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- Promote and advance the water quality profession.
- Promote scientifically sound environmental practices and regulation.
- Promote public and ecological health by preserving and enhancing Michigan's water environment.



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# Wastewater Management Handbook for Community Officials



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## Overview

The section provides an overview of wastewater treatment and is intended to provide a brief description of what processes may be at your wastewater plant. Although each plant is designed for particular conditions, there are many similarities in how different processes operate. There may be differences between your plant and a neighboring plant in terms of size, ground area, shape of tanks (circular or rectangular), or the types of treatment processes they use.

## What is wastewater?

Wastewater or sewage is the byproduct of many uses of water. There are the household uses such as showering, dishwashing, laundry and, of course, flushing the toilet. Additionally, companies use water for many purposes including processes, products, and cleaning or rinsing of parts. After the water has been used, it enters the wastewater stream, and it flows to the wastewater treatment plant. When people visit a treatment plant for the first time, often it is not what they perceived it would be. These wastewater plants are complex facilities and provide a high quality product.

## Why treat wastewater?

We need to remove the wastewater pollutants to protect the environment and protect public health. When water is used by our society, the water becomes contaminated with pollutants. If left untreated, these pollutants would negatively affect our water environment. For example, organic matter can cause oxygen depletion in lakes, rivers, and streams. This biological decomposition of organics could result in fish kills and/or foul odors. Waterborne diseases are also eliminated through proper wastewater treatment. Additionally, there are many pollutants that could exhibit toxic effects on aquatic life and the public.

## How do we collect the wastewater?

The sewer or collection system is designed so that it flows to a centralized treatment location. The collection system is comprised of smaller sewers with a diameter of about four inches. As more homes and companies are connected along the system, the pipes become larger in diameter. Where gravity systems are not practical, pumping stations are often included to lift the wastewater. In New York State and in many other states, there are some very old collection systems. Some sewer piping was actually installed in the late 1800's! Materials of construction and methods of construction have changed significantly over the years. Many systems experience problems during wet weather periods with inflow and infiltration. This is commonly referred to as "I&I." Wet weather operating periods typically occur when the snow melts in the spring and/or during heavy rainstorms. Water resulting from snowmelt or storms should flow into a storm water system and not into the sanitary sewer system. Unfortunately, this isn't always the case.

## Where does the water go after treatment?

The treated wastewater is referred to as effluent. The effluent is discharged to a water body such as a lake, river, stream, or groundwater. Conditions contained in the State Pollutant Discharge Elimination System (SPDES) Permit are designed to minimize the impact that the effluent may have on the receiving stream. Small streams that have a classification of trout spawning or that are used downstream for drinking purposes have more stringent (tighter) permit limits than streams that discharge into a water body with a higher flow and/or sizeable tributaries.

## What are common wastewater terms?

In wastewater vernacular, there are acronyms for many processes. Some of the most common terms are listed below with a brief description. A more comprehensive glossary of wastewater terms begins on page 110. *Aerobic*: A process that requires dissolved oxygen to operate properly. The microorganisms need the oxygen to "eat" the food properly. *Anaerobic*: A process that can operate or needs to operate without oxygen being present. A good example is an anaerobic digester used for solids handling. *Biochemical Oxygen Demand (BOD5)*: A test that measures the organic strength of a sample of wastewater. It provides information on the organic load or how much "food" there will be for organisms. The load can be either to a treatment plant unit or to a receiving water body.

*Clarifier or settling tank*: Tanks designed for the physical separation of wastewater floatable solids and settleable solids. These two terms are widely used interchangeably. *Disinfection*: Killing disease-causing organisms, differing from sterilization, which kills all organisms. *Dissolved Oxygen (DO)*: A test usually performed by an electronic meter that measures the dissolved oxygen of a sample or process unit. It is important because many of the treatment processes require oxygen (aerobic) to operate properly. Too much oxygen can mean that money is wasted through excess energy consumption to provide the oxygen, which is relatively insoluble in water. *Effluent*: Wastewater or other liquid, partially or completely treated, flowing from a reservoir, basin, treatment process, or treatment plant. *Influent*: Wastewater or other liquid flowing into a reservoir, basin, or treatment plant. *Parts per million (ppm) or milligrams per liter (mg/L)*: These terms refer to the results of analyses such as TSS or BOD5. These terms are used interchangeably and mean exactly the same thing. *Total Suspended Solids (TSS)*: Data from a test that measures by weight how much particulate material is contained in wastewater samples by filtering the sample through a special fiberglass filter. For example, TSS measures the solids that can be seen in a beaker.

### **What is Advanced Treatment?**

Some treatment plants may be required to remove nutrients (nitrogen and phosphorus) due to the possible negative impacts on the receiving stream (e.g., ammonia toxicity to fish). Advanced treatment processes are used to remove nutrients, additional solids, and/or biochemical oxygen demand. Advance treatment provides a very high level of treatment that goes beyond secondary treatment. In the case of nitrogen removal, the processes are biological. For phosphorus removal, chemical additives are normally required.

### **Where do all the solids go?**

Solids that settle out in the primary and secondary clarifiers are referred to as sludge. Sludge from biological treatment processes (e.g., activated sludge) are referred to as biosolids. Sludge is the byproduct of treating the liquid wastewater. Proper solids handling is of paramount importance. If sludge is not removed, problems will occur in other areas of the plant. Excess solids can also lead to SPDES Permit violations and odor problems. There are many different options available for solids handling. Local conditions usually dictate which option is best for your particular facility. General categories of sludge handling include digestion processes, hauling of liquid sludge to a larger treatment plant, thickening, dewatering by mechanical means (belt filter presses, centrifuges), incineration, land filling, and land application. The Herkimer County Wastewater Plant is designed for 6.1 million gallons per day (mgd). Sludge is pumped to a gravity thickener, treated to reduce odors, and dewatered using a belt filter press. The dewatered solids are treated using dry lime for stabilization and loaded into a roll off container. A contractor takes the container and stores the solids. The sludge is later land applied on crop fields. The City of Little Falls Wastewater Plant is a 5.0 mgd design and pumps the sludge to a gravity thickener. Solids are dewatered using a belt filter press and then incinerated. The remaining ash is landfilled. The Village of Clinton Wastewater Plant is a 2.5 mgd design that gravity thickens the sludge before pumping into an anaerobic digester. In the past, solids removed from the digester were pumped to a drying bed and landfilled. The drying beds were troublesome due to weather dependency e.g. rain and winter. Solids from the anaerobic digesters now go to a belt filter press, and then to a landfill. The Old Forge Wastewater Plant (0.45 mgd) pumps the sludge to an aerobic digester. When the digester approaches capacity, the solids are then treated with polymer and processed through a thickening device. The solids are stored in another aerated tank until it is time to call for a tank truck. A contractor hauls 6,000 gallons to the Watertown Wastewater Plant for further treatment and disposal. In summary, there are many options available for sludge treatment and handling.

### **What is Inflow & Infiltration (I&I)?**

Inflow is water from a sump pump or a roof leader. This is relatively clean water that should be discharged to a storm water system. In some cases, homeowners in low lying areas connect sump pumps (illegally) to the sewer because it is relatively easy and inexpensive. In many communities, there are "combined sewers" that carry street runoff, as well as wastewater. Infiltration is water from high groundwater levels. Older sewer pipes may have leaking joints or cracks that allows the water to enter the system. Infiltration usually occurs **Groundwater infiltration makes efficient** in the spring when melting snow and rain saturate the ground.

Excessive I&I can lead to Combined Sewer Overflow (CSO) and Sanitary Sewer Overflow (SSO) points in a collection system. If you have CSOs or SSOs, the NYSDEC is probably talking to you about it!

### **What happens after collection of the wastewater?**

The wastewater continues to flow through the collection system and eventually reaches the wastewater treatment plant. Upon reaching the plant, the flow first encounters preliminary treatment. Preliminary treatment is followed by primary treatment, then secondary treatment, and perhaps advanced or tertiary treatment. The solids or "sludge" removed from the wastewater stream also needs to be treated.

### **What is Preliminary Treatment?**

Preliminary treatment processes are the first processes that the wastewater encounters. This typically involves flow measurement so that the operator can quantify how much wastewater is being treated. Flow monitoring is commonly followed by screenings removal. Screenings are string like materials and large foreign objects like sticks or perhaps an errant golf ball. These materials need to be removed because they can damage machinery or clog processes. Screenings can be removed using bar screens and other devices designed for this purpose. The next process in preliminary treatment is grit removal. Grit is comprised of inorganic material such as sand, gravel, eggshells, etc. It is desirable to remove grit to prevent wear and abrasion on pumps and other mechanical equipment. Grit can also plug lines and pipes. In this influent area, sampling equipment is often used to collect small portions of the wastewater for analysis. Sampling enables the operator to determine the pollutant loadings entering the plant (influent). Preliminary treatment commonly includes raw sewage pumps. Screening and grit removal are important to the proper operation of the raw sewage pumps. These materials will cause clogging and cause wear on the internal parts. These raw sewage pumps deliver the flow to the next phase of treatment: Primary Treatment.

### **What is Primary Treatment?**

Primary treatment is a physical settling process that removes solids. Wastewater that enters the primary settling tank (or clarifier) is slowed down to enable the heavier solids to settle to the bottom. Lighter materials, such as grease, will float to the top of the tank. Settling tanks are designed with mechanisms to remove both the settled solids, as well as the floating solids. Primary clarifiers are either circular or rectangular. Both types work equally well when properly designed and maintained. Not all plants have primary treatment. Primary treatment generates primary sludge. The sludge is removed and pumped to the solids treatment process for ultimate removal. What's left after we remove the pollutants that settle and float? The wastewater still has solids remaining after primary treatment. These solids are either dissolved or suspended. Dissolved solids are very small solids (e.g., dissolving sugar in water). You cannot see the solids but they are there. Suspended solids can be likened to the same ends of a magnet. The solids repel each other. These solids are small, but are visible to the human eye. We remove these dissolved and suspended solids through the next phase of treatment: Secondary Treatment.

### **What is Secondary Treatment?**

Secondary treatment is a biological treatment process used to stabilize the dissolved solids. Microorganisms (e.g., bacteria) feed on the organic solids (food) in the wastewater and convert the organics into a cellular or biological mass that can later be removed. These biological processes are aerobic processes. Oxygen must be provided for these aerobic organisms to work properly and efficiently. An integral part of secondary treatment processes is another set of settling tanks or clarifiers. These secondary clarifiers (final clarifiers) remove the biological mass that has grown during biological treatment. There are many different kinds of secondary processes that can be employed. A very common secondary process is known as activated sludge. In activated sludge treatment, the wastewater is mixed with organisms that are returned from the secondary clarifiers. There is a continuous return of organisms from the secondary clarifiers. This is called return sludge or return activated sludge. Oxygen is provided in the aeration tank either by blowers and diffusers or by a mechanical mixing process. A variation of the activated sludge process that is becoming more popular is known as Sequential Batch Reactors (SBR's). This process differs from the more conventional activated sludge systems in that it also uses the aeration tank as a settling tank. This is accomplished by turning off the air to the diffusers or the mixers and allowing the solids to separate from the wastewater. During this settling period, the flow is diverted into a second SBR tank for continuous treatment. Advantages of this SBR process include a relatively small footprint and the capability of removing nutrients (both nitrogen and phosphorus). Lagoon systems are also a form of

biological or secondary treatment. These lagoon systems are used where there is a lot of land available and/or the wastewater flows (quantities) are low. Lagoons are constructed with lined earthen bottoms and are less expensive to construct than are activated sludge processes that use concrete tanks. Limitations of lagoons may include excessive algae growth (solids violations) and poor performance in the winter.

### **Common Secondary Treatment Processes**

Another type of secondary treatment is known as fixed film processes. Fixed film processes consist of two types: Trickling Filters or Rotating Biological Contactors (RBC's). Trickling filters are sometimes called BioTowers. Trickling filters are beds with a synthetic material (media). An under-drain system and a rotary distribution system apply the wastewater to the media. The microorganisms grow attached to the rocks or synthetic media as opposed to liquid suspension in the activated sludge. A circular rotary distributor moves over the media bed and the wastewater is trickled onto the media. As the wastewater flows over the media, it comes into contact with the microorganisms and picks up oxygen. When the biological growth becomes too thick, it falls off the media and flows with the wastewater to a secondary settling tank for removal. Many trickling filter plants that originally were designed with rock media have changed to the more efficient plastic media. The RBC is similar to the trickling filter in that it uses an attached biological growth. An RBC has panels that are circular and mounted to a shaft. The wastewater flows into a basin beneath the media and the media rotates with the shaft. The microorganisms are contacted with the wastewater. Since the RBC's expose the media to the air, oxygen is picked up and transferred into the growth. RBCs have low energy requirements. These systems need to be protected from cold weather by a building. Intermittent sand filters are employed in some smaller applications. As wastewater passes through the filter bed, solids are removed. Microorganisms grow in the removed solids layer and provide biological treatment of the wastewater as it flows through the sand bed. The sand will need to be replaced at some point in time. Additionally, these sand filter systems generally perform poorly in the winter. All of the secondary treatment processes produce biosolids. These biosolids are pumped to the solids treatment system for further processing.