Present Day Aerial View of Racine Wastewater Treatment Plant

City of **Racine** Wastewater Treatment Plant

INTRODUCTION

Racine, Wisconsin. *A Great City on a Great Lake*. Racine is a true gem of a city with a large amount of lakefront access for its residents to enjoy. Today bike paths, marinas and stately homes border Lake Michigan in a medium-sized city that truly provides affordable lakefront access for all walks of life. At the turn of the century, this former industrial city had far from a beautiful lakefront to enjoy. It was a busy port city and industries bordered its shores as industry thrived. A study performed in 1913 by Chicago engineer John Alvord demonstrated that the Root River was a cesspool of bacteria with results off the chart (or Petri dish). People were getting sick and the city was growing at an alarming rate and the surrounding natural waterways could not keep up with the pollution. The price tag was tough to swallow, and then the country entered World War I followed by the Great Depression. Local politicians struggled to fund the necessary improvements. Thank goodness they did find the funding.

The following story discusses the evolution of wastewater treatment in Racine, WI.

1927

Racine's earliest efforts at wastewater treatment occurred in 1927, with the start of construction for a Root River interceptor, a Sixth Street pumping station, and a force main near the St. Paul Railroad. All of this was in place by 1931 at a total cost of about $347,000. (The lift station and interceptor are still in use today)

In August of 1935, R.T. Reilly, a Chicago-based engineer, undertook a detailed study of Racine's water and sewage needs. Reilly noted that Racine had "a fine, new, up-to-date water treatment plant…furnishing pure, wholesome water." Reilly also observed that this community was "not lacking in a proper realization of its responsibilities" to neighboring cities in supplying adequate sewage treatment.

Simply diluting the sewage in Lake Michigan was no longer acceptable for Racine, concluded Reilly, because our drinking water and beaches were being polluted, the raw sewage was a general nuisance to those living near the beach, and we were failing to totally meet our obligations to other lakeshore cities.

Although some citizens continued to question the need to spend more money on a sewage plant, plans moved ahead to erect Racine's first large-scale sewage treatment facility off 21st Street. Alvord, Burdick and Hawson, a Chicago engineering firm, masterminded the construction plan.

1938

The new plant became operational on June 14, 1938, with a crew of 10 newly hired men reporting to Harly Boeke, the first plant superintendent. Roy Spencer was Mayor of Racine at the time.

Little fanfare accompanied the opening, which attracted nothing more than a five-inch article with a small headline on an inside page of *the Journal Times*.

According to that article, "All sewage from the Root River side, north side, south side and business district interceptors will not be pumped into the plant until the large tunnel designed to carry it is found to be in proper shape. In the meantime, some raw sewage is still being dumped into the lake and river near the Case plant."

A somewhat larger *Journal Times* headline of June 20, 1938 made this pronouncement: "New Plant Ends Lake Pollution." A subhead added, "All Raw Sewage Is Being Treated by Special Process." In the article which followed, then-Wastewater Commissioner Henry A. Nelson revealed that seven to eight million gallons of sewage now was being treated daily in the $1.5-million plant.

The original treatment process was described: "As the raw sewage comes into the plant…it goes through grinders and then into grit chambers, where all material that cannot be digested is removed. Then it goes into clarifiers and to the digesters and next to the drying beds, all of which are under glass. The effluent, clear as drinking water, is all that goes into the lake. End of the effluent line is far out in the lake, so even this does not pollute Racine beaches."

Racine's first Wastewater Treatment Plant was originally designed to treat 12 million gallons of wastewater per day; the plant now receives nearly 20 million gallons per day (MGD), with a design flow of 36 MGD, and a peak flow of 308 MGD.

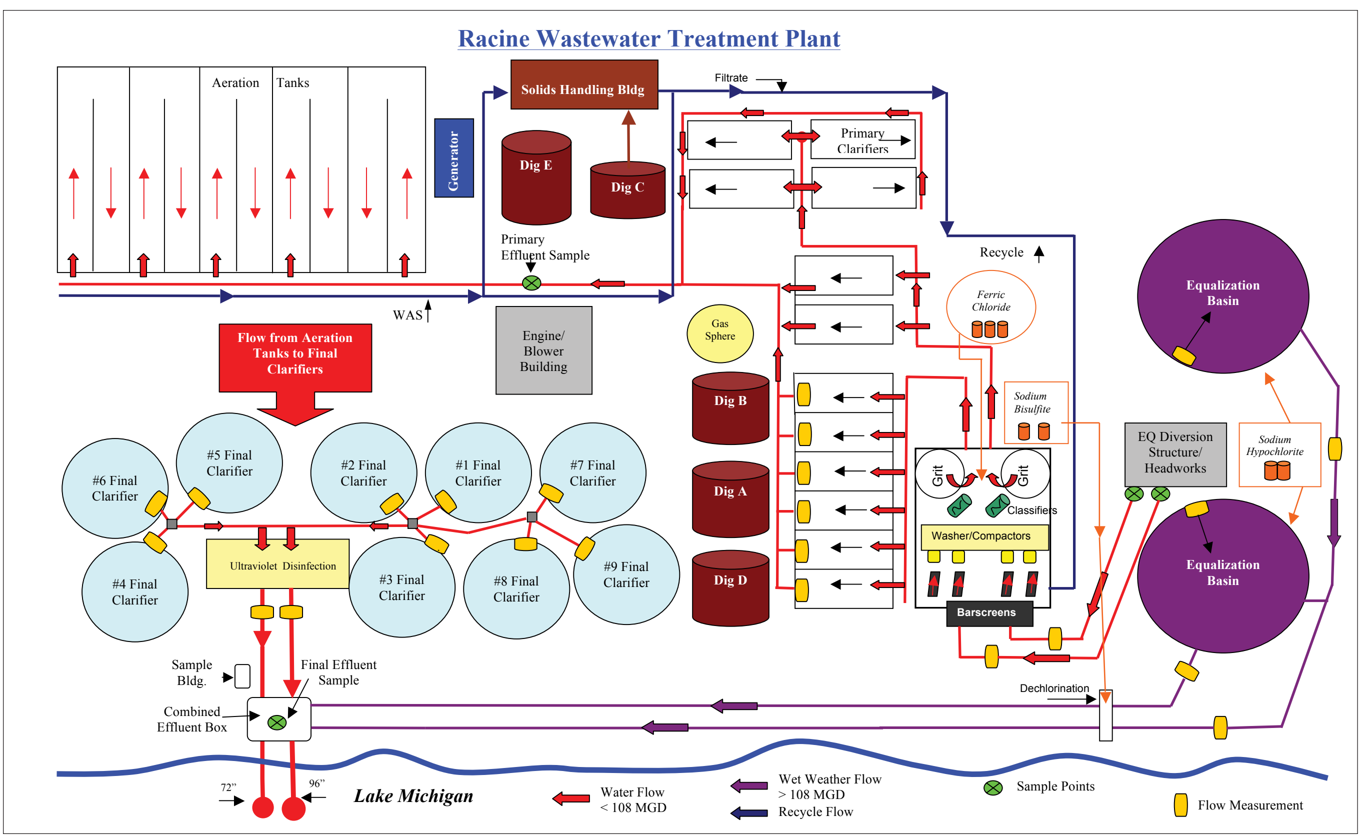
The original plant was a primary treatment installation. Wastewater was conveyed to the plant in a 72-inch diameter pipe and chlorinated, then passed through grinders known as comminutors that shredded the larger solids in the wastewater. Inorganic material was removed by a channeled grit removal system equipped with mechanical scrapers. Organic material was removed as biosolids from four primary settling tanks. The clarified liquid was then discharged directly to Lake Michigan and the biosolids were further treated in the anaerobic digesters. In the digesters, organisms acted to reduce the organic content of the biosolids. As part of this process, the organisms produce methane gas. From the beginning, this gas was harnessed and used in the plant to reduce energy costs. Although the original design was 12 MGD, it was found that the primary clarifiers were able to treat more flow during wet weather situations.

Boeke served as plant superintendent until January 1941 before giving way to Walter Schubert. The latter left the job after two months and was replaced by Tom Hay, who held the post until his retirement in January 1968.

1968

The 1938 plant was designed to provide primary level treatment for up to 12 million gallons of sewage per day. As the Racine area grew, however, so did its sewage problems and the plant's capacity was being strained. By the 1960s, the need for expansion was evident.

In 1968, with the aid of federal funds, a $3.7-million expansion of the existing treatment site was undertaken. At that time William Beyer was mayor. Primary level treatment capacity was increased to 23 MGD and upgrades allowed for 12 million gallons of treated wastewater being sent from the settling tanks (primary clarifiers) to a pair of newly constructed aeration tanks where oxygen-activated bacteria (activated biosolids) in the secondary process further broke down the harmful constituents in the wastewater. From here the flow was conveyed to two final settling tanks (final clarifiers). Any amount over the 12 MGD capacity of the aeration tanks that was flowing from the primary clarifiers bypassed this stage of treatment and blended with the effluent from the



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final clarifiers. Chlorine was then added to the wastewater, the flow passed through a chlorine contact tank (to give the chlorine time to work), and 30 minutes later was discharged through a 72-inch outfall extending 500 feet into Lake Michigan. Chlorine was applied to the wastewater to destroy any harmful bacteria that were still present in the wastewater.

A portion of the biological solids that settled in the final clarifiers were returned back to the aeration tanks to continue the secondary treatment process. The balance was pumped to the primary clarifiers where it became part of the biosolids that were pumped to the digesters. This was necessary because, like all organisms, the microbes in the aeration tanks reproduce and eventually there are too many of them to treat the wastewater at an optimal level.

SEWER SEPARATION

At approximately the same time as the 1968 plant expansion, Racine embarked on an ambitious program of sewer separation providing separate underground lines for sanitary sewer and storm runoff. The sanitary flow ended up at the treatment plant, the storm runoff in lakes or waterways.

Gary Coates was named plant superintendent in 1968, and later that year assumed the title of engineer-manager. At that time Stan Budrys was named plant superintendent.

1970s

Not even the 1968 expansion would prove sufficient. By the early 1970s, with the city plant now processing sewage from Mount Pleasant and several other surrounding communities, further expansion was indicated.

In 1972, expansion plans and specifications were approved by the State's Department of Natural Resources, and bonding was approved by the Racine City Council. There were the inevitable delays, however, and construction was not completed until 1977.

What had started as a $10-million expansion turned into a $14-million project. In any event, it was the largest government construction project in Racine history up to that point.

As was the case with the 1968 expansion, federal dollars paid for about 75% of the project. These funds were cleared in 1973 when Racine was placed in the top one percent of the State's priority list for Environmental Protection Agency Funds.

Construction took 2.5 years and was under the direction of another Chicago engineering firm, Conser Townsend. This same firm had been responsible for the 1968 expansion.

These upgrades added flow capacity through the addition of upgraded screening, more primary clarifiers, additional aeration tanks and digesters for biosolids treatment. Additionally, more final clarifiers were added after the aeration tanks and before chlorination to allow for secondary treatment of all of the flow from the plant.

Dedication of the new Wastewater Treatment Plant occurred on November 13, 1977, during the reign of Mayor Stephen Olsen. This upgraded plant made it possible to treat 30 million gallons of sewage per day through all processes. The hydraulic capacity of the plant was increased to 70 million gallons per day provided that 40 million gallons of the flow did not pass through the secondary process. The inability to treat all of the flow biologically was not a problem and the two flow trains were blended and chlorinated before being discharged to Lake Michigan.

The new addition also provided for chemical addition to the flow stream that enabled reduction of the amount of phosphorus discharged to the lake.

SINGLE UTILITY

Another key development of the 1970s was the merger of the city's water department and sewage divisions into a single Water and Wastewater Utility. Previously, they had operated individually with Wastewater being a division of the Public Works Department under Commissioner Fred Larson.

Les Hoganson followed Coates in 1977 as general manager of the new Utility, with Thomas White succeeding Hoganson in 1986.

1989

In the late 1980s, it was clear that while the plant was able to treat the normal everyday flows without problems, capacity was strained and often exceeded when there was rainfall or runoff from melting snow.

The Utility undertook another large project, that of adding a Flow

Equalization Basin (EQ) at the beginning of the plant, before screening. This EQ basin allowed the plant staff to change gates in use and valving and divert flow to the EQ basin. The tank has a capacity of 2.7 MG. The influent flow to the tank is chlorinated using strong liquid bleach. This tank is more than a holding tank, when it is full; the flow overflows from the tank. This EQ effluent is then treated with another chemical to remove the chlorine. The flow then blends with the effluent from the plant and is discharged into Lake Michigan. The use of this tank, allowed the plant to treat higher wet weather flows without causing a washing out of the microorganisms in the secondary process.

During the same time that the EQ basin was constructed, a change was made to the plant process to allow dechlorination of the plant effluent. At this time, chlorine was still added to the effluent to remove pathogens, but because chlorine was a hazard for some of the organisms in the lake, it was necessary to remove the chlorine before discharging into the lake.

2002

In the spring of 2002, the communities of Racine, Mount Pleasant, Caledonia, Sturtevant and respective sewer utilities of those communities signed a landmark agreement to provide for additional capacity at the Racine Wastewater Treatment Plant. The Village of Wind Point signed the agreement in February 2003. The signing of the "Racine Area Intergovernmental Sanitary Sewer Service, Revenue-Sharing, Cooperation and Settlement Agreement" paved the way for expansion of the treatment plant. The resulting project expanded the Utility's ability to handle average day flow as well as wet weather flow at the plant and in the collection system. The cost of this expansion was approximately $85 million. The expansion is expected to provide plant capacity until the year 2020.

This expansion was completed in 2005. The expansion provided the ability to treat an average flow of 36 MGD, with a peak flow of 108 MGD through the plant itself. With the addition of a second EQ basin, the plant is able to treat a peak flow of 308 MGD, with 200 MGD of this through the EQ basins.

The most current upgrade, provided for addition of or improvement to many of the processes at the plant. Major additions included another EQ basin, a new screening building, additional primary clarifiers, the addition of an anaerobic digester, more final clarifiers, a new solids handling building, upgrades to plant power, and the addition of UV Irradiation that allowed the Utility to eliminate the use of gaseous chlorine.

DESCRIPTION OF PLANT PROCESSES TODAY

The Racine Wastewater Treatment Plant is a conventional activated biosolids plant with chemical phosphorus precipitation, separate biosolids digestion, belt filter press dewatering and ultraviolet disinfection of effluent.

FLOW EQUALIZATION BASINS

The Racine Wastewater Treatment Plant flow equalization basins are designed to reduce flow to the treatment plant during periods of high influent flow. Flows exceeding 108 MGD (million gallons per day) will be directed to the flow equalization basins. Wastewater stored in the flow equalization basins is reintroduced into the normal wastewater stream at the option of the operator. Influent wastewater which is directed to the basin can be chlorinated. This will provide odor control for stored wastewater and disinfection for any amount that overflows the basins.

Prior to entering the equalization basins, wastewater is screened by mechanically cleaned bar screens. Wastewater in the basins is returned to the treatment flow scheme by gravity and by pumping. It can be returned to the headworks for full treatment, the aeration basins for secondary treatment, or to the digesters for biosolids handling. Both equalization basins are 200 feet in diameter and have a storage capacity of 2.7 million gallons each. The second equalization basin was completed in June of 2003.

FLOW

The wastewater flow enters the headworks of the plant through an 84- and a 72-inch diameter line. The design average flow is 36 MGD. From the headworks junction chamber, two 54-inch diameter pipes direct the flow into the preliminary treatment building.

MECHANICALLY CLEANED BAR SCREENS AND WASHING PRESSES

The preliminary treatment building contains four bar screens each with a rated maximum capacity of 35 MGD. The bar spacing between screen elements is one-half inch. Coarse sewage material is captured and removed from the flow to prevent plugging of pumps and unnecessary wear on downstream equipment. Each bar screen has a washing press to reduce organic content, moisture content, and volume of screenings.

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VORTEX GRIT REMOVAL EQUIPMENT

Two vortex grit removal units rated at 70 MGD each remove coarse abrasive inorganic material continuously from the screened wastewater flow.

GRIT CONCENTRATORS

Two grit concentrators remove water and organics from the material pumped to them from the vortex grit removal system.

PRIMARY CHANNEL BLOWERS

Two Hoffman blowers (100 horsepower) with a capacity of 2500 CFM. These blowers keep suspended solids in suspension until the flow reaches the primary clarifiers.

CHEMICAL FEED AND STORAGE FOR PHOSPHORUS REMOVAL

Phosphorus must be removed from wastewater to eliminate a major source of the primary element required for the growth of algae in Lake Michigan. Three 12,000-gallon fiberglass tanks store ferric chloride which is used to form insoluble ferric phosphates with the soluble phosphates in the raw wastewater. Total storage capacity equals 36,000 gallons.

PRIMARY CLARIFIERS

There are a total of 12 primary clarifiers. Six clarifiers are considered west bank and the other six east bank clarifiers. Four west bank clarifiers are 34.5 feet wide by 137.5 feet long and 10.5 feet deep. The other two west bank clarifiers are 122 feet long by 28 feet wide by 10.5 feet deep. The east bank of primary clarifiers has four clarifiers 120 feet long by 38 feet wide and 8 feet deep. The other two east bank clarifiers are 128 long by 30 feet wide by 10.5 feet deep. Total primary clarifier capacity is 3.7 million gallons. Average detention time in the primary clarifiers is 3.6 hours at 25 MGD. Mechanical scrapers push biosolids to sumps for removal to digesters. The scrapers also push scum to troughs for removal. The scum is then pumped into the digesters.

ANAEROBIC DIGESTERS

The plant has four-1-million gallon capacity digesters. Biosolids from the primary clarifiers is pumped to these digesters. Mechanical mixers and heat exchangers for heating are provided. Temperature is maintained at 95F. Through anaerobic bacterial action, biosolids are decomposed and converted into a more stable product. Methane gas is produced as a by-product of this decomposition. This gas is used as a fuel supply for engines and boilers.

HOLDING TANK

The plant has one holding tank with a volume of 552,000 gallons. After primary digestion, biosolids are transferred to the secondary digester. Digested solids are removed from this digester and pumped to the belt filter press operation for dewatering.

GAS STORAGE SPHERE

The gas produced in the digesters as a by-product of the digestion process consists mainly of methane and carbon dioxide. It is used as fuel for the engine driven blowers and in the boilers for building and biosolids heating. Since gas production is not uniform in rate, a gas storage sphere is provided for storage of gas produced at rates in excess of usage. Stored gas is removed and used during periods when demand is greater than production. The sphere is 40 feet in diameter, providing storage at 50 psi for 200,000 cubic feet of digester gas. If gas production exceeds capacity, it is flared off with an automatic gas flare.

AERATION TANKS

The aeration tanks are two pass tanks, each pass measuring (in feet) 168 by 30 by 15. The total volume of five aeration tanks equals 5.65 million gallons. The Racine Wastewater Treatment Plant retrofit the five existing aeration tanks with fine bubble diffusers in the fall of 1991.

AERATION CONTROL BUILDINGS

These buildings house the controls for the pumps and equipment involved with the aeration system.

AIR BLOWERS

Three Engine-Driven Blowers:

#2 Engine and Blower
- Engine: 426 horsepower
Blower Capacity: 9,600 CFM
at 8.5 psig

#3 Engine and Blower
- Engine: 675 horsepower
Blower capacity: 15,000 CFM
at 8.5 psig

#5 Engine and Blower
- Engine: 426 horsepower
Blower Capacity: 9,600 CFM
at 8.5 psig

Two Motor-Driven Blowers:

#1 Motor horsepower: 500
Blower Capacity: 11,000 CFM
at 7.5 psig

#4 Motor horsepower: 311
Blower Capacity: 6,900 CFM
at 8.5 psig

All air for the low-pressure system is filtered by a combination electrostatic and mechanical air filter. Accessory equipment includes silencers on air intake and discharge for each blower, and combination silencers and heat recovery units on the engine exhausts. Heat is recovered from engines by circulating the engine jacket water through heat exchangers in the building and biosolids heating system. The engines can be operated on biogas produced by the treatment plant or natural gas.

FINAL CLARIFIERS

Nine Clarifiers: Three 85 feet in diameter; three 90 feet in diameter and three 93 feet in diameter. Total volume equals 5,360,000 gallons. Detention time is 5.1 hours at 25 MGD. The plant has the ability to waste solids to the GBT or to the primary clarifiers, although wasting to the primary clarifier rarely happens. All final clarifiers are rim feed design to aid in the settling process. The clarified water or secondary plant effluent is conveyed to the U.V. disinfection process.

U.V. AND SODIUM HYPOCHLORITE DISINFECTION

Two UV systems are provided at the Racine facility. Ultraviolet light is used to provide disinfection of final clarifier effluent and a hypochlorite system is used to provide disinfection of wastewater diverted to the flow equalization basins.

The hypochlorite system is used to service the flow equalization facility. Chlorination is provided for odor control of wastewater temporarily stored in the equalization basins and for disinfection of wastewater which may overflow the equalization basins. Chlorination is provided at the equalization basin bar screen effluent channel and at the lift station force main discharge structure. Hypochlorite application to the RAS system is also provided. Sodium hypochlorite is stored in two tanks located in the liquid chlorine building. Liquid hypochlorite solution is delivered to the various points of application by chemical feed pumps located in the liquid chlorine building. The hypochlorite feed pumps are flow paced.

DECHLORINATION SYSTEM

Sodium bisulfite is used for dechlorination at the wastewater treatment facility. Liquid sodium bisulfite is stored in one tank located in the preliminary treatment building. Bisulfite is transferred to the point of application by chemical metering pumps and enters the equalization basins' effluent through diffusers. Dechlorination of equalization basin effluent is provided at the dechlorination structure located downstream from the two equalization basins. For dechlorination of equalization basin effluent, the bisulfite pump is flow paced.

NINETY-SIX AND SEVENTY-TWO-INCH DIAMETER OUTFALLS

Two outfall lines 72-inch and 96-inch, extend 500 feet out into the lake. There are three 48-inch openings at the end of each pipe for discharge purposes. The 96-inch line was added in early 2003.

BELT FILTER PRESSES

Six two-meter presses. The continuous stage belt filter presses consist of two polyester cloth belt sets one above another that maneuver through a series of pressure rollers. Biosolids are conditioned with a liquid polymer and are fed onto a gravity drainage section of the belts. Following gravity drainage, the biosolids are distributed on the lower pressure belt. After an additional small section of gravity drainage, the concentrated biosolids come in contact with the upper belt. The two belts form a wedge which gradually forces removal of water. The water removed (filtrate) is collected in drainage pans and combined with gravity drainage water and recycled back to the head of the plant. Pressure is increased as the belts pass through rollers of decreasing size. The final three rollers form an S-shaped configuration which generates a shear force and creates additional water drainage. Dewatered biosolids are hauled by truck to ultimate disposal. The filter belts are continuously washed with water at high pressure.

GRAVITY BELT THICKENERS

The gravity belt thickeners (2) are used to dewater waste activated biosolids (WAS) from the Secondary Activated Biosolids treatment process. Polymer is added to the WAS to help the dewatering process. Thickened WAS is pumped to the digesters.

FINAL EFFLUENT SYSTEM

Three final effluent pumps are located in the aeration pipe gallery. Final effluent is pumped to the yard hydrants and street hydrants. There are also two cooling water pumps installed in the aeration pipe gallery to pump screened final effluent to the engine jacket water cooling heat exchangers.

One F.E. Pump:
200 gpm at 243-foot head.
One Cooling Water Pump:
550 gpm at 55-foot head.
One Auxiliary Engine:
(use at time of power failure)
Pump: 550 gpm at 50-foot head.

TANK DRAINAGE SYSTEM

The tank drainage system consists of the drain system for all the treatment units and the bypassing arrangements for these units. Two tank drainage wells and five drainage pumps are provided.

Five Tank Drainage Pumps: 700 gpm at 30-foot TDH.

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PIPE GALLERY

The pipe gallery is the connection between the primary plant and the secondary plant. All necessary systems run through the pipe gallery.

PLANT WATER SYSTEM

This system provides a physical break between the incoming city water and the plant water distribution system.

HVAC

Hot water for space heating is provided by one continuous loop system. The system is provided with four multiple pass, horizontal fire tube boilers with five square feet of heating surface per rated boiler horsepower. Two of the four units can be fired by biogas or natural gas. Air circulation systems have been installed for space heating and cooling, odor control, and removal of dangerous gases. At critical areas or areas where air handling units are not installed, unit heaters are provided to heat the space, and exhaust fans with separate air intake louvers provide ventilation.

EMERGENCY GENERATOR

The Wastewater Treatment Plant has an emergency generator that can operate the plant independently of WE Energies. In the event of a power failure, the plant will continue to function and maintain permit limits. The generator has a capacity of 2000 kW.

As well as serving the City of Racine, the plant now accepts flow from Mount Pleasant, Caledonia, North Bay, Sturtevant, Wind Point and Elmwood Park.

The plant and staff will continue to be tasked with finding ways to provide the best quality effluent in order to protect our Great Lakes. The Department of Natural Resources is proceeding with new water quality standards (as required by the Clean Water Act and overseen by the United States EPA) that require diligent change and adaptation by the plant staff.

This is just another step in the evolution of wastewater treatment in Racine and the rest of the nation. The control of water pollution in whatever form it takes will continue to be the goal of the Racine Wastewater Utility for the next 50 years and beyond. CS