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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with operation of activated sludge wastewater treatment plants. Included are objectives, instructor guides, student handouts, and transparency masters. This is the first of a three module series and considers definition of terms, design and operation parameters, process observations, basic process controls and control tests. (Author/RH)

BASIC ACTIVATED SLUDGE

Training Module 2.115.2.77

Prepared for the

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by

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September, 1977

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SUMMARY

Module No:	Module Title: Basic Activated Sludge
Approx. Time. 14 Hours	Topics: 1. Introduction 2. Definition of terms 3. Conventional activated sludge, design & operation parameters 4. Modifications to the conventional system 5. Process observations 6. Basic process control 7. Operator control tests

Overall Objectives:

Upon completion of this module the operator should have a basic knowledge of the activated sludge process of wastewater treatment, be able to calculate basic process parameters, be able to run operations tests, and be able to plot basic trend charts.

Instructional Aids:

Handouts
Transparancies
Calculator

Instructional Approach:

Lecture
Discussion
Demonstration
Exercise
Hands-on

References:

1. Water Pollution Control Federation MOP 11.
2. Manual of Instruction for Sewage Plant Operators (New York Manual).
3. Operational Control Procedures for the Activated Sludge Process, Parts I, II, and Appendix.
4. Operators pocket guide to Activated Sludge, Parts I and II.

Class Assignments:

1. Given handouts to be read
2. In class problem solutions
3. Performance of control tests
4. Plotting trend charts

Module No:	Topic: Basic Activated Sludge

Instructor Notes:	Instructor Outline:

1. Handouts should be distributed as they appear in the module.

2. The module includes traditional lecture, in class problem solutions and hands on activity.

3. 12 x 20 division per inch graph paper should be made available to the student for trend chart plotting.

4. Laboratory equipment and glassware utilized to perform the "control tests" are listed in the appendix - Operational Control Procedures for the Activated Sludge Process.

5. The module would be most appropriately delivered in an activated sludge treatment facility as samples of process streams are needed to perform the control tests. It is also appropriate to be able to actually observe aeration tanks and clarifiers as the topic "Process Observations is discussed.

6. Microscope(s) should be available to observe the microorganisms existent in the mixed liquor.

7. Part I, Part II, and Appendix to the Operational Control Procedures for the Activated Sludge Process may be obtained from:

   Environmental Research Center
   U. S. Environmental Protection Agency
   26 W. St. Clair Street
   Cincinnati, Ohio 45268

8. Operator's Pocket Guides for the activated sludge process may be obtained from: (Nominal charge)

   Stevens, Thompson & Runyan, Inc.
   5505 S. E. Milwaukie Ave.
   Box 02201
   Portland, Oregon 97202

9. The evaluation includes the written test and for each student to perform the control tests and plot data trend charts to the satisfaction of the instructor.

Module No:	Module Title: Basic Activated Sludge
	Submodule Title:
Approx. Time: 1 hour	Topic: Introduction

Objectives:

1. Define the activated sludge process and its modifications (as defined in WPCF MOP 11).
2. List three basic operational requirements. (A. Adequate number of microorganisms. B. Suitable environment i.e. D.O. C. Ability to settle i.e. separate).
3. List the typical facility units (aeration tank; oxygen supply; final settling tanks; pumps for return sludge and waste sludge flows and their purpose).
4. Sketch and label a typical conventional activated sludge flow schematic.

Instructional Aids:

1. Transparancies

Instructional Approach:

1. Lecture
2. Discussion

References:

1. Water Pollution Control Federation MOP 11 (WPCF MOP 11).
2. Manual of Instruction for Sewage Treatment Plant Operators (New York Manual).
3. Operation Control Procedures for the Activated Sludge Process, Parts I and II, and Appendix (OCP for ASP).

Class Assignments:

Module No:	Topic: Introduction

Instructor Notes:	Instructor Outline:
From MOP 11, Page 118	I. Definition of the activated sludge process:

The activated sludge process and its modifications may be defined as the contacting of preformed biological floc (activated sludge) with incoming waste in an aeration tank supplied with sufficient dissolved oxygen to maintain aerobic conditions throughout the process, followed by liquid solids separation in a settling tank.

II. There are three basic operational requirements for the activated sludge process.

A. Microorganisms

An adequate number of microorganisms is needed to assimilate the suspended, colloidal, and dissolved organic material in the wastewater to form the final end products of carbon dioxide, water and inert materials.

B. Suitable environment

An aeration tank with sufficient dissolved oxygen, substrate and nutrients.

C. Separation

The activated sludge must be of a quality that readily separates from the treated wastewater in the settling tanks.

III. The following units make up the typical conventional activated sludge facility.

Figure I:

A. Aeration tank

1. Basin into which raw waste (system without primary clarifiers) or primary effluent flows.

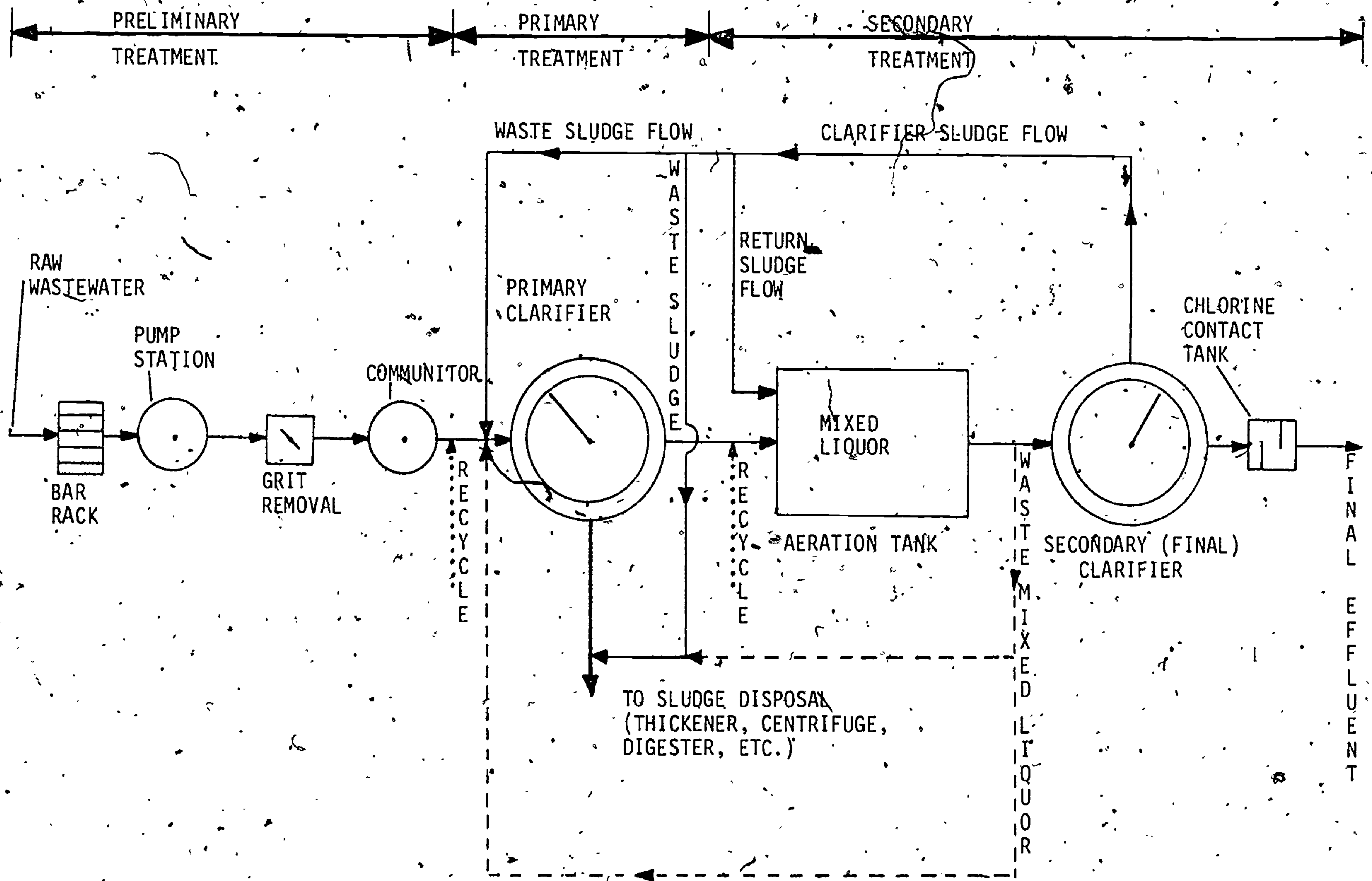


FIGURE 1
CONVENTIONAL ACTIVATED SLUDGE
PROCESS SCHEMATIC

Module No:	Topic: Introduction

Instructor Notes:

Students should use the proper vocabulary (and the instructor) i.e. be careful the proper name for a given process flow and/or unit.

Example:

The clarifier sludge flow is that flow of solids being removed from the bottom of the secondary clarifier. Clarifier sludge flow can then be directed either to the aeration tank and/or wasted. So return sludge flow plus waste sludge flow equals clarifier sludge flow. By being specific the operator then can address exactly the process flow being considered.

Instructor Outline:

2. Solids from the secondary clarifier, return sludge, also are pumped into the basin.
3. Provides the detention necessary for biological activity to occur.
4. Contents called "mixed liquor".

B. Secondary clarifier

1. Basin into which the overflow from the aeration tank flows.
2. Purpose is for liquid solids separation to occur.
3. Generally some type of sludge scraping device.
4. Pumps required to remove the settled solids.
5. Overflow generally flows into chlorine contact tank or tertiary treatment units.

C. Pumps

1. To remove sludge from secondary clarifier with capability of returning sludge to aeration tank or to remove waste (excess) sludge from the secondary system.
2. Should have ability to measure the sludge flows directed to the aeration tank or to waste.

Module No:	Topic: Definition of Terms

Instructor Notes:	Instructor Outline:
	D. Oxygen supply There are two main systems for providing aeration. 1. Diffused air system. Air supplied by blowers under relatively low pressure (8 - 10 psi) forced through a porous material. The porous material may be a plate, tube, or some type of synthetic material. Generally a sparger is an air diffuser designed to give large bubbles. A diffuser is generally the label given to the porous material which provides fine bubbles. The blowers are generally either positive displacement or centrifugal. 2. Mechanical aerators. There are several types of mechanical aerators in usage. a. Surface mechanical aerators are either mounted on a fixed platform (bridge) or float on the liquid surface. The aeration intensity is varied either by varying the depth of submergence (usually by adjusting the aeration tank overflow weir up or down) or by varying the speed of rotation (frequently two speed motors power the fixed bridge aerators.) b. Vertical draft tube. The mixed liquor is drawn up (or down) through a vertical tube by a revolving impeller. There are also aeration systems which combine diffused air and a mechanical device or turbine. In all of the systems the purpose is two-fold, to provide oxygen and to mix the contents of the aeration tank.

Module No:	Topic: Introduction

Instructor Notes:	Instructor Outline:
	IV. Conventional activated sludge process schematic.
	Although this is intended to be a course in activated sludge, the instructor should go over Figure 1 in detail. Note the preliminary treatment units and their purpose, primary treatment units and their purpose, and then the activated sludge units (secondary treatment). Point out the many possible flow configurations and emphasize the importance for each operator to know the exact flow diagram for his facility. While discussing the secondary treatment process units do not forget "recycle" flow possibilities. Supernatant from anaerobic or aerobic digesters, overflow from gravity sludge thickeners, recycled flow from sludge furnaces, and other possibilities which can be of significance when calculating the organic load to the aeration tank and/or troubleshooting process upsets.

Module No:	Module Title: Basic Activated Sludge
	Submodule Title:
Approx. Time: 1 hour	Topic: Definition of Terms

Objectives:

1. Define by matching the following terms: A. Adsorption; B. Absorption; C. Log growth phase; D. Declining growth phase; E. Endogenous phase; F. Sludge floc; G. Mixed liquor; H. Stabilization; I. Return sludge; J. Waste sludge; K. F/M; L. Diffuser; M. Sludge bulking.
2. Given the "ideal growth curve" label the three significant zones, the two curves, and the axis.

Instructional Aids:

1. Handout
2. Transparancies

Instructional Approach:

1. Lecture
2. Discussion

References:

1. WPCF MOP 11
2. N. Y. Manual
3. Operator's Pocket Guide to Activated Sludge, Part I and II, Stevens, Thompson & Ryan, Inc., Portland, Oregon (Pocket Guide).

Class Assignments:

Module No:	Topic: Definition of Terms

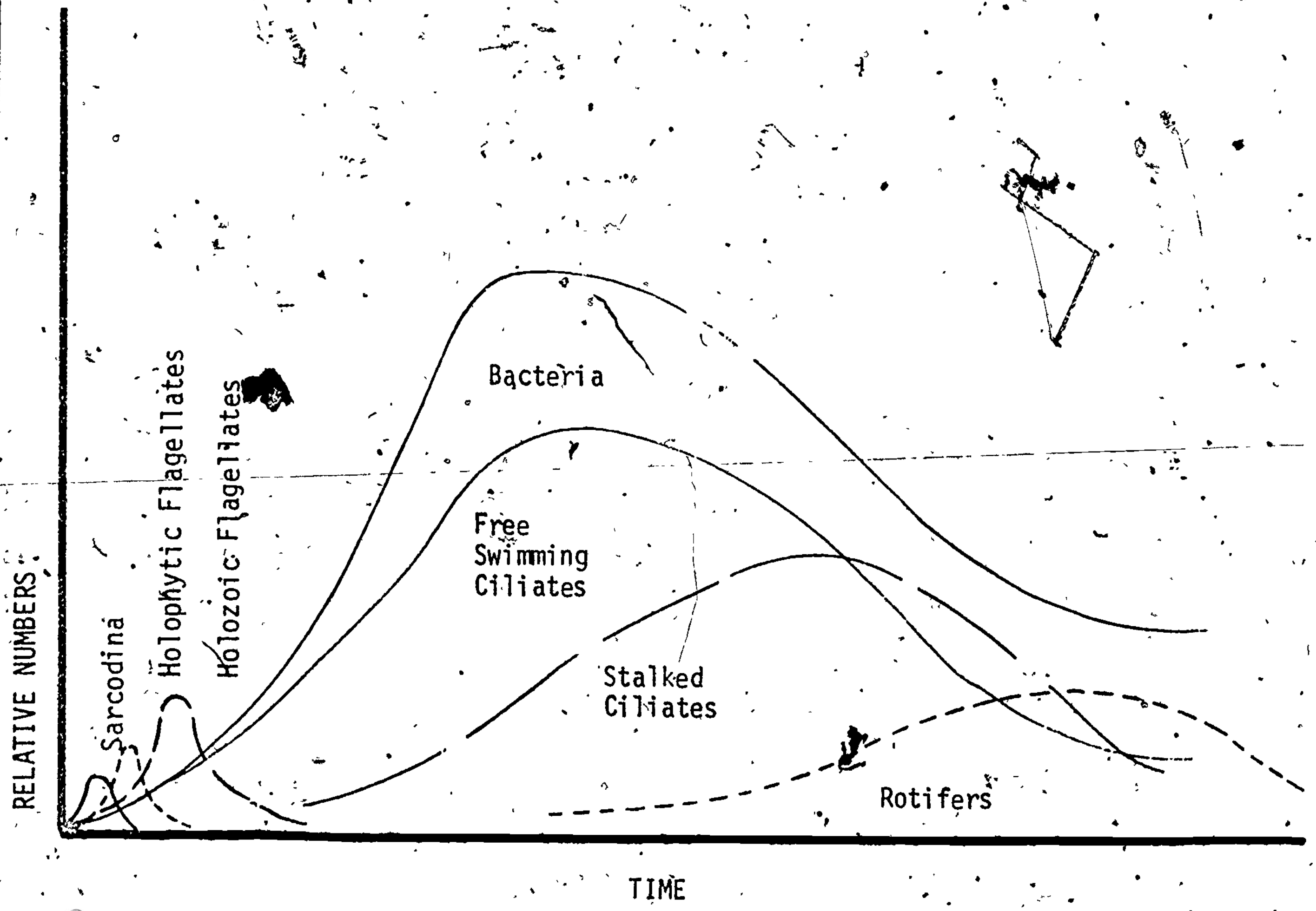
Instructor Notes:	Instructor Outline:
Student Handout I The definitions on the student handout are taken primarily from MOP 11. Some are taken from the "operator's pocket guide to activated sludge".	The operator must learn the vocabulary of the activated sludge process. The terms on the handout are not the total of those terms the operator will be using, rather only some of the basics. Each should be discussed in context. The list should be expanded, that is, give the student an opportunity to add terms to the handout if there are some which he does not understand.
Figure 2 - Ideal Growth Curve MOP 11 Discussion covers this topic satisfactorily.	A basic understanding of the activated sludge system requires the student to understand how food is utilized and bacteria grow in response to the food. The vertical axis is the mass (number of organisms), the horizontal axis is time. Discuss the "phases" including relation of F/M and the relative predominate microorganisms expected in each phase.
Figure 3 - Relative Predominance of Microorganisms	Figure 3 can be used as an overlay to Figure 2. Note that the "food" remaining curve is coincident on the two figures. It is also important to note where the "conventional" process fall operationally relative to "phase" and the microorganisms that should be in evidence.

ACTIVATED SLUDGE TERMS AND DEFINITIONS

From MOP 11

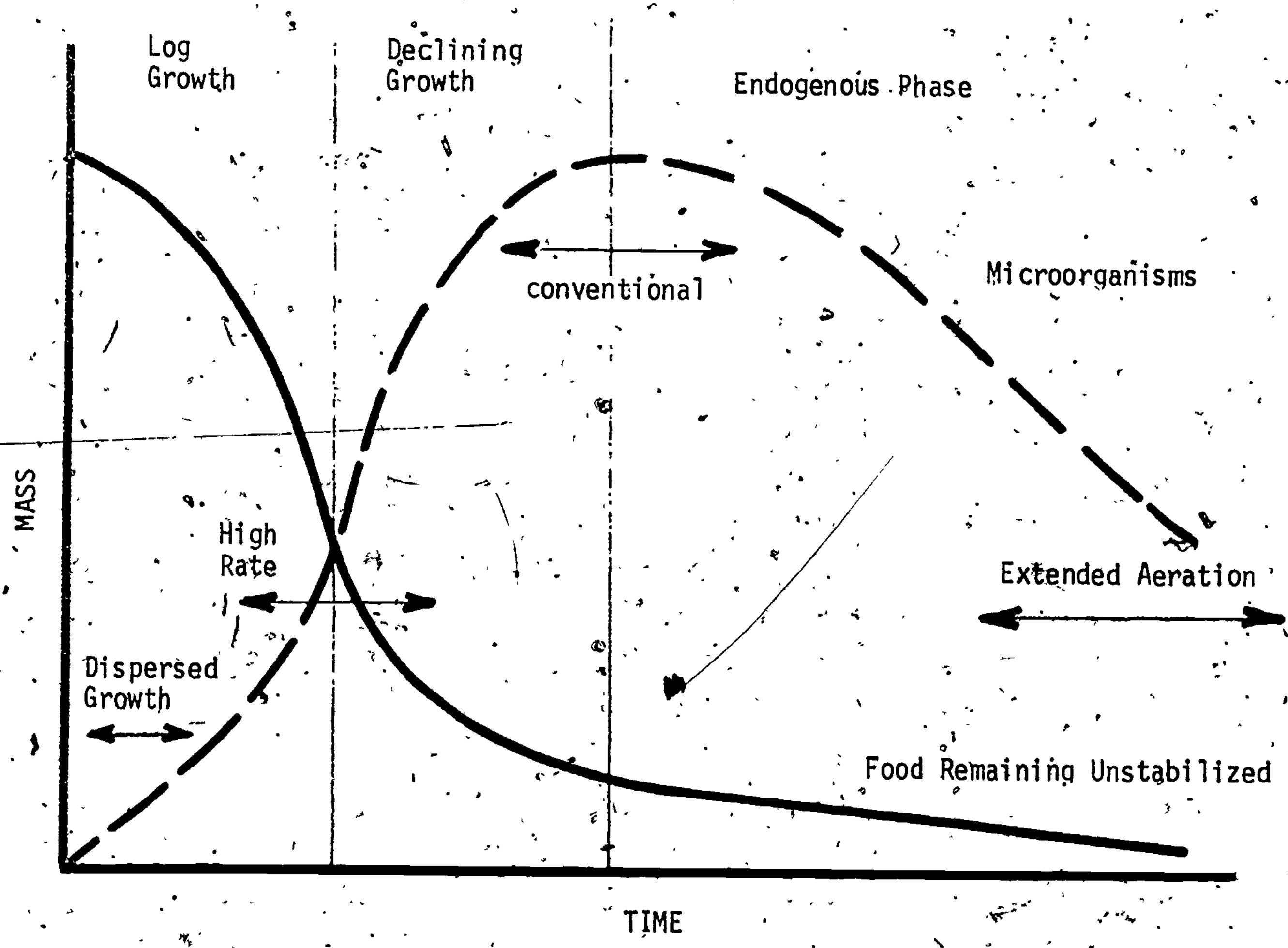
Absorption	The taking up of one substance into the body of another.
Adsorption	The adherence of a gas, liquid, or dissolved material on the surface of a solid.
Coagulation	The destabilization and initial aggregation of colloidal and finally divided suspended matter by the addition of a floc forming chemical or by biological processes.
Colloids	Finely divided solids that will not settle but may be removed by coagulation, biochemical action, or membrane filtration.
Declining Growth Phase	A growth phase in which the amount of available food begins to limit cell growth.
Endogenous Phase	The growth phase which due to a lack of available food and cannabalism between cells results in a net cell death.
Floc (sludge floc)	Small gelatinous masses formed in a liquid by agglomeration of smaller particles.
F/M	Food to Microorganism ratio. This is a calculated ratio of the pounds of food (lbs. BOD) flowing into an aeration tank divided by the pounds of solids in the aeration tank (lbs. suspended solids). Note: Some operators use the volatile suspended solids in this calculation.

Log Growth Phase	A growth phase in which cell production is at a maximum - abundance of food and suitable environment (oxygen, temp. etc.)
Mixed Liquor	The contents of an aeration tank - the mixture resulting from the combination of return sludge and primary effluent (raw sewage if primary treatment units are not a part of the facility.)
Return Sludge	That portion of the settled sludge removed from the clarifier which is returned to the aeration tank.
Sludge Bulking	A condition of activated sludge during which the sludge occupies excessive volumes and will not concentrate readily.
Stabilized	That quality of a waste or sludge when there is no capability for further change.
Waste Sludge	That sludge which is removed from the secondary treatment units. It is generally a portion of that sludge withdrawn from the clarifier, however, some activated sludge plants have the ability to waste mixed liquor.



RELATIVE NUMBERS
TIME
Sarcodina
Holophytic Flagellates
Holozoic Flagellates
Bacteria
Free
Swimming
Ciliates
Stalked
Ciliates
Rotifers

Figure 2



Log Growth
Declining Growth
Endogenous Phase
conventional
Microorganisms
MASS
High Rate
Extended Aeration
Dispersed Growth
Food Remaining Unstabilized
TIME

Figure 3

Module No:	Module Title: Basic Activated Sludge
	Submodule Title:
Approx. Time: 3 hours	Topic: Conventional Activated Sludge - Design and Operation Parameters

Objectives:

1. Using the "typical conventional activated sludge flow schematic", show the typical design values for:

   A. Aeration tank detention time.
   B. Final settling tank surface overflow rate
   C. Return sludge flow pump capacity

2. Given aeration tank dimensions, clarifier dimensions, flows, and appropriate plant data, calculate:

   A. Aeration tank detention time
   B. Clarifier surface settling rate
   C. Lbs. of BOD to aeration
   D. Lbs. of solids under aeration
   E. F/M

Instructional Aids:

1. Transparancies
2. Handout
3. Calculator

Instructional Approach:

1. Lecture
2. Discussion
3. In class problem solution

References:

1. WPCF MOP 11
2. N. Y. Manual

Class Assignments:

Module No:	Topic: Design and Operation Parameters.

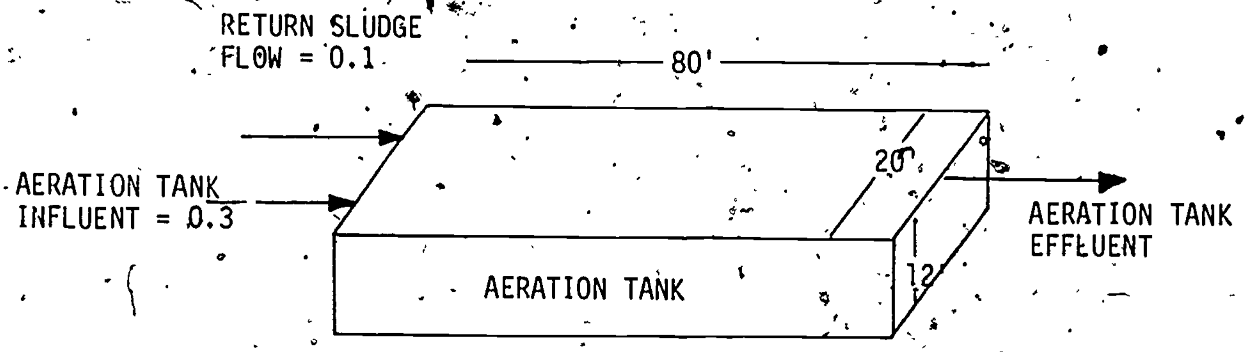
Instructor Notes:	Instructor Outline:
Figure I - Conventional Activated Sludge Flow Schematic Student Handout II - Design Parameters	An operator should know what the generally "accepted" design parameters are for the conventional activated sludge process units. The "Recommended Standards for Sewage Works" and the "New York Manual" values are shown on Student Handout II. The operator must realize that these are the design numbers. The operator must deal with that which exists, i.e. the daily flow variation, the daily load variation, the weekend changes, the seasonal changes, the new industry, the industry that shut down and on and on. The point is that design is probably past history to the operator. The operator faces operation or operational parameters. It then behooves the operator to routinely calculate operational parameters i.e. to document flows, loading, detention times, process performance et
	I. Aeration Tank Detention Time First notice that the design value is based on the design flow alone. This detention time will be called aeration tank detention time at flow. Understand, however, that the true hydraulic detention time must includ the return sludge flow into the aeration tank. This detention time will be called aeration tank detention time at total flow.
Figure 4 - Detention Time Example	Figure 4 is an example problem. If time permits and a student has "real" plant dimensions and flow data, solve the problem with the real data.
	II. Clarifier Surface Overflow Rate
Figure 5 - Overflow Rate Calculation Example	Notice the three flow values in this problem; clarifier influent, clarifier effluent, and clarifier sludge flow. The correct flow (clarifier effluent) must be used for this calculation.

CONVENTIONAL ACTIVATED SLUDGE DESIGN PARAMETERS

	New York Manual	Recommended Standards For Sewage Works
Aeration Tank		
Detention Time *(Hrs.)	6 - 8 **	6 - 7.5
Oxygen (cu. ft. air/lb. BOD)	1,500	1,500
Organic Load (i.e. BOD/1000 cu. ft.		30 - 40
Secondary Clarifier		
Surface Overflow (Gal. sq. ft./day)	800	600 - 800
Detention Time (Hrs.)		2 - 3
Clarifier Sludge Flow (%)	20 - 30	15 - 75

*Based on design flow

**Diffused air, for mechanical aerators 9 - 12



VOLUME = LENGTH X WIDTH X DEPTH = 20 X 80 X 12

VOLUME = 19,200 CUBIC FEET X 7.48 GAL./CUBIC FEET

VOLUME = 143,616 GALLONS

FLOW IN = .3 MGD + .1 MGD = .4 MGD

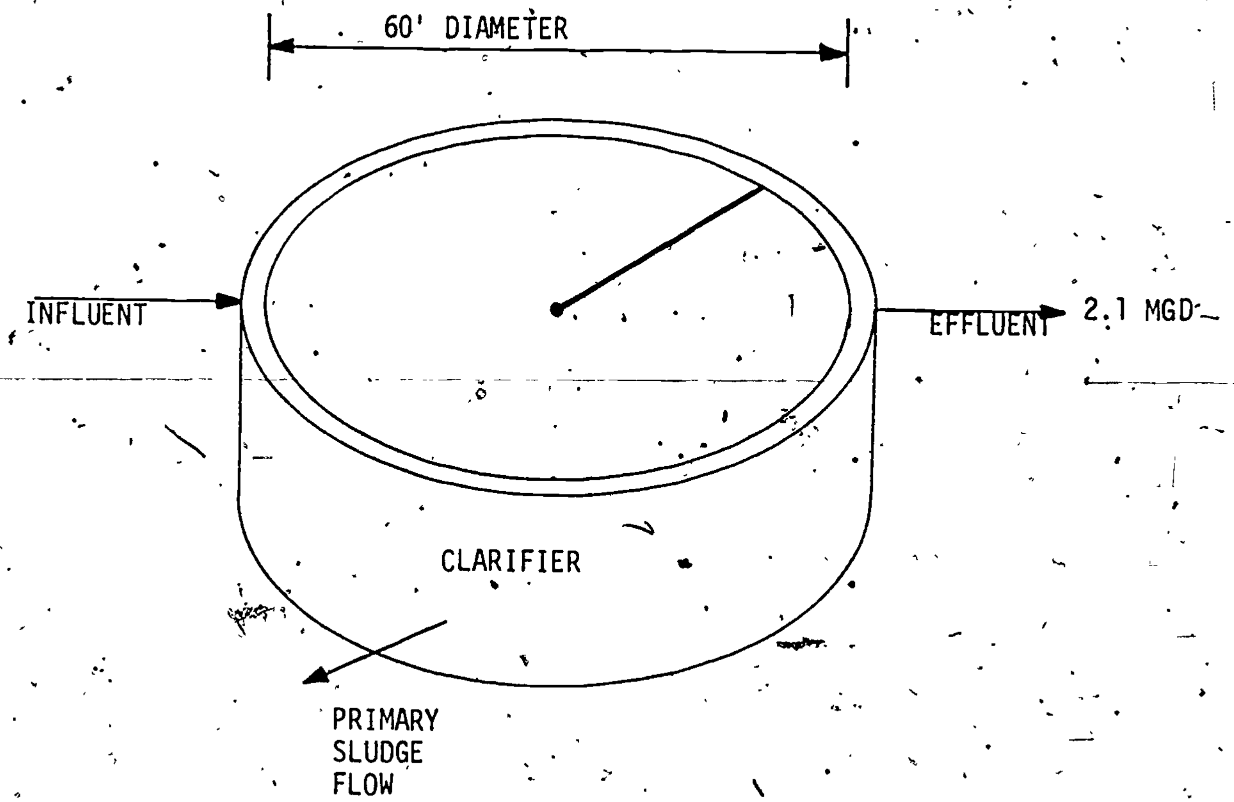
$$\text{DETENTION TIME} = \frac{\text{VOLUME}}{\text{FLOW IN}} \times 24$$

$$\text{DETENTION TIME} = \frac{143,616}{400,000} \times 24$$

DETENTION TIME = 8.6 HOURS

FIGURE 4

DETENTION TIME CALCULATION EXAMPLE



SURFACE AREA = $\frac{\pi d^2}{4} = \frac{3.14 \times 60^2}{4}$ = 2,826 SQ. FT.

OVERFLOW RATE = $\frac{\text{EFFLUENT}}{\text{SURFACE AREA}} = \frac{2,100,000}{2,826}$

OVERFLOW RATE = 743 GAL./SQ. FT./DAY

FIGURE 5

OVERFLOW RATE CALCULATION EXAMPLE

Module No:	Topic: Design and Operation Parameters

Instructor Notes:	Instructor Outline:
	III. Clarifier Detention Time The critical value again is flow. The detention time is calculated from the clarifier influent. Use a mean clarifier depth of 10 feet and a clarifier influent flow of 2.8 MGD to complete the calculation.
Figure 5 - Encourage Use of "Real" Data for Additional Calculation Practice. The operators should be able to furnish at least approximate dimensions and flow data.	IV. Pounds of BOD to Aeration (F)
	V. Pounds of Solids Under Aeration (M) Some operators use mixed liquor volatile suspended solids for this calculation. That's fine - just be consistent i.e. if volatile solids are being used, always use them and make appropriate notes in the plant data and trend charts.
Figure 6 - Organic Load Calculation Example.	
	VI. F/M Point out that this ratio is comparing the food to the organisms available to "eat" the food.

PRIMARY EFFLUENT BOD = 150 MG/L

PRIMARY EFFLUENT FLOW = 0.3 MGD

AERATION TANK VOLUME = 19,200 CUBIC FEET

AERATION TANK VOLUME = 143,616 GALLONS

MIXED LIQUOR SUSPENDED SOLIDS = 2,000 MG/L

POUNDS OF BOD/DAY = 150 X 0.4 X 8.34 = 500 LBS/DAY

$$\frac{\text{POUNDS BOD/DAY}}{\text{VOLUME (1,000 CUBIC FEET)}} = \frac{500}{19.2} = 26 \text{ LBS BOD/DAY/1000 CUBIC FEET}$$

POUNDS MIXED LIQUOR SOLIDS = .143616 X 2,000 X 8.34

POUNDS MIXED LIQUOR SOLIDS = 2,396 LBS

$$\frac{\text{POUNDS BOD/DAY}}{\text{POUNDS MIXED LIQUOR SOLIDS}} = \frac{500}{2396} = 0.21$$

FIGURE 6

ORGANIC LOAD CALCULATION EXAMPLE

Module No:	Module Title: Basic Activated Sludge
	Submodule Title:
Approx. Time: 1 hour	Topic: Modifications to the Conventional System

Objectives:

1. Identify by labeling given sketches:

   A. Conventional activated sludge
   B. Tapered aeration
   C. Step feed (step aeration)
   D. Contact stabilization
   E. Extended aeration

Instructional Aids:

1. Transparencies
2. Handouts

Instructional Approach:

1. Lecture
2. Discussion

References:

1. WPCF MOP 11
2. N. Y. Manual

Class Assignments:

Module No:	Topic: Modification to the Conventional System

Instructor Notes:	Instructor Outline:

Figure 7 - Conventional

Figure 8 - Tapered Aeration

Figure 9 - Step Feed

Figure 10 - Contact Stabilization

It is not the purpose of this basic course to gain a thorough understanding of the modifications to the conventional activated sludge process. It is the intent to introduce some of the modifications and offer an overview of the "purpose" of the modification each will be compared to the conventional system.

I. Tapered Aeration

Notice that the only difference between tapered aeration and the conventional system is the placement of diffusers. When microorganisms are introduced into the aeration tank as primary effluent is introduced to the aeration tank, the organisms begin to "eat"; using oxygen. The head of the aeration tank has the most food, therefore there lies the greatest demand for oxygen. So tapered aeration is a modification to better match the supply of oxygen to the area where most is needed. As the flow progresses through the tank (in a plug flow situation) there is a decrease in the availability of food, thus a decrease in the demand for oxygen. The aeration devices are relatively more concentrated at the head of the aeration tank. No change in tank dimensions.

II. Step Feed (Step Aeration)

MOP 11 calls this modification step aeration which is confusing. The modification came about in the same way as tapered aeration, that is to equalize the loading and available oxygen. This modification distributes the load rather than the aeration devices. Subsequent workshops on activated sludge will discuss process indicators leading to distribution of the feed as a function of process demand. A somewhat smaller aeration tank can be utilized with this modification."Recommended Standards for Sewage Works suggests that 5 hr. detention time (conventional 6) will suffice in plants greater than 1.5 MGD design flow. The New

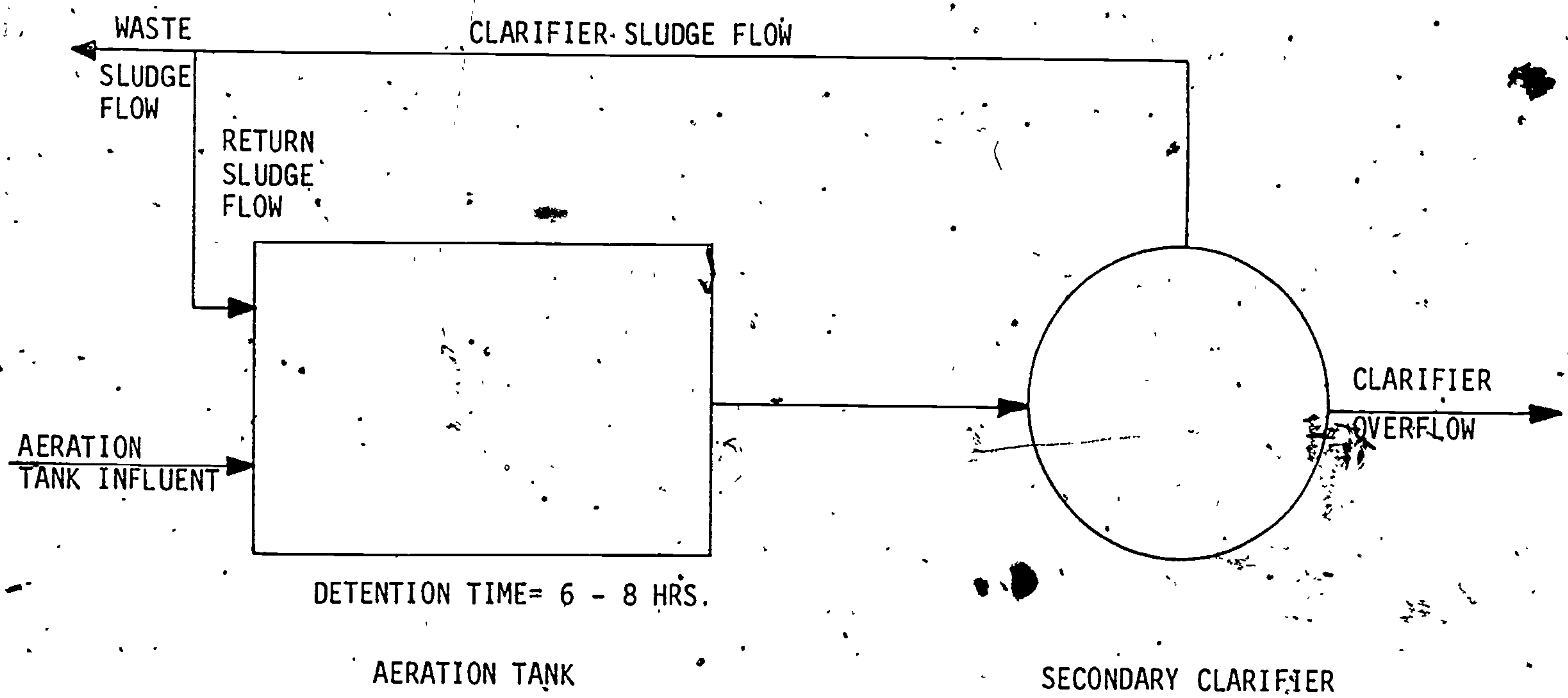
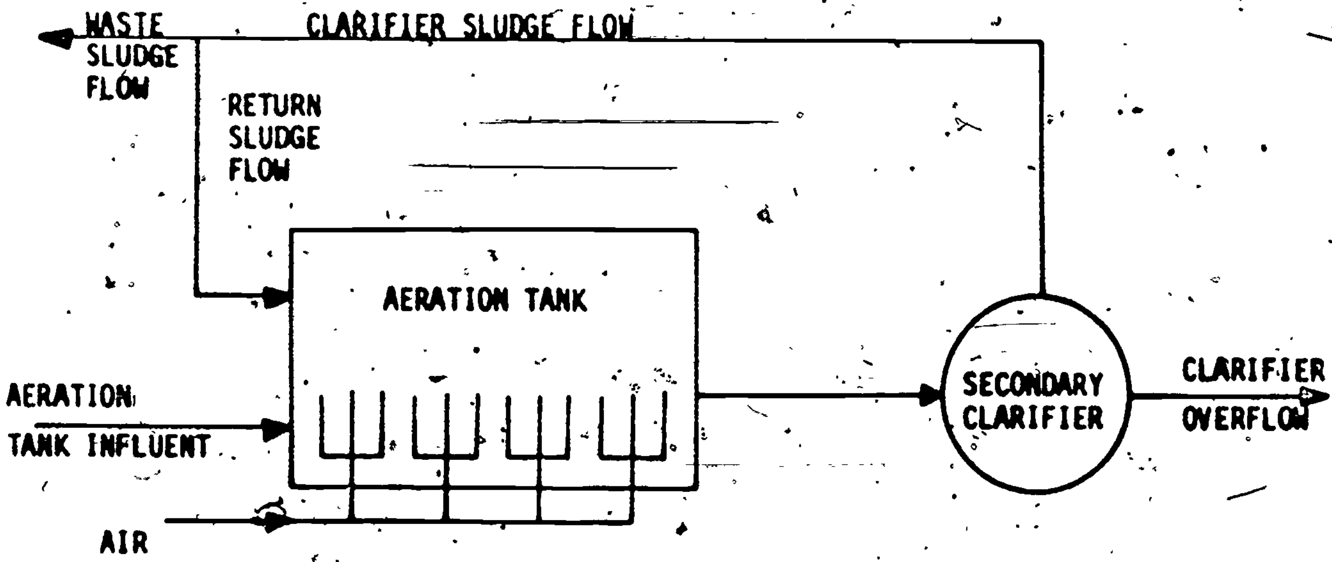
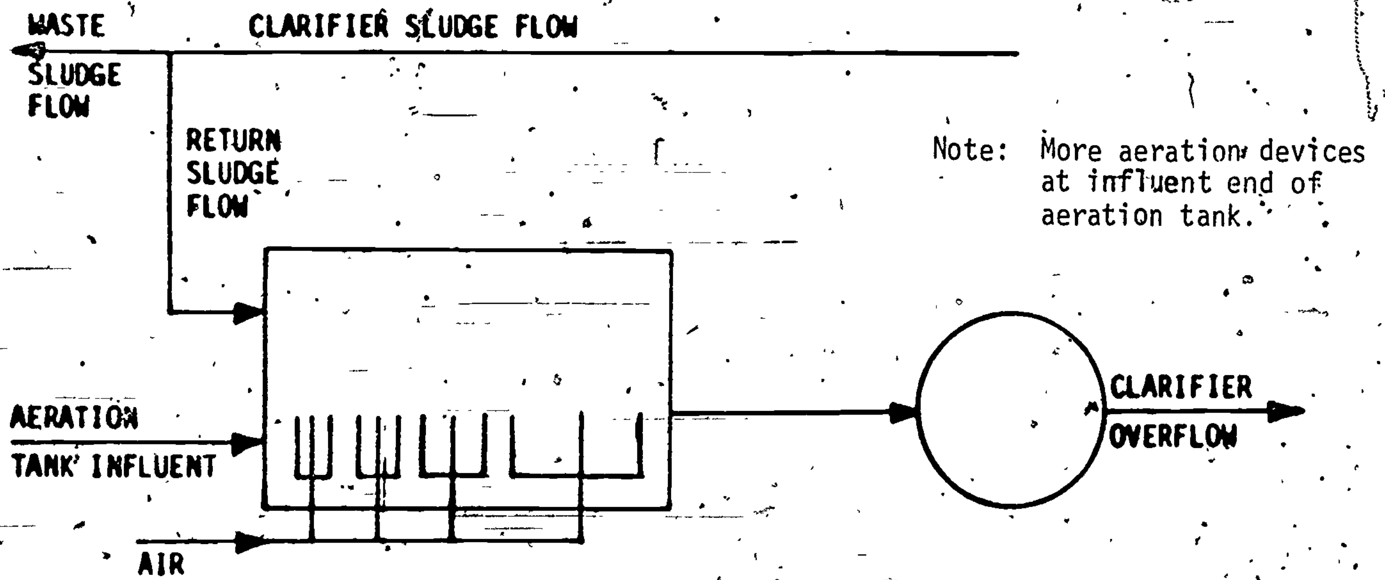


FIGURE 7
CONVENTIONAL ACTIVATED SLUDGE
PROCESS SCHEMATIC



CONVENTIONAL ACTIVATED SLUDGE



TAPERED AERATION ACTIVATED SLUDGE

FIGURE 8

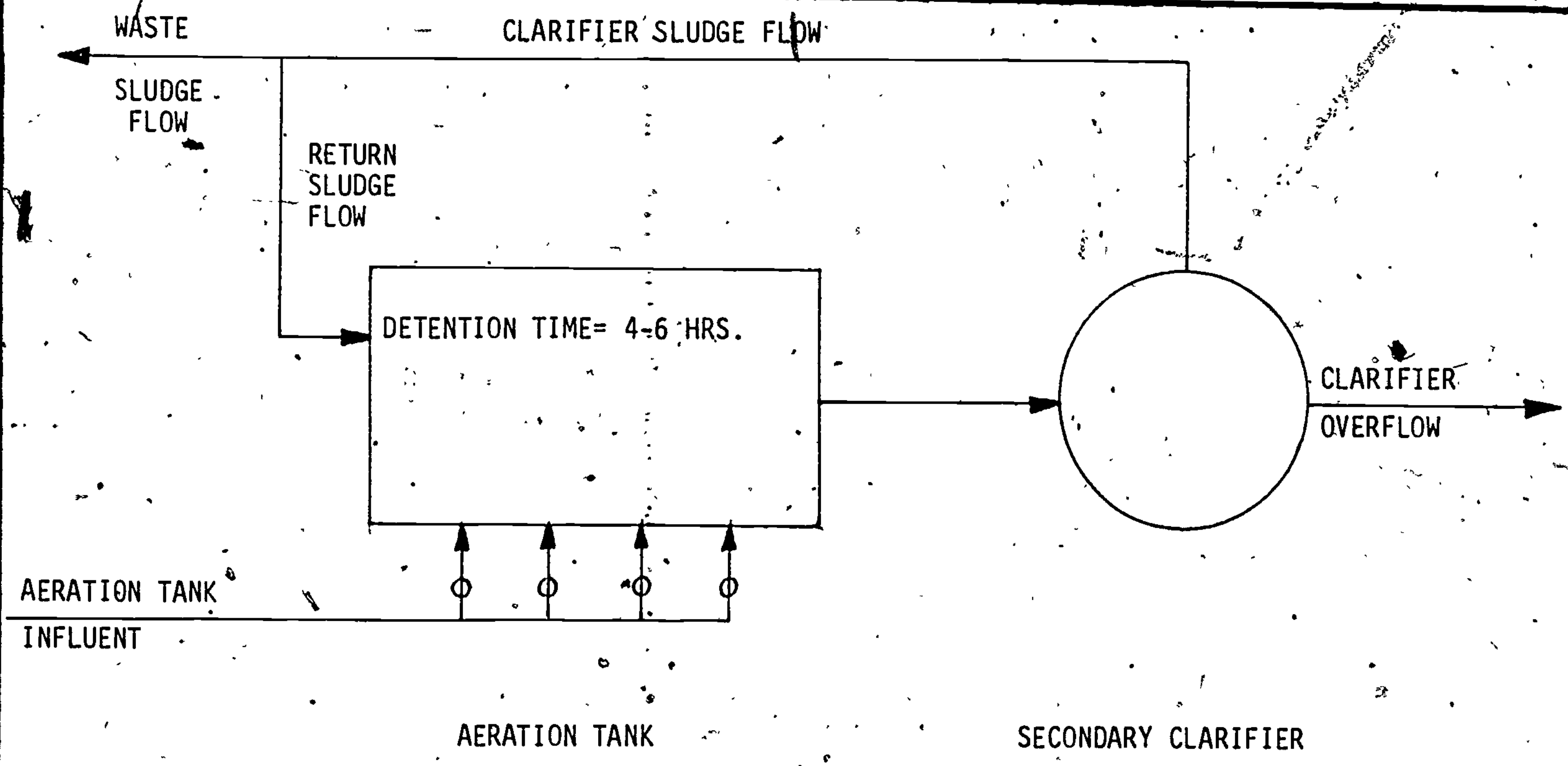


FIGURE 9
STEP-AERATION (STEP-FEED)
PROCESS SCHEMATIC

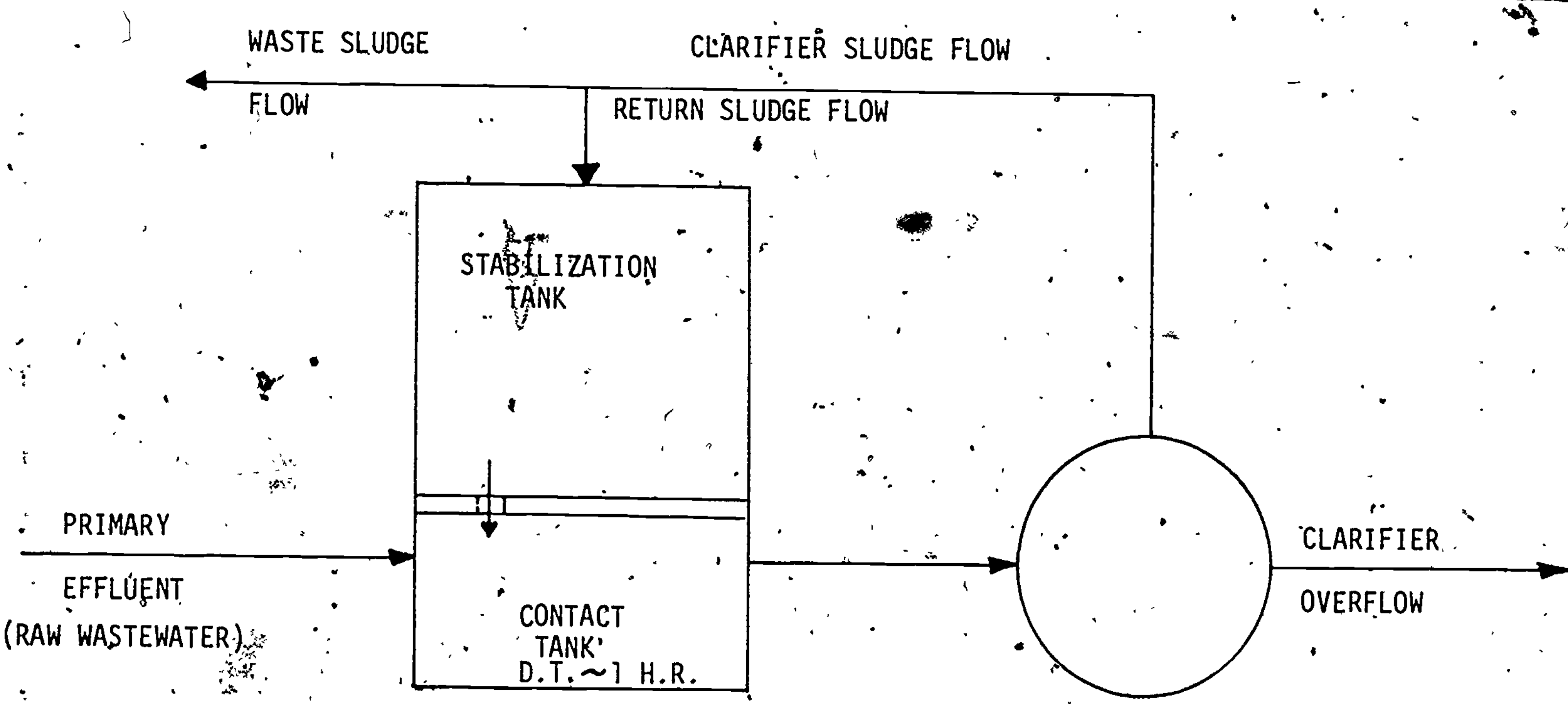


FIGURE 10
CONTACT STABILIZATION
PROCESS SCHEMATIC

Module No:	Topic: Modification to the Conventional System

Instructor Notes:	Instructor Outline:

York Manual suggests even smaller aeration tanks, but Iowa uses the former.

III. Contact Stabilization

This modification is the extreme of step feed in that the sludge is reaerated (stabilized) before it is combined with more waste flow (contact). Here again a net reduction in tankage results, compared to the conventional system the modification is most generally used in the treatment of industrial wastes, the rationale being that a given "slug" of waste only would affect that portion of sludge contacted and then reaeration would move that sludge to a more stabilized condition.

IV. Extended Aeration

The modification in this case is one of aeration tank capacity. Recall conventional on the order of six to eight hours detention time. This modification enlarges the aeration tank to provide a twenty-four hour detention time. The modification has historically been used in very small installations. (Frequently termed "package plants). All too frequently they have been abused by not wasting sludge from the process and using extremely excessive return sludge flow rates.

V. Complete Mix

WPCF MOP 11 includes the following definition of a "completely mixed system". "Activated sludge plants that use aeration tanks in which the influent wastewater is mixed throughout the tank are called completely mixed systems". This as opposed to plug flow. The configuration usually results from placing diffusers perpendicular to the direction of flow or utilization of surface mechanical aerations (no sketch included).

Module No:	Module Title: Basic Activated Sludge
	Submodule Title:
Approx. Time: 1 hour	Topic: Process Observations

Objectives:

1. Given brief aeration tank appearance descriptions, match to probable process indication.
2. Given brief final settling tank appearance descriptions, match to probable process indication.
3. Given sketches, identify microorganisms common to biological treatment - activated sludge.

Instructional Aids:

1. Transparancies
2. Handouts

Instructional Approach:

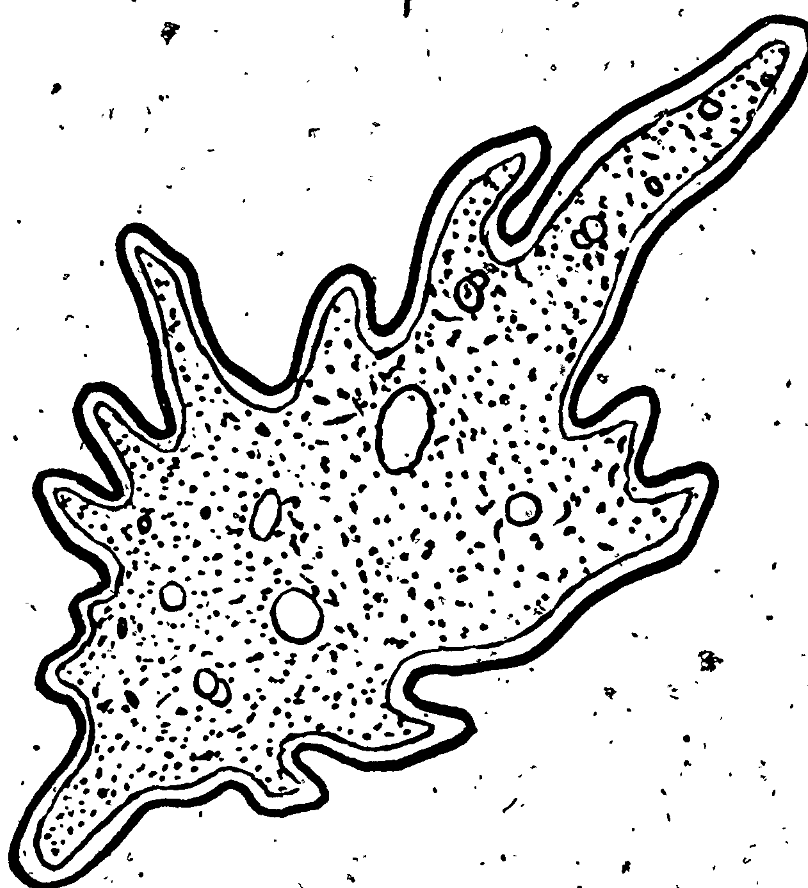
1. Lecture
2. Discussion

References:

1. WPCF MOP 11
2. OCP for ASP

Class Assignments:

Module No:	Topic: Process Observations
Instructor Notes:	**Instructor Outline:**
	The "Text" for this topic is primarily "Part I - Observations, Operational Control Procedures for the Activated Sludge Process". Pages 1 through 10 should be discussed.
Student Handout 3 - Microorganisms in Activated Sludge Floc.	Microscopic observations can also become a part of the routine process observations performed by the operator. The presence or relative change in predominance of microorganisms and documentation of these changes with other observations become one of the keys to successful operation.



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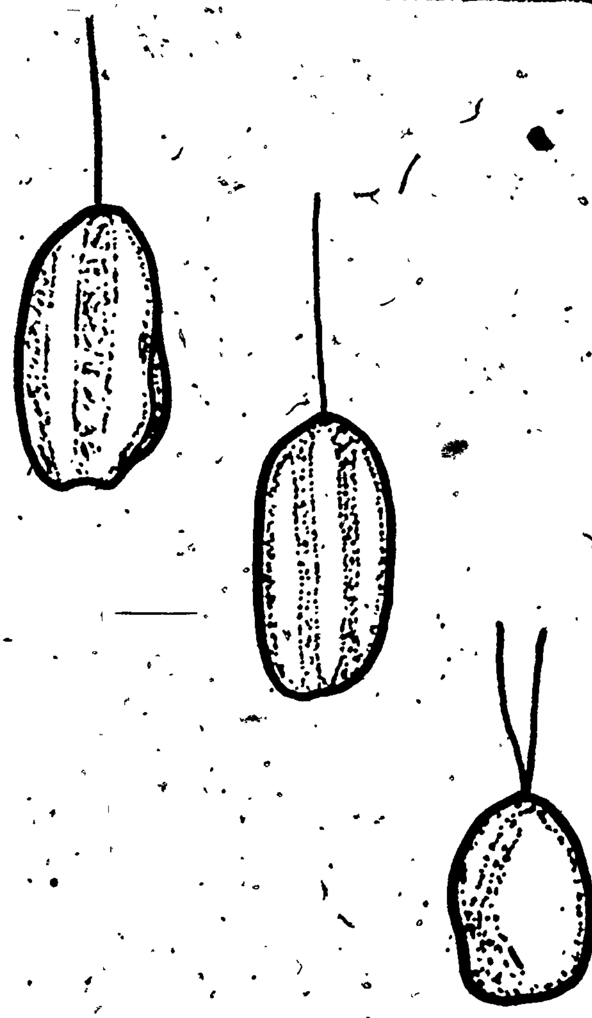
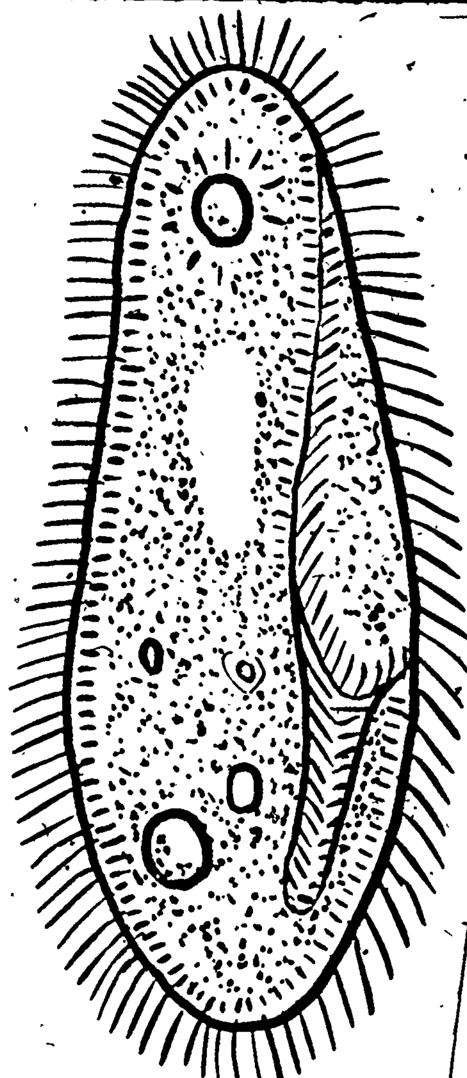


Flagellates



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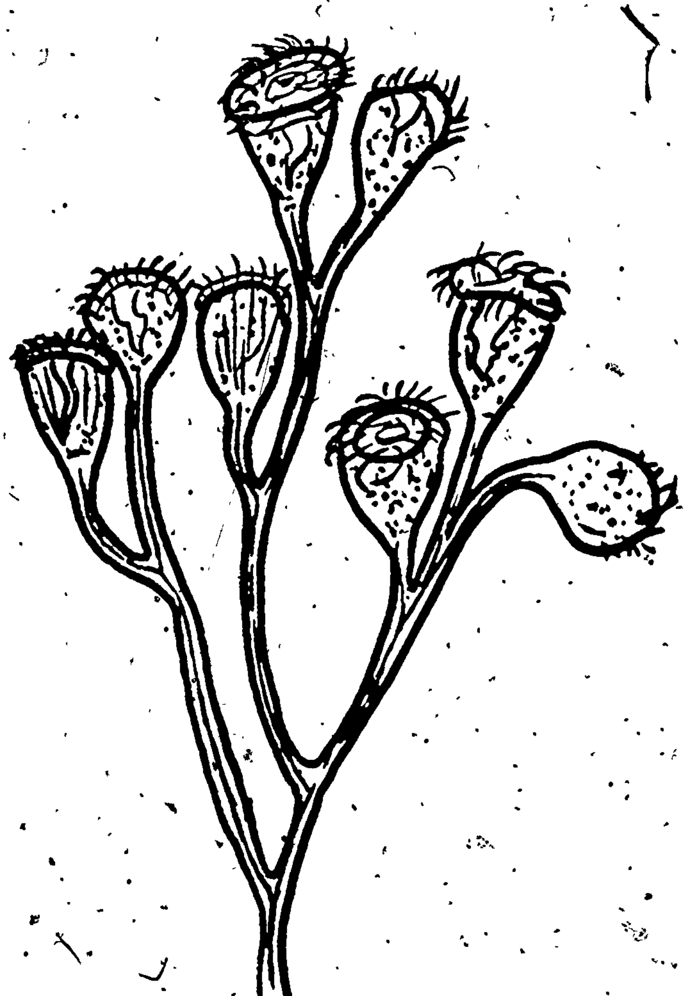
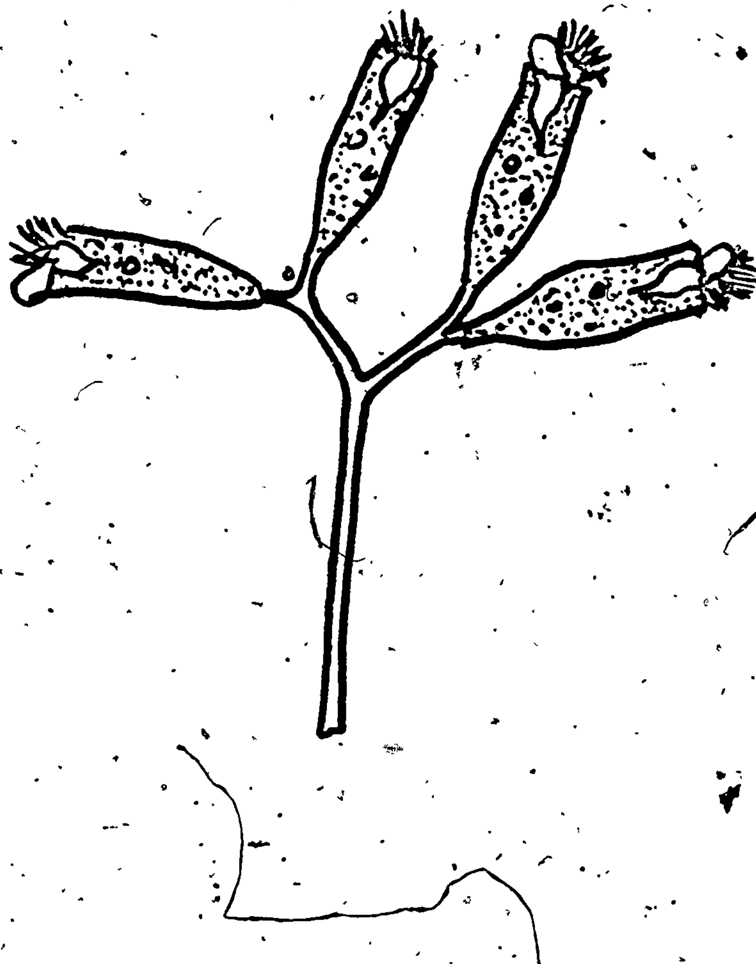
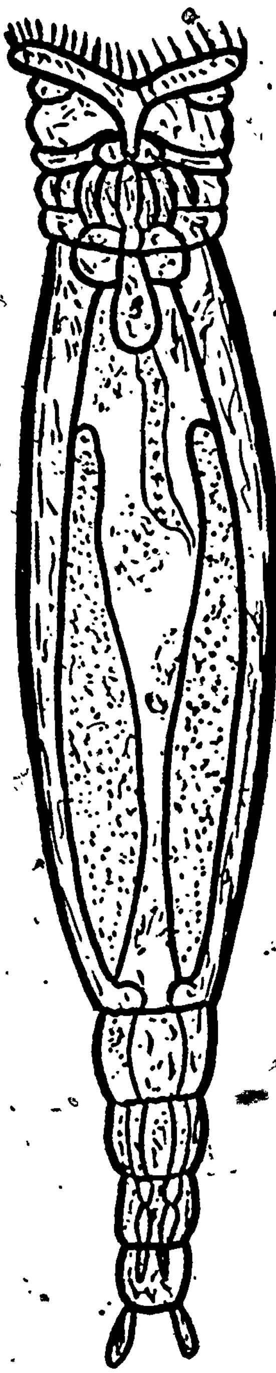


STALKED CILIATES



STALKED CILIATES



ROTIFER

Module No:	Module Title: Basic Activated Sludge
	Submodule Title:
Approx. Time: 3 hours	Topic: Basic Process Control

Objectives:

1. List two reasons for testing (1. Satisfy discharge permit requirements; 2. Obtain data from which to gain insight into process status and needs).
2. List those factors that the operator can "control" (air; return sludge flow; waste sludge flow; mode of operation if plant flexibility exists.)
3. List three "control techniques".

Instructional Aids:

1. Transparancies

Instructional Approach:

1. Lecture
2. Discussion

References:

1. WPCF MOP 11

Class Assignments:

Module No:	Topic: Basic Process Control

Instructor Notes:	Instructor Outline:

There are two basic reasons for testing and analyses in a waste treatment facility:

1. To document treatment plant performance (that is to obtain data for submission of the required self-monitoring reports.)

2. To gain insight to process needs (that is to assist in process control decision making.)

In most facilities and especially activated sludge facilities the required self-monitoring data is not sufficient to truly incorporate the data into a process control methodology. One example to illustrate what is meant. Solids separation must occur in a secondary clarifier leaving a clear supernatant or overflow for discharge to be of acceptable quality. BOD and suspended solids will document that quality of clarifier overflow. BOD and suspended solids, however, don't give you a clue as to changes in settling characteristics, only the results of what has occurred in the clarifier. However, the typical self-monitoring report requires nothing relative to settling.

It is then appropriate to focus on just what the operator can "control" or adjust in an activated sludge facility and then briefly focus on a few typical control techniques or methodologies.

I. Factors that the operator can control or adjust.

The degree of control will vary from plant to plant. Here once more the operator must learn his facility i.e. just what control capabilities exist.

1. Oxygen (air)

It is generally accepted that the level of dissolved oxygen should be maintained at about 2 mg/l.

Module No:	Topic: Basic Process Control

Instructor Notes:	Instructor Outline:
	Discuss the relative ease or difficulty of attaining a constant dissolved oxygen level of 2 mg/l in the aeration tank as a function of: A. Mechanical aerators, fixed and floating. B. Diffused air C. Organic load D. Mixed liquor suspended solids E. Measurement of dissolved oxygen level 2. Return sludge flow The clarifier may have its own lower limit above lowest pump capacity below which pipes plug, or an upper limit less than pump capacity from the piping. There may or may not be meters. 3. Waste sludge flow May be limited by the ability to handle waste sludge i.e. digester capacity, drying bed capacity, furnace capacity, thickener capacity etc. 4. Mode of operation If plant flexibility exists the ability to change from conventional to step feed for example. So there are generally three adjustments possible: Air Return sludge flow Waste sludge flow

Module No:	Topic: Basic Process Control

Instructor Notes:	Instructor Outline:

And if you are fortunate, a fourth:

Mode of operation

The amount or degree of capability of each is unique to a given facility. Each facility must determine its minimum and maximum return sludge flow capability, for example.

II. Control Technique (Methodology)

Given that some control capability exists, how does one know when a process flow adjustment should be made? This basic course will briefly focus on a few control methodologies.

1. Control by maintenance of a constant MLVSS. This is one common approach to controlling an activated sludge process. Its basic premise is: A certain level of mixed liquor volatile suspended solids has been resulting in acceptable effluent quality, therefore maintain that level of MLVSS.

How does one determine that level of solids which should be maintained? What are the limitations of this control methodology? What laboratory or control test data is necessary? What process flows are varied?

A. Solids level

There is no exact level, it is a matter of finding what appears to work, then maintaining that level. The F/M ratio presents a reasonable starting point. It is generally accepted that F/M ratios between 0.1 and 0.5 are acceptable. An F/M should be selected, say 0.25. It then is necessary to determine the amount of food entering the aeration

Module No:	Topic: Basic Process Control
Instructor Notes:	Instructor Outline:

tank and solve for the concentration of solids necessary to maintain the selected F/M (0.25). The system should then be operated at that solids level until final effluent quality can be judged, probably a month minimum. If effluent quality leaves something to be desired, select a new F/M, say 0.3, recalculate the solids concentration, build solids (or decrease as appropriate), and document effluent quality. A sample problem is appropriate.

Using the aeration tank from Figure 4, its dimensions and the flow shown and a BOD of 180 mg/l, calculate the solids concentration required to maintain an F/M or 0.25.

Given: Volume = 0.143616 million gal.

Flow = 0.3 MGD

BOD = 180 mg/l

F/M = 0.25

Find: MLVSS

Solution:

Lbs. food (F) = 0.3 x 180 x 8.34

F = 450 lbs. BOD

F/M = 0.25

M = F/0.3 = 450/0.25

M = 1,800 lbs. MLVSS

Module No:	Topic: Basic Process Control

Instructor Notes:	Instructor Outline:

Lbs. MLVSS = MLVSS mg/l x Vol. x 8.34

1,800 = MLVSS mg/l x 0.143616 x 8.34

MLVSS mg/l = 1800/0. 143616 x 8.34

MLVSS mg/l = 1,500 mg/l

B. Limitations to control

The two most glaring limitations are:

i) It assumes the load into the plant is constant.

ii) It does nothing to assist the operator in determining what return sludge flow should be.

C. Laboratory and control test data required.

i) The daily determination of MLVSS.

ii) Periodic BOD of the waste flow into the aeration tank.

D. Process flow control

Waste sludge flow is the only process flow varied with this control methodology. If MLVSS falls below the desired level, decrease waste. If MLVSS rises above the desired level, increase waste sludge flow.

2. Control by maintenance of a constant F/M ratio.

This methodology is slightly more sophisticated than constant MLVSS control. The operator still must arbitrarily decide on a target F/M ratio. It then becomes necessary to determine the load (F) and

Module No:	Topic: Basic Process Control

Instructor Notes:	Instructor Outline:

then waste sludge to vary M and hold F/M constant. Sounds easy. Consider the fact that BOD values are 5 days old when the final determination is made. Consider also that on occasion the calculation might suggest that the solids level should be markedly reduced and the next day the solids level should be at or above the level prior to your increased waste sludge flow. There are ways of speeding up the (F) determination. COD or TOC determinations can provide "same day" load values in lieu of the 5 day BOD. The MLVSS determination is not necessarily an accurate determination of the true number of microorganisms in the aeration tank. Tissue paper and dead cells register in the determination of MLVSS.

Waste sludge flow is again the primary process flow variable, although if some solids are "stored" in the secondary clarifier there is some capability of making minimal solids changes in the aeration tank.

Many activated sludge facilities are allegedly controlled by maintenance of a constant F/M. Significant laboratory data is required and the initially selected value for the F/M ratio may be wrong. Consideration of the merits of this control methodology should be judged against its inherent difficulties!

The calculation procedures require use of the identical equation used in the discussion of control by maintenance of a constant MLVSS. The difference is that daily (F) determinations are made and MLVSS is allowed to increase or decrease as opposed to maintaining constant MLVSS.

Module No:	Topic: Basic Process Control

Instructor Notes:	Instructor Outline:

Practically speaking the F/M control methodology where used successfully actually use a range for F/M as opposed to an exact F/M ratio. This alleviates attempting to make instantaneous adjustment in mixed liquor solids concentration.

3. Control by maintenance of a constant sludge age.

There are many equations used for "sludge age" determination. The SPCF MOP 11 suggests that average sludge age is the total amount of solids in the system divided by the amount of solids removed from the system each day. One must exercise great care when using the term sludge age due to the fact that so many different equations are used all to solve for what is labelled "sludge age".

Control by this methodology requires the selection of a value for sludge age. Then the volume of sludge to be wasted each day can be determined with only a few laboratory solids determinations.

A sample problem will illustrate the control methodology.

Sludge age (S.A.) = MLVSS (Va + Vc)/Qw RSTSS

Where MLVSS in mg/l

VA = Volume of aeration tank

Vc = Volume of clarifier

Qw = Waste sludge flow

RSTSS = Return sludge total suspended solids in mg/l

Module No:	Topic: Basic Process Control

Instructor Notes:

Instructor Outline:

If the operator assumes a value for sludge age, the waste sludge flow can be calculated given the appropriate volumes and solids concentrations.

Given: MLVSS = 2,000 mg/l

RSTSS = 8,000 mg/l

Va = 0.8 million gallon

Vc = 0.3 million gallon

S.A. = 5 days (operator selected)

Qw = 2,000 (0.8 + 0.3)/8,000 x 5

Qw = 0.055 MGD

The waste sludge flow for that day will then be 0.055 MGD.

The selection of the value for sludge age is certainly critical in this control methodology. A reasonable starting value would usually be in the range of 5 to 9 days. The process would be controlled using the selected value. If suitable effluent quality results, stick with it. If not, the value for sludge age is adjusted.

Once again the adjustment of return sludge flow is not addressed all inclusively. One would tend to adjust return sludge flows to the point of maximum achievable concentration of solids being withdrawn from the clarifier. This would then minimize the volume of required waste sludge flow for a given sludge age. Finally, the result of minimizing waste sludge flows results in lessening the probability of overloading the sludge digestors.

Module No:	Topic: Basic Process Control

Instructor Notes:	Instructor Outline:
	Once more, it sounds easy. There is one truth in this control methodology and that is that the wasting procedure will affect the effectiveness of the activated sludge plant.

Module No:	Module Title: Basic Activated Sludge
	Submodule Title:
Approx. Time: 4 hours	Topic: Operator control tests

Objectives:

1. To perform:

   A. Centrifuge test
   B. Settleometer test
   C. Sludge blanket determination
   D. Turbidity test

2. Plot trend charts from data obtained from the tests listed above.

Instructional Aids:

Instructional Approach:

1. Hands-on training at an activated sludge facility.

References:

1. OCP for ACP

Class Assignments:

Module No:	Topic: Operator Control Tests

Instructor Notes:	Instructor Outline:
Note: The second day of this module of instruction should include "hands-on" training in running control tests. It is appropriate to assign the student on the first day to read the Procedures Manual, Part II, Control Tests, so that he may in fact perform the tests during the second day.	There is more involved in the operation of an activated sludge facility than cutting grass, hosing overflow weirs and greasing pumps. That is not to say the above isn't necessary. There is more. Each and every employee at the activated sludge facility should have some familiarity with the facility. At the very least his senses, eyes, ears, and nose, should be alert - alert to change. The eyes can note if units are operating when they are supposed to be. Foam, color and general tank appearance should be noticed. The ears should be alert to change in the sounds of the facility. Has there been a noticeable change in the sound of the centrifugal blowers, the motors powering the clarifier scraping mechanism, etc? Finally, is the nose telling the operator of a need to increase the rate of waste sludge pumping, a need to hose down effluent weirs and troughs, a gravity thickener gone septic, etc? Such sensual observations and the recording of them are truly an integral part of process monitoring and control. There are also useful operator control tests which if performed routinely can all improve process control and ultimately lead to improved effluent-discharge quality, permit compliance. These control tests are exactly as named - control tests. The data thus accumulated combined with the routine laboratory data (BOD, suspended solids, pH, DO, NH_3, etc.) should enable the operator charged with control decision making responsibility to make better decisions, decisions based on response to process demands, not "seat of the pants" control adjustments.

Module No:	Topic: Operator Control Tests

Instructor Notes:	Instructor Outline:
	The control test series to be learned in this module of instruction includes: 1. Sludge blanket level determination 2. Settlometer test 3. Centrifuge test 4. Effluent turbidity test
The tests should be demonstrated by the instructor and then performed by each student.	The apparatus and technique for each test is thoroughly detailed in "Operational Control Procedures for the Activated Sludge Process, Part II - Control Tests". The purpose here in this module is to learn the technique and how to plot the data only. Test frequency and data interpretation are addressed in subsequent modules.
Student Handout IV - Data and beginning of a trend chart.	The final consideration of this workshop is to learn and practice data plotting or trend charts. Data routinely collected but recorded on "match book covers" or acid and coffee stained yellow pads is data seldom, if ever, used as a part of process control decision making. Data plotted on graph paper with appropriate notes becomes data used in process control decision making and should result in improved operation. The "Operational Control Procedures for the Activated Sludge Process, Appendix", (Pages 1 - 6) provides sample data sheets for control test data and trend charts. The six pages should be discussed in class. The remaining time should be spent in plotting data furnished to each student. Notice the graph paper used. It is divided into 12 segments per inch on the horizontal scale which lends itself very well to "time of day" plotting. 10 or 20 segments per inch on the vertical scale lends itself nicely. Finally 11" x 14" paper size is suggested with the 12 by 20 graduations.

The following materials are appended from which student handouts may be duplicated and transparencies produced:

Figure 1 - Conventional Activated Sludge Process Schematic

Figure 2 - Relative Predominance of Microorganisms

Figure 3 - Ideal Growth Curve

Figure 4 - Detention Time Calculation Example

Figure 5 - Overflow Rate Calculation Example

Figure 6 - Organic Load Calculation Example

Figure 7 - Conventional Activated Sludge Process Schematic

Figure 8 - Tapered Aeration Process Schematic

Figure 9 - Step-aeration Process Schematic

Figure 10 - Contact Stabilization Process Schematic

Student Handout I - 2 pages

Student Handout II - 1 page

Student Handout III - 6 pages

Student Handout IV - 11 pages

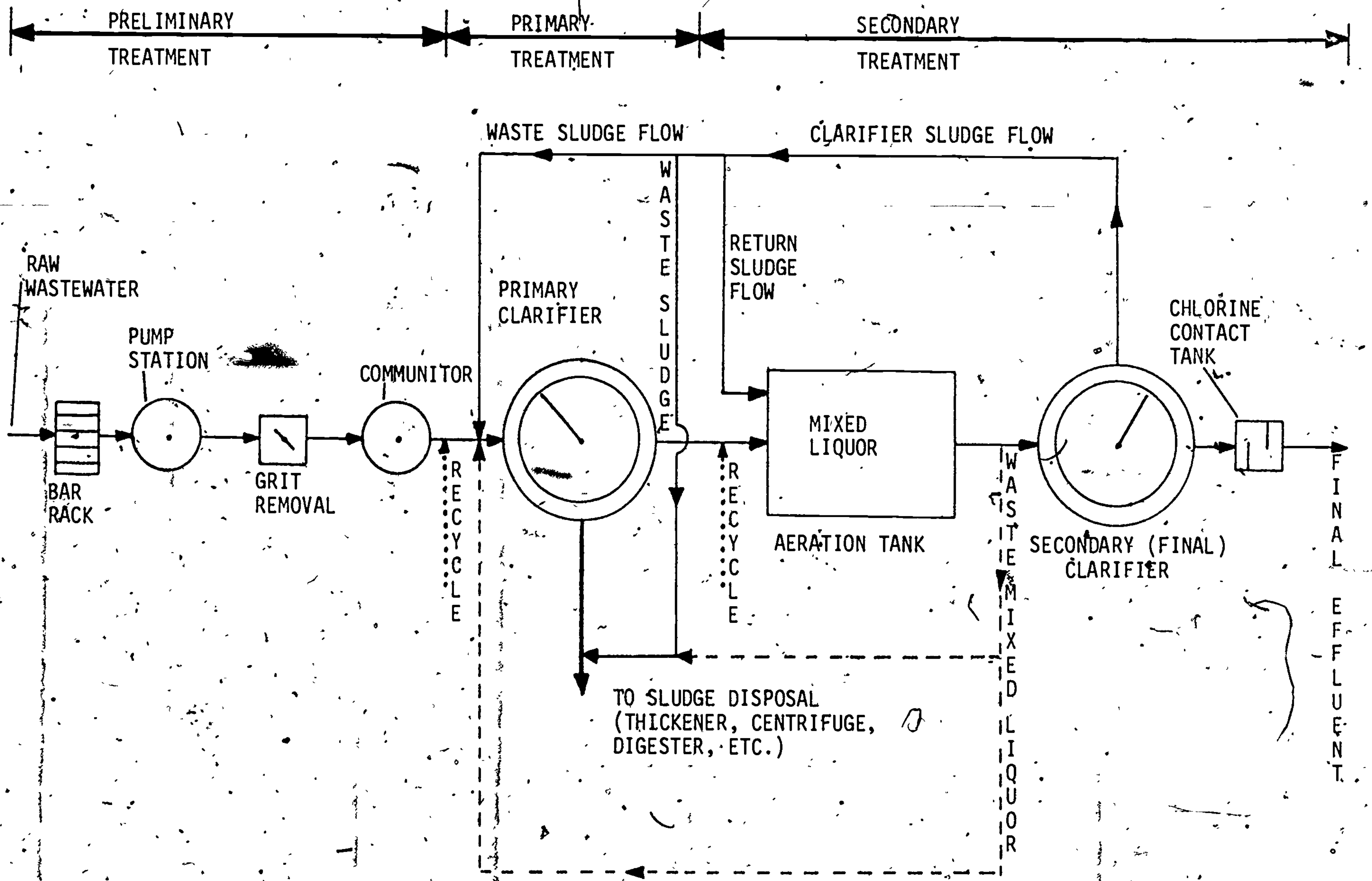


FIGURE 1
CONVENTIONAL ACTIVATED SLUDGE
PROCESS SCHEMATIC

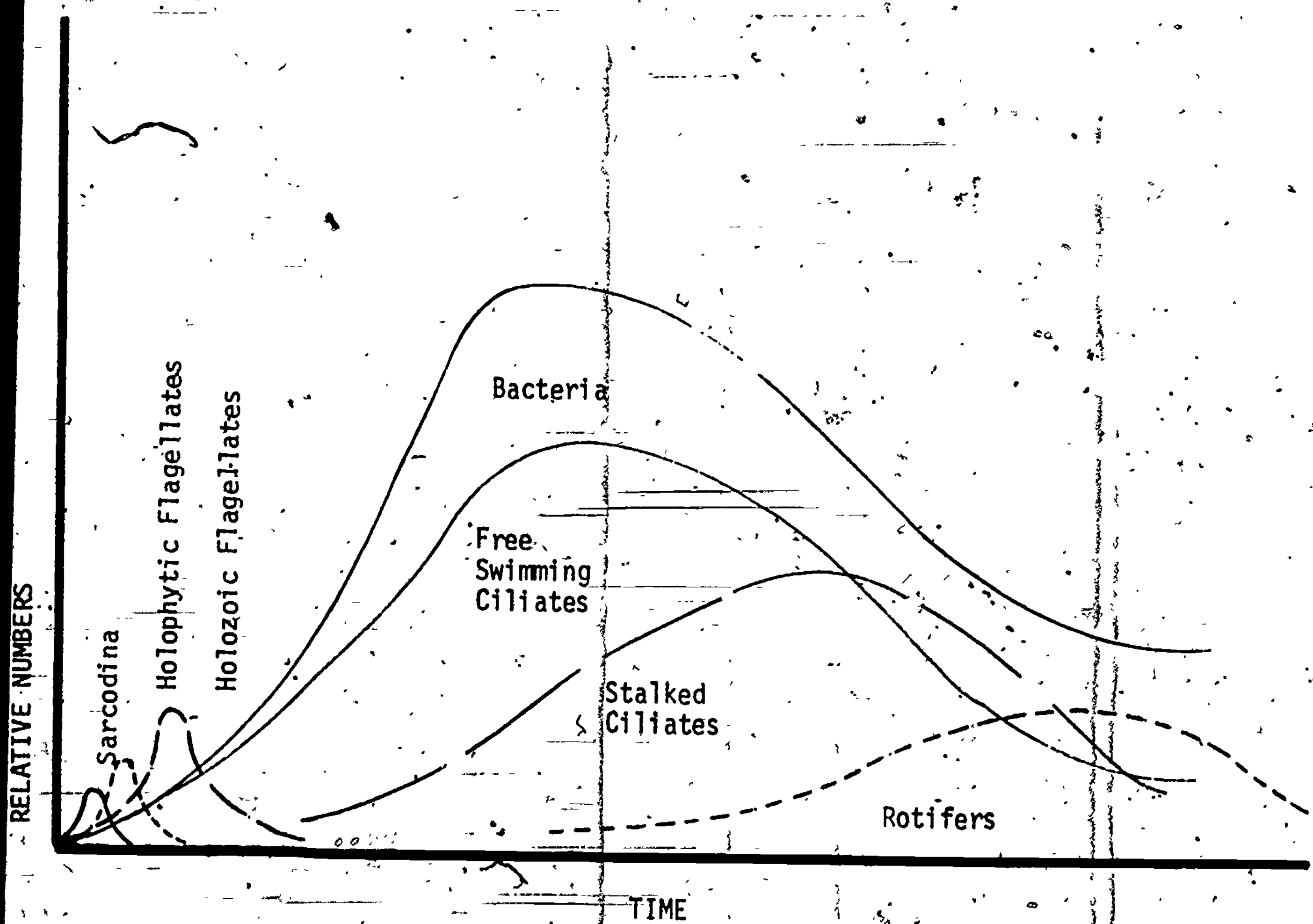
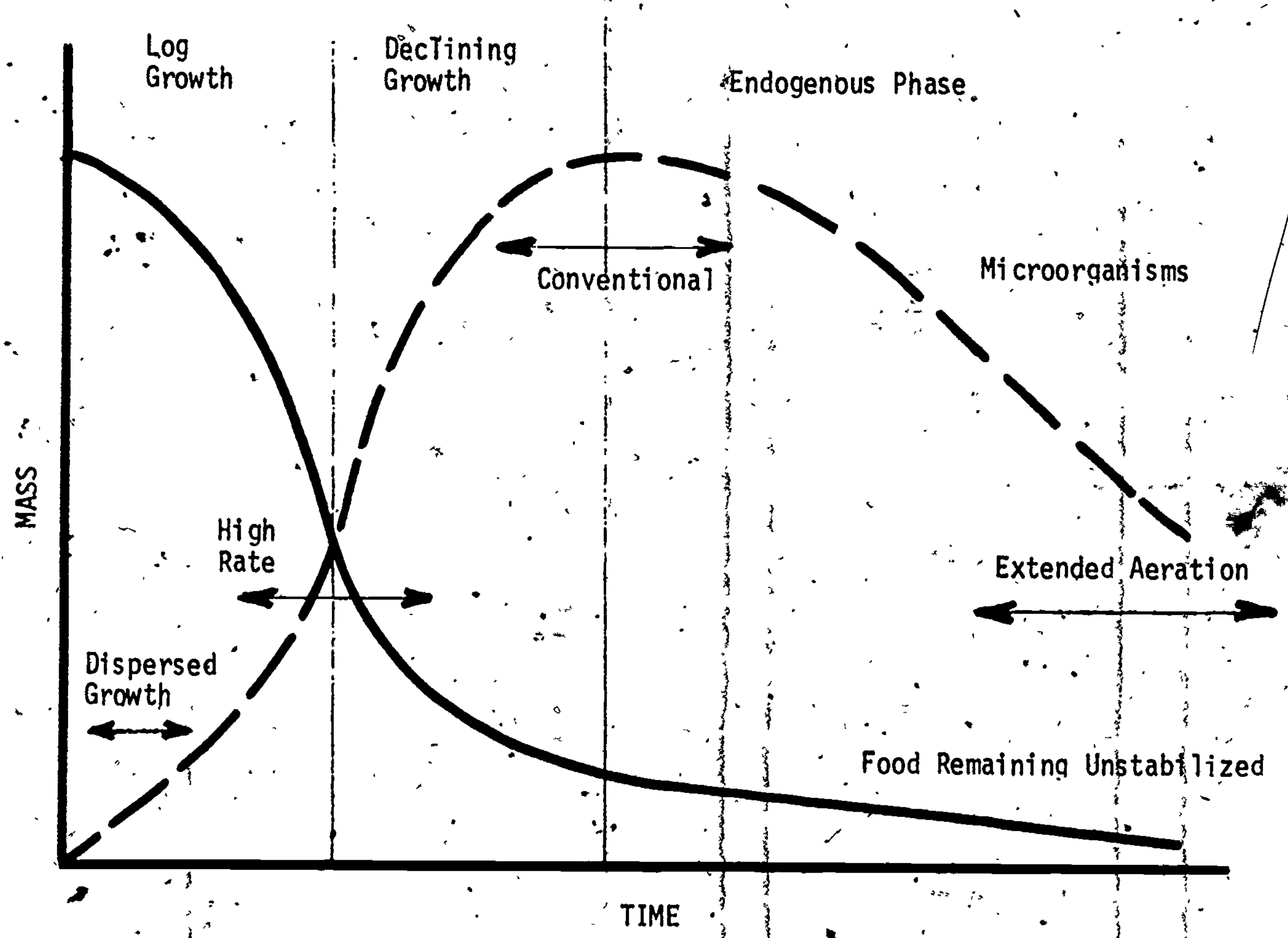
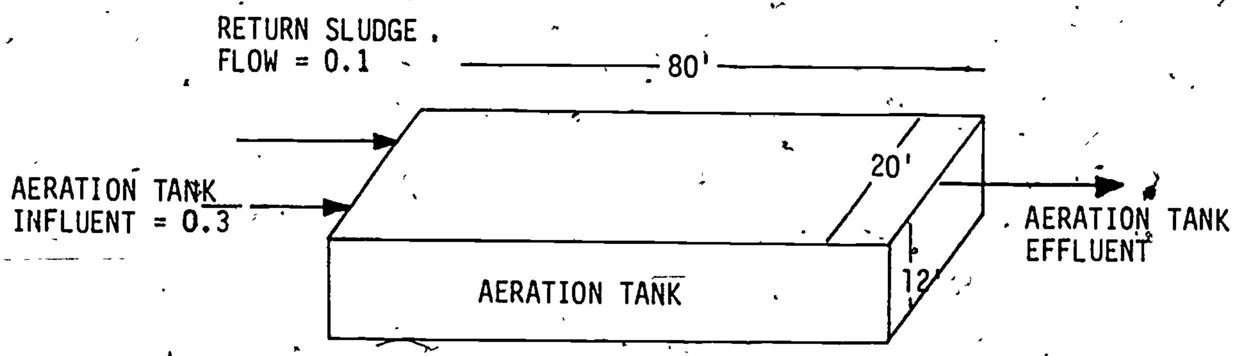

RELATIVE NUMBERS
Sarcodina
Holophytic Flagellates
Holozoic Flagellates
Bacteria
Free Swimming Ciliates
Stalked Ciliates
Rotifers
TIME

 Figure 2



Log Growth
Declining Growth
Endogenous Phase
Conventional
Microorganisms
MASS
High Rate
Extended Aeration
Dispersed Growth
Food Remaining Unstabilized
TIME

Figure 3



VOLUME = LENGTH X WIDTH X DEPTH = 20 X 80 X 12

VOLUME = 19,200 CUBIC FEET X 7.48 GAL./CUBIC FEET

VOLUME = 143,616 GALLONS

FLOW IN = .3 MGD + .1 MGD = .4 MGD

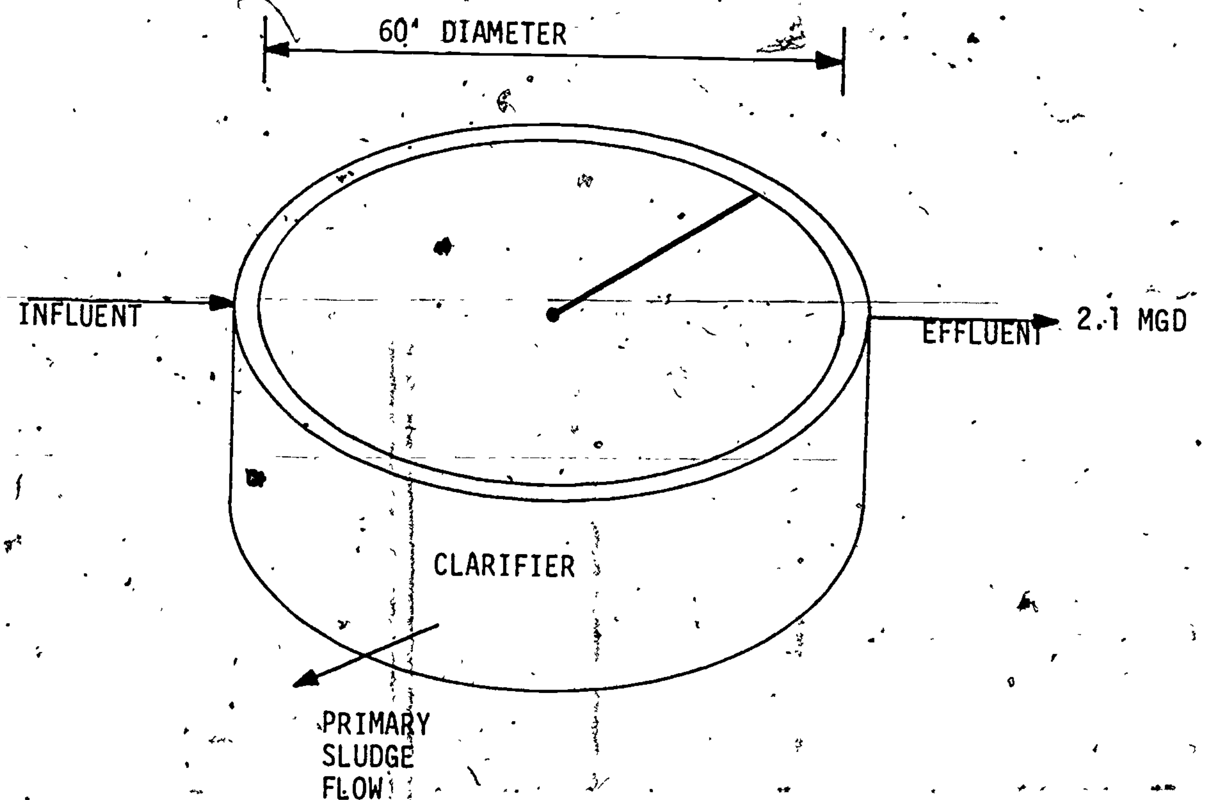
$$\text{DETENTION TIME} = \frac{\text{VOLUME}}{\text{FLOW IN}} \times 24$$

$$\text{DETENTION TIME} = \frac{143{,}616}{400{,}000} \times 24$$

DETENTION TIME = 8.6 HOURS

FIGURE 4

DETENTION TIME CALCULATION EXAMPLE



$$\text{SURFACE AREA} = \frac{\pi d^2}{4} = \frac{3.14 \times 60^2}{4} = 2{,}826 \text{ SQ. FT.}$$

$$\text{OVERFLOW RATE} = \frac{\text{EFFLUENT}}{\text{SURFACE AREA}} = \frac{2{,}100{,}000}{2{,}826}$$

OVERFLOW RATE = 743 GAL./SQ. FT./DAY

FIGURE 5

OVERFLOW RATE CALCULATION EXAMPLE

PRIMARY EFFLUENT BOD = 150 MG/L

PRIMARY EFFLUENT FLOW = 0.3 MGD

AERATION TANK VOLUME = 19,200 CUBIC FEET

AERATION TANK VOLUME = 143,616 GALLONS

MIXED LIQUOR SUSPENDED SOLIDS = 2,000 MG/L

POUNDS OF BOD/DAY = 150 X 0.4 X 8.34 = 500 LBS/DAY

$$\frac{\text{POUNDS BOD/DAY}}{\text{VOLUME (1,000 CUBIC FEET)}} = \frac{500}{19.2} = 26 \text{ LBS BOD/DAY/1000 CUBIC FEET}$$

POUNDS MIXED LIQUOR SOLIDS = .143616 X 2,000 X 8.34

POUNDS MIXED LIQUOR SOLIDS = 2,396 LBS

$$\frac{\text{POUNDS BOD/DAY}}{\text{POUNDS MIXED LIQUOR SOLIDS}} = \frac{500}{2396} = 0.21$$

FIGURE 6

ORGANIC LOAD CALCULATION EXAMPLE

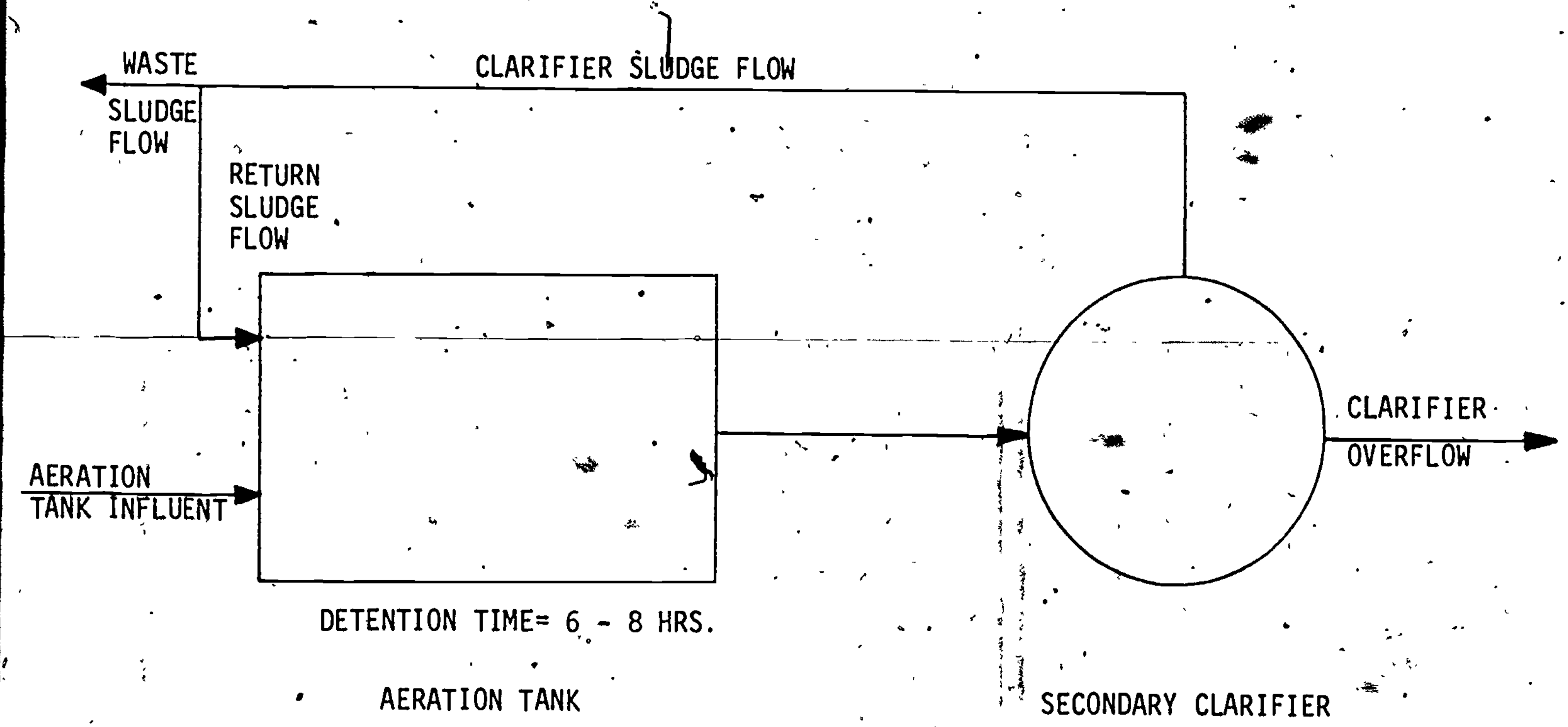
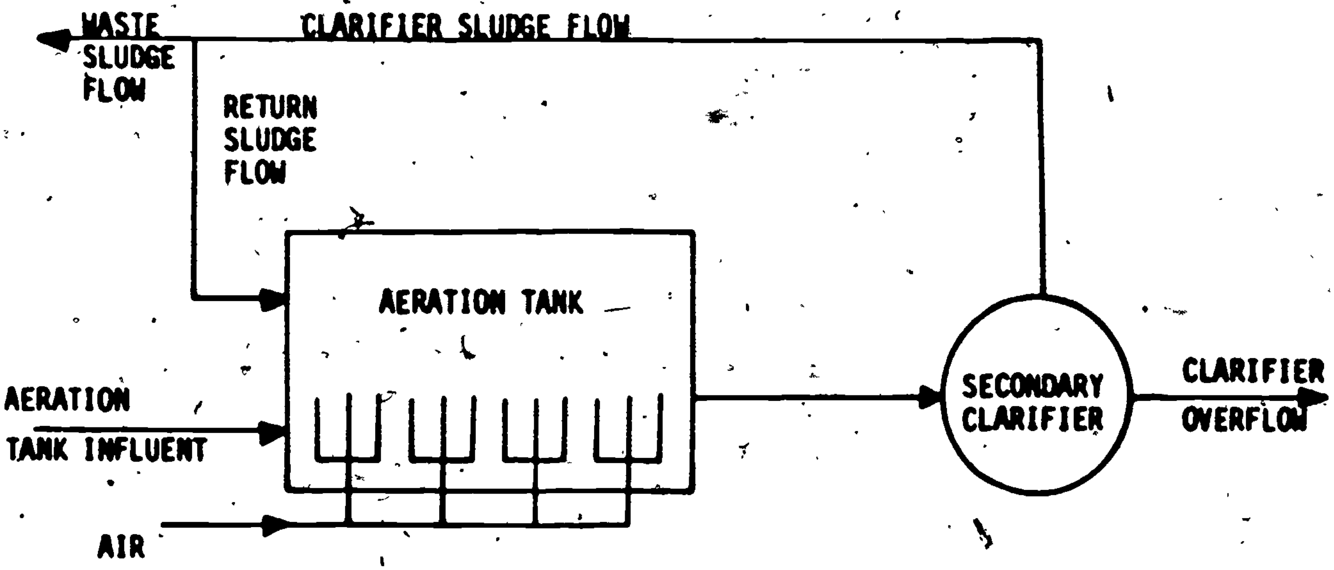
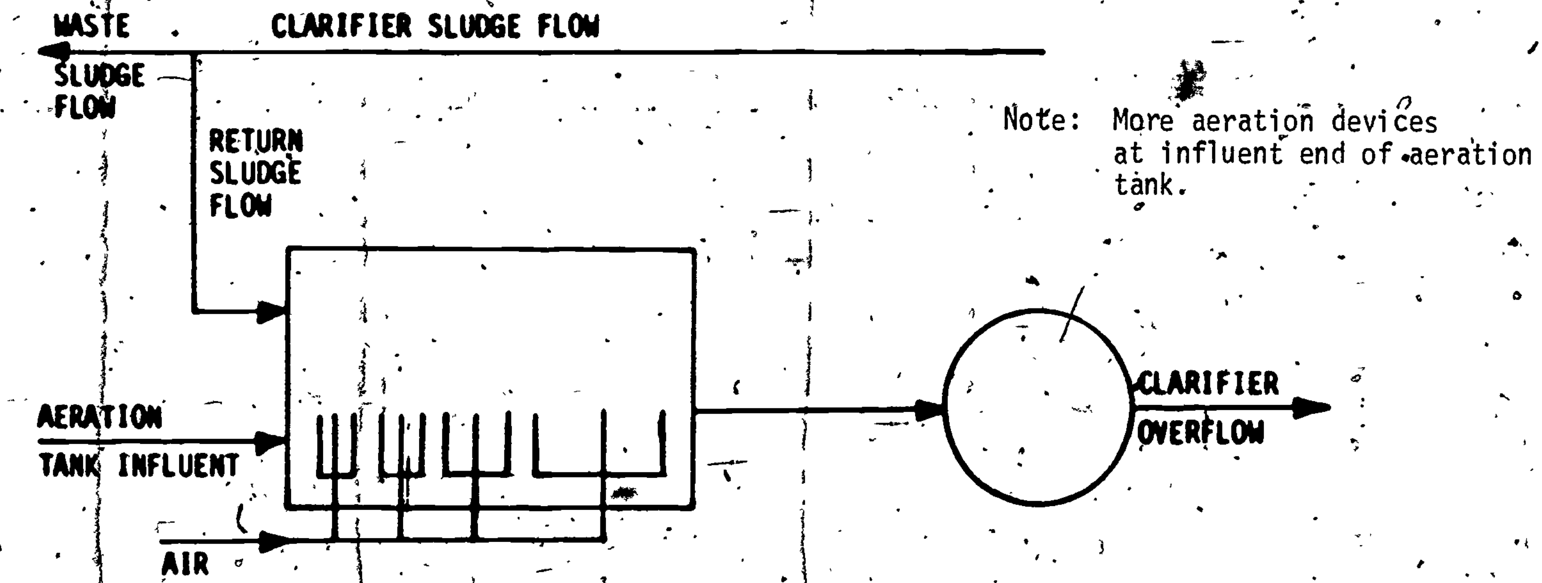


FIGURE 7
CONVENTIONAL ACTIVATED SLUDGE
PROCESS SCHEMATIC



CONVENTIONAL ACTIVATED SLUDGE



TAPERED AERATION ACTIVATED SLUDGE

FIGURE 8

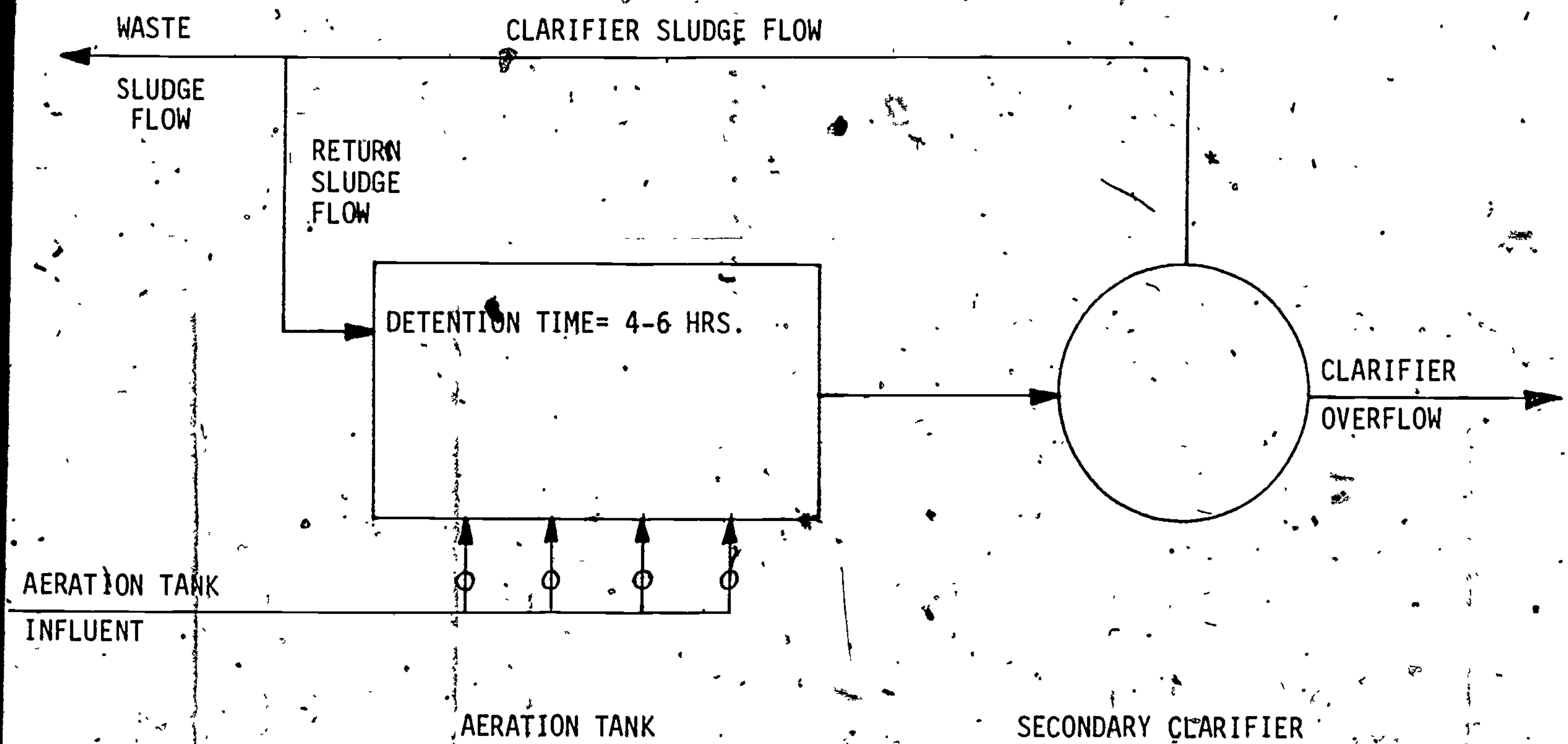


FIGURE 9.
STEP-AERATION (STEP-FEED)
PROCESS SCHEMATIC

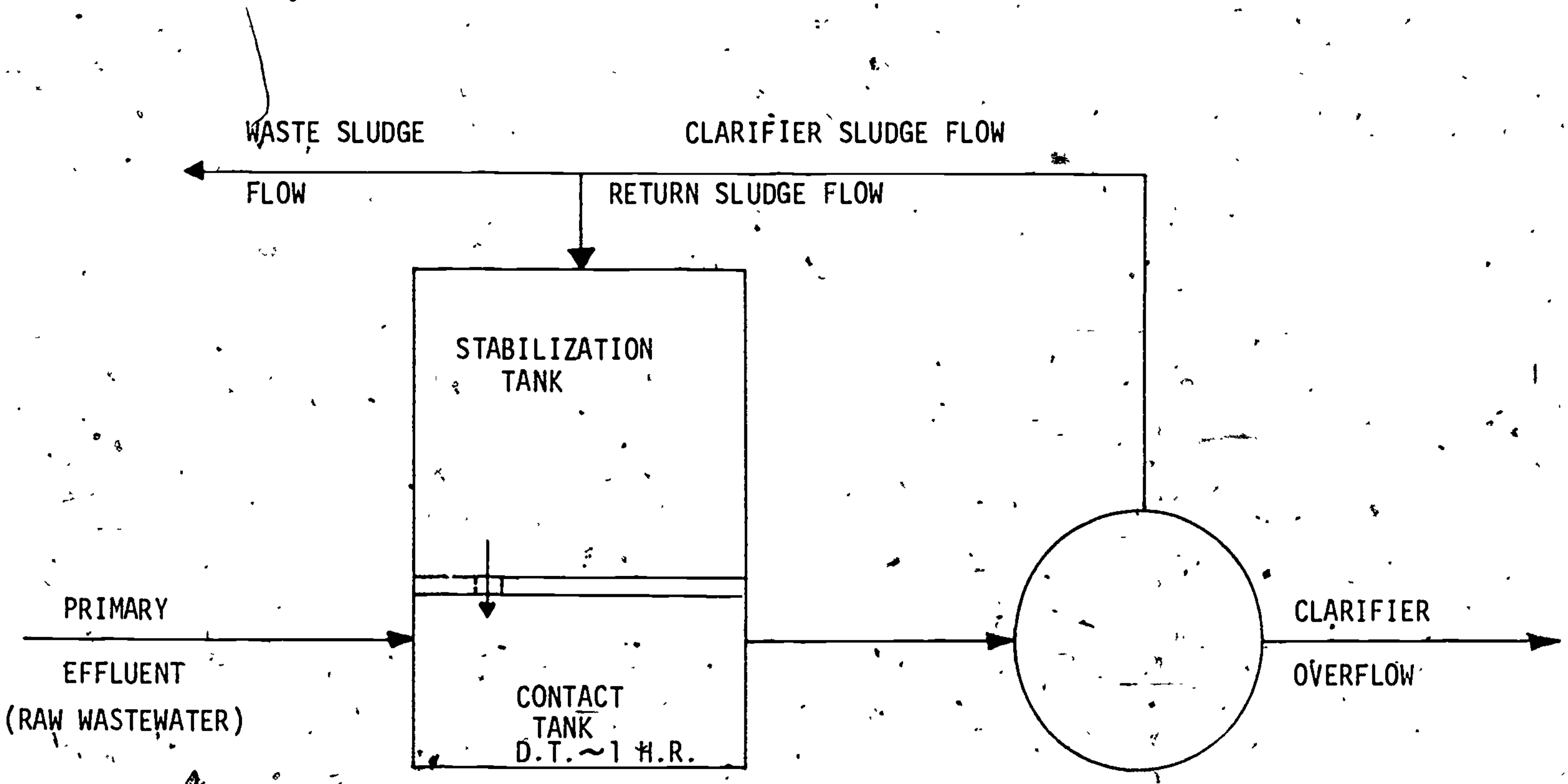


FIGURE 10
CONTACT STABILIZATION PROCESS SCHEMATIC

Student Handout I

ACTIVATED SLUDGE TERMS AND DEFINITIONS

From MOP 11

Absorption	The taking up of one substance into the body of another.
Adsorption	The adherence of a gas, liquid, or dissolved material on the surface of a solid.
Coagulation	The destabilization and initial aggregation of colloidal and finally divided suspended matter by the addition of a floc forming chemical or by biological processes.
Colloids	Finely divided solids that will not settle but may be removed by coagulation, biochemical action, or membrane filtration.
Declining Growth Phase	A growth phase in which the amount of available food begins to limit cell growth.
Endogenous Phase	The growth phase which due to a lack of available food and cannabalism between cells results in a net cell death.
Floc (sludge floc)	Small gelatinous masses formed in a liquid by agglomeration of smaller particles.
F/M	Food to Microorganism ratio. This is a calculated ratio of the pounds of food (lbs. BOD) flowing into an aeration tank divided by the pounds of solids in the aeration tank (lbs. suspended solids). Note: Some operators use the volatile suspended solids in this calculation.

Student Handout I (cont.)

Log Growth Phase	A growth phase in which cell production is at a maximum - abundance of food and suitable environment (oxygen, temp. etc.)
Mixed Liquor	The contents of an aeration tank - the mixture resulting from the combination of return sludge and primary effluent (raw sewage if primary treatment units are not a part of the facility.)
Return Sludge	That portion of the settled sludge removed from the clarifier which is returned to the aeration tank.
Sludge Bulking	A condition of activated sludge during which the sludge occupies excessive volumes and will not concentrate readily.
Stabilized	That quality of a waste or sludge when there is no capability for further change.
Waste Sludge	That sludge which is removed from the secondary treatment units. It is generally a portion of that sludge withdrawn from the clarifier, however, some activated sludge plants have the ability to waste mixed liquor.

Student Handout II

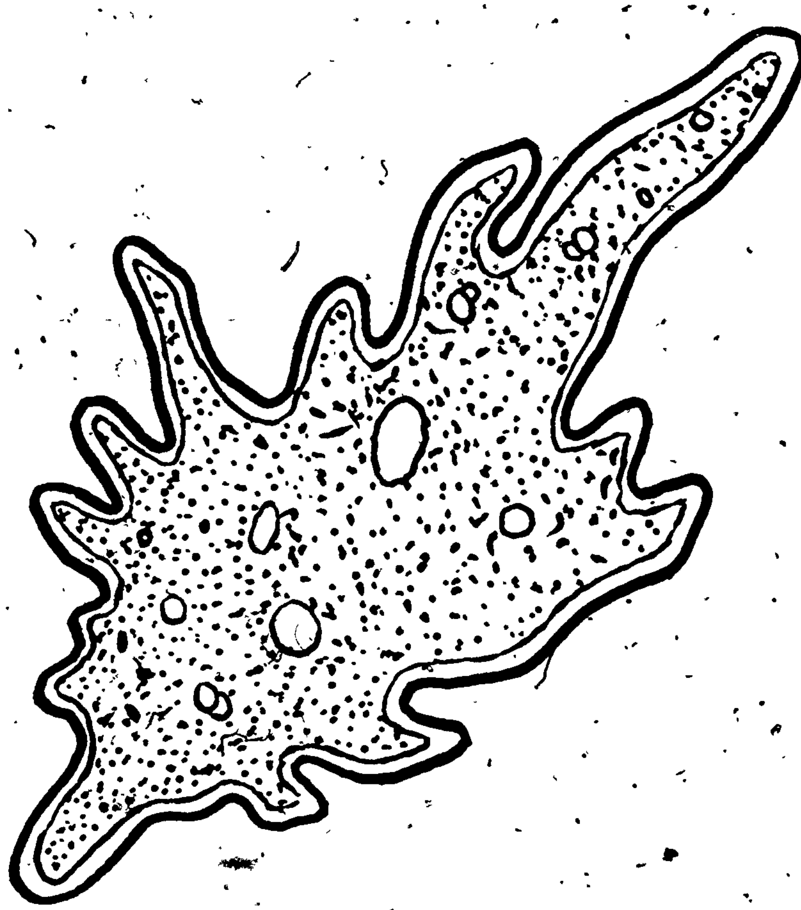
CONVENTIONAL ACTIVATED SLUDGE DESIGN PARAMETERS

	New York Manual	Recommended Standards For Sewage Works
Aeration Tank		
Detention Time *(Hrs.)	6 - 8 **	6 - 7.5
Oxygen (cu. ft. air/lb. BOD)	1,500	1,500
Organic Load (i.e. BOD/1000 cu. ft.		30 - 40
Secondary Clarifier		
Surface Overflow (Gal. sq. ft./day)	800	600 - 800
Detention Time (Hrs.)		2 - 3
Clarifier Sludge Flow (%)	20 - 30	15 - 75

*Based on design flow

**Diffused air, for mechanical aerators 9 - 12

Student Handout III - 1



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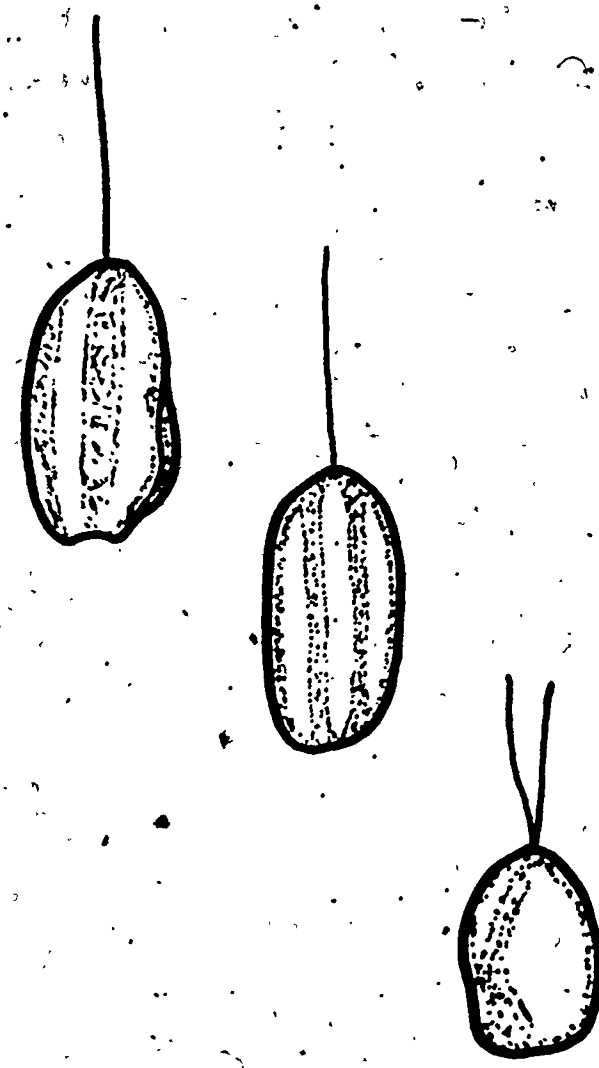
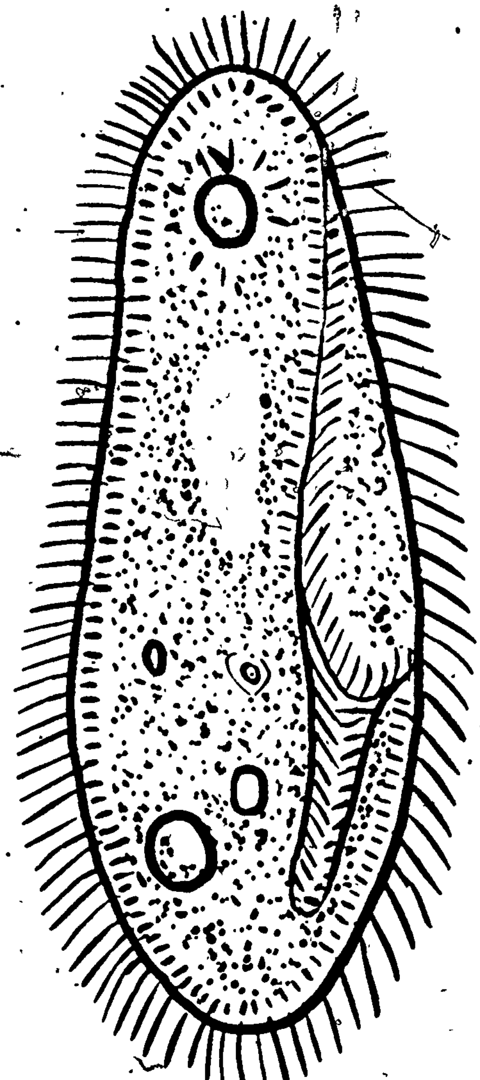
Student Handout III - 2



Flagellates

Student Handout III - 3



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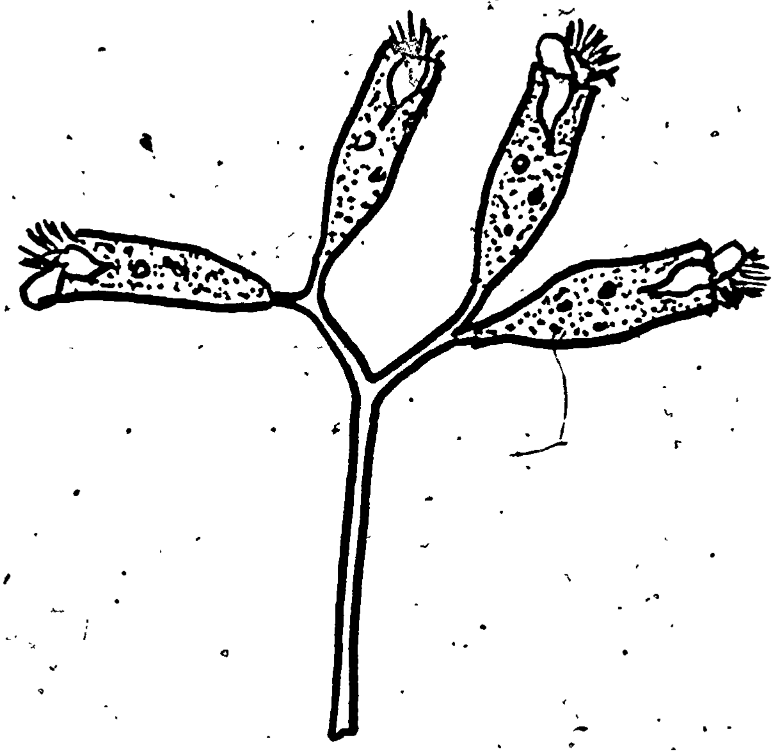
Student Handout III - 4

STALKED CILIATES

Student Handout III - 5



STALKED CILIATES

Student Handout III - 6

ROTIFER

Student Handout IV - 1

DATE 4/17/76

DAY ______

TEST TIME	0800		TEST TIME	1600		TEST TIME	2400	
RAW FLOW	410		RAW FLOW	415		RAW FLOW	405	
RETURN FLOW	190		RETURN FLOW	190		RETURN FLOW	215	
WASTE FLOW	6		WASTE FLOW	6		WASTE FLOW	6	
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	900		5	900		5	930	
10	820		10	800		10	850	
15	730		15	700		15	770	
30	560		30	530		30	580	
45	490		45	460		45	490	
60	450		60	410		60	440	
90			90			90		
ATC	8.0		ATC	7.4		ATC	7.6	
RSC	19.0		RSC	22.0		RSC	19.8	
DOB	8.2		DOB	6.5		DOB	7.0	
INITIAL TURBIDITY	7.0		INITIAL TURBIDITY	12.0		INITIAL TURBIDITY	16.0	
FINAL TURBIDITY	5.5		FINAL TURBIDITY	9.0		FINAL TURBIDITY	12.0	

Student Handout IV - 2

DATE 4/18/76

DAY

TEST TIME 0800			TEST TIME 1600			TEST TIME 2400		
RAW FLOW 465			RAW FLOW 490			RAW FLOW 500		
RETURN FLOW 190			RETURN FLOW 210			RETURN FLOW 245		
WASTE FLOW 6			WASTE FLOW 6			WASTE FLOW 5		
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	930		5	900		5	800	
10	860		10	800		10	690	
15	800		15	690		15	600	
30	620		30	520		30	490	
45	520		45	460		45	440	
60	455		60	420		60	410	
90			90			90		
ATC 7.5			ATC 8.0			ATC 8.1		
RSC 22.0			RSC 26.0			RSC 23.2		
DOB 5.0			DOB 6.5			DOB 7.3		
INITIAL TURBIDITY 26			INITIAL TURBIDITY 10.0			INITIAL TURBIDITY 7.0		
FINAL TURBIDITY 21			FINAL TURBIDITY 7.1			FINAL TURBIDITY 6.5		

Student Handout IV - 3

DATE 4/19/76

DAY ______

TEST TIME	0800	1600	2400
RAW FLOW	500	480	460
RETURN FLOW	250	230	255
WASTE FLOW	8	8	12

TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	800		5	830		5	940	
10	650		10	710		10	880	
15	560		15	620		15	820	
30	450		30	490		30	670	
45	410		45	440		45	550	
60	390		60	410		60	480	
90			90			90		

ATC	8.0	8.0	7.7
RSC	19.0	25.0	20.8
DOB	5.1	7.0	6.8
INITIAL TURBIDITY	18	12.0	12.0
FINAL TURBIDITY	15	10.5	11.0

Student Handoug IV - 4

DATE 4/20/76

DAY ______

TEST TIME 0800	TEST TIME 1600	TEST TIME 2400
RAW FLOW 450	RAW FLOW 450	RAW FLOW 440
RETURN FLOW 280	RETURN FLOW 220	RETURN FLOW 235
WASTE FLOW 12	WASTE FLOW 12	WASTE FLOW 10

TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	860		5	790		5	910	
10	720		10	650		10	820	
15	630		15	560		15	740	
30	480		30	460		30	560	
45	430		45	410		45	480	
60	390		60	390		60	430	
90			90			90		

ATC 8.0	ATC 7.8	ATC 8.4
RSC 17.8	RSC 20.8	RSC 22.0
DOB 5.9	DOB 6.5	DOB 7.1
INITIAL TURBIDITY 14.0	INITIAL TURBIDITY 14.0	INITIAL TURBIDITY 6.0
FINAL TURBIDITY 12.0	FINAL TURBIDITY 11.0	FINAL TURBIDITY 5.5

Student Handout. IV - 5

DATE 4/21/76

DAY ____

TEST TIME 0800			TEST TIME 1600			TEST TIME 2400		
RAW FLOW 430			RAW FLOW 450			RAW FLOW 435		
RETURN FLOW 275			RETURN FLOW 250			RETURN FLOW 255		
WASTE FLOW 12			WASTE FLOW 12			WASTE FLOW 12		
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	770		5	490		5	910	
10	640		10	450		10	830	
15	560		15	430		15	750	
30	450		30	410		30	580	
45	410		45	400		45	490	
60	390		60	390		60	440	
90			90			90		
ATC 8.3			ATC 7.1			ATC 7.6		
RSC 18.5			RSC 20.0			RSC 17.1		
DOB 7.6			DOB 8.3			DOB 7.5		
INITIAL TURBIDITY 6.7			INITIAL TURBIDITY 3.5			INITIAL TURBIDITY 4.6		
FINAL TURBIDITY 5.1			FINAL TURBIDITY 3.3			FINAL TURBIDITY 4.2		

Student Handout IV - 6

DATE 4/22/76

DAY ____

TEST TIME 0800	TEST TIME 1600	TEST TIME 2400
RAW FLOW 440	RAW FLOW 400	RAW FLOW 450
RETURN FLOW 270	RETURN FLOW 230	RETURN FLOW 190
WASTE FLOW 12	WASTE FLOW 12	WASTE FLOW 10

TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	690		5	730		5	850	
10	550		10	600		10	750	
15	490		15	520		15	670	
30	410		30	420		30	500	
45	380		45	390		45	430	
60	370		60	370		60	400	
90			90			90		

ATC 7.4	ATC 7.5	ATC 7.4
RSC 18.0	RSC 17.0	RSC 20.0
DOB 7.8	DOB 8.1	DOB 7.5
INITIAL TURBIDITY 5.3	INITIAL TURBIDITY 2.8	INITIAL TURBIDITY 6.2
FINAL TURBIDITY 4.9	FINAL TURBIDITY 2.6	FINAL TURBIDITY 5.8

Student Handout IV - 7

DATE 4/23/76

DAY ____

TEST TIME 0800
RAW FLOW 470
RETURN FLOW 220
WASTE FLOW 10

TIME	SSV	SSC
0	1000	
5	770	
10	650	
15	560	
30	440	
45	400	
60	375	
90		

ATC 7.5
RSC 23.5
DOB 7.3
INITIAL TURBIDITY 4.8
FINAL TURBIDITY 4.3

TEST TIME 1600
RAW FLOW 470
RETURN FLOW 255
WASTE FLOW 10

TIME	SSV	SSC
0	1000	
5	900	
10	815	
15	720	
30	540	
45	450	
60	410	
90		

ATC 7.0
RSC 19.0
DOB 8.0
INITIAL TURBIDITY 5.0
FINAL TURBIDITY 4.5

TEST TIME 2400
RAW FLOW 470
RETURN FLOW 255
WASTE FLOW 10

TIME	SSV	SSC
0	1000	
5	880	
10	770	
15	680	
30	510	
45	430	
60	400	
90		

ATC 7.1
RSC 19.8
DOB 7.5
INITIAL TURBIDITY 7.7
FINAL TURBIDITY 7.0

Student Handout IV - 8

DATE 4/24/76

DAY ______

TEST TIME	0800		TEST TIME	1600		TEST TIME	2400	
RAW FLOW	450		RAW FLOW	510		RAW FLOW	460	
RETURN FLOW	270		RETURN FLOW	230		RETURN FLOW	230	
WASTE FLOW	10		WASTE FLOW	11		WASTE FLOW	10	
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	770		5	860		5	930	
10	640		10	750		10	880	
15	560		15	650		15	830	
30	450		30	490		30	680	
45	410		45	410		45	570	
60	380		60	390		60	490	
90			90			90		
ATC	7.5		ATC	7.3		ATC	7.4	
RSC	18.0		RSC	18.9		RSC	20.0	
DOB	7.1		DOB	7.2		DOB	7.5	
INITIAL TURBIDITY	8.8		INITIAL TURBIDITY	7.7		INITIAL TURBIDITY	12.0	
FINAL TURBIDITY	7.7		FINAL TURBIDITY	6.8		FINAL TURBIDITY	8.0	

Student Handout IV - 9

DATE 4/25/76

DAY ______

TEST TIME 0800			TEST TIME 1600			TEST TIME 2400		
RAW FLOW 450			RAW FLOW 450			RAW FLOW 450		
RETURN FLOW 245			RETURN FLOW 295			RETURN FLOW 235		
WASTE FLOW 12			WASTE FLOW 12			WASTE FLOW 15		
TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	950		5	960		5	840	
10	920		10	920		10	720	
15	820		15	880		15	630	
30	680		30	770		30	490	
45	550		45	670		45	430	
60	480		60	580		60	400	
90			90			90		
ATC 7.5			ATC 7.5			ATC 7.4		
RSC 19.5			RSC 16.0			RSC 20.0		
DOB 6.9			DOB 3.5			DOB 6.0		
INITIAL TURBIDITY 24.0			INITIAL TURBIDITY 34			INITIAL TURBIDITY 31		
FINAL TURBIDITY 18.0			FINAL TURBIDITY 31			FINAL TURBIDITY 27		

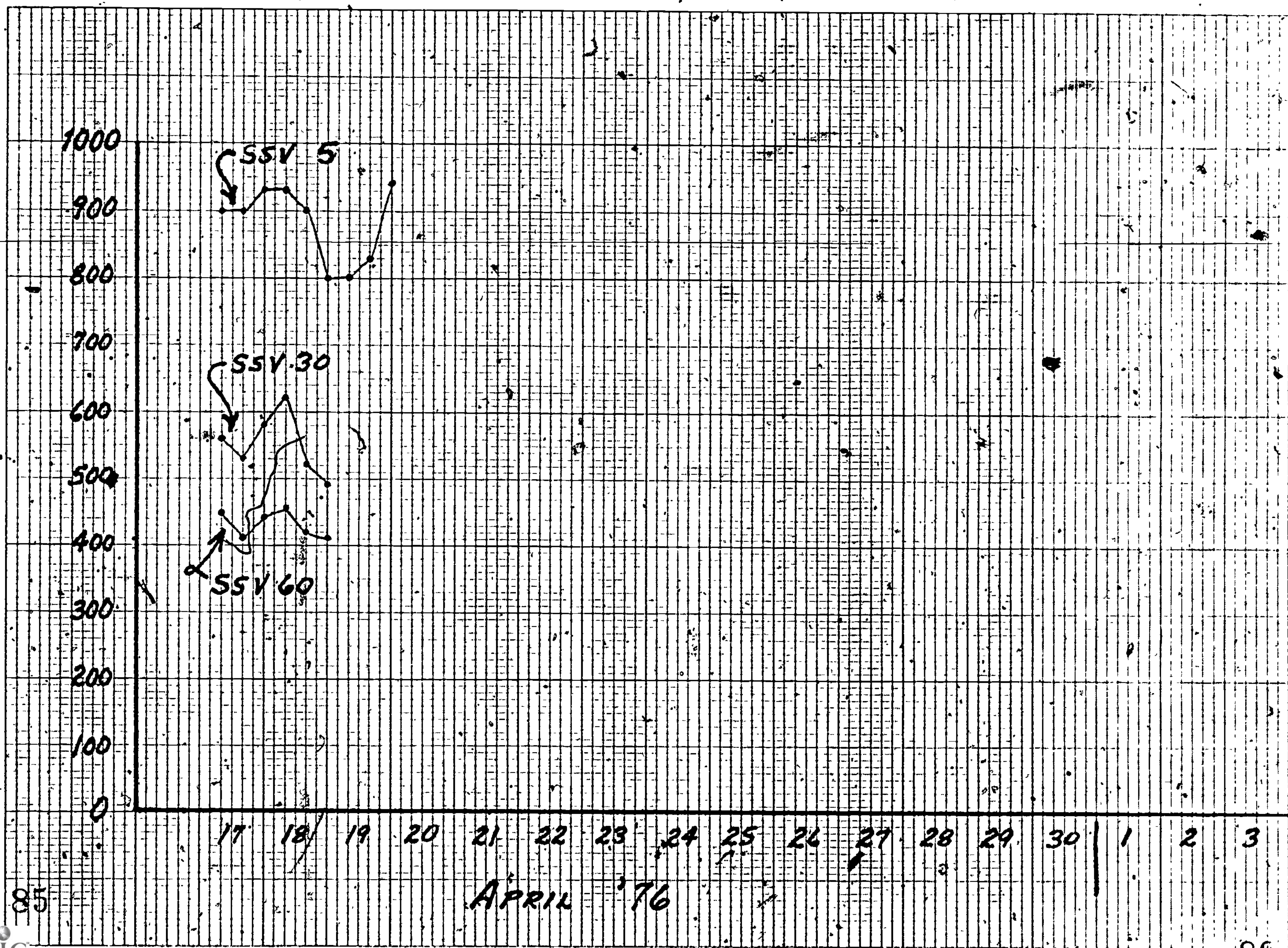
Student Handout IV - 10

DATE 4/26/76

DAY ______

TEST TIME	0800	1600	2400
RAW FLOW	380	375	485
RETURN FLOW	265	250	235
WASTE FLOW	10	12	20

TIME	SSV	SSC	TIME	SSV	SSC	TIME	SSV	SSC
0	1000		0	1000		0	1000	
5	930		5	910		5	820	
10	870		10	850		10	690	
15	820		15	790		15	600	
30	670		30	630		30	480	
45	560		45	550		45	430	
60	490		60	480		60	400	
90			90			90		
ATC	7.7		ATC	7.9		ATC	8.5	
RSC	16.1		RSC	21.0		RSC	23.0	
DOB	5.0		DOB	4.8		DOB	5.7	
INITIAL TURBIDITY	51		INITIAL TURBIDITY	37		INITIAL TURBIDITY	41	
FINAL TURBIDITY	39		FINAL TURBIDITY	31		FINAL TURBIDITY	37	



SSV 5
SSV 30
SSV 60
1000
900
800
700
600
500
400
300
200
100
0
17
18
19
20
21
22
23
24
25
26
27
28
29
30
1
2
3
APRIL '76

Module No:	Module Title: Basic Activated Sludge
	Submodule Title:
Approx. Time:	EVALUATION

Objectives:

The learner will demonstrate that he has achieved the objectives of the module by correctly answering 75% of the following questions.

1. Define the activated sludge process and its modifications as described in MOP 11.

2. List the basic operational requirements of the activated sludge process.

   A.____________________

   B.____________________

   C.____________________

3. For each of the following typical units of an activated sludge facility, briefly state the purpose:

   A. Aeration tank

   B. Air (oxygen) supply

   C. Final settling tanks

   D. Return sludge pumps

   E. Waste sludge pumps

4. Sketch and label the units for a typical conventional activated sludge facility. Omit pri. trmnt. Show typical detention, time, overflow rate and pump capacities.

5. Match the definitions to the terms

_____a. Absorption	A. Small gelatinous masses formed in a liquid by agglomeration of smaller particles.
_____b. Adsorption	B. A growth phase in which the amount of available food begins to limit cell growth.
_____c. Log growth phase	C. The growth phase which due to a lack of available food and cannabalism between cells results in a net cell death.

____d. Declining growth phase D. A growth phase in which cell production is at a maximum.

____e. Endogenous phase E. Treatment of waste or sludge to a condition from which there is no capability for further change.

____f. Sludge floc F. Food to microorganism ratio

____g. Mixed liquor G. A condition of activated sludge during which the sludge occupies excessive volumes and will not readily concentrate.

____h. Stabilization H. The adherence of a gas, liquid or dissolved material on the surface of a solid.

____i. Return sludge I. Aeration tank contents.

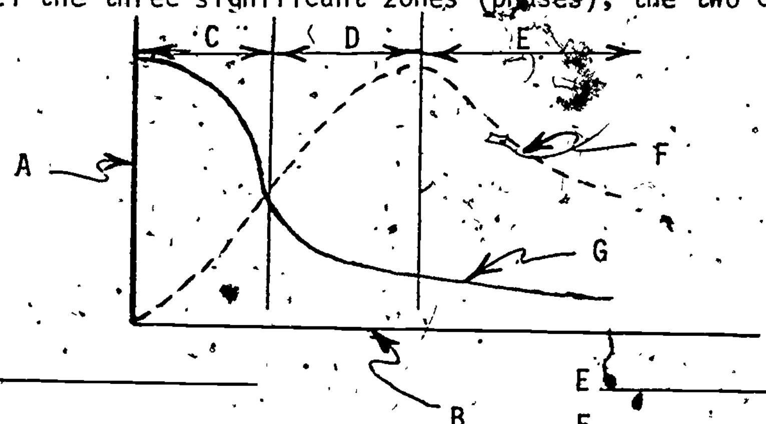
____j. Waste sludge J. That portion of settled sludge removed from the secondary clarifier and pumped to the aeration tank.

____k. F/M K. The taking up of one substance into the body of another.

____l. Diffuser L. That sludge which is removed from the secondary treatment units.

____m. Sludge bulking M. A device through which air is "blown" to provide bubbles of air (oxygen) to the aeration tank contents.

6. Label the three significant zones (phases), the two curves and the axes.



A ____________ E ____________

B ____________ F ____________

C ____________ D ____________ G ____________

7. Given the following data, calculate:

A. Aeration tank detention time. ____________

B. Clarifier surface settling rate. ____________

C. Pounds of BOD to aeration. ____________

D. Pounds of solids under aeration. ____________

E. F/M. ____________

Raw waste flow = 10.2 MGD

Raw BOD concentration = 192 mg/l

No primary clarifiers

Aeration tanks - two

Each 284' x 92' x 15'

Secondary clarifiers - two

Each 115' diameter x 12.66' average depth

Mixed liquor total suspended solids = 3000 mg/l

8. List three control techniques or methodologies.

A. ____________________________

B. ____________________________

C. ____________________________

9. List those factors the operator can control.

A. ____________________________

B. ____________________________

C. ____________________________

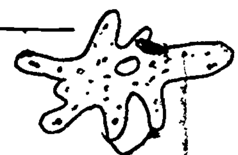
10. List two reasons for testing.

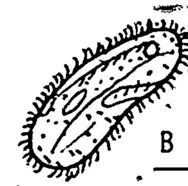
A. ____________________________

B. ____________________________

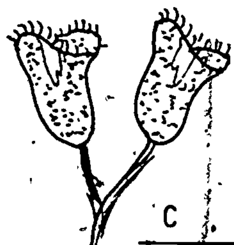
11. Identify the organisms shown.

A ______________





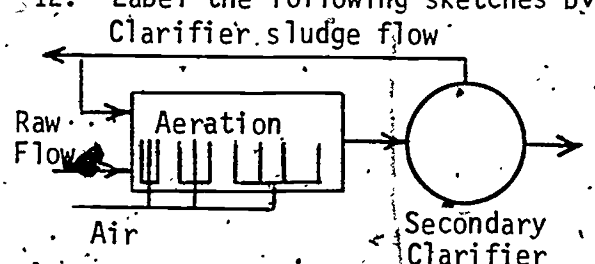
B ______________



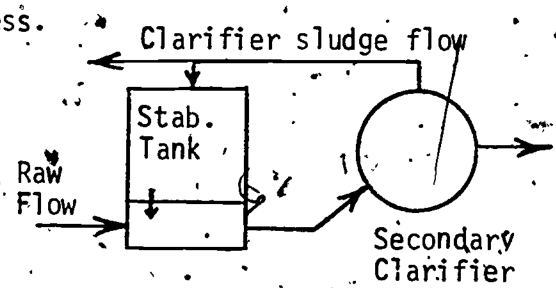
C ______________

D ______________

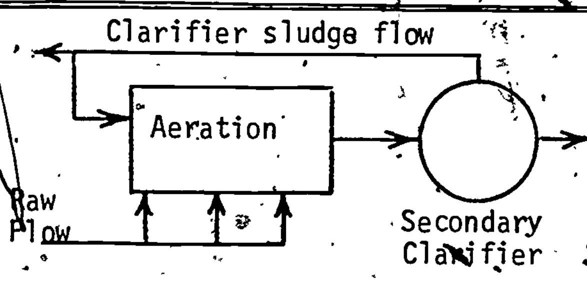
12. Label the following sketches by process.



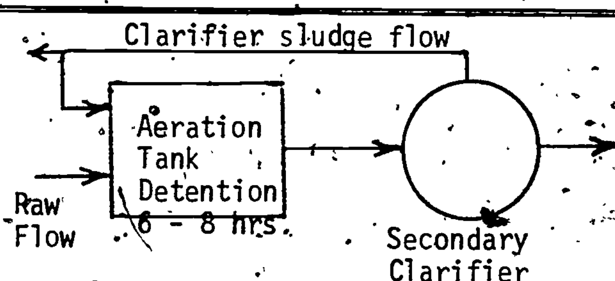
A ______________



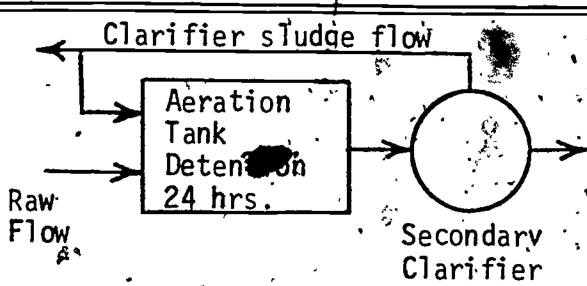
B ______________



C ______________



D ______________



E ______________

Module No:	Topic: Evaluation Answers

Instructor Notes:	Instructor Outline:

1. The contacting of preformed biological floc (activated sludge) with incoming waste in an aeration tank supplied with sufficient dissolved oxygen to maintain aerobic conditions throughout the process, followed by liquid solids separation in a settling tank.

2. An adequate number of microorganisms.

   A suitable environment.

   An ability to settle.

3. A. Basin in which biological activity occurs.

   B. Required for microorganisms to life and break down waste.

   C. Tank in which solid separation occurs.

   D. To return sludge solids from clarifier to aeration basin.

   E. To remove excess sludge solids from process units.

4. Detention time 6 - 8 hrs.

   Overflow rate 600 - 800 GPS FPD

   Pump capacities 15 - 75%

   Check sketch against Figure 7.

5. A. K

   B. H

   C. D

   D. B

   E. C

   F. A

   G. I

Module No:	Topic: Evaluation Answers

Instructor Notes:

Instructor Outline:

H. E

I. J

J. L

K. F

L. M

M. G

6. Check against Figure 3

7. A. 13.4 hrs.

   B. 490 gal/sq. ft./day

   C. 16,350 lb/day

   D. 142,614 lbs.

8. A. Constant MLTSS (MLVSS)

   B. Constant F/M

   C. Sludge age

9. A. Air

   B. Return sludge flow

   C. Waste sludge flow

   D. Mode of operation

10. A. Satisfy permit requirements

    B. Process control

11. A. Sarcodina

    B. Ciliate

    C. Stalked ciliates

    D. Flagellate

Module No:	Topic: Evaluation Answers

Instructor Notes:	Instructor Outline:
	12. A. Tapered aeration B. Contact stabilization C. Step aeration (step-feed) D. Conventional E. Extended aeration