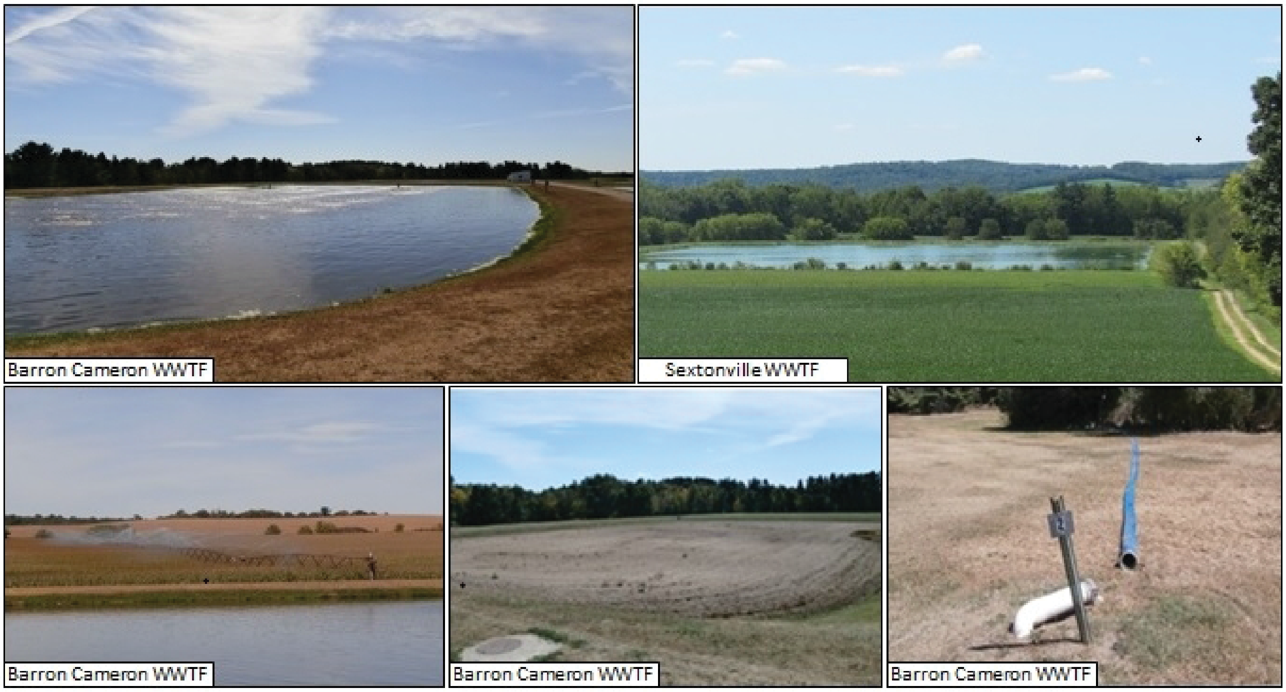
Wisconsin Department of Natural Resources
Wastewater Operator Certification

Ponds, Lagoons, and Natural Systems Study Guide

Subclass A4



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http://dnr.wi.gov

Preface

The Ponds, Lagoons, and Natural Systems Study Guide is an important resource for preparing for the certification exam and is arranged by chapters and sections. Each section consists of key knowledges with important informational concepts you need to know for the certification exam. This study guide also serves as a wastewater treatment plant operations primer that can be used as a reference on the subject.

In preparing for the exams:

1. Study the material! Read every key knowledge until the concept is fully understood and known to memory.

2. Learn with others! Take classes in this type of wastewater operations to improve your understanding and knowledge of the subject.

3. Learn even more! For an even greater understanding and knowledge of the subjects, read and review the references listed at the end of the study guide.

Knowledge of the study guide material will be tested using a multiple choice format. Every test question and answer comes directly from one of the key knowledges.

Choosing a test date:
Before choosing a test date, consider the time you have to thoroughly study the guides and any other training opportunities available. A listing of wastewater training opportunities and exam dates is available at http://.dnr.wi.gov by searching for the keywords “Operator Certification”.

Acknowledgements

The Ponds, Lagoons, and Natural Systems Study Guide was the result of a collaborative effort of yearlong monthly meetings of wastewater operators, trainers, consultants, the Wisconsin Wastewater Operator Association (WWOA), and the Wisconsin Department of Natural Resources (WDNR). This study guide was developed as the result of the knowledge and collective work of following workgroup members:

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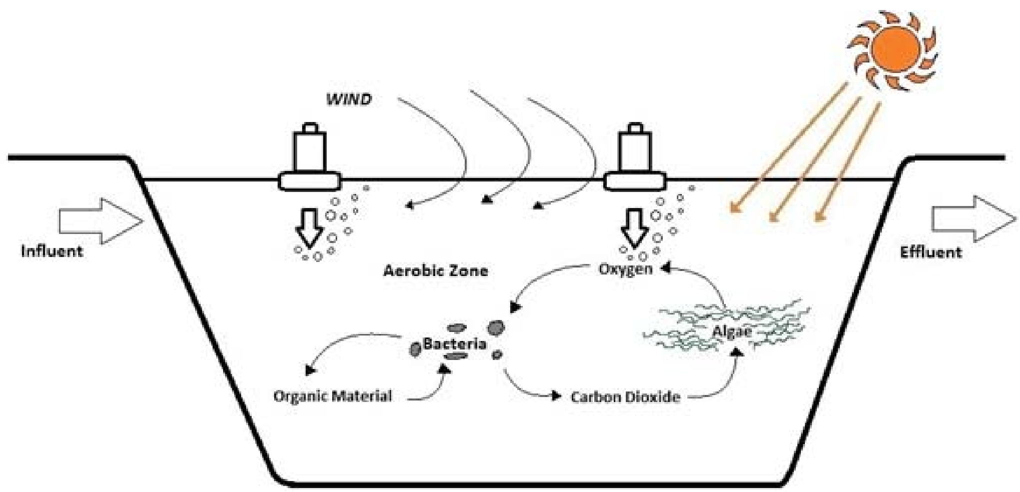
Chapter 1 - Theory and Principles

Section 1.1 - Definitions

1.1.1 Describe an aerated lagoon.

An aerated lagoon is a treatment pond with mechanical aeration to introduce oxygen into the pond in order to promote the biological oxidation of the wastewater. Operators utilize oxygen and microbial action in lagoons to treat the pollutants in the wastewater. Lagoon depths range from 10 to 15 ft.

Figure 1.1.1.1

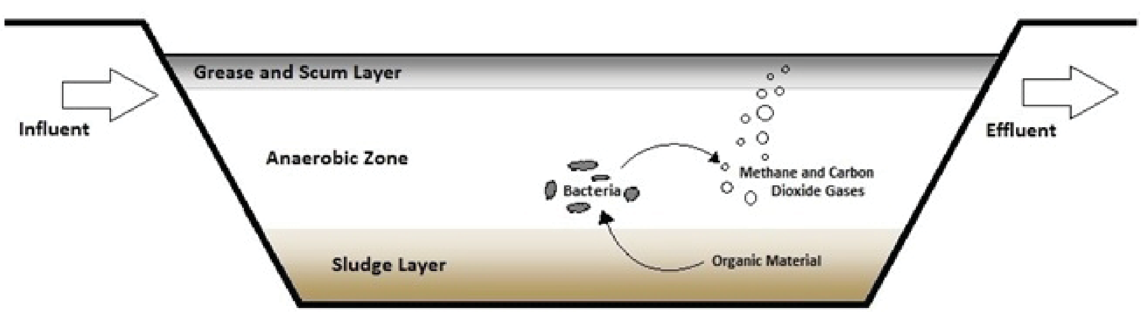


Source: Katherine Robles, WDNR

1.1.2 Describe an anaerobic pond.

Anaerobic ponds are more than 8 ft deep, have no dissolved oxygen (DO), and use anaerobic bacteria to treat organic material. They provide low cost treatment of high strength organic wastes, are typically used by industries to pre-treat wastewater, and are followed by aerobic treatment. Anaerobic ponds usually have a floating cover to contain odors, collect methane gas, and retain heat.

Figure 1.1.2.1

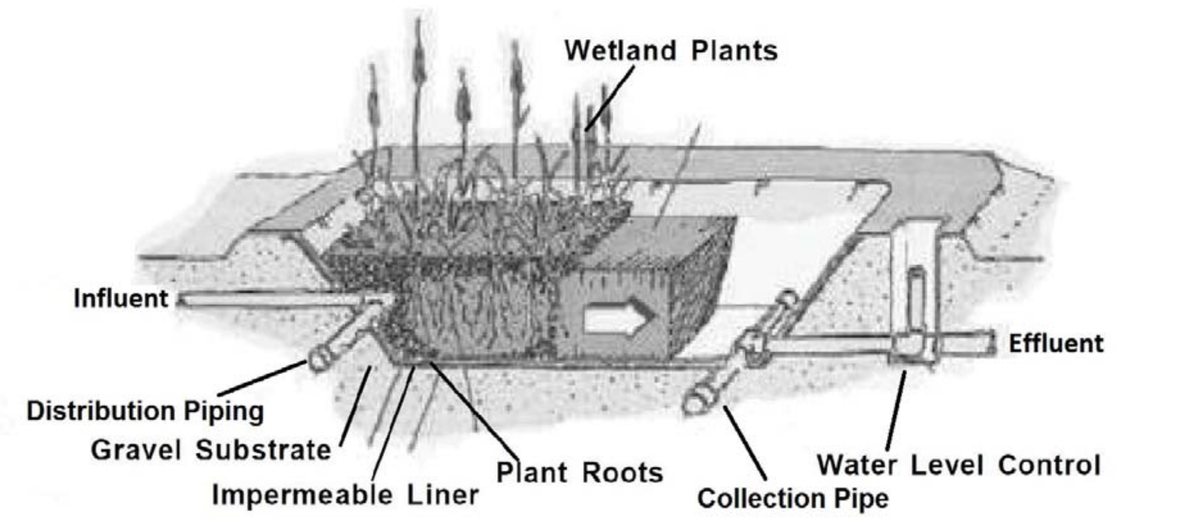


Source: Katherine Robles, DNR

1.1.3 Describe constructed wetlands.

Constructed wetlands are lined wetlands designed to promote wastewater flow through the system. Soil and vegetation act as a filter and slow water allowing suspended solids to settle out. Biological uptake and natural processes associated with wetland vegetation, soils, and soil microorganisms also remove contaminants.

Figure 1.1.3.1



USEPA, Constructed Treatment Wetlands Diagram

1.1.4 Describe freeboard in a pond or lagoon system.

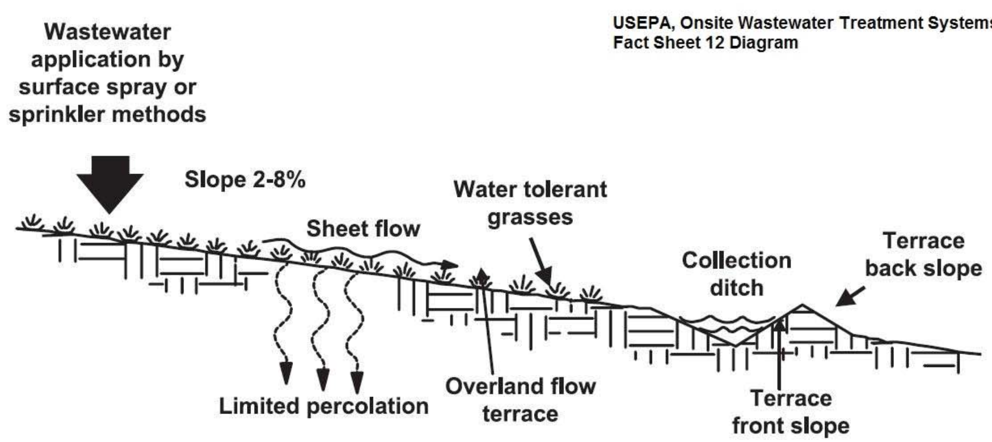
Freeboard is the distance between the normal maximum operating water surface of the pond and the top of the dike. Freeboard is normally 3 ft (meaning the water level should be kept below 3 ft from the dike top).

1.1.5 Describe overland flow.

Overland flow is a form of land application that treats wastewater by discharging it evenly over a vegetated sloping surface that has fairly impermeable soil. As the wastewater flows over the slope, contaminants and nutrients are absorbed and the water is then recollected at the base of the slope.

Figure 1.1.5.1

USEPA, Onsite Wastewater Treatment Systems Technology Fact Sheet 12 Diagram



1.1.6 Describe pond turnover.

Pond turnover is a term used to describe the natural seasonal (fall and spring) mixing of the water in a pond or lake creating a uniform temperature within the water column. This movement of water in a pond or lake is due to temperature and density differences between the top and bottom of the water column and wind action. During turnover, settled solids can be stirred up causing odors and raising effluent biochemical oxygen demand (BOD) and total suspended solids (TSS).

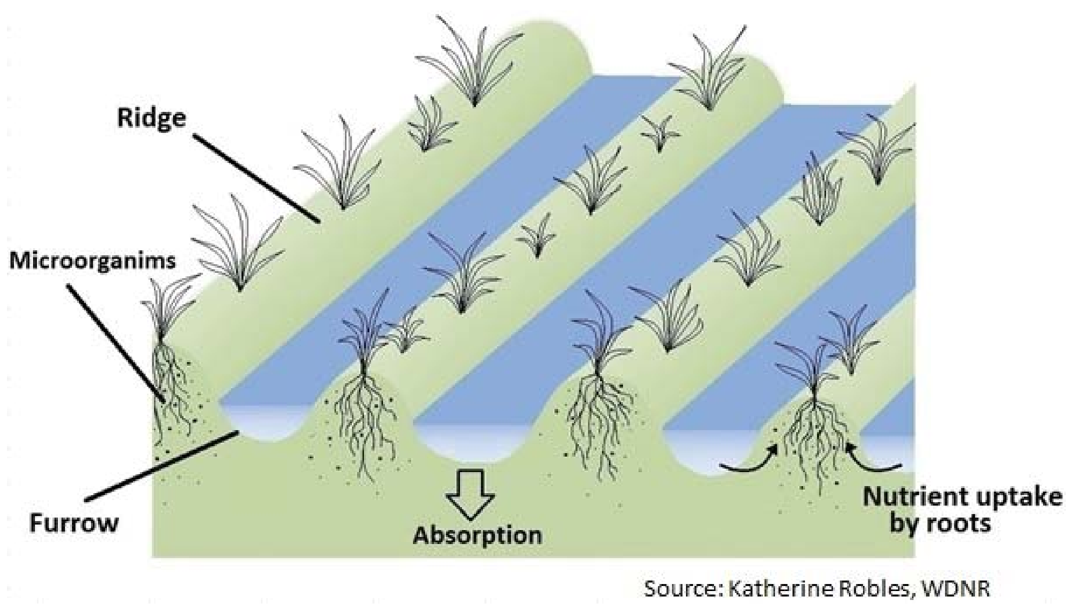
1.1.7 Define respiration.

Respiration is the process by which an organism (plant or animal) takes in oxygen and releases carbon dioxide.

1.1.8 Describe a ridge and furrow system.

Ridge and furrow systems are land treatment systems that allow wastewater to be absorbed into the soil by a series of shallow trenches. Wastewater is treated through biodegradation by soil organisms. Water tolerant grasses are grown on the ridges to help absorb water in the summer and to insulate the ground in the winter.

Figure 1.1.8.1



1.1.9 Describe seepage cells.

Seepage cells are a process that uniformly distributes treated wastewater across an unvegetated permeable soil. Suspended solids and organic wastes are removed as they filter through the soil. Typically, treated effluent enters the groundwater or is collected and discharged to surface water. Multiple seepage cells are often used to alternate flow for maintenance purposes.

Figure 1.1.9.1

Barron - Cameron WWTP Source: Jack Saltes, WDNR

1.1.10 Describe a spray and drip irrigation system.

Spray and drip irrigation systems are land treatment systems designed to apply wastewater to crops or vegetative cover. Wastewater and the nutrients it contains are taken up by the vegetation for plant growth. Soil microorganisms further treat the wastewater as it moves through the soil. Hydraulic loading rates are based on the crop irrigation requirement and soil type to which the wastewater is applied.

Figure 1.1.10.1

Drip Irrigation

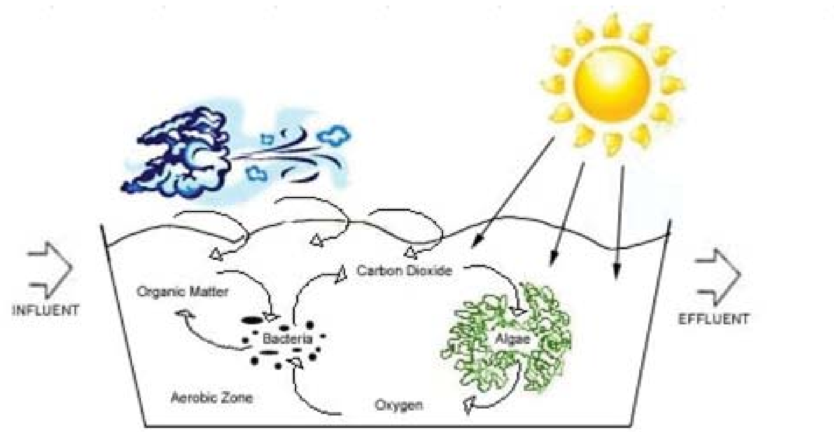
Spray Irrigation

USGS Photo

1.1.11 Describe a stabilization pond.

Stabilization ponds have historically been used to provide long detention times (greater than 150 days) for wastewater to be stabilized through natural processes. Wastewater is treated by the action of bacteria (both aerobic and anaerobic), algae, other micro and macro organisms, and by the physical process of gravity settling. When properly designed, ponds are capable of providing secondary treatment for both BOD and suspended solids. Pond depths range from 3 to 6 ft.

Figure 1.1.11.1



Source: Amy Garbe, WDNR

1.1.12 Define treatment facility overflow (TFO).

A TFO is a release of wastewater, other than through permitted outfalls, from a wastewater facility into a water of the state or the land surface. All TFOs must be reported to the Department of Natural Resources within 24 hours of the occurrence.

Section 1.2 - Biological Principles

1.2.1 Describe how stabilization of organic waste material occurs in nature, both in water and in soil.

In nature, organic material is used as a food and energy source for bacteria, protozoa, algae, and other life forms for their growth and metabolism. Natural treatment systems purify wastewater much like nature. Organic material in the wastewater is absorbed and broken down by microorganisms, green plants, and other life forms.

This process is much slower than mechanical plants. For example, a stabilization pond takes at least 150 days to achieve satisfactory treatment.

1.2.2 Discuss the climatic factors that affect stabilization pond activity.

The biological activity in a stabilization pond is affected by three primary climatic conditions.

A. Light
Sunlight is the driving force for photosynthesis and the production of oxygen in a pond. The depth that light penetrates the pond will determine the depth that algae grow and produce oxygen. Solar radiation is highest during the summer. Operating depths are between 3 to 6 ft to allow for sunlight penetration and mixing to effectively occur.

B. Temperature
Temperature affects the bacterial and algal growth rate and activity. As temperatures rise,

activity increases. Treatment is the highest during the summer and lowest during the winter. Ice and snow cover can help insulate a pond from extreme cold temperatures but also limit the sunlight penetration. While cold water has the ability to be saturated with more oxygen, biological activity is reduced during this time because of the cold temperatures.

C. Wind

Wind provides natural mixing to the pond. Some oxygen transfer also occurs at the pond surface. Mixing allows both influent wastewater and oxygen to be dispersed in the shallow water column of the pond. When adequate mixing of the food (biochemical oxygen demand or BOD), oxygen, algae, and bacteria occurs, the entire pond is a natural, active biological treatment facility. To some extent, the operator can ensure good air and wind movement across the pond surface by keeping vegetation, which can impede air flow over the pond, controlled along the inside dikes.

1.2.3 Discuss how precipitation and evaporation affect stabilization pond volume.

A. Precipitation

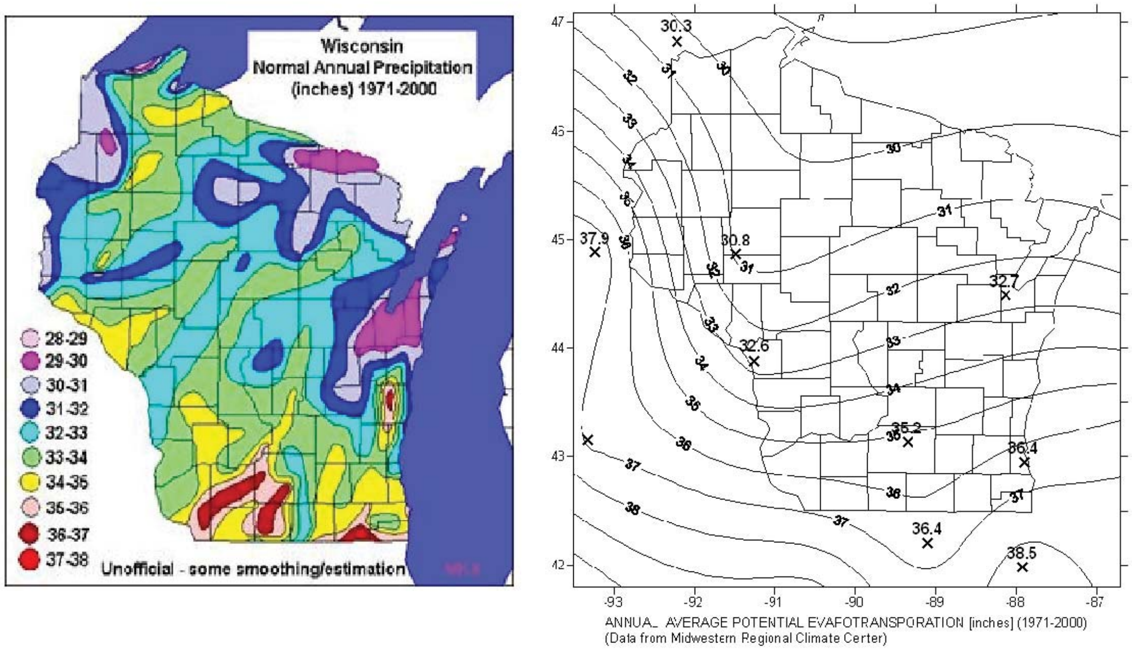
Severe and large amounts of rain can significantly add water directly and indirectly through inflow and infiltration (I/I) to a pond. It is important that the pond has adequate room and freeboard to accommodate rainfall and not pose any risk of over spilling the dike.

B. Evaporation

Water evaporation is highest during the summer months when solar radiation and heat is the highest. Days of high humidity will reduce the evaporation rate, while hot, sunny days with low humidity and breezes over the pond surface will result in very high evaporation rates.

In Wisconsin, the annual average precipitation (28 to 35 ins) closely equals the annual average evaporation (28 to 35 ins) depending on the location within the state (see figures). For this reason, if leakage is negligible, on an annual basis the amount of wastewater flowing into a pond or lagoon system should approximately the amount that is discharged (total flow in = total flow out). Leakage estimates can be made based on this knowledge.

Figure 1.2.3.1



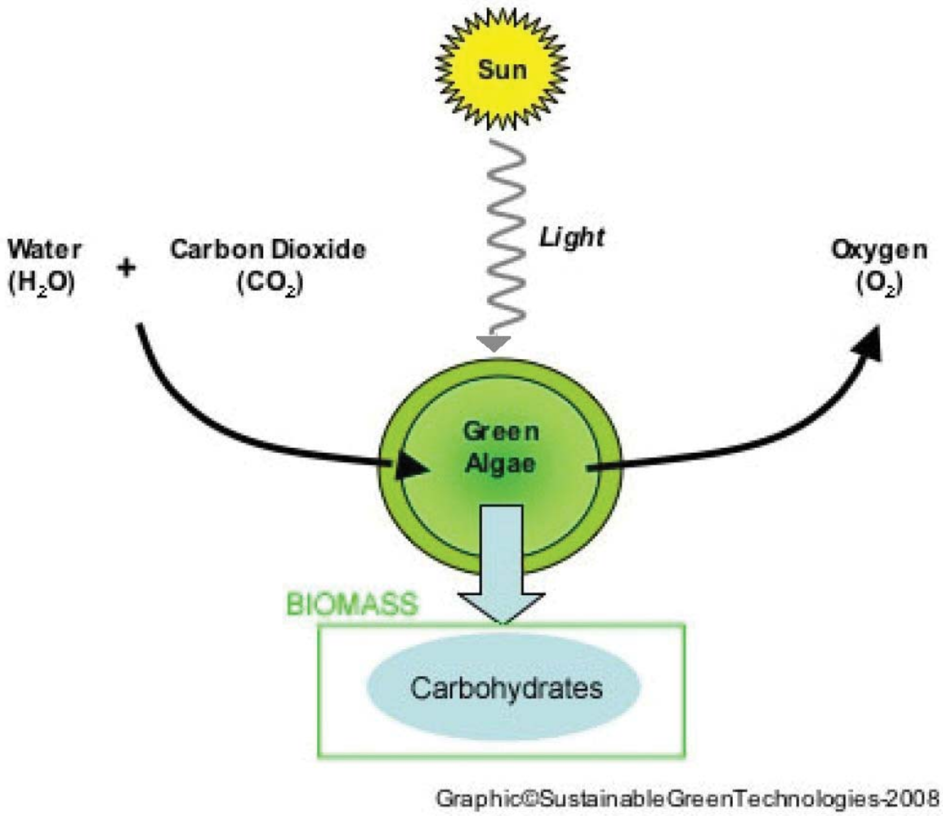
Wisconsin State Climatology Diagram

1.2.4 Discuss what photosynthesis is and how it aids the biological treatment of wastewater in stabilization ponds.

Photosynthesis is a naturally occurring chemical process in which green plants (algae in ponds) that contain chlorophyll use carbon dioxide in the presence of sunlight to produce carbohydrates to grow. In wastewater treatment ponds, oxygen released as a byproduct of photosynthesis is used by the bacteria that stabilize the suspended organic material in wastewater. Photosynthesis can be summarized by the equation:

Carbon dioxide + water => carbohydrate + water + oxygen
$6CO_2 + 12H_2O \Rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$

Figure 1.2.4.1



1.2.5 Discuss the relationship between bacteria and algae in a pond system.

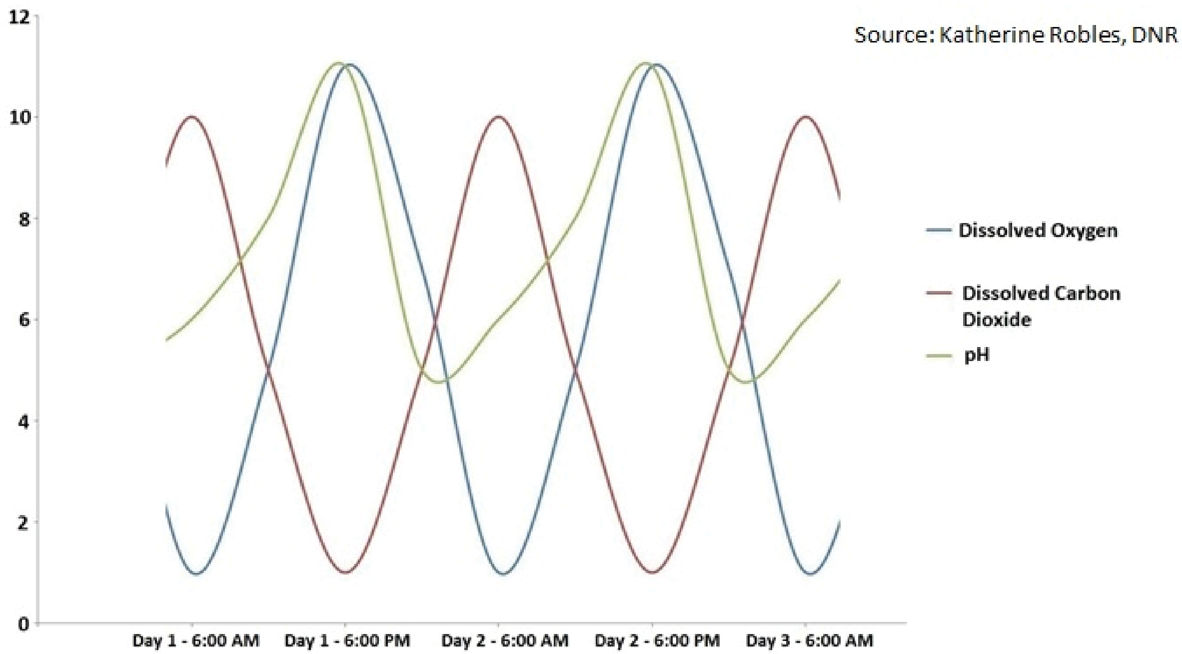
In any wastewater pond, treatment is accomplished by a complex community of organisms. They work and interact with each other in a way which is mutually beneficial. Algae, like all green growing matter, uses nutrients and carbon dioxide in the presence of sunlight to produce oxygen in a process called photosynthesis. The oxygen produced is used by bacteria to break down organic matter into simpler materials, releasing carbon dioxide used by the algae. Breaking down organic material reduces BOD.

1.2.6 Describe how photosynthesis and respiration effect pH, dissolved oxygen (DO), and carbon dioxide in a stabilization pond.

When the sun is out, algae uses up dissolved carbon dioxide (CO2) and gives off oxygen (O2) in the process of photosynthesis. At night, algae and microorganisms use DO and give off CO2 in the process of respiration; this lowers the pH. Thus, pH would be lowest at sunrise. In a non-aerated stabilization pond, this causes a daily swing in the concentration of DO and dissolved CO2.

Dissolved CO2 in the water forms carbonic acid (CO2 + H2O -> H2CO3), which lowers the pH. On long sunny days, most of the CO2 is used up by the algae, therefore there is less carbonic acid and the pH will rise. The pH can reach 11 or 12 in the evening of a sunny summer day.

Figure 1.2.6.1



Section 1.3 - Process Understanding

1.3.1 Discuss the effect turnover can have on a wastewater stabilization pond and effluent quality.

While stabilization ponds are relatively shallow and do not turnover like a lake does, it nevertheless can occur, especially after ice-out in the spring. With the advent of spring, the temperature gradients in the water along with winds create a spring turnover. When this occurs, the contents of the ponds are mixed from top to bottom and effluent quality may be poor for a few weeks in the spring. Operators should closely monitor their pond at this time and may not want to discharge any effluent when biochemical oxygen demand (BOD) and suspended solids violations may occur.

1.3.2 Discuss the advantages and disadvantages of pond and lagoon systems as compared to mechanical systems.

A. Advantages

1. Low construction cost
2. Low operational cost
3. Low energy usage
4. Can accept surge loadings
5. Low chemical usage
6. Fewer mechanical problems
7. Easy operation
8. No continuous sludge handling

B. Disadvantages

1. Large land requirements
2. Possible groundwater contamination from leakage

3. Climatic conditions affect treatment
4. Possible suspended solids problem (algae)
5. Possible spring odor problems (after ice-out)
6. Animal problems (muskrats, turtles, etc.)
7. Vegetation problems (rooted weeds, duckweed, algae)
8. Periodic, labor intensive, and costly sludge removal

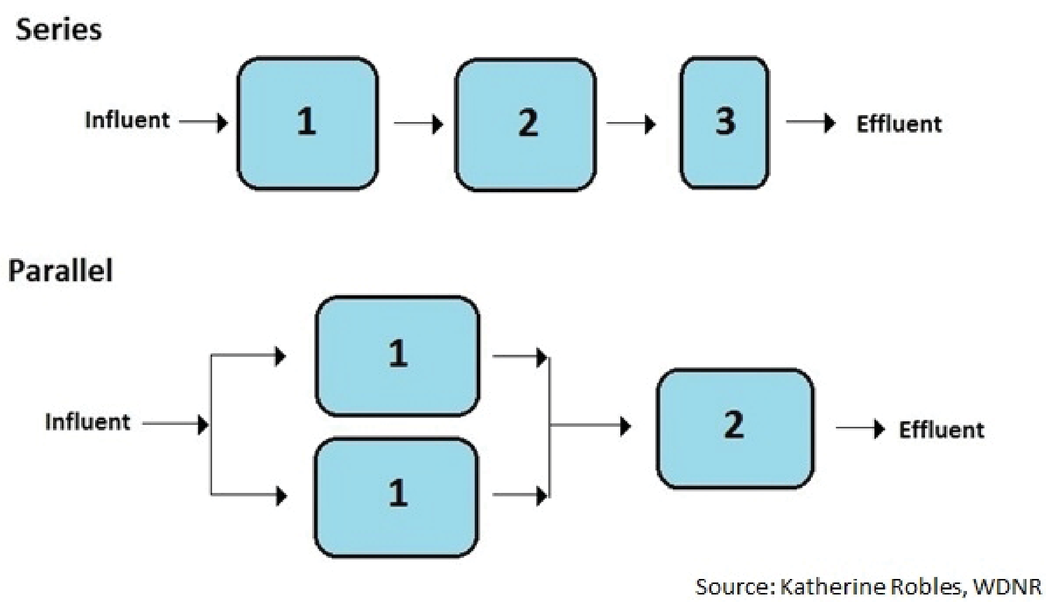
1.3.3 Describe series and parallel modes of pond operation and state conditions when each should be used.

A stabilization pond system is usually composed of a number of individual cells (ponds) and can be operated in several modes.

A. Series
In series mode, the flow goes through each cell (pond) in succession (e.g. 1st cell to 2nd cell to 3rd (finishing) cell). This type of flow pattern normally provides the best degree of treatment and minimizes algae in the effluent.

B. Parallel
In parallel mode, the influent flow is divided between two or more primary cells. Parallel operation can be used to evenly distribute high organic loading.

Figure 1.3.3.1



1.3.4 Discuss the following parts of a stabilization pond system.

A. Headworks and screening
Sometimes provided to remove rags and large objects before wastewater enters the pond

B. Flow meter and weirs
Devices to measure incoming or discharged wastewater flow rates

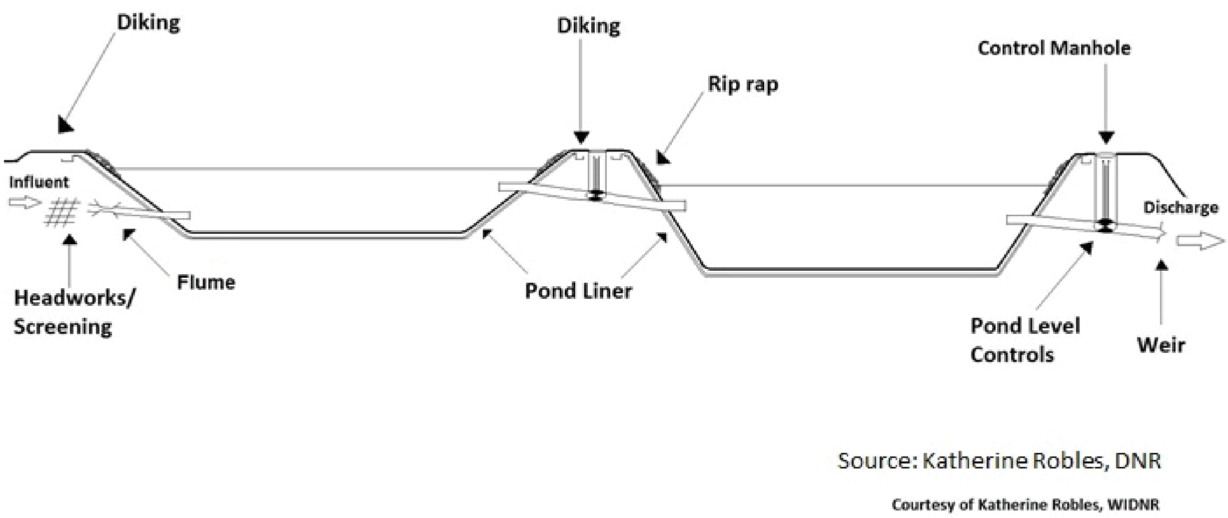
C. Dikes
The earthen pond sides which give the pond its shape and depth

D. Rip rap
Rock or stone placed at normal pond operating levels to prevent erosion of the inner slope that could occur from wind actions

E. Pond Liner
A clay or synthetic liner that keeps wastewater from leaking into the groundwater

F. Control structures
1. Influent flow
2. Discharge
3. Pond level controls

Figure 1.3.4.1



1.3.5 Discuss the advantages and disadvantages of duckweed.

A limited amount of duckweed can be advantageous to control algae growth and to absorb nutrients. However, if too much duckweed is allowed to grow on the surface it can block sunlight. This will cause a reduction in algae growth and a corresponding reduction in dissolved oxygen (DO) which can adversely affect treatment. Additionally, the duckweed mat can further affect DO by restricting oxygen transfer from wave action.

1.3.6 Discuss wastewater land treatment concepts.

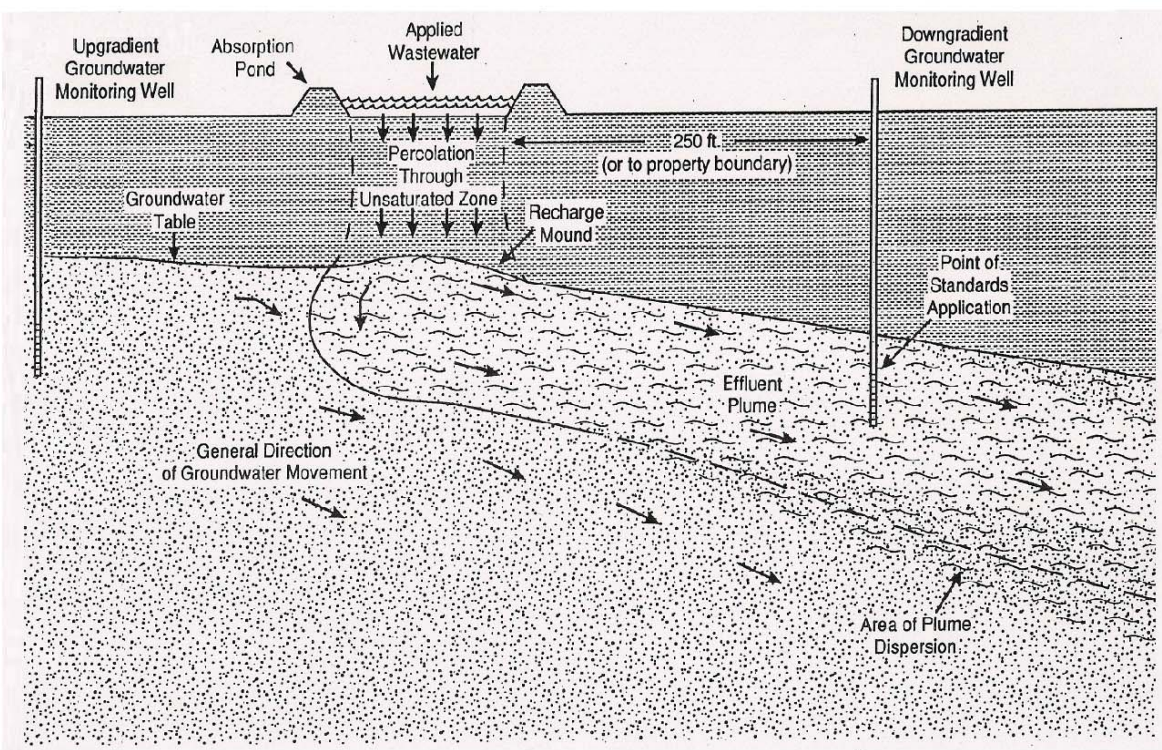
As wastewater moves through soil it is subjected to physical, chemical, and microbiological processes of a complex and dynamic nature. The effectiveness of these soil processes in treating wastewater depends on environmental conditions and the unique characteristics of the soil and applied wastewater.

The use of dosing and resting cycle is of principle importance to the operation of absorption ponds such as seepage cells and ridge and furrow systems. When a soil is allowed to drain and dry, air will be drawn into the soil pores creating suitable conditions for the degradation of applied wastes. Drying periods and periodic basin maintenance (scraping or tilling the bottom of the seepage cells) are necessary to restore infiltration capacity and to renew the biological and chemical treatment capabilities of the soil.

Soil type is a fundamental factor affecting both hydraulic and treatment capabilities. Soil particles are generally classified as sand, silt, or clay. Sand particles are the largest, therefore sandy soils are very permeable and wastewater seeps away fast. Silt and clay are smaller particles and thus less permeable. Silt and clay are important, however, because they are capable of absorbing many substances from the applied wastewater. Seeping away slower, pollutants held in the soil profile may subsequently be biodegraded by microbial activity in the soil. The key to successful land treatment performance is to have enough small soil particles and microbes to provide further treatment, but without excessive restriction of the soil hydraulic conductivity.

Treatment in the soil occurs predominantly within the first 3 ft of the cell bottom. The figure below shows how applied wastewater moves through the upper layers of soil where it eventually reaches the groundwater table. It then enters, recharging the groundwater directly below, and travels down gradient in a plume, spreading out as it travels. Groundwater quality standards apply in a down gradient monitoring well located 250 ft from the property boundary. This is known in NR 140 as the Point of Standards application. Between the treatment plant itself and treatment through the soil, groundwater protection can be achieved.

Figure 1.3.6.1



Wisconsin DNR, Land Treatment Concepts and Operational Guidelines for Municipal Absorption Pond Systems Diagram.

1.3.7 Discuss groundwater movement and potential contamination from pond and lagoon systems.

Groundwater typically moves from areas of higher elevation or head to lower elevation or head where it is released into streams, lakes, or wetlands. Groundwater moves extremely slow, only a few inches to a few feet per day, depending on the permeability of the soil it is traveling through. Leaking ponds or lagoon systems have the potential to contaminate groundwater. Monitoring wells are used to determine if groundwater contamination is present. Monitoring wells are installed hydraulically downgradient of the pond or lagoon. Another well is located upgradient of the pond or lagoon to determine groundwater quality prior to possible contamination. Monitoring well samples only need to be taken at least once a year due to the slow movement of groundwater.

1.3.8 List some possible consequences of exceeding the design organic loading rate of a pond system.

A. Poor treatment
B. High effluent BOD
C. Increase of sludge solids
D. Potential for objectionable odors
E. Excessive algae (blue-green filamentous mats)

Chapter 2 - Operation and Maintenance

Section 2.1 - Definitions

2.1.1 Define hydraulic application rate.

Hydraulic application rate is the volume of wastewater evenly spread over a designated acreage of the land treatment system divided by a period of time. The rate is calculated by dividing the volume discharged during the waste loading period by the acreage of land loaded and then dividing by the total time in the load/rest cycle (gal/acre/day or gpad).

2.1.2 Define hydraulic loading rate.

Hydraulic loading rate is the volume of wastewater discharged per day to the land treatment system. It is measured as gallons per day (gpd).

2.1.3 Define load/rest cycle.

Load/rest cycle is a schedule of operation in which a certain volume of waste is loaded on a portion of the treatment system and then rested. This allows the liquid to drain, the soil to re-aerate, and the soil microorganisms to break down the waste material.

Section 2.2 - Methods

2.2.1 Discuss common methods for controlling stabilization pond water levels.

Pond levels are usually controlled in manholes using boards or valves. In a manhole using boards, the boards are inserted or removed in the center wall to raise or lower the pond level. In a manhole using a valve, the valve is turned to raise or lower the pond. All valves in manholes should be exercised on a regular basis to ensure they are operable. Manholes using boards should be inspected regularly and boards replaced if leakage between boards is observed.

Figure 2.2.1.1

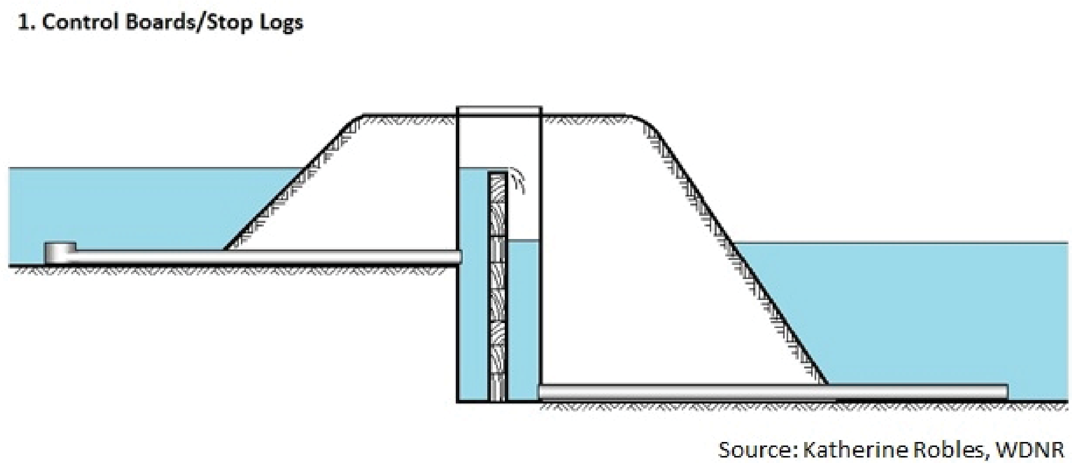
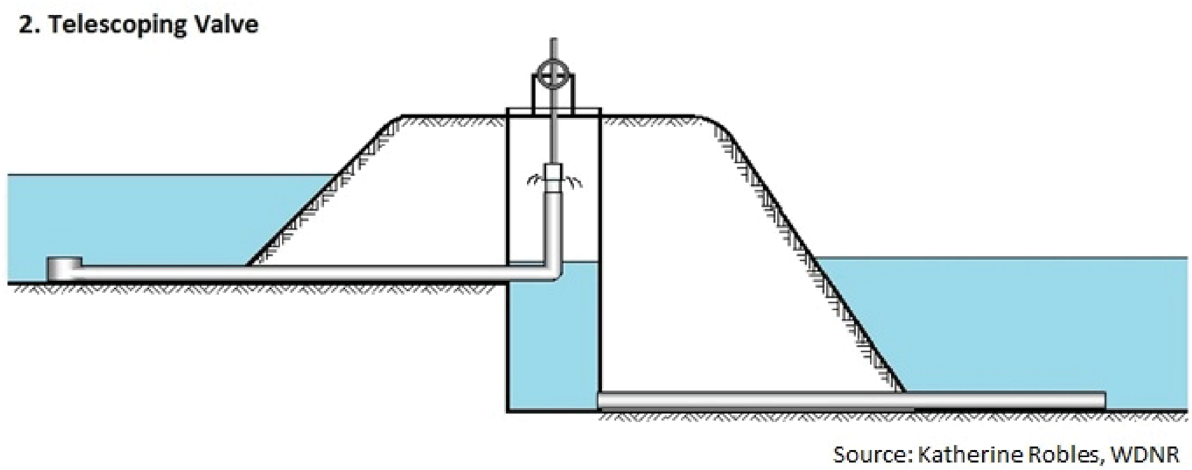


Figure 2.2.1.2



2.2.2 Describe the most common types of algae growing in ponds and lagoons

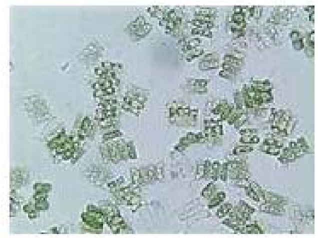
There are many forms of algae growing in wastewater treatment ponds. The two most common types are green and blue-green algae. Green algae, which give the green color to the ponds, predominate when pond conditions and treatment are good. Blue-green algae are filamentous and indicate poorer pond conditions, such as high organic loading, low dissolved oxygen (DO), low nutrients, and warm water conditions. They often form unsightly and odorous mats.

Some of the common forms of green algae are:

Figure 2.2.2.1

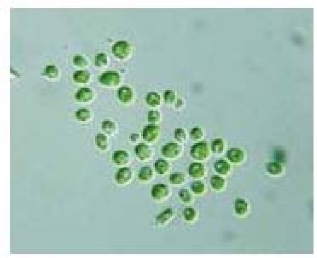
Chlorella

Scenedesmus

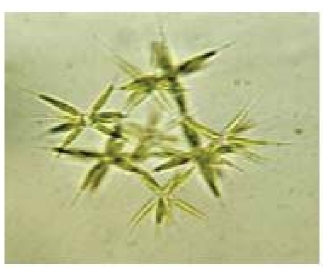


Euglena

Chlamydomonas



Actinastrum



Pediastrum

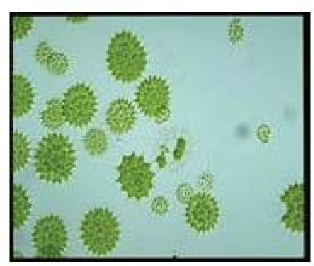
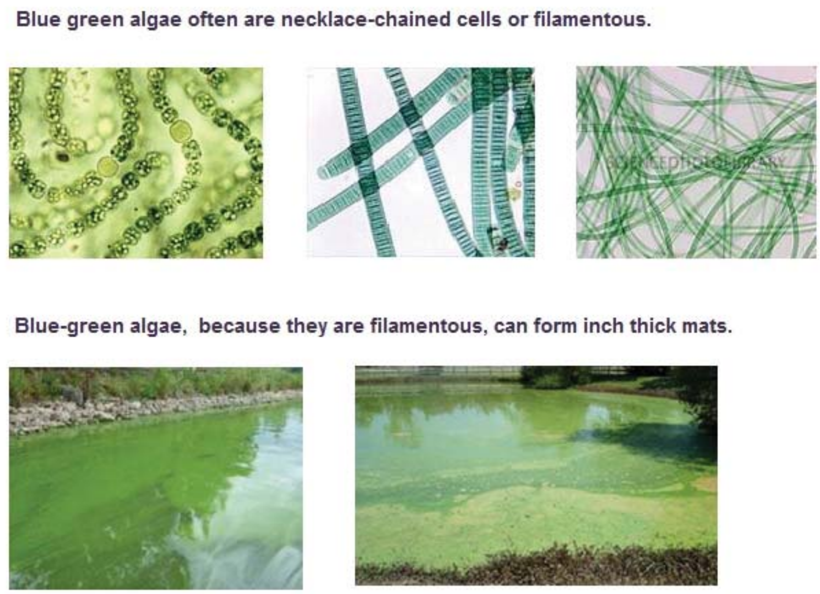


Figure 2.2.2.2



2.2.3 Discuss the significance of algal growth and blooms in stabilization ponds.

The prolific and excessive growth of algae in stabilization ponds can result in heavy algal blooms that cause a “pea soup” and high effluent total suspended solids (TSS). Algae blooms, most common during the summer, occur when the combined environmental conditions are just right for promoting high algal growth: influent food (biochemical oxygen demand or BOD) and nutrients (especially phosphorus), warm waters, and high solar radiation. The discharge of all this algae in the effluent can result in effluent BOD, TSS, and phosphorus violations. While many pond systems in Wisconsin have an algae variance of 60 mg/L for their TSS limit, it still may not help if effluent suspended solids are high due to an overabundance of algae. In ponds that have phosphorus limits and add chemicals for removing phosphorus, phosphorus violations may still occur due to the high phosphorus content of the algae themselves.

2.2.4 Discuss what an operator can do to control algae blooms.

First, it is important that the pond system is not overloaded and that it is sized correctly. Stabilization ponds should not be loaded greater than 20 lbs/acre/day and must have a minimum of 150 days of detention time. Second, operating them at the proper water levels (3 to 6 ft) is important for facultative conditions (aerobic upper layer and anaerobic bottom layer). While algae bloom control strategies are limited, some options are:

A. Barley straw (in very early spring or summer to reduce algae growth)
B. Chemical treatment (alum)
C. Storage and holding pond contents held until algae conditions naturally lessen (usually not practical)
D. Dyes (to reduce sunlight penetration and photosynthesis thus reducing growth)
E. Pond covers, especially on the last smaller polishing pond
F. Ultrasound (if studies prove it a safe and effective method)

2.2.5 Describe the purpose and operation of a fill and draw stabilization pond system.

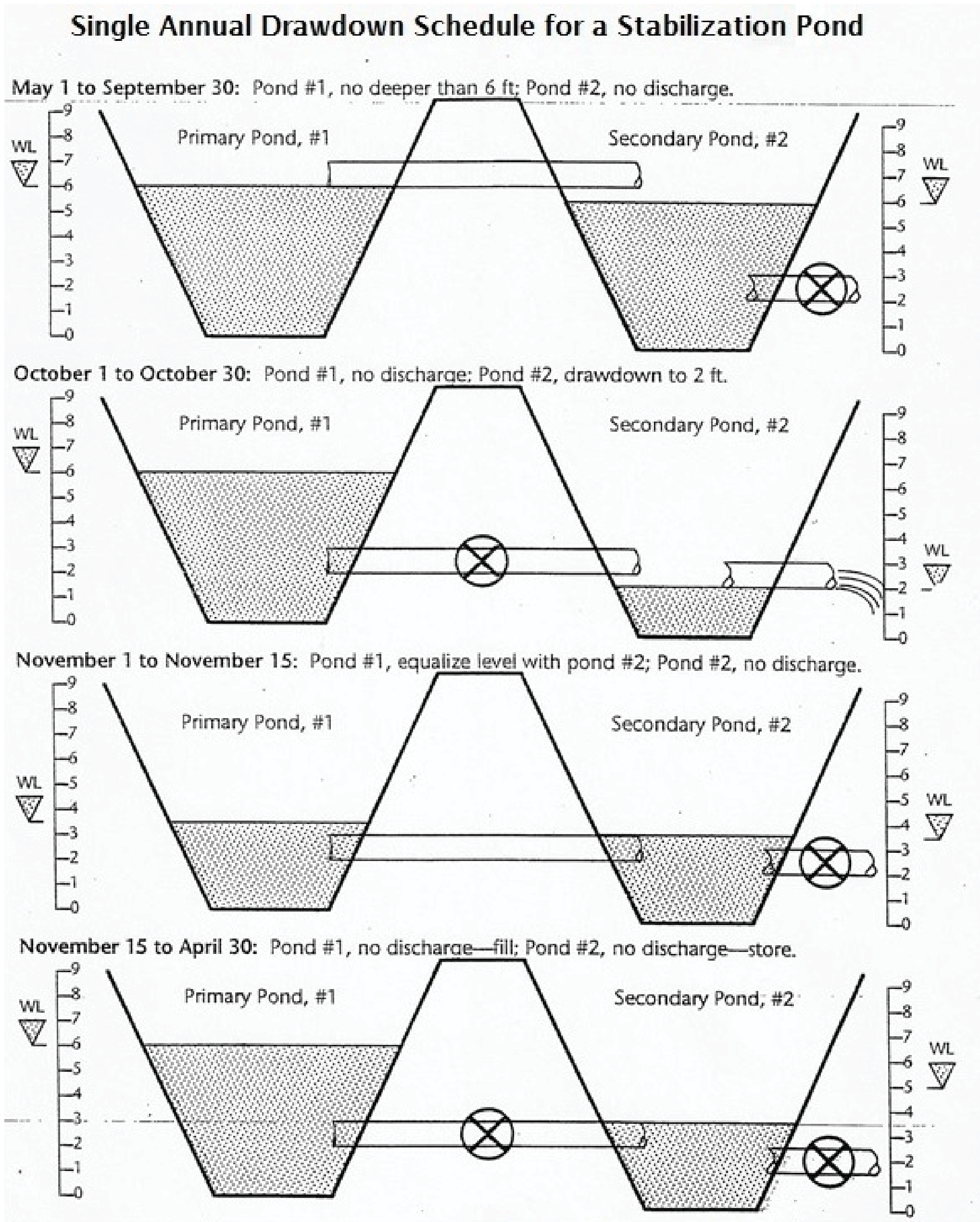
The purpose of a fill and draw mode of pond operation is to allow for the storage (fill) of wastewater when effluent quality may be poor (summer and winter) and for the discharge (draw) of wastewater when effluent quality is good (spring and fall). When not discharging, ponds are filling and receiving treatment. Sampling of the pond and DNR notification is required prior to discharging to ensure permit limits are met.

During spring and fall discharges, receiving streams are also colder and contain more oxygen. A spring discharge can commence almost immediately after ice-out if the BOD levels are acceptable. Algae levels in the pond are low at this time and streams flow high with plenty of oxygen making it a very good discharge period (March through May). While treatment is at its highest in the summer, discharging effluent during the summer depends upon the amount of algae in the pond. Excessive algae or algal blooms, if discharged, can result in effluent violations, especially TSS. Some operators may discharge in the summer only if effluent quality remains below permit limits. As algae concentrations significantly decrease in the fall with the onset of colder weather, operators again discharge while effluent BOD is low. In fact, October through November discharges often can be of the best quality of the year having received a high level of treatment during the summer.

2.2.6 Show a single annual drawdown schedule for a stabilization pond.

To drawdown a pond, isolate the pond, if possible, one month before the discharge period. Begin testing to monitor pond contents effluent limited parameters. Send results to the Department of Natural Resources and notify them of the intent to discharge. Calculate what volume will be needed for storage and discharge at least that amount. Determine from the discharge permit daily discharge volume and calculate total days required for discharge. Always leave at least 1 or 2 ft of treated wastewater in a pond so the wastewater will have an active bacterial concentration. This greatly aids in maintaining oxygen and prevents odors or organic upsets.

Figure 2.2.6.1



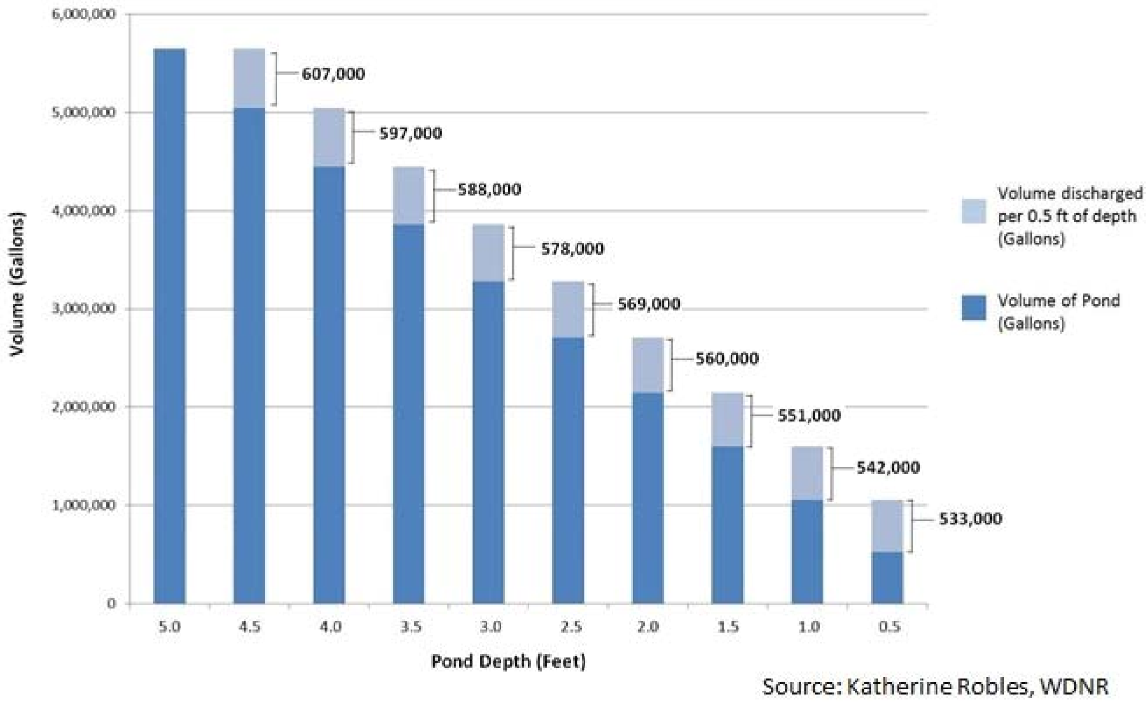
Source: WDNR

2.2.7 Show graphically the relationship between drawdown and pond volume during the drawing down of a pond.

Most stabilization ponds are constructed in a trapezoidal shape and therefore when drawing down such a pond from the top down, each foot of water above has a greater volume than the foot below it. Knowing the volume in each foot or half foot of water allows an operator to know how much the pond needs to be lowered to discharge a certain volume of water. By knowing the volume the pond has been emptied allows the operator to know how much storage volume he or she now has for the fill cycle of a fill and draw system. In a fill and draw system, the operator must adequately drawdown the pond system in the fall, allowing for sufficient fill volume during the winter and ensuring at least 3ft of freeboard.

The graph below shows two things: the volume of wastewater in every half foot of depth and the total volume of the pond with decreasing depth. Such graphs can be very helpful for both drawing down and filling a pond. By knowing influent flow or effluent flow rates, an operator will then know the time it will take to raise or lower the pond to desired depths.

Figure 2.2.7.1



2.2.8 List the reasons why an operator would vary pond levels.

A. Allow more treatment through increased detention time; raising pond levels increases detention time
B. Repair aeration equipment or other structure
C. Repair leaks
D. Control muskrats
E. Control rooted weeds
F. Flood cut cattails
G. Remove sludge
H. Remove pipe blockages

2.2.9 Describe the proper operation of multiple seepage cells.

The best operation for a seepage cell is loading cycles consisting of an application period and drying period (alternating cells giving each cell a load and rest period). During the drying period soil is able to drain, dry, and draw air in, maintaining aerobic conditions in the soil. An application period generally ranges from 1 to 3 weeks, while the drying period is 1 to 2 times the application period. Before discharging to a seepage cell, the pond contents must be monitored as required by the permit. During discharge, flow to the seepage cell is recorded daily. The flow should be uniformly distributed across the entire seepage cell.

Loading rates to seepage cells are up to 90,000 gals/acre/day (gpad).

2.2.10 Describe how to check for efficient aeration of a lagoon.

Checking for efficient aeration of a lagoon includes monitor lagoon DO, watch surface aeration patterns for changes, read airline pressure gauge, check for changes in effluent BOD, and monitor all aeration equipment. For proper treatment, an aerated lagoon should have an adequate supply of DO. The DO in the surface mixed zone should be at least 2 mg/L.

2.2.11 Describe the effects of seasonal changes on pond treatment efficiency.

A. Winter
Treatment efficiency decreases in the winter with colder temperatures. Shorter periods of sunlight and ice/snow cover limits the amount of photosynthesis. This may reduce DO in the pond. The cold water also slows down bacterial action, reducing treatment efficiency. If sufficient ice/snow cover is present, the pond may go anaerobic. Emergent weeds and duckweed die off. During this period, fill and draw ponds are operated by storing wastewater for a spring discharge.

B. Spring
After ice-out, odors may occur for several days until DO is restored. As temperatures increase, biological activity increases for both bacteria and algae. Treatment efficiency begins to improve with increasing biological activity. After the the pond has stabilized, a spring discharge for fill and draw type systems is usually done prior to active algae growth.

C. Summer
The long sunny days provide maximum oxygen levels from algae photosynthesis. Warm water temperatures increase bacteria action to provide the best environment for efficient treatment. Operational problems include: controlling rooted emergent weeds, removing duckweed, and controlling algae blooms. During this period, fill and draw pond systems are operated by storing wastewater for a fall discharge.

D. Fall
Fall is a transitional time, but in reverse of spring. Water temperatures begin dropping, reducing bacterial activity and photosynthesis as the days get shorter. Treatment efficiencies begin to drop as winter approaches. When the algae levels drop and the BOD stabilizes, fill and draw type systems normally discharge.

2.2.12 Discuss the operating procedures for dealing with a spring thaw.

Ponds will usually fill up fast during spring thaw and levels must be watched so dikes do not overflow. Discharge should be continuous and increased as needed until levels stabilize. Start spring drawdown of the ponds if operating on fill and draw. The collection system usually has infiltration and flow is quite large during the spring thaw. Draw ponds down when streams are cold and flows high.

2.2.13 Discuss the purpose of using rip rap on the inner dike of a lagoon or pond.

Rip rap is used for protecting the inner diking from erosion. Rip rap may consist of 3 to 5 inch stone placed at normal operating water levels. This size stone prevents erosion due to wave action and is small enough to deter weed growth and burrowing animals. Maintaining rip rap includes keeping it weed free and replenished.

2.2.14 Describe factors that affect the amount of metal salt needed to remove phosphorus in a pond system.

The initial estimate of the metal salt dose needed to remove phosphorus in a pond system can be calculated in the same manner as for an activated sludge system. As with activated sludge, competing reactions will require more metal salt than the theoretical dose. Total phosphorus in a pond includes soluble and particulate phosphorus and phosphorus contained in algal cells. While the metal salt will react with orthophosphate to create an insoluble precipitate, algae and particulates will also settle with precipitate.

2.2.15 Discuss the ways in which phosphorus removal chemicals can be added at a pond or lagoon system.

For continuous dosing, metal salts to remove phosphorus are usually added to the last pond or lagoon where the precipitation reaction and settling can occur. The chemical should be added where good mixing of the chemical with the wastewater can be achieved, such as the upstream manhole prior to the last pond or just before an aerator. For batch dosing of aluminum sulfate (alum) in fill and draw systems, some operators use a small motorboat to apply the alum where the propeller can provide the mixing. Another alternative is to spay alum directly to the surface.

2.2.16 Explain how a pond is batch treated using a small motorboat or pontoon type boat.

Alum is typically the phosphorus removal chemical applied to a pond by boat. The boat is fitted with a tank to hold the chemical. The chemical drains by gravity to the propeller area where it is mixed into the pond. The boat travels and applies chemical in a grid work pattern across the entire pond surface. The floc that forms is allowed to settle for 24 to 48 hours and a sample of the treated pond is taken to assure it meets effluent limits before the pond is discharged. This can be an inexpensive and effective method to treat and remove phosphorus from ponds and lagoons. Care must be taken in shallow ponds when boat propellers are used for mixing so as to not rile up the solids settled in the pond or damage the liner.

2.2.17 Discuss the build-up of sludge in lagoons and ponds using chemicals for phosphorus removal.

Solids will accumulate in the pond where precipitates form and settle. The amount of chemical sludge produced is 7.5 mg chemical sludge per mg phosphorus removed for alum and 10 mg chemical sludge per mg phosphorus removed for iron. Sludge depths should be measured annually and sludge removed as needed to avoid any release of the phosphorus from the settled sludge and organic material.

2.2.18 Discuss management plans for natural land treatment systems.

The Department of Natural Resources requires management plans for land treatment systems such as ridge and furrow, spray irrigation, and overland flow systems. These plans are for optimizing treatment system performance and achieving compliance. The treatment system must be operated in conformance with pretreatment processes, load and rest schedules, scheduled maintenance, weed control, strategies for adverse weather, and monitoring procedures.

Section 2.3 - Equipment

2.3.1 Describe common aeration equipment used in Wisconsin aerated lagoons.

There are many types and manufacturers of aeration equipment used in aerated lagoons. Some of the most common are diffusers (coarse bubble and fine bubble), static tube helixors, air spargers, floating surface aerators, and platform mounted turbines. Subsurface aeration equipment is much less affected by icing issues.

Figure 2.3.1.1

A. STATIC TUBE "HELIXORS" (Sanitherm Inc. - Pulcon Photo)

Figure 2.3.1.2

B. SURFACE AERATOR (AIR SPARGER) (Fuchs Aeration Photo)

Figure 2.3.1.3

C. SURFACE MECHANICAL AERATOR

Figure 2.3.1.4

D. PLATFORM MOUNTED TURBINES (Unitech Water Technologies Pvt. Ltd. Photo)

Figure 2.3.1.5

E. COURSE BUBBLE AND FINE BUBBLE DIFFUSERS (Environmental Dynamics International Photo)

Course Bubble **Fine Bubble**

2.3.2 Discuss the purpose of a blower air relief valve in a pond aeration system.

In the event of excess pressure (plugged diffusers or air lines) the pressure relief valve will open to release excess pressure and protect the piping, diffusers, and the blower.

2.3.3 Describe the meaning of blower air pressure gauge readings.

The normal operating discharge pressure from a blower is 5 to 14 psi. High readings of an air gauge are caused by plugged airline, orifices, diffusers, or ice cap. Low readings of an air gauge could be caused by a faulty blower, an air leak, or clogged blower inlet filter. In either case, there is a possibility that the blower could overheat, causing damage to the unit. A hot blower should be shut-down and corrective action taken.

2.3.4 Describe how pond depth and bubble size affect aeration efficiency.

The deeper the pond, the longer the contact time before the bubbles reach the surface. The smaller the bubbles are the more contact surface between the air and water, which increases the transfer rate.

Section 2.4 - Preventative Maintenance

2.4.1 List common maintenance considerations for a diffused aeration system.

A. Centrifugal blowers
1. Unusual noise or vibrations
2. Lubrication of blowers and motors
3. Check and lubricate couplings
4. Check discharge pressure and temperature
5. Check filters and obstructions
6. Check amperage meter

B. Positive displacement blowers
   1. Unusual noise or vibrations
   2. Lubrication of blowers and motors
   3. Check and lubricate couplings
   4. Check and exercise pressure relief valve
   5. Check discharge pressure and temperature
   6. Check filters and obstructions
   7. Check blower seals
   8. Check drive belt alignment and tension

An operator should refer to the O&M manual for all required maintenance. All maintenance and repairs should be documented.

2.4.2 List components of a maintenance recordkeeping system.

Typical equipment for ponds and lagoons that need maintenance are blowers, aerators, piping, pumps, manholes, valves, mowing, weed control, flow metering, and sampling equipment. Maintenance recordkeeping involves the use of various formats to record performed maintenance and repairs. Examples include a folder filing system, a card system, or computers with appropriate software.

Two major components of a good maintenance recordkeeping system are a history of repairs for major equipment items and a preventative maintenance program that schedules the interval frequency for routine maintenance tasks, such as lubrications and other tasks, for each piece of equipment. Preventative maintenance that is to be performed at a treatment facility can be found in the plant's O&M manual. A regular preventative maintenance program reduces major breakdowns, unexpected repairs, and excessive weed overgrowth.

2.4.3 List the most common maintenance tasks associated with pond systems.

A. Weed control of cattails and other rooted aquatic plants
B. Algae control of blue-green and associated floating algae mats, algal blooms
C. Control of burrowing animals such as muskrats and turtles
D. Duckweed control and removal
E. Floating sludge mats
F. Dike mowing and removing woody plants
G. Dike erosion control with rip rap and proper vegetation
H. Fence maintenance to restrict access
I. Mechanical equipment such as pumps, blowers, etc
J. Exercise valves regularly
K. Check manholes for hydrogen sulfide corrosion, especially influent manhole

2.4.4 Discuss the maintenance of seepage cells.

Seepage cell maintenance includes controlling weeds by tilling the soil. Keeping the cell level and tilling on a regular basis so that excessive vegetation growth does not occur. If weed growth becomes excessive, it may need to be mowed and removed before tilling. Seepage cell maintenance involves aerating the soil crust which builds-up at the soil and air interface. This crust impedes water and oxygen percolation into the soil. Any suitable tilling equipment can be used. Tilling 6 to 12 ins helps control weed growth which proliferates on the surface. Avoid unnecessary soil compaction.

2.4.5 List the ways to control aquatic vegetation.

Rooted weeds can be controlled by:
A. Physical removal of new growth by hand
B. Mowing with a sickle bar after ice has formed
C. Increasing the water level to reduce light penetration to stop photosynthesis
D. Lowering the water level and burning the weeds

2.4.6 Discuss how to deal with floating mats.

Floating mats on pond systems are caused by floating sludge, blue-green algae, or oil and grease; the most common are sludge and algae mats. Mats can cause odor problems. It can be corrected by trying to break-up the sludge or algae mats and allowing them to settle to the bottom. If this does not work, it will be necessary to rake them out and dispose of them. If oil and grease are a problem, the source of this material should be eliminated through a Grease Control Program.

2.4.7 Describe how cattails can be controlled without chemicals.

Cattails can establish themselves in shallow water and the soft bottom along the dikes. Cattails have extensive root systems and can spread using rhizomes and forming large interconnected stands. They can also spread by wind-dispersed seeds, so controlling them early as they try to establish themselves in the pond is desirable before they become large colonies and a labor intensive task. When cattails are young and just starting to grow, manually pulling them out is a very effective preventative maintenance task to regularly do.

If the cattails were left to mature and spread into colonies along the pond banks, then drowning them can be an effective method. There are two ways to do this:

A. During warm weather, a pond with a mature cattail stands is lowered, if possible. The cattail stalks are cut and then the water is raised to 2 to 3 ft over the stalks, thereby drowning and killing them. If lowering the pond is not possible; a boat mounted weed cutter can be used to cut the cattails below the water surface.

B. During the winter, an easier cutting method may be employed. In the previous fall, during a fall discharge, the pond is lowered and left as low as possible for the winter. Once ice covers the ponds, an operator can then walk to the cattails and easily cut them off at the ice surface. In the spring, the water is allowed to raise 2 to 3 ft over the cut stems with the same drowning result. If the cattail problem is excessive, this method may have to be repeated over a couple of winters reducing the cattails each summer until they completely disappear from the pond.

Figure 2.4.7.1

2.4.8 Discuss the use of chemicals for controlling vegetation both in and around the pond.

The use of chemicals to control vegetation in a pond should be limited. Due to toxicity concerns, manual or mechanical methods of control are preferred. Chemical vegetation control should only be used as a last resort in a pond and needs the Department of Natural Resource's approval.

When using chemicals to control vegetation on diking and around the pond, products such as Round Up® or equivalent can be used. Do not overspray into the pond and follow all the manufacturer's safety precautions and recommendations when handling chemicals.

2.4.9 Identify types of dike vegetation and how to control grass and other plant growths.

It is very important that dikes have a protective grass cover to prevent erosion from runoff and wave action. The grasses used should be fast growing and have spreading, shallow, but dense root systems (e.g. rye, brome, and quack). Mowing should be done periodically so dikes can be visually inspected and to reduce breeding areas for insects.

Trees and shrubs should not be allowed to grow on dikes as their root structure could cause dike leakage, damage to the pond seal, or structural failure to the dike. All woody plants should be removed by pulling or mowing and, in the event they become established, using brushing methods (e.g. pruning, chain saw, brush saw, weed whacker, etc.).

2.4.10 Discuss the solids build up in stabilization ponds.

Over time, sewage solids settle and can start to build up on the pond bottoms, especially in the first stabilization pond. Measuring solids deposition should start at about 10 years of operation or from the last sludge removal. Solids in a pond or lagoon can be measured using a sludge depth finder such as a Sludge Judge® from a row boat or through holes drilled into the ice. Using a surface grid, sludge depth measurements should be taken every so many feet, perhaps every 50 ft, starting near the influent pipe and recorded on a grid.

Many ponds eventually need to have solids mechanically removed, typically after 15 to 20 years. Accumulated solids reduce the detention time of the pond, which can reduce treatment. For example, every foot of a 3 acre, 5 ft deep pond contains about 1 million gallons (MG) or 50 days of detention time. Every foot of sludge thus reduces the detention time by 50 days (20%); 2 ft by 100 days (40%). Treatment will ultimately be effected. If sludge starts to accumulate to 1 ½ to 2 ft in much of the pond, removal should start to be considered and budgeted. Most solids will deposit within a certain radius of the influent pipe, causing a volcano type buildup effect. Sometimes solids may only need to be removed in the near vicinity of the influent pipe to ensure solids do not affect the influent flow rate.

Sludge removal, when necessary, should be planned and done through a consultant and contractor. It is extremely important that the equipment and methods used do not damage the pond liner and diking. The sludge removal plan must be sent to and approved by the Department of Natural Resources. The disposal of pond or lagoon sludge must meet all sludge sampling, reporting, and land application requirements of the Wisconsin Pollution Discharge Elimination System (WPDES) permit and Wisconsin Administrative code requirements.

2.4.11 Discuss the operation and maintenance needs of an overland flow treatment system.

Daily inspection of collection ditch integrity should be performed. If breeched, runoff collection ditches need to be restored. The overland flow terrace should be inspected for ponding or channeling. If these conditions exist, the terrace should then be taken offline, filled, and reseeded. The vegetation should be mowed or harvested as needed.

2.4.12 List the operation and maintenance needs of a spray irrigation treatment system.

A. Pumps
Lubrication, check seals, record pressure

B. Drive for the center pivot sprayer
Lubricate gears, check tire pressure and tread

C. Nozzles
Keep clean, unplug as needed

D. General
Drain system completely before freezing weather

2.4.13 List the operation and maintenance needs of a ridge and furrow system.

A. Remove grasses at beginning of or prior to growing season and at least one additional time during the growing season to maximize nutrient uptake. Prior to growing season, grasses may be burned.

B. Alternate loadings between cells to allow cells to rest prior to recharge.

C. Ensure adequate rest period to allow ridge soil to become unsaturated and aerobic.

D. Visually evaluate ridge and furrow system to verify uniform loading and verify no wastewater runoff.

E. Maintain pumps by lubrication, check seals, and record pressure and run time.

Chapter 3 - Monitoring, Process Control, and Troubleshooting

Section 3.1 - Definitions

3.1.1 Define enforcement standard (ES).

ESs are groundwater quality standards set for substances that pose a risk to public health or welfare. When a substance is detected in the groundwater in concentrations equal to or greater than its ES, the activity, practice, or facility that is the source of the substance is subject to enforcement action. Corrective action is required to bring a facility back into compliance.

3.1.2 Define point of standards application.

Point of standards application means the specific location, depth or distance from a facility, activity, or practice at which the concentration of a substance in groundwater is measured for purposes of determining whether a preventive action limit or an enforcement standard has been attained or exceeded.

3.1.3 Define preventive action limit (PAL).

PALs are a groundwater quality standard that serves two main purposes. First, PALs set limits to prevent contamination. PALs also serve as an indicator that remedial actions or a regulatory response may be necessary. The value or concentration of a PAL is less than the ES for a substance, with the intention of giving permitees time to take preventive action so that the ES is not exceeded.

Section 3.2 - Sampling and Testing

3.2.1 Describe the typical Wisconsin Pollution Discharge Elimination System (WPDES) permit monitoring requirements for a pond or lagoon system.

The WPDES permit for a pond or lagoon system will specify the types and frequency of influent and effluent sampling from a pond or lagoon system. Influent and effluent are always sampled for biochemical oxygen demand (BOD) and total suspended solids (TSS). Other effluent parameters may also be required such as pH, ammonia, total nitrogen, phosphorus, and chlorides depending on the receiving water (surface water or groundwater) and the effluent limits in the WPDES permit. Sampling results are entered on the electronic Discharge Monitoring Reports (eDMR).

The following eDMR shows the influent and effluent flow monitoring and sampling required for a stabilization pond system discharging to seepage cells.

Figure 3.2.1.1

Wastewater Discharge Monitoring Long Report

Facility Name:
Contact Address:

Facility Contact:
Phone Number:
Reporting Period: 04/01/2013 - 04/30/2013
Form Due Date: 05/15/2013
Permit Number:

For DNR Use Only

Date Received:
DOC:
FIN:
FID:
Region:
Permit Drafter:
Reviewer:
Office:

	Sample Point	701	701	701	701	701
	Description	INFLUENT	INFLUENT	INFLUENT	INFLUENT	INFLUENT
	Parameter	211	66	457	335	337
	Description	Flow Rate	BOD5, Total	Suspended Solids, Total	Nitrogen, Total Kjeldahl	Nitrogen, Organic Total
	Units	MGD	mg/L	mg/L	mg/L	mg/L
	Sample Type	CONTINUOUS	GRAB	GRAB	GRAB	CALCULATED
	Frequency	CONTINUOUS	2/MONTH	2/MONTH	MONTHLY	MONTHLY
Sample Results	Day 1	0.063				
	2	0.060				
	3	0.065				
	4	0.055				
	5	0.059				
	6	0.061				
	7	0.065				
	8	0.066	110	100	24	28
	9	0.075				
	10	0.090				
	11	0.100				
	12	0.100				
	13	0.057				
	14	0.056				
	15	0.065				
	16	0.075				
	17	0.070				
	18	0.120				
	19	0.080				
	20	0.070				
	21	0.065				
	22	0.080				
	23	0.054				
	24	0.053				
	25	0.055				
	26	0.065				
	27	0.065				
	28	0.062				
	29	0.064	230	260		
	30	0.061				
	31					

	Sample Point	701	002	002	002	002
	Description	INFLUENT	EFFLUENT (SEEPAGE CELL)	EFFLUENT (SEEPAGE CELL)	EFFLUENT (SEEPAGE CELL)	EFFLUENT (SEEPAGE CELL)
	Parameter	789	211	66	457	377
	Description	Nitrogen, Ammonia (NH3-N) Total	Flow Rate	BOD5, Total	Suspended Solids, Total	pH Field
	Units	mg/L	MGD	mg/L	mg/L	su
	Sample Type	GRAB	CONTINUOUS	GRAB	GRAB	GRAB
	Frequency	MONTHLY	CONTINUOUS	2/MONTH	2/MONTH	2/MONTH
Sample Results	Day 1		0.090			
	2		0.090			
	3		0.090			
	4		0.090			
	5		0.090			
	6		0.090			
	7		0.090			
	8	17	0.090	20	33	8.89
	9		0.090			
	10		0.090			
	11		0.090			
	12					
	13					
	14		0.090			
	15		0.090			
	16		0.090			
	17		0.090			
	18		0.090			
	19		0.089			
	20		0.090			
	21		0.090			
	22		0.090			
	23		0.090			
	24		0.090			
	25		0.090			
	26		0.090			
	27		0.090			
	28		0.090			
	29		0.090	11	26	8.97
	30		0.090			
	31					

	Sample Point	701	701	701	701	701
	Description	INFLUENT	INFLUENT	INFLUENT	INFLUENT	INFLUENT
	Parameter	211	66	457	335	337
	Description	Flow Rate	BOD5, Total	Suspended Solids, Total	Nitrogen, Total Kjeldahl	Nitrogen, Organic Total
	Units	MGD	mg/L	mg/L	mg/L	mg/L
Summary Values	Monthly Avg	0.0692	170	180	24	28
	Daily Max	0.12	230	260	24	28
	Daily Min	0.053	110	100	24	28
Limit(s) in Effect	Monthly Avg					
QA/QC Information	LOD					
	LOQ					
	QC Exceedance	N	N	N	N	N
	Lab Certification					

	Sample Point	701	002	002	002	002
	Description	INFLUENT	EFFLUENT (SEEPAGE CELL)	EFFLUENT (SEEPAGE CELL)	EFFLUENT (SEEPAGE CELL)	EFFLUENT (SEEPAGE CELL)
	Parameter	789	211	66	457	377
	Description	Nitrogen, Ammonia (NH3-N) Total	Flow Rate	BOD5, Total	Suspended Solids, Total	pH Field
	Units	mg/L	MGD	mg/L	mg/L	su
Summary Values	Monthly Avg	17	0.089964286	15.5	29.5	8.93
	Daily Max	17	0.09	20	33	8.97
	Daily Min	17	0.089	11	26	8.89
Limit(s) in Effect	Monthly Avg			50 0		
QA/QC Information	LOD	0.13				
	LOQ	0.25				
	QC Exceedance	N	N	N	N	N
	Lab Certification					

3.2.2 Describe flow monitoring and taking samples from a pond or lagoon system.

Sampling and flow monitoring requirements are contained in the WPDES permit. Influent and effluent flow metering is often required so that influent and effluent volumes are known and also so that leakage estimations can be made (see key knowledge 3.3.3). For remote fill and draw pond systems without nearby power, a portable battery or solar-powered flow meter can be used for effluent flow metering during discharge periods.

Samples of raw wastewater should be taken where it enters the pond system or at the lift station that pumps the wastewater. Flow-proportional samples are always preferred over grab samples and will be required in the permit if that capability exists or if power can be economically extended to the site.

In a fill and draw pond system, the pond has to be sampled prior to discharging to ensure it will meet effluent limits. It is important that this sampling be representative of the pond contents that are to be discharged. Multiple samples should be collected and then mixed together prior to laboratory analysis. One commonly used method is to collect a pond sample from the four corners of the pond as far as a sampling cup and long pole can be safely extended from the shore (6 to 10 ft) and below the surface of the water. The four samples of equal volume should be mixed together and then tested.

Samples of final effluent should be taken where the treated wastewater leaves the treatment system. The sample should be at a well-mixed representative location. Again, flow-proportional samples are always preferred over grab samples and will be required in the permit if that capability exists.

3.2.3 Explain how samples should be collected and preserved for analysis.

A. BOD and TSS
The most representative influent and effluent BOD and TSS sample is collected using a 24-hour flow-proportional sampler. Influent samples to a pond or lagoon site usually involve composite sampling because of power availability. Effluent composite samples are preferred at pond sites, but when electrical power is not available or possible, a grab sample is collected. The WPDES permit will specify the type and frequency of sample collection. BOD and TSS samples must be kept cool (6°C or less without freezing) and sent in or delivered to a lab for analysis within 48 hours.

B. Phosphorus and ammonia
The most representative samples collected for ammonia and phosphorus are 24-hour flow-proportional samples. If flow-proportional samples are not possible, but conditions allow for a portable sampler to be used, then time-proportional samples are the next best. If neither is used, then a grab sample can be collected. The WPDES permit will specify the type and frequency of sample collection. These nutrient samples must be collected in a special specific type of sample bottle, preserved with sulfuric acid, and kept cool (6°C or less without freezing) until they are analyzed.

C. Fecal coliforms
An effluent grab sample collected for fecal coliform analysis must be kept cool (6°C or less without freezing) and delivered to a lab immediately. The maximum holding time for a fecal coliform sample is 6 hours.

D. pH, chlorine residual, and dissolved oxygen (DO)
With no preservation method, these samples must be analyzed immediately onsite upon collection because these parameters will change over time.

3.2.4 Discuss purging a monitoring well so that a representative groundwater sample can be collected.

The goal of sampling a monitoring well is to collect unaltered samples that represent the physical and chemical composition of groundwater. Monitoring wells must be purged of four (4) well volumes before a sample can be collected. The goal of purging is to remove the stagnant water that has been sitting in the well casing which may no longer be a representative of the groundwater. Purging brings fresh groundwater through the well screen and into the well casing for a representative groundwater sample. Stagnant water does not represent groundwater. Purge and sample wells in order from least to most contaminated unless the sampler uses dedicated or disposable equipment.

The volume to be purged from a well can be determined from the following equation:

$V = 3.14 \times (\text{radius})^2 \times H \times 7.48\ \text{gals/ft}^3 \times 4$

V = total purge volume, four well volumes (gals)
D = inside diameter of well casing (ft), radius is half the diameter width
H = water in the well (ft) = depth to well bottom - depth to water

3.2.5 Describe how groundwater is monitored.

Groundwater is typically monitored at the system boundary. Monitoring wells are installed upgradient of lagoons to measure the background groundwater quality and downgradient to measure the impact of the lagoon. Typical monitor parameters include nutrients such as nitrate - nitrogen, ammonia nitrogen, organic – nitrogen, potassium, total dissolved solids, ortho phosphorus, total phosphorus, pH, and trace metals.

3.2.6 Describe a Groundwater Monitoring Report form.

The following is a typical Groundwater Monitoring Report form. The most important aspects to note are the sample values entered for each parameter for both the background and down gradient wells, as well as the preventative action limits (PAL) and enforcement standards (ES) for those parameters. The highlighted areas represent data or information entered by the operator for DNR reporting.

Figure 3.2.6.1

Groundwater Monitoring Form

Facility Name :
Contact Address :

Facility Contact :
Phone Number :
Reporting Period : 07/01/2012 - 09/30/2012
Form Due Date : 11/15/2012
Permit Number :

For DNR Use Only

Date Received:
DOC:
FIN:
FID:
Region:
Permit Drafter:
Reviewer:
Office:

Well No/Description: **801/MW1 (801) BACKGROUND WELL**

WI Unique No: Sample Date: 09/12/2012
Casing Top Elevation(Feet, MSL): 863.25
Casing Top Elevation New(Feet, MSL):
Well Is: Broken: N Frozen: N Dry: N Sample Has: Odor: Y Color: Y Turbidity: Y
Abandoned On: Abandoned By:

Parameter	Sample Value	Units	PALs	ESs	LOD	LOQ	Lab Certification Number
166 - Depth To Groundwater	35.9	feet					
227 - Groundwater Elevation	827.35	feet MSL					
329 - Nitrogen, Nitrite + Nitrate (as N) Dissolved	2.9	mg/L	10.7	10.7	0.050	0.15	721026460
106 - Chloride Dissolved	7.8	mg/L	141	250	2.5	5.0	721026460
377 - pH Field	7.56	su	8.3				
325 - Nitrogen, Total Kjeldahl Dissolved	0.27	mg/L			0.12	0.35	721026460
319 - Nitrogen, Ammonia Dissolved	0.15	mg/L	2.1		0.025	0.075	721026460
331 - Nitrogen, Organic Dissolved	00.00	mg/L	2.4		0.12	0.35	721026460
462 - Solids, Total Dissolved	450	mg/L	653				721026460

Well No/Description: **803/MW3 (803) DOWNGRADIENT WELL**

WI Unique No: Sample Date: 09/12/2012
Casing Top Elevation(Feet, MSL): 841.52
Casing Top Elevation New(Feet, MSL):
Well Is: Broken: N Frozen: N Dry: N Sample Has: Odor: Y Color: Y Turbidity: Y
Abandoned On: Abandoned By:

Parameter	Sample Value	Units	PALs	ESs	LOD	LOQ	Lab Certification Number
166 - Depth To Groundwater	14.90	feet					
227 - Groundwater Elevation	826.62	feet MSL					
329 - Nitrogen, Nitrite + Nitrate (as N) Dissolved	9.6	mg/L	10.7	10.7	0.25	0.75	721026460
106 - Chloride Dissolved	250	mg/L	141	250	13	25	721026460
377 - pH Field	7.27	su	8.3				
325 - Nitrogen, Total Kjeldahl Dissolved	0.18	mg/L			0.12	0.35	721026460
319 - Nitrogen, Ammonia Dissolved	0.11	mg/L	2.1		0.025	0.075	721026460
331 - Nitrogen, Organic Dissolved	00.00	mg/L	2.4		0.12	0.35	721026460
462 - Solids, Total Dissolved	810	mg/L	653				721026460

Section 3.3 - Data Understanding and Interpretation

3.3.1 Explain why dissolved oxygen (DO) concentrations vary with pond depth.

DO levels vary with pond depth for a number of reasons. The main reason is the relationship of the organisms within the pond; different bacteria survive under different conditions. Other reasons include the physical actions within the pond and the loading to the pond. For example:

A. The algae are the main source of oxygen in a pond system. Algae growth is greatest near the surface where light penetration and photosynthesis is the greatest.

B. Oxygen levels decrease with depth, due to less light penetration needed for photosynthesis. The algae use carbon dioxide in the process of photosynthesis and produce oxygen. The bacteria stabilize organic matter using the oxygen and produce carbon dioxide.

C. The diffusion of oxygen occurs at the surface of ponds and is mixed in the upper layers by wind action. The amount of mixing is limited, so the oxygen levels decrease with depth.

D. Organic loading to the pond system can significantly affect oxygen levels. If organic loadings are small, the oxygen levels will be maintained at greater depths. If organic overloading occurs, the whole pond could go anaerobic.

3.3.2 Discuss how leakage from a pond or lagoon system can be estimated each year.

Leakage is estimated each year in the DNR's Compliance Maintenance Annual Reports (CMAR). Because annual precipitation approximately equals annual evaporation in Wisconsin (see key knowledge 1.2.3), the volume of effluent discharged from a pond system each year should be approximately the amount of influent entering a pond system. In other words, the volume of wastewater coming in and going out should be the same each year. Storage can also be accounted for in this estimation. If the influent cannot be accounted for, whether through effluent discharged and/or storage, then leakage may be occurring. If leakage seems to be occurring each year through CMAR reporting, further leakage studies may need to be undertaken either by doing onsite leakage testing and/or installing groundwater monitoring wells.

Total influent volume (million gallons or MG) minus total effluent volume (MG) plus or minus the change in pond/lagoon storage (MG) is the net wastewater loss. The net loss divided by 0.000365 equals the estimated leakage amount in gallons per day (gpd). The estimated leakage rate in gallons per acre per day (gpad) is the leakage amount in gallons per day (gpd) divided by the total pond surface area (acres) (see key knowledge 5.5.1).

3.3.3 Describe how leakage testing can be performed at a wastewater pond site.

When leakage is suspected, further evaluation can be done by onsite leakage testing. Onsite testing involves isolating the pond suspected of leakage by not allowing any wastewater to enter or leave, if possible. The pond level is measured using a staffing gage. Evaporation and precipitation are measured each day, most often using a large barrel partially filled with water. The barrel is placed in the pond to keep the water in the barrel at the same temperature as the pond. The water level in the barrel is measured daily for either precipitation (+) or evaporation (-). Changes in pond and barrel water levels should be relatively the same. Onsite leakage testing is usually conducted over a long enough time period (at least 30 days) to allow for climatic variability and data authenticity. Duplicating the leakage test by doing it a second time the same year adds additional confidence in the testing. The reader is referred to the Minnesota Leakage Testing Guidelines for further details and guidance for performing leakage tests onsite.

3.3.4 Define a groundwater monitoring well.

A groundwater monitoring well is a small diameter well, usually constructed of a PVC tube, that is drilled to the groundwater table (surface). It is installed for the specific purpose of either determining the elevation of the groundwater table and/or the physical, chemical, biological, or radiological properties of the groundwater.

3.3.5 Describe a groundwater monitoring well system.

A groundwater monitoring well system usually consists of an upgradient monitoring well(s) and a number of downgradient monitoring wells spaced apart and correctly located to accurately measure groundwater elevations and quality. Groundwater moves from higher elevation to lower elevation. The upgradient monitoring well (or control well) measures the background water quality above a treatment pond or lagoon site while downgradient wells measure the impacts, if any, from the site. The groundwater parameters that have to be monitored are specified in the facility's Wisconsin Pollution Discharge Elimination System (WPDES) permit to determine compliance with meeting groundwater quality standards.

3.3.6 Discuss pond or lagoon system leakage and effects.

Wastewater treatment ponds and lagoons are required by code to be designed to have a leakage rate less than 1,000 gpad. Practically speaking, and in order to meet this leakage rate design standard, most ponds and lagoons are lined with a synthetic liner. Synthetic liners most commonly used are polyvinyl chloride (PVC) or high-density polyethylene (HDPE) with a nominal 30 mil thickness. Pond and lagoon systems can be lined with clay or bentonite but must have a leakage rate less than the 1,000 gpad design standard.

Leakage from pond and lagoon systems greater than 1,000 gpad has the potential to contaminate groundwater. Untreated or partially treated wastewater can percolate through the soil transporting pollutants to the groundwater below. As contaminated groundwater moves away from the treatment plant site, it can contaminate downgradient wells or, if recharging a nearby stream, add pollutants to the stream.

3.3.7 Discuss the effects of pumping sewage to a distant pond or lagoon site.

Raw sewage may become septic if it has to be pumped a long distance (1 to 5 miles) from a lift station in town to a distant pond or lagoon site outside of town. The septicity is caused by the long detention time of the wastewater in the pipe under anaerobic conditions before it reaches the pond site. Under anaerobic conditions, organic acids and sulfide compounds form. Organic acids can result in increasing the biochemical oxygen demand (BOD) of the wastewater once it reaches the pond site. Hydrogen sulfide results from the bacterial breakdown of organic matter in the absence of oxygen, such as in sewers. The wastewater, upon discharge to the influent manhole at the pond site, will release corrosive hydrogen sulfide gas leading to manhole deterioration. Because of this, pond influent manholes should be constructed and properly coated to protect against hydrogen sulfide corrosion.

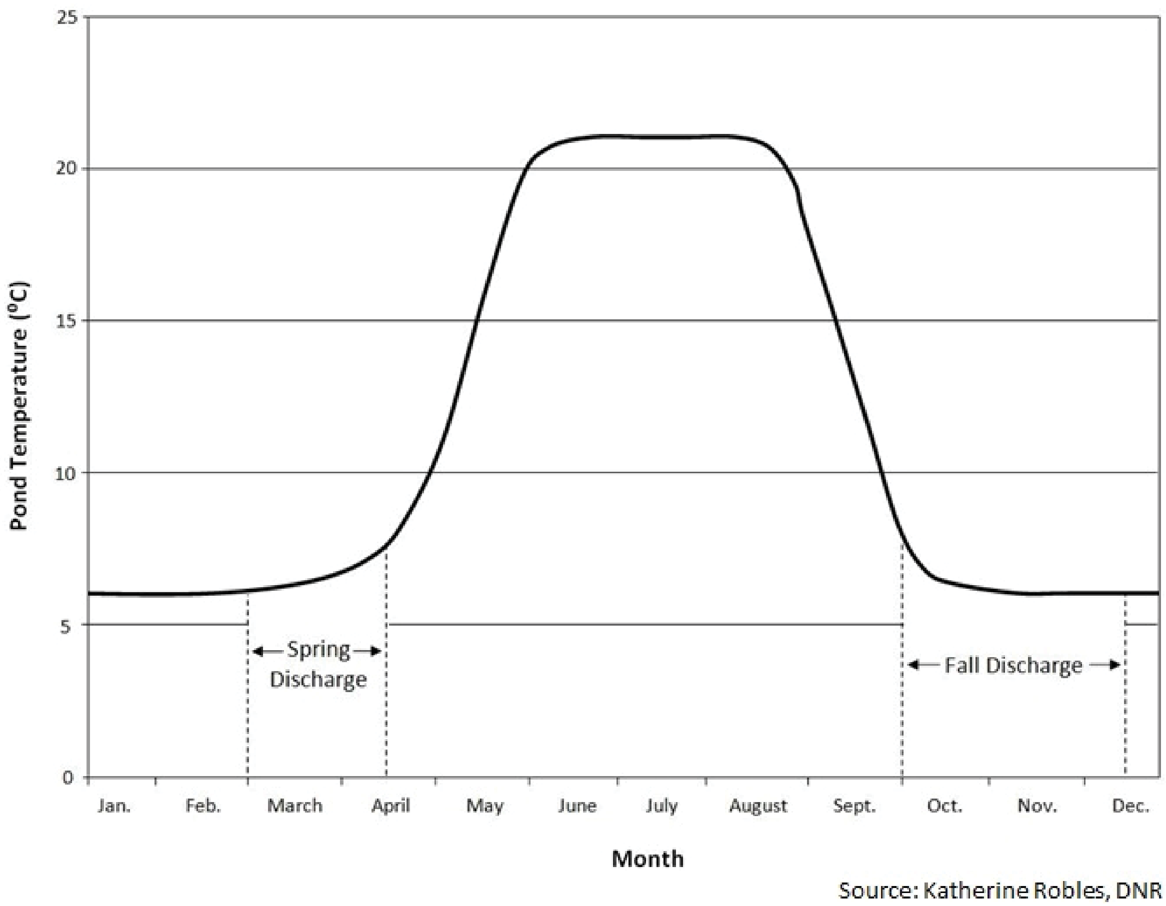
3.3.8 Describe the effect algae can have on effluent suspended solids and phosphorus being discharged from a pond or lagoon.

In a treatment system such as a pond or lagoon, phosphorus is a primary nutrient utilized by algae for growth. Excess phosphorus can result in algal blooms. Algae carried out with the effluent can not only result in effluent suspended solids violations but may also contain phosphorus associated with algal cells. Not discharging excessive algae will ensure meeting effluent limits.

3.3.9 Discuss how monitoring pond temperatures weekly can aid in deciding when to stop/start discharges from a fill and draw system.

Weekly pond temperatures, when graphed (see figure) can help an operator determine the best periods of seasonal discharges. The flat and knee of the curves are usually good times to discharge depending on a plant's effluent limits. Discharging on the steep slopes of a temperature graph (usually turnover periods or bacterial changes) usually results in poorer effluent quality and risks violations. Discharges early in the spring (March through April) before pond temperatures start to rise rapidly is one time to discharge. The best time is usually in the fall and early winter (October through December) after a summer of good treatment. A fill and draw system with ammonia limits usually has to discharge most of their effluent in the fall and early winter after a summer nitrification.

Figure 3.3.9.1



Section 3.4 - Performance Limiting Factors

3.4.1 Describe the consequences of not controlling floating mats and rooted weeds in a pond system.

Floating weed mats prevent sunlight from entering the pond, causing anaerobic conditions. Floating duckweed, if not removed, will continue to reproduce and make the problem worse. These mats block sunlight from entering the pond, slowing algae photosynthesis and reducing oxygen production. The pond could go anaerobic. Mats also blow into dead zones of the pond and reduce the effective area of the treatment pond and hinder surface aeration by reducing wind turbulence. Rooted weeds could pierce the pond seal and lead to leaks. The rooted weeds are food and cover habitat for muskrats. Muskrats build dens into the banks which also lead to significant leakage. Large amounts of rooted weeds in the pond could also cause short-circuiting.

3.4.2 Discuss pond short-circuiting and its effects.

Pond short-circuiting is an uneven flow distribution of wastewater in a pond or lagoon. Wastewater flows through the pond faster in some parts of the pond than in other parts. As a result, wastewater detention time is affected (reduced), with some wastewater getting poorer treatment than in other parts of the pond because the detention time is not long enough. If short-circuiting is severe, inadequate or partial treatment and effluent violations can occur.

Short-circuiting is evaluated through dye-testing. Dyes show how wastewater flows and moves through the pond. To correct short-circuiting, baffles, curtains, or mechanical mixers can be used in pond to better distribute and improve the uniformity of the flow.

3.4.3 Discuss ammonia removal in Wisconsin ponds or lagoons systems.

Because the conversion of ammonia to nitrates and nitrites (a process called nitrification) is greatly reduced by cold temperatures (less than 6°C), it is almost impossible for iced over pond systems that continuously discharge to meet effluent ammonia limits during the winter months (December through March). In cold weather, the reduced nitrification rates have to be considered and a large enough surface area provided for nitrifying bacteria to grow to achieve the proper nitrification rate. Extreme cold weather may still be the performance limiting factor. A tertiary bio-film reactor of some type can be added into or at the end of ponds to favor the growth of nitrifying bacteria such as trickling filters, aerated submerged bio-film reactors, or moving bed bio-film reactors (MBBRS). These add-on technologies for ammonia removal for pond systems have been sparsley applied thus far in Wisconsin.

The storage of treated wastewater during the winter and spring months and converting to a fill and draw mode in May maybe an option for those pond or lagoon system with winter ammonia limits. If ammonia limits are stringent enough during the entire year, some ponds and lagoons may have difficulty meeting ammonia limits even in the summer and fall depending on the limits.

3.4.4 List the considerations a pond operator would need to make if considering accepting septic tank waste.

A. High biochemical oxygen demand (BOD) and solids
B. High ammonia and phosphorus
C. Septicity (sulfides and lack of dissolved oxygen or DO)
D. Grit

Normally, ponds and aerated lagoons are not designed to accept septage.

Section 3.5 - Corrective Actions

3.5.1 List and discuss causes and corrective actions for problems in stabilization ponds.

Figure 3.5.1.1

Problem	Cause	Corrective Action
Rooted weeds	Occur in ponds by means of natural processes due to sprouting rhizomes or seed	If possible, pull weeds out by hand when they first appear
		If or when there are too many weeds to pull out by hand, cut them down low and then raise the pond level to drown the weeds
		If possible, lower pond level to dry the weeds out (see also key knowledges 2.4.7 and 3.4.1)
Excessive duckweed	Natural processes and high nutrient quantities in wastewater	Wait for wind to blow the duckweed to one side of the pond and then rake it out or use a vacuum truck (see also key knowledges 1.3.5 and 3.4.1)
Floating mats	Floating sludge, blue-green algae, oil or grease	Break up mats with a portable pump, rakes, or a motor boat; broken mats will typically sink
		Rake them out and remove them
		If mat is composed of oil and grease, then a Grease Control Program should be implemented (see also key knowledge 2.4.6)
Low DO	Poor light penetration, low detention time, high biochemical oxygen demand (BOD) loading	Remove duckweed if it covers 40% of the pond or greater
		If possible, reduce loading by switching to a parallel operation
		If possible, detain wastewater for a longer time period to obtain a better treatment
		Add supplemental aeration by means of pumps or motorboat operation
		Additional chemical treatment

3.5.2 List and discuss causes and corrective actions for problems in aerated lagoons.

Figure 3.5.2.1

Problem	Cause	Corrective Action
Excessive rooted weeds	Seeds get carried to ponds by wind or birds	If possible, pull the weeds out by hand when they first appear
		If or when there are too many weeds to pull out by hand, cut them down low and then raise the pond level to drown the weeds
		If possible, lower the pond level to dry the weeds out (see key knowledges 2.4.7 and 3.4.1)
Excessive duckweed	Ducks and geese can carry duckweed into the pond with their webbed feed	Wait for the wind to blow the duckweed to one side of the pond and then rake it out or use a vacuum truck (see key knowledges 1.3.5 and 3.4.1)
Insufficient DO	Inadequate aeration	Provide more air by turning up the aerators or adding more aerators
	Excessive organic loading	Find the source and try to reduce the organic loading
		Switch to parallel operation to reduce loading in the primary cell (see key knowledge 1.3.3)

3.5.3 List and discuss possible causes and corrective actions for excessive algae in the effluent.

Excessive algae growth is usually caused by one or more of these conditions:
A. Warm pond water and more sunshine
B. Excessive nutrients, especially phosphorus
C. Organic overloading of the pond

Corrective actions could be one or more of the following:
A. Draw-off effluent from below the surface where algae are less concentrated
B. Reduce organic loading or add mechanical aeration
C. Use a metal salt to precipitate phosphates
D. Use an effluent sand filter to remove algae
E. Add barley straw to the pond in the spring, this often inhibits algae growth
F. Add a dye to the final cell to block sunshine or cover the cell to block sunshine
G. If possible use another cell for discharge and let the other rest until the algae die off

3.5.4 List and discuss possible causes and corrective actions for pond organic overloading.

When properly operated and loaded, pond systems will normally experience odor problems only in the spring, right after ice-out. This odor is caused because of the anaerobic conditions that occurred under the ice. In most cases, this condition may only last from a few days to a week, until normal aerobic conditions are restored. When a pond system is not operated properly while receiving an industrial slug load or when being overloaded organically, anaerobic conditions can persist for some time with significant odors from both anaerobic conditions and the die-off of blue-green algae dominating the system. The pond system may have blue-gray appearance with the odor.

The first action to correct organic overloading (more than 20 lbs of BOD/acre/day) is to locate and control or reduce the sources of the high organic loading, especially if it is coming from a business or industry. A few operational changes that can be made are running the ponds in parallel instead of series (see key knowledge 1.3.3), adding supplemental aeration to one or more of the ponds, or recirculating final effluent back to the first or second ponds. Recirculation of effluent involves setting up a large pump and piping from the end of the last pond back to ponds at the front end of the system. This concept is similar to the operation of recirculating media filters and trickling filters. If organic overloading is chronically above 20 lbs of BOD/acre/day, an engineering consultant should be contacted to evaluate the upgrading needs of the treatment system.

3.5.5 Discuss control and removal methods for burrowing animals.

Burrowing animals can cause damage to pond banks and liners, which can lead to significant leakage. Vegetation control helps to discourage burrowing animals from establishing a habitat. Muskrats damaging wastewater treatment pond or lagoon dikes can be controlled through trapping or shooting (Wisconsin Administrative Code NR 12.10(1)(b)1.d.). Turtles can also be removed through trapping. Trapping can be done year round within the confines of the facility's property.

3.5.6 List and discuss possible causes and corrective actions for seepage cells that do not seep.

Figure 3.5.6.1

Problem	Cause	Corrective Action
Seepage cell does not seep	Compacted cell bottom	Re-work cell bottom with mechanical equipment to loosen and aerate soil
	Hydraulic overload	Reduce overload by alternating seepage cell loading
	Sludge build-up	Remove sludge from cell; correct operation of treatment ponds preceding seepage cells
	Dead matted vegetation	Remove vegetation; re-work cell bottom with mechanical equipment to loosen and aerate soil

3.5.7 Discuss causes and corrective actions for problems with overland flow treatment.

If an overland flow system is ponding due to hydraulic overloading, the application rate should be reduced to design rate or less. Over time, solids will build up at the top of the slope of an overland flow system. These solids will need to be incorporated into the soil to prevent smothering of plantings and poor treatment. If channeling starts to occur over time a consultant should be contacted for possible regrading and replanting.

Chapter 4 - Safety and Regulations

Section 4.1 - Safety

4.1.1 Discuss the safety concerns for limiting public access to ponds and lagoons.

A pond or lagoon may be attractive to hunters, fishers, or playing children. Ponds have steep slopes and pose the risk of drowning. Any recreational activities risk exposure to waterborne pathogens associated with wastewater. It is important that adequate fencing and signage be provided, to discourage trespassing and vandalism.

4.1.2 Discuss the safety precautions that should be practiced when controlling vegetation.

A. Spraying
Applicator must wear personal protective equipment (PPE) to prevent exposure to pesticides. Follow the product label for safety recommendations and wash hands after working with these products. Apply using an applicator to direct the spray. Spray vegetation carefully at the recommended dosage to control its potential of getting into the water.

B. Manual removal
Wear protective clothing and be sure co-workers are aware of your location. Work with another person if necessary. Wear a life jacket if working from a boat or on the shoreline.

4.1.3 Discuss safety precautions that should be practiced while using grass cutting equipment around a pond.

Use care when spraying weeds around electrical cables and equipment. The spray could conduct a current and cause electrical shock.

Use caution when operating mowing equipment on banks. Steep banks can be very hazardous.

4.1.4 List the personal safety precautions that should be practiced by persons operating a pond system.

A. Never perform any hazardous task around a pond alone.
B. Wear life jackets when working around or on ponds.
C. Use care when mowing grass on steep slopes.
D. Follow confined space entry procedures at all times.
E. Use lock-out/tag-out procedures on electrical equipment.
F. Turn aerators off and wear a life jacket when performing maintenance tasks from a boat (a person who falls overboard could sink faster if the aerators are working).
G. Follow manufacturer safety precautions when using chemicals.
H. Wash-up after contact with wastewater.
I. Use care if walking on a frozen pond. In addition to slip hazards, submerged influent piping, aerating, and mixing equipment may cause isolated areas of thin ice.

4.1.5 Discuss the importance of floatation devices at a wastewater treatment plant.

Sampling from basins, channels, and other treatment processes puts an operator at risk of falling into the wastewater. Basins that are aerated can be the most dangerous because the aeration process makes it extremely difficult to stay afloat in waters saturated with high concentrations of air. For this reason, an operator should never extend beyond the protection of the guardrails. OSHA highly recommends ring buoys with at least 90 ft of line be provided and readily available for emergencies and strategically placed around all process basins. OSHA also recommends any operator working over or near water where a risk of drowning is present be provided with a life jacket or buoyant work vest.

4.1.6 Discuss the importance of maintaining chemical delivery, storage, and usage records.

All phosphorus removal chemicals are considered hazardous materials. Therefore all amounts delivered, stored, and used need to be accounted for. Safety Data Sheets (SDS) are required to be kept on-site and available. Contact the Department of Natural Resources in event of a spill.

4.1.7 Discuss the reporting requirements for phosphorus removal chemicals under federal, state, and local laws.

In order to comply with Sections 311 and 312 - Community Right-to-Know Requirements of Title III of the Superfund Amendments and Reauthorization Act (SARA Title III), Wisconsin Statute 166.20 and Chapter SERB 1 of the Wisconsin Administrative Code, the Wisconsin State Emergency Response Board requires that all facilities having a hazardous chemical present at their facility in large volumes (greater or equal to 500 lbs) to annually submit a Tier two, Emergency and Hazardous Chemical Inventory Form. Facilities are required to maintain a file of SDS for all hazardous chemicals stored on site. If there are questions about the need to report hazardous chemical storage, contact your county hazardous waste coordinator.

The laws require that the chemical inventory report be sent annually to:

A. State Emergency Response Commission
B. Local Emergency Planning Committee
C. Local Fire Department

The report shall include the following information:

A. Chemical and common name of the chemical
B. Estimate of maximum amount of chemical stored at the facility in the preceding year
C. Estimate of the average daily amount of chemical stored at the facility in the proceeding year
D. Description of the manner of storage
E. Location of the stored chemical at the facility

4.1.8 Discuss preventative spill measures and procedures when handling phosphorus removal chemicals.

Storage tanks must have secondary containment that equals the volume of the storage tank. During unloading of delivery vehicles and when uncoupling fill lines, place containment pails under potential leak points. Inspect and maintain fill lines and valves. Inspect storage tank and hardware for integrity. Provide onsite containment equipment such as absorbent boom, sandbags, etc., and seal the yard and storm drains to prevent offsite loss of chemicals. Pay attention to what you are doing.

Section 4.2 - Regulations and Procedures

4.2.1 Discuss land treatment systems and groundwater standards.

Wisconsin Administrative Code NR 140 - Groundwater Quality defines the performance standards for land infiltration systems such as seepage cells. The specific groundwater standard of most concern for municipal systems is the 10 mg/L nitrate-nitrogen standard. Although nitrogen removal can also occur in the soil, the removal efficiency which can be achieved in any particular case can vary considerably. As a result, Wisconsin Administrative Code NR 206 – Land Disposal of Municipal and Domestic Wastewaters contains an effluent discharge limit of 10 mg/L for total nitrogen (total nitrogen includes nitrate, nitrite, ammonia, and organic nitrogen) to ensure the 10 mg/L nitrate standard is met in the groundwater. The other effluent limits specified in NR 206 are 50 mg/L for biochemical oxygen demand (BOD) and 250 mg/L for chlorides.

4.2.2 Discuss reasonable pond security precautions against trespassing and vandalism.

Security is necessary to protect the area from unauthorized access and to protect those who enter the facility. The community could become subject to liability and legal action if it fails to make a reasonable effort to restrict trespassing.

Reasonable fencing includes:
A. Gates and locks which are kept secure at all times to restrict vehicles and ATVs. At a minimum, steel or aluminum gates with solid anchor posts and a sign are required.

B. Sturdy, wire fences with signs. Fence lines should be brushed and signed at suitable intervals.

C. Regular drive-by patrols by the local police is recommended. Work with adjacent property owners to report suspicious vehicles or people in the area.

4.2.3 Discuss suspended solids effluent variances for excessive algae.

A suspended solids variance may be made for aerated lagoons and stabilization ponds. The suspended solids limit may be raised to a maximum of 60 mg/L for a 30-day average. This variance is not applicable to polishing or holding ponds which are preceded by other biological or physical/chemical treatment processes.

4.2.4 Discuss corrective actions for enforcement standard (ES) exceedances.

The owner/operator must notify the department in writing when the concentration of a substance in the groundwater exceeds the ES. The Department of Natural Resources must be notified in accordance within any applicable deadlines or within ten days after when the exceedance results were received. The notice includes the cause and significance of the concentration. The Department of Natural Resources will respond and possibly require further reporting with the facility assessing the cause and significance of the increased substance including a plan on how to achieve compliance with the ES in the future. Depending on the severity and frequency of the exceedance, a wastewater engineering consultant may need to be involved.

4.2.5 List the operating requirements for industrial and municipal ridge and furrow systems.

A. Industrial
1. Ridge top grasses should be cut and removed, or burned each spring and, if possible,

removed at least once later in the growing season.

2. Alternate discharge to sections of the system to allow resting periods to maintain the treatment capability of the soil.

3. Sections must have sufficient resting to allow soil conditions to become unsaturated and aerobic prior to being loaded.

4. At least 5 ft of separation must exist between the bottom of the furrows and groundwater.

B. Municipal

1. Discharge is limited so the discharge and precipitation does not flood the ridges and overflow the system.

2. Alternate discharge to sections of the system to allow sufficient resting periods.

3. The average hydraulic application rate may not exceed 10,000 gallons per acre per day (gpad). This is based on hydrogeologic conditions, soil texture, permeability, topography, cover crop, and wastewater characteristics. The recommended range is 2,000 to 5,000 gpad based on a monthly average.

4. The annual total nitrogen applied is limited to the annual nitrogen need of the cover crop.

5. Soil testing is done annually for available nitrogen, phosphorus, potassium, and pH to determine if the nutrients applied are meeting the agronomic needs of the cover crop.

4.2.6 List the operating requirements for industrial and municipal spray irrigation systems.

A. Industrial

1. The load/rest cycle must provide time for the soil organisms to decompose the organic pollutants in wastewater, for organic solids on the ground surface to decompose, and for the soil column to reaerate.

2. Cover crops are to be cut and removed at least twice a year to stimulate vegetation growth and nutrient removal.

3. Soil testing should be done annually for available nitrogen, phosphorus, potassium, and pH to determine if the nutrients applied are meeting the agronomic needs of the cover crop.

B. Municipal

1. Discharge is limited to prevent any runoff of effluent from the site and to prevent ponding.

2. Water may not be sprayed during any rainfall event that would cause runoff.

3. Only uncontaminated storm water may be allowed to drain from the site.

4. The average hydraulic application rate may not exceed 10,000 gpad. The recommended range is 2,000 to 7,000 gpad based on a monthly average.

5. The annual total nitrogen applied is limited to the annual nitrogen need of the cover crop.

6. Soil testing is done annually.

4.2.7 List the operating requirements for industrial and municipal overland flow systems.

A. Industrial

1. Alternate discharge to different sections of the system allowing sufficient resting to dry accumulated solids and maintain a complete grass cover.

2. Cover crops are to be cut and removed at least twice a year.

B. Municipal

1. Alternate discharge to different sections of the system allowing sufficient resting to dry accumulated solids and maintain a complete grass cover.

2. The hydraulic application rate is a flow rate per unit width of slope. The rate should be low when the vegetative cover is not developed sufficiently. A lower hydraulic application rate helps grow the vegetation and filter mat necessary for effective wastewater treatment. Once vegetation is established, the hydraulic application rate can be increased per system recommendations.

Chapter 5 - Calculations

Section 5.1 - Flow and Loading

5.1.1 Given data, calculate the biochemical oxygen demand (BOD) entering the stabilization pond (lbs of BOD/day).

GIVEN:
[MGD = million gallons per day]

Influent flow = 0.04 MGD
Influent BOD = 210 mg/L

FORMULA AND SOLUTION:

Influent BOD (lbs/day) = influent flow (MGD) × influent BOD (mg/L) × 8.34
= 0.04 MGD × 210 mg/L × 8.34
= 70 lbs of BOD/day

5.1.2 Given data, calculate the BOD loading to a 4 acre pond (lbs of BOD/acre/day).

GIVEN:

Influent flow =0 .04 MGD
Influent BOD = 210 mg/L
Pond surface area = 4 acres

FORMULA AND SOLUTION:

Influent BOD (lbs/acre/day) = [influent flow (MGD) × influent BOD (mg/L) × 8.34] ÷ pond surface area
= [0.04 MGD × 210 mg/L × 8.34] ÷ 4 acres
= 17.5 lbs of BOD/acre/day

Section 5.2 - Volume and Surface Area

5.2.1 Given data, calculate pond surface area (acres).

GIVEN:

Pond length = 400 ft
Pond width = 300 ft
1 acre = 43,560 ft^2

FORMULAS AND SOLUTION:

Area of pond (ft^2) = length (ft) × width (ft)
= 400 ft × 300 ft
= 120,000 ft^2

Area of pond (acres) = surface area (ft^2) ÷ 43,560 ft^2/acre
= 120,000 ft^2 ÷ 43,560 ft^2/acre
= 2.75 acres

5.2.2 Given data, calculate the pond volume (gals).

GIVEN:

Pond width at mid-depth = 200 ft
Pond length at mid-depth = 500 ft
Pond depth = 6 ft
1 ft^3 = 7.48 gals

FORMULA AND SOLUTION:
[MG = million gallons]

Volume (gals) = length at mid-depth (ft) × width at mid-depth (ft) × depth (ft) × 7.48 gals/ ft^3
= 500 ft × 200 ft × 6 ft × 7.48 gals/ ft^3

= 4,488,000 gals
= 4.5 MG

5.2.3 Given data, calculate the volume of water (gals) in a groundwater monitoring well casing.

GIVEN:

Inner well casing radius = 1 in
Depth of water = 15 ft
1 cubic foot = 7.48 gals
1 cubic foot = 1,728 in^3
1 ft = 12 in

FORMULA AND SOLUTION:

Volume (gals) = ([radius (in)]^2 × 3.14 × depth (ft) × 12 in/ft × 7.48 gals/ft^3) ÷ 1,728 in^3/ ft^3
= [1 in]^2 × 3.14 × 15 ft × 12 in/ft × 7.48 gals/ft^3 ÷ 1728 in^3/ft^3
= 2.45 gals

Section 5.3 - Detention Time

5.3.1 Given data, calculate a stabilization pond's detention time (days).

GIVEN:
[gpd = gallons per day]

Surface area = 8 acres
Average depth = 4 ft
Average daily flow = 60,000 gpd
1 acre = 43,560 ft^2
1 cubic foot = 7.48 gals

FORMULAS AND SOLUTION:

Volume (gals) = surface area (acres) × 43,560 ft^2/acre × depth (ft) × 7.48 gals/ft^3
= 8 acres × 43,560 ft^2/acre × 4 ft × 7.48 gal/ft^3
= 10,426,522 gals

Detention time (days) = volume (gals) ÷ avg. daily flow (gpd)
= 10,426,522 gals ÷ 60,000 gpd
= 173.78 days

5.3.2 Given data, calculate the detention time (days) of a 3-pond system.

GIVEN:

Number of ponds operating in series = 3 ponds
Volume of each pond = 5,000,000 gals/pond
Daily flow = 92,000 gpd

FORMULA AND SOLUTION:

Detention time (days) = [pond volume (gals/pond) × # of ponds] ÷ daily flow (gpd)
= [5,000,000 gals/pond × 3 ponds] ÷ 92,000 gpd
= 15,000,000 gals ÷ 92,000 gpd
= 163 days

Section 5.4 - Discharge

5.4.1 Given data, calculate the volume of water discharged (gals).

GIVEN:

Drawdown depth = 3.0 ft
Pond length = 675 ft
Pond width = 420 ft
1 cubic foot = 7.48 gals

FORMULA AND SOLUTION:
[MG = million gallons]

Volume (gals) = length (ft) × width (ft) × drawdown depth (ft) × 7.48 gal/ft^3
= 675 ft × 420 ft × 3.0 ft × 7.48 gal/ft^3
= 6,361,740 gals
= 6.4 MG

5.4.2 Given data, determine the fall drawdown volume (gals) and depth (ft).

The daily average influent flow into a fill and draw pond system is 30,000 gallons per day (gpd). An operator needs to draw down the pond in November to allow for enough storage during the 121 days of winter (December through March). The pond is at 5 ft. Allowing for some extra flow during spring thaw for infiltration and inflow (I/I), the operator determines he wants 150 days of storage. Using the graph provided, to what depth (ft) must the operator lower the pond?

GIVEN:

Daily influent flow = 30,000 gpd
Pond storage volume needed = 150 days
See figure below for graph

FORMULAS AND SOLUTION:

Total drawdown vol. (gals) = influent flow (gpd) × storage needed (days)
= 30,000 gpd × 150 days
= 4,500,000 gals

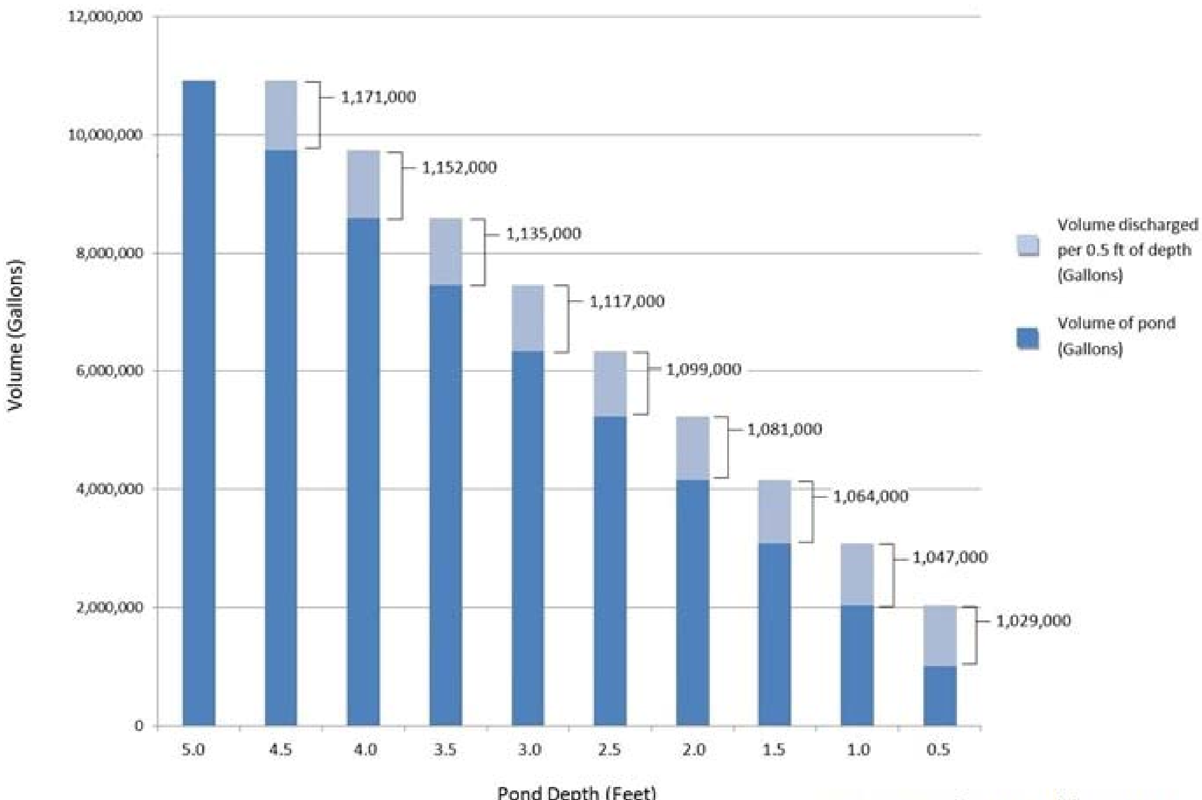
Reading the graph, the following volumes per half a foot of depth is shown:

5.0 to 4.5 ft = 1,171,000 gals
4.5 to 4.0 ft = 1,152,000 gals
4.0 to 3.5 ft = 1,135,000 gals
3.5 to 3.0 ft = 1,117,000 gals

Cumulative volume per ½ foot of drawdown = 1,171,000 gals + 1,152,000 gals + 1,135,000 gals + 1,117,000 gals
= 4,575,000 gals

The operator must discharge enough wastewater in November to lower the pond from 5 ft to 3 ft.

Figure 5.4.2.1



Source: Katherine Robles, WDNR

5.4.3 Given data for a fill and draw pond system, calculate the volume of drawdown (gals) required and the time (days) required to achieve drawdown.

GIVEN:

Pond width = 200 ft
Pond Length= 300 ft
Drawdown depth = 2 ft
Hydraulic discharge limit = 40,000 gpd
1 cubic foot = 7.48 gals

FORMULAS AND SOLUTION:

Drawdown volume (gal) = length (ft) × width (ft) × drawdown depth (ft) × 7.48 gals/ft³
= 300 ft × 200 ft × 2 ft × 7.48 gals/ft³
= 897,600 gals

Draw downtime (days) = drawdown volume (gals) ÷ hydraulic discharge limit (gpd)
= 897,600 gals ÷ 40,000 gpd
= 22.4 days

Section 5.5 - Leakage

5.5.1 Given data, estimate the leakage (gals/acre/day or gpad) from a wastewater stabilization pond.

GIVEN:
[MG = million gallons]
[gpd = gallons per day]

Total annual influent = 9.125 MG/year
Total annual effluent = 7.850 MG/year
Pond surface area = 2.5 acres
1 year/MG = 0.000365 days/gallon

FORMULA AND SOLUTION:

Leakage rate (gpad) = [total inf. vol. (MG/year) - total eff. (MG/year) ÷ 0.000365 (MG day/gals year)] ÷ surface area (acres)
= [(9.125 MG/year - 7.850 MG/year) ÷ 0.000365 MG day/gals year] ÷ 2.5 acres
= 3,493 gpd ÷ 2.5 acres
= 1,397 gpad

Section 5.6 - Groundwater Monitoring

5.6.1 Given data, calculate the amount of water that must be purged from a groundwater monitoring well before a sample can be collected.

GIVEN:

Well diameter = 2 ins
Well depth = 25 ft
Depth to well water = 18 ft
Volume to be purged = 4 well volumes of water

FORMULAS AND SOLUTION:

Well radius (ft) = well radius (ins) ÷ 12 ins/ft
= 1 ins ÷ 12 ins/ft
= 0.0833 ft

Water in well (ft) = well depth (ft) - depth to well water (ft)
= 25 ft - 18 ft
= 7 ft of water in well

Purge volume (gals) = 3.14 × [well radius (ft)]^2 × water in well (ft) × 7.48 gals/ft^3 × 4
= 3.14 × [0.0833 ft]^2 × 7 ft × 7.48 gals/ft^3 × 4
= 4.56 gals

Purge 5 gals from the well before collecting a sample.

References and Resources

1. **UW WATER LIBRARY**

   Most of the resources listed on this page can be borrowed through the UW Water Library as part of a partnership between the UW Water Library, the Wisconsin Wastewater Operator Association (WWOA), Central States Water Environmental Association (CSWEA), and the Wisconsin Department of Natural Resources. Instructions for borrowing materials from the UW Water Library can be found by visiting the website provided below, clicking on 'WISCONSIN RESIDENTS', and then clicking on 'HOW TO BORROW MATERIALS'.

   www.aqua.wisc.edu/waterlibrary

2. **OPERATION OF MUNICIPAL WASTEWATER TREATMENT PLANTS**

   Water Environmental Federation (WEF). (2008). Operation of Municipal Wastewater Treatment Plants: Manual of Practice No. 11 (6th ed., Vols. I, II, III). New York, New York: McGraw-Hill.

   www.wef.org

3. **OPERATION OF WASTEWATER TREATMENT PLANTS**

   Office of Water Programs, California State University, Sacramento. (2008). Operation of Wastewater Treatment Plants (7th ed.). Sacramento, CA: University Enterprises, Inc., California State University.

   www.owp.csus.edu

4. **PRINCIPLES OF DESIGN AND OPERATIONS OF WASTEWATER TREATMENT POND SYSTEMS FOR PLANT OPERATORS, ENGINEERS, AND MANAGERS**

   Office of Research and Development. (2011). Principles of Design and Operations of Wastewater Treatment Pond Systems for Plant Operators, Engineers, and Managers. Cincinnati, OH: Land Remediation and Pollution Control Division, National Management Research Laboratory.

   nepis.epa.gov

5. **STABILIZATION POND OPERATION AND MAINTENANCE MANUL**

   Erickson, G., Curtin, K., & Duerre, S. (2013). Stabilization Pond Operation and Maintenance Manual (2013 ed.). St. Paul, MN: Minnesota Pollution Control Agency.

   www.pca.state.mn.us

6. **INTRODUCTION TO LAGOONS**

   The Lagoon Task Force. (2003). Introduction to Lagoons. Retrieved from Lagoon Systems in Maine: www.lagoonsonline.com

   www.lagoonsonline.com

7. **PREFILL AND WATER BALANCE CRITERIA**

Ballavance, P.E., B., Erickson, G., Groh, N., Meyer, P.E., P., Sahli, P.E., D., Sathyaseelan, V., et al. (2010, December). Division of Water Quality Municipal Wastewater Treatment. Retrieved from Minnesota Pollution Control Agency: www.pca.state.mn.us

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8. **GROUNDWATER SAMPLING PROCEDURES**

Karklins, S. (1996). Groundwater Sampling Field Manual. (J. Lenon, Ed.) Madison, WI: Wisconsin Department of Administration.

dnr.wi.gov

9. **NR 140 GROUNDWATER QUALITY**

Wisconsin Administrative Code NR 140 Groundwater Quality (2015)

docs.legis.wisconsin.gov

10. **SPS 332: PUBLIC EMPLOYEE SAFETY AND HEALTH**

Wisconsin Administrative Code Chapter SPS 332: Public Employee Safety and Health. (2014).

docs.legis.wisconsin.gov

11. **OSHA CFR 29 PART 1910**

Occupational Safety & Health Administration (OSHA). (2012). Regulations (Standards-29 CFR 1910.1200)

www.osha.gov