CHAPTER 9

OPERATION AND MAINTENANCE

9.1 INTRODUCTION
The information presented in this chapter covers various topics related to operations and maintenance, including control testing, safety, troubleshooting and optimizing operations of a pond system. Much that has been written on these topics in the past 30 years remains valuable, but may not be readily available. This chapter summarizes much of that information and brings it up to date. It introduces the basic tools used to monitor an operating pond treatment system and provides guidance when the system does not seem to be functioning as designed. See also Appendices E (Troubleshooting) and F (Wisconsin Department of Natural Resources Study Guide *Introduction to Advanced Stabilization Ponds and Aerated Lagoons* (www.dnr.wigov/org/es/science/opert/doc).

9.2 TERMINOLOGY

9.2.1 Basic Nomenclature
A pond system is typically a number of earthen basins connected together to treat raw wastewater.

9.2.2 Types of Pond Systems

9.2.2.1 Anaerobic Ponds
Anaerobic pond cells receive such a heavy organic loading that there is no aerobic zone.

9.2.2.2 Facultative Ponds
Facultative pond cells are 1.2-2.4 m (4 - 8 ft) deep with an aerobic surface layer and an anaerobic bottom layer.

9.2.2.3 Aerated Ponds
The O_2 in the aerated pond cells is supplied or supplemented by surface mechanical or diffused aeration equipment.

9.2.3 Flow Configuration
Pond systems can be operated either in series or parallel.

9.2.3.1 Series
In series operation the influent wastewater flows into the primary cell, then to the secondary cell and finally to the polishing cell before being discharged.

9.2.3.2 Parallel
In parallel operation, the operator has the option of splitting the flow. This is usually done in equal parts between the first two cells. Facultative ponds are commonly operated in parallel under winter conditions. As water temperatures drop, biological activity is reduced and the primary cell of a facultative pond system can become organically overloaded. To prevent this,

the flow is sent to the first two cells at the same time, which reduces the organic load to each one. As water temperatures warm up in spring, biological activity increases, and the flow regime can return to series operations.

9.2.3.3 Recirculation

The operational flexibility to recirculate wastewater in a treatment plant or pump back treated wastewater from the end of the process to the first series of cells can be used to great advantage. The operator can introduce treated wastewater with a higher dissolved O_2 concentration into the first series of cells that have a higher organic loading. Recirculation also tends to smooth out the performance of the system. Entering flow varies significantly over 24 hours, and recirculation can create a more uniform flow rate.

9.3 CONTROL TESTING INFORMATION

For a facility to be consistently in compliance with discharge permit requirements, adequate process controls must be in place. The influent quantity and quality should be monitored on a regular schedule to provide the information needed to treat the wastewater stream adequately and operate the facility properly. It is also necessary to monitor the processes within the system in order to solve any effluent water quality problems. The influent, the internal pond processes and the plant effluent should be evaluated on a regular basis.

The wastewater must be analyzed for a number of water quality parameters. Typical tests and measurements include flow, temperature, *p*H, DO, BOD_5, soluble BOD_5 ($SBOD_5$), $CBOD_5$, TSS, NH_3, P, coliform (fecal or total) and chlorine (Cl^-) residual. The results of these tests are used to determine whether the treatment process is reducing the wastewater contaminants and to predict the impact of potential operational changes. Some of the tests can be performed with basic equipment (flow, temperature, *p*H, DO and Cl^- residual) and some require more time, specialized equipment and technical expertise (BOD_5, $SBOD_5$, $CBOD_5$, TSS, NH_3 and coliform). The operator of a small pond system may elect to collect samples for these tests and have a commercial lab complete some of the analyses. (U.S. EPA, 1977a).

All system operators will need to review the facility discharge permit to determine sample parameters to be tested, sample type, location and frequency needed to meet permit compliance. Operators of systems that have a controlled discharge will need to perform tests during the period prior to and during discharge as required by the regulatory agency. Those systems operating on a hydrograph controlled release discharge basis must monitor the treatment plant process and the quantity and quality of both the effluent and the receiving stream.

9.3.1 Sample Collection

Samples collected for analysis must be representative of the water being tested, which requires that they be taken at a location where the wastewater is well mixed and not subject to short circuiting. If the sample is to be stored before testing, it must be refrigerated. Sample containers must always be cleaned to method specifications before sampling to avoid confounding the results with background contamination. Temperature, *p*H, Cl^- residual and DO should always be taken in the field to prevent false readings and should be taken at the same time each day. These parameters should be measured at other times of the day from time to time to gain an understanding of the changes that occur throughout the day.

9.3.2 Types of Samples

9.3.2.1 Grab

Grab samples, taken at no set time or flow, are used to measure temperature, *p*H, DO, fecal and total coliform and Cl^- residual. As raw sewage flow varies in content, as well as volume, over the course of the day, samples taken at sunrise and in mid-afternoon and analyzed separately will yield the most information. Grab samples of effluent from controlled discharge ponds should be taken during discharge, perhaps one sample every two hours, but then should be combined into one composite sample (see Section 9.3.2.2). The operator should review state guidelines for specific information.

9.3.2.2 Composite Samples

9.3.2.2.1 Volumetric Composite

A volumetric sample is taken by collecting individual predetermined sample volumes at regular intervals over a selected period of time, usually using a sampling device designed for this purpose (see Section 9.3.3). The samples must be refrigerated. They are then mixed together and considered to be a representative sample for whatever analysis is being performed.

9.3.2.2.2 Flow Proportional Composite

A flow proportional composite is taken by collecting individual samples at regular intervals over a selected period of time. A flow measurement is taken and recorded at the time the individual sample is collected. All samples must be refrigerated. At the end of the sampling period, each sample is stirred and an amount that is proportional to the flow at the time the sample was taken is poured into the composite container.

9.3.2.2.3 Automatic Samplers

There are numerous types of automatic samplers on the market. Some are self-contained with battery packs while others must have an external power source. They take samples at chosen intervals, some as frequently as every 10 minutes, and composite the samples as they are collected. The samplers can be connected to existing flow measuring devices or may have built-in flumes that deliver flow-proportional composite samples. This equipment is most useful for sampling raw wastewater flow, but can be used for effluent as well.

9.3.3 Handling and Preservation of Samples

Sewage samples rapidly undergo biochemical changes if they are subjected to summer temperatures or freezing temperatures or if exposed to sunlight. Thus, collected samples should be transferred as soon as possible to a refrigerator. Keeping samples at a temperature of 4 °C reduces post-collection biochemical changes for 24 hours. Samples taken for bacterial analyses should be collected separately and analyzed or sent to a laboratory for analysis within 30 hours of collection (http://www.epa.gov/OGWDW/methods/methods.html).

Containers used for sample storage should be as clean as required for the specified method analysis. Stoppered glass bottles or wide-mouthed jars are preferred and are easiest to use for mixing and cleaning. Bacterial samples should be collected in sterile containers.

9.3.4 Sample Point Locations

9.3.4.1 Pond Influent

Samples of the raw wastewater can be collected at the wet well of the influent pump station, a manhole at the inlet diversion control structure, or the influent headworks.

9.3.4.2 In Pond

Pond composite samples should consist of four equal portions taken from four corners of the pond. The sample should be collected 2.4 m out from the water's edge and 0.3 m below the water surface or at the transfer structures between the cells if these are present. Care should be taken to avoid stirring up material from the pond bottom and should not be taken near mechanical aerators or during or immediately after high wind or strong storms, as these processes may stir solids into the water column.

9.3.4.3 Effluent

Effluent samples can be collected from the final cell outlet structure or at a well-mixed location in the outfall channel prior to mixing with any dilution waters such as the receiving stream waters.

9.3.5 Tests and Measurements

Test results, along with visual indicators, are used by the operator to evaluate whether the pond is in discharge permit compliance. The following sections describe the tests.

9.3.5.1 Temperature

The temperature of the influent wastewater can be used to detect inflow and infiltration (I&I) and some industrial wastes. A sudden increase in temperature may indicate the presence of warm industrial wastes. On the other hand, influent temperatures may cool rapidly in late fall and early winter. In one case, an investigation of the collection system revealed that owners of poorly insulated homes were bleeding their internal plumbing systems to prevent freezing of the pipes. This cold water diluted the influent sewage strength and cooled the temperature, which reduced the ability of the system to treat the waste.

Temperature can also be used to predict treatment efficiency and mode of operation (parallel or series) and estimate the necessary HRT. As influent water temperature cools, a facultative pond system may need to be changed from series to parallel operation to reduce organic loading to each cell. A mechanically aerated pond system subject to cooler ambient temperature may need to have all cells in series operation to obtain the correct HRT for continuous permit compliance. Conversely, as influent water temperature increases, a facultative pond system may need to be changed from parallel to series operation. The operator of a mechanically aerated pond system may choose to remove an individual cell from operation to reduce the overall HRT and prevent a possible algal overgrowth condition.

9.3.5.2 Flow

Keeping a record of accurate flow measurements is essential for successful operation and control and troubleshooting pond systems. Influent flow measurement can be used to detect I&I

problems, determine the HRT of a cell, calculate the organic loading to a cell, provide data for determining mode of operation and calculate appropriate chemical dosages. Effluent flow measurement is a requirement of the discharge permit and can be used to calculate chemical dosage needed for disinfection. Most states require both influent and effluent flow measurement to determine the extent of infiltration and/or exfiltration from the cells, depending on the distance of the system to groundwater.

9.3.5.3 *p*H Value

Large fluxes in influent *p*H may signal an industrial and/or septic waste problem. The range of *p*H for normal domestic influent waste is 6.8 - 7.5, depending on alkalinity and hardness of the water. The *p*H is a good indicator of the health of the pond system. Pond cells that have a dark green color generally have a high number of green algae and a corresponding higher *p*H. Algae take up CO_2 in the photosynthetic process. If CO_2 is not available, the algae will utilize a carbon source from the HCO_3^- alkalinity, which drives up the *p*H to 9.5 or above. At night, both the algae and aerobic bacteria utilize O_2 and produce CO_2. The CO_2 in solution forms carbonic acid (H_2CO_3) and drives the *p*H down. These diurnal *p*H patterns are indicators of internal pond conditions. Pond cells that appear black or gray in color and have a decreasing *p*H value (< 6.8) may be septic or moving toward a septic condition.

9.3.5.4 Dissolved Oxygen

Dissolved oxygen is an essential indicator of aerobic biological activity. The DO test is performed on a grab sample and must be performed immediately. The easiest method for analyzing for DO is with a portable meter. The test should be performed at sunrise and again around 2 - 3 p.m. Large fluctuations in the primary cell may signal problems with the influent, such as shock loading or toxic waste problems. Some fluctuation in day-to-day DO in the pond system is expected. The operator should plot daily readings and identify trends in concentrations. A decreasing trend in DO in the early morning test may indicate an increasing organic load, a developing short-circuiting problem or an algal overgrowth problem. All measures should be taken to avoid the DO concentration dropping to zero. This will cause incomplete treatment of the wastewater and will result in discharge permit violations. The operator may have to take corrective action, such as increasing aerator running time or aeration capacity or switching to parallel operation. An increasing trend in the DO concentration, on the other hand, may allow the operator to decrease aerator running time or switch from parallel to series operation.

9.3.5.5 Dissolved Oxygen Profile

A DO profile is developed by taking a series of DO measurements at 0.3 m increments from top to bottom on an individual cell. An informal grid system is established to ensure uniform coverage of the cell (Figure 9-1). This test is best performed by two people for safety reasons and data recording needs. A boat and a portable temperature-compensating DO meter with a long probe are required. The probe should be marked off in 0.3 m increments from the tip of the probe to a length that will allow the operator to have the probe touch the bottom of the cell from the boat. The water depth at which the probe goes slack should be recorded.

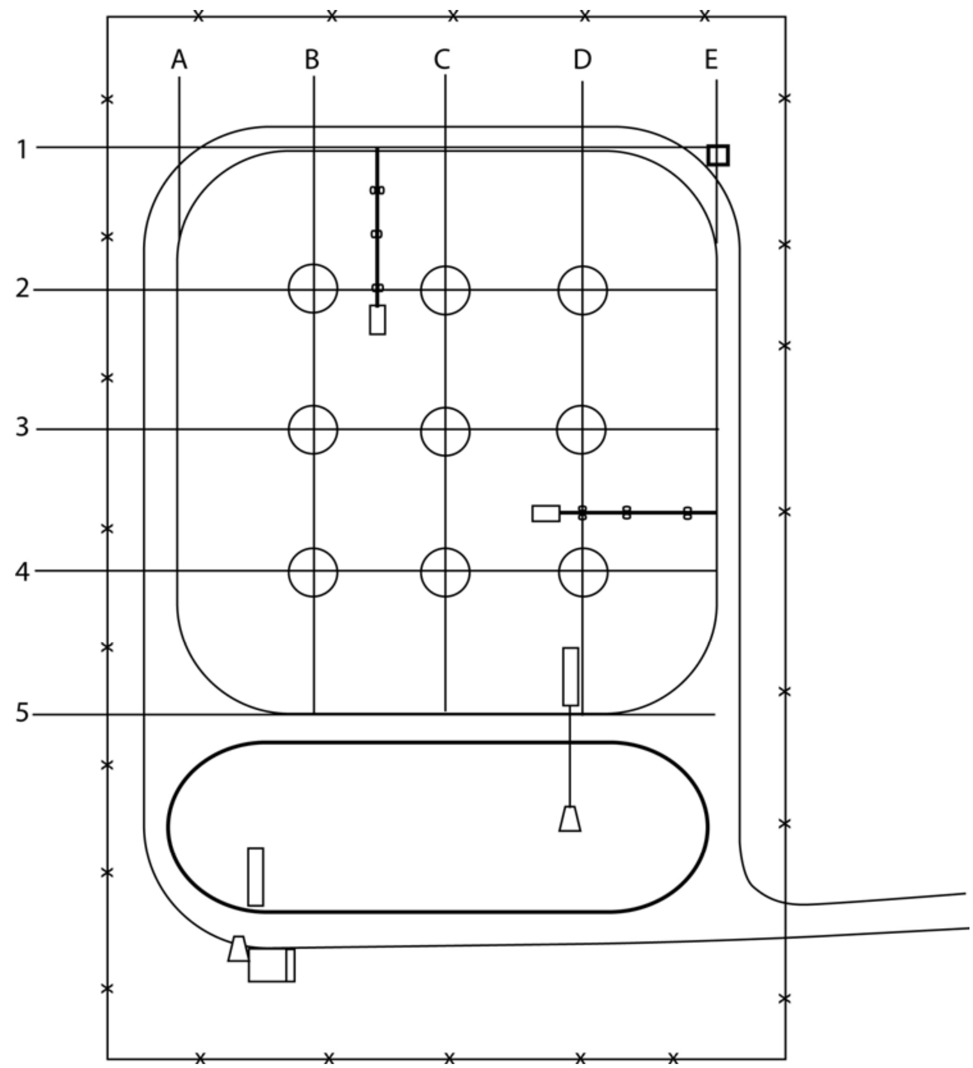

Figure 9-1. Sampling grid system (Richard and Bowman, 1991). Sampling points are located where lines with letters and numerals intersect.

This test allows the operator to determine if there is a DO deficit during evening hours when O_2 depletion is greatest due to biological activity. The test will also indicate if the pond is completely mixed or stratified; identify areas of low DO or dead spots; draw attention to short circuiting; and help define bottom pond contours and areas of possible sludge build-up. The test should be performed just as it is getting light. As is seen in Figure 9-2, the lowest O_2 reading is noted just prior to sunrise. Once it is daylight, the algae photosynthesize, which may become a supersaturated DO condition in early afternoon. As light intensity lessens and photosynthetic activity diminishes, O_2 is depleted. During the night, if the DO level in the ponds drops to zero, aerobic decomposition of organic matter stops, causing incomplete treatment. This can lead to BOD_5 permit violations.

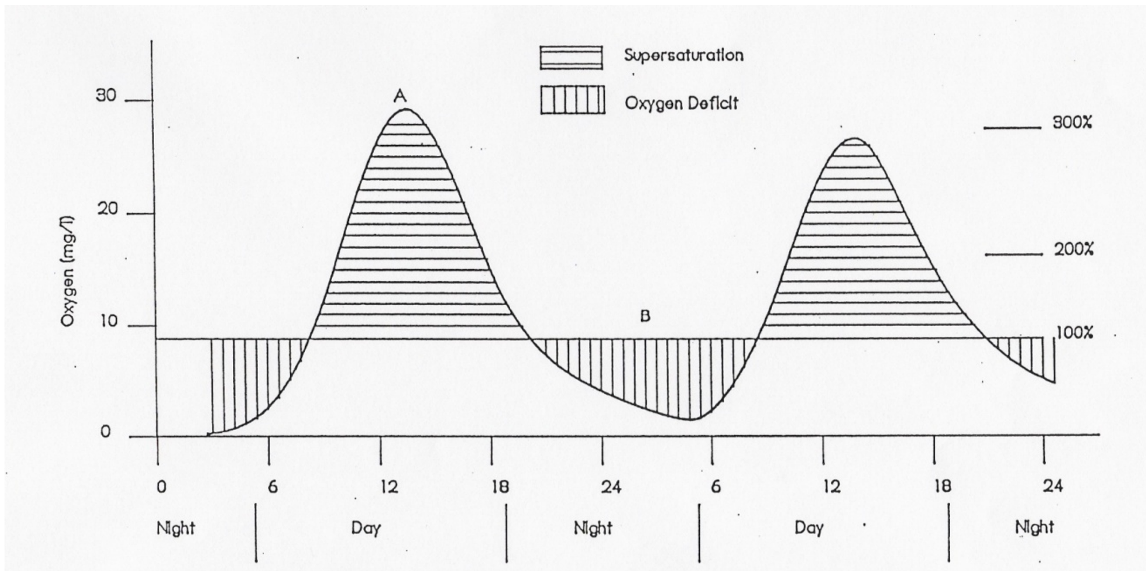

Figure Diurnal Oxygen Concentration in a Lagoon.
NOTE: The graph indicates that the lowest dissolved oxygen levels occur early in the morning due to the aerobic bacteria and algae utilizing oxygen during the night. The highest dissolved oxygen level is late in the afternoon due to algal photosynthesis. It is likely the aerators must run more at night to compensate for the algae metabolizing oxygen. It is important to insure proper aerator operation during the day for adequate mixing and to eliminate potential stratification.

Figure 9-2. Diurnal O_2 curve (Richard and Bowman, 1997).

9.3.5.6 Chlorine Residual

The Cl^- residual test determines the amount of Cl^- present after the detention time for disinfection (to destroy fecal coliform) has been met. The general rule is that there should be 0.5 mg/L remaining after a contact time of 1 hour. This grab sample must be tested immediately. The operator should review the National Pollution Discharge Elimination System (NPDES) permit, as some states may not require disinfection. Some states may designate a prescribed coliform minimum, and some may require dechlorination after disinfection.

9.3.5.7 BOD_5

The BOD_5 test measures the amount of O_2 used (depleted) by the microorganisms in metabolizing the organic material in a sample of wastewater. It is an indirect measurement of the relative organic strength of a sample. The test is performed over five days in a controlled environment. The sample is placed in an incubator at 20 °C with no light or additional O_2. The test is used to determine the influent wastes organic strength, calculate the organic loading to the pond system or an individual cell, make decisions about operational changes and determine whether the effluent is in compliance with the discharge permit.

The BOD_5 test can be misleading if there is a high concentration of algae in the effluent discharge. The BOD_5 test is an O_2 depletion test that is run in the dark. When algae are in the dark for long periods of time they cannot photosynthesize and will instead use O_2. The up take by the algae also reduces the O_2 concentration at the end of the five-day period. The result is a calculated BOD_5 value that is higher than it would be if it measured the organic loading from wastewater alone.

9.3.5.8 Soluble BOD_5

For this test, the BOD_5 sample is filtered using a 0.45 µ filter before the test is run. The filter should be observed for any obvious change and the color noted. The filtrate is then prepared in the same way and run at 20 °C, in the dark. It is recommended that a standard BOD_5 test and a soluble (filtered) BOD_5 test be run at the same time and the results compared. This is a valuable troubleshooting tool that will be discussed in Section 9.3.6.

9.3.5.9 Carbonaceous BOD_5 ($CBOD_5$)

It has long been recognized that ponds will nitrify (convert NH_3 to NO_3^-) under certain conditions. This process uses approximately 1.8 kg O_2 per 453 g of NH_3 converted to NO_3^- and approximately 4.1 kg of alkalinity per 453 g NH_3 converted NO_3^- (see Section 1.3.4.5 for a discussion of alkalinity). The nitrification process will continue in the BOD_5 bottle causing a higher BOD_5 test result. To compensate for this nitrogenous BOD in effluent BOD_5 testing, a $CBOD_5$ test can be substituted for the BOD_5 test. A $CBOD_5$ test is a BOD_5 test with inhibitor added to prevent O_2 depletion due to nitrification. To compensate for nitrification effects, regulatory agencies may allow operators to amend the discharge permit to substitute a $CBOD_5$ effluent limit for the BOD_5 parameter.

9.3.5.10 Suspended Solids

The suspended solids (TSS) test measures the dry weight of solids retained on a glass fiber or Millipore™ filter and is expressed in mg/L. Equipment required for this test includes a drying oven, a desiccator and a weighing balance. Tests must always be run on composited samples from both the influent and effluent.

Suspended solids removal is as important as BOD_5 removal in preventing stream pollution. In normal domestic sewage, the concentration of TSS and BOD_5 are similar. The origin of the suspended solids in the influent is not the same as in the effluent, however, as the former comes from the sewage, while the latter from algae growing in the final pond. As a result, the TSS may be higher than the BOD_5 in the effluent from pond systems.

9.3.5.11 TSS to BOD_5 Ratio

Effluent BOD_5 violations are often accompanied by high effluent TSS concentrations. Table 9-1 presents TSS to BOD_5 ratios that may indicate the cause of violations.

Table 9-1. TSS to BOD_5 Ratios as Problem Indicators (Richard and Bowman , 1997).

TSS to BOD_5 Ratio	Cause(s)
<1	old sludge solubilization and release of soluble BOD_5 nitrification in the BOD_5 test bottle
1	poor treatment or short circuiting with untreated wastewater mixing with the effluent
1.5	normal for most pond systems
2.0-3.0	algal overgrowth loss of old sludge particles

9.3.5.12 Microscopic Solids Analysis

The microscopic solids analysis is a test performed with samples from each pond cell taken at the transfer point and the final effluent before chlorination (Richard and Bowman, 1991). This requires the microscopic examination of fresh pond samples using a phase contrast microscope capable of achieving a total magnification of 1000X. Solids types present and their relative abundance are measured. Solids type categories include: (1) raw wastewater or sludge solids; (2) treatment solids (bacterial flocs); (3) filamentous bacteria; (4) sulfur bacteria; and (5) algae. These solids types are easily recognized with a little experience (Richard and Bowman 1997). The significance of these solids types is listed in Table 9-2.

Table 9-2. Problems Associated with Types of Solids (Richard and Bowman 1997).

Solids Type Present	Indicated Problem (s)
Raw wastewater solids	short-circuiting poor aeration and improper waste stabilization
Old sludge particles	sludge buildup and need for sludge removal
Treatment solids (bacterial flocs)	organic overloading or sludge accumulation
Filamentous bacteria	indicators of low oxygen conditions or septicity
Sulfur bacteria	anaerobic conditions and sulfides
Algae	algal overgrowth

9.3.5.13 Soluble and Total BOD_5

The difference between these two values is the amount of particulate BOD_5 present. A typical domestic wastewater contains 40 percent soluble and 60 percent particulate BOD_5. The soluble BOD_5 is rapidly removed in wastewater treatment and it is unusual to see a soluble BOD_5 in the effluent that is greater than 20 percent of the total. A particulate BOD_5 value greater than 70 percent of the total BOD_5 in the effluent indicates a solids loss problem. The microscopic examination is then used to identify the types of solids being lost (Richard and Bowman, 1997).

9.3.5.14 Microbial Tests

The coliform and other microbial tests (total and fecal coliform, *E. coli* and enterococci) indicate the possible presence or absence of pathogens (human disease-causing organisms). The sources of this group of organisms are the excreta of man, mammals, and birds. Tests are always run on grab samples collected in a sterile container. Recent regulations regarding which test method may be used for a particular discharge requirement may be found in the [Federal Register notice of 3/26, 2007 (http://www.epa.gov/fedrgstr/EPA-WATER/2007/March/Day-26/w1455.htm)].

9.3.5.15 Nitrogen

Wastewater contains organic N (protein) and NH_3. Organic N is converted to NH_3 by bacteria as protein is broken down. The NH_3 is further oxidized to $NO_2^{=}$ and then to NO_3^- by nitrifying bacteria. This latter step is called nitrification. In some cases, it is necessary to remove NO_3^- in order to control algal growth. Oxygen is removed under anaerobic conditions (NO_3^- is a source of O_2 for the anaerobic bacteria), and NO_3^- is reduced to nitrogen gas (N_2). This is the denitrification step.

Ponds will nitrify and produce low effluent NH_3 concentrations under certain conditions, particularly in the warmer months of the year. As wintertime cools the wastewater temperatures, longer HRTs are required to reduce both $CBOD_5$ and nitrogenous BOD_5. Ultimately, nitrification will cease at approximately 5 - 8 °C. In colder climates, ponds cease to nitrify and will actually produce NH_3 in the wintertime and early spring. Installation of floating insulated covers may extend the period of time a pond system will nitrify NH_3.
Low DO and low alkalinity can also limit nitrification. Typically, DO levels of 2.0 mg/L are required to optimize nitrification. Total carbonate (CO_3^{2-}) alkalinity of less than 60 mg/L usually limits nitrification. Nitrification can be increased or prolonged by raising the DO level in the pond and increasing the alkalinity by adding an inorganic *C* source such as lime.

9.3.6 Important Visual and Olfactory Observations

Operators' visual and olfactory observations are important pond troubleshooting tools. Color and odor can be important indicators of pond health and ability to meet discharge permit standards (Table 9-3).

Table 9-3. Important Indicators in Pond Troubleshooting (after Richard and Bowman, 1991).

Pond Appearance	Odor	Microscopic Observation	Problem	Solution
Clear	None	Little suspended material	None	None
Brown	Earthy	Small bacterial flocs	None; usually good operation	None
Grey-black floating sludge gas bubbles on pond surface	Septic-sewage	Precipitated sulfides in flocs; often filamentous sulfur bacteria	Organic overloading; low dissolved oxygen; influent sludge short circuiting	Increase aeration capacity, add baffles or additional cells, improve inlet-outlet design recirculation, remove sludge accumulation
Green	Grassy or earthy	Green algal bloom	Algal bloom, pH often >9; long detention time; organic under-loading	Recirculate; addition of a settling pond, land discharge
Floating mats of blue-green algae	Fishy	Blue-green bacterial bloom	See above	Remove cells from operation, decrease water depth to decrease HRT; CAUTION: MAY INCREASE ALGAL BLOOM
Red streaks	None or septic	High amounts of *Daphnia*	*Daphnia* overgrowth, often after algal bloom	Increase aerator running time, recirculate
Entirely red or pink	Septic (rotten egg odor)	Sulfur bacteria (*Chromatium* spp.)	Anaerobic; gross organic overloading and under aeration.	Increase aerator running time or increase aeration capacity, recirculate

9.3.7 Other Data

9.3.7.1 Weather

Weather plays a major role in an operator's ability to meet discharge permit requirements for a pond system consistently. The operator should keep a daily journal or log of periods of sunshine, cloudiness, air and pond temperature, precipitation (rain or snow levels should be recorded), and percentage of the individual cells that are ice covered. Prolonged periods of cloudiness may increase the effluent BOD_5 and require the operator to make a change from series to parallel operation in a facultative pond system. In an aerated pond system, the operator may be required to increase aerator running time to insure discharge permit compliance.

9.4 OPERATION AND MAINTENANCE FOR PONDS

The following sections are summaries from the Operations Manual: Stabilization Ponds, 1977, Office of Water Program Operations, U.S. EPA, Washington D.C. Another source of information about O&M for ponds is the Office of Water Programs at California State University, Sacramento, which offers training manuals and distance education courses for operators and managers on the safe operation and maintenance of wastewater collection systems, wastewater treatment plants, and utility management. Operations and maintenance of wastewater treatment ponds is found in *Operation of Wastewater Treatment Plants*, Volume 1, Chapter 9 (Kerri, 2002). To obtain more information about the program or to order the training manual, which is available in English and Spanish, go to the website at www.owp.csus.edu.

9.4.1 Operation and Maintenance Guidelines for Anaerobic Ponds

9.4.1.1 Anaerobic Ponds

A well-operating anaerobic pond is covered entirely with a dense scum blanket which helps to keep the pond anaerobic and minimizes foul odors.

9.4.1.2 Important Operation Considerations

- Keep the pond *p*H at or near neutral (*p*H = 7).
- Control odors by maintaining zero mg/L DO and a heavy scum blanket.
- Keep records of flow, HRT, *p*H, BOD_5 and TSS.
- Include information on volatile acids, scum and sludge depth.

9.4.1.3 On-site Attendance

Maintaining an aerobic pond in good condition requires full-time operator attention. These activities should be performed on a daily basis, on a regular schedule and as needed:

- Maintain mechanical equipment
- Keep pipelines, diversion boxes and screens clean
- Collecting samples
- Run lab tests
- Perform housekeeping

9.4.2 Operation and Maintenance Goals for Facultative Ponds

9.4.2.1 Pond Effluent Compliance Conditions

The pond effluent should:

- Meet the NPDES or other regulatory permit levels for BOD_5 and TSS for continuous flow systems.
- Discharge when the effluent has the best quality and will least affect the receiving stream.
- Have a deep green sparkling color in the primary pond.
- Have high DOs in the secondary or final cells.

9.4.2.2 Wave Action

The surface water should have wave action when wind is blowing. The absence of good wave action may indicate anaerobic conditions or an oily surface.

9.4.2.3 Maintenance

General maintenance guidelines:

- To maintain wave action, a pond should be free of weeds in the water or tall weeds on the banks.
- Dikes should be well seeded with grasses above the water line. Grass should be mowed regularly to prevent soil erosion and insect problems.
- Riprap, broken concrete rubble or a poured concrete erosion pad should be placed at the water's edge to prevent erosion of dikes.
- Inlet and outlet structures should be cleaned regularly to remove any floating debris, caked scum, or other trash that might produce odors or be unsightly.
- Mechanical equipment should be maintained according to a regular schedule. Maintenance records should be kept and be readily accessible.
- All pond operations should be listed on a posted schedule. The plant records should include weather data and basic test results such as flow, *p*H, DO, BOD_5, TSS and chlorine residuals.

9.4.3 Operation and Maintenance Goals for Aerated Ponds

In the past, many of the facultative pond systems were converted to aerated pond systems by the addition of mechanical aeration. This allowed the hydraulic and organic loading rates to increase, but caused many operational problems. Cell depths remain shallow (1.2 - 1.8 m and HRTs were typically lower than those used in facultative ponds, but greater than those used in aerated pond systems. Some problems were caused by the surface aerators mixing too deeply and scouring the bottom of the cells, compromising the integrity of the liners. The shallow depths and longer HRTs promoted algal overgrowth, making it difficult to meet discharge permit requirements in the summer months.

Aerated ponds require the same daily inspections and maintenance as any other treatment ponds. In addition, special attention must be paid to the aeration equipment. The following are minimal guidelines:

- Maintain a minimum of 1 mg/L DO throughout the pond at heaviest loading periods.
- Run the system so that surface mechanical aerators produce good turbulence and a light amount of froth.
- Monitor DO at aerated cell outlet daily.
- Keep large objects out of the pond to prevent damage to the aerator.

For diffused air systems that use a blower and pipelines to diffuse air over entire bottom of pond:

- Check the blower daily.
- Visually inspect the aeration pattern for dead spots or dead lines.
- Check for ruptures and repair them if necessary to maintain even distribution of air.
- Measure DO at several locations in the pond weekly and adjust air to maintain even distribution.

Periodic maintenance, such as lubrication, adjustment and replacement of parts, must be performed on a regular basis. A checklist of maintenance tasks and frequency, taken from the manufacturer's instructions bulletins, should be available and activities relating to maintenance recorded in a log book.

9.4.4. Pond System Checklist

A checklist is a handy tool for the operator to schedule activities. Most of the items are visual observations or maintenance needs that take little time if performed according to a regular schedule. Over time, the operator will develop ways to combine some of the duties. In many installations that are overseen regularly by a conscientious operator, the scheduled tasks can be accomplished in one to two hours a day, allowing the balance of the time to be used to complete laboratory work and other duties.

Table 9-4 is a sample O&M checklist for pond operation. Although it is not a complete list of everything the operator should be observing, it will serve as a guide for setting up a regular schedule and as a daily reminder. The schedule will help the operator organize work in a step-by-step fashion, which will also help operators coming on in relief during an emergency or new personnel who are not familiar with the system. The design engineer should develop a checklist for the system that is included in the O&M manual.

Table 9-4 Example Operation and Maintenance Checklist.

Operation and Maintenance	Frequency						
	Daily	Weekly	Monthly	3 mos.	6 mos.	Yearly	As Needed
Plant Survey							
Drive around perimeters of ponds taking note of the following conditions:							
Any buildup of scum on pond surface and discharge outlet boxes		x					
Signs of burrowing animals	x						

Operation and Maintenance	Frequency						
	Daily	Weekly	Monthly	3 mos.	6 mos.	Yearly	As Needed
Anaerobic conditions: noted by odor and black color, floating sludge, large number of gas bubbles	x						
Water-grown weeds	x						
Evidence of dike erosion	x						
Dike leakage	x						
Fence damage	x						
Ice buildup in winter						x	x
Evidence of short-circuiting	x						
A review of the information obtained from the observations should be included in the next year's planning activities.							
Plan, schedule, and correct problems found. Use troubleshooting section of this manual for information.						x	
Pretreatment							
Clean inlet and screens, and properly dispose of trash.	x						
Check inlet flow meter and float well.	x						
If discharge is once or twice per year, the discharge permit may require observations of the following:							
Odor		x					
Aquatic plant coverage of pond		x					
Pond depth		x					
Dike condition		x					
Ice cover		x					

Operation and Maintenance	Frequency						
	Daily	Weekly	Monthly	3 mos.	6 mos.	Yearly	As Needed
Flow (influent)	**x**						
Rainfall (or snowfall)	**x**						
Note: *Each state has requirements for data collected prior to and during discharge that are defined in the pond system discharge permit.*							
If discharge is continuous, the discharge permit may require the following information:							
Weather	**x**						
Flow	**x**						
Condition of all cells	x						
Depth of all cells	**x**						
Pond effluent:	**x**						
DO and *p*H grab sample	x						
Cl^- residual	x						
BOD_5 and TSS run on composited sampled							x
Microbial tests							x
kg (lb) of Cl^- used and remaining	x						
Other tests and frequency information will be defined in the individual permit.							
Mechanical Equipment							
Check mechanical equipment and perform scheduled preventive maintenance on the following pieces of equipment according to the manufacturer's recommendations:							
Pump stations:							
Remove debris	**x**						
Check pump operation	**x**						
Run emergency generator		**x**					
Log running times	**x**						

Operation and Maintenance	Frequency					
	Daily	Weekly	Monthly	3 mos.	6 mos.	Yearly	As Needed
Clean floats, bubblers, or other control devices		x					
Lubricate							x
Comminuting devices:							
Check cutters		x					
Lubricate							x
Aerators:							
Log running time	x						
Check amperage		x					
Chlorinators:							
Check feed rate	x						
Change cylinders							x
Flow measuring devices:							
Check and clean floats, etc.	x						
Verify accuracy		x					
Valves and gates:							
Check to see if set correctly	x						
Open and close to be sure they are operational		x					

9.4.5 Flexible Design to Improve Operation

9.4.5.1 Flow Regulation

Flow regulation is one of the most helpful operational tools. Without the flexibility to move water around where it is needed, the operator would be severely limited in his or her ability to troubleshoot and solve pond system problems. The following sections enumerate these options.

9.4.5.1.1 Single Cell Ponds

The only flexibility an operator has with a single cell pond is depth control. The water level may have to be varied seasonally or to control weeds and mosquitoes.

9.4.5.1.2 Multiple Cell Ponds

Multiple cell pond systems may be operated to optimize a number of different parameters. They may be operated so as to:

- Hold wastewater in the primary cell, especially during seasonal discharge operation.
- Move water from cell to cell to correct an O_2 deficiency problem.
- Control liquid depth to eliminate weeds or mosquitoes.
- Isolate a cell that has become anaerobic or to hold a toxic waste.
- Take advantage of both series and parallel operation to regulate loading.
- Rest a cell temporarily for recovery.
- Recirculate water from the last cell to the first cell, at a minimum. This allows the operator to increase the DO and to seed the first cell with algae. Remove an individual cell from operation which varies the HRT of the system, particularly in summer.

9.4.5.2 Baffles and Screens

Screens, often custom-made, are used around pond surface outlets to keep windblown weed and surface trash from entering a pipe.

Baffles may consist of pilings (5 by 24 cm) driven into the pond bottom. They are commonly used for a large variety of purposes, for example:

- Direct the flow of water, especially around inlets.
- Reduce or eliminate short circuiting.
- Allow selection of depth for pond draw-off and to keep surface scum and trash from entering.
- Provide a quiet zone ahead of a flow measuring device.
- Reduce the force of a pump discharge.

9.4.5.3 Inlet and Outlet Design

Submerged outlets should be used to prevent the discharge and/or transfer of floating material between ponds.

Variable depth draw-off is especially useful in parts of the country where algal overgrowth is a problem. The effluent should be able to be drawn from any depth in the pond cell, giving the operator the choice of transferring or discharging the best quality water. Variable depth discharge works best with surface mechanical aeration. Low discharge approach velocities are required to minimize the area of influence adjacent to the discharge structure.

There are numerous discharge structure designs that allow the operator to draw effluent in the area under the algal layer while staying 0.6 - 0.9 m above the benthic sludge layer. At a minimum, the pond should be designed with three draw-off points: the first below the algae layer, the second in approximately the mid-depth, and the third above the bottom of the pond.

The use of properly designed inlet and outlet manifolds may aid in the distribution and collection of wastewater flows and minimize short-circuiting.

Transverse perforated collection pipes may reduce approach velocities, increase the discharge collection area of influence and also help minimize short circuiting.

Having multiple inlets and outlets in the system design gives the operator greater flexibility to match the loading and discharge of a pond system more closely to environmental conditions.

9.4.5.4 Dike Erosion

Dike erosion from wave action can be prevented by using riprap in the form of rocks 8 - 48 cm laid along the water's edge. One unusual method employed was to sink 5 by 15 cm uprights into the pond floor extending above the water surface to dissipate the waves. In another case, the pond operator filled bags with a dry mix of sand, gravel and cement. These were laid side by side and stacked to form a system of riprap protection. Riprap should extend 0.3 m above and below extreme operating levels. Other forms of riprap or bank stabilization include cribbing (snow fence) laid on the bank and reed canary grass. Canary grass is effective in ponds that are deep, have steep slopes and a stable water level. If sod is used it should be at least 7.5 cm (3 in) square and placed not more than 1 m apart.

9.4.6 Pond Cleaning

When it becomes necessary to clean a pond, the operator should first contact the regulatory agency to find out about any special requirements. In most cases the operator and/or consulting engineer are required to develop a plan outlining the method of sludge removal, steps to be taken to ensure pond liner integrity, test of the sludge to be removed for volatile solids and metals, and describe the plan for ultimate disposal of the sludge. A separate permit may be required when land application of the sludge is selected for ultimate disposal. The regulatory agency may require site geological information (e.g., type of soil, slope of ground, depth to groundwater), type of crop grown and agronomic uptake rate of metals and nutrients of that crop, sludge testing, method of application, method of solids incorporation into the soil, irrigation practices, runoff control and disposal, and if applicable, vector control and monitoring requirements.

The most common method of sludge removal is to employ some type of sludge pumping equipment. Care should be taken to maintain the integrity of the pond liner. Damage to a pond liner may require repair or replacement, or at a minimum, increased monitoring and testing to ensure the pond is not adversely affecting surface water, groundwater and/or public health.

9.4.7 Procedures for Startup

9.4.7.1 Primary Cell

Spring or early summer is the best time for startup to avoid low temperatures and possible freezing. Fill primary cell(s) with water from a river or municipal system, if available, to the 0.6 m level. Begin to add the wastewater, keeping the *p*H above 9.5 and checking the DO daily (see Appendix G.) Algal blooms should appear in 7-14 d.

A good biological community will be established in about 60 d or less. The color will be a definite green, not blue or yellow-green. This procedure tends to avoid odorous anaerobic conditions and weed growth during the start-up phase.

If is it necessary to start in late fall or winter, the water level should be brought to 0.75 - 1 m and not discharged until late spring.

9.4.7.2 Filling Successive Ponds

- Begin filling when the water level in the first pond reaches a depth of 1 m.
- Add fresh water to a depth of 0.6 m.
- Begin adding water from previous pond observing the following:
    - Use top draw-off to achieve good transfer. Do not draw off from a level below the bottom 45 cm.
    - Do not allow the water depth in the previous pond(s) to fall below 1 m.
    - Equalize water depths in all ponds. This should be done in the following manner: Hold the discharge until all ponds are filled.

      Use effluent box with gates or valves to allow pumping of the effluent to any pond in the system if it is designed with this capability.

      Recycle the effluent continuously to the ponds with low water levels.

      Repeat the operation using 15 cm increments until ponds are at their operating depth.

Finally, start continuous or intermittent discharge, according to the system design.

9.4.8 Discharge Control Program for Seasonal Discharges

9.4.8.1 Preparation

- Make a note of conditions in the stream to receive discharge.
- Estimate duration of discharge and expected volume.
- Obtain state regulatory agency approval.
- Isolate cell to be discharged. Allow it to rest for at least one month, if possible.
- Arrange for daily sample analysis of BOD_5, TSS, *p*H, coliform and nutrients (if required).
- Plan other work so as to be able to devote full attention to control of discharge throughout the period.
- Sample contents of cell and analyze for DO; note and record turbidity, color and any unusual conditions.

9.4.8.2 Discharge Procedures

Ponds in a number of northern states are permitted to discharge effluent seasonally. Three or four weeks after ice break-up, the ponds generally return to normal operating conditions. Wastewater in the cells is tested and results are reported to the state. If the wastewater is of a quality suitable for discharging, the operator follows state guidelines for discharging. The NPDES permit contains information about the discharge quality.

The quality of the receiving stream is usually determined by the state water quality control agency as part of the discharge approval program. When discharge approval is obtained, proceed as follows:

- Begin the discharge program with the last cell in series.
- Draw off the discharge from the best level at a time when the discharge is acceptable.
- Stop the discharge when ponds are upset.

- Follow testing procedures outlined by the state regulatory agency.

9.5 SAFETY AROUND PONDS

9.5.1 Public Health

Operators and others conducting activities around treatment ponds must proceed with caution and make safety and public health a priority. Treatment ponds must be utilized for their designed purpose only, not for public recreation. The relative amount of water surface of treatment ponds is insignificant compared to the many natural bodies of open water in most localities. In some areas, however, treatment ponds represent the only sizeable body of water and have been sources of attraction for recreation purposes. Incidents of boating, ice skating, waterfowl hunting and even swimming in ponds have been reported. Recreational use should be discouraged and safety practices encouraged for several important reasons. Even though the efficiency of bacterial removal as measured by the MPN method is very high, the possibility of contamination or infection from pathogenic organisms does exist when a person comes in contact with wastewater in a treatment pond.

People can drown in treatment ponds. Clay and synthetic liners used in sealing ponds become very sticky when water is added. Should a person fall into a pond, the presence of liners would make it extremely difficult to get out. To discourage use of the ponds for recreation, the entire area should be fenced and warning signs displayed.

Another factor to be considered is the presence of mosquitoes. In a well-maintained pond system, mosquitoes usually are not a nuisance. According to studies by the U.S. Public Health Service, the density of the mosquito population is directly proportional to the extent of weed growth in a pond. Where weed growth in the ponds and along the water line of the dikes is negligible and where wind action on the pond is not unduly restricted, the likelihood of mosquitoes breeding is low.

9.5.2 Personal Hygiene

In the interest of the health of those who work around wastewater treatment ponds and their families, this list of *Do's* and *Don't's* for personal hygiene is presented.

- Never eat or put anything into your mouth without first washing your hands.
- Refrain from smoking while working in manholes.
- Wear gloves when working on pumps or other parts of the operation where hands may become contaminated.
- Don't wear work coveralls or rubber boots in the car or at home.
- Always clean any equipment, such as safety belts, harnesses, face masks, or gloves after use.
- Keep fingernails cut short and clean.

9.5.3 Safety

9.5.3.1 Sewer Maintenance Safety Precautions

- Remove and replace heavy manhole covers carefully and only with the proper tools.
- Descend into any manhole slowly and cautiously.

- Use the buddy system; do not enter without a spotter present.

See Section 9.5.3.4 for information regarding noxious gases that may be found in sewers.

9.5.3.2 Pumping Station and Treatment Pond Safety Precautions

- Maintain a high level of housekeeping. Keep floors, walls and equipment free from dirt, grease and debris. Keep tools properly stored when not in use.
- Keep walkways clean and free of slippery substances. If ice forms on walks, apply salt or sand or cover with earth or ashes that can be removed later.
- Be especially cautious when working with an electrical distribution system and related facilities. Never work on electrical equipment and wire with wet hands or in wet clothes or shoes. Always wear appropriate safety gloves for electrical work. Never use a switchbox as anything other than a switchbox.
- Keep all personnel safety conscious by providing training at regular intervals. Have specific safety instructions posted in appropriate places. Such instructions should include information as to how to contact the nearest medical center and fire station, rescue techniques, resuscitation and first aid techniques.
- Make certain that a sufficient number of trained and experienced personnel with proper equipment are assigned and present whenever it is necessary to perform any hazardous work.
- Staff should have boating safety training. Life preservers must be used whenever personnel are in a boat on treatment ponds. At least two people should work together around the ponds because of the danger of drowning and other accidents. Safety training for a pond operator should include life saving skills, including the ability to swim at least 30 m in normal work clothing.
- Sufficient fire extinguishers (Underwriter's Laboratories Approved) should be placed in readily accessible locations.

9.5.3.3 Body Infection and Disease Safety Precautions

Treat all cuts, skin abrasions and similar injuries promptly. When working with wastewater, the smallest cut or scratch is potentially dangerous and should be cleaned and treated immediately with a 2 percent solution of tincture of iodine. In addition, personnel should:

- Receive medical attention for all injuries.
- Be given first aid training.
- Be inoculated for waterborne diseases, particularly typhoid and para-typhoid fever.
- Keep a record of all immunizations in an employee health record.
- Review records annually for necessary boosters and new immunizations.

In the laboratory, always use appropriate laboratory equipment and supplies, and avoid any contamination by mouth. Don't take laboratory glassware for personal use. Paper cups should be provided in laboratories for drinking purposes. Never prepare or eat food in a laboratory.

9.5.3.4 Noxious Gases, Explosive Mixtures and Oxygen Deficiency

The principal air hazards associated with wastewater treatment are accumulations of sewer gas and its mixture with other gases or air, which may cause death or injury through explosion or asphyxiation as a result of O_2 deficiency. The term "sewer gas" is generally applied to the mixture of gases in sewers and manholes containing high percentages of CO_2, varying amounts of CH_4, H_2, H_2S, and low percentages of O_2. Such mixtures sometimes accumulate in sewers and manholes where organic matter has been deposited and has undergone decomposition. The actual hazards from sewer gas are the result of the explosive amount of CH_4, H_2S or in O_2 deficiency. Hydrogen sulfide is toxic at very low concentrations and a person's sensitivity to the odor is quickly deadened.

Chlorine gas, which is irritating to the eyes, respiratory tract and other mucous membranes, may settle in low-lying, still areas. The gas forms an acid in the presence of moisture. The gas may leak from cylinders and feed lines and diffuse and settle into these places.

9.5.3.5 Safety Equipment

A wastewater facility should have the following types of safety equipment:

- Detection equipment (for gases and O_2 deficiencies)
- Respirators (self-contained SCBA packs for O_2 deficiencies)
- Safety harnesses, lines and hoists
- Proper protective clothing, footwear and head gear
- Ventilation equipment
- Non sparking tools
- Communications equipment
- Portable air blower
- Explosion-proof lantern and other safe illumination
- Warning signs and barriers
- Emergency first aid kits
- Proper fire extinguishers
- Eye wash and shower stations in laboratory areas
- Safety goggles for work in laboratories and other dangerous areas

9.6 TROUBLESHOOTING

An operator or engineer must have a thorough understanding of the treatment process and tests required to diagnose problems affecting effluent quality (see Appendices E and F). This expertise must be brought to bear to achieve the highest level of process performance from a pond system and stay within the agency's budget. Prior to visiting the site, the following documents should be reviewed:

- Past inspection reports.
- The discharge permit.
- Discharge monitoring reports (DMRs) and plant performance records for a three-year period.
- Any noncompliance correspondence to compare to plant operation records and DMRs to look for trends.
- Plans and specifications to verify that they reflect current plant conditions.

- Current plant records to verify that it is operating within required parameters.
- Organic loading rates, surface loading rates and aeration capacity to determine whether the ponds are organically overloaded.
- O&M Manual to determine if the plant is being operated within the engineers' recommendations.

Once on site, the following items should be observed and reviewed:

- Plant appearance and maintenance, including weed control, dike vegetation, dike erosion and stability, fencing and out-building conditions.
- Individual cells: Note any floating material, such as grease, sludge, floating vegetation, or mats of blue-green algae; water depth; freeboard height; cell color; odor problems; septic conditions; sludge buildup.
- Influent and effluent flows for infiltration/inflow problems, influent septicity or odors, and unusually high effluent solids, and/or floating material.
- Plant influent and effluent parameters.
- Plant operation and maintenance and equipment records.
- Plant staffing for operations and maintenance.
- Safety equipment and procedures.
- Sampling locations, methods, frequency and weather records.

9.6.1 Common Causes of Pond Effluent Noncompliance

Pond effluent violations can be caused by organic overloading, short-circuiting, algal overgrowth conditions, sludge accumulation and nitrification, or partial nitrification. The following sections will describe some of the causes of effluent violation, troubleshooting tests and results, and present possible solutions to the problem.

9.6.1.1 Organic Overload

Organic overload is normally caused by influent organic shock loads or increased organic load with no corresponding increase in treatment plant capacity. This condition causes low dissolved O_2 concentrations (< 1.0 mg/L) and inhibits treatment. This can be verified by calculating the organic loading (BOD_5/d) and comparing it to design capacity. A DO test and DO profiles should be run at various times of the day to verify whether there is a continuous low DO condition.

The diagnostic troubleshooting tests will demonstrate high BOD_5, high $CBOD_5$, high soluble BOD_5, low DO, a low TSS to BOD_5 ratio and high NH_3. The immediate solution is to increase organic treatment capacity by increasing aeration. In the long term, a pretreatment program with collection system monitoring of those areas suspected of introducing high organic shock loads should be developed and implemented.

9.6.1.2 Short-circuiting

Short-circuiting normally occurs when untreated or partially treated wastewater does not have adequate detention time in the system for complete treatment. This can be caused by temperature stratification in the cells, poor inlet and/or outlet design, inadequate cell length-to - width ratio or cell shape, or poor mixing and improper aerator placement. Performing a DO profile test on an established grid system while recording both DO and temperatures in 0.3 m increments from the surface to the bottom should verify a short circuiting condition. The operator will note variations in DO and temperature indicating temperature stratification and or poor mixing. The diagnostic trouble shooting test will indicate high BOD_5, high soluble BOD_5, moderate TSS and high NH_3 levels. This condition should be verified with a microscopic examination of the effluent.

Possible solutions are relocating aerators, addition of directional aerators or mixers, adding baffles, recirculating to enhance mixing, and redesigning inlet and outlet structures to include manifolds or relocating structures.

9.6.1.3 Algal Overgrowth

Algal overgrowth is prevalent in the areas where there is a high number of sunny days during the year. This condition occurs predominantly in the spring and summer. Long detention times, shallow pond depths (1.2 - 1.8 m), abundant nutrients, warm water and sunshine promote algal growth. The diagnostic troubleshooting test results indicate high *p*H, high BOD_5, low $CBOD_5$, low soluble BOD_5, high TSS, a high TSS to BOD_5 ratio, low DO (early morning) and moderate-to-high NH_3 concentrations.

During the night, algae and aerobic bacteria will utilize O_2, potentially depleting the DO in the cells prior to sunrise. Lack of O_2 will cause incomplete treatment, possibly resulting in permit violation. A DO profile test run at sunrise will normally verify the lack of O_2 in the cells. A microscopic examination of the effluent and count of the algae will confirm the overgrowth condition.

Possible solutions include increasing the aerator running time at night. The operator may choose to reduce aerator running time during the day, allowing the algae to concentrate on the surface of the cells. The high concentration of algae at the surface will reduce sunlight penetration and may slow the algal growth rate. Drawing off the effluent from variable depths below the surface will also keep the algae in the cells, while allowing for the discharge of high quality water. The addition of floating covers will block the sunlight and, with the maintenance of adequate in-cell DO levels, produce a higher quality effluent. The addition of physical shade such as greenhouse fabric suspended above the surface of the cells, or chemicals such as Aquashade® or photo blue, used in accordance with EPA registry instructions (http://www.epa.gov/oppsrrd1/REDs/aquashade_red.pdf) may also prove effective in controlling algal growth.

9.6.1.4 Sludge Accumulation in Ponds

Sludge will accumulate in the bottom of pond cells over years of operation. Soluble organics are released from these benthic sludges and have the largest effect on ponds in the spring of the year. Diagnostic troubleshooting test results will indicate high $CBOD_5$, high soluble BOD_5, low to moderate TSS, a low TSS to BOD_5 ratio, low DO and high NH_3 concentrations. This condition can be verified with a microscopic examination. Increasing aerator running times may offer a temporary solution. Ultimately removal of the sludge from the bottom of the pond cells will be necessary. The operator must comply with all state and federal regulations and must take care to protect the pond liner during the process.

9.6.1.5 Nitrification or Partial Nitrification

Nitrification in ponds will occur under proper environmental conditions (in warmer water temperatures and adequate DO) and is most prevalent in late spring and summer. Complete nitrification would be indicated by low BOD_5, low $CBOD_5$, low to moderate TSS, moderate DO, low NH_3 and moderate NO_3^- levels.

Partial nitrification is common in ponds in late spring and summer when adequate DO levels are not maintained for complete treatment. Troubleshooting diagnostic tests will show high BOD_5, low $CBOD_5$, low soluble BOD_5, low to moderate TSS, a low TSS to BOD_5 ratio, low DO and moderate NH_3 concentrations.

Increased aeration (aerator running times) or, in some cases, increased aeration capacity may increase nitrification.