EPA 904/9-77-001

TECHNICAL ASSISTANCE PROJECT

AT THE

LENOIR WASTEWATER TREATMENT PLANTS

LENOIR, NORTH CAROLINA

SEPTEMBER 1976

ENVIRONMENTAL PROTECTION AGENCY
REGION IV
SURVEILLANCE AND ANALYSIS DIVISION

ATHENS, GEORGIA

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INTRODUCTION

A technical assistance study of operation and maintenance problems at the Lower Creek and Gun Powder Creek wastewater treatment plants, Lenoir, North Carolina, was conducted September 20-24, 1976, by the Region IV Surveillance and Analysis Division, U.S. Environmental Protection Agency. Operation and Maintenance technical assistance studies are designed to assist wastewater treatment plant operators in maximizing treatment efficiencies, as well as assisting with special operational problems.

These plants were selected based upon the recommendation of the U.S. EPA Enforcement and Water Divisions, NC-DNER, plant personnel, and an EPA reconnaissance visit to the plants. The Lower Creek Wastewater Treatment Plant was selected due to its difficulty in meeting the NPDES permit requirements. Some work was also performed at the Gun Powder Creek Wastewater Treatment Plant, even though plant performance was satisfactory and the plant had not been turned over to the City by the contractor. The specific study objectives were:

(1) To optimize treatment through control testing and recommended operation and maintenance modifications;

(2) To introduce and instruct plant personnel in new operational control techniques;

(3) To determine influent and effluent wastewater characteristics;

(4) To assist laboratory personnel with any possible laboratory procedure problems; and

(5) To compare design and current loading data.

The cooperation of the North Carolina Department of Natural and Environmental Resources is gratefully acknowledged. The technical assistance team is also especially appreciative for the cooperation and assistance received from personnel of the Lower Creek and Gunpowder Creek wastewater treatment plants.

SUMMARY

LOWER CREEK WASTEWATER TREATMENT PLANT

The Lower Creek Wastewater Treatment Plant (WTP) was designed as a 6 mgd extended aeration activiated sludge system. At the time of the study, flow into the plant was approximately 1.99 mgd; therefore, only one of two aeration basins and one of two clarifiers were being used. The effluent BOD_5 and TSS concentrations were less than 10 and 24 mg/l with the addition of polymers and 20 and 41 mg/l when not using polymers, respectively. Operating records for the period July 1975 through July 1976 showed average effluent BOD_5 and TSS concentrations of 33 and 40 mg/l, respectively, without the use of polymers.

Major problems observed during the study are listed below:

(1) According to City officials the design flow (6 mgd) for the WTP was greatly overestimated by the designer.

(2) The aeration basins are oversized for the extended aeration activated sludge process.

(3) The maximum mixed liquor suspended solids concentration attainable since the plant began operation in 1969 has been about 200-300 mg/l.

(4) Solids have never been wasted from the treatment system.

(5) Based on the interpretation of a US-EPA Notice of Violation and Order, WTP officials began using a polymer costing approximately $200 daily.

(6) Due to the light characteristics of the solids, a thick mat of solids continually formed on the clarifier surface when the polymer was used.

(7) The return sludge pumps are high volume, constant speed pumps, which do not permit variation in return rates.

(8) The approximate chlorine feed rate of about 220 pounds/day was excessive. Based on the orthotolidine color comparator the effluent chlorine residual was about 0.5 ppm, however with the EPA approved amperometric titrater measured chlorine residuals were of 2.5-2.7 ppm.

(9) City officials have voted to have a consulting engineer conduct a study to determine construction and design revisions necessary to bring the Lower Creek WTP into compliance with the NPDES permit requirements.

GUN POWDER CREEK WASTEWATER TREATMENT PLANT

The Gun Powder Creek WTP serving Southeast Lenoir, North Carolina was designed as a 1.0 mgd contact stabilization activated sludge system with additional nitrification of the effluent wastewater prior to final settling. During the study, WTP influent flow averaged 0.23 mgd, with a peak flow of 0.30 mgd. Average reductions of BOD_5 and TSS were greater than 93 and 95 percent, respectively. The activated sludge settled rapidly, resulting in a turbid supernatant. The additional nitrification system and polishing ponds made up for the lack of treatment optimization in the contact stabilization system. Dissolved oxygen (DO) uptake measurements indicated a poor quality sludge in terms of activity, but low flows and long detention times were compensating factors.

Problems and inadequacies observed during the study are as follows:

(1) Influent flow measuring equipment was not calibrated.

(2) Effluent sampling equipment was clogging due to location of sample pickup orifice.

(3) Volatile suspended solids content was only 47 percent of the total suspended solids under aeration and reaeration.

(4) Since the City of Lenoir had not accepted responsibility for operations from the contractor, WTP personnel were unable to make adjustments or process changes.

(5) The scum trough in the nitrification settling tank was flooded.

RECOMMENDATIONS

Based on observations and data collected during the study, it is recommended that the following measures be taken to improve wastewater treatment and plant operation. Some of the recommendations have been discussed with WTP personnel and have already been implemented.

LOWER CREEK WASTEWATER TREATMENT PLANT

1. The unused aeration basin should be employed as a settling lagoon. This may provide the additional treatment necessary for compliance with the NPDES requirements without using polymers.
2. As agreed upon by City officials, a consulting engineer should be employed to study construction and design revisions necessary to bring the Lower Creek WTP into compliance with the NPDES requirements.
3. The amperometric titrater should be used to measure chlorine residual at the effluent.

GUN POWDER CREEK WASTEWATER TREATMENT PLANT

No recommendations are made for this plant since it was not in full operation.

LOWER CREEK WASTEWATER TREATMENT PLANT

TREATMENT FACILITY

Treatment Processes

A schematic diagram of the 6 mgd (design) extended aeration activated sludge wastewater treatment plant (WTP) serving Lenoir, NC is presented in Figure 1. Design data are enumerated in Table I. The WTP began operation in 1969.

The wastewater treatment scheme consisted of comminutor, grit chamber, aeration basin, clarifier, and chlorine contact chamber. Since influent flows were less than 3 mgd, only one aeration basin and one clarifier were operated. Chlorinated effluent was discharged into Lower Creek. A sludge holding tank and drying beds were available, but had never been used.

Personnel

The WTP was staffed by eight persons of which two were certified. One held a Class IV certification and the other a Class II.

Study Results and Observations

A complete listing of all analytical data and general study methods are presented in the Appendix A and B. Significant results and observations are discussed in the following sections.

Flow

The WTP recorder and totalizer were not operating properly. Therefore, plant flow was measured by installing a Stevens stage recorder on a 5-foot rectangular weir (with end contractions) located at the effluent from the

FIGURE 1
LOWER CREEK WTP
LENOIR, NC

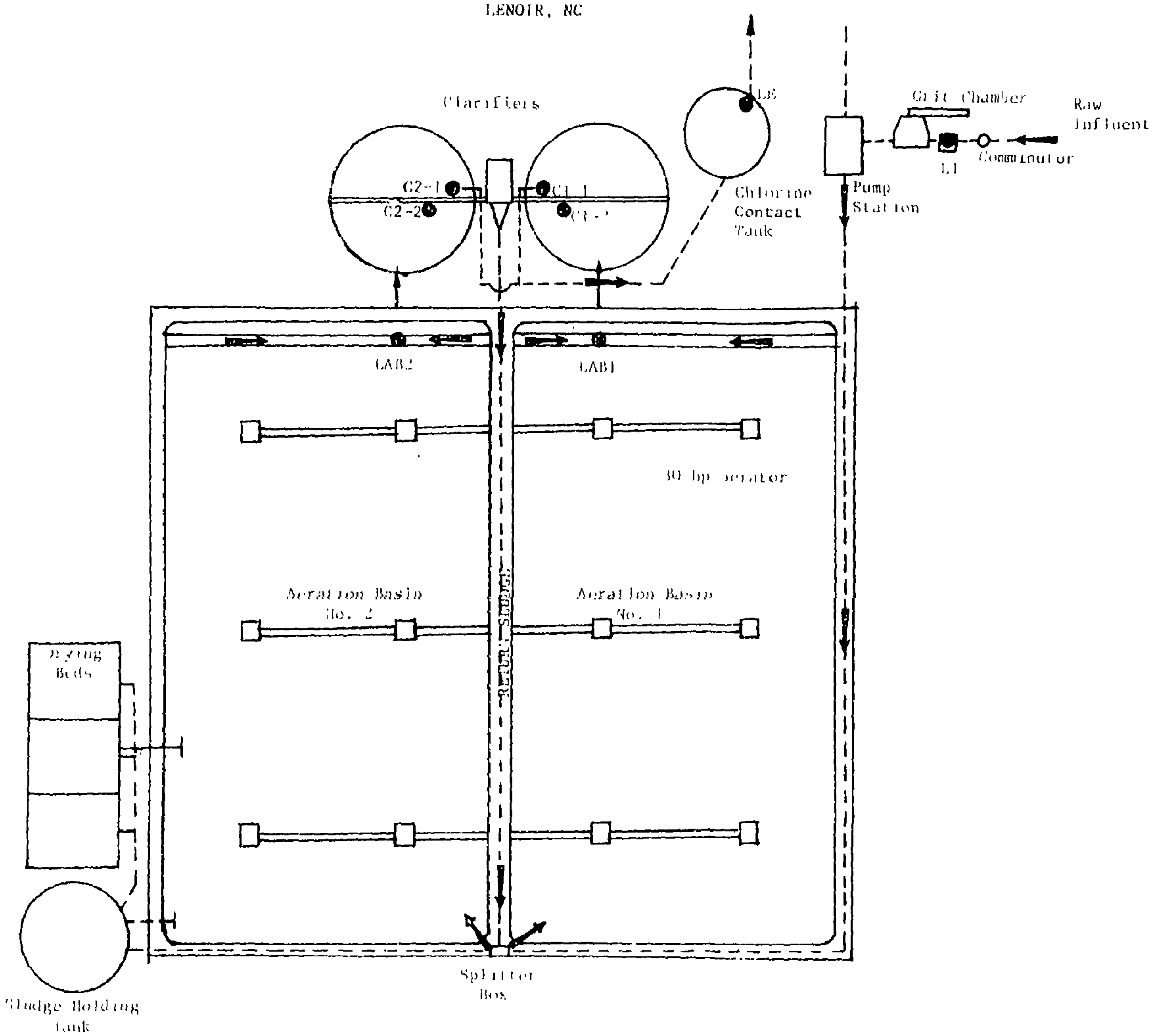


TABLE I
DESIGN DATA
LOWER CREEK WTP
LENOIR, NC

Flow Measurement

Type	Rectangular weir, recorder, totalizer
Size	5 ft.
Location	Effluent of chlorine contact chamber
Design Flow	6.0 mgd

Aeration Basins

Number	2
Volume (each basin)	895,722 cu. ft. (6.7 m. gal.)
Length	401 ft.
Width	221 ft.
Depth	12 ft.
Side Slopes	2:1
Aeration (each basin)	6-30 hp mechanical aerators

Clarifiers

Number	2
Diameter	95 ft.
Depth (side wall)	9.5 ft.
Area	7,088 sq. ft.
Volume	67,338 cu. ft. (.504 m. gal.)
Weir Length	300 ft.

Sludge Holding Tank

Diameter	72 ft.
Depth (side wall)	15 ft.
Volume	456,823 gal.

Drying Beds

Number	3
Area (total)	8,200 sq. ft.

chlorine contact chamber. The average flow during the study period was 1.99 mgd and ranged from a maximum of 2.68 mgd to a minimum of 1.18 mgd. Approximately 60 percent of the raw influent flow was from industrial sources and primarily from woodworking industries. According to WTP personnel, the design flow was a gross over estimation of projected flow into the plant.

Waste Characteristics and Removal Efficiencies

Table II presents a chemical description of the WTP influent and effluent wastewaters with calculated treatment reductions. Effluent characteristics were determined with and without the use of polymer, and based on one 24-hour composite sample under each condition. Influent analyses were made on 24-hour, flow proportional composite samples, collected on the first two days of the sampling period, and the results averaged.

TABLE II

WASTE CHARACTERISTICS AND REMOVAL EFFICIENCIES

LOWER CREEK WTP

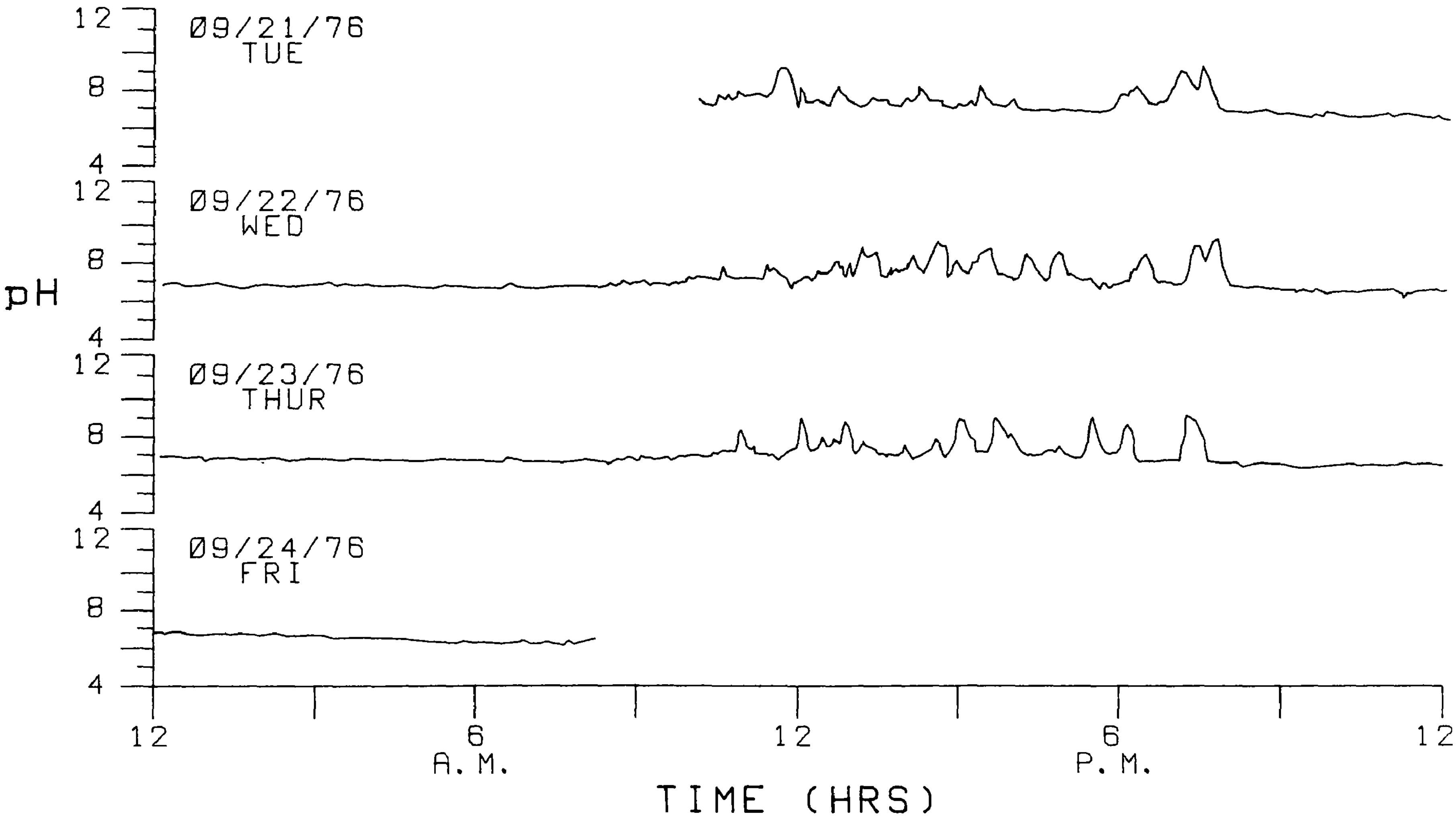
Parameter	Influent (mg/l)	Effluent * (mg/l)	Effluent ** (mg/l)	Reduction * (%)	Reduction ** (%)
BOD_5	214	<10	20	>95	86
COD	492	58	96	88	80
TOC	175	23	35	87	80
Total Solids	540	246	279	54	48
Total Volatile Solids	268	52	79	81	71
Suspended Solids	310	24	41	92	87
Suspended Volatile Solids	180	19	31	89	83
Settleable Solids (ml/l)	18	<0.1	<0.1	>99	>99
TKN-N	21.0	14	15.7	33	25
NH_3-N	13.2	13	11	1.0	16
NO_3-NO_2-N	0.04	.08	0.15	--	--
Total Phosphorus	6.2	4.3	4.4	31	29
Oil and Grease	29	<5	<6	>83	>79
Chlorine Residual	--	2.6	1.4	--	--
Lead	0.045	<0.05	<0.05	--	--
Chromium	<0.08	<0.08	<0.08	--	--
Cadmium	<0.01	<0.01	<0.01		
Copper	0.056	0.022	0.016	61	71
Zinc	0.227	0.038	0.046	83	80
Turbidity (NTU)	--	10	42	--	--

* With polymer
** Without polymer

The effects resulting from additions of the polymer are evident in Table II. A review of plant operating records for the period from July 1975 through 1976 showed average effluent BOD_5 and TSS concentrations of 33 and 40 mg/l, respectively, without the use of polymers.

Influent pH (Figure 2) was monitored continuously from 10 a.m. on September 21 to 8 a.m. on September 24. Influent pH remained fairly constant at 6.8 between 8 p.m. and 10 a.m., but began to rise and fluctuate greatly between 12 noon and 8 p.m. of each day. During the study period, the highest daily pH values (9.4 and 9.2) were recorded at approximately 7:30 p.m. on September 21 through 23. The high and variable pH values during the afternoons were probably caused by industrial discharges.

FIGURE 2
INFLUENT pH
LOWER CREEK WTP
LENOIR N.C.



Aeration Basins

Grab samples were collected daily from the aeration basin. These samples were analyzed for total suspended solids (TSS), volatile suspended solids (VSS), percent solids by centrifuge, and settleability as determined by the settlometer. Various operational parameters, calculated during the study period and the corresponding recommended values for the extended aeration activated sludge process are presented in Table III.

TABLE III

ACTIVATED SLUDGE OPERATIONAL PARAMETERS

LOWER CREEK WTP

	Measured	Recommended (1)(6)(7)*
MLSS (mg/l)	160	3,000 - 6,000
MLVSS (mg/l)	95	---
Lbs BOD/day/lb MLVSS (F/M)	.71	.05 - .15
Hydraulic Detention Time (hrs)	80	18 - 36
Lbs BOD/day/1,000 cu.ft. of aeration basin	4.2	10 - 25
Return Sludge Rate (% of average plant flow)	0**	75 - 150

* References appear on page 25.

** Negligible quantity of sludge pumped back to aeration basin twice daily for approximately five minutes.

The calculated parameters in Table III are more typical of an aerated lagoon operation rather than an extended aeration activated sludge system. According to plant personnel, no sludge had ever been wasted from the treatment system, nor had the MLSS concentration been much greater than that observed during the TA study. Difficulty in building mixed liquor solids would be expected based on the tremendous hydraulic detention time and gross over design of the basins. The volatile content of the MLSS was 59 percent. The appearance of the sludge coupled with this low volatile content, indicated that the solids were over aerated, approaching an ash. These types of solids are light and have a tendency to float rather than settle.

Dissolved oxygen concentrations (DO) in the aeration basin were adequate. The DO range was 1.6 to 4.8 mg/l (Appendix C). A few lower concentrations were measured, but were at the 9 to 10 foot depths. A sludge blanket appeared to exist throughout the aeration basin at depths greater than 9 feet and accounted for the low DO measurements.

Clarifier

Only one of two circular clarifiers was operating during the study. These clarifiers have a center feed, rim-takeoff flow configuration. No sludge blanket was observed during the study because of the negligible suspended solids entering the clarifier. Settled solids were pumped back to the aeration basin by operating the 2,100 gpm constant speed return sludge pump twice daily for approximately five minutes. The measured and recommended operating parameters for secondary clarifiers following the extended aeration activated sludge process are presented in Table IV.

TABLE IV

SECONDARY CLARIFIER OPERATIONAL PARAMETERS

LOWER CREEK WTP

	Measured	Recommended (2) (4)
Hydraulic Loading (gpd/sq.ft.)	280	200 - 400
Solids Loading (lbs/day/sq.ft.)	.37	20 - 30
Hydraulic Detention (hrs.)	6	2 - 2.5
Weir Overflow Rate (gpd/lin.ft.)	6,633	15,000
Depth (ft)	9.5	8 - 12

The final clarifiers, which are conservatively designed, were not effectively removing the suspended solids from the wastewater stream. Polymers were applied to the clarifier influent to increase solids settleability. Polymer utilization resulted in a thick floating mat of solids on the clarifier water surface. To assess the effectiveness of the chemical weighting agent, polymer addition was discontinued and the results are presented in Table II. The use of chemical weighting agents should not be considered as a long term treatment solution. Design flaws were the major obstacles hindering satisfactory wastewater treatment.

The major flaw in clarifier design was the use of large constant speed return sludge pumps instead of variable speed pumps.

The nature of problems at the plant were not operational, but over design. City officials had voted at the time of this study, to undertake a comprehensive engineering study to determine construction and design revisions necessary to bring the WTP into compliance with NPDES requirements.

Chlorine Contact Chamber

The typical chlorine feed rate at the WTP was 220 pounds/day which corresponded to a residual chlorine concentration of about 0.5 mg/l, using the orthotolidine color comparator. According to measurements with an amperometric titrater, however, the effluent chlorine residual was 2.5-2.7 mg/l. On September 22 it was suggested that the chlorine feed be reduced to 100 pounds/day. The subsequent residual ranged from 1.0 to 1.8 mg/l. On September 23 the chlorine feed was further reduced to 75 pounds/day. This subsequent residual ranged from 0.75-1.9 mg/l. Throughout this period of reduction, the bacterial kill was adequate. Based on a chlorine cost of $0.15/pound, these reductions averaged $22/day, amounting to a savings of $8,000/year.

GUN POWDER CREEK WASTEWATER TREATMENT PLANT

TREATMENT FACILITY

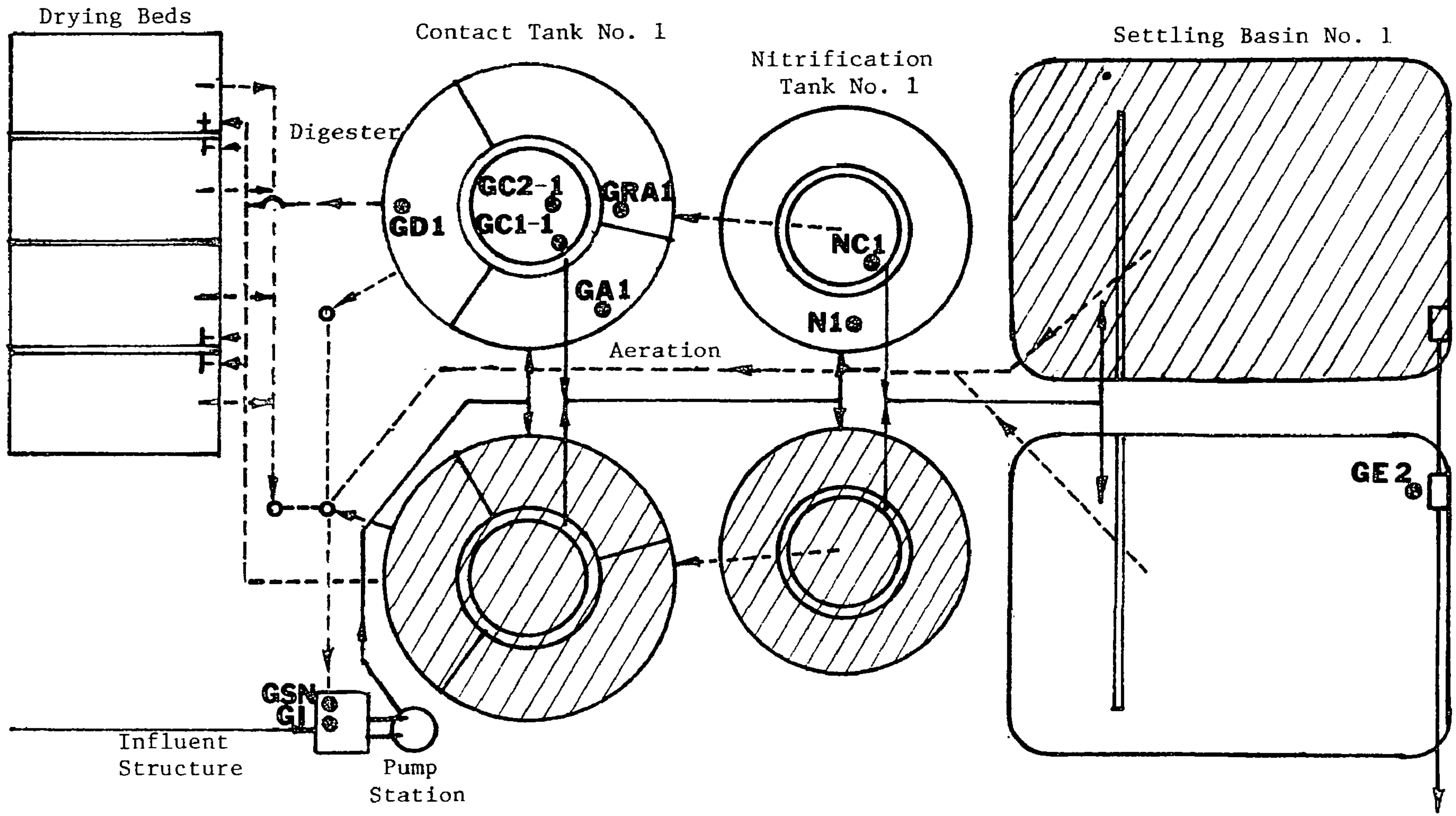
Treatment Process

The Gun Powder Creek Wastewater Treatment Plant (WTP) is a contact stabilization activated sludge system serving Southeastern Lenoir, North Carolina. A schematic diagram of the 1.0 mgd plant is presented in Figure 3; design data are enumerated in Table V. The WTP began operation in April 1976 and had not received a final inspection at the time of this TA study.

Influent wastewaters entered the treatment complex through preliminary units consisting of a mechanically cleaned bar screen, a 9 inch Parshall flume equipped with totalizer and recorder, and grit chamber. After grit removal, wastewater was pumped to one of two 0.5 mgd contact stabilization tanks. Individual units of the contact stabilization tank included contact, reaeration, and settling tank, plus an aerobic digester. Effluent wastewaters from the settling tank flowed by gravity to separate nitrification tanks. Clarified wastewater was then chlorinated and final settling was accomplished in two 614,000 gallon polishing ponds.

Sludge from the contact tank settling basin was pumped to the reaeration tank and/or aerobic digester. Sludge from the reaeration tank was introduced to the contact tank through two rectangular ports. One port was at the upper section and another at the lower section of the common wall which separates the two tanks. A portion of the sludge generated in the nitrification tank was wasted to the contact stabilization reaeration tank. The remainder of the sludge was recycled within the nitrification system.

FIGURE 3
GUN POWDER CREEK WTP
LENOIR, NC



/////- Not in operation

——— - Wastewater flow

– – – – - Sludge and underdrains

TABLE V
DESIGN DATA
GUN POWDER CREEK WTP
LENOIR, NC

Flow Measurement

Influent	9 in. Parshall flume, totalizer, recorder
Design flow	1.0 mgd
Average study flow	0.23 mgd as measured by recorder

Influent Pumps

Number	2 (one as standby)
Pump rating	2,100 gpm

Aeration Basins

Number	2
Volume (each)	10,333 cu.ft. (77,500 gals.)
Detention time (each)	3.7 hrs @ 0.5 mgd
Aerators	4-75 hp diffused air blowers (1,425 SCFM @ 7 psi)

Clarifiers

Number	4 (2-contact process, 2-nitrification process)
Volume (each)	10,923 cu.ft. (81,925 gals.)
Detention time (each)	3.9 hrs. @ 0.5 mgd

Reaeration Basins

Number	2
Volume (each)	16,930 cu.ft. (126,970 gals.)
Detention time (each)	6 hrs. @ 0.5 mgd

Nitrification Basins

Number	2
Volume (each)	23,194 cu.ft. (173,950 gals.)
Detention time (each)	8.3 hours @ 0.5 mgd

Aerobic Digesters

Number	2
Volume (each)	14,770 cu.ft. (110,775 gals.)

Final Settling Pond

Number	2
Volume (each)	81,900 fu.ft. (614,250 gals.)
Detention time (each)	17 hrs. @ 0.5 mgd

Personnel

The Gun Powder Creek WTP was staffed by two certified operators, an operator assistant and two laboratory technicians. The plant is operated for two eight-hour shifts.

STUDY RESULTS AND OBSERVATIONS

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

Flow

Plant flow was measured by a 9 inch Parshall flume equipped with a totalizer and recorder. Return sludge flow was not metered or measured.

Average hourly influent flow during the study was 0.23 mgd and varied from 0.12 to 0.30 mgd. The return sludge flow was maintained at a constant rate without any wasting.

Waste Characteristics and Removal Efficiencies

Table VI presents a chemical description of the WTP influent and effluent wastewaters with calculated treatment reductions. Analyses were made on 24-hour flow proportional composite samples, collected on two consecutive days. Percent reductions were calculated from average values. These data indicate that the WTP was meeting NPDES permit limitations.

TABLE VI

WASTE CHARACTERISTICS AND REMOVAL EFFICIENCIES

GUN POWDER CREEK WTP

Parameter	Influent (mg/l)	Effluent (mg/l)	Reduction %
BOD_5	152	<10	>93
COD	364	37	90
TOC	112	16	86
Total Solids	432	361	16
Total Volatile Solids	200	105	48
Suspended Solids	148	8	95
Suspended Volatile Solids	118	8	93
Settleable Solids (ml/l)	8	<0.1	>99
TKN-N	36.4	2.2	94
NH_3-N	20.8	0.10	99
NO_3-NO_2-N	<0.01	11	--
Total Phosphorus	9.6	7.0	27
Oil and Grease*	16	<5	>69
Chlorine Residual*	--	0.9	--
Turbidity (NTU)	--	3	--
Lead	<0.05	<0.05	--
Chromium	<0.08	<0.08	--
Cadmium	<0.01	<0.01	--
Copper	<0.046	0.016	>65
Zinc	0.172	0.060	65

* Average results of grab samples taken on two different days.

Aeration Basins

Grab samples were collected daily from the aeration and reaeration basins. These samples were analyzed for total suspended solids (TSS), volatile suspended solids (VSS), percent solids by centrifuge, and settleability as determined by settlometer.

The oxygen uptake rate, a method of measuring sludge quality was calculated using the depletion rate before and after introduction of the raw waste. The calculated uptake rate (load ratio) was 1.7. A five minute depletion rate for the unfed sludge averaged 0.14 mg/l/min.; a five minute depletion rate for the fed sludge averaged 0.25 mg/l/min. One would expect reaerated sludge to be much more active when introduced to the raw waste than was observed. The reason for this inactivity is revealed through observation of the percent volatile content of the total suspended solids. Volatile suspended solids content in the aeration basin was only 47 percent. Most activated sludge mixed liquor solids fall into a range of 70-80 percent volatile content. This content was unusually low and indicated retention of undesirable oxidized solids. Results from the settlometer test tended to compliment this data. Mixed liquor solids settled rapidly to 50 percent (500 ml/l) or less in five minutes, leaving a very turbid supernatant.

The above data and observations indicated that treatment can be further enhanced by disposal of the undesirable solids and by increasing the mixed liquor volatile content to 70-80 percent. Secondary treatment was not optimized and the extra treatment units (nitrification-settling and polishing pond) were responsible for the high treatment efficiencies.

Laboratory

The central laboratory for both the Gun Powder Creek and Lower Creek WTPs was located at the Gun Powder Creek WTP. The staff included a chemist and a laboratory technician who conducted a sampling program and routine analyses for both plants. These analyses included: BOD_5, COD, DO, TS, TSS, settleable solids, TKN-N, residual chlorine, fecal coliform, pH, and temperature. The laboratory was clean, adequate in size, and well equipped.

During the TA study, two afternoons were spent with the laboratory personnel, and the following observations and recommendations were made:

(1) Generally, the laboratory personnel were conscientious and exhibited good analytical techniques.

(2) The initial DO of the BOD_5 dilution water was occasionally as low as 4.5 ppm; however, it should be kept greater than or equal to 7.0 ppm.

(3) Chlorine residual was determined by using the visual orthotolidine method. The back titration procedure presented in Standard Methods (5) was discussed and recommended as a better procedure.

(4) The use of the centrifuge, settlometer test, and volatile suspended solids analysis as control procedures for the operations of WTPs were discussed.

(5) The use of trend charts was illustrated and discussed as a tool for operational control.

During the TA study, five composite samples were split for chemical analyses between EPA and Gun Powder Creek laboratory personnel for data comparison of BOD_5, COD, TSS, and TKN-N analyses. Generally, this data compared well.

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8. Alfred W. West. Operational Control Procedures for the Activated Sludge Process. Part I, Observations, April, 1973: Pages 7, 8.

APPENDICES

APPENDIX A

LABORATORY DATA

APPENDIX A
LABORATORY DATA
LOWER CREEK & GUNPOWDER CREEK WTP
LENOIR, NC

INFLUENT & EFFLUENT

O+M SAD #	STATION	MONTH	DAY	YEAR	TIME	BOD5 mg/1	COD mg/1	TOC mg/1	TOTAL SOLIDS mg/1	TOTAL VOLATILE SOLIDS mg/1	SUSPENDED SOLIDS mg/1	VOLATILE SUSPENDED SOLIDS mg/1	SETTLEABLE SOLIDS mg/1	TKN-N mg/1	NH3-N mg/1	NO_3-NO_2-N mg/1	TOTAL PHOSPHORUS mg/1	Pb μg/1	Cr μg/1	Cd μg/1	Cu μg/1	Zn μg/1	OIL & GREASE mg/1	Cl_2 Residual mg/1	TURBIDITY NTU	TURBIDITY @ 30 min NTU
1128	LI	9	21	76	1100	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	—	—	—
1145		9	21/22	76	24-hr. Comp.	192	448	168	523	253	294	180	21	20.8	12.0	0.05	5.8	45	<80	<10	55	202	—	—	—	—
1147		9	22	76	0930	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1161		9	22	76	1505	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1163		9	22	76	1415	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	58	—	—	—
1169		9	22/23	76	24-hr. Comp.	235	536	182	558	282	325	180	15	21.3	14.5	0.04	6.7	45	<80	<10	58	252	—	—	—	—
1186		9	23	76	1500	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1189		9	23/24	76	24-hr. Comp.	255	600	200	682	364	400	260	—	21.6	11.5	0.08	8.1	85	<80	<10	85	370	—	—	—	—
1191		9	24	76	0830	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	—	—	—
1122	LE	9	21	76	0910	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.7	—	—
1126		9	21	76	1020	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	9
1127		9	21	76	1100	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	<5	—	—	—
1140		9	21	76	1600	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.5	—	—
1143		9	21/22	76	24-hr. Comp.	<10	58	23	246	52	24	19	<0.1	16.0	13.0	0.08	4.3	<50	<80	<10	22	38	—	0.75	—	—
1144		9	22	76	0900	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.8	8	5
1159		9	22	76	1115	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.3	—	—
1162		9	22	76	1405	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	<5	1.2	—	—
1165		9	22	76	1615	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.0	—	—

APPENDIX A
LABORATORY DATA
LOWER CREEK & GUNPOWDER CREEK WTP
LENOIR, NC

INFLUENT & EFFLUENT

OTM SAD #	STATION	MONTH	DAY	YEAR	TIME	BOD_5 mg/1	COD mg/1	TOC mg/1	TOTAL SOLIDS mg/1	TOTAL VOLATILE SOLIDS mg/1	SUSPENDED SOLIDS mg/1	VOLATILE SUSPENDED SOLIDS mg/1	SETTLEABLE SOLIDS mg/1	TKN-N mg/1	NH_3-N mg/1	NO_3-NO_2-N mg/1	TOTAL PHOSPHORUS mg/1	Pb µg/1	Cr µg/1	Cd µg/1	Cu µg/1	ZN µg/1	OIL & GREASE mg/1	Cl_2 Residual mg/1	TURBIDITY NTU	TURBIDITY @ 30 min
1168	LE	9	23	76	0826	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.9	37	—
1170		9	22/23	76	24-hr comp	20	96	35	279	79	41	31	<0.1	15.7	11	0.15	4.4	<50	<80	<10	16	46	—	0.75	—	—
1182		9	23	76	1155	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		1.4	—	—
1185		9	23	76	1355	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		0.75	45	—
1187		9	23	76	1505	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	—	—
1188		9	24	76	0800	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		1.5	—	—
1192		9	24	76	0831	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	—	—
1148	GI	9	21/22	76	24-hr. comp	168	388	147	450	218	177	129	10	37.7	20	<0.01	9.5	<50	<80	<10	50	196	—	—	—	—
1150		9	22	76	0830	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	23	—	—	—
1179		9	23	76	0930	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	—	—	—
1180		9	22/23	76	24-hr. Comp.	137	340	78	413	183	118	198	6	35.2	21.5	<0.01	9.7	<50	<80	<10	41	168	—	—	—	—
1135	GE	9	21	76	1105	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.1	3	3
1149		9	21/22	76	24-hr. Comp.	<10	38	16	360	106	8	8	<0.1	2.24	0.10	10.0	6.7	<50	<80	<10	16	59	—	0.75	—	—
1151		9	22	76	0830	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	<5	—	—	—
1158		9	22	76	0845	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.7	3	3
1177		9	23	76	0875	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.0	4	—
1178		9	23	76	0950	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	<5	—	—	—
1181		9	22/23	76	24-hr Comp.	<10	36	15	362	104	9	8	<0.1	2.16	0.10	12.1	7.2	<50	<80	<10	16	62	—	0.3	—	—

APPENDIX A
LABORATORY DATA
LOWER CREEK & GUNPOWDER CREEK WTP
LENOIR, NC

AERATION BASINS & RETURN SLUDGE

C+M SAD #	STATION	MONTH	DAY	YEAR	TIME	TOTAL SUSPENDED SOLIDS mg/l	VOLATILE SUSPENDED SOLIDS mg/l	% SOLIDS v/v Centrifuge	SETTLOMETER 5	10	15	20	25	30	40	50	60	120	COMMENTS
1123	LAB	9	21	76	0940	292	166	<1.0	<5	<5	<5	<5	<5	<5	<5	<5	<5	—	Trace Amount of solids - Turbid Supernatant
1136	LAB-1	9	21	76	1500	84	54	<1.0	<5	<5	<5	<5	<5	<5	<5	<5	<5	—	" " " " " "
1137	LAB-2	9	21	76	1500	60	41	<1.0	<5	<5	<5	<5	<5	<5	<5	<5	<5	—	" " " " " "
1138	LAB-5	9	21	76	1500	198	118	<1.0	<5	<5	<5	<5	<5	<5	<5	<5	<5	—	" " " " " "
1139	LAB-6	9	21	76	1500	91	57	<1.0	<5	<5	<5	<5	<5	<5	<5	<5	<5	—	" " " " " "
1141	LAB	9	22	76	0815	198	112	<1.0	<5	<5	<5	<5	<5	<5	<5	<5	<5	—	" " " " " "
1160	LAB-Bottom Sludge	9	22	76	1520	TS 89,040	TVS 44,398	—	—	—	—	—	—	—	—	—	—	—	— — — — — — — —
1184	LAB	9	23	76	1355	196	116	—	<5	<5	<5	<5	<5	<5	<5	<5	<5	—	Trace Amount of solids - Turbid Supernatant
1130	GA-1	9	21	76	1050	6,360	3,140	5.5	47	39	35	32	30	28	26	25	25	—	@ 90 Min Rose To 28% - Very Turbid Supernatant
1152		9	22	76	0955	6,530	3,070	6.0	52	47	37	34	32	30	28	27	25	24	Very Turbid Supernatant with Film on Top
1175		9	23	76	1020	6,540	3,100	6.5	50	40	36.	33	31	30	27	25	25	—	Cloudy Supernatant
1132	GRA-1	9	21	76	1040	9,750	4,625	9.0	—	—	—	—	—	—	—	—	—	—	— — — — — — — —
1153		9	22	76	0940	9800	4,675	9.0	—	—	—	—	—	—	—	—	—	—	— — — — — — — —
1176		9	23	76	1015	9712	4,662	9.0	—	—	—	—	—	—	—	—	—	—	— — — — — — — —
1134	LRS	9	21	76	1000	11,325	6,550	9.0	—	—	—	—	—	—	—	—	—	—	— — — — — — — —
1146		9	22	76	0950	16,340	9,680	10.5	—	—	—	—	—	—	—	—	—	—	— — — — — — — —

APPENDIX A
LABORATORY DATA
LOWER CREEK & GUNPOWDER CREEK WTP
LENOIR, NC

NITRIFICATION TANK, DIGESTER & CLARIFIERS

O+M SAD #	STATION	MONTH	DAY	YEAR	TIME	TOTAL SUSPENDED SOLIDS mg/1	VOLATILE SUSPENDED SOLIDS mg/1	% v/v SOLIDS CENTRIFUGE	TURBIDITY NTU	TURBIDITY @ 30 min NTU
1133	N-1	9	21	76	1035	60	28	<1.0	—	—
1155		9	22	76	0935	47	25	<1.0	—	—
1173		9	23	76	1010	44	24	<1.0	—	—
1131	GD-1	9	21	76	1045	10,350	4,175	6.0	—	—
1154		9	22	76	0945	10,416	4,283	7.0	—	—
1174		9	23	76	1005	10,533	4,400	7.0	—	—
1125	LC-1	9	21	76	1015	—	—	—	11	10
1142		9	22	76	0815	—	—	—	8	5
1167		9	23	76	0825	—	—	—	37	—
1183		9	23	76	1355	—	—	—	48	—
1166	LC-2 SURFACE SCUM	9	22	76	1315	TS 78,472	TVS 47,592	—	42	—
1129	GC1-1	9	21	76	1055	—	—	—	8	6
1157		9	22	76	0950	—	—	—	10	6
1171		9	23	76	0950	—	—	—	10	—
1134	NC-1	9	21	76	1030	—	—	—	5	3
1156		9	22	76	0930	—	—	—	5	3
1172		9	23	76	1000	—	—	—	6	—

APPENDIX B

GENERAL STUDY METHODS

APPENDIX B

GENERAL STUDY METHODS

To accomplish the stated objectives, the study included extensive sampling, physical measurements, and daily observations. Gun Powder Creek WTP influent and effluent stations were sampled for two consecutive 24-hour periods. Lower Creek WTP influent station was sampled for three consecutive 24-hour periods, but because of an inoperative sampler, the effluent station was sampled for only two consecutive 24-hour periods.

A Stevens Type F water level recorder was installed on the Lower Creek plant effluent to record gage heights on the rectangular weir through the 24-hour compositing periods. These gage heights were converted to daily total flow (mgd). Dissolved oxygen was determined at stations throughout the plants and in the aeration basins using a YSI Model 51A dissolved oxygen meter. An Analytical Measurements Model 30 WP cordless pH recorder was installed at both plants to continuously monitor influent pH throughout the sampling period. Temperatures and pH were determined at other stations with a thermometer and portable pH meter.

Depth of the secondary clarifier sludge blankets were determined daily by use of equipment suggested by Alfred W. West, EPA, NFIC, Cincinnati. Sludge activity was determined by the oxygen uptake procedure presented in Appendix D.

The following series of standard operational control tests were run daily:

(1) Settleability of mixed liquor suspended solids (MLSS) as determined by the settlometer test;

(2) Percent solids of the mixed liquor and return sludge determined by centrifuge;

(3) Suspended solids and volatile suspended solids analysis on the aeration basin mixed liquor and return sludge;

(4) Turbidity of each final clarifier effluent.

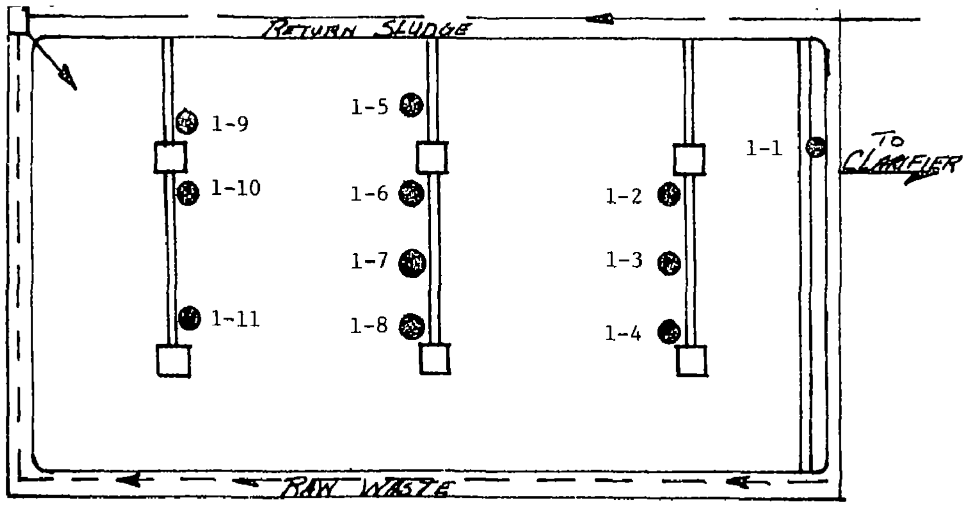
An amperometric titrator (Fischer & Porter Model 17T1010) was used to determine effluent chlorine concentrations. The procedure for BOD_5 determinations deviated from Standard Methods. Samples were set up and returned in an incubator to Athens, Georgia for completion. Visual observations of individual unit processes were recorded.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Environmental Protection Agency.

APPENDIX C

AERATION BASIN DISSOLVED OXYGEN CONCENTRATIONS - LOWER CREEK WTP

APPENDIX C
AERATION BASIN DISSOLVED OXYGEN CONCENTRATIONS
LOWER CREEK WTP, LENOIR, NC



STATION	DEPTH (FT)	DO (mg/l)	TEMP (°C)
1-1	1	0.0	20
1-2	1	4.8	20
	5	4.1	Aerator on
	8	3.6	
	10	0.2	
1-3	1	4.0	
	5	3.8	
	10	3.5	
	11	3.0	Sludge below 11 ft depth
1-4	1	3.4	Aerator off
	5	3.1	
	10	3.1	Sludge below 10 ft depth
1-5	1	3.0	Aerator on
	5	2.9	
	10	2.8	
1-6	1	3.7	
	5	3.4	
	9	3.3	
	10	3.0	
1-7	1	3.6	
	5	3.4	
	8	3.2	
	9	0.0	
1-8	1	2.4	Aerator off
	5	2.6	
	8	2.3	
	10	0.0	
1-9	1	2.6	Aerator off
	5	2.4	
	8	1.8	Sludge below 8 ft depth
1-10	1	2.0	Aerator off
	5	1.8	
	8	1.8	
	10	1.6	
1-11	1	2.4	Aerator on
	5	2.2	
	8	2.0	

APPENDIX D

OXYGEN UPTAKE PROCEDURE

APPENDIX D

OXYGEN UPTAKE PROCEDURE 1/

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 orginal 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 1 minute intervals until at least 3 consistent readings for the change in DO per minute are obtained (ΔDO/min). Check for 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. Teh 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 poinsoned the "bugs".

1/ 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 E

PROJECT PERSONNEL

APPENDIX E

PROJECT PERSONNEL

Ronald Barrow	Sanitary Engineer
Herb Barden	Microbiologist
Lavon Revells	Chemist
Tom Sack	Technician
Eddie Shollenberger	Technician
Richard Rehm	Student Trainee