City of Sheboygan Regional Wastewater Treatment Facility

Serving:
City of Sheboygan
City of Sheboygan Falls
Village of Kohler
Town of Sheboygan
Town of Sheboygan Falls
Town of Wilson
Town of Lima

In an effort to clean up our rivers and lakes by the mid-1980s, communities in Wisconsin and throughout the nation started working to meet stringent state and federal water quality standards. The high quality of effluent discharged from the facility into Lake Michigan is evidence of the positive action that has been taken to restore and maintain the lake's chemical, physical, and biological integrity. The facility also produces Class A biosolids which are required to meet more stringent limits by the Wisconsin Department of Natural Resources (WDNR).

History of the Sheboygan Regional Wastewater Treatment Facility

The City of Sheboygan constructed the first WWTP on the present site in 1937. This original plant provided primary treatment, which essentially consisted of removal of suspended solids. In 1957, the plant was upgraded to provide secondary treatment which is designed to remove soluble organic material.

By 1970, Sheboygan had outgrown the upgraded treatment plant. The City then authorized an engineering study to assess the community's wastewater treatment needs. Before design and construction of a plant addition could begin, Congress enacted the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500. In response to these new requirements, a feasibility study was conducted which indicated that a single wastewater treatment plant would be the most cost effective and environmentally sound method of treating wastewater produced in the region. The regional facility would serve the Cities of Sheboygan and Sheboygan Falls, the Village of Kohler, the Town of Sheboygan, and portions of the Town of Sheboygan Falls, Town of Lima, and the Town of Wilson.

The sanitary sewer system analysis and the wastewater treatment facilities plan were completed in 1975 and 1976, respectively. The facilities plan called for expansion of the existing Sheboygan wastewater treatment plant and the abandonment of the treatment facilities in Kohler and Sheboygan Falls. Many components of the previous Sheboygan treatment plant was incorporated into the new facilities, resulting in lower construction costs. This plan also included construction within the City of Sheboygan of the west interceptor to convey wastewater from Sheboygan Falls and Kohler. Other projects included a sanitary sewer rehabilitation and combined sewer (storm and sanitary) elimination program, and the upgrading of Sheboygan's two major wastewater-pumping stations located at North Avenue and N. 3rd Street and the other at Kentucky Avenue and S. 7th Street.

In 1977, the WDNR gave final approval for the plans and specifications of the WWTP. The City of Sheboygan received federal funding for 75% of the project cost, with the WDNR providing approximately 5% of the project cost. The remaining cost was funded locally.

In January 1978, construction of the $23.9 million regional treatment facilities commenced. The liquids handling portion became operational in December 1979. The solids handling portion was fully operational in the fall of 1981. Construction of the $1.04 million west interceptor, $810,000 sanitary sewer rehabilitation, and $1.55 million upgrading of the North Avenue and Kentucky Avenue pump stations was concurrent with construction of the treatment facilities.

Processes and Equipment Summary

The WWTP utilizes an activated sludge process to achieve secondary wastewater treatment. Process enhancements over time have been completed to increase plant efficiency and improve effluent quality.

Raw Wastewater Pumps

Raw wastewater, which enters the plant via large underground pipes, is pumped to the bar screens by six raw wastewater pumps with a firm pumping capacity (meaning one pump out of service) of 71.7 million gallons per day (mgd). Although daily average plant flow is around 11.0 mgd, a much higher capacity is required due to the infiltration of clear-water into the sanitary sewer system.

Raw Pumps

Screening

Raw wastewater is pumped to two self-cleaning center-flow fine screens with five mm openings. The screening process is designed to remove small and large non-biodegradable debris from the wastewater flow. The debris collected by the fine screens is compacted before being placed in a waste roll-off container and hauled to a landfill for disposal.

Grit Removal

After screening, wastewater flows through a 20-foot diameter, cyclone grit separator installed to remove sand and silt. Sand and silt enters the

Vortex Grit Washer

waste stream with the inflow/infiltration of rainwater and clear-water into the sanitary sewer system. The material removed is washed in a vortex grit washer, which removes any remaining organic matter from the grit before it is deposited in the waste roll-off with the screenings collected by the fine screens.

Primary Clarifiers

Four primary clarifiers (90 ft. x 90 ft.) provide 5.67 hours detention at 11.0 mgd average daily flow. Approximately 70% of the wastewater suspended solids are removed in primary clarification. The settled primary solids (biosolids) are pumped to the anaerobic digestion process for further treatment. Clarified effluent flows by gravity to the secondary treatment process.

Secondary Treatment

The facility operates an activated sludge process which is designed to remove nitrogen and phosphorous (nutrients) along with dissolved and suspended organic matter. Secondary treatment utilizes high concentrations of micro-organisms to break down the organic components remaining in the wastewater after primary clarification.

Anoxic Zone

The first step in the process is denitrification in an anoxic zone (free of dissolved oxygen) where the incoming sludge returned to the process from secondary clarification (return activated sludge or RAS) is mechanically mixed. In this zone the microbes utilize the oxygen from nitrate (NO_3) for an oxygen source reducing the NO_3 molecule and allowing the nitrogen to gas off to atmosphere, removing nitrogen from the system. Detention time in the anoxic zone is approximately 2.0 hours at average daily flow.

Anaerobic Zone

The denitrified return activated sludge (RAS) is combined with primary clarifier effluent and mixed under anaerobic conditions (without oxygen) where they remove and store organics coming in with the wastewater. The energy to store organics is obtained from stored polyphosphates, which results in the release of phosphorous. Detention time in the anaerobic zone is approximately 1.6 hours at average daily flow.

Aeration Basin

After the removal and storage of the incoming organics under anaerobic conditions to promote the release of phosphorous, oxygen is

again introduced in the aeration basin. Oxygen is supplied to the aeration basin through a fine bubble diffused air system which supplies the micro-organisms with oxygen, and provides mixing to maintain suspension. Under aerobic conditions (with dissolved oxygen), the micro-organisms convert the organics removed the anaerobic zone to new micro-organisms, carbon dioxide (CO_2) and water (H_2O). In this process they take up high levels of phosphorous (luxury phosphorous uptake), to replenish the polyphosphates previously used for energy. Detention time in the aeration basins is 5.0 hours at average daily flow.

Final Clarifiers

Four final clarifiers (105 ft. x 105 ft.), providing 4.75 hours detention at average daily flow, settle out the micro-organisms (activated sludge) by gravity. The clear water (final effluent) from the clarifier is then disinfected prior to being discharged. The micro-organisms (activated sludge) which settle in the final clarifier are returned to the activated sludge system to maintain the population of micro-

organisms in the system. A portion of activated sludge, known as waste activated sludge, is pumped to a point upstream of the primary clarifiers where it is co-mingled with the raw wastewater and removed in the primary clarifier. Waste activated sludge is removed from the system to maintain the proper population of micro-organisms to provide the most effective treatment.

Effluent Disinfection

The treated wastewater is disinfected with a 15% sodium hypochlorite (bleach) solution which is added in the chlorine contact basins at a low level to disinfect the effluent stream. Sodium bisulfite is added at the end of the chlorine contact basin to neutralize the chlorine in the wastewater before it is discharged to Lake Michigan. The now clean water flows through a 60-inch diameter concrete outfall pipe that extends 1,570 feet into Lake Michigan. Detention time in the contact basins is 2.0 hours at average daily flow.

Biosolids Digestion (Stabilization)

The primary sludge (biosolids) is pumped to three primary anaerobic (without oxygen) digesters. In the primary digesters, the biosolids are stabilized by anaerobic bacteria that convert organics to methane gas (65%), carbon dioxide gas (30%), hydrogen sulfide gas (5%), water and inert organic matter. After the biosolids are stabilized, the material is transferred to a secondary anaerobic digester for final stabilization. The primary and secondary digesters have a total volume of 3.0 million gallons with a detention time of approximately 40 days. While the biosolids are in the primary digesters, the biosolids are heated and mixed to create the appropriate environment for the anaerobic bacteria to breakdown the organics and minimizing pathogens stabilizing the biosolids. The methane gas produced in this process is used as a fuel to provide process heat for the wastewater plant.

Biosolids Dewatering/Handling/Storage

One two-meter and one three-meter gravity belt thickeners are used to thicken stabilized biosolids from a consistency of 2.5 % to 6.0 % solids to reduce the volume of material transferred to storage. The thickened material is stored in two, 2,000,000 gallon holding tanks from where it is pumped to the drying process. During the first step in the drying process, the biosolids are further dewatered using two screw presses to raise the consistency from 6% to approximately 20%, prior to being dried.

Biosolids Drying

The dewatered biosolids are pelletized and discharged to a belt dryer where the material is dried to >90% solids at temperatures above 180 F to produce Class A biosolids. The dryer utilizes hot water for heat generated from two digester gas boilers and one dual fuel (natural or biogas) boiler, which are used to generate hot water for process and building heat. The biosolids are dried for approximately 5 hours prior to being conveyed to a storage silo, from where they are stored. A third party manages the inventory and utilizes the biosolids as a soil conditioner/fertilizer.

Instrumentation & Controls

The control system enables the wastewater operators to monitor equipment and processes at the wastewater plant and the five-wastewater pump stations located throughout the City of Sheboygan. Programmable Logic Controllers (PLCs) control, monitor and record the operating status of all critical equipment and collect data to provide a historical record of how each system functions. The data is collected by a centralized Supervisory Control and Data Acquisition (SCADA) server that logs the data and displays it graphically on a video monitor. The plant operators can examine the operating status of all process equipment throughout the treatment facility, as well as the wastewater pump stations from one central location at the wastewater treatment plant.

Laboratory

The wastewater laboratory uses analytical equipment to monitor the quality of the wastewater as required by the WDNR and U.S. EPA as stated in the facility's WPDES permit. The laboratory technician analyzes compliance samples daily to monitor influent and effluent quality at the plant. In addition process control samples are analyzed daily to verify the performance of online instrumentation throughout the plant. In addition, raw wastewater samples, collected by the member communities and hauled wastes are brought to the laboratory served by the WWTP are analyzed.

Plant Maintenance

The wastewater plant maintenance staff maintains all plant and lift station equipment from preventative maintenance (PM) and equipment rebuilds to piping installation and building maintenance. The staff also maintains the facilities medium and low voltage electrical equipment as well as plant instrumentation. The staff is routinely involved in the upgrading and replacement of equipment and electrical/ instrumentation to control costs and maintain process reliability.

Pretreatment Program

The wastewater Pretreatment Program is required by the WDNR and U.S. EPA for any WWTP built to treat 5.0 million or more gallons of wastewater per day. The pretreatment program monitors 15 permitted industries for regulated parameters, once every 6 month period, or per their permit requirement. Each industry is required to be within their permit limits. A mandatory semi-annual and annual report are submitted to the WDNR (due March 31 and September 30 annually). Each permitted industry has an Annual Site Inspection completed by the Industrial Wastewater Supervisor.

Facilities Design Data	
Design Population:	86,500
Average Design Flow:	18.4 mgd
Maximum Design Flow:	56.8 mgd
Organic (BOD) Load:	27,940 lbs/day
Suspended Solids Load:	25,040 lbs/day
Phosphorus Load:	1,130 lbs/day

2019 Average Daily Loading	
Average Daily Flow:	12.86 mgd
Average CBOD Load:	12,035 lbs, 116 ppm
Average Suspended Solids:	21,383 lbs, 205 ppm
Average Phosphorus:	381 lbs, 3.7 ppm
Average Ammonia:	1,746 lbs, 16.5 ppm
Average Mercury:	0.026 lbs, 0.0002 ppt

Effluent Permit Limitations	
Permit Limit CBOD:	25 ppm
Permit Limit Suspended Solids:	30 ppm
Permit Limit Phosphorus:	0.9 ppm
Permit Limit Ammonia:	23 ppm
Permit Limit Mercury:	2.8 ppt(ng/l)

2019 Average Daily Discharge	
Average CBOD:	310 lbs, 2.7 ppm
Average Suspended Solids:	514 lbs, 5.0 ppm
Average Phosphorus:	40 lbs, 0.4 ppm
Average Ammonia:	195 lbs, 1.6 ppm
Average Mercury:	0.00001 lbs, 0.94 ppt

Sheboygan Wastewater Treatment Facility Flow Diagram