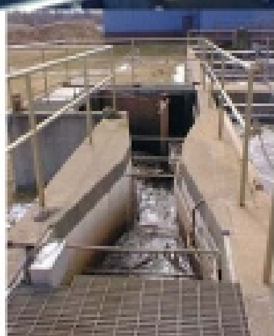
Wisconsin Department of Natural Resources
Wastewater Operator Certification

Introduction To General Wastewater Study Guide

December 2011 Edition

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Preface

This operator's study guide represents the results of an ambitious program. Operators of wastewater facilities, regulators, educators, and wastewater businesses jointly prepared the objectives and exam questions for this subclass.

How to use this study guide with references

In preparation for the exams you should:

1. Read all of the key knowledges for each objective.

2. Use the resources listed at the end of the study guide for additional information.

3. Review all key knowledges until you fully understand them and know them by memory.

It is advisable that the operator take classroom or online training in this process before attempting the certification exam.

Choosing A Test Date

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates is available on the internet at http://dnr.wi.gov, keyword search "operator certifcation". It can also be found in the annual DNR "Certified Operator" or by contacting your DNR regional operator certification coordinator.

Acknowledgements

This Study Guide is the result of the efforts of the following workgroup individuals:

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Chapter 1 - Terminology

Section 1.1 - Flows and Pollutants

1.1.1 Influent

Wastewater entering a treatment plant (raw sewage).

1.1.2 Effluent

Treated wastewater discharged from a treatment plant to the environment.

1.1.3 Biochemical Oxygen Demand (BOD)

A test that measures the organic strength of a sample by measuring the amount of oxygen consumed.

1.1.4 Total Suspended Solids (TSS)

A test that measures the total amount of solids suspended in a sample.

1.1.5 pH

A measure of the acidity or alkalinity of a sample on a scale of 0-14 (acidic-alkaline). pH 7 is neutral.

1.1.6 Dissolved Oxygen (DO)

A measure of the amount of oxygen dissolved in water.

1.1.7 Gallons per Minute (gpm)

A common measurement of wastewater flow expressed as the number of gallons flowing each minute (gpm).

1.1.8 Gallons per Day (gpd)

A common measurement of wastewater flow expressed as the number of gallons flowing each day (gpd).

1.1.9 Million Gallons per Day (MGD)

A common measurement of wastewater flow in a treatment plant, expressed as millions of gallons of wastewater flowing each day (MGD).

1.1.10 Milligrams per Liter (mg/L)

The concentration of a substance in a liquid expressed as a weight in milligrams per liter of volume (mg/L). Milligrams per liter is the same as parts per million (ppm). 1 mg/L = 1 ppm.

1.1.11 Composite Sample

A sample prepared by combining a number of grab samples, typically over a 24 hour period.

1.1.12 Grab Sample

A single sample taken at a particular time and place that is representative of the current conditions.

1.1.13 Weir

A weir is a level control structure used to provide uniform flow.

1.1.14 Flume

A restriction in an open channel used to measure flow.

1.1.15 Septage

A high strength waste pumped out of septic tanks, sometimes disposed at WWTPs.

1.1.16 Hydraulic Retention Time (HRT)

The period of time that wastewater remains in a tank. This term is also known as detention time.

Section 1.2 - Sewer Systems

1.2.1 Inflow/Infiltration (I/I)

Any unwanted clearwater that leaks into a collection system. Generally it consists of groundwater, rainwater, or snowmelt.

1.2.2 Sanitary Sewer (Collection System)

An underground pipe system used to convey wastewater to a treatment facility.

1.2.3 Storm Sewer

An underground pipe system that collects rainwater from streets and conveys it to a place other than the wastewater treatment plant.

1.2.4 Combined Sewer

Pipe conveyances that carry both wastewater and storm water in a single pipe. During dry weather conditions, combined sewers discharge to a wastewater treatment plant. During wet weather conditions, combined sewers used to discharge directly to a water body. Now the extra wet weather volume is stored until it can be returned to the wastewater treatment plant.

1.2.5 Lift Stations

An underground chamber with pumps that is used to elevate (lift) wastewater to a higher grade. Lift stations are located within a collection system.

1.2.6 Manhole

A manhole is a structure that provides access to a sewer system. They usually are a round opening with an iron lid.

1.2.7 Wet Well

A wet well is a tank where wastewater is collected. The wastewater is then pumped from the wet well. Wet wells are commonly found in lift stations and at the headworks of the wastewater treatment plant.

Section 1.3 - Wastewater Processes

1.3.1 Microorganism

A living organism too small to be seen with the naked eye but is visible under a microscope such as a bacteria, viruses, fungi, or protozoa.

1.3.2 Sidestreams

A flow generated within the plant, usually from solids processing, that then is recycled back through the plant.

1.3.3 Aerobic (oxic) [O2]

A condition in which free and dissolved oxygen is available in an aqueous environment.

1.3.4 Anaerobic (septic) [Ø]

A condition in which free, dissolved, and combined oxygen is unavailable in an aqueous environment.

1.3.5 Treatment Process

A treatment process means a physical, biological, or chemical action that is applied to wastewater to remove or reduce pollutants.

1.3.6 Treatment Unit

A treatment unit is an individual structure or equipment within a sewage or wastewater treatment facility that is part of a treatment process.

1.3.7 Preliminary Treatment

A treatment process consisting of screening and grit removal before the wastewater flows on to other treatment processes.

1.3.8 Primary Treatment

A treatment process that usually consists of clarification by solid-liquid separation that removes a substantial amount of suspended and floating matter.

1.3.9 Secondary Treatment

A treatment process that uses biological processes utilizing bacteria to remove pollutants.

1.3.10 Tertiary Treatment

A treatment process that uses physical, chemical, or biological processes to remove suspended solids and nutrients in wastewater to accomplish a level of treatment greater than what can be achieved by secondary treatment.

1.3.11 Headworks

Headworks is the beginning, or head, of a treatment plant where influent flow is measured and sampled and where preliminary treatment occurs.

1.3.12 Grit

The fine abrasive particles removed from wastewater, such as sand and eggshells.

1.3.13 Screenings

The materials in wastewater that are removed on screens at the headworks of treatment plants, such as sticks, stones, plastics, and personal hygiene products.

1.3.14 Aeration Basin

A tank in which wastewater is aerated to achieve biological treatment.

1.3.15 Clarifier

A circular or rectangular tank used to remove floatable and settleable solids in wastewater.

1.3.16 Disinfection

A process used to destroy most pathogens in the effluent to a safe level. Disinfection does not destroy all microorganisms.

1.3.17 Biosolids

The nutrient-rich, organic byproduct of a municipal wastewater treatment plant that is utilized as fertilizer.

1.3.18 Process Control

The tools and methods used to optimize treatment plant operations.

1.3.19 Return Activated Sludge (RAS)

The settled activated sludge (biomass) that is collected in a secondary clarifier and returned to the secondary treatment process to mix with incoming wastewater. This returns a concentrated population of microorganisms back into the aeration basin.

1.3.20 Waste Activated Sludge (WAS)

The activated sludge (excess biomass or cell mass) removed from the secondary treatment process. For most treatment plants, this will be a portion of the Return Activated Sludge (RAS) flow stream.

Section 1.4 - Safety and Regulations

1.4.1 Confined Space

A space that is large enough for an operator to enter and perform assigned work. It has limited or restricted means for entry or exit and is not designed for continuous occupancy.

1.4.2 Pathogens

Infectious microorganisms in wastewater that pose health risks.

1.4.3 Wisconsin Pollutant Discharge Elimination System (WPDES) Permit

A Wisconsin Pollutant Discharge Elimination System permit is issued to wastewater facility owners, which contains facility effluent and biosolids/sludge limitations, conditions, and reporting requirements.

Chapter 2 - Influent Wastewater

Section 2.1 - Sources

2.1.1 Discuss the early historical methods of dealing with wastewater.

Early, human waste and wastewater was basically disposed of directly on the land surface. In urban communities, it was common to discharge human waste in gutters and ditches. This situation created sanitary problems (illnesses and diseases), nuisance odors, and unsightliness. Rains were counted on to flush the waste away. Later development of the pit toilet or outhouse facility continued until underground collection systems were developed.

The development of water supply systems increased the volume of wastewater generated. Early health concerns led to the building of pipe collection systems to convey this material away from human habitation, usually to a river, stream, or other body of water. Early systems received both wastewater and storm water. This improved public health concerns, but transferred the problem to receiving water streams.

2.1.2 Discuss why it is important to treat wastewater.

We treat wastewater for two main reasons:

1. To protect public health, by destroying pathogens
2. To protect the environment, by removing pollutants

Pathogenic organisms are disease-causing microorganisms. They include various bacteria, viruses, and parasites. The discharge of waterborne human wastes will contain these organisms from ailing individuals, and would be expected to be present in wastewater entering a wastewater treatment plant.

Although wastewater treatment is taken for granted in the United States, rivers and lakes are more polluted and waterborne diseases are more prevalent in countries that do not properly treat wastewater.

2.1.3 Describe the sources of wastewater in a community.

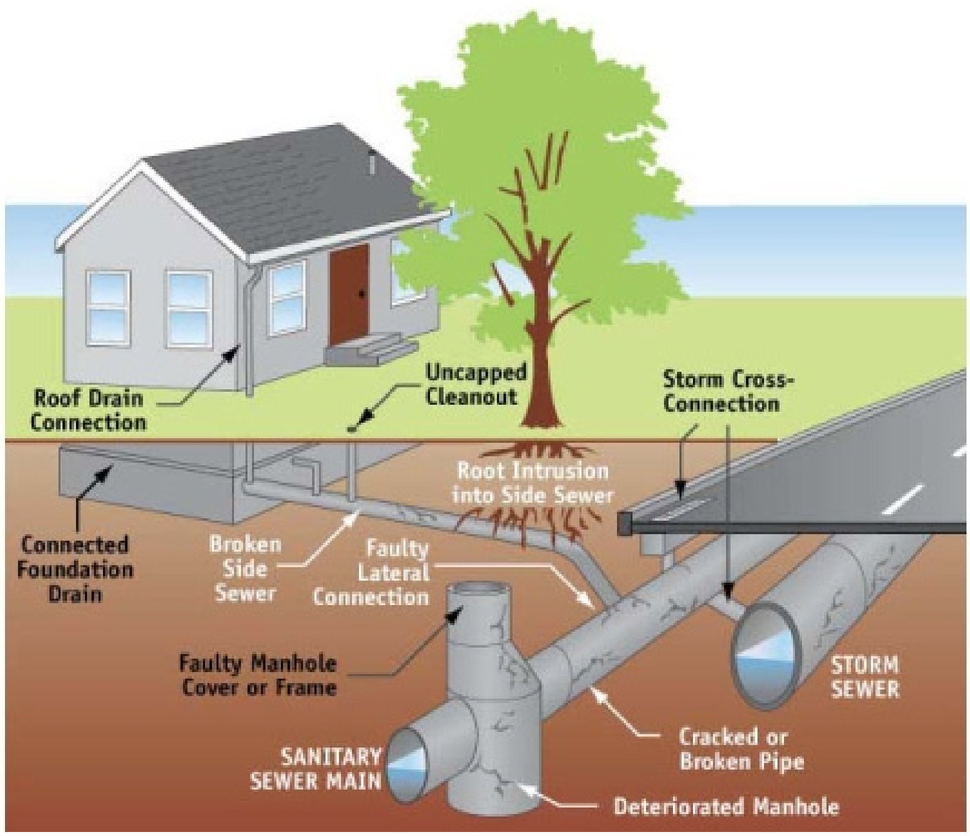
Wastewater is “used” water that goes down the drain and flows to the wastewater treatment plant. Flows originate from domestic (household), industrial, and commercial sources. Some wastewater is trucked to the WWTP (septage, holding tanks, leachate and some high strength industrial wastewater). In addition, clearwater (rain, snow and groundwater) from inflow/infiltration can get into the collection system.

2.1.4 List and define common sources of inflow/infiltration (I/I).

Inflow/infiltration is unwanted clearwater that gets into the collection system. Clearwater is classified by how fast it gets into the collection system, and is determined by weather and groundwater conditions. If the flow increases as soon as there is significant rainfall, and subsides soon after the rain stops, it is called inflow. If the flow goes up gradually after a rainfall, and stays up as long as the groundwater remains high, it is called infiltration. Common sources of clearwater (I/I) are:

A. Roof leaders connected to the sanitary sewer
B. Storm/sanitary crossovers
C. Low lying manholes in roads or ditches subject to flooding
D. Uncapped lateral connections
E. Sump pumps and foundation drains
F. Cracks and offset joints in the sanitary sewer
G. Manhole cracks and defects
H. Buried manholes
I. Cracks and leaks in building sewers

Figure 2.1.4.1



2.1.5 Discuss the effect of infiltration and inflow (I/I) of clearwater into a sewer system.

When I/I enters sewer pipes, it can exceed the flow capacity of the pipes and result in surcharging, basement backups, and sanitary sewer overflows. I/I in the sewer system can also lead to very high flows entering the wastewater treatment plant and can lead to wastewater pumping and treatment problems. Too much flow going through aeration basins and clarifiers can wash out solids creating a loss of treatment efficiency and resulting in permit violations.

Section 2.2 - Conveyance

2.2.1 Trace the sequence of events from the time one flushes a toilet until treated wastewater reaches a receiving stream.

Potable water is provided by the water supply system into a building and is used to flush or drain wastes into the building's sanitary sewer pipes and into the wastewater collection system. Wastewater is conveyed through gravity sewers, lift stations, and force mains until it makes its way into the headworks of a wastewater treatment facility. The wastewater is then treated by both physical and biological unit operations and processes, and then clean water is discharged into a receiving waterbody.

2.2.2 Explain the components of a sanitary sewer collection system.

A. Private Building Lateral Sewer
A private building lateral sewer is a 6-inch pipe that conveys sewage from the building to the public sewer main, usually under the street.

B. Mainline Sewer
Mainline sewers are pipes that collect sewage from buildings and flow by gravity to the treatment plant.

C. Force Mains
Force main sewer pipes are where wastewater is pumped (forced) under pressure to a specific location. Force mains are used when sewage cannot flow by gravity.

D. Lift (Pump) Stations
A lift station is a location in the sewer system where wastewater is collected (wet well) and then pumped to another location. The purpose of a lift station is to lift (pump) wastewater to a higher elevation where it can flow by gravity.

E. Inverted Siphon
An inverted siphon is a pipe that must dip below an obstruction and will normally form a U-shaped flow path. The liquid flowing in one end simply forces liquid up and out the other end. Inverted siphons are commonly used when a sewer pipe must be routed under a river or other deep obstructions.

F. Manholes
A manhole is a structure, usually circular, at the surface that allows access to the sewer pipes buried below.

2.2.3 Discuss the operation and maintenance (O&M) of a collection system.

The primary activities of operating and maintaining a sanitary sewer collection system are:

A. Cleaning
B. Root removal
C. Televising
D. Flow monitoring

E. Smoke testing
F. Manhole inspections
G. Lift station maintenance
H. Manhole rehabilitation
I. Mainline rehabilitation
J. Private sewer inspections
K. Private sewer I/I removal
L. Fat, oil and grease control program

Operating and maintaining a sewer system will ensure the wastewater flows to the wastewater treatment plant, without any overflows or basement back-ups anywhere in the sewer system. Regularly televising a certain percentage of the sewer system each year to assess pipe conditions is the most important inspection tool available to operators as it is the only way to "see" the pipe.

Section 2.3 - Characteristics of Wastewater

2.3.1 Describe the characteristics of influent domestic wastewater.

Sewage is >99% water. It is gray in color and has an earthy, musty odor. Typical influent wastewater concentrations are:

Figure 2.3.1.1

Courtesy of Wisconsin Rural Water Association (WRWA)

POLLUTANT	CONCENTRATION [mg/L]
BOD	250
TSS	300
Total Nitrogen	40
Ammonia	25
Total Phosphorus	9
Fats, Oil, and Grease (FOG)	100
pH	6.5-8.0

2.3.2 Discuss the potential impacts of industrial and commercial discharges.

Industrial discharges may vary in strength and volume. Of special concern are slug loads that can upset or pass through the treatment plant. High levels of BOD, TSS, phosphorus, ammonia, and grease can effect treatment. High or low pH can also be a problem.

Section 2.4 - Flow Monitoring

2.4.1 Discuss the importance of wastewater flow measurement.

It is very important to know how much influent is flowing and being treated in the plant. Treatment efficiency is dependent on loadings and detention time. It is also required to report how much treated wastewater flows into a receiving waterbody. To measure the influent entering a treatment plant from the community, flow measurements should be taken before sidestreams. To know the actual flow and loading to the treatment units, sidestreams need to be included in the flow measurements.

2.4.2 List the common types of flow measurement devices.

A. Open Channel Flow

Flow through an open channel can be measured by installing a structure in the channel. This structure is usually either a flume or weir. The most common type of flume is a Parshall Flume. The most common type of weir is either a 60º or 90º v-notch weir.

As water flows through a flume or weir, the level of water flowing through it is measured. The most common water level measurement device is a ultrasonic meter, but other devices such as pressure measurement, bubbler tubes and staff gauges are also used.

In order to get an accurate flow measurement, the weir or flume has to be sized correctly for the expected range of flows; the flow leading to it must be smooth and the water level measurement device must be properly located.

The reader is referred to the ISCO Open Channel Handbook for complete information about open channel flow monitoring equipment and tables.

B. Pipe Flow Meters

The most common way to measure the flow of wastewater through a pipe is a magnetic flow meter, commonly referred to as a magmeter. A magmeter operates on the principle of electromagnetic induction. Other devices, such as pressure or ultrasonic meters are also used.

As flows are metered, the flow data is recorded and stored in a computer or charted and totaled. This information is then used for operational and reporting purposes. All flow measurement devices must be calibrated annually by Wisconsin Adm. Code and records kept.

Figure 2.4.2.1

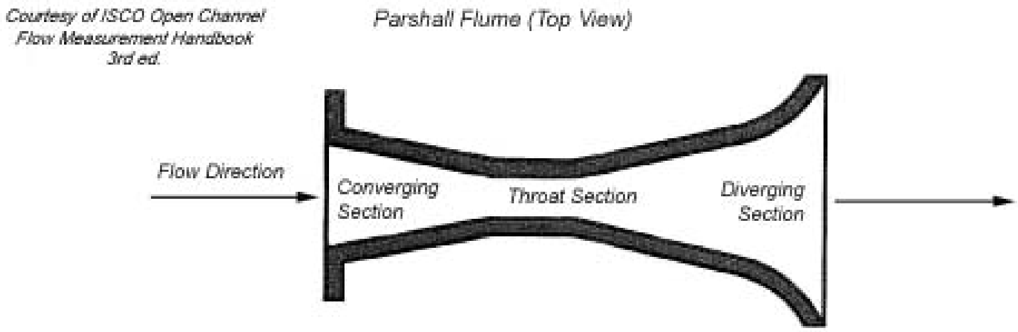
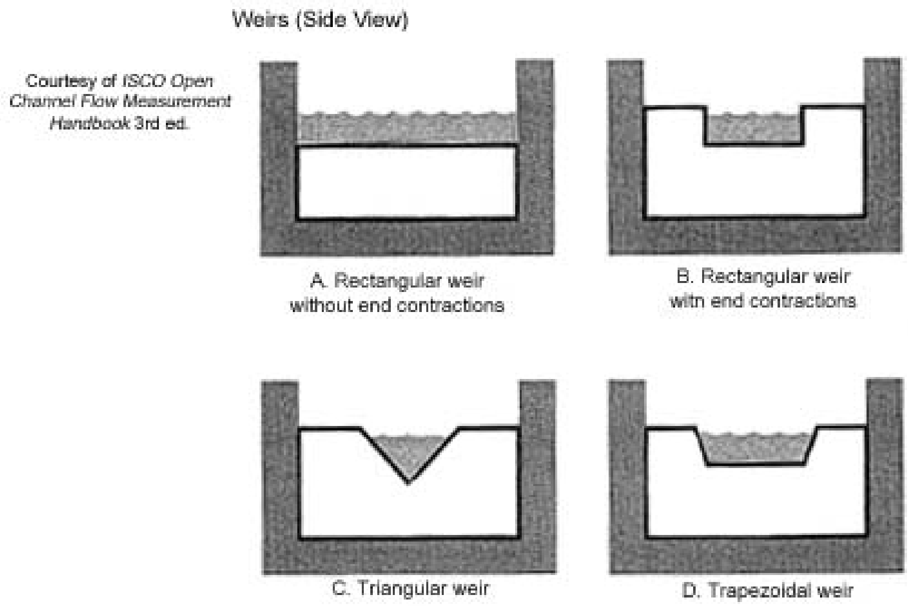


Figure 2.4.2.2



2.4.3 Describe how daily flow measurements are recorded.

For Discharge Monitoring Reports (DMRs), the day in which most of the flow is received is the date the flow should be recorded. For example, influent wastewater flow entering the plant is recorded and totaled from 7:00 am, July 14 to 7:00 am, July 15. The total flow read the morning of July 15 is 475,000 gallons. The operator would report this flow as the flow for July 14. Flows should be recorded at about the same time each day. Flows are most commonly reported on DMRs in million gallons per day (MGD). In the example above, the flow would be recorded as 0.475 MGD.

Section 2.5 - Sampling

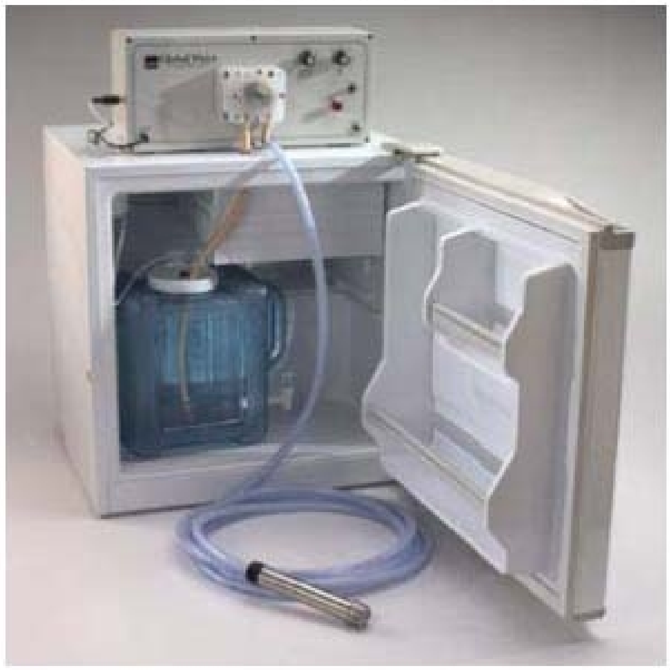
2.5.1 Discuss grab and composite influent sampling.

A grab sample is a sample collected at a single instant in time. A composite sample is a collection of samples taken over a longer period of time (usually 24 hours) and mixed/stored in a larger container. A composite sample represents the average wastewater quality being received into a wastewater treatment plant. If samples collected over 24 hours are stored in a composite sampling jug or container, the jug or container must be shaken and well mixed before pouring the actual sample to be used for testing. Some samples, for example pH, dissolved oxygen, and chlorine residual must be grab samples because compositing and holding such samples would change the test results.

Figure 2.5.1.1

REFRIGERATED COMPOSITE SAMPLER

Courtesy of North Central Labs



2.5.2 Discuss the difference between a time proportional and flow proportional composite sample.

A time proportional composite sample is a collection of samples over time, usually after so many minutes. A flow proportional composite sample are samples collected per unit of flow, after so many gallons. Flow-proportional samples are collected directly proportional to the flow, with more samples taken when flows are higher and less samples when flows are lower. Automatic flow proportional composite samplers are required for almost all wastewater treatment plants, as it is the most representative way of collecting samples from continuous flowing treatment systems, especially for BOD and TSS.

2.5.3 Describe a good sampling location and procedure for collecting representative influent wastewater samples.

It is important that raw influent wastewater be sampled in a location where it is well mixed and represents the actual wastewater going into the treatment plant. It is best to collect the sample after the headworks (after screenings and grit removal) as this is most representative of the BOD and TSS going into downstream treatment units.

2.5.4 List the information that must be recorded for influent wastewater samples.

Automatic composite samplers must be refrigerated and maintained at a temperature not to exceed 6ºC (centigrade) and must not be frozen. A thermometer immersed in a small capped bottle of liquid is usually kept in the sampler to check and record temperatures. A 24-hour composite sample is the common requirement. For Discharge Monitoring Reporting (DMR), the day on which most of the composite sample was taken is the date of the sample. A sampling log must be maintained at the automatic composite sampler and the following information recorded.

A. Sample identification
B. Date started
C. Time started
D. Date collected
E. Time collected
F. Sampler temperature
G. Operator initials
H. Comments

Chapter 3 - Wastewater Treatment

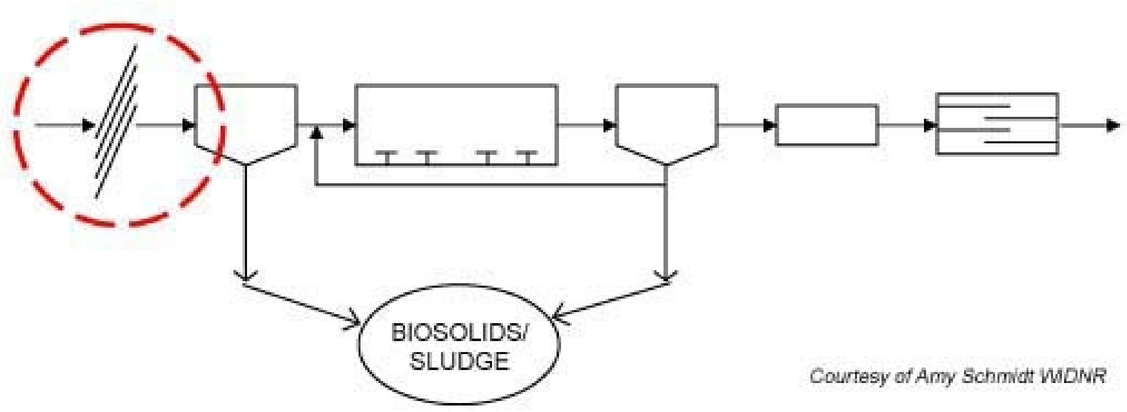
Section 3.1 - Preliminary Treatment

3.1.1 Discuss the Preliminary Treatment Process.

The purpose of preliminary treatment is to remove larger materials (rags, sticks, stones, plastics, personal hygiene products, etc) and grit from the wastestream before it flows to downstream treatment units. This is done to significantly reduce the plugging and clogging of pumps and pipes, the abrasive action of grit on equipment, and the settling of these materials in downstreams tanks and basins.

Preliminary treatment usually consists of screening and grit removal equipment. Sewage grinders and comminutors that shred larger materials into smaller pieces are not commonly used anymore. Newer preliminary treatment units now automatically clean, dewater, and bag/containerize these materials thus greatly reducing exposure to operators.

Figure 3.1.1.1



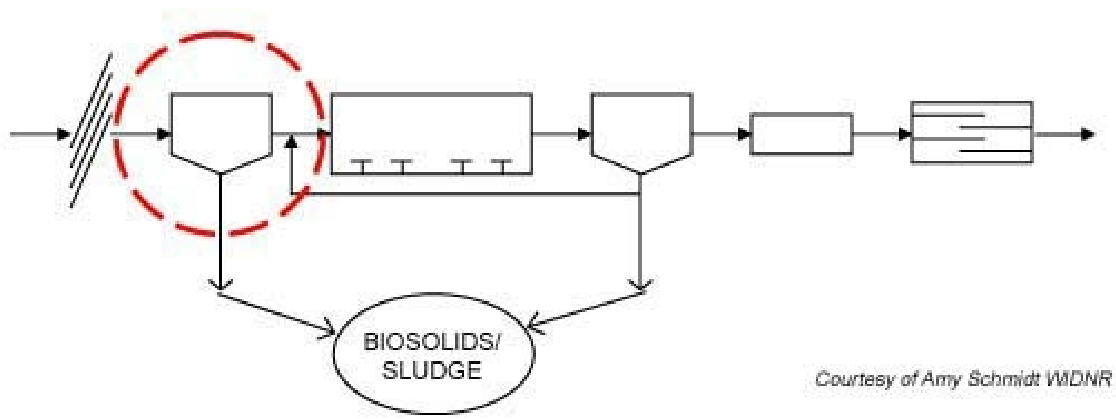
Section 3.2 - Primary Treatment

3.2.1 Discuss the Primary Treatment Process.

The purpose of primary treatment is to settle wastewater solids and capture floatable substances (such as oil & grease). Some BOD is also removed in the settling of these solids. The solids that settle in primary clarifers and the oil & grease skimmed off the surface are directly removed from the process.

Primary treatment commonly consists of circular or rectangular clarifiers. Sometimes dissolved air flotation thickeners or other processes are used for primary treatment. Primary effluent containing soluble BOD and some suspended solids flows to a secondary biological treatment process for further treatment.

Figure 3.2.1.1



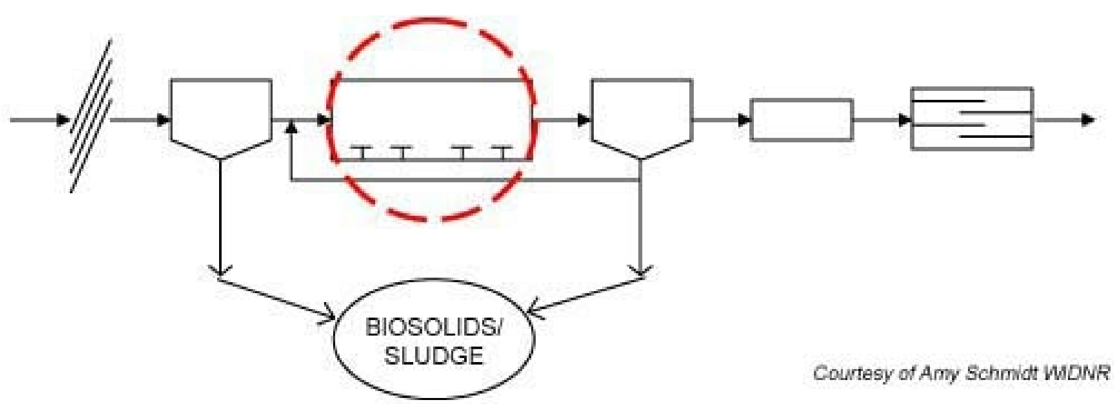
Section 3.3 - Secondary (Biological) Treatment

3.3.1 Discuss the secondary biological treatment process.

The purpose of secondary biological treatment is to remove dissolved and suspended organic material from wastewater to produce an environmentally-safe treated effluent and biosolids/sludge.

Secondary biological treatment consists of microorganisms (bacteria), either in mixed suspension in a basin or attached to a media of some type, where the organic material is broken down and consumed by the microorganisms. Most secondary treatment processes require oxygen for the bacteria.

Figure 3.3.1.1



3.3.2 Discuss Suspended Growth Systems (Activated Sludge).

Activated sludge is a suspension of sewage and microorganisms in an aeration basin. The mixture of wastewater and microorganisms is referred to as mixed liquor suspended solids (MLSS). Aeration equipment provides dissolved oxygen to promote the growth of microorganisms that substantially remove organic material. Some common types of suspended growth processes are conventional and extended aeration activated sludge plants, oxidation ditches, and sequencing batch reactors (SBRs). The reader is referred to the Activated Sludge Operator Study Guide for more detailed information about suspended growth processes.

3.3.3 Discuss Attached Growth Systems (Rotating Biological Contactor/Trickling Filter).

A fixed-film process utilizes microorganisms that are fixed in place on a solid surface (attached). As wastewater passes through and around the solid surface, the microorganisms remove the food (organic content) from the wastewater. This "attached growth type" aerobic biological treatment process creates an environment that supports the growth of microorganisms. Some common types of fixed film processes are trickling filters, biotowers, and rotating biological contacters (RBCs). The reader is referred to the Trickling Filter/RBC Operator Study Guide for more detailed information about attached growth processes.

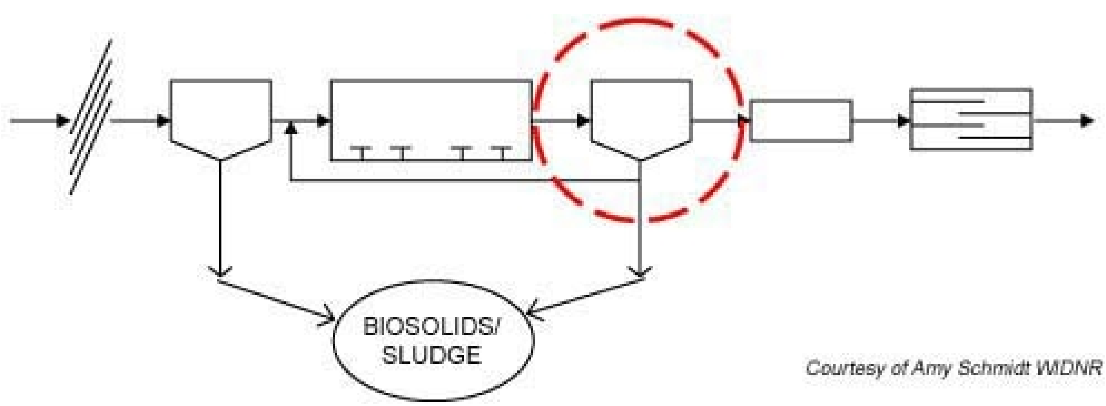
Section 3.4 - Final Clarification

3.4.1 Discuss the final clarification process.

The purpose of final clarification is to settle secondary biological treatment solids and discharge clear effluent. The settled solids can be returned (RAS) to the aeration tank or wasted (WAS) for biosolids/sludge processing.

Final clarification consists of clarifiers.

Figure 3.4.1.1

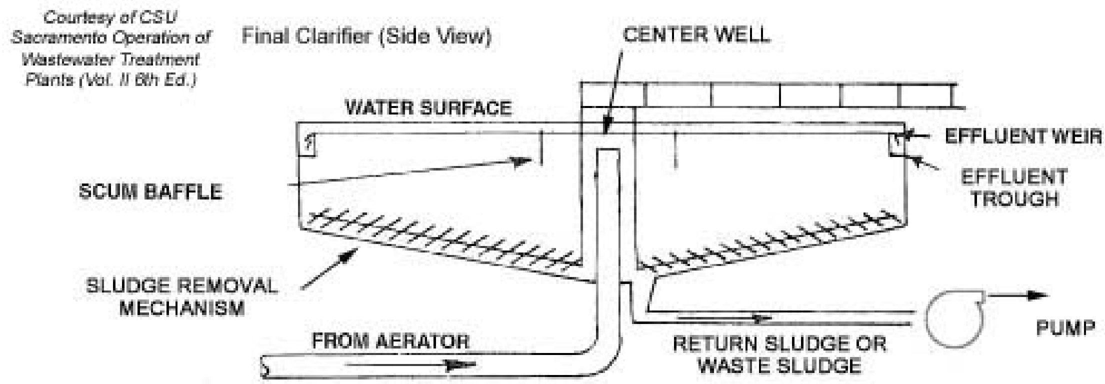


3.4.2 List the parts of a final clarifier.

A. Motor & drive system
B. Center stilling well
C. Skimmer

D. Scum skimmer
E. Scum beach
F. Baffles
G. Weirs
H. Effluent trough
I. Sludge collection and removal mechanism
J. RAS/WAS pump

Figure 3.4.2.1



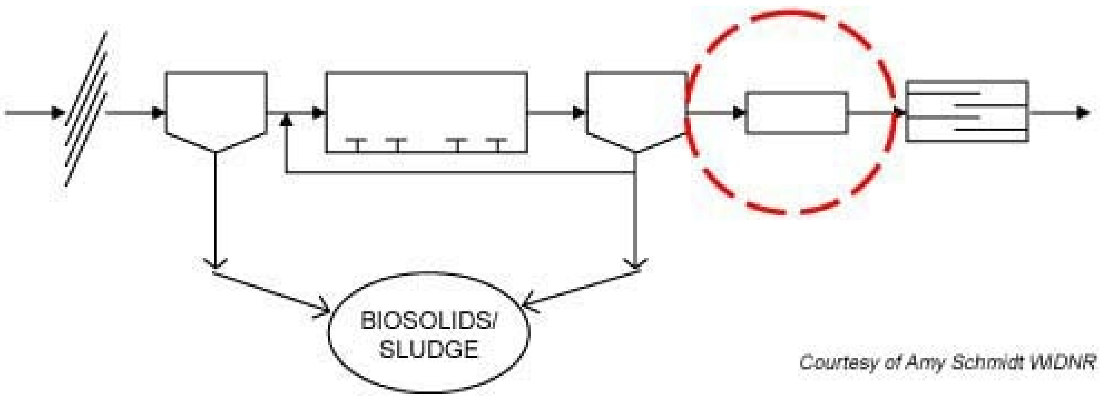
Section 3.5 - Tertiary Treatment

3.5.1 Discuss the tertiary treatment process.

The purpose of tertiary treatment is to provide advanced wastewater treatment beyond secondary biological treatment. It results in a very high quality effluent, extremely low in BOD, suspended solids and nutrients. Wastewater treatment plants that have discharge limits less than 10 mg/L of BOD and total suspended solids or have very low phosphorus limits, usually need to provide tertiary treatment.

Tertiary treatment usually consists of a type of physical and/or chemical process. Sand or mixed media filters, cloth discs, membranes, or other treatment units can remove total suspended solids and/or phosphorus to very low levels. Chemicals can also be used to precipitate some pollutants in the wastewater. Air stripping or activated carbon is sometimes used to remove volatile organic chemicals from the wastewater.

Figure 3.5.1.1



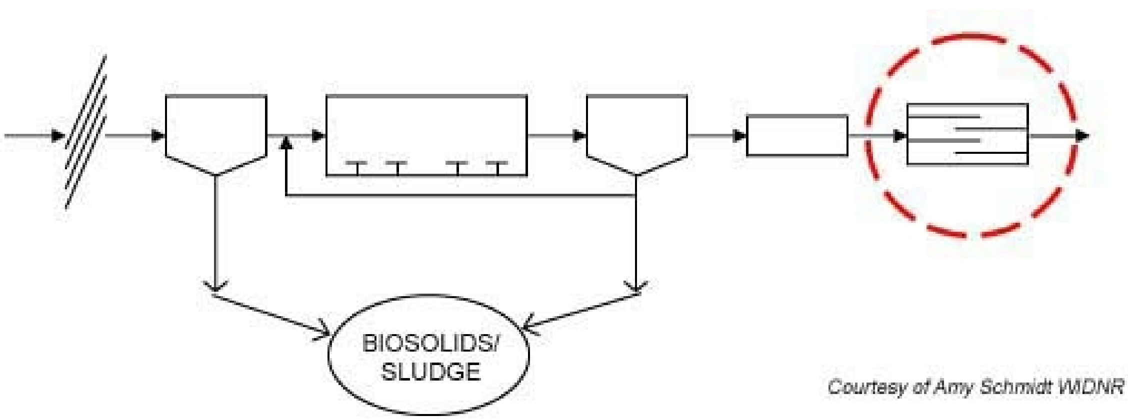
Section 3.6 - Disinfection

3.6.1 Discuss the disinfection process.

The purpose of disinfection of treated wastewater is to kill and thus reduce the discharge of waterborne pathogenic organisms that cause illness. This is done to protect public health as related to surface drinking water supplies and recreational use of downstream areas. Seasonal disinfection provides disinfection during the months when recreational activities are using downstream areas.

Disinfection consists of either chlorination tanks or ultraviolet radiation units in Wisconsin.

Figure 3.6.1.1



Section 3.7 - Ponds and Lagoons

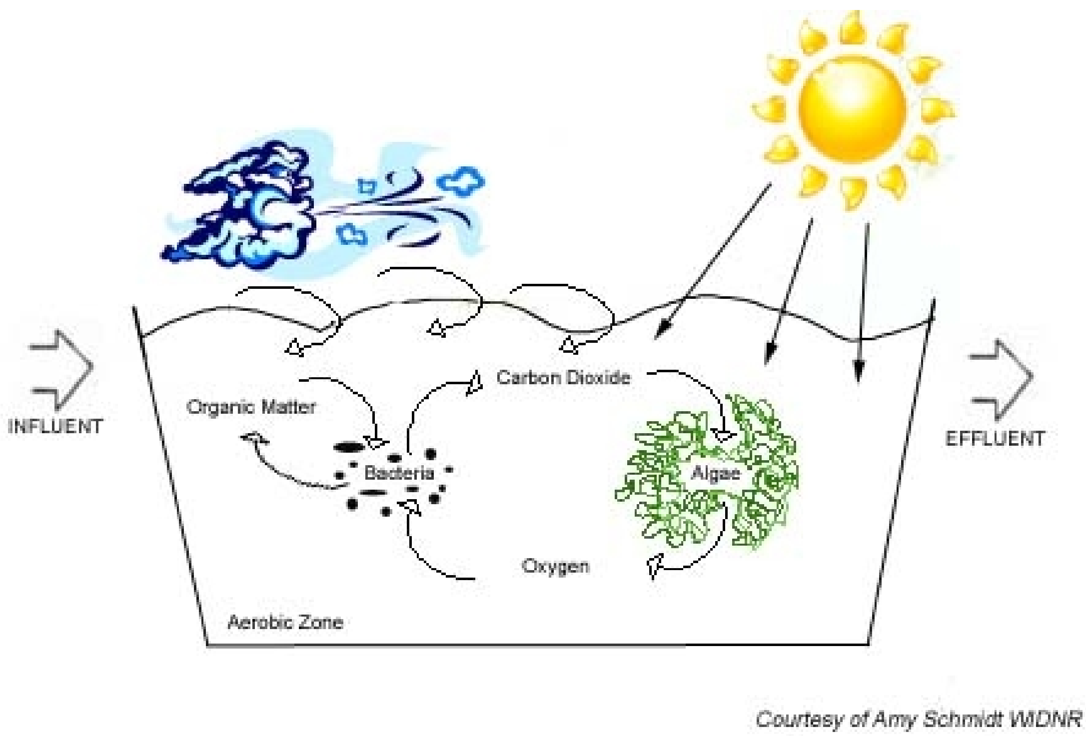
3.7.1 Discuss Pond and Lagoon Systems.

Pond and lagoon systems are earthen basins with a liner to prevent leakage. These systems are classified as secondary biological treatment, and are an economical way to accomplish biological treatment. Pond systems are typically used for BOD and TSS removal when limits are 30 mg/L; however, when limits are more restrictive or include nutrient limits, mechanical treatment is necessary. The flow often goes through more than one pond in series. Their large size provides a long detention time for the bacteria to break down the wastes. Due to their large size, pond systems are mostly used in small communities when land is available.

3.7.2 Describe a Stabilization Pond system.

Stabilization ponds are large, non-aerated, and normally less than 10 feet deep. Algae growing in the ponds provide most of the oxygen to the bacteria to remove pollutants. Solids settle to the bottom of the pond and are further stabilized by bacteria.

Figure 3.7.2.1



3.7.3 Describe an Aerated Lagoon system.

Aerated Lagoons are normally more than 10 feet deep. Aeration is provided by diffusers or surface aerators. Aeration improves removal efficiency. Aerated lagoons are followed by non-aerated lagoons to allow settling of suspended solids before discharge.

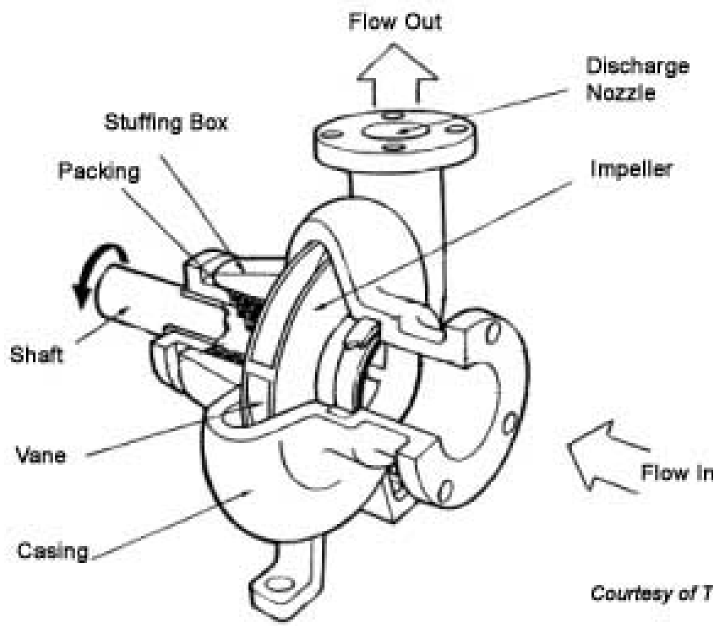
Section 3.8 - Equipment

3.8.1 Describe the types of pumps used in wastewater treatment:

Figure 3.8.1.1

Centrifugal Pump

A pump with an impeller that rotates in a casing to pump large volumes of liquid through a pipe. A centrifugal pump is the most commonly used wastewater pump. They are used most commonly for raw wastewater pumping; at lift stations, recirculation flows, for return activated sludge, waste activated sludge, and final effluent pumping.



Courtesy of The McNally Institute

Figure 3.8.1.2

Submersible Pump

The pump and motor combination are submerged in the liquid being pumped. They are a type of centrifugal pump often used for lift stations and wet wells.

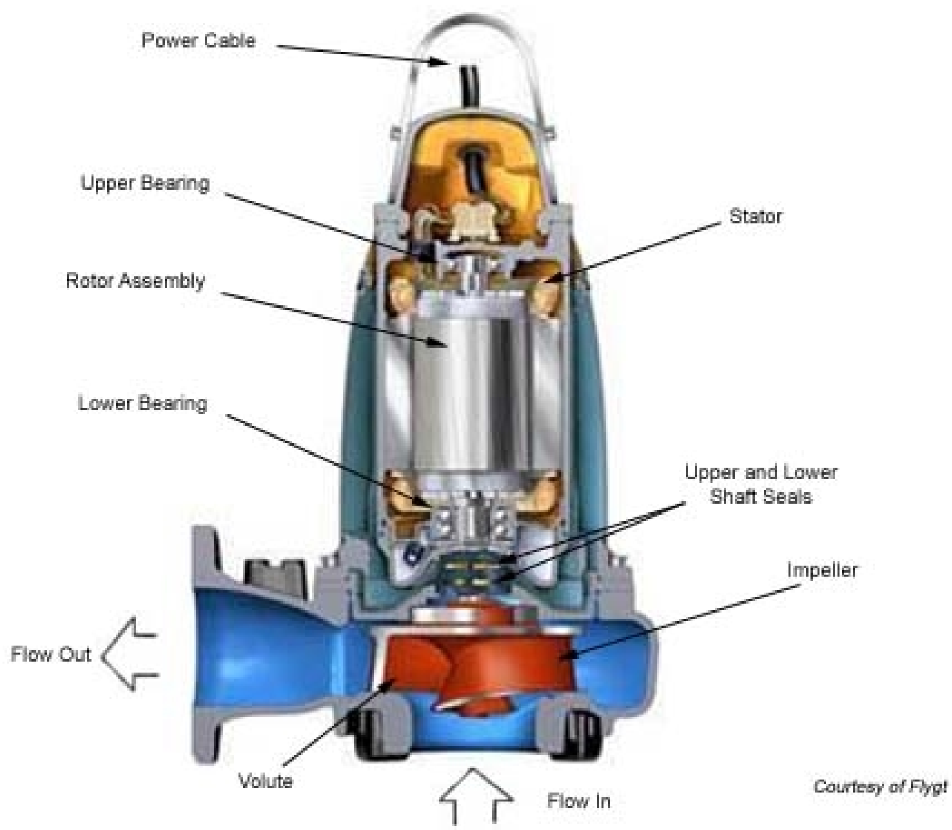
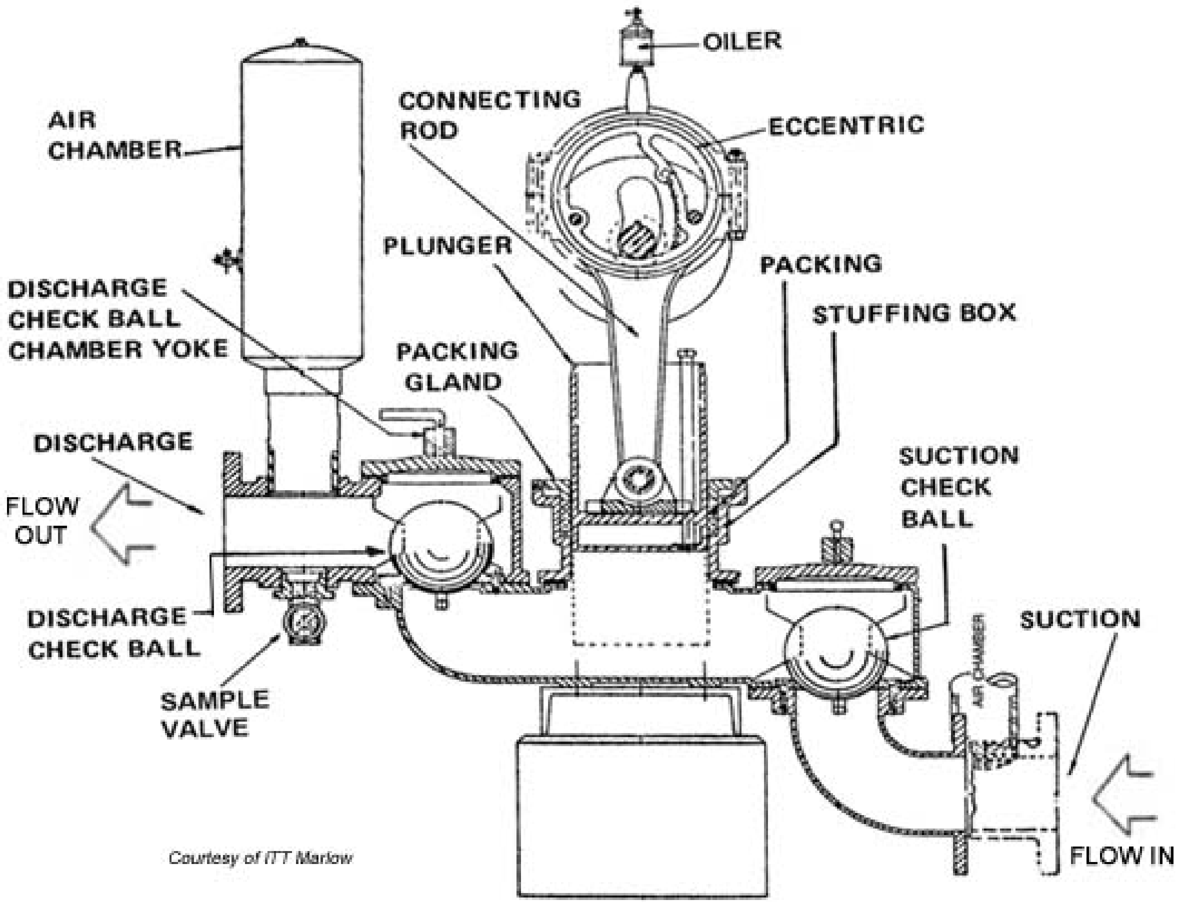


Figure 3.8.1.3

Positive Displacement Piston Pump

This type of pump operates using a piston in a reciprocating motion to pump fluids (similar to piston in an automotive engine). These pumps are commonly used for pumping sludges.



Courtesy of ITT Marlow

Figure 3.8.1.4

Courtesy of Megator & Gorger Company

Rotary Lobe Pump Cutaway

Rotary lobe pumps are used to pump both sewage and sludge. They are self-priming, valveless, positive displacement pumps. Two synchronized rotors rotating against each other create chambers between the lobes and pump casing. At the suction side the open chambers fill with the sewage or sludge. The sewage or sludge is displaced in the direction of the volume flow into the discharge side. When not operating, the rotors align and form a seal.

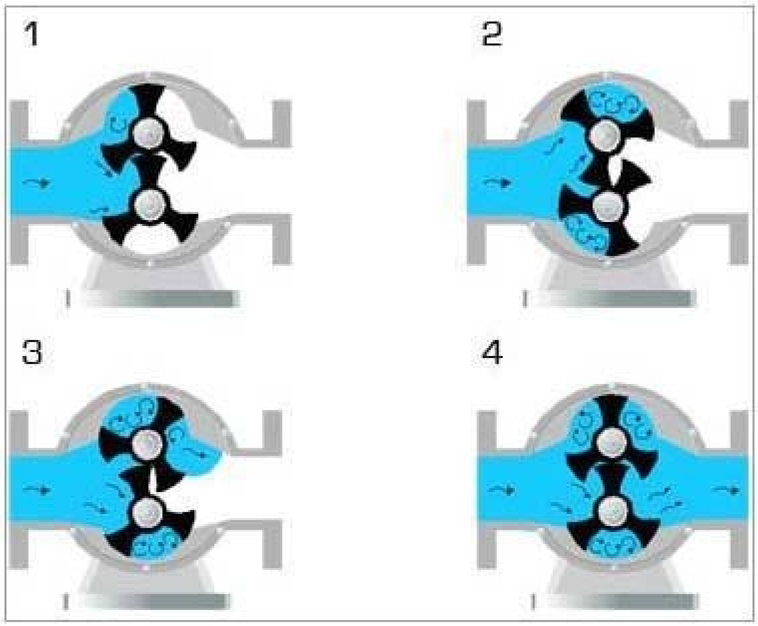


Figure 3.8.1.5

Peristaltic Pump

A small positive displacement pump commonly used for sampling and chemical addition.

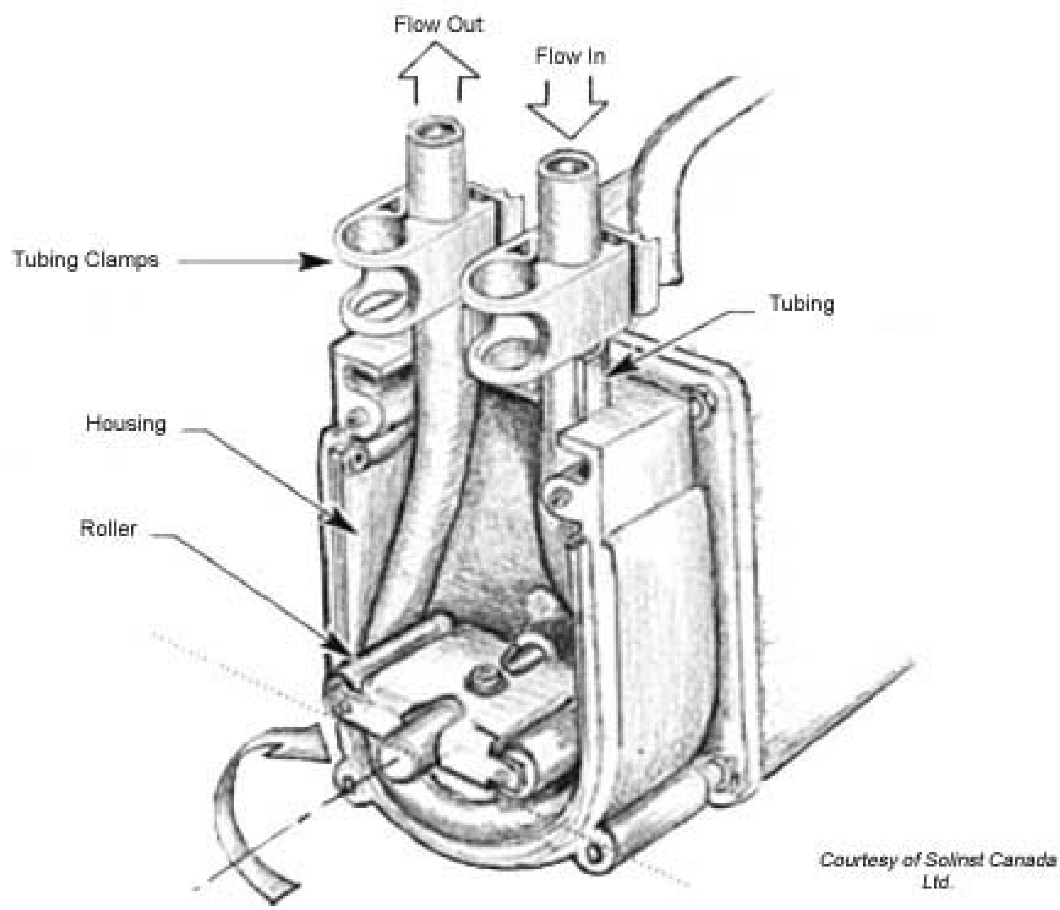


Figure 3.8.1.6

Progressive Cavity Pump

A fixed flow rate pump that turns a corkscrew shaped rotor inside a flexible rubber stator to transfer sludges. These pumps offer long life and reliable service as long as they don't run dry or with excessive grit.

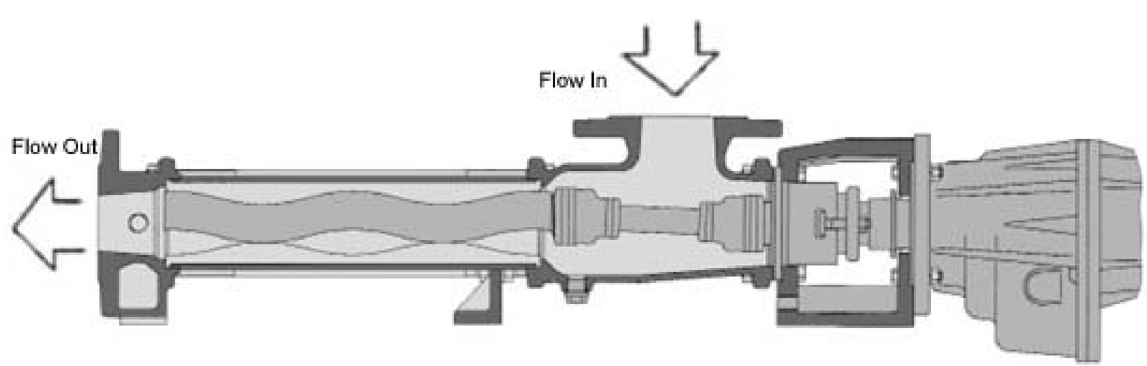


Figure 3.8.1.7

Airlift Pump

Airlife pumps are mostly used in small activated sludge plants to return and waste sludge from the system. They operate on the principle of water/air displacement. Airlift pumps are prone to plugging, especially at low return flow rates. Operators should closely monitor these pumps often to ensure sludge is being returned at all times.

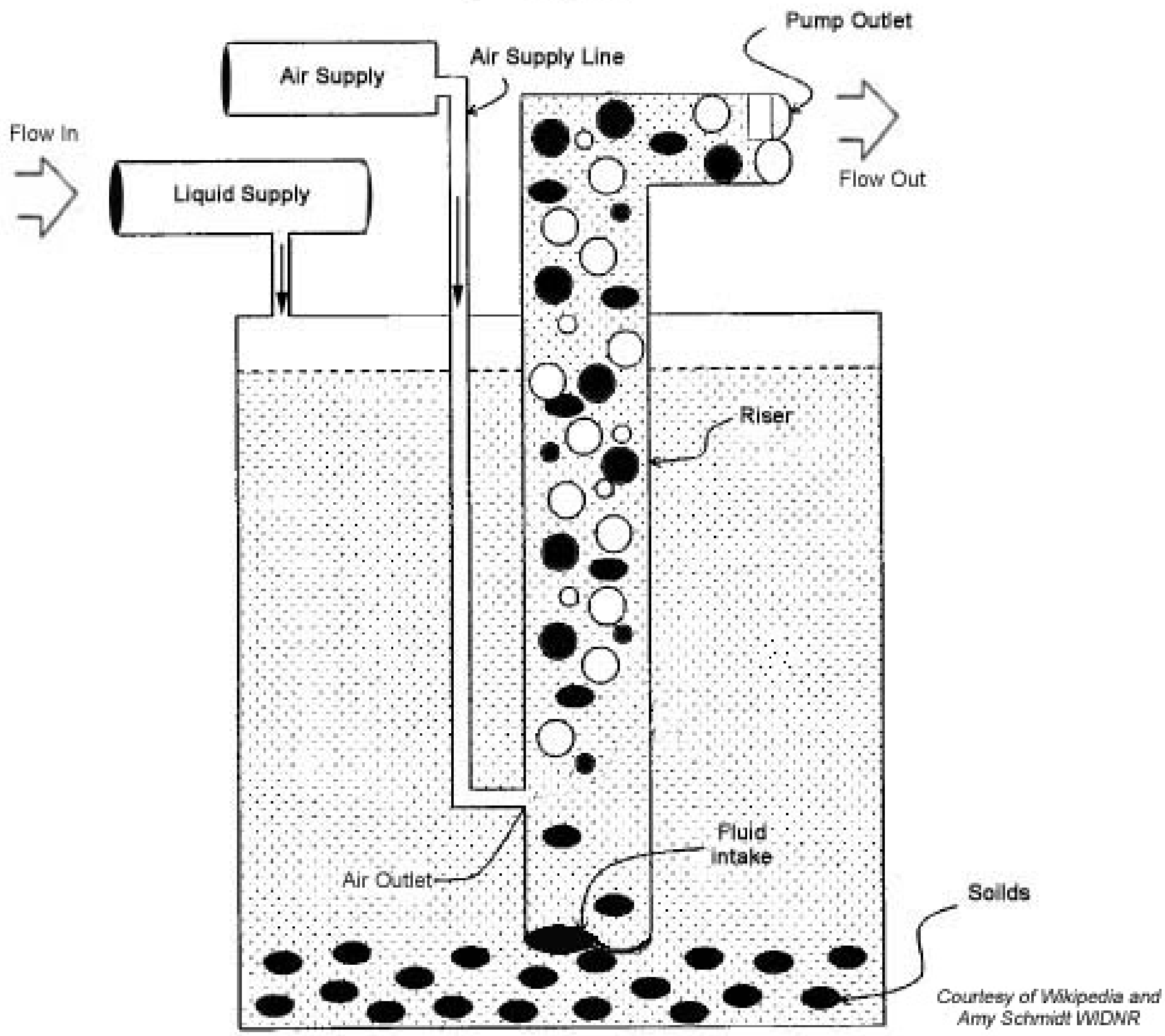
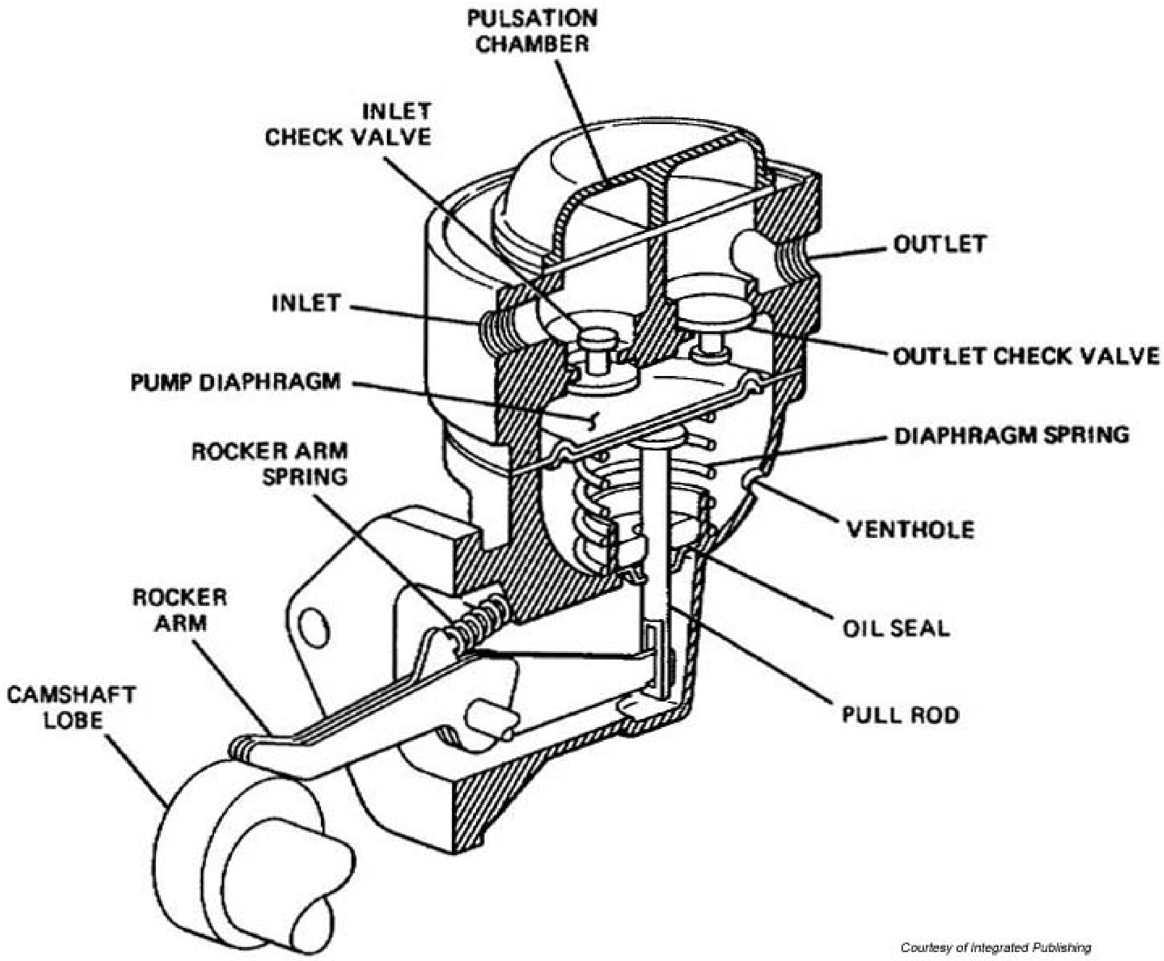


Figure 3.8.1.8

Diaphragm Pump

A diaphragm pump is a type of positive displacement pump. They differ from other positive displacement pumps in that the pumping mechanism is protected from the material being pumped. They are often used for adding chemicals or polymers. Larger diaphragm pumps are used for pumping sludge.

Chemical Metering Diaphragm Pump

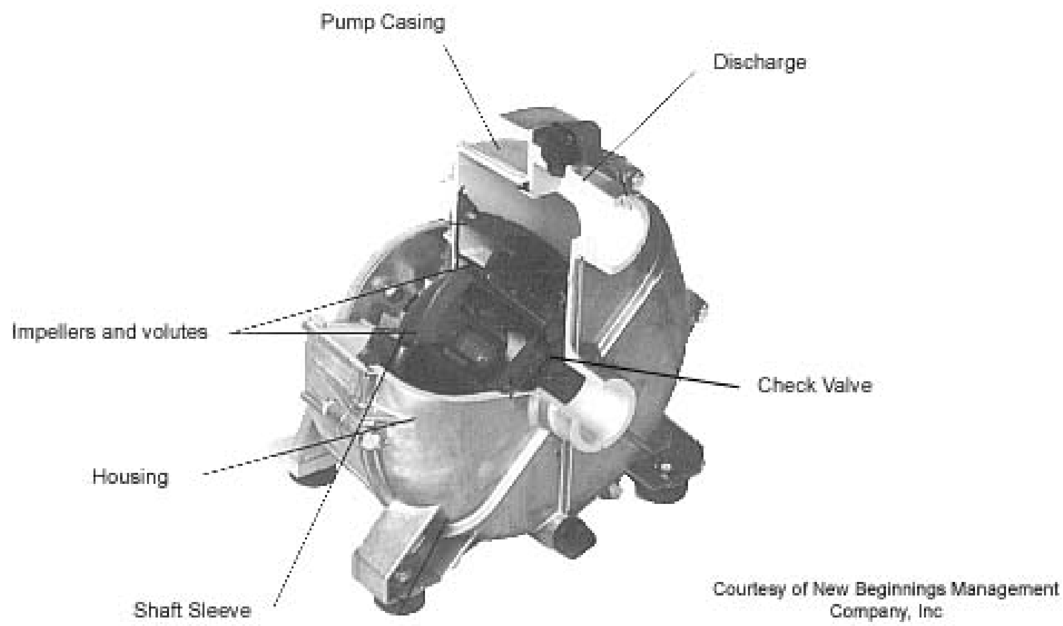


Courtesy of Integrated Publishing

Figure 3.8.1.9

Trash Pump

They are usually gasoline or diesel operated positive displacement portable pumps with a suction hose and a discharge hose. They are non-clogging (can handle a 3 or 4 inch diameter object without clogging). They are used for moving large volumes of wastewater quickly such as, dewatering, bypassing, emptying treatment tanks, etc.



3.8.2 Describe the valves used in a wastewater treatment plant:

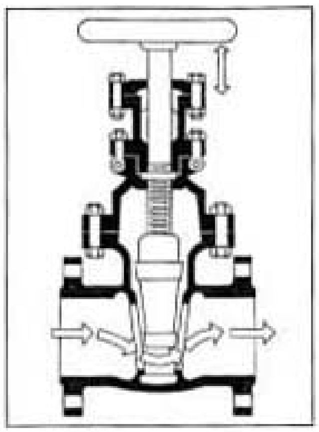
Valves are devices placed in piping systems to stop, regulate, divert, or change flow. Proper procedures for opening and closing valves must be followed to prevent personal injury and equipment damage. Valves used in wastewater treatment plants are:

Figure 3.8.2.1

MULTI TURN VALVES

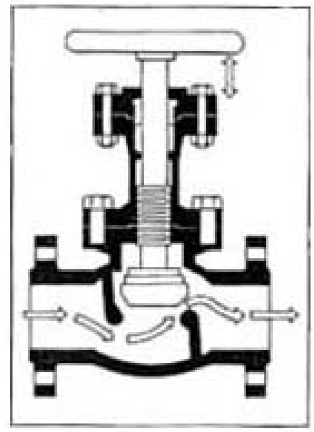
GATE VALVE

A gate valve is a general service valve used mostly for full open flow or no flow applications. This valve is closed using a gate or plate that slides the valve down to block the flow.



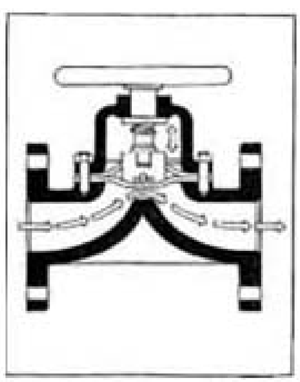
GLOBE VALVE

A globe valve is used for full flow or no flow applications as well as throttling clean water flows. This valve is closed by a flat or convex plug that is lowered onto a matching seat.



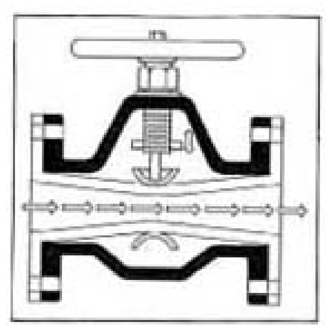
DIAPHRAGM VALVE

A diaphragm valve is often used for corrosive wastewaters. It is closed by a flexible diaphragm that is attached to a compressor. The diaphragm is lowered by the valve stem onto a weir, sealings, and shutting off the flow.



PINCH VALVE

A pinch valve is often used on sludge lines or wastewater with a high amount of suspended solids. The valve is closed by a flexible member in a valve that can be pinched close to shut off flow.



Courtesy of Water Engineering & Managment, Oct. 1988, Vol 135

Figure 3.8.2.2

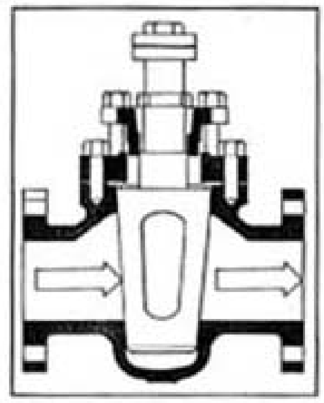
QUARTER TURN VALVES

NEEDLE VALVE

A needle valve is used for regulating flow in small lines, such as instrument air lines or fuel lines. A rod with a cone shaped tip is raised and lowered relative to a seat, thus creating a certain size opening for which flow to pass.

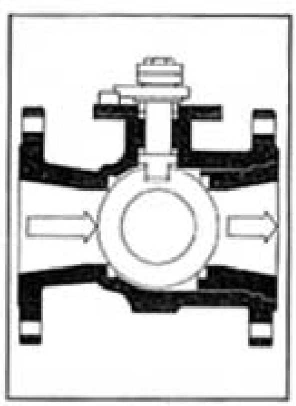
PLUG VALVE

A plug valve is used for on-off and some throttling application. It is closed by turning a cylindrical or tapered plug with a hole in the center. When open to allow full flow, the hole lines up directly with the flow path. A quarter turn in either direction blocks the flow.



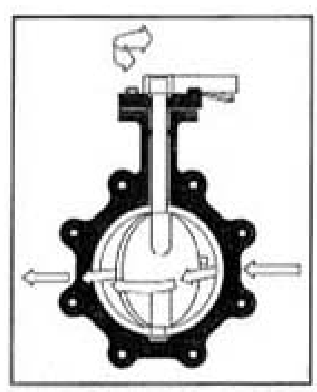
BALL VALVE

A ball valve is used for on-off and some throttling applications. It operates similarly to a plug valve but uses a rotating ball with a hole in the center. When open to allow full flow, the hole lines up directly with the flow path. When closed, the ball is rotated 90 degrees to block the flow.



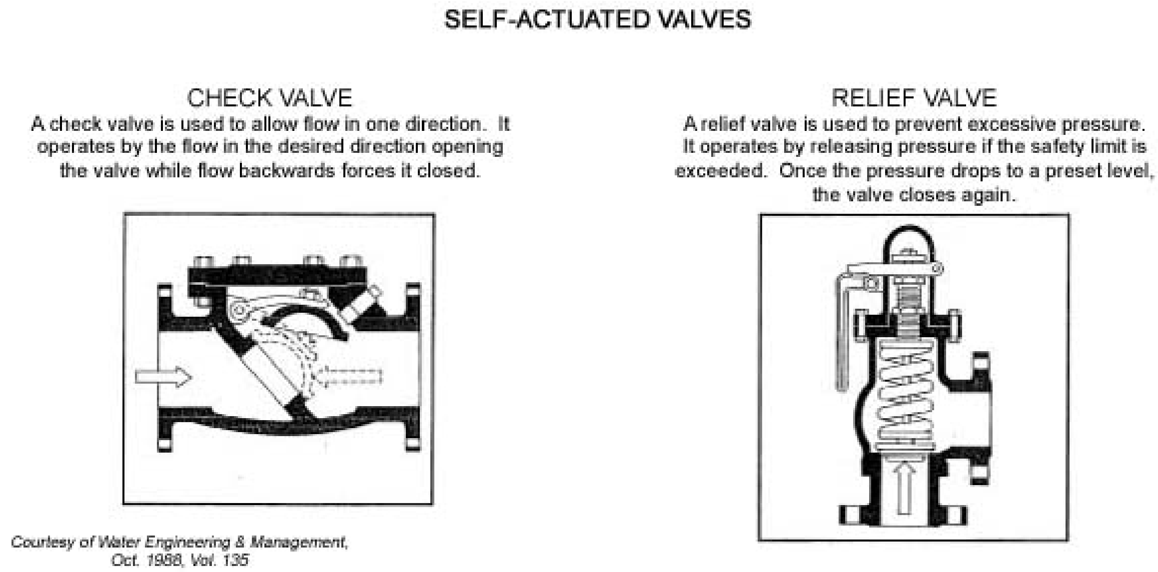
BUTTERFLY VALVE

A butterfly valve is used for on-off and good for throttling applications. A butterfly valve regulates flow by turning a circular disk or vane. When open to allow for full flow, the vane is directly parallel to the flow. when closed, the vane is perpendicular to block the flow.



Courtesy of Water Engineering & Managment, Oct. 1988, Vol 135

Figure 3.8.2.3



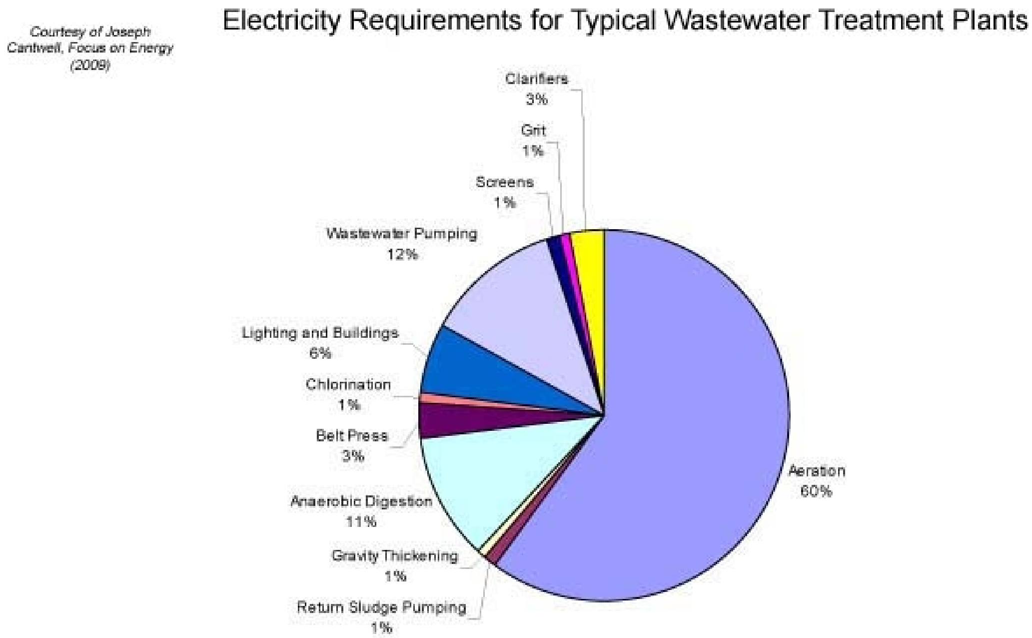
3.8.3 Describe wastewater treatment plant back-up power sources.

During power outages, treatment plants have generators to provide power to some or all of the plant. Generators are run by fuels. Back-up generators should be routinely operated to ensure their reliable operation during an actual emergency.

3.8.4 Discuss energy usage in a wastewater treatment plant.

The aeration system of a wastewater treatment plant uses the largest percentage (60%+) of the energy in the treatment process. Wastewater pumping is another large energy user (12%) at a wastewater plant. Energy usage can be reduced with cost savings by having energy-efficient aeration systems, blowers, motors, and pumps.

Figure 3.8.4.1



3.8.5 Describe aeration equipment used in a wastewater treatment plant.

A. Blowers

Blowers provide the air that is pumped through diffusers.

1. Centrifugal: A blower consisting of an impeller fixed on a rotating shaft and enclosed in a casing having an inlet and a discharge connection.

2. Positive Displacement: A positive displacement (PD) blower forces air to move by trapping a fixed amount, then displacing that trapped volume into the discharge pipe.

B. Diffusers

1. Fine Bubble: A device through which air is pumped and divided into very small bubbles that are used to introduce and dissolve oxygen into the liquid. Fine bubble diffusers are normally disks or tubes that use membranes or ceramic materials to create the bubbles and gentle mixing action.

2. Coarse Bubble: A device through which air is pumped and divided into large bubbles that are transferred and dissolved into the liquid. Coarse bubble diffusers normally discharge air at a high rate and are installed to induce a spiral or cross roll mixing pattern.

C. Mechanical Aerators

The most common types of mechanical aerators utilize paddles or discs and spray or turbine mechanisms. By agitating the wastewater, air from the environment is introduced.

3.8.6 Describe instrumentation and controls used in a wastewater treatment plant.

A. Process Probes and Analyzers

Process probes, such as pH, total suspended solids (TSS), dissolved oxygen, turbidity, and temperature, are used throughout the treatment plant. Usually they are wired to an analyzer that sends data to a computer.

B. Supervisory Control and Data Acquisition (SCADA)
SCADA is a computer program that is used solely for gathering the plant's operational data. The program shows different parts of the plant and what is happening in real time. An operator can see flows, dissolved oxygen levels, blowers, pumps, tank levels, probe readings, and other operational data. The data is stored within the program.

C. Programmable Logic Controller (PLC)
A PLC is a programmable electronic device that has inputs and outputs and is usually found in a control panel. For example a PLC could turn a pump on and off, controlling the liquid level of a tank. An operator would program the PLC with set points to define the levels that the pump turns on and off.

D. Flow Meters
Flow meters are used to measure the flow of liquids. Some areas of measurement include: influent, effluent, recycle streams, sludge pumping, septic stations, lift stations, and chemical feed systems. Flow meters are usually wired to a SCADA system that displays and stores flow data.

E. Alarms
Alarms notify operators of operational problems and emergencies. Alarms could be during the working day or programmed to notify operators after hours. An alarm could be a high or low water level, a high or low dissolved oxygen level in the aeration process, a malfuctioning pump, a high temperature reading on a pump, a problem at a lift station, or many other things.

Section 3.9 - Treatment Plant and Equipment Maintenance

3.9.1 Discuss the importance of having a WWTP preventative maintenance program.

A. Minimize unanticipated breakdowns or emergency maintenance
B. Maximize operational consistent performance
C. Long-term cost savings
D. Prevent violations
E. Energy efficiencies

3.9.2 Describe a preventative maintenance system for wastewater treatment plant equipment.

A. Inventory and label all equipment
B. Use Operation and Maintenance Manuals for preventative maintenance tasks and frequencies
C. Establish a preventative maintenance record keeping system for maintenance schedules and history of repairs/maintenance for each piece of equipment
D. Establish a follow-up system to ensure maintenance is performed
E. Have a spare parts inventory

3.9.3 Explain how to prevent grease and grit build-up in lift station wetwells.

A preventative measure would be to control grease and grit at its source. This means having stringent pretreatment requirements in the sewer use ordinance and through a grease control program. Monitor commercial and industrial sources to ensure good maintenance is performed on grease traps, oil separators, and any solids removal system.

3.9.4 Develop a routine lubrication maintenance schedule for all wastewater treatment plant equipment.

Lubrication is one of the most important preventative maintenance tasks at a wastewater treatment plant. The O&M manual specifies the type of lubricants and the frequencies of lubrication for each piece of equipment.

3.9.5 List common critical maintenance tasks for pumps.

A. Lubrication
B. Amperage checks
C. Packing if leaking
D. Flushing water seals
E. Check for clogging

Follow the O&M manual for all specific maintenance tasks.

3.9.6 List common critical maintenance tasks for valves.

A. Exercise
B. Check for clogs (check valves)

Follow the O&M manual for all specific maintenance tasks.

3.9.7 List common critical maintenance tasks for motors.

A. Grease
B. Temperature check
C. Amperage check
D. Inspect for noise and vibration

Follow the O&M manual for all specific maintenance tasks.

3.9.8 List the informational content of an WWTP O&M manual.

The Wisconsin Department of Natural Resources requires the following topics in a treatment plant O&M manual:

A. General Information
B. Staffing
C. Records System
D. Laboratory
E. Safety
F. Security and Emergencies
G. Utilities and Electrical Systems
H. Appendices
I. Process Description, Operation and Control (Liquid and Solids)

J. Sludge Management
K. Maintenance
L. Recommended Reference Materials (Manuals, Books, Codes)

Chapter 4 - Biosolids/Sludge - Processing, Handling, and Land Application

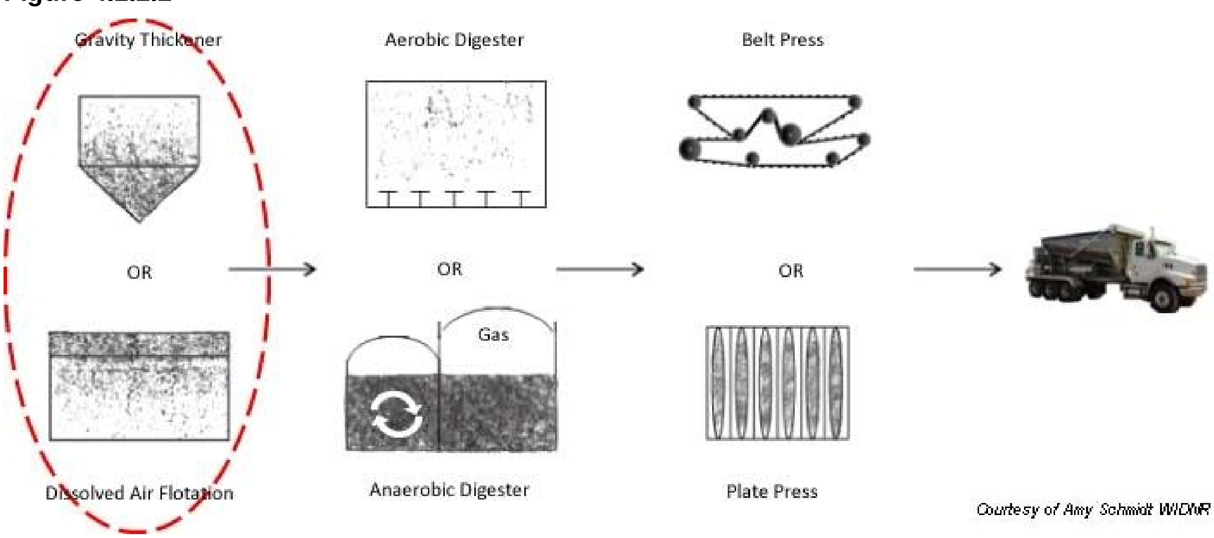
Section 4.1 - Thickening

4.1.1 Discuss the thickening of biosolids/sludges.

The purpose of sludge thickening is to further concentrate and thicken solids settled and wasted from treatment plant processes. In the treatment of wastewater, solids from the primary and secondary treatment processes can range from 1,000 to 10,000 mg/L suspended solids. Sludge thickening further concentrates these solids from 10,000 to 30,000 mg/L to allow for further handling and processing.

Sludge thickening most commonly consists of gravity thickeners (settling tanks) or dissolved air flotation. A polymer can be added and used to enhance thickening. Plants with aerobic digesters simply thicken their sludge by turning off the air for a short time, allow the sludge to settle, and thicken by decanting the clear liquid off the tank. Sludge drying beds can be used to thicken and store solids but are not as commonly used as they once were because of handling/odor issues and space limitations at a treatment plant site.

Figure 4.1.1.1



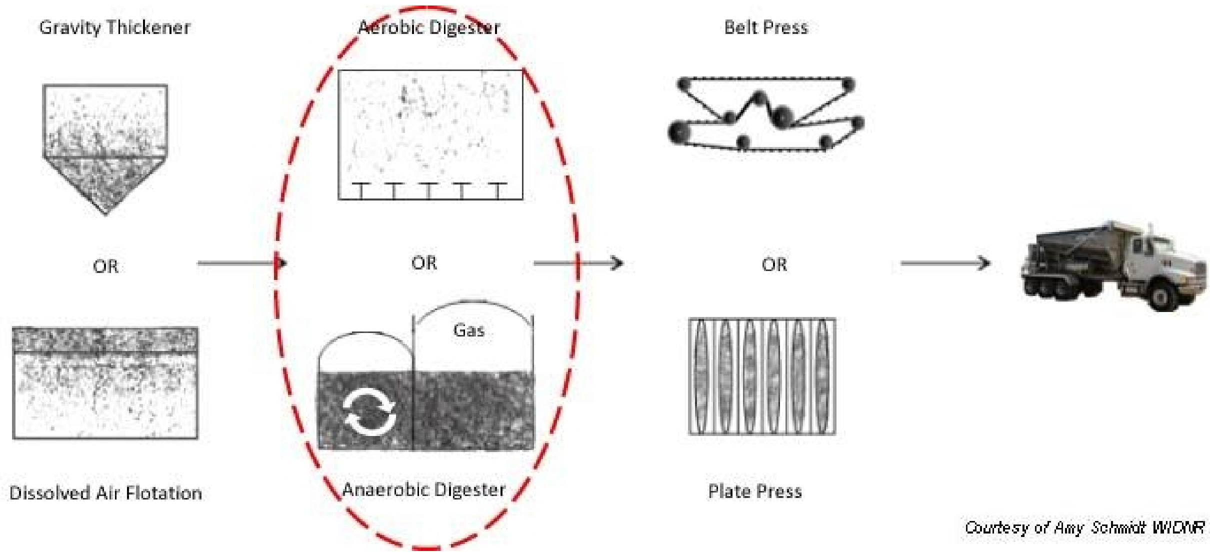
Section 4.2 - Treatment

4.2.1 Discuss the treatment of biosolids/sludges.

The purpose of sludge treatment, sometimes also referred to as sludge stabilization, is to reduce the pathogens (fecal coliforms) in the sludge and the attraction of vectors (flies, mosquitos, vermin, birds, etc.) that transmit diseases. Wisconsin DNR establishes pathogen control and vector attraction reduction criteria in WPDES permits that must be met before the sludge can be landspread.

Sludge treatment most commonly consists of aerobic or anaerobic digesters. Digesters utilize bacteria in the treatment of the sludge. Heat and chemicals can be used to treat sludges.

Figure 4.2.1.1



4.2.2 Describe how aerobic digesters work.

Aerobic digesters utilize microorganisms and oxygen to digest the remaining organic material in wasted sludge from the primary and secondary treatment processes. The detention time in a aerobic digester is sufficiently long to allow for most of organic material to be consumed resulting in a stabilized sludge. Aerobic digesters are similar to the activated sludge process except well digested, stabilized sludge in the tanks is thicker and darker.

4.2.3 Describe how anaerobic digesters work.

Anaerobic digesters utilize microorganisms without oxygen to digest the remaining organic material in wasted sludge from the primary and secondary treatment processes. Anaerobic digesters are heated and covered. The process generates methane gas, that can be recovered and used as an energy source in the treatment plant.

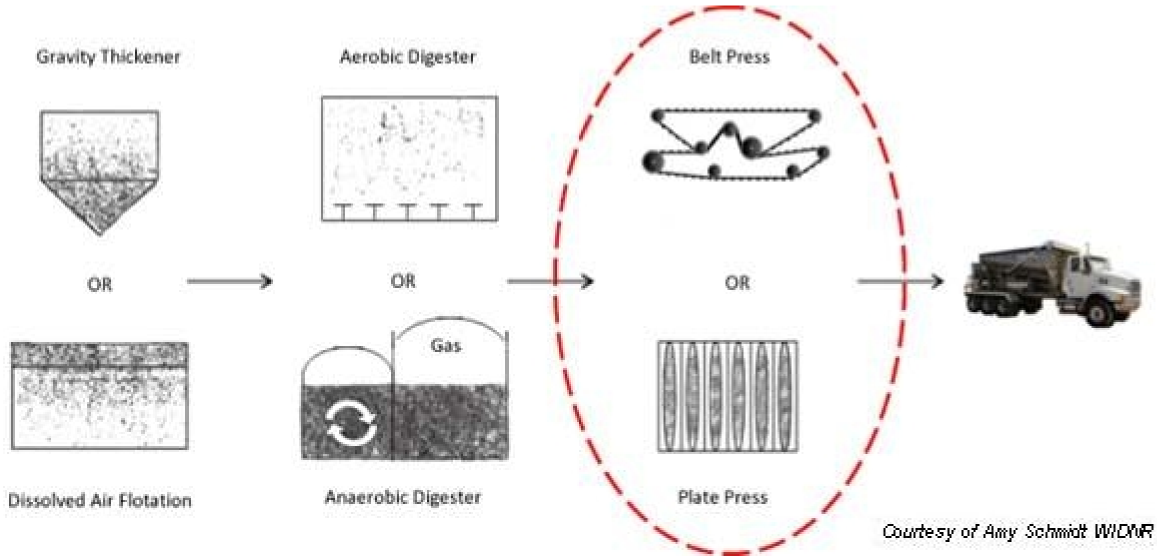
Section 4.3 - Dewatering

4.3.1 Discuss the dewatering of biosolids/sludges.

The purpose of dewatering biosolids and sludges is to significantly concentrate the solids and reduce the liquid content of the sludge. Dewatering reduces the sludge volume that has to be stored, transported, and landspread thus reducing storage and hauling volume. Large treatment plants that generate large liquid volumes of sludge often use some type of sludge dewatering.

Sludge dewatering is done mechanically and most often consists of presses (belt or plates), vacuum filters, and centrifuges. Sludge can also be dewatered in sludge drying beds, reed beds, and other ways. Dewatered sludges are typically 15-30% solids and referred to as cake sludge. Cake sludge handling, transport, and land application is different than liquid sludge. Dewatered sludge is drier, thicker, and more solid and thus can be shoveled, moved using belt conveyors and transported in dump trucks rather than pumper trucks.

Figure 4.3.1.1

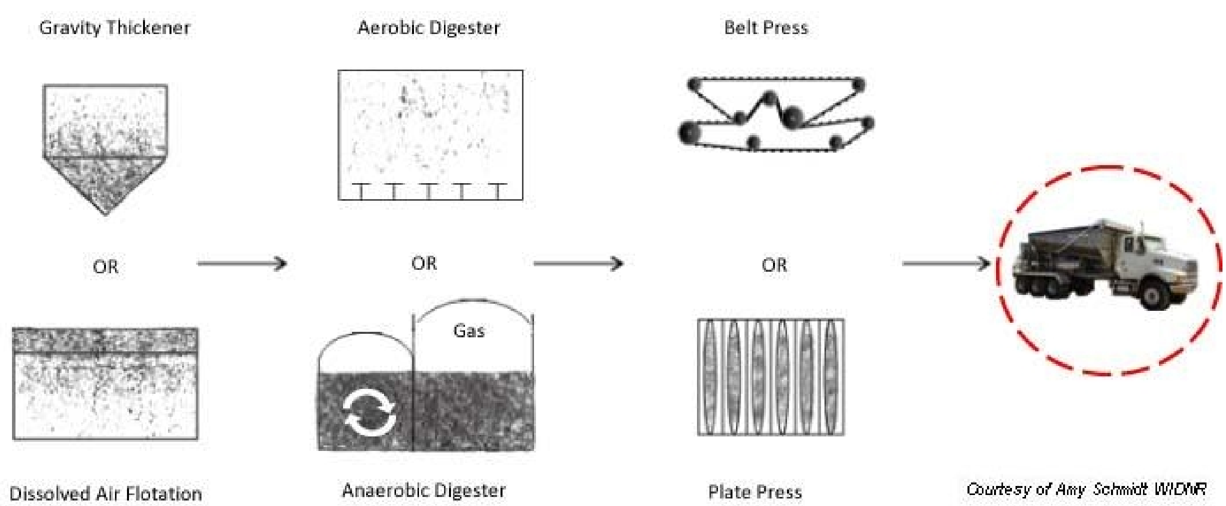


Section 4.4 - Land Application

4.4.1 List the common methods of sludge disposal.

Federal and state regulations establish two levels of quality for municipal biosolids for final use or disposal. Class A biosolids receive a very high degree of treatment and can thus be used by the public in parks, gardens and golf courses. Some biosolids are used in composting programs. Class B biosolids do not meet all the criteria of a Class A sludge and thus are land applied on agricultural lands or disposed of in a landfill. Land application is the most common method of sludge reuse in Wisconsin.

Figure 4.4.1.1



4.4.2 List the two Wisconsin Administrative Codes regulating municipal and industrial sludge.

A. NR 204 Domestic sewage sludge management

B. NR 214 Land treatment of industrial liquid wastes, by-product solids and sludges

Section 4.5 - Sampling and Reporting

4.5.1 Discuss sludge sampling and reporting prior to their reuse or disposal.

Municipal sludge regulations require that sludge meet certain criteria before they can be re-used as a Class A or Class B sludge. Industrial sludges must also meet certain criteria. The main parameters analyzed prior to the land application of a Class B sludge are:

A. Nutrients (Nitrogen and Phosphorus)
Nitrogen and Phosphorus should be added to the cropland at the proper amount for the crop being grown (the agronomic rate). If more nutrients are added than the crop will use, the excess may seep down into the groundwater or run-off into rivers and streams.

B. Metals
Metals can be toxic and thus limits are set for their safe application on agricultural lands.

C. Pathogen Densities
Fecal coliform bacteria must be below certain limits before the sludge can be landspread.

D. Vector Attraction Reduction
Sludge must be treated and stabilized to below an acceptable level so that when land applied, it does not attract flies, mosquitos, vermin, and birds that can carry and transmit diseases.

4.5.2 Discuss the records an operator must keep when hauling and landspreading sludge.

A treatment plant operator has to maintain a daily application log for biosolids land applied each day when land application occurs. The following minimum records must be kept, in addition to all analytical results for the biosolids land applied.

The daily log must include the following information:

A. Approved site used
B. Number of acres of sludge applied on that day
C. Amount of sludge applied that day and amount per acre
D. Amount of nitrogen applied per acre
E. Method of application of the sludge (injection, incorporation, or surface application)

Chapter 5 - Effluent Discharge

Section 5.1 - Flow Monitoring

5.1.1 Explain effluent flow measurement.

Effluent flow measurement is WPDES permit required at all wastewater treatment facilities for measuring flows to the receiving water. It also is used for the operation of effluent flow proportional composite samplers and for the pacing of chemical addition equipment. Effluent flow measurement equipment should be close to the end of the wastewater treatment plant. Wastewater treatment facilities are typically equipped with an open-channel flow measurement structure, which is fitted with a (primary) V-notch weir, or Parshall flume. See key knowledge 2.4.2 for more information on these flow measurement devices.

5.1.2 Describe how daily flow measurements are recorded.

For Discharge Monitoring Reports (DMRs), the day in which most of the flow is received is the date the flow should be recorded. For example, influent wastewater flow entering the plant is recorded and totaled from 7:00 am, July 14 to 7:00 am, July 15. The total flow read the morning of July 15 is 475,000 gallons. The operator would report this flow as the flow for July 14. Flows should be recorded at about the same time each day. Flows are most commonly reported on DMRs in million gallons per day (MGD). In the example above, the flow would be recorded as 0.475 MGD.

Section 5.2 - Sampling

5.2.1 Describe a good sampling location and procedure for collecting representative effluent wastewater samples.

It is very important that the final effluent discharged from a wastewater treatment plant be sampled in a location where it is well mixed and represents the actual water being discharged to the receiving water. The sample should be collected using a flow-proportional composite sampler. Sample strainers or tubes should not lay on the bottom of a channel (where some solids may accumulate) or against any tank wall or in a corner (which may be a stagnant zone). They should be suspended a foot or two below the water surface that has been well mixed or in a channel where it is mixed well, such as just before entering a flume or exiting a weir. The sampling strainer should be checked and cleaned regularly.

Often an effluent sample is collected just prior to disinfection so that the sample does not have to be seeded in the BOD test. If the sample is collected after disinfection, the BOD sample will have to be "seeded" with a very small amount of the supernatant of settled influent to reintroduce microorganisms to the BOD bottle.

5.2.2 List the information that must be recorded for effluent wastewater samples.

Automatic composite samplers must be refrigerated and maintained at a temperature of 0-6ºC (centigrade) at all times. A thermometer immersed in a small capped bottle of liquid is usually kept in the sampler to check and record temperatures. A 24-hour flow-proportional composite sample is the common requirement. For Discharge Monitoring Reporting (DMR), the day on which most of the composite sample was taken is the date of the sample. A sampling log must be maintained at the automatic composite sampler and the following information recorded.

A. Sample identification
B. Date started
C. Time started
D. Date collected
E. Time collected

F. Sampler temperature
G. Operator initials
H. Comments

5.2.3 Discuss the water pollution concerns related to the discharge of insufficiently treated wastewater.

The discharge of insufficiently treated wastewater can affect fish and aquatic life in the receiving water course. These biological organisms are dependent on sufficient dissolved oxygen to live and the oxygen demand of the effluent can reduce or use up the oxygen present. Other concerns from wastewater discharges would include: toxics, deposition of suspended solids, and excessive growth of aquatic plants from the nutrients in the discharge.

Section 5.3 - Permitting and Reporting

5.3.1 Describe how water quality standards and limits are established in WPDES permits.

Some effluent limitations listed in a WPDES permit are derived from water quality based standards which vary depending on the receiving water. These limits are set to protect the water quality of the receiving water.

Other limits found in a WPDES permit are established based on the type of wastewater treatment plant processes and the amount of treatment they are technologically able to provide.

5.3.2 Define Discharge Monitoring Reports (DMRs)

A Discharge Monitoring Report is an electronic submittal required by DNR, which includes routine monitoring data from a wastewater facility primarily to determine compliance with permit limits. The monitored parameters and frequencies are outlined in the facility's WPDES permit.

5.3.3 Describe other reports required in WPDES permits submitted to the DNR.

In addition to the DMR, there are several other required reports listed in the WPDES permit. These include: the Compliance Maintenance Annual Report (CMAR), Whole Effluent Toxicity (WET), General Sludge Management, Sludge Characteristics, and Land Application reports. Compliance schedules in a WPDES permit may require other reports.

5.3.4 Discuss certifications needed at a wastewater treatment plant.

A. Operator Certification
Each wastewater treatment facility must have an operator-in-charge (OIC). The operator-in-charge must be a WIDNR certified operator. Different size plants and different types of treatments determines the type of operator certification required for that plant.

B. Lab Registration/Certification
Wisconsin state law requires that sampling and testing shall be performed by a Certified or Registered lab. A Registered lab runs tests for only their plant. A Certified lab generally performs tests for any treatment plant.

Chapter 6 - Safety and Regulations

Section 6.1 - Personal Safety

6.1.1 Identify prevalent diseases that can be contracted through wastewater exposure.

Gastroenteritis
Dysentery
Hepatitis
Giardiasis
Upper respiratory illnesses

6.1.2 Identify potential toxic gases at a wastewater treatment plant.

Hydrogen Sulfide
Methane
Carbon Monoxide
Chlorine

6.1.3 Define Personal Protective Equipment (PPE).

Protective clothing and other devices designed to protect an individual while in potentially hazardous areas or performing potentially hazardous operations. Examples of PPE include: gloves, hard hat, steel toed boots, safety glasses, and appropriate clothing.

6.1.4 Describe a potential safety hazard with anaerobic digesters.

A potential safety hazard with anaerobic digesters is the possibility of an explosive atmosphere being formed. If air is mixed with the methane gas from the digestion process, either in the digester or from any methane gas leak, any spark could cause a severe explosion.

6.1.5 Discuss precautions for entering treatment tanks or vessels.

Owners of wastewater treatment facilities should clearly define all confined spaces. Operators should know them and follow all confined space entry procedures.

6.1.6 Describe the applicable safety program and requirements municipal wastewater treatment plants must follow.

Wisconsin Department of Commerce Adm. Code Chapter Comm 32- Public Employee Safety and Health must be followed. Some of the important safety requirements are: confined space, excavation, hearing conservation, bloodborne pathogens, CPR- First Aid, MSDS, electrical, fall protection, hazardous materials, as well as others. Non-public entities follow OSHA CFR 29 part 1910.

Section 6.2 - Chemical

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

Some chemicals used in wastewater treatment plants are hazardous materials and must be identified. Material Safety Data Sheets for them are required to be kept on-site and readily available. In the event of a spill, WIDNR must be contacted.

6.2.2 Discuss what should be done in the event of a chemical spill.

Any spill of hazardous material should be reported to WIDNR within 24 hours and to the local emergency response agencies.

Chapter 7 - Calculations

Section 7.1 - Flow Conversions and Flow Rate

7.1.1 Given a flow rate in gallons per day (gpd), convert the flow rate to million gallons per day (MGD).

GIVEN:
Flow rate = 600,000 gpd

FORMULA & SOLUTION:
Flow rate (MGD) = flow rate (gpd) ÷ 1,000,000

= 600,000 gpd ÷ 1,000,000
= 0.600 MGD

7.1.2 Given a flow rate in gallons per minute (gpm), convert the flow rate to million gallons per day (MGD).

GIVEN:
Flow rate = 500 gpm
1 day = 1440 minutes

FORMULA & SOLUTION:
Flow rate (MGD) = [flow rate (gpm) × 1440 min/day] ÷ 1,000,000

= [500 gpm × 1440 min/day] ÷ 1,000,000
= 0.720 MGD

Section 7.2 - Tank Areas/Volumes

7.2.1 Given the dimensions of a rectangular basin, calculate the volume in gallons.

GIVEN:
Length = 60 feet
Width = 20 feet
Depth = 10 feet
1 cubic foot = 7.48 gallons

FORMULA & SOLUTION:
Basin volume (gal) = [length (ft) × width (ft) × depth (ft)] × 7.48 gal/cu. ft
= [60 ft × 20 ft × 10 ft] × 7.48 gal/cu. ft
= 89,760 gallons

7.2.2 Given the dimensions of a circular basin, calculate the volume in gallons.

GIVEN:
Diameter = 30 feet
Depth = 10 feet
1 cubic foot = 7.48 gallons

FORMULA & SOLUTION:
Basin volume (gal) = [3.14 × (radius squared (ft)) × depth (ft)] × 7.48 gal/cu. ft
= [3.14 × (15 ft × 15 ft) × 10 ft] × 7.48 gal/cu. ft
= 52,846 gallons

Section 7.3 - Pounds Formula

7.3.1 The "pounds formula" is one of the most commonly used formulas by operators. Given data, convert a pollutant concentration and flow to pounds per day.

GIVEN:
Influent BOD = 200 mg/L
Flow = 1.0 MGD
1 gallon = 8.34 pounds

FORMULA & SOLUTION:
Influent BOD (lbs/day) = influent flow (MGD) x influent BOD (mg/L) x 8.34 lbs/gal

= 200 mg/L × 1.0 MGD × 8.34 lbs/gal
= 1668 lbs/day

Section 7.4 - Pump Rate

7.4.1 Given the dimensions of a rectangular sewage wetwell, calculate the pump rate in gallons per minute (gpm) for the given pumping draw-down. Assume influent flow is shut-off.

GIVEN:
Wetwell length = 16 feet
Wetwell width = 13 feet
Pumping drawdown = 1.75 feet
Pumping time = 6 minutes
1 cubic foot = 7.48 gallons

FORMULA & SOLUTION:
Pump rate (gpm) = [length (ft) × width (ft) × drawdown (ft) × 7.48 gal/cu.ft] ÷ pumping time (min)

= [16 ft × 13 ft × 1.75 ft × 7.48 gal/cu.ft] ÷ 6 min
= 454 gpm

7.4.2 Given the dimensions of a circular sewage wetwell, calculate the pump rate in gallons per minute (gpm) for the given pumping drawdown. Assume influent flow is shut-off.

GIVEN:
Wetwell diameter = 8 feet

Pumping drawdown = 4.25 feet
Pumping time = 5 minutes
1 cubic foot = 7.48 gallons

FORMULA & SOLUTION:
Pump rate (gpm) = [3.14 × (radius squared (ft)) × drawdown (ft) × 7.48 gal/cu.ft] ÷ pumping time (min)

= [3.14 × (4 ft × 4 ft) × 4.25 ft × 7.48 gal/cu.ft] ÷ 5 min
= 319 gpm

Section 7.5 - Detention Time

7.5.1 Given data, calculate the detention time (in hours) for a clarifier.

GIVEN:
Volume of clarifier = 95,000 gallons
Flow rate = 540,000 gpd

FORMULAS & SOLUTION:
Gallons per hour = flow rate (gpd) ÷ 24 hour/day
= 540,000 gpd ÷ 24 hr/day
= 22,500 gal/hr

Detention time (hours) = volume (gal) ÷ flow (gal/hr)
= 95,000 gal ÷ 22,500 gal/hr
= 4.22 hours

Section 7.6 - Percent Removal

7.6.1 Given data, calculate the percent (%) removal of BOD in a wastewater treatment plant.

WPDES permits require that treatment plants remove at least 85% of the influent BOD and suspended solids. The intent of this permit condition is to ensure that "the solution to pollution is not dilution."

GIVEN:
BOD (influent) = 250 mg/L
BOD (effluent) = 10 mg/L

FORMULA & SOLUTION:
Percent (%) removal = [(influent BOD (mg/L) - effluent BOD (mg/L)) ÷ influent BOD (mg/L)] × 100
= [(250 mg/L - 10 mg/L) ÷ 250 mg/L] × 100
= (240 mg/L ÷ 250 mg/L) × 100
= 96%

References and Resources

1. **OPERATION OF MUNICIPAL WASTEWATER TREATMENT PLANTS (2008)**

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2. **OPERATION OF WASTEWATER TREATMENT PLANTS – A FIELD STUDY TRAINING PROGRAM (2002)**

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   http://www.owp.csus.edu/ or available through inter-library loan at http://aqua.wisc.edu/waterlibrary

3. **ISCO OPEN CHANNEL FLOW MEASUREMENT HANDBOOK (2011)**

   6th EDITION. ISCO, INC. P.O. BOX 82531 LINCOLN, NE. iscoinfo@teledyne.com

   www.isco.com/flowbook

4. **A DROP OF KNOWLEDGE - THE NON-OPERATOR'S GUIDE TO WASTEWATER SYSTEMS (2011)**

   RURAL COMMUNITY ASSISTANCE PARTNERSHIP, INC.

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