Wastewater Operator Certification Training
Instructor Guide

Module 4:
Fundamentals of Wastewater Treatment

This course includes content developed by the Pennsylvania Department of Environmental Protection (Pa. DEP) in cooperation with the following contractors, subcontractors, or grantees:

The Pennsylvania State Association of Township Supervisors (PSATS)
Gannett Fleming, Inc.
Dering Consulting Group
Penn State Harrisburg Environmental Training Center

A Note to the Instructor

Dear instructor:

The primary purpose of Module 4 is to provide a foundation about wastewater treatment from which more in-depth learning can occur. In this Module, three phases of wastewater treatment, Preliminary treatment, Primary treatment, and Biological Secondary treatment are introduced. This module has been designed to be completed in 3 hours, but the actual course length will depend upon content and/or delivery modifications and results of course dry runs performed by the Pa. DEP-approved sponsor. The number of contact hours of credit assigned to this course is based upon the contact hours approved under the Pa. DEP course approval process. To help you prepare a personal lesson plan, timeframes have been included in the instructor guide at the Unit level and at the Roman numeral level of the topical outline. You may need to adjust these timeframes as necessary to match course content and delivery modifications made by the sponsor. Please make sure that all teaching points are covered and that the course is delivered as approved by Pa. DEP.

Web site URLs and other references are subject to change, and it is the training sponsor's responsibility to keep such references up to date.

Delivery methods to be used for this course include:

- Lecture
- Small group and full group discussion
- Individual and small group activities.

To present this module, you will need the following materials:

- One workbook per participant
- *Operators of Wastewater Treatment Plants Volume I,* Sacramento Foundation, 1998
- Extra pencils
- Laptop (loaded with PowerPoint) and an LCD projector or Overheads of presentation and an overhead projector
- Screen
- Flip Chart
- Markers

Icons to become familiar with include:

Participant Workbook	Instructor Guide
Exercise/Activity	Same icons for Participant Workbook apply to the Instructor Guide.
Case Study	Ans: Answer to exercise, case study, discussion, question, etc.
Discussion Question	PowerPoint Slide
Calculation(s)	Overhead
Exercise	Flip Chart
Key Definition(s)	Suggested "Script"
Key Point(s)	

Instructor text that is meant to be general instructions for the instructor are designated by being written in script font and enclosed in brackets. For example:

[*Ask participants if they have any questions on how to read the table. Answer any questions participants may have about how to read the table.*]

If your module includes the use of a PowerPoint presentation, below are some helpful controls that you may use within the Slide Show.

PowerPoint Slide Show Controls

You can use the following shortcuts while running your slide show in full-screen mode.

To	**Press**
Advance to the next slide	N, ENTER, or the SPACEBAR (or click the mouse)
Return to the previous slide	P or BACKSPACE
Go to slide <number>	<number>+ENTER
Display a black screen, or return to the slide show from a black screen	B
Display a white screen, or return to the slide show from a white screen	W
Stop or restart an automatic slide show	S
End a slide show	ESC
Return to the first slide	Both mouse buttons for 2 seconds
Change the pointer to a pen	CTRL+P
Change the pen to a pointer	CTRL+A
Hide the pointer and button temporarily	CTRL+H
Hide the pointer and button always	CTRL+L
Display the shortcut menu	SHIFT+F10 (or right-click)
Erase on-screen annotations	E
Go to next hidden slide	H
Set new timings while rehearsing	T
Use original timings while rehearsing	O
Use mouse-click to advance while rehearsing	M

INTRODUCTION OF MODULE: 5 minutes

Display Slide 1, Module 4: Fundamentals of Wastewater Treatment

[Welcome participants to "Module 4: Fundamentals of Wastewater Treatment." Indicated the primary purpose of this course is to provide a foundation about wastewater treatment from which a more in-depth learning can occur.]

[Introduce yourself.]

[Provide a brief overview of the module.]

This module contains three units. On page i, you will see the topical outline for Unit 1 – Preliminary Treatment: Screening & Degritting, and, Unit 2 – Primary Treatment: Sedimentation and Flotation. If you turn the page, you will see the topical outline for Unit 3 – General Overview of Biological Secondary Treatment.

[Continue to briefly review the outline.]

UNIT 1 – PRELIMINARY TREATMENT: SCREENING & DEGRITTING: 40 minutes

Display Slide 2 and 3, Unit 1 Learning Objectives

[Review each of the Learning Objectives for the Unit.]

At the end of this unit, you should be able to:

- Explain the general purpose of the Preliminary Treatment Process.
- Explain the purpose of Screening (racks, screens, & comminutors), Grit Removal (channels & separators) and Pre-aeration.
- Indicate the differences between manually and mechanically cleaned racks and screens.
- Define differences between screening and comminution.
- Describe safe disposal of screenings and grit.

GENERAL OVERVIEW: 2 minutes

The Preliminary Treatment Process General Overview

[Review what is found in influent and why preliminary treatment is important.

- ***What**: Cans, bottles, rubbish, sticks, rocks, building materials, toys, household items, sand, money, diamond rings, etc.*
- ***Why Preliminary Treatment:** Save equipment]*

SCREENING: 10 minutes

General Overview

[Review text as written.]

Screening is the initial removal of floating material and larger suspended solids from the wastewater influent stream. The largest wastes are separated from the wastewater by the water flowing through screens and bar racks which prevent them from moving any further into the plant and interfering with the downstream treatment processes. These items must be removed either manually or mechanically. In some plants, the debris is run through cutters, which shred the debris, which has been accumulated on the screens or drums. The shredded material is then returned back into the flow, allowed to pass through the screens and proceed through the remainder of the wastewater treatment process.

Bar Screens & Racks

Bar screens and racks prevent large solids from damaging pumps, plugging pipes etc. Let's take a closer look at what this equipment looks like and how it functions.

Display Slide 4, Manually cleaned bar screen (Figure 1.1 in participant workbook)

[As you review the information on manually cleaned bar screens & racks, use this slide to point out:

1. *Location of bars—discuss orientation (perpendicular to flow) and bar spacing.*
2. *Debris drainage area at top.*
3. *Debris build-up and relationship to screen head loss.*
   As debris collects on up stream side of screens, the greater the head loss.
   The difference of water level in front of and behind the screens = head loss.
4. *Tell about head loss and relationship to influent velocity.*
   Flow area – as water increases in front of screen, flow area increases and causes the velocity to be reduced. This may be touched on later in Degritting.]

Mechanically Cleaned Bar Screens & Racks

Display Slide 5, Mechanically cleaned bar screen (Figure 1.2 in participant workbook)

[Review the information on mechanically cleaned bar screens & racks, use this slide to point out:

1. Similarities to manually cleaned screens, and

2. Control options (head loss, time, etc).]

Screenings Disposal

The wastes removed from the screening process need to be carefully disposed of. There are environmental regulations and permit requirements governing this process. These guidelines are to help ensure our safety and wellbeing.

Some reasons for these requirements are:

1. Screenings attract vermin.
2. May contain organic material including organisms, which could cause disease.
3. Material is offensive.

Once the largest materials are removed during the screening process, the wastewater is then ready for further treatment, and it enters the grit removal process.

GRIT REMOVAL: 15 minutes

General Overview

[As you review the information on Grit, help the participants make the following connections:

1. *This is yet another stage of removing materials that could cause problems in the subsequent treatment process units.*

2. *Several devices are available for use in the grit removal process, grit channels, aerated grit chambers and cyclone separators.*

3. *Grit Washing occurs after each of these (which ever is used in the plant) and,*

4. *Grit disposal is the final stage of this process.]*

Grit

[Review what "Grit" is and why it should be removed.]

Grit Removal Devices

Grit Channels

Grit should be removed as soon as possible. The simplest way of doing this is by allowing the wastewater to pass through channels that allow the flow to slow down, resulting in the heavier grit settling to the bottom. Once the grit is settled it needs to be removed and disposed of. This removal can be accomplished by a range of techniques from manually scooping or shoveling to mechanically collecting or conveying. Let's open our text, *Operation of Wastewater Treatment Plant, Volume I* to page 84. Find Table 4.4 Purpose of Grit Channels and Parts, on the top right.

[Review the table as presented.]

In order to effectively remove the grit, we need to control the flow (velocity) of the wastewater through the channels. Open your text, *Operation of Wastewater Treatment Plants, Volume I* to page 86. We are going to look carefully at two example calculations that would help us with this task. Example Calculations 3 (Velocity computation) and 4 (settling length calculation).

[Using a Flip chart to record process and procedures, Review Example Calculations 3 (Velocity computation) and 4 (settling length calculation) as presented on page 86. Point out how, if the grit channel dimensions are not properly proportioned, grit may not be removed.]

Aerated Grit Chamber

Please turn to page 88 in your text. At the bottom left you will find Table 4.5 Purpose of Aerated Grit Chamber and Parts.

[Review the information in Table 4.5.]

Display Side 6, Aerated grit chamber (Figure 1.3 in participant workbook)

[Use this slide to illustrate those items addressed in the both the Table and the text of the workbook.]

Another method of separating grit from organic matter is by the use of cyclone grit separators.

Cyclone Separator

Display Slide 7, Cyclone Separator (Figure 1.4 in participant workbook)

In this process, wastewater containing grit enters the cyclone. The speed at which the slurry enters the separator (point to inlet) causes it to swirl like a cyclone. This is the primary vortex (point to primary vortex). While swirling about, the heaver grit is forced outward and downward to the apex (point out apex). The grit passes out of the cyclone through the orifice (point out orifice). While this whirling is happening, the secondary vortex (point out secondary vortex) moves the lighter particles toward the center of the cyclone and upward.

[As you prepare to move on to the final stages of the preliminary process, ask participants to respond to the following question.]

Before we move on to Grit Disposal, who can tell me what purpose grit washing serves within wastewater treatment?

Ans: To remove excess organic materials so that when the grit is removed and disposed of, it less likely to attract vermin or cause odors.

[Use participant responses to segue into the next page.]

Grit Washing

Display Slide 8, Grit Washer (Figure 1.5 in participant workbook)

[Use this illustration to point out how the grit washer pictured works by capturing the heavier grit, which settles to the screw conveyor while returning the wash water and lighter organic material back into the process stream.]

Grit Disposal

[Review information on grit disposal.]

COMMINUTION: 10 minutes

Remember the first step in the preliminary treatment process? The wastewater is screened as it enters the wastewater treatment plant. Comminution is the next step in wastewater treatment. During this process, the now largest wastes are made smaller by cutting them into smaller pieces. Once again a screen is used to keep out the larger pieces of waste from the flow. It is then cut into smaller pieces that either a) can reenter the flow and continue through the process, or b) must be removed and disposed of.

General Overview

[Review what happens during the process as presented.]

Comminutors

Display Slide 9, Comminutor (Figure 1.6 in participant workbook)

[Review the text and use this slide to point out general operating principles of the comminutor. Wastewater flow must pass through cutting chamber before it continues to further treatment]

Display Slide 10, Comminutor with by-pass screen (Figure 1.7 in participant workbook)

[Review the information on comminutors with by-pass screens, use this slide to point out: installation of comminutor with a by-pass bar rack permits continued operation in event of comminutor maintenance; and, larger facilities may have duplicate comminutors rather than bar rack.]

There is a specialized comminutor called a Barminutor.

Barminutors

Display Slide 11, Barminutor (Figure 1.8 in participant workbook)

[Review the information on barminutors, use this slide to illustrate.]

Review: 3 minutes

[As a class, discuss the following questions and explore possible answers.]

What is the purpose of preliminary treatment as it relates to screening and comminution?

Ans: Screening is the initial removal of floating material and larger suspended solids from the wastewater influent stream. The largest wastes are separated from the wastewater by the water flowing through screens and bar racks which prevent them from moving any further into the plant and interfering with the downstream treatment processes. These items must be removed either manually or mechanically. Comminution is the next step in wastewater treatment. During this process, the now largest wastes are made smaller by cutting them into smaller pieces. Once again a screen is used to keep out the larger pieces of waste from the flow. It is then cut into smaller pieces that either a) can reenter the flow and continue through the process, or b) must be removed and disposed of.

List at least two differences between screening and comminution.

Ans:

1. Screening REMOVES the LARGEST materials from the influent wastewater stream. Comminution REDUCES the size of materials in the influent stream by cutting or shredding. Material generally stays in the wastewater (Exception – wood and plastic materials will not pass cutter and must be removed manually).
2. Bar racks and screens are used to protect downstream equipment from damage by large floating objects. Comminutors generally reduce the size of material, preparing this material for further treatment.

PRE-AERATION: 3 minutes

Purposes

[Review the information of pre-aeration purposes. Make connections to previous information – grit removal process. Use as a preview for what is yet to come—Primary Treatment, sedimentation and Secondary Treatment, biological.]

This process tends to increase the overall efficiency of solids and BOD removal.

This is the end of Unit 1.

[Ask participants if they have any questions on the material covered in Unit 1. Answer questions as needed—suggest that you not spend more than 5 minutes at this point. Suggest participants use their text Chapter 4 to assist with questions they may have later.]

We've just completed the Preliminary waste treatment process. The next unit, Unit 2, addresses the next step, that of Primary Treatment. Turn to page 2-1 in your workbook.

UNIT 2: PRIMARY TREATMENT: SEDIMENTATION AND FLOTATION: 45 minutes

INTRODUCTION OF UNIT 2: 2 minutes

Display Slide 12, Unit 2 Primary Treatment: Sedimentation and Flotation

[Review each of the Learning Objectives for the Unit.]

At the end of this unit, you should be able to:

- Explain sedimentation and flotation principles.
- List factors that indicate when a clarifier is not performing properly.
- Use mathematical formulas to solve for detention time, weir overflow, surface loading, and solids loading.

PURPOSE OF PRIMARY TREATMENT: 3 minutes

In the wastewater treatment process the first level of treatment is known as the preliminary treatment, which we just reviewed in Unit 1. Primary Treatment is the second level of wastewater treatment. It consists of two components, sedimentation and flotation.

[Review each of the two key concepts.]

Sedimentation

Sedimentation is the removal of heavier solids (and any remaining grit not previously removed) and generally takes place in clarifiers or combined sedimentation-digestion units.

Flotation

Flotation is the removal of grease and other lighter solids which will not settle.

Types of Units

Clarifiers are used for sedimentation. Flotation units are used for floation. Combined sedimentation-digestion units are a specialzed process in which sedimentation occurs in one part and digestion of solids in another. We will go over more specifics of each type of unit as well as some important considerations for each throughout this unit.

Before we move on, take a minute to think about what you learned in Unit 1 – Preliminary Treatment and what we just went over. Now, in your own words, I'd like you to write a definition for both sedimentation and flotation in the space provided.

☑ Define sedimentation.

☑ Define flotation.

[Give participants about a minute to complete this task. Ask for a volunteer or two to offer their definitions.]

As we continue through this unit, I'd like to encourage you to come back to this page and add to your definitions any information that will help you understand them.

PRINCIPLES OF OPERATION: 40 minutes

Clarifiers

The most important function of a clarifier is to remove as much settleable and floatable material as possible. Clarifiers are settling tanks or sedimentation basins in which wastewater is held for a period of time during which lighter materials float to the surface and the heavier materials sink or, as we say, settle to the bottom. Let's take a look at a clarifier and how it works. Open your *Operation of Wastewater Treatment Plants, Volume I (SAC)* text to Figure 5.4 on page 115.

[Sketch a clarifier schematic similar to the SAC figure on the board. Use this sketch to review operating principles of a clarifier, including both liquid and solids flow paths. Point out the various components of the clarifier such as the influent well, sludge collector and drive, skimmer/scum collection mechanism, and overflow weirs.]

Settling Characteristics

Settling characteristics of suspended particles in water is one of the most important factors in the design and operation of clarifiers.

[Review the material on settling characteristics.]

Factors which Influence Settling Characteristics

Many factors influence settling characteristics. The most common are: temperature, detention time, short circuits, weir overflow rate, surface settling rate and, solids loading. Let's look at each of these separately beginning with Temperature.

[Review the material on temperature in the workbook.]

[Review the information on Detention time. Indicate that this is really a factor used in the design of the plant.]

Turn to page 134 in your SAC textbook, and look at Figure 5.6 on the bottom right. This chart illustrates the path of settling particles. A particle settles depending on the rate of flow (direction) and rate of particle movement downward. On this graph, it takes 60 minutes for the particle to go from the surface to the bottom where it is captured. If the flow only takes 30 minutes, then the particle would only fall 5 feet and it would not be able to be captured.

Display Slide 13, Detention Time Formulas (also in participant workbook)

[Ask participants to look at the formulas in the box. Review each formula with participants.]

Let's try to use these formulas in solving a problem or two.

Display Slide 14, Sample 2.1

[Read the slide. Use the PowerPoint slides to walk the class through the problem solving process.]

Display Slide 15, Volume

We know by following the formula and given data that the Volume = 18,000 cu ft.

Display Slide 16, Flow

We were told in the problem that the Flow = 3.0 MGD.

Display Slide 17, Calculation

Therefore, when we follow these steps, we know that the detention time = 1.08 hours in this instance.

On this next problem, try to solve it independently.

Continued

Display Slide 18, Detention Time Sample 2.2

What is the detention time at a plant flow of 2.5 MGD in a circular clarifier is 60 feet in diameter, with a water depth of 12 feet? Take a minute to solve this in the space provided.

[Allow the participants to work through, then ask for volunteers.]

[Once you have received the correct solution, review the steps by displaying slides 19 thru 21].

Display Slide 19, Volume

Clarifier diameter = 60 feet and depth is 12 feet

Volume = Area * h (height/depth)

Area = π * d * d/4 Note: π/4 =0.785

Volume = 0.785 * $(d)^2$ * h(height/depth)

Volume = (0.785) * $(60)^2$ * 12

= 33,912 cubic feet

Display Slide 20, Flow

Flow = 2.5 MGD

Display Slide 21, Calculation

Therefore,

Detention
Time = (33,912 cu ft * 7.48 gal/cu ft * 24 hr/day) / 2.5 MGD
= 6,087,882 gal hr/day / 2,500,000 gal/day
= 2.44 hours

[Review information provided in participant workbook.]

Short circuits resulting in reduced detention times and higher localized velocities will result in reduced sedimentation efficiency. Solids that would normally be retained in the clarifier will escape and be carried to the next process unit. This could result in deterioration in the overall plant treatment efficiency since the additional solids load may exceed the design parameters for the subsequent units.

The only influence participants may be able to have regarding adjusting weir overflow rate, is if there would be a localized pooling that could be remedied by leveling the weir.

Display slide 22, Weir Overflow Rate (also in workbook pg 2-5)

[After reviewing the formula with participants, ask participants to open their SAC text to page #136, Example 3 on the top right.]

What is the weir overflow rate when the flow is 5.0 MGD in a circular tank with a 90 foot. Weir diameter?

[Review sample calculation of weir overflow rate using Example problem #3 on page 136 of the SAC text.]

Weir diameter. Many circular clarifiers have a circular weir with the outside edge of the clarifier. All the water leaving the clarifier flows over this weir. The diameter of the weir is the length of a line from one edge of a weir to the opposite edge and passing through the center of the circle formed by the weir. Now, I'd like you to try to solve a problem on your own.

Display Slide 23, Weir Overflow Rate - Problem 2.1

Compute the weir overflow rate for a circular clarifier with a 75 foot diameter overflow weir when 3.5 MGD is the flow rate into the unit.

Ans. Weir Length = 3.1416 * 75 feet = 235.6 feet

Therefore, WOR = 3,500,000 GPD / 235.6 feet

= 14,855 gpd/ft

[Encourage participants to use the space provided in their workbooks to complete the calculation of weir overflow rate. Allow the participants to work through the problem.]

[Ask for volunteers to show solution by writing steps on the flipchart.]

[Review the information presented on surface settling rate (pertains to flow).]

[Review the formula with participants, then ask them to solve for the following:]

Display Slide 24, Surface Loading Rate – Problem 2.2

Problem 2.2: Compute the Surface Loading Rate, when: Flow into a rectangular clarifier 40 feet wide by 110 feet long by 12 feet deep is 5.0 MGD.

Ans: Surface area = 40 feet * 110 feet = 4400 sq ft (Note: that depth is not relevant)

Surface Loading Rate = 5,000,000 GPD / 4400 sq ft

= 1136 GPD/sq ft

[Encourage participants to use the space provided in their workbooks to complete the following calculation of surface loading rate.]

[Allow the participants to work through, ask for volunteers to show solution on flip chart.]

Solids Loading is the amount of solids that can be removed daily by each square foot of clarifier surface area.

[Present the following Typical Clarifier Solids Loadings as identified in the SAC Manual pg 137 and Pa DEP. Note that Pa. DEP design guidelines for clarifier solids loading differ slightly from SAC.]

Display Slide 25, Solids Loading Guidelines

	Pa DEP	<u>Operation of Wastewater Treatment Plants, Vol I</u>
Primary Clarifiers	Not considered	Not generally considered
Conventional Activated Sludge Secondary Clarifiers	40 #/day/sq ft average, 50 peak	12 to 30 lbs/day/sq ft
Extended Aeration Secondary Clarifiers	30 #/day/sq ft average, 50 peak	N/A
Nitrification Secondary Clarifiers:		
Separate Nitrification Stage	30 average, 50 peak	N/A
Carbonaceous Stage	45 average, 50 peak	N/A
Dissolved-Air Flotation	40 #/day/sq ft (w/o polymer addition), 20 # /day sq ft (w/o)	5 to 40 lbs/day/sq ft
Sludge Thickening	5 to 12 #/day/sq ft	5 to 20 lbs/day/sq ft

Display Slide 26, Solids Loading

[After reviewing the formulas with participants, ask them to solve for the following:]

Display Slide 27, Solids Loading - Problem 2.3

Problem 2.3: A circular clarifier with a diameter of 125 ft is operating with a forward flow of 6.0 MGD and a return sludge flow of 2.0 MGD. The MLSS is 4,000 mg/L. Compute the solids loading at which the clarifier is operating.

Ans. Applied solids = (6.0 MGD + 2.0 MGD) * 4,000 mg/L * 8.34 lbs/gal

= 8.0 MGD * 4,000 mg/L * 8.34 lbs/gal

= 266,880 lbs/day

Surface Area = (3.1416 * (125 ft)^2) / 4= 12,272 sq ft

Solids loading = 266,880 lbs/day/12,272 sq ft

= 21.75 lbs/day/sq ft

Continued

[Encourage participants to use the space provided in their workbooks to complete the following calculation of solid loading. Allow the participants to work through.]

[Ask for volunteers to show solution on flip chart.]

[Ask participants if they have any questions about settling factors and the formulas and calculations used in this section.]

Clarifier Operating Problems

[Review the material relating to operating problems.]

All of the items we discussed relate specifically to clarifier problems. And, although it is beyond the scope of this introductory unit, being aware of some of the causes and solutions is critical to running your wastewater plant. For that purpose, and as a future reference, I'd like you to bring to your attention the Troubleshooting Guide – Primary Clarification found on pages 123 – 128 in your *SAC* text.

[Pause for about 30 seconds to let participants get a "glimpse" of the tool. Continue on by referring participants to the activities at the bottom of their workbook page.]

Please take 2 minutes to complete the activities on this page.

[Allow 2 minutes and then ask for volunteers to respond.]

There are several factors that affect proper clarifier operation. List as many as you can.

Ans: Temperature, detention time, short circuits, weir overflow rate, surface settling rate and, solids loading.

What are some indicators of clarifier problems? List several below.

Ans: Floating Sludge (Bulking); black, odorous septic wastewater entering clarifier; black, odorous septic wastewater leaving clarifier; scum in clarifier effluent; sludge hard to remove from hopper; and low sludge solids.

Miscellaneous problems: Surging flow; Slime growth; and Excessive corrosion.
Mechanical problems: Chain/drive problems; Seal problems; and Bearing problems.

We started this unit by talking about two processes, sedimentation and flotation. But, we have only investigated one. It's now time to learn more about flotation.

The information covered on these pages is a general overview. These processes are so rarely used that it doesn't warrant any further discussion other than what is presented in the workbook at this time.

Flotation

[Review the information.]

Specialized Processes

Combined Sedimentation-Digestion Units

The combined sedimentation-digestion unit is considered a "packaged treatment plant" because often it is fabricated at a factory, hauled to the site, and installed as one facility. The sedimentation-digestion units consist of a small clarifier constructed over a sludge digester. This is an older technology that is seldom used today.

[Review the information on combined sedimentation-digestion units.]

Septic Tanks

No course on wastewater treatment would be complete without discussing septic tanks.

[Review the information on septic tanks.]

Are there any questions dealing with any of the material covered to this point?

[Answer questions as they arise. Don't hesitate to refer participants to their workbook or text to read and learn the answers for themselves.]

We have completed both the Preliminary and Primary Processes of Wastewater Treatment Plants.

The last section we will cover in the wastewater treatment process is Secondary Treatment.

[About ½ of the material has been presented for this Module. Now would be an appropriate time for participants to take a 10 minute break.]

UNIT 3 – GENERAL OVERVIEW OF BIOLOGICAL SECONDARY TREATMENT: 92 minutes

INTRODUCTION AND GENERAL OVERVIEW: 2 MINUTES.

The purpose of Unit 3 is to provide you with a basic introduction to four biological secondary treatment processes and how they function. Each of the processes, trickling filters, RBCs, activated sludge, and Ponds and Lagoons, are covered in greater detail in the advanced treatment-specific courses being offered.

Display Slide 28 and 29, Unit 3 General Overview of Biological Secondary Treatment

[Review each of the Learning Objectives for the Unit.]

At the end of this unit each of you should be able to:

- List four biological secondary treatment processes.
- Explain the principles of the trickling filter process.
- Identify the different types of trickling filters.
- Explain the principles of the RBC process.
- Explain the principles of the activated sludge process.
- List the three waste treatment pond classifications and explain the principles of each.

TICKLING FILTERS: 20 minutes

Process Description

[Review the material on Biological Process – Fixed Film System.]

Fixed film is a biological film (slime) consisting of bacteria, protozoa, and fungi, which coat the media surface and feed on the organic material in the applied wastewater. Both Trickling Filters and Rotating Biological contactors are fixed film systems.

[Review each of the bullet items.]

Display Slide 30, Trickling Filter Process (Figure 3.1 in participant workbook)

[Use slide to point out where and how the trickling filter process fits.]

Major Components

Display Slide 31, Trickling Filter (Figure 3.2 in participant workbook).

[Use the slide to point out the distribution system, media, and underdrain as you review the information in the workbook.]

[As you point out the components, show the flow of the trickling filter represented.]

Classification of Filters

[Review the three classifications of trickling filters and point out where each would likely be used:]

Standard Rate is usually an older design prior to the use of plastic media. Hydraulic and organic loadings are significantly less than for High Rate or Roughing filters.

High Rate is a more modern design that incorporates recirculation for more effective treatment. It usually uses modern plastic media with greater void area that provides greater surface area for film growth. Hydraulic and Organic loading are higher than Standard Rate (4 – 10 times higher for rock media and 10 – 15 times higher with synthetic media).

Roughing Filters are generally used as a primary treatment process to reduce organic loading prior to other oxidation processes. When BOD is removed using the roughing filter, prior to the subsequent process, a higher overall level of treatment efficiency can be achieved. (Organic loading to the roughing filter is much higher than to filters used to provide secondary treatment because additional treatment follows the filter).

Abnormal Conditions

Occurrence of any of these abnormal conditions would serve as an indication that there is an operational problem that should be corrected.

[Review material on ponding, odors, filter flies, and sloughing. Incorporate the following:]

Some amount of sloughing of the slime layer is normal. As the layer continues to grow, excess or aged growth detaches and is washed from the filter by the wastewater flow. This material is then removed by the secondary clarifier. Uniform and continuous sloughing is important because it provides a more aggressive surface of new growths to treat the wastewater. However, excessive film loss is an indication that there are problems with the biological activity within the filter media.

Ask participants to work in groups of 2 or 3 to respond to the question. Have each group select a volunteer to report. Give them 2 minutes, then ask 2 or 3 groups to report their answers.

[Write key ideas on chart.]

[After the 3rd group has finished, read the answer to the group.]

What are the operating principles of the trickling filter process?

Ans: Wastewater is passed over the surface of a fixed media, which, in the presence of aerobic conditions, promotes the growth of a biological slime consisting of bacteria, protozoa, and other organisms on the media. These organisms absorb and use much of the suspended, colloidal, and dissolved organic matter from the wastewater. Part of this organic matter is used by the organisms as food for the production of new cells, while another part is oxidized to carbon dioxide and water. Partially decomposed organic matter, dead organisms (film), and excess organisms are washed off the media and out of the filter with the effluent flow, to be subsequently removed by the secondary clarifiers.

ROTATING BIOLOGICAL CONTACTORS: 15 minutes

[Rotating biological contactors are another type of fixed film system.]

[Refer the participants to Figure 3.3 Rotating biological contactor in their workbooks.]

Process Description

Biological Process – Fixed Film System

[Review the material on Biological Process – Fixed Film System.]

Rotating Biological Contactors is a Biological Process – Fixed Film System similar to trickling filters in that a biological film grows on the surface of a media provided for that purpose.

Media

[Review the material on Media.]

Operation differs from Trickling Filters in that the media is moved through the wastewater providing alternating periods of wetting and exposure to oxygen, unlike the Trickling Filters which operate by having the wastewater intermittently applied to a fixed media with sufficient void to permit air flow through the media bed.

Covered

[Review the material on Covered.]

Display Slide 32, Rotating Biological Contactor Process (Figure 3.4 in participant workbook)

[Refer to this slide as you restate the process and point out each element.]

Principles of Operation

Process Operating conditions

[Review material on process operating conditions.]

Hydraulic loading is the amount of wastewater applied per sq. ft. of media. It varies based on performance characteristics desired. Organic loading refers to the amount of BOD applied per sq. ft. of media.

Pretreatment Requirements

[Review material on pretreatment requirements.]

In order for this process to be most effective, the process is usually preceded by both preliminary and primary treatment processes.

RBC Abnormal Conditions

As with any system, there can be abnormal conditions. For the Rotating Biological Contactor, these are decreased treatment efficiency, biomass sloughing, and snails.

[Review material on each of these conditions.]

ACTIVATED SLUDGE: 40 minutes

[Review material as presented in participant workbook. This is intended to be an introductory overview. All of these will be covered in much greater detail in the Level 2 courses on Activated Sludge.]

The Activated Sludge Process is one of the most involved wastewater treatment processes. We will be just touching the tip of the iceberg on this topic. More information is offered in your *SAC* text, and there will be several other courses offered in order to cover the topic.

Activated Sludge Process

[Review material on biological process.]

Principles of Operation

[Review material on process description and process objectives.]

Classification of Processes

There are several modifications of the conventional activated sludge process in general use. These modifications are used to provide process flexibility by modifying the arrangement of the process streams. Commonly used modifications include: complete mix, contact stabilization, and extended aeration. Additionally, the extended aeration process has been adapted for application in sequencing batch reactors and in oxidation ditches.

Note that in the process schematics that will be shown to illustrate the various process modifications, only a single train of treatment units is shown. In actual practice, duplicate units are provided. This permits the removal of a unit from operation so that maintenance may be performed on the mechanical components while maintaining treatment of the wastewater flowing through the plant.

Let's begin with complete mix.

Complete Mix

Display Slide 33, Complete Mix Activated Sludge (Figure 3.5 in participant workbook)

[Review the material on complete mix and use Slide 33 to point out where and how the process takes place.]

[(If time permits, contrast with extended aeration.)]

Let's take a look at contact stabilization.

Contact Stabilization

Display Slide 34, Contact Stabilization Activated Sludge Schematic (Figure 3.6 in participant workbook)

[As you review the material, use the schematic to point out where and how the process takes place.]

[(If time permits, contrast with extended aeration.)]

Extended Aeration

Display Slide 35, Extended Aeration Activated Sludge Schematic (Figure 3.7 in participant workbook).

[Review the information on extended aeration. Use the schematic to point out where and how the process takes place.]

The extended aeration modification has been adapted to sequencing batch reactors and oxidation ditches. Let's go on to learn more about these.

Sequencing Batch Reactors

The sequencing batch reactor layout is similar to the extended aeration slide previously shown, except that no secondary clarifier is provided. In this process, the sequencing batch reactor tank acts as the equivalent of several components in the conventional activated sludge treatment process, as follows:

1. Aeration Tank: the sequencing batch reactor tank acts as an aeration tank during the reaction stage where the activated sludge is mixed with the influent under aerated conditions.
2. Secondary Clarifier: the sequencing batch reactor tank acts as a secondary clarifier during the settling and decanting stages where the mixed liquor is allowed to settle under calm conditions, and the overflow is discharged to the next stage of treatment.
3. Sludge Return System: the activated sludge, following settling in the sequencing batch reactor tank, is mixed with the influent similar to the sludge return system, except that the feed is transferred to the sludge rather than the sludge being transferred to the front end of the plant.

The process is completed in a single reactor tank by timing the sequential control stages as noted in the participant workbook. Just to get an idea of how the timing works, the timing of a typical 2-unit sequencing batch reactor operating on an 8-hour cycle would be as follows:

Display Slide 36, Two Unit Sequencing Batch Reactor (SBR) Time Chart

Time Period (hrs)	Unit #1	Unit #2
0 – 1	Fill	Aeration
1 – 2	Fill	Settle
2 - 3	Fill / Aeration	Settle
3 – 4	Fill / Aeration	Draw
4 – 5	Aeration	Fill
5 – 6	Settle	Fill
6 – 7	Settle	Fill / Aeration
7 - 8	Draw	Fill / Aeration

Oxidation Ditches

[This is last modification covered.]

Display Slide 37, Oxidation Ditch Schematic (Figure 3.8 in participant workbook)

[Review the material and use the schematic to point out where and how the process takes place.]

Aeration Methods

There are basically two methods of aerating wastewater in the activated sludge process: mechanical and diffused. Look at Figure 3.9 to see an example of a mechanical aeration device.

[Review the material on mechanical aeration devices.]

Now let's look at Figure 3.10 to see an example of an air diffuser.

[Review the material on diffusers.]

Activated Sludge Abnormal Conditions

Abnormal conditions of activated sludge come in three forms: solids carryover in effluent; odors; and foaming or frothing.

[Review material on solids carryover in effluent, odors, and foaming and/or frothing.]

[There is no need for further explanation at this time unless participants have questions.]

Review Activity: 5 minutes

As a quick review of some key points on Activated Sludge processes, let's look at this page together.

Ask for a recorder to write responses on flip chart as you move about the room to help get participants involved. Continue until all responses are given.

List 5 forms of the activated sludge treatment process.

Ans: extended aeration

contact stabilization

complete mix

sequencing batch reactors

oxidation ditches

What 2 aeration methods are used to provide oxygen to the activated sludge treatment process?

Ans: Mechanical

Diffused

Why might solids be found in the secondary clarifier effluent of an activated sludge treatment plant?

Ans: Return Sludge rate out of balance with process requirements

Sludge not settling (bulking) in clarifier

WASTE TREATMENT PONDS: 15 minutes

Another treatment process that is in common use today, particularly for smaller systems, is the Waste Treatment Pond.

Process Description

[Review the material on Waste Treatment Ponds.]

Pond Classifications

There are three types or classifications of ponds: aerobic, anaerobic, and facultative. Let's take a closer look at each of these.

[Review each type of pond.]

Aerobic

[Bacteria need dissolved oxygen.]

Anaerobic

[Bacteria do not need dissolved oxygen.]

Facultative

[Bacteria can use either dissolved molecular oxygen or oxygen obtained from food materials.]

Waste Treatment Ponds Abnormal Conditions

Abnormal conditions within ponds fall into three basic categories: scum, odors, and weeds and insects.

[Review the information on each of the conditions.]

Scum

[Review material on scum.]

Odors

[Review material on odors.]

Weeds and Insects

[Review material on weeds and insects.]

[Ask the whole class to respond to the following question.]

What are the three types of waste treatment ponds? List them below.

Ans. Aerobic

Anaerobic

Facultative

This concludes the formal instruction for Module 4: Fundamentals of Wastewater Treatment.

[Ask for and respond to questions at this point.]

[Thank attendees for their participation. Offer words of positive encouragement. Remind participants that both the participant workbook from this class and the Operation of Wastewater Treatment Plants Volume I textbook, will serve as good references in preparation for the state test.]