EPA 904/9-76-07

TECHNICAL ASSISTANCE PROJECT AT THE THOMAS P. SMITH WASTEWATER TREATMENT PLANT TALLAHASSEE, FLORIDA

February 1976

Environmental Protection Agency
Region IV
Surveillance and Analysis Division
Athens, Georgia

TECHNICAL ASSISTANCE PROJECT

AT THE

THOMAS P. SMITH

WASTEWATER TREATMENT PLANT

TALLAHASSEE, FLORIDA

February 1976

Environmental Protection Agency
Region IV
Surveillance and Analysis Division
Athens, Georgia

TABLE OF CONTENTS

Page

INTRODUCTION 1
SUMMARY 2
RECOMMENDATIONS. 3
TREATMENT FACILITY 4
TREATMENT PROCESSES 4
PERSONNEL 6
STUDY RESULTS AND OBSERVATIONS 7
FLOW. 7
WASTE CHARACTERISTICS AND REMOVAL EFFICIENCIES. 7
AERATION BASINS 12
OXYGEN UPTAKE RATES 14
CLARIFIERS. 14
DISINFECTION. 18
DIGESTER AND DRYING BEDS. 18
LABORATORY. 18
REFERENCES 19

APPENDICES

A - CHEMICAL LABORATORY DATA. 20
B - GENERAL STUDY METHODS 26
C - OXYGEN UPTAKE PROCEDURE 28
D - DESIGN DATA 30

FIGURES

1 - THOMAS P. SMITH - SOUTHWEST TREATMENT PLANT 5
2 - ACTIVATED SLUDGE PLANT EFFLUENT AND RETURN SLUDGE FLOWS. 8
3 - FLOW STRIP CHARTS 9
4 - SETTLOMETER TEST. 13
5 - DYE CONCENTRATION CURVE 17

TABLES

1 - WASTE CHARACTERISTICS AND REMOVAL EFFICIENCIES - THOMAS P. SMITH WTP 7
2 - WASTE CHARACTERISTICS AND REMOVAL EFFICIENCIES - TRICKLING FILTER PLANT. 11
3 - ACTUAL AND RECOMMENDED PARAMETERS FOR CONVENTIONAL AND CONTACT STABILIZATION ACTIVATED SLUDGE PROCESS 12
4 - ACTUAL AND RECOMMENDED PARAMETERS FOR SECONDARY CLARIFIERS. 16

INTRODUCTION

A technical assistance study of operation and maintenance problems at the Thomas P. Smith Wastewater Treatment Plant (WTP) serving Tallahassee, Florida was conducted during February 8-13, 1976 by the Region IV, Surveillance and Analysis Division, U.S. Environmental Protection Agency. Operation and maintenance technical assistance studies are designed to assist local WTP operators in maximizing treatment efficiencies as well as assisting with special operational problems. Municipal wastewater treatment plants are selected for technical assistance studies after consultation with state pollution control authorities. Visits are made to each prospective plant prior to the study to determine if assistance is desired and if study efforts would be productive.

Historically, the Thomas P. Smith plant had BOD_5 removal efficiencies in the 75-85 percent range. This was much less than optimum, especially for a facility with little or no influent industrial wastewaters. This study was conducted at the request of plant personnel to:

- Optimize treatment through control testing and recommended operation and maintenance modifications,
- Determine influent and effluent wastewater characteristics,
- Assist laboratory personnel with any possible laboratory procedure problems, and
- Compare design and current loadings.

A follow-up assessment of plant operation and maintenance practices will be made at a later date. This will be accomplished by utilizing data generated by plant personnel and, if necessary, subsequent visits to the facility will be made. The follow-up assessment will determine if recommendations were successful in improving plant operations and if further assistance is required. Contact has been maintained with plant personnel since the study in order to relate preliminary study findings and stay abreast of process changes and results. Most of the recommendations in this report have been implemented since the study and a visit to the plant on April 14 indicated significantly improved removal efficiencies.

SUMMARY

The Thomas P. Smith activated sludge WTP was designed for an average flow of 7.5 mgd. On site with the activated sludge facility is an older 2.5 mgd trickling filter plant. With pump station controls, the trickling filter plant is used to relieve the activated sludge plant when total inflow exceeds 7.5 mgd. Flows to the Thomas P. Smith plant averaged 6.35 mgd during the study and average 0.6 mgd at the trickling filter plant The influent wastewater was relatively weak with an average BOD_5 of 152 mg/1 and COD of 333 mg/1. This produced a food to microorganism (F/M) ratio of about half the minimum recommended levels.

The two aeration basins were constructed for capabilities of plug flow, step feed or contact stabilization; however, the step feed mode could not have been utilized since the motorized butterfly valves on the raw waste lines could not be maintained in a partially open position. At the time of the study, the plant was being operated in the contact stabilization mode. Good mixing and oxygen transfer was accomplished by four fixed mechanical aerators in each basin.

Based on present loading conditions, the aeration system contained excess solids. Even though the mean cell residence time (MCRT) was within accepted limits, the characteristics of an old sludge were apparent.

Effluent quality during the study period was typical of removal efficiencies in recent months. BOD_5 and suspended solids removals were 88 and 84 percent respectively. Approximately one-half of the ammonia nitrogen was oxidized to nitrate-nitrite nitrogen. Turbidity of the clarifier effluents averaged 6 NTU.

The two secondary clarifiers were not hydraulically overloaded during the study. Dye used to observe the flow patterns revealed even dispersement of wastewater throughout the basins.

Return sludge is pumped from the clarifiers back to the aeration basins; however, the lines were inadvertently crossed in a design revision. Sludge from the north aeration basin and west clarifier is returned to the south aeration basin and visa versa (Figure 1).

Disinfection of the treated wastewater was with chlorine gas in a contact tank with 30 minutes detention at the design flow of 7.5 mgd. Residual chlorine concentrations in the effluent were higher than necessary to attain proper disinfection.

Sludge handling facilities include two aerobic digesters with mechanical aerators. Conditioned sludge is placed on drying beds and then spread on WTP property.

The laboratory was well arranged and had all required analytical capabilities.

RECOMMENDATIONS

The following recommendations are made to improve treatment and plant operations:

1. Switch the operational mode back to conventional plug flow. If the scum problem reappears temporarily switching to contact stabilization should increase the oxidation pressure on the waste and breakdown the scum.

2. Switch the return sludge lines so that sludge is returned back to the proper aeration basin.

3. Waste mixed liquor suspend solids down to 2000 to 2500 mg/l level or until the food to microorganism (F/M) ratio reaches the minimum recommended range of 0.2.

4. Shut off one aerator in each aeration basin if the reduced oxygen demand due to the reduction in mixed liquor solids permits. Check to see that adequate mixing is maintained.

5. Monitor food to microorganism, mean cell residence time, sludge settleability and other process control parameters. Establish historical operating data and maintain trend charts where cause and effect relationships can be easily determined.

6. Repair or replace the motorized butterfly valves on the raw waste lines to the aeration basin so that they can be held in the partially open position.

7. The pump stations should be regulated to deliver a smoother flow to the plant.

8. A good operation and maintenance manual is a useful operational tool and would be useful at the Thomas P. Smith WTP.

TREATMENT FACILITY

TREATMENT PROCESSES

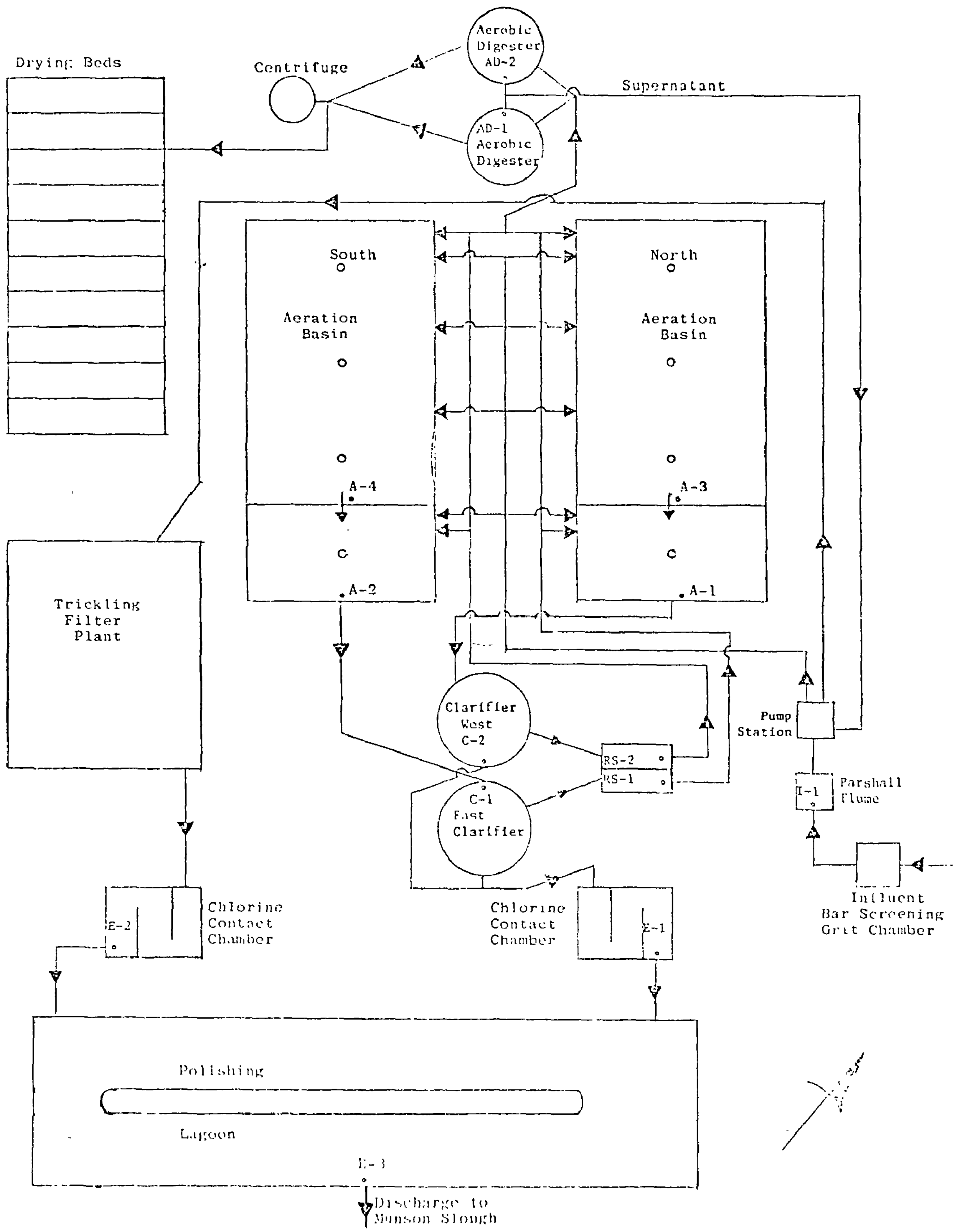
A schematic diagram of the Thomas P. Smith activated sludge WTP is presented in Figure 1. Also located on the same site is the older Southwest WTP, a trickling filter facility designed for 2.5 mgd. These two plants receive all of the waste from the City of Tallahassee except for the 4.5 mgd treated at the Lake Bradford Road WTP. Future plans are to expand the Thomas P. Smith plant to treat all of the wastewaters from the City of Tallahassee. There are no major industrial wastewater discharges into the system.

Raw sewage is pumped to the plant site from a pump station located on Spring Hill Road. A manually cleaned bar screen is located at the pump station. Approximately 150 lbs/day of chlorine is added for odor control. The pump station contains 3 two-speed pumps rated at 3,600 gpm at low speed and 7,200 gpm at high speed at 57 feet total dynamic head. Water level in the wet well is monitored and transmitted to a recorder on the plant control panel. On site, the wastewater flows through a bar screen, grit chamber, and Parshall flume into the pump station wet well. From this point the wastewater is split and pumped to the two wastewater treatment plants, which contain three 5,500 gpm pumps and one 1,800 gpm pump. All pumps discharge to a common header with a control valve provided to regulate flow to the trickling filter. Under the present mode of operation, the pump station is controlled to maintain a flow as constant as possible through the activated sludge system and the trickling filter handles a portion of the excess flow over 8 mgd. This is done by isolating the small pump during the daytime to pump to the filter when the plant inflow exceeds 8 mgd. Approximately 1 mgd is recirculated to keep the filter wet during low flow periods. At night, the small pump is switched back to pump to the activated sludge plant. The trickling filter receives no flow during this period. The flow rate to the activated sludge plant is measured by an in-line magnetic flow meter.

The aeration basins are designed to offer considerable flexibility in operational modes. Each basin contains four 50 hp fixed mechanical aerators. The fourth bay of each basin is segregated from the rest of the basin with a wall and sluce gate. Raw wastewater can be fed into all four bays of each basin by automatically controlled butterfly valves and return sludge can be fed into the first and fourth bays. This permits the system to be operated in either conventional plug flow, step feed or contact stabilization modes.

Mixed liquor flows over a weir at the end of each aeration basin into two final clarifiers. The circular clarifiers are rim feed and rim take-off type. Two in-line propeller type flow meters are used to measure the discharge from each clarifier to the chlorine contact tank and the effluent from the contact tank is measured by a rectangular weir.

FIGURE I
THOMAS SMITH - SOUTHWEST TREATMENT PLANT
TALLAHASSEE, FLA.



Settled sludge from each clarifier is removed by vacuum pick-up into separate sludge sumps. The sludge is pumped back into the aeration basins by 75 hp duplex pumps. A sluce gate is provided in the common wall between the sludge sumps. In a design revision, the sludge return lines were inadvertently crossed. This takes away the option of operating each side of the system independently. Sludge from the north aeration basin and west clarifier is returned to the south aeration basin and visa versa. Flow meters are provided on each return sludge line. Sludge can be wasted to the two aerobic digesters by turning a manually controlled valve on either return sludge line. Each digester is equipped with a 100 hp fixed mechanical aerator.

Effluent wastewater from each clarifier passes through a flow meter and into a rectangular baffled chlorine contact chamber. Chlorine gas, added at the basin influent, is used for disinfection. After chlorination, the wastewater is discharged into a polishing pond where a portion is spray irrigated on a test plot and the remainder is discharged to Munson Slough. Spray irrigation of the total plant effluent on the municipal airport property is planned.

PERSONNEL

The plant is well staffed with two Class A, one Class B and six Class C operators plus three trainees. The plant is manned 24 hours per day, 7 days per week.

STUDY RESULTS AND OBSERVATIONS

A complete listing of all analytical data and study methods are presented in the Appendices. Significant results and observations made during the study are presented in the following sections.

FLOW

Figure 2 presents the wastewater flow variation during the study. The weekly flow averaged 6.35 mgd and varied from near zero to 12 mgd. An additional 0.6 mgd was treated in the trickling filter plant

Surges in flow are created when rags are periodically removed from the manually cleaned bar screen at the Spring Hill Road Pump Station. Wastewater stored in the sewer flows into the wet well which causes an additional pump to be activated. This surge is reflected throughout the treatment unit as Figure 3 demonstrates.

The lower curve (contact chamber) is the sum of the two clarifier curves. The wrong type of strip chart paper was used in the lower two curves. The scale on all three charts should be the same as the top curve (west clarifier).

Raw wastewater is repumped into each bay of the aeration basins from a common header through separate butterfly valves. Any differences in water surface elevation in either aeration basin produces a disproportionate split in waste flow to the basins.

WASTE CHARACTERISTICS AND REMOVAL EFFICIENCIES

Table 1 presents a chemical description of the activated sludge plant influent and effluent with calculated average percent reductions. The removal efficiencies were calculated using data from Stations I-1 and E-1 which were collected on a 24-hour proportional to flow composite basis for the period February 9-12, 1976.

TABLE 1
WASTE CHARACTERISTICS AND REMOVAL EFFICIENCIES
THOMAS P. SMITH WTP

Parameter	Influent	Effluent	% Reduction
BOD_5 (mg/l)	152	19	88
COD (mg/l)	333	55	83
Suspended Solids (mg/l)	70	11	84
Total Solids (mg/l)	454	352	22
TKN-N (mg/l)	23.3	11.2	52
NH_3-N (mg/l)	18.9	8.5	55
NO_3-NO_2-N (mg/l)	.01	9.2	--
Total Phosphorus (mg/l)	8.4	7.2	14
Pb (μg/l)	<80	<80	--

FIGURE 2
ACTIVATED SLUDGE PLANT EFFLUENT AND RETURN SLUDGE
TALLAHASSEE, FL

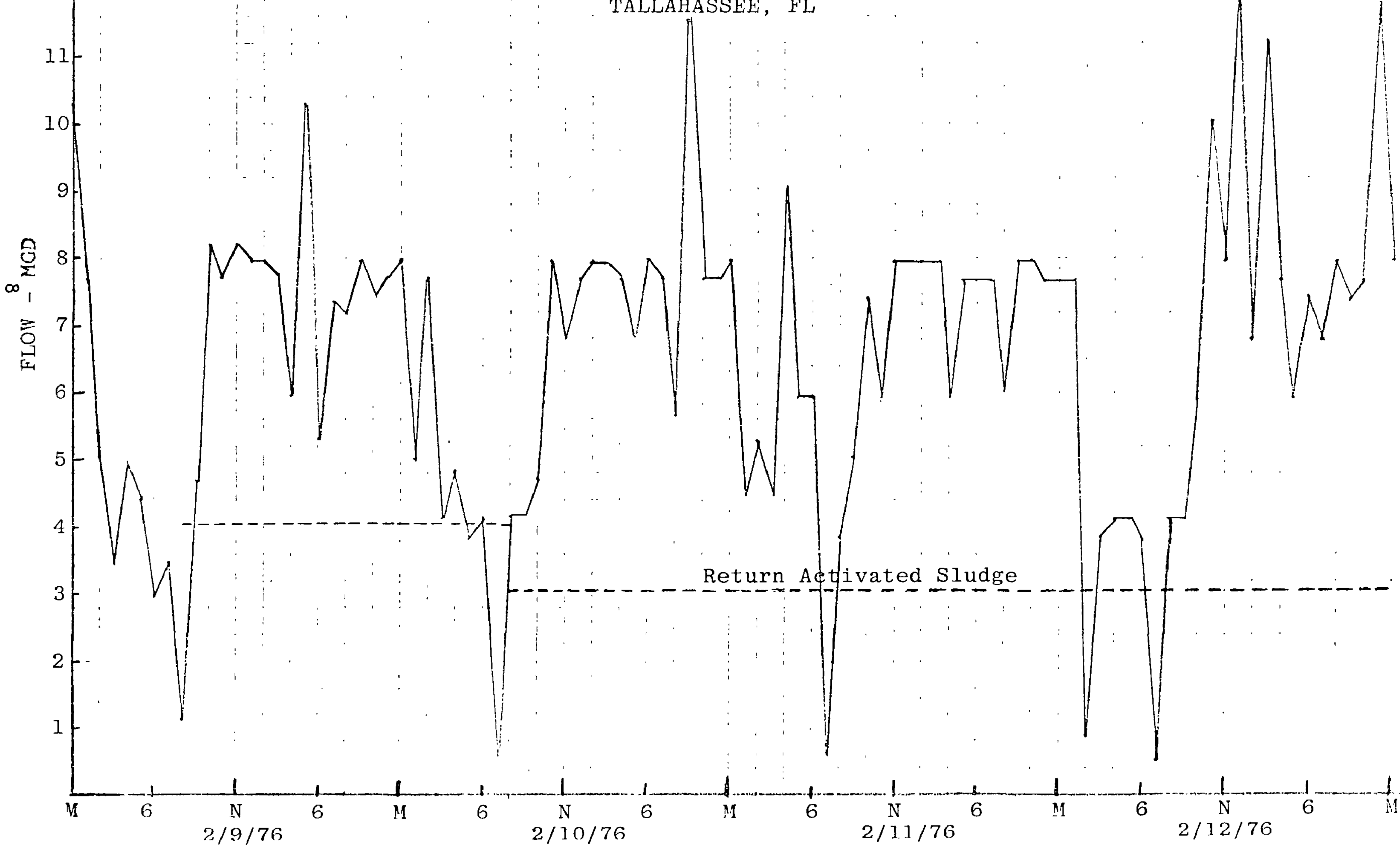


FIGURE
FLOW STRIP CHARTS
THOMAS P. SMITH WTP
TALLAHASSEE FL

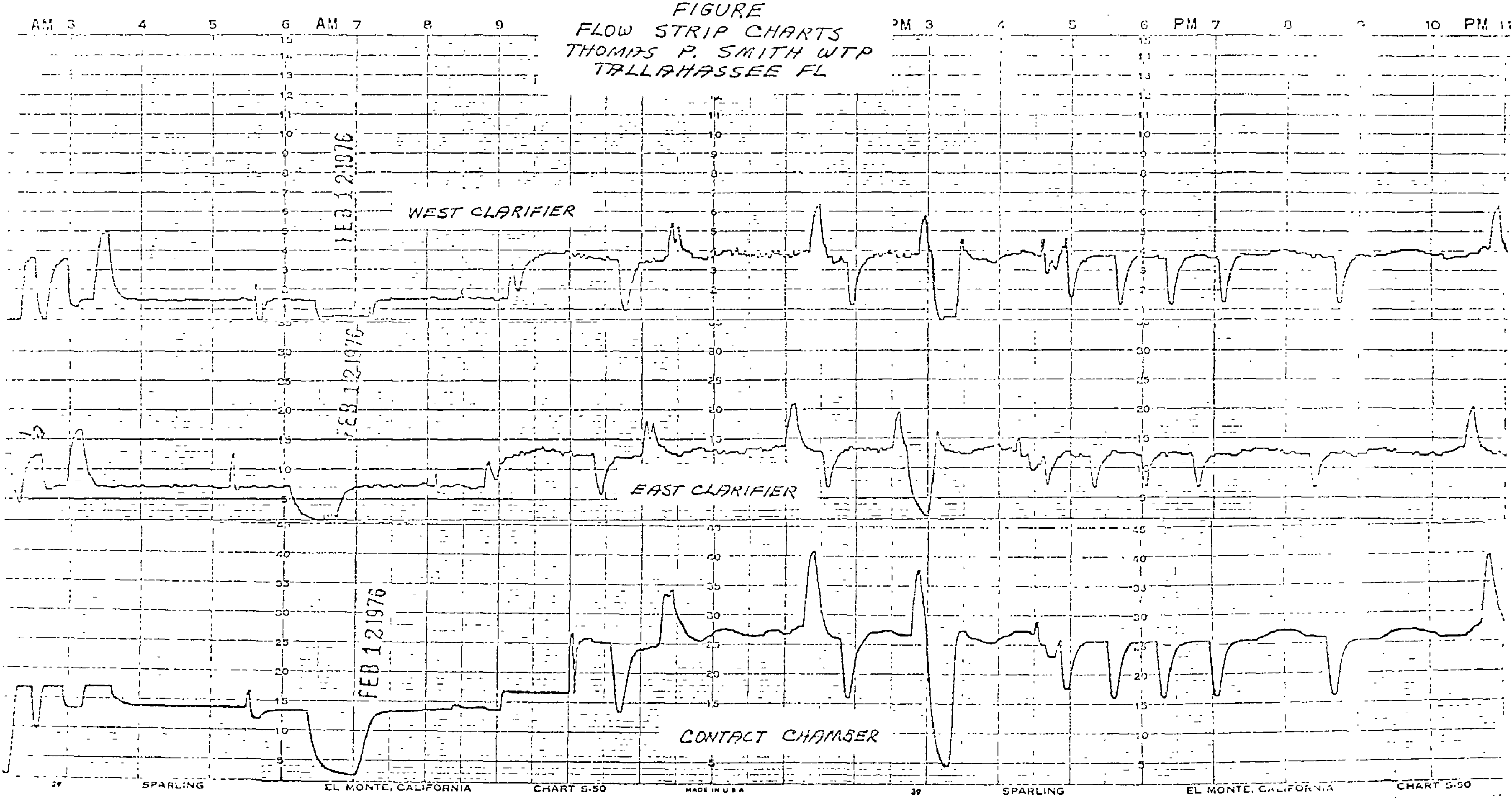


TABLE 1 (Cont)

Parameter	Influent	Effluent	% Reduction
Cr (μg/l)	< 80	< 80	--
Cd (μg/l)	< 20	< 20	--
Cu (μg/l)	63	25	60
Zn (μg/l)	246	80	67

It is apparent from the data in Table 1 that nitrification was taking place in the plant. Approximately one-half of the ammonia in the influent was oxidized to nitrate-nitrite nitrogen. The remaining one-half was discharged in the effluent. In plants where partial nitrification is accomplished, special precautions must be taken in running and interpreting the BOD_5 results. Much of the oxygen demand in the BOD5 test may result from the oxidation of ammonia. In these situations, nitrification can be expected to exert a demand for the entire 5-day period rather than exhibiting the characteristic 8-12 day lag time. The lag time is normally required to build up an effective population of the relatively slow growing nitrifying organisms. In plants where partial nitrification is accomplished, an effective population of nitrifiers is already present in the sample.

Clair N. Sawyer[8] stated that BOD tests run on the effluents of plants accomplishing partial nitrification will have a considerable nitrogenous BOD superimposed upon the small remaining residual carbonaceous BOD. He also stated that "it is theoretically possible for plant effluents which are in the so-called "incipient nitrification stage" to exhibit greater 5-day BOD values than those shown by the untreated sewages."

At the Thomas P. Smith plant, the average BOD_5 of samples collected from the two clarifier effluents (before chlorination) stations C-1 and C-2 was 33 mg/l. The average results from station E-1 (chlorine contact chamber effluent) was 19 mg/l. This amounts to a 42 percent reduction or 740 lbs/day of BOD_5 at the average flow of 6.35 mgd. Chlorine application during the study ran about 220 lbs/day. Assuming a one for one destruction of BOD_5 due to chlorine oxidation[5] this leaves 520 lbs/day of BOD_5 which is apparently due to nitrification.

The samples collected from station E-1 were reseeded with final clarifier effluent. Each bottle contained 0.9 ml of clarifier effluent per 300 ml. This volume evidently did not provide enough nitrifying bacteria to provide significant nitrification.

In the clarifier effluent samples 10 and 25 percent dilutions for the BOD_5 test were set up. This gave 30 and 75 ml of clarifier effluent per 300 ml sample bottle, providing a sufficient nitrifying bacteria population for nitrification to occur. The 10 and 25 percent dilutions gave comparable values indicating that the additional bacteria in the 25 percent dilution did not further increase the oxygen demand due to nitrification.

The effects of nitrification on the BOD_5 test can be avoided by collecting effluent samples after chlorination (as shown by the results of this study) or sterilizing the sample with heat and reseeding. The degree of nitrogenous demand can be monitored and separated from the carbonaceous demand by measuring the relative amount of ammonia and nitrate-nitrite in the BOD bottles as the test progresses.

The trickling filter plant's efficiencies were determined using samples from the influent and effluent station E-2. Analyses were made on grab samples since there were periods of no flow from the trickling filter plant. Table II lists an average of the data on the influent and effluent with calculated percent reduction.

TABLE II
WASTE CHARACTERISTICS AND REMOVAL EFFICIENCIES
TRICKLING FILTER PLANT

Parameter	Influent	Effluent	% Reduction
BOD_5 (mg/l)	152	22	86
COD (mg/l)	333	60	82
Suspended Solids (mg/l)	70	11	84
Total Solids (mg/l)	454	332	27
TKN--N (mg/l)	23.3	9.0	61
NH_3-N (mg/l)	18.9	5.6	70
NO_3-NO_2-N (mg/l)	<.01	8.4	--
Total Phosphorus (mg/l)	8.4	7.5	11
Pb (μg/l)	<80	<80	--
Cr (μg/l)	<80	<80	--
Cd (μg/l)	<20	<20	--
Cu (μg/l)	63	25	60
Zn (μg/l)	246	68	72

AERATION BASINS

During the study, the system was operated in the contact stabilization mode. The plant had operated previously, with some success, in the conventional "plug flow" configuration. Due to the development of a scum problem, contact stabilization was initiated and the scum dissipated. Under contact stabilization, the oxidative pressure on the waste is increased and the scum is biodegraded.

Table III lists actual and recommended parameters for both the conventional and contact stabilization process.

TABLE III
ACTUAL AND RECOMMENDED PARAMETERS FOR THE CONVENTIONAL AND CONTACT STABILIZATION ACTIVATED SLUDGE PROCESS

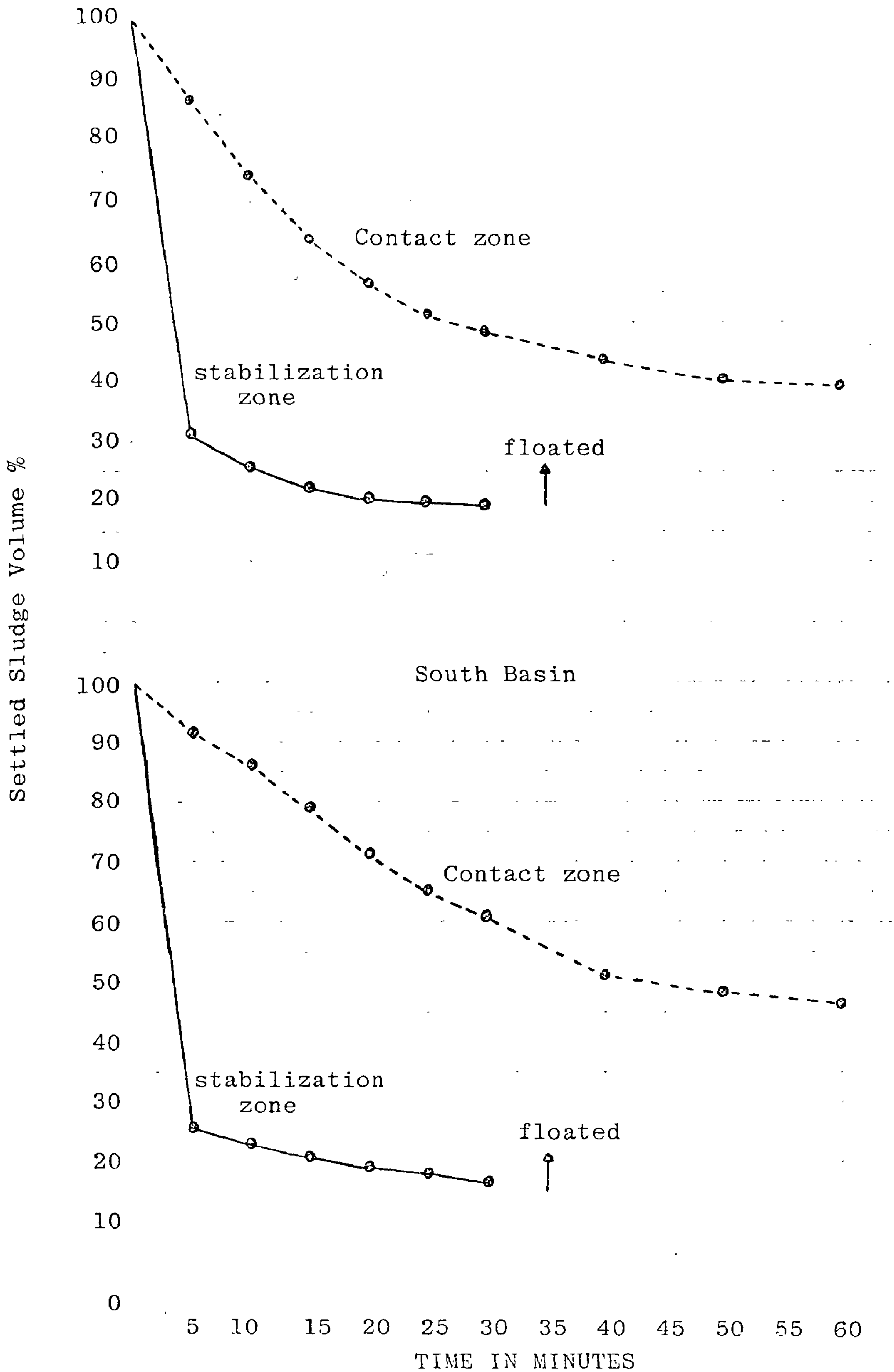
	Actual	Recommended (5) (6)	
Hydraulic Retention Time (hrs.)		Conventional	Contact
Contact Basin	2.8	4-8	0.5-1
Stabilization Basin	7.4		3-6
Mean Cell Residence Time (days)	13.0	5-15	5-15
Sludge Age (days)	24.0	3.5-10	3.5-10
Lbs BOD_5/day/lb MLVSS (F/M)	0.11	0.2-0.4	0.2-0.6
Lbs COD/day/lb MLVSS	0.25	0.5-1.0	
Lbs BOD /day/1000 cu. ft.	25.0	20-40	60-75
Return Sludge Rate (% of average design flow)	54.0		15-75
Average Flow (mgd)	6.35		7.5 (Design)

Aeration and mixing in the basins were efficiently accomplished by the 50 hp mechanical aerators. Dissolved oxygen concentrations of 2.0 mg/l or greater were measured throughout the aeration basins with no dead spots or solids blanket observed.

Solids concentrations in the aeration system were determined by analyzing for suspended solids, volatile suspended solids and percent solids by centrifuge. Settleability of the sludge was determined by the sixty minute settlometer test (see Figure 4). Samples for these tests were taken from the stabilization zone discharges (stations A-3 and A-4) and from the contact zone discharge (Stations A-1 and A-2).

Samples from the contact zone contained from 1,200 to 2,400 mg/l total suspended solids. The varying solids concentrations are attributed to the influent flow, i.e., samples in the afternoon had a lower total suspended solids concentration since the flows were higher, effectively diluting the solids. The solids settled rapidly with maximum compaction attained in most cases in less than twenty minutes.

FIGURE 4
SETTLOMETER TEST
NORTH BASIN



OXYGEN UPTAKE RATES

The oxygen uptake rate is a measure of the general sludge activity, i.e., the biodegradability of a particular waste by a particular activated sludge. This activity is measured by mixing return activated sludge with influent (fed) and nonchlorinated effluent (unfed) and determining the uptake rates and calculating the load ratio.

$$\text{Load Ratio} = \frac{\Delta \text{DO (ppm/min) fed sludge}}{\Delta \text{DO (ppm/min) unfed sludge}}$$

Details of the procedure and the significance of the test are presented in Appendix B.

The following lists the oxygen uptake data and the calculated load ratio:

Date	Time	Station	% RS	Average Oxygen Uptake ppm/min URS2/	ppm/min FRS3/	Load Ratio
2-10-76	1500	RS-2	63%	0.6	1.1	1.83
2-11-76	0830	A-3	36%	0.16	0.35	2.23
2-12-76	1400	A-3	36%	0.36	0.60	1.67

1/ RS - Return Activated Sludge
2/ URS - Unfed Return Sludge
3/ FRS - Fed Return Sludge

On February 10, the return sludge sample was taken from the west return sludge well (station RS-2). Since the plant was operated in the contact mode, this sludge contained a large amount of undigested waste which had been adsorbed in the contact tank. This was essentially a "fed" sludge sample. On February 11 and 12, the activated sludge sample was taken from the discharge of the stabilization zone where the organisms had completely digested the adsorbed waste (Station A-3). Although the load ratios are fairly consistent, the uptake rates show significant difference. This is most likely due to the different concentrations of solids in the activated sludge and the one supposedly "unfed" sample which actually contained a considerable amount of food. Calculated load ratios indicate a well acclimated sludge and a readily biodegradable waste.

Clarifiers

Clarifier effluent turbidity ranged from 6.5 to 9.0 nephelometric turbidity units (NTU) based on grab samples collected each day. Occasional clumps of rising sludge deteriorate the aesthetic and physical quality of the effluent. This condition is caused by sludge collecting under the influent troughs and weir pans, becoming septic, and rising to the surface to flow over the weir. The problem is more severe when the plant is operated in the contact mode, since the settled sludge becomes septic rapidly and tends to rise to the surface.

Denitrification in the contact zone samples, with the resultant floating of the sludge, occurred in 40 to 75 minutes. Deoxygenation of the sludge occurs very rapidly in the clarifier when using the contact stabilization mode of operation. The operators must maintain close control on the return sludge rate to prevent denitrification and rising sludge in the clarifier.

Samples taken from the stabilization zone had a fairly consistent suspended solids concentration of 4,200-4,500 mg/l. Denitrification occurred and the solids floated to the surface in 80 to 90 minutes. Observations of the settlometer indicated that the sludge settled slower, leaving a much clearer supernatant, indicating that conventional plug flow would likely produce a better effluent than contact stabilization. Plug flow would also slow down denitrification of solids in the clarifier and make for generally easier operation.

If a scum problem reappears, the contact mode has been proven effective in correcting the problem at this plant. Other modes of operation, such as step feed,(feed waste into number 2, 3, and 4 bays) may be effective in controlling scum and should also produce a good effluent.

Food to microorganism ratios (F/M) using BOD_5 and COD concentrations were calculated using the total pounds of volatile suspended solids in the aeration system. The BOD_5 F/M ratio was 0.11 and the COD, F/M ratio was 0.25. These ratios are about half the recommended minimums.[6]

Motorized automatic butterfly valves on the raw waste lines feeding the aeration basins were inoperative. The valves could not be maintained in a partially open position. For step feed operations, it is essential to be able to operate the individual valves and make exact settings. Proper operation of the valves would also help to prevent uneven splitting of flow into the basins.

The clarifiers were designed for an overflow rate of 590 gal/day/ ft^2 at the design flow of 7.5 mgd and a weir overflow rate of 9,375 gal/day/ft (14,600 gal/day/ft without weir pans). The actual and recommended hydraulic loading, solids loading, and weir overflow rates for final clarifiers following activated sludge wastewater treatment are presented in Table IV.

TABLE IV
ACTUAL AND RECOMMENDED PARAMETERS FOR SECONDARY CLARIFIERS

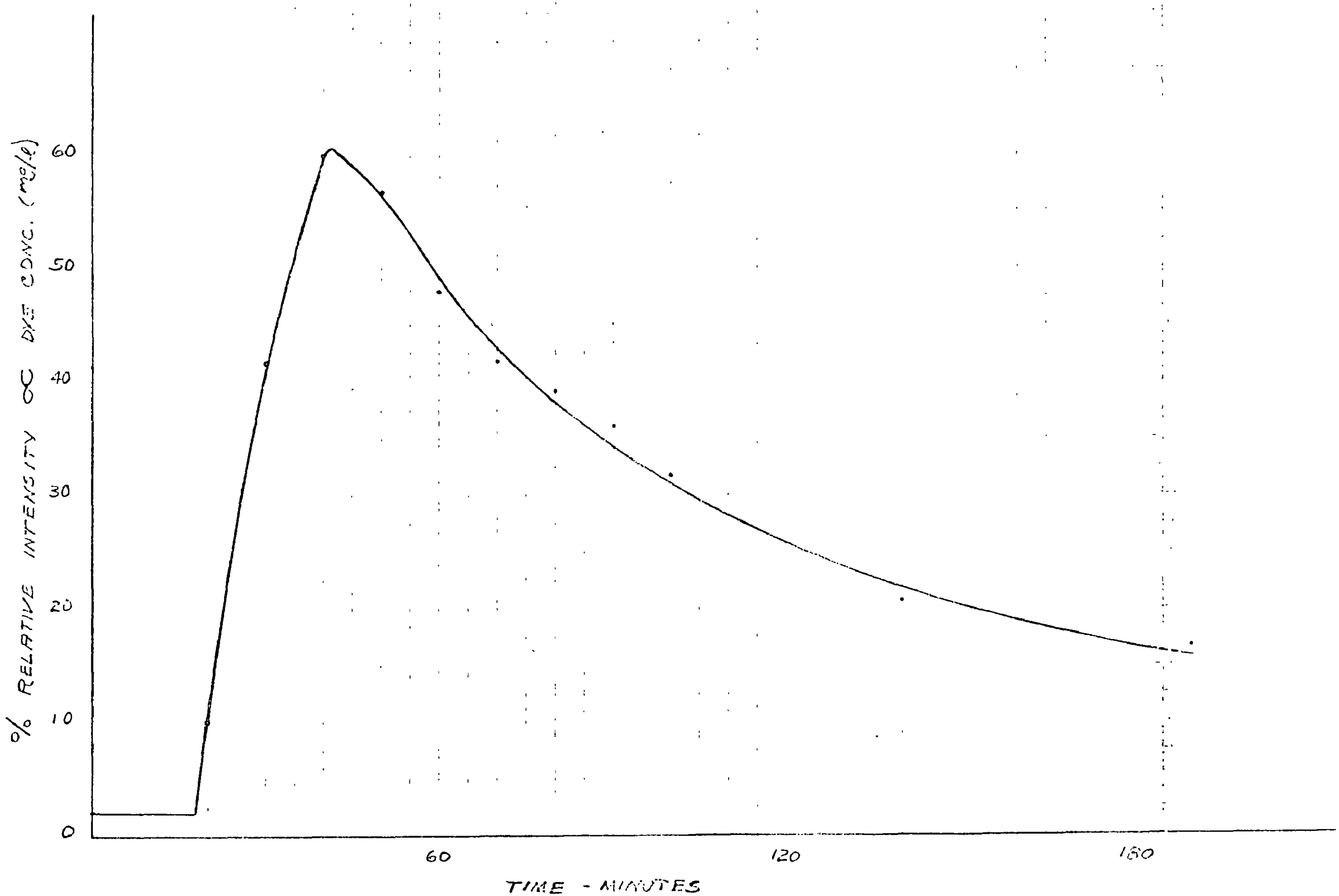
	Actual	Recommended (2)(3)(6)
Hydraulic Loading (gpd/ft^2)	480	400-800
Solids Loading (lbs/day/ft^2)	120	20-30
Weir Overflow Rate (gpd/ft)	7,700, 12,000*	<15,000
Hydraulic Detention Time (hrs.)	5	2-3

*Extra weir length due to weir pans not included

Calculations in Table IV are based on an average flow of 6.35 mgd. From Figure 2 it can be seen that a sustained flow of approximately 8 mgd occurs each day. This flow is only slightly above the average design flow of 7.5 mgd and does not produce overloading. Maximum peak flow during the study was 12 mgd caused by irregular pump cycling. This produced a weir overflow rate of 12,300 gpd/ft or 19,000 gpd/day/ft^2 not considering the extra weir length due to weir pans. These loading rates should not present any problems; however, the flow surging in the clarifiers due to pumping may cause problems.

As mentioned above, the weir pans provide several additional feet of weir length and are some improvement over the single peripheral weir. However, the additional weir length is not equivalent to the same length of peripheral weir. Approach velocities to the weir are the critical factor. A small volume of dye was added to the west clarifier influent to determine flow patterns and distribution in the clarifier. The dye was added at 1340 hours on February 11, 1976 when the clarifier was receiving a waste flow of 3.75 mgd (7.5 mgd for both clarifiers). Samples were collected at the clarifier effluent and results are shown in Figure 5. The first traces of dye appeared in the effluent in 20 minutes with a peak concentration in 45 minutes. The centroid of the dye curve appears to be between one and two hours. This point (centroid) represents the average detention time in the clarifier. Visual observations indicated that the dye was well dispersed throughout the entire area of the clarifiers. The average detention time as measured by the dye study approaches the recommended detention time.

FIGURE 5
CLARIFIER DYE TRACER STUDY
TALLAHASSEE FLORIDA



Researchers (2) have shown that the rim feed, rim take-off clarifier generally performs better than the center feed clarifier. Similar dye studies conducted on a number of clarifiers by the EPA team indicate that the flow distribution in the west clarifier is better than in most clarifiers observed.

DISINFECTION

Disinfection of the treated wastewater was accomplished by the injection of chlorine gas at the entrance to the contact chamber. At an average dosing rate of 220 lbs/day, an average residual of 2.48 mg/l was observed at the overflow weir. Automatic chlorine feed and monitoring equipment is being installed and should provide better chlorine control.

DIGESTERS AND DRYING BEDS

The two aerobic digesters are operated on a fill and draw basis. Normally waste sludge is pumped to each digester once or twice per day. The procedure takes approximately two hours. First, the fixed surface aerator in the digester is shut off and the sludge is allowed to settle. Then approximately 20 inches of supernatant is drawn off and returned to the on-site lift station. Waste activated sludge is then pumped to the digester to bring the water surface up to operating level and the aerator restarted.

Sludge is discharged on drying beds or spread on the plant site. A centrifuge unit is available for sludge dewatering, but has not been used.

LABORATORY

The laboratory is well organized and has many analytical capabilities. The facility serves as a central laboratory, performing analyses for all Tallahassee water and sewerage facilities. The staff included a chief chemist, one biologist and three laboratory technicians.

In general, analytical techniques were good. In the BOD_5 test, however, the routine procedure at the time of the study for chlorinated samples was to dechlorinate without reseeding. It was suggested by EPA personnel that seeding be performed per "Standard Methods for the Examination of Water and Wastewater", 13th Edition, 1971. At the conclusion of the study, plant personnel were adding this step to their routine procedure.

REFERENCES

1. "Process Design Manual for Suspended Solids Removal", US-EPA Technology Transfer, January 1975.

2. "Process Design Manual for Upgrading Existing Wastewater Treatment Plants", US-EPA Technology Transfer, October 1974.

3. "Sewage Treatment Plant Design", American Society of Civil Engineers, Manual of Engineering Practice No. 36, 1959.

4. "Standards for Sewage Works", Upper Mississippi River Board of State Sanitary Engineers, Revised Edition, 1971.

5. "Wastewater Engineering", Metcalf and Eddy, Inc., 1972.

6. "Operation of Wastewater Treatment Plants", A Field Study Training Program, US-EPA, Technical Training Grant No. 5TT1-WP-16-03, 1970.

7. "Standard Methods for the Examination of Water and Wastewater", 13th Edition, 1971.

8. "Modernization of the BOD Test for Determining the Efficiency of Sewage Treatment Processes", Sawyer and Bradney, Reprinted from Sewage Work Journal, Vol. XVIII, No. 6, November, 1946.

APPENDIX A
LABORATORY DATA
THOMAS P. SMITH WTP
TALLAHASSEE, FLORIDA

Influent and Effluents

O+M SAD #	STATION	MONTH	DAY	YEAR	TIME	Residual Chlorine mg/l	BOD5 mg/l*	COD. mg/l	Suspended Solids mg/l	Volatile Suspended Solids mg/l	Total Solids mg/l	Total Volatile Solids mg/l	Settleable Solids ml/l	Pb µg/l	Cr µg/l	Cu µg/l	Cd µg/l	Zn µg/l	TKN-N mg/l	NH_3-N mg/l	NO_3-NO_2-N mg/l	Total Phosphorus mg/l	Turbidity NTU
0728	I-1	2	9	76	1445	<.05	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—
0735		2	9/10	76	24 hr. Comp.	<.05	142	294	48	42	435	160	—	<80	<80	60	<20	235	23.5	18.9	<.01	8.8	—
0750		2	10	76	1430	<.05	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—
0758		2	10/11	76	24 hr. Comp.	<.05	173	331	66	60	437	167	—	<80	<80	63	<20	248	22.5	18.3	.01	7.8	—
0786		2	11/12	76	24 hr. Comp.	<.05	140	373	97	80	490	222	4.0	<80	<80	65	<20	255	24.0	19.4	<.01	8.6	—
0729	E-1	2	9	76	1445	3.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0736		2	9/10	76	24 hr. Comp.	1.52	22	60	12	10	356	124	—	<80	<80	25	<20	80	10.8	7.9	9.6	8.5	—
0747		2	10	76	1430	2.90	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6.5
0759		2	10/11	76	24 hr. Comp.	2.37	15	54	12	10	350	130	—	<80	<80	25	<20	80	11.6	8.8	8.7	6.3	—
0770		2	11	76	1615	2.22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9.0
0782		2	12	76	0915	3.45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.0
0788		2	11/12	76	24 hr. Comp.	1.90	20	51	10	10	351	120	<.5	<80	<80	25	<20	80	11.3	8.8	9.3	6.8	—
0730	E-2	2	9	76	1445	2.32	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0738		2	9/10	76	24 hr. Comp.	7.62	33	66	11	10	355	109	—	<80	<80	25	<20	75	10.5	7.0	7.5	7.5	—
0748		2	10	76	1430	13.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16.0
0760		2	11	76	1110	10.9	14	66	12	11	338	74	—	80	<80	25	<20	75	11.5	7.0	9.8	8.9	—
0771		2	11	76	1615	10.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10.0
0787		2	12	76	1000	7.00	20	47	11	9	302	77	<.5	<80	<80	20	<20	55	5.1	2.9	8.0	6.0	6.0

*See Study Methods

APPENDIX A (continued)
LABORATORY DATA
THOMAS P. SMITH WTP
TALLAHASSEE, FL

Effluents (continued)

O+M SAD #	STATION	MONTH	DAY	YEAR	TIME	Residual Chlorine mg/l	BOD5 mg/l*	COD mg/l	Suspended Solids mg/l	Volatile Suspended Solids mg/l	Total Solids mg/l	Total Volatile Solids mg/l	Settleable Solids ml/l	Pb µg/l	Cr µg/l	Cu µg/l	Cd µg/l	Zn µg/l	TKN-N mg/l	NH_3-N mg/l	NO_3-NO_2-N mg/l	Total Phosphorus mg/l	Turbidi
0731	E-3	2	9	76	1445	2.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0737		2	9/10	76	24 hr. comp.	1.32	32	78	16	15	342	112	—	<80	<80	25	<20	95	12.3	8.4	8.5	7.5	—
0749		2	10	76	1430	1.60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.5
0761		2	10/11	76	24 hr. comp.	1.32	25	70	16	13	337	102	—	<80	<80	25	<20	95	13.7	10.0	8.2	6.8	—
0772		2	11	76	1615	1.10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8.0
0783		2	12	76	0915	1.50	—	—	—	—	—	—	<.5	—	—	—	—	—	—	—	—	—	10.0
0791		2	11/12	76	24 hr. comp.	0.60	21	159	12	10	345	99	—	<80	<80	20	<20	80	12.8	9.8	8.2	6.8	—

*See Study Methods

APPENDIX A (cont'd)
LABORATORY DATA
THOMAS P. SMITH WTP
TALLAHASSEE, FLORIDA

Aeration Basins

O+M SAD #	STATION	MONTH	DAY	YEAR	TIME	SETTLOMETER (settled sludge volume %) 5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	40 min.	50 min.	60 min.	COMMENTS	% Solids V/V Centrifuge	Suspended Solids mg/l	Volatile Suspended Solids mg/l
0725	A-1	2	9	76	1330	30	24	21	18	18	18	–	–	–	Floated at 39 min.	3.1	1630	1310
0739		2	10	76	1345	24	18	16	15	15	15	–	–	–	Floated at 40 min.	2.7	1290	–
0752		2	11	76	0930	42	32	28	27	26	25	24	24	–	Floated at 58 min.	3.9	2120	1700
0766		2	11	76	1510	26	20	18	17	16	16	–	–	–	Floated at 40 min.	3.0	–	–
0774		2	12	76	0900	45	36	32	29	27	26	25	24	24	Floated at 75 min.	4.8	2400	1900
0792		2	12	76	1500	29	24	20	19	18	18	18	18	18	Floated at 70 min.	3.0	–	–
0726	A-2	2	9	76	1330	28	21	18	16	16	16	–	–	–	Floated at 39 min.	2.9	1540	1260
0740		2	10	76	1350	27	20	18	16	16	15	15	–	–	Floated at 42 min.	2.8	1420	1140
0753		2	11	76	0930	36	27	24	23	22	20	20	20	–	Floated at 58 min.	4.0	1920	1520
0767		2	11	76	1510	26	20	18	17	17	17	–	–	–	Floated at 40 min.	3.3	–	–
0775		2	12	76	0900	37	30	26	25	23	23	22	22	–	Floated at 55 min.	3.9	1940	1520
0793		2	12	76	1500	27	22	19	18	17	17	17	17	–	Floated at 60 min.	3.0	–	–
0741	A-3	2	10	76	1355	90	80	70	65	60	55	50	48	48		7.9	4175	3275
0754		2	11	76	0930	85	70	59	54	49	46	41	39	39	Floated at 80 min.	7.0	3650	2875
0768		2	11	76	1510	87	75	64	56	51	48	45	40	38	Floated at 90 min.	7.0	–	–
0776		2	12	76	0900	85	74	65	57	50	47	41	37	36	Floated at 83 min.	6.5	4025	3225
0794		2	12	76	1500	87	76	65	56	51	46	42	40	38		7.3	–	–
															A-3 and A-4 left clearer supernatant all week.			

APPENDIX A (cont'd)
LABORATORY DATA
THOMAS P. SMITH WTP
TALLAHASSEE, FLORIDA

Aeration Basins (continued)

O+M SRD #	STATION	MONTH	DAY	YEAR	TIME	SETTLOMETER (settled sludge volume %) 5 min	10 min	15 min	20 min	25 min	30 min	40 min	50 min	60 min	Comments	% Solids V/V Centrifuge	Suspended Solids mg/l	Volatile Suspended mg/l
0742	A-4	2	10	76	1400	92	86	78	75	67	63	55	53	50		8.2	4675	3675
0755		2	11	76	0930	95	88	80	75	69	64	55	50	48	Floated at 85 min.	8.0	4525	3575
0769		2	11	76	1510	94	87	80	73	68	63	57	52	50	Floated at 90 min.	8.5	—	—
0777		2	12	76	0900	88	81	73	66	59	54	48	44	42	Floated at 83 min.	8.0	4350	3400
0795		2	12	76	1500	91	86	80	72	66	59	52	49	45		8.5	—	—

APPENDIX A (continued)
LABORATORY DATA
THOMAS P. SMITH WTP
TALLAHASSEE, FLORIDA

Clarifiers

O+M SAD #	STATION	MONTH	DAY	YEAR	TIME	Turbidity	Suspended Solids mg/l	Volatile Suspended Solids mg/l	Pb µg/l	Cr µg/l	Cu µg/l	Cd µg/l	Zn µg/l	BOD5 mg/l*	COD mg/l	TKN-N mg/l	NH_3-N mg/l	NO_3-NO_2-N mg/l	Total Phosphorus				
0733	C-1	2	9/10	76	24 hr. Comp. **	–	–	–	<80	<80	50	<20	95	40	58	14.8	8.9	8.7	6.8				
0745		2	10	76	1415	5.4	–	–	–	–	–	–	–	–	–	–	–	–	–				
0763		2	11	76	1300	5.5	–	–	–	–	–	–	–	–	–	–	–	–	–				
0780		2	12	76	0900	6.0	–	–	–	–	–	–	–	–	–	–	–	–	–				
0784		2	11/12	76	24 hr. Comp. **	–	9.0	9.0	<80	<80	25	<20	90	34	54	14.5	10.0	8.7	8.0				
0798		2	12	76	1500	7.0	–	–	–	–	–	–	–	–	–	–	–	–	–				
0734	C-2	2	9/10	76	24 hr. Comp. **	–	8.0	8.0	<80	<80	25	<20	80	34	51	11.5	6.3	10.7	8.0				
0746		2	10	76	1415	5.0	–	–	–	–	–	–	–	–	–	–	–	–	–				
0764		2	11	76	1300	3.5	–	–	–	–	–	–	–	–	–	–	–	–	–				
0773		2	11	76	1600	–	–	–	–	–	–	–	–	–	–	–	–	–	–				
0781		2	12	76	0900	7.0	–	–	–	–	–	–	–	–	–	–	–	–	–				
0785		2	11/12	76	24 hr. Comp. **	–	7.0	7.0	<80	<80	25	<20	90	24	46	10.8	7.7	10.5	8.5				
0799		2	12	76	1500	6.0	–	–	–	–	–	–	–	–	–	–	–	–	–				

* See Study Methods

** Composites manual by plant personnel - one sample per hour for 24 hours

APPENDIX A (cont'd)
LABORATORY DATA
THOMAS P. SMITH WTP
TALLAHASSEE, FLORIDA

Return Sludge and Aerobic Digestors

O+M SAD #	STATION	MONTH	DAY	YEAR	TIME	Suspended Solids mg/l	Volatile Suspended Solids mg/l	Total Solids mg/l	Total Volatile Solids mg/l	Pb µg/l	Cr µg/l	Cu µg/l	Cd µg/l	Zn µg/l	% Solids V/V Centrifuge
0724	RS-1	2	9	76	1330	3362	2738	–	–	–	–	–	–	–	6.0
0743		2	10	76	1400	4075	3225	–	–	–	–	–	–	–	7.9
0756		2	11	76	1000	4600	3600	–	–	–	–	–	–	–	8.9
0779		2	12	76	0845	3725	2975	–	–	–	–	–	–	–	6.8
0796		2	12	76	1500	–	–	–	–	–	–	–	–	–	7.5
0727	RS-2	2	9	76	1400	4788	3825	–	–	–	–	–	–	–	8.3
0744		2	10	76	1400	4600	3600	–	–	–	–	–	–	–	8.3
0757		2	11	76	1000	5925	4525	–	–	–	–	–	–	–	10.0
0778		2	12	76	0845	5300	4100	–	–	–	–	–	–	–	8.9
0797		2	12	76	1500	–	–	–	–	–	–	–	–	–	9.9
0765	AD-1	2	11	76	1320	8700	6650	8837	6395	2350	2200	5250	120	16500	–
0789		2	12	76	1100	8650	6550	9086	6542	2475	2500	5350	130	17000	15.0
0751	AD-2	2	10	76	1630	7250	5600	8148	5892	2250	2200	4900	110	15500	–
0762		2	11	76	1100	7950	6050	8556	6170	2375	2400	5050	130	16500	–
0790		2	12	76	1100	7950	6050	8994	6480	2467	2400	5250	130	16500	15.0

Appendix B
GENERAL STUDY METHODS

To accomplish the stated study objectives, extensive sampling was conducted, physical measurements taken, and daily observations recorded during the study.

Automatic ISCO samplers, Model 1392-X, were installed on the plant influent, activated sludge plant effluent, trickling filter plant effluent, and polishing pond effluent (stations I-1, E-1, E-2, and E-3, respectively) to sample for three 24-hour periods. Aliquots of sample were pumped at hourly intervals into individual glass bottles on ice which were composited proportional to flow at the end of each sampling period. Twenty-four hour composite samples were collected by plant personnel, from stations C-1 and C-2 by pouring equal volumes of hourly grab samples into an insulated sample container.

Flows were determined from totalizer readings on the main plant control panel. Additional instantaneous flows were acquired by measuring the head on each individual flow device. A Stevens Model F stage recorder was installed at the effluent of the chlorine contact chamber serving the activated sludge unit to check totalizer and flow chart accuracy.

A series of standard operational control tests were run daily. These tests consisted of:

- Sludge settleability as determined by the settlometer test;
- percent solids by centrifuge determined on the reaeration and contact basins, return sludge and aerobic digester;
- TSS and VSS analysis on the reaeration and contact basins, return sludge and aerobic digester;
- turbidity of the effluent from the activated sludge section;
- depth of clarifier sludge blanket.

Dissolved oxygen was determined at all sampling stations using a YSI model 51A dissolved oxygen meter.

The BOD_5 test deviated from standard procedure. The samples were set up at the study site and then transported, within the mobile laboratory incubator, to Athens, Georgia. The samples were then removed from the mobile laboratory and placed in an incubator at the Athens facility. The time of travel was 7 hours and the temperature at arrival was 20.5°C.

(the temperature was measured using a calibrated thermometer placed in a BOD bottle of distilled water and incubated along with the samples.)

Sludge activity was determined using the oxygen uptake procedure presented in Appendix C. The oxygen uptake rate for fed and unfed sludge was determined and a load factor was calculated. The load factor reflects the conditions at the beginning and end of aeration and is helpful in assessing sludge activity for plant operation.

All chlorine residuals were determined using the Fisher and Porter Model 17T1010 amperometric titrator.

Physical observations of individual unit processes were recorded daily.

The mention of trade names does not constitute endorsement or recommendation by the EPA.

APPENDIX C

OXYGEN UPTAKE PROCEDURE [8]

A. Apparatus

1. Electronic DO analyzer and bottle probe
2. Magnetic stirrer
3. Standard BOD bottles (3 or more)
4. Three wide mouth sampling containers (approx. 1 liter each)
5. DO titration assembly for instrument calibration
6. Graduated cylinder (250 ml)
7. Adapter for connecting two BOD bottles

B. Procedure

1. Collect samples of return sludge, aerator influent and final clarifier overflow. Aerate the return sludge sample promptly.

2. Mix the return sludge and measure that quantity for addition to a 300 ml BOD bottle that corresponds to the return sludge proportion of the plant aerator, i.e. for a 40% return sludge percentage in the plant the amount added to the test BOD bottle is:

$$\frac{300 \text{ X } .4}{1.0 + .4} = \frac{120}{1.4} = 86 \text{ ml}$$

3. Carefully add final clarifier overflow to fill the BOD bottle and to dilute the return sludge to the plant aerator mixed liquor solids concentration.

4. Connect the filled bottle and an empty BOD bottle with the BOD bottle adapter. Invert the combination and shake vigorously while transferring the contents. Re-invert and shake again while returning the sample to the original test bottle. The sample should now be well mixed and have a high D.O.

5. Insert a magnetic stirrer bar and the previously calibrated DO probe. Place on a magnetic stirrer and adjust agitation to maintain a good solids suspension.

6. Read sample temperature and DO at test time t=0. Read and record the DO again at 1 minute intervals until at least 3 consistent readings for the change in DO per minute are obtained (Δ DO/min). Check the final sample temperature. This approximates sludge activity in terms of oxygen use after stabilization of the sludge during aeration (unfed sludge activity).

7. Repeat steps 2 through 6 on a replicate sample of return sludge that has been diluted with aerator influent (fed mixture) rather than final effluent. This Δ DO/minute series reflects sludge activity after mixing with the new feed. The test results indicate the degree of sludge stabilization and the effect of the influent waste upon that sludge.

The load factor (LF), a derived figure, is helpful in evaluating sludge activity. It is calculated by dividing the DO/min of fed sludge by the DO/min of the unfed return sludge. The load ratio reflects the conditions at the beginning and end of aeration. Generally, a large factor means abundant, acceptable feed under favorable conditions. A small LF means dilute feed, incipient toxicity, or unfavorable conditions. A negative LR indicates that something in the wastewater shocked or poisoned the "bugs."

(8) Taken from "Dissolved Oxygen Testing Procedure," F. J. Ludzack and script for slide tape XT-43 (Dissolved Oxygen Analysis - Activated Sludge Control Testing) prepared by F. J. Ludzack, NERC, Cincinnati.

APPENDIX D

DESIGN DATA

THOMAS P. SMITH WASTEWATER TREATMENT PLANT
TALLAHASSEE, FL

DESIGN FLOWS

Average 7.5 mgd

SPRING HILL ROAD LIFT STATION

Pumping capacity - 3, two speed 150 hp pumps
Bar screen - 2 inch centers, manually cleaned
Chlorination - 200 lbs. high flow, 50 lbs. low flow
Bar screen - manually cleaned

INFLUENT UNITS

BAR SCREEN

Bar screen on 2 inch centers, mechanically cleaned equipped with belt conveyor

AERATED GRIT CHAMBER

Dimensions

Length - 36 ft.
Width - 14 ft. 2 inches
Depth - 9.5 ft.

Mechanically cleaned - screw conveyor for transfer to trash container
Aerated - 7 1/2 hp blower

PLANT FLOW MEASURING DEVICES

Influent - 3 ft. Parshall flume with recorder and totalizer.
Aeration tank influent - magnetic meter with totalizer and recorder.
Clarifier effluents - individual propeller meters with totalizer and recorder.
Return activated sludge - propeller meter with dial flow control and totalizer.
A/s effluent (chlorine contact chamber) - 4 ft. rectangular weir with totalizer and recorder.
Sludge wasting - propeller meter with totalizer.
Trickling filter effluent - 1 ft. Parshall flume with recorder and totalizer.

STABILIZATION BASINS

Number - 2
Dimensions
Length (inside) - 162 ft.
Width (inside) - 54 ft.
Depth - 13.5 ft.
Volume - 115,832 $ft.^3$, 869,000 gal.
Detention time - w/50% return sludge - 3.8 hrs.
Aerators - 3 fixed 50 HP surface each basin

CONTACT BASINS

Number - 2
Dimensions
Length - 54 ft.
Width - 54 ft.
Depth - 13.5 ft.
Volume - 38,300 $ft.^3$, 287,000 gal.
Detention time - 2/50% return sludge - 1.3 hrs.
Aerator - 1 fixed 50 HP surface each basin

CLARIFIER

Number - 2 circular, rim-feed, rim take-off
Dimensions
Diameter (Inside) - 90 ft.
Depth - 13.4 ft.
Surface Area - 6,358 $ft.^2$
Volume - 85,204 $ft.^3$, 639,000 gal.
Weir length with pans - 400 ft.
without pans - 258 ft.
Weir overflow rate - with pans - 9,375 gal/day/ft.
without pans - 14,565 gal/day/ft.
Detention time - 50% return sludge - 2.7 hrs.
Surface loading - 590 $gal/day/ft.^2$

DIGESTORS - 2 circular aerobic basins

Dimensions
Diameter - 80 ft.
Depth - 16.7 ft.
Volume - 83,900 $ft.^3$, 629,000 gal.
Aerator - Fixed surface - 1,100 hp

CHLORINE CONTACT CHAMBER

Dimensions
Length - 52.8 ft.
Width - 50 ft.
Depth - 8 ft.
Volume - 21,120 $ft.^3$, 158,000 gal.
Detention time - 0.5 hrs.

RETURN SLUDGE PUMPS

Number - 4, 75 hp variable speed
Capacity - 5,250 gpm
Sludge recirculation - 0-100%

SLUDGE DRYING BEDS

Number - 12
Dimensions
Length - 450 ft.
Width - 250 ft.
Total area - 112,500 $ft.^2$

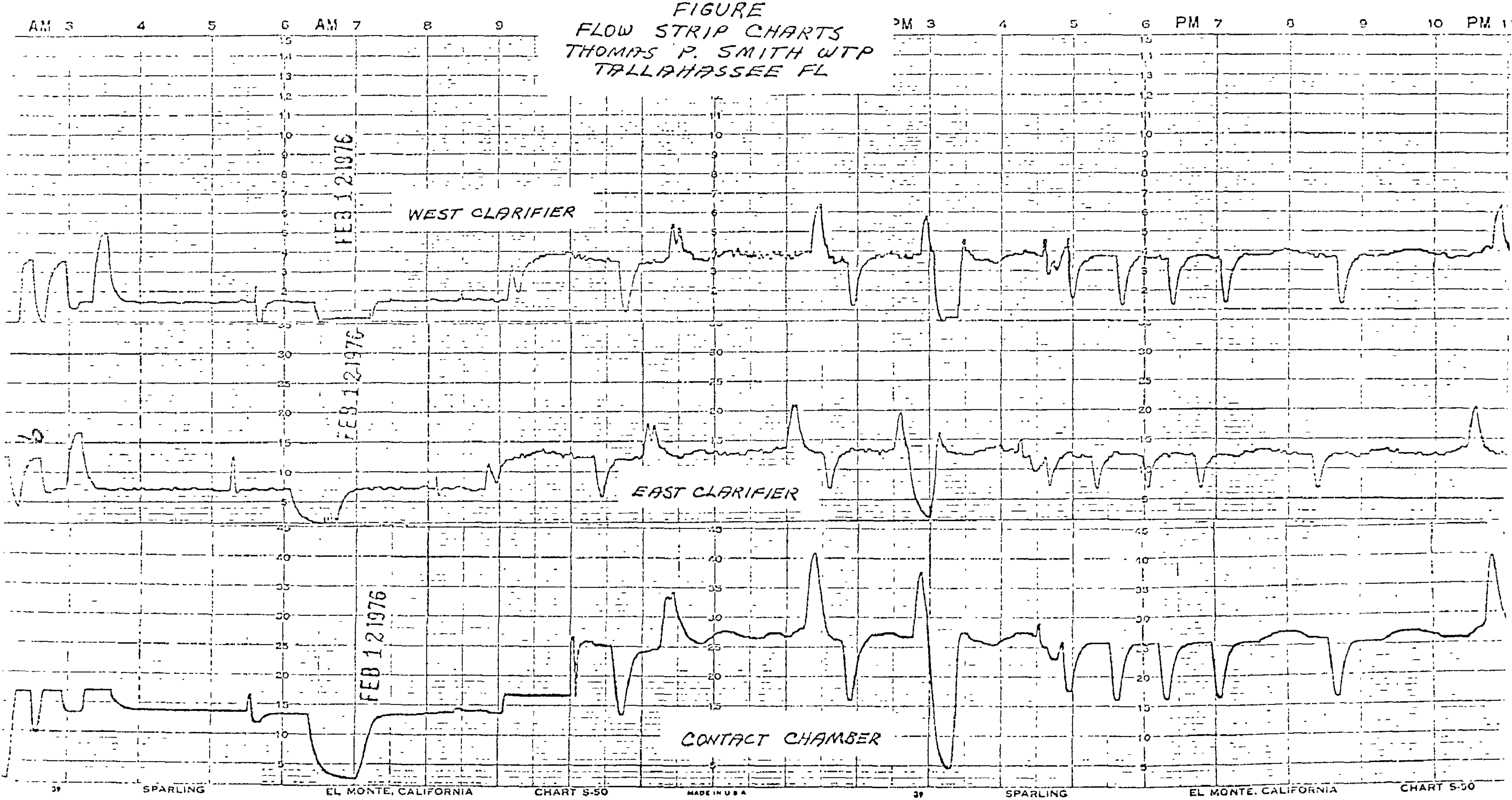


FIGURE
FLOW STRIP CHARTS
THOMAS P. SMITH WTP
TALLAHASSEE FL