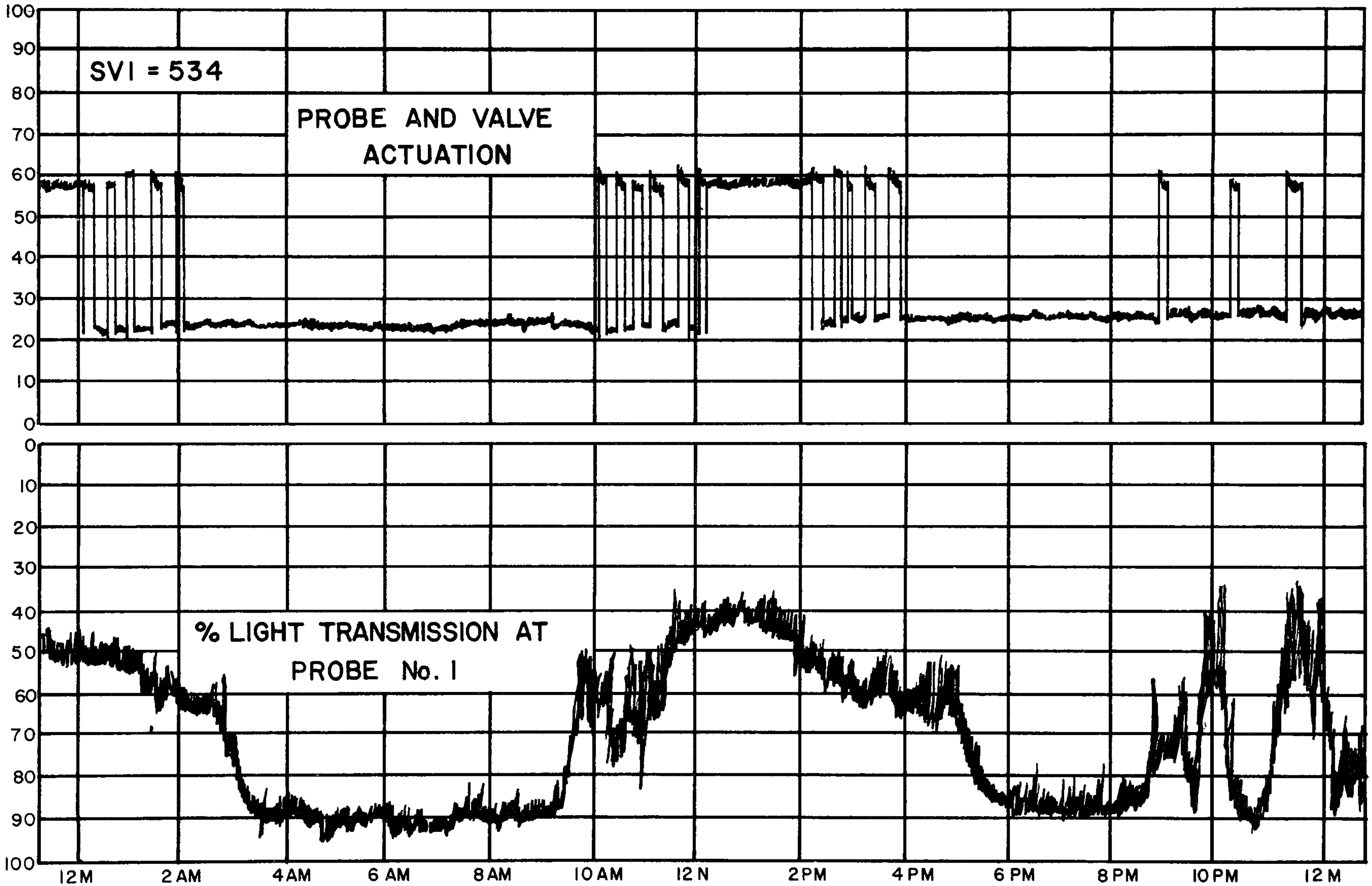


FIGURE 39 LIGHT TRANSMISSION AND PROBE ACTUATION

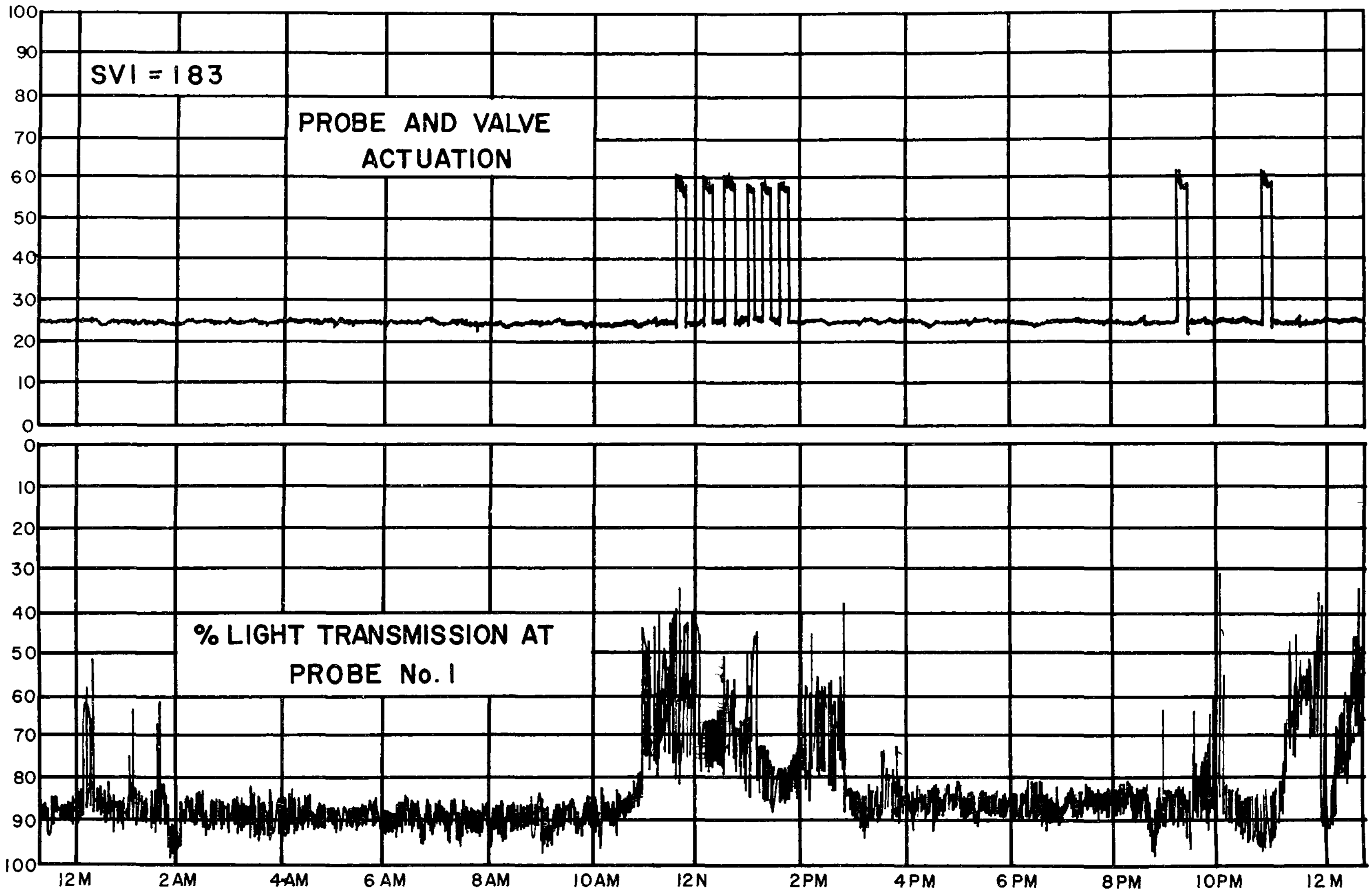


FIGURE 40 LIGHT TRANSMISSION AND PROBE ACTUATION

TABLE 6

PROBE ACTUATION

SVI Range	Time of Probe Activation Expressed as a Percentage of Total Time Probe No. 1	Probe No. 2
50	0-2	0
100	1-10	0-1
200	10-45	0-2
300	30-60	0-4
400	40-70	0-20
500	40-70	0.1-20
600	45-70	3-20

because the probes deactivated following the timer interval. In any event, the problem was not serious and did not significantly affect probe performance.

Fouling of the probes to such an extent as to cause continuous probe actuation was observed three times during the study period. In all cases, the fouling material was easily removed by raising and lowering the probe in the water column. Based upon this experience, the probes should be cleaned at least weekly to avoid gradual accumulations of biological growths.

SUMMARY

Based upon results collected during a two-month study period, the following conclusions can be drawn with regard to return sludge flow control using Keene probes.

1. Return sludge flow control is practical and offers the advantage of increased return and waste sludge solids concentrations.
2. In general, the sludge blanket could be maintained at a constant level during peak flow conditions but was always drawn down during low flow periods.
3. A definite sludge blanket interface existed for SVI values below about 200. Increasing SVI resulted in a gradual loss of the interface until at SVI levels greater than 500 no definite interface existed. Instead a gradual increase in solids concentration was observed with no distinct liquid-sludge interface.
4. Sludge bulking did not adversely affect probe performance although the time of probe actuation increased significantly.
5. Equations 4 and 6 can be used to estimate proper return sludge flow rates.
6. Fouling of the probes was not a severe problem and could generally be avoided by regular probe cleaning on a weekly basis.
7. Two probes were not required to maintain a constant sludge blanket level and probe no. 2 was not used to control valve

operation in this study. In future designs, probe no. 2 can either be completely eliminated or used as an alarm to signal adversely high blanket levels. Should the probe function as an alarm, a timer should be included so that the probe must sense sludge continuously for at least 15 minutes before the alarm is actuated.

8. Equalization of wastewater flows prior to secondary treatment is being considered as a method of increasing plant capacity. Under these conditions, flow rate to the final clarifiers would be constant. Return sludge control equipment could then maintain a constant sludge blanket level at all times and not just during the high flow period. Maximum return and waste sludge concentrations would also be realized.

SECTION VIII

WASTE ACTIVATED SLUDGE - FLOW CONTROL

INTRODUCTION

The fundamental equation describing cell growth in a biological reactor is

$$\frac{dX}{dt} = Y \frac{dF}{dt} - bX \qquad (1)$$

Where dX/dt = growth rate of microorganisms
Y = cell yield coefficient
dF/dt = rate of food utilization
b = endogenous respiration coefficient
X = cell mass

Equation 1 basically states that net production of new cells is a function of both rate of food utilization and loss of cells due to endogenous respiration. Dividing equation 1 by X yields

$$\frac{dX/dt}{X} = Y \frac{dF/dt}{X} - b \qquad (2)$$

In this equation

$$\frac{X}{dX/dt} = \theta_c = \frac{\text{mass of cells in the system}}{\text{mass of cells grown per day}} \qquad (3)$$

If the biological reactor is at steady state, or nearly so, the mass of organisms grown per day will equal the mass of organisms wasted per day. Thus, if the system is at steady state, θ_c will equal the average retention time of a cell in the system which is commonly referred to as mean cell retention time (MCRT). Also in equation 2

$$\frac{dF/dt}{X} = \frac{\text{rate of food utilization}}{\text{mass of organisms in system}} \qquad (4)$$

= food to microorganism ratio (F:M)

Thus,

$$\frac{1}{\theta_c} = Y\ (F{:}M) - b \qquad (5)$$

The terms Y and b should be approximately constant for a given waste and, hence, MCRT and F:M are inversely proportional.

Lawrence and McCarty,[1] applied equation 1 to the activated sludge process and found that effluent substrate concentration was a function of the mean cell residence time, decreasing with increasing MCRT. Since MCRT is, in turn, related to the food to microorganism ratio, it implies that either parameter can be used to theoretically describe effluent quality from the activated sludge process. In practice, however, effluent quality is not as pronounced a function of MCRT. This is because effluent quality is determined to a large extent by settling properties of the mixed liquor. Nevertheless, MCRT and F:M have a sound theoretical basis for use as control parameters for the activated sludge process.

Which of the parameters, either MCRT or F:M, to use in practice has been the subject of much debate in the technical literature. Use of F:M ratio requires considerable laboratory work since it is necessary to know both the amount of food removed and the mass of organisms in the system. This requires tests for total BOD or COD in the influent and soluble BOD or COD in the effluent as well as volatile suspended solids, VSS, in the aeration tanks. COD tests are usually used to avoid delays associated with the BOD test. In addition, VSS is a relatively poor measure of the true active mass of microorganisms in the mixed liquor (sometimes referred to as viability). In practice, however, this latter disadvantage may not be significant since the active mass is probably a fairly constant percentage of the VSS. However, little laboratory data exists to substantiate this latter claim.

Conceptually MCRT is an easier parameter to use. Should the operator desire a 5-day MCRT, he need waste 20 percent of the total plant solids each day. Viability or active mass of the mixed liquor need not be considered since if 20 percent of the total solids are wasted daily, then 20 percent of the active mass is also wasted. Thus, the operator must know the total solids, TS, in the system as well as the TS lost from the system each day.

In LACSD practice, the MCRT is normally used as the control parameter for the activated sludge process,[2]. A given fraction of solids, therefore, must be wasted daily. It remains then to describe control schemes for solids wasting.

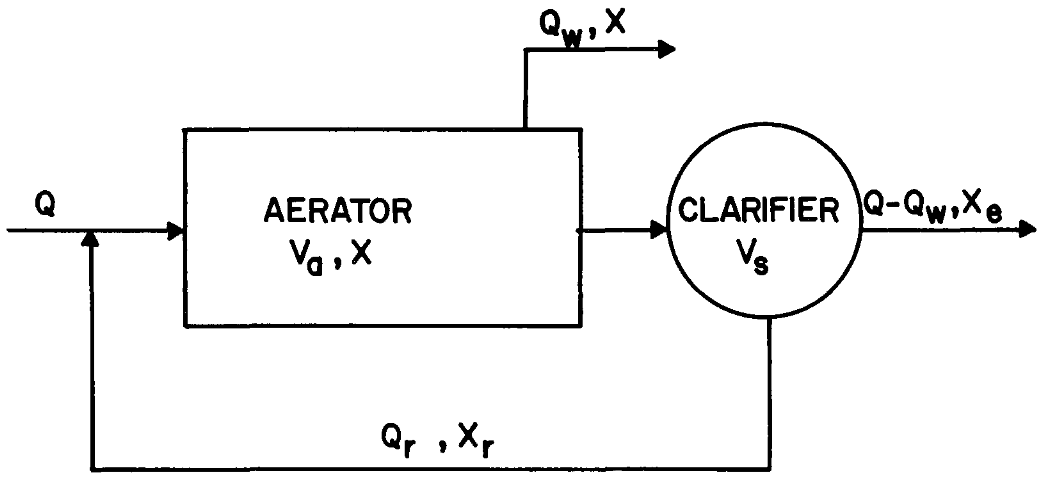
CONTROL SCHEMES FOR SOLIDS WASTING

Two different control schemes have been proposed to accomplish solids wasting from the activated sludge process. One involves wasting mixed liquor directly from the aeration tank while the other involves wasting from the return sludge line coming from the secondary clarifier. Both of these will be described so as to better evaluate the advantages and disadvantages of control techniques used by LACSD.

Wasting from the Aeration Tank

A schematic diagram of an activated sludge process in which wasting is accomplished directly from the mixed liquor is shown in Figure 41. The wasting rate (Q_w), required to achieve a given MCRT in this system can be determined through use of equation 3. The total mass of solids in the system is the sum of solids held in the aeration tank and final clarifier. Total solids mass in the aeration tank can be described as XV_a, where X is the concentration of solids if the aeration tank is completely mixed or the average concentration if the reactor is not.

Estimating solids mass in the secondary clarifier is more difficult since a sludge blanket normally forms at the bottom of the clarifier. Average solids retention time in the sludge blanket is difficult to ascertain. Burchett and Tchobanoglous,[3] suggested that the mass of organisms in the secondary clarifier is approximately equal to the volume of the clarifier times the MLVSS, V_sX.



Q = PRIMARY EFFLUENT FLOWRATE

Q_w = WASTE SLUDGE FLOWRATE

Q_r = RETURN SLUDGE FLOWRATE

V_a = VOLUME OF AERATOR

V_s = VOLUME OF CLARIFIER

X = MIXED LIQUOR VOLATILE SUSPENDED SOLIDS CONCENTRATION

X_e = SECONDARY EFFLUENT VOLATILE SUSPENDED SOLIDS CONCENTRATION

X_r = RETURN SLUDGE VOLATILE SUSPENDED SOLIDS CONCENTRATION

FIGURE 41 SCHEMATIC DIAGRAM OF ACTIVATED SLUDGE PROCESS WITH WASTING FROM MIXED LIQUOR

This is strictly true only if the detention time of the solids in the clarifier equals the liquid detention time. Nevertheless, it should provide a reasonable approximation of the true mass. Deaner and Martinson,[6] have recently questioned whether cell mass stored in the final clarifier should be included in the cell balance. While this point is of theoretical interest, it is beyond the scope of this report and cell storage in the final clarifier will be considered in the cell balance.

Organisms are wasted from the system from two places, intentionally from the aeration basin and unintentionally in effluent from the secondary clarifier. A third source of possible wasting is the surface skimmings collected in the secondary clarifier. Such skimmings may represent a significant loss of solids if foaming or sludge bulking occur in the aeration system. Under normal operation, however, this loss is not significant and need not be considered in this discussion.

Mass of solids wasted intentionally from the aeration tank is represented by XQ_w, while that in the effluent as $(Q-Q_w)X_e$. Using equation 3, MCRT can be described as

$$\theta_c = \frac{XV_a + XV_s}{XQ_w + (Q-Q_w)X_e} \qquad (6)$$

If the treatment plant is operating properly, effluent solids loss should be a small fraction of the solids intentionally wasted. Under these conditions, equation 6 can be simplified to

$$\theta_c = \frac{X(V_a + V_s)}{Q_w X} \qquad (7)$$

Solving for Q_w

$$Q_w = \frac{V_a + V_s}{\theta_c} \qquad (8)$$

If solids are wasted directly from the mixed liquor, the wasting rate is a function only of the aeration and clarifier tank volumes and the desired MCRT. No laboratory measurements are necessary. Despite these advantages, the number of treatment plants employing this control scheme is limited,[3,4]. The reason for this is that a greater volume of waste sludge must be handled and an additional waste activated sludge clarifier is required. In addition, laboratory measurements required to waste from the return sludge line are usually performed as a routine part of plant operation. As such, wasting from the mixed liquor offers little advantage in saving laboratory work since the control tests are performed anyway.

Wasting from the Return Sludge Line

A schematic diagram of an activated sludge process with sludge wasting from the return sludge line is shown in Figure 42. Employing the same procedure as previously described, the MCRT can be described as

$$\theta_c = \frac{XV_a + XV_s}{Q_w X_r + (Q-Q_w) X_e} \tag{9}$$

Solving equation 9 for Q_w gives

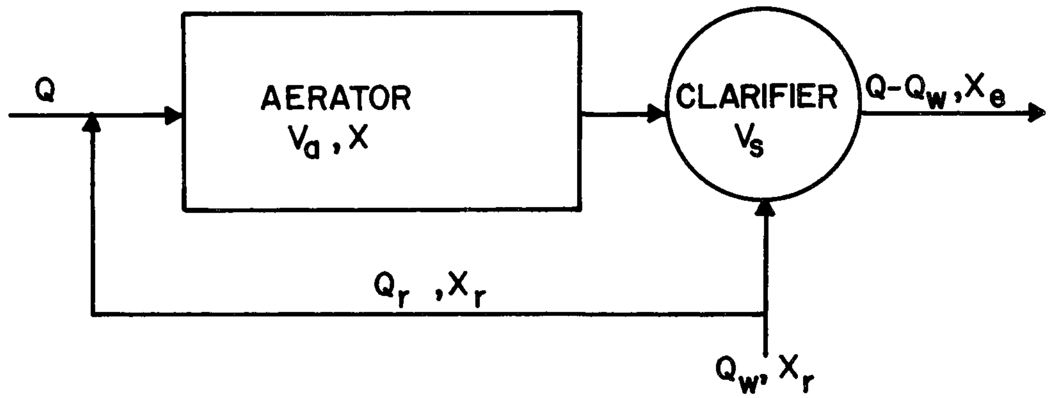
$$Q_w = \frac{X(V_a + V_s) - \theta_c (Q-Q_w) X_e}{X_r \theta_c} \tag{10}$$

Since Q_w is normally much smaller than the plant flow rate, Q, it can be neglected on the right side of equation 10 allowing a direct solution for Q_w.

$$Q_w = \frac{X(V_a + V_s) - \theta_c Q X_e}{X_r \theta_c} \tag{11}$$

Thus, to determine the required wasting rate from the return sludge line, the plant operator must know the volumes of both the aerator and final clarifier and must measure mixed liquor, return sludge and secondary effluent suspended solids concentrations.

Since return sludge is more concentrated than mixed liquor, a smaller volume of waste sludge need be handled and additional waste sludge clarifiers are not required. These considerations



Q = PRIMARY EFFLUENT FLOWRATE

Q_w = WASTE SLUDGE FLOWRATE

Q_r = RETURN SLUDGE FLOWRATE

V_a = VOLUME OF AERATOR

V_s = VOLUME OF CLARIFIER

X = MIXED LIQUOR VOLATILE SUSPENDED SOLIDS CONCENTRATION

X_e = SECONDARY EFFLUENT VOLATILE SUSPENDED SOLIDS CONCENTRATION

X_r = RETURN SLUDGE VOLATILE SUSPENDED SOLIDS CONCENTRATION

FIGURE 42 SCHEMATIC DIAGRAM OF ACTIVATED SLUDGE PROCESS WITH WASTING FROM RETURN SLUDGE LINE have led the LACSD to incorporate sludge wasting from the return sludge line in its activated sludge plant designs. The LACSD recognizes, however, that wasting from the mixed liquor is a viable alternative and that the particular wasting scheme in any design must be chosen after consideration of all factors.

CONTROL OF RETURN SLUDGE WASTING

Several different schemes have been used to control solids wasting from the return sludge line. Two of the most popular control techniques are (1) wasting a constant percentage of the return sludge flow (sometimes referred to as hydraulic control) and (2) wasting a fixed volume of return flow. Both of these control schemes will be described since the control calculations and required laboratory measurements depend on the techniques chosen.

Wasting a constant percentage of the return sludge flow was described by Walker,[5] in 1965 and is sometimes referred to as hydraulic control. Referring to Figure 42, to maintain a given MCRT, it is necessary to waste 100/MCRT percent of the total plant solids each day. However, 100/MCRT percent of the return sludge flow can not be wasted since solids make several passes through the return line each day. Total flow rate through the aeration tank and secondary clarifier is $Q + Q_r$. Thus, the liquid makes a total of $(Q + Q_r)/(V_a + V_s)$ passes per day. The solids should make the same number of passes per day provided there is no accumulation in the secondary clarifier which is unlikely. Thus, for a conventional plant, the continuous wasting rate, W, figured as a percent of the gross return sludge flow rate $(Q_r + Q_w)$ can be calculated as

$$W = \frac{100}{MCRT} \; \frac{(V_a + V_s)}{(Q + Q_r)} \qquad (12)$$

For a given plant, the aeration and clarifier tank volumes are fixed. Thus, the operator need know only the desired MCRT, average plant flow rate, and return sludge flow rate to calculate the percentage of return sludge to be wasted. Mixed liquor and return sludge concentration need not be determined. Should mixed liquor and return sludge concentrations vary diurnally, as they usually do, it in no way affects the wasting percentage, W. One disadvantage of this control technique, however, is that variations in return sludge flow rate necessitate readjustments of the wasting percentage. If the return rate is constant, as it is in many plant designs, the wasting percentage is fixed. But if it varies, as it might if Keene probes were used to maintain a constant sludge blanket level (see Section VII) constant readjustment of the wasting percentage would be required.

Operating practice at LACSD activated sludge plants involves using equation 11 to calculate a waste sludge flow rate. 24-hour composite samples of mixed liquor, return sludge and secondary effluent suspended solids collected the previous day are used in equation 11 to predict the wasting flow rate. Thus, calculations are always one day behind. This is not a serious drawback, however, since mean cell residence times are normally on the order of 5 to 15 days and operating parameters should not change significantly in the course of a single day.

It is important that 24-hour composite samples be used to calculate mixed liquor, return sludge, and effluent suspended solids concentrations used in equation 11. Diurnal variations in these parameters would be expected in any treatment plant experiencing diurnal flow variations. A representative sample of return sludge concentrations experienced at the LBWRP is shown in Figure 43. Samples were collected every 15 minutes over a 24-hour period in 1973 with each bar representing the average results of a 4-hour composite sample. Return flow rate was constant during the time of sampling. Equation 11 only predicts the flow rate required to waste a given mass of solids. Therefore, composite samples are an absolute necessity. In addition, the flow rate predicted by equation 11 must be maintained constant so as to waste evenly from all sludge concentrations experienced throughout the day.

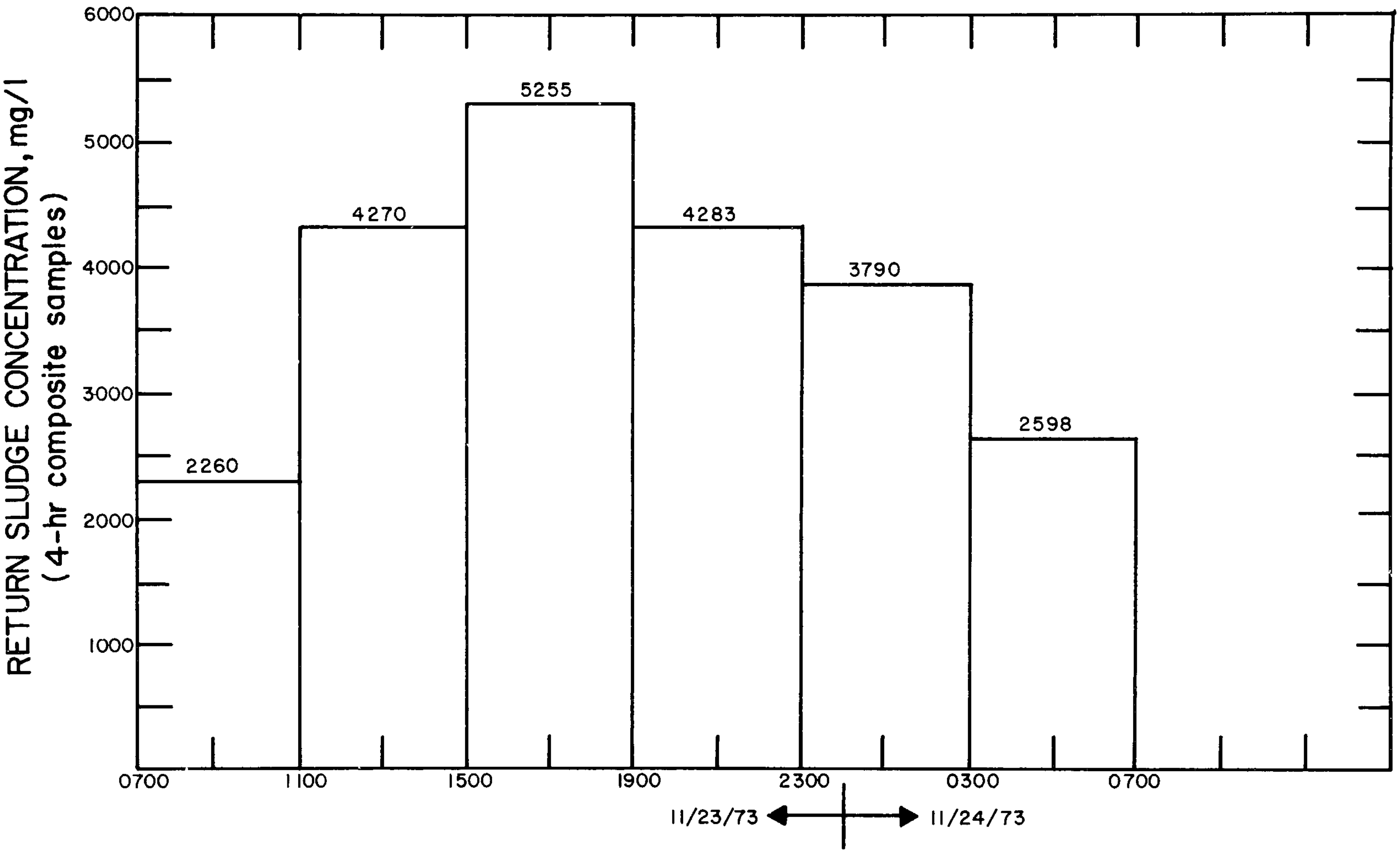


FIGURE 43 DIURNAL VARIATION IN RETURN SLUDGE CONCENTRATIONS AT LONG BEACH WATER RENOVATION PLANT

LACSD ACTIVATED SLUDGE WASTING FACILITIES

A schematic diagram of the waste sludge control system employed at LACSD activated sludge plants is shown in Figure 44. Heart of the system is the flow measurement device used to generate a control signal. Any number of flow measuring devices, including orifice plates, venturi meters, magnetic and propeller flowmeters, could be used. The only requirement is that the device generate a signal that is a function of flow rate. LACSD design practice has been to use propeller meters which are considerably less expensive than comparable magnetic flowmeters and create less headloss than orifice plates. The main disadvantage of a propeller meter is that it is subject to fouling by material contained in the flowstream.

Treatment plants which employ anaerobic digestion of primary sludge commonly return digested supernatant back to the primary tanks. Depending on digester performance, the supernatant may contain quantities of stringy material which could buildup in the activated sludge mixed liquor. If such were the case, propeller meters would require regular cleaning to avoid fouling. All of the LACSD activated sludge plants using propeller meters discharge primary sludges back to the sewer for subsequent treatment at the District's Joint treatment plant. Thus, the waste sludge is relatively free of fouling material.

Examination of maintenance records indicated that propeller meters in the waste sludge lines were cleaned about twice a year on the average. Generally, cleaning was performed only if the operator observed erratic response from the meter. A propeller meter removed from the waste sludge line after three months of continuous operation was found to be completely free of fouling material.

The pulse signal generated by the propeller meter is sent to a pulse to current converter. Converter output is a 4 to 20 ma signal proportional to flow rate. This signal is compared with a set point value and used to control the position of a motorized throttling valve. The signal also actuates a recorder, flow

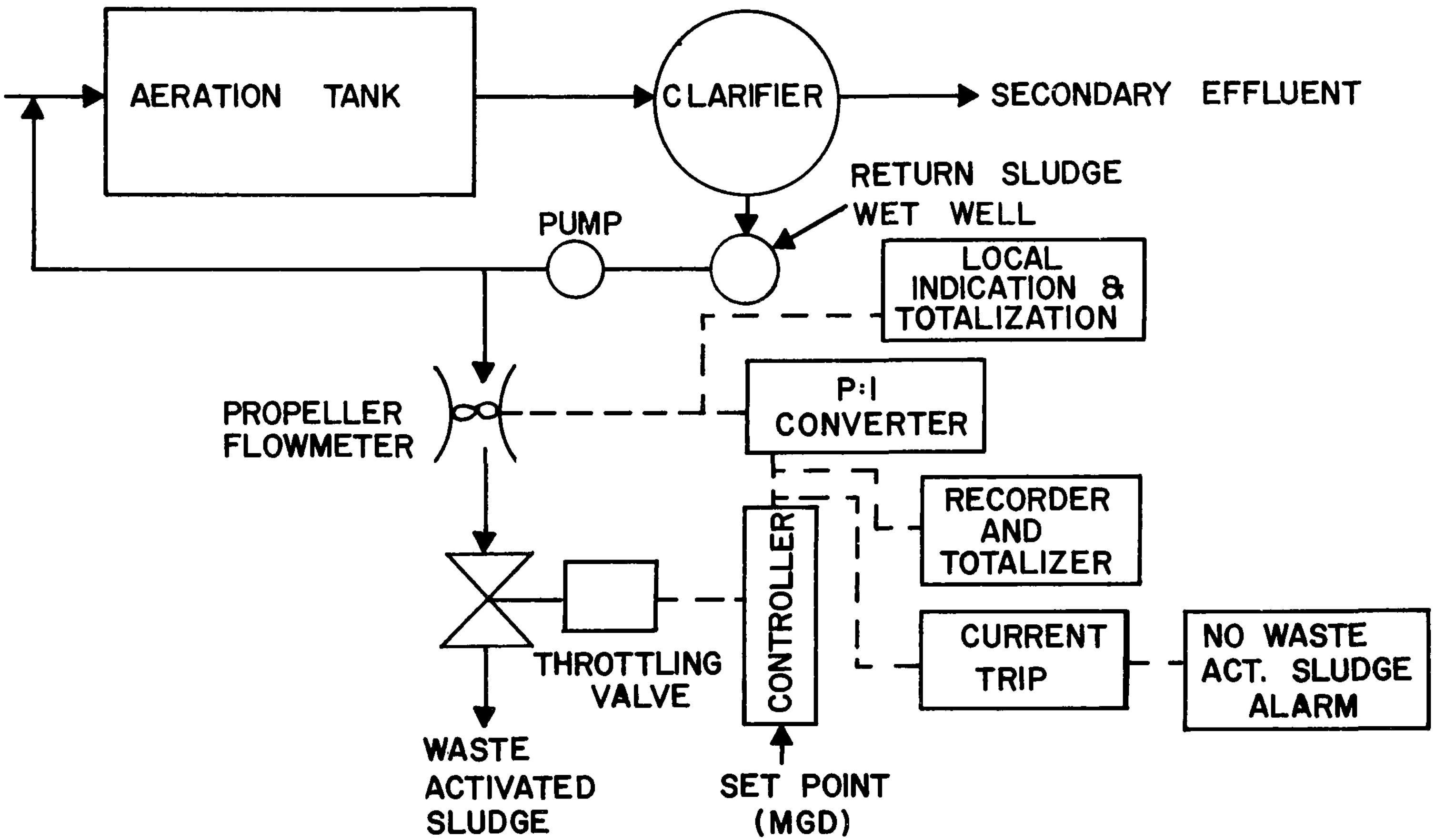


FIGURE 44 SCHEMATIC DIAGRAM OF WASTE SLUDGE FLOW CONTROL SYSTEM

totalizer, and a no-flow alarm. Thus, if something should accidently stop the propeller, an alarm is immediately sounded alerting the operator.

The valve actuator is either an electro-hydraulic or electro-pneumatic device which positions the actuator stem proportionally to the input current command signal. Both butterfly and diaphram valves are currently used in LACSD installations. Both types of valves have given good service.

OPERATIONAL EXPERIENCE

Daily operational practice at LACSD activated sludge installations utilizes the automatic collection of 24-hour composite samples (one sample every 15 minutes) of aeration tank mixed liquor, return sludge, and secondary effluent suspended solids. These values are then applied to equation 11 to predict the waste sludge flow rate required to achieve a certain mean cell residence time. It is essential that 24-hour composite samples be used since solids concentrations will vary diurnally. Also, it is essential that the wasting rate calculated from equation 11 remain constant throughout the day so as to waste evenly from all return sludge concentrations.

The technique of wasting a constant flow rate from the return sludge line has been used in LACSD installations for many years. The control equipment functions with a minimum of maintenance. However, the main test of any sludge wasting technique is whether it actually wastes the correct mass of cells and can maintain desired MCRT values. Years of operational experience with daily treatment plant solids inventories indicates that the wasting technique and associated control equipment function properly. Analysis of several months operational data indicated that, in general, waste flow rate could be maintained within about 2 or 3 percent of the desired set point value. With a fixed set point, however, daily waste volumes were reproducible to within 0.5 percent.

Certain characteristics of the control equipment are worthy of discussion. Should the propeller meter become fouled, control signal to the electronic controller will indicate a no-flow condition. The controller will signal for additional valve opening in an attempt to readjust the flow rate to the desired set point value. This will continue until the valve is in a full open position and solids are being wasted at an extremely high rate. Since the propeller meter is fouled, it will continue to register zero flow. Fortunately, the no-flow alarm will actuate under these conditions alerting the plant operator. If the operator is slow to respond to the alarm, however, considerable solids will be lost from the plant.

Conditions somewhat less extreme than the above will result if the propeller meter loses its calibration. This could happen, for example, if fouling material slowed propeller response to a given flow rate. Under these conditions, an excessive amount of solids would be wasted from the plant but no alarm would be sounded to alert the operator. His only control is to watch the solids inventory in the plant and check for any sharp reduction in total plant solids. Loss of calibration in this manner has not been a significant problem in LACSD installations.

One might suspect that control valve plugging by suspended solids would be a potential problem. It is not, however, because of the nature of the feedback control loop. Should the control valve plug (as butterfly valves, in particular, are prone to do when only partially open) the decreased flow rate would be sensed by the flowmeter. The controller in turn would call for increased valve opening to readjust the flow rate. Thus, valve plugging is not a problem unless the line remained plugged with the valve fully open which is extremely unlikely.

SECTION VIII

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SECTION IX

COMPUTER CONTROL APPLICATIONS

INTRODUCTION

The Sanitation Districts of Los Angeles County have developed an on-line computerized data management system capable of providing a treatment plant operator with daily reports including operational calculations and effluent compliance checks. The system also produces monthly summaries of all data for management review and monitoring reports submitted to regulatory agencies. The evolution of the present system was a staged process, each step of which was a response to increasing demands for additional information relative to the status of treatment plant operations.

HISTORY

During the mid-1960's the Sanitation Districts operated four activated sludge treatment plants. To provide management with monthly status reports on operation conditions, a system was devised whereby the operator of each plant entered certain daily data onto summary sheets. At the end of the month, these sheets were forwarded to the administration office where an engineer, with the aid of the desk top calculator, performed certain calculations. The raw data and calculations were then typed onto final sheets and circulated among management. Obviously, this procedure provided no opportunity to immediately recognize at the operational level significant trends in other than raw data. In response to the heavy demand this procedure placed upon the engineer's time, his role was eliminated by sending the raw data directly to the Districts' Data Processing Department at the end of each month for keypunching. The Districts' computer at that time consisted of a Univac 9300, a business oriented computer which could, however, support FORTRAN language programs. The computer performed the necessary calculations, and the results, along with the raw data, were typed onto appropriate sheets for circulation among management.

By 1970 it became obvious that some method was needed to perform many of these calculations on a daily basis and make the results available to the operator as soon as possible, so that undesirable operating trends could be recognized and quickly corrected. After review of possible alternatives, the Sanitation Districts chose to install teletype terminals at each of the treatment facilities and to lease time-sharing computer services. In addition, the Districts leased a high speed printer terminal at the administrative office building to provide, on a monthly basis, the summaries of data for management review. The main criterion for selection of a commercial time-sharing service organization was that the stored data base be available to both low speed teletype terminals, to be installed in each treatment facility, and to the high speed printer to be installed at the administrative office. In addition, as a secondary criterion, the commercial organization needed to provide some programming assistance and expertise to assist the Districts' staff in developing the necessary software. In 1970 there were few organizations which provided services meeting both criteria.

From 1970 through mid-1974 this computerized data management system underwent several revisions in number of calculations performed and format of the monthly summaries of data. As the Districts placed three new activated sludge treatment plants into service (1970-1973), each was provided with a teletype terminal and utilized the computer services.

In mid-1974 two events occurred which required a significant expansion of the District's computer services. The first was the decision to obtain an in-house computer. Usage of the commercial time-sharing services, both for the treatment plant data and, also, for various other work combined with increased accounting and personnel workloads on the Univac 9300, made it obvious that obtaining in-house hardware would be more cost-effective than continuing to lease such services. The second factor was the issuance of two new independent discharge permits for each of the seven activated sludge treatment plants. These new permits were promulgated under the National Pollutant Discharge Elimination System (NPDES) Permit Program and under the California Water Code. Each permit requires that monthly monitoring reports containing extensive statistical evaluations of data be prepared for each facility. The revised computer system now in use incorporates the previous system, which performed plant operational calculations only, and a complete data management system which monitors the status of all information required for reporting purposes, performs daily effluent statistical calculations and informs operations' personnel of violations of specified effluent limits. In addition, the data management system can inform the operator which data, while not constituting violations of discharge requirements, are not within a desired range of values.

EQUIPMENT

Hardware

Each treatment plant is equipped with a Teletype Corporation TWX model 33 terminal capable of a 110 baud (bits per second) transmission rate. The information is transmitted over normal voice grade telephone lines to the Districts' administrative office, the site of the computer hardware. The computer is an IBM 370 model 125. The Central Processing Unit (CPU) of the computer is a multiprogramming, fixed partition environment having a 196K byte real storage memory. Supporting the CPU are three IBM model 3340 disc drive storage units each with a 70M byte storage capacity. The Virtual Storage (VS) concept of exchanging CPU storage with disc storage is utilized to effectively increase the CPU capacity to 1.4M bytes. Additional hardware in use includes an IBM model 3504 card reader, an IBM model 3203 high speed printer capable of 1100 lines per minute, two IBM model 3410 tape drives capable of 800 or 1600 bits per inch recording densities and operating speeds of 50 inches per second, and four local IBM model 3270 CRT terminals operating at channel speeds. These latter terminals are utilized by various departments at the administrative office.

Software

There are two operating systems which control all work in the computer. The first, Disc Operating System/Virtual Storage (DOS/VS) supervises all work not involving the on-line applications, that is, the computer jobs submitted in batch at the main office. The on-line applications, which include the treatment plant data management system, are controlled by the second operating system, Customer Information Control System/Virtual Storage (CICS/VS), working in conjunction with DOS/VS.

One of the four fixed partitions of the CPU is dedicated exclusively to CICS. This partition has a 40K byte real storage capacity. In addition, CICS shares up to an additional 66K byte real storage capacity with the other partitions of the CPU, the amount shared at any time depends upon the demand DOS places upon this capacity. The Virtual Storage operation gives the CICS partition an effective working capacity of 528K bytes.

The software required to run the on-line time-sharing operations consists of approximately 240,000 lines of programming instructions, most of which were supplied by the equipment hardware manufacturer. In addition, there are approximately 12,000 lines of programming instructions to operate the data management system described herein. These latter instructions are broken up into separate programming modules or programs. All programs are written in PL/I language.

DATA MANAGEMENT SYSTEM

The operation of the existing Water Renovation Plant Data Management System (WRPDMS) will be described in seven sections: Overview, Data Preparation, Data Entry, Plant Operational Calculations, Effluent Compliance Calculations, Reports, and System Management Programs.

Overview of System

Shown in Figure 45 is a schematic diagram of the WRPDMS. Note that not all operations are performed under CICS, the on-line portion of the system. Batch processing, which includes report generations, file maintenance, and performing 30-day average calculations are reserved for the p.m. shift when the on-line system is not in service. Calculation of the 30-day averages is a time consuming process and if performed on-line will interrupt all other work of the computer. Hence, by reserving these calculations for the p.m. shift, the time spent at a terminal is decreased and the overall computer throughput is increased.

Figure 46 illustrates the interrelationship of the various programs developed for the on-line system. There are nine different transaction options the operator can use to enter or retrieve stored data and calculation results from the system. The step-by-step process of each of these transactions is shown in Figure 46 and each will be described below.

Data Preparation

Shown in Figure 47 are the raw data sheets used at the Long Beach Water Renovation Plant. All other treatment plants use nearly identical sheets; however, the first and last pages vary with each plant to account for differences in numbers of discharge points and numbers of aeration systems. These sheets include all of the data gathered at the five activated sludge treatment

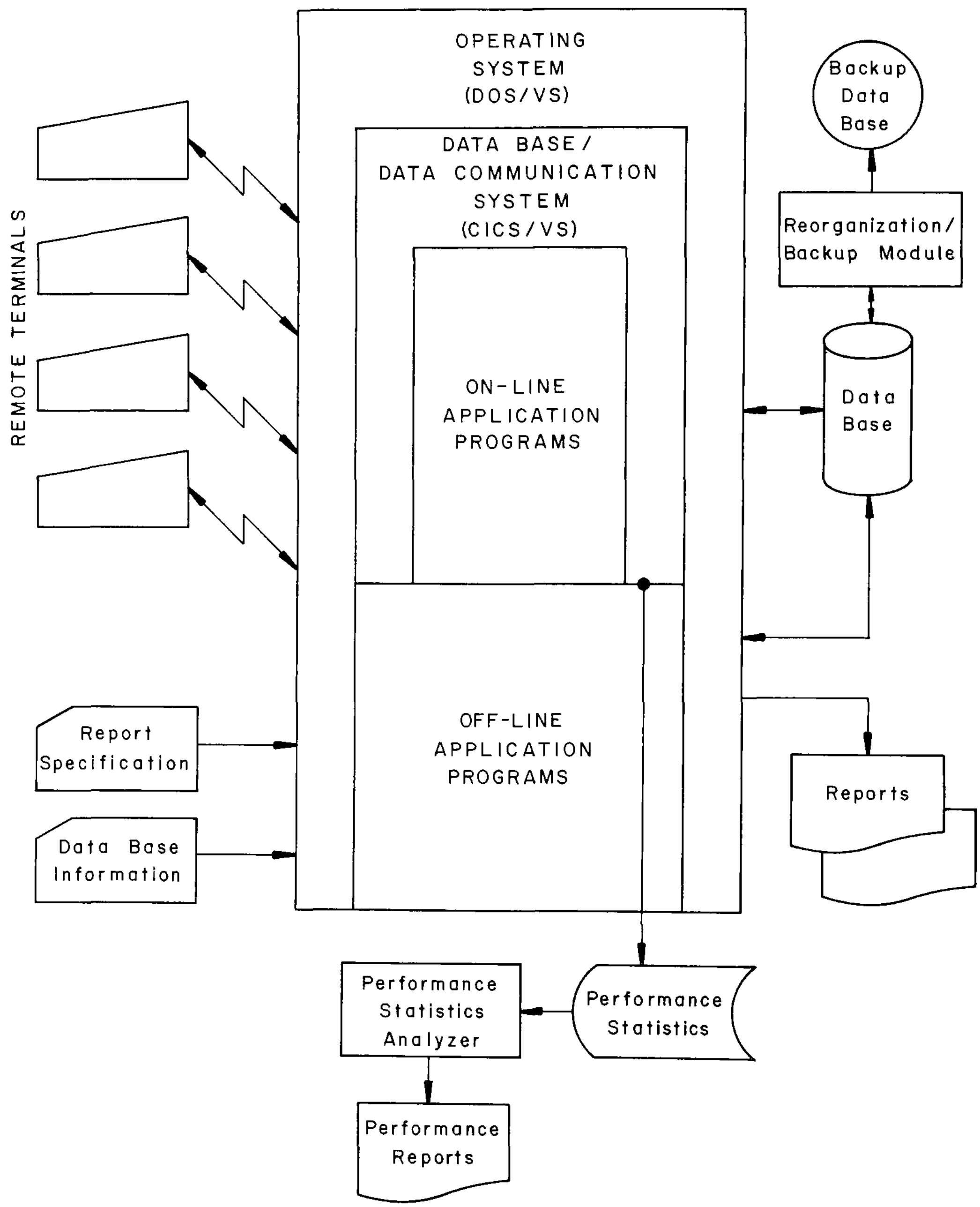

FIGURE 45 WATER RENOVATION PLANT DATA MANAGEMENT SYSTEM

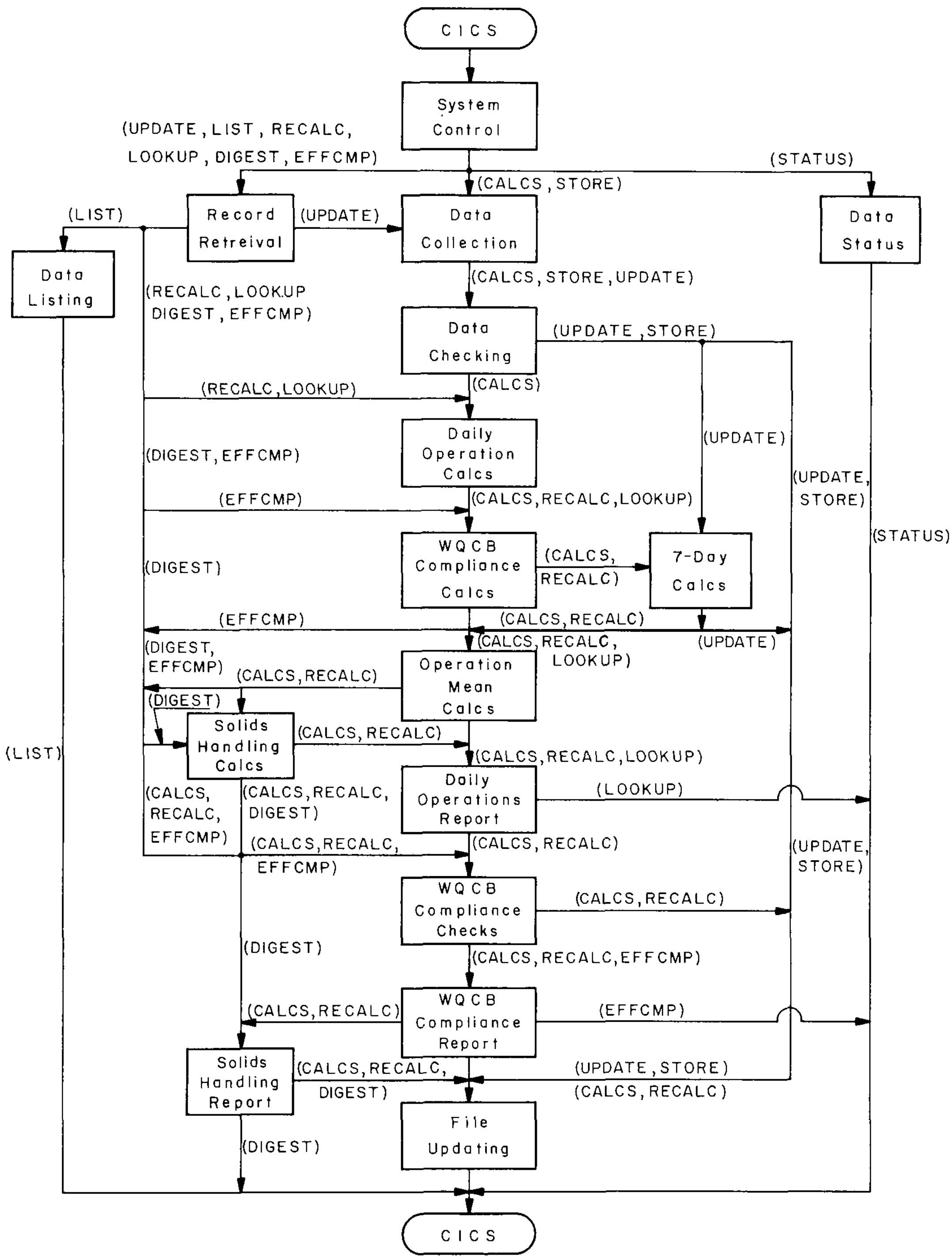

FIGURE 46 WRPDMS-SCHEMATIC DIAGRAM OF ON-LINE PROGRAMS

PLANT: LONG BEACH WRP MONTH: 197

DATE	FLOWS								
	TOTAL PLANT					EFFLUENT DISCHARGE POINTS			
	AVERAGE DAILY	PEAK DAILY	TOTAL RETURN ACTIVATED SLUDGE	WASTE ACTIVATED SLUDGE	PROCESS AIR	NO. 001 COYOTE CREEK	CITY OF LONG BEACH		
	mgd	mgd	mgd	mgd	mcf/day	mgd	mgd	mgd	mgd
	1	2	3	4	5	6	7	8	9
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
AVG.									

COLUMN :

DATE :

REMARKS :

FIGURE 47 EXAMPLE OF RAW DATA COLLECTION SHEETS

PLANT:										MONTH:			197
DATE	SUSPENDED SOLIDS												
	RAW SEWAGE	PRIMARY EFFL.	SEC. EFFL.	FILTER EFFL.	FINAL EFFLUENT		REQUIREMENTS GOVERNING DISCHARGE TO: NAVIGABLE WATERS & TRIBUTARIES THERETO — ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS DATA: FINAL EFFLUENT		PLANT REMOV.	ARITHMETIC MEAN OF PAST 7 CALENDAR DAYS FINAL EFFLUENT DATA		ALLOWABLE REUSES — ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS FINAL EFFLUENT DATA	
	mg/l	mg/l	mg/l	mg/l	mg/l	lbs/day	mg/l	lbs/day	%	mg/l	lbs/day	mg/l	lbs/day
	10	11	12	13	14	15	16	17	18	19	20	21	22
1													
2													
3													
4													
5													

PLANT:						MONTH:		197
DATE	CHEMICAL OXYGEN DEMAND (COD)							
	RAW SEWAGE	PRIMARY EFFLUENT	SECONDARY EFFLUENT		FILTER EFFLUENT		FINAL EFFLUENT	
	TOTAL	TOTAL	TOTAL	SOLUBLE	TOTAL	SOLUBLE	TOTAL	SOLUBLE
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	23	24	25	26	27	28	29	30
1								
2								
3								
4								
5								

PLANT:							MONTH:			197
DATE	5-DAY BIOCHEMICAL OXYGEN DEMAND (BOD_5)									
	RAW SEWAGE	PRIMARY EFFLUENT	FINAL EFFLUENT		REQUIREMENTS GOVERNING DISCHARGE TO: NAVIGABLE WATERS & TRIBUTARIES THERETO — ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS DATA: FINAL EFFLUENT		PLANT REMOV.	ARITHMETIC MEAN OF PAST 7 CALENDAR DAYS FINAL EFFLUENT DATA		ALLOWABLE REUSES — ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS FINAL EFFLUENT DATA	
	mg/l	mg/l	mg/l	lbs/day	mg/l	lbs/day	%	mg/l	lbs/day	mg/l	lbs/day
	31	32	33	34	35	36	37	38	39	40	41
1											
2											
3											
4											
5											

EXAMPLE OF RAW DATA COLLECTION SHEETS
(NOTE: ONLY TOP PORTION OF EACH SHEET IS SHOWN)
FIGURE 47 (CONTINUED)

PLANT: MONTH: 197

DATE	BACTERIA					
	CHLORINE CONTACT CHAMBER EFFLUENT DAILY GRAB SAMPLES		REQUIREMENTS GOVERNING DISCHARGE TO:			
			NAVIGABLE WATERS & TRIBUTARIES THERETO			ALLOWABLE REUSES
			GEOMETRIC MEAN OF FECAL COLIFORM DATA DURING PAST:		MEDIAN OF LAST 7 TOTAL COLIFORM SAMPLES	MEDIAN OF LAST 7 TOTAL COLIFORM SAMPLES
	TOTAL COLIFORM	FECAL COLIFORM	30 DAYS	7 DAYS		
	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml	MPN/100 ml
	42	43	44	45	46	47
1						
2						
3						
4						
5						

PLANT: MONTH: 197

DATE	RESIDUAL CHLORINE				pH	OIL AND GREASE			
	CHLORINE CONTACT CHAMBER EFFLUENT		DAILY GRAB SAMPLES		FINAL EFFLUENT DAILY GRAB SAMPLE	FINAL EFFLUENT DAILY GRAB SAMPLE		ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS EXCLUDING DAYS OF REUSE	
	MINIMUM DAILY VALUE	MAXIMUM DAILY VALUE	CHLOR-INATED	DECHLOR-INATED					
	mg/l	mg/l	mg/l	mg/l		mg/l	lbs/day	mg/l	lbs/day
	48	49	50	51	52	53	54	55	56
1									
2									
3									
4									
5									

PLANT: MONTH: 197

DATE	NITROGEN												
	24-HOUR FLOW COMPOSITE SAMPLES								ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS TOTAL NITROGEN DATA				AERATION SYSTEM AMMONIA OXID.
	PRIMARY EFFLUENT		FINAL EFFLUENT						NAVIGABLE WATER DISCHARGE		REUSE DISCHARGE		
	ORGANIC	NH_3	ORGANIC	NH_3	NO_2	NO_3	TOTAL N						
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day	%
	57	58	59	60	61	62	63	64	65	66	67	68	69
1													
2													
3													
4													
5													

EXAMPLE OF RAW DATA COLLECTION SHEETS
(NOTE: ONLY TOP PORTION OF EACH SHEET IS SHOWN)
FIGURE 47 (CONTINUED)

PLANT:				MONTH:		197

DATE	TURBIDITY					SECCHI DISC	
			FINAL EFFLUENT				
	SECONDARY EFFLUENT	FILTER EFFLUENT	DAILY 24-HOUR COMPOSITE	CONTINUOUS READING METER: MINIMUM DAILY VALUE	CONTINUOUS READING METER: MAXIMUM DAILY VALUE	SECONDARY EFFLUENT	FILTER EFFLUENT
	TU	TU	TU	TU	TU	feet	feet
	70	71	72	73	74	75	76
1							
2							
3							
4							
5							

PLANT:					MONTH:			197	

DATE	SETTLEABLE SOLIDS			TDS		SPECIF. CONDUC.	TEMP.	COLOR	
	DAILY 24-HOUR COMPOSITE	PAST 30-DAY AVERAGE: NAVIGABLE WATER DISCHARGE	PAST 30-DAY AVERAGE: REUSE DISCHARGE	DAILY 24-HOUR COMPOSITE 180° C EVAP. TEMP.		DAILY 24-HOUR COMPOSITE	DAILY GRAB SAMPLE	SECONDARY EFFLUENT	FILTER EFFLUENT
	ml/l	ml/l	ml/l	mg/l	lbs/day	μmho/cm	°F	UNITS	UNITS
	77	78	79	80	81	82	83	84	85
1									
2									
3									
4									
5									

PLANT:					MONTH:		197

DATE	CHLORIDE		SULFATE		CHLORIDE PLUS SULFATE		DETERGENTS (MBAS)
	DAILY 24-HOUR COMPOSITE		DAILY 24-HOUR COMPOSITE		ARITHMETIC SUM OF THE TWO ANALYSES		DAILY 24-HOUR COMPOSITE
	mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day	mg/l
	86	87	88	89	90	91	92
1							
2							
3							
4							
5							

EXAMPLE OF RAW DATA COLLECTION SHEETS
(NOTE: ONLY TOP PORTION OF EACH SHEET IS SHOWN)
FIGURE 47 (CONTINUED)

PLANT:								MONTH:		197	
DATE	MISCELLANEOUS										
	RETURN SLUDGE SUSPENDED SOLIDS	UNITS OUT OF SERVICE									
		PRIMARY TANKS	AERATION TANKS	FINALS SYSTEM NO. 1	FINALS SYSTEM NO. 2	FINALS SYSTEM NO. 3	FILTERS				
	mg/l										
	93	94	95	96	97	98	99	100	101	102	103
1											
2											
3											
4											
5											

PLANT:																MONTH:			197
DATE	AERATION SYSTEM NO. 1																		
	SUSPENDED SOLIDS 24-HOUR COMPOSITES				RETURN ACTIVATED SLUDGE		MIXED LIQUOR DISSOLVED OXYGEN		LOADING PATTERN				SVI GRAB SAMPLE				NO_2		NO_3	
	TANK 1	TANK 2	TANK 3	TANK 4	FLOW RATE	AERAT. VOLUME	MAX.	MIN.	TANK 1	TANK 2	TANK 3	TANK 4	SETTL. SOLIDS	SUSP. SOLIDS	SVI	VOLAT. SOLIDS	LOW FLOW GRAB SAMPLE	HIGH FLOW GRAB SAMPLE	LOW FLOW GRAB SAMPLE	HIGH FLOW GRAB SAMPLE
	mg/l	mg/l	mg/l	mg/l	mgd	mg	mg/l	mg/l	%	%	%	%	ml/l	mg/l	ml/g	%	mg/l	mg/l	mg/l	mg/l
	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123
1																				
2																				
3																				
4																				
5																				

EXAMPLE OF RAW DATA COLLECTION SHEETS
(NOTE: ONLY TOP PORTION OF EACH SHEET IS SHOWN)
FIGURE 47 (CONTINUED)

plants that do not have solids handling processes. For the District 26 Water Renovation Plant and the District 32 Water Renovation Plant, which process solids by anaerobic digestion, centrifugation and/or air flotation, additional data sheets are utilized. Shown in Figure 48 are these data sheets.

Examination of Figure 47 shows that there are a maximum of 84 raw data columns on the sheets. Note, however, that not all are presently used. Many have been crossed out because applicable treatment process are not now in operation. However, within several years, it is anticipated that all plants will have some form of tertiary treatment involving filtration. The sheets have been designed to handle additional data to be generated when this additional treatment begins. The remaining 39 columns on the sheets are reserved for inserting calculated values generated by the computer.

As shown in Figure 48 there are a maximum of 54 columns of data to handle the digestion and solids processing equipment at the two applicable treatment plants. In actual practice, neither treatment plant measures all parameters on a daily basis.

Data Entry

Because several of the data, e.g. BOD_5 and coliform bacteria, require several days of laboratory testing time before results are available, whereas most other data are available within one day, the WRPDMS is designed to accept both types of data when they first become available. Obviously, a system user could become easily confused as to which data have been entered and which have not. To avoid this, the first transaction the treatment plant operator should run each day is STATUS. Figure 49 shows a typical STATUS transaction. The data specified ON-LINE refer to all data columns except those eight specifically listed in the printout, and include all daily data for which results are available on the day following the day in question. Those specific data listed in the STATUS transaction either take more

PLANT:														MONTH:		197		
DATE	SOLIDS HANDLING																	
	SLUDGE						CENTRIFUGE						AIR FLOTATION UNIT					
	RAW			WASTE ACTIVATED			CENTRATE		CAKE				UNDERFLOW		CAKE			
	FLOW	TOTAL SOLIDS	VOLATILE SOLIDS	FLOW TO CENTRIFUGE	FLOW TO A F UNIT	TOTAL SOLIDS	FLOW	TOTAL SOLIDS	FLOW	TOTAL SOLIDS	VOLATILE SOLIDS	TIME IN OPERATION	FLOW	TOTAL SOLIDS	FLOW	TOTAL SOLIDS	VOLATILE SOLIDS	TIME IN OPERATION
	MGD	%	%	MGD	MGD	%	MGD	%	MGD	%	%	hours	MGD	%	MGD	%	%	hours
	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
1																		

PLANT															MONTH:			197	
DATE	SOLIDS HANDLING																		
	SMALL DIGESTION SYSTEM																		
	PRIMARY DIGESTER									SECONDARY DIGESTER									
	RAW SLUDGE FLOW	CENT. DEWAT. W.A.S. FLOW	A.F. DEWAT. W A S FLOW	pH	ALKALINITY	VOLATILE ACIDS	TEMP	EFF. TOTAL SOLIDS	EFF. VOLATILE SOLIDS	RAW SLUDGE FLOW	CENT. DEWAT. W.A.S FLOW	A F DEWAT. W.A.S. FLOW	pH	VOLATILE ACIDS	SUPERNATANT SOLIDS	HAULED SLUDGE FLOW	HAULED SLUDGE TOTAL SOLIDS	HAULED SLUDGE VOLATILE SOLIDS	GAS PRODUCTION
	MGD	MGD	MGD		mg/l	mg/l	°F	%	%	MGD	MGD	MGD		mg/l	% T S	MGD	%	%	MCF
	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179
1																			

PLANT·															MONTH:			197	
DATE	SOLIDS HANDLING																		
	LARGE DIGESTION SYSTEM																		
	PRIMARY DIGESTER									SECONDARY DIGESTER									
	RAW SLUDGE FLOW	CENT. DEWAT W.A.S. FLOW	A F. DEWAT. W.A.S. FLOW	pH	ALKALINITY	VOLATILE ACIDS	TEMP	EFF. TOTAL SOLIDS	EFF. VOLATILE SOLIDS	RAW SLUDGE FLOW	CENT. DEWAT. W.A.S. FLOW	A.F. DEWAT. W A S. FLOW	pH	VOLATILE ACIDS	SUPERNATANT SOLIDS	HAULED SLUDGE FLOW	HAULED SLUDGE TOTAL SOLIDS	HAULED SLUDGE VOLATILE SOLIDS	GAS PRODUCTION
	MGD	MGD	MGD		mg/l	mg/l	°F	%	%	MGD	MGD	MGD		mg/l	% T.S.	MGD	%	%	MCF
	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198
1																			

RAW DATA COLLECTION SHEETS USED FOR SOLIDS HANDLING UNIT PROCESSES
FIGURE 48 (NOTE: ONLY TOP PORTION OF EACH SHEET IS SHOWN)

```
   WRPDMS,STATUS

LACSD WRP DATA MANAGEMENT SYSTEM
FOR SYSTEM AVAILABILITY CALL: JAO (213) 699-7411 EXT. 499


STATUS FOR: LONG BEACH WRP
DATE:  6/24/75   TIME: 13/15
ON-LINE DATA :   1/ 1/75 THROUGH  6/22/75

*** DATA ***   LAST ENTERED
 B O D            6/17
 TOTAL COLI       6/21
 FECAL COLI       6/21
 NITROGEN         6/10
 T D S            6/10
 CHLORIDE         6/10
 SULFATE          6/10
 DETERGENTS       6/10

TRANSACTION COMPLETE
```

EXAMPLE OF PRINTOUT OF
A STATUS TRANSACTION

FIGURE 49

than one day for analysis or are normally entered at less than a daily frequency. From the STATUS transaction then, the operator can determine his latest entries of data, and from this enter new data in correct chronological sequence.

Having determined from the STATUS transaction his most recent entries, the operator next determines if he has available data such as BOD_5 or bacterial data taken on days for which other data have already been entered. If this is the case, he would use an UPDATE transaction to enter the data. The UPDATE transaction will retrieve the already created data record for that day and insert the data in the appropriate storage column. In addition, if the data include bacterial, BOD_5, total nitrogen, TDS, chloride, or sulfate data, the appropriate calculations associated with these parameters will also be automatically calculated and stored. Figure 50 shows the results of a typical UPDATE transaction, in which influent and effluent BOD_5 data and effluent total coliform and fecal coliform data were entered.

After updating all necessary data records, the operator next begins to enter those data for the day following the last day for which data are stored. To do this, he has two transaction options available to him: STORE and CALCS. The former will only store data, while the latter will perform necessary calculations with the data, and, if successful in this latter task, will store both raw data and results of calculations. Figure 51 shows the results of a typical STORE transaction.

If the data entry is achieved with the CALCS transaction, no further steps are necessary. If, however, all new data are entered with the STORE transaction, the operator next performs RECALC, the transaction which simultaneously performs plant operational calculations and effluent compliance calculations. Of course, if the data are being entered with a CALCS transaction, these calculations would be automatically performed.

Plant Operational Calculations

The daily plant operational calculations can be divided into five groups of calculations:

```
   WRPDMS,UPDATE,06/01/75

LACSD WRP DATA MANAGEMENT SYSTEM
FOR SYSTEM AVAILABILITY CALL: JAO (213) 699-7411 EXT. 499

 BEGIN DATA ENTRY
/     31,181
/     33,6
/     42,<2
/     43,<2
/     EOD/

TRANSACTION COMPLETE-- DATA STORED
```

EXAMPLE OF PRINTOUT OF
AN UPDATE TRANSACTION

FIGURE 50

```
   WRPDMS,STORE,06/14/75

LACSD WRP DATA MANAGEMENT SYSTEM
FOR SYSTEM AVAILABILITY CALL: JAO (213) 699-7411 EXT. 499

 BEGIN DATA ENTRY
/     1,1.78
/     2,2.35
/     3,.8
/     4,0
/     5,6.62
/     6,1.78
/     10,344
/     11,172
/     12,108
/     14,13
/     23,715
/     24,484
/     29,63
/     30,46
/     42,<2
/     50,2.9
/     52,7.1
/     58,27
/     60,14
/     61,E
/     62,E
/     72,6.5
/     75,2.5
/     77,<.1
/     83,78
/     93,7638
/     94,0
/     95,0
/     96,0
/     104,5801
/     105,2605
/     104,5393
/     105,2447
/     106,1917
/     108,.8
/     109,.235
/     110,1.1
/     111,.1
/     112,0
/     113,100
/     114,0
/     116,350
/     117,2658
/     118,132
/     119,83
/     120,E
/     121,E
/     122,E
/     123,E
/     143,.0042
/     144,3.23
/     147,0
/     160,0
/     161,.0042
/     163,0
/     164,7.45
/     165,3800
/     166,20
/     167,96
/     170,0
/     172,0
/     176,0
/     177,0
/     178,0
/     EOD/

TRANSACTION COMPLETE-- DATA STORED
```

FIGURE 51 TYPICAL STORE PRINTOUT

Loading Calculations - Table 7 lists the formulas used in calculation of the following COD and Process Air Loading Parameters.

1. Total Mass of COD Applied to the Aeration System Per Day - The units calculated are lbs/day. To convert to the metric units of kg/day multiply by 0.4536.
2. Total Mass of COD Applied Each Day to the Total Mass of Volatile Suspended Solids in the Secondary Treatment System - The Calculated units are lbs COD/lb TPVSS/day. The metric units of kg COD/kg TPVSS/day are identical.
3. Total Mass of COD Applied Each Day to the Mass of Volatile Suspended Solids in the Mixed Liquor in the Secondary Treatment System - The calculated units are lbs COD/lbs MLVSS/day. Again, metric units of kg COD/kg MLVSS/day are identical numbers.
4. Cubic Feet of Air Applied per Gallon of Measured Flow Per Day - To convert to the metric units of m^3 of air/m^3 of flow multiply by 7.48.
5. Cubic Feet of Air Applied per Unit of Mass of COD Removed in the Secondary Treatment System - The calculated units are ft^3/lb COD. To convert to the metric units of m^3/kg COD multiply by 0.0624.

Solids Calculations - Table 8 lists the formulas used in the calculation of the following solids parameters:

1. Total Mass of Suspended Solids in the Aeration System - The calculated units are lbs. To convert to kg multiply by 0.4536.
2. Total Mass of Suspended Solids in the Mixed Liquor Portion of the Aeration System - The Sanitation District's activated sludge treatment plants employ the step-feed process, wherein primary effluent is introduced at several points along the aeration system. There is thus a continual variation in suspended solids ranging from that of undiluted return sludge at the upstream end of the aeration system, to complete mixed liquor at the furthest downstream portion of the system.

Table 7. LOADING CALCULATIONS FORMULAS

AERATION SYSTEM LOAD - (COD LOAD)

$$(ASL) = (PECOD_T)(Q_p)(8.34)$$

where:

ASL = Aeration system load, lbs/day

$PECOD_T$ = Primary effluent COD, total, mg/l

Q_p = Total plant flow, mgd

8.34 = lbs/M.G. per mg/l

TOTAL PLANT LOADING

$$(TPL) = \frac{(ASL)}{(TPSS)(PV)/(100,\%)}$$

where:

TPL = Total plant loading, lbs COD/lb TPVSS/day

ASL = Aeration system load, lbs/day

TPSS = Total plant suspended solids, lbs

PV = Percent volatile suspended solids, %

MIXED LIQUOR LOADING

$$(MLL) = \frac{(ASL)}{(MLSS)(PV)/(100,\%)}$$

where:

MLL = Mixed liquor loading, lbs COD/lb MLVSS/day

ASL = Aeration system load, lbs/day

MLSS = Mixed liquor suspended solids, lbs

PV = Percent volatile suspended solids, %

AIR RATE (AIR RATIO)

$$(AR) = \frac{(Q_a)}{(Q_p)}$$

where:

AR = Air rate, ft^3/gal

Q_a = Process air flow, mcf/day

Q_p = Total plant flow, mgd

AIR RATE

$$(AR) = \frac{(Q_a)(10^6)}{(PECOD_T - SECOD_S)(Q_p)(8.34)}$$

where:

AR = Air rate, ft^3/lb COD removed

Q_a = Process air flow, mcf/day

Q_p = Total plant flow, mgd

$PECOD_T$ = Primary effluent COD, total, mg/l

$SECOD_S$ = Secondary effluent COD, soluble, mg/l

8.34 = lbs/M.G. per mg/l

10^6 = ft^3/million ft^3

Table 8. SOLIDS CALCULATIONS FORMULAS

TOTAL AERATION SOLIDS

$$(TAS) = \frac{(SS_1 + SS_2 + \ldots SS_{NT})(TAV)(8.34)}{NT}$$

where:

TAS	=	Total aeration solids, lbs
SS_i	=	Suspended solids in tank or pass i, i=1 to NT, mg/l
TAV	=	Total tank volume of aeration system, MG
NT	=	Number of tanks or passes in aeration system
8.34	=	lbs/MG per mg/l

MIXED LIQUOR SUSPENDED SOLIDS

$$(MLSS) = [(SS_i)(TLxi-RSAL)/(TL)+(SS_{i+1}+\ldots SS_{NT})](AV)(8.34)$$

where:

$$(RSAL) = \frac{(RSAV)(10^6)}{(XS)\ (7.48)}$$

and:

MLSS	=	Mixed liquor suspended solids, lbs
SS	=	Suspended solids in tank or pass, mg/l
TL	=	Aeration tank length, ft
i	=	Tank or pass number in which centroid of loading is located
RSAL	=	Return sludge aeration length, ft
NT	=	Total number of tanks or passes in aeration system
AV	=	Aeration tank volume, MG
RSAV	=	Return sludge aeration volume, MG
XS	=	Aeration tank cross-section area, ft^2
8.34	=	lbs/MG per mg/l
7.48	=	$gallons/ft^3$
10^6	=	gallons/M.G.

Table 8 (continued). SOLIDS CALCULATIONS FORMULAS

SECONDARY EFFLUENT SUSPENDED SOLIDS MASS EMISSION RATE

$$(SESSMER) = (SESS)(Q_p)(8.34)$$

where:

SESSMER	=	Secondary effluent suspended solids mass emission rate, lbs/day
SESS	=	Secondary effluent suspended solids, mg/l
Q_p	=	Total plant flow, mgd
8.34	=	lbs/M.G. per mg/l

TOTAL PLANT SUSPENDED SOLIDS

$$(TPSS) = (TAS)+(SS_f)(VOL_f)(8.34)$$

where:

TPSS	=	Total plant suspended solids, lbs
TAS	=	Total aeration solids, lbs
VOL_f	=	Volume of final sedimentation tanks in service, M.G.
8.34	=	lbs/M.G. per mg/l
SS_f	=	Suspended solids concentration at end of final aeration tank, mg/l

WASTED SUSPENDED SOLIDS

$$(WSS) = (RSSS)(Q_w)(8.34)$$

where:

WSS	=	Wasted suspended solids, lbs/day
RSSS	=	Return sludge suspended solids, mg/l
Q_w	=	Total waste activated sludge flow, mgd
8.34	=	lbs/M.G. per mg/l

Table 8 (continued). SOLIDS CALCULATIONS FORMULAS

DAILY NET GROWTH

$$(DNG) = (TPSS)-(PTPSS)+(WSS)+(SESS)$$

where:

DNG = Daily net growth, lbs/day

TPSS = Total plant suspended solids, lbs/day

PTPSS = Previous day's total plant suspended solids, lbs/day

WSS = Wasted suspended solids, lbs/day

SESS = Secondary effluent suspended solids, lbs/day

AVERAGE NET GROWTH

$$(ANG) = \frac{(AQ_w)(ARSS)+(AQ_p)(ASESS)}{(ATAS)(AV)+(ASSEF)(AFNLS)(FV)}$$

where:

ANG = Average net growth, lbs growth/lbs system solids/day

AQ_w = Average waste activated sludge flow, mgd

ARSSS = Average return sludge suspended solids, mg/l

AQ_p = Average total plant flow, mgd

ASESS = Average secondary effluent suspended solids, mg/l

ATAS = Average total aeration solids, mg/l

AV = Aeration tank volume, M.G.

ASSEF = Average suspended solids effluent to finals, mg/l

AFNLS = Average number of finals in service

FV = Final sedimentation tank volume, M.G.

To classify the aeration into two components, return sludge aeration and mixed liquor aeration, the concept of Centroid of Loading is used. The centroid of loading is that hypothetical point in the aeration system which, if all primary effluent were introduced there, would be equivalent to the step feed pattern used. The total mass of suspended solids in the mixed liquor, then is calculated as those suspended solids downstream of the centroid of loading. The calculated units are lbs. To convert to metric units of kg multiply by 0.4536.

3. Total Mass of Suspended Solids in the Entire Secondary Treatment System Including Aeration Tanks and Final Clarifiers - This parameter is called Total Plant Suspended Solids and the units are lbs. To convert to the metric units of kg multiply by 0.4536.
4. Total Mass of Activated Sludge Intentionally Wasted from the Treatment System Each Day - The calculated units are lbs/day. To convert to kg/day multiply by 0.4536.
5. Total Mass of Suspended Solids Discharged Each Day in the Treated Effluent - The calculated units are lbs/day. To convert to kg/day multiply by 0.4536.
6. Daily Net Growth - This calculation is a mass balance on the suspended solids in the aeration system, and represents the mass of suspended solids grown in the treatment system each day. This calculation can yield a negative result. The calculated units are lbs/day. To convert to kg/day multiply by 0.4536.
7. Average Net Growth - The theory of biological reactors and the equations derived therefrom in Section VIII are based on the assumption that the biological reactor is in a steady state of operation. In reality, however, this is many times not the case. Thus, it is that from day to day there can be significant changes in the Daily Net Growth and Daily Cell Residence Time (to be discussed in the next section). To overcome these short-term fluctuations, which disappear if

data are averaged over a long period of time, the concept of average net growth was developed. The average net growth is calculated using the average of all necessary parameters over the period of time equal to the previous days' cell residence time. However, there are minimum and maximum time limits to this averaging period of 7 and 15 days respectively. These are necessary to insure that sufficient number of days of data are being averaged to smooth out the fluctuations and, for the other limit,to prevent the computer from averaging an excessive number of days which would make the results meaningless and restrict other computer usage for an excessive period of time. The units calculated are pounds of growth per day per pound of system solids, or $days^{-1}$.

Aeration Time Calculations - Table 9 lists the formulas used in the calculation of the following aeration time parameters:

1. Return Sludge Hydraulic Aeration Time - This parameter is the reaeration time the concentrated return sludge receives in the aeration system upstream of any introduction of primary effluent. It is calculated using the assumption that 20 feet (6.1 meters) upstream of the first feed gate, the aeration system is essentially undiluted return sludge. Note that for all treatment plants it is not possible to calculate this parameter, for the first feed gate is within 20 feet of the furthest upstream end of the aeration system. The calculated units are hours.
2. Mixed Liquor Hydraulic Aeration Time - This parameter is calculated using the assumption that all primary effluent and all return sludge are introduced at the most upstream end of the aeration system. The calculated detention time is the maximum that could occur, for it assumes a plug flow reactor whereas the step feed process simulates a series of complete mix reactors. The calculated units are hours.
3. Return Sludge Centroidal Aeration Time - This parameter is the aeration time upstream of the hypothetical point of centroidal loading. The calculated units are hours.

Table 9. AERATION TIME CALCULATIONS FORMULAS

RETURN SLUDGE AERATION TIME (HYDRAULICS)

$$(HRSAT) = \frac{(24)(HRSAV)}{(RAS)}$$

where:

$$(HRSAV) = \frac{(XS)(FG1-20)}{(133700)}$$

and:

HRSAT	=	Return sludge aeration time, hrs
HRSAV	=	Hydraulic return sludge aeration volume, M.G. (if HRSAV $\leq$=0, HRSAT=0)
RAS	=	Return activated sludge flow, mgd
XS	=	Aeration tank cross - section area, ft^2
FG1	=	Distance from upstream end of aeration system to first feed gate location, ft
24	=	hours/day
133700	=	ft^3/M.G.

MIXED LIQUOR AERATION TIME (HYDRAULIC)

$$(HMLAT) = \frac{(HRSAV)\ (24)}{(Q_p)/NS + (RAS)}$$

where:

HMLAT	=	Mixed liquor aeration time, hrs
HRSAV	=	Hydraulic return sludge aeration volume, M.G.
Q_p	=	Total plant flow, mgd
NS	=	Number of aeration systems in operation
RAS	=	Return activated sludge flow, mgd
24	=	hours/day

Table 9 (continued). AERATION TIME CALCULATIONS FORMULAS

RETURN SLUDGE AERATION TIME (CENTROIDAL)

$$(CRSAT) = \frac{(RSAV)\ (24)}{(Q_r)}$$

where:

CRSAT = Return sludge aeration time, hrs

RSAV = Return sludge aeration volume, M.G.

Q_r = Return activated sludge flow, mgd

24 = hours/day

MIXED LIQUOR AERATION TIME (CENTROIDAL)

$$(CMLAT) = \frac{(TAV - RSAV)\ (24)}{(Q_p)/NS + (Q_r)}$$

where:

CMLAT = Mixed liquor aeration time, hrs

TAV = Total tank volume of aeration system, M.G.

RSAV = Return sludge aeration volume, M.G.

Q_p = Total plant flow, mgd

Q_r = Return activated sludge flow, mgd

NS = Number of aeration systems in operation

24 = hours/day

4. Mixed Liquor Centroidal Aeration Time - This parameter is the aeration time downstream of the hypothetical point of centroidal loading. The calculated units are hours.

Cell Residence Time Calculations - Table 10 lists the formulas used in the calculation of the following parameters:

1. Daily Cell Residence Time - As explained in Section VIII, the mean cell residence time of a biological reactor at steady state is calculated using the assumption that the mass of organisms grown per day equals the sum of mass of organisms intentionally wasted per day from the return sludge line and those organisms unintentionally wasted in the secondary effluent.

2. Average Cell Residence Time - This parameter is the reciperocal of the Average Net Growth. As previously explained, it represents the average of appropriate data over a period of time ranging from 7 to 15 days.

3. Waste Activated Sludge Rate to Maintain Desired Cell Residence Time Using Daily Data - The formula used in this calculation is derived from equation (3) of Section VIII, using the assumption that the mass of cells grown per day equals the solids discharged in effluent and wasted from the return sludge line. Obviously, with daily fluctuations in plant performance, this particular waste rate may be inappropriate. The calculated units are mgd. To convert to m^3/day multiply by 3785.

4. Waste Activated Sludge Rate to Maintain Desired Cell Residence Time Using Average Data - This calculation is based on the average of data over the same period used

Table 10. CELL RESIDENCE TIME CALCULATIONS FORMULAS

AVERAGE CELL RESIDENCE TIME

$$(ACRT) = \frac{1}{(ANG)}$$

where:

ACRT = Average cell residence time, days

ANG = Average net growth, lbs growth/day/lb system solids

DAILY CELL RESIDENCE TIME

$$(DCRT) = \frac{(TPSS)}{(SESS)+(WSS)}$$

where:

DCRT = Daily cell residence time, days

TPSS = Total plant suspended solids, lbs

SESS = Secondary effluent suspended solids, lbs/day

WSS = Wasted suspended solids, lbs/day

Table 10 (continued). CELL RESIDENCE TIME CALCULATIONS FORMULAS

DAILY WASTE RATE FOR DESIRED CRT

$$(DWR) = \frac{(TAS)(AV)+(SSEF)(FNLS)(FV)-(DSCRT)(Q_p)(SESS)}{(DSCRT)(RSS)}$$

where:

DWR	=	Daily waste rate, mgd
TAS	=	Total plant aeration solids, mg/l
AV	=	Aeration tank volume, mg
SSEF	=	Suspended solids effluent to finals, mg/l
FNLS	=	Number of finals in service
FV	=	Final sedimentation tank volume, mg
DSCRT	=	Desired cell residence time, days
Q_p	=	Total plant flow, mgd
SESS	=	Secondary effluent suspended solids, mg/l
RSSS	=	Return sludge suspended solids, mg/l

AVERAGE WASTE FLOW FOR DESIRED CRT

$$(AWF) = \frac{(ATAS)(AV)+(ASSEF)(AFNLS)(FV)-(DSCRT)(AQ_p)(ASESS)}{(DSCRT)(ARSSS)}$$

where:

AWF	=	Average waste flow for desired CRT, mgd
ATAS	=	Average total aeration solids, mg/l
AV	=	Aeration tank volume, mg
ASSEF	=	Average suspended solids effluent to finals, mg/l
AFNLS	=	Average number of finals in service
FV	=	Final sedimentation tank volume, mg
DSCRT	=	Desired cell residence time, days
AQ_p	=	Average total plant flow, mgd
ASESS	=	Average secondary effluent suspended solids, mg/l
ARSSS	=	Average return sludge suspended solids, mg/l

to calculate the Average Cell Residence Time. This value is less affected by short-term fluctuations and is, therefore, a more appropriate waste sludge rate to use. Obviously, if the biological treatment system has been operating in a state of steady state for some time, this calculation should agree closely with the one derived from daily data only. The calculated units are mgd. To convert to m^3/day multiply by 3785.

Solids Handling Calculations

The District 26 Water Renovation Plant and the District 32 Water Renovation Plant both process solids, generated in the primary and secondary treatment processes, by a combination of thickening and anaerobic digestion. To better understand the operational calculations used to monitor and control these processes the following description of these processes is presented.

Figure 52 presents a schematic flow diagram of the thickening and digestion processes. Raw sludge from the hoppers of the primary sedimentation tanks is of sufficient thickness to be fed directly to the anaerobic digester. However, the waste activated sludges require treatment to increase solids content prior to digestion. At the District 26 Water Renovation Plant centrifuges are used for this purpose, while at the District 32 Water Renovation Plant dissolved air flotation units are utilized. The combination of the two sludges is fed into the first of a series of two digesters. This first digester is referred to as the primary digester and employs gas recirculation to maintain a complete mix state. It is in the primary digester where the major portion of the anaerobic stabilization of the solids occurs. The effluent from the primary digester flows into the second of the series of digesters, referred to as the secondary digester. This latter digester is not mixed or heated. Solids settle to the bottom, while the supernatant

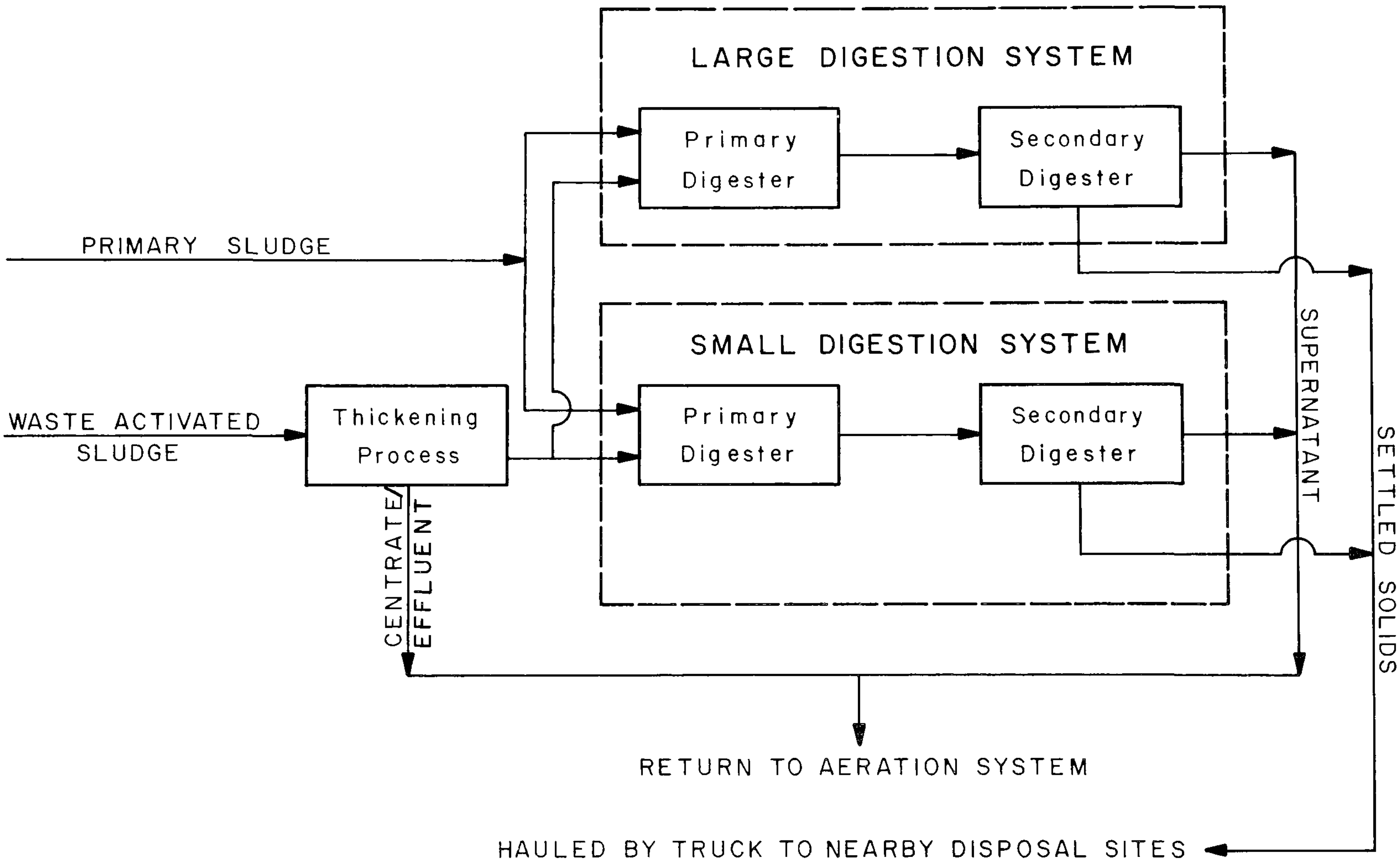

FIGURE 52 SCHEMATIC FLOW DIAGRAM OF THICKENING AND ANAEROBIC DIGESTION PROCESS AT THE DISTRICT 26 & 32 WRPs

is returned to the aeration system of the activated sludge process. Daily monitoring of the solids content of this latter supernatant is maintained. When supernatant solids concentrations reach 0.5%, the solids which have settled in the secondary digester are removed and trucked to nearby farm land for tilling into the soil. Both the District 26 Water Renovation Plant and the District 32 Water Renovation Plant have two of these digestion systems, each consisting of the series of two digester tanks. The two systems at each plant are referred to as "Small Digestion System" and "Large Digestion System."

Several deviations from the above mentioned flow pattern can be implemented. Each plant also has the capability to feed primary sludge and/or thickened waste activated sludge directly into the secondary digester.

The computer transaction which performs the Solids Handling Calculations is called DIGEST. It can be executed as a separate transaction, or provisions are available to make it an extension of the CALCS or STORE/RECALC transactions. Whichever method of execution is used, the process consists of entering appropriate data and then performing pertinent calculations. Table 11 lists the formulas used in these calculations. Each is briefly discussed below.

1. Total Raw Sludge Flow - This is the total flow of sludge put into the digesters each day. Note that under normal operating conditions all raw sludge is fed into the primary digester, and hence, the second term of the equation is normally zero. The units are million of gallons per day. To convert to cubic meters per day multiply by 3785.

2. Raw Solids Loading-Individual Digesters - This represents the total mass of raw sludge, including volatile and inert solids, loaded into either the primary or secondary digester each day. The calculated units are lbs/day. To

convert to kg/day multiply by 0.4536.

3. Total Raw Solids Loading-All Digesters - This is the sum of the individual loadings calculated above. The units are identical as above.

4. Total Dewatered Waste Activated Sludge Flow - This is the volume of thickened waste activated sludge fed to the digesters each day. Again, under normal conditions, no flow would go to the secondary digesters. The calculated units are mgd. To convert to m^3/day multiply by 3785.

5. Dewatered Waste Activated Sludge Solids Loading-Individual Digester - This is the mass of total solids fed to either the primary or secondary digester each day. The units are lbs/day. To convert to kg/day multiply by 0.4536.

6. Total Dewatered Waste Activated Sludge Solids Loading - This is the sum of the above calculations made for both digesters

7. Centrifuge/Air Flotation Unit Solids Loading - This calculation gives the mass loading rate of the particular sludge thickening process. The calculated units are lbs/hour. To convert to pounds per day multiply by 24. To convert to kg/day multiply by 10.89. To convert to kg/hour multiply by 0.4536.

8. Centrifuge/Air Flotation Unit Solids Recovery - This is the percentage of the suspended solids in the unthickened waste activated sludge which end up in the flow to the digesters.

9. Primary Digester Volatile Solids Loading - This calculation gives the mass of volatile solids loaded into the primary digester per day per unit of volume of digester capacity. As most of the digestion occurs only in the primary digester, no similar calculation is made for the secondary digester. The calculated units are pounds of volatile solids per day per cubic foot of digester volume. To convert to the

Table 11. SOLIDS HANDLING CALCULATIONS

TOTAL RAW SLUDGE FLOW

(TRSF) = (RSRSF)+(SDRSF)

where:

TRSF	=	Total raw sludge flow, mgd
PDRSF	=	Primary digester raw sludge flow, mgd
SDRSF	=	Secondary digester raw sludge flow, mgd

RAW SOLIDS LOADING INVIDIVUAL DIGESTERS

(RSL) = (RSF)(TS)(8.34)(10^4)

where:

RSL	=	Raw sludge loading, lbs total solids/day
RSF	=	Raw sludge flow, mgd
TS	=	Total solids content of raw sludge, %
8.34	=	lbs/M.G./ppm
10^4	=	ppm/%

TOTAL RAW SOLIDS LOADING - ALL DIGESTERS

(TRSL) = (PDRSL)+(SDRSL)

where:

TRSL	=	Total raw solids loading, lbs TS/day
PDRSL	=	Primary digester raw solids loading, lbs TS/day
SDRSL	=	Secondary digester raw solids loading, lbs TS/day

Table 11 (continued). SOLIDS HANDLING CALCULATIONS

TOTAL DEWATERED WASTE ACTIVATED SLUDGE FLOW

(TDWASF) = (PDWASF)+(SDWASF)

where:

TDWASF	=	Total dewatered waste activated sludge flow, mgd
PDWASF	=	Primary digester waste activated sludge flow, mgd
SDWASF	=	Secondary digester waste activated sludge flow, mgd

DEWATERED WASTE ACTIVATED SLUDGE SOLIDS LOADING - INDIVIDUAL DIGESTER

(DWASSL) = (DWASF)(TS)(8.34)(10^4)

where:

DWASSL	=	Dewatered waste activated sludge solids loading, lbs/day
DWASF	=	Dewatered waste activated flow, mgd
TS	=	Total solids, %
8.34	=	lbs/M.G./ppm
10^4	=	ppm/%

TOTAL DEWATERED WASTE ACTIVATED SLUDGE SOLIDS LOADING

(TDWASSL) = (PDDWASSL)+(SDDWASSL)

where:

TDWASSL = Total dewatered waste activated sludge solids loading, lbs TS/day

TDDWASSL = Primary digester dewatered waste activated sludge solids loading, lbs TS/day

SDDWASSL = Secondary digester dewatered waste activated sludge solids loading, lbs TS/day

CENTRIFUGE/AIR FLOATATION UNIT SOLIDS LOADING

$$(CASL) = \frac{(WASF)(TS)(8.34)(10^4)}{(TIO)}$$

where:

CASL = Centrifuge/air floatation unit solids loading, lbs/hr

WASF = Waste activated sludge flow, M.G.

TS = Total solids, waste activated sludge, %

TIO = Time in operation, hours

8.34 = lbs/M.G./ppm

10^4 = ppm/%

CENTRIFUGE/AIR FLOATION UNIT SOLIDS RECOVERY

$$(CASR) = \frac{(CTS)[(WASTS)-(TS)](100)}{(WASTS)[(CTS)-(TS)]}$$

where:

CASR = Centrifuge/air floation unit solids recovery, %

CTS = Cake total solids content, %

WASTS = Waste activated sludge total solids content, %

TS = Centrate or underflow total solids content, %

PRIMARY DIGESTER VOLATILE SOLIDS LOADING

$$(SL) = \frac{(RSL)(VS)+(DWASSL)(VS)}{(PDV)(1.34\times10^5)}$$

where:

SL = Solids loading, lbs VS/day/ft^3

RSL = Raw solids loading, lbs TS/day

VS = Corresponding volatile solids content, %

DWASSL = Dewatered waste activated sludge solids loading, lbs TS/day

PDV = Primary digester volume, M.G.

1.34×10^5 = ft^3/M.G.

Table 11 (continued). SOLIDS HANDLING CALCULATIONS

HYDRAULIC DETENTION TIME (Primary Digester)

$$(PHDT) = \frac{(PDV)}{(PDRSF)+(PDWASF)}$$

where:

PHDT = Primary digester hydraulic detention time, days

PDV = Primary digester volume, M.G.

PDRSF = Primary digester raw sludge flow, mgd

PDWASF = Primary digester dewatered waste activated sludge flow, mgd

VOLATILE SOLIDS DESTRUCTION

$$(VSD) = \frac{(VOLI)-(EVS)(10^{-2})}{(VOLI)-(VOLI)(EVS)(10^{-2})}$$

where: $$(VOLI) = \frac{[(PDRSF)(RSPV)+(PDWASF)(WASPV)]10^{-2}}{(PDRSF+WASF)}$$

and

VSD = Volatile solids destruction, %

VOLI = Volatile solids influent to digester, %

PDRSF = Primary digester raw sludge flow, mgd

RSPV = Raw sludge volatile content, %

PDWASF = Primary digester waste activated sludge flow, mgd

WASPV = Waste activated sludge volatile content, %

EVS = Primary digester effluent volatile content, %

10^{-2} = Conversion from percent to decimal

Table 11 (continued). SOLIDS HANDLING CALCULATIONS

VOLATILE MATTER DESTROYED

$$(VMD) = \frac{(SL)(VSD)(1000)}{(100)}$$

where:

VMD	=	Volatile matter destroyed, lbs VS/day/$10^3 ft^3$
SL	=	Solids loading, lbs VS/day/ft^3
VSD	=	Volatile solids destruction, %
1000	=	Ft^3/thousand ft^3
100	=	Conversion from %

GAS PRODUCTION

$$(GP) = \frac{(GF)(10^6)(1000)}{(VMD)(PDV)(1.34x10^5)}$$

where:

GP	=	Gas production, ft^3/lb VMD
GF	=	Gas flow, MCF
VMD	=	Volatile matter destroyed, lbs VS/day$10^3 ft^3$
PDV	=	Primary digester volume, M.G.
10^6	=	ft^3/MCF
1000	=	ft^3/thousand ft
$1.34x10^5$	-	ft^3/M.G.

HYDRAULIC DETENTION TIME (Secondary Digester)

$$(SHDT) = \frac{(SDV)}{(PDRSF)+(PDWASF)+(SDRS)+(SDWASF)}$$

where:

SHDT	=	Secondary digester hydraulic detention time, days
SDV	=	Secondary digester volume, M.G.
PDRSF	=	Primary digester raw sludge flow, mgd
PDWASF	=	Primary digester waste activated sludge flow, mgd
SDRSF	=	Secondary digester raw sludge flow, mgd
SDWASF	=	Secondary digester dewatered waste, mgd activated sludge flow, mgd

SOLIDS HAULED

$$(SH) = (HSF)(HSTS)(8.34)(10^4)$$

where:

SH	=	Solids hauled, lbs/day
HSF	=	Hauled sludge flow, mgd
HSTS	=	Hauled sludge total solids content, %
8.34	=	lbs/M.G./ppm
10^4	=	ppm/%

VOLATILE SOLIDS HAULED

$$(VSH) = \frac{(SH)(HSVS)}{(100)}$$

where:

VSH	=	Volatile solids hauled, lbs/day
SH	=	Solids hauled, lbs/day
HSVS	=	Hauled sludge volatile solids content, %
100	=	Conversion from %

metric units of kilograms of volatile solids per day per cubic meter multiply by 16.02.

10. Hydraulic Detention Time in Primary Digester - This gives the average detention time assuming a complete mix system. The calculated units are days.

11. Volatile Solids Destruction - This gives the percentage of volatile solids destroyed in the primary digester.

12. Volatile Matter Destroyed - This gives the mass of volatile matter destroyed each day per thousand units of digester volume. The units are pounds per day per 1,000 cubic feet. To convert to the metric units of kilograms of volatile solids per day per cubic meter multiply by 0.01602.

13. Gas Production in Primary Digester - This is the volume of gas produced per unit mass of volatile matter destroyed. The units are cubic feet per pound of volatile matter destroyed. To convert to metric units of cubic meters per kilogram of volatile solids destroyed multiply by 0.06243.

14. Hydraulic Detention Time in Secondary Digester - This gives a theoretical average detention time in the secondary digester assuming the unit is completely mixed which it is not. The calculated units are days.

15. Solids Hauled from Plant - This represents the mass per day of solids hauled by truck to the farm land for tilling. The units are lbs/day. To convert to kg/day multiply by 0.4536.

16. Volatile Solids Hauled from Plant - This is the mass of volatile solids hauled from the plant each day. Again, the units are lbs/day. To convert to kg/day multiply by 0.4536.

Effluent Compliance Calculations

Each of the activated sludge treatment plants operated by the

Sanitation Districts has two independent sets of effluent discharge requirements established by the Regional Water Quality Control Board, the state regulatory agency which establishes and enforces discharge requirements in California. One set of requirements at each plant governs the discharge into navigable waters and tributaries thereto, and hence is regulated by discharge criteria promulgated in PL92-500, the 1972 Amendments to the Federal Water Pollution Control Act. These discharge requirements are contained in the National Pollutant Discharge Elimination System (NPDES) permit issued for each plant, and are referred to in this report as NPDES requirements. The other set of requirements for each plant are those issued by the Regional Water Quality Control Board under criteria promulgated in the California Water Code to govern those discharges of effluent which involve or result in a reuse of the effluent. For this report these discharge requirements are referred to as REUSE requirements and all calculations associated therewith are referred to as REUSE calculations.

The calculations involved in the evaluation of compliance to discharge requirements are part of the routine in the CALCS and the RECALC transactions. There is a transaction which will produce the report only. It is called EFFCMP (for EFFluent CoMPliance). Shown in Figure 53 is the printout of a typical EFFCMP report. Note that the calculations are divided into three groups: those involving data specifically for the day in question, those involving data averaged over the latest 7-day period, and those involving data averaged over the latest 30-day period. Each is discussed below.

<u>Daily Calculations</u> - Table 12 lists the formulas used to calculate these daily parameters. Note, however, in Figure 53, that the concentration data listed for the various parameters are input data, not calculated values. The mass emission rates listed are based on the flow to either NPDES discharge or to REUSE discharge and may not be based on total plant flow.

```
   WRPDMS,EFFCMP,05/01/75

LACSD WRP DATA MANAGEMENT SYSTEM
FOR SYSTEM AVAILABILITY CALL: JAO (213) 699-7411 EXT. 499
  WQCB COMPLIANCE CALCS NOW IN PROGRESS

  NO PLANT EFFLUENT COMPLIANCE VIOLATIONS


SAN JOSE CREEK WRP      WQCB COMPLIANCE CALCULATIONS    DATE:  5/ 1/75

                             NPDES REUSE                       NPDES REUSE

DAILY VALUES
-------------
FLOW                05/01                 TURBIDITY          05/01
    MG **                   15.4    9.8    1 CONC, TU               3.0    3.0
SUSPENDED SOLIDS    05/01                 BOD(5-DAY)         05/01
  2 CONC, MG/L **              9      9    4 CONC, MG/L **           12     12
  3 MER, LBS/DAY            1156    739    5 MER, LBS/DAY          1541    985
TDS(180 DEG)        05/01                 TOTAL NITROGEN
  6 CONC, MG/L **            654    654    8 CONC, MG/L
  7 MER, KLBS/DAY *                  54    9 MER, LBS/DAY
OIL & GREASE        05/01                 CHLORIDE
 10 CONC, MG/L             < 1.0          12 CONC, MG/L *
 11 MER, LBS/DAY           < 128          13 MER, KLBS/DAY *
SULFATE                                   SULFATE+CHLORIDE
 14 CONC, MG/L *                          16 CONC, MG/L *
 15 MER, KLBS/DAY *                       17 MER, KLBS/DAY *
SETTLEABLE SOLIDS 05/01                   DETERGENTS
 18 CONC, ML/L             <   .1 <   .1  19 CONC, MG/L **

7-DAY VALUES
-------------
SUSPENDED SOLIDS    05/01                 BOD(5-DAY)         05/01
 20 CONC, MG/L                10          22 CONC, MG/L               9
 21 MER, LBS/DAY            1490          23 MER, LBS/DAY          1289
TOTAL COLIFORM      05/01                 FECAL COLIFORM     05/01
 24 MEDIAN, MPN/100 ML         2      2   25 G.M., MPN/100 ML  <    3

30-DAY VALUES
-------------
SUSPENDED SOLIDS    05/01                 BOD(5-DAY)         05/01
 26 CONC, MG/L                 6     10   29 CONC, MG/L               5      9
 27 MER, LBS/DAY            1063    873   30 MER, LBS/DAY           863    830
 28 REMOVAL, %              98.5          31 REMOVAL, %            98.4
OIL & GREASE        05/01                 TOTAL NITROGEN     05/01
 32 CONC, MG/L             < 1.1          34 CONC, MG/L            15.4
 33 MER, LBS/DAY           < 204          35 MER, LBS/DAY          2729
SETTLEABLE SOLIDS 05/01                   FECAL COLIFORM     05/01
 36 CONC, ML/L             <   .1 <   .1  37 G.M., MPN/100 ML  <    3


 * NPDES VALUE APPLIES TO DISCHARGE TO UNLINED RIVERS ONLY
** NPDES VALUE HAS NO NPDES MAXIMUM LIMIT
```

PRINTOUT OF A TYPICAL EFFCMP TRANSACTION

FIGURE 53

Table 12. EFFLUENT COMPLIANCE DAILY CALCULATIONS FORMULAS

DAILY MASS EMISSION RATES (Suspended Solids, BOD, Total Nitrogen, TDS, Chloride, Sulfate, Chloride plus Sulfate

(MER)	=	(CONC)(DISCH)(8.34) for CONC>0 & DISCH>0

where:

MER	=	Mass emission rate of particular parameter, lbs/day
CONC	=	Concentration of particular parameter, mg/l
DISCH	=	NPDES discharge for 'navigable water & tributaries' (NPDES) calculation, mgd
DISCH	=	REUSE discharge for 'allowable reuse' calculation, mgd
8.34	=	lbs/M.G./mg/l

FINAL EFFLUENT OIL & GREASE MASS EMISSION RATE

(OGMER)	=	(FEOG)(NPDES)(8.34) for FEOG>0, NPDES>0

where:

OGMER	=	Final effluent oil & grease mass emission rate, lbs/day
FEOG	=	Final effluent oil & grease concentration, mg/l
NPDES	=	NPDES discharge, mgd
8.34	=	lbs/M.G. per mg/l

Table 12 (continued). EFFLUENT COMPLIANCE DAILY CALCULATIONS FORMULAS

FINAL EFFLUENT TOTAL NITROGEN

(TN) = (ORG)+(NH3)+(NO2)+(NO3)
for ORG>0 & NH3>0 & NO2>0 & NO3>0

where:

TN	=	Final effluent total nitrogen (as N), mg/l
ORG	=	Final effluent organic nitrogen, mg/l
NO3	=	Final effluent NH_3-N, mg/l
NO2	=	Final effluent NO_2-N, mg/l
NO3	=	Final effluent NO_3-N, mg/l

FINAL EFFLUENT TOTAL NITROGEN MASS EMISSION RATE

(TNMER) = (TN)(DISCH)(8.34)
for TN>0

where:

TNMER	=	Final effluent total nitrogen mass emission rate, lbs/day
TN	=	Final effluent total nitrogen concentration, mg/l
DISCH	=	NPDES discharge for 'navigable water & tributaries' (NPDES) calculation, mgd
DISCH	=	REUSE discharge for 'allowable reuse' calculation, mgd
8.34	=	lbs/M.G. per mg/l

Seven Day Average Calculations - Table 13 lists those formulas used in these calculations. The seven-day arithmetic and geometric means are required for evaluation of NPDES discharge only, not REUSE discharges. Thus, in Figure 53 these particular parameters are not listed in the REUSE column even though there was REUSE flow for that day. The seven-day median total coliform calculations are required for both types of discharge and are thus shown in both columns.

Thirty Day Average Calculations - Table 14 lists the formulas used in these calculations. Again, some of the parameters are required for NPDES discharges only, and, hence, the results of calculations are not listed in the REUSE column.

In addition to calculation of the above parameters, the results are automatically compared to the discharge limits established for each facility. Figure 54 illustrates these limits which are stored in the computer for one of the treatment plants. A similar list exists for the other six facilities. This printout of limits is not included as part of the on-line printouts, but is rather a part of the System Management Programs to be discussed below. As an example of how the operator is informed of violations of limits, the data for one of the treatment plants were deliberately altered to cause all of these limits to be exceeded. Figure 55 illustrates the message which preceeds every EFFCMP printout if there are violations of effluent discharge standards. If there were no violations of effluent discharge standards, this fact too would be printed at the start of each EFFCMP printout.

Reports

Figure 56 illustrates the portion of the daily report transmitted to the operator listing the summary of operational data. The report which lists the effluent compliance calculations was shown in Figure 53. Shown in Figure 57 is the additional report obtained at the two facilities which have solids

Table 13. EFFLUENT COMPLIANCE 7-DAY AVERAGE CALCULATIONS FORMULAS

FINAL EFFLUENT SUSPENDED SOLIDS 7 DAY-MEAN

$$(SS7) = \frac{[\sum_{i=1}^{7}(FESS_i)]}{N}$$

for $FESS_i>0$ & $NPDES_i>0$, $N>2$, $NPDES_7>0$

where:

SS7	=	Final effluent suspended solids 7-day mean, mg/l
$FESS_i$	=	Final effluent suspended solids for day i, mg/l
$NPDES_i$	=	NPDES discharge for day i, mgd
N	=	Number of days where $FESS_i$ 0 and $NPDES_i$ 0

and:

$NPDES_7$	=	Most recent day in the seven day period

FINAL EFFLUENT SUSPENDED SOLIDS MASS EMISSION RATE 7-DAY MEAN

$$(SSMER7) = \frac{[\sum_{i=1}^{7}(FESS_i)(NPDES_i)(8.34)]}{N}$$

for $FESS_i>0$ & $NPDES_i>0$, $N>2$, $NPDES_7>0$

where:

SSMER7	=	Final effluent suspended solids mass emission rate 7-day mean, lbs/day
$FESS_i$	=	Final effluent suspended solids for day i, mg/l
$NPDES_i$	=	NPDES discharge for day i, mgd
N	=	Number of days where $FESS_i>0$ and $NPDES_i>0$
8.34	=	lbs/M.G. per mg/l

and:

$NPDES_7$	=	Most recent day in the seven day period

Table 13 (continued). EFFLUENT COMPLIANCE 7-DAY AVERAGE CALCULATIONS FORMULAS

FECAL COLIFORM BACTERIA 7-DAY GEOMETRIC MEAN

$$(FCOLI7) = [\prod_{i=1}^{7}(FCOLI_i)]^{1/N}$$

for $FCOLI_i>0$ & $NPDES_i>0$, $N>2$, $NPDES_7>0$

where:

FCOLI7 = Fecal coliform bacteria 7-day geometric mean, MPN/100 ml

$FCOLI_i$ = Fecal coliform bacteria count for day i, MPN/100 ml

$NPDES_i$ = NPDES discharge for day i

N = Number of days where $FCOLI_i>0$ and $NPDES_i>0$

and:

$NPDES_7$ = Most recent day in the seven day period

TOTAL COLIFORM BACTERIA 7-DAY MEDIAN

$$(TCOLI7) = (TCOLI_4)$$

for $DISCH_7>0$

where:

TCOLI7 = Total coliform bacteria 7-day median, MPN/100 ml

$TCOLI_4$ = Fourth highest total coliform bacteria count after the values of the last 7 days where DISCH>0 have been arranged in ascending order, MPN/100 ml

$DISCH_7$ = NPDES discharge for 'navigable water & tributaries' calculation or REUSE discharge for 'allowable reuse' calculation; day seven is the most recent in the seven day period

Table 13 (continued). EFFLUENT COMPLIANCE 7-DAY AVERAGE CALCULATIONS FORMULAS

FINAL EFFLUENT BOD_5 7-DAY MEAN

$$(BOD7) = \frac{[\sum_{i=1}^{7}(FEBOD_i)]}{N}$$

for $FEBOD_i>0$ & $NPDES_i>0$, $N>2$, $NPDES_7>0$

where:

BOD7 = Final effluent BOD_5 7-day mean, mg/l

$FEBOD_i$ = Final effluent BOD for day i, mg/l

NPDES = NPDES discharge for day i, mgd

N = Number of days where $FEBOD_i>0$ and $NPDES_i>0$

and:

$NPDES_7$ = Most recent day in the seven day period

FINAL EFFLUENT BOD MASS EMISSION RATE 7-DAY MEAN

$$(BODMER7) = \frac{[\sum_{i=1}^{7}(FEBOD_i)(NPDES_i)(8.34)]}{N}$$

for $FEBOD_i>0$ & $NPDES_i>0$, $N>2$, $NPDES_7>0$

where:

BODMER7 = Final effluent BOD mass emission rate 7-day mean, lbs/day

$FEBOD_i$ = Final effluent BOD for day i, mg/l

$NPDES_i$ = NPDES discharge for day i, mgd

N = Number of days where $FEBOD_i>0$ and $NPDES_i>0$

8.34 = lbs/M.G. per mg/l

and:

$NPDES_7$ = Most recent day in the seven day period

Table 14. EFFLUENT COMPLIANCE 30-DAY AVERAGE CALCULATION FORMULAS

FINAL EFFLUENT SUSPENDED SOLIDS 30-DAY MEAN

$$(SS30) = \frac{[\sum_{i=1}^{30} (FESS_i)]}{N}$$

for $FESS_i>0$ & $DISCH_i>0$, $N>3$, $DISCH_{30}>0$

where:

- SS30 = Final effluent suspended solids 30-day mean, mg/l
- $FESS_i$ = Final effluent suspended solids for day i, mg/l
- $DISCH_i$ = Discharge for day i
- N = Number of days where $FESS_i>0$, and $DISCH_i>0$

and:

- $DISCH_i$ = NPDES discharge for 'navigable waters & tributaries' calculation
- $DISCH_i$ = REUSE discharge for 'allowable reuse' calculation
- $DISCH_{30}$ = Most recent day in the 30-day period

FINAL EFFLUENT SUSPENDED SOLIDS MASS EMISSION RATE 30-DAY MEAN

$$(SSMER30) = \frac{[\sum_{i=1}^{30} (FESS_i)(DISCH_i)(8.34)]}{N}$$

for $FESS_i>0$ & $DISCH_i>0$, $N>3$, $DISCH_{30}>0$

where:

- SSMER30 = Final effluent suspended solids mass emission rate 30-day mean, lbs/day
- FESS = Final effluent suspended solids, mg/l
- $DISCH_i$ = Discharge for day i, mgd
- N = Number of days where $FESS_i>0$ and $DISCH_i>0$
- 8.34 = lbs/M.G. per mg/l

and:

- $DISCH_i$ = NPDES discharge for 'navigable water & tributaries'
- $DISCH_i$ = REUSE discharge for 'allowable reuse' calculation
- $DISCH_{30}$ = Most recent day in the 30-day period

Table 14 (continued). EFFLUENT COMPLIANCE 30-DAY AVERAGE CALCULATION FORMULA

FINAL EFFLUENT BOD 30-DAY MEAN

$$(BOD30) = \frac{[\sum_{i=1}^{30}(FEBOD_i)]}{N}$$

for $FEBOD_i>0$ & $DISCH_i>0$, $N>3$, $DISCH_{30}>0$

where:

BOD30	=	Final effluent BOD 30-day mean, mg/l
$FEBOD_i$	=	Final effluent BOD for day i, mg/l
$DISCH_i$	=	Discharge for day i
N	=	Number of days where $FEBOD_i>0$ and $DISCH_i>0$

and:

$DISCH_i$	=	NPDES discharge for 'navigable waters & tributaries'
$DISCH_i$	=	REUSE discharge for 'allowable reuse' calculation
$DISCH_{30}$	=	Most recent day in the 30-day period

FINAL EFFLUENT BOD MASS EMISSION RATE 30-DAY MEAN

$$(BODMER30) = \frac{[\sum_{i=1}^{30}(FEBOD_i)(DISCH_i)(8.34)]}{N}$$

for $FEBOD_i>0$ & $DISCH_i>0$, $N>3$, $DISCH_{30}>0$

where:

BODMER30	=	Final effluent BOD mass emission rate 30-day mean, lbs/day
$FEBOD_i$	=	Final effluent BOD for day i, mg/l
$DISCH_i$	=	Discharge for day i, mgd
N	=	Number of days where $FEBOD_i>0$ and $DISCH_i>0$
8.34	=	lbs/M.G. per mg/l

and:

$DISCH_i$	=	NPDES discharge for 'navigable water & tributaries' calculation
$DISCH_i$	=	REUSE discharge for 'allowable reuse' calculation
$DISCH_{30}$	=	Most recent day in the 30-day period

Table 14 (continued). EFFLUENT COMPLIANCE 30-DAY AVERAGE CALCULATION FORMULAS

SUSPENDED SOLIDS PLANT REMOVAL 30-DAY MEAN

$$(SSR30) = \frac{[(\sum_{i=1}^{30}(RSS_i))/N1-(\sum_{i=1}^{30}(FESS_i))/N2)](100)}{(\sum_{i=1}^{30}(RSS_i))/N1}$$

for $RSSS_i>0$, $FESS_i>0$, $NPDES_i>0$, $N1>3$ & $N2>3$, $NPDES_{30}>0$

where:

SSR30	=	Suspended solids plant removal 30-day mean, %
$RSSS_i$	=	Raw sewage suspended solids for day i, mg/l
$FESS_i$	=	Final effluent suspended solids for day i, mg/l
$NPDES_i$	=	NPDES discharge for day i, mgd
N1	=	Number of days where $RSSS_i>0$
N2	=	Number of days where $FESS_i>0$

and:

$NPDES_{30}$	=	Most recent day in the 30-day period

BOD_5 PLANT REMOVAL 30-DAY MEAN

$$(BODR30) = \frac{[(\sum_{i=1}^{30}(RSBOD_i))/N1-(\sum_{i=1}^{30}(FEBOD_i))/N2](100)}{(\sum_{i=1}^{30}(RSBOD_i))/N1}$$

for $RSBOD_i>0$, $FEBOD_i>0$, $NPDES_i>0$, $N1>3$ & $N2>3$, $NPDES_{30}>0$

where:

BODR30	=	BOD_5 plant removal 30-day mean, %
$RSBOD_i$	=	Raw sewage BOD for day i, mg/l
$FEBOD_i$	=	Final effluent BOD for day i, mg/l
$NPDES_i$	=	NPDES discharge for day i, mgd
N1	=	Number of days where $RSBOD_i>0$
N2	=	Number of days where $FEBOD_i>0$

and

$NPDES_{30}$	=	Most recent day in the 30-day period

Table 14 (continued). EFFLUENT COMPLIANCE 30-DAY AVERAGE CALCULATION FORMULAS

FECAL COLIFORM BACTERIA 30-DAY GEOMETRIC MEAN

$$(FCOLI30) = \left[\prod_{i=1}^{30} (FCOLI_i)\right]^{1/N}$$

for $FCOLI_i>0$ & $NPDES_i>0$, $N>3$, $NPDES_{30}>0$

where:

FCOLI30 = Fecal coliform bacteria 30-day geometric mean, MPN/100 ml

$FCOLI_i$ = Fecal coliform bacteria count for day i, MPN/100 ml

$NPDES_i$ = NPDES discharge for day i

N = Number of days where $FCOLI_i>0$ and $NPDES_i>0$

and:

$NPDES_{30}$ = Most recent day in the 30-day period

SETTLEABLE SOLIDS 30-DAY MEAN

$$(STS30) = \frac{\left[\sum_{i=1}^{30} (STS_i)\right]}{N}$$

for $STS_i>0$ & $DISCH_i>0$, $N>3$, $DISCH_{30}>0$

where:

STS30 = Settleable solids 30-day mean, ml/l

STS_i = Settleable solids for day i, ml/l

$DISCH_i$ = Discharge for day i

N = Number of days where $STS_i>0$ and $DISCH_i>0$

and:

$DISCH_{30}$ = Most recent day in the 30-day period

Table 14 (continued). EFFLUENT COMPLIANCE 30-DAY AVERAGE CALCULATION FORMULAS

FINAL EFFLUENT TOTAL NITROGEN 30-DAY MEAN

$$(TN30) = \frac{[\sum_{i=1}^{30} (TN_i)]}{N}$$

for $TN_i>0$ & $DISCH_i>0$, $N>3$, $DISCH_{30}>0$

where:

TN30	=	Final effluent total nitrogen 30-day mean, mg/l
TN_i	=	Final effluent total nitrogen for day i, mg/l
$DISCH_i$	=	Discharge for day i
N	=	Number of days where $TN_i>0$ and $DISCH_i>0$

and:

$DISCH_i$	=	NPDES discharge for 'navigable waters & tributaries'
$DISCH_i$	=	REUSE discharge for 'allowable reuse' calculation
$DISCH_{30}$	=	Most recent day in the 30-day period

FINAL EFFLUENT TOTAL NITROGEN MASS EMISSION RATE 30-DAY MEAN

$$(TNMER30) = \frac{[\sum_{i=1}^{30} (TN_i)(DISCH_i)(8.34)]}{N}$$

for $TN_i>0$ & $DISCH_i>0$, $N>3$, $DISCH_{30}>0$

where:

TNMER30	=	Final effluent total nitrogen mass emission rate 30-day mean, lbs/day
TN_i	=	Final effluent total nitrogen for day i, mg/l
$DISCH_i$	=	Discharge for day i, mgd
N	=	Number of days where $TN_i>0$ and $DISCH_i>0$
8.34	=	lbs/M.G. per mg/l

and

$DISCH_i$	=	NPDES discharge for 'navigable waters & tributaries' calculation
$DISCH_i$	=	REUSE discharge for 'allowable reuse' calculation
$DISCH_{30}$	=	Most recent day in the 30-day period

Table 14 (continued). EFFLUENT COMPLIANCE 30-DAY AVERAGE CALCULATION FORMULAS

FINAL EFFLUENT OIL & GREASE 30-DAY MEAN

$$(OG30) = \frac{\left(\sum_{i=1}^{30}(FEOG_i)\right)}{N}$$

for $FEOG_i>0$ & $NPDES_i>0$, $N>3$, $NPDES_{30}>0$

where:

OG30	=	Final effluent oil & grease 30-day mean, mg/l
$FEOG_i$	=	Final effluent oil & grease for day i, mg/l
$NPDES_i$	=	NPDES discharge for day i
N	=	Number of days where $FEOG_i>0$ and $NPDES_i>0$

and:

$NPDES_{30}$	=	Most recent day in the 30-day period

FINAL EFFLUENT OIL & GREASE MASS EMISSION RATE 30-DAY MEAN

$$(OGMER30) = \frac{\left(\sum_{i=1}^{30}(FEOG_i)(NPDES_i)(8.34)\right)}{N}$$

for $FEOG_i>0$ & $NPDES_i>0$, $N>3$, $NPDES_{30}>0$

where:

OGMER30	=	Final effluent oil & grease mass emission rate 30-day mean, lbs/day
$FEOG_i$	=	Final effluent oil & grease for day i, mg/l
$NPDES_i$	=	NPDES discharge for day i, mgd
N	=	Number of days where $FEOG_i>0$ and $NPDES_i>0$
8.34	=	lbs/M.G. per mg/l

and:

$NPDES_{30}$	=	Most recent day in the 30-day period

WRP DATA MANAGEMENT SYSTEM
FILE MAINTENANCE PROGRAM

PLANT: LONG_BEACH_WATER_RENOVATION_PLANT DATE: 06/02/75

FUNCTION: PRINT TYPE: WQCB_LIMIT_RECORD

RECORD KEY: P0700010

NPDES ITEM NO.	MAXIMUM	MINIMUM
1	10.000	0.000
2	10000.000	0.000
3	4170.000	0.000
4	10000.000	0.000
5	3128.000	0.000
6	10000.000	0.000
7	10000.000	0.000
8	10000.000	0.000
9	10000.000	0.000
10	15.000	0.000
11	1564.000	0.000
12	10000.000	0.000
13	10000.000	0.000
14	10000.000	0.000
15	10000.000	0.000
16	10000.000	0.000
17	10000.000	0.000
18	0.200	0.000
19	10000.000	0.000
20	40.000	0.000
21	4170.000	0.000
22	30.000	0.000
23	3128.000	0.000
24	10000.000	0.000
25	400.000	0.000
26	15.000	0.000
27	1564.000	0.000
28	100.000	85.000
29	20.000	0.000
30	2085.000	0.000
31	100.000	85.000
32	10.000	0.000
33	1043.000	0.000
34	10000.000	0.000
35	10000.000	0.000
36	0.100	0.000
37	200.000	0.000

REUSE ITEM NO.	MAXIMUM	MINIMUM
1	10.000	0.000
2	40.000	0.000
3	4170.000	0.000
4	30.000	0.000
5	3128.000	0.000
6	1000.000	0.000
7	104.300	0.000
8	40.000	0.000
9	4170.000	0.000
12	250.000	0.000
13	26.060	0.000
14	10000.000	0.000
15	10000.000	0.000
16	500.000	0.000
17	52.130	0.000
18	0.200	0.000
19	10000.000	0.000
24	23.000	0.000
26	15.000	0.000
27	1564.000	0.000
29	20.000	0.000
30	2085.000	0.000
34	30.000	0.000
35	3128.000	0.000
36	0.100	0.000

NOTE: Values of 10,000 (for maximum limits) and 0 (for minimum limits) denote the fact that no limit exists at this time; however, such limits may be prescribed in the future.

FIGURE 54 EXAMPLE OF STORED EFFLUENT COMPLIANCE LIMITS

```
WRPDMS,EFFCMP,02/28/75

LACSD WRP DATA MANAGEMENT SYSTEM
FOR SYSTEM AVAILABILITY CALL: JAO (213) 699-7411 EXT. 499
  WQCB COMPLIANCE CALCS NOW IN PROGRESS

*****************************************
***PLANT EFFLUENT COMPLIANCE VIOLATIONS***
*****************************************
```

NPDES:

DATE	ITEM	VALUE	LIMIT
2/28	1	10.1	10.0
2/28	3	5066.7	4170.0
2/28	5	3815.7	3128.0
2/28	10	15.1	15.0
2/28	11	1889.1	1564.0
2/28	18	0.3	0.2
2/28	20	40.5	40.0
2/28	21	4171.0	4170.0
2/28	22	30.5	30.0
2/28	23	3128.5	3128.0
2/28	25	401.0	400.0
2/28	26	16.0	15.0
2/28	27	1565.0	1564.0
2/28	28	84.0	85.0
2/28	29	21.0	20.0
2/28	30	2086.0	2085.0
2/28	31	84.0	85.0
2/28	32	10.1	10.0
2/28	33	1044.0	1043.0
2/28	36	0.2	0.1
2/28	37	201.0	200.0

REUSE:

DATE	ITEM	VALUE	LIMIT
2/28	1	10.1	10.0
2/28	2	40.5	40.0
2/28	3	5066.7	4170.0
2/28	4	30.5	30.0
2/28	5	3815.7	3128.0
2/28	6	1000.5	1000.0
2/28	7	125.0	104.3
2/28	8	41.0	40.0
2/28	9	5129.1	4170.0
2/28	12	250.5	250.0
2/28	13	31.0	26.1
2/28	16	500.5	500.0
2/28	17	63.0	52.1
2/28	18	0.3	0.2
2/28	24	24.0	23.0
2/28	26	15.5	15.0
2/28	27	1564.5	1564.0
2/28	29	20.5	20.0
2/28	30	2085.5	2085.0
2/28	34	31.0	30.0
2/28	35	3129.0	3128.0
2/28	36	0.2	0.1

NOTE: Stored data were intentionally altered to cause every limit to be exceeded.

INITIAL PORTION OF EFFCMP PRINTOUT WHEN EFFLUENT COMPLIANCE VIOLATIONS OCCUR
FIGURE 55

LONG BEACH WRP WQCB COMPLIANCE CALCULATIONS DATE: 2/28/75

DAILY VALUES

		NPDES	REUSE			NPDES	REUSE
FLOW	02/28			TURBIDITY	02/28		
MG **		15.0	15.0	1 CONC, TU		10.1	10.1
SUSPENDED SOLIDS	02/28			BOD(5-DAY)	02/28		
2 CONC, MG/L **		41	41	4 CONC, MG/L **		31	31
3 MER, LBS/DAY		5067	5067	5 MER, LBS/DAY		3816	3816
TDS(180 DEG)	02/28			TOTAL NITROGEN	02/28		
6 CONC, MG/L **		1001	1001	8 CONC, MG/L		41.0	41.0
7 MER, KLBS/DAY *			125	9 MER, LBS/DAY		5129	5129
OIL & GREASE	02/28			CHLORIDE	02/28		
10 CONC, MG/L		15.1		12 CONC, MG/L *		251	251
11 MER, LBS/DAY		1889		13 MER, KLBS/DAY *			31
SULFATE	02/28			SULFATE+CHLORIDE	02/28		
14 CONC, MG/L *		250	250	16 CONC, MG/L *		501	501
15 MER, KLBS/DAY *			31	17 MER, KLBS/DAY *			63
SETTLEABLE SOLIDS	02/28			DETERGENTS	02/28		
18 CONC, ML/L		.3	.3	19 CONC, MG/L **		< .1	< .1

7-DAY VALUES

		NPDES	REUSE			NPDES	REUSE
SUSPENDED SOLIDS	02/28			BOD(5-DAY)	02/28		
20 CONC, MG/L		41		22 CONC, MG/L		31	
21 MER, LBS/DAY		4171		23 MER, LBS/DAY		3129	
TOTAL COLIFORM	02/28			FECAL COLIFORM	02/28		
24 MEDIAN, MPN/100 ML		5	24	25 G.M., MPN/100 ML		401	

30-DAY VALUES

		NPDES	REUSE			NPDES	REUSE
SUSPENDED SOLIDS	02/28			BOD(5-DAY)	02/28		
26 CONC, MG/L		16	16	29 CONC, MG/L		21	21
27 MER, LBS/DAY		1565	1565	30 MER, LBS/DAY		2086	2086
28 REMOVAL, %		84.0		31 REMOVAL, %		84.0	
OIL & GREASE	02/28			TOTAL NITROGEN	02/28		
32 CONC, MG/L		10.1		34 CONC, MG/L			31.0
33 MER, LBS/DAY		1044		35 MER, LBS/DAY			3129
SETTLEABLE SOLIDS	02/28			FECAL COLIFORM	02/28		
36 CONC, ML/L		.2	.2	37 G.M., MPN/100 ML		201	

* NPDES VALUE APPLIES TO DISCHARGE TO UNLINED RIVERS ONLY

** NPDES VALUE HAS NO NPDES MAXIMUM LIMIT

TRANSACTION COMPLETE

REMAINING PORTION OF EFFCMP PRINTOUT

FIGURE 55 (CONTINUED)

LONG BEACH WRP   DATE: 5/28/75

FLOWS (MGD)		COD (MG/L)	
TOTAL PLANT	7.9	PRIMARY EFFLUENT TOTAL	323
RETURN SLUDGE	3.52	FINAL EFF. TOT/SOLUBLE	38/ 30
WASTE ACTIVATED SLUDGE	.123	REMOVAL (% TOTAL)	91
		AERATION SYSTEM LOAD (LBS TOTAL COD/DAY)	21300
SUSPENDED SOLIDS (MG/L)			
PRIMARY EFFLUENT	120		
FINAL EFFLUENT	5.0	NITROGEN (MG/L)	
RETURN SLUDGE	4200	PRIMARY EFF. NH3-N	23.8
		FINAL EFF. NH3-N	.1
PROCESS AIR		NO3-N	18.0
TOTAL (MSCF/DAY)	27.3	NO2-N	
RATIO (SCF/GAL)	3.5		
SCF/LB COD REMOVED	1412	YESTERDAY'S FINAL EFF. TDS	
TOTAL MLSS (LBS)	34200	VOLATILE CONTENT (%)	83

	UNIT-1	UNIT-2	UNIT-3	TOTAL	AVERAGE
SLUDGE VOLUME INDEX (ML/GM)	168				168
AERATION SOLIDS (LBS)	49500			49500	
CENTROIDAL					
MIXED LIQUOR AERATION (HRS)	5.1				5.1
RETURN SLUDGE AERATION (HRS)	4.1				4.1
HYDRAULIC (V/Q+R)					
MIXED LIQUOR AERATION (HRS)	6.4				6.4
RETURN SLUDGE AERATION (HRS)					

OPERATION PARAMETERS

DATE	TAS(LBS)	COD/TPVSS	COD/MLVSS	CENT MLAT(HRS)	CRT(DAYS)
24	52300	.385	.653	5.10	9.41
25	52000	.396	.665	5.47	13.21
26	51600	.424	.719	4.85	13.70
27	54100	.446	.753	4.99	13.92
28	49500	.442	.750	5.09	12.54

SOLIDS MASS BALANCE

DATE	TPSS(LBS)	WASTED (LBS)	SESS (LBS)	DAILY NET GROWTH(LBS)
24	61500	6337	197	5534
25	61500	4419	237	4656
26	60400	3916	493	3309
27	63200	4067	473	7340
28	58000	4294	330	-575

AVERAGE CRT (DAYS)   11.1

AVERAGE NET GROWTH (LBS SOLIDS/LBS SYS SOLIDS/DAY)   .090

CALCULATED WASTE RATES (MGD)

FOR AVERAGE 7 DAY CRT   .23

FOR DAILY 7 DAY CRT   .19

FIGURE 56   EXAMPLE OF PRINTOUT OF DAILY OPERATIONAL DATA AND CALCULATIONS

DISTRICT 26 WRP   WRP/SOLIDS HANDLING   DATE: 5/ 1/75

DIGESTER	RAW SLUDGE FLOW (MGD)	DEWAT WAS FLOW (MGD) CENT./A.F.	RAW LOADING (LB TS/DAY)	WAS LOADING (LB TS/DAY) CENT./A.F.
LARGE PRIMARY	.0080		3740	
LARGE SECONDARY				
SMALL PRIMARY	.0018	.0042	840	1930
SMALL SECONDARY		.0620		28440
TOTALS				

OPERATING PARAMETERS	LARGE PRIMARY	SMALL PRIMARY	LARGE SECONDARY	SMALL SECONDARY
CRT (DAYS)				
LOADING (LB VS/DAY/CF)				
VOLATILE DESTRUCTION (%)				
UNIT DESTRUCTION (LB VS/DAY/1000 CF)				
TOTAL GAS PRODUCTION (MCF/DAY)	.028	.010		
UNIT GAS PRODUCTION (CF/LB VS DESTROYED)				
VOLATILE ACIDS (MG/L)	23.000	26.000		

SLUDGE DEWATERING	CENTRIFUGE	AIR FLOTATION UNIT
LOADING (LB/HR)	178.0000	
SOLIDS RECOVERY (%)	51.0000	

SLUDGE HAULING	LARGE SYSTEM	SMALL SYSTEM
HAULED SLUDGE FLOW (MGD)		.0200
TOTAL SOLIDS HAULED (LB/DAY)		6000.0000
VOLATILE SOLIDS HAULED (LB/DAY)		4700.0000

EXAMPLE OF PRINTOUT OF
SOLIDS HANDLING DATA AND CALCULATIONS
FIGURE 57

handling equipment.

Shown in Appendix A is the monthly report listing all operational and discharge compliance data and calculations.

There is an additional transaction, LIST, which prints out for any particular specified day the raw data and calculations stored for that day. This transaction is useful for determining the source of error if calculations cannot be successfully performed using the stored data.

System Management Programs

Date Record Management Program - Shown in Figure 58 are those parameters for which required entries are needed. That is, the effluent discharge permits specify the frequency of analyses of numerous parameters. This program then maintains a file on most recent entry of each of the parameters. Also, the program directs the off-line portion of the WRPDMS to perform necessary 30-day statistical calculations.

Parameter Record Management Program - Shown in Figure 59 are typical stored operational data needed to calculate daily operational parameters.

Lower and Upper Limit Management Program - A program is available to establish upper and/or lower limits for all columns of data and calculated results. Entry of any value lying outside these limits will cause a message to be transmitted to the operators that the data are abnormal. At the present time this program is not in use. When normal operational ranges for all parameters have been established, these limits will be utilized to signal abnormal operation.

Required Data Record Management Program - This program operates in conjunction with the Data Record Management Program to keep track of when data are required. Thus, if a parameter is specified to be monitored on a weekly basis, this program checks if data are entered within the appropriate time. If not, a message is sent to the operator informing him of

WRP DATA MANAGEMENT SYSTEM
FILE MAINTENANCE PROGRAM

PLANT: WHITTIER_NARROWS_WATER_RECLAMATION_PLANT DATE: 06/02/75

FUNCTION: PRINT TYPE: DATE_RECORD

RECORD KEY: P0200001

		DATE	WRP DATE
1.	FIRST RECORD	8/ 1/74	2039
2.	LAST RECORD	5/31/75	2342
3.	BOD ENTRY	5/25/75	2336
4.	TOTAL COLIFORM ENTRY	5/26/75	2337
5.	FECAL COLIFORM ENTRY	5/26/75	2337
6.	NITROGEN ENTRY	5/20/75	2331
7.	T D S ENTRY	5/20/75	2331
8.	CHLORIDE ENTRY	5/20/75	2331
9.	SULFATE ENTRY	5/20/75	2331
10.	DETERGENT ENTRY	5/20/75	2331
11.	OIL & GREASE ENTRY	5/31/75	2342
12.	SULFATE+CHLORIDE ENTRY	5/20/75	2331
13.	SUSPENDED SOLIDS ENTRY	5/31/75	2342
14.	SETTLEABLE SOLIDS ENTRY	5/31/75	2342
15.	B O D CALC	5/25/75	2336
16.	TOTAL COLIFORM CALC	3/27/75	2277
17.	FECAL COLIFORM CALC	5/26/75	2337
18.	NITROGEN CALC	5/20/75	2331
19.	T D S CALC	5/20/75	2331
20.	CHLORIDE CALC	5/20/75	2331
21.	SULFATE CALC	5/20/75	2331
22.	OIL & GREASE CALC	5/31/75	2342
23.	SULFATE+CHLORIDE CALC	5/20/75	2331
24.	SUSPENDED SOLIDS CALC	5/31/75	2342
25.	SETTLEABLE SOLIDS CALC	5/31/75	2342
26.	OPERATION DAILY PRINTOUT	5/31/75	2342

NOTE: WRP Date is a chronological date numbering system that arbitrarily begins with day 0001 on January 1, 1969.

FIGURE 58 DATE RECORD MANAGEMENT PROGRAM - TYPICAL PRINTOUT

WRP DATA MANAGEMENT SYSTEM
FILE MAINTENANCE PROGRAM

PLANT: WHITTIER_NARROWS_WATER_RECLAMATION_PLANT DATE: 06/02/75

FUNCTION: PRINT TYPE: PARAMETER_RECORD

RECORD KEY: P0200002

1.	PLANT IDENTIFICATION NUMBER	2
2.	NUMBER OF DATA POINTS	142
3.	NUMBER OF AERATION SYSTEMS	1
4.	NUMBER OF TANKS PER SYSTEM	3
5.	AERATION TANK LENGTH, FT.	300
6.	AERATION TANK VOLUME, MG	1.000
7.	AERATION TANK CROSS-SECTIONAL AREA, SQ. FT.	450
8.	NUMBER OF FINAL SED. TANKS (TOTAL PLANT)	5
9.	FINAL SEDIMENTATION TANK VOLUME PER SYSTEM, MG	1.122
10.	NUMBER OF DISCHARGE POINTS	4
11.	NUMBER OF FEED GATES	13
12.	FEED LOCATIONS (DISTANCE FROM UPSTREAM END OF AERATION SYSTEM), FT.	0 75 150 225 289 310 375 450 525 600 675 750 825

FIGURE 59 OPERATIONAL DATA MANAGEMENT PROGRAM - TYPICAL PRINTOUT

of the lacking data.

EXPERIENCES USING THE WRPDMS

The on-line computer system is available for use seven hours per day, five days per week. The actual amount of time the treatment plant operator spends at the teletype terminal can vary considerably depending upon his typing speed and number of typing errors committed. The WRPDMS has program logic which requires that transaction instructions be typed in an exact specific order. Failure to do so elicits diagnostic error messages from the computer with instructions to repeat the attempted transaction. Personnel who have had sufficient training on the system to know what to do without referring to printed instructions and whose typing speed averages no more than 20-30 words per minute have routinely demonstrated that one day of data can be entered and calculations performed in approximately 20 minutes. However, at the other extreme, personnel with little or no typing ability and a general lack of understanding of the system have spent over three hours accomplishing the same task.

Calculation of statistical averages for monitoring reports has required approximately 24 man-hours per plant per month utilizing a desk top calculator. With the WRPDMS, this man-power requirement has essentially been reduced to zero.

FUTURE MODIFICATIONS

Anticipated future modifications to the WRPDMS include utilizing the upper and lower limits to signal possible abnormal trends, to develop statistical predictive equations which can signal possible effluent compliance violations if recent trends in data occur, and putting printouts of data and calculations in a form suitable for direct submittal in monthly monitoring reports.

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	FLOWS								
	TOTAL PLANT					EFFLUENT DISCHARGE POINTS			
	AVERAGE DAILY INFLUENT	PEAK DAILY INFLUENT	TOTAL RETURN ACTIVATED SLUDGE	WASTE ACTIVATED SLUDGE	PROCESS AIR	NO. 001 SAN GABRIEL RIVER	NO. 002 SAN JOSE CREEK	SPREADING GROUNDS	
	MGD	MGD	MGD	MGD	MCF/DAY	MGD	MGD	MGD	
	1	2	3	4	5	6	7	8	9
1	27.28	46.0	7.16	.011	55.20	27.3	.0	.000	
2	28.49	42.0	7.25	.008	54.22	28.5	.0	.000	
3	21.68	32.0	6.95	.072	42.36	21.7	.0	.000	
4	21.59	30.0	6.59	.248	42.40	21.6	.0	.000	
5	22.08	30.0	7.71	.315	45.90	22.1	.0	.000	
6	22.43	29.0	6.84	.306	45.34	22.4	.0	.000	
7	24.35	28.0	6.44	.297	45.02	24.3	.0	.000	
8	21.14	30.0	6.51	.331	41.95	21.1	.0	.000	
9	21.87	31.0	6.66	.359	43.53	21.9	.0	.000	
10	22.70	31.0	6.54	.335	43.63	22.7	.0	.000	
11	22.69	32.0	5.89	.282	43.67	22.7	.0	.000	
12	22.39	32.0	6.27	.257	43.33	22.4	.0	.000	
13	21.55	31.0	5.86	.326	42.31	21.5	.0	.000	
14	21.76	30.0	5.72	.367	42.47	21.8	.0	.000	
15	21.89	31.0	6.13	.213	46.01	21.9	.0	.000	
16	21.10	32.0	6.11	.100	41.76	21.1	.0	.000	
17	21.58	38.0	6.17	.113	43.74	21.6	.0	.000	
18	21.33	30.0	6.27	.098	43.11	21.3	.0	.000	
19	20.99	31.0	6.05	.238	42.32	21.0	.0	.000	
20	20.90	31.0	5.95	.417	41.87	20.9	.0	.000	
21	21.22	32.0	6.03	.461	40.47	21.2	.0	.000	
22	19.97	31.0	5.40	.338	38.54	20.0	.0	.000	
23	20.80	32.0	6.16	.325	39.92	20.8	.0	.000	
24	20.63	30.0	6.11	.271	42.60	20.6	.0	.000	
25	21.74	30.0	6.24	.294	43.94	21.7	.0	.000	
26	21.95	31.0	6.44	.396	45.23	21.9	.0	.000	
27	22.01	31.0	6.31	.448	44.18	22.0	.0	.000	
28	21.81	31.0	6.03	.655	43.19	21.8	.0	.000	
MEAN	22.14	32.0	6.35	.281	43.86	22.1	.0	.000	
TOTAL	619.92					619.9			

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	SUSPENDED SOLIDS												
							REQUIREMENTS GOVERNING DISCHARGE TO:						
							NAVIGABLE WATERS & TRIBUTARIES THERETO					ALLOWABLE REUSES	
	RAW SEWAGE	PRIMARY EFFL.	SEC. EFFL.	FILTER EFFL.	FINAL EFFLUENT		ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS DATA			ARITHMETIC MEAN OF PAST 7 CALENDAR DAYS FINAL EFFLUENT DATA		ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS FINAL EFFLUENT DATA	
							FINAL EFFLUENT		PLANT REMOV.				
	MG/L	MG/L	MG/L	MG/L	MG/L	LBS/DAY	MG/L	LBS/DAY	%	MG/L	LBS/DAY	MG/L	LBS/DAY
	10	11	12	13	14	15	16	17	18	19	20	21	22
1	322	146			54	12286	13	3014	96	27	6364		
2	234	116			65	15444	15	3498	95	35	8160		
3	378	100			12	2170	15	3539	95	34	7983		
4	408	116			7	1260	15	3511	95	34	7830		
5	432	116			10	1841	15	3487	96	33	7748		
6	434	104			8	1497	15	3479	96	30	6796		
7	352	106			9	1828	15	3475	96	24	5182		
8	282	112			8	1410	15	3431	96	17	3636		
9	304	108			8	1459	15	3447	96	9	1638		
10	414	136			10	1893	15	3462	96	9	1598		
11	322	122			10	1892	15	3469	96	9	1689		
12	440	140			8	1494	15	3452	96	9	1639		
13	578	114			8	1438	15	3435	96	9	1631		
14	412	90			6	1089	15	3438	96	8	1525		
15	290	98			7	1278	15	3411	96	8	1506		
16	254	90			7	1232	15	3351	96	8	1474		
17	244	108			8	1440	15	3339	96	8	1409		
18	430	114			4	712	15	3260	96	7	1241		
19	376	132			9	1576	15	3200	96	7	1252		
20	426	104			8	1394	14	3170	96	7	1246		
21	254	112			8	1416	15	3169	96	7	1293		
22	304	140			8	1332	14	3096	96	7	1300		
23	340	124			4	694	14	3062	96	7	1223		
24	584	162			8	1376	14	3059	96	7	1214		
25	528	166			6	1088	14	2999	96	7	1268		
26	496	146			7	1281	14	2928	96	7	1228		
27	488	124			6	1101	14	2887	96	7	1184		
28	400	72			4	728	13	2831	96	6	1086		
MEAN	383	119			11	2273	15	3282	96	14	2905		

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	CHEMICAL OXYGEN DEMAND (COD)							
	RAW SEWAGE	PRIMARY EFFLUENT	SECONDARY EFFLUENT		FILTER EFFLUENT		FINAL EFFLUENT	
	TOTAL	TOTAL	TOTAL	SOLUBLE	TOTAL	SOLUBLE	TOTAL	SOLUBLE
	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
	23	24	25	26	27	28	29	30
1	460	290					115	34
2	716	255					100	36
3	629	269					31	18
4	961	312					41	20
5	967	356					36	29
6	659	273					49	38
7	983	375					47	34
8	517	268					42	29
9	402	230					37	30
10	530	292					38	24
11	846	343					31	24
12	619	278					33	22
13	641	313					33	28
14	494	319					40	31
15	596	261					31	22
16	400	222					29	22
17	749	255					31	22
18	615	331					36	31
19	1,022	350					38	27
20	1,155	347					33	29
21	663	327					35	27
22	462	290					33	24
23	571	264					33	22
24	575	345					22	20
25	659	338					35	27
26	571	308					29	18
27	630	300					28	22
28	584	311					30	24
MEAN	667	301					40	26

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	5-DAY BIOCHEMICAL OXYGEN DEMAND (BOD)										
					REQUIREMENTS GOVERNING DISCHARGE TO:						
					NAVIGABLE WATERS & TRIBUTARIES THERETO					ALLOWABLE REUSES	
	RAW SEWAGE	PRIMARY EFFLUENT	FINAL EFFLUENT		ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS DATA			ARITHMETIC MEAN OF PAST 7 CALENDAR DAYS FINAL EFFLUENT DATA		ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS FINAL EFFLUENT DATA	
					FINAL EFFLUENT		PLANT REMOV.				
	MG/L	MG/L	MG/L	LBS/DAY	MG/L	LBS/DAY	%	MG/L	LBS/DAY	MG/L	LBS/DAY
	31	32	33	34	35	36	37	38	39	40	41
1	333		> 22	> 5,005	7	1,729	98	> 11	> 2,552		
2	308		> 12	> 2,851	7	1,801	98	> 11	> 2,617		
3	291		7	1,266	8	1,797	98	> 11	> 2,554		
4	388		10	1,801	8	1,802	98	> 12	> 2,660		
5	488		9	1,657	8	1,789	98	> 12	> 2,658		
6	435		8	1,497	8	1,797	98	> 12	> 2,471		
7	455		7	1,422	8	1,804	98	> 11	> 2,214		
8	420		> 12	> 2,116	8	1,833	98	> 9	> 1,801		
9	347		> 12	> 2,189	8	1,866	98	> 9	> 1,707		
10	280		7	1,325	8	1,870	98	> 9	> 1,715		
11	497		6	1,135	8	1,867	98	> 9	> 1,620		
12	450		6	1,120	8	1,829	98	> 8	> 1,543		
13	460		8	1,438	8	1,829	98	> 8	> 1,535		
14	513		7	1,270	8	1,813	98	> 8	> 1,513		
15	428		7	1,278	8	1,803	98	> 8	> 1,394		
16	320		6	1,056	8	1,805	98	7	1,232		
17	385		7	1,260	9	1,832	98	7	1,222		
18	475		4	712	8	1,784	98	6	1,162		
19	438		B		8	1,774	98	7	1,169		
20	358		7	1,220	8	1,755	98	6	1,133		
21	397		5	885	8	1,744	98	6	1,069		
22	292		4	666	8	1,688	98	6	967		
23	357		> 12	> 2,082	8	1,692	98	> 7	> 1,137		
24	435		> 12	> 2,065	9	1,730	98	> 7	> 1,272		
25	658		5	907	9	1,679	98	> 7	> 1,304		
26	780		6	1,098	8	1,658	98	> 7	> 1,275		
27	410		5	918	8	1,653	98	> 7	> 1,232		
28	288		5	909	8	1,627	98	> 7	> 1,235		
MEAN	417		8	> 1,524	8	1,773	98	> 8	> 1,642		

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	BACTERIA					
	CHLORINE CONTACT CHAMBER EFFLUENT DAILY GRAB SAMPLES		REQUIREMENTS GOVERNING DISCHARGE TO:			
			NAVIGABLE WATERS & TRIBUTARIES THERETO			ALLOWABLE REUSES
	TOTAL COLIFORM	FECAL COLIFORM	GEOMETRIC MEAN OF FECAL COLIFORM DATA DURING PAST		MEDIAN OF LAST 7 TOTAL COLIFORM SAMPLES	MEDIAN OF LAST 7 TOTAL COLIFORM SAMPLES
			30 DAYS	7 DAYS		
	MPN/100 ML	MPN/100 ML	MPN/100 ML	MPN/100 ML	MPN/100 ML	MPN/100 ML
	42	43	44	45	46	47
1	< 2	< 2	< 2	< 2	< 2	
2	< 2	< 2	< 2	< 2	< 2	
3	172	8	< 3	< 3	< 2	
4	> 2400	175	< 3	< 5	< 2	
5	< 2	< 2	< 3	< 5	< 2	
6	4	4	< 3	< 6	< 2	
7	< 2	< 2	< 3	< 6	< 2	
8	< 2	< 2	< 3	< 6	< 2	
9	< 2	< 2	< 3	< 6	< 2	
10	< 2	< 2	< 3	< 5	< 2	
11	5	< 2	< 3	< 3	< 2	
12	8	< 2	< 3	< 3	< 2	
13	4	< 2	< 3	< 2	< 2	
14	< 2	< 2	< 3	< 2	< 2	
15	< 2	< 2	< 3	< 2	< 2	
16	< 2	< 2	< 3	< 2	< 2	
17	< 2	< 2	< 3	< 2	< 2	
18	2	< 2	< 3	< 2	< 2	
19	< 2	< 2	< 3	< 2	< 2	
20	5	< 2	< 3	< 2	< 2	
21	8	< 2	< 3	< 2	< 2	
22	< 2	< 2	< 3	< 2	< 2	
23	< 2	< 2	< 3	< 2	< 2	
24	< 2	< 2	< 3	< 2	< 2	
25	< 2	< 2	< 3	< 2	< 2	
26	< 2	< 2	< 3	< 2	< 2	
27	< 2	< 2	< 3	< 2	< 2	
28	< 2	< 2	< 3	< 2	< 2	
MEDIAN	< 2	< 2				

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	RESIDUAL CHLORINE				PH	OIL AND GREASE			
	CHLORINE CONTACT CHAMBER EFFLUENT		DAILY GRAB SAMPLES		FINAL EFFLUENT DAILY GRAB SAMPLE	FINAL EFFLUENT DAILY GRAB SAMPLE		ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS DATA USING ONLY DAYS NAVIGABLE WATER DISCHARGE OCCURRED	
	MINIMUM DAILY VALUE	MAXIMUM DAILY VALUE	CHLOR- INATED	DECHLOR- INATED		CONCEN- TRATION	NAVIGABLE WATER DISCHARGE		
	MG/L	MG/L	MG/L	MG/L		MG/L	LBS/DAY	MG/L	LBS/DAY
	48	49	50	51	52	53	54	55	56
1	.9	> 10.0	3.6		6.60	< 1.0	< 228	< 1.3	< 312
2	.3	> 10.0	2.2		6.70	< 5.7	1,354	< 1.5	< 350
3	.2	8.6	8.1		6.70	< 1.0	< 181	< 1.5	< 348
4	.9	7.3	.7		6.70	1.2	216	< 1.5	< 347
5	1.4	> 10.0	8.0		6.60	1.1	203	< 1.5	< 346
6	1.6	> 10.0	10.4		6.70	< 1.0	< 187	< 1.4	< 335
7	1.4	> 10.0	12.0		6.80	< 1.0	< 203	< 1.4	< 322
8	4.9	> 10.0	3.0		7.00	< 1.0	< 176	< 1.4	< 320
9	4.2	> 10.0	3.5		6.90	< 1.0	< 182	< 1.4	< 318
10	3.8	9.8	4.0		6.80	< 1.0	< 189	< 1.4	< 311
11	5.6	7.4	4.8		6.90	1.1	208	< 1.4	< 310
12	4.7	7.6	4.7		6.90	< 1.0	< 187	< 1.4	< 308
13	4.1	7.6	3.4		6.90	1.7	306	< 1.4	< 310
14	.2	> 10.0	4.4		7.00	< 1.0	< 181	< 1.4	< 308
15	4.5	> 10.0	5.7		6.90	1.3	237	< 1.4	< 307
16	5.3	> 10.0	8.4		6.70	2.1	370	< 1.4	< 308
17	.6	9.5	5.2		6.70	< 1.0	< 180	< 1.4	< 303
18	4.4	9.6	3.8		6.80	< 1.0	< 178	< 1.4	< 301
19	.2	> 10.0	10.8		6.80	< 1.0	< 175	< 1.4	< 298
20	.2	> 10.0	7.0		6.80	1.7	296	< 1.4	< 300
21	5.2	> 10.0	4.7		6.90	< 1.0	< 177	< 1.4	< 298
22	5.6	> 10.0	11.3		6.70	< 1.0	< 167	< 1.4	< 281
23	5.2	> 10.0	12.6		6.60	< 1.0	< 173	< 1.4	< 279
24	7.8	> 10.0	9.5		6.60	1.9	327	< 1.4	< 282
25	5.1	> 10.0	15.2		6.80	< 1.0	< 181	< 1.4	< 280
26	.3	> 10.0	22.0		6.90	< 1.0	< 183	< 1.4	< 269
27	2.2	7.8	7.2		7.00	< 1.0	< 184	< 1.4	< 268
28	3.8	6.5	4.8		7.00	< 1.0	< 182	< 1.3	< 250
MEAN	3.0	> 9.3	7.2		6.80	< 1.3	< 250	< 1.4	< 306

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	NITROGEN												
	24-HOUR FLOW COMPOSITE SAMPLES								ARITHMETIC MEAN OF PAST 30 CALENDAR DAYS TOTAL NITROGEN DATA				AERATION SYSTEM AMMONIA OXID.
	PRIMARY EFFLUENT		FINAL EFFLUENT						NAVIGABLE WATER DISCHARGE		REUSE DISCHARGE		
	ORGANIC	NH3	ORGANIC	NH3	NO2	NO3	TOTAL N						
	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	LBS/DAY	MG/L	LBS/DAY	MG/L	LBS/DAY	%
	57	58	59	60	61	62	63	64	65	66	67	68	69
1		25.8		2.8	.020	21.3			19.4	4642			89.1
2		24.1		3.9	.030	26.0			19.4	4642			83.8
3		19.6		< .1	.010	22.0			19.4	4642			> 99.5
4		24.9	1.7	.9	.010	15.5	18.1	3261	19.2	4366			96.4
5		25.2		2.7	.030	17.0			19.2	4366			89.3
6		18.5		4.1	E	E			19.6	4369			77.8
7		27.4		4.9	.010	9.5			19.6	4369			82.1
8		24.6		6.0	.030	10.0			19.6	4369			75.6
9		25.2		4.1	.030	22.0			19.6	4369			83.7
10		26.6	2.0	5.6	.040	11.1	18.7	3548	19.4	4204			78.9
11		30.2		11.2	E	E			19.4	4204			62.9
12		28.8		9.8	.060	8.0			18.9	3915			66.0
13		25.2		9.4	.060	10.1			18.9	3915			62.7
14		25.2		12.6	.080	3.8			18.9	3915			50.0
15		24.6		7.8	.080	11.5			18.9	3915			68.3
16		25.2		2.1	E	E			18.9	3915			91.7
17		23.8		4.9	.020	18.0			18.9	3915			79.4
18		25.2	1.9	8.3	.080	5.9	16.2	2878	18.4	3708			67.1
19		24.6		11.9	.020	2.8			18.4	3708			51.6
20		23.8		12.2	.020	1.6			18.4	3708			48.7
21		18.5		13.3	.050	1.5			17.6	3334			28.1
22		21.8		12.2	.070	2.5			17.6	3334			44.0
23		23.8		12.9	.030	9.0			17.6	3334			45.8
24		26.6		12.9	.030	4.2			17.6	3334			51.5
25		23.8	1.1	11.8	.040	2.7	15.6	2836	17.2	3235			50.4
26		24.6		12.3	.080	3.5			17.2	3235			50.0
27		25.8		13.3	,050	1.8			17.2	3131			48.4
28		26.0		12.9	.050	6.4			17.2	3131			50.4
MEAN		24.6	1.7	< 8.1	.041	9.9	17.2	3131	18.6	3901			> 66.9

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	TURBIDITY					SECCHI DISC	
			FINAL EFFLUENT				
				CONTINUOUS READING METER			
	SECONDARY EFFLUENT	FILTER EFFLUENT	DAILY 24-HOUR COMPOSITE	MINIMUM DAILY VALUE	MAXIMUM DAILY VALUE	SECONDARY EFFLUENT	FILTER EFFLUENT
	TU	TU	TU	TU	TU	FEET	FEET
	70	71	72	73	74	75	76
1			42.0	8.0	80.0	6.0	
2			37.0	8.0	98.0	2.5	
3			40.0	7.0	21.0	3.5	
4			6.0	7.0	10.0	4.5	
5			4.0	7.0	8.0	3.5	
6			6.0	5.0	13.0	4.0	
7			2.5	4.0	9.0	4.0	
8			3.5	4.0	5.8	3.0	
9			4.0	3.8	6.1	3.5	
10			5.5	4.0	6.0	3.5	
11			3.0	6.0	6.0	3.5	
12			3.0	3.2	3.6	4.0	
13			3.0	3.2	3.4	4.5	
14			1.6	3.2	3.6	4.5	
15			3.0	2.7	3.8	4.0	
16			2.5	2.6	3.6	4.0	
17			3.0	2.8	3.3	5.0	
18			2.5	2.8	3.2	4.0	
19			3.0	2.6	3.7	4.5	
20			3.0	2.9	3.4	5.0	
21			3.0	3.0	3.4	4.5	
22			3.0	2.9	3.4	3.5	
23			2.5	2.8	3.6	4.0	
24			2.5	2.6	4.6	4.0	
25			2.5	2.8	3.4	5.0	
26			2.5	2.5	4.0	5.0	
27			2.0	2.6	3.5	5.0	
28			2.0	2.4	3.0	4.5	
MEAN			7.1	4.0	11.5	4.2	

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	SETTLEABLE SOLIDS			T D S		SPECIF. CONDUC.	TEMP.	COLOR	
	DAILY 24-HOUR COMPOSITE	PAST 30-DAY AVERAGE NAVIGABLE WATER DISCHARGE	PAST 30-DAY AVERAGE REUSE DISCHARGE	DAILY 24-HOUR COMPOSITE 180 DEG C TEST	DISCHARGE TO UNLINED RIVERS AND/OR TO REUSE	DAILY 24-HOUR COMPOSITE	DAILY GRAB SAMPLE	SECONDARY EFFLUENT	FILTER EFFLUENT
	ML/L	ML/L	ML/L	MG/L	LBS/DAY	UMHO/CM	DEG. F	UNITS	UNITS
	77	78	79	80	81	82	83	84	85
1	4.5	< .4		700		1,100	72		
2	3.5	< .5		569		1,050	72		
3	< .1	< .5		554		975	72		
4	< .1	< .5		640		1,075	72		
5	< .1	< .5		650		1,075	72		
6	< .1	< .5		682		1,195			
7	< .1	< .5		718		1,230	71		
8	< .1	< .5		615		1,190	71		
9	< .1	< .5		544		1,070	70		
10	< .1	< .5		564		1,075	71		
11	< .1	< .5		621		1,175	71		
12	< .1	< .5		700		1,130	72		
13	< .1	< .5		560		1,160	71		
14	< .1	< .5		667		1,175	72		
15	< .1	< .5		596		1,175	72		
16	< .1	< .5		570		1,000	70		
17	< .1	< .5		587		1,025	72		
18	< .1	< .5		614		1,085	72		
19	< .1	< .5		591		1,210	72		
20	< .1	< .5		661		1,075	73		
21	< .1	< .5		655		1,262	73		
22	< .1	< .5		598		1,175	70		
23	< .1	< .5		553		1,100	71		
24	< .1	< .5		569		1,125	72		
25	< .1	< .5		622		1,260	72		
26	< .1	< .5		656		1,230	72		
27	< .1	< .5		664		1,240	72		
28	< .1	< .5		647		1,112	73		
MEAN	< .4	< .5		620		1,134	72		

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT

SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	CHLORIDE		SULFATE		CHLORIDE PLUS SULFATE		DETERGENTS (MBAS)
	DAILY 24-HOUR COMPOSITE	DISCHARGE TO UNLINED RIVERS AND/OR TO REUSE	DAILY 24-HOUR COMPOSITE	DISCHARGE TO UNLINED RIVERS AND/OR TO REUSE	DAILY 24-HOUR COMPOSITE	DISCHARGE TO UNLINED RIVERS AND/OR TO REUSE	DAILY 24-HOUR COMPOSITE
	MG/L	LBS/DAY	MG/L	LBS/DAY	MG/L	LBS/DAY	MG/L
	86	87	88	89	90	91	92
1							
2							
3							
4	135		78		213.0		.1
5							
6							
7							
8							
9							
10	123		85		208.0		.1
11							
12							
13							
14							
15							
16							
17							
18	131		90		221.0		.1
19							
20							
21							
22							
23							
24							
25	154		104		258.0		.2
26							
27							
28							
MEAN	136		89		225.0		.1

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LCS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	MISCELLANEOUS										
		UNITS OUT OF SERVICE									
	RETURN SLUDGE SUSPENDED SOLIDS	PRIMARY TANKS	AERATION TANKS	FINALS SYSTEM NO.1	FINALS SYSTEM NO.2	FINAL SYSTEM NO.3	FILTERS				
	MG/L										
	93	94	95	96	97	98	99	100	101	102	103
1	6,202	0	0	0	0	1					
2	7,464	0	0	0	0	1					
3	6,602	0	0	0	0	1					
4	6,789	0	0	0	0	1					
5	6,220	0	0	0	0	1					
6	6,838	0	0	0	0	1					
7	6,406	0	0	0	0	1					
8	6,165	0	0	0	0	1					
9	5,784	0	0	0	0	1					
10	5,426	0	0	0	0	1					
11	6,493	0	0	0	0	1					
12	5,902	0	0	0	0	1					
13	5,644	0	0	0	0	1					
14	4,724	0	0	0	0	1					
15	5,170	0	0	0	0	1					
16	5,456	0	0	0	0	1					
17	6,574	0	0	0	0	1					
18	7,233	0	0	0	0	1					
19	7,611	0	0	0	0	1					
20	7,559	0	0	0	0	1					
21	6,534	0	0	0	0	1					
22	6,530	0	0	0	0	1					
23	5,878	0	0	0	0	1					
24	6,383	0	0	0	0	1					
25	6,305	0	0	0	0	1					
26	6,305	0	0	0	0	1					
27	5,889	0	0	0	0	1					
28	5,603	0	0	0	0	1					
MEAN	6,275	0	0	0	0	1					

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	AERATION SYSTEM NO. 1							
	SUSPENDED SOLIDS 24-HOUR COMPOSITES				RETURN ACTIVATED SLUDGE		MIXED LIQUOR DISSOLVED OXYGEN	
	PASS 1	PASS 2	PASS 3	PASS 4	FLOW RATE	AERAT. VOLUME	MAX.	MIN.
	MG/L	MG/L	MG/L	MG/L	MGD	MG	MG/L	MG/L
	104	105	106	107	108	109	110	111
1	2997	1673	1411	1228	2.29	1.093		
2	3036	1744	1562	1355	2.33	1.093		
3	3283	2188	1606	1538	2.08	1.093		
4	3053	2252	1557	1781	2.19	1.093		
5	3038	1942	1602	1673	2.57	1.093		
6	3160	2187	1535	1551	2.28	1.093		
7	3329	2055	1797	1806	2.18	1.093		
8	3145	2012	1639	1660	2.14	1.093		
9	3087	1940	1638	1639	2.08	1.093		
10	2951	1782	1634	1385	2.01	1.093		
11	2960	2116	1751	1421	1.98	1.093		
12	2113	1875	1712	1590	1.94	1.093		
13	3349	1895	1785	1465	1.84	1.093		
14	2864	2128	1652	868	1.67	1.093		
15	2959	1794	1517	1600	1.89	1.093		
16	2899	1895	1502	1457	1.85	1.093		
17	2805	2023	1515	1463	1.97	1.093		
18	3089	2100	1604	1553	2.01	1.093		
19	3045	2027	1576	1667	1.92	1.093		
20	3121	2154	1576	1598	1.85	1.093		
21	3210	2007	1612	1705	1.87	1.093		
22	3088	1772	1486	1491	1.74	1.093		
23	3269	1796	1618	1549	1.91	1.093		
24	3317	1880	1593	1469	2.03	1.093		
25	3407	1909	1652	1559	1.92	1.093		
26	3176	1857	1615	1529	2.03	1.093		
27	3204	1943	1532	1507	1.94	1.093		
28	2633	1641	1497	1315	1.89	1.093		
MEAN	3057	1950	1599	1515	2.01	1.093		

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT

SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	AERATION SYSTEM NO. 1											
	LOADING PATTERN				SVI GRAB SAMPLE				NO2		NO3	
	PASS 1	PASS 2	PASS 3	PASS 4	SETTL. SOLIDS	SUSP. SOLIDS	SVI	VOLAT. SOLIDS	LOW FLOW GRAB SAMPLE	HIGH FLOW GRAB SAMPLE	LOW FLOW GRAB SAMPLE	HIGH FLOW GRAB SAMPLE
	%	%	%	%	ML/L	MG/L	ML/G	%	MG/L	MG/L	MG/L	MG/L
	112	113	114	115	116	117	118	119	120	121	122	123
1	30.0	45.0	25.0	.0	245	1366	179	79	.030	.300	20.0	30.0
2	30.0	45.0	25.0	.0	220	1459	151	78	.040	.320	23.0	29.3
3	30.0	45.0	25.0	.0	225	1832	123	79	.010		17.0	
4	30.0	45.0	25.0	.0	225	1832	123	79	.010	< .010	17.0	19.3
5	30.0	45.0	25.0	.0	230	1763	130	77	.080	.010	15.0	20.0
6	30.0	45.0	25.0	.0	220	1718	128	77	.100	.770	10.0	11.0
7	30.0	45.0	25.0	.0	200	1677	119	77	E	.090	E	15.9
8	30.0	45.0	25.0	.0	190	2004	95	79	.060	.070	9.5	13.3
9	30.0	45.0	25.0	.0	210	1900	111	81	.090	.040	11.0	24.9
10	30.0	45.0	25.0	.0	200	1507	133	78	.120	.090	17.3	19.0
11	30.0	45.0	25.0	.0	200	1473	136	78	.120	.100	3.7	9.0
12	30.0	45.0	25.0	.0	190	1726	110	79	E	E	E	E
13	30.0	45.0	25.0	.0	200	1547	129	76	.100	.080	4.0	9.6
14	30.0	45.0	25.0	.0	200	1558	128	77	.110	.070	3.3	3.5
15	30.0	45.0	25.0	.0	200	1482	135	76	.120	.120	7.0	14.5
16	30.0	45.0	25.0	.0	235	1509	156	77	.110	.150	17.8	24.2
17	30.0	45.0	25.0	.0	240	1728	139	78	E	E	E	E
18	30.0	45.0	25.0	.0	240	1756	137	77	.110	.090	5.0	8.0
19	30.0	45.0	25.0	.0	250	1936	129	78	.060	.050	.6	1.4
20	30.0	45.0	25.0	.0	250	1834	136	79	.050	.050	1.1	1.0
21	30.0	45.0	25.0	.0	290	1922	151	79	.010	.050	.2	1.1
22	30.0	45.0	25.0	.0	300	1626	185	78	.020	.060	.2	3.1
23	30.0	45.0	25.0	.0	345	1753	196	82	.130	.035	1.5	15.0
24	30.0	45.0	25.0	.0	350	1674	209	79	.090	.090	2.5	7.1
25	30.0	45.0	25.0	.0	350	1680	208	78	.070	.110	6.4	6.4
26	30.0	45.0	25.0	.0	380	1732	219	78	.140	.100	2.9	9.7
27	30.0	45.0	25.0	.0	425	1574	270	77	.040	.080	.2	7.4
28	30.0	45.0	25.0	.0	390	1494	261	77	.120	.100	2.6	8.3
MEAN	30.0	45.0	25.0	.0	257	1681	155	78	.078	< .121	8.0	12.5

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	AERATION SYSTEM NO. 2							
	SUSPENDED SOLIDS 24-HOUR COMPOSITES				RETURN ACTIVATED SLUDGE		MIXED LIQUOR DISSOLVED OXYGEN	
	PASS 1	PASS 2	PASS 3	PASS 4	FLOW RATE	AERAT. VOLUME	MAX.	MIN.
	MG/L	MG/L	MG/L	MG/L	MGD	MG	MG/L	MG/L
	124	125	126	127	128	129	130	131
1	2890	1735	1347	1306	2.35	1.093		
2	3043	1794	1417	1397	2.38	1.093		
3	3204	2010	1486	1539	2.28	1.093		
4	2942	2129	1510	1489	2.09	1.093		
5	2795	2084	1481	1434	2.57	1.093		
6	3005	1705	1561	1580	2.09	1.093		
7	3180	2100	1681	1644	2.03	1.093		
8	2895	1838	1697	1614	2.15	1.093		
9	3181	1970	1690	1639	2.28	1.093		
10	2915	1704	1613	1392	2.24	1.093		
11	3013	2071	1564	1563	2.07	1.093		
12	3088	1873	1340	1544	2.20	1.093		
13	3257	1827	1691	1705	2.09	1.093		
14	3015	2098	1588	1884	2.03	1.093		
15	3068	2073	1503	1674	2.19	1.093		
16	2926	1851	1614	1576	2.14	1.093		
17	2916	1783	1291	1447	2.16	1.093		
18	3182	2092	1531	1697	2.22	1.093		
19	3370	2092	1593	1575	2.15	1.093		
20	3181	2042	1421	1685	2.08	1.093		
21	3139	2110	1675	1655	2.11	1.093		
22	2966	1805	1494	1564	1.89	1.093		
23	3105	1772	1491	1408	2.12	1.093		
24	3123	1938	1611	1529	2.03	1.093		
25	3296	2012	1706	1612	2.25	1.093		
26	3149	1916	1687	1647	2.31	1.093		
27	3298	2023	1691	1638	2.25	1.093		
28	2658	1725	1334	1504	2.13	1.093		
MEAN	3064	1935	1547	1569	2.17	1.093		

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	AERATION SYSTEM NO.2											
	LOADING PATTERN				SVI GRAB SAMPLE				NO2		NO3	
	PASS 1	PASS 2	PASS 3	PASS 4	SETTL. SOLIDS	SUSP. SOLIDS	SVI	VOLAT. SOLIDS	LOW FLOW GRAB SAMPLE	HIGH FLOW GRAB SAMPLE	LOW FLOW GRAB SAMPLE	HIGH FLOW GRAB SAMPLE
	%	%	%	%	ML/L	MG/L	ML/G	%	MG/L	MG/L	MG/L	MG/L
	132	133	134	135	136	137	138	139	140	141	142	143
1	30.0	45.0	25.0	.0	250	1343	186	79	.060	.350	20.0	25.0
2	30.0	45.0	25.0	.0	230	1445	159	78	.050	.370	20.7	28.7
3	30.0	45.0	25.0	.0	245	1532	131	78	.040	< .010	22.8	17.9
4	30.0	45.0	25.0	.0	245	1870	131	79	.020	.090	13.9	15.9
5	30.0	45.0	25.0	.0	210	1852	113	79	.050	.010	17.0	20.1
6	30.0	45.0	25.0	.0	215	1709	126	79	.100	.730	8.0	10.0
7	30.0	45.0	25.0	.0	200	1728	116	1	E	.080	E	19.3
8	30.0	45.0	25.0	.0	200	1928	104	79	.060	.090	8.5	15.9
9	30.0	45.0	25.0	.0	215	1904	113	81	.070	.070	16.0	20.0
10	30.0	45.0	25.0	.0	210	1642	128	79	.120	.110	19.2	19.0
11	30.0	45.0	25.0	.0	200	1817	110	80	.100	.080	3.7	7.5
12	30.0	45.0	25.0	.0	200	1815	110	79	E	E	E	E
13	30.0	45.0	25.0	.0	220	1675	131	76	.110	.060	3.3	6.6
14	30.0	45.0	25.0	.0	230	1666	138	78	.120	.060	4.0	3.0
15	30.0	45.0	25.0	.0	220	1607	137	76	.110	.220	6.5	16.0
16	30.0	45.0	25.0	.0	240	1548	155	77	.020	.130	20.8	31.3
17	30.0	45.0	25.0	.0	250	1769	141	78	E	E	E	E
18	30.0	45.0	25.0	.0	240	1768	136	78	.120	.090	7.0	10.0
19	30.0	45.0	25.0	.0	260	2122	123	79	.060	.060	2.5	2.4
20	30.0	45.0	25.0	.0	270	1920	141	80	.090	.060	2.2	2.6
21	30.0	45.0	25.0	.0	290	1922	42	80	.080	.060	1.8	2.6
22	30.0	45.0	25.0	.0	320	1762	181	79	.110	.090	2.4	4.8
23	30.0	45.0	25.0	.0	335	1720	194	82	.130	.080	4.0	12.0
24	30.0	45.0	25.0	.0	360	1642	219	79	.090	.090	7.1	7.4
25	30.0	45.0	25.0	.0	350	1810	193	79	.170	.100	7.6	4.1
26	30.0	45.0	25.0	.0	425	1835	232	79	.150	.120	3.0	7.6
27	30.0	45.0	25.0	.0	460	1674	275	78	.070	.060	.2	4.1
28	30.0	45.0	25.0	.0	430	1570	274	77	.080	.080	1.9	4.1
MEAN	30.0	45.0	25.0	.0	269	1736	151	76	.087	< .129	9.0	12.2

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	AERATION SYSTEM NO. 3							
	SUSPENDED SOLIDS 24-HOUR COMPOSITES				RETURN ACTIVATED SLUDGE		MIXED LIQUOR DISSOLVED OXYGEN	
	PASS 1	PASS 2	PASS 3	PASS 4	FLOW RATE	AERAT. VOLUME	MAX.	MIN.
	MG/L	MG/L	MG/L	MG/L	MGD	MG	MG/L	MG/L
	144	145	146	147	148	149	150	151
1	2899	1797	1632	1469	2.51	1.093		
2	2935	1901	1544	1446	2.54	1.093		
3	3216	2128	1708	1871	2.59	1.093		
4	3282	2251	1663	1848	2.31	1.093		
5	2986	2031	1712	1553	2.57	1.093		
6	3215	2251	1700	1745	2.47	1.093		
7	3235	2166	1899	1724	2.22	1.093		
8	3020	1988	1652	1665	2.21	1.093		
9	2882	1896	1528	1433	2.30	1.093		
10	2860	1845	1650	1443	2.29	1.093		
11	2803	1960	1643	1530	1.98	1.093		
12	3098	2018	1723	1601	2.13	1.093		
13	3023	1859	1555	1667	1.93	1.093		
14	2905	1953	1498	1492	1.92	1.093		
15	2888	2007	1612	1554	2.05	1.093		
16	2735	1896	1576	1439	2.11	1.093		
17	2370	1686	1348	1200	2.02	1.093		
18	2721	1791	1466	1683	2.04	1.093		
19	3090	2042	1704	1623	1.98	1.093		
20	2988	2042	1601	1535	2.02	1.093		
21	3055	2190	1646	1651	2.05	1.093		
22	2762	1960	1490	1492	1.76	1.093		
23	2959	1926	1364	1457	2.13	1.093		
24	3063	1866	1566	1604	2.05	1.093		
25	3183	2069	1537	1548	2.10	1.093		
26	2984	1949	1577	1525	2.10	1.093		
27	3063	1999	1500	1629	2.12	1.093		
28	2606	1787	1419	1518	2.01	1.093		
MEAN	2958	1973	1590	1569	2.16	1.093		

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	AERATION SYSTEM NO.3											
	LOADING PATTERN				SVI GRAB SAMPLE				NO2		NO3	
	PASS 1	PASS 2	PASS 3	PASS 4	SETTL. SOLIDS	SUSP. SOLIDS	SVI	VOLAT. SOLIDS	LOW FLOW GRAB SAMPLE	HIGH FLOW GRAB SAMPLE	LOW FLOW GRAB SAMPLE	HIGH FLOW GRAB SAMPLE
	%	%	%	%	ML/L	MG/L	ML/G	%	MG/L	MG/L	MG/L	MG/L
	152	153	154	155	156	157	158	159	160	161	162	163
1	30.0	45.0	25.0	.0	270	1533	176	80	.050	.290	16.0	24.6
2	30.0	45.0	25.0	.0	230	1436	160	78	.060	.360	21.1	29.1
3	30.0	45.0	25.0	.0	210	1532	135	78	.050	< .010	21.2	23.5
4	30.0	45.0	25.0	.0	270	1990	136	79	.030	.040	13.5	18.3
5	30.0	45.0	25.0	.0	250	1816	138	77	.040	.010	15.0	20.5
6	30.0	45.0	25.0	.0	245	1704	144	77	.090	.730	7.5	10.5
7	30.0	45.0	25.0	.0	220	1896	116	78	E	.090	E	15.0
8	30.0	45.0	25.0	.0	200	1993	100	79	.060	.070	10.5	14.1
9	30.0	45.0	25.0	.0	210	1858	113	81	.100	.020	15.0	23.5
10	30.0	45.0	25.0	.0	200	1544	129	78	.130	.100	17.0	17.5
11	30.0	45.0	25.0	.0	200	1655	120	79	.120	.090	3.7	8.0
12	30.0	45.0	25.0	.0	180	1651	109	79	E	E	E	E
13	30.0	45.0	25.0	.0	215	1612	133	77	.120	.090	2.0	8.5
14	30.0	45.0	25.0	.0	200	1480	135	78	.120	.070	5.0	3.5
15	30.0	45.0	25.0	.0	210	1467	143	75	.110	.240	6.5	17.0
16	30.0	45.0	25.0	.0	230	1435	160	76	.010	.050	21.2	25.5
17	30.0	45.0	25.0	.0	240	1636	147	77	E	E	E	E
18	30.0	45.0	25.0	.0	200	1421	141	78	.120	.110	7.5	12.5
19	30.0	45.0	25.0	.0	235	1824	129	79	.060	.070	3.0	3.0
20	30.0	45.0	25.0	.0	250	1877	133	80	.090	.050	2.3	3.2
21	30.0	45.0	25.0	.0	270	1993	135	80	.080	.060	2.0	3.0
22	30.0	45.0	25.0	.0	310	1742	178	79	.070	.050	1.8	4.3
23	30.0	45.0	25.0	.0	290	1540	188	81	.150	.100	4.6	12.5
24	30.0	45.0	25.0	.0	330	1583	208	79	.100	.080	5.6	7.3
25	30.0	45.0	30.0	.0	320	1520	211	78	.180	.090	7.8	3.6
26	30.0	45.0	25.0	.0	360	1760	205	79	.150	.120	2.5	6.2
27	30.0	45.0	25.0	.0	380	1505	252	77	.150	.110	1.5	7.3
28	30.0	45.0	25.0	.0	395	1445	273	76	.090	.110	4.6	8.2
MEAN	30.0	45.0	25.2	.0	254	1659	155	78	.093	< .123	8.7	12.7

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	KINETIC PARAMETERS									
	AIR RATES		COD		TOTAL AERATION SOLIDS			MIXED LIQUOR SUSPENDED SOLIDS		
	CUBIC FEET/ GALLON EFFLUENT	CUBIC FEET/ POUND COD REMOVED	REMOVAL	AERATION SYSTEM LOAD	AERATION SYSTEM 1	AERATION SYSTEM 2	AERATION SYSTEM 3	AERATION SYSTEM 1	AERATION SYSTEM 2	AERATION SYSTEM 3
			%	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.
	164	165	166	167	168	169	170	171	172	173
1	2.02	948	88.3	66,000	61,800	61,400	64,200	26,300	26,200	28,900
2	1.90	1,042	85.9	60,600	67,900	67,500	68,400	28,000	27,500	28,800
3	1.95	933	93.3	48,600	70,400	68,000	71,300	31,500	29,700	32,800
4	1.96	806	93.6	56,200	70,400	67,700	72,700	31,900	29,900	33,200
5	2.08	762	91.9	65,600	66,500	64,300	67,000	30,300	29,000	30,900
6	2.02	1,031	86.1	51,100	69,900	66,200	72,300	30,900	28,500	33,000
7	1.85	650	90.9	76,200	71,300	69,400	71,800	33,000	31,700	33,800
8	1.98	996	89.2	47,300	67,600	65,200	66,800	31,000	29,900	30,800
9	1.99	1,193	87.0	42,000	65,500	66,600	62,600	30,500	31,100	28,600
10	1.92	860	91.8	55,300	61,700	60,900	61,800	28,600	28,100	29,100
11	1.92	723	93.0	64,900	68,100	67,400	65,800	31,100	30,300	29,800
12	1.94	906	92.1	51,900	59,600	63,300	66,900	28,800	28,000	31,300
13	1.96	826	91.1	56,300	66,800	66,000	63,700	31,100	30,800	29,500
14	1.95	813	90.3	57,900	59,600	63,200	59,700	28,700	31,600	28,900
15	2.10	1,054	91.6	47,600	61,000	63,600	62,300	28,600	30,400	30,000
16	1.98	1,187	90.1	39,100	61,600	62,500	61,000	28,500	29,400	28,600
17	2.03	1,043	91.4	45,900	65,400	63,100	58,700	29,100	26,600	24,700
18	2.02	808	90.6	58,900	70,600	71,200	65,900	30,800	30,900	28,200
19	2.02	748	92.3	61,300	71,300	73,500	72,300	30,500	31,200	31,300
20	2.00	755	91.6	60,500	72,200	71,100	70,600	31,100	29,900	30,200
21	1.91	762	91.7	57,900	69,100	69,600	69,300	31,100	31,700	31,700
22	1.93	870	91.7	48,300	65,400	65,100	64,500	28,200	28,500	28,600
23	1.92	951	91.7	45,800	65,600	63,200	62,600	29,700	28,000	27,900
24	2.06	762	94.2	59,400	67,700	67,100	66,200	29,800	30,000	29,500
25	2.02	779	92.0	61,300	68,800	69,300	67,700	30,700	31,500	30,400
26	2.06	852	94.2	56,400	66,700	67,700	65,800	29,700	30,800	29,600
27	2.01	866	92.7	55,100	65,500	68,000	65,200	29,600	31,600	29,800
28	1.98	827	92.3	56,600	58,300	58,500	59,200	26,300	26,300	27,100
MEAN	1.98	884	91.2	55,500	66,296	66,093	65,939	29,836	29,611	29,893

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT
SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	KINETIC PARAMETERS											
	CENTROIDAL						HYDRAULIC					
	RETURN SLUDGE AERATION TIMES			MIXED LIQUOR AERATION TIMES			RETURN SLUDGE AERATION TIMES			MIXED LIQUOR AERATION TIMES		
	AERATION SYSTEM 1	AERATION SYSTEM 2	AERATION SYSTEM 3	AERATION SYSTEM 1	AERATION SYSTEM 2	AERATION SYSTEM 3	AERATION SYSTEM 1	AERATION SYSTEM 2	AERATION SYSTEM 3	AERATION SYSTEM 1	AERATION SYSTEM 2	AERATION SYSTEM 3
	HRS.	HRS.	HRS.	HRS.	HRS.	HRS.	HRS.	HRS.	HRS.	HRS.	HRS.	HRS.
	174	175	176	177	178	179	180	181	182	183	184	185
1	11.46	11.16	10.45	4.08	4.06	4.00				6.38	6.35	6.26
2	11.26	11.02	10.33	3.93	3.91	3.86				6.14	6.12	6.04
3	12.61	11.51	10.13	4.99	4.88	4.73				7.81	7.64	7.40
4	11.98	12.55	11.36	4.95	5.00	4.88				7.74	7.83	7.64
5	10.21	10.21	10.21	4.68	4.68	4.68				7.32	7.32	7.32
6	11.51	12.55	10.62	4.76	4.85	4.67				7.45	7.60	7.31
7	12.03	12.92	11.82	4.51	4.58	4.49				7.06	7.16	7.03
8	12.26	12.20	11.87	5.06	5.05	5.02				7.91	7.90	7.85
9	12.61	11.51	11.41	4.96	4.85	4.84				7.76	7.59	7.58
10	13.05	11.71	11.46	4.85	4.74	4.71				7.59	7.41	7.37
11	13.25	12.67	13.25	4.87	4.82	4.87				7.61	7.54	7.61
12	13.52	11.92	12.32	4.94	4.81	4.84				7.73	7.52	7.58
13	14.26	12.55	13.59	5.15	5.01	5.10				8.05	7.84	7.97
14	15.71	12.92	13.66	5.20	5.00	5.06				8.14	7.83	7.92
15	13.88	11.98	12.80	5.06	4.90	4.97				7.91	7.66	7.78
16	14.18	12.26	12.43	5.23	5.06	5.08				8.18	7.92	7.95
17	13.32	12.14	12.99	5.07	4.97	5.04				7.93	7.77	7.89
18	13.05	11.82	12.86	5.09	4.98	5.08				7.97	7.79	7.94
19	13.66	12.20	13.25	5.21	5.08	5.17				8.15	7.95	8.10
20	14.18	12.61	12.99	5.27	5.13	5.17				8.24	8.03	8.09
21	14.03	12.43	12.80	5.19	5.06	5.09				8.13	7.91	7.97
22	15.08	13.88	14.90	5.53	5.43	5.52				8.65	8.50	8.63
23	13.73	12.37	12.32	5.25	5.13	5.12				8.22	8.03	8.02
24	12.92	12.92	12.80	5.21	5.21	5.20				8.16	8.16	8.14
25	13.66	11.66	12.49	5.07	4.89	4.97				7.93	7.65	7.78
26	12.92	11.36	12.49	4.97	4.82	4.93				7.78	7.55	7.72
27	13.52	11.66	12.37	5.01	4.84	4.91				7.83	7.58	7.68
28	13.88	12.32	13.05	5.07	4.94	5.00				7.93	7.73	7.83
MEAN	13.13	12.11	12.25	4.97	4.88	4.89				7.78	7.64	7.66

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
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EXAMPLE OF MONTHLY REPORT
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APPENDIX (CONTINUED)

SAN JOSE CREEK WATER RENOVATION PLANT
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY, CALIF.
JOHN D. PARKHURST - CHIEF ENGINEER & GENERAL MANAGER
*** SUMMARY OF OPERATIONS ***
FEBRUARY 1975

DATE	KINETIC PARAMETERS								
	COD LOADING		DAILY CELL RES. TIME	SOLIDS BALANCE				AVERAGE NET GROWTH	AVERAGE CELL RES. TIME
	LBS. COD/ LBS. TPVSS/ DAY	LBS. COD/ LBS. MLVSS/ DAY		TOTAL PLANT SUSPEND. SOLIDS	WASTED SOLIDS	SEC. EFFLUENT SUSPEND. SOLIDS	DAILY NET GROWTH	#GROWTH/ #SYSTEM SOLIDS DAY	
			DAYS	LBS.	LBS.	LBS.	LBS.		DAYS
	186	187	188	189	190	191	192	193	194
1	.36	1.02	17.9	229,800	569	12,286	18255	.068	14.6
2	.31	.92	15.6	248,300	498	15,444	34442	.069	14.5
3	.24	.66	42.7	262,200	3,964	2,170	20034	.064	15.6
4	.27	.75	17.3	265,100	14,042	1,260	18202	.062	16.0
5	.34	.94	13.6	247,200	16,341	1,841	282	.062	16.2
6	.25	.71	13.7	260,100	17,451	1,497	31848	.061	16.3
7	.55	1.46	15.1	267,400	15,868	1,828	24996	.062	16.0
8	.24	.65	13.7	252,000	17,019	1,410	3029	.066	15.2
9	.21	.57	13.0	244,600	17,318	1,459	11377	.069	14.5
10	.31	.82	13.4	229,100	15,160	1,893	1553	.071	14.1
11	.33	.90	14.5	249,200	15,271	1,892	37263	.072	13.9
12	.27	.75	17.0	240,000	12,650	1,494	4944	.073	13.6
13	.30	.81	14.8	247,800	15,345	1,438	24583	.077	13.0
14	.33	.84	14.6	227,500	14,459	1,089	-4751	.054	18.6
15	.26	.71	22.8	238,100	9,184	1,278	21062	.053	18.8
16	.22	.59	40.2	232,500	4,550	1,232	182	.052	19.3
17	.26	.73	30.2	230,800	6,195	1,440	5935	.050	19.9
18	.29	.84	39.3	260,000	5,912	712	35824	.051	19.8
19	.29	.84	16.1	268,700	15,107	1,576	25383	.051	19.7
20	.29	.83	9.6	265,000	26,289	1,394	23983	.052	19.1
21	.28	.77	9.8	261,100	25,122	1,416	22638	.051	19.8
22	.25	.72	12.3	243,200	18,408	1,332	1840	.051	19.8
23	.24	.66	14.3	238,200	15,932	694	11626	.053	19.0
24	.30	.84	15.8	249,800	14,426	1,376	27402	.053	18.9
25	.31	.85	15.5	255,800	15,460	1,088	22548	.053	18.9
26	.29	.80	11.3	250,000	20,823	1,281	16304	.054	18.5
27	.29	.78	10.8	249,300	22,003	1,101	22404	.055	18.1
28	.33	.93	7.1	222,000	30,608	728	4035	.069	14.5
MEAN	.29	.81	17.6	247,671	14,499	2,273	16686	.060	17.0

A-SAMPLER MALFUNCTION, B-ANALYTICAL ERROR, C-INSUFFICIENT SAMPLE VOLUME, D-HOLIDAY NO ANALYSIS, E-INSUFFICIENT MANPOWER
F-ON-LINE INSTRUMENT OUT OF SERVICE

EXAMPLE OF MONTHLY REPORT SUMMARIZING ALL DATA AND CALCULATIONS

APPENDIX (CONTINUED)

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-75-058	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE State of the Technology SEMI-AUTOMATIC CONTROL OF ACTIVATED SLUDGE TREATMENT PLANTS		5. REPORT DATE December 1975 (Issuing Date) 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Carl A. Nagel		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS County Sanitation Districts of Los Angeles County 1955 Workman Mill Road Whittier, California 90607		10. PROGRAM ELEMENT NO. 1BB043; ROAP 21-ASC; Task 31 11. CONTRACT/GRANT NO. R803 055-01-0
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE EPA-ORD

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report documents the theory, design and operation of continuous on-line instrumentation currently in use by the County Sanitation Districts of Los Angeles County California and further describes computer applications which provide daily operational calculations.

Instrumentation sections include Water Level Control of Influent Pumping, Density Control of Primary Sludge Pumping, and Process Air, Return Sludge and Waste Sludge Control in Activated Sludge Plants. Theory, design, operation and maintenance characteristics, maintenance requirements, and results are presented for each system.

A computer application system is described which provides daily operational parameters to the operators and prepares monthly summary of operations reports. A review of other computer applications and a subroutine to compare effluent characteristics with discharge limits is included.

This report was submitted in fulfillment of Contract Number R 803 055-01-0, by the County Sanitation Districts of Los Angeles County, under the sponsorship of the Environmental Protection Agency. Work was completed as of March 1975.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Automatic control Automatic control equipment Data processing Data storage Data retrieval Waste treatment Waste water	Influent pumping control Sludge pumping control Process air control Waste activated sludge control	13B

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 212
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

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