WASTEWATER STABILIZATION POND (WWSP) STUDY GUIDE

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF WATER
OPERATOR TRAINING AND CERTIFICATION PROGRAM
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Introduction

This study guide is made available to examinees to prepare for the Wastewater Stabilization Pond (WWSP) certification exam. This study guide covers only topics concerning non-aerated WWSPs. The WWSP certification exam is comprised of 50 multiple choice questions on various topics. These topics will be addressed in this study guide.

The procedure to apply for the WWSP certification exam is available on our website at: http://dec.alaska.gov/water/operator-certification/wastewater-stabilization-ponds/.

It is highly recommended that an examinee complete the Wastewater Stabilization Ponds Correspondence Course, https://dec.alaska.gov/water/operator-certification/wwsp/. However, if you are familiar with the operation of WWSPs, then reviewing this study guide may be sufficient.

If you have any questions, please contact the Operator Training and Certification Program staff at (907) 465-1139 or dec.opcert@alaska.gov.

Definitions

1. **Aerobic:** A condition in which “free” or dissolved oxygen is present in an aquatic environment.
2. **Algae:** Simple microscopic plants that contain chlorophyll and require sunlight; they live suspended or floating in water, or attached to a surface such as a rock.
3. **Anaerobic:** A condition in which “free” or dissolved oxygen is ***not*** present in an aquatic environment.
4. **Bacteria:** Microscopic organisms consisting of a single living cell. Most bacteria utilize organic matter for food and produce waste products as a result of their life process.
5. **Biochemical Oxygen Demand (BOD):** The quantity of oxygen required by microorganisms when stabilizing decomposable organic matter under aerobic conditions at 20^{o} C.
6. **Cell:** An individual pond in a waste pond system.
7. **Detention Time:** The amount of time that wastewater remains in the waste pond.
8. **Dissolved Oxygen (DO):** Oxygen dissolved in water or wastewater.
9. **Effluent:** Treated wastewater flowing out of the waste pond.
10. **Freeboard:** The vertical distance from the waste pond water surface to the top of the waste pond’s dike.
11. **Hydraulic Loading:** The depth of wastewater, in inches, introduced into the waste pond in one day.
12. **Influent:** The raw wastewater flowing into the waste pond for treatment.
13. **Organic Loading:** The amount of Biochemical Oxygen Demand (BOD) applied to a waste pond per acre of waste pond surface per day.
14. **Pathogen:** Microorganisms that can cause disease.
15. **Photosynthesis:** A process in which organisms with the aid of chlorophyll, convert carbon dioxide and inorganic substances into oxygen and more plant materials.
16. **Protozoa:** A small one-celled animal including but not limited to amoebae, ciliates, and flagellates. Protozoa eat organic matter, including bacteria cells.
17. **Secondary Treatment:** A wastewater treatment process used to convert dissolved or suspended materials into a form readily separated from the water being treated.
18. **Short-circuiting:** A condition where untreated wastewater travels the shortest path from inlet to outlet.
19. **Sludge:** The accumulated settled solids deposited from sewage, raw or treated, in the waste pond and containing more or less water to form a semi-liquid mass.
20. **Stabilization:** The process of converting a material to a form that resists change. Organic material is stabilized by bacteria which convert the material to gases and other relatively inert substances. Stabilized organic material generally will not give off obnoxious odors.
21. **Wastewater:** A community’s used water and solids that flow to a treatment plant or receiving stream.
22. **Virus:** A very small organism that is not visible under a light microscope and needs to live inside a host cell in order to reproduce.

Principles of Wastewater Stabilization Ponds (WWSP)

1. **What is a wastewater stabilization pond used for?**

    - Secondary treatment of wastewater by biological means.
    - Stabilize the wastewater prior to releasing it into the environment.

2. **What are the advantages and disadvantages of using WWSPs compared to conventional wastewater treatment processes?**

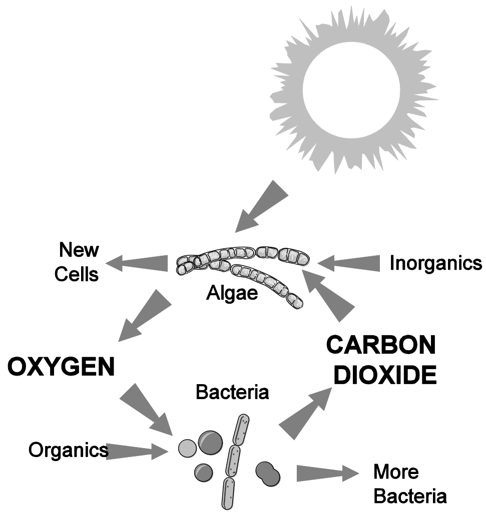
Advantages	Disadvantages
Relatively inexpensive to construct in areas where land is available	Less efficient in cold climates, i.e. treatment takes longer
Uses less energy than other treatment systems	In extreme cold, the WWSP can freeze solid and no treatment occurs
Easy to operate and maintain	Breeding area for mosquitoes and other insects
Can handle intermittent and shock loads	Possible contamination of groundwater due to leakage
Effective at removing pathogens from wastewater	Possible odor problems
Long daylight hours in northern climates during summer are beneficial to WWSPs with algae.	Lack of control over effluent quality, e.g. high total suspended solids in the effluent

3. **What are some types of WWSPs?**

    - *Aerobic WWSPs:*
        - Shallow, usually, two to three feet deep, to permit light penetration to support the photosynthesis of algae.
        - Have dissolved oxygen available throughout the whole pond.
        - Dependent on wind action and algae to provide oxygen.
        - The main biological processes are aerobic bacterial oxidation and algal photosynthesis.
    - *Anaerobic WWSPs:*
        - Usually eight to 20 feet deep.
        - High organic loading.
        - Intended to contain no dissolved oxygen.
        - Typically used for the treatment of industrial wastewater.
        - The sludge needs to be periodically removed from the bottom of the pond.
    - *Facultative WWSPs:*
        - The most common type of WWSP.
        - Usually three to eight feet deep.
        - Contain an aerobic zone, an anaerobic zone, and a transitional (facultative) zone in between.
        - Oxygen is provided by algae and wind action.
        - Sludge in the bottom layer is anaerobically digested.

4. **What happens in an aerobic WWSP or the aerobic layer of a facultative WWSP?**

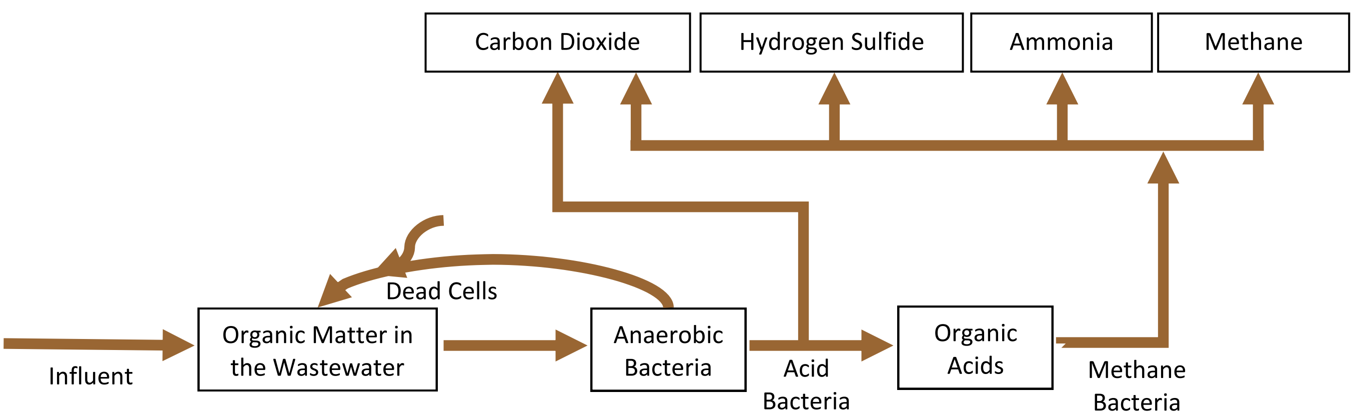
- Organic matter in the wastewater is converted to carbon dioxide, phosphate, and ammonia by the bacteria in the WWSP.
- The carbon dioxide, phosphate, and ammonia are used by the algae by way of photosynthesis to produce more algae cells and oxygen.
- The oxygen in turn is used by the bacteria to reduce and stabilize the incoming wastewater.
- When older cells die off, nutrients are released which are either used by other bacteria and algae or discharged with the effluent.



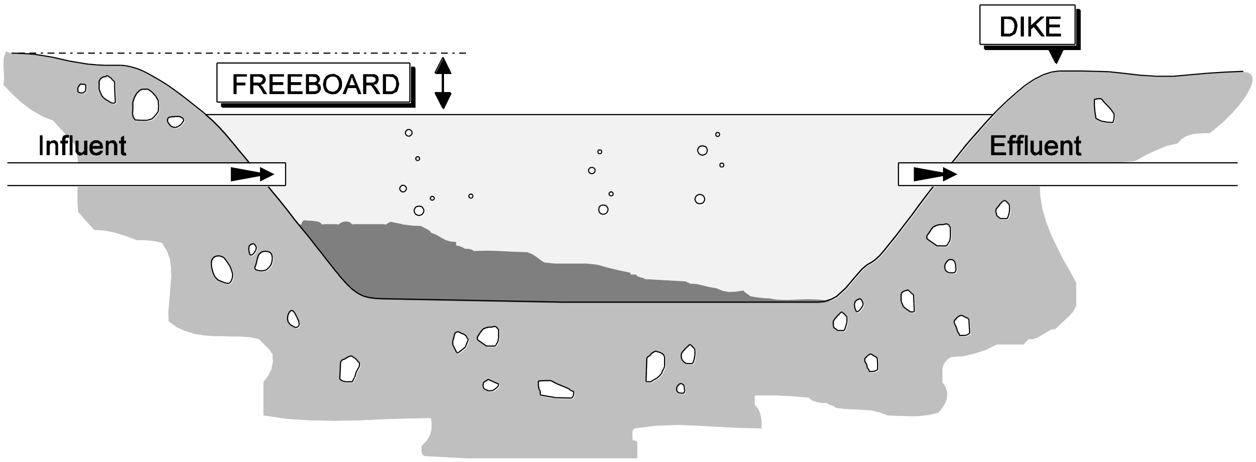
PHOTOSYNTHESIS

5. **What happens in an anaerobic WWSP or the anaerobic layer of a facultative WWSP?**

- Organic matter in the wastewater is converted into organic acids, nitrogen, and carbon dioxide by acid bacteria.
- Methane bacteria feed on the organic acids and convert them to carbon dioxide, hydrogen sulfide, ammonia, and methane.
- As the bacteria die off, nutrients are released which are used by other bacteria or in the case of facultative WWSPs, used by algae and bacteria in the aerobic zone.

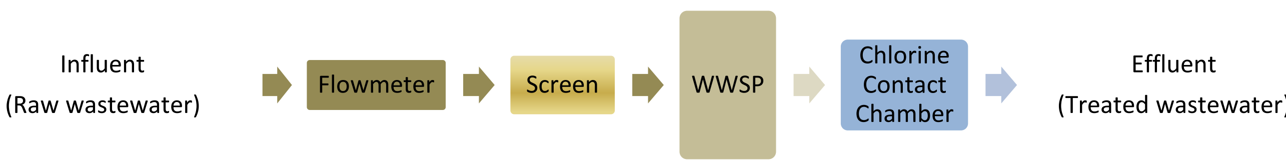


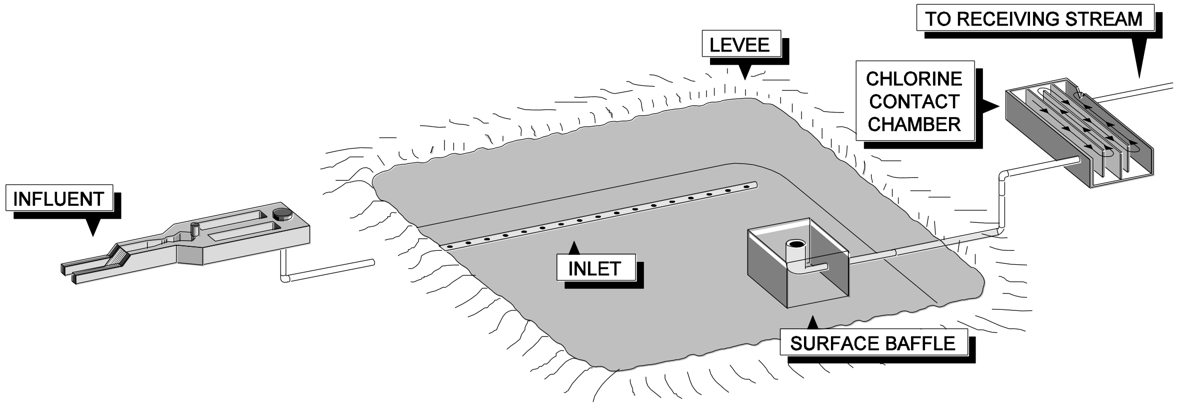
Components of a WWSP



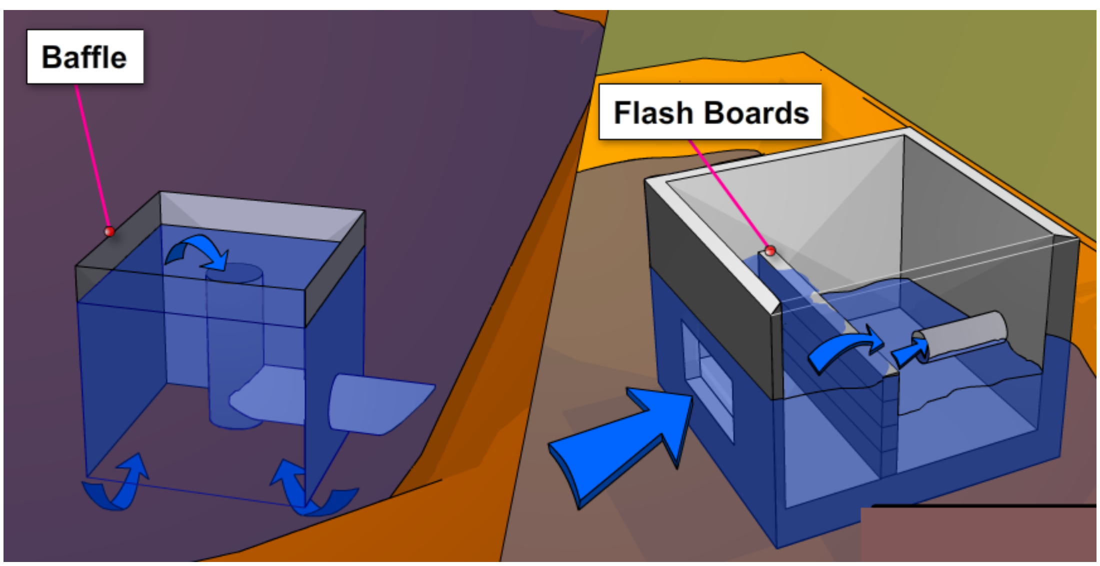
1. *Influent:* The raw wastewater flowing into the waste pond for treatment.
2. *Dike:* The sides or walls of the WWSP. The optimal bank slope is 3:1 (three feet horizontal to one foot vertical).
3. *Freeboard:* The vertical distance between the WWSP water surface and the top of the dike.
4. *Effluent:* Treated wastewater flowing out of the waste pond.

Typical Flow:





Influent Flowmeter: If flow measurement is conducted, a Parshall flume may be used.
Levee: The sides or walls of a WWSP, also known as the dikes.
Surface Baffle or Flash Board: The outlet for the WWSP; it prevents scum and other floating materials, such as algae, from flowing out of the pond. Also, may control the depth of WWSP.
Chlorine Contact Chamber: If disinfection is required, provides contact time for chlorinating the WWSP's effluent.



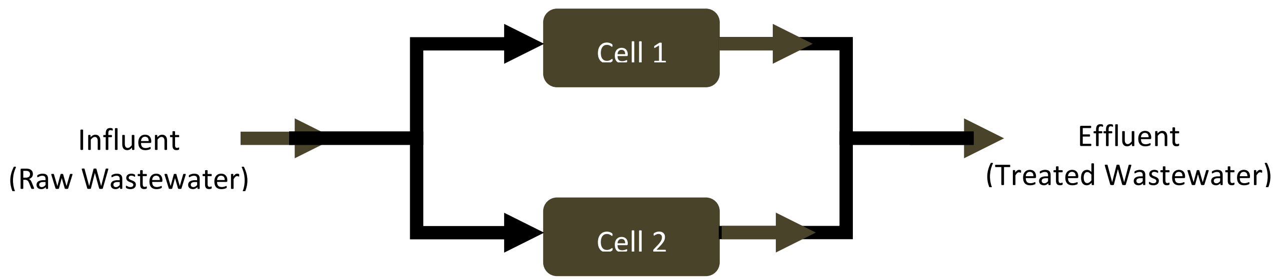
Operation and Maintenance of a WWSP

Modes of Operation:

WWSPs in Series:

- WWSPs operated in series are
  - best under low organic and low hydraulic loadings,
  - best in warm climates,
  - best for having good quality effluent due to a longer detention time, and
  - more likely to have the first waste pond in the series become overloaded

WWSPs in Parallel:



- WWSPs operated in parallel are
  - best for high organic and high hydraulic loadings,
  - suited for cold climates, and
  - suited for spreading the incoming load evenly among the ponds.

Types of Discharges:

1. **Total Retention:** No effluent is discharged and the treated wastewater is allowed to either evaporate into the atmosphere and/or seep through the walls or the bottom of the WWSP.
2. **Continuous Discharge:** The effluent is allowed to continuously flow from the WWSP.
3. **Controlled or Intermittent Discharge:** The effluent from the WWSP is discharged in controlled amounts, for example in the fall and spring.

WWSP Color:

1. **Dark sparkling green:** The desired color. The WWSP is in a good condition with high pH and DO. Green algae are flourishing.
2. **Dull green to yellow:** The health of WWSP is deteriorating. The pH and DO are decreasing. Blue-green algae are starting to establish themselves in the pond.

3. **Tan to brown:** Acceptable if caused by an algae bloom but not desirable if caused by silt or erosion.
4. **Red or pink:** Acceptable. The color is due to the presence of purple sulfur bacteria or red algae.
5. **Milky:** The WWSP is becoming anaerobic, usually from being overloaded.
6. **Gray to black:** Highly undesirable. Anaerobic conditions exist in the WWSP. (Desired in anaerobic WWSPs).

Algae:

1. **Green algae:** Desired type of algae in the WWSP. Provides DO for the pond through photosynthesis.
2. **Blue-green algae:** Not desired. Indication of incomplete treatment, overloading, and/or poor nutrient balance. Blue-green algae can form clumps or mats that prevent sunlight from penetrating the surface of the pond which can lower DO levels. Blue-green algae can be controlled by breaking up the algal blooms mechanically by using a boat with an air-cooled engine, or a water hose connected to a portable pump. As a last resort, copper sulfate can be used to control blue-green algae.

WWSP Startup:

The best time to start a WWSP is in the spring or early summer to avoid low temperature and freezing.

To fill primary cell or only cell:

1. Fill the cell with fresh water, if possible to the one to two foot level. This prevents odors when wastewater is introduced to the cell.
2. During the first few weeks add wastewater intermittently to the cell while monitoring the pH.
3. Maintain pH above 7.5.
4. Check DO levels daily.

If started during warm weather, an algal bloom should appear within 7 to 14 days and good treatment will be established within 60 days.

To fill additional cells:

1. Start filling when the water level in the primary cell reaches 3 feet by adding fresh water to the one to two foot level.
2. Start adding water from the previous cell by:
    a. Drawing water from the top of the cell. Avoid drawing within 18 inches of the bottom.
    b. Do not allow the water level in the previous cell to fall below 3 feet.
    c. Equalize the water depth in all ponds.
        i. Do not discharge until all ponds are filled.
        ii. Continuously recycle the effluent to the ponds that need the water level raised.
3. Repeat step 2.c. until ponds are at their operating depth.
4. Discharge per design.

Sampling

Purpose

1. To monitor the health of the pond and to determine if any corrective action is necessary.
2. To ensure that toxic materials are not entering the WWSP via the influent.
3. To ensure that the effluent meets discharge permit limits.

Types of Samples

1. **Grab Sample:** A single sample taken at any flow rate or time.
2. **Composite Sample of a Waste Pond:** Composed of at least 4 grab samples taken at each corner of the waste pond 8 feet from the water's edge and 1 foot below the surface.

Sampling Devices and Containers:

1. Manual sampling can be conducted by using a weighted bottle that is attached to a cord, or a dipper where a bottle or can is attached to a long stick.
2. Ensure that the sample container is sterile before collecting a sample to avoid bad results.

Sample Hold Time

1. Temperature, pH, or dissolved oxygen (DO) samples taken should be tested immediately.
2. Fecal coliform samples should be preserved with ice and sent for analysis as soon as possible.
3. Biochemical Oxygen Demand (BOD) and Suspended Solids (SS) samples must be analyzed within 48 hours.
    a. These samples must be preserved at a constant temperature of 40^{o} F to prevent deterioration.

Analyses

1. Temperature:
    a. Temperature samples should be analyzed immediately.
    b. Indicates the overall metabolic rate of organisms in the pond. Warmer temperatures allow for a higher metabolic rate while lower temperatures result in a lower metabolic rate.
    c. Colder water will hold more dissolved oxygen than warmer water.
2. pH:
    a. pH samples should be analyzed immediately.
    b. pH is the numerical measure of hydrogen ion activity of a solution, i.e. the negative decimal logarithm of the hydrogen ion activity in a solution.
        i. $pH = -log[H^+]$
        ii. pH scale is 0 to 14.
        iii. A pH of 7 is neutral.
        iv. A pH $<$ 7 is acidic.
        v. A pH $>$ 7 is basic (alkaline).
    c. pH is an indicator of the waste pond's condition.
    d. The optimum pH range is typically 6.5 to 10.5.

   e. Pond color can be related to the pH of the waste pond.
      i. A green color indicates a high pH (alkaline environment).
      ii. A yellow-green color indicates a lower pH (more acidic environment).
   f. Bacteria through respiration produce carbon dioxide (CO_2) which combines with water to form an acid thereby lowering the pH (more acidic). Algae in a waste pond consume CO_2 during photosynthesis thereby causing the pH to increase (less acid is formed).
3. Dissolved Oxygen (DO):
   a. DO samples should be analyzed immediately.
   b. DO is an indicator of the activity of an aerobic or aerobic zone of a facultative waste pond.
   c. DO is required by aerobic bacteria to breakdown the organic matter in the wastewater.
   d. The typical DO range of a waste pond is 4-12 mg/L.
4. Fecal Coliform:
   a. Fecal coliform samples are taken at the effluent of the waste pond.
   b. Samples are sent to a certified laboratory for testing.
   c. Fecal coliform tests indicate the possible absence or presence of pathogenic microorganisms.
   d. Typical effluent fecal coliform using the Most Probable Number (MPN) method is less than 24,000/100 mL.
5. Biochemical Oxygen Demand (BOD):
   a. The BOD test measures the amount of oxygen required in a 5 day period by microorganisms to consume organic matter in the wastewater.
   b. The BOD test indirectly measures the strength of the wastewater.
   c. Typical influent BOD is 100-300 mg/l and typical effluent BOD is 20-50 mg/L.
6. Suspended Solids (SS):
   a. SS test measures the amount of solids suspended in a sample.
   b. SS has an impact on the effluent receiving stream.
   c. The removal of SS is as important as the removal of BOD to prevent pollution of the effluent receiving stream.
   d. High SS can be the result of high levels of algae in the effluent.
   e. Typical effluent SS is 10-80 mg/L.

Maintenance

Inspections/Maintenance/Troubleshooting

1. Physical Structures Surrounding WWSP
   a. Ensure any fencing, gates, or locks are free from damage.
   b. Fencing around a pond is important to prevent unauthorized access.
2. WWSP Components
   a. Inspect inlet and outlet structures to ensure there is no damage or blockages.
   b. Walls/Dikes

i. Check for damage from burrowing animals such as muskrats and beavers.
    1. Holes/burrows dug by animals may cause the walls/dikes to leak or fail.

ii. Check for overgrown vegetation.
    1. Vegetation with long roots such as willows can damage the integrity of the walls/dikes.
    2. Overgrown vegetation along the water's edge can be a breeding ground for insects such as mosquitoes.
    3. Some vegetation such as grasses is desired on the walls/dikes to prevent erosion from wave action or runoff.
    4. Overgrown vegetation can be controlled by mowing or using a brush cutter

c. WWSP - Problems

i. Duckweed
    1. Excessive duckweed on the WWSP's surface can interfere with pond aeration by blocking sunlight and hindering wave action.
    2. Duckweed must be removed physically by use of a rake, pushboard, or broom. If there is enough wind, the duckweed may be pushed to one side of the pond where it can be removed by raking.
    3. Duckweed can also be an odor and BOD problem when it decomposes.

ii. Pond Scum
    1. Excessive pond scum can block sunlight, cause odor problems, and support insect breeding.
    2. Pond scum can be caused by large amounts of oil and fats in the influent, sludge turn-over (sludge floating up from the bottom of the pond), and poor circulation or wind action.
    3. Pond scum can be removed by skimming and removing by hand, or by breaking up the scum using a rake, boat, or water jet and then it will sink to the bottom of the pond.

iii. Sludge
    1. During fall or spring turnover, sludge may rise to the surface of the pond causing high suspended solids. This is a sign of a pond that needs to be taken out of service and cleaned. Ponds having a bottom sludge layer exceeding one foot should be cleaned.
    2. "Turnover" is a phenomenon where the surface water of the pond becomes cooler than the water near the bottom. As such the water from the bottom being warm rises, and the surface water being cooler falls toward the bottom. This results in an up-current of water from the bottom of the pond which carries sludge along for the ride.

iv. Blue-green Algae
    1. Appears when the pond's pH is less than 6.5 and dissolved oxygen is less than 1 mg/L.
    2. Indication of incomplete treatment, poor aeration, incorrect operating mode, organic overloading, or poor nutrient balance.
    3. Blue-green is undesirable because it can form clumps and mats that prevent sunlight penetration thereby lowering dissolved oxygen levels.
    4. Blue-green algae can be controlled by:
        a. Application of copper sulfate,
        b. Correction of the organic overloading condition, or
        c. Correction of any aeration problems.

v. Odors
    1. Bad odors can be produced when aerobic conditions are not maintained.
        a. Spring or fall turnover.
        b. Organic overloading.
            i. To reduce organic overloading, if using more than one cell and in series mode, switch to parallel mode. Or divert some or all of the influent flow.
        c. Poor pond circulation.
            i. Poor circulation can be corrected by recirculation of the effluent back to the influent. This will provide additional dissolved oxygen.
        d. Algae die off.

Troubleshooting

1. Low Dissolved Oxygen (DO)
    a. Causes:
        i. Inadequate photosynthesis,
        ii. Organic overloading,
        iii. Excessive scum accumulation,
        iv. Toxic waste in influent, or
        v. Incorrect operating mode.
    b. Solutions;
        i. Recirculate the last pond effluent to the inlet of the first pond,
        ii. Reduce loading and if more than one cell is available, then switch to parallel operation,
        iii. Break up scum or remove it by skimming the pond's surface,
        iv. Eliminate the toxic loading, or
        v. Eliminate any short-circuiting.
2. Organic Underloading (Can produce filamentous green algae or moss)

a. Causes:
    i. The system has too much capacity, i.e. the lagoon is too large for the amount of loading,
    ii. Unusually low seasonal flows, or
    iii. Insufficient pond water depth.
b. Solutions:
    i. If using more than one cell, take some cells off-line,
    ii. Use series operation, or
    iii. Increase pond water depth.

3. High Effluent BOD (**B**iochemical **O**xygen **D**emand)
    a. Causes:
        i. Organic overloading,
        ii. Hydraulic overloading,
        iii. Short detention time/short-circuiting, or
        iv. Toxic influent.
    b. Solutions:
        i. Reduce loading and if more than one cell is available, then switch to parallel operation,
        ii. Eliminate any infiltration,
        iii. Recirculate the effluent/correct short-circuiting, or
        iv. Eliminate the toxic influent source.
4. Decreasing Pond pH
    a. Causes:
        i. Organic overloading,
        ii. Long periods with no sun, or
        iii. Influent that is toxic to algae.
    b. Solutions:
        i. If more than one cell is available, change to a parallel operating mode or bypass a cell and let it recover,
        ii. Recirculate the effluent,
        iii. Check to see if there is any short-circuiting, or
        iv. Locate and eliminate the source of toxic influent.

Wastewater Stabilization Pond Formula Sheet

Acronyms

A	area
ac	acre
avg	average
BOD	***B***iochemical ***O***xygen ***D***emand
DO	***D***issolved ***O***xygen
cu ft	cubic feet
ft	feet
ft^2	square feet
ft^3	cubic feet
gal	gallons
gpd	gallons per day
gpm	gallons per minute
in	inches
lbs	pounds
MG	million gallons
MGD	million gallons per day
mg	milligrams
L	liters
sq ft	square
V	volume

Formulas

$$Pond\ Area, sq\ ft = (Length, ft) \times (Width, ft)$$

$$Pond\ Area, ac = \frac{(Length, ft) \times (Width, ft)}{43{,}560\ sq\ ft/ac}$$

$$Average\ Area, sq\ ft = \frac{(area\ of\ surface, ft) + (area\ of\ bottom, ft)}{2}$$

$$Pond\ Volume,\ cu\ ft = (Average\ Length, ft) \times (Average\ Width, ft) \times (Depth, ft)$$

$$Pond\ Volume,\ cu\ ft = (Avg\ Area, sq\ ft) \times (Depth, ft)$$

$$Pond\ Volume,\ gal = (Average\ Length, ft) \times (Average\ Width, ft) \times (Depth, ft) \times \left(7.48\,\frac{gal}{cu\ ft}\right)$$

$$Detention\ Time\ (in\ days) = \frac{Pond\ Volume,\ gal}{(Influent\ Flow\ Rate,\ gpm) \times (1{,}440\ minutes\ per\ day)}$$

$$Pond\ Volume,\ gal = (Avg\ Area, sq\ ft) \times (Depth, ft) \times \left(7.48\,\frac{gal}{cu\ ft}\right)$$

$$Detention\ Time\ (in\ days) = \frac{Pond\ Volume,\ MG}{Influent\ Flow\ Rate,\ MGD}$$

$$Population\ Loading, Persons\ per\ Acre = \frac{Population\ Served, persons}{Surface\ Area\ of\ Pond, ac}$$

$$Inflow,\ ac\text{-}in\,per\ day = (Inflow, MGD) \times (36.8) \quad 1\ MGD\ = 36.8\ \frac{ac-in}{day}$$

$$Hydraulic\ Loading, inches/day = \frac{Depth\ of\ Pond, inches}{Detention\ Time, days}$$

$$Hydraulic\ Loading, gallons\ per\ day/square\ feet = \frac{Inflow\ Rate, gpd}{Area, sq\ ft}$$

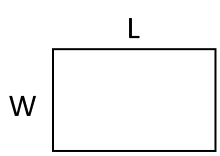
$$Organic\ Loading, lbs\ BOD/day/ac = \frac{(BOD, mg/L) \times (Flow, MGD) \times (8.34\ lbs/gal)}{Pond\ Area, ac}$$

$$Removal\ Efficiency, \% = \frac{(Influent - Effluent) \times (100\%)}{Influent}$$

Area

Square or Rectangle

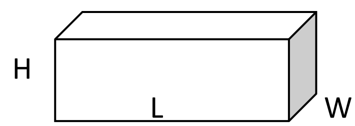
$A = Length\ (L) \times Width(W)$



Volume

Cube

$V = Length\ (L) \times Width\ (W) \times Height\ (H)$

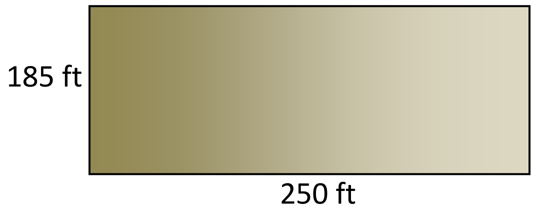


Conversion Factors

1 acre = 43,560 sq ft
1 acre foot = 326,000 gallons
1 cubic foot = 7.48 gallons
1 MGD = 3.0689 ac-ft/day = 36.8 ac-in/day = 694.4 gpm
1 cu ft = 7.48 gal

Math Problems

1. Calculate the area of a waste pond, in square feet and acres, with sides that are 185 feet and 250 feet long.



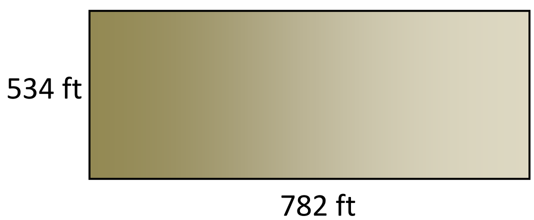
$$width, feet \times length, feet = area, square\ feet$$

$$185\ feet \times 250\ feet = 46{,}250\ square\ feet$$

$$46{,}250\ square\ feet \times \frac{1\ acre}{43{,}560\ feet} = 1.06\ acres$$

The area of the waste pond is 46,250 square feet or 1.06 acres.

2. Calculate the area of a waste pond, in square feet and acres, with sides that are 534 feet and 782 feet long.



$$width, feet \times length, feet = area, square\ feet$$

$$534\ feet \times 782\ feet = 417{,}588\ square\ feet$$

$$417{,}588\ square\ feet \times \frac{1\ acre}{43{,}560\ feet} = 9.59\ acres$$

The area of the waste pond is 417,588 square feet or 9.59 acres.

3. Calculate the volume of a waste pond, in million gallons (MG), given the following dimensions:
   Area of waste pond surface: 260,000 sq ft
   Area of waste pond bottom: 240,000 sq ft
   Depth of waste pond: 7 feet

$$Avg\ Area, sq\ ft = \frac{area\ of\ surface, sq\ ft + area\ of\ bottom, sq\ ft}{2}$$

$$Avg\ Area, sq\ ft = \frac{260{,}000\ sq\ ft + 240{,}000\ sq\ ft}{2}$$

$$Avg\ Area, sq\ ft = \frac{500{,}000\ sq\ ft}{2}$$

$$Avg\ Area, sq\ ft = 250{,}000\ sq\ ft$$

$$Pond\ Volume, gal = (Avg\ Area, sq\ ft) \times (Depth, ft) \times \left(7.48 \frac{gal}{cu\ ft}\right)$$

$$Pond\ Volume, gal = 250{,}000\ sq\ ft \times 7\ feet \times 7.48 \frac{gal}{cu\ ft}$$

$$Pond\ Volume, gal = 13{,}090{,}000\ gal$$

$$Pond\ Volume, MG = \frac{(Pond\ Volume, gal)}{1{,}000{,}000\ gal/MG}$$

$$Pond\ Volume, MG = \frac{13{,}090{,}000\ gal}{1{,}000{,}000\ gal/MG}$$

$$Pond\ Volume, MG = 13.1\ MG$$

The volume of the waste pond is 13.1 MG.

4. Calculate the volume of a waste pond, in million gallons (MG), given the following dimensions:
   Area of surface of waste pond: 1,524,600 sq ft
   Area of bottom of waste pond: 1,306,800 sq ft
   Depth of waste pond: 8 feet

$$Avg\ Area, sq\ ft = \frac{area\ of\ surface, sq\ ft + area\ of\ bottom, sq\ ft}{2}$$

$$Avg\ Area, sq\ ft = \frac{1{,}524{,}600\ \text{sq ft} + 1{,}306{,}800\ sq\ ft}{2}$$

$$Avg\ Area, sq\ ft = \frac{2{,}831{,}400\ sq\ ft}{2}$$

$$Avg\ Area, sq\ ft = 1{,}415{,}700\ sq\ ft$$

$$Pond\ Volume, gal = (Avg\ Area, sq\ ft) \times (Depth, ft) \times \left(7.48 \frac{gal}{cu\ ft}\right)$$

$$Pond\ Volume, gal = 1{,}415{,}700\ sq\ ft \times 8\ feet \times 7.48 \frac{gal}{cu\ ft}$$

$$Pond\ Volume, gal = 84{,}715{,}488\ gal$$

$$Pond\ Volume, MG = \frac{(Pond\ Volume, gal)}{1{,}000{,}000\ gal/MG}$$

$$Pond\ Volume, MG = \frac{84{,}715{,}488\ gal}{1{,}000{,}000\ gal/MG}$$

$$Pond\ Volume, MG = 84.7\ MG$$

The volume of the waste pond is 84.7 MG.

5. Calculate the detention time of a waste pond with the following information:
   Pond volume: 35,000,000 gallons (35 MG)
   Influent flow rate: 300,000 gpd (0.3 MGD)

$$Detention\ Time\ (in\ days) = \frac{Pond\ Volume,\ MG}{Influent\ Flow\ Rate,\ MGD}$$

$$Detention\ Time\ (in\ days) = \frac{35\ MG}{0.3\ MGD}$$

$$Detention\ Time\ (in\ days)\ = 117\ days$$

   The detention time for the waste pond is 117 days.

6. Calculate the detention time of a waste pond with the following information:
   Pond volume: 15,000,000 gallons
   Influent flow rate: 100,000 gpd

$$Detention\ Time\ (in\ days) = \frac{Pond\ Volume,\ MG}{Influent\ Flow\ Rate,\ MGD}$$

$$Detention\ Time\ (in\ days) = \frac{15\ MG}{0.1\ MGD}$$

$$Detention\ Time\ (in\ days)\ = 150\ days$$

   The detention time for the waste pond is 150 days.

7. Calculate the detention time of a waste pond with the following information:
   Average Area of Waste Pond: 523,250 sq ft
   Depth of Waste Pond: 8 feet
   Influent Flow Rate: 150 gpm

$$Pond\ Volume,\ gal = (Avg\ Area,\ sq\ ft) \times (Depth,\ ft) \times \left(7.48\frac{gal}{cu\ ft}\right)$$

$$Pond\ Volume,\ gal = (523{,}250\ sq\ ft) \times (8\ ft) \times \left(7.48\frac{gal}{cu\ ft}\right)$$

$$Pond\ Volume,\ gal = 31{,}311{,}280\ gal$$

$$Detention\ Time\ (in\ days) = \frac{Pond\ Volume,\ gal}{(Influent\ Flow\ Rate,\ gpm) \times (1{,}440\ minutes\ per\ day)}$$

$$Detention\ Time\ (in\ days) = \frac{31{,}311{,}280\ gal}{(150\ gpm) \times (1{,}440\ minutes\ per\ day)}$$

$$Detention\ Time\ (in\ days) = \frac{31{,}311{,}280\ gal}{216{,}000\ gpd}$$

$$Detention\ Time\ (in\ days) = 145\ days$$

The detention time for the waste pond is 145 days.

8. Calculate the detention time of a waste pond with the following information:
   Average Area of Waste Pond: 325,000 sq ft
   Depth of Waste Pond: 7 feet
   Influent Flow Rate: 100 gpm

$$Pond\ Volume, gal = (Avg\ Area, sq\ ft) \times (Depth, ft) \times \left(7.48 \frac{gal}{cu\ ft}\right)$$

$$Pond\ Volume, gal = (325{,}000\ sq\ ft) \times (7\ ft) \times \left(7.48 \frac{gal}{cu\ ft}\right)$$

$$Pond\ Volume, gal = 17{,}017{,}000\ gal$$

$$Detention\ Time\ (in\ days) = \frac{Pond\ Volume, gal}{(Influent\ Flow\ Rate, gpm) \times (1{,}440\ minutes\ per\ day)}$$

$$Detention\ Time\ (in\ days) = \frac{17{,}017{,}000\ gal}{(100\ gpm) \times (1{,}440\ minutes\ per\ day)}$$

$$Detention\ Time\ (in\ days) = \frac{17{,}017{,}000\ gal}{144{,}000\ gpd}$$

$$Detention\ Time\ (in\ days) = 118\ days$$

The detention time for the waste pond is 118 days.

9. Calculate the population loading of a waste pond given the following information:
   Population Served: 250 persons
   Surface Area of Pond: 5 acres

$$Population\ Loading, Persons\ per\ Acre = \frac{Population\ Served, persons}{Surface\ Area\ of\ Pond, ac}$$

$$Population\ Loading, Persons\ per\ Acre = \frac{250\ persons}{5\ ac}$$

$$Population\ Loading, Persons\ per\ Acre = 50\ persons\ per\ acre$$

The population load for the waste pond is 50 persons per acre.

10. Calculate the population loading of a waste pond given the following information:
    Population Served: 625 persons
    The dimensions of the Waste Pond are: 725 ft by 560 feet

$$Pond\ Area, ac = \frac{(Length, ft) \times (Width, ft)}{43{,}560\ sq\ ft/ac}$$

$$Pond\ Area, ac = \frac{(725\ ft) \times (560\ ft)}{43{,}560\ sq\ ft/ac}$$

$$Pond\ Area, ac = \frac{406{,}000\ sq\ ft}{43{,}560\ sq\ ft/ac}$$

$$Pond\ Area, ac = 9.3\ ac$$

$$Population\ Loading, Persons\ per\ Acre = \frac{Population\ Served, persons}{Surface\ Area\ of\ Pond, ac}$$

$$Population\ Loading, Persons\ per\ Acre = \frac{625\ persons}{9.3 ac}$$

$$Population\ Loading, Persons\ per\ Acre = 67\ persons\ per\ acre$$

The population load for the waste pond is 67 persons per acre.

11. Calculate the hydraulic loading of a waste pond given the following information:

Depth of the Waste Pond: 7 feet (84 inches)
Detention Time: 130 days

$$Hydraulic\ Loading, inches/day = \frac{Depth\ of\ Pond, inches}{Detention\ Time, days}$$

$$Hydraulic\ Loading, inches/day = \frac{84\ inches}{130\ days}$$

$$Hydraulic\ Loading, inches/day = 0.6\ inches/day$$

The hydraulic loading of the waste pond is 0.6 inches per day.

12. Calculate the hydraulic loading of a waste pond given the following information:

Inflow Rate: 144,000 gpd
Area of Waste Pond: 108,900 sq ft

$$Hydraulic\ Loading, gallons\ per\ day/square\ feet = \frac{Inflow\ Rate, gpd}{Area, sq\ ft}$$

$$Hydraulic\ Loading, gallons\ per\ day/square\ feet = \frac{144{,}000\ gpd}{108{,}900\ sq\ ft}$$

$$Hydraulic\ Loading, gallons\ per\ day/square\ feet = 1.3\ gallons\ per\ day\ /sq\ ft$$

The hydraulic loading of the waste pond is 1.3 gallons per day per square foot.

13. Calculate the organic loading of a waste pond given the following information:

BOD: 90 mg/L
Flow: 0.8 MGD
Pond Area: 12 acres

$$Organic\ Loading, lbs\ BOD/day/ac = \frac{(BOD, mg/L) \times (Flow, MGD) \times (8.34\ lbs/gal)}{Pond\ Area, ac}$$

$$Organic\ Loading, lbs\ BOD/day/ac = \frac{(90\ mg/L) \times (0.8\ MGD) \times (8.34\ lbs/gal)}{12\ ac}$$

$$Organic\ Loading, lbs\ (BOD/day)/ac = 50\ lbs\ BOD/day/ac$$

The organic loading of the waste pond is 50 pounds of BOD per day per acre.

14. Calculate the organic loading of a waste pond given the following information:

BOD: 150 mg/L

Flow: 0.2 MGD

The dimensions of the Waste Pond are: 710 feet by 575 feet

$$Pond\ Area, ac\ = \frac{(Length, ft) \times (Width, ft)}{43{,}560\ sq\ ft/ac}$$

$$Pond\ Area, ac\ = \frac{(710\ ft) \times (575\ ft)}{43{,}560\ sq\ ft/ac}$$

$$Pond\ Area, ac\ = \ 9.4\ acres$$

$$Organic\ Loading, lbs\ BOD/day/ac = \frac{(BOD, mg/L) \times (Flow, MGD) \times (8.34\ lbs/gal)}{Pond\ Area, ac}$$

$$Organic\ Loading, lbs\ BOD/day/ac = \frac{(150\ mg/L) \times (0.2\ MGD) \times (8.34\ lbs/gal)}{9.4\ ac}$$

$$Organic\ Loading, lbs\ (BOD/day)/ac = \ 26.6\ lbs\ BOD/day/ac$$

The organic loading of the waste pond is 26.6 pounds of BOD per day per acre.

15. Calculate the removal efficiency of a waste pond given the following information:

Influent BOD: 250 mg/L

Effluent BOD: 25 mg/L

$$Removal\ Efficiency, \% = \frac{(Influent - Effluent) \times (100\%)}{Influent}$$

$$Removal\ Efficiency, \% = \frac{(250\ mg/L - 25\ mg/L) \times (100\%)}{250\ mg/L}$$

$$Removal\ Efficiency, \% = \frac{(225\ mg/L) \times (100\%)}{250\ mg/l}$$

$$Removal\ Efficiency, \% = 90\%$$

The removal efficiency of the waste pond is 90%.

16. Calculate the removal efficiency of a waste pond given the following information:

Influent BOD: 315 mg/L
Effluent BOD: 100 mg/L

$$Removal\ Efficiency, \% = \frac{(Influent - Effluent) \times (100\%)}{Influent}$$

$$Removal\ Efficiency, \% = \frac{(315\ mg/L - 100\ mg/L) \times (100\%)}{315\ mg/L}$$

$$Removal\ Efficiency, \% = \frac{(215\ mg/L) \times (100\%)}{315\ mg/l}$$

$$Removal\ Efficiency, \% = 68\%$$

The removal efficiency of the waste pond is 68%.