Wastewater Treatment Plant Operator Certification Training Instructor Guide

Module 19: Treatment Ponds and Lagoons

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 this course, *Treatment Ponds and Lagoons,* is to introduce participants to the topic of treatment ponds, their purposes and their maintenance. This module has been designed to be completed in approximately 3 hours but the actual course length will depend upon content and delivery modifications and results of course dry runs performed by the approved 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
- Discussion Questions
- Calculations and Exercises
- Visuals and Graphics

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
Unit 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 19: Treatment Ponds and Lagoons.

[Welcome participants to "Module 19 – Treatment Ponds and Lagoons." Indicate the primary purpose of this course is to familiarize the participants with the uses, purposes, and maintenance of ponds.]

[Introduce yourself.]

This module contains 3 units. On page i, you will see the topical outline for Unit 1 – General Overview and Unit 2 – General Operation and Maintenance.

[Briefly review outline.]

If you turn the page, you will see the topical outline for Unit 3—Typical Operating Problems.

[Continue to briefly review outline.]

UNIT 1: 90 minutes

Display Slide 2—Unit 1: General Overview.

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

- Describe why ponds are used in wastewater treatment.
- Identify three (3) types of ponds.
- Discuss the advantages and disadvantages of using ponds for treatment.
- Name two levels of treatment that ponds are capable of achieving.
- Discuss why ponds have long detention times and large volumes.

HISTORICAL USES: 5 minutes

To begin our study of treatment ponds, let's take a look at the history and evolution of wastewater treatment ponds.

[Briefly review the Historical Uses section.]

As we noted, increased populations and the need to separate clean water and sanitary wastes prompted the isolation of wastewater from other water supplies.

What are some undesired effects of discharging wastewater directly into clean water sources?

[Ans: Some possible answers include odor, disease, and destruction of habitat.]

TYPES OF PONDS: 15 minutes

Now that you know how ponds came to be used for wastewater treatment, we can begin to look at the types of ponds in use today.

It is important to remember that, when we discuss treatment ponds and lagoons, we use the words interchangeably. The most often used term is "pond." There are three types of ponds in use today: Aerobic, anaerobic, and facultative. We will first look at the aerobic ponds.

Review the definition of aerobic ponds.

[Review the methods for introducing oxygen into a treatment pond.]

[Remind participants that the chart on page 1-3 will help them see the relationship between the depth of a pond and the method needed to introduce DO.]

An aerobic pond with no mechanical agitation should be shallow. Why is this important?

[Ans: An aerobic pond, by definition, has DO throughout its entire depth. Shallow depth allows for distribution of DO throughout; a deeper pond would not have an adequate DO supply using natural methodology, such as algae or wind.]

Review the definition of anaerobic ponds.

[Review the content on anaerobic ponds.]

Review the definition of facultative ponds.

[Remind students that the presence of algae in the effluent can result in high total suspended solids in a facultative pond.]

Ask students to apply their critical thinking skills to the following questions about facultative ponds:

- What supplies the dissolved oxygen (DO) for the supernatant layer of the facultative pond?

  [Ans: Algae; wind; mechanical aeration devices; and diffused aeration can supply DO.]

- What stabilizes organic waste in the supernatant layer of the facultative pond?

  [Ans: Aerobic bacteria and algae stabilize organic waste.]

- What ferments the organic waste in the anaerobic layer of the facultative pond?

  [Ans: Anaerobic bacteria ferment organic waste in the anaerobic layer.]

- Why is the facultative pond the most common type of treatment pond?

  [Ans: It is nearly impossible to maintain completely aerobic or anaerobic conditions in a pond.]

ADVANTAGES OF PONDS: 3 minutes

There are some good reasons to use ponds in the treatment process. For the smaller installations, treatment ponds and lagoons offer many advantages.

Display Slide 3—Advantages of Ponds.

[Briefly review the information on the slide.]

DISADVANTAGES OF PONDS: 2 minutes

Ponds and lagoons are not the perfect treatment solution. Here are some disadvantages to using the process.

Display Slide 4—Disadvantages of Ponds.

[Briefly review the information on the slide.]

POND DESIGN AND PERFORMANCE OVERVIEW: 15 minutes

Review the definitions of **series ponds** and **parallel ponds**.

[Note the importance of the key point.]

[Refer students to Figure 1.1, on page 1-7 of the workbook. Note the Series Pond's design that allows straight-through treatment. Note the Parallel Pond's design that allows influent to enter all the ponds, while effluent leaves through all ponds.]

Although we see the models displayed separately for ease of understanding, you will most often encounter ponds capable of both modes of operation. Note in your workbook that the DEP's *Facilities Manual* recommends that an optimal system should contain at least three cells and should be designed to operate in series *and* parallel.

Treatment Uses

Review the definition of an Oxidation Pond.

[Refer students to Figure 1.2, on page 1-8 of the student workbook.]

Review the definition of a Polishing Pond.

[Refer students to Figure 1.3, on page 1-8 of the student workbook.]

Although Figures 1.2 and 1.3 indicate locations where treatment ponds are typically situated in conjunction with other treatment units, our focus today is only on the pond itself.

Potential Treatment Efficiencies

[Review the bulleted items that detail the factors that impact potential treatment efficiencies for ponds and lagoons.]

Display Slide 5—Percent Removal Calculation

To determine the percent removal, you should perform this calculation:

$$\text{Percent Removal (\%)} = \frac{\text{(Influent Concentration, mg/l)} - \text{(Effluent Concentration, mg/l)}}{\text{(Influent Concentration, mg/l)}} \times 100$$

Display Slide 6—Percent Removal Calculation Exercise

[When students have had the opportunity to perform the calculation, click the mouse to show the calculation on the same slide. Finally, after explaining the calculation, click the mouse again to show the answer on the same slide.]

Now we will perform the calculation using some real numbers. Insert the numbers on the screen into the appropriate spot in the calculation. Figure the answer; remember that the answer you want will be represented as a percentage.

Influent Ammonia Nitrogen = 25 mg/l
Effluent Ammonia Nitrogen = 20 mg/l
What is the percent removal?

[Ans: [(25 – 20) / 25] x 100 = 20
The answer is 20%.]

NATURALLY OCCURRING PROCESSES: <u>10 minutes</u>

Ponds support naturally occurring processes in each zone. Each zone has its own environment; as the zones mesh together, the interdependence of each environment becomes evident. Let's take a look at what happens in the aerobic and anaerobic zones of a pond. Then we will look at a diagram to support this information.

[Review the key information on this page, highlighting the aerobic and anaerobic sections.]

[Have the participants review Figure 1.4 which depicts the temperature variation in a thermocline.]

What questions do you have about these processes?

[Have the participants review Figure 1.5 which depicts aerobic and anaerobic pond processes.]

PHYSICAL PARAMETERS: 40 minutes

Ponds and lagoons must be designed within specific parameters in order to ensure that proper wastewater treatment occurs. There are many design variations, however, due to different combinations of these parameters. Let's take a look at the way we calculate these parameters.

We will look at five characteristics: surface area, volume, detention time, depth, and oxygen requirements. The first topic is surface area.

Surface Area

[Review the importance of surface area.]

Display Slide 7—Surface Area Calculation

$$\text{Surface area (in acres)} = \frac{\text{(Surface width, in feet) x (Surface length, in feet)}}{43{,}560}$$

To calculate the surface area of a pond, use the calculation on the screen now. Remember that the bottom number (the denominator) is simply a conversion factor that we use to change square feet into acres.

[Write this equation on the flip chart: 1 acre = 43,560 square feet]

Now, try to use the formula with real numbers.

Display Slide 8—Surface Area Calculation Exercise

[When students have had the opportunity to perform the calculation, click the mouse to show the calculation on the same slide. Finally, after explaining the calculation, click the mouse again to show the answer on the same slide.

Surface Length = 700 feet
Surface Width = 400 feet
Depth = 5 feet
What is the surface area of the pond?

Ans: $$\text{Surface area (in acres)} = \frac{\text{700 feet x 400 feet}}{43{,}560} = \text{6.4 acres]}$$

That was great! Now we will learn to calculate the pond's volume, which is another design parameter.

Volume

Because ponds use basically natural processes to treat the wastewater, they are typically slower than conventional processes. Large quantities of water are required to drive the system. In order to calculate the volume of a pond, we use this formula.

Display Slide 9—Volume Calculation

[Volume (in gallons) = (Average Length) x (Average Width) x (Average Depth) x 7.48 (in gallons)]

Because ponds have sloped sides, some complicated equations are necessary to determine exact measurements of a pond. For our purposes, however, we will be working with average length, average width, and average depth. These average figures will allow us to get a good estimate of pond volume.

The number you see at the end of this equation, 7.48, is simply a conversion factor that changes cubic feet into gallons. We always want to know the volume of a pond in gallons, so we must change the length, width, and depth numbers—which were given in cubic feet—into a gallon measurement. One cubic foot equals 7.48 gallons.

Let's try a calculation together.

Display Slide 10—Volume Calculation Exercise

[When students have had the opportunity to perform the calculation, click the mouse to show the calculation on the same slide. Finally, after explaining the calculation, click the mouse again to show the answer on the same slide.

Average Length = 700 feet
Average Width = 400 feet
Average Depth = 5 feet
What is the volume of the pond?

Ans: *Volume (in gallons) = 700 feet x 400 feet x 5 feet x 7.48 = 10,472,000 gallons]*

Detention Time

The third parameter for pond design is detention time. Detention time is important because the natural processes occurring in a treatment pond, like in any other natural system, require considerable time.

[Review the detention times and corresponding processes from the workbook. Review the key point, ***Short Circuiting****, by using the script below.]*

Short-circuiting is a problem that affects detention time. If a section of a pond is hydraulically isolated and a "dead zone" develops, that "dead zone" is no longer contributing to the detention time. For the purposes of the detention time calculation, the "dead zone" would not part of the pond volume.

There is an easy calculation that tells us how much time a drop of wastewater will remain in a pond or lagoon.

[*Display Slide 11—Detention Time Calculation*

Detention time (in days) = $\dfrac{\text{Pond Volume (in gallons)}}{\text{Influent Flow (in gallons/day)}}$*]*

Now we can try to perform this calculation with real numbers. Remember that we want to calculate in gallons per day. If the flow rate has already been calculated in mgd, or million gallons per day, you will have to convert that number into gallons. In our example, 0.125 mgd translates into 125,000 gallons per day.

[*Display Slide 12—Detention Time Calculation Exercise*

When students have had the opportunity to perform the calculation, click the mouse to show the calculation on the same slide. Finally, after explaining the calculation, click the mouse again to show the answer on the same slide.

Pond Volume = 5 million gallons
Influent Flow Rate = 0.125 million gallons per day (mgd)
What is the detention time of this pond?
Detention time (in days) = $\dfrac{\text{5,000,000 gallons}}{\text{125,000 gallons/day}}$ *= 40 days*

Ans: *Detention time (in days) =* $\dfrac{\text{5,000,000 gallons}}{\text{125,000 gallons/day}}$ *= 40 days]*

Depth

Depth is the fourth design parameter.

[Review the factors affecting pond depth.]

Oxygen Requirements

The fifth design parameter for ponds, the oxygen requirement, can vary according to the type of pond. Aerobic ponds, of course, require certain levels of oxygen in order to allow aerobic bacteria to stabilize waste efficiently and without stress.

Anaerobic ponds contain bacteria that do not require oxygen; introducing excess dissolved oxygen into that type of pond can actually have harmful effects.

A chart has been included on page 1-16 of your workbook that will allow you to see how various design elements influence, and are influenced by, treatment processes. Ponds typically need to be designed within certain parameter conditions in order to efficiently operate and produce properly treated effluent. The chart summarizes these normal design parameters.

You can look at the chart more closely when you have time to study it.

Unit 1 is now complete. We have covered a great deal of information. You should now be aware of the ways that ponds are used in wastewater treatment; the three types of ponds; the advantages and disadvantages of using ponds; the levels of treatment that ponds can achieve; and the reason that ponds require long detention times and large volumes. Additionally, you have learned to perform the calculations necessary to determine parameters in pond design.

In the next unit, we will look at factors that affect pond operation and pond maintenance.

[Review the Key Points for Unit 1 – General Overview.]

Exercise for Unit 1 – General Overview

1. List the three basic types of ponds used in wastewater treatment processes.
   a. aerobic
   b. anaerobic
   c. faculative

2. Aerobic ponds contain dissolved oxygen (DO) throughout the entire depth of the pond all of the time.

   a. True   b. False

3. Anaerobic ponds function without dissolved oxygen (DO) and rely on anaerobic bacteria at the bottom of the pond to ferment the sludge.

4. Water can flow through ponds connected together in either parallel or series configurations.

5. The influent to a facultative pond contains 30 mg/l of total nitrogen. What is the percent removal if the effluent contains 6 mg/l of total nitrogen?

$$\text{Percent Removal (\%)} = \frac{\text{(Influent, mg/l)} - \text{(Effluent, mg/l)}}{\text{(Influent, mg/l)}} \times 100\% = \frac{30 - 6}{30} \times 100\%$$

$$= \frac{24}{30} \times 100\% = 80\%$$

6. A thermocline can act as a physical barrier between surface water and bottom water.

7. A pond is 500 feet long by 200 feet wide and the water is 5 feet deep.
   a. What is the surface area of this pond in acres? (1 acre = 43,560 square feet)

$$\text{Area} = 500\text{ ft} \times 200\text{ ft} = 100{,}000\text{ ft}^2$$

$$100{,}000\text{ ft}^2 \times \frac{1\text{ acre}}{43{,}560\text{ ft}^2} = 2.3\text{ acres}$$

   b. What is the volume of the pond in gallons? (1 ft^3 = 7.48 gallons)

$$\text{Volume} = 500\text{ ft} \times 200\text{ ft} \times 5\text{ ft} = 500{,}000\text{ ft}^3$$

$$500{,}000\text{ ft}^3 \times \frac{7.48\text{ gal}}{1\text{ ft}^3} = 3{,}740{,}000\text{ gal}$$

   c. What is the detention time if the influent flow rate is 125,000 gallons per day?

$$\text{Detention Time} = \frac{\text{Pond Volume}}{\text{Influent Flow}} = \frac{3{,}740{,}000\text{ gallons}}{125{,}000\text{ gal / day}} = 30\text{ days}$$

[Page 17 of the workbook contains references for the first unit..

UNIT 2: <u>45 minutes</u>

Display Slide 13—Unit 2: General Operation and Maintenance.

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

- List the three general types of factors affecting pond operation.
- Describe how the dissolved oxygen level in a pond impacts its operation.
- Describe the types and functions of organisms found in a treatment pond.
- List the five types of pond structures and the maintenance strategies of each one.
- List four items that should be tracked in operation logs and two reasons for tracking.

This unit, "Operation and Maintenance of Ponds," requires that you build upon the information we covered in Unit 1 so that you can begin to understand how the physical, biochemical, and microbiological factors of a pond are all related to its operation and the need for maintaining its environment. We will begin our study by looking at the first of those factors—physical factors.

FACTORS AFFECTING POND OPERATION: 30 minutes

Physical Factors

Surface Area

Six main physical factors, or parameters, influence the processes that occur in the pond. Take a look in your workbook to see what they are. We will begin by examining the surface area.

[Review the surface area information.]

Depth

The second factor is the depth of a pond. Recalling the information we discussed in Unit 1, let's review the aerobic and anaerobic processes of a pond, remembering that depth is important in natural ponds because of the different biological activities that can occur near the surface and at greater depths.

It is important to note that ponds do not have completely distinct, separate layers. There is more of a gradient through the depth of the pond. Starting at the pond surface, where the DO is highest, the DO will slowly deplete through the depth of the pond until some point where it is completely gone.

[Very briefly review the section on depth.]

Hydraulic Load

Review the definition of **hydraulic load**.

Display Slide 14--Hydraulic Load Calculation.

The hydraulic load is a means of describing the volume of flow into a pond as it relates to the depth of the pond; the result is the "height" of influent wastewater into the pond on a daily basis. To determine the hydraulic load, you should perform this calculation:

$$\text{Hydraulic Load (inches per day)} = \frac{\text{Depth of Pond, inches}}{\text{Detention Time, days}}$$

Display Slide 15—Hydraulic Load Calculation Exercise.

[*When students have had the opportunity to perform the calculation, click the mouse to show the calculation on the same slide. Finally, after explaining the calculation, click the mouse again to show the answer on the same slide.]*

Now we will perform the calculation using some real numbers. Insert the numbers on the screen into the appropriate spot in the calculation. Figure the answer; remember that the answer you want will be represented as inches per day.

Width of Pond = 700 feet
Length of Pond = 400 feet
Depth of Pond = 5 feet
Influent Flow = 275,000 gpd
Detention Time = 38 days

[Ans: $$\text{Hydraulic Load} = \frac{(5\text{ feet})\ (12\text{ inches/feet})}{38\text{ days}} = 1.58\text{ inches/day}$$ *]*

Obviously, the hydraulic load will impact a pond's operation. The type of aeration in the pond also affects its operations. Interestingly enough, the aeration method is determined by the previous factors we have discussed, namely, organic loading, surface area, and depth, as well as the type of pond. Let's take a look at four different aeration methods.

Type of Aeration

[Briefly review the types of aeration available in ponds. Remind students that the pond type defines the mode of aeration: Aerobic ponds typically use only natural means of aeration (algae and wind), Aerated ponds use either mechanical aeration or diffused aeration equipment, Facultative Ponds might use a combination of aeration methods and anaerobic ponds employ no aeration methods.]

[Figure 2.1 and 2.2 are representative photographs two methods of aeration. Point out to students that the mechanical agitation device introduces dissolved oxygen on the surface of the pond by agitating the water while the diffused aerator introduces dissolved oxygen into the bottom of the pond by forcing compressed air into the water.]

Temperature

[Briefly review the information in this section; it is a review of information they should know.]

Incoming Flow Variations

[Review information in this section; be sure to mention the key points.]

There, in a brief synopsis, are the six **physical** factors that affect pond operation. We will turn our attention now to the biochemical factors.

[Refer students to the last line in Unit 1's Design Parameter chart on page 1-16:]

Type of Pond	BOD Loading
Aerated	80 - 95
Aerobic	60 - 120
Facultative	50 - 180
Anaerobic	200 - 500

After reviewing that portion of the Design Parameter chart from Unit 1, what effect does the type of pond (and its major mode of aeration) have on the amount of organic loading which can be adequately treated by the pond?

[ANS: Of the three types of ponds with aerobic zones, aerated ponds are typically able to treat higher minimum organic loading rates. This is because they employ mechanical aeration or diffused aeration equipment, which provide a higher dissolved oxygen transfer rate than the natural methods of algae or wind.]

Anaerobic ponds are capable of treating very high organic loading rates, which make them very desirable for high strength industrial wastes; however, anaerobic ponds always need to be followed by an aerated, aerobic, or facultative pond due to undesired anaerobic byproducts that must be removed prior to effluent discharge.

Let's turn the page now and start our discussion of the Organic Loading Calculation.

Biochemical Factors

Surface Organic Load Rate

[Briefly review the typical organic loading of a facultative pond.]

Display Slide 16—Organic Loading Calculation.

To determine the organic load of a pond, you should perform this calculation:

$$\text{Organic Load (lb. BOD/day/acre)} = \frac{\text{(BOD, mg/L) x (flow, mgd) x (8.34 lb./gallon)}}{\text{(Area, acres)}}$$

Display Slide 17—Organic Loading Calculation Exercise

[When students have had the opportunity to perform the calculation, click the mouse to show the calculation on the same slide. Finally, after explaining the calculation, click the mouse again to show the answer on the same slide.]

Now we will perform the calculation using some real numbers. Insert the numbers on the screen into the appropriate spot in the calculation. Figure the answer. Remember that the answer you want will be represented as pounds of BOD per day, per acre; therefore, you will need to calculate the number of acres of the pond before calculating the organic load.

Width of Pond = 700 feet
Length of Pond = 400 feet
Depth of Pond = 5 feet
Influent Flow = 275,000 gpd
Influent BOD = 240 mg/L

[Ans: *Surface Area (acres) =* $\frac{\text{(700 feet) x (400 feet)}}{\text{43,560 square ft./acre}}$ *= 6.4 acres]*

Display Slide 18—Next Step

After we determined the acreage, we can use that figure to finish the calculation.

[Ans: *Organic Load =* $\frac{\text{(240 mg/L) x (0.275 mgd) x (8.34 lb/gallon)}}{\text{(6.4 acres)}}$ *= 86 lb. BOD/day/acre*

The answer is 86 lb. BOD, per day, per acre.]

Great! You are learning to do many different calculations in this module. Are you beginning to see how the numbers they use are related to each other?

pH

Another important biochemical factor is pH. You probably perform this routine test on a regular basis at the treatment plant. Pond color can also be used as a valuable general indicator of pH range and a guideline of pond health.

[Briefly review pH information.]

Dissolved Oxygen Level

As the amount of organic waste increases, so does the amount of DO required. Let's review the key points of this section.

[Review information about the dissolved oxygen level; be sure to highlight the key points.]

Alkalinity

Review the definition of **alkalinity**.

[Review the information on alkalinity.]

Although the process is more complicated than this, you may want to visualize the bacteria feeding on organic waste, or BOD. Alkalinity is used in that process; therefore, BOD removal causes that slight decrease in alkalinity.

At your treatment plant, your National Pollution Discharge Elimination System (NPDES) Permit will impose restrictions on the amount, or concentration, of certain pollutants, such as pH, ammonia, and phosphorus.

Nutrient Levels

Sometimes, other factors affect the pond operation. In this section on biochemical factors, we will also discuss the broader topic of nutrient levels and influent toxicity, as well as the process of sampling and testing the pond's influent, body, and effluent.

Algae, like any other plant, require nitrogen and phosphorous to grow and reproduce.

[Very briefly review information on nutrient levels.]

Influent Toxicity

[Very briefly review information on influent toxicity.]

Toxic discharges, typically associated with industries discharging into the system, could include metals like copper or zinc, cyanide, high ammonia levels, industrial cleaning chemicals, and so forth.

Sampling and Testing

Sampling satisfies some of the requirements of your facility's NPDES Permit. Additionally, these tests are used for process control; tests are done to ensure proper performance of the facility. The results are used to make changes to obtain better treatment removal. Most facilities test daily or several times per week.

[Very briefly review information on sampling and testing.]

Microbiological Factors

Remember that physical factors and biochemical factors impact a pond's operation. The third, and final, factor that we will discuss is microbiological factors. This includes bacteria and algae, with which you are familiar, as well as a few other types of microorganisms that are typical to treatment ponds.

[Review the key point, highlighting the importance of understanding that these are natural systems.]

Bacteria

Review the definition of bacteria.

[Point out the general shapes of bacteria depicted in the rendering.]

Aerobic Bacteria

[Review the information on aerobic bacteria; remind students of the aerobic/anaerobic process diagrams of ponds in Unit One and recall how these processes are being reviewed now.]

Anaerobic Bacteria

[Briefly review information on anaerobic bacteria. The information is summarized in the script below.]

To summarize the technical information in this section: Bacteria require oxygen in order to feed on the organic waste. If oxygen in the form of DO is not present, some bacteria can obtain oxygen by breaking apart nitrate molecules. If neither DO nor nitrate is present, some bacteria can obtain oxygen by breaking apart sulfate molecules.

Bacteria are lazy, however, so they will always use dissolved oxygen first if it is available. Dissolved oxygen is already in a form that can immediately be utilized by the bacteria so no additional energy needs to be exerted by the organism, unlike nitrate and sulfate sources.

Algae

Review the definition of **algae**.

Take a moment to think back to Unit 1. Remember that carbon Dioxide (CO_2) is released from the bacterial degradetation of organic wastes. Bacteria, in turn, utilize the DO that is produced by algae. This syymbiotic relationship between aerobic bacteria and algae is vital for a properly performing, healthy treatment pond.

Dissolved Oxygen (DO) is produced as a waste product of photosynthesis during active sunlight hours. DO is used by algae for respiration, however, during night hours.

Phosphorus and Nitrogen are inorganic nutrients that are necessary for algae growth.

[Review the key points on this page and briefly discuss the two types of algae. Remind students that blue-green algae only thrive in conditions which are considered not to be optimal for pond operation, such as low pH and low nutrient levels.]

Why is algae found near the surface of a pond?

[Ans: Algae require oxygen; in typical facultative ponds, oxygen is most plentiful near the surface. Algae also use sunlight in the photosynthesis process.]

Other Microorganisms

Bacteria and algae are quite familiar to most of us. Some other microorganisms that are common to ponds may not be as familiar to you. We will take a few minutes to look at three other groups of organisms. This section will just give you an introduction to protozoa, rotifers, and crustaceans. Let's take a look at their "pictures."

[Review the key point that applies to all diagrams in this section.]

Protozoa

We will be looking at two types of protozoa.

Flagellates

Display Slide 19--Flagellates.

Review the information on flagellates; point out the flagella on the diagrams.

Ciliates

Now see some protozoa that utilize cilia.

Display Slide 20--Ciliates.

[Review the use of cilia for mobility, ingestion, or filtering organic waste.]

Rotifers

Display Slide 21—*Rotifers.*

[Review the information on Rotifers.]

Crustaceans

Display Slide 22—*Crustaceans*.

[Review information on Crustaceans.]

You now know how certain physical, biochemical, and microbiological factors affect the operation of a wastewater pond. The structure of the pond itself must also be considered in order to ensure proper treatment. The next section in your workbook will address some of these structural considerations.

POND MAINTENANCE: 15 minutes

Maintaining Pond Structures

We will briefly describe some of the maintenance functions; watch for these potential problem areas.

[Note that the six areas of pond structures should be covered in approximately ten minutes.]

Headworks

[Very briefly review the headworks information.]

Transfer Piping

Most often, these valves are not needed and might not be used for years. However, if they are not exercised, and then one day are needed, they may not be operational.

[Very briefly review the information.]

Transfer Structures

Another area to maintain is the transfer structure.

[Very briefly review the information on transfer structures.]

Embankments

It is always best to take preventive action to keep erosion from occurring.

[Very briefly review the information on embankments.]

Animal Burrows

[Very briefly review this section.]

Aerator Maintenance

[Very briefly review aerator maintenance information.]

Controlling Vegetation

Controlling vegetation is important for maintaining the pond structure and attaining optimal treatment results.

[Review the definition of ***emergent weeds****; point out pertinent information in this section.]*

[Review the definition of ***suspended vegetation****; discuss the information in the workbook.]*

[Review the definition of ***dike vegetation****; review the bulleted items in this section.]*

Maintaining Operation Logs

The final item that bears mentioning is the operation log with which you are all familiar. Each plant has its own system for tracking operations data, of course, but there are two reasons for recording specific information on a very regular basis.

[Briefly review the information provided in the workbook.]

Every month, every treatment facility sends a report to DEP with the results of all the testing that its NPDES Permit requires.

If tests for process control purposes give undesired results, then certain adjustments will be made to correct the problem. For example, aerator speed or water levels may be adjusted. However, if tests for permit limits are not within the required parameters, a written explanation must also be submitted to DEP in a timely manner.

Unit two is complete. We will discuss typical operating problems in Unit Three. Keep in mind the parameters we have discussed so far, so that you can see how problems develop and can understand how the corrections can lead to a healthier and more efficient treatment process.

[Review the Key Points for Unit 2 – General Operation and Maintenance.]

Exercise for Unit 2 – General Operation and Maintenance

1. Factors that can affect the operation and treatment efficiency of a pond or lagoon include:
   a. physical
   b. biochemical
   c. microbiological
   d. all of the above

2. Hydraulic load is the height in inches of the average volume of wastewater introduced into a pond in one:
   a. hour
   b. day
   c. week
   d. month

3. Water in the winter months can hold nearly twice as much dissolved oxygen (DO) as in the summer.
   a. True   b. False

4. List four biochemical factors that can significantly affect pond operation.

   Answers could include: surface organic load rate, pH, DO, alkalinity, nutrient levels, and influent toxicity.

5. _Aerobic_ bacteria require oxygen for respiration, but _anaerobic_ bacteria do not require oxygen for respiration.

6. Protozoa are classified into two broad groups called _flagellates_ and _ciliates_.

7. The three basic types of vegetation in a pond environment are: _emergent weeds_, _suspended vegetation_, and _dike vegetation_.

8. List five items that should be recorded in your maintenance operation logs.
   a. water temperature and pH
   b. DO
   c. Influent and effluent DOD and TSS
   d. water depth
   e. number of aerators in operation

9. Using the skills you have learned in the preceding units, calculate the surface area, volume, detention time, hydraulic load, and organic load of a pond with the following dimensions, influent BOD, and flow rate:

Surface Length = 200 feet	Average Length = 190 feet	Influent Flow = 15,000 gallons per day
Surface Width = 50 feet	Average Width = 40 feet	Influent BOD = 110 mg/L
	Depth = 5 feet	

SURFACE AREA: Note: in this step, we calculate the entire surface area of the water. The volume calculation in the next step will use the average length and width to account the sloped sides of the pond.

surface area = 200 ft x 50 ft = 10,000 sq ft

$$10{,}000 \text{ sq ft} \times \frac{1 \text{ acre}}{43{,}560 \text{ sq ft}} = 0.23 \text{ acres}$$

VOLUME: Note: to calculate volume, use the average length and average width.

volume = 190 feet x 40 feet x 5 feet = 38,000 cubic feet

convert to gallons: $38{,}000 \text{ ft}^3 \times 7.48 \text{ gallons / ft}^3 = 284{,}240$ gallons

DETENTION TIME:

$$\text{Detention time (days)} = \frac{\text{Pond volume (gallons)}}{\text{Influent flow (gal / day)}} = \frac{248{,}240 \text{ gallons}}{15{,}000 \text{ gal / day}} = 19 \text{ days}$$

HYDRAULIC LOAD:

$$\text{Hydraulic Load} = \frac{\text{Depth of pond (inches)}}{\text{Detention time (days)}} = \frac{60 \text{ inches}}{19 \text{ days}} = 3.16 \text{ inches / day}$$

ORGANIC LOAD: note: a BOD of 110 mg/L is the same as a BOD of 110 lb / million lb of water.

$$\text{Organic Load} = \frac{\text{BOD (mg/L)} \times \text{Flow (mgd)} \times 8.34 \text{ (lb/gal)}}{\text{Area (Acres)}}$$

$$\text{Organic Load} = \frac{110 \text{ lb} \times 0.015 \text{ mgd} \times 8.34 \text{ lb/gal}}{1 \text{ million lb} \times 0.23 \text{ acre}} = \frac{60 \text{ lb}}{\text{day} \times \text{acre}}$$

[The references used in Unit 2 are listed on this page.]

[This page was intentionally left blank.]

UNIT 3: 45 minutes

Display Slide 23—Unit 3: Typical Operating Problems.

In this final unit, we will see how the basic premises and parameters of pond operation come together. Since you are familiar with the treatment processes and the causes and results of poor pond health, this unit will serve as a recap of that information. Therefore, at the end of this unit, you should be able to:

- Identify three potential causes of poor quality effluent.
- Discuss how toxic material in the influent waste flow can result in poor quality effluent.
- Discuss the laboratory testing used to investigate a possible organic overload.
- List two possible reasons for low dissolved oxygen levels in a pond.
- Identify one potential cause of odor from a pond.
- Explain what structural damage could occur from animal burrows and why removing burrows is important.

POOR QUALITY EFFLUENT: 8 minutes

Poor effluent quality is a common problem with treatment ponds and lagoons. The majority of compliance problems are related to excess algae in the effluent that increases TSS and BOD. However there are numerous causes for high biochemical oxygen demand, high total suspended solids, or high ammonia and phosphorous in the effluent. If you look at the chart of problems and solutions on page 2, you will see the causes of poor quality effluent. Let's briefly review the information; it should make sense to you after mastering units one and two.

[Briefly review the problems, things to monitor, and solutions for the following outline headings:]

Aeration Equipment Failure

Organic Overload

High TSS

Page 3 is a continuation of the chart.

[Briefly review the information on poor quality effluent, covered under the headings listed below:]

Light Blockage

Toxic Influent Material

On page 4 you will find the last two sections associated with poor quality effluent. Let's review these topics.

[Briefly review the information on poor quality effluent, covered under the headings listed below:]

Loss of Pond Volume

Short Circuiting

LOW DISSOLVED OXYGEN: 5 minutes

Maintaining proper dissolved oxygen levels within a pond or lagoon is critical to the adequate treatment of the wastewater. Aerobic bacteria require certain levels of DO to remain productive. Some common causes of exceedingly low dissolved oxygen levels in a pond or lagoon include those seen on pages 5 and 6 of your workbook. We will review those now.

[Briefly review the following sections:]

Low Algae Growth

Excessive Scum Accumulation

Aeration Problems

[Finish reviewing the chart on page 6, including the following headings:]

Organic Overload

What do you think will be accomplished when we suggest that running ponds in parallel mode rather than series mode may be a solution to the organic overload problem?

[Ans: As an example, imagine two identical ponds that can be run either in parallel or series. By running the two ponds in parallel as opposed to series operation, several operating parameters change:

- *The volume is doubled because the flow is split into two ponds instead of one, which is twice as large of a volume.*
- *The detention time is cut in half because the flow, however, only travels through one pond instead of two, which takes half of the time.]*

Parallel operation allows the organically overloaded wastewater to be "spread out" over two ponds instead of just one; in the Organic Loading Rate formula in Unit 2, the denominator, Acres, is doubled in parallel operation.

Short Circuiting

ODORS: 2 minutes

Typically, aerobic and facultative ponds require very little odor control if they are designed and operated properly. The most common problem with odor comes from anaerobic conditions in the pond. On page 7, you will see some problems, monitoring techniques, and solutions associated with odors.

Anaerobic conditions

"Spring or Fall Turnover" is a natural pond phenomenon which occurs primarily due to the seasonal temperature changes in the surface waters. There is a complete mixing of the pond strata during a turnover which can release odors from the bottom sludge blanket if the sludge becomes disturbed.

Any condition that creates an excessive organic loading to the pond has the potential to create odor problems. Excessive organic loading exerts additional dissolved oxygen demands on the pond and, if the DO is used up then, anaerobic conditions develop that lead to odor issues. Algae die-off, organic overloading, and scum accumulation all create additional organic loading and can produce offensive odors.

Hydrogen Sulfide

Whether you know it or not, you are probably familiar with one of the problems associated with Hydrogen Sulfide. Does anyone know what it smells like?

[Ans: It emits that classic "rotten egg" smell.]

[Very briefly note the information in this chart.]

FALLING LIQUID LEVELS: 4 minutes

A desired water level for a pond or lagoon should be established to optimize treatment efficiency. Keep records to track the water level in order to establish a normal operating range for your site. Several actions can cause the water level to drop significantly. Let's look at the chart on page 8.

Leakage of Levees

Bentonite clay is one alternative to use when repairing a levee leak. Bentonite (sodium bentonite with hydratable colloids) is naturally occurring clay that swells as water enters between its clay platelets, allowing it to absorb 5 times its weight in water. Bentonite will occupy a volume 12-15 times its dry weight at saturation. It will lower the permeability of the soil and form an impermeable water barrier upon wetting.

[Briefly review the information contained in this chart.]

ANIMAL BURROWS: 2 minutes

Animals, such as muskrats, find treatment ponds and lagoons to be attractive habitats. Burrowing animals must be removed promptly, and their burrows should be repaired immediately. Let's look at the chart on page 9.

[Briefly review the chart on page 9.]

EXCESSIVE VEGETATION: 4 minutes

Vegetation and weeds will overrun the pond embankments if left unattended. Excessive vegetation can have a detrimental effect on pond treatment efficiencies, as well as causing a safety hazard to staff. Embankment vegetation should always be properly maintained for ease of access to the pond.

You should recall that we learned about the three types of vegetation in unit two. Let's look at page 10 in your workbook for some solutions to vegetation problems.

[Briefly review the chart on page 10.]

[Review the Key Points for Unit 3 – Typical Operating Problems.]

☑ Exercise for Unit 3 – Typical Operating Problems

1. Malfunctioning or inadequate aeration equipment can result in low levels of dissolved oxygen (DO) and poor effluent quality.
   a. True
   b. False

2. The addition of the chemical _copper sulfate_ can help to settle algae out of the effluent.

3. It is suspected that a toxic substance has been discharged into the collection system. List three things to monitor in the influent water.

   a. Influent pH
   b. Influent DO
   c. Influent Temperature

4. The build-up of a sludge blanket on the bottom of a pond will lessen the capacity of the pond. It may be necessary to dredge the pond after a period of several years of operation.

5. A possible solution mentioned for many of the problems in the table is to recirculate part of the effluent flow back into the _influent_ flow.

6. Explain in an example how the recirculation solution mentioned above can help solve a pond problem. One example would be to increase DO, since effluent usually has a higher DO than influent.

7. Running ponds in _parallel_ mode may be a solution if _organic_ overload is the suspected problem.

8. List three examples of problems that may produce odors.

   a. anaerobic conditions
   b. presence of hydrogen sulfide
   c. Spring/Fall turnover, algae die-off, organic overloading, poor pond circulation, scum accumulation on pond surface, insufficient sludge.

9. List three problems or hazards that may be caused by burrowing animals.

   a. structural stability
   b. tripping hazard
   c. equipment damage

10. Explain how the choice of ground cover on a dike can make the maintenance of the dike easier. Can eliminate other undesirable growth, make mowing easier, a low-growing ground cover may improve general appearance.

[Thank the participants for attending the class. Ask if there are any questions concerning the material covered.]