# Class A Training Manual

For the Ohio Wastewater Treatment Certification Exam

Division of Surface Water
Compliance Assistance Unit
March 2015

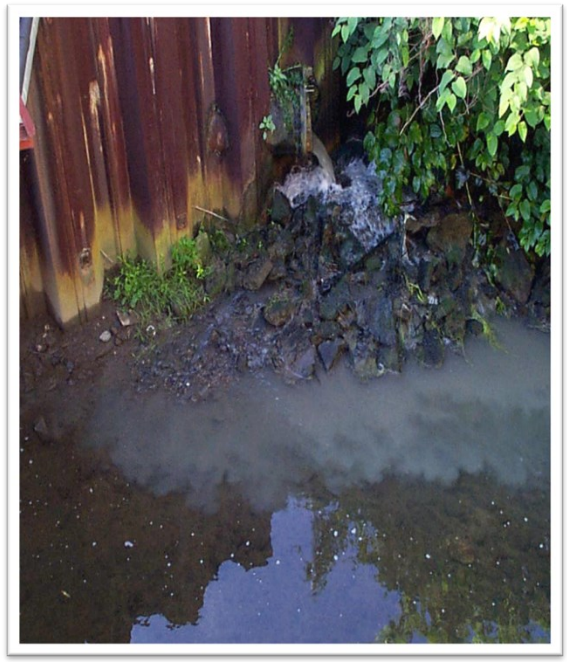
# Table of Contents

# Introduction

The main focus of this training document is to assist you in becoming proficient in the operation and maintenance of a small wastewater treatment system. Specifically this training material will focus on the effective operations and maintenance of the extended aeration activated sludge treatment system commonly referred to as a "Package Plant".

The concepts and information presented in this training material have been identified by other successful certified operators of package treatment systems as critical in producing clean water acceptable for discharge into your local waterways; your environment.

This training document is designed to explain the concepts that were identified by those wastewater experts operating in the field and should be useful in guiding you in the proper operation and maintenance of your package plant. As you become more knowledgeable in the treatment of wastewater, you also become better prepared for successfully obtaining your wastewater certification. This material should be useful in your preparation for the Ohio EPA's Class "A" Wastewater certification examination. While this information will encompass many of the basic concepts for proper operation of your package plant, it should not be the only source of training material that you explore.



Maintaining a wastewater treatment system to provide the highest quality effluent being discharged to Ohio's receiving streams is an important responsibility. As a certified wastewater operator in the state of Ohio, you will be the front line of defense protecting your local water resource.

The Ohio EPA is responsible for the protection of the state's water quality. Direct dischargers into Ohio's receiving streams and lakes can significantly impact environmental quality. This requires the state to monitor each discharger to ensure water quality is maintained or improved. Discharges from even small wastewater treatment systems can significantly impact the water quality in Ohio.

The Ohio EPA requires the operator in responsible charge of these small treatment systems, to be certified. This certified operator, through an examination procedure, has demonstrated a level of competency in the proper operation of a treatment system. This is one of many steps the Ohio EPA uses to ensure protection of the receiving waters from dischargers.

So who determines what concepts are critical to producing a quality effluent? Competent operators do. Operators of treatment systems which have demonstrated high quality effluent were gathered together and asked a simple question. What do you do? What are the duties you perform on a routine basis that results in the high quality of your effluent? We next asked, "Of theses duties, how often do you perform this duty?", and, "How critical is this duty in achieving compliance with your discharge requirements?"

The data collected from this process was used to first, determine the content of this training material and second, used to determine the composition of the Class "A" wastewater examination.

Competent operators have identified critical concepts necessary for proper operation of a wastewater treatment system. These same concepts are presented in this training material and will also be the focus of the Class "A" wastewater examination.

**Wastewater Operator Duties**

Compliance:

Major effect on a long term repetitive basis.
Minimum effect on a routine basis or major effect on a periodic basis
Minor effect on compliance
No effect on maintaining compliance

| | Frequency | | | | | | Compliance | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wastewater Operator Duties | Daily | Weekly | Monthly | Annually | Once every 5 years | Never performed | Major effect | Minimum effect | Minor effect | No effect |
| A- 1 Perform visual walk through analysis | | | | | | | | | | |
| A- 2 Record flow meter readings | | | | | | | | | | |
| A- 3 Collect grab samples | | | | | | | | | | |
| A- 4 Measure sample temperature | | | | | | | | | | |
| A- 5 Measure sample dissolved oxygen concentration | | | | | | | | | | |
| A- 6 Measure sample pH | | | | | | | | | | |
| A- 7 Record odor, color, and turbidity values | | | | | | | | | | |
| A- 8 Measure chlorine residual | | | | | | | | | | |
| A- 9 Collect fecal coliform sample | | | | | | | | | | |
| A-10 Set up composite sampler | | | | | | | | | | |
| A-11 Collect composite samples | | | | | | | | | | |

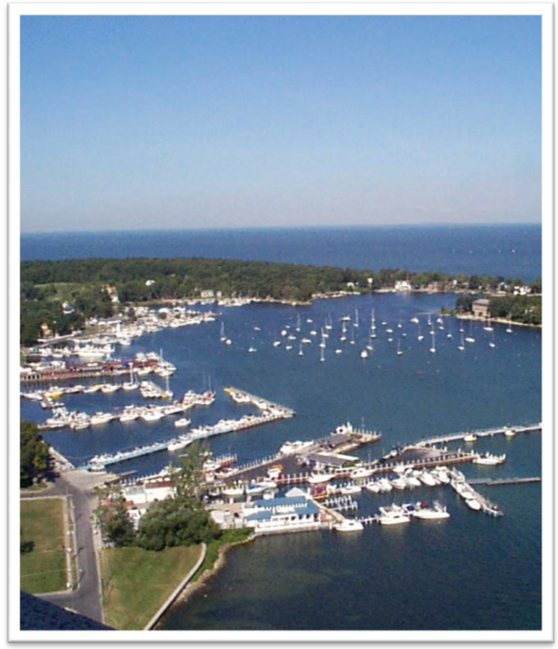
Select one column for **Frequency** and one column for **Compliance** for each **Duty** listed.

Because of the process used to assemble this training material, if reviewed and applied in the field, should provide direction in the operation of your treatment system to produce a high quality effluent, as well as, provide direction in becoming certified as a Class "A" wastewater operator.

This is not the only material you should rely on, nor does it guarantee successfully passing the certification examination, however, it does contain critical concepts to understand and build on.

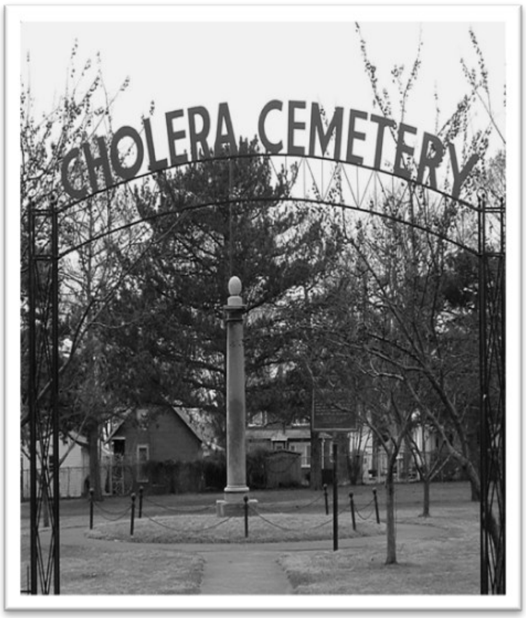
Why is it so important that we are diligent in producing the highest quality of effluent to the receiving stream? Another way of asking this is, . . . "What are the consequences of discharging pollutants into the receiving stream?"

One consequence is failure to operate the system properly and maintain compliance with the permit limits, which could eventually lead to enforcement action. The Ohio EPA's responsibility is to protect the water quality in Ohio for all of its citizens. If owners and operators fail to do their part, the Ohio EPA will use various forms of enforcement action to protect the environment.



Another consequence is degradation of one of Ohio's most valued resources. Ohioans enjoy the benefit of many sources of high quality water environments, from the great lakes to the Ohio River, and many other streams, rivers and reservoirs in between. As water quality decreases, so do the benefits we receive from these environments.

Not only is there damage to the environment, but it can also impact the health of the citizens of Ohio. Untreated waste or discharges from upset conditions within the treatment system can lead to public health issues.




This cemetery, located in Ohio, tells of a different time when we did not fully accept the responsibility of protecting our water resources.

Initially it was dedicated to the physicians and nurses who struggled to reduce the loss of life from this outbreak from untreated human waste. Many Ohioans lost their lives from our insufficient response in protecting the public's health. Today, this monument stands as a constant reminder of the dangers when we view wastewater treatment as a job, and not as a responsibility.

Although they are significantly fewer, even today, events can still occur which could affect our health and the environment. The Ohio EPA works diligently to bring enforcement action against owners and operators who neglect their responsibility of protecting our water resources.

The Ohio EPA would prefer to work alongside owners and operators to assist in prevention of these events. Together we can protect this resource.

As we experienced these tragic events we gained wisdom and began to work diligently to protect Ohio's waters so that future generations will also have access to clean water.

As an owner or operator of a wastewater treatment system you are the first line of defense in its protection. The Ohio EPA is here to assist you and to prevent others from abusing it.

Previous generations were unaware of their impact on the environment and the public's health. This training document was developed to provide the knowledge and tools to assist you in continuing the protection of our state's finest resource.

We offer this training as a first step in assisting you in our responsibility. Together we can protect Ohio's water resources for our benefit and for future generations.

## Basic Treatment Units

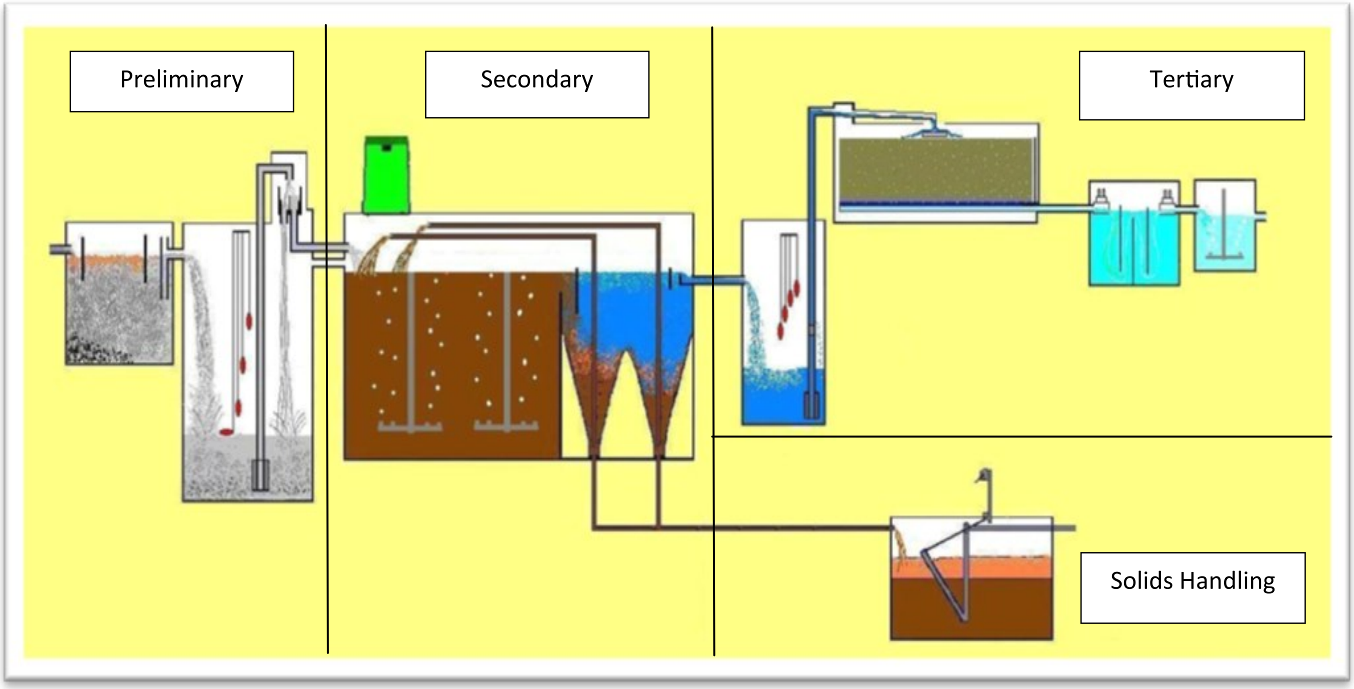
A wastewater treatment system is classified as a Class A if it receives 25,000 gallons per day or less. These smaller treatment systems use the same method of wastewater treatment (activated sludge) as large municipalities. The basic treatment processes and concepts apply at both systems, but at much lower flows.

These treatment systems consist of multiple units working together to remove the pollutants from the wastewater, so the final discharge will be safe and acceptable for maintaining the water quality in the receiving stream or lake.

Each package plant is designed around basic physical, biological and chemical processes to treat the wastewater. Because of various designs, the system takes on various "looks". However, they all perform the same principles and concepts.

This discussion of the basic treatment units will identify each unit and how each unit is designed to function, so that if your system "looks" slightly different, you will have a strong foundation to understand your treatment system.

If we could view a typical package plant from the side, it would look similar to the profile below. The treatment system consists of four stages of treatment; preliminary, secondary, tertiary and



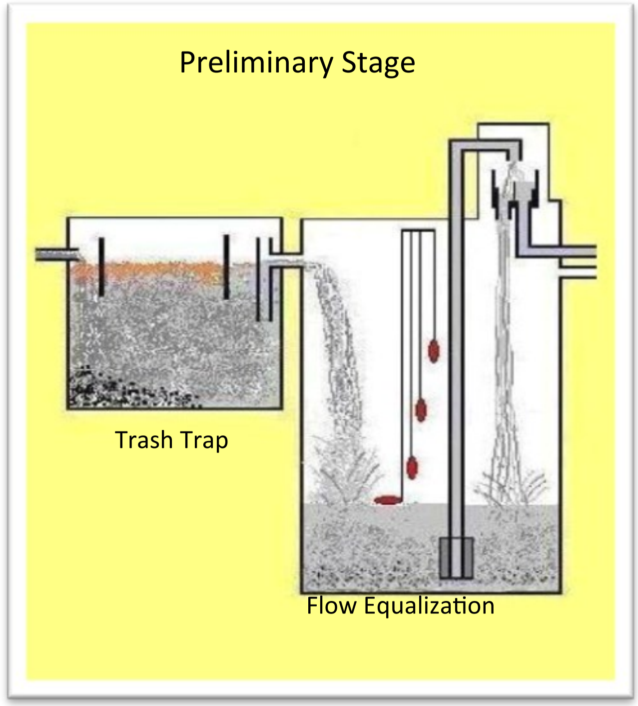

solids handling. Within each stage are individual units which perform a specific function in the removal of pollutants from the water by physical, biological or chemical processes. This training document will look at each of the individual treatment units and their specific function, and their combined contribution to the overall goal of each stage.

## Preliminary Stage

Raw wastewater first enters the treatment system through the preliminary stage. The preliminary stage consists of a trash trap and a flow equalization tank.

The trash trap removes inert or non-biodegradable pollutants; sand, gravel, grit, plastic and paper products. The trash trap is also effective in removal of grease, which is commonly associated with domestic wastewater.

The flow equalization tank, commonly referred to as flow EQ, provides a means to regulate flow to prevent hydraulic overloading of the remaining units beyond their intended flow rates. Both of these units use a "physical" process.

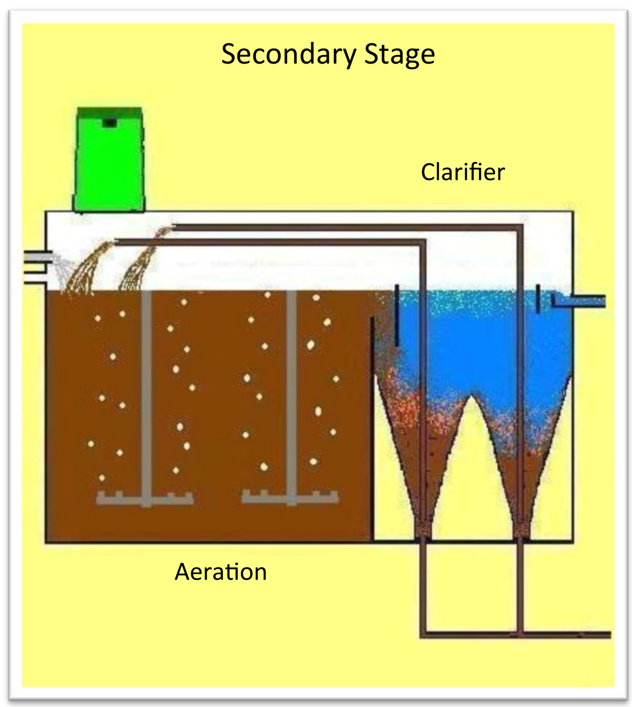



## Secondary Stage

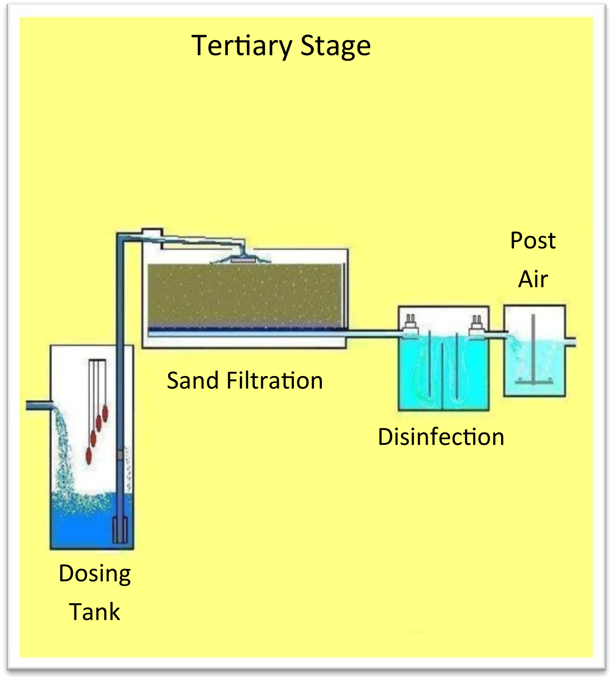
The pollutants remaining after the preliminary stage are typically dissolved and suspended solids in the wastewater. The secondary stage is designed specifically for removal of these types of pollutants. The secondary stage uses a two-step process for the removal of these dissolved and suspended solids.

The first treatment unit in the secondary stage is the aeration tank. The aeration tank contains a high concentration of bacteria that consume and convert these dissolved and suspended solids into more bacteria. After conversion of pollutants into bacteria, the bacteria are separated from the water in the clarifier.

The aeration tank is a "biological" process which converts waste into bacteria. The clarifier is a physical process, which allows the bacteria to separate, or settle out, resulting in a significantly improved water quality discharged from the secondary stage.



## Tertiary Stage



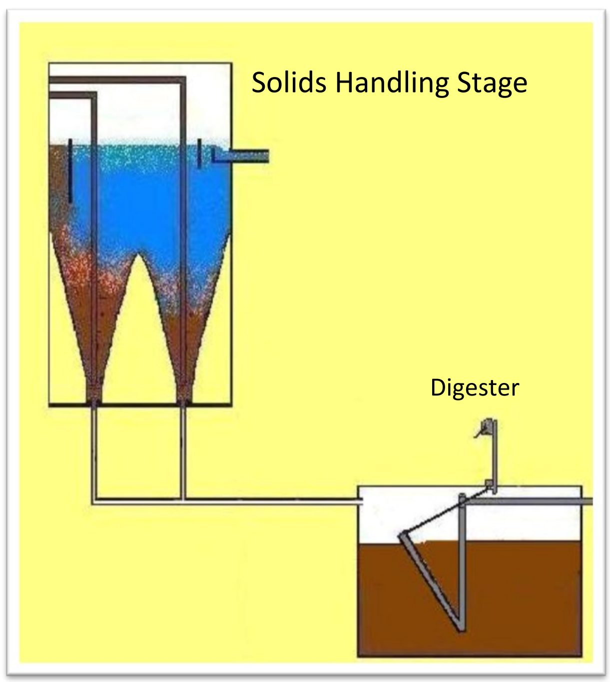

The final treatment stage before water is discharged to the receiving stream is the tertiary stage. The tertiary stage typically consists of a dosing tank to pump water to the top of the sand filter.

The water flows through the sand media for polishing to remove fine suspended solids and is collected in an underdrain system prior to discharging into the disinfection unit.

The water is then disinfected to reduce pathogens or disease causing organisms from entering the receiving stream. The final treatment unit of the tertiary stage is another aeration tank. This post aeration tank is used to increase the dissolved oxygen concentration of the final discharge.

The filtration and aeration units are "physical" processes. The disinfection unit can be either performed with a chemical (chlorine) or biological (uV light) process depending on the type of unit designed and installed.

## Solids Handling Stage




The last piece of the treatment process, the Solids Handling Stage, is not directly responsible for removal of pollutants from the wastewater.

In the secondary stage pollutants are converted to bacteria and then separated from the water in the clarifier. As pollutants continue to enter the treatment system more bacteria are produced. Eventually the concentration of bacteria in the secondary stage becomes too excessive and the treatment process will degrade if adjustments are not implemented. A balance of bacteria is required.

When the concentration of bacteria in the secondary stage becomes too excessive, bacteria are removed from the secondary stage and placed in the digester or sludge holding tank.

The digester or sludge holding tank use "physical" and "biological" processes in the storage and handling of these "solids" generated in the secondary process.

## The Treatment Process: Putting the pieces together

Each stage of treatment is designed for a specific purpose. The preliminary stage provides removal of inert settable solids (sand, gravel), non-biodegradable pollutants (plastic) and grease.

The secondary stage converts the remaining biodegradable pollutants into bacteria, which will settle out leaving behind fairly clean water.

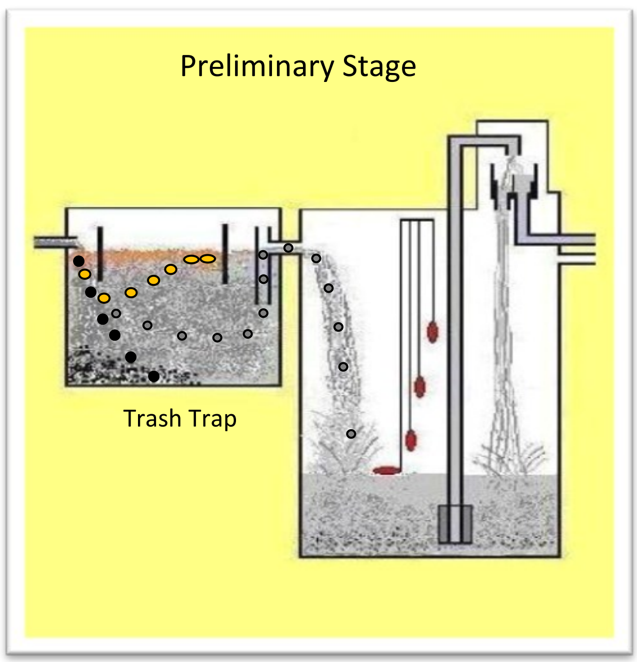
The tertiary stage provides a fine polishing of the water quality to insure protection of the water quality of the receiving stream.

The solids handling stage provides storage of excess bacteria to keep the biological process of the secondary stage under control.

Each stage must prepare the water for the next stage of treatment. Each stage is designed for a specific purpose in the treatment process. If any stage fails in performing its designed function then a waste load is passed on to a treatment stage in which it was not designed to remove. Units begin to fail and a domino effect occurs, which typically leads to major upsets and violation of effluent limits.

Understanding each unit and its design will allow you to identify when signs of failure start, so corrective actions can be implemented to bring the system back from the edge of non-compliance.

## Preliminary Stage: Trash Trap



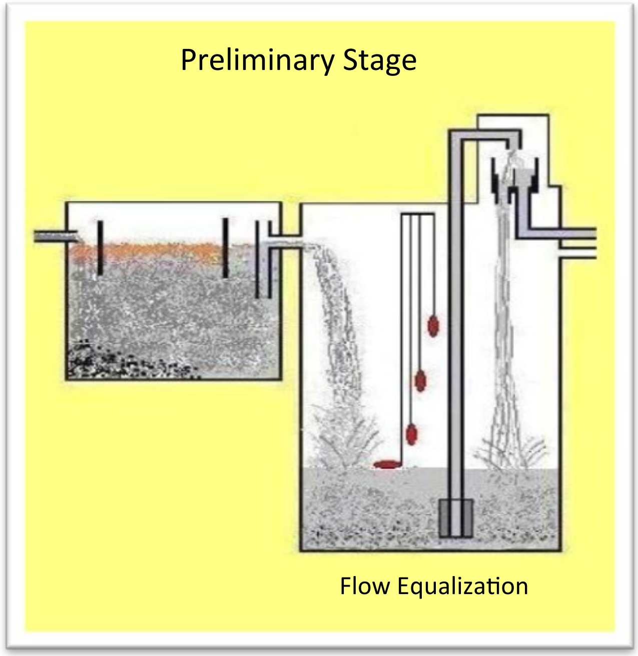

The first unit in the preliminary stage is the trash trap. The trash trap removes pollutants by use of "physical" principles. In general anything that will sink or float in the wastewater should be retained in the trash trap.

As wastewater flows into the trash trap, heavy solids will settle to the bottom of the tank. The trash trap is designed to allow heavy solids like sand, grit, and gravel to be captured so they do not accumulate in units downstream or cause damage to pumps.

The trash trap also uses the principle of floatation to remove other types of pollutants. As wastewater flows into the trash trap, grease, plastic and other materials that will float are retained on the surface in the trash trap between the two baffles located at the surface.

The remaining pollutants are mostly in the form of dissolved and suspended solids. These two forms of pollutants are specifically what the secondary stage is designed to remove. Ideally only dissolved and suspended pollutants pass through the trash trap into the flow equalization tank.

**Preliminary Stage: Flow Equalization**




The influent flow rate is mainly determined by the users connected to your treatment system. Because all flow into a wastewater plant is variable and not consistent, situations occur when the influent flow rate could exceed the treatment capacity of a downstream unit. As an operator of a treatment system, you have little control over the flows coming into the treatment system. However, with a flow equalization tank you gain some control of the flows through the system.

The flow EQ tank should contain at least two submersible pumps for lifting the wastewater into the splitter box located on top of the tank. The pumping sequence is established by the float switches located in the tank.

Typically there are three to four floats in the tank to control the cycling on and off of the submersible pumps. The lowest float is referred to as the shut-off float. When all four floats are hanging straight down, no pumps should be operating if the pump controls are set to "AUTO" in the control panel.

As wastewater is pumped into the splitter box it will overflow one of two weirs and be diverted in two different directions. One weir is more restrictive than the other weir in the flow splitter box. This could be due to a narrower opening of the weir or one weir being at a slightly higher elevation than the other weir. This restrictive flow rate is designed into the system to prevent high volumes of wastewater, referred to as hydraulic pressure, from being pumped too rapidly through the downstream units.

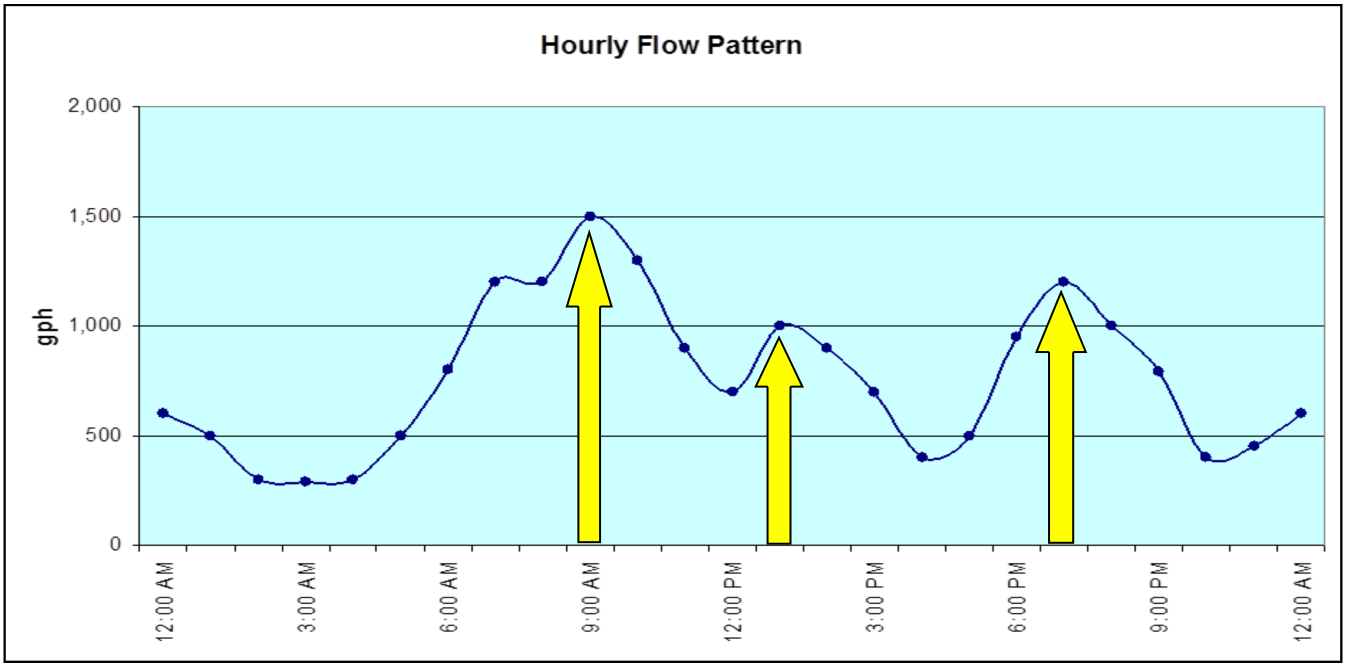
Influent flows, at times, will exceed the effluent flow of the flow splitting box. This excessive flow is stored in the flow equalization tank. The flow EQ tank is designed large enough to hold this wastewater until influent flows rates decrease and the flow equalization pumps can begin to pump down the stored wastewater.

Thus, the peaks and valleys of the influent flows can be equalized to provide a more consistent flow rate that will not negatively impact the downstream treatment units.

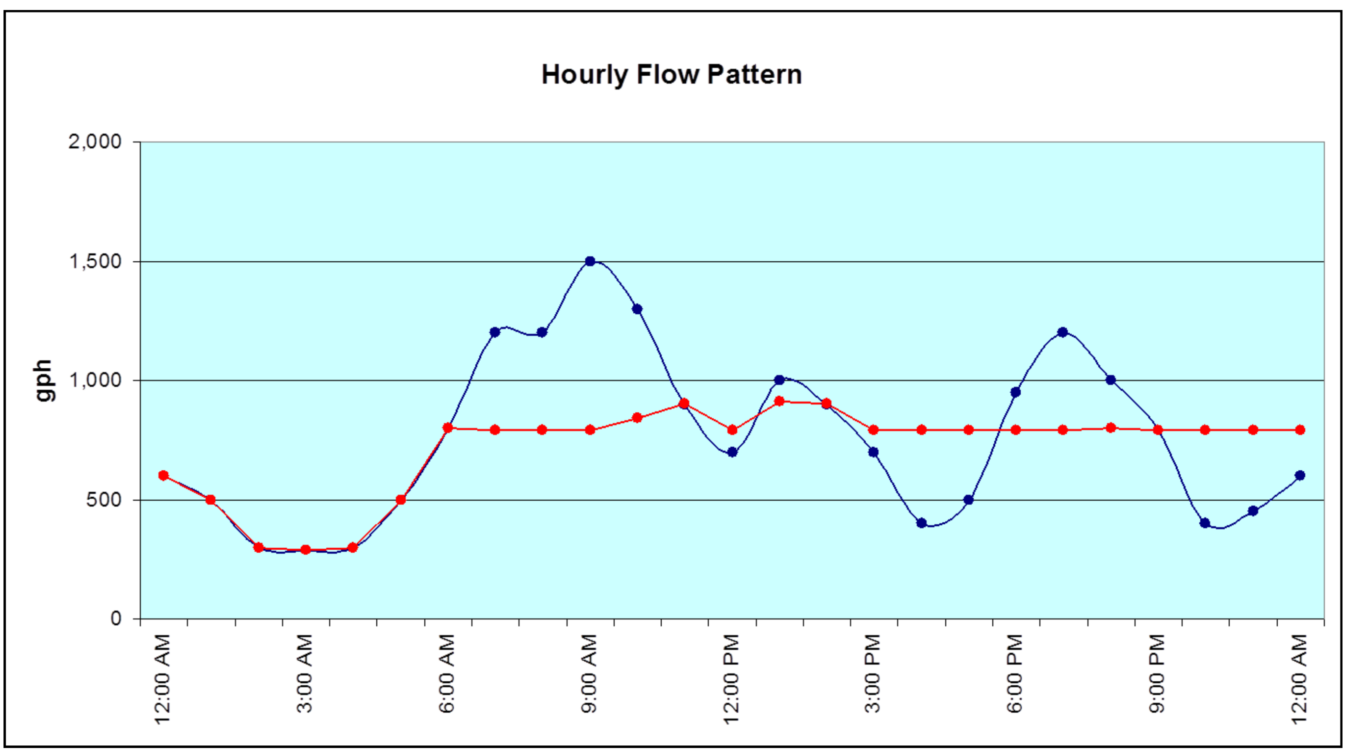
If the water elevation in the flow EQ tank increases, the shut-off float is activated. However a pump should not start until the next float up is also activated. Under lower flow rates the EQ pump will probably lower the water elevation in the tank until the shut-off float is again deactivated, when it again is hanging straight down the EQ pump will then shut off.

### Preliminary Stage: Flow Equalization

In the example below, the chart indicates the total gallons received at a package plant on an hourly basis. Flows are the lowest at night when fewer users are contributing to the flow. As the day continues peak flows are reached at 9:00 am, 1:00 pm and 7:00 pm.



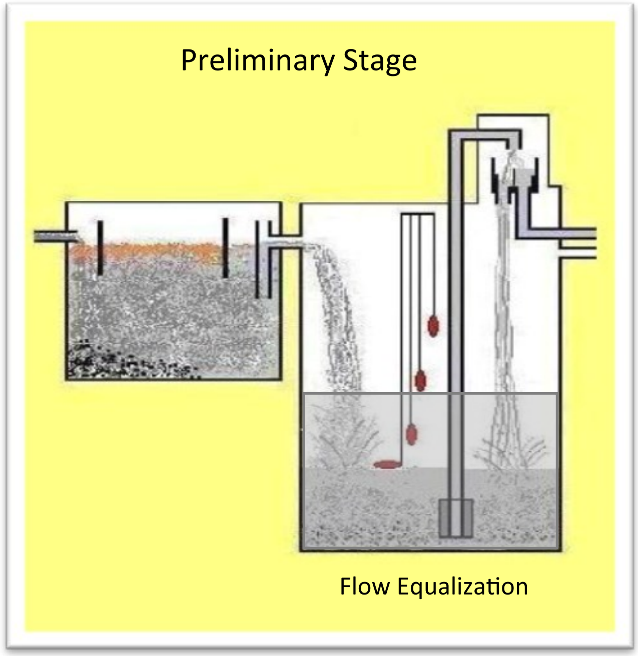

The flow EQ tank will balance out the peaks and provide a more consistent flow rate throughout the day. The actual flow rate through the treatment system is represented by the red line in the chart below. The peak flows were stored in the flow equalization tank. When the influent flows decreased, the flow EQ pumps continued to operate at a consistent flow rate and eventually the water in the flow EQ tank was lowered.



## Preliminary Stage: Flow Equalization

If the influent flow is greater than the design flow of the splitter box, the water elevation in the tank will continue to increase. If the next float up (the third float) becomes activated, one of two actions will occur depending on how the floats and controls have been electrically wired. Either a second submersible pump will be activated so that both pumps are engaged, or a high level alarm will be activated to notify the operator of a potential high water event. Again, each system can be designed or wired differently and you need to be aware of your system's specific pumping protocol.

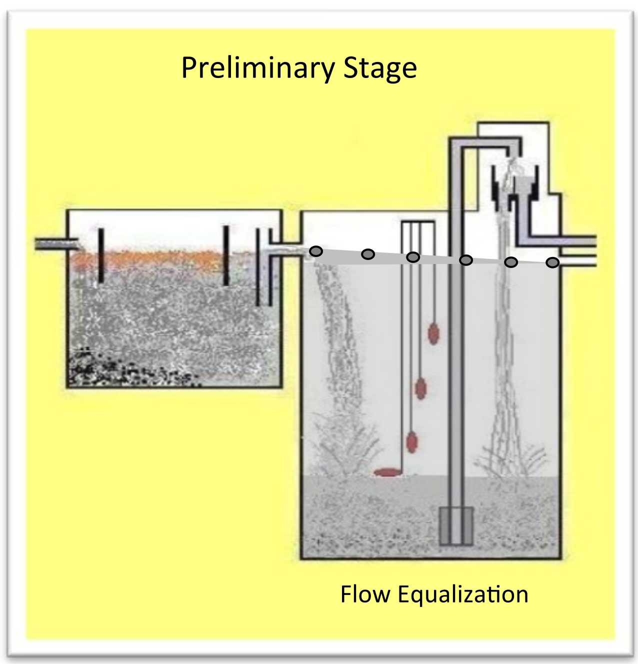
If your third float activated a second pump, then the fourth float will most likely activate your high water level alarm. If your third float activated a high level alarm, then the fourth float will activate your second pump.




It is possible during high flow events, or if a submersible pump is inoperable, for the water elevation to continue to increase. To prevent a back-up into the trash trap, the flow EQ tank is designed with a pipe to allow wastewater to flow by gravity to the secondary stage.

The pipe that allows for gravity flow is referred to as a transfer pipe. When the flow equalization tank is full and the "transfer pipe" is in use, the downstream units are no longer protected from hydraulic pressures which could potentially lead to upset treatment conditions.

As influent flow decreases, the submersible pumps will begin to lower the water elevation in the flow EQ tank. When the water level drops below the transfer pipe, the system will have regained protection from hydraulic pressure on downstream units.



## Preliminary Stage: Flow Equalization

Not all the waste entering the flow equalization tank is dissolved or suspended. Settable solids, which are solids that are dense enough to settle out, will build up on the bottom of the flow equalization tank. To prevent accumulation of solids, the flow equalization tank provides mixing through diffused aeration near the bottom of the flow EQ tank.

The primary function of the aeration in the flow EQ tank is for mixing, but a secondary benefit is to “freshen up” the wastewater prior to it entering the Secondary Stage.

## Summary: Preliminary Stage

The trash trap is the beginning of the Preliminary Stage. The primary function of the trash trap is to remove inert or non-biodegradable solids; plastic, paper, sand and grit and biodegradable solids, fats and grease so that dissolved and suspended solids pass through to the downstream treatment units.

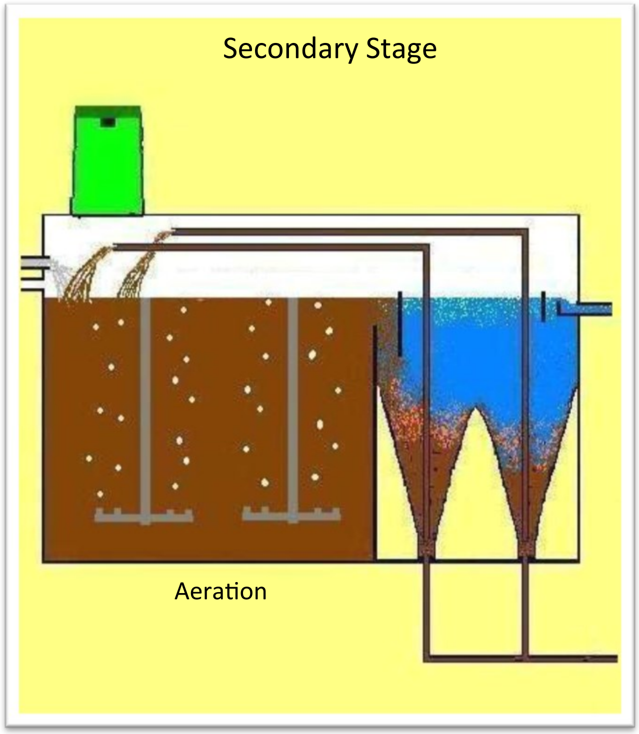
The flow equalization tank is the next unit in the preliminary stage. A flow splitter box is used to restrict forward flow to the treatment system. There is typically an electrical panel with float switches to provide controls to operate the submersible pumps, which provide protection from peak hydraulic flows. Aeration is also provided in the flow equalization tank to mix the tank’s contents.

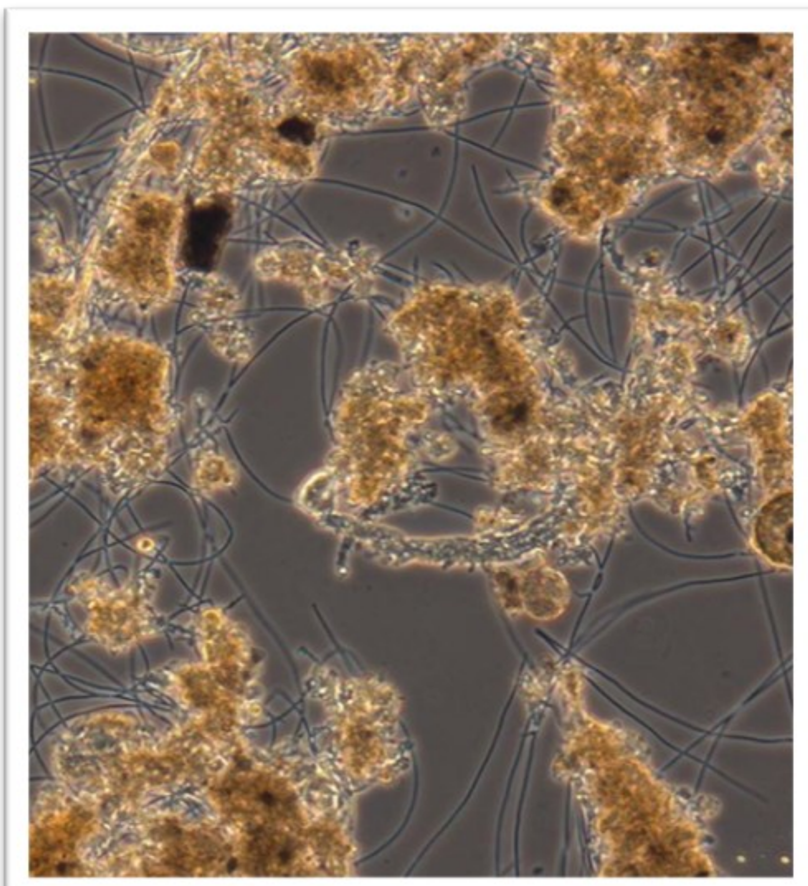
## Secondary Stage: Aeration

The dissolved and suspended pollutants entering the secondary stage will require a different process than the physical process used by the trash trap. The first treatment unit in the secondary stage is the aeration tank. The aeration tank relies on a biological process to convert dissolved and suspended solids into bacteria.

The bacteria require oxygen to biologically convert or consume the pollutants. The energy gained by consuming these waste pollutants is used by the bacteria to regenerate or reproduce into more bacteria.

These bacteria are commonly referred to as aerobic bacteria, because they require oxygen to survive. The bacteria and other microorganisms that feed on these waste pollutants tend to flocculate or "stick together" to form a heavier biological mass that will settle and separate from the water in the clarifier.



There are two structural types of bacteria which dominate in the aeration tank. The first type is a bacteria which grows together and resemble a cluster of grapes. These are referred to as flocculating bacteria. The flocculating bacteria are the dark brown clusters in the microphotograph to the left.

Another type of structural growth exhibited by bacteria is referred to as filamentous bacteria. These type of bacteria attached to each other only at the ends. The filamentous bacteria are the thin "stringy" structure in the microphotograph to the left.

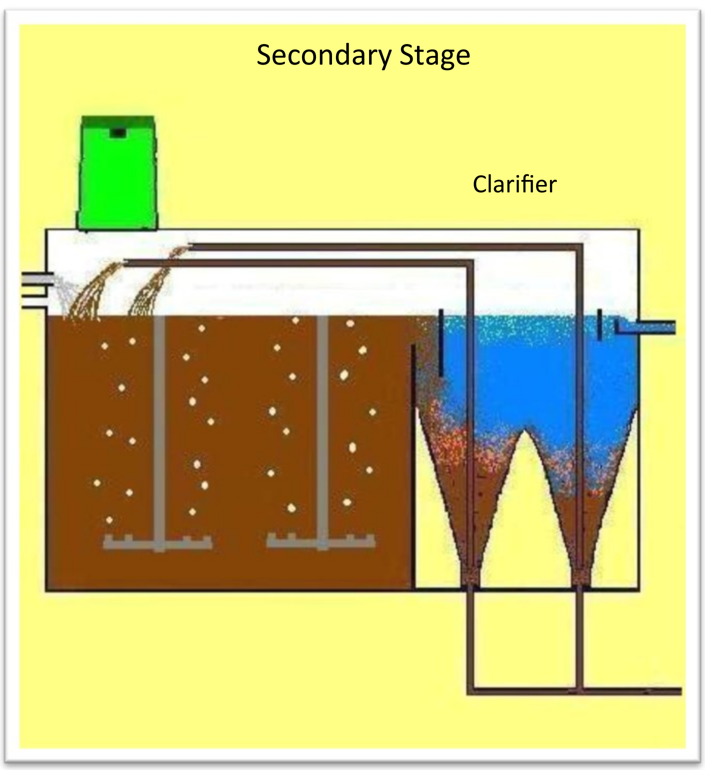
As this biological mass settles, it can and does act as a type of filter collecting smaller pieces of suspended material and removing it from the water.

## Secondary Stage: Aeration

Aeration provides a dual function. Not only does it provide dissolved oxygen in the water, which is necessary for the bacteria to digest the dissolved and suspended pollutants, but it also provides the mixing necessary to bring the pollutants in contact with the bacteria.

Inside an aeration tank is a vertical drop pipe which delivers compressed air to a horizontal pipe with diffusers attached near the bottom of the tank. This piping design allows the compressed air to be spread out along the length of the aeration tank to insure mixing of the entire tank.

As the air rises to the surface on one side of the tank it creates a natural rolling action within the tank which is sufficient for mixing.



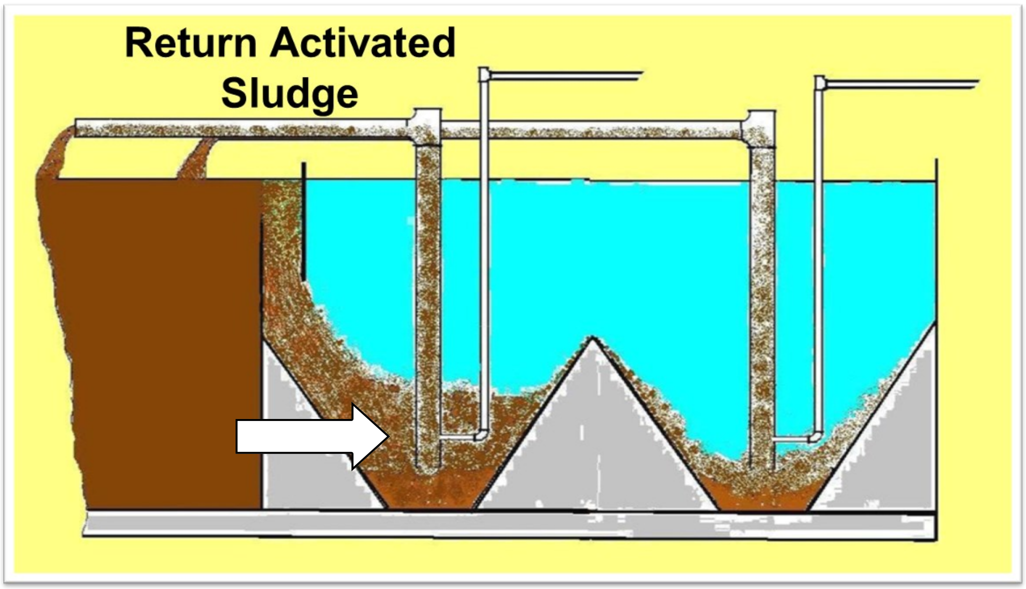

The clarifier is designed to provide a quiet hydraulic environment to allow the bacteria to flocculate, settle and filter out fine suspended solids. As the bacteria separate from the water the clarifier becomes clear and low in suspended solids.

To prevent the clarifier from filling up with settled bacteria, a pump is used to "return" this settled mass back to the aeration tank to repeat the biological process.

It is critical that this settled sludge is returned to the aeration tank where the bacteria can repeat the process of converting waste to bacteria. These bacteria are aerobic bacteria, which means they require dissolved oxygen in the water for their survival. The water surrounding the bacteria in the compacted sludge blanket of the clarifier can be void of dissolved oxygen. If the bacteria remain in this low dissolved oxygen environment too long, it will impact their ability to remove pollutants when they are returned to the aeration tank. It could cause the settled sludge in the bottom of the clarifier to rise to the clarifier surface. Thus, the clarifier design provides for a method of pumping the settled sludge back to the aeration tank.

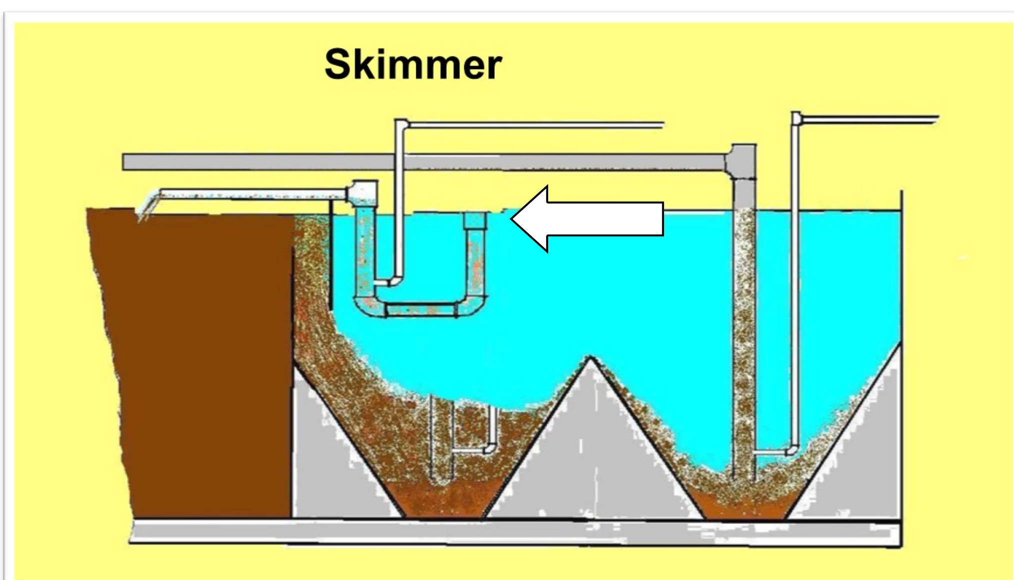
**Secondary Stage: Clarifier**

Air lift pumps are typically used to return settled bacteria in the clarifier to the aeration tank. An air lift pump is designed with a pipe that extends near the bottom of the clarifier floor. An air-line injects air near the bottom of this pipe. As the air is injected near the bottom of the return sludge pipe the fluid inside the pipe becomes more buoyant than the fluid outside the pipe. This difference in buoyancy creates a lifting of the settled sludge blanket. Bacteria which have settled to the clarifier bottom, near the opening of the return sludge pipe, is lifted up and returned to the aeration tank. This process is referred to as return activated sludge or R.A.S. There is a RAS line for each hopper in a clarifier.



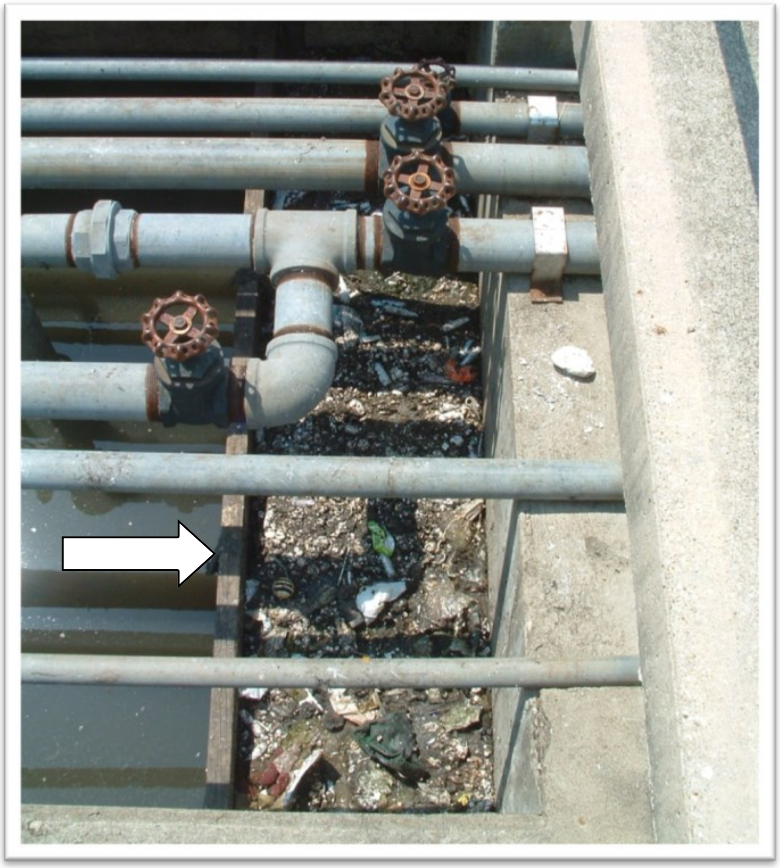

Two return activated sludge lines returning settled sludge from the bottom of a two-hopper clarifier back to the aeration tank.

The clarifier also has a surface skimmer to remove any floating debris. The skimmer and RAS pumps both operate on the air lift pumping principles. Both skimmer and RAS are pumped back to the aeration tank. The skimmer discharge should appear clear and the RAS pump should appear brown from the settled and compacted sludge in the clarifier hopper.



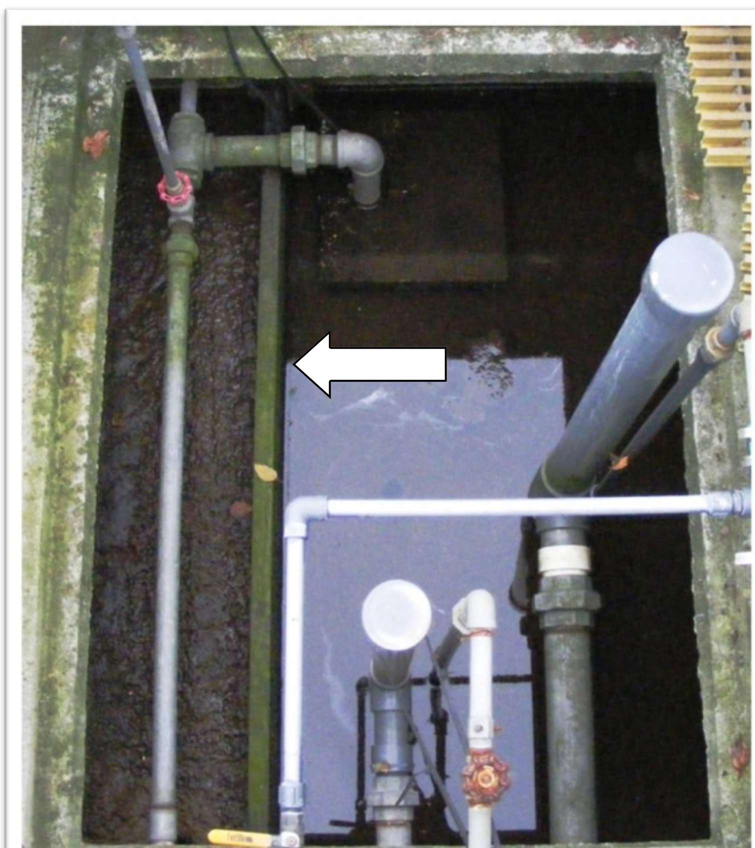

A skimmer, located on the clarifier surface, returns floating materials back into the aeration tank.

## Secondary Stage: Clarifier Scum Baffle



The trash trap, in the Preliminary Stage, will not always remove all undesirable floating material. These materials would flow across the clarifier surface and be combined with the clear water. This would eventually be passed on to the Tertiary Stage and cause pumps to clog or require removal from the surface of the sand filter. To prevent floating material from entering the clarifier there is a scum baffle installed at the inlet of the clarifier.

It is easier to remove trash (paper, plastic, grease) in the Preliminary Stage than to manually remove trash behind the clarifier scum baffle The piping arrangement of this clarifier design (photo on right) adds to the difficulty in removal of trash.



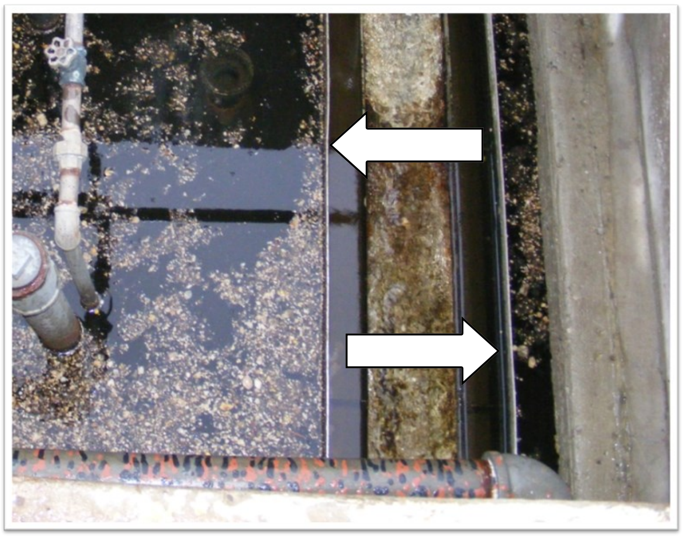
In addition, it is also possible to generate a biological foam in the aeration tank under certain operational conditions. The scum baffle (photo on right) is performing its task, however, the biological foaming needs to be eliminated by making adjustments to the aeration tank environment.

Here we see the clarifier inlet scum baffle preventing this biological foam from moving across the surface of the clarifier.

## Secondary Stage: Clarifier Weir Baffle

It is possible for the biological foam generated in the aeration tank to be so severe that it is not contained by the influent scum baffle and begins to migrate across the clarifier surface. As a backup to the influent scum baffle, the clarifier also has a baffle located near the effluent weir.

Grease that enters the package plant is significantly reduced by being captured in the trash trap. If the trash trap is not maintained or pumped out when needed, grease will begin to pass through the preliminary stage and will be transferred to the clarifier surface.



Not all grease will be retained by a well-designed trash trap. These smaller grease particles will also not be retained by the clarifier's influent scum baffle. The last device to prevent it leaving the secondary stage is the clarifier effluent weir baffle. When the grease has made it this far into the treatment system, it will most likely require the operator to manually skim off the clarifier surface. This weir has a baffle on both sides.

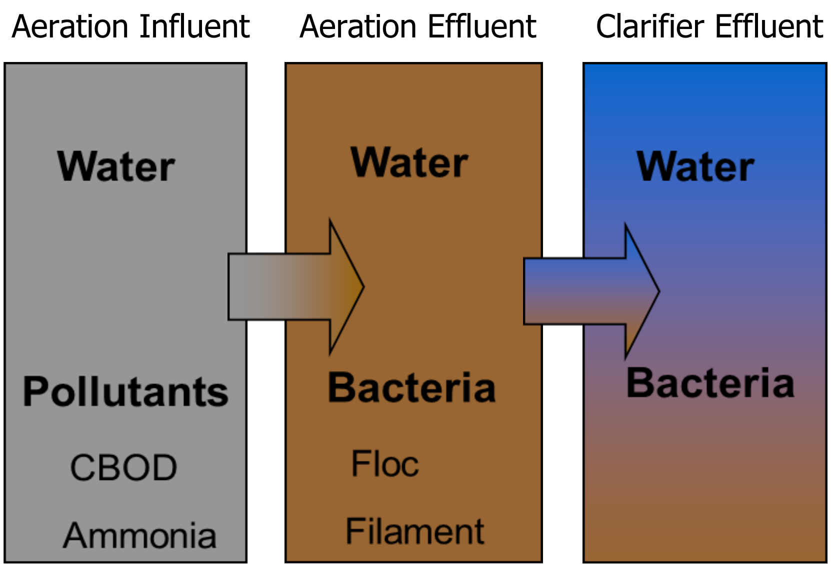
This weir baffle prevents floating materials from leaving the Secondary Stage. The source of the floating materials can be either from the influent trash (plastic, paper) or from bacteria which have settled in the clarifier, but have "popped" to the surface due to a process called denitrification.

It is possible for bacteria which have settled in the clarifier to become buoyant and float to the surface if they are retained in the clarifier too long. This is referred to as denitrification and if severe will bring the entire settled sludge blanket to the surface.

Without a clarifier effluent weir baffle these bacteria would leave the secondary stage and be passed onto the sand filter which causes clogging of the tertiary stage sand filter unit. Denitrification will be discussed further in the Controlling The Units section.

**Summary: Secondary Stage**

The aeration tank is the first unit in the Secondary Stage. The function of the aeration tank is to provide the proper biological environment for aerobic bacteria to consume or convert dissolved and suspended pollutant into bacteria.



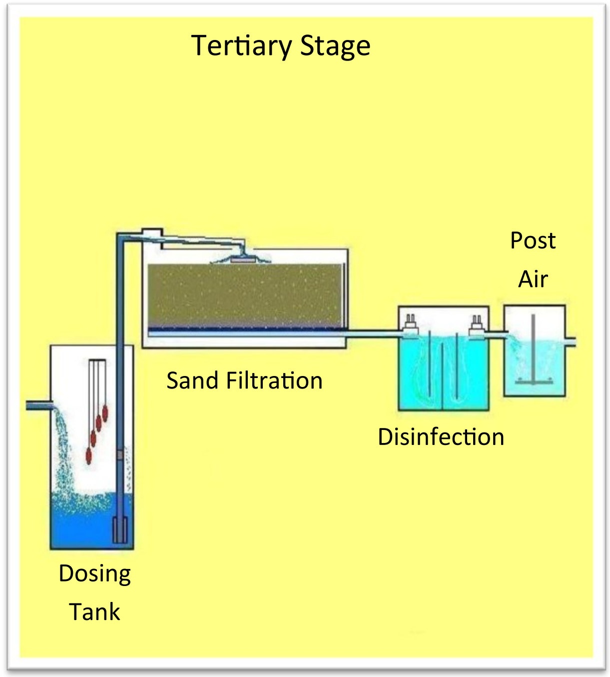

These dissolved and suspended pollutants are in the form of carbon waste ( cBOD) or nitrogen waste (ammonia). The aeration environment generates either flocculating (clusters) or filamentous (stringy) types of bacteria structure. As these bacteria flocculate together they become dense enough to separate from the clean water surrounding them. This occurs in the clarifier, the second unit of the Secondary Stage.

The clarifier contains baffles (scum and weir) to prevent floating materials from leaving the Secondary Stage. The clarifier also has a return sludge pump to removed settled sludge and return it back to the aeration tank. A surface skimmer is also available in the clarifier.

The Secondary Stage is a biological and physical process. Failure to convert pollutants into bacteria will cause them to pass through the treatment system, which will lead to effluent violations of the permit. Failure to separate the bacteria from the clean water in the clarifier will cause loss of treatment due to bacteria not being returned to the aeration tank. If the solids loss is severe, it will clog the sand filter and then treatment will be out of control. Failure to convert or failure to separate both lead to operational problems and potential effluent violations.

## Tertiary Stage: Filtration

The final stage prior to discharging the water to the receiving stream or lake provides a fine polishing of the water. We will refer to this as the Tertiary Stage.

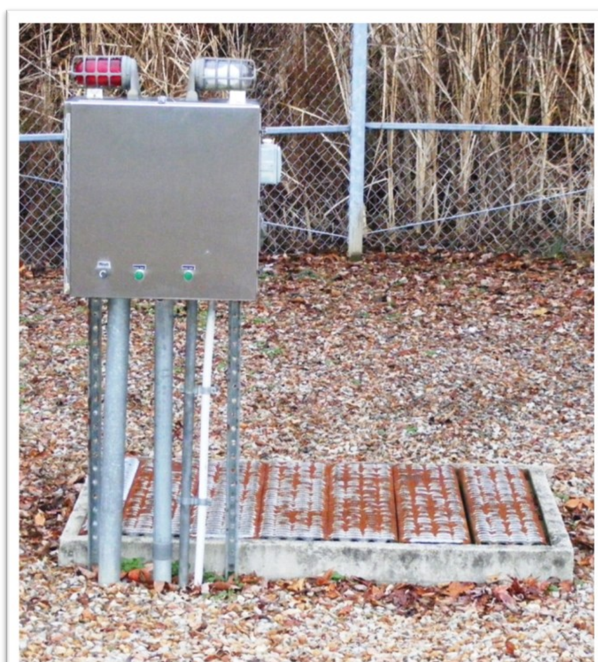



The tertiary stage is typically a three step process before discharging water to the environment. The first is filtration to remove fine suspended solids, then disinfection to prevent disease-causing organisms from entering the environment, and finally increasing the dissolved oxygen concentration in the water by providing aeration prior to discharge.

The first units in the tertiary stage are the filtration units. The filtration process consists of a dosing tank and a sand filter.

At the Preliminary Stage the wastewater was pumped to a higher elevation in the flow equalization tank and the process flowed by gravity through the Secondary Stage. Typically the water has reached an elevation that it can no longer flow by gravity and again must be lifted to a higher elevation to flow through the tertiary stage.

Submersible pumps located in the dosing tank pump, or lift the water, to an elevation above the sand filter to continue the treatment process.

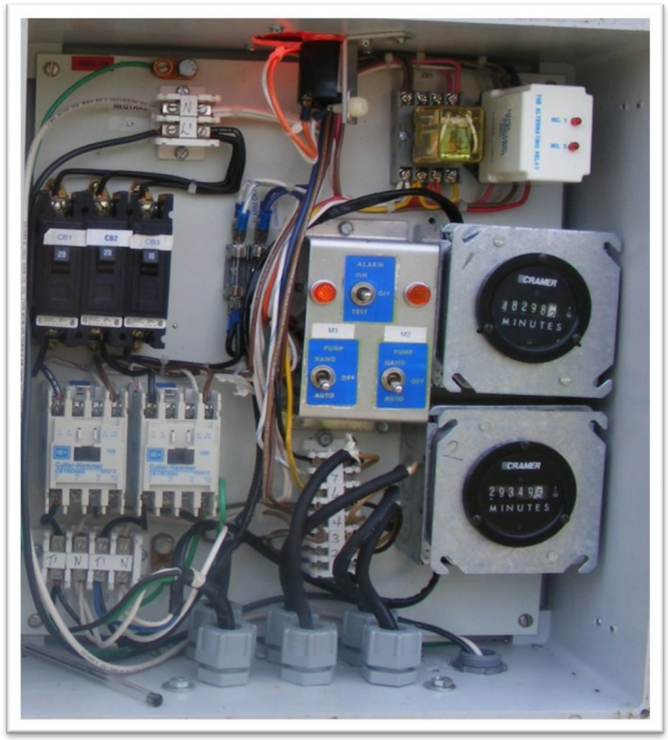


It is also beneficial to dose the sand filter rather than to provide a continuous flow-through pattern. The dosing tank pumps allow for this "dosing" of filters.

Similar to the flow equalization tank, the dosing tank also relies on submersible pumps controlled by float switches to activate pumping conditions.

The floats and pumps are powered and electronically controlled through a control panel, typically located immediately above the dosing tank.

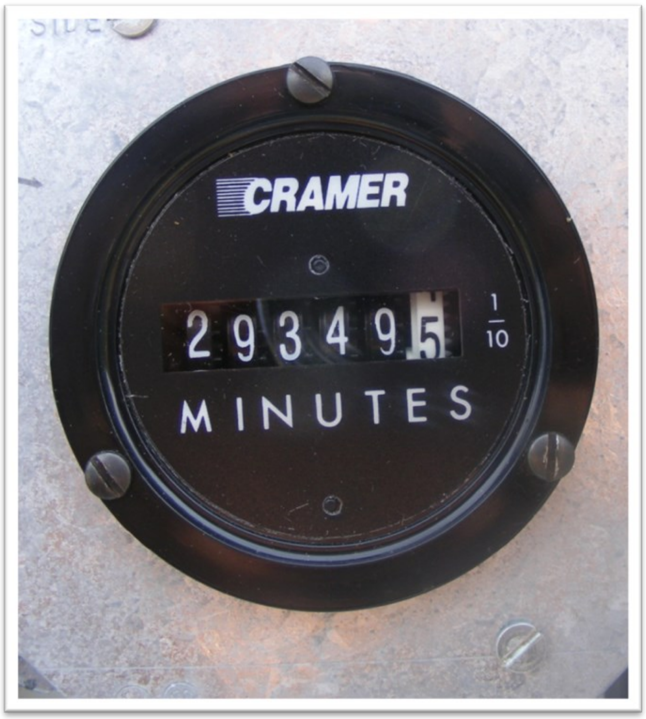
## Tertiary Stage: Filtration



Inside the control panel are electrical components, breakers, pump controls, relays and run time meters.

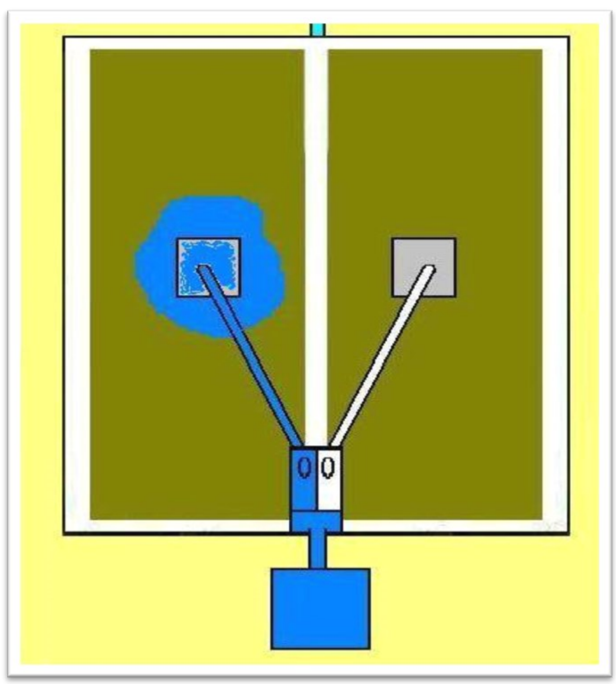
These run time meters record minutes and/or hours of operation of the dosing tank pumps. Tracking the hours of pump operations has two purposes.

One purpose is the ability to determine when preventative maintenance of the pumps is required.




A second purpose is to calculate the volume of flow which has passed through the treatment system. This becomes critical since you are required to report to the Ohio EPA the daily flow received through the system.

The dosing pumps lift the Secondary Stage effluent into a flow diversion box. The flow diversion box allows the operator to place in service the sand filter that is ready for use. A single filter is to be used until the filtration rate through the filter is decreased by solids clogging or binding of the sand media



There are at least two filters to allow for the cleaning of one while the other is providing filtration. When a filter becomes clogged the operator will remove the clogged filter from service, allow it to dry, remove the solids which have accumulated on top of the filter and place it on stand-by, so it is available whenever the other filter becomes ineffective in filtration.

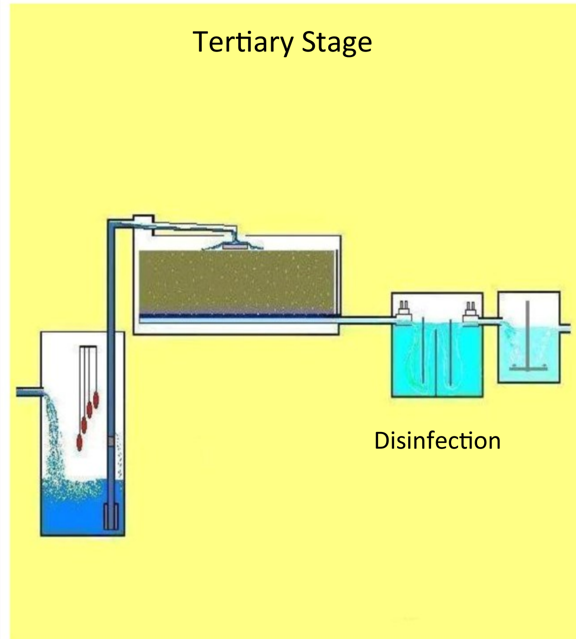
**Tertiary Stage: Filtration**

The velocity of the water being pumped from the dosing tank is strong enough to scour the sand away in the sand filter. To prevent this scouring effect, a splash pad is placed under the influent pipe to direct the water horizontally. This will allow the water to spread out over the surface of the filter and not "wash away" the sand media directly below the pipe's discharge.

Sand media can be too course, which allows large gaps between the media. These large gaps can lead to an inability of the filter to remove suspended solids from the water, as the suspended solids flow around the media and are not retained on the surface of the filter. Sand media can also be a mixture of various sizes, which allows the fine particles to fill in any gaps between the media. This can prevent even clean water from filtering through the media.

Sand media that drains clean water effectively, while retaining suspended solids on the surface, is the desired goal. The Ohio EPA provides recommendations to owners and operators of treatment systems on sand media specifications.

## Tertiary Stage: Disinfection




The water at this point in the treatment process may look clean and safe, but looks can be deceiving. Small organisms, undetectable to the eye, may be living in the water. Organisms that cause diseases in humans are referred to as pathogens. Pathogens in the raw wastewater have been significantly reduced at this point in the treatment process; however, the potential exists that pathogens can still be released to a receiving stream or lake. If treatment systems are discharging water free of pathogens, people can safely enjoy Ohio's waterways.

One method of disinfection is achieved through a "chemical" process using calcium hypochlorite. As water flows into the disinfection tank it passes through a chlorine tablet feeder. This feeder contains tablets composed of calcium hypochlorite. As the water flows around these hypochlorite tables, the tablets dissolve, releasing a disinfecting solution.

The disinfection tank is usually baffled to force the flow through the entire tank and to prevent "short-circuiting" of the flow. After the introduction of the calcium hypochlorite, the chemical process needs sufficient contact time to achieve disinfection of the water. The disinfection tank is also referred to as the chlorine contact tank.

## Tertiary Stage: Disinfection

High levels of chlorine are desired to achieve the most effective disinfection of the water. However, even small concentrations of chlorine can have a negative impact on the aquatic species in the receiving stream or lake. To prevent a negative impact on these aquatic species, another chemical is used to reduce the chlorine residual in the water.

The same process and equipment we use to introduce calcium hypochlorite into the disinfection tank will be used to de-chlorinate the effluent of the disinfection tank. The difference will be the chemical composition of the tablet used in the chemical feeder. To eliminate the chlorine residual, sodium sulfite tables are inserted into the chemical feeder which discharges from the disinfection tank.

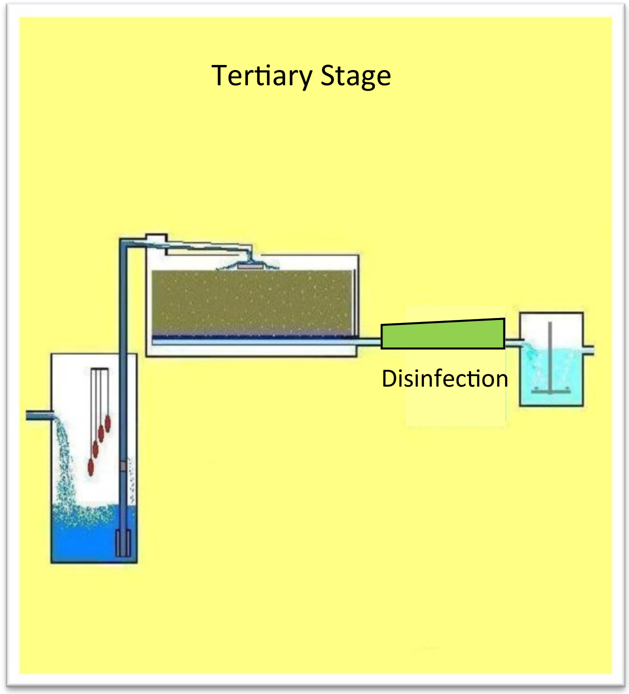
Both chemicals can be reactive and need to be stored separately and according to the manufacture's recommendations. Please be aware of storage and handling procedures of any chemical used in the wastewater treatment process.

On a similar note, there are different types of disinfecting chemicals used for swimming pools. Some of these chlorinated chemicals, intended for swimming pool environments, could cause dangerous situations when used in the treatment of wastewater. The most common chemical used in disinfection of wastewater is calcium hypochlorite.

## Tertiary Stage: Disinfection

Another option for a treatment system to provide disinfection is by the use of ultra-violet radiation, or UV light. An advantage of UV disinfection over chlorine disinfection is UV does not require the addition of another chemical to negate the chlorine residual in the water prior to being discharged.

The flow from the filtration unit is exposed to a lamp which emits a specific wavelength of light to kill or prevent reproduction of unwanted microorganisms.

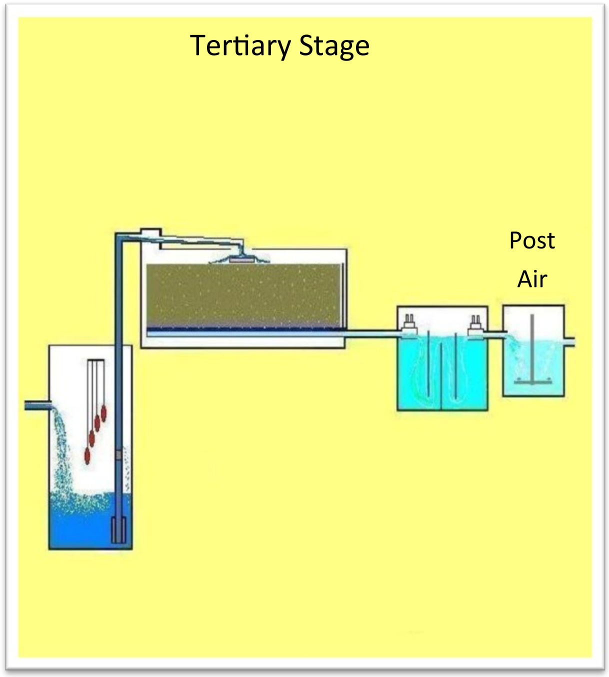




Here is a UV unit with one lamp. As the water flows horizontally through the unit, the microorganisms in the water are exposed to the UV light. Treatment systems with higher flow may have more than one lamp.

Another design of UV disinfection uses this vertical tube with the UV lamps concealed inside.

## Tertiary Stage: Post Aeration




The last unit in the Tertiary Stage is the Post Aeration tank. The function of post aeration is to increase the dissolved oxygen concentration of the water prior to being discharged.

During the warmer summer months the water temperature of the final effluent increases. As water temperature increases it becomes more difficult to maintain dissolved gasses in solution. Your NPDES permit will require a minimum concentration of dissolved oxygen in the final effluent. Adding dissolved oxygen in the last unit prior to being discharged to the receiving stream assures the final effluent will achieve the permit limit for DO.


Increasing the dissolved oxygen concentration is a simple, physical process. Diffusers, similar to the diffusers used in the other treatment units, are used to inject air near the bottom of the post aeration tank.

In this example, compressed air is piped into a small well after UV disinfection and prior to being discharged to the receiving stream.

You are required to sample the final effluent from your treatment system and report the results to the Ohio EPA. The sampling location for reporting these final effluent parameters is after the final treatment process, the post aeration unit, and prior to the receiving body of water.

### Summary: Tertiary Stage

The first units in the Tertiary Stage are the filtration units, which consists of a dosing tank and sand filters.

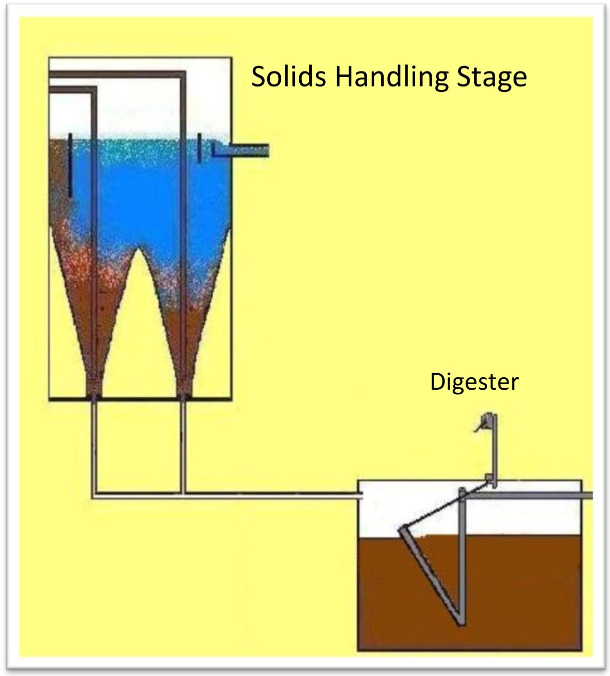
The next unit in the Tertiary Stage is the disinfection unit. Disinfection can be performed by chemical or biological processes and is designed to control pathogens being discharged from the treatment system.

The last unit in the Tertiary Stage is the post aeration, a physical process designed to increase the dissolved oxygen concentration of the final effluent.

All of these units work together and in a specific order to ensure the highest quality water is being discharged.

## Solids Handling Stage

The solids handling stage does not directly impact the treatment process, but is critical for long term compliance and control of the process. The solids handling stage consists of a digester or holding tank and uses "biological" and "physical" processes.




It is in the Secondary Stage where dissolved and suspended pollutants are converted to bacteria. Pollutants in the aerobic environment are mixed and aerated and more bacteria are generated. As these bacteria reach the clarifier, they settle to the bottom of the clarifier and are then returned to the aeration tank to continue the biological treatment process. As the secondary system continues to receive wastewater, more bacteria are regenerated. As the bacteria concentration increases the Secondary Stage process will fail. It is the operator's responsibility to identify when this situation is beginning to occur and remove sufficient bacteria from the secondary stage to prevent this loss of control.

The controls available to the operator to maintain this desired balance of bacteria is to remove (waste) excess bacteria from the Secondary Stage to the Solids Handling Stage.

As excess bacteria are pumped to the digester or holding tank, the bacteria concentration in the Secondary Stage is reduced and the treatment process continues to perform as designed.

After the operator has wasted the appropriate amount of bacteria from the Secondary Stage, the system is returned to its normal mode of returning settled bacteria to the aeration tank.

Typically, the same pipe used to return settled bacteria from the clarifier to the aeration tank is also used to remove excess bacteria from the system. In the photo to the left, here, there are two valves which are used to direct the settled sludge being returned from the clarifier. The valve on the left, the return valve, will return settled sludge to the aeration tank. When excess bacteria need to be removed the valve on the right, the waste valve, is opened and the RAS valve is closed to direct settled sludge to the digester located in the background.

Settled sludge being directed to the digester is referred to as "wasting". When sufficient sludge has been wasted to balance the bacteria concentration in the Secondary Stage, the RAS valve is opened and the waste valve is closed.

## Solids Handling Stage: Digester

The aerobic bacteria being removed or wasted to the digester still require dissolved oxygen in the water to survive. Typically diffused air is injected near the bottom of the digester to provide mixing and dissolved oxygen to further biologically break down the bacteria.

The bacteria, if aerated, will continue to break down biologically. Since they are not being fed regularly from the raw wastewater the only food source they have in the digester is from other bacteria that have died or their own internal food storage. As these bacteria continue to digest themselves and other bacteria, the aeration can be discontinued to allow for a separation of sludge and water. This excess water can then be removed with the decanting mechanism to provide more sludge storage in the digester.

With the aeration off, the solids will separate from the surrounding water. Then the clearer water, or supernatant, can be removed by lowering the decanting pipe into the clear water that has formed above the settled sludge level. This decanted supernatant is pumped back to the head of the treatment system for further treatment. The removal of this supernatant provides for more capacity to waste bacteria from the secondary stage.

Eventually the solids concentration of the digester reaches a point where there is no longer any supernatant and the digester is full of wasted sludge. The sludge in the digester is then pumped out so capacity is again available to waste excess bacteria.

**Summary: Basic Treatment Units**

The package plant consists of multiple individual treatment units. These units operate individually, but also in unison, to remove pollutants from the wastewater. When properly operated, the final effluent will not have a negative impact on human health or the environment.

It starts with a physical treatment process in the preliminary stage and continues with biological and physical processes to remove dissolved and suspended pollutants in the secondary stage. Finally, a fine polishing of the water occurs using a physical process, followed by disinfection in the tertiary stage.

To maintain the proper environmental conditions of the Secondary Stage excess bacteria are stored “off-line” in the digester. When the digester reaches full capacity, it is emptied so the treatment process can continue without experiencing upset conditions.

Each stage is designed to treat a specific type of pollutant. Proper operation and maintenance of each unit allows each stage to perform its specific purpose to prepare the water for the next treatment stage and final effluent to the receiving stream.

## Controlling the Units

In the Basic Treatment Units, we discussed the four basic stages of treatment in the activated sludge package plant; preliminary, secondary, tertiary and solids handling. We also introduced the idea that each stage uses physical, biological or chemical processes to remove pollutants and prepare the water for final discharge. The type of process will determine which type of control method is used.

| Stage | Process | Control Method |
|---|---|---|
| Preliminary | Physical | Visual Observation |
| Secondary | Physical | Visual Observation |
| | Biological | Chemical Analysis |
| Tertiary | Physical | Visual Observation |
| | Chemical | Visual Observation |
| Solids Handling | Physical | Visual Observation |

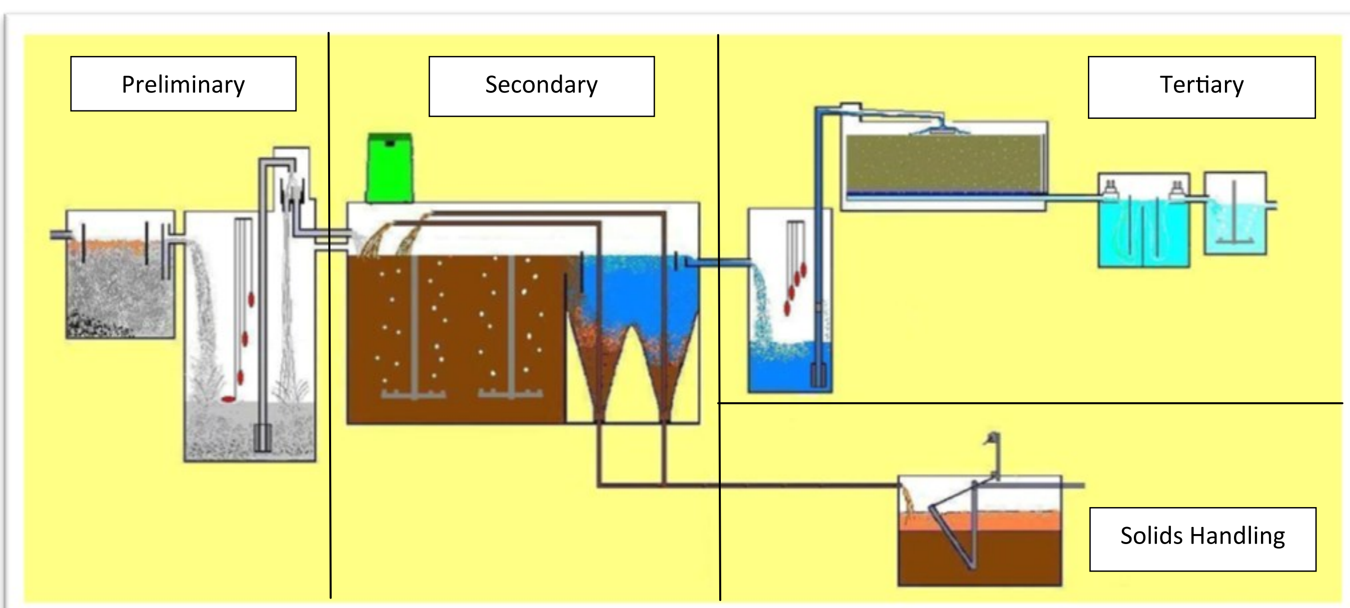
The units in the Preliminary Stage use physical processes, so visual monitoring or observations of the process will provide insight into whether these units are performing as designed.

The Secondary Stage also uses physical processes, so observations are valuable monitoring tools. However, the aeration tank is a biological process within the Secondary Stage. This biological process cannot be evaluated by observations alone, but requires additional chemical analysis to track performance.

The Tertiary Stage, relies mainly on physical processes and can be monitored visually. The disinfection unit in the Tertiary Stage may use a chemical process, however, it can be monitored by visual observations.

The Solids Handling Stage relies mainly on physical processes which can be controlled by visual observations.

Each stage is designed for the removal of a specific pollutant . As pollutants are removed an excess of bacteria are generated which also must be disposed of properly. Each stage must perform its task or a problem will be passed on to the next treatment stage. Failure of any stage to perform its designed function will lead to loss of control. This sets in motion the "domino effect" in which small stress events are multiplied through the treatment system.



## Controlling the Units

An initial failure within a specific treatment unit is multiplied as it travels through the remaining treatment system. The causes for failed performance may be identified from within that specific unit or, like a row of fallen dominos, might need to be traced back to a treatment unit upstream of the "observed" failure.

As more dominos fall, the system becomes more labor intensive and more expensive to maintain. Upsets will occur, but each upset requires cleanup. If the process is not controlled you will find yourself in a reactive mode, constantly "fixing" instead of "preventing". A well-controlled treatment system produces the fewest upsets. A common myth is "I don't have enough time to operate the system." In reality a small investment in controlling the process is the most efficient use of your time. The truth is "You won't have enough time if you fail to control the process."

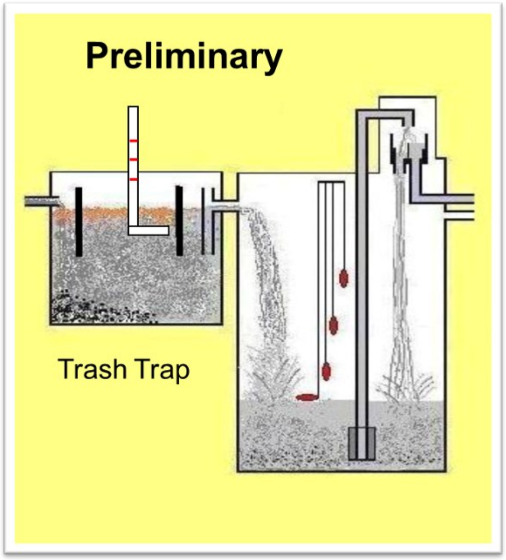
Loss of control can also lead to a loss of revenue. As effluent violations continue, so does the possibility of enforcement action with the probability of monetary fines. As if inefficiency and expense were not sufficient, there is also the degradation of the water quality in the local environment. So the most efficient and economical approach to wastewater treatment is to control each individual process.

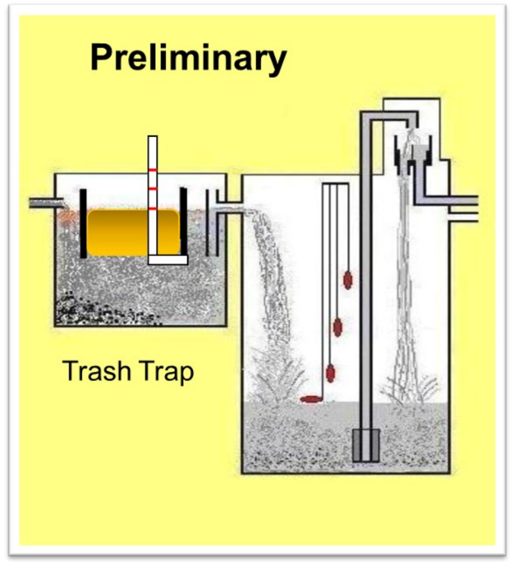
In order to control the package plant we need to first understand what is expected of each treatment process, so we collect data or information to measure if the expected performance is being achieved. When the data indicates a process is drifting outside its intended design, determine the cause of the drift and the correct response to reverse the trend. Then implement the correct response to bring the system back in line.

The data should indicate the system is trending back into control. The same tools and methods that are used to adjust the process are also the same tools and methods used to troubleshoot the cause of an upset. If the process is controlled there is no need to troubleshoot upsets. The goal is to respond before the upset occurs.

## Preliminary – Trash Trap

The trash trap is a physical process which can be monitored by simple observations. The purpose of the trash trap is to remove scum and grit, but allow suspended and dissolved pollutants to pass through to the secondary stage. Measuring the scum level in the trash trap provides information to prevent pass through of scum.




If we could view the trash trap from the side it would be obvious as to when the trap would need to be pumped out. Unfortunately we can only view the trap from the surface and the scum depth is difficult to determine. A simple tool to gage the depth of the floatable material is an "L" shaped staff. First determine the depth of the baffle in the trash trap. Next lower the staff into the grease layer and slowly raise the staff until you can feel resistance from the bottom of the scum layer. The side of the staff is marked in increments. By noting where the markings on the staff line up with the top of the trash trap you can estimate the depth of the scum layer. When the scum blanket reaches the bottom of the baffle, pass through of scum increases. When the baffled zone is full of floating grease it can no longer perform its design function and these undesirable pollutants pass through to the next treatment stage.

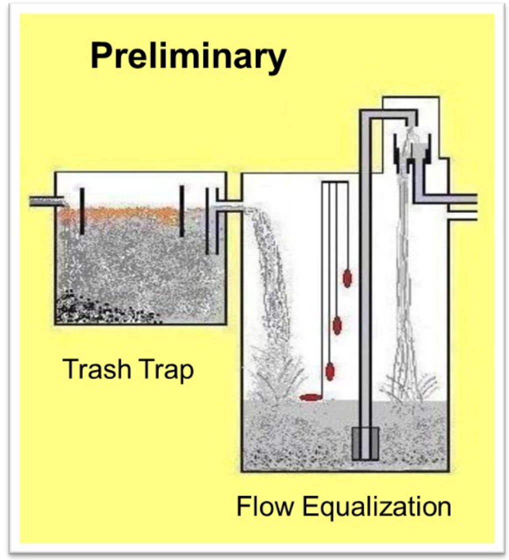
Another visual check is to examine for evidence of scum or grease passing through the trash trap. If you observe excessive amounts of grease downstream of the trash trap, then the trap is failing or the grease loading is too excessive and needs to be controlled at the source.

The evidence is most obvious in the secondary clarifier. As the trash trap's effectiveness decreases, more scum is observed in downstream units, typically in the clarifier.

The trash trap is designed to prevent scum and debris from passing through. Eventually it needs to be physically removed to maintain effectiveness. Contact a local septage hauler to have the scum and grease pumped out and disposed of properly.

## Preliminary – Flow Equalization (EQ)

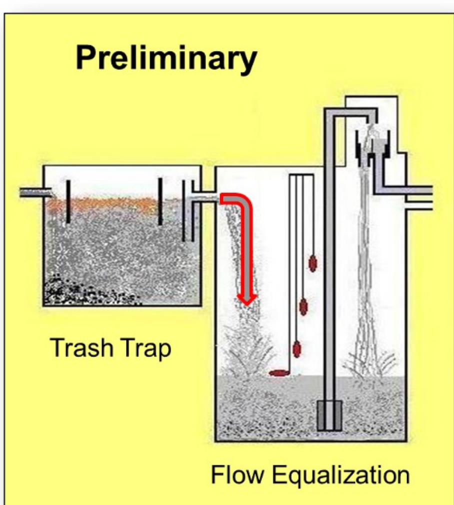
When influent flows exceed the pumping capacity of the flow equalization pumps wastewater accumulates in the flow EQ tank.

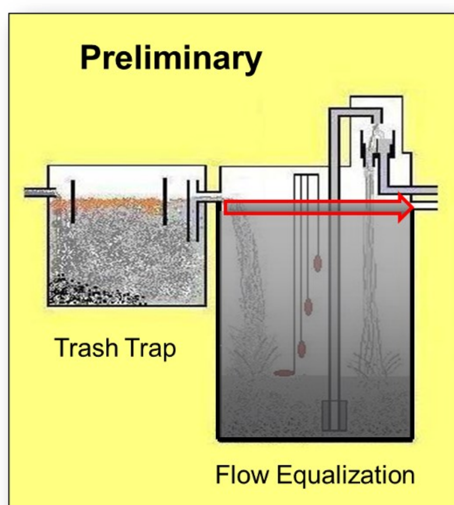




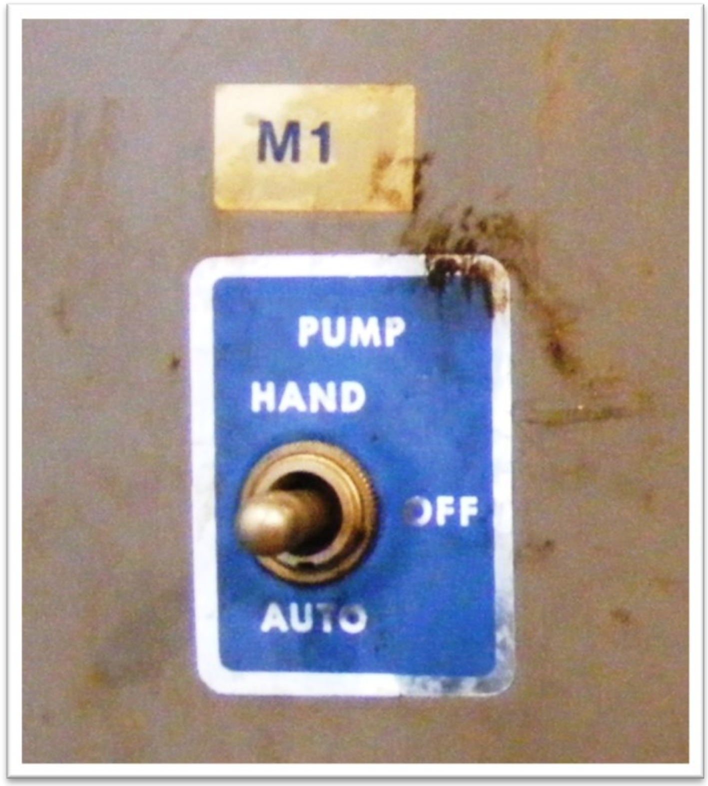
Mechanical pumps in the flow equalization tank operate off of a sensor that monitors water elevation in the tank. The sensor is typically a float switch. As water elevation increases, the floats will activate electrical controls to turn pumps on or off.

If influent flows exceed the pumping capacity of the flow equalization pumps, eventually the tank fills to an elevation where it will flow through a transfer line into the aeration tank to prevent an overflow of the preliminary stage. This also serves as a back-up if electrical power is lost to the treatment system or if the flow equalization pumps are out of service. When the EQ tank is full there is no flow equalization being provided to the downstream treatment stages.



**Preliminary – Flow Equalization (EQ)**




If the flow equalization tank is passing wastewater to the Secondary Stage through the transfer line, either there is more flow being received than the system was designed for or there is an issue with the Flow EQ pumps keeping up with the flow rate. It will be obvious if the pumps are not operational due to a power failure. However, if there is a problem with the actual pumps or the floats, a little detective work is needed. This begins by looking into the electrical control panel which services the flow EQ pumps.

Inside the control panel there typically is a control for each submersible pump in the EQ tank. The pump controls are designed with three operational modes. The "off" position of the pump control should prevent the pump from operating. However, to isolate if the problem exist with the pump, switch the controls to the "Hand" or "On" position. If the pump does not start the issue is associated with the pump or the electrical control wired directly to the pump.

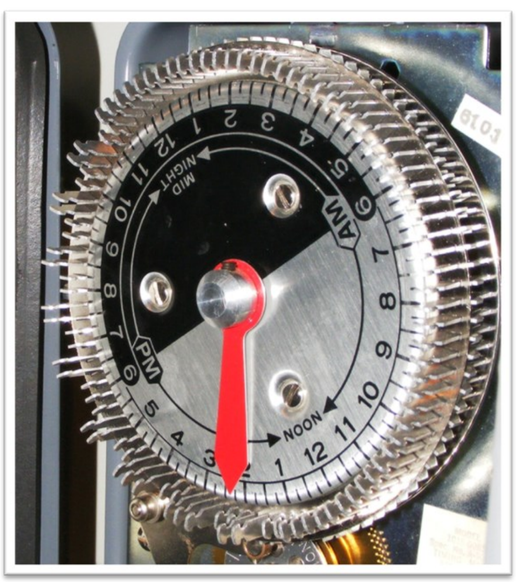
If the EQ pumps operate properly when in the Hand or "on" position, then evaluate if there is a problem in the float switches causing improper operation. Switch the pump control to the "Auto" position. Manually activate the float switches by raising them and tipping the floats by hand to close the contacts and monitor if the pumps are activated.

If the pumps do not operate there could be an electrical connection problem in the float and the float switch might need to be replaced. Perform the same test on both pumps. The transfer line might be overflowing due to just one pump being operational.

## Preliminary – Flow Equalization (EQ)

Air is diffused into the bottom of the EQ tank to provide for mixing and suspension of pollutants and prevents their deposition on the bottom of the EQ tank. There is typically a blower and motor unit specifically for the Flow EQ tank.

Similar to the Flow EQ pump controls, the blower and motor controls also have a Hand, Off, Auto control option. Typically a clock located inside the control panel is used to cycle the blower on and off when the blower controls are set to the Auto setting.


The same process for troubleshooting the EQ pumps can be used to troubleshoot the EQ blower. Switch the controls to Hand or "on" position to confirm a problem with the motor, blower or diffusers then switch the controls to Auto and adjust the clock to operate the blowers. Failure of the blower to operate in either the "Hand" or "Auto" setting will lead you to follow up with the necessary diagnostic to ensure proper aeration of the Flow EQ tank.

As the water elevation increases in the flow EQ tank, diffusing air on the bottom of the tank requires more pressure from the blower. Be sure to verify the aeration provided by the blower provides mixing at these high water elevations in the flow equalization tank.

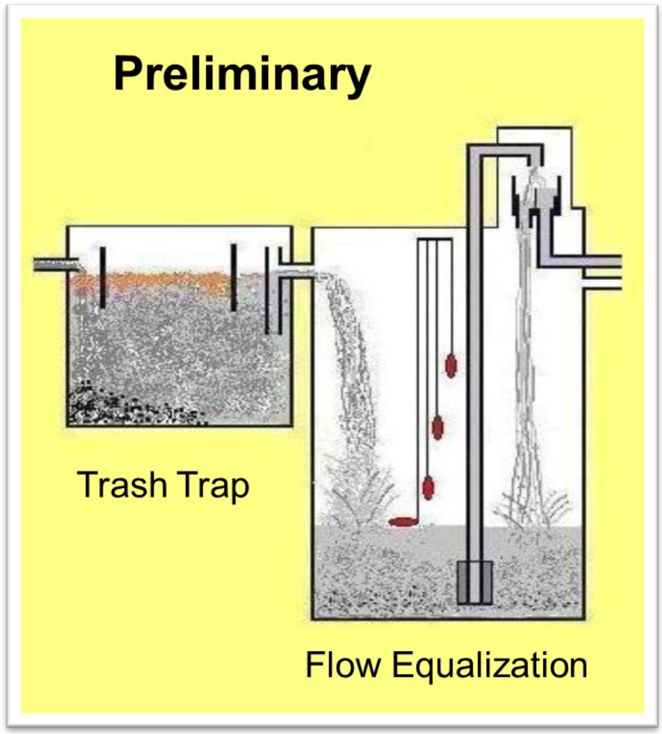
## Preliminary Stage– Summary

Visual observation is the primary tool to monitor the process. A walk through the system will expose the operator to potential issues. Visual observations do not require any expensive specialized tools, but will identify the onset of an upset condition.

Unfortunately, many operators fail to notice the subtle changes which signify the beginning of an upset. Visual observations are limited by the thoroughness and awareness of the person making the observations.

Trash Trap

Monitor the scum accumulation in the trash trap and have it pumped out before it allows undesirable pollutants to pass through. This is achieved by measuring the depth of scum in the trash trap and by monitoring plastic/paper/grease accumulation in the clarifier scum baffle area.




Flow Equalization

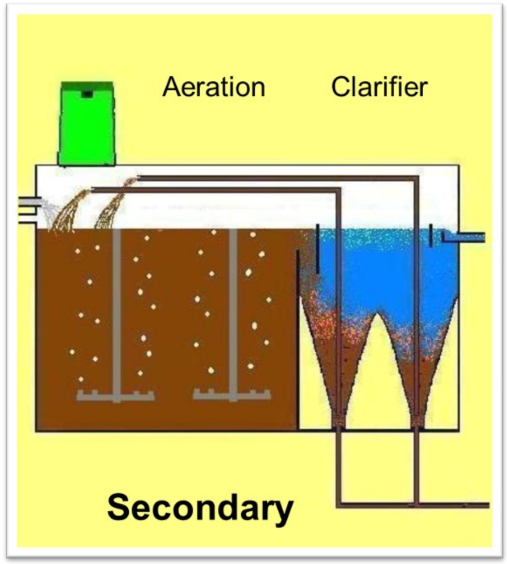
If the transfer line is continually flowing full there is a problem which needs to be investigated and eliminated. The transfer line is designed to prevent the wastewater from backing up into the trash trap by allowing wastewater to flow by gravity if there is an electrical outage or the EQ pumps become inoperable.

Verify all submersible pumps in the flow EQ tank function in the "ON" and "AUTO" position of the controls. It could be a mechanical problem with the pumps or an electrical problem with the control panel or floats.

Verify the motor and blower, which provide mixing to the Flow EQ tank, is operational. Confirm the blowers provide sufficient pressure to mix the Flow EQ tank when the water elevation in the EQ tank reaches the same elevation as the transfer line.


Problems that occur this early in the treatment process have a greater impact on effluent quality. When the first domino falls, all downstream treatment stages are impacted. These physical processes require visual analysis which is inexpensive and prevents the "domino effect", but typically is neglected due to complacency. The most valuable tool available to you in controlling the process is to notice what the system "looks" like when operating efficiently and be aware of the subtle changes that indicate a drifting from this idea operational condition.

## Secondary Stage - Aeration




The secondary stage is a physical and biological process which will require visual observations for the physical processes and chemical analysis to monitor the biological process.

The two units in the Secondary Stage, aeration tank and clarifier, work together to first convert dissolved and suspended pollutants to bacteria in the aeration tank and then to separate the bacteria from the water in the clarifier.

Visual observations of the aeration tank can provide information on the operational condition. Several factors to note are the color of bacteria in the aeration tank, the amount and type of foam on the aeration tank surface and the aeration mixing pattern.

Aeration Color

Aeration tanks treating domestic waste typically have a brown color. Color can range from a light, milky brown shade to a heavier, dark brown appearance. One reason for this variation in shades of color can be caused by the concentration of bacteria in the aeration tank. As bacteria concentrations increase, a darker shade develops.

Abnormal colors can be a grey shade, usually due to insufficient bacteria concentrations or insufficient aeration being applied or a black color from anaerobic condition. Neither of these conditions is acceptable for an aeration tank environment.

Observe the color of the aeration tank, and then compare the current color with the color of the aeration tank when the system is operating properly. This is a simple method of monitoring performance. The health and condition of the bacteria in the aeration tank determine the quality of the water discharged from the treatment system.

## Secondary Stage - Aeration

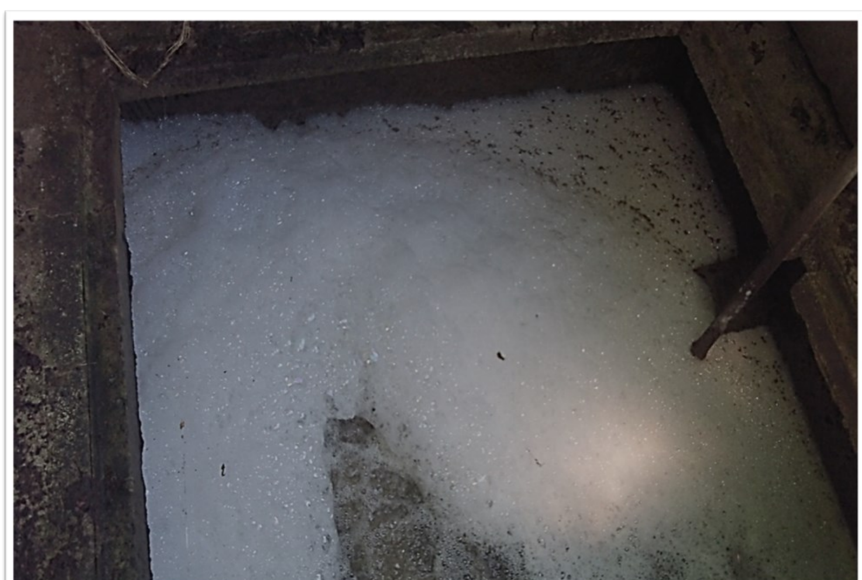
Aeration Foam

In addition to color, another visual clue is the appearance and amount of foam on the aeration tank. Foaming on the aeration tank surface is typically associated with one of two probable causes.

Having sufficient bacteria in the aeration tank to treat all of the influent pollutants is critical to prevent effluent violations. However, having an excessive amount of bacteria in the aeration tanks creates a "starved" growth condition in the aeration tank. Under this situation certain bacteria will generate faster than other types. Those bacteria, which will dominate in population under this starved condition, also generate a stable brown foam.

Typical remedies for eliminating the condition is to reduce the concentration of bacteria in the aeration tank. This requires the operator to reduce the amount of bacteria being used to treat the pollutants entering the aeration tank. The situation can also be adjusted by reducing the number of aeration tanks in service and/or reducing the run-time of the aeration tank blowers. This will be discussed in more detail later in this section on Controlling the Units.

Another foaming condition occurs when the concentration of bacteria necessary for treatment is insufficient. This type of biological environment develops white, crispy foam. This foam can be "knocked down" by spraying water. This typically occurs when the operator has removed too much bacteria from the aeration tank by over wasting or the biological environment is recovering from a toxic load or an extended time of having the aeration blower off.



## Secondary Stage - Aeration

Mixing Intensity

Another observation is the rolling pattern created by the diffused aeration. There needs to be sufficient mixing within the aeration tank to mix the influent pollutants with the bacteria. An important observation of the aeration tank should include the operation and mixing intensity of the diffused air.

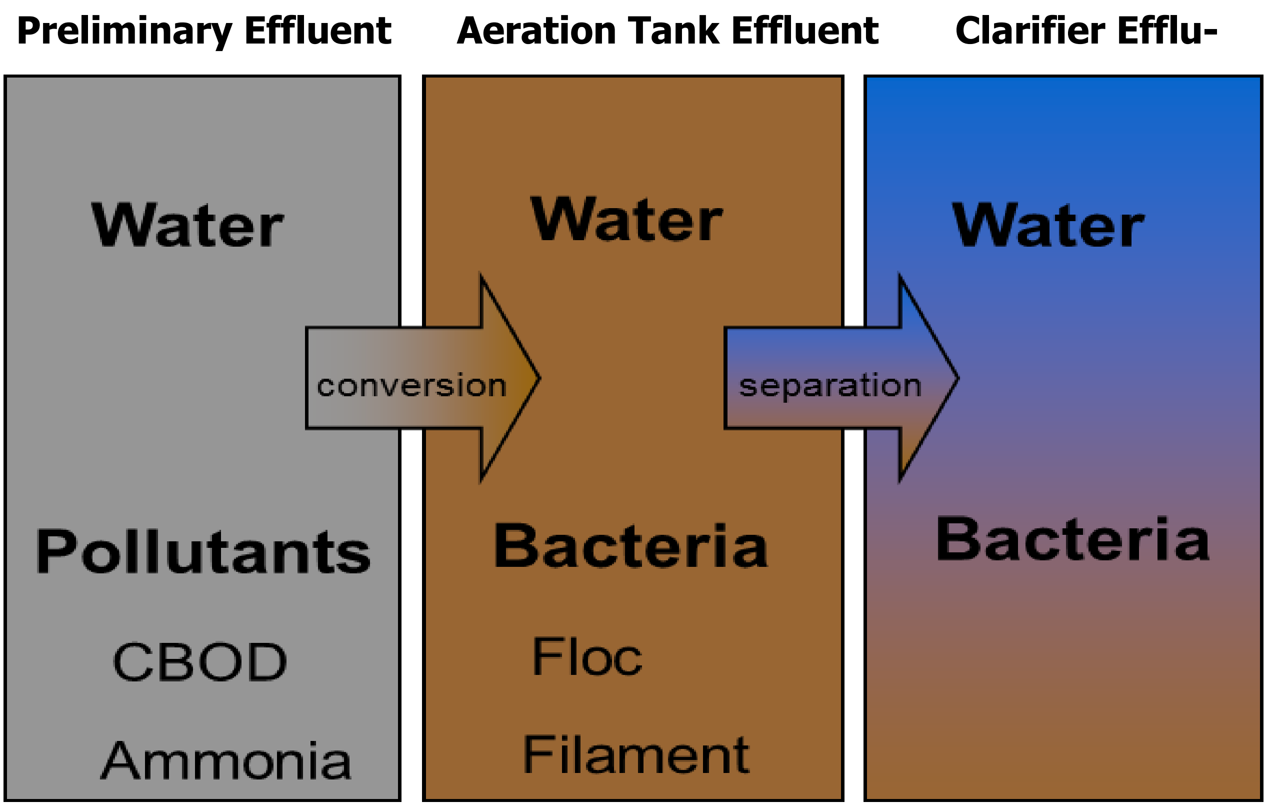
Ideally diffusers should be designed on the length of the aeration tank. Systems with diffusers along the width might require additional aeration to provide sufficient mixing within the aeration tank.


The aeration tank is typically designed with equipment similar to the flow EQ for providing air and mixing. Switching the blower motor controls to "Hand" should bring the aeration unit into service. Switching the blower motor controls to "Auto" should bring the aeration unit into service depending on the timer setting on the clock located in the control panel. Manually adjust the clock to confirm the aeration unit is functioning properly. Once the aeration system is providing mixing to the aeration tank, observe the aeration pattern for mixing intensity and coverage.

By opening the valves controlling the air flow to the drop pipe, the mixing intensity and mixing coverage can be improved. When sufficient aeration is applied for adequate mixing you should be able to observe a rolling action across the surface of the aeration tank.

## Secondary Stage - Aeration

It is impossible to control the Secondary Stage by visual observations alone. There is a biological process associated with the conversion process in the aeration tank. This will require a different method for monitoring the process. The dissolved and suspended pollutants enter the aeration tank in the form of carbon, quantified as cBOD, and in the form of nitrogen as ammonia. These pollutants serve as a "food" source for aerobic bacteria in the aeration tank. These pollutants are consumed and then converted into more bacteria.



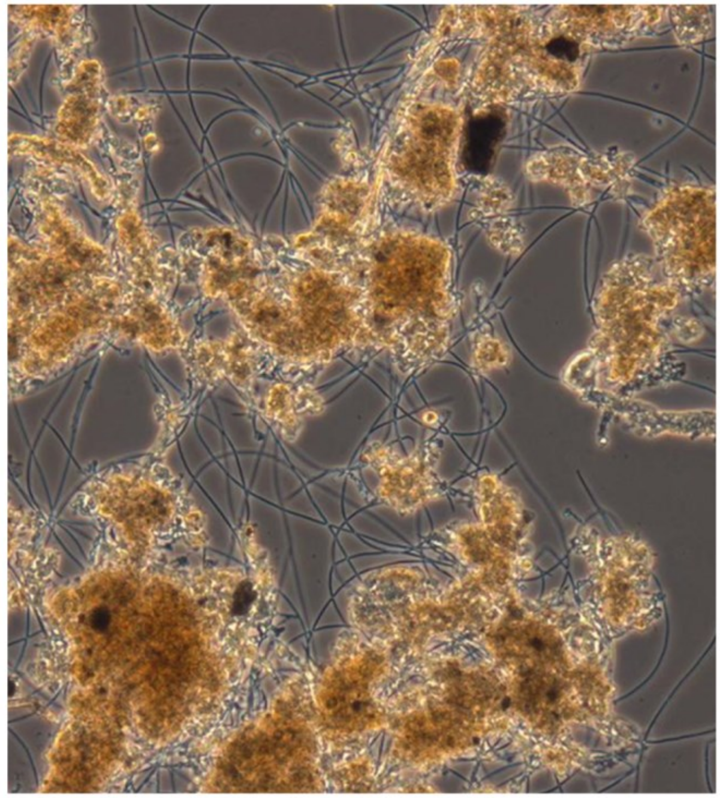

The Preliminary effluent has a high concentration of dissolved and suspended pollutants as cBOD and ammonia. These pollutants are converted to additional bacteria in the Secondary Stage aeration tank. The aeration tank effluent has a high concentration of flocculating and filamentous bacteria. As these bacteria separate from the water in the secondary Stage clarifier, the clarifier effluent has a low concentration of bacteria which prepares the water for final treatment in the Tertiary Stage.

The conversion process is monitored by measuring the ammonia concentrations after the Secondary Stage. Both pollutants, cBOD and ammonia are converted in the aeration tank, however the bacteria that convert the ammonia are more sensitive to the aeration tank environment. If the aeration tank environment is not adequate, ammonia will not be converted and will pass through the Secondary Stage. If ammonia concentrations from the Secondary Stage are less than 1 mg/L, then conditions are also adequate to convert the less difficult cBOD pollutants.

Because of the sensitivity of the nitrifying bacteria, we can chemically monitor the Secondary Stage ammonia concentrations to determine if conversion is complete. If ammonia values are low, conversion is complete. Chemical analysis for ammonia can be performed in the field within a few minutes.

## Secondary Stage - Aeration

These bacteria develop into one of two basic structures, either flocculating or filamentous bacteria. The dark brown clusters are flocculating bacteria. These bacteria grow together like "clusters of grapes" and add density which promotes faster settling characteristics.



A second type of bacteria structure, the filament, grows "end to end" and develops a "stringy" structure. This type of bacteria structure tends to settle much slower than the flocculating bacteria, however it helps to filter out fine suspended solids from the water column.

As these bacteria enter the clarifier this combination of flocculating and filamentous bacteria have sufficient density to settle and filter the water allowing clean water to leave the Secondary Stage and flow into the Tertiary Stage for final treatment.


Failure to convert pollutants to bacteria allows pollutants to pass through the Secondary Stage into the final effluent. Failure to separate bacteria from the clean water causes solids to accumulate on the sand filter. Neither is desirable. Controlling the biological environment in the aeration tank is critical to first provide the necessary conditions to convert all the pollutants into bacteria and to "develop" a bacterial culture which will settle and filter in the clarifier.

Conversion of pollutants is the first goal. You can not settle bacteria in a clarifier if you have not grown them in the aeration tank. When Secondary Stage effluent ammonia values are less than 1 mg/l, conversion is complete. Chemical monitoring of the secondary stage effluent will notify the operator is the conversion process is effective.

## Secondary Stage - Clarifier

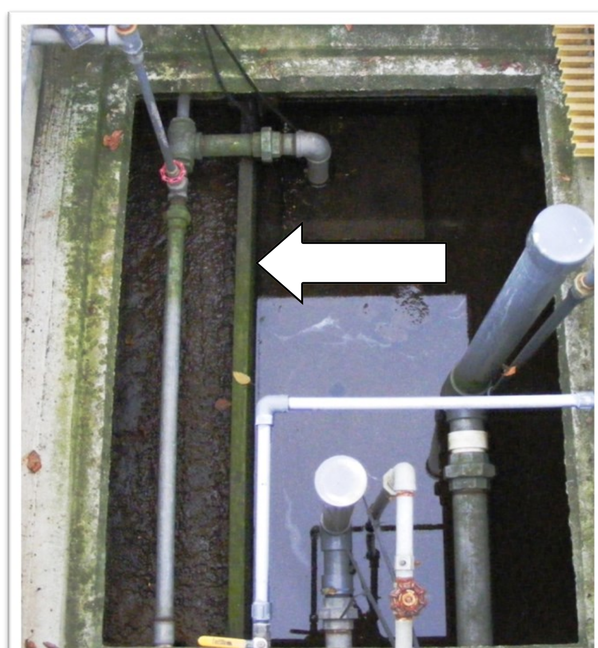
The clarifier is a physical process of gravity separation of bacteria from the clean water. These physical processes can be monitored by visual observation. Key monitoring points of the clarification process include the scum baffle, surface skimmer, weir baffle, weirs and the return pumping rate of settled bacteria (sludge) back to the aeration tank.

<u>Clarifier Scum Baffle</u>

To prevent floating materials not captured by the trash trap from entering the clarifier, a scum baffle is designed at the inlet to the clarifier.

Failure of the trash trap to capture these materials in the Preliminary stage allows them to accumulate in the clarifier scum baffle area.

The more significant the trash accumulation in the clarifier scum baffle area, the more likely the trash trap needs pumped out. While the septic hauler is on site pumping out the trash trap, request the scum baffle area be pumped out.



If the biological environment in the aeration tank is not properly maintained, strong, viscous type foam can be generated. This foam will naturally collect in the clarifier scum baffle area and harden over time. As this foam begins to break down anaerobically, dissolved pollutants are dispersed into the clarifier and will lead to upset conditions or violations of the permitted effluent limits.

Pumping out the foam is similar to placing a "Band-Aid" on a deep cut. The foam will return unless there is a change to the aeration tank environment which is producing the foam. Change the condition which is generating the foam in the aeration tank, then removal of the scum is beneficial.

## Secondary Stage - Clarifier

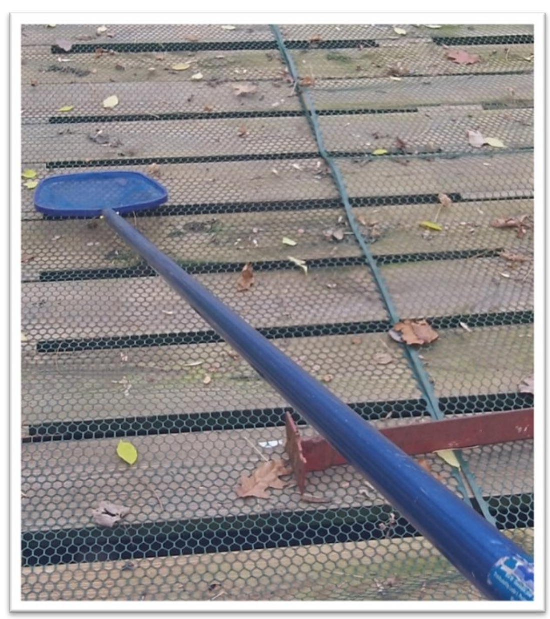
<u>Skimmer– operational</u>

The clarifier is designed with a skimmer to prevent undesirable material (paper, plastic, grease, biological foam, floating bacteria) from exiting the Secondary Stage and accumulating on the sand filter in the Tertiary Stage immediately downstream.

The first observation is to verify if the skimmer is operational. A visual inspection should verify if the skimmer is operational. The skimmer discharge will be directed to the aeration tank and should appear as clear water.

<u>Clarifier Skimmer– paper, plastic, grease</u>

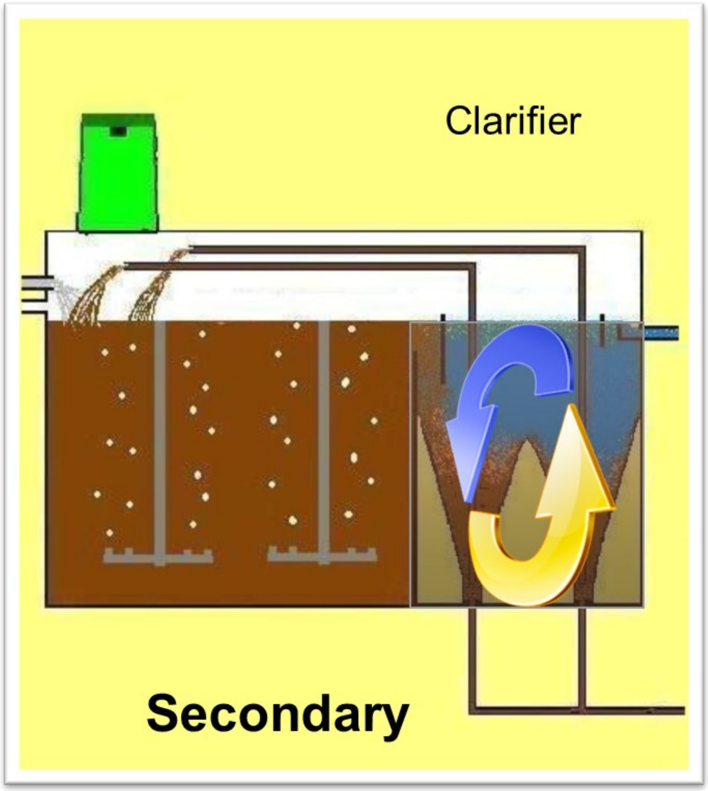
The skimmer operates on the principles of an air lift pump. (This air lift pumping is discussed in the <u>Basic Units</u> chapter.) The airlift pump has several advantages for use in a package plant treatment system, however, it has a limitation in effective removal of low density material (plastic, grease) from the clarifier's surface.



These low density materials will not be removed from the clarifier surface and will need to be manually skimmed from the clarifier. Manual removal is the best option for permanent removal.

Skimmer– paper, plastic, grease

Material of low density requires manual removal by the operator, but even material of higher density (paper, rags), normally removed by the skimmer, are pumped back into the aeration tank only to find their way back into the clarifier. In essence the clarifier surface skimmer does not necessarily remove floating material but recycles these material through the Secondary Stage.




This recycling of material does not provide a significant treatment value, however, it does have a negative effect by increasing the hydraulic flow through the clarifier. This increase in turbulence in the clarifier makes it more difficult to separate bacteria from the clean water.

Operating the skimmer continuously is not necessarily the most effective mode of operation. Manually cleaning floating material is more effective, then the skimmer can be taken out of service so the hydraulic pressures through the clarifier are more conducive for separation of bacteria from the water in the clarifier.

Clarifier Skimmer– biological foam

The environmental condition of the aeration tank has a significant impact on the types and concentration of bacteria which are generated. As discussed previously, the aeration tank which experiences a "starved" growth environment will generate a type of bacteria which causes a brown foam on the aeration tank. If the aeration growth environment is not corrected, this biological foam will become so excessive the foam will migrate to the clarifier and can cover the entire surface area.

Biological foams generated from improper aeration tank environments can be returned, but depending on the severity of the foaming conditions the skimmer will eventually become overwhelmed. Again, first focus on stopping the generation of the foam in the aeration tank, and then, work on removal of the foam from the clarifier.

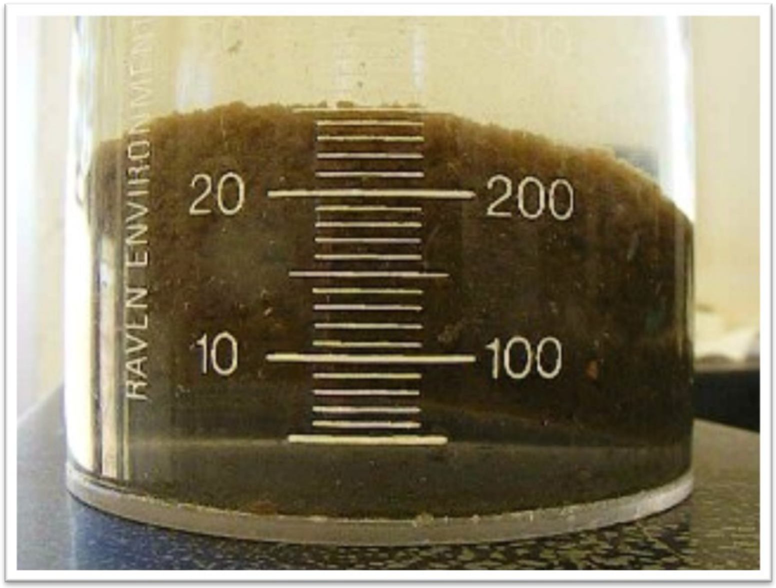
Since this biological foam is generated in an aeration tank which is operating at a "starved" growth condition, the solution is typically to adjust the ratio of food (pollutants coming into the aeration tank) to micro-organisms (the concentration of bacteria in the aeration tank). Since there is no control for increasing the influent pollutant concentration (food) the only option is to reduce "oxidative pressure" in the aeration tank. (reduce amount of bacteria in the aeration tank, reduce the number of aeration tanks in service, reduce aeration cycle times, combinations of all three options).

Skimmer– floating bacteria

There is a situation where the skimmer is very effective and continuous operation of the skimmer is beneficial. This occurs when the clarifier experiences floating bacteria in the clarifier.

In the aeration tank environment, the pollutant ammonia nitrogen ($NH_3$) is oxidized or converted to nitrate nitrogen ($NO_3$). Under aerobic conditions in the aeration tank the nitrate nitrogen is stable. However, it is possible for nitrate nitrogen to be converted to a nitrogen gas bubble ($N_2$) under certain environmental conditions (no dissolved oxygen), which can exist in the settled bacteria in the clarifier.

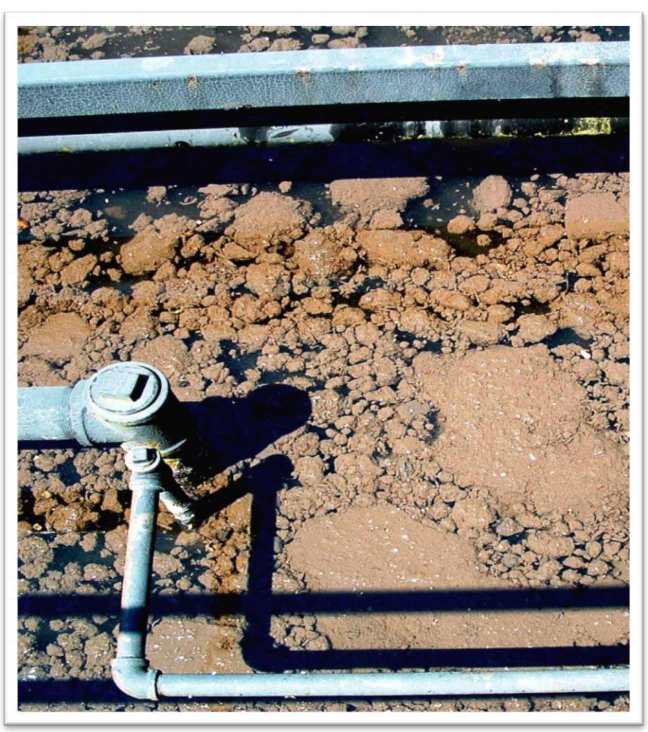
This environmental condition will occur if bacteria that have settled in the clarifier remain too long and are not returned back into the aeration tank.




When sufficient nitrogen gas bubbles are generated in the settled bacteria, the settled sludge becomes buoyant and is lifted to the clarifier surface. This is commonly referred to as "popping" of the settled sludge and technically termed denitrification.

Here is a photo of bacteria which has settled in a settleometer and now is beginning to "pop" due to nitrogen gas bubbles being generated within the compacted sludge.

The surface of the clarifier will contain "clumps" of sludge which are being suspended by the nitrogen gas bubbles attaching themselves to the once settled sludge. To confirm this as denitrified sludge, a gentle agitation of the floating sludge will typically detach the nitrogen gas bubbles and the floating solids will immediately settle out.



Since the floating sludge will settle out after the gas bubble is removed, the skimmer is capable of returning the sludge back to the aeration tank. Unlike low density material, like plastic and grease, floating sludge is temporarily buoyant because of the gas bubble. If you remove the bubble, you remove the buoyancy.

Observation of "clumps" of compacted bacteria floating on the surface indicate settled bacteria are remaining in the clarifier too long and denitrification is occurring. To confirm if floating bacteria is due to denitrification gently disturb the floating bacteria on the clarifier surface. If the floating bacteria is gently agitated the nitrogen gas bubble will release and the bacteria will settle into the clarifier.

Skimmer– floating bacteria

Two possible causes for denitrification are (1) settled bacteria are not able to reach the inlet to the return activated sludge pump (RAS) which pumps settled bacteria back to the aeration tank or (2) the clarifier sludge blanket is too high in the clarifier.

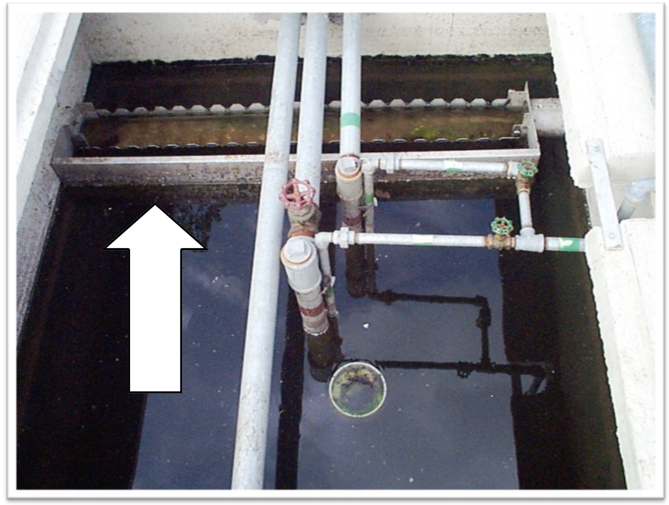
Bacteria entering the clarifier may settle out and be unable to reach the inlet of the RAS pump. This is due to bacterial solids settling on the sloped side walls. The typical clarifier used in package plant design is the "hopper" type clarifier. The hopper design has side walls that slope to the center of the tank to allow settled sludge to accumulate near the intake of the return sludge pump.

The solution requires the operator to scrape the side walls to prevent solids build up in the clarifier. A simple squeegee can be used to gently push solids on the side wall down to the inlet of the return pump.

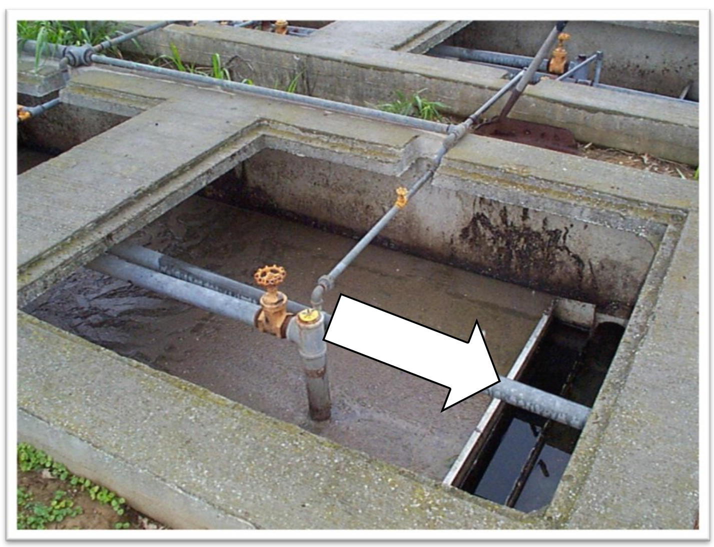
An early indicator of the onset of denitrification is that the clarifier surface may contain a dusting of what appears to be ashes on the surface. This is commonly referred to as "ashing" and can be a visual indicator . Again, a gentle agitation of the floating ashes will release the nitrogen gas bubble and the floating solids will settle out. Ashing by itself is not an operational issue, but is an indicator of the potential of more serious denitrification to follow if the situation is not addressed.

## Weir Baffle

The last step to prevent floating material from exiting the clarification unit of the Secondary Stage is the weir baffle. This baffle is located near the clarifier's effluent weir and is intended to retain any surface scum that has made it past the trash trap and clarifier scum baffle or, denitrified sludge which has "popped" to the surface after entering the clarifier.



At this point in the treatment process it is best to physically remove any floating paper, plastic or grease. A swimming pool net is a useful tool for cleaning the clarifier's surface.



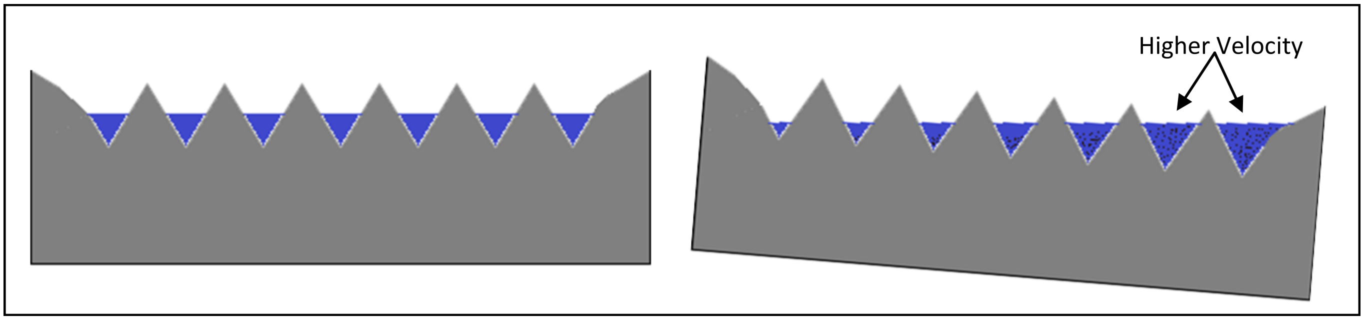
Excessive biological foam generated in the aeration tank will be retained by the weir baffle however, the floating bacteria will begin decaying and re-releasing dissolved pollutants into the water which will lead to effluent violations of the NPDES permit. Don't allow the clarifier to be smothered by biological foam.

Solids which overflow the clarifier weir at this point in the treatment process are captured on the sand filter. The skimmer is most effective in removing this floating bacteria if the operator guides this floating bacteria into the skimmer and physically removes the low density material.

## Weir

The clarifier effluent weir is the exit point of the treated water from the secondary stage. As water enters the clarifier from the aeration tank, the solids settle and the clean water overflows the weirs and discharges into the next treatment stage.

The weir must be keep level so the water overflows the entire length of the weir. If the weir is not level, water will overflow a smaller section of the weir. This smaller overflow area increases the velocity of the water overflowing the weir. An increase in velocity overflowing the weir can cause suspended solids to be "pulled" up and out of the clarifier.



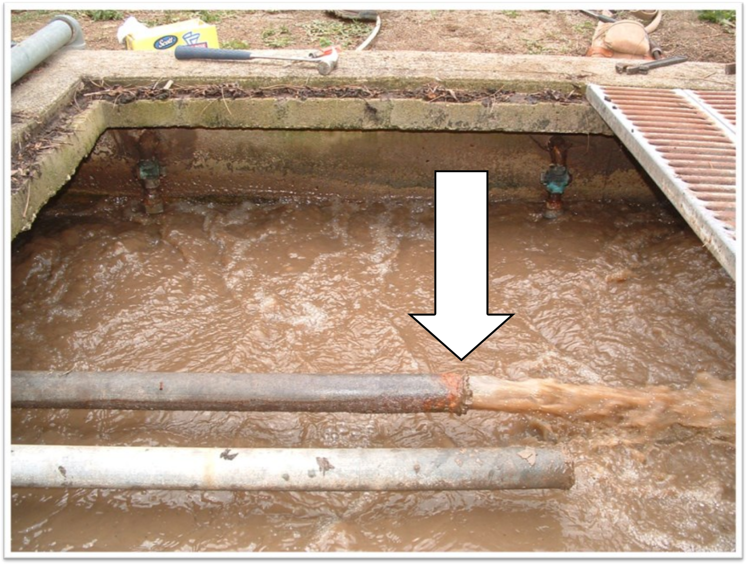

The weir on the left is level which causes the water to overflow each v-notch equally. The weir on the right is not level. As the water elevation rises in the clarifier more flow occurs at the v-notches which are lower. The flow through the lower v-notches has a higher velocity which "pulls" solids over the weir and leads to solids loss.

Weirs should be level when installed, however, algae growth on sections of the weir can cause sections of the weir to be obstructed, which leads to higher velocity in other areas. The solution is keep algae growth from blocking sections of the weir.

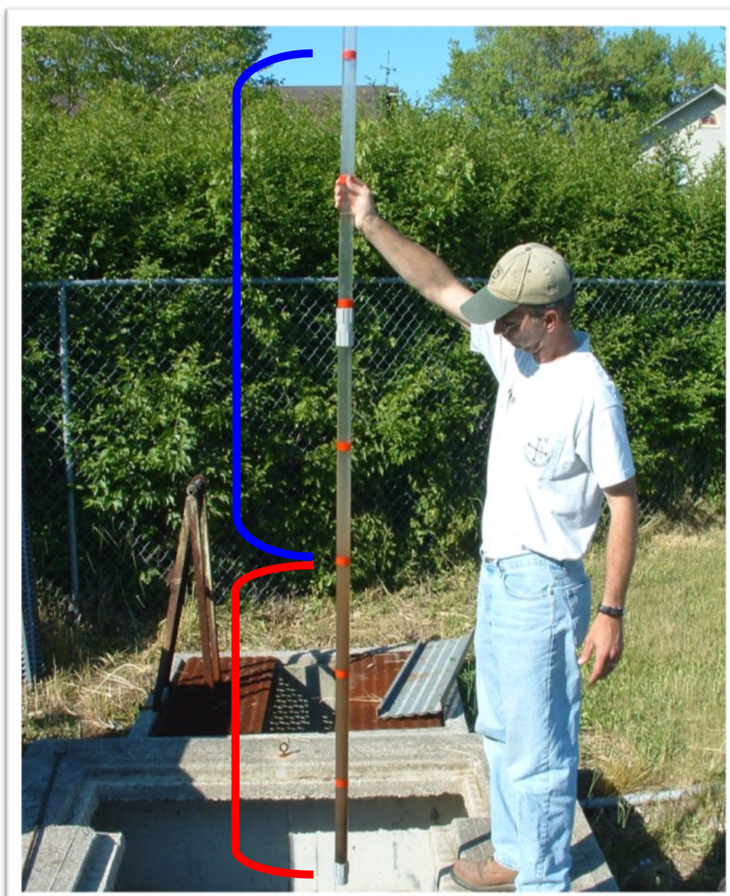
A " swimming pool" brush can be used to prevent the excessive build up of algae on the clarifier effluent weirs.

Return Sludge Pump

One last device within the clarifier is the return sludge pump. A simple visual observation is used to determine if the return sludge pump is operational. The return sludge pump is an air lift pump and requires a blower to provide air to operate. If the blower is not in operation the RAS pump will be off.



The settled bacteria being returned from the clarifier hopper will typically be a darker color since the settled sludge should be at a higher concentration.

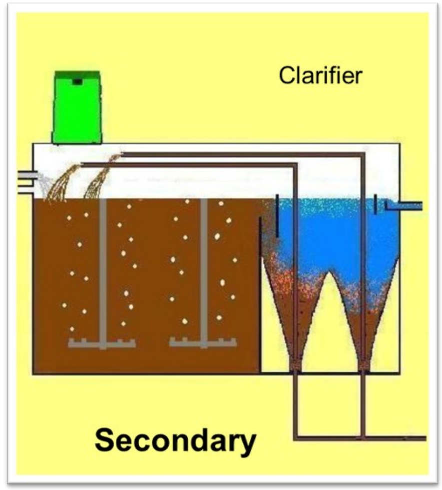


After confirming the Return Activated Sludge (RAS) pump is operational the next visual observation is to determine if the pumping rate is correct. A clarifier core sampler is slowly used to visually monitor the settling effects of the bacteria in the clarifier. The core sampler is inserted into the clarifier from the surface to the deepest depth located near the inlet of the RAS pump. As the core sampler is withdrawn, a foot valve at the bottom seals off the tube and a representative profile of the settling environment of the clarifier is obtained.

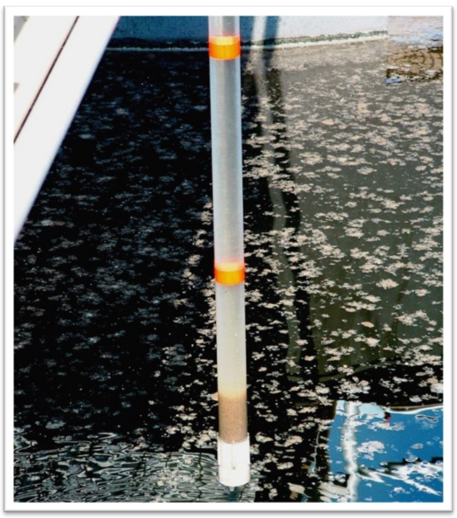
In the photo on the right the bacteria have accumulated and formed a "sludge blanket" of approximately three feet in depth (red bracket). The area above the sludge blanket in this core sample is fairly clear and is referred to as "supernatant". There is approximately four feet of supernatant in this core sample (blue bracket).

Return Sludge Pump

When the return sludge pumping rate is correct, a sludge blanket occupies approximately 20% to 30% of the clarifier depth. Like most dual hopper clarifiers, the first hopper will typically have a higher sludge blanket level than the second hopper. Use a clarifier core sampler and measure each hopper. Average the two sludge blanket levels and determine if they are less than 30% of the clarifier water depth.




Each hopper has its own RAS pump and it can be adjusted by increasing or decreasing the air flow into the RAS inlet pipe. Minor adjustments are possible, however, the air lift pump has a narrow operational range. If the air flow to the inlet pipe is restricted too much the pump will fail and the sludge blanket will increase in depth. Because of this narrow range, operators will error on operating the RAS pumping rate greater than desired, however, too fast of a return rate also has disadvantages.

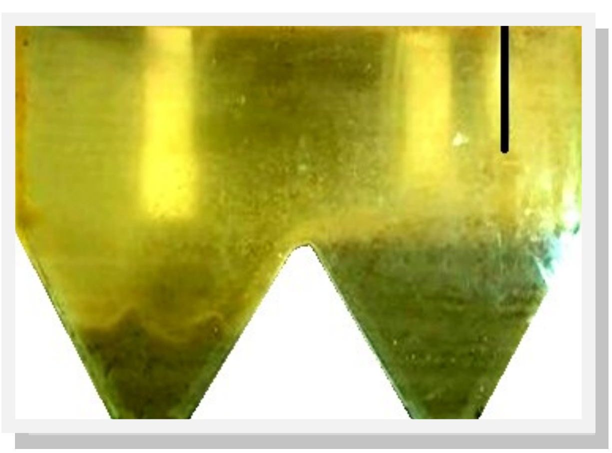


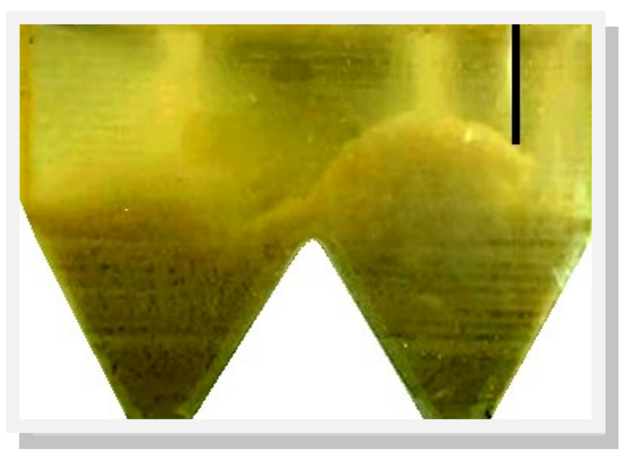
The faster the RAS pumps the more the clarifier experiences greater hydraulic pressure. This increased flow through the clarifier works against the clarifier's main responsibility; separating bacteria from the clean water.

The RAS pump is capable of pumping faster than bacteria can settle to the bottom of the clarifier. Increasing the RAS pumping rate will NOT bring bacteria to the bottom of the clarifier faster, but can actually keep them from settling due to the increased hydraulic pressure within the clarifier.

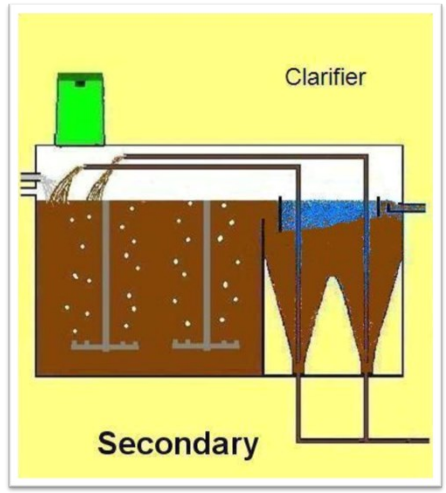
Sludge blankets less than one foot in depth are close to being non-existent. A LOW sludge blanket is okay, but NO sludge blanket can eventually lead to solids loss.

The photos below show what happens to the sludge blanket if the RAS pumping rate is faster than the bacteria settling rate. The photo on the left represents the sludge blanket condition at a certain pumping rate. The photo on the right is the same clarifier which has increased the RAS pumping rate. The black line in each clarifier represents the influent scum baffle to the clarifier. Notice the increase in the sludge blanket in the photo on the right due to the increased RAS pumping rate.





## Return Sludge Pump




The pumping rate of the return sludge can have a significant impact on performance.

If the return sludge pumping rate is too slow more solids are going into the clarifier than what is being pumped out of the clarifier. Eventually the solids will accumulate in the clarifier and the settled sludge blanket will increase in depth.

As the sludge blanket increases, the efficiency of the clarifier in retaining solids decreases, which leads to solids loss from the secondary stage. An adjustment to increase the pumping rate will bring the sludge blanket down to a more desirable depth.

A sludge blanket which occupies 80% of the clarifier capacity only has 20% of the clarifier available for solids separation.

Using the clarifier core sampler to identify if the RAS rate is too slow or too fast is simple and easy to perform. If the sludge blanket is within the desired 20% to 30% range, then no adjustments are necessary. However, if the blanket doesn't fall within this range the desired RAS pumping rate needs to be determined and then adjustments made to bring the pumping rate within an acceptable range.

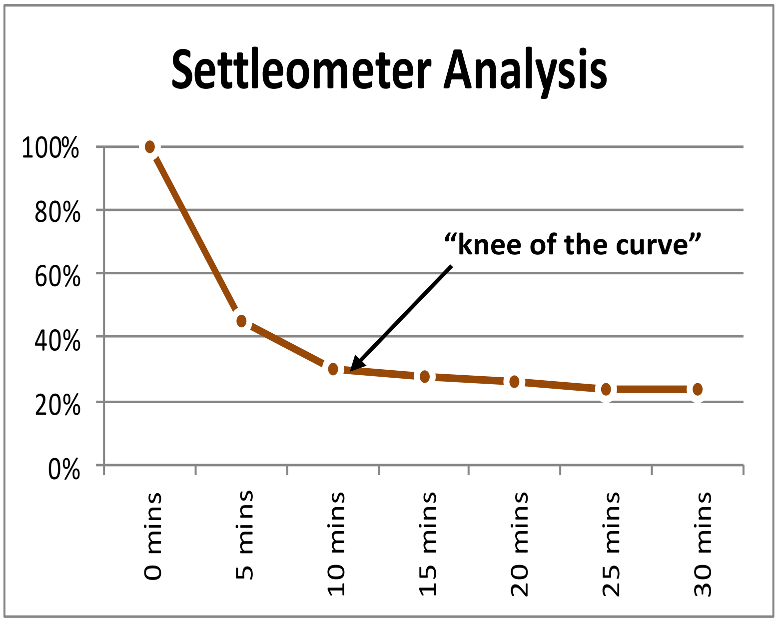
The first step is to determine the settling rate of the bacteria. After the bacteria settling rate is determined then the RAS pumping rate needs to be determined. If the pumping rate is faster than the settling rate, the RAS rate is decreased. If the pumping rate is slower than the settling rate, the RAS rate is increased.

Both of these measurements (settling and pumping rate) can be determined with in a few minutes with the use of a settleometer and a centrifuge. It is important to know you cannot use the RAS pump to "pull" bacteria to the bottom of the clarifier, but you can use the RAS pump to "expand" the settled sludge blanket! RAS pumping rates must be adjusted to match the sludge settling rate. RAS rates based on another condition can eventually lead to solids loss from the clarifier.

Return Sludge Pump

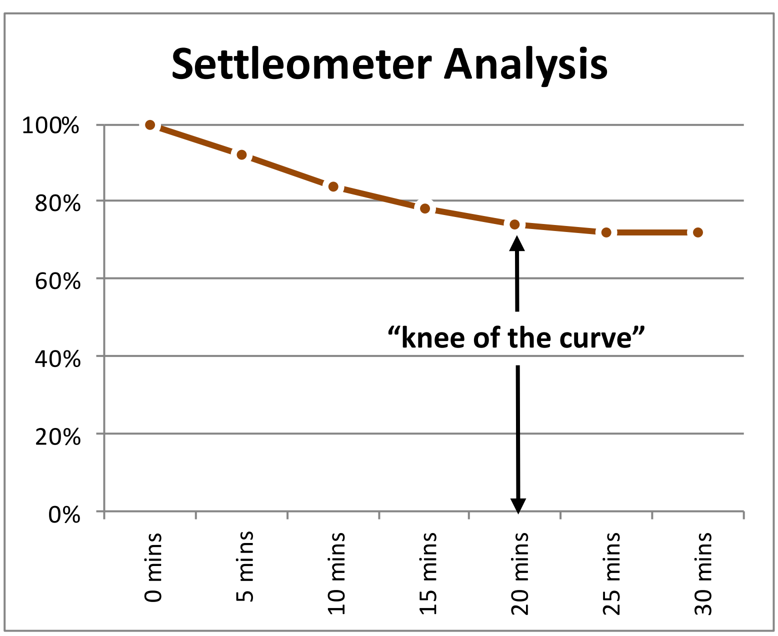
Determining the settling rate of bacteria

The settling rate is determined by the use of a settleometer. A settleometer is a clear cylinder marked with increments in percent by volume. A sample of the aeration tank effluent is collected and the settleometer is filled to the 100% mark. As the sludge settles in the settleometer the sludge elevations are recorded at 5 minute intervals.





The data recorded is then charted to visually identify the settling rate. The data represented in the chart above indicates the bacteria settled fairly fast in the first 5 minutes of the analysis, but the settling rate decreased and experienced less compaction as time went on. Based on the chart the bacteria settled well in the first 10 minutes, a 70% reduction in volume, however only reduced in volume by 6% in the remaining 20 minutes. This break in the curve is the referred to as the "knee of the curve". The knee is the point at which the bacteria has settled sufficiently and should be returned back into the aeration tank by the RAS pump.



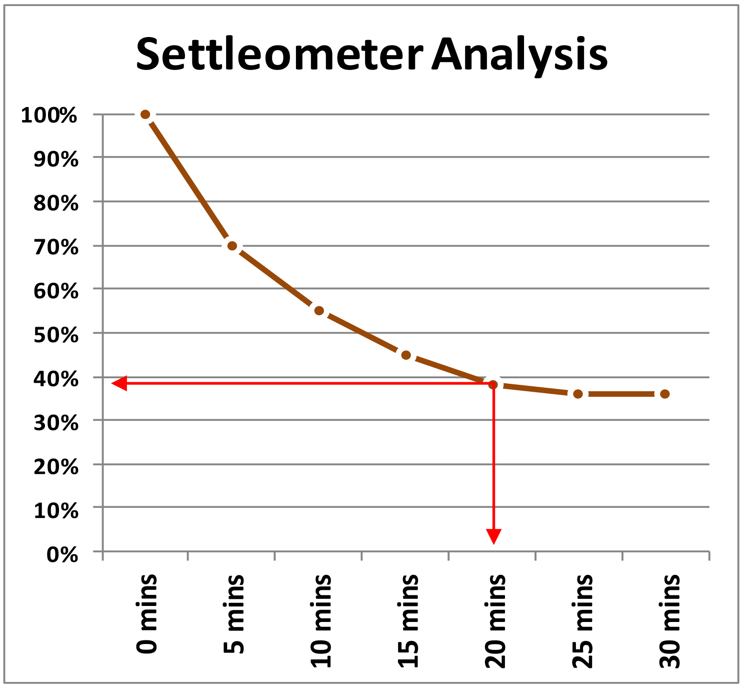

The settling curve could look significantly different when the bacteria settles slower. In the chart to the left the knee of the curve occurs at the 20 minute time frame and has not even reduced in volume by 50%.

The settleometer has no internal hydraulic currents to keep bacteria suspended. If the bacteria are settling this slow in a settleometer, it will settle even slower in the clarifier with an internal recycle from the RAS pump. A slower settling rate requires a slower RAS pumping rate.

## Return Sludge Pump

Determining the pumping rate of RAS

Based on the settleometer data below, the bacteria settling rate does not significantly changes after the 20 minutes interval (knee of the curve).




| Time, mins | Settled Volume % |
|---|---|
| 0 | 100% |
| 5 | 70% |
| 10 | 55% |
| 15 | 45% |
| 20 | 38% |
| 25 | 36% |
| 30 | 35% |

Since the bacteria has settled as effectively as possible at this point the RAS pumping rate should be removing the settled sludge from the clarifier after 20 minutes of settling. If so then the RAS pumping rate would match the bacteria settling rate.


Knowing the bacteria settling rate is the first step. Knowing that the RAS pumping rate needs to match the settling rate is also important. The last piece of information missing is determining what the actual RAS pumping rate is and that is done with the use of a centrifuge.

The centrifuge allows the operator to measure the solids concentration of the bacteria in the aeration tank and the clarifier RAS within 15 minutes.

By measuring these two locations for solids concentration and using the settleometer data, sufficient information is available to determine if adjustments are necessary to the RAS pumping rate.

## Return Sludge Pump

### Determining the pumping rate of RAS


Collect a sample of the aeration tank effluent and RAS being pumped into the aeration tank (left photo). Fill a centrifuge tube to the 100% mark on the centrifuge tube (center photo). Spin the centrifuge tube for 15 minutes and record the compacted sludge volume in centrifuge tube (right photo).


The centrifuge provides an estimate of the bacteria concentration in the aeration tank and in the RAS. The RAS pumping rate will be adjusted based on the bacteria concentration of the RAS and settling rate of the bacteria.

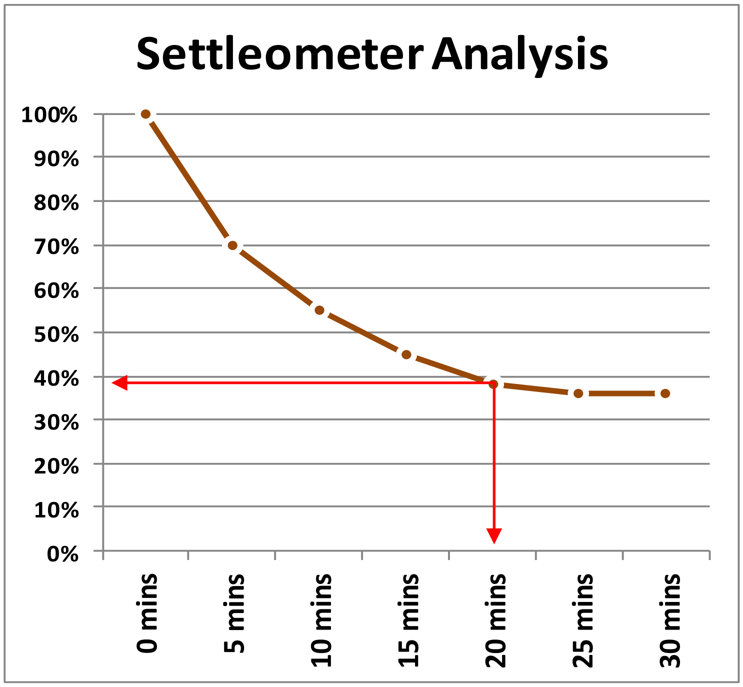
The Aeration Tank Concentration, (ATC), is the bacteria concentration of the aeration tank by percent volume. The Return Sludge Concentration, (RSC), is the bacteria concentration of the RAS by percent volume.

When performing the settleometer analysis, the bacteria settle and compact over time. As the bacteria compacts in the settleometer the concentration of bacteria increases. Eventually the bacteria reach the "knee" and the settling rate decreases significantly. It is at this point in the settling analysis that the return pump should be removing the bacteria and returning it back to the aeration tank.

We can perform a simple calculation to determine the bacteria concentration in the settleometer at this "knee". If the concentration of the RAS matches the concentration of the bacteria at the 'knee" then the RAS pumping rate is dialed in and does not need adjustments. If the RAS concentration is greater than the "knee" concentration, the RAS rate is too slow and the needs to be increased. If the RAS concentration is less than the 'knee" concentration, the RAS rate is too fast and needs to be decreased. If the RAS pumping rate is correct, but the sludge blanket in the clarifier is greater than 30% of the clarifier water depth, then most likely too many solids are in the system and wasting to the digester is

Return Sludge Pump

Adjusting the RAS pumping rate to match settling rate




| Time, mins | Settled Volume % |
|---|---|
| 0 | 100% |
| 5 | 70% |
| 10 | 55% |
| 15 | 45% |
| 20 | 38% |
| 25 | 36% |
| 30 | 35% |

**ATC (aeration tank concentration) = 2.5 %**

**RSC (return sludge concentration) = 5.5 %**

Using the data above we can determine what the desired RAS concentration should be and if the RAS pumping rate needs to be adjusted.

Use the following formula to determine the desired RAS concentration:

$$\frac{\text{ATC x 100}}{\text{"knee value"}}$$

The "knee value" is the settled volume of the settleometer, which identifies where the bacteria have stopped settling. Drop all percent signs and use absolute values (i.e. (2.5 x 100)/38 = 6.5 )

$$\frac{2.5 \times 100}{38}$$

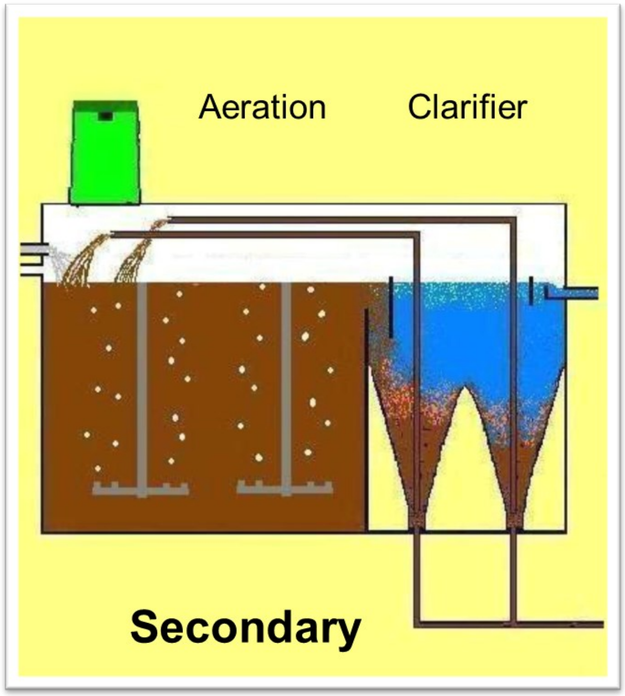
The settling characteristics indicate that when the bacteria in the settled sludge concentrates to 6.5 % by volume, the settled bacteria should be returned to the aeration tank.

If we compare the desired RAS concentration (6.5%) to the actual RAS concentration (5.5%), you can see the actual RAS is lower in concentration than the target RAS concentration. Increasing the RAS concentration would require the RAS rate to be reduced to allow for the sludge blanket in the clarifier to thicken and move towards the target value of 6.5% .

If the actual RAS concentration is greater than the target RAS concentration (based on settling rate of bacteria), then the RAS pumping rate is too slow and would need to be increased.

Measure the settling rate and RAS concentration, then adjust the RAS pumping rate to optimize the clarifier's performance.

**Secondary—Summary**




The two goals of the Secondary Stage are to completely convert pollutants into bacteria.

Under the proper environmental conditions in the aeration tank, the bacteria which are generated have the capability to flocculate or stick together and have sufficient density to settle in the clarifier.

The clarifier provides a quiet area for these bacteria to settle and compact, so that they can be returned back to the aeration tank to continue the conversion process.

The conversion process in the aeration tank is a biological process which requires chemical analysis to monitor and control. A simple field test kit can be used to determine if the conversion process is complete.

There are also visual indicators of the aeration tank to track the process.

Some of the visual indicators used to monitor the aeration tank are:

1. The color of the aeration tank bacteria.
2. Presence of foam on the aeration tank surface.
3. Mixing pattern of the aeration tank.

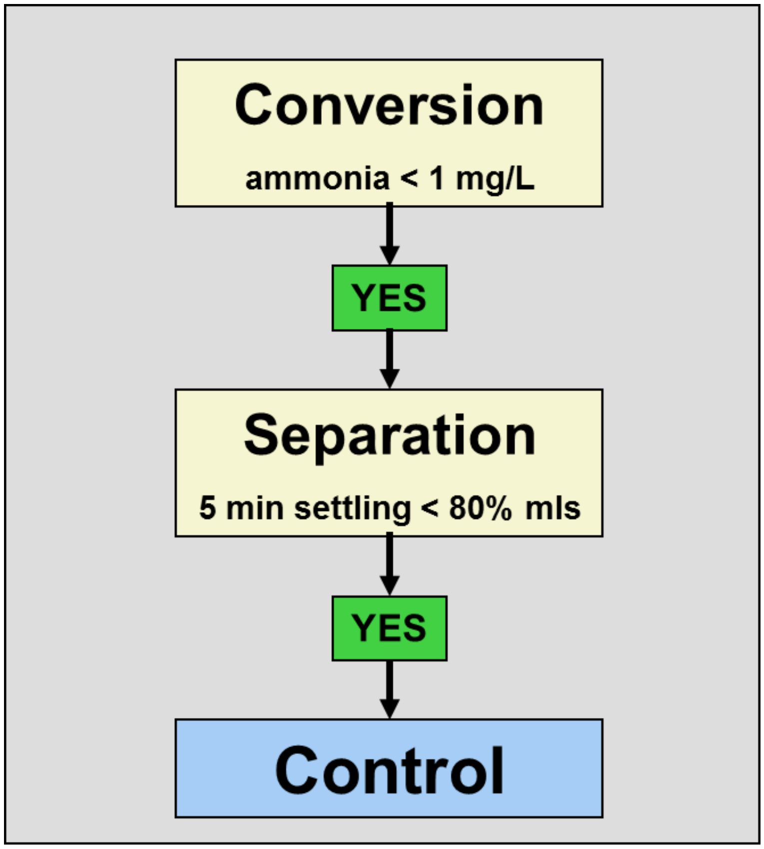
The clarifier is a physical process which also can be monitored by observations.

Visual indicators used to monitor the clarifier are:

1. Scum accumulation behind the clarifier scum baffle.
2. Clarifier surface free from floating grease, denitrified sludge, plastic, and paper.
3. Surface skimmers and return activated sludge pumps are operational.
4. Clarifier weirs level and water flows over evenly.
5. RAS pumps adjusted to the settling rate of the bacteria.

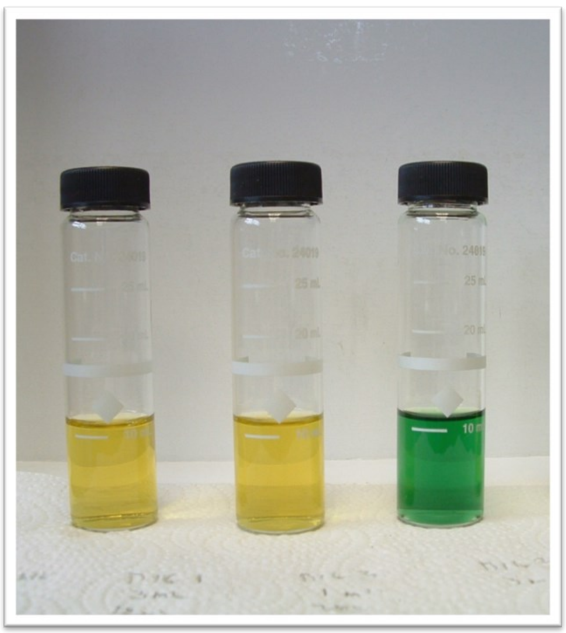
Controlling the "heart" of the activated sludge treatment system is based on a simple objective of converting pollutants into bacteria which will separate, filter and compact in a clarifier.

## Secondary—Process Control




Two simple methods to determine if conversion is complete and the settling characteristics are desirable is to monitor the ammonia concentration from the clarifier effluent and to observe the settling rate of a sample from the aeration tank effluent.

In the conversion process, it is more difficult for the bacteria to convert the ammonia pollutants than the carbon pollutants. Because of this condition, if the biological system begins to experience difficulty in the conversion process it will first be identified by an increase in the ammonia nitrogen concentration in the clarifier effluent.



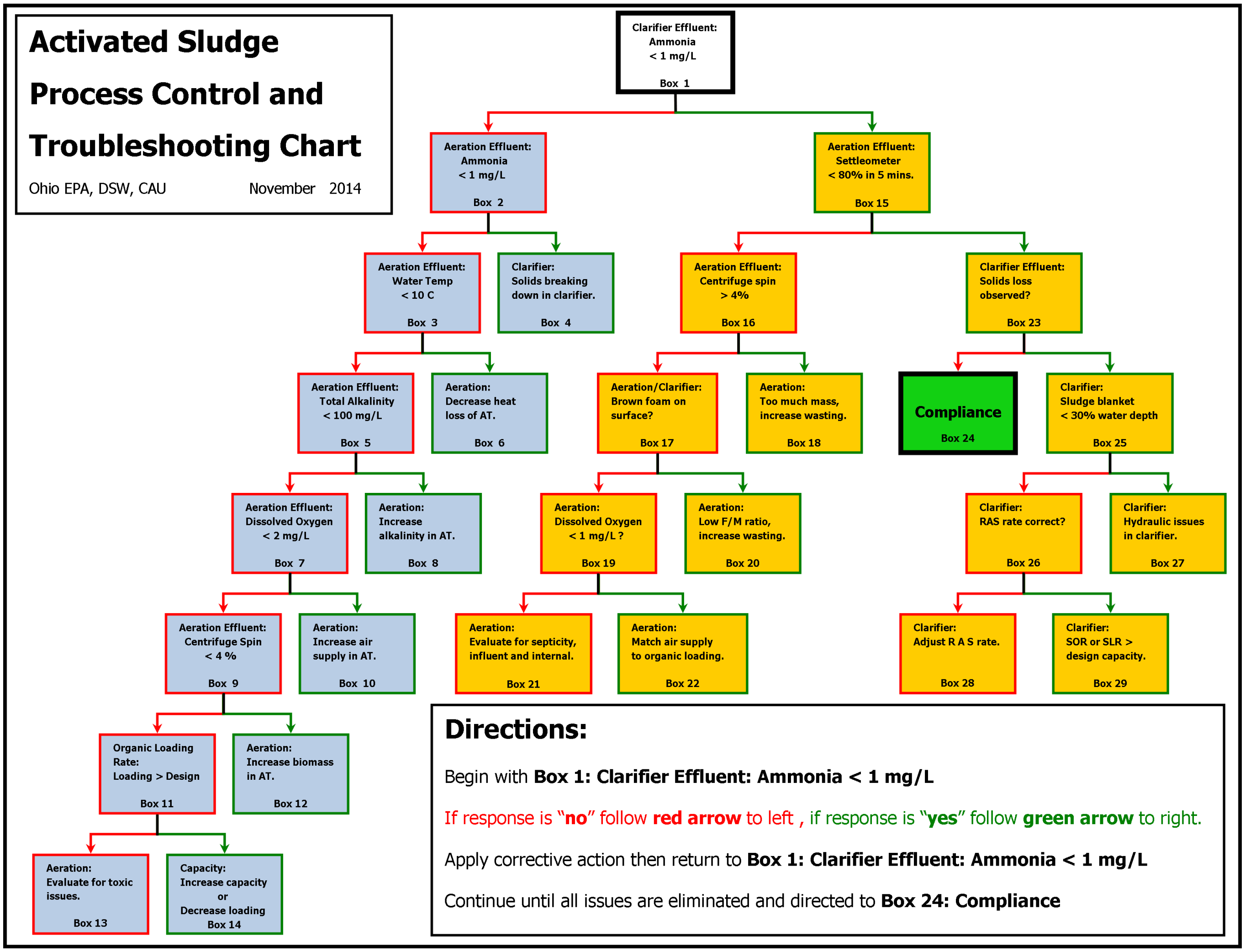
Monitoring ammonia nitrogen concentrations will provide an "early warning" when the system is being stressed and requires an adjustment. When clarifier ammonia concentrations are less than 1 mg/L, conversion is complete.

When the bacteria will not settle or flocculate in the clarifier, excess solids will be lost to the sand filter. Monitoring the settling characteristics of the bacteria will indicate when a problem is starting to develop. Making corrections to the treatment system before problems develop is "process control". Waiting until control is lost moves you into trouble-shooting and clean-up mode. The settleometer analysis will identify if the settling rate is an issue within 5 minutes.

## Secondary—Process Control Methodology

The following ***"Activated Sludge Process Control and Troubleshooting Chart"*** methodology was developed by the Ohio EPA Compliance Assistance Unit based on lessons learned from experienced operators and is intended to provide a streamlined approach to *"diagnose"* problems associated with the activated sludge process. The techniques employed offer the opportunity to incorporate these simplified methods into the daily *"control"* of the various activated sludge processes.

This methodology evolved from many years of field work and was developed out of the necessity to quickly diagnosis process control problems and return wastewater treatment facilities to NPDES permit compliance. It is designed to confirm and/or eliminate potential process control issues with the least amount of time, effort, sampling and analysis.




### How to Use the "*Activated Sludge Process Control and Troubleshooting Chart*"

The reader is to begin at the top (Box #1) of the ***"Activated Sludge Process Control and Troubleshooting Chart"***. Respond to the statement with a "yes" or "no" and follow the directions provided at the bottom of the chart. If the response to the question asked in the box is "no", follow the red arrow to the left to be directed to collect additional information to continue the diagnoses of the situation. If the response to the question asked in the box is "yes", follow the green arrow to the right to be directed to the cause and solution to the issue. A copy of the chart is attached.

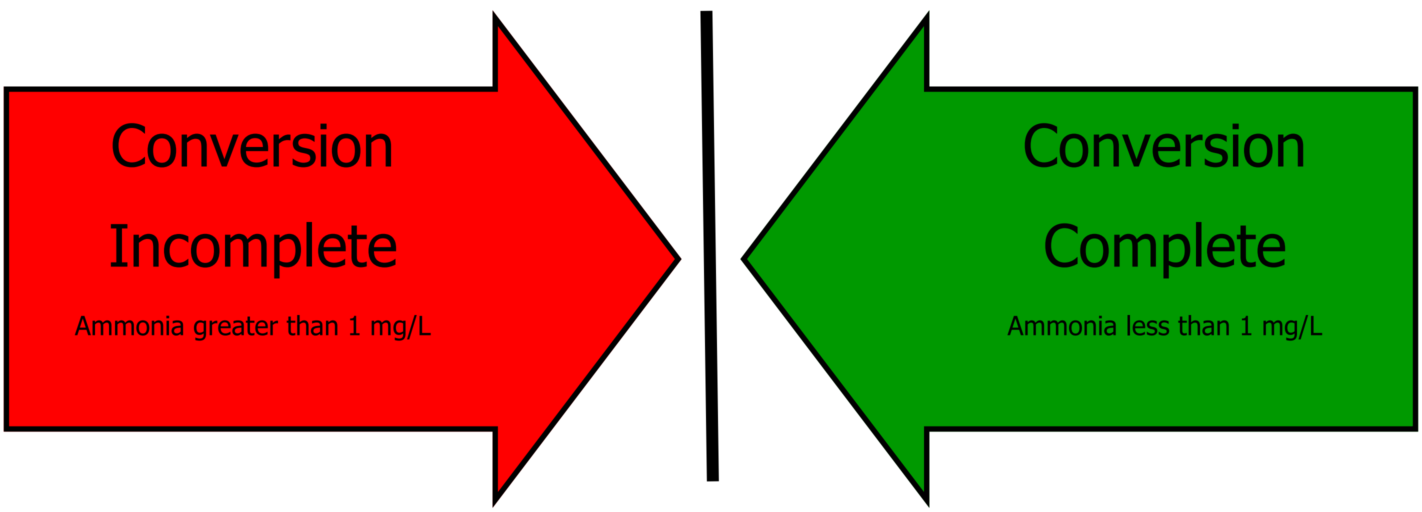
## Activated Sludge Process Control and Troubleshooting Chart

### Box # 1: Clarifier Effluent Ammonia < 1 mg/L

Wastewater contains pollutants in the form of carbon (cBOD) and ammonia nitrogen ($NH_3$). Bacteria in the aeration tank convert these pollutants into new bacterial cells (biomass) and more desirable forms of carbon ($CO_2$) and nitrogen ($NO_3$), thus preventing degradation of the receiving stream. Nitrifying bacteria in the aeration tank convert the incoming ammonia nitrogen to the less objectionable form of nitrogen called nitrate ($NO_3$).

These nitrifying bacteria are very sensitive to environmental conditions for growth. Due to this sensitivity, monitoring the conversion of ammonia to nitrate provides an "early warning" indicator of when an adjustment to the process is necessary. Anything which limits the effectiveness of the nitrifying bacteria to convert ammonia to nitrate will cause the aeration tank effluent ammonia concentrations to increase, an indication of loss of the conversion process (i.e. loss of control). Ammonia nitrogen is not removed in the clarifier therefore it will pass through to the Tertiary Stage.

Typically, if the ammonia nitrogen concentration from the aeration tank effluent is <1 mg/L, it is assumed that both of the major pollutants (cBOD and $NH_3$) have been successfully converted, therefore the treatment objective of the aeration tank (conversion) is now complete. If conditions are met, then the clarifier effluent will also have an ammonia concentration of < 1 mg/L.




The aeration tank "conversion" process must be completed first; therefore it is always the first measurement in the troubleshooting processes for activated sludge systems. If the ammonia nitrogen concentration from the clarifier effluent is greater than 1 mg/L, it indicates the aeration tank conversion process is incomplete or ammonia nitrogen is being generated downstream of the aeration tank in the clarifier. Ammonia nitrogen is only converted to nitrate in the aerobic environment of the aeration tank.

See "How do I . . . measure ammonia in the clarifier effluent?"

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 2: Aeration Effluent Ammonia: <1 mg/L

Ammonia nitrogen ($NH_3$) in the influent is converted to nitrate ($NO_3$) in the aeration tank. If this process is performing as designed, then the ammonia nitrogen should be < 1 mg/L in the aeration tank effluent. If the ammonia nitrogen is > 1 mg/L in the clarifier effluent, then one of two causes are possible. To determine the specific cause of the high ammonia, first measure the ammonia nitrogen in the aeration tank effluent.

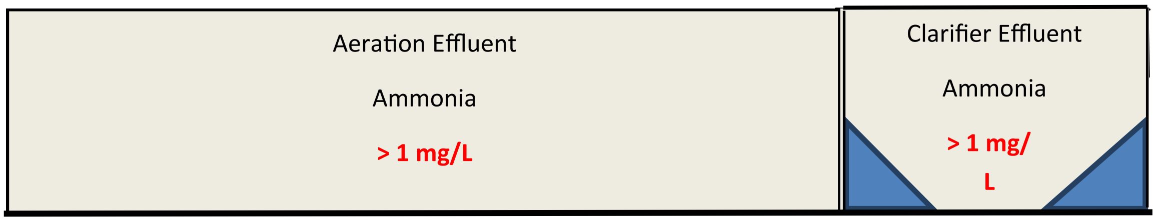



Figure 1: failure in aeration tank

If ammonia nitrogen is > 1 mg/L in the aeration tank effluent (Fig. 1), then the source (location) of the incomplete conversion is in the aeration tank. At this point the reason for the incomplete conversion must be identified and data will need to be collected from the aeration tank to identify the specific cause.

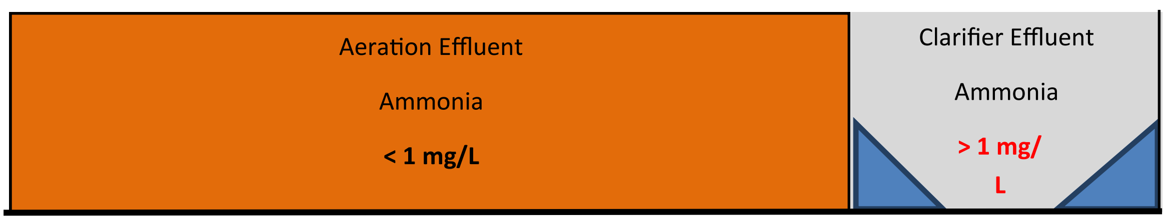



Figure 2: failure in clarifier

If ammonia nitrogen is < 1 mg/L in the aeration tank effluent, but > 1 mg/L in the clarifier effluent (Fig. 2), then the source (location) of the problem is in the clarifier. This situation indicates that all the ammonia was converted in the aeration tank, but is being generated in the clarifier. Data needs to be collected to identify the specific cause for the excessive ammonia nitrogen in the clarifier.

It is important to identify the location of the high ammonia value first, and then operational adjustments can be directed to the specific treatment unit of the activated sludge system causing the problem. Making adjustments to one unit of the treatment system when the issue is located in another unit is a common mistake in troubleshooting the activated sludge process.

See "How do I . . . measure ammonia in the aeration tank?"

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 3: Aeration Effluent: Water Temperature < 10 C

If the aeration tank effluent ammonia concentration is > 1 mg/L, then an environmental condition exists in the aeration tank that is limiting the complete conversion of the influent waste into bacterial cells.

Water temperature in the aeration tank has a direct impact on the growth rate of the nitrifying bacteria needed to convert the ammonia to nitrate. When aeration tank water temperatures decrease below 10 C, the nitrifying bacteria might not reproduce fast enough to maintain a sufficient population to convert all the influent ammonia nitrogen to nitrate.

As bacteria convert the waste in the influent to new bacterial cells in the aeration tank, heat is generated. This heat is transferred into the aeration tank environment and the water temperature typically maintains above 10 C. However, if the influent organic loading is low, less heat is generated. In addition, if more aeration is applied than necessary for the organic load, the aeration tank is being over-exposed to the colder ambient air, thereby causing heat loss. Over-aeration of low organically loaded systems can lead to aeration tank water temperatures decreasing below 10 C.


Measure the water temperature in the aeration tank effluent.

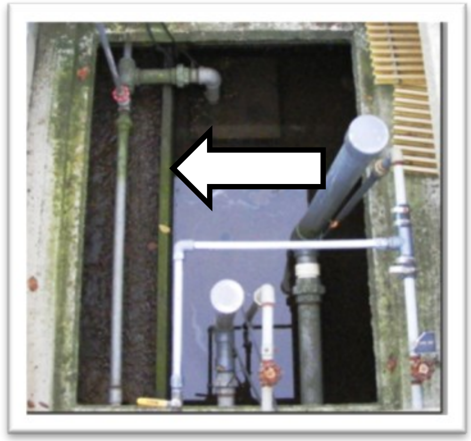
This dissolved oxygen meter is measuring over 2 mg/L of dissolved oxygen (DO) and a water temperature of 9.9 C. A reduction in the aeration would prevent heat loss and save on electrical expenses.

Aeration tank effluent DO concentrations of 2 mg/L should be sufficient to achieve complete conversion, however, if over aeration is lowering water temperature, a reduction in aeration run time would be required.

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 4 Clarifier: Solids breaking down in clarifier (ammonia re-release)

Bacterial cells are made from carbon and nitrogen. When aerobic bacteria are in an environment without oxygen for an extended period of time, the bacteria die and break apart (lyse). When bacteria lyse, they release ammonia nitrogen back into the water column. If you measure higher ammonia in the clarifier effluent than the aeration tank effluent, the bacteria are likely breaking down in the clarifier. Dead bacteria typically turn black in color; therefore examine the clarifier sludge blanket for sources of decaying bacteria.



**Possible Source: Scum Baffle**

Biological foam can be generated in the aeration tank. These buoyant bacteria will migrate to the clarifier and accumulate behind the clarifier scum baffle. Eventually this biological foam begins to lyse and release ammonia nitrogen from the bacterial cells. Since the clarifier is not designed to remove ammonia, it passes through the clarifier to the plant effluent.

Solution: Clean the scum baffle area.

**Possible Source: Clarifier Surface**

If biological foam generation is excessive in the aeration tank, foam will eventually overload the scum baffle and migrate to cover the entire clarifier surface. Brown colored foam is typically associated with having more biomass in the aeration tank than necessary for the influent waste load (low F/M ratio).

Solution: See "How do I . . . eliminate the biological foam on the aeration tank?"

**Possible Source: Clarifier Sludge Blanket**

As the clarifier sludge blanket increases in depth, it becomes more likely for biomass to lyse and release ammonia in the sludge blanket. Since ammonia is soluble, it will release into the water column and pass through the clarifier to the effluent. A dark or black layer in the sludge blanket is a visual sign of potential ammonia release.

Solution: See "How do I . . . determine if ammonia is being released in the blanket?"

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 5 Aeration Effluent: total alkalinity <100 mg/L

If the aeration tank effluent ammonia concentration is > 1 mg/L, then a condition exists in the aeration tank that is limiting complete conversion of the influent waste into bacterial cells.

Nitrifying bacteria convert ammonia nitrogen ($NH_3$) in the influent to nitrate ($NO_3$) in the aeration tank. During this conversion of ammonia to nitrate, the nitrifying bacteria also generate acids. If sufficient acids are generated, the pH of the aeration tank will decrease and eventually inhibit the conversion process.

Alkalinity is naturally found in water and acts as a buffer to the acids that are generated by the nitrifying bacteria. If sufficient alkalinity is available, the pH remains within the desired range for the nitrifying bacteria and conversion is completed. However, if the influent waste stream contains a significantly higher concentration of ammonia nitrogen and/or the influent wastewater is low in natural alkalinity, a decrease in pH could occur and inhibit the conversion process.

Measure the total alkalinity in the aeration tank effluent using a field titration kit.


If the total alkalinity is > 100 mg/L, then the conversion process has not been limited by alkalinity.

Continue to evaluate other possible causes for the incomplete conversion.

If the total alkalinity is < 100 mg/L, then it is more likely alkalinity is the limiting factor.

It is not sufficient to measure total alkalinity only one time, or at the same time each day. To develop a true picture of the total alkalinity, it is important to measure the total alkalinity at different times and different days of the week.

Monitoring the total alkalinity (and not pH value) is critical to prevent upset conditions. The pH will drop quickly when alkalinity is consumed in the nitrification process. The goal is to provide sufficient alkalinity to prevent the pH from dropping and causing an upset condition.

See "How do I . . . measure total alkalinity in the aeration tank?"

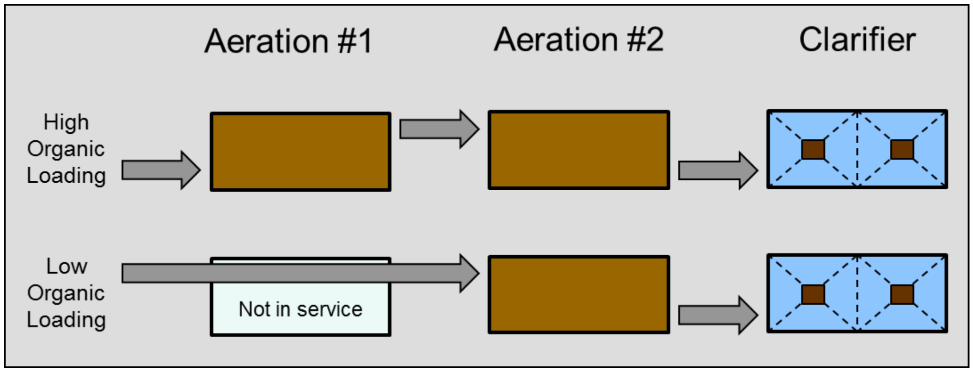
## Activated Sludge Process Control and Troubleshooting Chart

### Box # 6: Aeration: Decrease heat loss of aeration tank

To prevent heat loss, match the amount of aeration applied to the waste load being received.

### Reduce Heat Loss: Aeration Tank Capacity

Systems that are subject to seasonal flow variations (i.e. campgrounds, schools on break) could experience significant decreases of influent organic loadings during the colder winter season. If influent loadings decrease, one option is to remove an aeration tank from service if the system is designed with this flexibility.




DON'T ADD DOG FOOD TO INCREASE ORGANIC LOADING—spending money to purchasing food to feed bacteria and then paying to remove it from the waste stream is illogical.

Solution: See "How do I . . . determine how much aeration capacity is required?"

### Reduce Heat Loss: Timers

Applying more aeration than necessary over-exposes the warmer aeration tank contents to the colder ambient air temperature and uses more electricity than needed. Reduce aeration timing cycles to prevent over exposure. *(Caution: Airlift return systems (RAS) are controlled by aeration "on" cycles.)* Consider


### Reduce Heat Loss: Covers

When colder ambient air comes in contact with the warmer aeration tank contents, the heat from the aeration tank water is lost to the atmosphere.

Solution: Prevent heat loss by covering the aeration tank with an insulating tarp or some other type of insulating material. In extreme cold situations, also protect exposure areas upstream of the aeration tank (i.e. flow EQ basin).

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 7: Aeration Effluent: Dissolved Oxygen (D0) < 2 mg/L

If the aeration tank ammonia concentration is > 1 mg/L, then a condition exists in the aeration tank that is limiting the complete conversion of the influent waste into bacterial cells.


The nitrifying bacteria, which convert ammonia to nitrate, require adequate DO throughout the aeration tank environment. If insufficient DO is available, the conversion process is inhibited and aeration tank effluent ammonia may be > 1 mg/L.

Field monitoring of the DO concentration throughout the aeration tank is required to determine if insufficient oxygen is the cause for the incomplete conversion. The DO concentration is very dependent upon aeration tank loadings. Therefore a "true" picture of the available DO requires monitoring of the aeration tank at different times during the day and different days of the week to identify both the peaks and the valleys.

A data logging DO meter will assist the operator to trend the DO levels in the aeration tank environment over an extended period of time.

If your DO meter does not data log, measure aeration tank effluent periodically throughout the day, and throughout the week, to develop a DO profile.

Measuring DO levels at different depths and locations within the aeration tank provides the best overall picture of the oxidative condition within the tank. However, the most critical sampling location for data logging DO concentrations is the aeration tank effluent. This is typically the location of the highest aeration tank DO value.

Solution: Increase the dissolved oxygen concentration of the aeration tank. It could be as simple as increasing the blower run times, opening partially closed valves on diffusers drop pipes or may require cleaning of aeration tank diffusers. If available, additional aeration tanks can be brought into service to increase the aeration capacity if necessary.

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 8: Aeration: Increase alkalinity in aeration tank to >100 mg/L

Measure the total alkalinity of the aeration tank effluent.

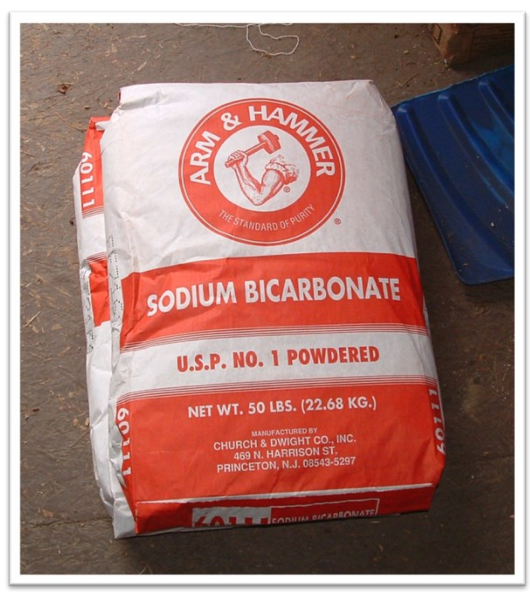
### Field Measurement –"prevention" method

The nitrifying bacteria require more than seven times the alkalinity for each mg/L of ammonia nitrogen converted to nitrate. Thus, alkalinity concentrations can change rather quickly and adjustments need to be made without delay.

Use a simple titration method to estimate the total alkalinity on site. It is more important to measure the total alkalinity in the field, so adjustments can be made immediately.


### Field Measurement – "post-mortem" method

When total alkalinity drops to < 100 mg/L, the biological environment is nearing a "cliff". When the alkalinity is consumed by the nitrifying bacteria, the pH can quickly drop off the "cliff". Since nitrifying bacteria cannot function at these lower pH environments, conversion is inhibited and ammonia concentration will increase. Monitoring total alkalinity allows time to correct the situation; monitoring pH informs you when it is too late. Aeration tank environments should not drop below 6.5 pH units.




### Solution: Supplement Alkalinity

If the demand for alkalinity is greater than what is available, supplement with sodium bicarbonate.

If the influent ammonia load is excessive or if the natural alkalinity is insufficient, a stronger source of alkalinity than sodium bicarbonate may be required.

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 9: Aeration Effluent: Centrifuge Spin < 4%

If the aeration tank effluent ammonia concentration is > 1 mg/L, then a condition exists in the aeration tank that is limiting complete conversion of the influent waste into bacterial cells.

The cBOD and ammonia nitrogen entering the aeration tank is considered "food" for the bacterial cells (biomass). The bacteria must consume or convert all these waste products into new bacteria or harmless by-products before it leaves the aeration tank. When influent loadings increase, the available biomass (bacterial population) in the aeration tank must be adequate to insure complete conversion of the ammonia to nitrate before leaving the tank.


Estimating the amount of biomass in the aeration tank can be performed with a centrifuge. It is more important to know the relative concentration of biomass and its trending pattern (increasing/decreasing) than to know the exact amount of biomass. A centrifuge can determine biomass concentrations in 15 minutes and is sufficiently accurate for process control.

As the concentration of biomass in the aeration tank increases, the aeration tank can theoretically treat an increase in influent organic loading. However when the biomass concentration (as determined by the centrifuge) increases above 4%, the proper settling rate of the biomass can be inhibited or slowed down. When this happens, the clarifier sludge blankets can begin to rise. If allowed to continue, the blankets can rise to the point where the biomass (sludge blanket) can exit over the clarifier weirs and consequently enter the final effluent.

If ammonia concentrations in the aeration tank are > 1 mg/L and centrifuge data indicates the biomass concentration is too low, then increase the biomass concentration in the aeration tank. This is accomplished by decreasing the sludge wasting rate

### Solution: Track the solids in the aeration tank

The centrifuge is very useful in quickly identifying the amount of biomass in the aeration tank.

If the RAS pump is not functioning properly, solids could be collecting in the clarifier. First, core sample the clarifier to confirm solids are not "hiding" in the clarifier.)

See "How do I . . . measure the solids in the clarifier?"

Typical aeration tank concentrations range between 2% and 4% by volume. The trending of the biomass concentration is valuable in process control decisions.

See "How do I . . . determine how much to waste?"

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 10 Aeration: Increase air supply in aeration tank

If insufficient aeration is being applied to the aeration tank, it can be an operational issue (increase blower run time) or a mechanical issue (evaluate blower output, restricted air flow).

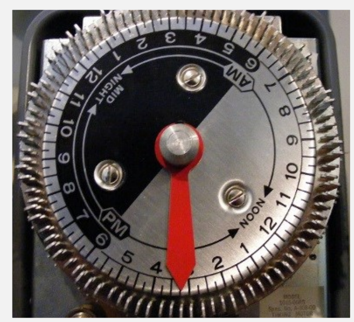
### Diagnosis

A snapshot picture of the DO (grab sample) in the aeration tank is not conclusive evidence that aeration is sufficient. Several measurements at different times and days of the week will provide a clearer picture. A data logging meter reveals all peaks and valleys of dissolved oxygen.


See "How do I . . . measure the DO in the aeration tank?"

### Operational Issue: Timers

Aeration tank blowers are typically controlled by a timer. Increasing the aeration time can be achieved by either increasing the frequency of cycles and/or the duration of each cycle. Select a timer with more timer setting options for more flexibility.




See "How do I . . . determine how much aeration time is required?"

### Mechanical Issue: Blowers/Motors/Diffusers

Mechanical equipment loses efficiency over time. In addition, influent organic loadings typically increase over time. Either of these situations can lead to insufficient aeration being applied to the aeration tank.

Items to evaluate:

1. Clogged valves/pipes/diffusers
2. Inadequate mixing can be caused by:

    *diffusers installed along width and not length of tank

    *course bubble diffusers replaced with fine bubble diffusers and not adjusted for full floor coverage

3. Blower discharge pressure

## Activated Sludge Process Control and Troubleshooting Chart

**Box # 11** **System Loading Rate: Loading greater than design**

Determine if the influent organic loading is greater than design loading of the treatment system.

To determine the influent loading rate, collect the following data; average influent flow and average influent BOD.

To calculate influent loading:

**(Influent flow, MGD) x (influent BOD, mg/L) x 8.34 = pounds BOD/day**

**Example: Influent Flow = 15,000 gpd = 0.015 Million Gallons/day**

**Influent BOD = 200 mg/L**

**Actual Pounds of BOD/day = (0.015 MGD) x (200 mg/L) x (8.34) = 25 lbs BOD/day**

Determine if the influent loading rate is greater than the design loading rate of the treatment system. Organic loading rates are calculated in pounds/day/1,000 $ft^3$ of aeration capacity. Once you have calculated the actual pounds of BOD per day being added to the aeration tank, you only need to divide this value by the 1,000 $ft^3$ of aeration tank capacity. For example:

**Aeration Tank Dimensions: 12 ft. length, 6 ft. width, and 9 ft. water depth**

**Aeration Tank, $ft^3$ = (12') x (6') x (9') = 648 $ft^3$**

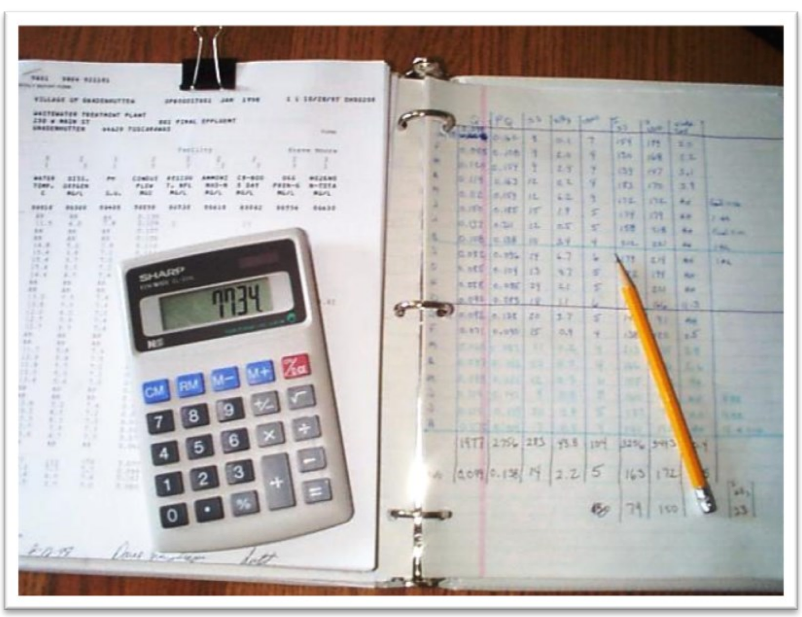
**Aeration Tank 1,000 $ft^3$ = 648 $ft^3$/ 1,000 $ft^3$ = 0.648 / 1,000 $ft^3$ aeration capacity**

**Organic Loading Rate = 25 lbs BOD per day / 0.648 (1,000 $ft^3$) = 38 lbs/d/1,000 $ft^3$**

A typical organic loading rate of an extended aeration package plant is 15 to 25 lbs BOD/day/1,000 $ft^3$ of aeration tank capacity. Review your design data to confirm your systems actual design organic loading rate.

Compare the actual organic loading rate to the design organic loading rate to determine if the treatment system is operating beyond its intended capability.

In our example, the actual organic loading rate is significantly higher than the design loading rate, which can result in incomplete "conversion" in the aeration tank.




Actual loading rate:

**38** lbs BOD/day/1,000 $ft^3$

Design loading rate:

**15** lbs BOD/day/1,000 $ft^3$

If actual loading exceeds the design loading conversion can be incomplete.

**Activated Sludge Process Control and Troubleshooting Chart**

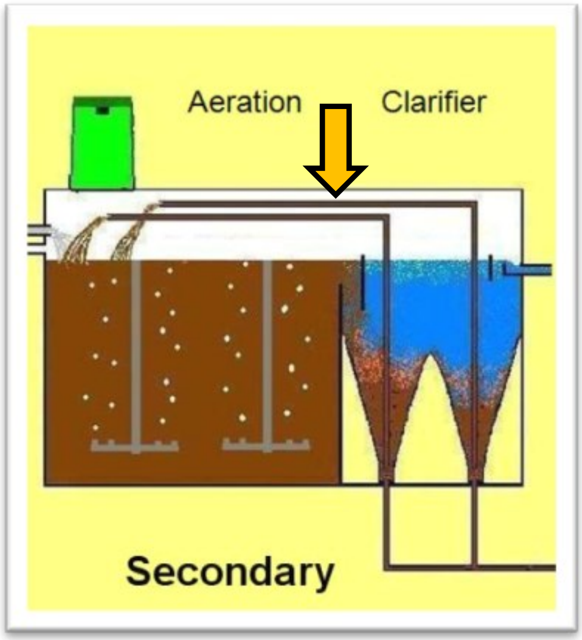
**Box # 12** **Aeration: Increase biomass in aeration tank**

If the aeration tank effluent ammonia concentration is >1 mg/L, then a condition exists in the aeration tank that is limiting complete conversion of the influent waste into bacterial cells.

The concentration of biomass in the aeration tank is a function of the influent organic loading. The higher the organic loading in the influent, the more biomass is needed in the aeration tank.

**Sample Aeration Tank Effluent**

Sample the aeration tank effluent and perform a centrifuge spin to determine concentration of biomass.




**Sample Aeration Tank Effluent**

If the aeration tank biomass concentration is less than 4%, then increase aeration tank biomass concentration. As concentration increases, continue to monitor the aeration tank effluent ammonia concentration. The ammonia concentration should decrease as the biomass concentration increases if this is the cause for incomplete conversion.


Aeration tank concentrations which exceed 4% typically causes the bacteria to settle slower due to the increased concentration.


Increasing the bacteria concentration in the aeration tank will provide more bacteria for conversion, but too many bacteria in the clarifier negatively affects the settling rate.

See "How do I . . . measure biomass in the aeration tank?"

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 13 Aeration: Evaluate for possible toxicity issues.

If the aeration tank effluent ammonia concentration is > 1 mg/L, then a condition exists in the aeration tank that is limiting complete conversion of the influent waste into bacterial cells.

If an activated sludge system which treats typical domestic waste is operating within its design organic and hydraulic loading capacity, and other operational limitations have been eliminated (i.e. temperature, DO, mass), then there are two probabilities for limited performance. In this situation there is either an internal side stream which is limiting conversion (i.e. digester supernatant containing high ammonia) or the possibility of a toxic or inhibitory substance in the influent which is impacting conversion.

### Evaluate Potential Internal Recycle Streams

Aerobic digesters left un-aerated for extended periods of time can generate a high concentration of ammonia nitrogen. When this is decanted back to the head of the treatment system it can appear as if nitrification has been inhibited, when in actuality it was a slug loading from an internal side stream.

Evaluate internal recycle streams as potential sources of high ammonia concentrations. Check "inside the fence" first for internal recycles. A slug load of high ammonia could be a "self-inflicted wound" and appear as if the treatment system has experienced a toxic event.

See "How do I . . . identify internal side streams as sources?"

### Inspect Collection System

Inspection of the collection system could provide an indication of an uncharacteristic (toxic) influent source.

Evaluate external sources (collection system) for potential sources. Evaluate conditions of manholes in the collection system. Examine for visual signs of corrosion, color, stains, or odors.

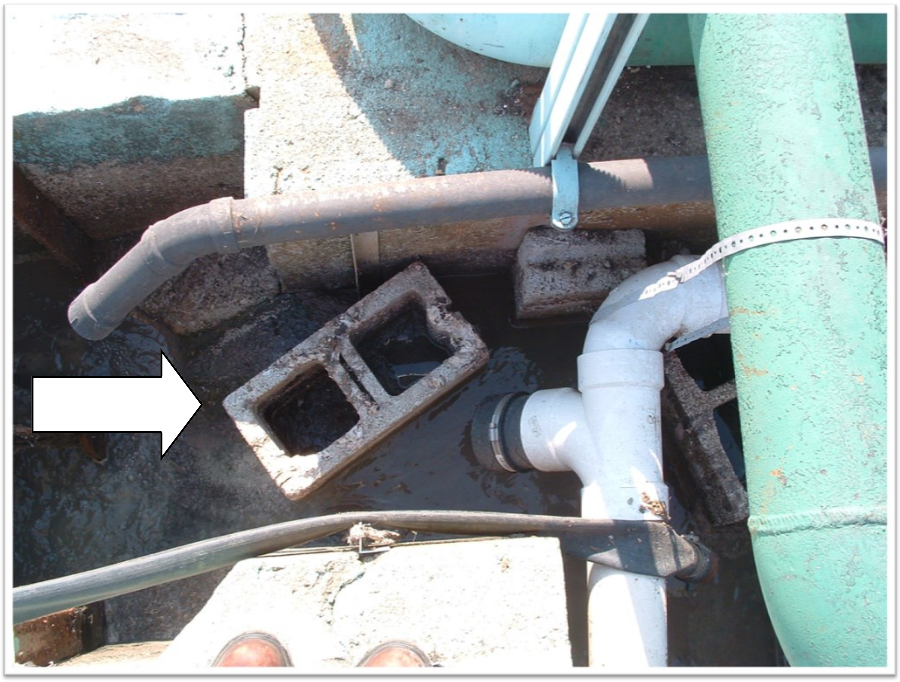
Other potential sources: septage receiving stations, and force mains with long detention times.

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 14 Capacity: Increase capacity or decrease loading to aeration system

If the aeration tank effluent ammonia concentration is > 1 mg/L, then a condition exists in the aeration tank that is limiting complete conversion of the influent waste into bacterial cells.

It is possible that the average daily flow is within the system's design capacity, however the actual influent pumping rate could be in excess of the system's design. This issue can arise from at least two common problems. First, if the influent pumping rate is higher than the design flow rate of the system; and second, if the flow splitting device or flow equalization tank have an inferior design or are improperly adjusted. This causes the average daily flow to appear within design limits; however the system is actually exceeding its design flow rate each time the influent pump cycles on.



The "classic" flow splitting block operators use to equalize flow between parallel aeration tanks is not very effective. If influent flows are not split equally, then more treatment demand is placed on a the system. While the average daily flow may be within design, you could be only using 50% of the treatment capacity to treat a higher percentage of the flow.

**If the influent pumping rate is exceeding the design flow:**

Evaluate influent loading characteristics to determine if treatment modifications are necessary to achieve compliance with the discharge limits (i.e. improved flow splitting design, increased flow equalization capacity).

Evaluate pretreatment options to reduce potential high strength organic loadings from system dischargers.

Increase aeration efficiency by converting from course bubble diffusers to full floor fine bubble aeration diffusers.

Place additional aeration tanks into service to adequately process organic loadings.

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 15 Aeration Effluent: Settleometer Analysis < 80% in 5 minutes

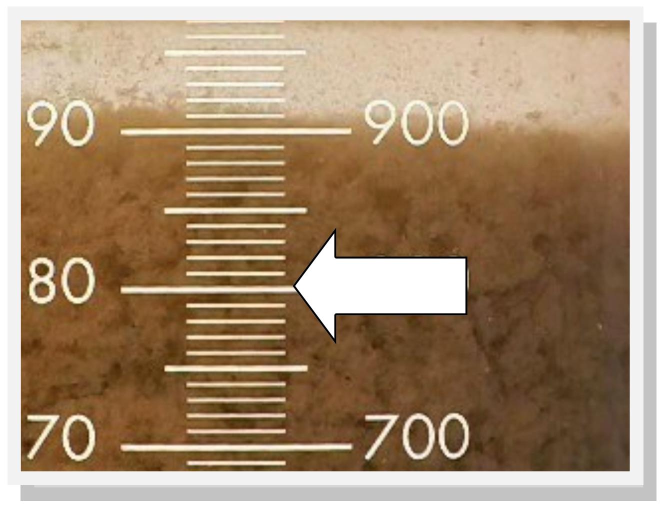
If the aeration tank effluent ammonia concentration is < 1 mg/L, the conversion of all influent organic waste into bacterial cells has been achieved. In short, the aeration tank has properly performed its function. The focus now moves towards separating the bacteria from the clean water in the clarifier. This is a function of the settling rate of the biomass, which must be maintained at the proper concentration to assist gravity settling in the clarifier. An evaluation of the settling rate is the first analysis to perform.

The settleometer test mimics the sludge setting characteristics within the clarifier. However, the settleometer represents a "perfect clarifier", meaning there are no hydraulic currents from influent or RAS flows, which can negatively affect the settling characteristics of the biomass.

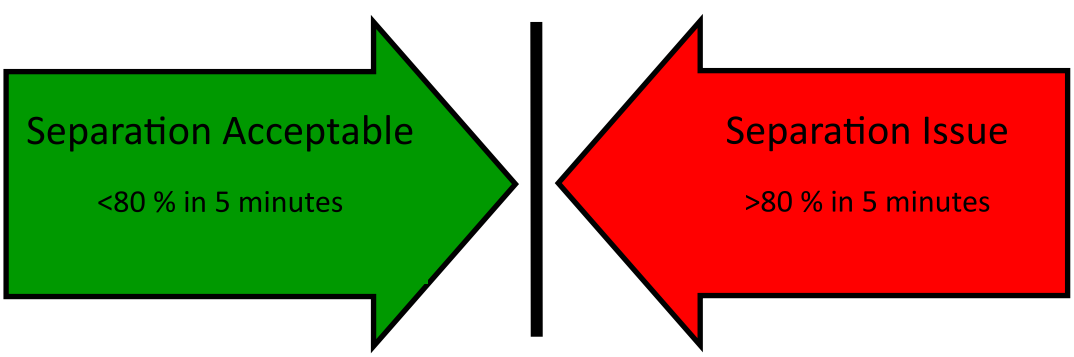
The settling characteristics are best reflected in the first five minutes of the settleometer test. As the biomass settles in the settleometer, the solids concentration increases in the settled sludge. As the settled sludge concentration increases, the settling rate decreases, therefore the first five minutes more accurately reflects the "true" settling characteristics of the biomass.

### Settleometer Test

Within five minutes of the settleometer test, the settled biological mass should be below 80%. Biomass that settles slowly and cannot compact below this 80% mark is considered inhibited or "slow settling" and can be easily "carried" up and over the clarifier weir.




Settling rates of < 80% in 5 minutes should not cause solids loss in the clarifier, however this is a worst case scenario and can be adjusted to a lower percentage, (e.g. 70%), for a more conservative control parameter if desired. Maintaining a clarifier effluent ammonia concentration of < 1 mg/L is the first goal. Maintaining a sufficient settling rate is the second goal. Both are required for compliance.



## Activated Sludge Process Control and Troubleshooting Chart

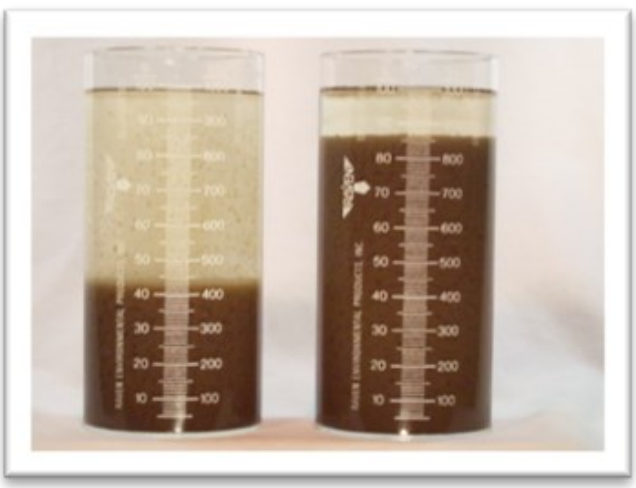
### Box # 16 Aeration Effluent: Centrifuge Spin > 4%

If the biomass does not settle below the 80% mark within five minutes, there is a problem with the settling characteristics. This condition can lead to a loss of biomass from the secondary clarifier. The first step is to identify the cause for the slower settling biomass. There are typically two main causes, (1) the concentration of the biomass is too high, or (2) the density of the biomass is too low.

### Diagnosis

If the aeration tank biomass is too concentrated (i.e. high MLSS) then settling will be impaired. Typically when the aeration tank concentration exceeds 4% by centrifuge spin, slow settling is due to the high concentration of biomass.

The "two-minute diluted" settleometer test can also assist in identifying which of the two causes are at play.



### Two-Minute Diluted Settleometer Analysis

Analysis: Concentration (left photo)

The diluted settleometer (on the left) settled significantly faster than the undiluted settleometer (on the right). The more significant the difference after two minutes indicates the slow settling is due to an excessive biomass in the aeration tank.

Analysis: Density (right photo)

The diluted settleometer (on the left) did not settle any differently than the undiluted settleometer (on the right). Concentration is not the issue here; however the biomass is "light weight" or of a low density. This is typical of a filamentous biomass.

See "How do I . . . evaluate settling with the two minute diluted settleometer analysis?"

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 17 Aeration or Clarifier: Brown foam on surface

If the five minute settleometer is > 80%, then the settling rate is too slow. If the aeration tank concentration is < 4%, or the two minute diluted settleometer analysis indicates slow settling then it is likely due to excessive filamentous bacteria growth in the aeration tank.

If there is excessive brown foam on the aeration tank and/or clarifier, this is a biological foam which grows in a low F/M aeration tank environment; high MLSS. Another possible indicator of low F/M growth conditions is very low effluent ammonia (< 0.3 mg/L), however this is not the most reliable indicator.

**Aeration Tank Foam:**

The observation of light brown/tan foam on the aeration tank is typical. If this foam is trapped in the aeration tank, it will accumulate and darken in color.

The foam can eventually become dried at the surface and resemble "floating soil".

**Clarifier Foam:**

If the foam is generated in the aeration tank, it can migrate to the clarifier, eventually covering the clarifier surface.

In this photo, the weir baffle is preventing the foam from escaping the clarifier.

**Settleometer Test:**

Another clue to an excessive filamentous growth condition is when the biomass develops a depression, or cone, in the center of the settleometer test after 30 to 60 minutes.

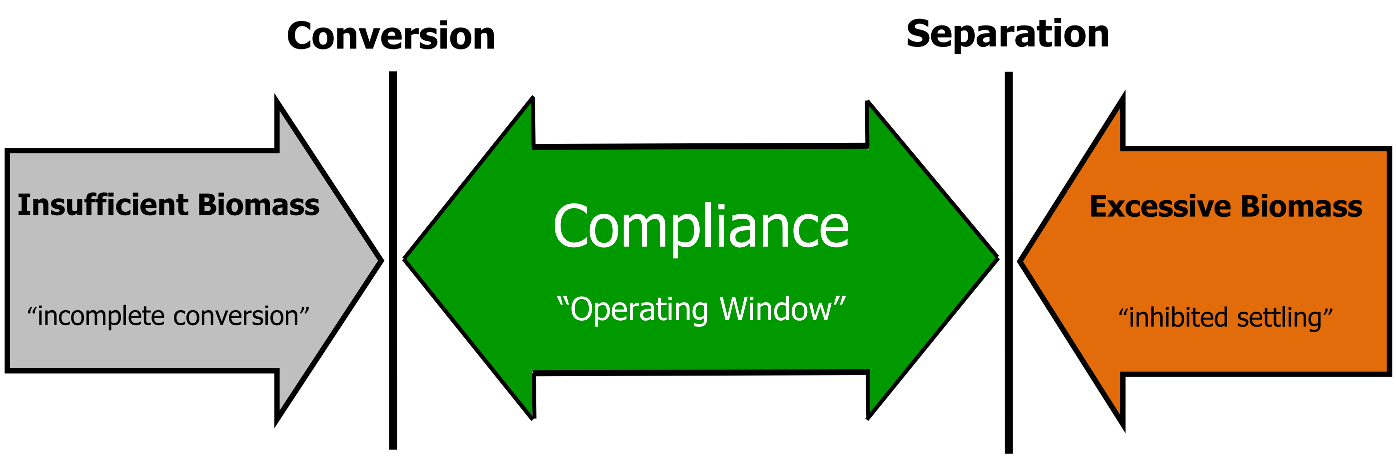
This cone develops because of the low density of the biomass caused by excessive filamentous bacteria. Also note the clarity of the supernatant in the settleometer. This clarity is also associated with a filamentous growth condition.

## Activated Sludge Process Control and Troubleshooting Chart

**Box # 18** **Aeration: Too much biomass in system, increase wasting rate**

Typically domestic activated sludge systems operate within a range of 2-4% concentration (v/v) based on a centrifuge analysis. Systems with aeration tank concentrations > 4% may begin to experience a slow settling rate due to a high concentration of biomass.

To correct, slowly increase the sludge wasting rate to reduce the aeration tank biomass. Continue to decrease the aeration tank biomass until the desired settling rate is achieved.




**Establishing a wasting rate is simply a process of maintaining sufficient biomass to achieve complete conversion in the aeration tank (ammonia < 1 mg/L), while not maintaining an excessive amount of biomass to inhibit the settling rate in the clarifier (< 80% in 5 minutes).**

The amount of biomass that provides complete conversion and does not inhibit settling is the target in which the treatment system performs the best. This aeration tank concentration typically ranges between 2% to 4% (v/v) based on a centrifuge analysis.

As the aeration tank concentration increases above the target value, increase the wasting rate to maintain the desired aeration tank concentration to remain within the proper operating window.

If the wasting rate is too excessive, the decreasing concentration of biomass in the aeration tank will be quickly identified by an increase in ammonia concentration leaving the aeration tank. Ammonia concentrations increase if too much biological mass is removed.

As influent organic loads increase or aeration tank water temperatures decrease, you may need to increase the target value by decreasing the wasting rate.

**Activated Sludge Process Control and Troubleshooting Chart**

**Box # 19** **Aeration: Dissolved oxygen < 1 mg/L for extended period of time**

If the five minute settleometer is > 80%, then the settling rate is too slow. If the aeration tank concentration is < 4%, or the two minute diluted settleometer analysis indicates slow settling, then it is likely due to excessive filamentous bacteria growth in the aeration tank.

One of the more common aeration tank environments which generate filamentous bacteria is operating at a low DO concentration. Unlike the low F/M environment, which typically generates brown foam, low DO environments are typically absent of heavy brown foam.

Another indicator that the aeration tank is experiencing a low DO environment (and not a low F/M environment) is the aeration tank effluent could have ammonia values significantly greater than 1 mg/L.


To properly identify the DO concentration in the aeration tank, a data logging DO meter should be used to evaluate the DO concentrations and duration of time the system experiences concentrations of < 1 mg/L.

The aeration tank DO does not always need to be maintained above 2 mg/L. However, the lower and longer the DO concentration is maintained in the aeration tank, the more likely that low DO filamentous growth conditions exist.

Data logging the aeration tank DO will provide the best information to determine the possibility of a low DO growth environment. Measure daily diurnal swings and weekends/weekdays concentrations to obtain a complete DO profile picture.

See: "How do I . . . measure the DO in the aeration tank?

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 20 Aeration: Low F/M ratio, increase wasting rate

If the five minute settleometer is > 80%, then the settling rate is too slow. If the aeration tank concentration is < 4%, or the two minute diluted settleometer analysis indicates slow settling, then it is likely due to excessive filamentous bacteria growth in the aeration tank.

One of the most common aeration tank environments that generate excessive filamentous bacteria is operating the aeration tank in a "starved" condition, which means having more bacteria (biomass) in the aeration tank than the influent food (BOD) source can support. This is commonly referred to as a low food to micro-organism ratio (low F/M).

Increase the sludge wasting rate (WAS) to reduce the aeration tank biomass concentration as measured by the centrifuge test. Continue to decrease the aeration tank biomass concentration until the desired settling rate is achieved. The settling rate will increase as the filamentous bacteria are wasted from the system and a more dense floc structure develops.

If the sludge wasting rate (WAS) is too excessive, the reduction in biomass in the aeration tank will be quickly identified by an increase in ammonia concentrations in the aeration tank effluent.

Remove accumulated foam from aeration tank and/or clarifiers after the aeration tank growth environment has been modified to the point where low F/M filamentous bacteria are no longer dominant. Stop the madness, then clean up the mess.

## Activated Sludge Process Control and Troubleshooting Chart

**Box # 21** **Aeration: Evaluate influent/internal side streams for septic sources**

If the five minute settleometer is > 80%, then the settling rate is too slow. If the aeration tank concentration is < 4%, or the two minute diluted settleometer analysis indicates slow settling, then it is likely due to excessive filamentous bacteria growth in the aeration tank.

Low F/M and low DO concentrations are common conditions for filamentous bacteria growth in activated sludge systems. However a third environmental condition, which could cause filament growth, is an influent loading or internal side streams containing by-products of septicity (i.e. organic acids, hydrogen sulfide).

Sources of influent septicity can originate from collection systems with long force mains, low flows resulting in solids deposition in the sewer pipe, industrial dischargers and/or internal flow streams (i.e. "anaerobic" digester supernatant).


**Collection System**:

Strong "rotten egg" odors in the influent can be an indication of septicity in the collection system. If you detect hydrogen sulfide odor in the influent, it is likely that products of septicity are being generated in the collection system. These by products of septicity can generate filaments.

**Head works Condition**:

Hydrogen sulfide is generated under septic conditions in the collection system. Significant corrosion could indicate products of septicity are contributing to filamentous growth in the aeration tank. Lift stations may also show signs of corrosion.

**Influent Characteristics:**

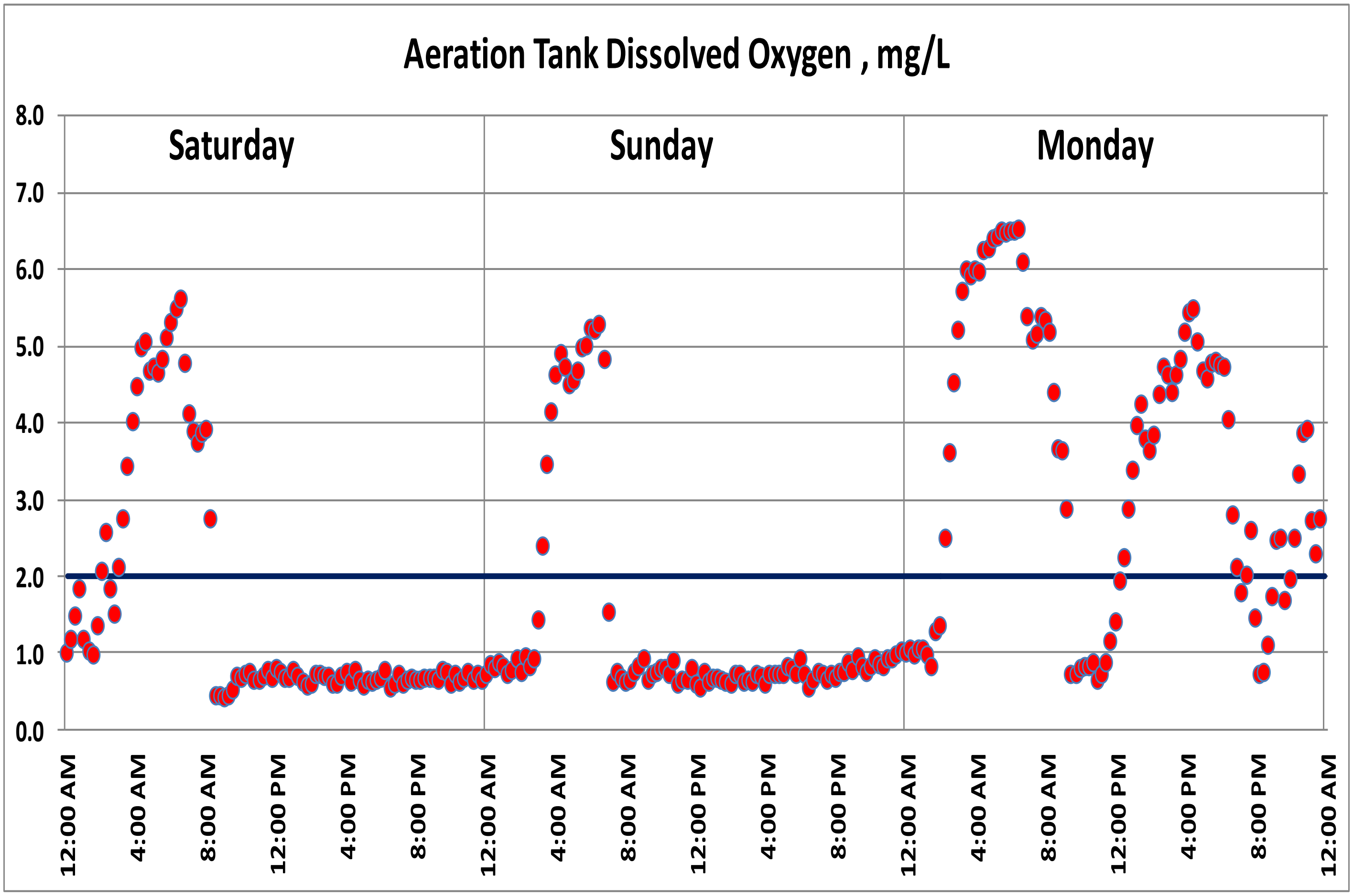
If you don't smell it, you still might see it. Influent domestic wastewater typically has a grey color. Influent flows which are more black in color are more likely to be from anaerobic environments or septic sources.

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 22 Aeration: Increase air supply to match organic loading

If a low DO concentration is the cause of filamentous growth, the aeration being applied must be adjusted to more accurately reflect the influent organic loading.

Data logging will identify the aeration cycle periods that need to be adjusted. In the chart below, if low DO filament growth conditions exist in the aeration tank, they are most likely being generated during low DO conditions (< 1 mg/L) on Saturday and Sunday due to the extended, low DO environment.




Increase the aeration cycle periods or bring additional blowers on line during low DO conditions.

Evaluate the aeration distribution system for clogged diffusers, pipes and valves which could be restricting flow.

Evaluate the mixing intensity of the aeration pattern. Diffusers which are designed along the width of the aeration tank are more likely to experience mixing issues than diffusers which are designed along the length of the aeration tank.

The color of a healthy aerobic biomass is typically light to dark brown depending on concentration. Aeration tanks limited by DO and sufficient mixing intensity will appear more grey in color.

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 23 Clarifier Effluent: Biomass observed leaving the clarifier

If the biomass settles below the 80% mark in five minutes, there is typically no problem with the settling characteristics (not a biological issue). However biomass can still be lost from the clarifier due to a hydraulic issue.

### Observed Biomass Loss:

The most obvious sign is solids deposition in the receiving stream. Depending on the effluent sampling criteria (grab vs. flow composite), effluent sampling data may not identify the solids loss.

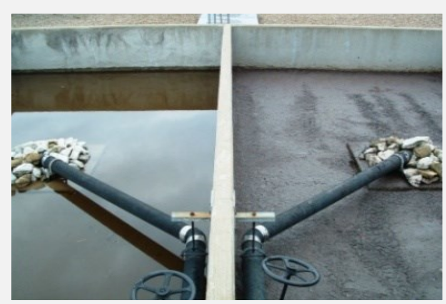
Biomass deposition in the clarifier trough is another indicator.

Another evaluation method is to use the clarifier core sampler to measure solids deposition in the dosing tank prior to sand filtration or solids deposition in the disinfection unit.

### Life Expectancy of a Sand Filter

Systems with slow sand filters provide an obvious method to evaluate solids loss over time. The more biomass lost through the clarifier effluent, the shorter the life expectancy of the sand filter. Package plants using slow sand filters typically experience 2-3 months of operation. They must then be taken out of service and cleaned. If the sand filter is operating on less than 2-3 months of service, then loss of biomass from the clarifier is probably occurring.





Left Photo: Youthful - water filters through sand before reaching walls.

Center Photo: Aging - water reaching side walls, begins to cover entire floor.

Right Photo: Deceased - water ponding on surface

Does the sand filter survive at least 2 to 3 months?

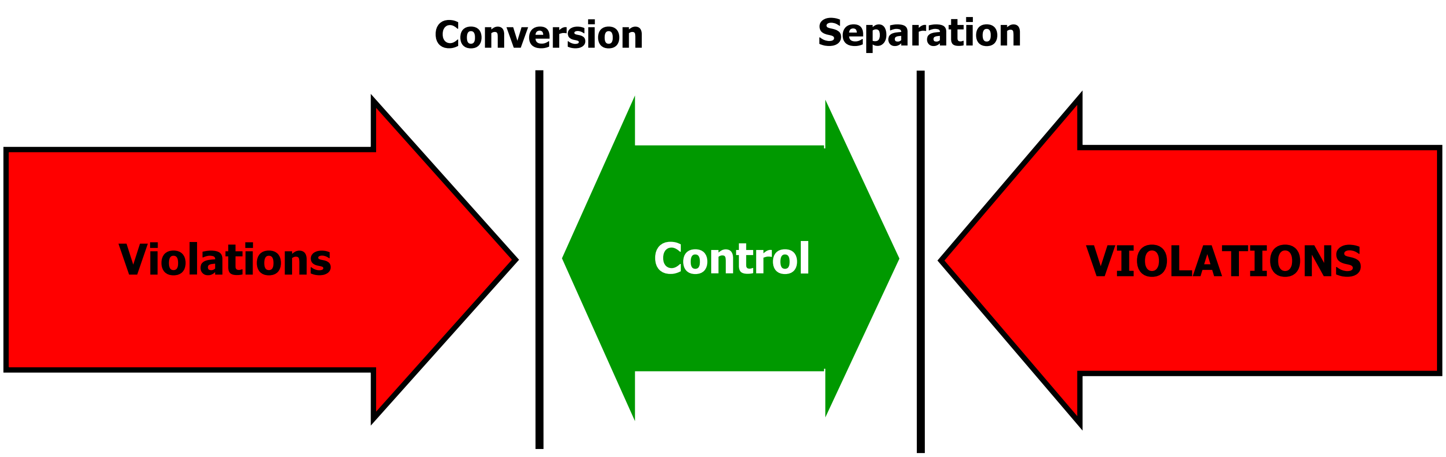
**Activated Sludge Process Control and Troubleshooting Chart**

**Box # 24** **Compliance**

If clarifier effluent ammonia values are <1 mg/L, then conversion is complete. If the biomass will settle below the 80% mark in the settleometer in five minutes then separation is adequate. The area between these two process control criteria is the "operating window" in which the treatment system will perform most effectively and efficiently.


The ammonia and settleometer analysis establishes the "operating window". Maintaining the process between these two criteria provides the best effluent with the least amount of expense and effort. As organic and hydraulic loadings change, the operating window will also change. As more pressure is applied to the treatment system the window becomes smaller, but by measuring and adjusting the process you can maintain in the safest location; the "middle of the window".

As water temperatures change, the operating window will also change. Warmer temperatures typically expand the window, while colder temperatures contract the size of the window. Good operations begin with locating the system's current location and then adjusting the process to maintain a position in the middle.




Lack of monitoring the system leads to a smaller operating window. This results in an increase in violations and the system becomes more labor intensive to "correct" something which could have been prevented. Don't create more work for yourself. Small adjustments can prevent most upset conditions.

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 25 Clarifier: Sludge blanket < 30% of clarifier water depth

As the biomass settles in the clarifier, a concentrated sludge layer or "blanket" develops on the bottom.

As this sludge blanket increases in depth, clarifier capacity decreases. The closer the blanket is to the clarifier surface, the more likely biomass will be carried over the clarifier weir.

Sludge blankets can increase and/or decrease in depth based on high influent flows, return pumping rates and settling characteristics of the biomass.

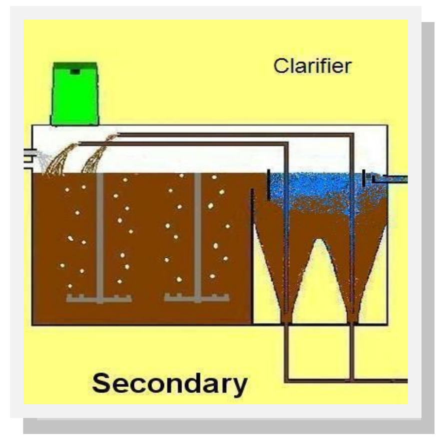
Measure the sludge blanket depth with a "core sampler".

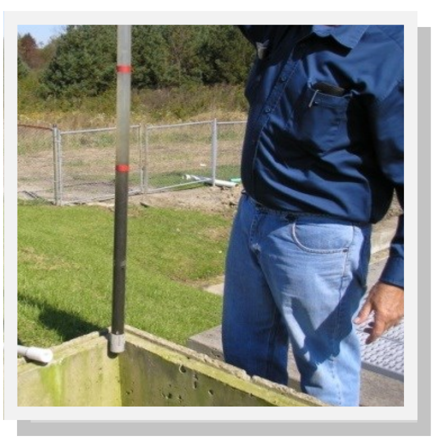
See: "How do I . . . measure solids in the clarifier?"

**High Sludge Blanket Depth**

The blanket is too close to the effluent weir.

Biomass entering the clarifier will travel across the top of the sludge blanket and be drawn out over the effluent weir.

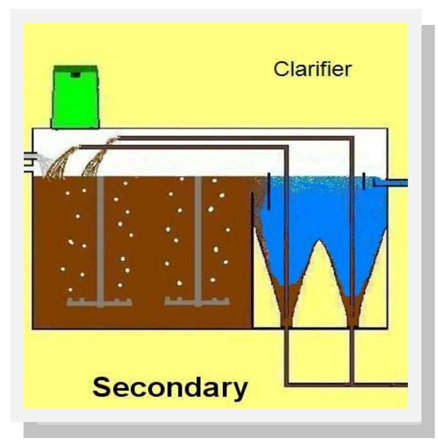


**Normal Sludge Blanket Depth**

The blanket is less than 30% of the clarifier water depth.

Biomass entering the clarifier has room to settle out and should not be drawn over the effluent weir.




Eliminating the sludge blanket depth as a cause for solids loss is easy to confirm with a clarifier core sampler.

See "How do I . . . interpret the core sampler results?"

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 26 Clarifier: Return Activated Sludge rate

Ideally, the return activated sludge pumping rate (RAS) needs to match the settling rate of the biomass coming from the aeration tank. A slow settling biomass requires a slower RAS rate and a fast settling biomass requires a faster RAS rate. Failing to match the RAS pumping rate to the biomass settling rate may cause solids to overflow the clarifier weir. Basing RAS rates on a percentage of influent flow is a common, but faulty, method.

The return sludge pump can only remove biomass that has already settled to the bottom of the clarifier. The biomass cannot be "drawn" to the bottom of the clarifier by increasing the RAS pumping rate.

An RAS pumping rate that is slower than the settling rate of the biomass creates a condition where more biomass is entering the clarifier than is being pumped out. This results in an accumulation of sludge (increased sludge blanket) in the clarifier. An increasing sludge blanket can result in decreasing clarifier efficiency and increasing solids loss.

An RAS pumping rate that is faster than the settling rate of the biomass creates a condition where excess water is being returned to the aeration tank. This results in additional hydraulic pressures (more flow) within the clarifier. Increased hydraulic pressures within the clarifier results in the biomass being unable to properly settle and concentrate into a sludge blanket. Biomass remaining in suspension in the clarifier will be more likely to be push out over the clarifier weir. This is exaggerated when filamentous bacteria (slow settling biomass) dominate in the secondary system.

Evaluate the RAS rate and then adjust the pumping rate to match the biomass settling rate.

If the biomass is settling well, but solids are observed leaving the clarifier, then there is a problem within the clarifier itself. A high sludge blanket (> 30%) will be the primary cause for potential solids loss. If the RAS pumping rate needs to be increased, then the loss of biomass from the clarifier should decrease. However if the RAS pumping rate is correct, then typically too much biomass is in the system and the sludge wasting rate should be increased.

See "How do I . . . determine the correct RAS pumping rate?"

## Activated Sludge Process Control and Troubleshooting Chart

### Box # 27 Clarifier: Hydraulic issues in clarifier.

If clarifier biomass loss is observed, but is not caused by a slow settling biomass (> 80% in 5 minutes in settleometer) or a sludge blanket which is > 30% of the clarifier water depth, it is possible there are unique hydraulic pressures within the clarifier "carrying" solids over the clarifier weir.

There are three common design features that can possibly lead to the loss of biomass in the clarifier; uneven flow splitting into the clarifiers, density currents within the clarifier, and weir locations/elevation removing flow from the clarifier.

### Flow Splitting

Devices that are designed to split the flow horizontally are incapable of equalizing loadings to downstream tanks. In this design, flow splitting is impacted as hydraulic flow rates change. That is why the strategically place "flow splitting brick" only performs well at certain flow rates.

See "How do I . . . correct a flow splitting issue into the clarifier?"

### Internal Density Currents

Even if the flow is split evenly among the clarifiers, internal density currents can short circuit through a clarifier and cause solids loss.

See "How do I . . . eliminate a density current within a clarifier?"

### Weir Location/Elevation

Effluent weirs located next to the back wall of a rectangular clarifier; or weirs which are uneven, will allow biomass to be drawn out of the clarifier. Weirs designed too close to a wall can be removed from operation by sealing off the weir area.

See "How do I . . . correct effluent weirs which are causing solids loss?

## Activated Sludge Process Control and Troubleshooting Chart

**Box # 28** **Clarifier: Adjust return activated sludge (RAS) rate.**

A quick and simple method to evaluate the proper RAS rate is to perform a centrifuge analysis of the aeration tank effluent and the RAS.

The aeration tank biomass concentration is typically between 2% and 4%. As the biomass settles in the clarifier, it will increase in concentration. A "rule of thumb" is that the RAS concentration should be at least 1.5 to 2 times the concentration of the aeration tank biomass. If the RAS is less than 1.5 times the aeration tank biomass, then the RAS rate is probably set too fast.

If the RAS concentration is twice the aeration tank concentration, then theoretically biomass is being returned at a rate which is slow enough to allow a 50% reduction in volume. A fast settling biomass can actually produce a RAS concentration 3 times the aeration tank concentration. RAS concentrations greater than 2 times the aeration tank concentration can be a very effective way to operate, resulting in reduced WAS volumes and longer biomass detention times in the aeration tank. However, RAS concentrations greater than 2 times the aeration tank concentration approach a condition which may allow an excessive sludge blanket to accumulate, resulting in reduced clarifier efficiency. Always use a "core sampler" to determine if the RAS flow rate is too slow for the biomass settling characteristics.

### RAS Rates

A centrifuge is used to measure the aeration tank and return sludge concentrations. This data used with the results of a settleometer analysis can identify what the current RAS rate is and if it needs to be adjusted.

See "How do I . . . determine the correct RAS pumping rate?

## Activated Sludge Process Control and Troubleshooting Chart

**Box # 29** **Clarifier: SOR or SLR in excess of clarifier design capacity**

Clarifiers are designed to allow adequate detention time for the biomass to separate and concentrate by gravity. This separation process can be affected by either hydraulic pressure within the clarifier and/or biomass loading into the clarifier.

Surface Overflow Rate (SOR) is a measurement of the "overflow velocity" per square foot of the clarifier surface. As the upward, overflow velocity increases, it is more difficult for the biomass to settle to the clarifier bottom.

**SOR**

If only one clarifier is available, determine if it is exceeding its designed SOR during peak flows.

If more than one clarifier is in service, each clarifier should receive equal flow. Don't allow 50% of the clarifiers to handle more than 50% of the flow.

See "How do I . . . calculate the SOR in the clarifier?"

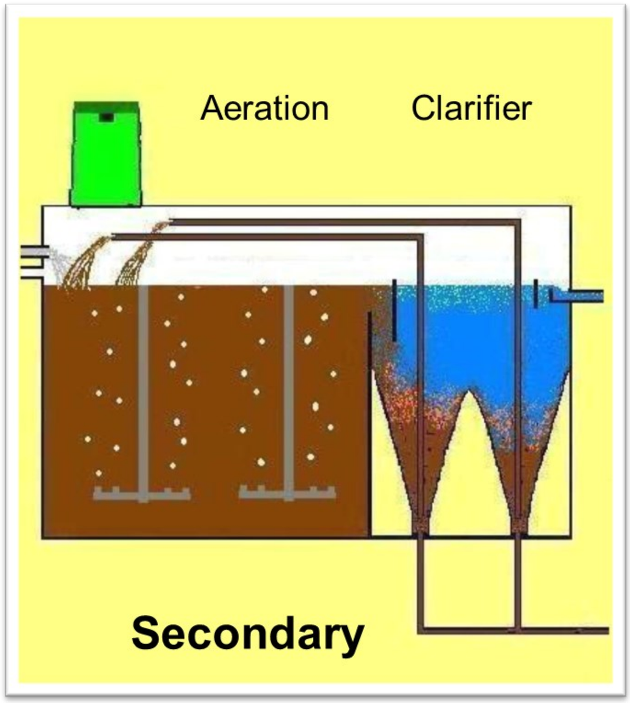
Solids Loading Rate (SLR) is a measurement of the "settling velocity" of the biomass per square foot of the clarifier surface. As the biomass loading rate increases, it is more difficult for biomass to settle to the clarifier bottom.

**SLR**

As biomass concentration increases, it will settle slower in the clarifier. Reducing the aeration tank biomass concentration or placing another clarifier in service will lower the SLR to the clarifier(s).

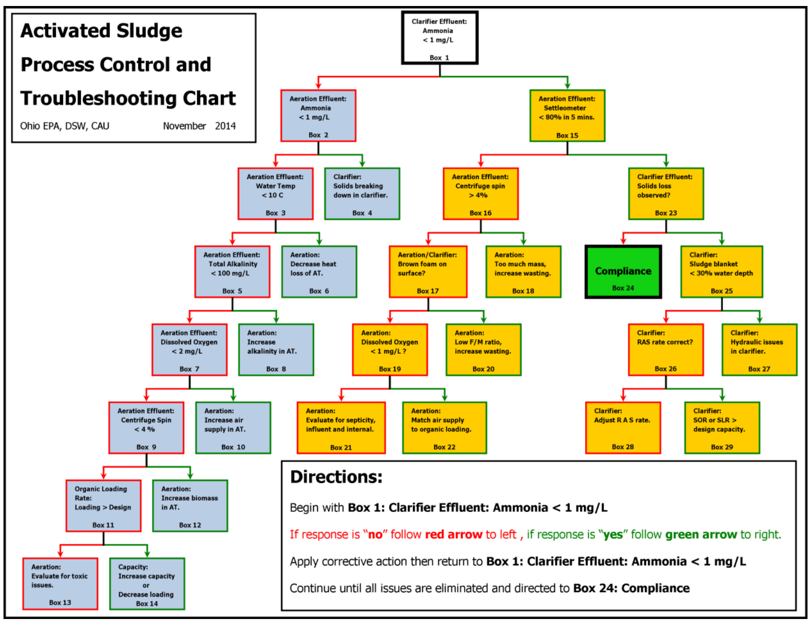
See "How do I . . . calculate the SLR in the clarifier?"

## Secondary Stage—Summary




The secondary stage is a physical and biological process which will require visual observations for the physical processes and chemical analysis to monitor the biological process. The two units in the Secondary Stage, aeration tank and clarifier, work together to first convert dissolved and suspended pollutants to bacteria in the aeration tank and then to separate the bacteria from the water in the clarifier.

Visual observations assist in determining the condition of the secondary treatment process, however, chemical analysis must be performed to monitor the conversion of dissolved and suspended pollutant into bacteria and physical analysis is required to monitor the settling characteristics of the bacteria produced in the aeration unit.




Using the Process Control and Troubleshooting Chart will direct you to where the treatment performance is being limited and allow for the correct action to maintain compliance.

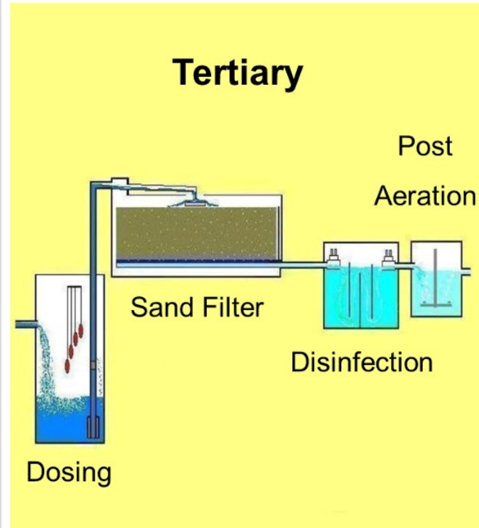
The treatment system operates on a few basic and dependable concepts. Understanding these concepts and their interaction allows you to correctly identify when the system is drifting outside its "operating window", so you can apply a corrective action to bring the system back to a more stable condition.

Identifying the operating window and maintaining a position in the center of the window provides the best effluent with the least amount of time and expense. It also provides a cushion before an upset occurs.

As the Secondary Stage performs its task of conversion and separation, the clarifier effluent will be low in pollutants and suspended solids which prepares the water for final treatment in the Tertiary Stage.

## Tertiary Stage

The tertiary stage consists of a dosing tank, sand filters, disinfection, and post-aeration. All of the units in the tertiary stage are physical and chemical process which can be monitored by visual observation.



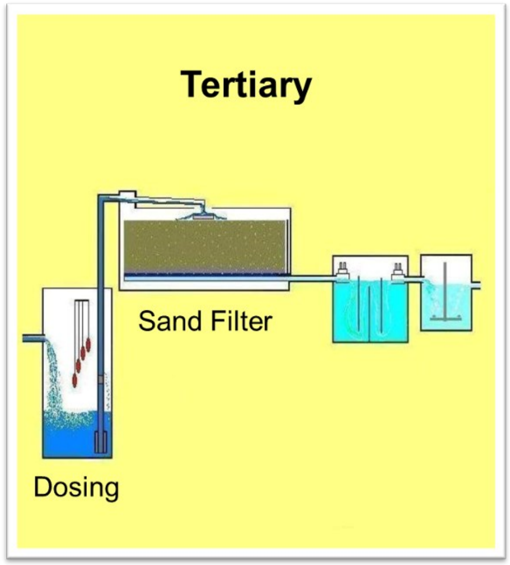

The dosing tank pumps the water to the top of the sand filters in doses. As the water travels through the sand media fine suspended solids are removed. The polished water from the sand filter is collected at the bottom of the sand filter and conveyed to a disinfection unit. Here either ultra-violet light or calcium hypochlorite is used to kill pathogens-disease causing organisms. Finally the water is aerated to increase the dissolved oxygen concentration before being discharged into the receiving stream.

A visual walk-through will be the primary method of controlling the process if careful observations are made. The sand filters are typically the last domino to fall if there has been an upset to the treatment process.

Proper control of the upstream treatment units reduces the frequency of over loading sand filters, and the work required to clean them.

## Tertiary Stage - Dosing Tank/Sand Filter

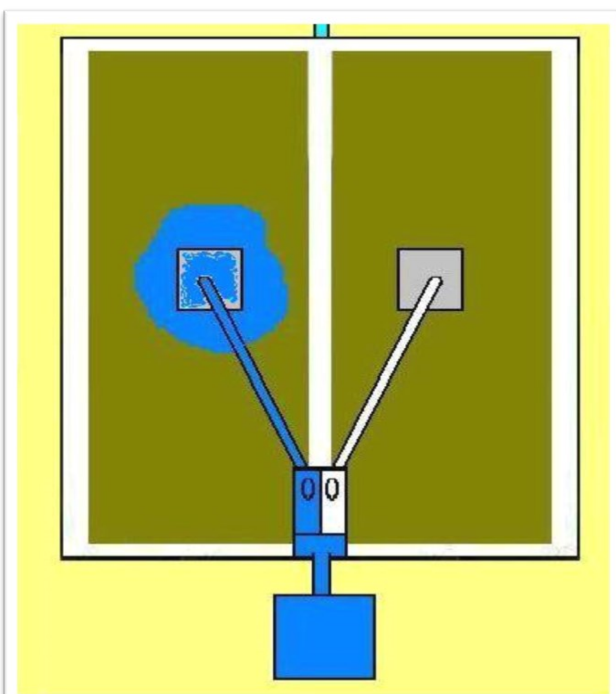
The dosing tank and sand filter work as a unit. Typically water flows by gravity from the flow splitting device of the preliminary stage through the treatment system to the clarifier of the secondary stage. A dosing pump receives the clarifier effluent flow and pumps it in "doses" to the top of the sand filter.




From this higher elevation the water can then continue to gravity flow through the tertiary stage and into the receiving stream. This also allows the sand filter to drain completely before the dosing pumps is activated again.

Dosing is required by many regulatory agencies because filters operate more efficiently. In extremely cold seasons, if water "ponds" too long on a filter it can freeze and seal off the filter. Dosing allows for filters to quickly drain to decrease the likelihood of freezing.

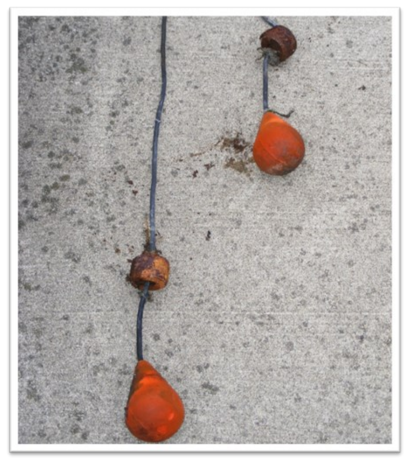
It is recommended to have only one filter in operation. This allows the filter which is out of service to dry and be cleaned by the operator.



**Tertiary Stage - Dosing Tank/Sand Filter**

A control panel above the dosing tank contains the electrical components to active the correct pumping sequences.


This control panel operates very similar to the flow equalization tank control panel. There are contacts to operate the pumps either manually ON (Hand), OFF, or based on the float switches (AUTO) located in the dosing tank.



The dosing tank pumps are controlled by a water level sensor when the controls are in the AUTO position. Typically float switches are used as level sensors to determine the operation of the dosing tank pumps.


When the pumps are activated a "run-time" meter records the minutes or hours of operation. This run-time data is important to track the hours of operation to determine when preventative maintenance is required on pumps.

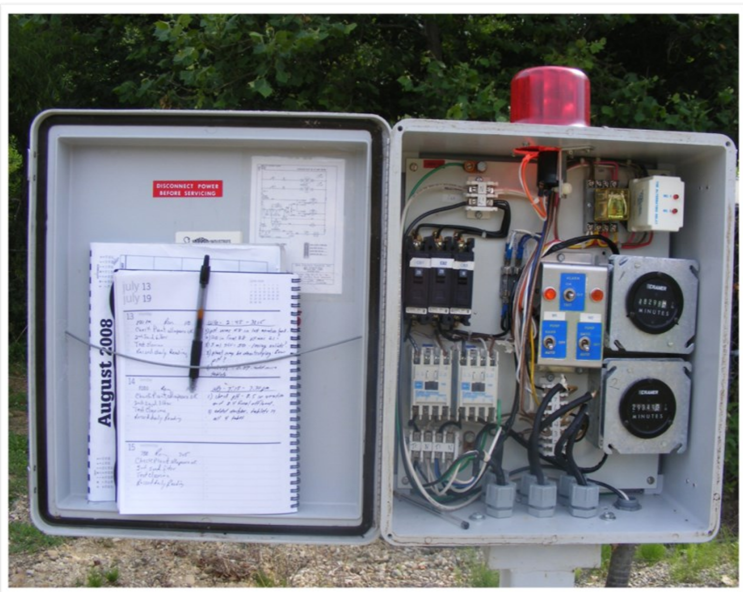
This data is also critical to measure the daily flow which passes through the treatment system. As an operator, it is important to determine if the daily flows are exceeding the hydraulic design capacity of the treatment system, but it can also be used for reporting the daily flow which is a requirement of the discharge permit.

## Tertiary Stage - Dosing Tank/Sand Filter

A treatment system which receives twice the daily flow for which it was designed will experience difficulty in achieving compliance. In addition, systems which experience flows significantly lower than design can also be difficult to operate. Thus, calculating the flow through the treatment process is critical. A simple and approved method for reporting flow from the treatment system is to calculate flow based on the run time of the dosing pumps.

If you know the pumping rate of the dosing pumps, it is a simple calculation of multiplying the minutes of operation from the run-time meter in a 24 hour period times the gallon per minute pumping rate of the dosing pumps.

Flow, gallons per day = runtime meter, minutes x pumping rate, gpm



Here the operator has kept the operational log book for the treatment system in the control panel box. By recording the run time meter daily the operator can determine how many gallons were pumped from the dosing tank in a 24 hour period.

The equation does require the operator to know an accurate pumping rate of the dosing pumps. This is determined by a draw-down test. Once the pumping rate for each pump is determined, a periodic check of the pumping rate to determined if the pumping rate has change is all that is required.

<u>Draw Down Test</u>

To determine the pumping rate perform a draw down test of the dosing tank. This is accomplished by first measuring the surface area of the dosing tank. In this example the dosing tank is 4 foot in diameter. To determine the surface area use either of the following formulas:

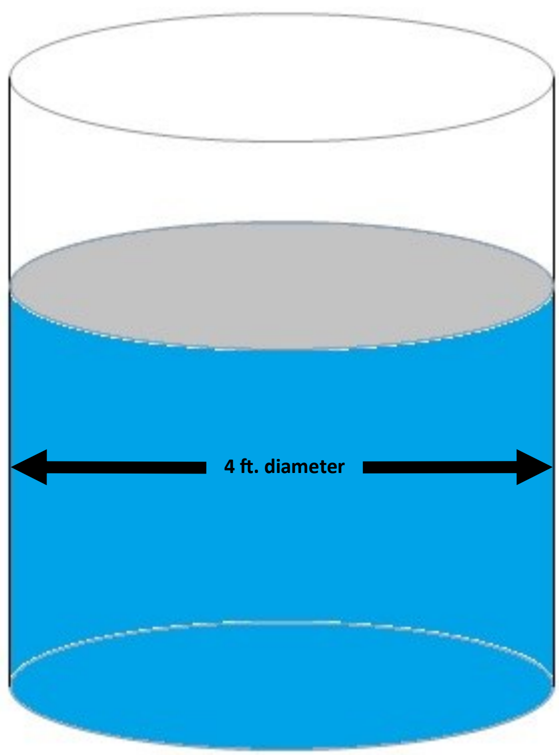
surface area = 3.14 x radius x radius

or

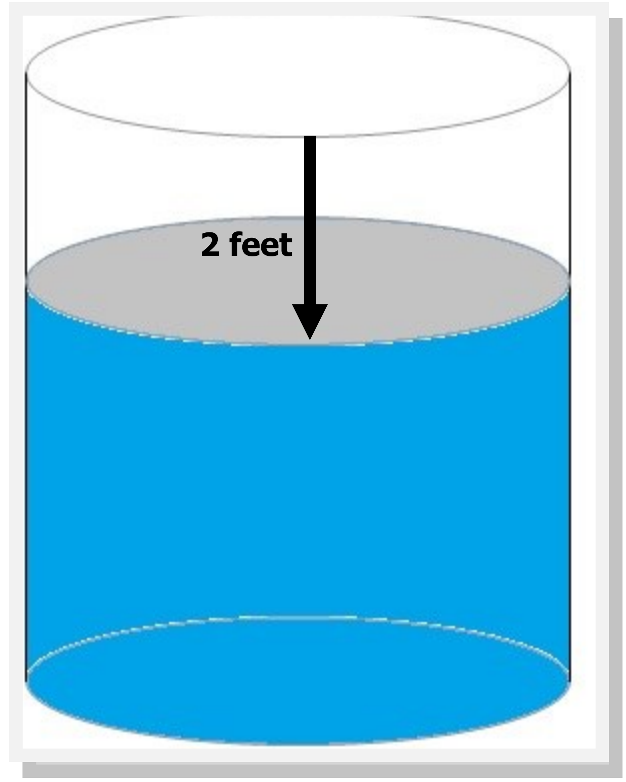
surface area = 0.785 x diameter x diameter

In this example the surface area is:

0.785 x 4 ft. x 4 ft. = 12.56 square feet

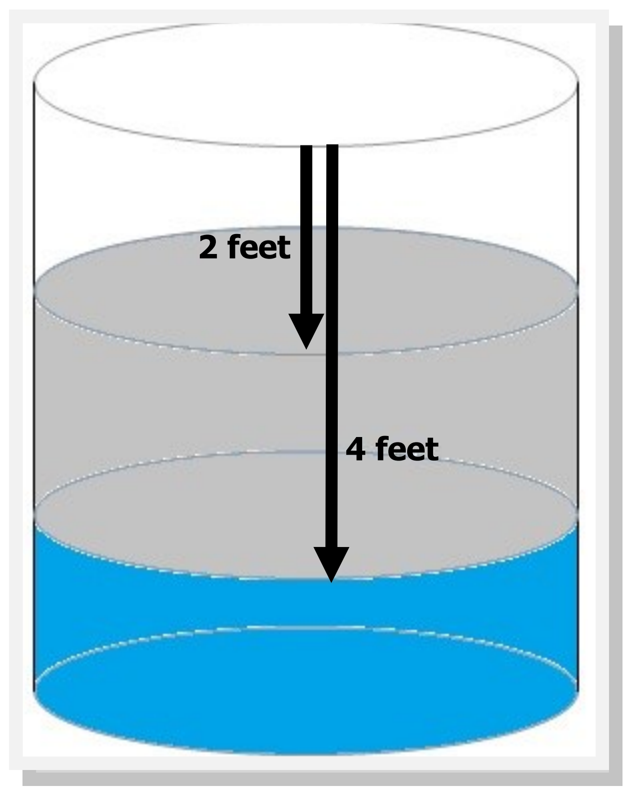


**Tertiary Stage - Dosing Tank/Sand Filter**




After the surface area is determined, measure the distance between the top of the dosing tank to the surface of the water. While the influent pumps are off and no flow is discharging into the dosing tank, turn one dosing pump to the ON position and draw the water down to the shut-off float (bottom float). With a stop watch record the time to draw the water elevation down.

The difference between the two water elevation measurements is the water depth pumped during the draw down test. If the first water elevation measurement is 2 feet and the second measurement after operating the pump is 4 feet, then then the difference in water elevation is 2 feet.




First we will determine the gallons of water pumped during the draw down test. Since we know the surface area of the dosing tank (12.56 $ft^2$), we can multiply the surface area by the change in water elevation (2 ft.) to determine the cubic feet of water pumped from the dosing tank.

12.56 $ft^2$ surface area x 2 ft. water pumped = 25.12 $ft^3$

Since 25.12 $ft^3$ of water was removed and each cubic foot of water contains 7.48 gallons of water, we can determine the exact volume of water pumped from the dosing tank by multiplying the cubic foot of volume pumped by 7.48 gallons.

25.12 $ft^3$ x 7.48 gallons/ $ft^3$ = 188 gallons pumped

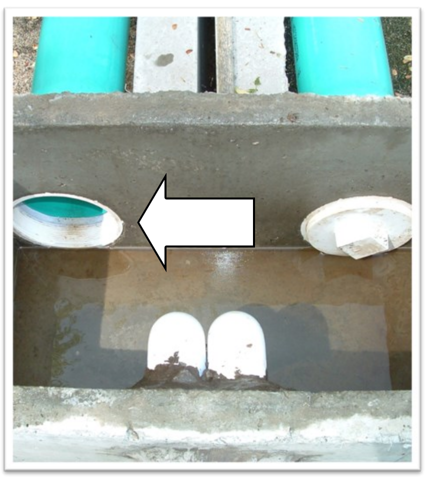
If you divide the gallons of water pumped by the time required to pump the water out, you will have an accurate pumping rate for the pump being tested. If in our example it required 5 minutes to pump the water down 2 feet then our pumping rate is:

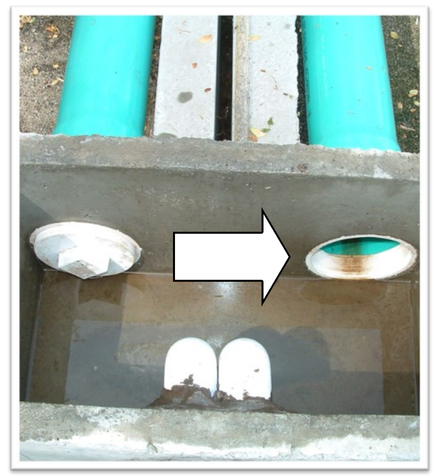
188 gallons of water pumped / 5 minutes to pump = 37.6 gpm pumping rate.

## Tertiary Stage - Dosing Tank/Sand Filter

The dosing pumps lift the water to a flow diversion box to control which sand filter is in operation.

Flows leaving the flow diversion box are typically controlled by simple plugs or slide gates.





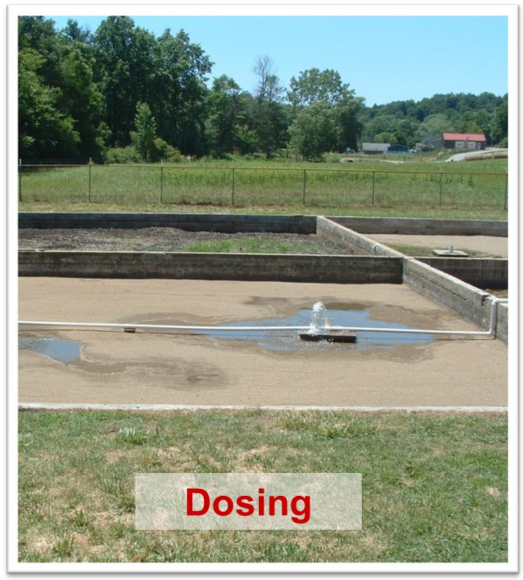
When a filter has reached the end of its life, then it is removed from service to allow for cleaning. Dried solids removed from the sand filter need to be disposed of properly. One method is to dispose of dried solids in a landfill.

## Tertiary Stage - Dosing Tank/Sand Filter

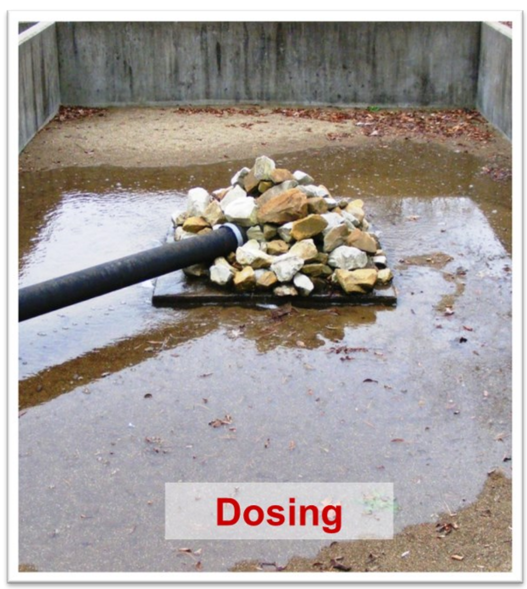
The Life Expectancy of a Sand Filter

If clean water is placed on a sand filter, it would theoretically operate forever and never need to be cleaned. However, even if a small concentration of suspended solids is passed through the filter, it would eventually become clogged and need cleaned. Typically systems which are operated effectively and not exposed to hydraulic flows greater that design can operate up to 3 months before needing to be removed from service. There is a way to "read" a filter to determine its stage in life and when cleaning will be required.

Infancy




A sand filter with clean sand and clean water from the clarifier effluent will filter through the sand media with little to none of the water reaching the side walls of the sand filter.




As the filter remains in operation and as the sand begins to clog, the flow from the dosing tank will reach more of the side walls before filtering through the sand.

## Tertiary Stage - Dosing Tank/Sand Filter

Deceased

Eventually the water from the dosing cycle will reach the side walls of the sand filter and begin to climb up the wall. When the water does not filter through the sand media completely before the dosing pump cycles again, the filter is said to be ponding and should be removed from service for cleaning.

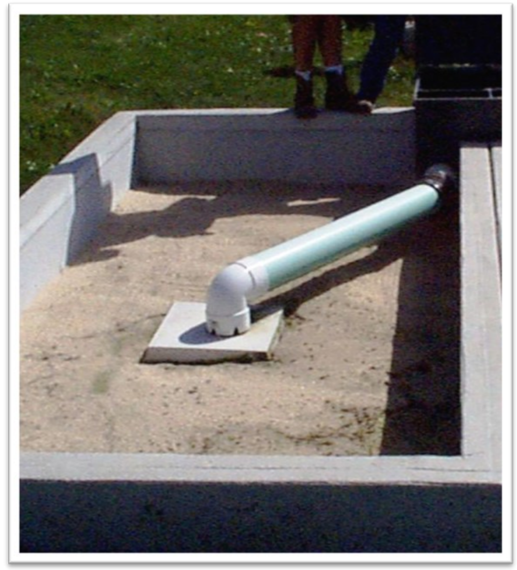


After taking the ponding sand filter out of service, the solids collected on the surface are allowed to dry. When the solids are sufficiently dried they can be scrapped or skimmed off the surface. After removal of the dried solids, a rake can be used to open the top few inches of the surface of the sand media. Raking will also provide a way of leveling out the sand media.


Once cleaned the filter is placed on stand-by to be brought back into service when the current filter in operation becomes deceased.

## Tertiary Stage - Dosing Tank/Sand Filter

The velocity of the flow from the diversion box onto the sand filter can cause a scouring effect of the sand media. To prevent this high velocity flow from pushing away the sand media a splash plate is used to disperse the flow over the sand filter. A concrete pad will assist in spreading the influent hydraulic pressure horizontally.



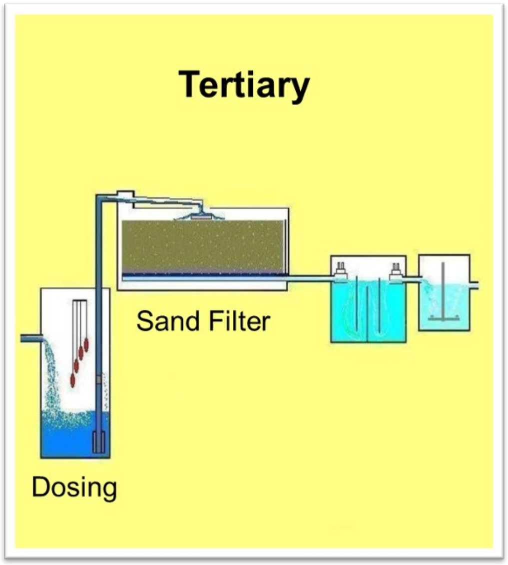
Some systems will direct the discharge pipe upward, so water has to over flow the pipe and flow down onto the splash pad. Remember to drill a drain hole in the bottom to the discharge elbow to prevent freezing during the winter months.

Often stones or gravel will be placed on the perimeter of the splash pad to disperse the influent velocity and prevent the scouring of sand.

As filters cycle through cleaning, sand media is lost along with the dried solids that are captured on the filter's surface. This becomes obvious when the sand media level drops below the splash pad.

As sand media is removed through the cleaning process additional sand must be brought in to maintain the intended media depth.

## Tertiary Stage - Dosing Tank/Sand Filter




The beginning of the tertiary stage is a physical process of pumping and filtration to remove fine suspended solids.

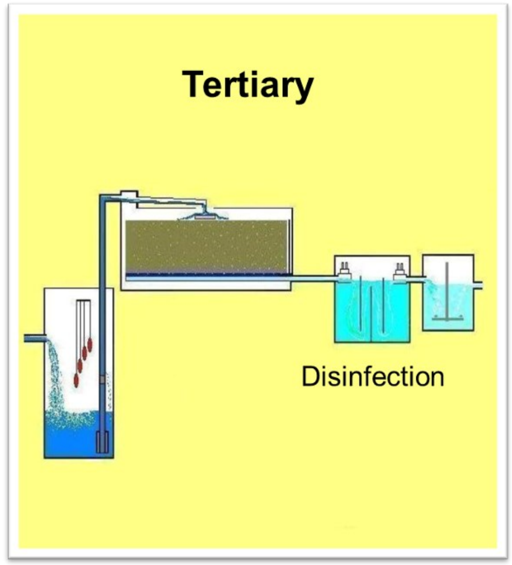
One filter should be in operation, while the other filter is on standby. This allows time for a clogged filter to dry and be cleaned.

The dosing tank set up is similar to the preliminary stage's flow equalization tank. An electrical panel contains the equipment to control the pumping sequences (ON, OFF, AUTO) and also provide the run time of the pumps to determine the volume of flow which has passed through the treatment system. This flow data is critical in determining if sufficient treatment capacity is available; if too much treatment capacity is in service; and required to calculate daily flow for reporting purposes.


When upsets occur in the treatment system, the problem is multiplied through the system and eventually ends up on the sand filter. The sand filter is the last domino to fall and usually the biggest domino.

A sand filter has a specific life expectancy. The cleaner the water passing through the filter, the longer the life of the filter.

## Tertiary Stage - Disinfection




After the fine suspended particles are removed through the filtration process, there still remain biological organisms (pathogens) which could cause human health issues if released into the receiving stream. These pathogens need to be prevented from entering the receiving stream. That is the purpose of the disinfection unit of the tertiary stage.

As water collects in the drain lines of the sand filter, it is next directed to the disinfection unit. Water enters the chlorine contact tank by passing through a tablet chlorinator.

The vertical tubes from the chlorinator can be removed so compressed tablets of calcium hypochlorite can be placed inside the tubes.

As water flows across the hypochlorite tablets in the bottom of the tubes, the calcium hypochlorite dissolves and a strong "bleach" solution is formed. This chlorinated water then enters the disinfection tank (also referred to as a chlorine contact tank) and the hypochlorite solution comes in contact with and kills the pathogens.

There are baffles within the disinfection tank to prevent short circuiting of the flow with the bleach solution for the most effective kill of pathogens.

A final effluent sample from the treatment system will be monitored for a type of coliform bacteria. The system must provide sufficient disinfection to be below the acceptable limit for coliform bacteria in the effluent. Violations of effluent coliform is usually due to inadequate hypochlorite tablets in use to achieve the desired disinfection necessary. Not using the tablet chlorinator as designed will lead to violations of the coliform limit and ineffective use of chemicals.

## Tertiary Stage - Disinfection

Another possible cause for elevated coliform bacteria in the final effluent could be solids which have deposited in either the dosing tank or the chlorine contact tank. Over time, solids can accumulate within either of these tanks. As the settled bacteria begin to increase in volume and die in the bottom of the tank, they can become a demand on the disinfecting capabilities of the bleach in solution.

By placing a larger demand on the hypochlorite solution, it is more probable that coliform bacteria may pass through the disinfection unit. Using a clarifier core sampler to check for sludge deposits on the bottom of these tanks is a simple way to determine if solids are leading to coliform violations.

A pumping out of deposited solids will bring the system back into compliance with effluent coliform limits and reduce chemical costs, since fewer tablets will be required.

While we need to protect humans from pathogens entering the receiving stream, the system cannot discharge a high concentration of chlorinated water into the receiving stream because of its negative impact on the aquatic species.

Low levels of chlorine can have a detrimental effect on fish in the stream. In order to protect the aquatic species, another tablet feeder is designed into the effluent of the disinfection tank. The process is exactly the same as that is used for disinfection, except a different type of chemical tablets is used. Sodium sulfite is a reducing agent and when exposed to chlorine, an oxidizing agent, will neutralize the excess chlorine.

## Tertiary Stage - Disinfection

Calcium hypochlorite is used for disinfection of the water prior to being discharged to the final effluent. Disinfection is adequate if you are maintaining compliance with the final effluent limit for coliform bacteria.

Sodium sulfite is used to remove excess chlorine in the water prior to being discharged to the final effluent. De-chlorination is adequate if you are maintaining compliance with the final effluent limit for total chlorine residual.


ULTRA-VIOLET DISINFECTION

Another method of disinfection is to use ultra-violet light instead of chemicals. Since we are not adding chlorine for disinfection, there is no need to add a de-chlorinating chemical. The ultra-violet, or uV disinfection process uses light to disable pathogens from reproducing. Since they are unable to reproduce, they are prevented from becoming a health hazard for humans in the receiving streams.

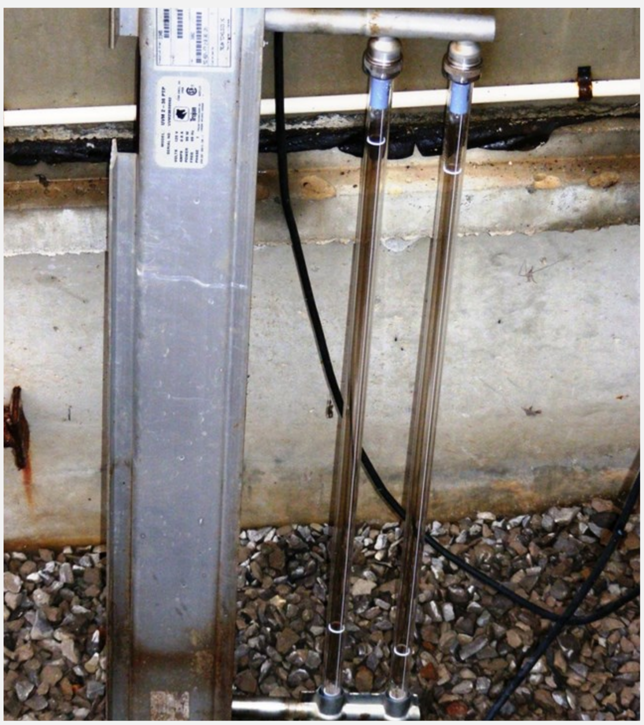

Systems which treat larger flows will typically have more uV bulbs available for disinfection. Above is a system with a lower flow design (1 bulb) than the system to the right (2 bulbs).

**Tertiary Stage - Disinfection**

Here is another type of uV disinfecting unit in which the water flows vertically around the uV lamp.

If the system is experiencing effluent violations for coliform bacteria then there is either insufficient uV light to inactivate the bacteria which pass through the uV channel, or something is obstructing the path of light from the uV bulb.

Overtime the uV bulbs develop a scale which restricts the uV light from reaching the bacteria in the water. These bulbs require periodic cleaning to allow for the most effective light transmittance in to the water column for the best disinfection of bacteria.

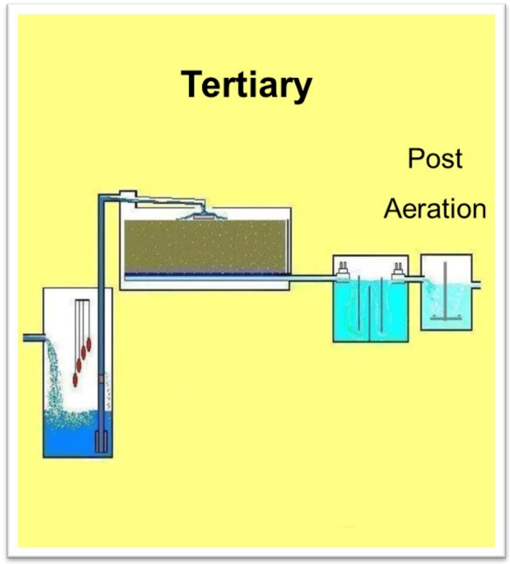


The uV bulbs also lose intensity over time, and like a regular light bulb in your office, will eventually dim and burn out. These bulbs need to be replaced after extended hours of service.

One other possibility of uV failure is if the water entering the disinfection unit is not clear. High turbidity from suspended solids or unconverted pollutants will hide or cover pathogens for the uV light path. This allows bacteria to leave the disinfection unit.

### Tertiary Stage - Post Aeration

The last step in the treatment process before discharging into the receiving stream is to increase the dissolved oxygen concentration in the water. This is done by diffusing air into the water after the disinfection unit but before the final discharge.




If the air supply which is used to provide post aeration is connected to other air supply lines (aeration diffusers), care must be taken when making adjustments to the entire aeration system. The air will travel to the path of least resistance.

Adjustments to increased air flow to the aeration tank diffusers could reduce air flow to the post aeration diffusers. Insufficient air flow to the post aeration tank could lead to violations of the discharge limit for not maintaining a minimum dissolved oxygen concentration in the final effluent.

## Tertiary Stage - Post Aeration

Aeration should be provided after any de-chlorination process. The sodium sulfite which is used to remove excess chlorine will also remove dissolved oxygen. De-chlorination units downstream of the post-aeration could lead to low dissolved oxygen concentrations in the final effluent.

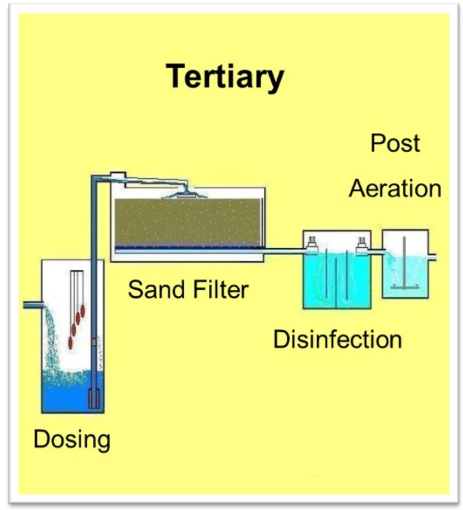
The design to the right has the post aeration after the de-chlorination unit. This prevents low DO due to chemical addition of sodium sulfite.

The design above has post-aeration prior to de-chlorination and could be the cause of low dissolved oxygen violations in the final effluent, due to the de-chlorinating chemical reducing the dissolved oxygen concentration.


Since the post aeration process is a physical process, it requires visual monitoring. If adjustments are made to the air flow in one part of the system, visually inspect to make sure it did not negatively impact the air flow to the post aeration. Of course the best assurance is to actually measure the DO concentration of the effluent.

## Tertiary Stage—Summary

The Tertiary Stage is mainly a physical process which will require visual observations. The four units in the Tertiary Stage, dosing tank, sand filter, disinfection and post aeration, work together to provide a fine polishing of the water prior to discharge to the receiving stream.




The dosing tank also provides an accurate and simple method for monitoring the flow through the treatment system. Not only is the data critical for making operational decisions, it is also required to be reported to the Ohio EPA. Failure to report accurate flow values is a reporting violation.

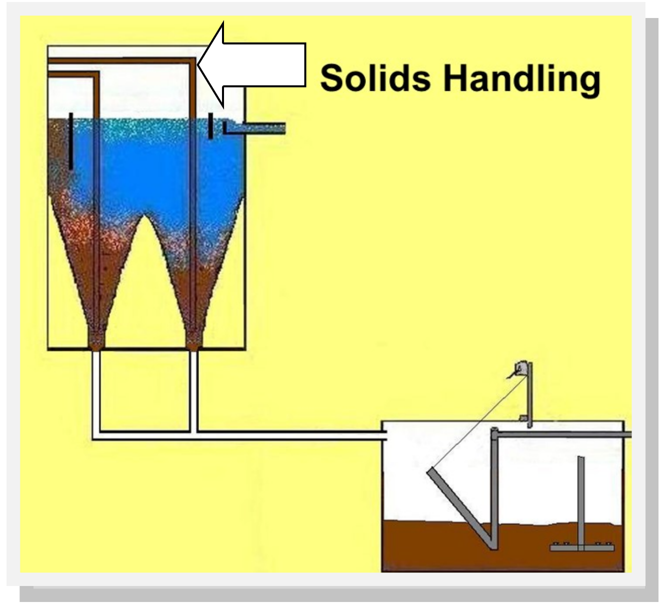
Sand filters have a limited life expectancy depending on the amount of suspend solids placed on the filter. The cleaner the water flowing on the filter the longer the life span. Typically a filter should be able to survive 2 to 3 months before needing cleaned. If the system losses control problems get magnified as they pass through, however, the sand filter is the "safety net" where most mistakes are captured.

Disinfection can be either accomplished chemically with the use of tablet chlorinators or biologically with the use of UV lamps. The purpose is to inhibit and/or kill pathogenic bacteria and prevent their regeneration in the receiving stream. If chemicals are used to disinfect, then chemicals are used to remove excess chlorine from the water due to its negative impact to the fish in the receiving stream.

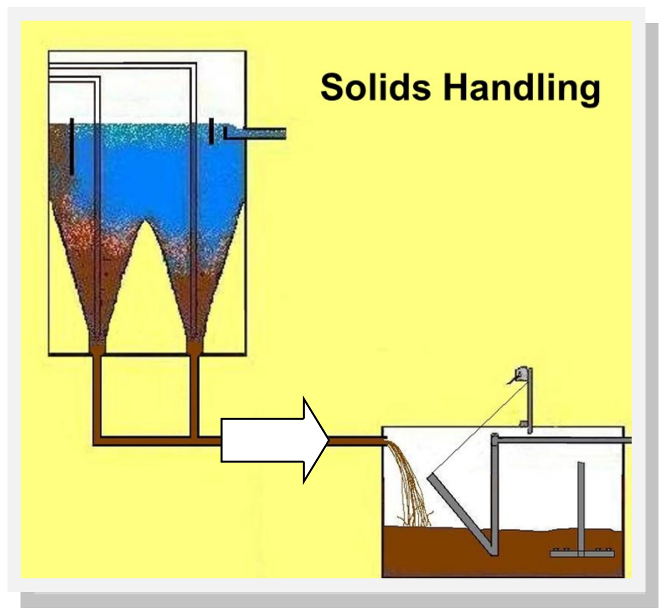

The permit requires a final effluent discharge of greater than 6 mg/L. If the post aeration is operational, this is typically not a problem. However, when adjustments are made to the lines which feed the post aeration, it is possible to lose the post aeration process. Measure with a DO meter to know if sufficient oxygen is available in the receiving stream.

## Solids Handling Stage - Digester

The activated sludge treatment process is designed to convert dissolved and suspended pollutants in the aeration tank into bacteria, which will separate from the water by sedimentation in the clarifier. These settled bacteria are returned back into the aeration tank and continue to convert pollutants into more bacteria cells. This settled bacteria is referred to as Return Activated Sludge (RAS).



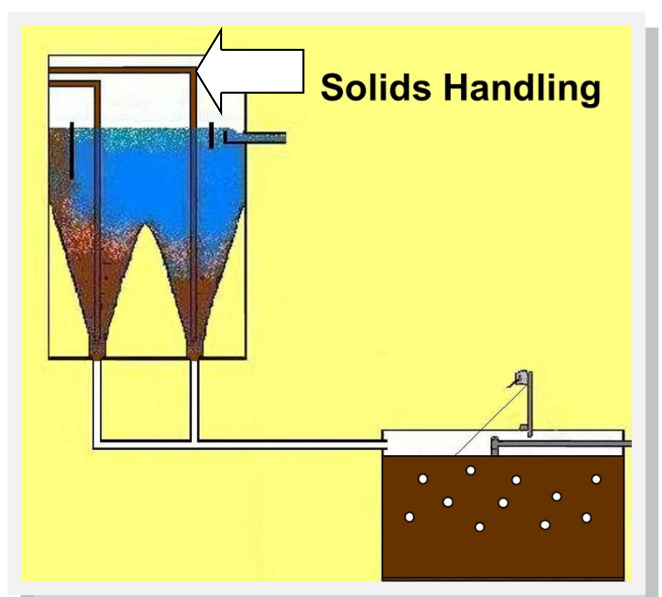

As pollutants continue to enter the treatment system, more bacteria are grown in the aeration tank. Eventually the bacteria concentration will become too excessive and the system will lose control. To maintain control, excess bacteria must be removed from the treatment system. This is usually performed by diverting the bacteria which is being pumped from the bottom of the clarifier back into the aeration tank to the digester or sludge holding tank. This removal of bacteria from the secondary stage is referred to as wasting (WAS).




When the proper amount of bacteria has been removed from the secondary stage, the wasting vales are closed and the return valve are open to allow for the bacteria to be directed to the aeration tank again.

The digester will hold excess bacteria to prevent upsets to the in-line treatment process. The bacteria in the digester need to be aerated to prevent them from becoming anaerobic.

Under anaerobic conditions the bacteria will create strong odor problems and will not allow for separation or thickening of the bacteria in the digester.

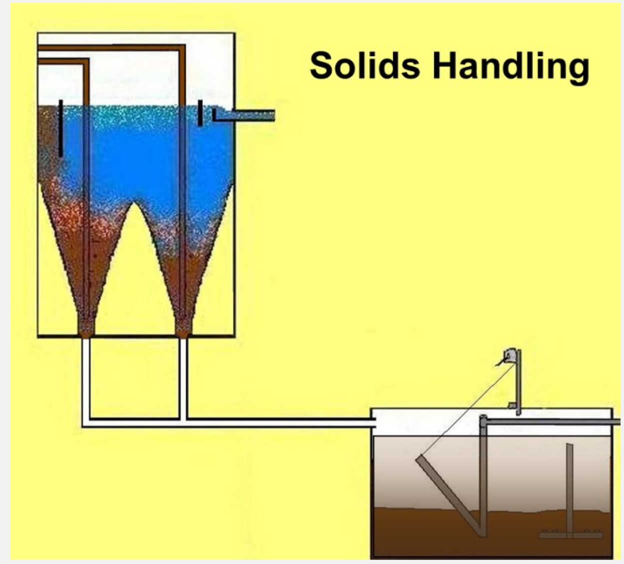


## Solids Handling Stage - Digester

When the digester becomes full the air can be discontinued for a short period to allow for solids to separate.

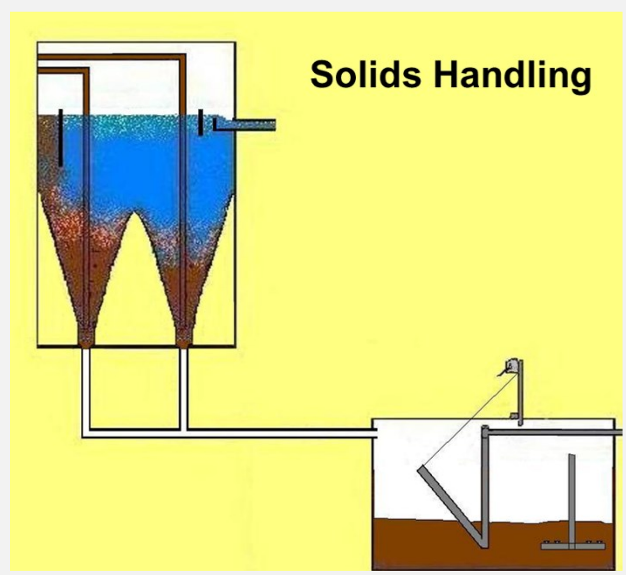
The supernatant, or clearer liquid on top, can be decanted and sent back to the head of the treatment system to be processed.

Decanting of the supernatant in the digester will allow you to extend the capacity, however, as the solids concentration increase in the digester separation becomes less effective.



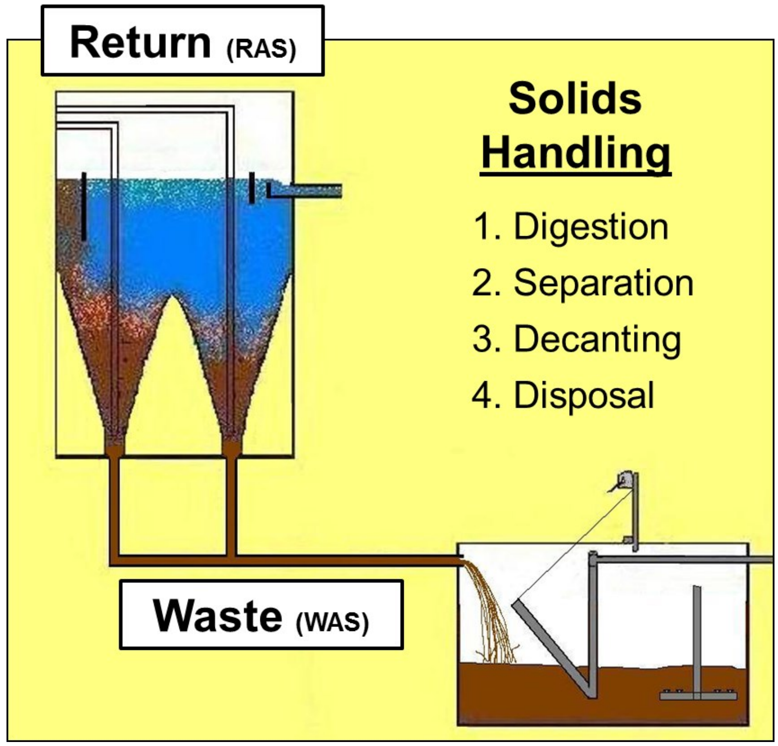

Eventually the digester has to be emptied by the septic hauler. The higher the concentration of pollutants in the influent, the more solids the system will generate, the more frequently the digester will need to be pumped out.

Having capacity to "waste" excess bacteria into the digester is a critical control measure. If excess bacteria can not be removed from the Secondary Stage the treatment system will become upset and either will require cleaning of the sand filters due to solids loss or violation of the effluent permit limits or both. Knowing when and how much to waste is critical in controlling the treatment system, having digester capacity to waste into is just as critical.



## Solids Handling Stage—Summary

The Solids Handling Stage is an off-line process, referring to the main wastewater flow does not go through this stage. However, in order for the treatment system to perform properly, excess solids or bacteria must be consistently removed and stored in this off-line unit.




The digester is used to further digest bacteria, which converts them to carbon dioxide (gas) and water. This digestion process reduces the concentration of bacteria in the digester.

Eventually the digestion process can not significantly reduce the bacteria. If the aeration is temporarily discontinued, the bacteria will separate and allow for decanting of excess water from the digester. This creates additional storage capacity in the digester.

As the bacteria concentration increases, separation of water and bacteria becomes less effective. At this point the digester needs to be pumped out so digester capacity is available to prevent an upset to the treatment process due to high bacteria concentrations in the Secondary Stage.

Visual Inspection includes:

1. adequate aeration provided to maintain aerobic conditions in digester

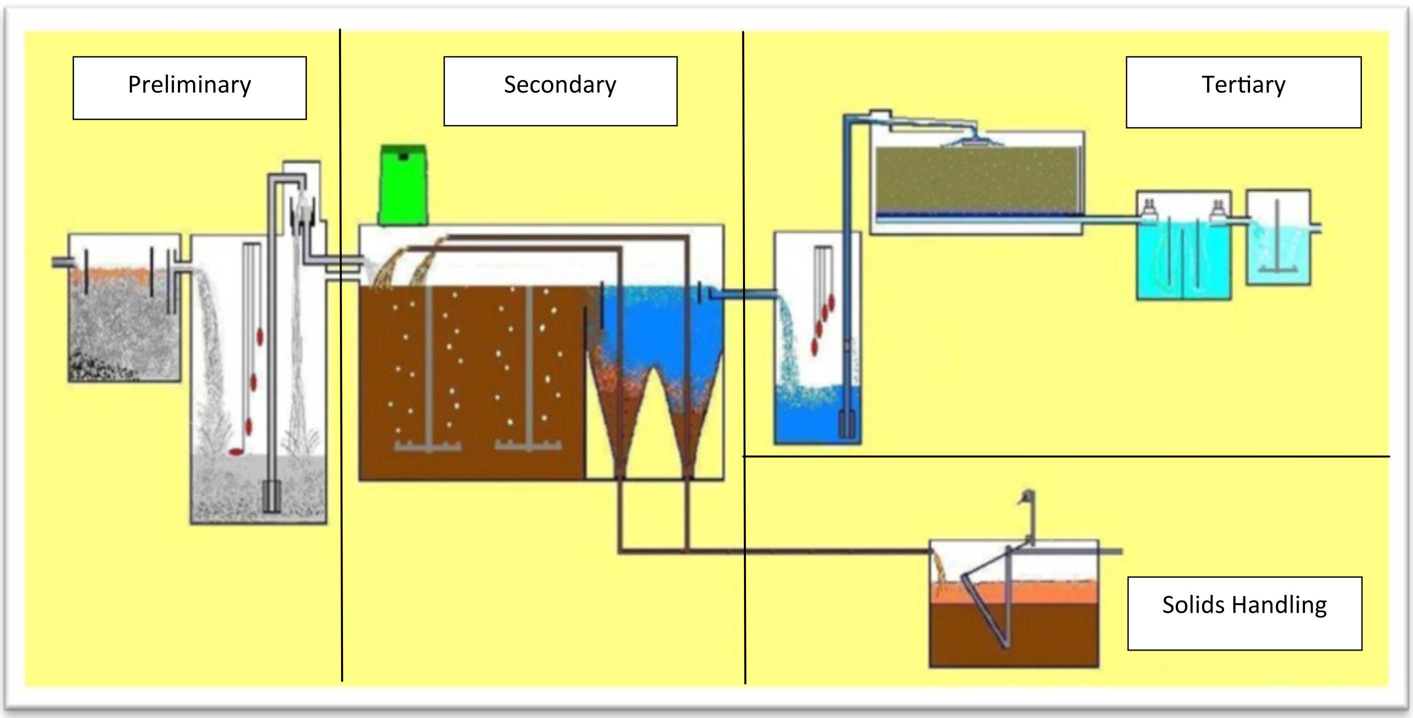
2. decanting mechanism operational to increase digester capacity

3. sufficient digester capacity available to not limit operational control of Secondary Stage (limited wasting capability)

## Controlling the Process

Process control is monitoring the system and making minor adjustments to keep the process balanced and performing effectively. Troubleshooting is collecting data to identify the cause of an upset condition and making more significant adjustments to bring the system back into compliance. Both situations, process control and troubleshooting, use the same methodology for identification of the issue(s) limiting performance.

The type of monitoring required is mainly determined by the type of process used in the treatment system. Physical processes can be monitored by visual observations. Biological processes can be monitored by a simple chemical analyses. Knowing what to look for or what to test for is the first step. Interpreting the results accurately is the second. Since this treatment process operates on a few basic concepts, understanding these concepts and their interaction with each other provides the evidence to accurately identify causes of limited performance.




Monitor each stage separately. Adjust the process based on visual and chemical data collected. Implement the correct action which is required. Then monitor each stage to confirm the limiting performance was identified and a proper response was implemented for correction.

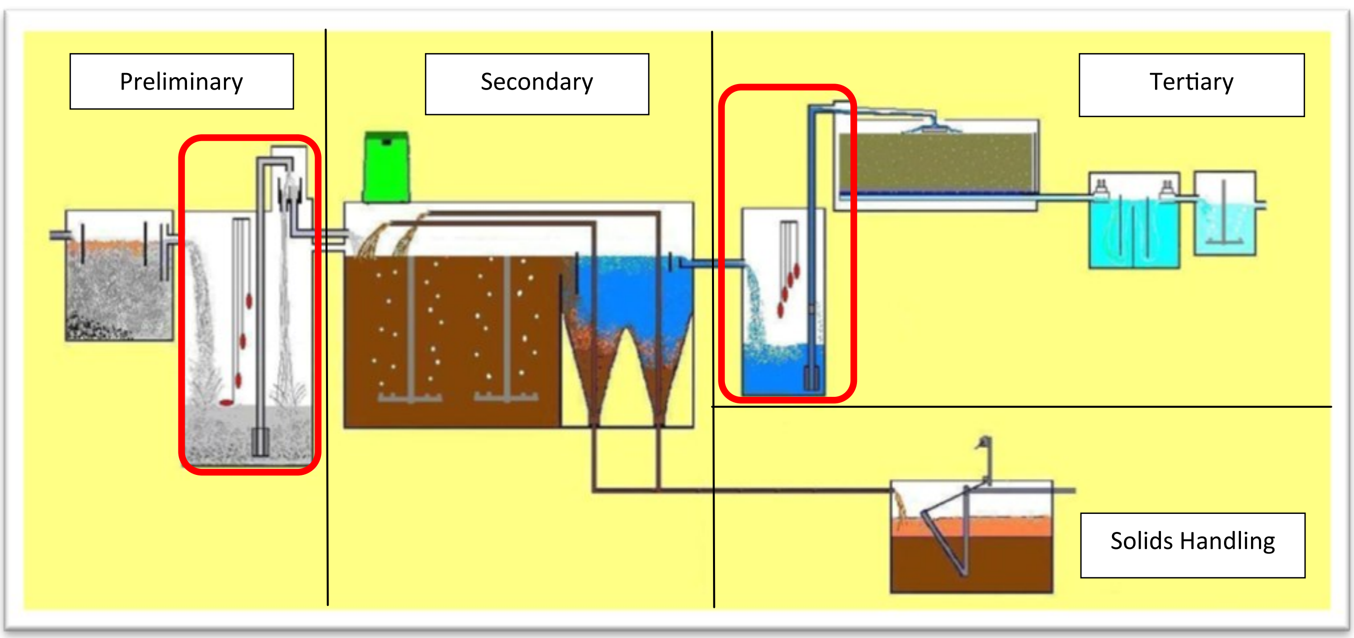
Each stage is designed to prepare the water for the next treatment stage. If this is achieved, the system will operate at its highest efficiency. High efficiency is defined as the cleanest effluent with the least amount of resources (time, money) invested. The individual stages can operate in sync with each other or spiral out of control. As the operator, you determine the direction of the process by monitoring what the system needs and providing timely adjustment. Either the gears mesh together for smooth performance or they can grind the system to a halt.

## Maintenance

Maintaining operational control of the treatment system requires making the correct operational decisions, but it also requires the equipment to be operational. Knowing that the aeration tank needs more aeration does not prevent upset conditions if the equipment is unavailable for use.

There are three general areas which this maintenance section will address; pumping equipment, aeration equipment and infrastructure. Again, this will be a general overview of the equipment necessary to maintain control, which will include the basic units of a pumping or aeration system and protection of the treatment system. As an Operator in Responsible Charge (ORC) of a treatment system, you should become familiar with your specific equipment and their mechanical maintenance requirements. You don't need to be a certified electrician or mechanic to operate a treatment system, however, you are responsible for understanding the maintenance requirements to contract for services which you are unqualified to perform. Knowing a problem exists, or is pending, is key. As the ORC, it is your decision to contract repair/maintenance to a professional, or perform the work yourself.

Pumping Equipment: control panels, pumps, floats



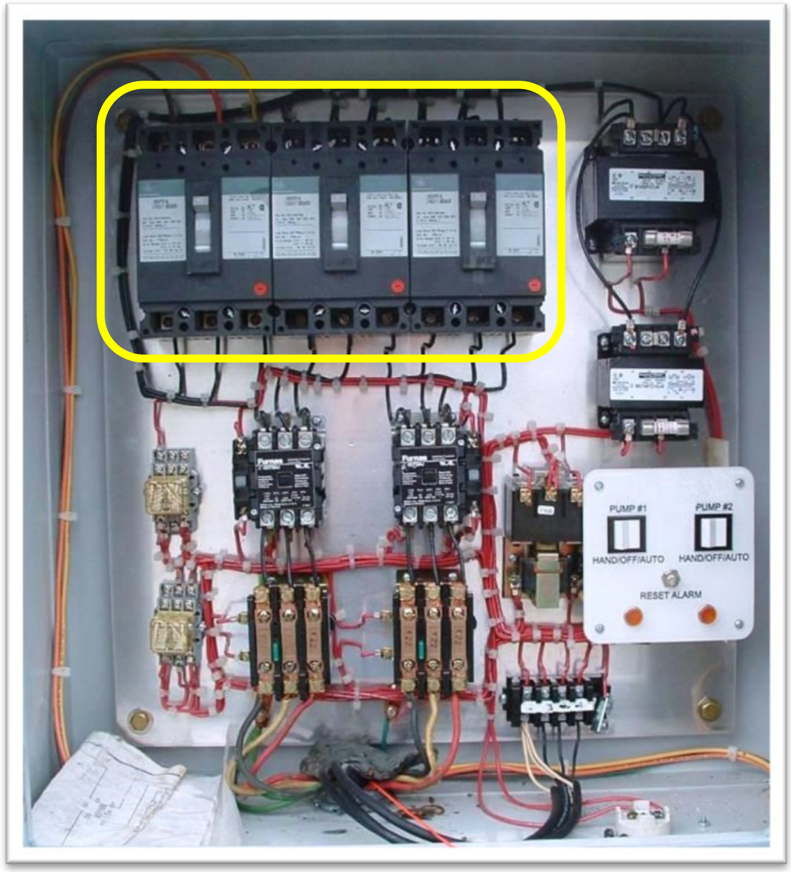

The flow EQ tank and the dosing tank are usually equipped with submersible pumps for raising the water to a higher elevation to gravity flow through the treatment system.

An electronic control panel is located near the pumps and used to activate the proper pumping sequence. Most control panels contain an audible alarm or light to indicate if there is a mechanical failure with the pumping system.

## Control Panel

Control panels will contain similar components. Power supplied from the incoming feed line enters the control panel and must first pass through the circuit breakers.

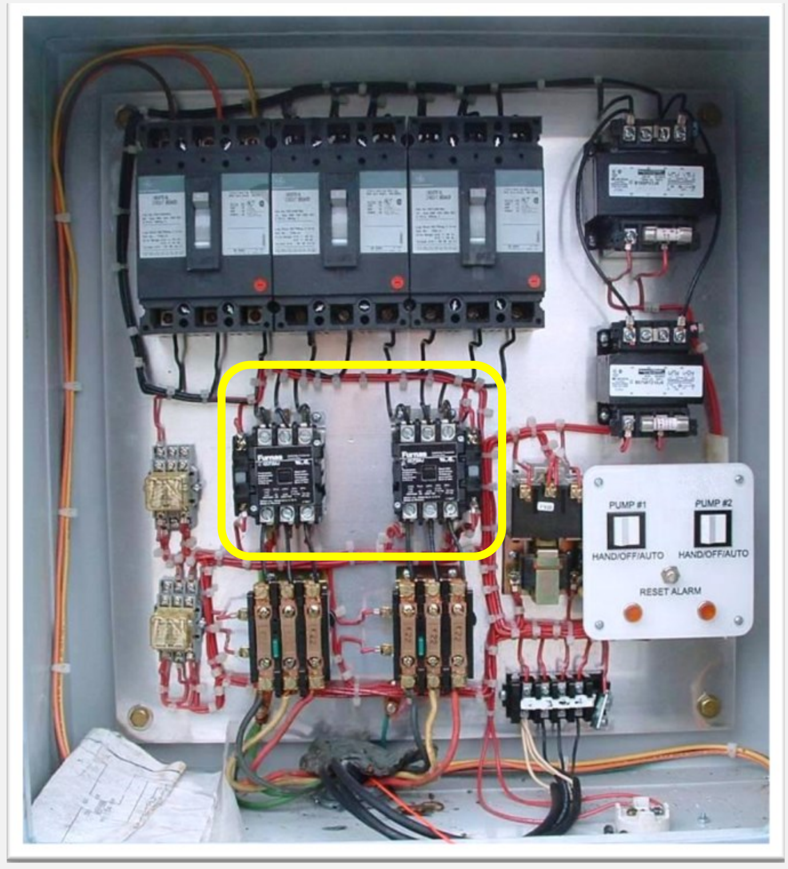
If any work is to be performed on the electrical components, the circuit breakers must be opened to prevent an electrical hazard. To protect yourself from electrical injury, lock out the control panel while working on the mechanical components of the system, so no one can re-energize the system while it is being serviced.




If the breakers are in the closed position, power passes through the breakers to the contactors.

## Control Panel

Power next passes through the contactors. The contactors are either in the open or closed position based, on the position of the control switches.

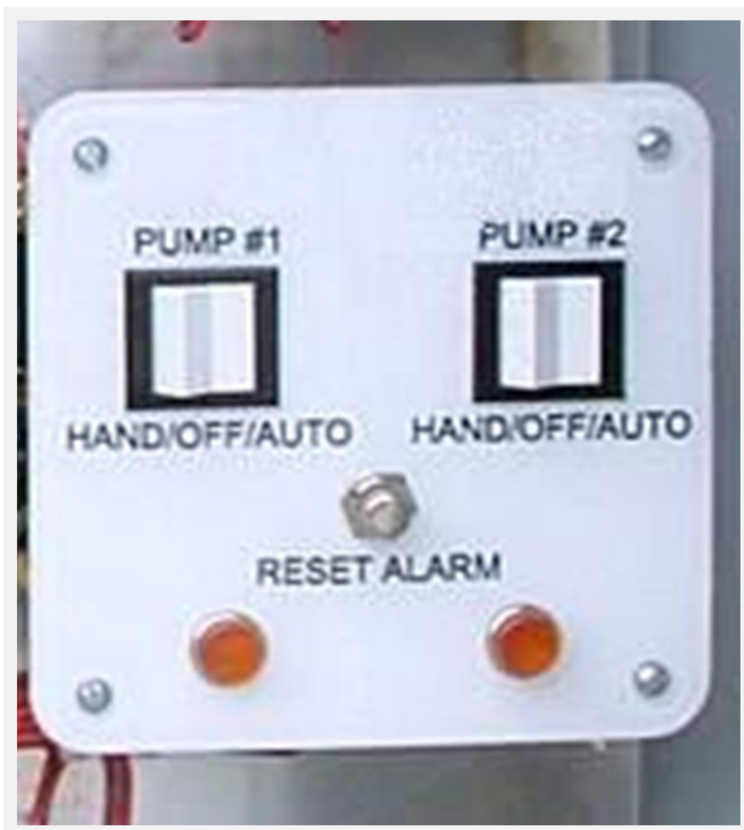




The pump controls determine if the contactors are in the open or closed position.

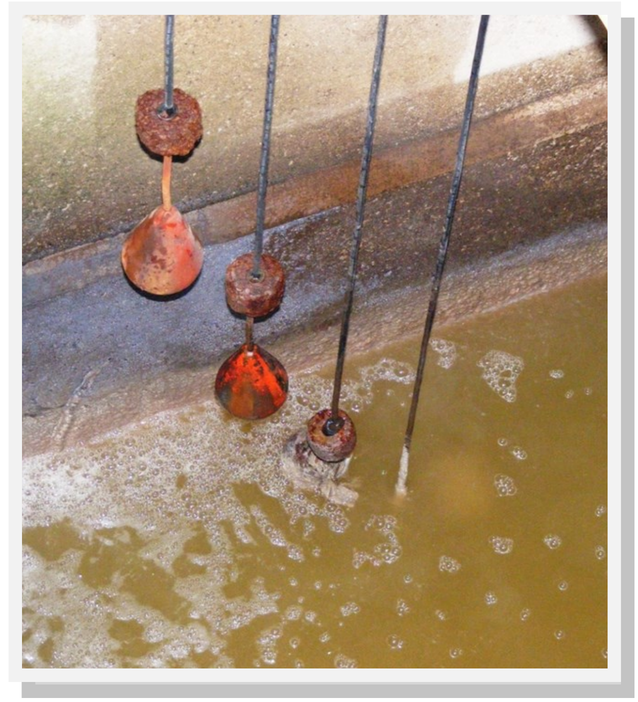
When in the "HAND" or ON position the contactor is closed, completing the circuit and allowing the pump to be energized.

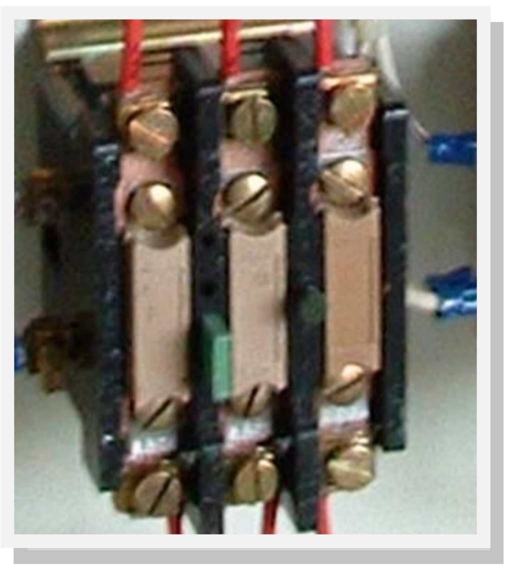
If the controls are in the "OFF" position, the contactor is in the open position and the pump is not energized. When performing maintenance on the pump, disconnect the power with the breaker and not the pump controls.



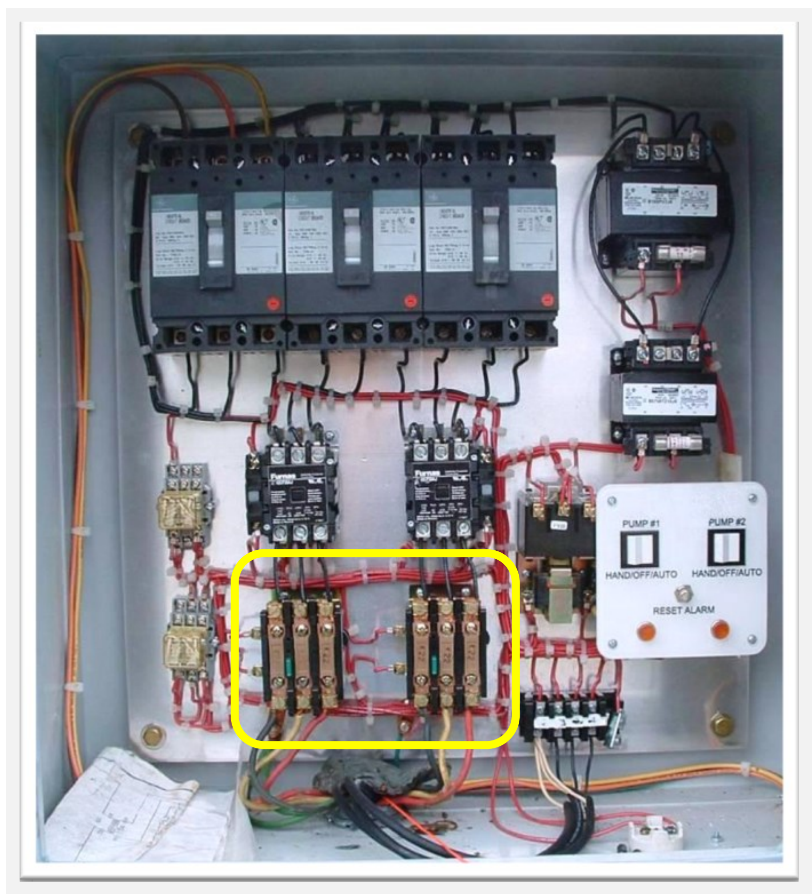
## Control Panel

If the pump controls are in the AUTO position then the position of the contactor is controlled by the float switches in the tank. As the float switches are activated by the water elevation in the tank, the contactor is closed and the pump is energized. As the water elevation in the tank decreases, the float switches open the circuit and the pumps shut off.





If power passes through the contactors, it must also pass through the overload. The overload provides protection of the pump and/or wiring if the pump begins to draw too high of an amperage load.




If the pump impeller becomes obstructed, it will draw more amps. This increase in amperage could lead to the pump burning up or damage to electrical wiring. To prevent excessive amperage draw, the overload will open the circuit and power will be discontinued to the pump.

In the overload above, the green pin (above) will “kick” out to open the circuit. Sometimes the overload will kick out due to fluctuations from the power feed. Resetting the overload can be achieved by pushing the green pin back in. If the overload kicks out again, evaluate the source of the increased amperage draw.

## Control Panel

Measuring the actual amperage being drawn by the submersible pump can be achieved with an amp meter. It is best to measure the amp draw when a new pump is installed and record this value in the control panel. Periodic evaluation of the amp draw will allow you to determine when a problem is occurring by comparing the initial amp reading to future amp readings.

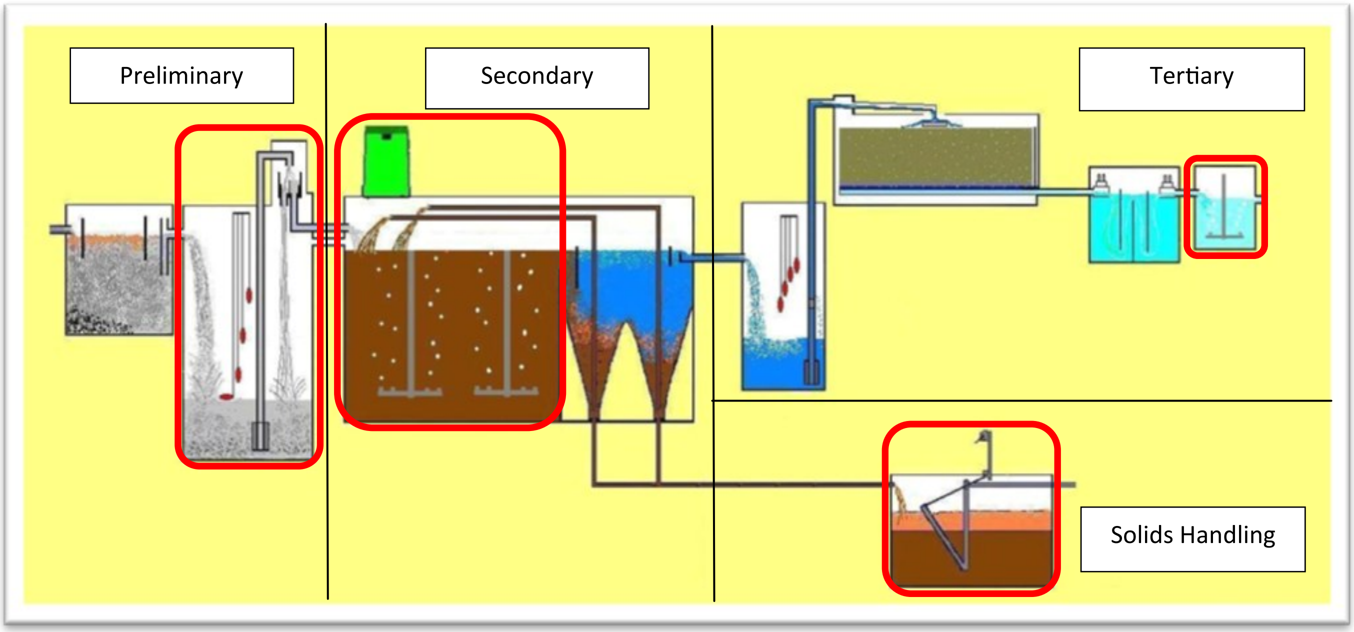

To verify the pumps are operational, switch the controls to the HAND or on position. If the pump is not energized, there is a problem with the pump or the controls.

Next switch the controls to AUTO and manually raise the floats to actuate the contactors. The proper sequence should be first activating the bottom float and then activating the next higher float. The lead pump should be energized and begin pumping. By activating the next higher float, a second or lag pump should be energized. If there is a problem with the pumps being energized, there could be a problem with the pump, the controls or the float switches.


The electrical controls for the flow EQ tank and the dosing tank are similar, and troubleshooting either will be similar. Power from the line first passes through the breakers. The system needs to be de-energized before working on the pumps. Contactors are controlled by the pump controls settings (HAND/OFF/AUTO), which are also controlled by the float switches if in the AUTO position. The overload prevents excessive amperage draw to protect the equipment from damage.

## Aeration Equipment: Control Panels, Motors, Blowers, Piping

A second important area requiring monitoring and maintenance is the aeration equipment. Aeration is required in the aeration tank for conversion of pollutants to bacteria. However, aeration is also provided in the flow EQ tank for mixing of suspended pollutants and post aeration to increase the dissolved oxygen levels to achieve compliance with the effluent limit. Aeration is also provided in the solids holding tank or digester to maintain an aerobic environment while storing excess bacteria.




Often the aeration for the post aeration tank or digester is provided by the blower which also supplies diffused air to the aeration tank. Care must be taken to insure proper adjustments when these tanks are connected by the same blower. The compressed air will take the path of least resistance, so water depth above the diffusers, friction loss through the pipes, and clogged diffusers or piping will affect the aeration that can be applied.

Similar electrical components are used in the control panel for the blowers as is used in the control panel for the submersible pumps. A look inside the panel will reveal breakers, contactors, and overloads. The main difference will be the blower controls operate off of a timer instead of float switches.

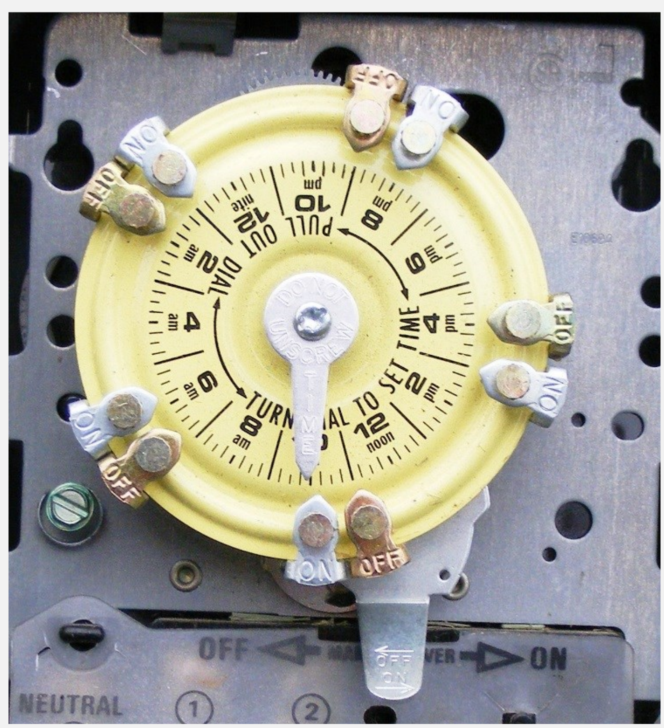
## Aeration Equipment: Control Panels


With the blower controller set to the "HAND" position, the blower motor will not operate until the time clock closes the contactor to energies the motor.

A typical time clock contains 96 pins which can be used to determine motor run time at 15 minute increments. Some time clocks have fewer pins and are less expensive, but you are sacrificing control, especially if you are working with a time clock with only a few settings available.


To the left is another time clock with a 96 pin on/off options.

To the right is a time clock with limited on/off options. This clock will allow the operator only five on/off cycles in a 24 hour period. Most aeration systems would benefit with more flexibility in aeration cycles, both in frequency and duration.



## Aeration Equipment: Motors

The control panel houses the electrical equipment to control and power the motor. The motor/ blower assembly uses this power to provide the compressed air necessary for treatment.

Because the motor can be energized automatically, based on the control settings, you should approach any motor/blower assembly as a potential safety hazard. A guard must be in place to protect yourself from accidents when the motor is energized.

Some motor/blower assemblies are designed so the housing unit is also the guard assembly. Here is a motor/blower assembly in which the housing is removed to prevent heat buildup. The danger here is the housing unit is also the guard for the moving pulley/belt. This has now become a safety issue.

## Aeration Equipment: Motors

Remember, if performing any maintenance or repair work on the motor or the blower, disconnect the power source at the breaker, then lock out the control panel so it can not be energized without your knowledge.

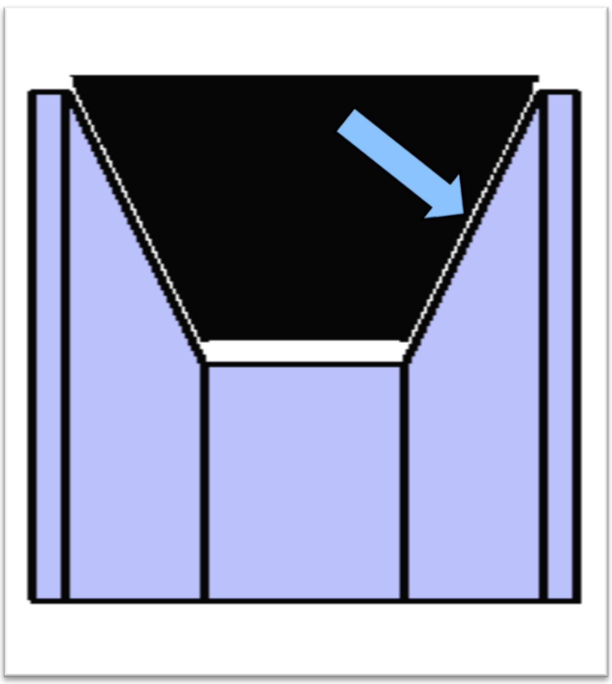

The electrical motor driving the blower needs to be maintained for the highest efficiency and longest life. Some electrical motors require lubrication on a regular schedule. There are several manufactures of electrical motors and each manufacturer is the best resource on when lubrication is necessary and the type of lubricant to be used. Consult the equipment manufacturer's recommendation on the frequency and type of lubrication for optimum performance.

## Aeration Equipment: Motors

Electrical energy is transformed into mechanical energy in the motor, which is then transferred to the blower by pulleys and v-belts.

The incorrect combination of pulley or belt could lead to loss in efficiency in transferring the mechanical energy from the motor to the blower, decreased belt life, or damage to bearings in the motor or blower.

Belt tension and alignment is critical in prevention of mechanical problems from the motor/blower assembly.

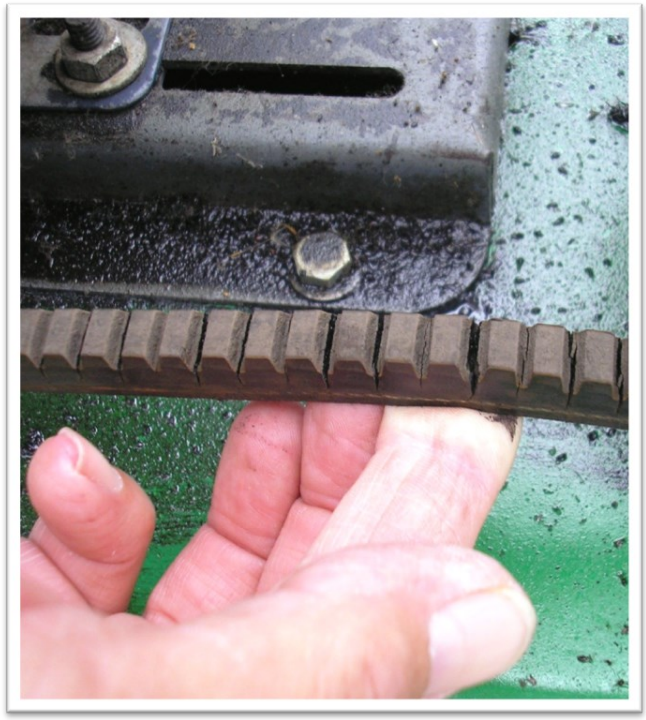


Energy is transferred from the motor to the blower by a v-belt. The power transfer occurs between the sidewall of the v-belt and the pulley. If the v-belt sits low enough in the pulley to ride against the base of the pulley, power will be lost and slippage will occur.

A sign that the v-belt is riding too low in the base of the pulley is if this area has a "polished" look to it. The friction of the belt on the base will produce a polished look to the base.

## Aeration Equipment: Motors

A visual inspection of the belt will prevent many unexpected mechanical issues. Before physically examining the v-belt, open the electrical breaker to prevent the motor from being energized and lock out the control panel.



A simple inspection of this v-belt indicates it is running on electricity or luck. These cracks are deep and the belt needs to be replaced.

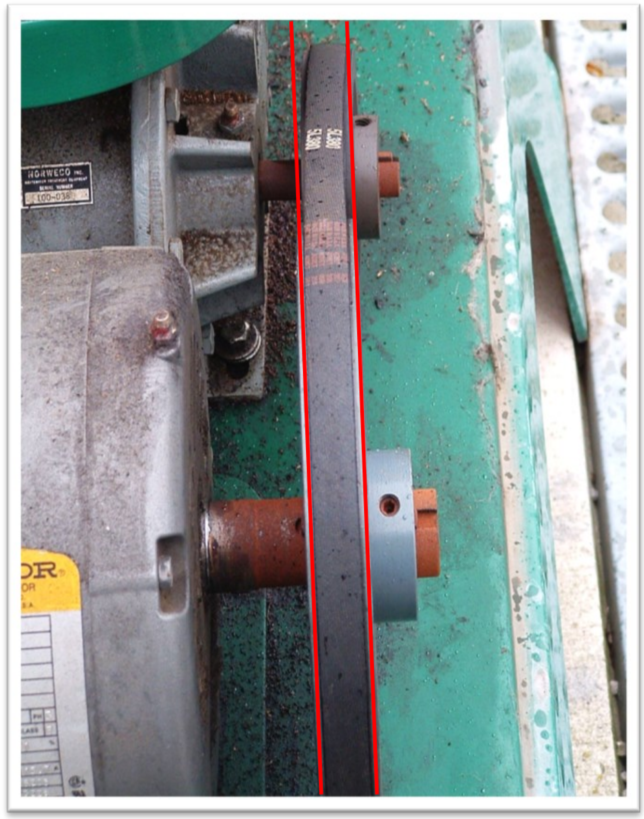
Belt tension is also an important factor in transferring power to the blower unit. When tension is insufficient power is lost through slippage of the v-belt. If belt tension is too tight it will decrease belt life, increase pulley wear and exert a load on the bearings of the motor and blower. Increased bearing loads lead to expensive equipment repairs.

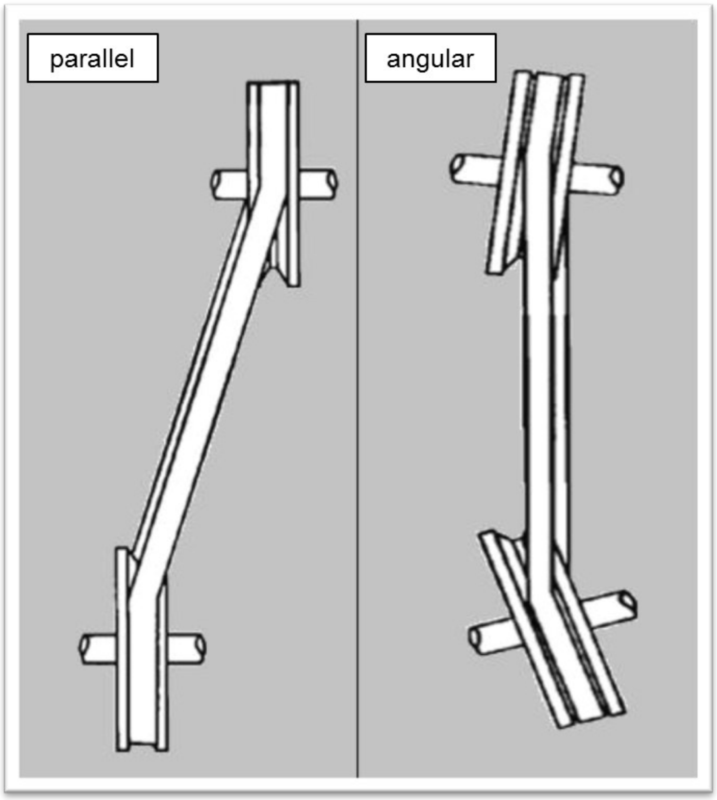
A belt tension tester is inexpensive and provides an accurate measurement of the belt tension.

Measuring the belt tension is significantly cheaper than replacing a motor or blower.


## Aeration Equipment: Motors

Alignment of the v-belt between the pulleys is critical to prevent decreased belt life. When the belt is not aligned it creates pinch points which causes a wear pattern leading to a belt failure and also places uneven loading on the bearings of the motor or blower.






A misaligned belt can be parallel or angular. The photo above is an angular misalignment.

A simple way to determine if the pulleys are misaligned is to use a straight edge and measure if the belt is aligned. (Even a piece of string will indicate if an adjustment is necessary.)

Again, remember to open the circuit breaker and lock out the control panel before exposing fingers to potential moving assemblies.

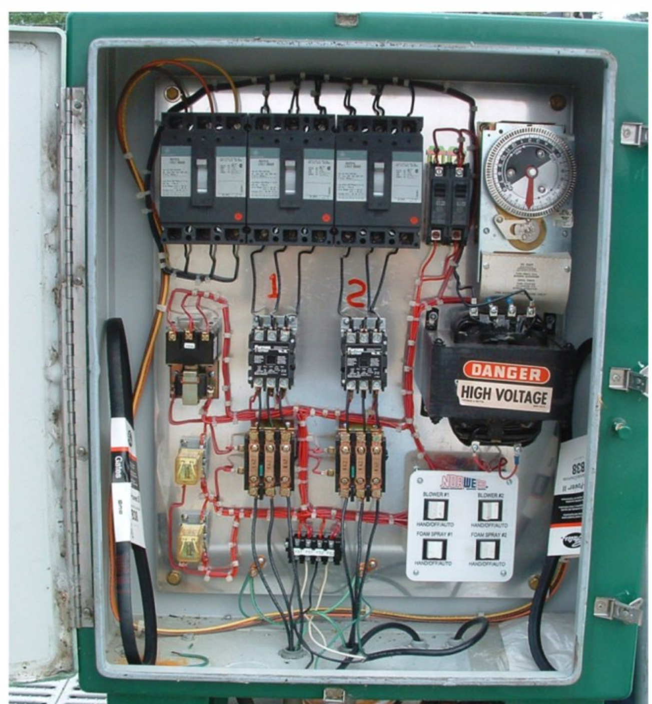
## Aeration Equipment: Motors

Improper belt tension and misalignment will decrease belt life, so measure the tension and alignment to extent belt life.  However, one thing is certain, no matter how well you maintain the motor/blower assembly, belt failure will eventually occur.  The aerobic treatment process will not function unless aeration is provided, so it is critical to have replacement belts available to decrease the down time of the aeration system.

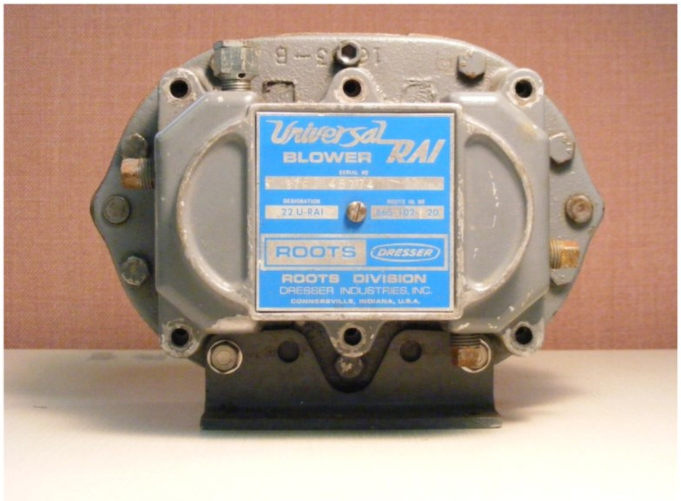
When replacing v-belts a "run-in" time is required, since belts will stretch after a short period of operation.  It is best to run the new belt and return to re-adjust the tension of the belt.

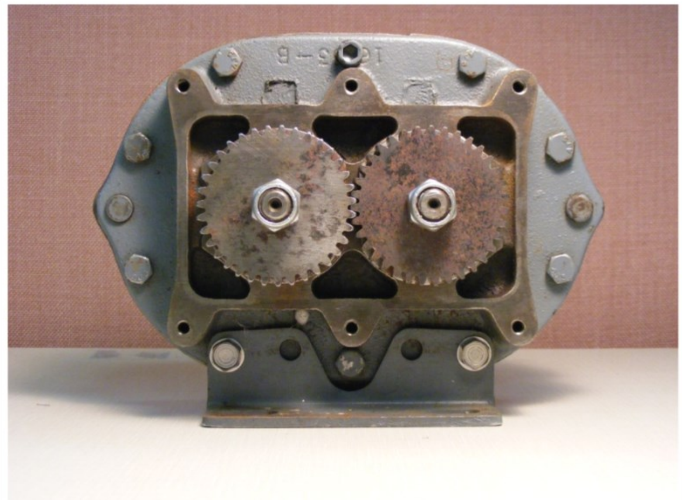
If a system has multi-belts it is recommended to replace all the belts and not just the one that broke.

Belts tend to reach a failure point at the most inconvenient time.  Having replacement belts onsite allows you to initiate repair immediately.



## Aeration Equipment: Blowers



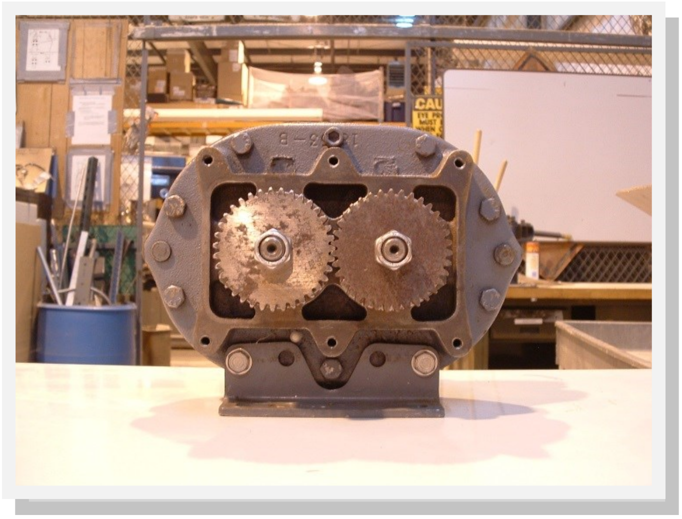
Power is delivered to the blower to rotate timing gears that generate the compressed air necessary for the aeration tank. These timing gears need to be lubricated according to the manufacturer's specifications. Each manufacture will specify the type and volume of lubrication required for optimum performance.

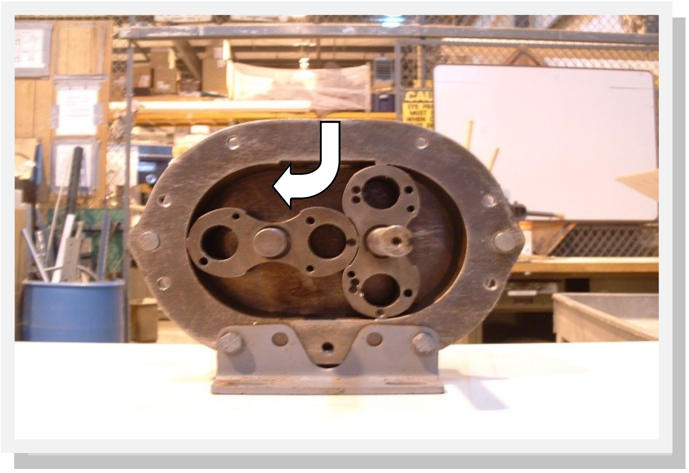
Insufficient lubrication will decrease blower life from friction. Too much lubricant will cause a foaming effect, which can damage seals on bearings.

If the motor/blower mounting table is kept clean of excess oil and grease, it becomes more obvious if problems are developing.

## Aeration Equipment: Blowers

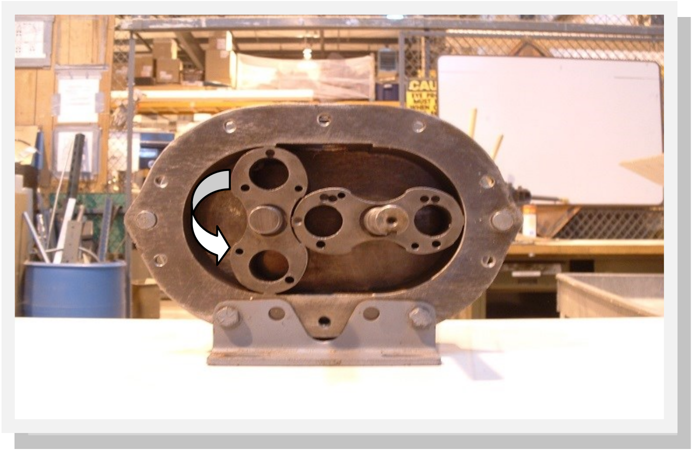
The timing gears on one side of the blower drive the lobes on the other side, which is where the inlet air is compressed and discharged into the piping to deliver air to the aeration tank diffusers.

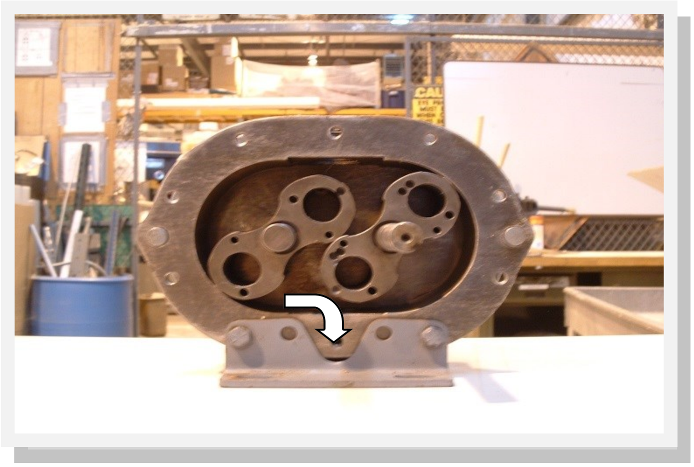




As the lobes rotate, they draw atmospheric air through an air filter located on top of the blower.

The rotating lobes push the air through the open cavity of the blower.

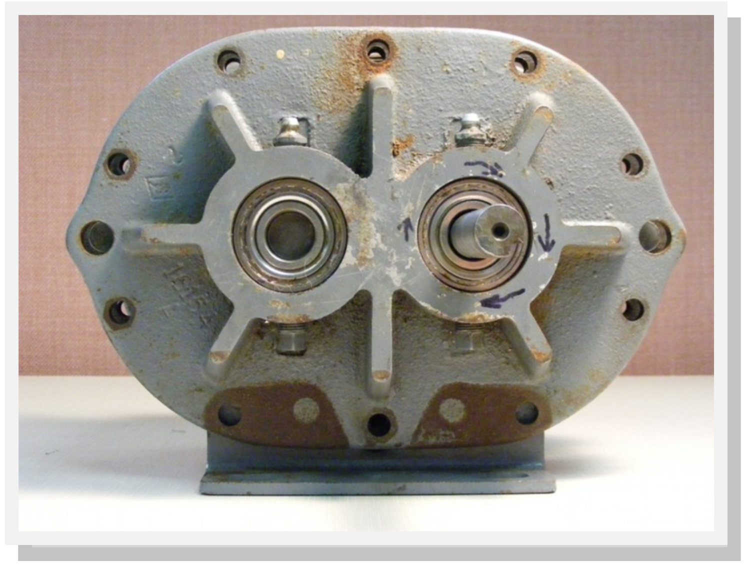


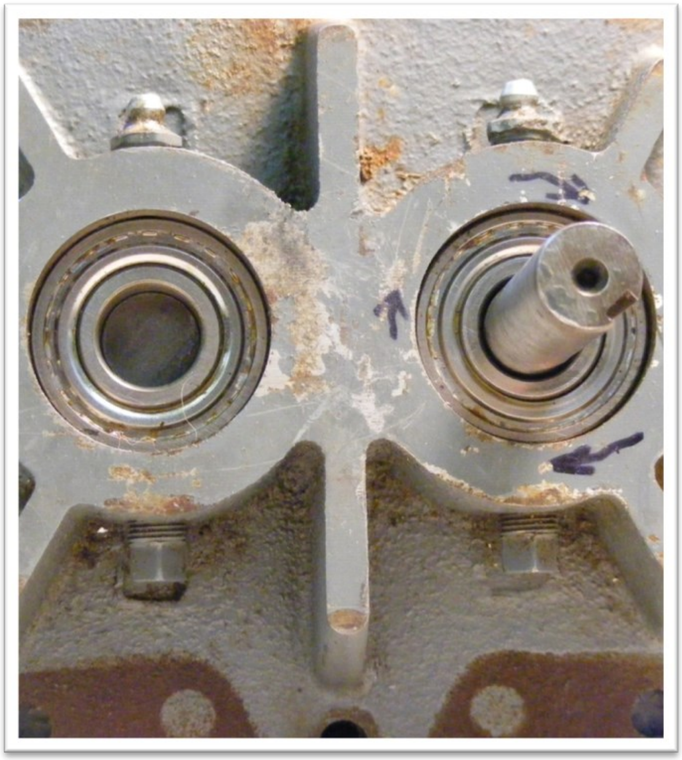


As the lobe rotates, the air is allowed to escape through an opening in the bottom of the blower. The air is forced out of the blower into a piping system, which directs the air to the diffusers in the bottom of the aeration tank.

## Aeration Equipment: Blowers

There will be grease ports located for each bearing which requires periodic lubrication.

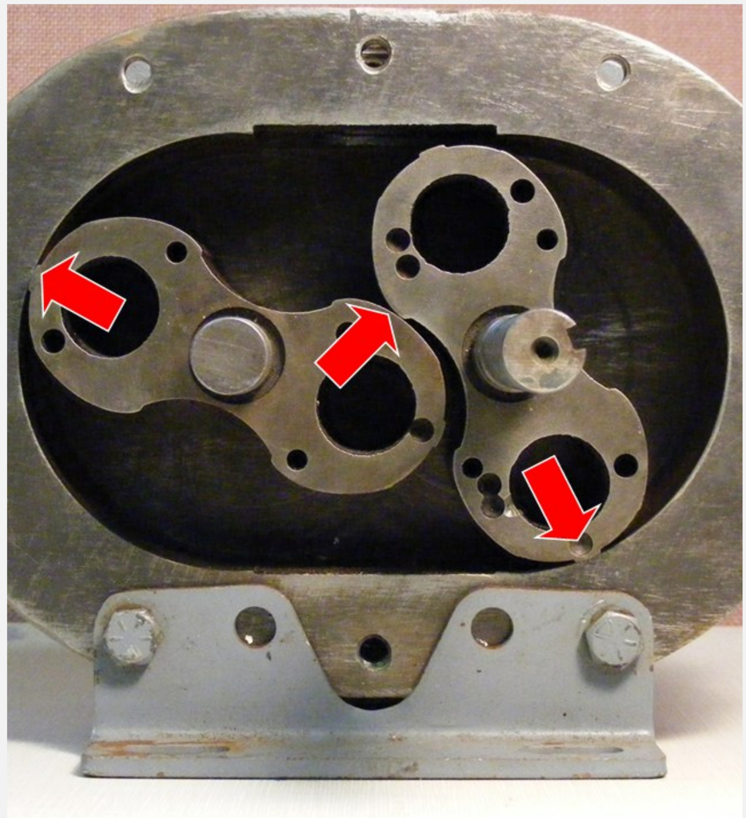




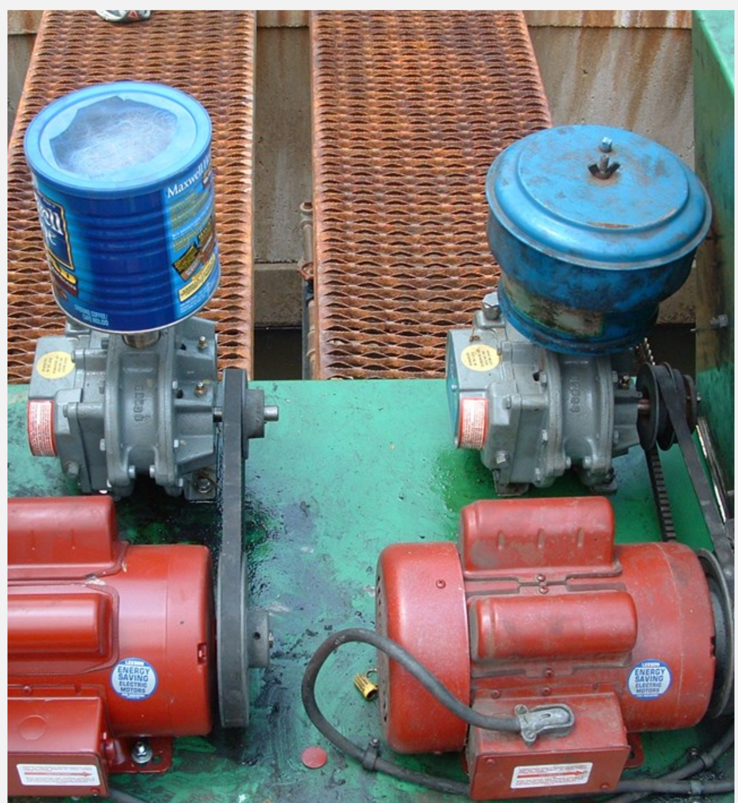
The bearings on both sides of the blower require lubrication.  Again, follow the manufacture's recommendations for the type and frequency of lubrication.

## Aeration Equipment: Blowers

The tolerances within the rotating lobes are measured to a few thousandths of an inch. To protect the lobes from damage, it is important that the air being drawn into the blower has been filtered to eliminate dust, dirt or foreign particles. Thus, blower units without filters will be unable to protect the blower or achieve an extended operational life.

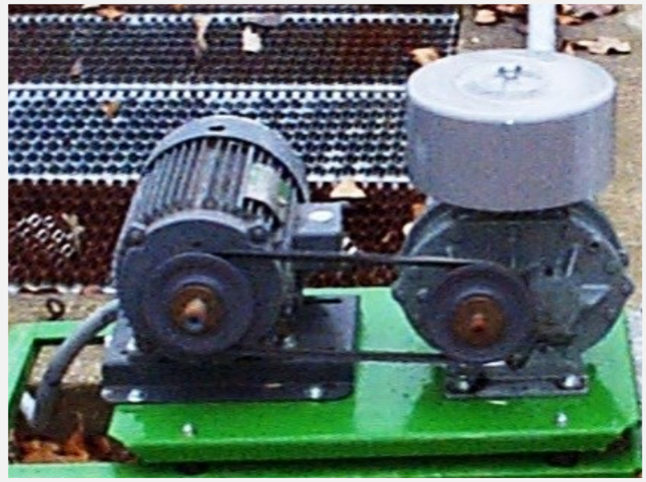


Filtration systems which have been modified from the original design might look impressive and be better than no filter, but will fail to remove particulates smaller than a few thousandths of an inch.

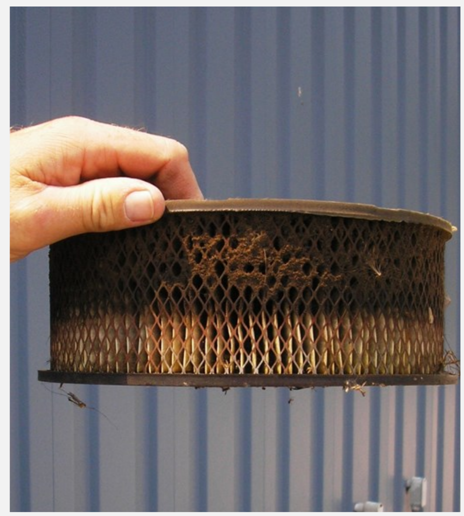


**Aeration Equipment: Blowers**

A proper motor/blower assembly requires a filtration system to protect the blower. The air filter used should be inspected regularly for indications of needing replaced. It is not adequate to replace the filter based on time in service, because ambient air quality also determines filter life.

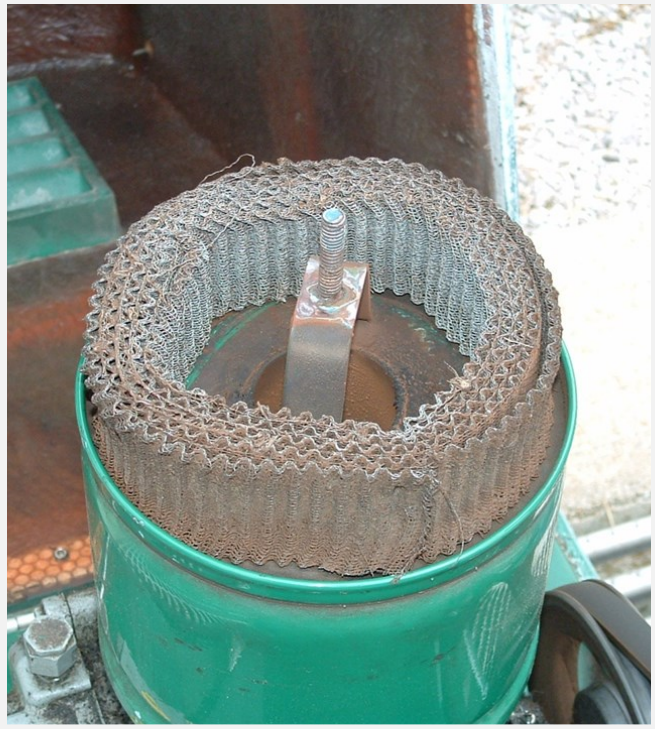


Package plant systems are typically located in rural settings. Depending on the time of the year and potential surrounding activities, filter life can be dramatically impacted.



Here a v-belt has been shredded and produced a large volume of charred rubber particles. The intake of the blower created a perfect vacuum effect drawing particles into the filter.

## Aeration Equipment: Blowers



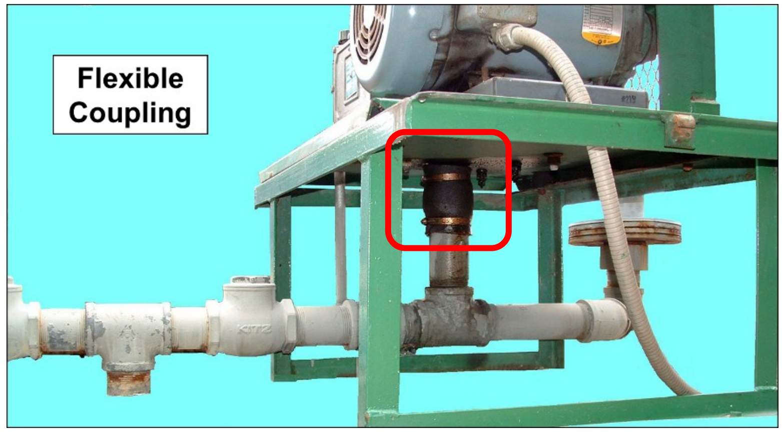
Many older air filtration systems were designed with a fine wire mesh screen to prevent particles into the blower. These older filters were designed to be soaked with oil, which would improve particle capture.

Many of these older filters show strong signs of rust. This could be the worst possible situation, since fine metal flakes will dislodge from the filter and be drawn directly into the blower unit. Contact the equipment manufacture for possible paper filter options .

Another seasonal event that causes filter issues is the summer "snow" from cottonwood trees. These seedlings from trees will cause a filter to be replaced more frequently than the expected calendar replacement date.

Filters should be inspected periodically and more frequently based on ambient air conditions. Replacement filters are inexpensive, so backup filters should be available.

## Aeration Equipment: Blowers



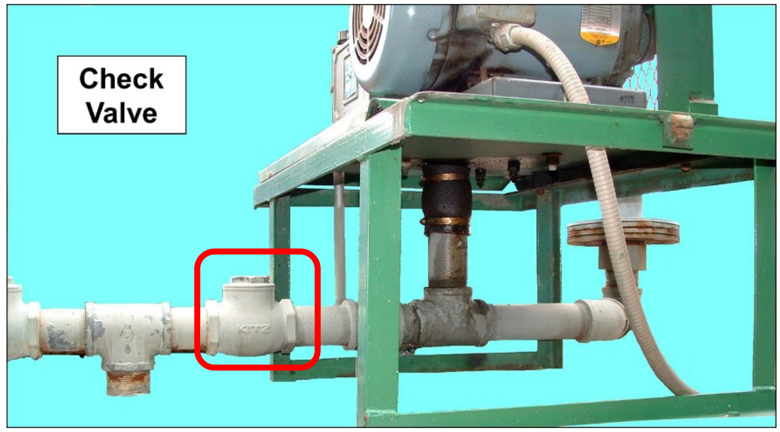

Compressed air is discharged from the blower into the piping to convey the air to its intended discharge point. The motor/blower assembly is fixed, but the unit experiences continual vibrations when in operation. The piping which conveys the air is also fixed. These vibrations from the motor/blower assembly do not allow a fixed connection to the piping, thus a flexible coupling is used.

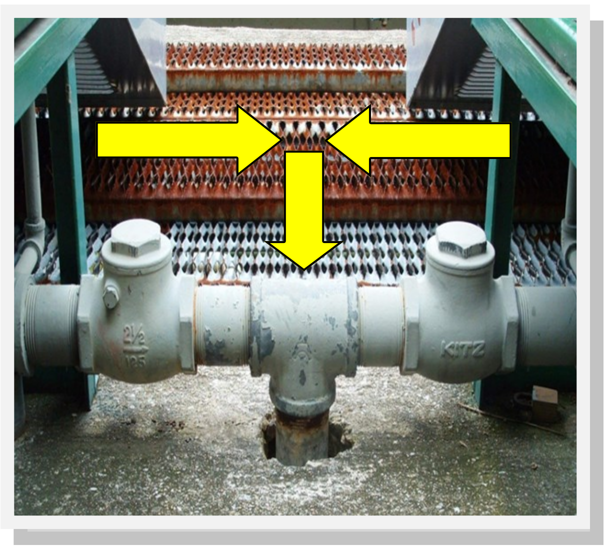
A flexible coupling typically used is a short section of straight hose with a couple of clamps.


The flexible coupling absorbs the vibrations from the motor/blower assembly to maintain integrity of the air distribution system. The coupling is exposed to expansion and an increase in temperature when air is flowing through the piping. In addition, oil and grease will weaken the material and failure will occur. Visual inspection of the flexible coupling for signs of cracking or a weakening of the hose should be performed frequently. If there are any signs of expected failure replace the flexible coupling. Air loss at the coupling may cause system failure, since air will not reach the aeration tank diffusers if it can escape at the coupling.

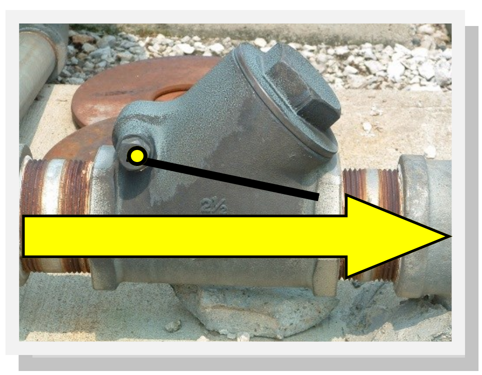
## Aeration Equipment: Piping

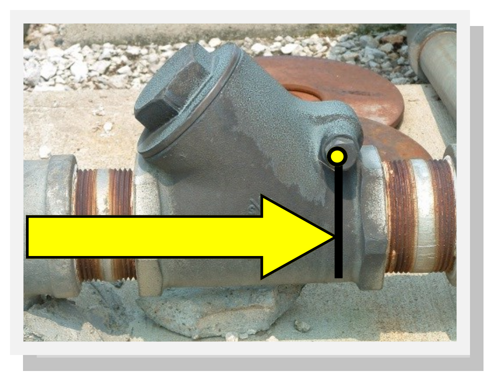
Providing aeration to the treatment system is critical and loss of control will occur without air being provided to the aeration tank. Because of this, treatment systems are required to have a backup motor/blower assembly.



Typically both blowers discharge into the same piping distribution system. The purpose of the check valve is to direct air flow to the diffusers in the aeration tank and not allow air to escape through the piping system to another blower which is not in operation.

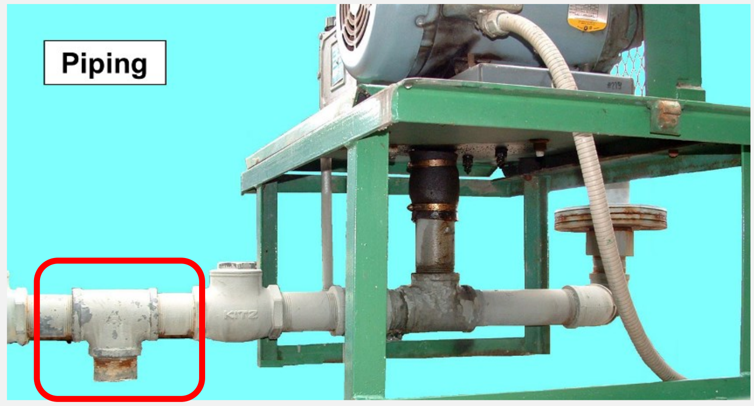




In the photo on the left, neither blower is in operation and the check valve is in a vertical position. In the center photo, the blower feeding from the left pushes the check valve into a horizontal position and allows the air to pass through to the piping leading to the aeration tank diffusers. In the photo on the right, the check valve for the other blower is forced into the vertical position so air flow is restricted and unable to continue back into the blower which is out of service. This causes all air to go to the aeration tank diffusers, but also allows for air flow if both blowers are in operation at the same time.

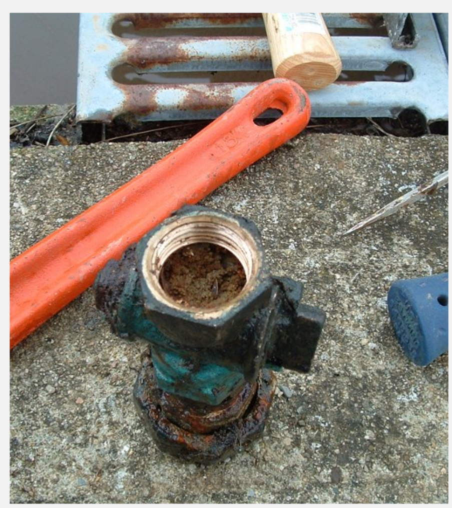
## Aeration Equipment: Piping

The air distribution system can also experience issues which will prevent air flow to be discharged from the aeration tank diffusers.




Plastic, paper and rags which are not removed in the trash trap will combine around diffusers and seal them off. Aeration tank diffusers need to be inspected periodically and cleaned off to prevent clogging of the air flow.

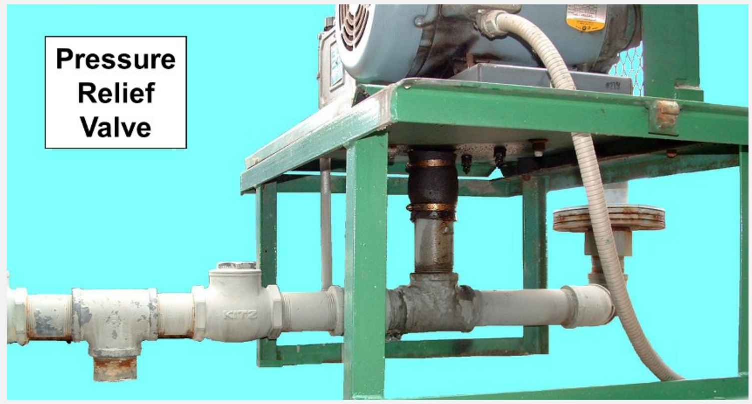
It is obvious if the diffusers need cleaning, but not so obvious is sand, gravel and grit have clogged the inside of the piping system. If the blower is unable to provide sufficient mixing and aeration for conversion and the diffusers are not clogged, it is possible the piping needs to be disassembled and cleaned. Don't try to bring another blower on line to force more air in the aeration tank. The correct response is to clean the air distribution system.



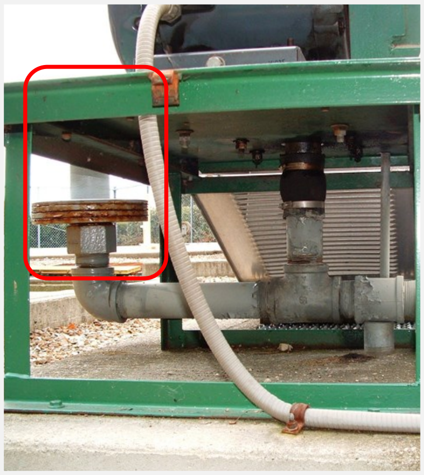
Measuring the air pressure leaving the blower is another way to quantify if air flow is being restricted. Knowing what the blower discharge pressure is when the distribution system is clean will allow you to determine when back pressure (clogging) is increasing.

Not only will the headers which hold the diffusers become clogged, but even the drop pipe which feeds air flow into the headers can become clogged. The photo on the right is of a 90 degree valve used to regulate air flow from the main aeration line to the individual drop pipes in the aeration tank.

## Aeration Equipment: Piping




The blowers used in most package plants are positive displacement blowers. If the aeration tank piping experiences clogging, air flow is restricted. This causes a backpressure effect on the blower and will either cause it to trip out or overheat.



To prevent damage to the blower, a pressure relief valve is designed into the aeration distribution system.

The pressure relief valve, PRV, consists of weighted plates which has sufficient weight to hold down the cap. When the cap is in its lowest position, no air is permitted to escape the air distribution system. When pressure in the distribution system increases, the additional pressure will lift the cap upward to expose the discharge ports.

Rotate the cap by turning it by hand on a regular basis. Over time the cap can become rusted and needs to move freely up and down based on air pressure. Using a light oil on the surface of the discharge ports will also prevent the cap from "locking" on.

**Infrastructure**

A well operated and maintained system will fail if it is not protected from vandals. Installing a barrier around the treatment system is an inexpensive and effective step.

A fence is a strong barrier to prevent intentional vandalism, however, the fence is only as effective as the difficulty it presents to a vandal.

Sometimes vandals are kids that are bored and looking for something "fun" to investigate. Here is a system located in a rural setting which is wide open to explore.

In fact, not even the electrical panel is secure. Everyone knows the combination on this screwdriver lock.

For convenience, many systems are "dummy locked" where it looks like the system is secure, however the padlocks have not been clasped together. There is a reason this is referred to as "dummy locked", because it is a dumb idea.

## Infrastructure

Physical barriers like locks and fences will make it difficult for vandals to damage systems. Lighting will also discourage illegal activity. A well lit area provides a spotlight on any activity near the system.

Vandals prefer not to get caught. They will evaluate if an area is easy to get into and if they will be noticed.

A security system which provides lighting and a camera adds to the reasons to pass on by.

Maybe a camera is more expensive than the budget allows. Then again what is the cost of replacement or repair of mechanical equipment. Electronic surveillance equipment is becoming more affordable.

## Infrastructure

Besides the infrastructure, the other half of the system that requires protection is you, the operator. The operator is exposed to chemical, biological, mechanical, and electrical hazards. To prevent accidents you need to place a barrier between you and the hazard.

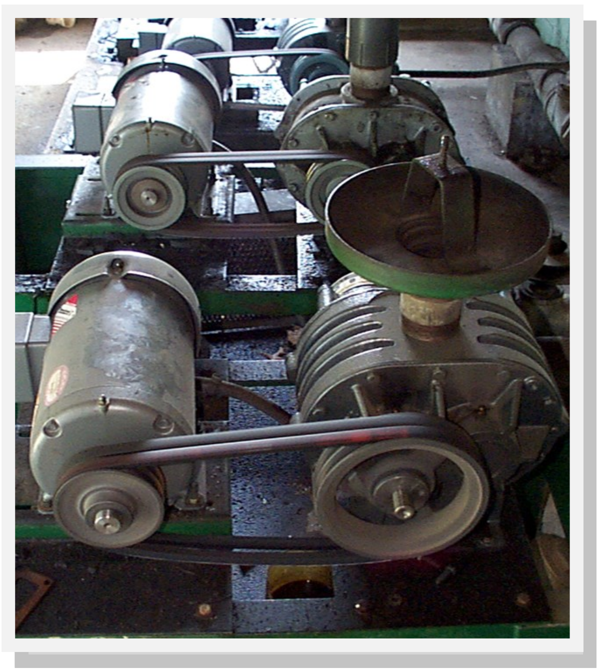
Chemical disinfection of the water in the tertiary stage requires oxidizing and reducing reagents. These compounds are chemical opposites and react when brought into contact with each other. Personal protective equipment (gloves, eye protection) should be worn when handling chemicals.

Biological hazards exist in the treatment system and a barrier should be placed between you and the potential biological hazard.

Personal protective equipment should be available for all involved with the treatment process.

## Infrastructure

Equipment in which the protective guards have been removed open the door for accidents to happen. Accidents are not intentional, they occur because there was no barrier between the operator and the unsafe condition.



Grates on tanks prevent an operator from accidentally falling in open tanks. In the situation on the right, the operator has removed the grates to expose and open tank and also used the grates as a trip hazard to increase the probability of an accident.

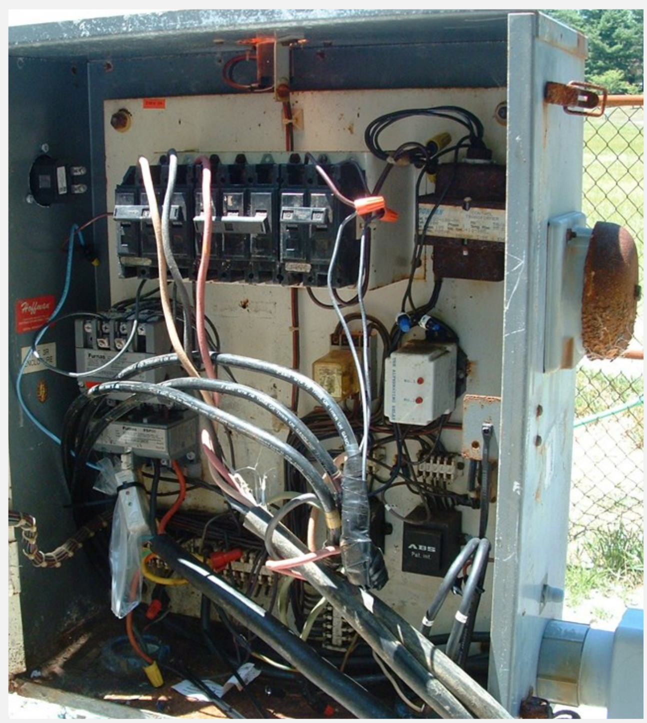
Try standing on this platform to read the daily runtime meter in the dosing tank control panel. Just don't step back.

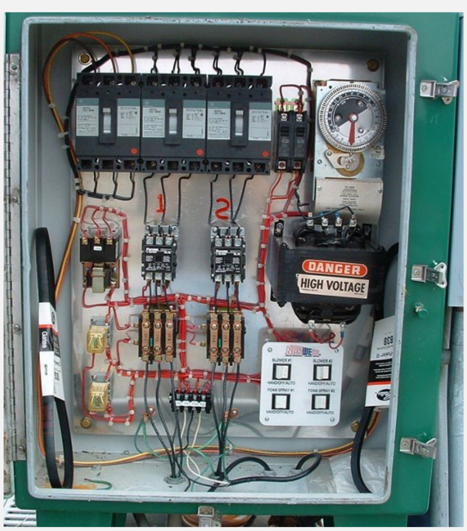
### Infrastructure

Even if the grating is in place, it could provide a false sense of security. Stepping through this screen would cut on the way down, expose the wound to a serious bacterial infection and maybe even cut a second time on the way up.

Keep the work area clean and free of trip hazards.

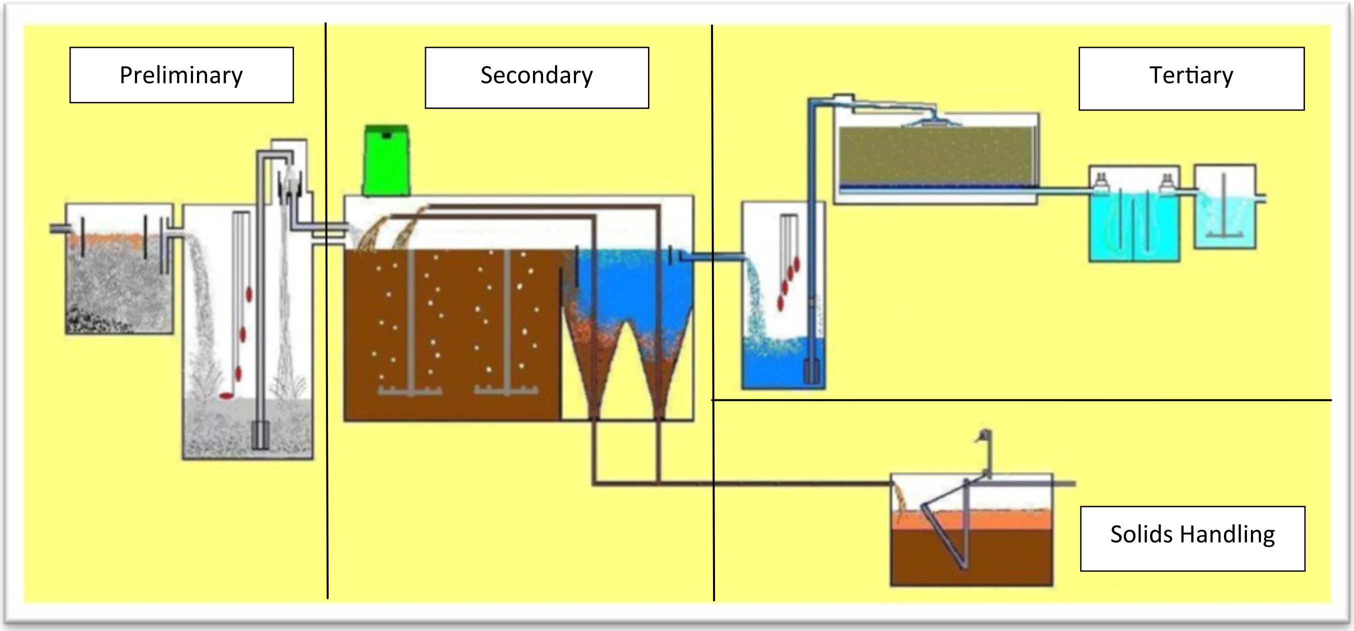
Finding a certified electrician to work on this influent pump station control panel might be the most difficult aspect of the job.






A clean wiring panel with a schematic is ideal. The sign says it all' "**DANGER HIGH VOLTAGE**"

## Maintenance: Summary

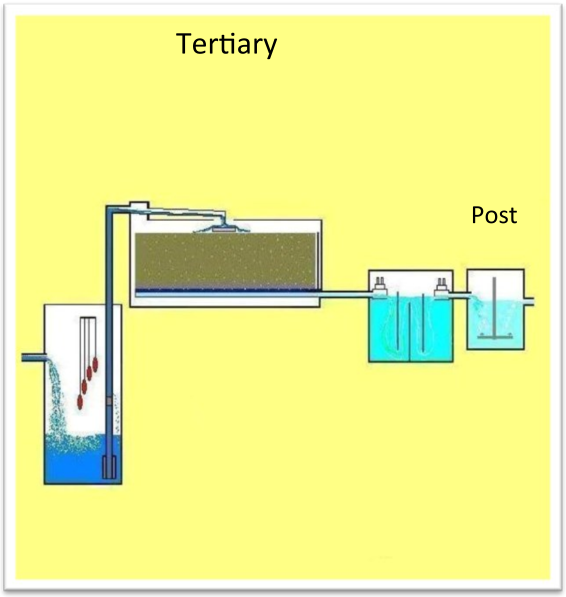



Maintenance is the task of keeping mechanical and electrical components operational. The two general areas of maintenance are (1) the flow equalization tank and dosing tank pumps and (2) the aeration system for the flow equalization, aeration and post-aeration units.

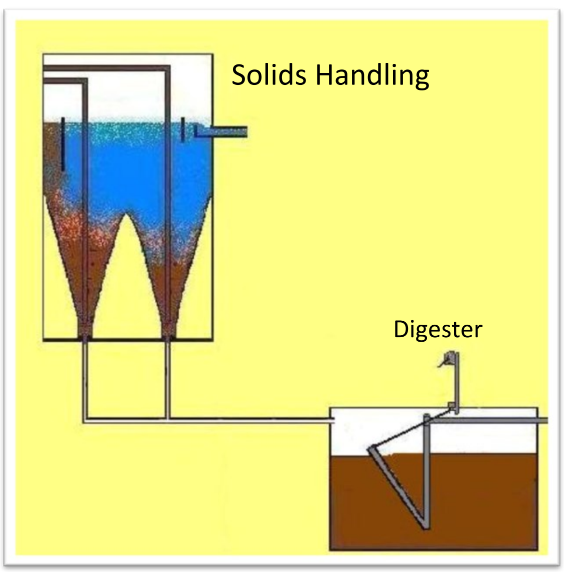
In addition to maintaining the hardware components, the operator is also responsible for keeping the area secure from vandals and safe for plant personnel.

## Regulations

Everything leaving the treatment system needs to be monitored and measured. This includes the water discharging from the tertiary stage into the receiving stream and the digested sludge removed from the solids handling stage. It is important for the certified operator to be aware of the regulatory requirements for the treatment system in which they are in responsible charge of operating.




Final effluent samples are to be collected for analysis and reporting purposes at a specific location. Final effluent samples shall be collected following treatment and prior to direct discharge to the receiving stream. In the tertiary stage, the post aeration unit is typically the last treatment before discharge.




Excess bacteria generated in the secondary stage is stored in the digester of the solids handling stage. Eventually the digester becomes full and needs to be emptied. All sludge removed from the digester must be reported to the Ohio EPA. Most Class A systems are just required to report the total gallons removed annually from the digester.

In addition to these reporting requirements there are requirements, for reporting operational activities and time spent on site at the treatment system. It is also important for the certified operator to be aware of the requirements for obtaining and maintaining a valid operator certification to legally be classified as the operator in charge or more commonly known as the operator of record.

## Regulations: NPDES Permit

The document that allows you to discharge into Ohio's receiving streams is referred to as the NPDES permit. This National Pollutant Discharge Elimination System (NPDES) permit specifies the conditions by which you are allowed to discharge the treatment system's effluent into Ohio's waterways. The first page of the permit will look similar to this:

Ohio EPA Permit No: 5PGS0004
NPDES Permit No. OHS00004
Page 1 of 23

Effective Date: January 1, 2015
Expiration Date: December 31, 2019

**OHIO ENVIRONMENTAL PROTECTION AGENCY**

**GENERAL PERMIT AUTHORIZATION TO DISCHARGE**

**WASTEWATER FROM SEWAGE TREATMENT SYSTEMS DESIGNED TO TREAT AN AVERAGE FLOW OF 25,000 GALLONS PER DAY OR LESS UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM**

At the top, right hand side of the page will be an identification number you will use to communicate with the Ohio EPA. This number is referred to as your **Ohio EPA Permit Number** and should be included on all correspondence with the Ohio EPA. The second number used to identify your treatment facility is the **NPDES Permit Number**. This identification number is used for tracking by the US EPA and is your federal permit number. Most communication between you and the Ohio EPA will require the Ohio EPA Permit Number.

Permits are typically valid for a five year period. Your permit will state the **Effective Date** and an **Expiration Date** to indicate when the permit is valid.

Class A wastewater treatment systems are typically issued a **General Permit,** which has a standard requirement for sampling frequency and types of parameters to monitor. General permits can only be issued to systems which are designed to treat an average flow of 25,000 gallons per day or less.

## Regulations: NPDES Permit, Part 1

Your NPDES permit will have six parts to the document. Part 1 defines which wastewater treatment systems are covered under this permit. Based on Ohio Revised Code 6111 " . . . anyone which discharges pollutants from a point source (i.e. pipe) to waters of the state of Ohio are unlawful, unless authorized by an NPDES permit."

"Entities who are eligible for coverage under this permit and who submit a Notice of Intent (NOI) in accordance with Part 2 of this permit are in compliance with the NPDES application requirements for such wastewater dischargers."

Page 2

Part I. COVERAGE UNDER THIS PERMIT

A. Permit Area. This permit covers the entire state of Ohio.

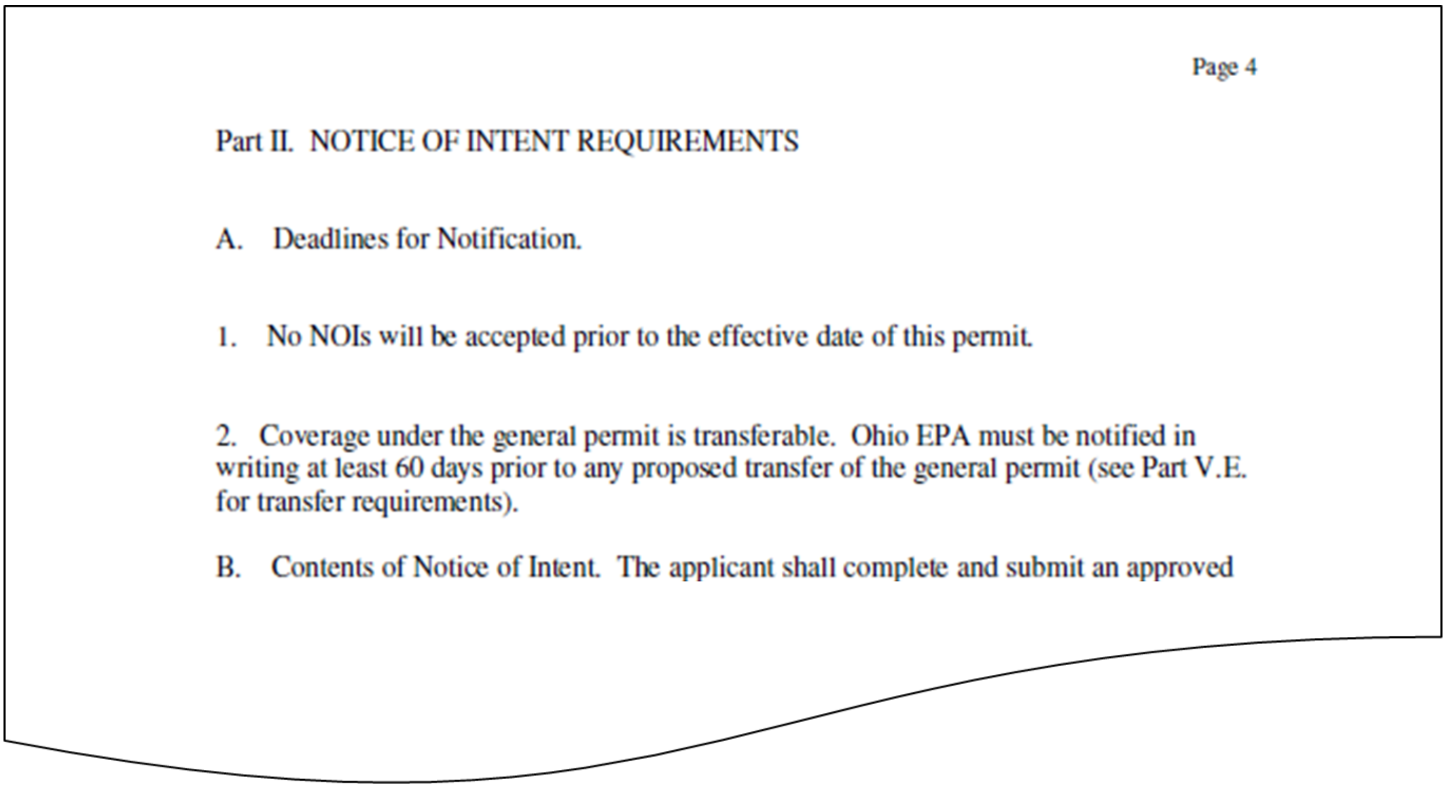
B. Applicability. Ohio Revised Code Chapter 6111 provides that discharges from a point source to waters of the state are unlawful, unless authorized by an NPDES permit. Entities that are eligible for coverage under this permit and that submit a Notice of Intent application (NOI) in accordance with the requirements of Part II of this permit are in compliance with the NPDES application requirements for such wastewater discharges.

C. Eligibility.

## NPDES Permit: Part II

Part 2 of the permit defines the requirements for Notice of Intent (NOI). Part 2 provides information of NOI deadlines, content required, where to submit, and how to notify the Ohio EPA if you desire to terminate the NPDES permit due to the elimination of the discharge.

The NPDES permit is effective for a 5 year period. In order to receive authorization to discharge beyond the expiration date of the general permit the permittee shall notify the Ohio EPA and submit the necessary forms to have the permit renewed.


Page 4

Part II. NOTICE OF INTENT REQUIREMENTS

A. Deadlines for Notification.

1. No NOIs will be accepted prior to the effective date of this permit.

2. Coverage under the general permit is transferable. Ohio EPA must be notified in writing at least 60 days prior to any proposed transfer of the general permit (see Part V.E. for transfer requirements).

B. Contents of Notice of Intent. The applicant shall complete and submit an approved

## NPDES Permit: Part lll

Part 3 of the NPDES permit lists the limitations and monitoring requirements of the final effluent. The table below is designated for a treatment system which is not a lagoon type system; which treats a design flow of 5,000 gallon per day, but less than 25,000 gallons per day. The monitoring requirements in this table are for systems that do not discharge directly to the Ohio River.

This sampling location is referred to in this permit as Final Outfall 001. The table lists the specific parameter to be measured, the concentration or discharge limit for the specific parameter and the frequency of monitoring.

Page 6

5PGS00004

**TABLE III A. 1.-FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS FOR DISCHARGES OTHER THAN LAGOON SYSTEMS-DESIGN FLOW 5000 GALLONS PER DAY OR MORE THAT DO NOT DISCHARGE DIRECTLY TO THE OHIO RIVER**

1. During the period beginning on the effective date of this permit and lasting until the expiration date, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements.

Table – Final Outfall – 001 – Final

| Effluent Characteristics | Discharge Limitations | | | | Monitoring Requirements | | |
|---|---|---|---|---|---|---|---|
| | Concentration Specified Units | | | | Measuring | Sampling | Monitoring |
| Parameter | Max | Min | Weekly | Monthly | Frequency | Type | Months |
| Flow Rate-GPD | - | - | - | - | 1/Day | Total Estimate | All |
| Color, Severity – Units | - | - | - | - | 1/Day | Estimate | All |
| Dissolved Oxygen – mg/l | - | 6.0 | - | - | 1/Quarter | Grab | Quarterly |
| Total Suspended Solids – mg/l | - | - | 18 | 12 | 1/Quarter | Grab | Quarterly |
| Nitrogen, Ammonia (NH3) – mg/l | - | - | 4.5 | 3.0 | 1/Quarter | Grab | Winter-Qtrly |
| Nitrogen, Ammonia (NH3) – mg/l | - | - | 1.5 | 1.0 | 1/Quarter | | |
| Odor, Severity – Units | - | - | - | - | | | |
| Turbidity, Severity – Units | - | - | - | | | | |

## NPDES Permit: Part lll

Understanding when to sample and the discharge limits are critical for staying in compliance. Lets walk through a few of the sampling parameters and their monitoring frequency to prevent reporting violations of the NPDES permit.

To begin, the parameter which requires monitoring is **Flow Rate-GPD**. This requires the flow which the treatment system received during a 24 hour period is reported in gallons per day. We see that there is no **Discharge Limitations,** only that the flow is reported **1/Day** (daily).

Page 6

OHS00003

**TABLE lll A. 1.-FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS FOR DISCHARGES OTHER THAN LAGOON SYSTEMS-DESIGN FLOW 5000 GALLONS PER DAY OR MORE THAT DO NOT DISCHARGE DIRECTLY TO THE OHIO RIVER**

1. During the period beginning on the effective date of this permit and lasting until the expiration date, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements.

Table – Final Outfall – 001 – Final

| Effluent Characteristics | Discharge Limitations | | | | Monitoring Requirements | | |
|---|---|---|---|---|---|---|---|
| | Concentration Specified Units | | | | Measuring | Sampling | Monitoring |
| Parameter | Max | Min | Weekly | Monthly | Frequency | Type | Months |
| Flow Rate-GPD | - | - | - | - | 1/Day | Total Estimate | All |

**Acceptable methods for estimating flow are, in order of preference:**

**(1) elapsed time meters on sand filter dosing pumps;**

**(2) elapsed time meters on influent pumps**

**(3) water use records; and**

**(4) bucket and stop watch.**

There are several acceptable methods for estimating the daily flow. At the bottom of the table is a list of methods for estimating daily flow through the treatment system. In the Controlling section we have discussed how to estimate flow based on (1) elapsed time meters on sand filter dosing pumps. This is the preferred method because it is simple to implement and the most accurate measurement of flow through the treatment system, however, other acceptable methods can be used to determine flow for reporting purposes. Flow is required to be reported daily and for each month of the year.

## NPDES Permit: Part III

The next parameter in the table is **Color, Severity-Units**. Similar to the Flow Rate measurement there are no **Discharge Limitations** required. The frequency of monitoring is daily and is an estimate.

Page 6

OHS00003

**TABLE III A. 1.-FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS FOR DISCHARGES OTHER THAN LAGOON SYSTEMS-DESIGN FLOW 5000 GALLONS PER DAY OR MORE THAT DO NOT DISCHARGE DIRECTLY TO THE OHIO RIVER**

1. During the period beginning on the effective date of this permit and lasting until the expiration date, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements.

Table – Final Outfall – 001 – Final

| Effluent Characteristics | Discharge Limitations | | | | Monitoring Requirements | | |
|---|---|---|---|---|---|---|---|
| | Concentration Specified Units | | | | Measuring | Sampling | Monitoring |
| Parameter | Max | Min | Weekly | Monthly | Frequency | Type | Months |
| Flow Rate-GPD | - | - | - | - | 1/Day | Total Estimate | All |
| Color, Severity – Units | - | - | - | - | 1/Day | Estimate | All |

Color, Odor, and Turbidity – See Part IV, Item E.

At the bottom of the table is a comment for estimating Color, Odor and Turbidity. The comment directs you to Part IV, item E of the NPDES permit.

Part IV SPECIAL CONDITIONS

E. For turbidity, odor, and color, use the following table to determine the value between 0 and 4 that is reported.

| REPORTED VALUE | SEVERITY DESCRIPTION | TURBIDITY | ODOR | COLOR |
|---|---|---|---|---|
| 0 | None | Clear | None | Colorless |
| 1 | Mild | | | |
| 2 | Moderate | Light Solids | Musty | Grey |
| 3 | Serious | | | |
| 4 | Extreme | Heavy Solids | Septic | Black |

## NPDES Permit: Part III

Use this table to estimate which values to report for turbidity, odor and color. Estimate which conditions best reflect the final effluent sample. Interpolate between descriptive phases.

The next monitoring parameter is Dissolved Oxygen, mg/L. The permit indicates there is no maximum concentration limit required, however, the final effluent must maintain a minimum dissolved oxygen concentration of 6 mg/L. Maximum and minimum concentrations are specific measurements never to be exceeded and sample results can not be averaged together.

Page 6

OHS00003

**TABLE III A. 1.-FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS FOR DISCHARGES OTHER THAN LAGOON SYSTEMS-DESIGN FLOW 5000 GALLONS PER DAY OR MORE THAT DO NOT DISCHARGE DIRECTLY TO THE OHIO RIVER**

1. During the period beginning on the effective date of this permit and lasting until the expiration date, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements.

Table – Final Outfall – 001 – Final

| Effluent Characteristics | Discharge Limitations | | | | Monitoring Requirements | | |
|---|---|---|---|---|---|---|---|
| | Concentration Specified Units | | | | Measuring | Sampling | Monitoring |
| Parameter | Max | Min | Weekly | Monthly | Frequency | Type | Months |
| Flow Rate-GPD | - | - | - | - | 1/Day | Total Estimate | All |
| Color, Severity – Units | - | - | - | - | 1/Day | Estimate | All |
| Dissolved Oxygen – mg/l | - | 6.0 | - | - | 1/Quarter | Grab | Quarterly |

These “absolute limits”, maximum and minimum, shall be determined from any single value for effluent samples measured.

Thus, according to the permit above, any final effluent sample measured for dissolved oxygen concentration must be above 6.0 mg/L or it is a violation of the NPDES permit. This should never be an issue if the treatment system is performing well and the post aeration unit is in operation.

There are three categories under **Monitoring Requirements**: Measuring Frequency, Sampling Type and Monitoring Months. Measuring Frequency indicates how often a sample is required to be collected for analysis, Sampling Type determines how the sample is to be collected and Monitoring Months indicate which specific months of the year sample collection and analysis is required.

Monitoring for final effluent dissolved oxygen requires at least one sample collected during the quarter. You may measure final effluent dissolved oxygen more frequently than the permit requires, however, if you are sampling from an approved sample location (i.e. Station 001) and you use an approved method for performing the analysis, the permit requires the results must be reported.

## NPDES Permit: Part III

The dissolved oxygen **Sample Type** is a grab sample.

Page 6

OHS00003

**TABLE III A. 1.-FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS FOR DISCHARGES OTHER THAN LAGOON SYSTEMS-DESIGN FLOW 5000 GALLONS PER DAY OR MORE THAT DO NOT DISCHARGE DIRECTLY TO THE OHIO RIVER**

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Table – Final Outfall – 001 – Final

| Effluent Characteristics | Discharge Limitations | | | | Monitoring Requirements | | |
|---|---|---|---|---|---|---|---|
| | Concentration Specified Units | | | | Measuring | Sampling | Monitoring |
| Parameter | Max | Min | Weekly | Monthly | Frequency | Type | Months |
| Flow Rate-GPD | - | - | - | - | 1/Day | Total Estimate | All |
| Color, Severity – Units | - | - | - | - | 1/Day | Estimate | All |
| Dissolved Oxygen – mg/l | - | 6.0 | - | - | 1/Quarter | Grab | Quarterly |

Part IV B of the permit defines what is a grab sample.

Part IV. SPECIAL CONDITIONS

A. This permit may be modified, or alternatively, revoked and reissued to the permit holder, to comply with any applicable standards or regulations.

B. Grab samples shall be collected at such times and locations, and in such fashion, as to be representative of the facility's performance.

C. Samples taken in compliance with the effluent monitoring requirements shall be collected following treatment (if provided) and prior to either direct to the receiving water or via storm sewer discharge to the receiving stream.

A grab sample is never a composite of several samples collected throughout the day, but one sample collected and analyzed for the specific parameter required in the permit. A grab sample is never a "selective" sample which occurs only when the system is performing well, but a sample that represents the actual treatment system's performance.

## NPDES Permit: Part III

Monitoring months for dissolved oxygen are listed as Quarterly in the permit. Part VI of the permit defines quarterly specifically as the months of March, June, August and December.

Page 6

OHS00003

**TABLE III A. 1.-FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS FOR DISCHARGES OTHER THAN LAGOON SYSTEMS-DESIGN FLOW 5000 GALLONS PER DAY OR MORE THAT DO NOT DISCHARGE DIRECTLY TO THE OHIO RIVER**

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Table – Final Outfall – 001 – Final

| Effluent Characteristics | Discharge Limitations | | | | Monitoring Requirements | | |
|---|---|---|---|---|---|---|---|
| | Concentration Specified Units | | | | Measuring | Sampling | Monitoring |
| Parameter | Max | Min | Weekly | Monthly | Frequency | Type | Months |
| Flow Rate-GPD | - | - | - | - | 1/Day | Total Estimate | All |
| Color, Severity – Units | - | - | - | - | 1/Day | Estimate | All |
| Dissolved Oxygen – mg/l | - | 6.0 | - | - | 1/Quarter | Grab | Quarterly |

The system can report sampling data for other months, however, if a sample is not reported for the required months, it will result in a violation of the permit. The system is required to sample at least one time during the months of March, June, August and December.

Part VI - DEFINITIONS

"Quarterly sampling frequency" means the sampling shall be done in the months of March, June, August, and December.

Also note the required sampling months are not evenly spaced through out the year. The sampling months are the 3rd, 6th, 8th and 12th month of the year. A sample reported for the 9th month, September, will not meet the permit requirement of quarterly reporting.

## NPDES Permit: Part III

The next parameter listed on the permit is **Total Suspended Solids– mg/L**. The **Monitoring Requirements** for total suspended solids are the same as the dissolved oxygen parameter, however, the **Discharge Limitations** are different. Unlike the minimum dissolved oxygen discharge limits, total suspended solids has weekly and monthly concentrations which need to be achieved.

Page 6

OHS00003

**TABLE III A. 1.-FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS FOR DISCHARGES OTHER THAN LAGOON SYSTEMS-DESIGN FLOW 5000 GALLONS PER DAY OR MORE THAT DO NOT DISCHARGE DIRECTLY TO THE OHIO RIVER**

1. During the period beginning on the effective date of this permit and lasting until the expiration date, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements.

Table – Final Outfall – 001 – Final

| Effluent Characteristics | Discharge Limitations | | | | Monitoring Requirements | | |
|---|---|---|---|---|---|---|---|
| | Concentration Specified Units | | | | Measuring | Sampling | Monitoring |
| Parameter | Max | Min | Weekly | Monthly | Frequency | Type | Months |
| Flow Rate-GPD | - | - | - | - | 1/Day | Total Estimate | All |
| Color, Severity – Units | - | - | - | - | 1/Day | Estimate | All |
| Dissolved Oxygen – mg/l | - | 6.0 | - | - | 1/Quarter | Grab | Quarterly |
| Total Suspended Solids – mg/l | - | - | 18 | 12 | 1/Quarter | Grab | Quarterly |

In Part III General Conditions of the NPDES permit weekly and monthly frequencies are defined as:

| | |
|---|---|
| Week 1 | 1st through 7th of calendar month |
| Week 2 | 8th through 14th of calendar month |
| Week 3 | 15th through 21st of calendar month |
| Week 4 | 22nd through 28th of calendar month |
| Monthly | 1st day of calendar month through last day of calendar month |

The permit requires at least one sample collected during the quarterly monitoring month (March, June, August, December), however additional samples can be collected for analysis if desired. Any sample collected from an approved sample site (i.e. Final effluent) and analyzed by approved methods must be reported. Weekly and monthly concentrations are individual measurements, but can be averaged together. Only one sample is required to be taken during the monitoring month. If only one sample is analyzed, it must meet both the weekly and monthly discharge requirement of the permit.

**NPDES Permit: Part lll**

Here is an example to assist in understanding the effluent limitations for total suspended solids (TSS) required to achieve compliance with the NPDES permit.

Since June is a specified sampling month, at least one sample must be collected and analyzed for meeting the reporting requirement of the permit. On June 2, a sample is collected and submitted to the lab for analysis which results in a TSS concentration of 15 mg/L. If this the only sample reported during the month of June the system would be in compliance for the weekly TSS limit because the reported value is less than 18 mg/L. However, the system would be in violation of the monthly TSS limit, because the reported value is greater than 12 mg/L.

| Sample Date | TSS Result | Weekly Limit | Monthly Limit |
|---|---|---|---|
| June 2 | 15 mg/L | **compliance** | **violation** |
| Permit Limit | (15 mg/L) | 18 mg/L | 12 mg/L |

Because of this potential monthly violation, the operator decides to collect another sample for analysis. Additional samples can be collected, but must be averaged together for weekly and monthly calculations. The second sample results in a TSS value of 5 mg/L being report from the lab.

| Sample Date | TSS Result | Weekly Limit | Monthly Limit |
|---|---|---|---|
| June 2 | 15 mg/L | | |
| June 4 | 5 mg/l | **compliance** | **compliance** |
| Permit Limit | (10 mg/L) | 18 mg/L | 12 mg/L |

Since the 2nd and the 4th sample dates are within the designated window of Week 1 (1st-7th) these two values can be averaged to determine compliance with weekly limits. The average of the two samples reported is 10 mg/L which is in compliance with both the weekly and monthly limit.

**NPDES Permit: Part lll**

The system is therefore in compliance with the reporting requirements and effluent limitations of the NPDES permit. However, if another sample was collected and analyzed using approved analytical methods, that value must also be reported. If another sample was analyzed with a reported value of 40 mg/L TSS the compliance situation would change.

| Sample Date | TSS Result | Weekly Limit | Monthly Limit |
|---|---|---|---|
| June 2 | 15 mg/L | | |
| June 4 | 5 mg/L | | |
| June 7 | 40 mg/L | **violation** | **violation** |
| Permit Limit | (20 mg/L) | 18 mg/L | 12 mg/L |

The last sample reported causes the average TSS value to increase to 20 mg/L, which is a violation of the weekly and monthly permit limit. Thus, it is possible to have more than one violation of a single parameter during a monitoring period. If the system was experiencing difficulty with TSS all month and samples were collected and analyzed by approved methods there could be five violations of the permit; four weekly, one monthly.

Part V. STANDARD PERMIT CONDITIONS

L. Reporting.

5. If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified below, the results of such monitoring shall be included in the calculation and reporting of the values required in the reports specified above.

Additional sampling is allowed to bring systems into compliance, but failure to report valid data is considered falsification and consequence move from the civil to the criminal arena with steeper penalties.

## NPDES Permit: Part III

A review of the next parameter listed in the permit indicates two different effluent limits for **Nitrogen, Ammonia (NH3)-N– mg/L** . The reason for the two different limits is due to the monitoring months. Some parameters have different limits depending on the month of the year. Some parameters like Coliform and Chlorine Residual are monitored only during the summer months.

Page 6

OHS00003

**TABLE III A. 1.-FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS FOR DISCHARGES OTHER THAN LAGOON SYSTEMS-DESIGN FLOW 5000 GALLONS PER DAY OR MORE THAT DO NOT DISCHARGE DIRECTLY TO THE OHIO RIVER**

1. During the period beginning on the effective date of this permit and lasting until the expiration date, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements.

Table – Final Outfall – 001 – Final

| Effluent Characteristics | Discharge Limitations | | | | Monitoring Requirements | | |
|---|---|---|---|---|---|---|---|
| | Concentration Specified Units | | | | Measuring | Sampling | Monitoring |
| Parameter | Max | Min | Weekly | Monthly | Frequency | Type | Months |
| Flow Rate-GPD | - | - | - | - | 1/Day | Total Estimate | All |
| Color, Severity – Units | - | - | - | - | 1/Day | Estimate | All |
| Dissolved Oxygen – mg/l | - | 6.0 | - | - | 1/Quarter | Grab | Quarterly |
| Total Suspended Solids – mg/l | - | - | 18 | 12 | 1/Quarter | Grab | Quarterly |
| Nitrogen, Ammonia (NH3) – mg/l | - | - | 4.5 | 3.0 | 1/Quarter | Grab | Winter-Qtrly |
| Nitrogen, Ammonia (NH3) – mg/l | - | - | 1.5 | 1.0 | 1/Quarter | Grab | Summer-Qtrly |

Nitrogen ammonia reporting is required both in the winter and summer monitoring periods. Samples reported for nitrogen ammonia in March and December have a permit limit of 4.5 mg/L weekly and 3.0 mg/L monthly and in June and August the limit is more stringent at 1.5 mg/L weekly and 1.0 mg/L monthly.

Sampling and reporting for once per quarter for all months is required in March, June, August and December.

Sampling and reporting for once per quarter in winter months is March and December.

Sampling and reporting for once per quarter in summer months is June and August.

Your permit will contain more parameters for monitoring than discussed here. However, you should be able to apply the same interpretation of the monitoring requirements to these other parameters. If you have additional question contact your Ohio EPA District office for assistance.

## NPDES Permit: Part lll

Part lll of the NPDES permit contains reporting requirements for the final effluent into the receiving stream and also sludge hauled from the treatment system. Class A treatment systems which have the sludge hauled from the Solids Handling Stage to another wastewater treatment system need to report the total volume removed. The station code used to designate this location is **Final Outfall-588**.

Page 6

OHS00003

**TABLE III C. SLUDGE MONIITORING REQUIREMENTS**

1. All permittees shall monitor the treatment works' final sludge and report to the Ohio EPA in accordance with the following table.

Report data using station designation 588.

Table - Final Outfall - 588 - Final

| Effluent Characteristics | Discharge Limitations | | | | Monitoring Requirements | | |
|---|---|---|---|---|---|---|---|
| | Concentration Specified Units | | | | Measuring | Sampling | Monitoring |
| Parameter | Max | Min | Weekly | Monthly | Frequency | Type | Months |
| Sludge Volume, Gallons - Gals | - | - | - | - | 1/Year | Total | December |

- The total sludge volume transferred to another NPDES permit holder for the entire year shall be reported on the December Discharge Monitoring Report (DMR).

-See Part IV, Item D.

Every load that is hauled out of the sludge holding tank (i.e. digester) and transported to another wastewater treatment system needs to be recorded. At the end of the calendar year the total gallons removed from the Solids Handling Stage is reported to the Ohio EPA.

The gallons reported does NOT include trash trap pump outs or any other pumping within the treatment system, only the total gallons of digested sludge is reported.

## Annual Sludge Report

In addition to reporting the total gallons of sludge hauled from the treatment system on the December discharge monitoring report, an Annual Sewage Sludge Report is also required to be submitted. The Annual Sewage Sludge Report forms are available on the Ohio EPA's web-site.

OhioEPA

**Division of Surface Water**
Annual Sewage Sludge Report 2013

**General Information**

| | | |
|---|---|---|
| Facility name: | | |
| Ohio NPDES permit No: | | County: |
| Mailing address: | | |
| City: | State: | Zip: |

☐ **Mark box with an "X" if no sewage sludge has been removed from the facility for the year 2013.**

If no sewage sludge was removed from the facility during 2013, on what date was sewage sludge last removed from the facility?

Date: ____/____/_____

☐ **Mark box with an "X" if sewage sludge has never been removed from the facility.**

**Certification Statement**

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for

The first page of the **Annual Sludge Report** requires general information to identify the Class A system where the sludge was removed. This includes the system's Ohio NPDES permit Number located on the first page of the permit.

This general information page also requires a signature certifying the data being submitted is valid.

## Annual Sludge Report

The second page to the Annual Sewage Sludge Report again requires the facility name and the Ohio NPDES Permit number where the sludge was removed. The typical Class A permit requires that the total gallons removed be reported. Enter the gallons removed in the row designated with the Station Code 588 and the column with a reporting category designated 80991.

**Division of Surface Water**
Annual Sewage Sludge Report 2013

**Stations 585, 586, 588, and Transfer to PPG Lime Lakes – Sewage Sludge/Biosolids Disposal**

| Facility name: | Ohio NPDES permit #: |
|---|---|

**Table 3 – Sewage Sludge/Biosolids Disposal Methods**

| Disposal Method | Sewage Sludge Fee Weight (Dry Tons) DMR Reporting Code **51129** | Sewage Sludge Weight (Dry Tons) DMR Reporting Code **70316** | Sewage Sludge Volume (Gallons) DMR Reporting Code **80991** |
|---|---|---|---|
| Incineration (Station 585) | | | |
| Landfill (Station 586) | | | |
| Transferred to Another NPDES Permit Holder (Station 588) | | | |
| Transferred to PPG Lime Lakes | | | |

If transferring sewage sludge to another NPDES permit holder, you must also provide the name and NPDES Permit Number of the wastewater treatment system receiving the sewage sludge.

**If the facility is reporting with Station 588, provide the following information:**

| | |
|---|---|
| Name of receiving NPDES permittee: | |
| Receiving permittee's Ohio NPDES Permit #: | |
| If receiving permittee is located outside the State of Ohio, the receiving permittee's USEPA NPDES Permit #: | |

## NPDES Permit: Part V

Part V of the NPDES permit contains conditions which are requirements in all general permits. Item M discusses the methods approved for sampling and analysis.

Part V. STANDARD PERMIT CONDITIONS

M. Sampling and Analytical Methods. Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored flow. Test procedures for the analysis of pollutants shall conform to regulation 40 CFR 136, "Test Procedures For The Analysis of Pollutants" unless other test procedures have been specified in this permit. The permittee shall periodically calibrate and perform maintenance procedures on all monitoring and analytical instrumentation at intervals to insure accuracy of measurements.

Samples collected for analysis and reporting must be representative of the treatment system's discharge. Sample collection and analysis must also conform to 40 CFR 136, which is the federal regulation for testing pollutants which are used for reporting purposes of an NPDES permit.

The guidelines establish that samples are required to be collected in a specific container, may require a specific preservative, and/or possess a specific holding time, which can not be exceeded. Violation of any of these requirements would invalidate sample results and would require resampling and analysis.

**Title 40: Protection of Environment**

**PART 136—GUIDELINES ESTABLISHING TEST PROCEDURES FOR THE ANALYSIS OF POLLUTANTS**

**Contents**



AUTHORITY: Secs. 301, 304(h), 307 and 501(a), Pub. L. 95-217, 91 Stat. 1566, *et seq.* (33 U.S.C. 1251, *et seq.*) (the Federal Water Pollution Control Act Amendments of 1972 as amended by the Clean Water Act of 1977).

Class A systems typically use a contract laboratory to perform the analysis for reporting requirements. These contract laboratories will provide the specific container, necessary preservative and instructions on sample collection. The critical issue if you are collecting the sample for reporting purposes is to use clean sampling equipment. Don't use the same sampling device to collect effluent samples that are also used for collecting influent or in-plant process monitoring.

## NPDES Permit: Part V

Another critical issue in sample collection is the Chain of Custody form associated with the samples collected. The Chain of Custody is a paper trail detailing when the sample is collected, where the sample is collected, and by whom is the sample collected. If the Chain of Custody forms are not completed, the test results will be unusable for reporting purposes. The contract laboratory performing the analysis should provide the forms.

Part V. Item O under the Standard Permit Conditions requires all records pertaining to the wastewater treatment works be retained for a minimum of three years. Required reports are any sampling and/or analytical records. This will include all process control data and maintenance records.

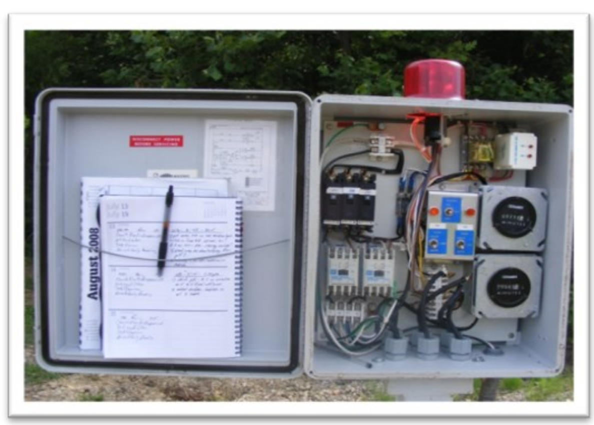
Part V. STANDARD PERMIT CONDITIONS

O. Records Retention. The permittee shall retain all of the following records for the wastewater treatment works for a minimum of three years, including:

1. All sampling and analytical records (including internal sampling data not reported);
2. All original recordings for any continuous monitoring instrumentation;
3. All instrumentation, calibration and maintenance records;
4. All plant operation and maintenance records;
5. All reports required by this permit; and
6. Records of all data used to complete the application for this permit for a period of at least three years

from the date of the sample, measurement, report, or application.

A log book or journal can be used to enter daily information and should be kept on site for review by EPA inspectors.

## NPDES Permit: Part V

Authority to assess penalties for violations of the NPDES permit are found in the Ohio Revised Code.

Part V. STANDARD PERMIT CONDITIONS

AF. Penalties for Violations of Permit Conditions.

4. ORC 6111.99 provides that any person who violates Sections 6111.04, 6111.042., 6111.05., or division (A) of Section 6111.07 of the Revised Code shall be fined not more than twenty-five thousand dollars or imprisoned not more than one year, or both.

ORC 6111 states anyone who knowingly submits false information, knowingly makes false statements or violates other sections of the code can be fined up to $25,000, imprisoned up to one year or both.


## Ohio Administrative Code 3745-07

The NPDES permit determines the sampling frequency and effluent discharge limits which need to be achieved to maintain compliance. The NPDES permit requires an operator that is certified to be in operational control of the treatment system.

OhioEPA

**FACT SHEET**
Division of Drinking and Ground Waters
January 2014

**How to Become a Certified Water or Wastewater Operator**

*Serve your community by helping ensure people receive safe drinking water and wastewater is discharged in an environmentally safe manner.*

**Eligibility**
To become a certified Class A, I, II, III or IV Water Supply, Water Distribution, Wastewater Treatment or Wastewater Collection operator in the State of Ohio, you must apply for and pass the state operator certification exam and document the appropriate level of hands on work experience

The process by which operators are certified in Ohio is contained in the Ohio Administrative Code 3745-7. OAC 3745-7 are the rules which classify treatment systems as to the certification level that is required, lists the eligibility requirements for anyone desiring to be certified and rules on maintaining a valid certificate upon successfully passing an examination.

3745-7-04 Treatment works and sewerage system classification and staffing requirements.

(C) Staffing.

(1) The operator of record shall, at a minimum, be physically present at the treatment works and fulfill the time requirements in the following table and perform technical operation as assigned by the permittee of the treatment works.

**Minimum staffing requirements for the operator of record**

| System Classification | Staffing requirements |
|---|---|
| Class A | 2 days per week for a minimum of 1 hour per week |

OAC 3745-7-04 specifies the staffing requirements of a Class A wastewater treatment system. Class A systems require a certified operator to be on site two days per week for a total of one hour.

This is a minimum requirement and additional time should be spent on site to maintain proper operation and maintenance. An uncertified operator can perform additional site visits for monitoring and maintenance, however, the certified operator of record must be on site for two visits per week for at least one hour.

OAC 3745-7-09 lists the recordkeeping responsibilities of a certified operator. A logbook needs to be maintained for the system and retained on site. The log should contain a minimum of the following: location of treatment system, date and time of arrival and departure, operational and maintenance activities performed, test results (both reportable NPDES and non-reportable process control data) and identification of the person making the entry into the log book.

3745-7-09 Recordkeeping requirements and responsibilities of a certified operator.

(A) "The owner and operator of record . . . shall maintain or cause to be maintained operation and maintenance records . . ."

(3) At a minimum, the following information shall be recorded:

**(a) Identification of sewerage system . . .**

**(b) Date and times of arrival and departure . . .**

**(c) Specific operation and maintenance activities . . .**

**(d) Results of tests performed and samples taken . . .**

**(e) Performance of preventative maintenance and repairs . . .**

**(f) Identification of person making entry**

**Ohio Administrative Code 3745-07**

3745-7-09 Recordkeeping requirements and responsibilities of a certified operator.

(A) "The owner and operator of record . . . shall maintain or cause to be maintained operation and maintenance records . . ."

(4) The records shall be kept up to date, contain a minimum of the previous three months of data at all times, and be maintained for at least three years.

One other requirement of OAC 3745-7-09 is the recorded data needs to be maintained for at least three years.

In addition to the potential of fines and jail time for violation of ORC 6111, violations of 3745-7-12 could lead to suspension or revocation of your Class A certification.

3745-7-12 Suspension or revocation of certification.

(A) The director may suspend or revoke the certificate of an operator, issued under this chapter, upon finding that the operator has:

(1) Fraudulently obtained any certificate or renewal . . .

(2) Perform duties of an operator in a negligent or incompetent manner,

(3) Knowingly or negligently submitted misleading, inaccurate reports,

(4) Operate in manner endangering the public health . . .

(5) Violation of 6109 or 6111

(6) Represent self as certified without valid certificate . . .

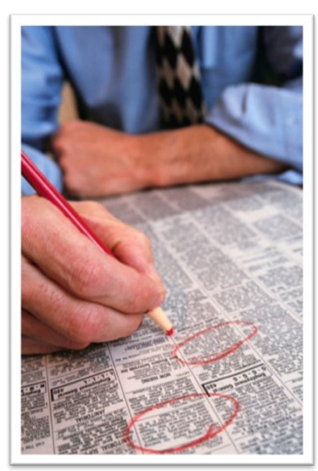
Actions which can lead to suspension or revocation are fraudulent, negligent or incompetent activity.

Operating a treatment system in a manner which would endanger the public's health could also lead to suspension or revocation. As an environmental steward of Ohio's waterways, you have a significant impact on the public exposure to health hazards.

3745-7-12 Suspension or revocation of certification.

(E) Revocation of an operator's certificate shall be permanent.

A wastewater treatment system's effluent can have a significant impact on the public's health.



Because of this level of responsibility any certified operator who has had their certification revoked will be unable to reapply for certification.

## Ohio Administrative Code 3745-07

Becoming certified as a Class A operator indicates at a point in time you have successfully demonstrated the basic knowledge level to be in responsible charge of a Class A wastewater treatment system. However, as in any other aspect in life, things change. New regulations, treatment technology and skills are required to continue to maintain compliance with the NPDES permit discharge limits. To insure certified operators are keeping up, each certified operator is required to complete eight approved contact hours to keep their individual certificates valid. Class A certificates are valid for a two year period. Thus, a certified operator must obtain eight contact hours within this two year period. Each certified operator is required to maintain documentation of contact hours received and be able to provide this documentation if requested by the Ohio EPA.

3745-7-15 Expiration and renewal of operator certification.

(D) Contact hours.

(1) The minimum number of contact hours that shall be completed by operators holding a single certificate as a :

(a) Class A or a limited Class A is eight hours of director-approved contact hours;

The Ohio Administrative Code 3745-07 contains the rules which pertain to the certification of operators of wastewater treatment systems in Ohio. Become familiar with these rules so that you can qualify for admission into the examination, be successful in passing the examination, and to insure you maintain a valid certificate after passing the examination.

Ohio EPA Permit No: 5PGS0004
NPDES Permit No. OHS00004
Page 1 of 23

Effective Date: January 1, 2015
Expiration Date: December 31, 2019

**OHIO ENVIRONMENTAL PROTECTION AGENCY**
**GENERAL PERMIT AUTHORIZATION TO DISCHARGE**
**WASTEWATER FROM SEWAGE TREATMENT SYSTEMS DESIGNED TO TREAT AN AVERAGE FLOW OF 25,000 GALLONS PER DAY OR LESS UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM**

The NPDES permit is the document which establishes the effluent quality that needs to be achieved to discharge into Ohio's waterways.

OhioEPA

**Division of Surface Water**
Annual Sewage Sludge Report 2013

**General Information**

| | | |
|---|---|---|
| Facility name: | | |
| Ohio NPDES permit No: | County: | |
| Mailing address: | | |
| City: | State: | Zip: |

☐ **Mark box with an "X" if no sewage sludge has been removed from the facility for the year 2013.**

The Annual Sludge Report is the document which monitors the amount of sludge produced in a year's time and where the sludge was disposed.

These three documents identify the rules and regulations required to operate within to maintain compliance and should be reviewed and understood for those in responsible charge of Class A treatment systems.

# How do I . . .

. . . measure ammonia in the clarifier effluent?

. . . measure ammonia in the aeration tank?

. . . eliminate the biological foam on the aeration tank?

. . . determine if ammonia is being released in the clarifier sludge blanket?

. . . measure total alkalinity in the aeration tank?

. . . determine how much aeration capacity is required?

. . . measure solids in the clarifier?

. . . determine how much to waste?

. . . measure the DO in the aeration tank?

. . . determine how much aeration time is required?

. . . measure biomass in the aeration tank?

. . . identify internal side streams as additional pollution sources?

. . . evaluate settling with the two-minute diluted settleometer analysis?

. . . interpret the clarifier core sampler results?

. . . determine the correct RAS pumping rate?

. . . correct a flow splitting issue into a clarifier?

. . . eliminate a density current within a clarifier?

. . . correct effluent weirs which are causing solids loss?

. . . calculate the SOR in the clarifier?

. . . calculate the SLR in the clarifier?

## How do I measure ammonia in the clarifier?

If the clarifier effluent is low in suspended solids, a sample can be collected from the clarifier surface to perform an ammonia analysis. If the clarifier effluent is high in suspended solids, such that it would affect the ammonia analysis, use a centrifuge to separate the suspended solids and perform an analysis on the centrate of the centrifuge tube.


There are several methods for analyzing the sample. The degree of accuracy of the method is not as critical as the ability to measure the ammonia concentration, monitor the trending of the ammonia concentration, and make timely process control decisions on-site. Small, single parameter colorimeters are available for accurate ammonia analysis. This method provides a digital readout of the ammonia concentration of the sample. The initial cost for the meter is more than an aquarium kit, however, the colorimeter does provide a more accurate analysis, especially when ammonia concentrations are high. However, it will likely require you to dilute the sample so the results are within the range of the meter.

A less expensive method is to purchase a test kit for ammonia nitrogen, commonly sold at aquarium stores. While this type of test kit can be accurate enough for process control testing, you will need to verify its accuracy. When collecting a final effluent sample for submitting to a lab for reporting purposes, draw off some of the sample and perform an ammonia analysis with your field test kit. Record this data and compare it to the ammonia value that your contract laboratory reports. If the ammonia values determined by your field test kit is close to the ammonia value reported from your approved lab, you will have confidence in using the field test kit for operational decisions. Performing this "split-sampling" procedure periodically can also indicate when the chemical reagents in the field test kit are becoming ineffective and the data is unreliable. Once you have determined which field kit provides accurate data, you can begin evaluating the treatment system for complete conversion.


There are two different methodologies for measuring ammonia nitrogen. The Nessler method offers a higher detection range than the Salicylate method, however, the Nessler method contains a mercury compound in the reagents. The waste products from the Nessler analysis are considered hazardous waste and need to be disposed of in an approved manner.

## How do I measure ammonia in the aeration tank?

The difference between measuring ammonia in the aeration tank and in the clarifier is that the suspended solids concentration in the aeration tank will invalidate the results. Use the centrifuge to quickly separate the suspended solids and obtain a sufficient sample for ammonia analysis.

**Collect a sample from the aeration tank effluent.** Fill two centrifuge tubes to the 100% mark and spin the sample for two minutes. After centrifuging, the clear liquid on top will be of sufficient volume to analyze for ammonia.

Another method is to draw a sample for ammonia analysis from the supernatant of a settleometer analysis after it has had time to allow for bacteria separation from the clear water. Collect a fresh sample from the aeration tank but don't allow the settleometer to sit for more than a few minutes before a sample is collected for analysis.

Once a clear sample of the aeration tank effluent is collected, analyze with the same ammonia test methodology you use for process control.

## How do I eliminate the biological foam on the aeration tank?

As the dissolved and suspended pollutants continue to flow into the aeration tank, more bacteria are generated. If excess bacteria are not removed or "wasted" from the Secondary Stage, the bacteria concentration increases to a point where competition for the in coming "food" becomes extreme.

There are certain bacteria which can naturally out-compete for the food source when the food becomes more scarce. These types of bacteria are also known to generate a brown foam on the aeration tank's surface. This "starved growth" condition is commonly referred to as a low F/M ratio environment (low food to microorganism ratio). A low F/M ratio in the aeration tank can promote biological foam which may migrate to the clarifier surface. To prevent this low F/M ratio in the aeration tank, an operator must either increase the food (influent cBOD) coming into the aeration tank or decrease the oxidative pressure within the aeration tank.

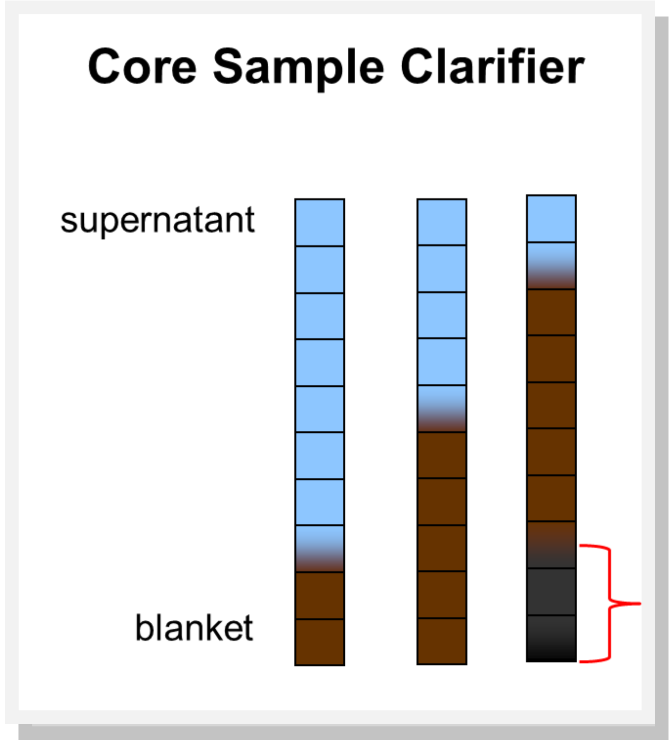
Operators have little control of the organic load coming into the treatment system. However, operators have several methods to control the "oxidative pressure" which is applied to treat the influent organic loading. Oxidative pressure is defined as anything which allows the treatment system to move closer to complete conversion of the influent organic loading. An example of adding oxidative pressure would be to bring more aeration tanks into service and thereby increasing the available detention time for treatment. Other examples include increasing the run-time of the blowers to provide longer aeration cycles, or increasing the concentration of bacteria in the aeration tank. Oxidative pressures are operational modifications which apply more "pressure" to completely oxidize the waste and reach complete conversion.

If an aeration tank is experiencing a low F/M ratio, which in turn is generating a biological foam, the operator needs to reduce the oxidative pressure to prevent this foam generating environment. Operational controls which reduce oxidative pressure on the aeration tank are to reduce the blower run-time (reduce timer settings), reduce the concentration of the bacteria in the aeration tank (increase wasting rate) or, if necessary, reduce the aeration tank capacity (take aeration tanks off line).

If the aeration tank effluent ammonia concentrations are < 1 mg/L, you have sufficient aeration tank detention time, sufficient volume of mass in the aeration tank, and/or sufficient aeration being applied. Start reducing these sources of oxidative pressure until you detect an increase in aeration tank effluent ammonia concentrations. An increase in aeration tank effluent ammonia will indicate you have reduced the oxidative pressure too much.

Instead of reducing oxidative pressure some operators will attempt to increase the influent organic loading to increase the aeration tank F/M ratio. Attempts include adding a waste load to the influent to change the aeration tank environment. Typically this is done by supplementing the influent with an inexpensive dog/rabbit food. This method is strongly discouraged because you are spending time and money to add waste to the treatment system, which costs you time and money to remove again. By reducing oxidative pressure you eliminate the generation of the biological foam, reduce your operational cost (reduced pumping, electrical costs) and avoid increasing cost by purchasing a supplemental organic loading. There are just too many starving dogs in the world to waste dog food! Focus on reducing oxidative pressures in the treatment system, which will save you money.

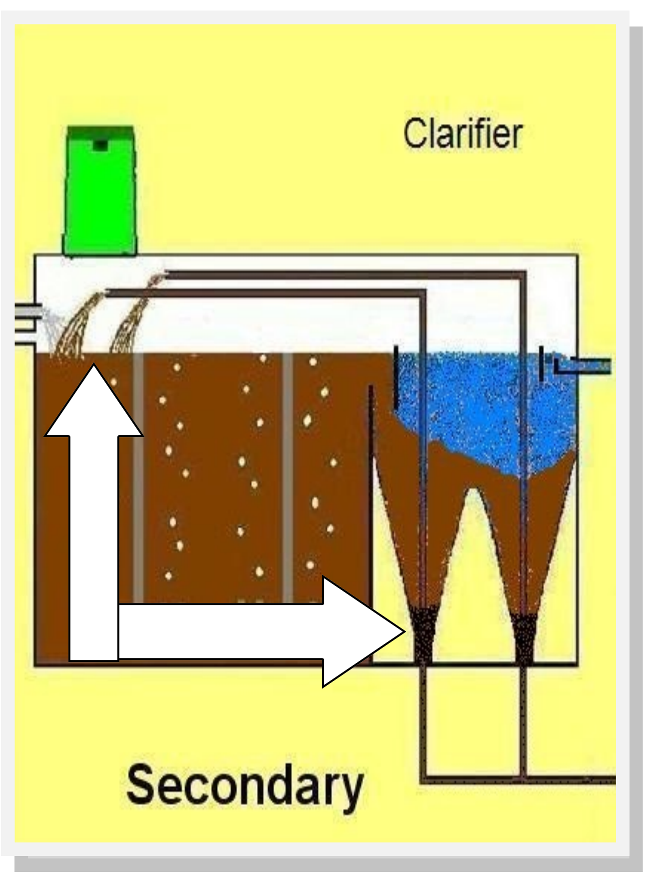
## How do I determine if ammonia is being released in the clarifier blanket?




If clarifier effluent ammonia values are greater than the aeration tank effluent ammonia values, then aerobic bacteria are breaking down and releasing ammonia nitrogen in the clarifier. As the sludge blanket increases in depth it is more likely for the sludge blanket to release ammonia nitrogen. If the situation is severe you may notice a darker color to the sludge layer in the bottom of the clarifier when using the clarifier core sampler.

If the problem is just starting to become an issue, you might not notice a darker color to the sludge blanket. To stay ahead of this problem, you could monitor the ammonia concentration in the clarifier's Return Activated Sludge (RAS).

Collect a sample of the clarifier RAS and centrifuge it to obtain a clear liquid sample (centrate) at the top of the centrifuge tube. Use this sample to chemically measure the ammonia concentration. If the RAS is starting to release ammonia nitrogen, you should see an increase in ammonia nitrogen in the RAS when compared to the aeration tank effluent.




If ammonia nitrogen is being released from the sludge blanket, an operational adjustment is required. Ammonia is released in the clarifier sludge blanket because the aerobic bacteria are without dissolved oxygen for too long.

If the RAS ammonia nitrogen is greater than aeration tank effluent ammonia nitrogen then bacteria are breaking down in the clarifier and need to be brought back into an aerobic environment in the aeration tank to prevent ammonia release.

It could be that the RAS pumping rate is too slow, which causes bacteria to remain in the clarifier too long. If the RAS pumping rate has been measured and found to be acceptable, then typically the entire system contains too much bacteria and an increase in wasting would be indicated.

## How do I measure total alkalinity in the aeration tank?

**Collect a sample from the aeration tank effluent.** Fill two centrifuge tubes to the 100% mark and spin the sample for two minutes. The clear liquid left on top after centrifuging is of sufficient volume to analyze using most field test kits.

It is recommended that you do not use "test strips" as a methodology to determine total alkalinity because it is too subjective. There are inexpensive titration test kits which use eye droppers to apply the acid reagent. Simply count the drops of acid that is added to the sample until you observe an obvious color change. Multiply the number of drops by the test kit multiplication factor to determine the total alkalinity in the aeration tank.

The test kits typically allow you to measure both phenolphthalein alkalinity and total alkalinity, depending on which indicator reagent is used in the analysis. It is the <u>total alkalinity</u> that is required to be greater than 100 mg/L in the aeration tank effluent to prevent lowering of the pH and inhibition of the nitrification or conversion process. The phenolphthalein alkalinity <u>is not</u> used in making process control decisions.

Measure the total alkalinity in the aeration tank effluent. Since the nitrification process (conversion of ammonia to nitrate) occurs in the aeration tank, it is critical to the treatment process to monitor total alkalinity in the aeration tank. Total alkalinity values can change as the water passes through downstream treatment stages. Values measured at locations downstream of the aeration tank (i.e., final effluent) might not accurately reflect the total alkalinity situation in the aeration tank.

When total alkalinity concentrations decrease below 100 mg/L, the system could quickly consume the remaining alkalinity depending on the remaining ammonia nitrogen to be converted. Ammonia nitrogen requires 7.14 mg/L of alkalinity for every 1.0 mg/L of ammonia present in the aeration tank that is converted to nitrate nitrogen. For example, having 100 mg/L of total alkalinity while still needing to convert 10 mg/L of ammonia is not sufficient. Although the system is nitrifying well, the alkalinity demand will require an additional 71.4 mg/L of the available alkalinity leaving less than the desired target of 100 mg/L of alkalinity.

Monitoring with pH is ineffective if your desire is to prevent a process upset. When alkalinity is depleted the pH will drop rapidly <u>after</u> it is too late to make an adjustment. Monitoring total alkalinity will provide an early warning to prevent an upset.

## How do I determine how much aeration capacity is required?

The treatment system is designed for an influent cBOD concentration and average daily flow rate. The total organic loading to the system is a function of both of these values. If influent cBOD concentrations remain the same but the influent flows decrease, then less aeration or "oxidative pressure" is required because the total organic loading will be less at lower flow rates.

As the bacteria convert influent pollutants into more bacteria, they generate heat that will assist in keeping the aeration tank water temperature above 10 C. However, when the influent organic loading is low, less heat is generated. When this situation is compounded with cold ambient air and excessive aeration, the water temperature can drop well below 10 C.

A simple calculation can be used to estimate how much aeration capacity is required. One parameter used to design treatment systems is the organic loading rate. Compare the actual organic loading rate that is received at the treatment system to the design organic loading capacity to determine the percent of capacity in use. If the system is not using all of its design organic loading capacity, it may be possible to reduce the oxidative pressure being applied (i.e., take aeration tanks out of service, reduce aeration blower run-time).

For example:

A treatment system is designed for a flow of 10,000 gallon per day and an influent cBOD concentration of 200 mg/L. This system actually receives only 4,000 gpd with an influent cBOD concentration of 175 mg/L. What is the percent oxidative capacity being used?

Design Organic Loading =

(10,000 gpd x 200 mg/L cBOD x 8.34 lbs/gallon)/1,000,000 = 16.7 lbs cBOD/day

Actual Organic Loading =

( 4,000 gpd x 175 mg/L cBOD x 8.34 lbs/gallon)/1,000,000 = 5.8 lbs cBOD/day

Percent Oxidative Pressure =

(5.8 lbs cBOD/d actual loading / 16.7 lbs cBOD/d design loading) x 100 = 35%

Since the treatment system is receiving only 35% of its design organic loading, in theory, you should be able to reduce the aeration to match this lower loading. Begin by reducing blower run-time and monitor the aeration tank water temperature and effluent ammonia. Reduction in the aeration should increase water temperature, which will eventually lead to a reduction in effluent ammonia. If less than half of the design organic loading is being used then taking half of the aeration tanks out of service would move the system closer to its design aeration requirement.

Taking half the aeration capacity out of service could prove to be too much of a reduction of oxidative pressure and periodic ammonia spikes may occur. If so, increase the biomass concentration in the aeration tank in service until you reach a centrifuge spin which will consistently produce an ammonia concentration less than 1 mg/L but does not impact the settling characteristics (such as an aeration tank centrifuge spin of 4% or greater that would typically impact settling).

## How do I measure solids in the clarifier?

A simple method to identify if bacteria are "hiding" in the clarifier is to use the core sampler and measure the compacted sludge blanket in the clarifier. If the sludge blankets are less than 30% of the clarifier water depth, then the majority of solids are in the aeration tank. If the sludge blanket in the clarifier is greater than 30%, the bacteria are "hanging out" in the clarifier too long. For clarifiers designed with multiple hoppers, measure the blanket depth of each hopper and average the values. It is common to see the first hopper in a multiple hopper clarifier maintain a higher blanket level than downstream hoppers.

Lower the core sampler slowly into the middle of the hopper clarifier, carefully avoiding submerged piping. "Dropping" the core sampler into the clarifier will provide inaccurate sludge blanket depths. Also lower the core sampler vertically and do not collect a sample as if you were "spear fishing".

If the sludge blanket is less than 20% to 30% of the clarifier water depth, then the majority of the bacteria are in the aeration tank.

One way to quantify, or measure, the amount of bacteria in the clarifier is to discharge the clarifier core sample into a bucket and use the centrifuge to determine the amount of bacteria in this clarifier "profile" sample.

If there is a two-hopper clarifier, core each hopper and mix both core samples in a bucket before centrifuging. Neither hopper should have a sludge blanket greater than 30% of the clarifier water depth, however, the first hopper sludge blanket depth is typically higher than the second hopper.

The centrifuge values of clarifier core samples should be less than the aeration tank centrifuge values. If the clarifier core samples are similar in value to aeration tank values, then there is too much mass in the clarifier.

## How do I determine how much sludge to waste?

Knowing how much mass is enough for complete conversion and when too much mass affects the separation process are the keys to maintaining the biological process of the treatment system. We can easily determine when sufficient mass is available by maintaining aeration tank ammonia nitrogen concentrations at less than 1 mg/L. By using the centrifuge you can measure or quantify how much mass is needed to convert all the waste into bacteria. Typically, small activated sludge package plant will achieve complete conversion with aeration tank concentrations between 2% and 4% when measured with the centrifuge. The minimum aeration tank centrifuge spin concentration which provides ammonia nitrogen concentrations less than 1 mg/L is the minimum target concentration. Simply maintain an aeration tank concentration which achieves ammonia nitrogen concentrations less than 1 mg/L. As the aeration tank centrifuge concentration increases, bacteria settling rates slow down. Typically the settling rate is not significantly impacted until the aeration tank concentrations begin to exceed 4% or unless the filamentous bacteria are dominating the treatment system.

Build up sufficient biomass to reduce effluent ammonia below 1 mg/L. When the settling rate is greater than 80% in the settleometer after 5 minutes, reduce the aeration tank centrifuge spin by increasing the wasting rate. This is the target aeration tank centrifuge spin you should maintain.

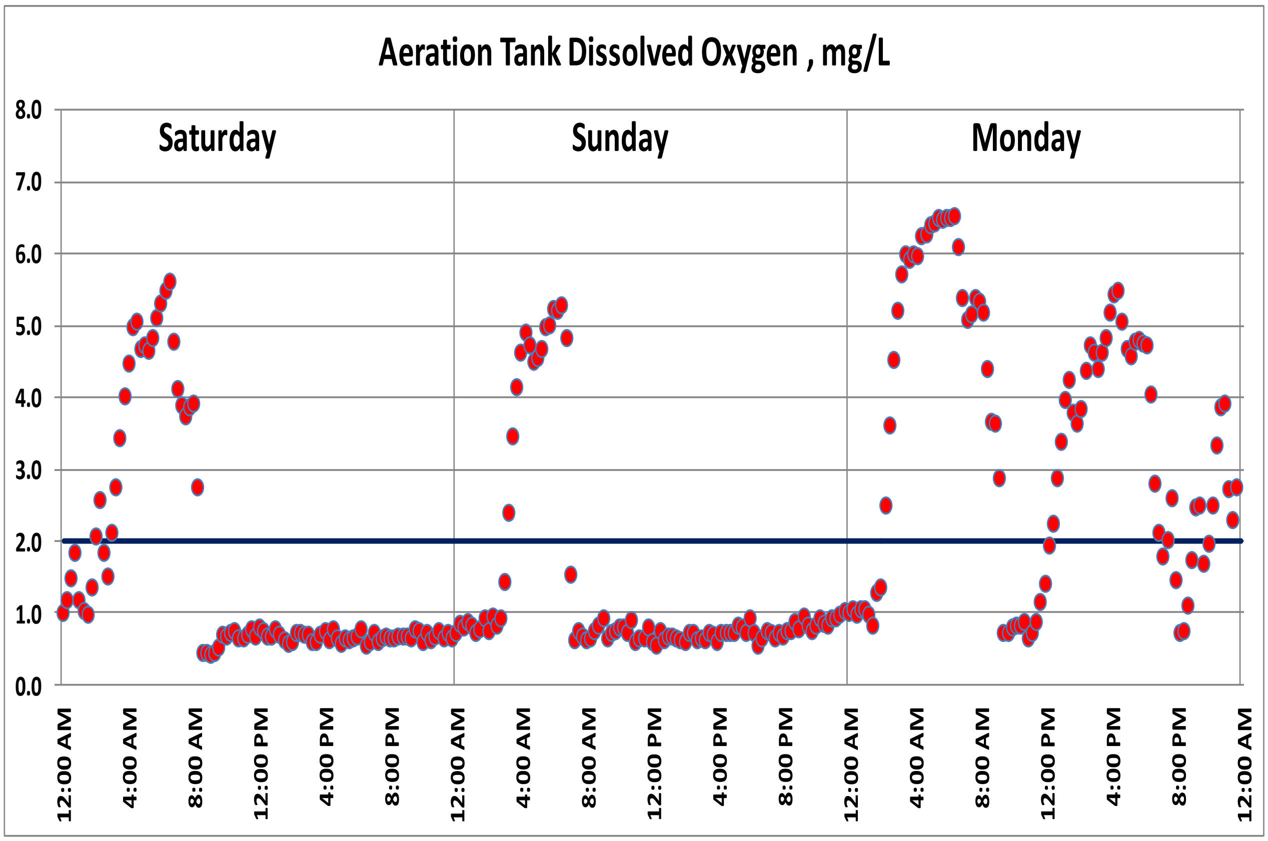
There are many ways operators "calculate" how much mass to waste. This method does work to provide a bacteria concentration which achieves complete conversion but does not inhibit separation. However, there is a simpler way. If you measure ammonia concentrations of less than 1 mg/L, you have sufficient bacteria mass. As long as it is settling well (less than 80% in 5 minutes), there is not an excessive amount of biomass. By simply measuring the concentration of mass in the aeration tank by centrifuge, you can maintain this target centrifuge spin, which provides complete conversion and adequate separation. A 15 minute centrifuge spins will indicate if you need to increase or decrease the wasting rate to bring balance back to the process. (No math involved!)

## How do I measure DO in the aeration tank?

Begin by monitoring the DO concentration near the discharge of the aeration tank into the clarifier. Place the DO probe within 1-2 feet of the surface of the water and record the data. Use this same location as a reference point so all the dissolved oxygen data collected will be related to this same location. The data loses significance if you measure the aeration tank effluent one day and then measure a different location the next time in the aeration tank.

In a small treatment system, which has only one aeration tank, this should be sufficient since these smaller aeration tanks exhibit a complete mix environment. In a larger treatment system, which has multiple aeration tanks, monitoring the DO at the effluent of each aeration tank will provide valuable insight of the oxygen demand as it travels through the treatment process.

The DO concentrations which provide sufficient conversion of ammonia nitrogen will be your targeted DO values. DO residuals of 2 mg/L typically are sufficient for complete conversion.




A data logging DO meter can provide the detail necessary to determine if the DO being applied is sufficient. If you are measuring dissolved oxygen one time during the day it would be like picking just one data point on the chart and basing your operational decision on that one event.

If a data logging DO meter is not available, a more complete DO profile can be obtained by measuring aeration tank DO at different times during the day <u>and</u> different days of the week. Once a more complete DO profile has been determined, adjustments to the aeration blower cycles can be made to maintain adequate dissolved oxygen in the treatment system.

## How do I determine how much aeration time is required?

Matching the aeration being applied to the waste load being received provides for optimal treatment conditions and saves operational costs by reducing blower/motor runtimes. However, not meeting the aeration requirements will lead to upsets and permit violations. A simple way to "estimate" blower runtime is to calculate the actual organic loading being received and compare it to the design organic loading of the system.

For example: A treatment system is designed for a flow of 10,000 gallon per day and an influent cBOD concentration of 200 mg/L. This system actually receives only 4,000 gpd with an influent cBOD concentration of 175 mg/L. What is the percent oxidative capacity being used?

Design Organic Loading =

(10,000 gpd x 200 mg/L cBOD x 8.34 lbs/gallon)/1,000,000 = 16.7 lbs cBOD/day

Actual Organic Loading =

( 4,000 gpd x 175 mg/L cBOD x 8.34 lbs/gallon)/1,000,000 = 5.8 lbs cBOD/day

Percent Oxidative Pressure =

(5.8 lbs cBOD/d actual loading / 16.7 lbs cBOD/d design loading) x 100 = 35%

If the treatment system is operating at one-half or less of its design loading rate, then you might be able to operate the aeration at one-half its design (12 hours in a 24 hour period).

Begin by spreading the blower run time to a total of 12 hours of on-time, but avoid excessive periods of off-times. More aeration on-time should be programed into the timer when the organic loading is being received and more blower off-time during periods of low flows and/or loadings (i.e., typically midnight to 5 am). Since the RAS is also controlled by the blower run times, extended blower off-times could allow settled solids to remain too long in the clarifier and denitrify. If the system does not receive sufficient aeration, the aeration tank effluent ammonia concentrations will increase.

If you are not sure of the actual influent loading or the intended design loading you can start by aerating continuously and measuring the aeration tank effluent ammonia nitrogen concentration. If the aeration tank effluent ammonia concentration is less than 1 mg/L you can begin decreasing blower runtime.

Important issues to consider:

The air-lift return activated sludge (RAS) pumps operate using the same aeration source as the aeration tank. Reducing blower runtime affects both the aeration tank and the RAS. A decrease in the air being supplied to the RAS pump will allow bacteria to remain in the clarifier too long. Solids which remain in the clarifier too long can denitrify and float to the clarifier's surface, which leads to solids loss or solids break down resulting in ammonia nitrogen release in the clarifier effluent. To prevent either of these situations in the clarifier, limit the duration of the blower off-time.

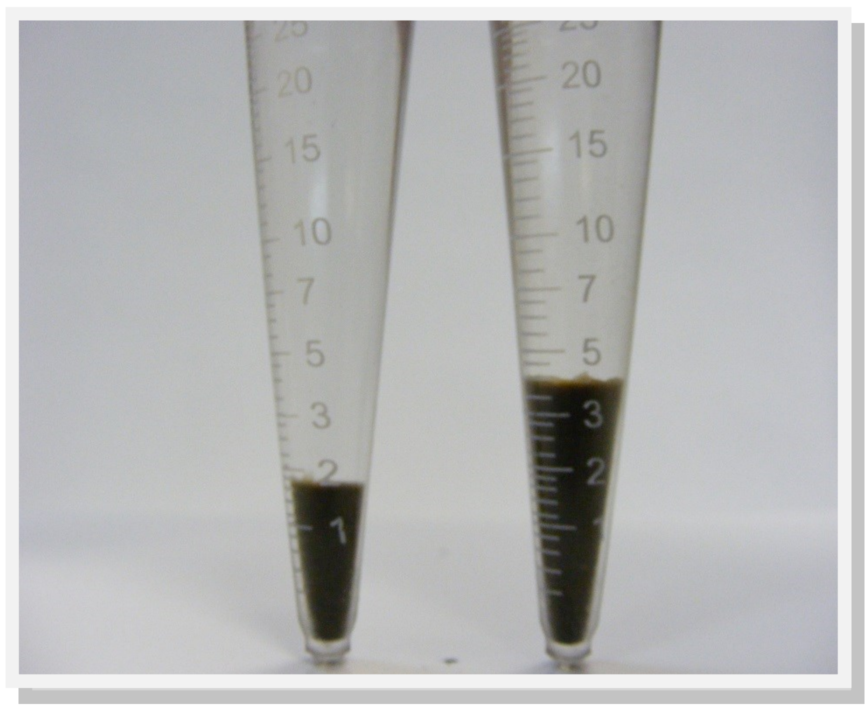
If the treatment system receives the majority of the organic loading during a specific time of the day (i.e. morning) the blowers should be operate more frequently during this period. If influent organic loadings decrease (i.e. school on summer break) longer aeration off-time can be used.

## How do I measure biomass in the aeration tank?

Collect a sample of the aeration tank effluent and perform a centrifuge analysis to determine the concentration of bacteria by percent volume (v/v%). It is best to begin the analysis within 15 minutes of sample collection. Collect sufficient aeration tank effluent volume to fill 2 centrifuge tubes. This allows the centrifuge to be balanced and sample results should not differ significantly. If values are too varied, resample and perform another centrifuge analysis.

Fill each centrifuge tube to the 100% mark on the tube. Load the centrifuge tubes opposite each other in the centrifuge to prevent an unbalanced load. Typical sampling locations are the aeration tank effluent (to determine the amount of biomass in the aeration system); the return activated sludge (RAS) (to determine the compaction of the biomass in the clarifier and also to evaluate RAS pumping rates); and the core sample of the volume of solids in the clarifier (which is used in evaluating improper RAS rates or excessive biomass in the treatment system).

Aeration tanks usually operate well when spins range from 2 to 4%. Aeration tanks with spins less than 2% sometimes flocculate insufficiently to filter out suspended solids as it settles in the clarifier. If the system can achieve ammonia nitrogen values below 1 mg/L with aeration tank centrifuge concentrations less than 2%, then less oxidative pressure needs to be applied to prevent over oxidation of the biomass. This is best achieved by taking aeration tanks out of service, if possible, or by reducing the aeration runtime in order to limit the oxidative pressure.




Treatment systems which are consistently over-oxidized could experience an extremely fast settling biomass which does not filter out suspended solids. This may result in more frequent binding of slow sand filters due to solids loss. If tertiary treatment is not available, there may even be a possibility of exceeding effluent total suspended solids limits.

Another possibility with an over-oxidized treatment system is that the aeration tank will experience a low food to microorganism ratio (low F:M) environment. Low F:M aeration tank environments can produce excessive filamentous bacteria which settle slow and are susceptible to hydraulic washout, even under design flow conditions. An increase in the wasting rate will address both of these situations. By increasing wasting, the aeration tank centrifuge concentration will decrease from its previous concentration.

## How do I identify internal side streams as additional pollution sources?

Aerobic digesters are designed to store excess bacteria from the Secondary Stage. As the digester becomes full, the air can be turned off to allow the settling of solids. The clear water on top, the supernatant, can then be decanted off the top to recover additional digester capacity.

The decanted water should not cause a problem with the treatment system unless the aerobic digester has turned into an anaerobic digester by having the air off too long during solids separation. This becomes an even more important issue when the ambient air temperature is warmer. Digester supernatant can be a major source of addition ammonia to the treatment system.

A simple method to determine if the aerobic digester contains a high concentration of ammonia nitrogen is to sample the decant for ammonia nitrogen with the field test kit prior to decanting back to the aeration tank or to the head works of the treatment system.


If the decant is high in ammonia nitrogen, a "slug" load of high ammonia supernatant could pass through the secondary system not completely converted. The ammonia nitrogen is not necessarily toxic, but rather it may provide a load that exceeds the design capacity. A high ammonia slug load could cause a "toxic" effect if the total alkalinity is depleted and the aeration tank pH drops too low impacting the conversion process.

If the decant is high in suspended solids use the centrifuge to separate solids from the water and perform an ammonia analysis on the centrate of the centrifuge tube.

## How do I evaluate settling with the two-minute diluted settleometer analysis?

Slow settling of the biomass (> 80% in 5 minutes) is usually caused by one of two situations: either the density of the biomass is low (bacteria wearing floatation devices) or the concentration of the biomass is too high (too crowded in the settleometer). The correct operational response depends on the situation, a density problem or a concentration problem.

To determine which situation is inhibiting settling, a two-minute diluted settleometer analysis is performed. Collect a sample of aeration tank effluent. Fill one settleometer to the 100% mark and a second settleometer to the 50% mark. To the second settleometer, which is one-half full, add clarifier effluent to bring the total volume to the 100% mark.

The two settleometers will have the exact same biomass but one is only 50% of the concentration of the other settleometer. Since there are no internal or external hydraulic pressures (density currents, RAS pumping rates), these settleometers reflect the "true" settling characteristics of the biomass.


***Diluted and Undiluted Settleometers of Dense Biomasss***

Gently stir both settleometers and then hold the paddle still a few seconds to eliminate and water movement in the settleometers. Pull the paddles out and begin timing the settleometers. Record the values after 2 minutes to determine the cause for the slow settling.

***Diluted Settleometer of Dense Biomass***

If the diluted settleometer settles significantly faster (photo above) than the undiluted, then the cause of the slow settling is that the concentration of the biomass is too high. If wasting is increased, reducing the concentration, the biomass should settle faster.

Another indicator of a dense biomass is if the bacteria settle so fast they do not provide any "filtering" of suspended solids as it settles (photo to the left). This is indicated initially by a cloudy, turbid supernatant which will clear up as time goes on.

If after 2 minutes the diluted settleometer is not significantly different than the undiluted settleometer (photo to the right), this indicates a density issue. Density issues point to excessive growth of filamentous bacteria. The photo below illustrates "coning" which is another indicator of excessive fil-

***Coning Effect of Filamentous Biomass***


***Diluted and Undiluted of Filamentous Biomass***

## How do I interpret the clarifier core sampler results?

The Core Sampler provides a window into clarifier operation. While the settleometer test reveals the settling characteristics of mixed liquor, the core sampler will show the actual settling characteristics of the mixed liquor in the clarifier.

In a clarifier core sample, look for three distinct zones: the Supernatant Zone, the Interface Zone, and the Blanket Zone. The Supernatant Zone will be at the top of the core sample and should be clear with little or no solids present. The Interface Zone will be in the middle of the core sample. These are uncompacted solids and usually indicate that the solids are still settling. The Interface Zone can also be due to the presence of an over abundance of filamentous bacteria. The Blanket Zone is at the bottom of the core sample and represents the amount of fully compacted solids.

One, two or all three zones may be present in a core sample. Ideally, a large fraction of the core sample would be clear supernatant with a small amount of interface and a blanket of less than 30% of the clarifier depth. This would represent a good settling sludge that separates well and compacts adequately. If the core sample is mostly blanket with little supernatant or interface, then it is likely that the RAS rate is too slow or that there are too many solids in the entire system (i.e., aeration tank spin is greater than a 4.0% centrifuge spin). If the core sample is mostly interface with little supernatant or blanket, then it is likely that excessive amounts of filamentous bacteria are present in the mixed liquor or the RAS rate is too fast. If the supernatant is cloudy or turbid, then the RAS rate is probably too fast.

By tracking the day to day variations in core sampler results, an operator can gain insights into the onset of settling problems. If the interface begins to increase over time, then an operator would expect that filamentous bacteria are beginning to dominate the mixed liquor in the aeration tank. Another filament indicator is that the supernatant will be very clear, a result of the filtering effect that filamentous bacteria provide by capturing small flocs and debris incorporating them into the flocs.

If the blanket begins to increase over time, the RAS rate should be checked and readjusted if necessary. Also, if the sludge at the bottom of the blanket is black or much darker than the rest of the blanket, the clarifier hopper walls may need to be scraped or possibly the RAS riser pipe is too far from the bottom of the sludge hopper and may need to be extended.

## How do I determine the correct RAS pumping rate?

The target RAS pumping rate can be determined with the results of the settleometer test and the centrifuge test. To find the target RAS rate, first prepare a settleometer test with aeration tank effluent and record the settled sludge volume every 5 minutes for 30 minutes if the mixed liquor settles well, or every 5 minutes for 45 to 60 minutes if the settleometer settles slowly. While the settleometer test continues, prepare the centrifuge test with multiple samples from the aeration tank effluent and the RAS being returned to the aeration tank. Average the results from each sample location.

Once the test data is completed, set up a table to analyze the data. In the first line (Time =0) the settleometer test just begins and the Settled Sludge Spin is the aeration tank spin. The calculation column divides the aeration tank spin by the Settled sludge volume percentage (as a decimal). Once the table is complete, compare the theoretical settled sludge spin to the actual RAS centrifuge spin. For instance, if the actual RAS spin is 5.2, then the solids retention time in the clarifier is just over 10 minutes. But the sludge does not stop settling until about 25 minutes indicated by very little settling in the time interval.

Determine the target RAS rate with settleometer and centrifuge by finding where the settleometer begins to "flatten out." In the example that would be between 20 and 25 minutes with a theoretical settled sludge spin between 7.6 and 8.2. Choosing 7.8 for the target RAS spin, adjust the telescoping valve upward until the RAS spin reaches the desired concentration. If the actual RAS spin would have been 8.8, then the telescoping valve would have to be lowered to increase the RAS rate to the desired spin.

| Settled Sludge Time | Settle Sludge Volume Percentage | Theoretical Settled Sludge Spin | Calculation |
|---|---|---|---|
| 0 | 100 | 3.2 | 3.2 / 1.00 = 3.2 |
| 5 | 78 | 4.1 | 3.2 / 0.78 = 4.1 |
| 10 | 64 | 5.0 | 3.2 / 0.64= 5.0 |
| 15 | 51 | 6.3 | 3.2 / 0.51 = 6.3 |
| 20 | 42 | 7.6 | 3.2 / 0.42 = 7.6 |
| 25 | 39 | 8.2 | 3.2 / 0.39 = 8.3 |
| 30 | 38 | 8.4 | 3.2 / 0.38 = 8.4 |
| 35 | 37 | 8.6 | 3.2 / 0.37= 8.6 |
| 40 | 37 | 8.6 | 3.2 / 0.37= 8.6 |
| 45 | 36 | 8.9 | 3.2 / 0.36 = 8.9 |

## How do I correct a flow splitting issue into a clarifier?

Splitting flow equally between two parallel clarifiers is essential to optimizing treatment. If one unit receives more flow than another parallel unit, then that unit could likely fail under peak flow conditions, unable to perform beyond its design capabilities. Meanwhile the unit receiving less flow will be under utilized, performing well below its design capacity. The net result will be a less efficient treatment system and potential permit violations for suspended solids.

The best way to split any flow is to utilize a flow splitter box. In a properly designed flow splitter box, the flow is directed upward to neutralize any horizontal momentum of the flow and then allow the flow to proceed over equal length weirs that are at equal elevations. If the flow is not directed upward, the forward horizontal momentum of the water could cause a turbulent environment in the flow splitter box that may direct more flow over an individual weir. If the weirs are not level, or are at different elevations, then flows will definitely be unequal. If there are no overflow weirs, then the flow splitting would be random.

Poor flow splitting between clarifiers can be difficult to retrofit due to buried pipes and insufficient available head between the aeration tank and the clarifier to build a splitter box. However, if the flow can be equally split upstream of the clarifier, then the flows should be equal all the way through the parallel treatment trains.

***Random Flow Splitter: No weirs, no flow control.***

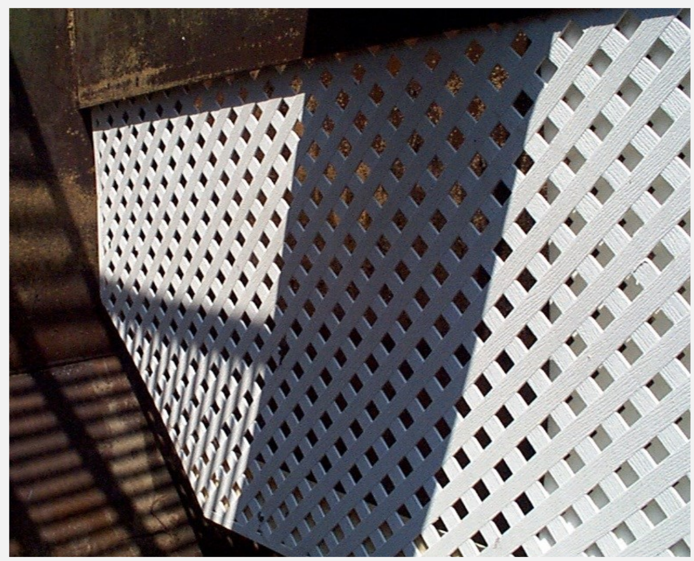
***Proper Flow Splitter: Overflow weirs of equal length.***

## How do I eliminate a density current within a clarifier?

A clarifier density current occurs when mixed liquor enters a clarifier and flows between the higher density sludge blanket and the lower density clarifier supernatant. The mixed liquor has momentum and will continue in the direction of flow until it encounters the clarifier wall. Upon hitting the end wall of the clarifier, the momentum is disrupted and some of the mixed liquor can surface and flow over the weirs into the clarifier effluent. This loss of solids can impact sand filters by clogging them or be discharged into the receiving stream resulting in a permit violation. The installation of properly located baffles can break up a density current thus preventing solids loss and can also improve flocculation of the mixed liquor.

There are two locations in a hopper type clarifier where baffles can improve performance. A flocculation baffle can be installed at the influent end of a clarifier where the scum baffle is located. A mid-tank baffle can be constructed at the peak of a two-hopper clarifier where the side walls of the hoppers come together.

To install a flocculation baffle, the scum baffle can be extended downward to within 1-2 feet of the hopper slant. Rigid plastic sheeting or landscape lattice can be fixed to the existing scum baffle to make the baffle. When mixed liquor enters this baffled region, the flow is gently mixed. This mixing increases collisions between bacterial flocs which promotes bigger, heavier flocs that will settle well. In addition, influent flows will "hit" the baffle and are redirected back into the influent flow. This rebound effect will help to disrupt currents which can persist through the length of the clarifier and carry solids to the effluent weir.



Installing a mid tank baffles is a little trickier. There is usually nothing for a mid-tank baffle to be anchored upon, the baffle will need to be fixed to the side walls of the clarifier. Typically, metal angle is attached to the clarifier side walls and wood boards or plastic sheets are then bolted to the angle. Care must be given to keep the top of the baffle below the water surface so that scum and other floatables are not trapped on the "wrong side of the skimmer.

## How do I correct effluent weirs which are causing solids loss?

Clarifier effluent weirs can contribute to solids loss in two ways. Weirs that are not level can establish a current in the clarifier that leads directly to the lower end of the weir. Also weirs that are not optimally located in the clarifier can collect solids that are influenced by clarifier end wall current effects and flow over the weirs.

Clarifier weirs usually have some adjustments so that a weir can be re-leveled should the clarifier settle unevenly or shift slightly. To level a weir, fill the clarifier, block off the influent flow to the clarifier, and shut off the RAS. Since water will seek its own level, just loosen the adjustments and reposition the weir until the water level is even all around the weir. Then retighten the adjustments.

An example of a poorly located weir would be one that is perpendicular to the clarifier end wall or even too close to the end wall. If there is a density current of mixed liquor flowing across the clarifier (see How Do I Eliminate a Density Current Inside a Clarifier), it will continue uninterrupted until it encounters an obstacle, the end wall. Because there is a current flowing over the weir, solids will be carried along with that current over the weir. A simple method to reduce this effect is to block off the portions of the weirs that are close to the end wall. For a weir that is perpendicular to the end wall, taking the 2-3 feet of weir out of service by clamping wood or plastic to the weir. This will allow solids to resettle to the bottom of the clarifier rather than escape over the weirs. For a weir parallel to the end wall, taking the back side weir (the one closest to the end wall on a double sided weir) out of service can also reduce solids loss.

## How do I calculate the SOR in the clarifier?

The Surface Overflow Rate (SOR) is a design criteria for clarifiers. The number is calculated by determining the peak flow rate into the clarifier (gallons per day) and then dividing that number by the clarifier surface area (square feet).

The significance of the surface overflow rate is that it provides a numeric value for the hydraulic capacity of a clarifier. In a clarifier, suspended solids settle with a downward velocity. But clear water is flowing upward toward the effluent weir at the same velocity that the mixed liquor enters the clarifier. This results in opposing flows. If the upward flow rate of the clear water is greater than the settling sludge flow rate of the mixed liquor, then solids can be carried over the weir into the effluent trough. If the settling sludge velocity is greater that the upward velocity of the effluent, then there should be no solids loss.

For example, a package plant clarifier may have surface dimension of 6 feet wide by 15 feet long. The clarifier surface area would be:

$$\mathbf{6\ ft \times 15\ ft = 90\ ft^2}$$

If the design peak flow to the clarifier is **40,000 gallons per day**, then:

$$\mathbf{SOR = \frac{40{,}000\ gpd}{90\ ft^2} = 444\ gpd/ft^2}$$

For small package plant clarifiers the maximum design surface overflow rate is typically 600 — 800 gpd/$ft^2$. For larger clarifiers with active sludge scrapers, the design surface overflow rate is usually 1000 gpd/$ft^2$**.**

## How do I calculate the solids loading rate in the clarifier?

The Solids Loading Rate (SLR) is a design criteria for clarifiers. The number is calculated by determining the mass of mixed liquor (in pounds) into the clarifier and then dividing that number by the surface area of the clarifier.

The significance of the solids loading rate is that it provides a numeric value, not to be exceeded, for the amount of the solids entering a clarifier. In a clarifier, suspended solids settle, compact and only then will be pumped back to the aeration tank. A high solids loading rate to a clarifier can lead to a slower sludge settling condition, due to the high concentration and/or a sludge blanket that is greater than desired. Either condition can lead to solids loss.

For example, a package plant clarifier may have surface dimension of 6 feet wide by 15 feet long. The clarifier surface area would be:

$$\textbf{6 ft x 15 ft = 90 ft}^2$$

The design mass into the clarifier can be calculated by multiplying the mixed liquor suspended solids concentration by design peak influent flow rate plus the peak design return sludge flow rate and then multiplying by the conversion factor of 8.34.

For example:

MLSS = 3000 mg/L

Clarifier Influent Flow = 0.040 MGD

RAS Flow = 0.040 MGD

**lb/d of solids = 3000 mg/L MLSS x 0.080 MGD x 8.34 = 2002 lb/d**

$$\text{SLR} = \frac{2002\text{ lb}}{90\text{ ft}^2} = 22.2\text{ lbs/d/ ft}^2$$

For small package plant clarifiers the limiting design solids loading rate is 25 lbs/day/$ft^2$. For larger clarifiers with active sludge scrapers, the design solids loading rate is usually 35 lbs/day/$ft^2$.