Wastewater Treatment Plant Operator Certification Training Instructor Guide

Module 20: Trickling Filters

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 20: Trickling Filters* is to provide an overview of the operation of a Trickling Filter. 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 DEP-approved sponsor. The number of contact hours of credit assigned to this course is based upon the contact hours approved under the 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 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.

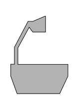
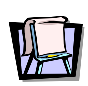
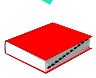
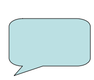
Delivery methods to be used for this course include:

- Lecture
- Examples
- Exercises

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

- One workbook per participant
- 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
	Quiz		Flip Chart
	Key Definition(s)		Suggested "Script"
	Key Point(s)		

Instructor text that is meant to be general instructions for the instructor is 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: <u>5 minutes</u>

Display Slide 1—Module 20: Trickling Filters.

[Welcome participants to "Module 20 – Trickling Filters." Indicate that the primary purpose of this course is to provide an overview of the operation of a trickling filter.

Introduce yourself.

Provide a brief overview of the module.]

This module contains 3 units. On page i, you will see the topical outline for Unit 1 – Process Description and Classifications of Trickling Filters.

[Briefly review the outline.]

If you turn the page, you will see the topical outline for the remaining sections in Unit 1.

[Continue to briefly review the outline.]

On page iii, you will see the topical outline for Unit 2 – Trickling Filter Operating Strategies.

[Continue to briefly review the outline.]

If you turn the page, you will see the topical outline for the remaining sections in Unit 2.

[Continue to briefly review the outline.]

On page v, you will see the remaining topics for Unit 2 and the topical outline for Unit 3 – Start-Up and Maintenance of Trickling Filters.

[Continue to briefly review the outline.]

[Continue to briefly review the outline.]

Let's now discuss the components and operation of a trickling filter.

UNIT 1 – PROCESS DESCRIPTION AND CLASSIFICATIONS OF TRICKLING FILTERS: 80 minutes

Display Slide 2—Unit 1: Process Description and Classifications of Trickling Filters.

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

- Name the three components of a trickling filter.
- Name the two general types of trickling filters based on method of distribution.
- Describe the process and operation of a trickling filter.
- Identify the three classifications of trickling filters based on hydraulic and organic loading rates.
- Calculate hydraulic loading rates for trickling filters.
- Calculate organic loading rates for trickling filters.

Let's begin with a brief overview and history of trickling filters.

OVERVIEW OF A TRICKLING FILTER: 10 minutes

Overview

[When reviewing the material in the workbook, include the following information:]

- The removal of rags, grit, and settleable solids, through the use of bar screens and primary clarifiers, is very important to avoid clogging the void space in the filter medium.

[In Figure 1.1, point out that the sides of the trickling filter in the bottom picture are higher than the sides of the trickling filter in the middle picture. The bottom picture is a trickling filter that contains synthetic media. The middle picture is a trickling filter that contains rock media.]

History

[When reviewing the information in the workbook, include the following information:]

- The simplicity of trickling filters was a key factor in improving wastewater treatment from just primary clarification to a new age of biological systems.

[When discussing synthetic media, include the following information:]

- Synthetic materials allow for better void space.
- Better void space enhances air circulation which allows the media to be taller.

[Also note that in some wastewater treatment plants, trickling filters may precede a more sophisticated treatment process such as activated sludge.]

Now that we have discussed the history of the trickling filter, let’s take a look at the main components.

Physical Description

[Review the information in the workbook.

Note that both types of trickling filters will have a distribution system, filter media, and underdrain system. In addition, the biomass which grows on the media will be the same.]

[When reviewing Figure 1.3, include the following information:]

- The black objects are spray heads. The concrete structure on the right of the picture is the dosing chamber which controls flow to the spray heads.
- Dosing of the spray field may occur every few minutes, depending on the influent flow.
- The rectangular design of this stationary filter saves space.
- This trickling filter was originally constructed in the 1920's and as of 2004 is still in existence as a pretreatment plant.

[When reviewing Figure 1.4, include the following information:]

- When wastewater fills the chamber to a sufficient elevation, a siphon will start and dose the distribution field. The dosing will continue until the siphon effect is broken. This allows for uniform distribution throughout the field, even at low flow periods.
- At low flow periods, the dosing may decrease to a few times per hour.

Let's first take a look at the distribution system.

Distribution System

[Review the material in the workbook.]

Circular Trickling Filter with Rotary Arms

[When reviewing the material in the workbook, include the following information:]

- The circular trickling filter with a rotary arm is the most common form of trickling filter.
- It is critical that the orifices be kept clear because this provides the thrust which turns the arm. If too many orifices are clogged, the distributor arm may stop.
- The advantage of a motor driven distribution arm is that the hydraulic loading rate to the surface can be controlled. With hydraulic thirsted arms, there may be periods when the surface loading rate is not uniform, such as during high flow periods. During this time, the arm may tend to rotate very quickly and the proper distribution may not be achieved. Conversely, at low flow periods, the arms may stop if the flow decreases. Low flow periods often occur at night.

Stationary Trickling Filter with Fixed Spray Heads

[After reviewing the material in the workbook, note the following information:]

- Very few new trickling filters are stationary with fixed spray heads.
- Spray heads are only used in stationary filters.
- An advantage of fixed or stationary filters is that they do not have to be round. They can be square or rectangular which may save space at the plant.

[When reviewing Figure 1.6, include the following information:]

- Normal area of distribution for each spray head is a 6 to 10 foot circle.
- The flow comes up from the center and hits the pointed object which creates an umbrella effect of wastewater being distributed in a circular pattern around each spray head.
- Typically the spray patterns will overlap so that full coverage of the media is attempted. However, very rarely is full coverage obtained.

Now that we have discussed the distribution system, let's review the filter medium.

Filter Medium

[Review the information in the workbook.]

Rock (or slag)

[When reviewing the material in the workbook, include the following information:]

- The mixing of different size rocks will tend to clog the void space. Sufficient void space must be allowed for growth of media and also air flow.
- If poor rock is used and it starts to break apart, the small rock particles may result in clogging. The rock must be a hard rock, such as granite.
- Slag is rarely used because of the inability to control the void space.

Redwood

[Review the information in the workbook.]

Synthetic Material

[When reviewing the material in the workbook, include the following information:]

- Greater filter depth is the most evident feature of a synthetic media trickling filter.
- Depending on the type of treatment desired, different media density can be specified.
  - A roughing filter or a filter intended for carbonaceous removal may use a media density of 30 sq. ft./1 cubic foot.
  - A nitrification filter, which is never the first in a series, may use a higher density of 45 sq. ft./cubic foot.
- Plastic "random dump" trickling filter media may be thermoplastic homopolymer, fully stabilized. The surface media density may range from 30 sq.ft./cubic foot up to 60 sq.ft./cubic foot.
- Plastic "random dump" media is easier to install because it is simply dumped into the filter.
- Point out that "random dump" plastic trickling filter media may look the picture in the workbook, or it may consist of materials that look like hollow balls.

Now that we have reviewed the distribution system and the filter medium, let's discuss the underdrain system.

Underdrain System

[While reviewing the information in the workbook, include the following information:]

- Vitrified clay blocks are more common in older, rock media trickling filters.
- Fiberglass grating over collection troughs are common with trickling filters that use synthetic media.

[When reviewing Figure 1.12, include the following information:]

- The flow comes out along the side of the wall and flows to a central collection point.
- At the time of this picture, the trickling filter was temporary out of service for maintenance.

Now that we have reviewed the physical components of a trickling filter, let's discuss the processes that make the trickling filter function.

Process Description

Process Biology

[<u>Note to Instructor:</u> Do not spend a lot of time on process biology. The most important item participants must understand is that the metabolizing actions of the bacteria and micro-organisms in the slime layer filter the wastewater.

Review the material in the workbook.]

Bacteria

[Review the material in the workbook.]

[While reviewing the material in the workbook, include the following information:]

- Anaerobic bacteria are rarely a concern in an aerobic trickling filter.

Micro-organisms

[Review the material in the workbook.]

[Continue to review the material in the workbook.]

[Continue to review the information in the workbook.]

The micro-organisms we have just discussed primarily reduce the biochemical oxygen demand of the wastewater and use it as an energy source. There are micro-organisms, however, that can reduce ammonia nitrogen (NH_3-N) in the wastewater through a process called “nitrification.”

Nitrification

[While reviewing the material in the workbook, include the following information:]

- A nitrification trickling filter is never the first trickling filter at a wastewater treatment plant. The oxidation of CBOD must occur before nitrification can be started.

Ammonium and Ammonia

[Review the material in the workbook.]

Nitrite

[Review the material in the workbook.]

Nitrate

[Review the material in the workbook.]

Organic-Nitrogen

[Review the material in the workbook.]

Total Kjeldahl Nitrogen (TKN)

[Review the material in the workbook.]

[While reviewing Figure 1.20, include the following information:]

- The diagram includes items not associated with trickling filters.
- Note that there are 2 ways nitrogen is handled through the filter system. The nitrogen is either is discharged through the effluent or released to the atmosphere.

Nitrogen's Effect on Receiving Waters

[While reviewing the information in the workbook, include the following information:]

- When ammonia is not converted to an oxidized form, such as nitrate, the ammonia will have a large oxygen demand on the receiving stream. Typically, for every 1 mg/L of ammonia discharged to the stream, about 4.5 mg/L of oxygen will be required to stabilize the partially treated wastewater.

Biological Nitrification

[While reviewing the information in the workbook, include the following information:]

- Although detailed information is presented in this section, the important part is to understand that more oxygen is being added to the ammonia. Notice how it goes from NH_4 to NO_2 to NO_3. (adding more oxygen as the bio-mass further stabilizes the wastewater).

- Organic Loading is controlled by having enough filters in service. Operation of upstream treatment processes such as the primary clarifier are critical. An excessive sludge blanket in a primary clarifier may result in solublization of the waste and increased organic loadings. The depth of sludge in the primary clarifier should be controlled by adequate pumping.
- Hydraulic Loading is controlled by the recycle ratio. During periods of low influent flow, such as at night, it may be necessary to increase the recirculation ratio to keep the distribution arms moving on a circular trickling filter.
- Temperature—An operator can not control the temperature of the incoming wastewater. During winter, a high recirculation ratio will further cool the wastewater.
- pH—This is one aspect over which the operator has control. If the pH or alkalinity is not within design guidelines, the addition of alkalinity will help elevate a low pH. Generally a trickling filter designed for BOD removal will not have a need for pH adjustment, however, a nitrifying trickling filter may need some adjustment. An example of alkalinity supplementation would be sodium hydroxide (NaOH).
- Dissolved Oxygen—Avoiding clogged areas will help maintain adequate void space to allow for dissolved oxygen.
- Filter Media selection was conducted during the plant design and is not controlled by the operators.

Biological Denitrification

[Review the material in the workbook.]

Now that we have reviewed nitrification, let's look at the advantages and disadvantages of trickling filters.

Advantages of a Trickling Filter

[While reviewing the information in the workbook, include the following information:]

- Consistent Effluent Quality—A trickling filter will provide a reasonable amount of treatment but due to a lack of ability to fully control the biological population, a very high level of treatment is generally not possible. However, obtaining a moderate amount of treatment for carbonaceous BOD should be easily achievable.

Disadvantages of a Trickling Filter

[While reviewing the material in the workbook, include the following information:]

- Odors and Nuisance Organisms—You cannot spray an insecticide on the surface of a trickling filter to control filter flies because this would adversely affect treatment of the wastewater. Several trickling filter plants have used natural control techniques to reduce filter flies. These include bird houses or bat boxes along the perimeter or near the wastewater treatment plant fence.
- Cold Weather Can Cause Freezing—During prolonged periods of extreme winter weather, it may be necessary to manually remove ice every few days. This would include those areas which are intermittently splashed with the wastewater such as the column or along the outside edge of the rotary distributor.
- Pumping Costs—The pumping is necessary so that the flow through the filter will be by gravity after the wastewater has been elevated to a sufficient height. One of the key features of a trickling filter is the center column where the wastewater comes in. It is almost always the highest point of a trickling filter.

Now that we have reviewed the advantages and disadvantages of trickling filters, let's discuss some trickling filter classifications.

CLASSIFICATION OF TRICKLING FILTERS: 20 minutes

[Review the material in the workbook.]

Standard Rate Filters

Design Loading

[Review the material in the workbook.]

Media

[Review the material in the workbook.]

Effluent Quality

[Review the material in the workbook.]

Recirculation Capabilities

[Review the material in the workbook.]

Seasonal Sloughing

[Review the material in the workbook.]

Problems

[Review the material in the workbook.]

High Rate Filters

Design Loading

[Review the material in the workbook.]

Media Depth

[Review the material in the workbook.]

Effluent Quality

[Review the material in the workbook.]

Recirculation Capabilities

[Review the material in the workbook.]

Roughing Filters

DESIGN LOADING

[Review the material in the workbook.]

USES

[While reviewing the material in the workbook, include the following information:]

- Figure 1.3 on page 1-6 is an example of a high rate rock media roughing filter.
- Modern high rate filters use synthetic media because of the larger void area and greater depth.

Now that we have reviewed the various trickling filter classifications, let’s discuss loading rates.

LOADING RATES FOR TRICKLING FILTERS: 10 minutes

Hydraulic Loading Rate

[Review the material in the workbook.]

☑ **Exercise:** Calculate the hydraulic loading of a Trickling Filter with the following data:

Diameter of TF	=	40 ft
Influent Flow	=	2.0 mgd

Ans: Surface Area = (π) x (radius)^2 = (3.14) x (20)^2 = 1,256 ft^2

$$\text{Hydraulic Loading} = \frac{(2{,}000{,}000 \text{ gpd})}{(1{,}256 \text{ ft}^2)} = 1{,}592 \text{ gpd/ft}^2$$

Organic Loading Rate

[Review the material in the workbook.]

- When discussing the calculation for organic loading, note that the same type of calculation can be used for nitrification. To use the same calculation, substitute the ammonia nitrogen influent rate for the influent BOD.

Exercise: Calculate the organic loading of a Trickling Filter with the following data:

Diameter of TF	=	60 feet
Depth of Media	=	6 feet
Influent Flow	=	100,000 gpd
Influent BOD	=	200 mg/L

Ans: Media Volume (ft^3) = (π) x $(radius)^2$ x (depth) = (3.14) x $(30 \text{ feet})^2$ x (6 feet) = 16,956 ft^3

Organic Load = $\frac{(200 \text{ mg/L}) \times (.1 \text{ mgd}) \times (8.34 \text{ lb/gallon}) \times (1{,}000 \text{ ft}^3)}{(16{,}956 \text{ ft}^3)}$ = 10 lb BOD/day/1,000 ft^3

Now that we have reviewed organic loading rates, let's discuss trickling filter staging patterns.

STAGING PATTERNS: 15 minutes

Basic Treatment Unit Arrangement

[Review the material in the workbook.]

Single-Stage Arrangement

[While reviewing the material in the workbook, include the following information:]

- This is a common arrangement for smaller wastewater treatment plants or plants of an older design.

Two-Stage Arrangement

[While reviewing the material in the workbook, include the following information:]

- The media density of the first filter is never greater than the media density of the second filter. This is because the first filter will have the strongest wastewater and heaviest bio-growth.
    - The lower the media density, the more void space between the media.

Use of Intermediate Clarification

[While reviewing the material in the workbook, include the following information:]

- In this arrangement, it is very likely that the second filter will have a higher media density than the first filter. This is because the intermediate clarifier minimizes the potential for clogging. Density for the second filter might be around 45 sq. ft./cubic foot.
- The effluent from the intermediate clarifier would be a good point for alkalinity addition, if the pH is not within the desired range.

Orientation of Trickling Filters

[Review the material in the workbook.]

Series Orientation

[Review the material in the workbook.]

Parallel Orientation

[While reviewing the material in the workbook, include the following information:]

- It is also possible to have both series and parallel orientation. For example, two filters in series could run parallel to two additional filters in series. Or two parallel filters could be setup in series. These configurations allow for a filter to be removed from service without significantly affecting the quality of the effluent.

[Review the information in the workbook.]

Now that we have reviewed the orientation of trickling filters, let's discuss recirculation.

RECIRCULATION PATTERNS: 10 minutes

Benefits of Recirculation

[Review the material in the workbook.]

Keeping the Filter Wet

[While reviewing the material in the workbook, include the following information:]

- If there are several clogged nozzles on a rotary distributor and large areas of the filter are being missed, recirculation will not help those areas remain wet.

Diluting Toxic Influent Flow

[Review the material in the workbook.]

Improving Treatment Efficiency

[Review the material in the workbook.]

Controlling Excess Biomass

[Review the material in the workbook.]

Recirculation Arrangements

[Review the material in the workbook.]

Single-Stage Recirculation Patterns

[Review the material in the workbook.]

- While reviewing the “Single Stage Trickling Filter with Filter Effluent Recirculation” diagram, note that recirculation in this manner is considered the minimum basic pattern. It would include a portion of the sloughed off solids being re-applied to the trickling filter.
- While reviewing the “Single Stage Trickling Filter with Final Clarifier Effluent Recirculation” diagram, note that this has the advantage of removing excess solids from the re-applied waste stream.

Two-Stage Recirculation Patterns

[Review the material in the workbook.]

Description of Common Two Stage Patterns

[Review the material in the workbook.]

- While reviewing the "Two Stage Trickling Filter Arrangement with Intermediate Clarification and Recirculation" diagram, note that this would be an example for a wastewater treatment plant expected to be achieving nitrification. It is a good possibility that the first trickling filter would have a more open density of media than the second filter. The removal of solids by the intermediate clarifier would greatly reduce the chance of large objects clogging the nozzles on the second trickling filter.

Now that we have looked at several recirculation patterns, let's wrap up recirculation with some general comments.

Notes Regarding Recirculation

[Review the material in the workbook.]

[Have the participants review the Key Points for Unit 1 – Process Description and Classifications of Trickling Filters.]

☑ UNIT 1 EXERCISE: 15 minutes

Ask the participants to take 10 minutes to complete the quiz. Then spend 5 minutes reviewing the answers.

1. Name the three components of a trickling filter.

Ans: Distribution System
Filter Media
Underdrain System

2. Name the two general types of trickling filters based on method of distribution.

Ans: Circular trickling filter with rotary arms
Stationary trickling filter with spray heads

3. Describe the process and operation of a trickling filter.

Ans: Wastewater is distributed over the top of a filter media. Bacteria and micro-organisms attached to the filter media metabolize the organic substances in the wastewater, producing waste products such as carbon dioxide, ammonia, and phosphates. The treated wastewater is discharged, or pumped, to sedimentation tanks. A portion of the filter effluent may be re-circulated back to the trickling filter to improve removal efficiencies.

4. Identify the three classifications of trickling filters based on hydraulic and organic loading rates.

Ans: Standard Rate Trickling Filter
High Rate Trickling Filter
Roughing Trickling Filter

5. Calculate the hydraulic loading rate of a trickling filter, given a diameter of 55 feet and an influent flow of 1.25 mgd.

Ans: Surface Area = (π) x (radius)^2 = (3.14) x (27.5 feet)^2 = 2,375 ft^2

Hydraulic Loading (gpd/day/ft^2) = $\frac{\text{Influent Flow, gpd}}{\text{(Surface Area, ft}^2\text{)}}$

= $\frac{\text{1,250,000 gpd}}{\text{2,375ft}^2}$ = 526 gpd/day/ft^2

6. Calculate the organic loading rate of the trickling filter in the above question, given a media depth of 20 feet and an influent BOD of 235 mg/L.

Ans: Media Volume = (π) x (radius)^2 x (depth) = (3.14) x (27.5 feet)^2 x (20 feet) = 47,493 ft^3

Organic Load (lb BOD/day/1,000 ft^3) = $\frac{\text{(BOD, mg/L) x (Flow, mgd) x (8.34 lbs/gallon) x (1,000 ft}^3\text{)}}{\text{(Volume, ft}^3\text{)}}$

= $\frac{\text{(235 mg/l) x (1.250 mgd) x (8.34 lbs/gallon) x (1,000 ft}^3\text{)}}{\text{47,493 ft3}}$

= 51.6 lb BOD/day/1,000 ft^3

UNIT 1 REFERENCES: 0 minutes

[The references page does not need to be mentioned during the class.]

[This page was intentionally left blank.]

UNIT 2 – TRICKLING FILTER OPERATION STRATEGIES: 60 minutes

Display Slide 3—Unit 2: Trickling Filter Operation Strategies.

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

- Identify five daily operations inspections appropriate for trickling filters.
- List three abnormal operating conditions typically encountered in a trickling filter facility and explain what steps can be taken to correct each problem.
- Give one example of an operation modification that may be required due to sampling results.

Let's begin with a brief overview of daily operations.

DAILY OPERATIONS: 10 minutes

Physical Inspections

[Review the material in the workbook.]

In addition to conducting daily inspections, it is important to take samples and maintain accurate records.

Sampling and Recordkeeping

Developing a Sampling Plan

[While reviewing the material in the workbook, include the following information:]

- *Review NPDES Permit parameters*—this establishes a minimum sampling frequency and a list of parameters.
- *Review the types of discharges to the collection system*—If industrial waste is being discharged to the system, the influent sampling should check for excessive concentrations.
- *Determine if any upsets have occurred in the past*—This is an effective way to identify possible repeat problems.
- *Review solids disposal procedures*—If inadequate solids disposal operations are being performed, there may be a backlog of solids at the plant which will hinder efficient operations.

Importance of a Sampling Plan

[Review the material in the workbook.]

Factors to Consider

[Review the material in the workbook.]

Suggested Testing Parameters

[Review the material in the workbook.]

Influent Flow and Recirculation Rates

[Review the material in the workbook.]

Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS)

[Review the material in the workbook.]

pH

[Review the material in the workbook.]

Dissolved Oxygen (DO)

[Review the material in the workbook.]

Settleable Solids or Suspended Solids

[While reviewing the material in the workbook, include the following information:]

- Settleable Solids test is conducted with an Imhoff Cone in the lab and provides a very quick and easy visual idea of the type of waste being treated. However, it yields a limited amount of information.
- The Suspended Solids test requires more sophisticated lab equipment but yields more reliable information.

Recordkeeping

[While reviewing the material in the workbook, include the following information:]

- It is impossible to remember everything that happens at a plant. Therefore, proper recordkeeping goes beyond just having sufficient information to satisfy the regulatory requirements. It helps maintain a historical record that can be used to identify trends.

Uses of Data

[While reviewing the material in the workbook, include the following information in the "Process Loading Rates" section:]

- *Maintain proper hydraulic loading to units*—It is important to know if the facility is within design limits for each unit or if insufficient or excessive recirculation is being provided.
- *Maintain proper organic loading to units*—This will allow the operator to determine if upstream processes, such as a primary clarifier, are operating properly.

☑ Exercise: Calculate the Ammonia Nitrogen removal efficiency of a Trickling Filter with the following data:

Influent NH_3-N = 10 mg/L
Effluent NH_3-N = 2.5 mg/L

Ans: [(10-2.5)/10] x 100 = 75%

Graphing

While reviewing the material in the workbook, include the following information:

- Putting data into a spreadsheet such as Lotus or Excel allows for quick graphing.
- Long-term plotting, such as plotting several years worth of data, may allow for an accurate prediction of when efficiency will decrease.

When reviewing Figure 2.1, point out that at this particular plant, the influent BOD averages approximately 150 mg/L with a maximum monthly average of 175 mg/L (September to November).

- TSS appears to average approximately 110 mg/L per month with a maximum month average of 140 mg/L in September.
- There is a nice correlation between BOD and TSS concentrations.

Continue to review the material in the workbook.

[When reviewing Figure 2.2, note that while the historic influent BOD average appears to be around 150 mg/L. In September the BOD averaged around 250 mg/L.

- *There are several explanations for this. The wastewater collection system lines could have been flushed, sending excessive BOD and TSS to the plant, or an industrial user in the system could have discharged high concentration wastewater.*
- *In addition, the TSS concentration was higher than the BOD concentration for this month, indicating excessive grit or non-organic solids to the plant.]*

Now that we have reviewed sampling and recordkeeping, let's discuss various causes of poor effluent quality.

RECOGNIZING POOR EFFLUENT QUALITY: 20 minutes

High Total Suspended Solids

Causes and Effects

[Review the material in the workbook.]

Responses

[While reviewing the material in the workbook, include the following information:]

- High flows will tend to flush solids out of a primary clarifier. This could create high suspended solids loading to the trickling filter.

High Biochemical Oxygen Demand

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

High Settleable Solids

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

Low Dissolved Oxygen

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

High Chlorine Demand

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

Poor Clarity

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

Low or High pH

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

High Fecal Coliform

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

Nutrient Imbalance

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

Now that we have reviewed the causes of poor effluent quality, let's discuss some typical operating problems.

TYPICAL OPERATING PROBLEMS: 15 minutes

Ponding

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

Odors

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

Filter Flies

[Review the material in the workbook.]

Causes and Effects

[While reviewing the information in the workbook, include the following information:]

- Stationary trickling filters may be more prone to filter fly problems because of the limitations of the fixed spray heads.

Responses

[While reviewing the information in the workbook, include the following information:]

- Swallowtails and bats are common predators of small flying insects.

Sloughing

[Review the material in the workbook.]

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

Weather Concerns

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

Shock Loads

Causes and Effects

[Review the material in the workbook.]

Responses

[Review the material in the workbook.]

[Review the material in the workbook.]

Impacts of Other Processes

[Review the material in the workbook.]

Screening

[Review the material in the workbook.]

De-gritting

[Review the material in the workbook.]

Primary Clarification

[Review the material in the workbook.]

Secondary Clarification

[Review the material in the workbook.]

Chlorination

[Review the material in the workbook.]

Now that we have reviewed typical operating problems, let’s discuss safety.

SAFETY: 5 minutes

Distributor Arm

[Review the material in the workbook.]

Media

[While reviewing the material in the workbook, include the following information:]

- Walking on unprotected synthetic media may crush the top surface area. Open weave fiberglass grating placed on the filter media can be used to create a walk path. The open grating should have about 1.5 to 2 inch square openings. Each walk path should be about 4 to 6 feet wide. This allows for adequate distribution of the weight and also provides room to work on the nozzles when the distributor arm is stopped.

This concludes Unit 2. In Unit 3 we will discuss the start-up and maintenance of a trickling filter.

[Have the participants review the Key Points for Unit 2 – Trickling Filter Operation Strategies.]

☑ UNIT 2 EXERCISE: 10 minutes

Ask the participants to take 5 minutes to complete the quiz. Then spend 5 minutes reviewing the answers.

1. Identify five daily operations inspections appropriate for trickling filters.

Ans: Trickling filters should be inspected on a daily basis for signs of:

- Ponding
- Uneven distribution of flow
- Clogging
- Roughness or vibration
- Leakage
- Filter flies
- Unusual odors

2. List three abnormal operating conditions typically encountered in a trickling filter facility and explain what steps can be taken to correct each problem.

Ans: Ponding—Increase the recirculation rate to flush out solids. Slow the rotary distribution arm to flush out solids. As a last resort, chlorinate the filter media to kill excess biomass.

Odors—Pre-aerate the wastewater if the influent wastewater is the cause of odor. Increase the recirculation rate to flush out excessive solids from the filter media. Verify that the nozzles are allowing for equal distribution across the media surface.

Filter flies—Increase the recirculation rate to flush out the filter media. Temporarily and periodically flood the filter media. As a last resort, chlorinate the filter media to kill the filter flies.

Sloughing—Either increase or decrease the recirculation rate depending on the suspected cause of excessive sloughing: increase the rate if low organic loading or decrease the rate if high hydraulic loading. Divert a portion of the flow to additional treatment units to control the high hydraulic loading effect, if possible.

Weather conditions—Decrease the recirculation rate to maintain a warmer temperature. Remove orifices and end plates from the distributor arms to reduce the icing caused by spraying. Breakup any ice that forms on the filter media.

Shock loads—Increase the recirculation rate to dilute high organic loading. Operate multiple filters in series to limit the damage caused by high organic loading (organic loading should only affect the first filter and be harmless to the preceding ones). Operate multiple filters in parallel to reduce the high hydraulic loading.

3. Give one example of an operation modification that may be required due to sampling results.

Ans: High Total Suspended Solids—Adjust the hydraulic loading rates as necessary. Excessive flow through the filter can flush out solids and cause high TSS.

High Biochemical Oxygen Demand—Develop and implement sewer-use ordinances to establish limitations on organic loading discharges.

High Settleable Solids—Adjust the hydraulic loading rate as necessary. Calculate the organic loading rate to determine if the rate is acceptable: increase recirculation to dilute the organic loading, place additional trickling filters units in service to distribute the excessive organic loading.

Low Dissolved Oxygen—Check for filter media clogging. Calculate the organic loading rate to determine if the rate is acceptable: increase recirculation to dilute organic loading, place additional trickling filters units in service to distribute excessive organic loads.

High Chlorine Demand—Survey sewer system customers to determine the source, it is most likely a non-domestic type wastewater discharge.

Poor Clarity—Adjust the hydraulic loading rate as necessary to control high settleable solids.

Low or High pH—Survey sewer system customers to determine the source, it is most likely a non-domestic type wastewater discharge. Adjust the pH with sodium hydroxide (to increase pH).

High Fecal Coliform—Increase solids and/or sludge disposal operations to remove the excessive solids.

Nutrient Imbalance—Adjust the number of upstream treatment units (i.e. primary clarifiers) to better control the treatment efficiency and nutrient loadings. Add necessary nutrients, if deficiency is the cause.

UNIT 3 – START-UP AND MAINTENANCE OF TRICKLING FILTERS: 35 minutes

Display Slide 4—Unit 3: Start-Up and Maintenance of Trickling Filters.

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

- List five items that should be inspected after new construction of a trickling filter and before start-up of the operation.
- Describe the process of putting a filter into operation with no growth on the media.
- List and describe five normal maintenance tasks required for trickling filters.

Let's begin with a discussion on the inspection and start-up of a new trickling filter.

NEW CONSTRUCTION: 10 minutes

Inspection

Packing Grease

[Review the material in the workbook.]

Nozzles

[Review the material in the workbook.]

Media

[Review the material in the workbook.]

Distributor Arm

[Review the material in the workbook.]

Underdrain System

[Review the material in the workbook.]

Painted Surfaces

[Review the material in the workbook.]

Valves

[Review the material in the workbook.]

Manuals

[Review the material in the workbook.]

Start-Up

Mechanical

[Review the material in the workbook.]

Biological

[Review the material in the workbook.]

Now that we have reviewed new construction, let's discuss maintenance issues.

MAINTENANCE: 15 minutes

Bearings and Seals

Location

[Review the material in the workbook.]

Oil

[Review the material in the workbook.]

Mercury Seals

[Review the material in the workbook.]

Distributor Arms

Procedure

[Review the material in the workbook.]

Adjustments

[Review the material in the workbook.]

Fixed Nozzles

[Review the material in the workbook.]

Procedures

[Review the material in the workbook.]

Adjustments

[Review the material in the workbook.]

Underdrains

Description

[Review the material in the workbook.]

Maintenance

[Review the material in the workbook.]

Pumps and Level/Recirculation Control System

[Review the material in the workbook.]

[Have the participants review the Key Points for Unit 3 – Start-Up and Maintenance of Trickling Filters.]

Unit 3 Exercise: 10 minutes

Ask the participants to take 5 minutes to complete the quiz. Then spend 5 minutes reviewing the answers.

1. List five items that should be inspected after new construction of a trickling filter and before start-up of the operation.

Ans:
- Packing grease
- Nozzles
- Media
- Distributor Arm
- Underdrain System
- Painted Surfaces
- Valves
- Manuals

2. Describe the process of putting a filter into operation with no growth on the media.

Ans: After checking all components, begin operation of the unit. Allow several weeks for the bio-growth to develop. High rate recirculation will help to establish growth. Attempt to equalize flow in upstream processes so that high hydraulic peak loadings are minimized. Maintain a low sludge blanket level in the upstream primary clarifier so that organic loading to the trickling filter is minimized as much as possible. Notify regulatory agencies that effluent quality may not be in compliance with the NPDES Permit until the bio-growth is established.

3. List and describe five normal maintenance tasks required for trickling filters.

Ans: Bearings and Seals—Both distributor bearings should be lubricated as per the manufacturer's recommendations. Check the manufacturer's recommendations and change the oil accordingly. Replace the mercury seals as needed.

Distributor Arms—Use a carpenter level to check the vertical alignment of the center column and the distributor arms. Check for the proper tension of the horizontal and vertical guy supports between the column and arms. Clean the nozzles when they become clogged. Flush out each distributor arm at least once a month. Major variations in vertical alignment should be corrected.

Fixed Nozzles—Conduct a pan test annually to determine if all nozzles are providing equal flow. Flush out internal piping to prevent solids accumulation, especially at the end of the manifold nozzles.

Underdrains—Check annually for any accumulation of solids or debris. Visually inspect underdrains using a flashlight, mirror, or robotic sewer TV camera on an annual basis.

Pumps and Level/Recirculation Control System—Verify level control system set points on a quarterly basis. Test all low level and high level alarms on a quarterly basis. Follow any additional manufacturer's recommendations.

This is the end of *Unit 3 – Start-Up and Maintenance of Trickling Filters* and the end of *Module 20: Trickling Filters*.

[Ask participants if they have any questions. Thank them for their participation. Remind participants that the workbook has been designed not only for instructional purposes but as a reference resource.]