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1.0 Executive Summary

1.1 Purpose

The Racine Wastewater Utility (RWU) provides conveyance and wastewater treatment for the City of Racine and several other contributing communities. Management of the Utility is provided by several key staff with oversight and direction provided by the Wastewater Commission. Requirements for coordination and communication between the Utility as a Sewer Service Provider (SSP) and the major contributing public entities, the Sewer Service Recipients (SSRs), are defined in an Intergovernmental Agreement (IGA) developed and signed in the early 2000s.

The IGA requires RWU to initiate Facilities Planning upon a request from any of the SSRs for increased capacity in the overall wastewater system. Caledonia submitted a request for additional capacity allocation and the initiation of a Facilities Plan update in 2017. In addition, the previous Facilities Plan was completed in 1998 and was based on a 20-year planning window. The resulting treatment plant improvements are now nearly 20 years old and may have already served their useful life. Lastly, development in Mount Pleasant, created in part by the Foxconn development and subsequent completion of a TID 5 Facilities Plan, identified a need for potentially increased capacity within the next planning period. The combination of these factors created the need for a Facilities Plan.

This Facilities Plan was created to meet Wisconsin Department of Natural Resources (WDNR) requirements as defined in Administrative Rule Chapter NR110. The plan projects flows and loadings for a 20-year planning period, identifies deficiencies and other necessary improvements in both the conveyance system and at the wastewater treatment plant (WWTP), and identifies necessary future evaluations to maintain reliable wastewater services for the SSRs. Using the 20-year planning window, the Facilities Plan is based on a projection to Year 2040.

1.2 Approach

Review of the 1998 Facilities Plan provided information on the basis for the current facilities. The scope of this plan included analysis of the existing environmental and physical conditions of the service area, the conveyance system, and the treatment plant. Significant additions to both the conveyance system and the WWTP were made since the 1998 Facilities Plan. Wastewater and development information was requested from the contributing communities. Status of the plan development was provided to RWU staff and the Wastewater Commission on a regular basis. A Technical Advisory Committee (TAC), with representatives of the contributing communities, was reinitiated to review and discuss the progress and content of the Facilities Plan. The WDNR also participated in a TAC meeting. This interactive approach provided the opportunity for input from public officials and the SSRs.

Significant time and effort were spent to understand the existing conveyance system for both condition and for computer modeling of the system. Time was also spent with the treatment plant staff and Utility management to understand the condition, deficiencies, and needs of the existing wastewater treatment plant. Substantial plant operating data was also obtained and reviewed to assess WWTP performance under current conditions. That data was then analyzed using a computer model to verify the current and future capacity of treatment plant.

1.3 Projected Flows and Loadings

Based on population projections and information from the SSRs, future flows and loadings were identified. The 1998 Facilities Plan and subsequent plant improvements resulted in a design average hydraulic capacity of the treatment plant of 36 mgd. Current flows are significantly less than the design capacity due to less than anticipated growth, loss of industrial wastewater flows, and generally reduced water usage. The combination of these factors resulted in a projected year 2040 average flow of less than

36 mgd. Therefore, any improvements for the treatment plant based on average flow are required due to age or other deficiency.

However, both the conveyance system and the treatment plant have needs to address peak flows. Several storm events since the 1998 Facilities Plan created excess flow in the conveyance system and at the treatment plant. While an ongoing program of conveyance system improvements and repairs has been helpful, basement backups have occurred and use of the safety sites has continued. Therefore, improvements in both the conveyance system and at the treatment plant are required to manage future flows and loadings.

The 2002 agreement establishes flow allocations to parties of the IGA. These capacity allocations are expressed in measurement of Average Day Flow capacity. Exhibit E of the 2002 IGA, as amended from time to time, shows each community's allocated capacities. Each 1 MGD of average day flow is then allocated a unit of Peak Day Flow, Peak Hour Flow, BOD, TSS, and other parameters. The IGA has trigger points where the SSP monitors flows at various metered points. As the metered connection points meet each allocation of peak flow at 80%, 90%, 95% or exceeding 100%, notices are sent to each SSR Party to trigger various requirements in the IGA. Some of these can consist of triggering facility planning or instituting a sewer moratorium for various levels of exceedance. Currently sewer moratoriums exist in some sub basins of some SSR Parties.

While population can be used as a typical measuring tool for necessary plant expansion, other factors need to be considered as well. Peaking factors in various sub basins and collection systems may have peaking factors of between 1:6 or 1:15. Since Peak Flow allocations are directly related to average day capacity, a SSR party may find a need to acquire additional Average Day capacity in order to meet a Peak Day or Peak Hour threshold in the IGA. With 18 years of experience operating under the sewer IGA, several communities now have a better handle on their Peak Capacities or limitations. In addition, they may also have a better planning horizon for the next 20 years of development within their community.

The IGA gives each SSR Party the autonomy of calculating what they believe are their future needs for their unique collection system and 20 year planning horizon. A community with a large infiltration and inflow (I &I) problem might decide to request more capacity for treatment rather than going after foundation drains and sump pumps. Individual community's also have the luxury of mitigating peak flows within their own boundaries to stay below triggering thresholds in the IGA. After an SSR Party weighs the plusses and minuses and costs of various alternatives, they can then approach the wastewater Commission with a request for more treatment capacity and possibly conveyance capacity to meet their needs.

Table ES-1, from Chapter 9 of this plan, lists the projected annual average flow and loading conditions for the Year 2040. The existing wastewater treatment plant has adequate capacity to treat these flows and loadings. Table ES-2, also from Chapter 9, summarizes the annual average and maximum month design year flows and loadings.

Table ES-1. Development of Design Annual Average Conditions for 2040

Parameter	Unit		Existing Annual Average Conditions		Additional Annual Average		Design Annual Average Conditions	
Year	(year)		2016 - 2018		Growth to 2040		2040	
Population	(capita)		136,000		14,685		150,685	
Flow	(MGD)		22.0		1.9		23.9	
TSS	(lbs/d)	(mg/L)	26,601	145	2,937	184	29,538	148
BOD	(lbs/d)	(mg/L)	23,544	129	2,643	166	26,188	132
TKN	(lbs/d)	(mg/L)	3,402	18.6	426	27	3,828	19.2
TP	(lbs/d)	(mg/L)	384	2.1	68	4.2	452	2.3

Table ES-2. Projected Annual Average and Maximum Month Conditions for 2040

Parameter	Unit		Annual Average		Maximum Month Average	
Flow	(MGD)		23.9		41.3	
TSS	(lbs/d)	(mg/L)	29,538	148	38,400	112
BOD	(lbs/d)	(mg/L)	26,188	132	32,211	94
TKN	(lbs/d)	(mg/L)	3,828	19.2	4,593	13.3
TP	(lbs/d)	(mg/L)	452	2.3	542	1.6

Separate from this analysis, several SSR communities have requested increases in their average daily flow allocations at the WWTP. As discussed earlier, flow allocations are governed by the IGA and are a driver for this planning process. Table ES-3 presents the current average flows, current flow allocations and the requested flow allocations for each community.

Table ES-3. SSR Average Daily Flow Requests

Community	2016-2018 Average mgd [1]	Current Flow Allocation Average Day [2] mgd	Requested/Projected 2040 Flow Average Day mgd
Caledonia	3.60	5.13[3]	9.75[4]
Mount Pleasant	6.06	11.49[3]	19.60[5]
Somers			
Elmwood Park	0.10		
North Bay	0.07		
Sturtevant	1.02	1.78	3.00[6]
Wind Point			
Racine	11.28	17.06	17.06[7]
Total	**22.13**	**35.46**	**49.41**

Sources: 1. Racine Wastewater Utility 2016-18 Annual Reports, calculated
2. Racine Wastewater Utility 2018 Annual Report
3. After 1.0 MGD transfer from Caledonia to Mount Pleasant, 2018
4. E-mail from Anthony Bunkelman to Keith Haas, August 1, 2018
5. E-mail from Anthony Beyer to Keith Haas, October 10, 2018
6. Email from Jeff Seitz to Keith Haas, April 9, 2020
7. No increase in growth projections.

The requested flow allocations from the SSRs indicate a need to expand the wastewater treatment capacity sometime in the future to provide to the SSR Parties additional capacity. The current growth projections, based on population data, do not support this growth in the average flow. However, peak flows have had a more controlling influence on the SSR decision making process, helping them determine how additional treatment capacity that they may need to manage their requirements under the IGA. Therefore, the plan has identified a location for additional treatment capacity should the requested capacity allocations be required. The SSR parties requesting additional capacity will be paying for the increased share and capacity that each has requested. While the treament plant analysis indicates that it can treat for BOD, TSS and phosphorus going forward, and that the constructuion of these capcital assets could be deferred for a period of time, the construction cost for these requested improvements will continue to grow with inflation of materials such as concrete and steel and labor. As the IGA is founded on the priciple of Average Day treatment capacity as it relates to increased peak capacity, postponing these improvements to a future window of time runs afoul of the structure of the current agreement. It is worth noting that increasing the average daily flow capacity at the plant does not address the peak flow exceedances that are currently the source of the sewer moratoriums, nor does it address peak flow issues in the conveyance system during the 20 year planning period. Additional planning to manage these flows and associated loadings will need be completed at that time.

1.4 Conveyance System Evaluation

Chapter 10 of this Facilities Plan identifies conveyance system deficiencies and improvements needed to mitigate the deficiencies. The results of hydraulic modeling of the Racine interceptor sewer network to identify conveyance system capacity constraints are summarized. Predictions of future wastewater flows arriving at the wastewater treatment plant based on modeling are provided. A phased approach to conveyance system improvements is outlined, prioritizing improvements based on the projected “system build-out” and the anticipated benefit of each proposed improvement.

MIKE URBAN 2016 software was used to model the conveyance system. The hydraulic model created during the 2009 Storage Optimization Study was used as the starting point for modeling conducted for this Facilities Plan. The existing model dataset was updated by incorporating modeling results from separate sanitary sewer system projects, as well as sanitary sewer as-built drawings, known sewer improvements and field information. A total of sixteen (16) projects were added to the previous model.

The 5-year, 6-hour rainfall event was selected as the design storm based on discussions with Wisconsin Department of Natural Resources (WDNR).

After the hydraulic model was updated to reflect current conditions, it was first calibrated to dry weather flow, then calibrated to wet weather flow using a variety of rainfall events with different return intervals. Future flows for existing catchments were calculated using each community’s 2035 Master Plan land use and the open space analysis using an aerial map in GIS.

Service criteria utilized for this study were:

1. All gravity interceptor sewers must be capable of transporting wastewater flows generated by the 5-year, 6-hour rainfall event (2.6 inches) with limited surcharging.
2. Surcharging of gravity sanitary sewers should be limited to short durations during (and immediately following) the 5-year, 6-hour rainfall event and should not result in the backup of wastewater into basements.
3. Lift stations should be capable of handling wet weather flows generated by the 5-year, 6-hour rainfall event
4. Bypassing of untreated wastewater from the sewer system during (and immediately following) all rainfall events up to the 5-year, 6-hour rainfall (2.6 inches), except overflows at existing safety sites, is not allowed in the design year 2040 condition.
5. No significant increase in the volume of Safety Site Overflows resulting from the 5-year, 6-hour rainfall event during the 2040 Design condition from the 2020 condition.
6. Wherever possible, providing flow equalization throughout the overall wastewater conveyance system is preferred over improvements which increase peak flow arriving at the WWTP.

The following three (3) wastewater flow scenarios were evaluated as part of the conveyance system study:

- Conveyance System Performance: 5-Year, 6-Hour Storm, 2020 Existing Condition
- Conveyance System Performance: 5-Year, 6-Hour Storm, 2030 Condition
- Conveyance System Performance: 5-Year, 6-Hour Storm, 2040 Design – Baseline Condition

Four alternative conditions to the 2040 Design – Baseline Condition were also evaluated.

After identifying the existing capacity constraints, numerous modeling runs were conducted to determine potential improvements to the RWU conveyance system to mitigate anticipated constraints during the planning period. Some of the improvements proposed in this Facilities Plan serve specific areas. Other projects serve a large geographical area and provide a benefit to the overall RWU service area.

This Facilities Plan prioritizes proposed conveyance system improvements and lays out time frames for implementation. Modeling predicts that implementation of the proposed improvements will significantly reduce surcharging of interceptor sewers and the amount of bypassing occurring at Safety Sites during the 2040 design condition when compared to the 2020 existing condition.

The conveyance system improvements described in this Facilities Plan were categorized as Near-Term, Mid-Term or Long-Term Conveyance Improvements.

Near-Term Conveyance Improvement Projects include the following. These are projects anticipated by SSR communities prior to the plan and are in various stages of planning or construction.

- Pike River Lift Station Phase 1 and Force mains to KR Interceptor (at Old Green Bay Road)
- Abandonment of KR Lift Station and Interconnection to Pike River Lift Station
- Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 1,2 and 3 from Pike River Lift Station to STH 11
- Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 7 from STH 11 to STH 20.
- 1.0 MG Flow Equalization for Chicory Road Interceptor Capacity Constraint
- 3.5 MG Flow Equalization Storage at North Park Lift Station .   Based on the May 2020 storm events, this project may be considered a higher priority.

The total estimated cost of Near-Term Conveyance Improvements, in 2020 dollars, is $69.6 million.

Mid-Term Conveyance Improvements consist of projects anticipated to be completed between 2025 and 2030. Mid-Term Conveyance Improvements Projects include the following:

- 11.0 MG Flow Equalization Storage at Pike River Lift Station
- Additional 1.5 MG Flow Equalization Storage at Hood’s Creek Lift Station. Based on the May 2020 storm events, this project may be considered a higher priority.

The total estimated cost of Mid-Term Conveyance Improvements, in 2025 dollars, is $43.5 million.

Long-Term Conveyance Improvements consist of projects anticipated to be completed between 2030 and 2040. Long-Term Conveyance Improvements Projects include the following:

- 10.0 MG Flow Equalization Storage at Lift Station 01
- Additional 1.0 MG Flow Equalization Storage at Caledonia -Riverbend Lift Station (LS31).   Based on the May 2020 storm events, this project may be considered a higher priority.
- 1.0 MG Flow Equalization Storage at Lakeview Park.
- Osborne Boulevard / Kinzie Avenue Interceptor Sewer Upgrade
- Miscellaneous Interceptor and Trunk Sewer Upsizing
    - LaSalle Street Trunk Sewer
    - Geneva Street Interceptor
- 1.65 MG Flow Equalization Storage Along Mt. Pleasant /Sturtevant Interceptor Sewer

The total estimated cost of Long-Term Conveyance Improvements, in 2035 dollars, is $47.7 million.

This Facilities Plan recommends implementation of projects currently under design or construction (Near-Term Projects) followed by preliminary design of projects slated for construction in the 2025 – 2030 timeframe (Mid-Term Projects). As Near-Term and Mid-Term projects are completed, the hydraulic model of the conveyance system should be used to fine-tune predictions for the 2030 – 2040 timeframe based on actual development of the service area. Long-Term Projects should be implemented if growth/development in the RWU service area occurs as predicted in this Facilities Plan.

1.5 Treatment Plant Evaluation

1.5.1 Treatment Plant Performance Evaluation

AECOM reviewed data as a critical first step in evaluating process performance, oxygen transfer, and potential nutrient removal configurations. This data review was then incorporated into the WWTP modeling. This methodology also provided an accurate accounting of plant performance. In conjunction with historical data, Chapter 8 and Chapter 9 summarize how the plant met WDNR permit requirements historically and how modeling projects the plant will continue to do so for the facility planning period with the following summary findings.

As modeled as part of this work effort, the Racine Wastewater WWTP capacity is sufficient for 2040 population growth projections on a design average flow and loading basis. A summation of flow allocations requested by SSR communities' results in a required design average flow capacity of approximately 48 to 49 mgd. Existing daily average flow is 22 MGD. The projected additional average flows and loadings for 2040, *based on population projections,* are calculated to only increase design daily flows to approximately 24 MGD, which is well within plant design capacity of 36 MGD. Similarly, maximum month flow projection for 2040 of approximately 41 MGD is within design capacity maximum month flow of 49 MGD.

The plant utilizes chemical phosphorus removal with ferric chloride addition to the primary influent for many years to successfully meet its historical 1.0 mg/L monthly average total phosphorus (TP) limit. The new TP permit limit is 0.86 mg/L. The WWTP can achieve this lower limit with the current chemical feed system. Conversion to biological phosphorus is feasible as a future improvement item that will require further evaluation to implement.

Long-term historical primary treatment demonstrates better than typical removals for the observed primary clarifier hydraulic retention times.

Activated sludge treatment operation achieves nitrification occasionally, depending upon weather, as well as flows and loadings. Nitrification of ammonia is not required by the current permit, nor is nitrogen removal. Implementation of full nitrification/denitrification is addressed in the modeling work as requiring significantly higher solids retention time than available (aeration tankage) but has not been costed as an alternative in this facility plan other than to allow for acquisition of adjacent CNH site for future, additional treatment facilities.

Secondary clarifiers operate with very good performance. Surface overflow rates (SOR) are well within typical values at 400 gallons per day per square foot (gpd/ft^2) and solids loading rates (SLR) of about 13 pounds per day per square foot (lbs/d/ft^2), resulting in effluent Total Suspended Solids (TSS) of 6 mg/l, even when SLR loadings are on the order of 20 lbs/d/ft^2, the effluent TSS is less than 10 mg/l.

Biogas production ranges from 12-18 cubic feet per pound of volatile suspended solids (VSS) destroyed with observed VSS destruction well correlated to predicted 60-64% VSS destruction. The plant has long used biogas as fuel for engine-driven aeration blowers as well as fuel for hot water boilers for digestion and plant heat.

Biosolids dewatering has very good overall capture efficiencies of 95% of solids. RWU biosolids meet "High Quality Sludge" classification criteria as defined by NR214 pollutant concentration limits and are principally applied to farmland under contracted services agreements.

The plant meets effluent requirements during wet weather optimization by using the Flow Equalization basins and limiting peak flow through the plant to 95 MGD. There are flow equalization screening and basin rehabilitation upgrades needed. Several opportunities have been identified to optimize peak flow through the plant. However, there are no significant opportunities to improve equalization capacity on the existing constrained site. Planning to obtain acquire adjacent properties is needed to allow for any further flow equalization or treatment capacity expansion.

1.5.2 Treatment Plant Facility Needs

AECOM met with RWU Staff to conduct a facilities assessment as well obtain input on plant needs. The WWTP Condition Assessment is found in Table 7-2. Review and discussion of plant needs and the condition assessment with RWU staff led to the development of the Alternatives Evaluation detailed in Table 11-1. Further planning resulted in the WWTP Facility Plan Recommendations with capital cost estimates subtotaled by facility or process area at the plans found in Table 13-1. Subsequently, a proposed Implementation Plan, Table 14-1, was developed with subjective implementation priorities

Wastewater treatment plant needs and alternative evaluations have been categorized as follows regarding recommendations:

Remedy deficiency category covering replacement/upgrade of facilities and equipment or processes that are past useful life or deficient in performance. The majority of items and needs fall into this categorization and include items like upgrades to UV disinfection, digester cover rehabilitation, and Administration Building roof replacement.

Further evaluation items are based on changes to facilities and processes that will upgrade performance or efficiency, with a potential payback for the item based on life cycle analysis but do need further engineering to develop as projects. This includes key recommendations for aeration system changes and upgrades, and biogas utilization conversion to combined heat and power (CHP), and solar energy opportunities.

Future improvements address items that may be eventually needed or beneficial during the planning period but are either not current deficiencies or are lesser priority initiatives. This category includes potential for opportunities such as conversion to biological phosphorus removal, addition of belt filtrate equalization, addition high strength waste receiving, and issues associated with the acquisition of adjacent CNH properties discussed in Chapter 14.

Key WWTP Facility Plan Needs to remedy deficiencies or to implement with further evaluation needed are summarized as follows as condensed from detailed summary Table 13-1 and are identified on an aerial photo of the plant site in Figures 13-1 through 13-4.

The total capital cost of recommendations in the Facility Plan as found in Table 13-1, inclusive of future improvement opportunities, is approximately $ 37.1 million

1.6 Implementation Plan

The individual SSR parties are responsible for their collection systems and would need to implement their own programs including system assessment, improvements, and capacity increases. The collection system within the City of Racine conveys wastewater from both the city, and combined flows from the city and SSR communities. The plan identifies and has listed recommended prioritization of the proposed improvements based on the needs identified throught the conveyance system modeling. Implementation of necessary improvements requires the continued collaboration between the Utility, the City of Racine, and the other SSR parties. Development of those implementation plans is beyond the scope of this plan. The wastewater treatment plant improvements are required due to age, technology improvements, and changing facility needs. Many of the systems required further engineering analysis for definition of the required improvements. The Facilities Plan classifies the recommended improvements in three needs categories:

- Deficiencies requiring immediate repair or replacement.
- Issues requiring further evaluation to determine the required repair or replacment for those deficiencies.

- Future improvements required for either future aging of existing systems and equipment or as future flows and loads increase.

Implementation of these improvements will be developed through Utility capital planning.

The cost of improving deficiencies in the current plant will be shared by all SSR Parties in proportion to their unique capacity allocations. Fututre growth capacity needs requested by the Parties will be shared by the requesting Party in proportion to their unique capacities that have been requested. For example, a community that has not requested additional capacity will likely not pay for any costs associated with new growth related improvements. At the time of this facilty plan, the SSR parties of Mt. Pleasant, Caledonia, and Sturtevant have gone on record requesting additional capacity in this Facilites Planning effort to meet their current or future needs for growth or for excess flow mitigation.

Following acceptance of this Facilities P-lan, the Racine Wastewater Commisison will engage the services of a consulting firm to properly allocate the costs of deficiencies and new growth onto the proper current SSR Parties or future SSR parties should any request capacity in the near future. The SSR Parties will than have a chance to study the associated costs and decide whether to move forward with all or some of the improvements in a defined time schedule.

2.0 Introduction

The Racine Wastewater Utility (RWU), a department of the City of Racine, currently provides wastewater collection and treatment services to eight communities in the greater Racine area. These communities include:

- City of Racine
- Village of Mount Pleasant
- Village of Caledonia
- Village of Sturtevant
- Village of Wind Point
- Village of Elmwood Park
- Village of North Bay
- A portion of the Town of Somers, Kenosha County

The aforementioned communities, with the exception of North Bay and Elmwood, entered into the "Racine Area Intergovernmental Sanitary Sewer Service, Revenue Sharing, Cooperation and Settlement Agreement" (IGA) in 2002. North Bay and Elmwood contended they had a 50-year agreement from a 1975 two-page agreement that they signed off on in order for Racine to accept an EPA Grant at that time. If that agreement is valid, it would expire in 2025. The 2002 agreement was entered into to replace the expired previous 20-year Sewer Service Agreement and provide the legal framework for implementing projects identified in the Facilities Plan for the Racine Wastewater Utility, authored by Rust Environment & Infrastructure/Applied Technologies, February 1998. The 2002 IGA is a 50-year agreement that includes 30 years of revenue sharing.

The civil units served by the Racine WWTP combined into a Sewer Service Area (SSA) authorized by WDNR and adopted by SEWRPC in June 2003.

This facilities plan is prepared and submitted to meet the following objectives:

- Meet the twenty-year planning guidelines from WDNR. The 1998 Facilities Plan projected flows, loadings, and wastewater management needs through the year 2020.
- Assess the conveyance and treatment plant requirements based on the new significant industrial development in the sewer service area. This includes the ability to meet the water return requirements of the recently approved Lake Michigan water diversion approval. Mount Pleasant submitted a facilities plan for TID 5 in the southwest portion of the SSA in 2018 to provide service for Foxconn and associated development. This plan incorporates those additions into the overall planning for the SSA.
- Address the plant capacity requests from the sewer service recipients. This is a trigger for a Facilities Plan under the IGA. Currently Mount Pleasant and Caledonia have capacity allocation increase requests before RWU.

This planning process includes both the Racine Wastewater Treatment Plant (WWTP) and the major interceptors and lift stations in the system. The sewers convey wastewater to the WWTP for treatment. Some of these conveyance facilities are owned and operated by RWU. Others are owned and operated by community signatories to the IGA. For planning purposes, the major interceptors and lift stations are treated as a system regardless of ownership.

Development of this facility plan included active participation from the Sewer Service Recipient (SSR) communities. Representatives of the SSR communities participated in regular Technical Advisory Committee meetings, approximately monthly during plan preparation. Minutes from these committee meetings are presented in Appendix G.

2.1 Wastewater Treatment Plant

The Racine WWTP was originally constructed at the existing site in the 1930s. Major additions and expansions were completed in 1968, 1977, 1992 and 2005 to bring the WWTP to its current configuration. The WWTP is a conventional activated sludge treatment plant. Biosolids are treated through anaerobic digestion before being land applied as a fertilizer and soil conditioner. Treated effluent is discharged to Lake Michigan. Racine WWTP is operated under the terms of WPDES discharge permit no. WI-0025194-09-0. This permit is effective January 1, 2020 and expires December 31, 2024. A copy of this permit is included in Appendix A

The WWTP is rated for an average flow capacity of 36 MGD. It has an approximate peak flow capacity of between 95 to 108 MGD. The plant optimizes treatment performance by limiting flows through the plant to approximately 95 MGD. Flow in excess of 95 MGD is sent to the wet weather optimization system.

Wastewater flows, particularly peak flows during storm events, are expected to increase over the next twenty years due to increases in population and development. Mount Pleasant and Caledonia both have average and peak flow capacity allocation requests before RWU. Loadings are not expected to increase above the plant's current rated capacity during the planning period, apart from peak flows. However, because two communities have requested average flow allocation increases, the plan includes provisions for a satellite treatment plant south of the existing WWTP when the average flows dictate the need. The site is the former Case New Holland plant site.

2.2 Conveyance System

The conveyance system has been constructed in stages over the years as development and growth occurred in the SSA beyond the city limits of Racine. The entire system is comprised of interceptor gravity sewers, force mains and lift stations. Portions of the system are owned and operated by RWU while other portions of the conveyance system are owned and operated primarily by four entities: City of Racine, Village of Mt. Pleasant, Village of Caledonia and Village of Sturtevant.

Collection sewers and associated lift stations within each community are not part of this planning study.

The existing system is described in greater detail in Section 6.

2.3 Organization of Plan

The plan addresses the requirements of NR 110 including the following:

- A description of the planning area including population, land use, and the relevant environmental setting.
- An evaluation of the existing WWTP.
- An evaluation of the existing conveyance system.
- Development and analysis of the planning period projections for wastewater flows and loadings and the impact on WWTP performance.
- Development and analysis of the planning period projections for wastewater peak flows and the impact on conveyance system performance.

Alternatives are developed for WWTP improvements and capacity expansion that may be required during the planning period. Alternatives for conveyance system improvements and capacity expansion during the planning period are also developed Where applicable, they include cost-effectiveness analyses. Recommendations are developed and an implementation schedule provided.

2.4 Impact of Intergovernmental Agreement

The 2002 IGA establishes flow allocations to parties of the IGA. These capacity allocations are expressed in measurement of Average Day Flow capacity. Exhibit E of the 2002 IGA, as amended from time to time, shows each community's allocated capacities. Each 1 MGD of average day flow is then allocated a unit of Peak Day Flow, Peak Hour Flow, BOD, TSS, and other parameters. The IGA has trigger points where the SSP monitors flows at various metered points. As the metered connection points meet each allocation of peak flow at 80%, 90%, 95% or exceeding 100%, notices are sent to each SSR Party to trigger various requirements in the IGA. Some of these can consist of triggering facility planning or instituting a sewer moratorium for various levels of exceedance. Currently sewer moratoriums exist in some sub basins of some SSR Parties.

While population can be used as a typical measuring tool for necessary plant expansion, other factors need to be considered as well. Peaking factors in various sub basins and collection systems may have peaking factors of between 1:6 or 1:15. Since Peak Flow allocations are directly related to average day capacity, an SSR party may find a need to acquire additional Average Day capacity in order to meet a Peak Day or Peak Hour threshold in the IGA. With 18 years of experience operating under the IGA, several communities now have a better handle on their peak capacities or limitations. In addition, they may also have a better planning horizon for the next 20 years of development within their community.

The IGA gives each SSR Party the autonomy of calculating what they believe are their future needs for their unique collection system and 20 year planning horizon. A community with a large infiltration and inflow (I &I) problem might decide to request more capacity for treatment rather than going after foundation drains and sump pumps. Individual community's also have the luxury of mitigating peak flows within their own boundaries to stay below triggering thresholds in the IGA. After an SSR Party weighs the plusses and minuses and costs of various alternatives, they can then approach the Wastewater Commission with a request for more treatment capacity and possibly conveyance capacity to meet their needs.

Separate from this analysis, several SSR communities have requested increases in their average daily flow allocations at the WWTP. The requested flow allocations from the SSRs indicate a need to expand the wastewater treatment capacity sometime in the future to provide to the SSR Parties additional capacity. The current growth projections, based on population data, do not support this growth in the average flow. However, peak flows have had a more controlling influence on the SSR decision making process, helping them determine how much additional treatment capacity that they may need to manage their requirements under the IGA. Therefore, the plan has identified a location for additional treatment capacity should the requested capacity allocations be required. The SSR parties requesting additional capacity will be paying for the increased share and capacity that each has requested. While the treatment plant analysis indicates that it can treat for BOD, TSS and phosphorus going forward, and that the construction of these capital assets could be deferred for a period of time, the construction cost for these requested improvements will continue to grow with inflation of materials such as concrete and steel and labor. As the IGA is founded on the principle of Average Day treatment capacity as it relates to increased peak capacity, postponing these improvements to a future window of time runs afoul of the structure of the current agreement. Additional planning to manage these flows and associated loadings will need be completed at that time.

3.0 General Description of Planning Area

The Racine planning area is located within the eastern portion of Racine County, which is situated in the southeast corner of Wisconsin, as shown on Figure 3-1. The County has an area of approximately 337 square miles and is bounded on the east by Lake Michigan, on the west by Walworth County, on the south by Kenosha County, and on the north by Waukesha and Milwaukee Counties.

The Racine facilities planning area is shown on Figure 3-2. The planning area includes that portion of Racine County from Interstate Highway 94 (I-94) east to Lake Michigan and a 400-acre area in the Town of Somers (Kenosha County) along County Trunk Highway (CTH) KR. Eight civil units are included in the

Planning area:

- City of Racine
- Village of Mount Pleasant
- Village of Caledonia
- Village of Sturtevant
- Village of Wind Point
- Village of Elmwood Park
- Village of North Bay
- A portion of the Town of Somers, Kenosha County

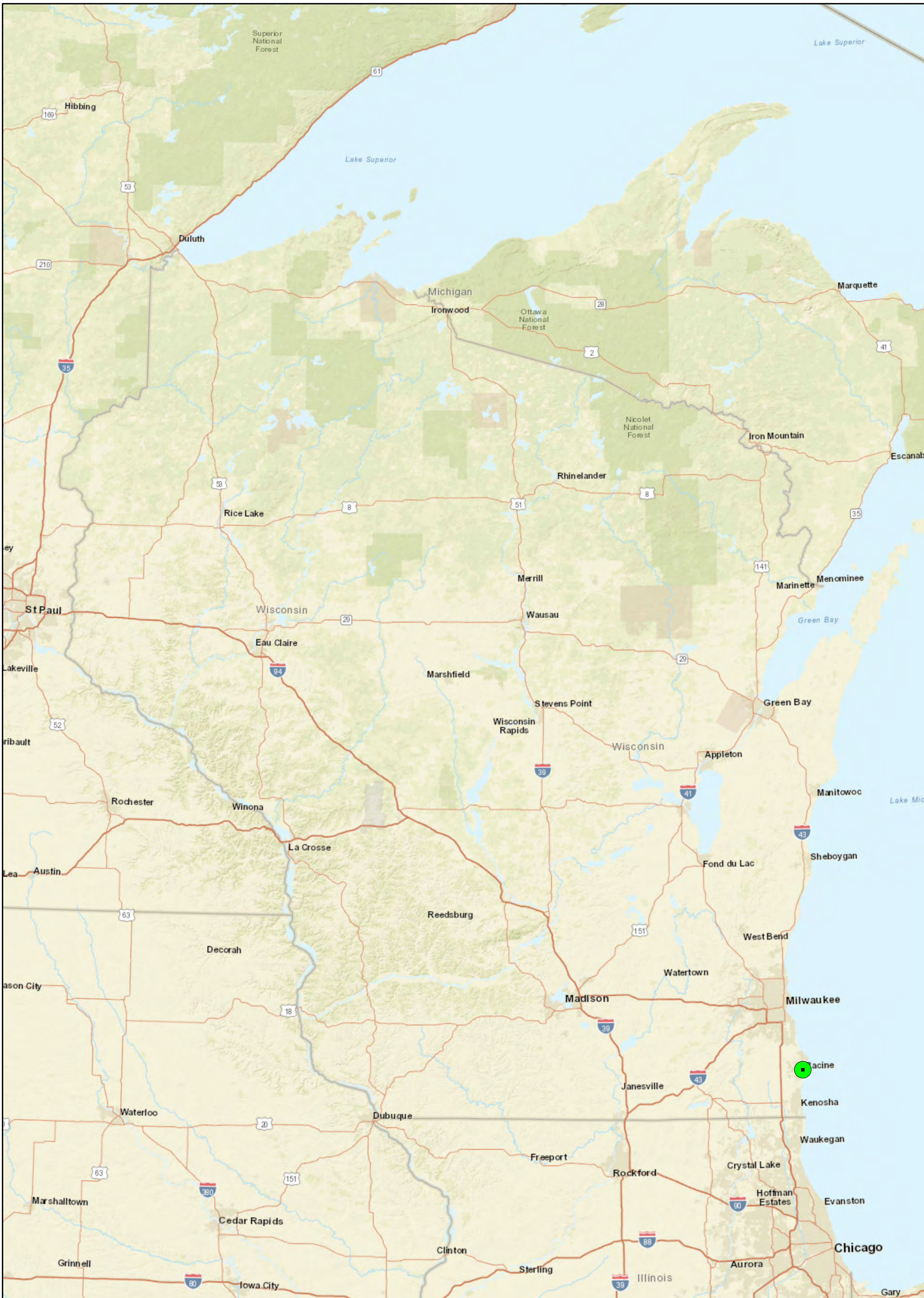
As stated previously, the civil units served by the Racine WWTP combined into a sewer service area authorized by WDNR and adopted by SEWRPC in June 2003. The SSA is consistent with long term planning in southeast Wisconsin and has been modified since the original to the current boundaries. The most recent expansion of the SSA was approved in 2018. This added the southwest portion of the village of Mt. Pleasant, including the proposed Foxconn development. The SSA is shown on Figure 3-3. A portion of this planning area lies in the village of Caledonia but outside the boundary of the SSA. There are no plans to expand the SSA included in this plan.

The planning area is between Milwaukee (approximately 25 miles to the north) and Chicago (approximately 65 miles to the south). The City of Racine is at the mouth of the Root River along the Lake Michigan shoreline. The City is at the core of the planning area and is a major industrial and population center. The majority of development in the planning area forms a concentric pattern radiating out from the City of Racine.

3.1 Land Use and Population

3.1.1 Land Use

The areas of the civil units in the planning area are summarized in Table 3-1. The villages of Caledonia and Mt. Pleasant comprise the largest areas. These two villages have a combination of both urban and non-urban land uses. The city of Racine is highly urbanized, over 90%.



AECOM

Figure 3-1 - Project Location

Projection: NAD_1983_2011_StatePlane_Wisconsin_South_FIPS_4803_Ft_US

Drawn By: JFP

Checked By: MJZ

Date:

Project #: 60554970

Racine Facilities Plan
Racine Wastewater Utility

N

0 15 30 60 Miles

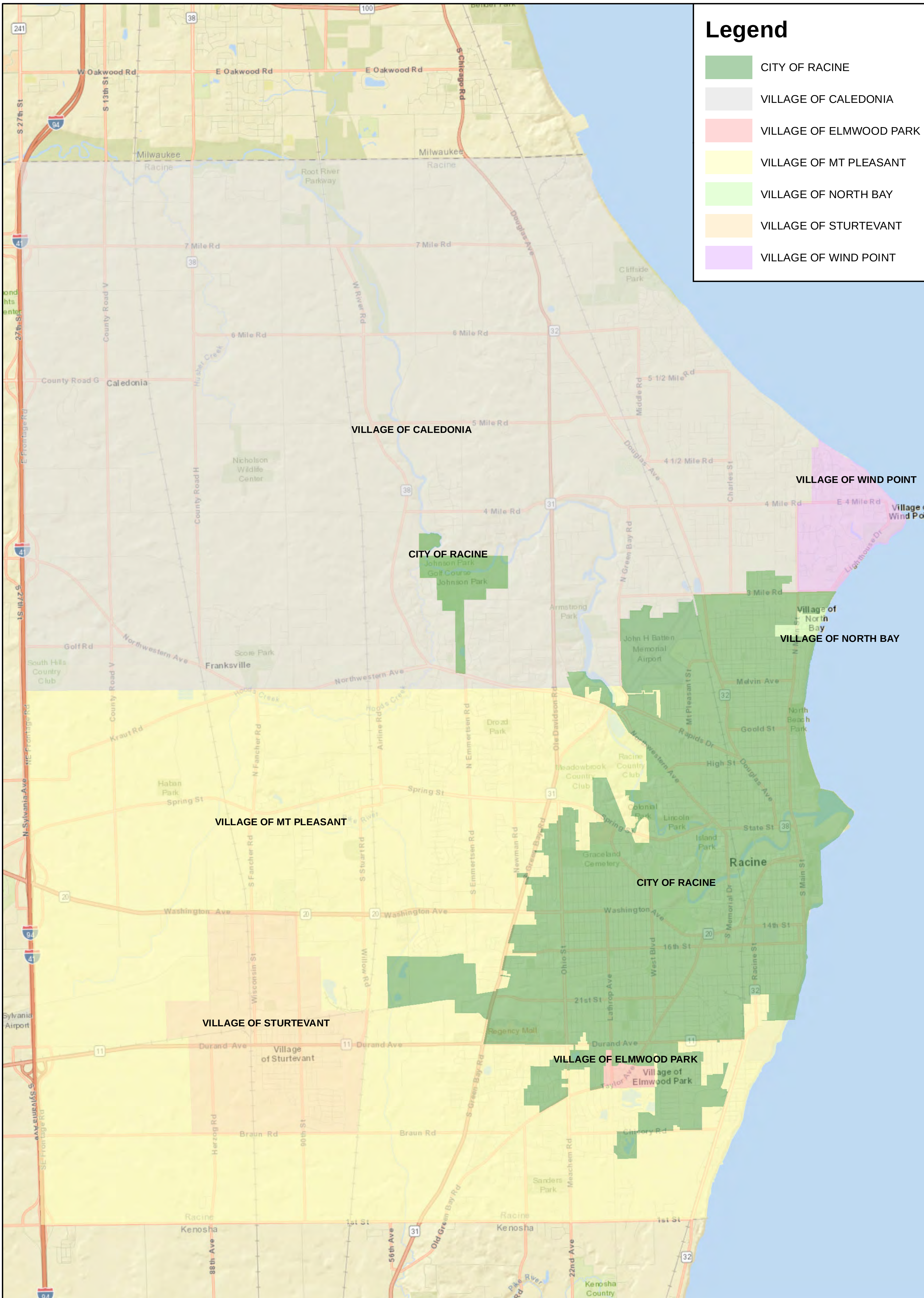


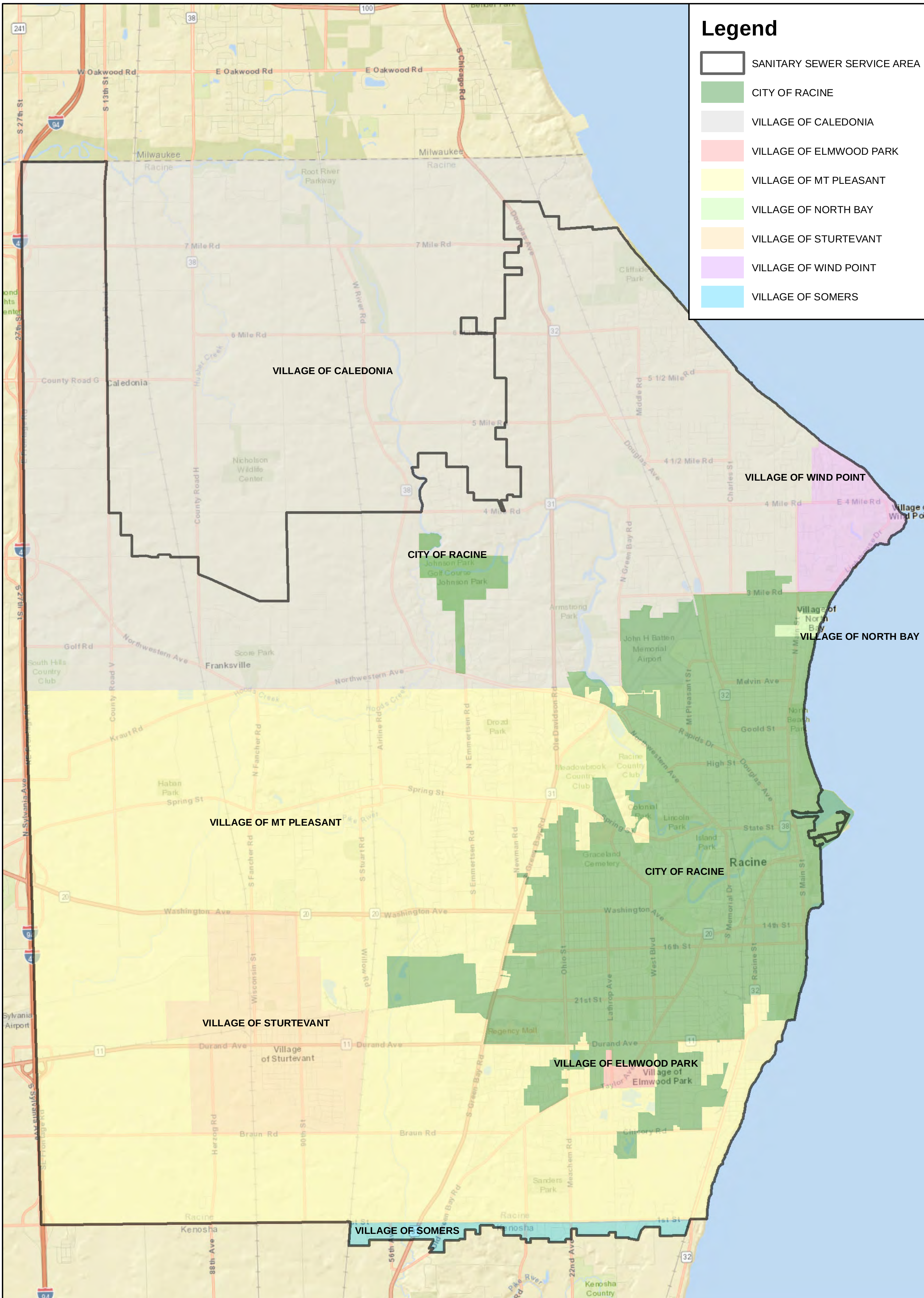
Figure 3-2 - Planning Area

Projection:
NAD_1983_2011_StatePlane_Wisconsin_South_FIPS_4803_Ft_US

Drawn By: JFP
Checked By: MJZ
Date:
Project #: 60554970

Racine Facilities Plan
Racine Wastewater Utility

0 0.5 1 2 Miles



AECOM

Figure 3-3 - Sanitary Sewer Service Area

Projection:
NAD_1983_2011_StatePlane_Wisconsin_South_FIPS_4803_Ft_US

Drawn By: JFP

Checked By: MJZ

Date:

Project #: 60554970

Racine Facilities Plan
Racine Wastewater Utility

Table 3-1. Civil Divisions Comprising the Racine Planning Area

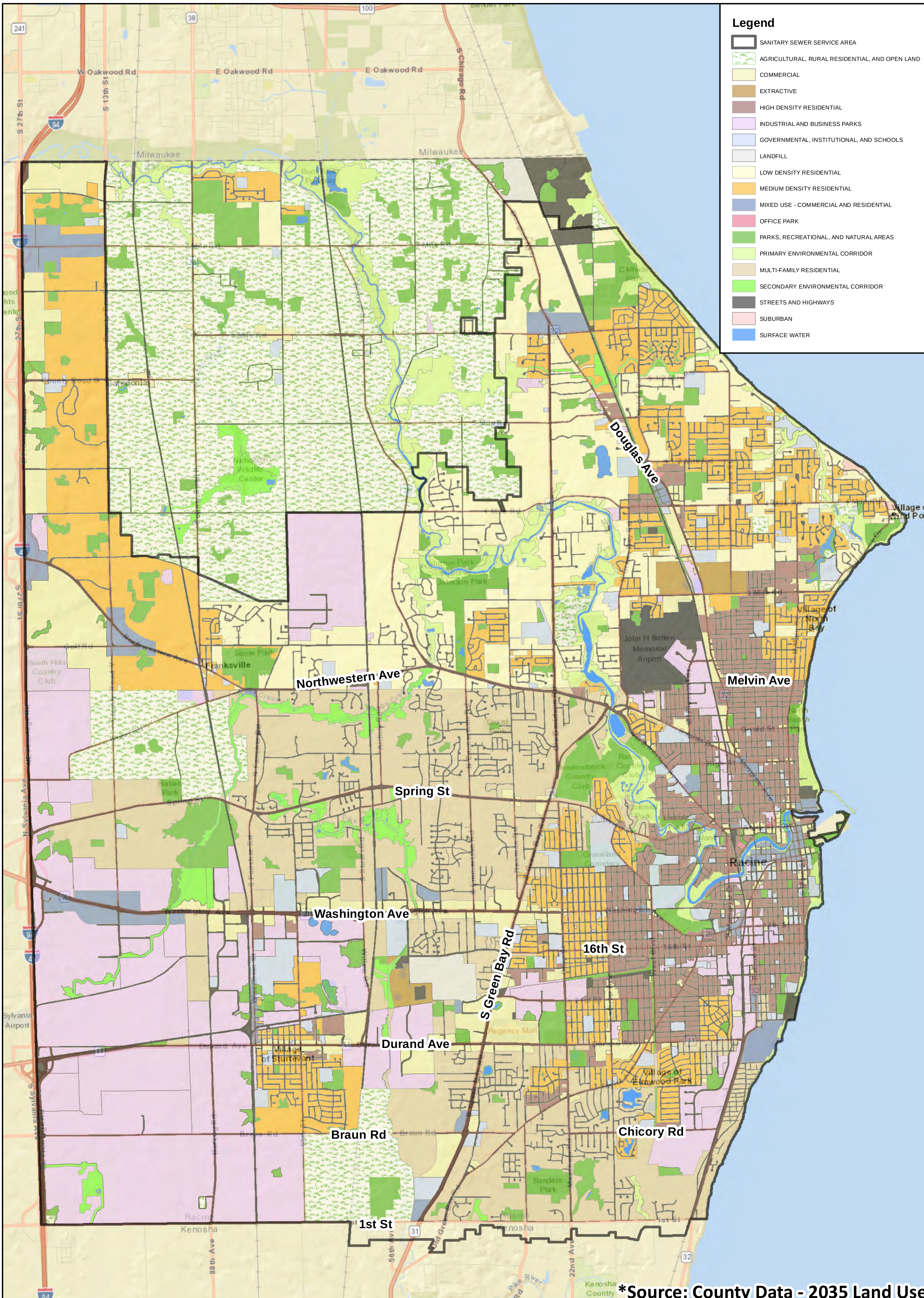
Civil Unit	Total Planning Area	
	2019 Square Miles	Percent Study Area
Caledonia Village	45.52	44.8
Elmwood Park Village	0.15	0.1
Mt. Pleasant Village	34.03	33.5
North Bay Village	0.10	0.1
Racine City	16.33	16.1
Sturtevant Village	4.11	4.0
Wind Point Village	1.29	1.3
Study Area Total	**101.53**	**100.0**

Note: Does not include 0.60 square mile which comprises the Town of Somers “KR” Sewer Utility District in Kenosha County and which is served by the City of Racine WWTP.

Source: 2019 US Census Gazette

Figure 3-4 presents the projected 2035 land use in the planning area. The 2035 land use plan was selected since it is the closet to the 2040 planning period. The trend toward greater urbanization in the Villages of Mt. Pleasant and Caledonia is expected to continue with subsequent population growth. Additional industrial growth is anticipated with Foxconn and associated ancillary development being the most significant.

The 2035 land use projections for the planning area are summarized in Table 3-2.



AECOM

Figure 3-4 - Land Use

Projection:

NAD_1983_2011_StatePlane_Wisconsin_South_FIPS_4803_Ft_US

Drawn By: JFP

Checked By: MJZ

Date:

Project #: 60554970

Racine Facilities Plan
Racine Wastewater Utility

N

0 0.5 1 2 Miles

Table 3-2. Projected 2035 Land Use, acres

	Caledonia	Mt. Pleasant	Racine	Sturtevant	Wind Point	Elmwood Park	North Bay	Total	Percentage of Total
Residential	8065	7007	3695	739	394	71	54	20025	31%
Commercial	1520	564	737	281	20	2	-	3124	5%
Industrial	704	1815	761	624	-	-	-	3904	6%
Transportation	3612	2992	2453	512	100	20	10	9699	15%
Government	386	329	651	205	59	5	1	1636	3%
Recreation	893	1075	783	53	52	-	1	2857	4%
Urban Subtotal	**15180**	**13782**	**9080**	**2414**	**625**	**98**	**66**	**41245**	**64%**
Agricultural/Unused	10037	6455	-	154	-	-		16646	26%
Primary Environmental Corridor	1930	216	547	-	103	-	2	2798	4%
Secondary Environmental Corridor	303	664	18	21	-	-		1006	2%
Isolated Natural Resource Areas	1293	575	113	102	36	-		2119	3%
Other Open Lands	150	-	-	-	61	1		212	0%
Extractive and Landfill	292	-	293	-	-	-		585	1%
Nonurban Subtotal	**14005**	**7910**	**971**	**277**	**200**	**1**	**2**	**23366**	**36%**
Total	**29185**	**21692**	**10051**	**2691**	**825**	**99**	**68**	**64611**	**100%**

Source: A Multi-Jurisdictional Comprehensive Plan for Racine County: 2035, SEWRPC November 2009

3.1.2 Population

Past population and forecasts of probable future population are essential parameters in planning sewerage and wastewater treatment systems. Past population growth in the Racine area has been well documented by census data. Table 3-3 summarizes the past population data for the planning area as well as the 2040 population projections used in this plan.

Table 3-3. Racine Population Data and Projection

Municipality	1990 Population US Census	2000 Population US Census	2010 Population US Census	2018/19 Population [1]	2040 Population Projection [2]
Caledonia	20,999	23,614	24,705	25,021	27,910
Mount Pleasant	20,084	23,142	24,705	26,310	31,650
Somers				1,100 [3]	1,360
Elmwood Park	534	474	497	491	535
North Bay	246	260	241	234	230
Sturtevant	3,803	5,287	6,970	6,615	6,666 [4]
Wind Point	1,941	1,853	1,723	1,689	1,645
Racine	84,298	81,855	78,860	77,807	78,750
Totals	**131,905**	**136,485**	**137,701**	**139,267**	**148,746**

Sources:

1. 2018/19 population from Ruekert and Mielke 2020 Revenue Sharing utilizing Wisconsin DOA data UNO.
2. Year 2035 projection, Wisconsin DOA population projections 2010-2040, January 2013 UNO
3. Estimate of sewered population, Wisconsin DOA population projections 2010-2040, January 2013
4. Confirmation from Jeff Seitz (Village of Sturtevant) at TAC meeting

The 2040 population projections are based on those established by the Wisconsin Department of Administration in January 2013. While that document projected populations out to the year 2040, the year 2035 population projections were used in this plan. We selected the 2035 population projection based on our review of other similar data sets and the actual growth experienced compared to the projections in those data sets. Population growth in the Racine planning area has not been as robust as projected at the time of the 1998 Facilities Plan or more recent planning documents prepared by SEWRPC. The 2040 projections in this plan allow for a 6.8% growth in the service area over the 20-year life of the plan. By comparison growth from 1990 through 2018, 28 years, was only approximately 5.6%

3.2 Archaeological and Cultural Resources

Resources of historical, architectural, cultural, or archeological importance are limited, non-renewable portion of the human environment. These remnants of our past are protected to prevent an irretrievable loss of our heritage. They are often referred to collectively as "cultural resources." It is important that these cultural resources be evaluated for their intrinsic significance and for the expected impact upon them by a proposed project.

The Wisconsin State Archaeological Site Inventory currently lists 347 sites in Racine County. The most significant projects presented in this plan are not anticipated to impact any cultural or archaeological resources. The Racine WWTP has been developed on Lake Michigan fill. The project area associated with the Pike River Lift Station was approved in the recent Facilities Plan for TID 5 Interceptor Sewer System[1]. The potential satellite WWTP contemplated for the Case New Holland property south of the existing WWTP has been under industrial development for over 100 years and is currently undergoing environmental remediation. Other contemplated storage facilities are adjacent to existing storage and lift station facilities.

As projects are selected to begin the design process, the Wisconsin State Historic Preservation Office and other appropriate agencies will be contacted to determine if there are any archaeological or historical resources near the proposed project location that may be impacted by the project. Based on the response, an appropriate plan for investigation and preservation will be implemented if required.

[1] Foth, July 2018

4.0 Environmental Inventory

4.1 Climate and Weather

Racine has a humid continental climate. Winters are generally long and cold, and summers are warm and humid. Lake Michigan moderates the climatic extremes along the coastal area. The temperature changes vary widely according to seasons and years. For the City of Racine, July, the warmest month, has an average daily temperature range of 62° F to 80° F, and January, the coldest month, has an average daily temperature range of 11° F to 28° F. Lake Michigan affects the temperature of the area significantly, particularly during the spring, summer and fall. Because the lake warms more slowly than the adjacent land area, the spring temperatures increase more slowly in the shoreland area than in inland areas. Summer temperatures adjacent to the coast are seldom higher than inland areas. During the fall-winter transition period, the coastal area has a lower monthly mean temperature drop than inland areas. Therefore, the growing season (frost-free period) is slightly longer than that of inland areas because of Lake Michigan's moderating effects. The frost-free period averages 186 days, from April 17 to October 26. Table 4-1 summarizes the climatological data for Racine.

Average annual precipitation (includes rain, hail, sleet and snow) is 36.0 liquid inches. Annual snowfall averages 42.4 inches and ranges from less than 15 inches to more than 80 inches. Half of the average precipitation, as liquid volume, occurs from May through September. Rainfall intensities of approximately 1.3 inches in one hour, 2.0 inches in six hours and 3.0 inches in 48 hours are expected approximately once every two years. The estimated evapotranspiration (total water loss due to evaporation and water taken up by vegetation) averages from 20 to 29 inches per year.

The prevailing wind direction varies with the seasons. In winter, northwest winds prevail, in spring and early summer, northeast winds prevail. In late summer and fall, the prevailing winds are from the southwest. The strongest winds are generally from the west or southwest. Annual wind speeds average from 10 to 16 miles per hour. September through April are the windiest months.

Table 4-1. Climatological Summary, Racine, Wisconsin

Month	Monthly Average Temperature (F^o)			Precipitation (inches)	
	Daily Maximum	Daily Minimum	Monthly Average	Total	Snow [1]
January	29.5	15.5	22.6	1.75	15.4
February	32.6	19.4	26.0	1.62	9.5
March	41.2	28.2	34.7	2.19	5.8
April	51.5	37.8	44.6	3.75	1.3
May	61.3	46.7	54.0	3.94	0.1
June	72.3	56.9	64.6	3.83	0
July	78.2	64.2	71.2	3.33	0
August	77.4	64.3	70.9	4.06	0
September	70.2	56.2	63.2	3.67	0
October	58.7	44.0	51.4	2.75	0.2
November	46.3	33.1	39.7	2.96	2.1
December	33.6	20.4	27.0	2.18	8.0
Avg/Total	**54.5**	**40.17**	**47.6**	**36.03**	**42.4**

Source: (Midwest Climate Research Center, NECI 1981-2010)

[1] Snow Average 1971-2000

4.2 Physical Geography, Geology and Hydrogeology

4.2.1 Topography and Drainage

The topography of the planning area is generally flat to gently rolling, with an average gradient sloped towards Lake Michigan of less than five percent. The City datum is at 580.71 feet above mean sea level (MSL) with elevations increasing to about 750 feet above MSL near I-94.

Surface drainage in the planning area is divided into four watersheds which are shown on Figure 4-1. These watersheds include the Root River, the Pike River, direct drainage to Lake Michigan, and a small area at the southwestern comer of the planning area that is part of the Des Plaines River watershed, which drains to the Mississippi River. The Root River drains approximately three-fifths of the planning area. The river varies between 20 and 100 feet in width and drops 80 feet in the 18.5 miles it travels across the planning area to Lake Michigan. The Pike River originates in Racine County several miles northeast of Sturtevant and drains the south-central portion of the planning area. Generally, the eastern quarter of the planning area drains directly to Lake Michigan via minor streams and drainageways.

Most of the urban runoff generated within the planning area enters the Root River. The Root River from the Horlick Dam to Lake Michigan is six river miles long and slopes 10.4 feet per mile. Steeper channel slopes occur at the headwaters and at the mouth of the river than at the mid-reaches of the river. Overall, the slopes could be described as flat, resulting in low stream flow velocities and long flood-peak times.

4.3 Geology and Groundwater

Racine is underlain by glacial deposits overlaying consolidated Paleozoic shallow sea sediments which dip eastward at about 15 feet per mile. A cross-section of this geologic sequence through the planning area is shown on Figure 4-2.

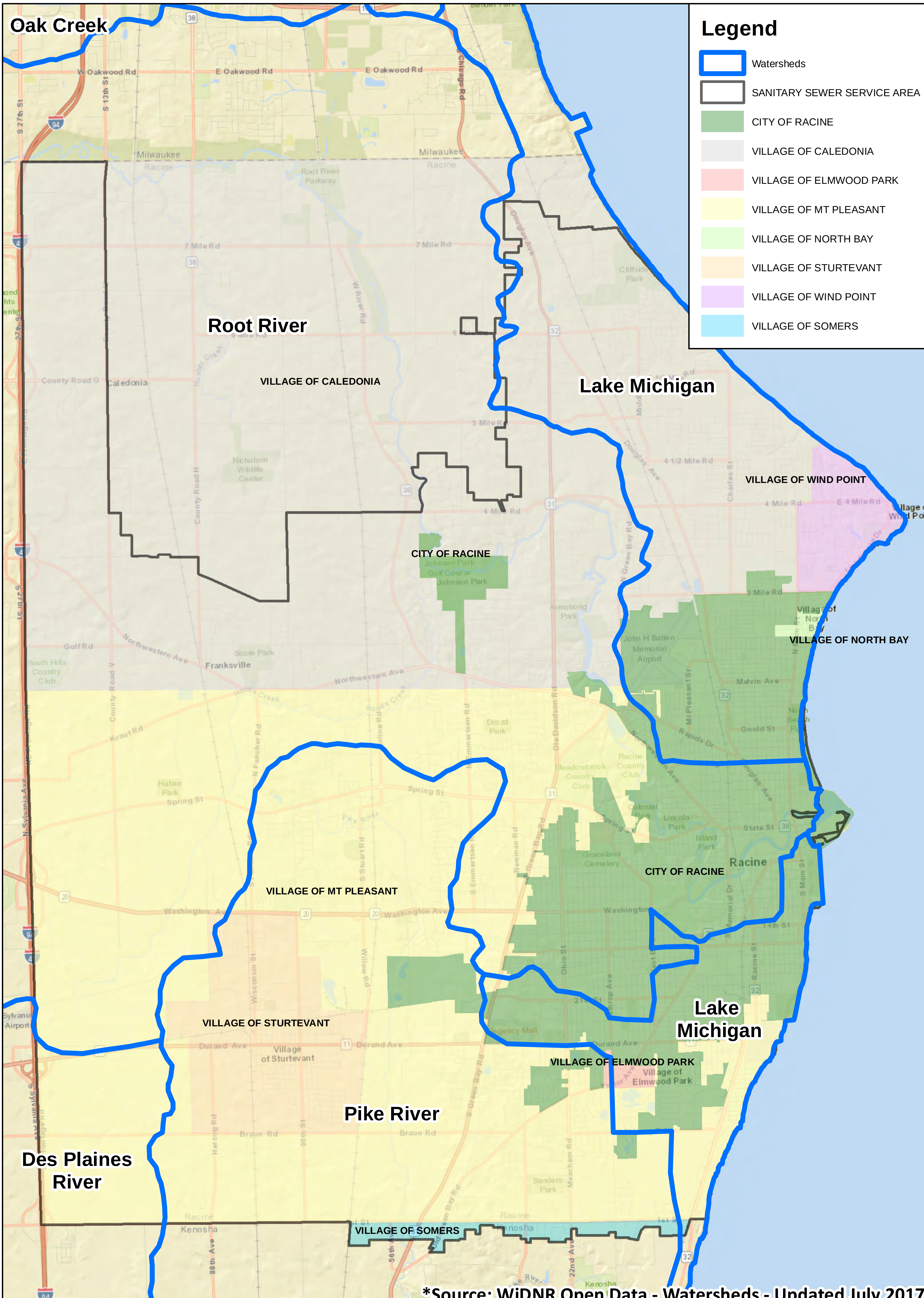
The unconsolidated glacial deposits consist of lake deposits and alluvium in the east and silty-clay till in the west. These sediments were deposited during the final stage of glaciation which occurred approximately 10,000 years ago and now form the upper part of the shallow aquifer. Well yields from the sand and gravel aquifers are generally low except in the case of buried stream beds and where the deposits are in hydrologic continuity with the underlying Niagara dolomite.

The bedrock in the study area is formed by the Niagara dolomite of the Silurian age. Well logs in the City record the depth to bedrock anywhere from 35 to 120 feet below the surface. The average depth is approximately 100 feet. The bedrock formation is generally in hydrologic continuity with the glacial material and forms the low part of the shallow aquifer which provides water for small communities, domestic stock, irrigation and industrial uses to the west of the City. Wells in this aquifer exhibit a wide range of specific capacities with the lowest capacities occurring near Lake Michigan.

Prominent in the Racine area are numerous Silurian age coralline reef structures surrounded by steeply dipping reef flank deposits which grade outward into dense, flat-lying, thin-bedded inter-reef rocks. One of these reef complexes is exposed at Quarry Lake Park, northwest of Racine.

Maquoketa shale underlies the Niagara dolomite at a depth of approximately 310 to 440 feet. This shale formation, which has a low structural competence (poorly suited for tunneling) and is nearly impervious, separates the shallow and sandstone aquifers. The sandstone aquifer is comprised of the Galena dolomite and several units of Cambrian and Ordovician sandstone. The piezometric surface of the sandstone aquifer is nearly flat at an elevation of approximately 550 feet below mean sea level. However, water levels are declining because of heavy withdrawal in the Milwaukee and Chicago metropolitan areas.

Both the shallow and the sandstone aquifers can be polluted by infiltration, but this problem is greater in the shallow aquifer. This aquifer is recharged locally, and because it is shallow, there is less time and distance for diluting, filtering and other purifying processes. Most of the recharge of the sandstone aquifer occurs in Walworth County, where the Platteville-Galena unit underlies the glacial deposits. However,



AECOM

Figure 4-1 - Watersheds

Drawn By: JFP

Checked By: MJZ

Date:

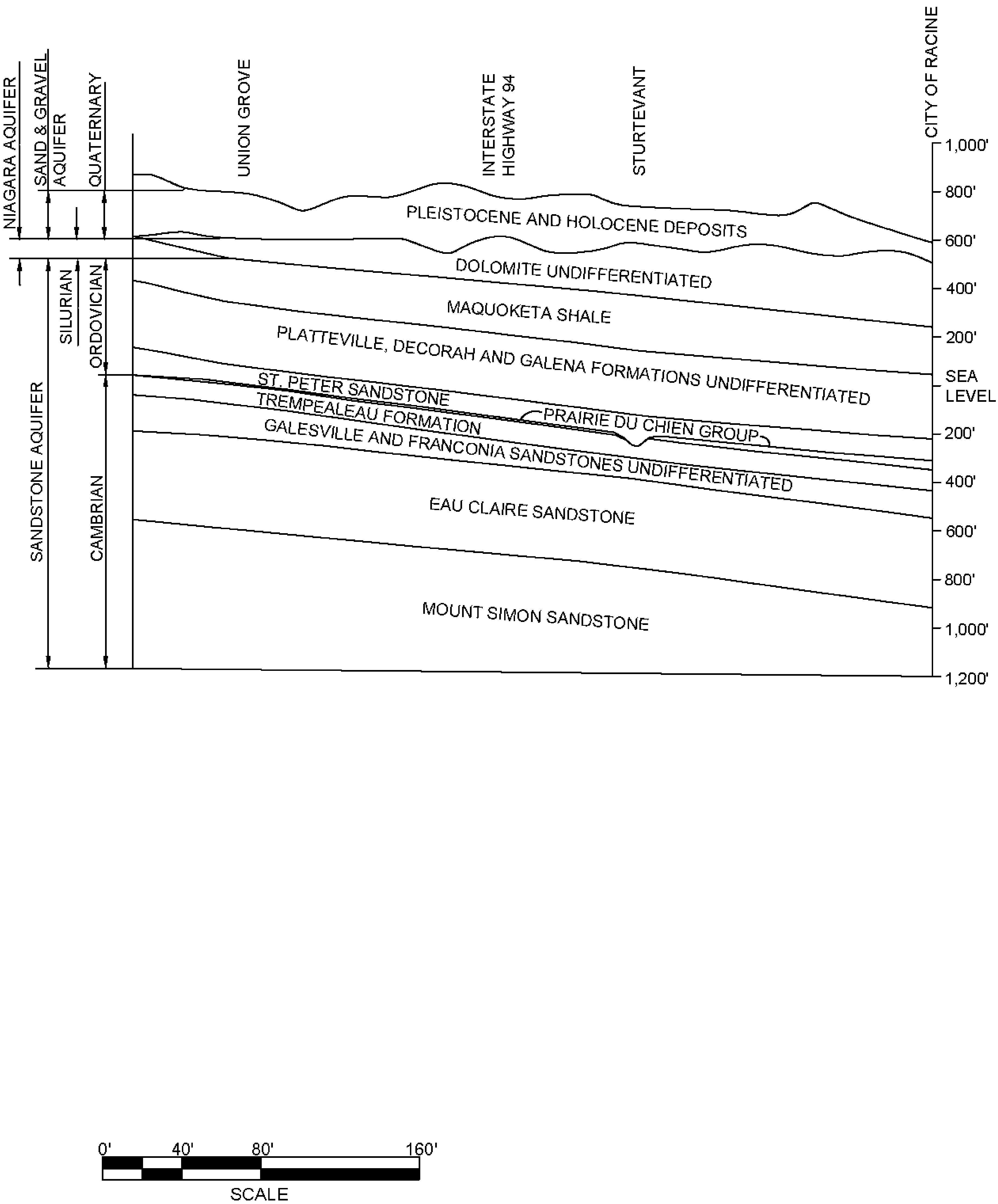
Project #: 60554970

Racine Facilities Plan
Racine Wastewater Utility

Projection:
NAD_1983_2011_StatePlane_Wisconsin_South_FIPS_4803_Ft_US

N

0 0.5 1 2 Miles



[redacted]

Figure 4-2
Geologic Section

Projection:

Drawn By: CAS/JFP

Checked By: MJZ

Date:

Project #: 60554970

Racine Facilities Plan
Racine Wastewater Utility

since some recharge occurs by seepage through the Maquoketa shale and through leakage in wells open to both the sandstone and the upper rocks, the deep aquifer can also be contaminated.

The planning area has seven public water supply systems which are served by two public water suppliers, namely, the Racine Water Utility and the Oak Creek Water and Sewer Utility, both of which utilize Lake Michigan as the source of supply. The Oak Creek Water and Sewer Utility is not located in the planning area. Areas not served by the public systems obtain water from private wells in the shallow sand and gravel aquifers.

Table 4-2 provides data on the water quality from Lake Michigan.

Table 4-2. Lake Michigan Raw Water Quality, Racine Water Utility

Parameter	Average 2017-2019
Direct Lake Michigan Analysis	
pH	8.09
Alkalinity (mg/l)	113.00
Turbidity (NTU)	7.87
Fluoride (mg/l)	0.13
Total Organic Carbon (mg/l)	1.70
Temperature (^{0}F)	46.80
Coliform Bacteria (cfu/100 ml)	134.00
Heterotrophic Plate Counts (cfu/ml)	35.33
Indirect Lake Michigan Analyses*	
Heavy Metals	
Antimony (ug/l)	0.19
Arsenic (ug/l)	0.68
Barium (ug/l)	19.00
Berylilium (ug/l)	ND
Cadmium (ug/l)	ND
Chromium (ug/l)	ND
Mercury (ug/l)	ND
Nickel (ug/l)	0.65
Selenium (ug/l)	ND
Thallium (ug/l)	ND
Other Inorganics	
Nitrogen as Nitrite (mg/l)	ND
Nitrogen as Nitrite/Nitrate (mg/l)	0.32
Sodium (mg/l)	6.80
Sulfate (mg/l)	22.67
Calcium (mg/l)	34.33
Hardness (mg/l)	133.67
Chloride (mg/l)	15.67

*For in-direct results, actual tests were performed on finished water.

The concentrations of these constituents essentially remain unchanged from the Lake water through the treatment process.

4.4 Soils

Soils in the planning area were produced by the action of soil forming processes on material deposited or accumulated by glaciers. Climate, plant, and animal life, particularly vegetation, are the active forces in soil formation.

There are four general soil associations or groupings found in the planning area. These associations are described below in relation to the relative amounts within the planning area[2].

Varna-Elliot-Ashkum

These poor draining fertile soils have a silty-clay loam to clay subsoil. They are generally found on the slopes of hills in the western and southwestern section of the planning area. The well-drained Varna soils are on ridges and knobs where the natural vegetation was prairie grasses. The somewhat poorly drained Elliot soils and poorly drained Ashkum soils are found in depressions and drainage-ways where the natural plant cover was water-tolerant grasses.

The soils of this association are well suited to farming, and are used for wheat, oats, soybeans, and corn. Slow permeability and a high-water table are soil features that severely limit use of onsite sewage disposal systems.

Morely-Beecher-Ashkum

This group of soils is composed of 10 to 20 inches of windblown silt underlain by clay loam to silt-clay loam. Morely soils were formed under hardwood forests and are well drained and occupy broad glacial ridges; whereas the Beecher and Ashkum soils were formed under prairie grasses and are poorly drained and occupy broad low-lying wet depressions. Beecher and Ashkum soils have slow infiltration rates. One minor soil found in this association is Markham, which is moderately well-drained soil that developed under prairie grass and sparse hardwoods. This group of soils is found in Caledonia and in a north-south band crossing part of Racine and Mount Pleasant.

The soils of this association are some of the most important for farming in the area. They have high natural fertility and are well suited to crops. Use of the soils for onsite sewage disposal systems is severely limited by slow permeability and, in places, by a high-water table. The Morley soils are subject to water erosion.

Hebron-Montgomery-Aztalan

The well-drained Hebron soils were developed under forests and occupy upland areas. The poorly drained Montgomery and Aztalan soils were formed under wetland grasses and occupy the flat plains areas. They are found in Caledonia and along a north-south band crossing part of Racine and Mount Pleasant.

The soils of this association are highly suitable for farming and used for vegetable crops such as corn, small grain, soybeans, and forage crops. Erosion is a hazard on the Hebron soils, and improved drainage is needed in the Montgomery and Aztalan soils. Because permeability is slow and, in places, the water table is high, the soils have severe or very severe limitations that restrict their use for onsite sewage disposal systems.

Boyer-Granby

This soil association was formed in sandy glacial outwash material and has a loam to sand subsoil. These soils occupy the glacial plains and terraces near Lake Michigan. Its drainage characteristics, depending on the height of the water table, vary from excellent to poor.

The soils of this association are not well suited to crops, and they have little value for farming. Wildlife and recreation are the chief uses. For onsite sewage disposal system, limitations are only slight on the well-

[2] USDA Soil Conservation Service, 1970

drained soils but are severe or very severe on soils having a high-water table. The Boyer soils are droughty and, unless protected, are subject to wind damage.

With the exception of the urbanized areas, the majority of the soils in the planning area are well suited to agriculture. The western third of the planning area contains prime agriculture land (SEWRPC Planning Report No. 30). The majority of the soils in the planning area cannot provide a suitable medium for conventional on-site waste treatment and disposal systems because of slow percolation rates due to underlying clay layers or a seasonally high-water table. Three soil types found in eastern Racine County are suitable for land spreading municipal wastewater sludge - Morely, Markham, and Varna.

4.5 Surface Water Resources

The major surface water resources in the Racine planning area include Lake Michigan, Root River, Pike River, and Des Plaines River. These four watersheds are located within two distinct drainage basins. Three of the four watersheds, Lake Michigan, the Root River and the Pike River are located in the Lake Michigan drainage basin.

Lake Michigan

The most significant water resource in the planning area is Lake Michigan. The lake supplies drinking water to over 80 percent of the population residing in the planning area. The water quality of this resource is generally good, but seasonally it can receive locally heavy pollutant loadings through surface runoff pollution. Pollutants along the nearshore water course in Lake Michigan near Racine vary sharply from year to year and by season because of fluctuations in rainfall and surface runoff.

Water level in Lake Michigan is determined primarily by the difference between the amounts of precipitation and evaporation. The discharge of surface water from the Racine area into Lake Michigan has little effect on the level of the lake. Lake Michigan water level is monitored by the U.S. Army Corps of Engineers and averaged 578.84 feet above mean sea level (International Great Lakes Datum) during the period 1918-2019. The current level is approximately 582 feet above mean sea level. The year 2020 will bring the highest recorded lake levels in Lake Michigan in the 150 years of recorded records.

Root River

The streams in the planning area play an important role in surface drainage, supporting fish and wildlife, providing scenic areas, and transporting and diluting pollutants. These streams are not used for industrial or municipal water supply. The major stream in the area is the Root River. The source of the Root River lies in the Milwaukee suburb of West Allis, and the total length of the river is approximately 44 miles. The Root River watershed covers approximately 198 square miles. The Root River watershed lies within the Counties of Racine, Milwaukee, Waukesha, and Kenosha. Generally, the Root River is shallow with depths of less than three feet prevalent until the last 900 feet where the depths exceed ten feet. Flow and velocity vary markedly with season and weather.

The flow range for the river is summarized below[3]:

Peak Flow	8,200 cubic feet per second
Minimum Flow	1.0 cubic feet per second
Long-Term Average Flow	162 cubic feet per second

The two major tributaries to the Root River are the Root River Canal and Hood's Creek. The Root River Canal enters the Root River 26 miles from its mouth. The long-term average annual flow of the Root River Canal is 53 cubic feet per second (cfs) with a range of 5 to 106 cfs. The total drainage area contributing to the Root River Canal is approximately 57 square miles. Hood's Creek joins the Root River 12 miles upstream from its mouth. The Hood's Creek drainage area is approximately 10 square miles. Though no precise data is available on the flow range of Hood's Creek, the creek is known to flow only intermittently during dry seasons and as wide as 12 feet during wet periods.

[3] United States Geological Survey and SEWRPC

About 65 percent of the total area of the watershed is rural, and 80 percent of this rural land is in agricultural use. Residential and industrial growth in the watershed is projected to continue. SEWRPC predicts that by 2035 the watershed will be 52 percent urban and only 48 percent rural.

The water quality of the river is designated for recreational use and for the maintenance of a warmwater fishery and other aquatic life. SEWRPC prepared a watershed management plan for Root River in 2014.

Pike River

The Pike River drains an area of approximately 51 square miles. About 40 percent of the area is in the planning area. The headwaters of the river are about three miles north of the Village of Sturtevant, and the river flows easterly and southerly through the northern part of the City of Kenosha to Lake Michigan. Approximately 46% of the watershed lies within the SSA.

About 80 percent of the total area of the watershed is still in rural land uses, with about 48 percent of the rural area in agricultural use. Most of the urban-related land uses are in the north-central and eastern portions of the watershed. Urbanization is expected to increase during the years of this Facilities Plan.

The long-term average annual flow of the Pike River is 40 cubic feet per second (cfs) with a range of 8 to 72 cfs. The Pike River is currently undergoing a long-term restoration project begun in 2001. The goals of the project include flood control, removal of properties and structures from the floodplain, ecological and habitat restoration and recreational corridor development.

Des Plaines River

The main stem of the Des Plaines River originates just south of Union Grove near the Racine-Kenosha County line and is located outside of the study area. A secondary stem of the Des Plaines River rises adjacent to I-94 near the Racine-Kenosha County line. The upstream portion of the watershed of this secondary stem is situated within the planning area.

With a watershed of 5.8 square miles and a river length of only a few miles situated within the planning area, the Des Plaines River is of minor importance. The area is significant however, for sewerage system planning for the planning area since it is located in a different catchment area from Lake Michigan.

4.6 Endangered Resources

According to the Wisconsin Natural Heritage Inventory database, a number of endangered resources have been identified in Racine County. Once more specific site locations are defined during design, the endangered resources impact review can be conducted. The most significant projects are planned for previously developed areas and road corridors.

5.0 Water Quality Standards

Effluent limitations are based on water use objectives and water quality standards and are developed to

achieve the objectives. In Wisconsin, these objectives and standards are established by Federal, State and regional agencies and administered through the Wisconsin Pollutant Discharge Elimination System (WPDES). Under this system, the WDNR issues WPDES permits to each discharger in the state, setting forth the effluent limitations which must be met.

Water Use Objectives and Water Quality Standards

Wisconsin water use objectives and water quality standards are promulgated and identified in Chapters NR 102, NR 103 and NR 104 of the Wisconsin Administrative Code with amendments and revisions being made as needed. Regional water quality objectives are developed through planning efforts of the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and are contained in A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds-- 2007[4] which is authorized under Section 208 of Public Law 92-500.

The Racine WWTP discharges to Lake Michigan through two outfall lines which extend 500 feet into the lake. Lake Michigan is designated to meet the standards for recreation, fish, and aquatic life and shall meet the requirements for public water supplies. The standards for recreation, fish, and aquatic life, and public water supplies are contained in Chapter NR 102 of the Wisconsin Administrative Code. These standards include the regulations on floating debris, toxic materials, maintenance of specified levels of dissolved oxygen, pH, temperature, suspended solids, bacteria counts, carcinogenic agents, taste and odor.

Current Effluent Requirements

Public Law 92-500 requires a National Pollutant Discharge Elimination System (NPDES) permit for any point source discharge of pollutants into the nation's navigable waters. Chapter 147, Wisconsin Statutes, authorizes the WDNR to "establish, administer and maintain a state pollutant discharge elimination system." This permit system, known as the Wisconsin Pollutant Discharge Elimination System (WPDES), conforms with the objectives and requirements of Public Law 92-500. The State of Wisconsin has expanded the permit system beyond the navigable waters concept by applying it to all receiving waters of the state.

On December 30, 2019, the Racine Wastewater Utility was granted WPDES Permit No. WI-0025194-09-0 for discharging effluent from the WWTP into Lake Michigan. A copy of this permit is contained in Appendix A. This permit expires December 31, 2024.

Table 5-1 presents the current effluent limitations and monitoring requirements.

[4] SEWRPC Planning Report No. 50

Table 5-1 Effluent Limits and Monitoring Requirements

Parameter	Limit Type	Limit and Units	Sample Frequency	Sample Type
Flow Rate		MGD	Daily	Continuous
BOD_5, Total	Weekly Avg	45 mg/L	Daily	24-Hr Flow Prop Comp
BOD_5, Total	Monthly Avg	30 mg/L	Daily	24-Hr Flow Prop Comp
Suspended Solids, Total	Weekly Avg	45 mg/L	Daily	24-Hr Flow Prop Comp
Suspended Solids, Total	Monthly Avg	30 mg/L	Daily	24-Hr Flow Prop Comp
pH Field	Daily Min	6.0 SU	Daily	Continuous
pH Field	Daily Max	9.0 SU	Daily	Continuous
Fecal Coliform	Weekly Avg	970 #/100 ml	Daily	Grab
Fecal Coliform	Monthly Avg	400 #/100 ml	Daily	Grab
E.coli		#/100 ml	Daily	Grab
Chlorine, Total Residual	Daily Max	38 µg/L	Per Occurrence	Grab
Chlorine, Total Residual	Weekly Avg	38 µg/L	Per Occurrence	Grab
Chlorine, Total Residual	Monthly Avg	38 µg/L	Per Occurrence	Grab
Nitrogen, Ammonia Variable Limit		mg/L	Daily	Calculated
Nitrogen, Ammonia (NH,-N) Total	Daily Max - Variable	mg/L	Daily	24-Hr Flow Prop Comp
Nitrogen, Ammonia (Nll,-N) Total	Weekly Avg	62 mg/L	Daily	24-Hr Flow Prop Comp
Nitrogen, Ammonia (NH,-N) Total	Monthly Avg	25 mg/L	Daily	24-Hr Flow Prop Comp
Nitrogen, Total Kjeldahl		mg/L	Quarterly	24-Hr Flow Prop Comp
Nitrogen, Nitrite+ Nitrate Total		mg/L	Quarterly	24-Hr Flow Prop Comp
Nitrogen, Total		mg/L	Quarterly	Calculated
Phosphorus, Total	Monthly Avg	0.86 mg/L	Daily	24-Hr Flow Prop Comp
Mercury, Total Recoverable	Daily Max	4.0 ng/L	Monthly	Grab
Hardness, Total as $CaCO_3$,		mg/L	Quarterly	24-Hr Flow Prop Comp
Arsenic, Total Recoverable		µg/L	Quarterly	24-Hr Flow Prop Comp
Cadmium, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp
Chromium, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp
Copper, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp
Lead, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp
Nickel, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp
Zinc, Total Recoverable		µg/L	Monthly	24-Hr Flow Prop Comp
Temperature Maximum		Deg F	3/Week	Continuous
Temperature Maximum	Weekly Avg	61 deg F	3/Week	Continuous
Temperature Maximum	Weekly Avg	62 deg F	3/Week	Continuous
Temperature Maximum	Weekly Avg	52 deg F	3/Week	Continuous
Chronic WET		TUc	See Listed Qtr(s)	24-Hr Flow Prop Comp
Acute WET		TU,	See Listed Qtr(s)	24-Hr Flow Prop Comp

Future Permit Requirements

In the current permit, total phosphorus is listed as an interim limit of 0.86 mg/l. This is classified as an interim limit pending the development of a near shore or whole lake model for Lake Michigan. WDNR may incarnate stricter phosphorus limits in the future. RWU is required to continue to implement and report on phosphorus removal optimization during this permit period.

RWU is required to perform a dissipative cooling evaluation and take actions to meet the effluent temperature limits. Those limits are effective October 1, 2023.

Existing Plant Performance

The current treatment facility is meeting all discharge permit requirements.

6.0 Existing Conveyance System

6.1 General Overview – Racine Wastewater Utility

The Racine Wastewater Utility (RWU) owns and operates the wastewater interceptor system and treatment plant and provides conveyance and treatment, under contractual agreement, for the City of Racine and five sewer service recipients (SSR) communities and the Villages of Elmwood and North Bay. The eight communities currently served by the Utility are:

- City of Racine
- Village of Mt. Pleasant
- Village of Caledonia
- Village of Sturtevant
- Village of Elmwood Park
- Village of North Bay
- Village of Wind Point
- A portion of the Town of Somers, Kenosha County (KR Utility District)

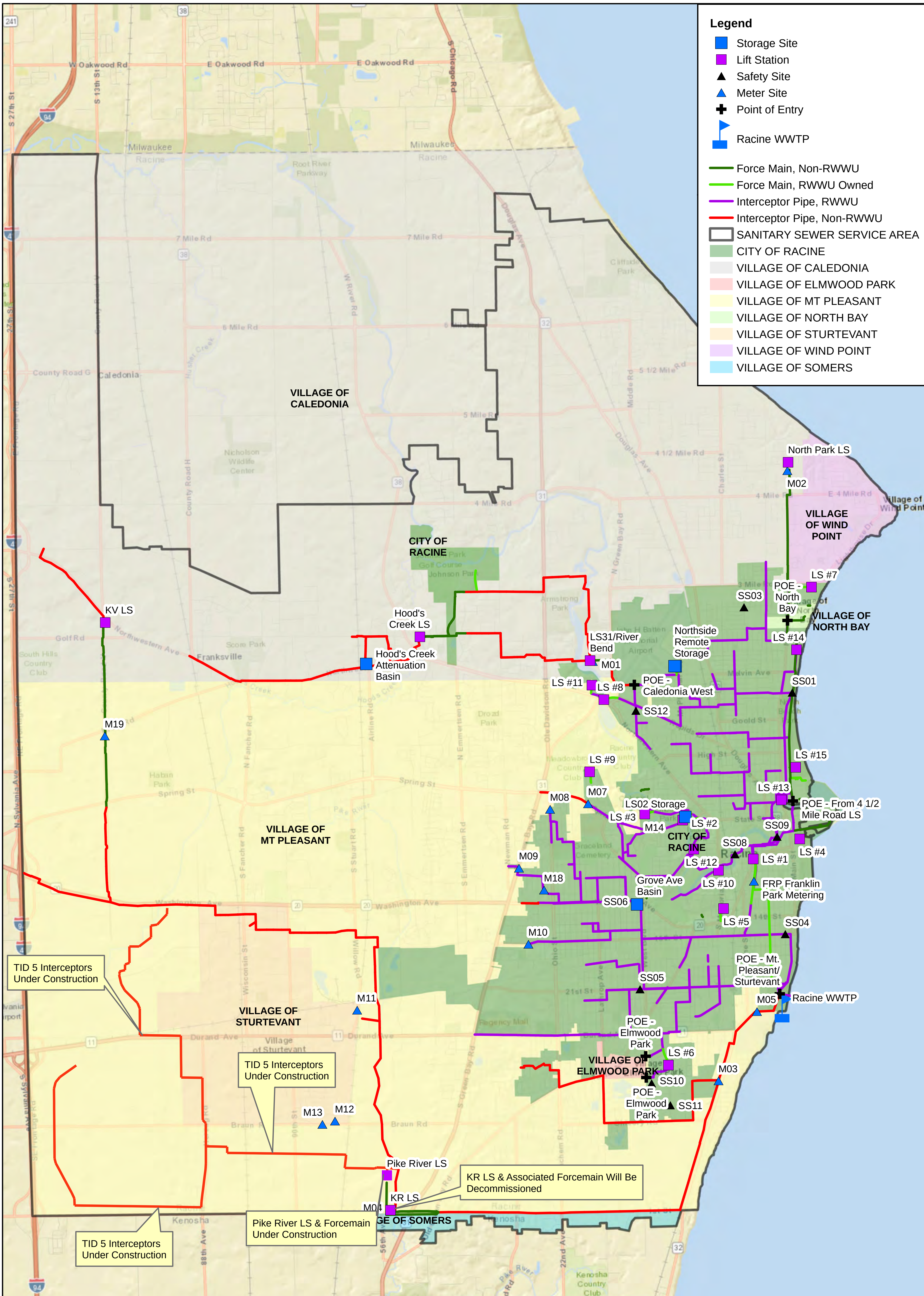
The sanitary sewer service area for the above entities is shown on Figure 6-1.

The Utility does not fund, operate, or control the collection systems of the five SSRs, including North Bay and Elmwood, which are owned by each community. The SSRs discharge to various locations in the Utility's interceptor system and flows are monitored at significant connection points. Under contract to the City of Racine, the Utility provides maintenance of the City's collection system. The Utility is not responsible for the City of Racine or each SSR's implementation of Capacity, Management, Operation and Maintenance (CMOM) measures within those organizations. Agreements are in place that identify which sewers within the City of Racine are the responsibility of the City and which are the responsibility of the Utility.

6.2 Lift Stations and Safety Sites

The Racine Wastewater Utility owns and operates lift stations which serve the City of Racine and many of the SSRs. The Utility, under contract with the City of Racine, also provides design and sewer system maintenance for the City of Racine. The local collector systems, however, remain the property of the City of Racine. The sanitary sewer system within the City (City and Utility) is a conventional gravity flow system with sewer diameters ranging from 4 to 84 inches. There are 14 lift stations in this portion of the system. Thirteen of the fourteen lift stations provide service to relatively small collector system networks. Lift Station No. 1 is a major lift station on the interceptor network with a rated capacity of 90 MGD. This station pumps wastewater from portions of the City of Racine, the Caledonia Utility District and portions of the Mt Pleasant Utility District.

Racine Wastewater Utility lift station data including identifying number, location and capacity are presented in Table 6-1. Not included are small lift stations serving a single building, or service areas with low wastewater flows such as golf courses and parks.



AECOM

Figure 6-1
Sanitary Sewer System Major Components

Projection:
NAD_1983_2011_StatePlane_Wisconsin_South_FIPS_4803_Ft_US

Drawn By: JFP
Checked By:
Date:
Project #: 60554970

Racine Facilities Plan
Racine Wastewater Utility

0 0.5 1 2 Mile

Table 6-1. RWU Lift Station Location and Capacity

Lift Station Number	Lift Station Location	Total [1] Capacity (MGD)	Firm [2] Capacity (MGD)
LS-01**	736 Washington Avenue	112	90
LS-02**	2022 Spring Street & Luedtke Court	9.07	6.05
LS-02*	2022 Spring Street & Luedtke Court	2.88	1.44
LS-03	1004 Riverbrook Drive	0.648	0.324
LS-04	Festival Site/ 6-5th Street	1.82	0.91
LS-05	1530-13th Street & Lockwood Avenue	2.06	1.03
LS-06**	3236 Drexel Avenue	4.32	2.88
LS-07	45 Steeplechase Drive	1.224	0.612
LS-08	3625 Rapids Court at Root River	5.27	3.51
LS-09	3908 Frances Drive and Harrington Drive	0.34	0.172
LS-10	800 South Memorial Drive & Root River	3.67	2.44
LS-11	2750 Old Mill Road	0.792	0.396
LS-12	334 Park View Drive	0.346	0.173
LS-13	1100 N. Main Street	0.128	0.064
LS-14	3205 Michigan Boulevard	1.44	0.72

Note 1: Total Capacity is the estimated capacity with all pumps in service.
Note 2: Firm Capacity is the estimated capacity with the single largest pump out of service.
* This is an emergency bypass pump at LS02.
** Modeled lift station.

Presented in Table 6-2 are major lift stations included in the conveyance system which are owned and operated by SSR communities.

Table 6-2. SSR Lift Stations

Lift Station Name	Lift Station Location	Community
KR	CTH KR	Mount Pleasant
KV	CTH K & CTH V	Caledonia
North Park	4 ½ Mile Road & Birchview Road	Caledonia
Hood's Creek	South Lane & Gifford Road	Caledonia
LS-31/River Bend	River Bend Drive & Dan-Mor Lane	Caledonia
Pike River	Along the west side of Pike River approximately 2000' north of CTH KR	Mount Pleasant

There are 16 untreated wastewater discharge sites located throughout the conveyance system (11 Safety Sites and 5 Lift Station discharge sites) and another discharge site at the headworks of the WWTP. Discharges through the safety sites (manholes) are deemed sanitary sewer overflows and are prohibited. RWU must report any discharges through these safety sites. The flow rate and hours of diversion to the waters of the state must be reported on the Utility's Discharge Monitoring Reports. The safety sites listed in RWU's NPDES permit can be found in Table 6-3.

Lift Station and WWTP discharge site numbers and locations are also presented in Table 6-3.

Table 6-3. Safety Site Number and Location

No.	Location	Manhole
SS 01	Augusta Street & Michigan Avenue	SS-AC003
SS 02	Michigan Boulevard & South Street Extended.	SS-B0045
SS 03	Carlton Drive & La Salle Street	SS-B0133R
SS 04	16th Street & College Avenue	SS-T0005
SS 05	21st Street & Grove Avenue	SS-U0040
SS 06	Washington Avenue & Grove Avenue	SS-Z0010
SS 08	East 6th Street Siphon	SS-QQ006
SS 09	Ontario Street & 4th Street Siphon	SS-MC001
SS 10	Spruce Street & Brentwood Court	SS-U0430
SS 11	Knoll Place & Norwood Drive	SS-KK005
SS 12	Golf Avenue & Conrad Drive	SS-A0428
LS 02	Spring Street & Luedtke Court LS #2	SS-Y0001
LS 06	Drexel Avenue & Maryland Avenue	SS-U0352
LS 07	Steeple Chase Drive	SS
LS 08	Rapids Court LS #8	SS-BB005
LS 09	Frances Drive & Harrington Drive LS #9	Station
WWTP	21st Street & Roosevelt Avenue	SS-U0904

Sanitary sewer level indicators have been installed as part of Instrument and Controls system monitoring for optimizing the operation of Lift Station No. 1 (LS-01) and the Northside Remote Storage Facility equalization basin. Level indicator locations are shown in Table 6-4.

Table 6-4. Level Monitoring Locations

No.	Location
1	200 Augusta Street
2	501 Augusta Street
3	209 Dodge Street
4	303 Dodge Street
5	1549 College Avenue
6	1200 6th Street
7	540 Ontario Street
8	Gaslight Point 1 Main Street

The current RWU rain gauge network includes a total of nine sites spread throughout the sewer service area. Rainfall is tracked at the WWTP through telemetry at each of the rain gauge sites. Rain gauge locations are presented in Table 6-5.

Table 6-5. Rain Gauge Locations

No.	Location
1	North Park Sanitary District
2	S12 – Golf Avenue and Conrad Court
3	Bryn Mawr Metering Station
4	Perry Avenue Water Tank – 16th Street and Perry Avenue
5	KR Metering Station
6	Festival Park - Racine Lake Front
7	Wastewater Treatment Plant – 21st Street and Wisconsin Avenue
8	21st Street and Grove Avenue
9	Water Department – 100 Hubbard Street
10	Echo Lane

RWU owns and operates five storage facilities in the sewer conveyance system. Table 6-6 presents the conveyance system storage facilities, plus one inline storage system, with their capacity and other attributes.

Table 6-6. Conveyance System Storage and Capacity Summary

Storage Name Location	Ownership	Total Storage Capacity (MG)	Flow Source
Northside Remote Storage Facility - 3026 Mt. Pleasant St.	RWU	8.4	Caledonia-Riverbend Lift Station
Grove Ave. Storage - 1218 Grove Ave.	RWU	0.65	Racine and Mt. Pleasant
Ohio Street Inline Storage - (North side of Lockwood Park)	RWU	0.16	Racine and Mt. Pleasant
LS02 Storage - Brose Park	RWU	2.4	Mt Pleasant and Racine
Wastewater Treatment Plant - EQ Basins	RWU	2 Basins 2.7 MG Each	Entire Planning Area
Hood's Creek Attenuation Basin	Caledonia	1.5	Caledonia

Wastewater flows are monitored and tracked at the WWTP for lift stations, safety sites, storage basins, and satellite community connection points. A radio telemetry system is used to transmit data from these sites to the Wastewater Treatment Plant on a continuous basis.

Table 6-7 presents the wastewater flow metering locations.

Table 6-7. Wastewater Flow Metering Locations

Meter No.	Location	Community Meter
1	River Bend Lift Station – River Bend Drive	Caledonia
2	North Park Lift Station – 4 1/2 Mile Road	Caledonia
3	HWY 32 & Bryn Mawr Avenue	Mount Pleasant
4	KR Lift Station	Mount Pleasant
5	24th Street & Howe Street	Mount Pleasant
6	Northwestern Avenue & Rapids Drive	Mount Pleasant
7	Spring Street & Spring Valley Drive	Mount Pleasant
8	Shirley Avenue & Ohio Street	Mount Pleasant
9	Westmore Drive & Green Bay Road	Mount Pleasant
10	16th Street & Ostergaard Avenue	Mount Pleasant
11	Willow Road & Cobble Court	Sturtevant
12	Willow Road & Braun Road	Mount Pleasant
13	Citadel & Braun	Mount Pleasant
14	Colonial Heights, Riverbrook Drive	Mount Pleasant
18	Echo Lane & Crab Tree	Racine
19	CTH V & CTH K	Caledonia
Other	Northside Remote Storage	Caledonia
Other	Franklin Park	Racine

Figure 6-1 shows the locations of the Racine Wastewater Utility Lift Stations, Safety Sites, Level Monitors, Rain Gauges, Equalization Storage Basins and Flow Meters.

7.0 Description And Evaluation Of Existing Wastewater Treatment Plant

The Racine Wastewater Utility operates a wastewater treatment plant (WWTP) which treats wastewater generated within the Racine Sewer Service Area. The treatment facilities were originally constructed at the existing site in 1938. These facilities and all subsequent facilities were constructed on lake fill. A plant expansion including secondary treatment facilities was constructed in 1968. The facilities were further expanded in 1977. A peak flow equalization basin was added in 1992. A second peak flow equalization basin was added in 2005. In general accordance with the 1998 Facilities Plan, the plant was most recently expanded and upgraded in 2005 as shown in site plan Figure 7-1 and process flow diagram Figure 7-2.

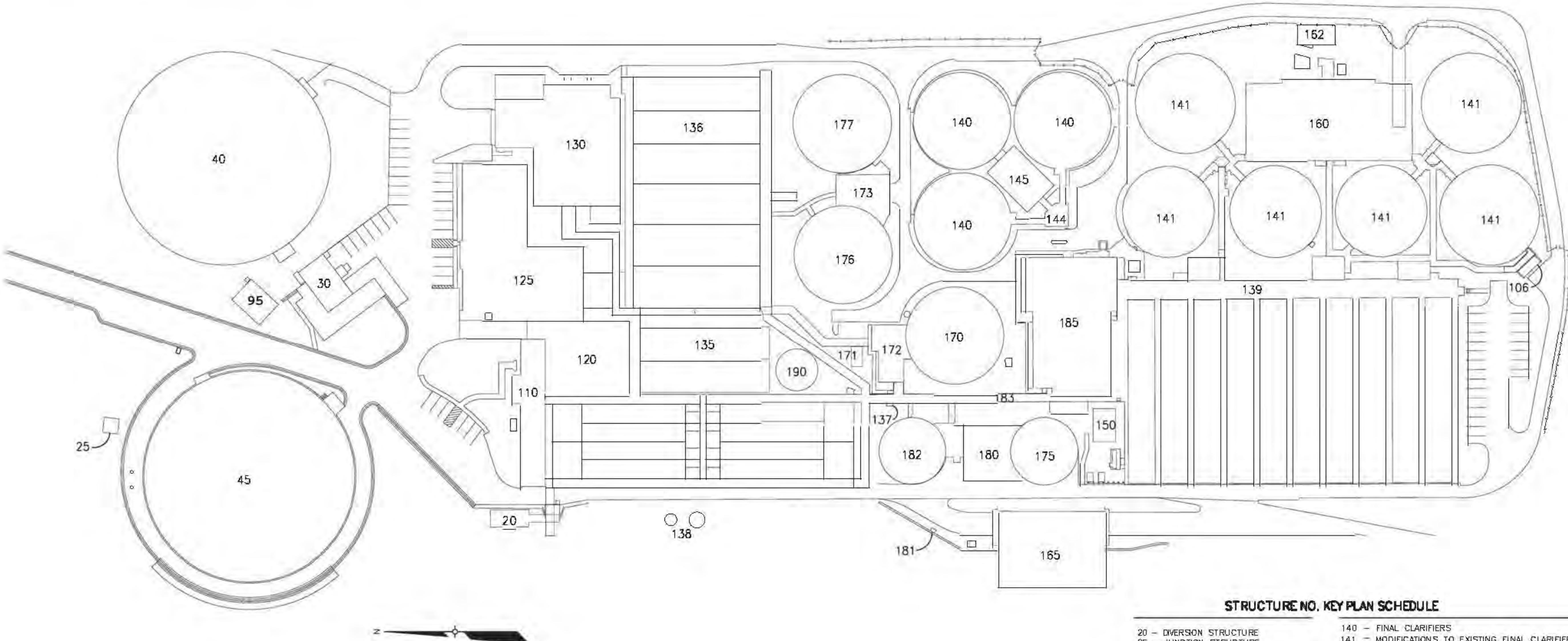
Description of Plant Process & Equipment

The Racine WWTP is a conventional activated sludge plant with a design average daily flow capacity of 36 MGD. Phosphorus is removed chemically using ferric chloride. Secondary treatment effluent is disinfected via ultraviolet (UV) disinfection prior to discharge to Lake Michigan. Dewatered sludge is contract hauled, stored and land applied.

Wet weather optimization facilities manage flows in excess of 95 MGD via two flow equalization basins in parallel that provide primary clarification with effluent disinfected via sodium hypochlorite and sodium bisulfite dechlorination prior to combining with disinfected secondary treatment effluent.

The treatment plant unit processes include (See Unit Process Equipment Table 7-1):

1. Flow Equalization with Screening, Primary Clarification and Sodium Hypochlorite Disinfection
2. Preliminary Treatment with Screening and Grit Removal
3. Primary Clarifiers with Sludge and Scum Removal
4. Aeration Tanks with Activated Sludge
5. Final Settling Clarifiers with Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) Pumping
6. UV Disinfection
7. Aeration Blowers
8. Sludge Thickening
9. Anaerobic Sludge Digestion and Biogas
10. Sludge (Biosolids) Dewatering
11. Ferric Chloride Chemical Feed for Phosphorus Removal
12. Plant Water and Heating Systems



STRUCTURE NO. KEY PLAN SCHEDULE

20 – DIVERSION STRUCTURE
25 – JUNCTION STRUCTURE
30 – EQ SCREENING BUILDING
40 – EAST EQUALIZATION BASIN EQ 1
45 – WEST EQUALIZATION BASIN EQ 2
95 – SODIUM HYPOCHLORITE BUILDING
106 – VACTOR DUMP STATION
106 – VACTOR DUMP STATION
110 – ADMINISTRATION BUILDING
120 – CHEMICAL WING
125 – PRETREATMENT BUILDING (REMOVALS)
125 – LAB/OFFICE (NEW)
130 – PRELIMINARY TREATMENT BUILDING
135 – PRIMARY CLARIFIERS (WEST BANK)
136 – PRIMARY CLARIFIERS (EAST BANK)
137 – PRIMARY CLARIFIER TUNNEL
138 – WEST DRAIN PUMP STATION
139 – AERATION BASIN/GALLERY
140 – FINAL CLARIFIERS
141 – MODIFICATIONS TO EXISTING FINAL CLARIFIERS
144 – DISTRIBUTION BOX
145 – RAS PUMP STATION
150 – PLANT GENERATOR BUILDING
160 – UV DISINFECTION
162 – EFFLUENT JUNCTION BOX
165 – SOLIDS PROCESSING BUILDING
170 – DIGESTER "B"
171 – ACCESS VAULT
172 – DIGESTER CONTROL BUILDING NO.1
173 – DIGESTER CONTROL BUILDING NO.2
175 – DIGESTER "E"
176 – DIGESTER "A"
177 – DIGESTER "D"
180 – DIGESTER CONTROL BUILDING NO.3
181 – WASTE GAS BURNER NO.2
182 – DIGESTER "C"
183 – TUNNELS
185 – MAIN EQUIPMENT BUILDING
190 – GAS STORAGE SPHERE
250 – GENERATOR BUILDING (OFF SITE)

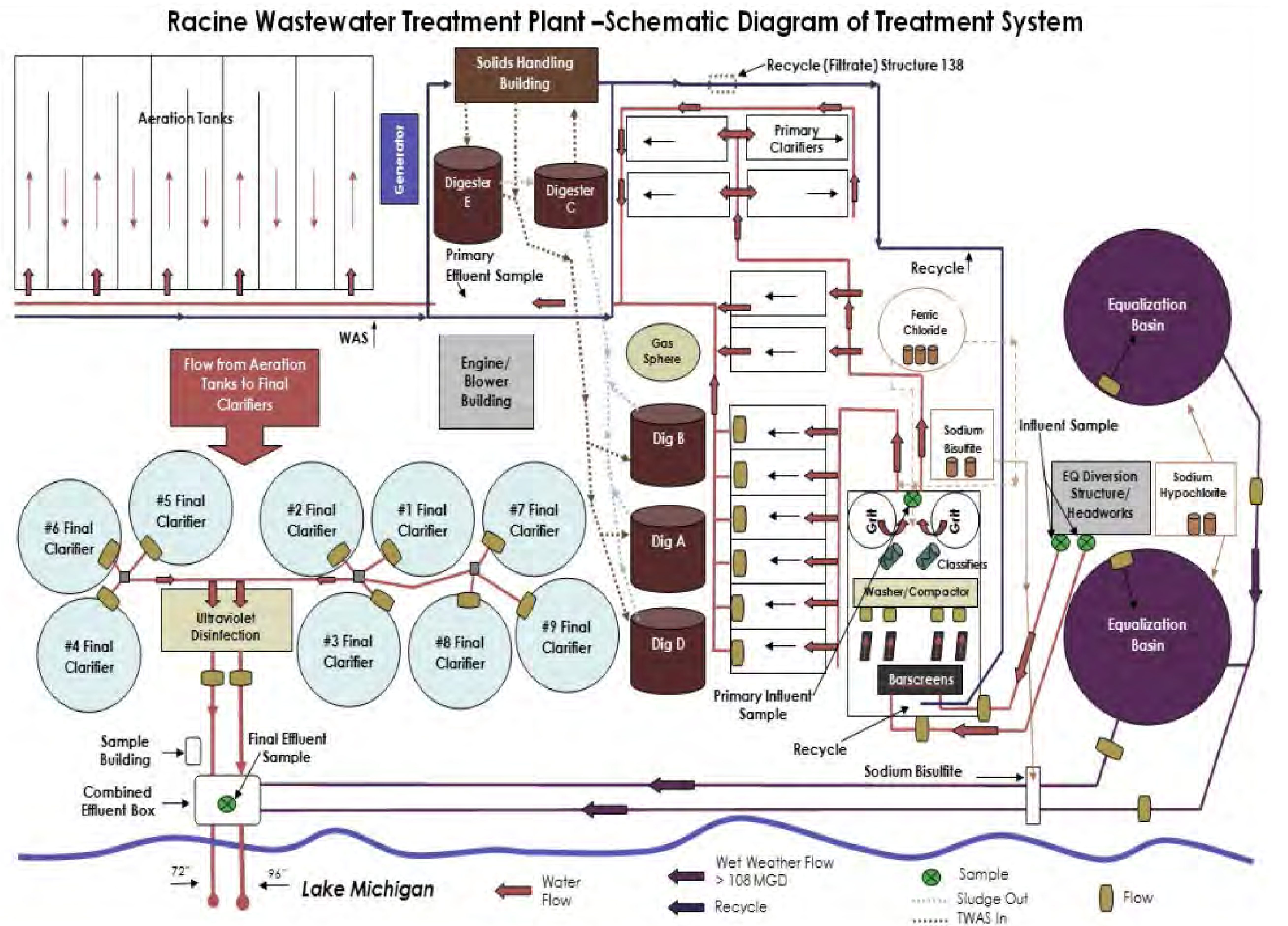
Projection:

Figure 7-1
Racine WWTP Existing Facility Site Plan

Racine Facilities Plan
Racine Wastewater Utility

[redacted]

Drawn By: JFP
Checked By: MJZ
Date:
Project #: 60554970



*SOURCE: 2018 ANNUAL REPORT

Projection:

Figure 7-2
WWTP Treatment Schematic

Racine Facilities Plan
Racine Wastewater Utility

[redacted]

Drawn By: JFP
Checked By: MJZ
Date:
Project #: 60554970

Table 7-1. Racine Wastewater Treatment Facility Unit Process Data

Flow Equalization Basins (Structure 40 and 50)	
Manufacturer (clarifier mechanism)	Envirex
Number	2
Size	200 ft diameter x 9.71 ft SWD
Surface Area	62,832 ft^2
Volume	2.7 million gallons each
Structure 30 Bar Screens - Number	2
Basin Installation Years	1992, 2005
Mechanical Bar Screens (Structure 130)	
Manufacturer	Vulcan
Number	4
Width	6 ft
Clear Opening	½ inch
Capacity (maximum)	35 MGD, each
Installation Year	2005
Vortex Grit Units	
Manufacturer	Smith & Loveless/Jones & Atwood
Number	2
Diameter	24 ft
Capacity (maximum)	70 MGD, each
Grit Pump	
Number	2
Capacity	250 gpm, each
Grit Concentrator	
Number	2
Capacity	250 gpm, each
Grit Screw Conveyor	
Number	2
Screw Diameter	9 inch
Installation Year	2005
Ferric Chloride Feed Pumps	
Manufacturer	Wallace and Tiernan – Pennwalt
Number	3
Type	Diaphragm, dual head
Motor	3 hp, DC variable speed
Ferric Chloride Storage Tanks	
Number	3
Dimensions	12 ft diameter x 16.5 ft
Volume	12,000 gal, each
Total Volume	36,000 gal
Primary Clarifiers	
Equipment Manufacturer	Envirex
Type	Rectangular, Chain and Flight

Table 7-1. Racine Wastewater Treatment Facility Unit Process Data

Primary Clarifiers Continued	
Number	12
Size (W x L x SWD)	4 @ 34.5 ft x 137.5 ft x 10.5 ft (Tanks 135- No. 1,2,3,4) 4 @ 38 ft x 120 ft x 8. ft (Tanks 136- No. 7,8,9,10) 2 @ 30 ft x 115 ft x 8 ft (Tanks 135- Nos. 5 and 6) 2 @ 30 ft x 120 ft x 8 ft (Tanks 136- Nos. 11 and 12)
Surface Area	51,315 ft^2 total
Volume	3.425 mgal, total
Hydraulic Retention Time (HRT) @ 36 MGD Design Ave Flow @95 MGD Peak Hourly Flow	 2.3 hours 1.2 hours
Surface Overflow Rate (SOR) @ 36 MGD	 773 gpd/ft^2
Installation Years	1938, 1977, 2005
Primary Sludge Pumps	
Manufacturer	Moyno
Number	6
Type	Progressing Cavity
Capacity	215 gpm @ 30 psig, each
Motor	15 hp
Installation Year	2002-2005
Primary Scum Pumps	
Manufacturer	Yeomans
Number	2
Type	Pneumatic Ejector
Capacity	100 gpm @ 50 ft
Air Requirement	90 cfm @17 psig (maximum)
Installation Year	2002-2005
Aeration Blowers	
Manufacturer	Roots
Number	5
Type	Positive Displacement
Capacity	1 @ 11,000 icfm, 7.9 psig, 500 hp, 720 rpm motor 1 @ 8,000 icfm, 9.0 psig, 440 hp, 935 rpm engine 1 @ 11,000 icfm, 9.0 psig, 675 hp, 935 rpm engine 1 @ 7,100 icfm, 9.0 psig, 300 hp, 720 rpm motor 1 @ 9,600 icfm, 9.0 psig, 440 hp, 935 rpm engine
Firm Capacity @ 7.9 psig @ 9.0 psig	 35,700 icfm 17,500 icfm
Aeration Tanks	
Diffuser Manufacturer	Sanitaire
Diffuser Type	Fine Pore Ceramic Disks
Diffuser Submergence	12.75 ft
Number	5, each 2-pass

Table 7-1. Racine Wastewater Treatment Facility Unit Process Data

Aeration Tanks Continued	
Size	30 ft x 168 ft x 15 ft, each pass
Volume	5.65 million gallons, total
Oxygen Transfer Capacity @ 35,700 icfm to blower @ 17,500 icfm to blower	 65,800 lb O_2 xfer/day (field transfer rate) 34,300 lb O_2 xfer/day (field transfer rate)
Installation Years	1990
Final Clarifiers	
Manufacturer	Envirex
Size	3 @ 85 ft diameter x 12 ft SWD Clarifier #1, 2 &5 3 @ 93 ft diameter x 12 ft SWD Clarifier #3, 4, & 6 3 @ 90 ft diameter x 14 ft SWD Clarifier #7-8-9
Volume	5.36 mgal, total
Surface Area	56,487 ft^2, total
Weir Length	2,413 ft
Detention Time @ 30 MGD @ 70 MGD	 4.28 hours 1.84 hours
Surface Overflow Rate @ 30 MGD @ 70 MGD	 531 gpd/ft^2 1,239 gpd/ft^2
Installation Years	3 in 1968, 3 in 1976, 3 in 2005
RAS Pumps	
Manufacturer	Chicago Pump Chicago Pump/Yeomans
Number	13
Type	Centrifugal
Capacity	9 @ 3,400 gpm @ 20 ft 4 @ 4,500 gpm @ 35 ft
Motor	25 hp (Pump Nos. 2-4, 6-8, 10-12) 60 hp (Pump Nos. 13-16)
Installation Year	2002 -2005 (Pump Nos. 13-16)
WAS Pumps	
Manufacturer	Chicago Pump Chicago Pump/Yeomans
Number	4
Type	Centrifugal
Capacity	700 gpm @ 35 ft, each
Motor	10 hp (Pump Nos. 1, 5, 9) 15 hp (Pump No. 17)
Installation Years	1968 (Pump No. 1), 1976 (Pump No. 5), (Pump No. 9), 2002-2005 (Pump No. 17)
Secondary Scum Pumps	
Manufacturer	Yeomans
Number	2
Type	Pneumatic Ejector
Capacity	100 gpm @ 50 ft

Table 7-1. Racine Wastewater Treatment Facility Unit Process Data

Secondary Scum Pumps Continued	
Air Requirement	90 cfm @17 psig (maximum)
Installation Year	2002-2005
UV Disinfection	
Manufacturer	Trojan
Number	2
Type	Model UV 4000
Channel Width	6 ft
Number of Lamps	320, total
Capacity	108 MGD, total
Power Consumption	896 kW (maximum)
Anaerobic Digesters	
Number	5
Primary Digester Size	3 @ 90 ft diameter x 18 ft SWD
Total Volume of Primary Digesters	3.00 Mgal (401,000 ft^3)
Secondary Digester Size	2 @ 60 ft diameter x 47.25 ft SWD
Total Volume of Secondary Digesters	2.06 Mgal (275,000 ft^3)
Total Digester Volume	5.06 Mgal (676,000 ft^3)
Sludge Thickening	
Thickener Feed Pumps	
Manufacturer	Moyno
Number	2
Type	Progressing Cavity
Capacity	450 gpm @ 100 ft, each
Motor	40 hp
Installation Year	2002-2005
Polymer Feed System	
Manufacturer	Stranco
Number	2
Polymer Feed Pump Capacity	18 – 180 gph
Installation Year	2002-2005
Gravity Belt Thickeners	
Manufacturer	Ashbrook
Number	2
Size	2 meter
Feed Solids Concentration	0.4 – 1.0 %
Capacity Design Maximum Solids Loading, each Design Average Solids Loading, each Allowable Hydraulic Loading, each Design Average Hydraulic Feed Rate, each	 916 lb dry solids/hr 708 lb dry solids/hr 600 gpm 224 gpm
Thickened Sludge Solids	4 – 8 %
Thickened Sludge Pumps	
Manufacturer	Moyno

Table 7-1. Racine Wastewater Treatment Facility Unit Process Data

Sludge Thickening Continued	
Number	2
Type	Progressing Cavity
Capacity	69 gpm @ 100 ft, each
Motor	7.5 hp
Installation Year	2002-2005
Sludge Dewatering	
Belt Press Feed Pumps	
Manufacturer	Moyno
Number	6
Type	Progressing Cavity
Capacity	240 gpm @ 100 ft, each
Motor	20 hp
Installation Year	2002-2005
Polymer Feed System	
Manufacturer	Stranco
Number	2
Polymer Feed Pump Capacity	57.5 – 575 gph
Installation Year	2002-2005
Belt Presses	
Manufacturer	Ashbrook
Number	6
Size	2 meter
Feed Solids Concentration	2–4 %
Capacity Allowable Solids Loading, each Design Solids Loading, each Maximum Hydraulic Feed Rate, each	 2,400 lb dry solids/hr 750 lb dry solids/hr 240 gpm
Thickened Sludge Solids	24 – 28 %

7.1 Flow Equalization

Flow Equalization Basins

The Racine Wastewater Treatment Plant has two flow equalization basins designed to reduce flow to the treatment plant during periods of high influent flow. Influent flows to the site via 84-inch and 72-inch collection system sewers. Flow exceeding a rate of approximately 95 MGD (million gallons per day) overflows weirs at the influent channel at the Equalization Screening Building 30 and is screened by mechanically cleaned bar screens prior to flowing to the basins. Both equalization basins are 200 feet in diameter and have a storage capacity of 2.7 million gallons each. The basins serve as primary clarifiers during peak flow events.

The two flow equalization basins each have a surface area of approximately 31,400 ft^2, for a total of 62,800 ft^2. In an overflow condition, the basins have a theoretical capacity of 94 MGD each, based on the maximum hourly surface settling rate of 1,500 gpd/ft^2 from Chapter NR 110.

Wastewater in the basins is returned to the treatment flow scheme by gravity and by pumping. It is normally returned to the headworks for full treatment but can be pumped to the aeration basins for secondary treatment, or to the digesters for sludge handling. Wastewater stored in the flow equalization basins is reintroduced into the normal wastewater stream as plant capacity is available.

Sodium Hypochlorite / Sodium Bisulfite

Sodium hypochlorite is provided for odor control of wastewater temporarily stored in the equalization basins and for disinfection of wastewater which may overflow the equalization basins. Sodium hypochlorite is stored in two tanks located in Building 95. Hypochlorite feed pumps are controlled by flow pacing and there are multiple points of application.

If peak flow exceeds equalization capacity, the basin effluent is chlorinated, then dechlorinated using sodium bisulfite before combining with the plant effluent. Dechlorination occurs at the downstream dechlorination Structure 47 via flow paced chemical metering pumps with injection into the EQ Basin effluent through diffusers. Dechlorination can also be performed at the effluent junction chamber (Structure 162) via a temporary line and a manually controlled feed system.

7.2 Preliminary Treatment

Influent Flow to Headworks: From the headworks junction chamber, two 54" diameter pipes direct the flow into the Preliminary Treatment Building.

Mechanically Cleaned Bar Screens and Washing Presses: Preliminary Treatment Building 130 contains four bar screens in six-foot-wide channels. Each screen has a rated maximum capacity of 35 MGD. The spacing between the individual bars is one-half inch. Course 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.

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 from the vortex grit removal system. The concentrators each have a capacity of 250 gpm. Concentrated grit and screenings are transported by conveyors to the Container Room and deposited in dumpsters.

Dechlorination System: The sodium bisulfite feed facility is located in the Sodium Bisulfite Room in the Preliminary Treatment Building. The room is isolated from the bar screen and grit unit areas. There are two feed systems and one storage tank. The feed systems have a capacity of 125 gpm each and the storage tank has a volume of approximately 10,000 gallons. Sodium bisulfite is fed from this location to the discharge from the stormwater clarifiers.

7.3 Primary Treatment

Primary Clarifiers**:** There are a total of twelve primary clarifiers in rectangular concrete structures. There are six clarifiers in the west bank and six in the east bank. Four of the west bank clarifiers were constructed in the late 1930s and two were constructed in 2002-2005 The six east battery primary clarifiers were constructed in 1973 and 2002-2005.

Mechanical scrapers push settled sludge to pits for removal by pumping to the digesters. These same scrapers also push floating scum to troughs that enable the scum to be pumped to the digesters.

The four older west bank clarifiers are 137.5 feet long by 34.5 feet wide by 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 clarifiers has four clarifiers that are 120 feet long by 38 feet wide by 8 feet deep. The other two east bank clarifiers are 128 feet long by 30 feet wide by 10.5 feet deep. Four of the clarifiers in the west bank each have a surface area of approximately 4,700 ft^2 and the other two clarifiers each have a surface area of 3,400 ft^2. The six east bank clarifiers each have a surface area of approximately 4,600 ft^2.

The capacity of the primary clarifiers is 80 MGD, based on the maximum hourly surface settling rate of 1,500 gpd/ft^2 from Chapter NR 110. Higher flows are acceptable by Ten States Standards, however, reduced BOD and TSS removal performance would occur. Total primary clarifier volume is 3.7 million gallons.

<u>Primary Influent Channel Blowers</u>**:** Two blowers (100 HP) with a capacity of 2500 CFM are used to keep solids in suspension through diffused air mixing in channel flow until the flow reaches the primary clarifiers. This aeration also helps with odor control by providing some dissolved oxygen to the primary influent.

<u>Pipe Gallery:</u> Connection between primary plant and secondary plant. All necessary systems run through the pipe gallery.

7.4 Activated Sludge Treatment

<u>Aeration Tanks:</u> The aeration tanks are two pass tanks, each pass measuring 168 feet by 30 feet by 15 feet. The total volume of five aeration tanks equals 5.65 million gallons. The aeration system can be operated in several modes. Currently the conventional activated sludge process is being used. It consists mainly of microbiological organisms (“bugs”) and organic material (wastewater). The contents are mixed by the introduction of air through (9-inch diameter) ceramic fine bubble diffuser discs located along the length of each tank. The air also provides a supply of oxygen for the microorganisms which feed and multiply on organic materials contained in the wastewater. The resulting mixed liquor is transferred from the aeration tanks to the Final Clarifier tanks where settling occurs followed by return pumping microorganisms to the aeration tanks or waste pumping of excess organisms.

7.5 Final Settling

<u>Final Clarifiers</u>: There are nine rim fed Final Clarifiers; three 85-foot diameter units, three 93-foot diameter units and three 90-foot diameter units. The total volume equals 5,930,000 gallons. The activated sludge from the aeration tanks settles in the final tanks.

The Final Clarifiers have a total surface area of approximately 56,500 ft^2. Using a maximum hourly surface overflow rate of 1,200 gpd/ft^2 from Chapter NR 110, the peak flow for Final Clarifiers is approximately 68 MGD. However, the clarifiers have performed well up flows of around 95 MGD. The overflow rate at this flow is approximately 1,680 gpd/ft^2.

Settled sludge is drawn through rotating collector tubes and the connected piping system by pumps, which return the major portion to the aeration tanks. Because a balance must be maintained between the number of microorganisms held in the secondary treatment plant and the food supply in the primary effluent, excess waste activated sludge (WAS) is pumped to the gravity belt thickeners. The ability to pump the WAS to the primary clarifiers is also provided.

There are thirteen RAS pumps. Nine pumps have a capacity of 3,400 gpm each at 20 feet total discharge head (TDH). These pumps are dedicated to Final Clarifiers #1 – #6. Four pumps have a capacity of 4,500 gpm each at 35 feet TDH. These pumps are dedicated to Final Clarifiers #7 – #9. There are three backup RAS pumps for Final Clarifiers #1 – #6 and one backup RAS pump for Final Clarifiers #7 – #9. The total firm RAS pumping capacity is 48.8 MGD.

There are three WAS pumps for Final Clarifiers #1 – #6 and one WAS pump for Final Clarifiers #7 – #9. The WAS pumps have a capacity of 700 gpm each at 35 feet TDH.

The clarified water, secondary effluent, flows by gravity to the UV system for disinfection.

7.6 Ultraviolet Light and Sodium Hypochlorite Disinfection

Ultraviolet light is used to provide disinfection of Final Clarifier effluent. A sodium hypochlorite system is used to provide disinfection of wastewater delivered from the flow equalization basins as well as for filament control at the south end of the plant. The facility is required to disinfect its effluent year around. The monthly average effluent limit for fecal coliform is less than FF400 colonies per 100 ml; however, the pathogen standard has changed and the next permit will have more stringent limits based on E. coli bacteria.

There are two UV reactors in six foot wide channels. Each reactor is comprised of eight modules with 20 lamps per module, for a total of 320 lamps. The UV disinfection system provides a minimum dosage of 24,000 microwatt-seconds/cm^2 at a flow of 108 MGD. The dosage will need to be increased for E.coli disinfection.

The facility utilizes liquid sodium hypochlorite for disinfecting Flow Equalization Basin effluent and liquid sodium bisulfite for dechlorination. Liquid hypochlorite is also used for controlling odors.

7.7 Aeration Blowers

Aeration Control Building: The building houses the controls for the pumps and equipment involved with the aeration system.

Air Blowers:

Biogas Engine Driven Blowers:

#2 Engine 380 HP, Blower Capacity 9,600 CFM at 8.2 psig
#3 Engine 675 HP, Blower Capacity 15,000 CFM at 8.5 psig
#5 Engine 440 HP, Blower Capacity 9,600 CFM at 8.2 psig

Motor Driven Blowers:

#1 Motor HP 500, Blower Capacity 11,000 CFM at 8.5 psig
#4 Motor HP 300, Blower Capacity 6,900 CFM at 8.5 psig

The blowers provide air for the aeration tanks. 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.

7.8 Outfall Sewers

Two outfall lines (72-inch diameter and 96-inch diameter) extend 500 feet out into the lake. The 72-inch diameter outfall was installed as part of the construction in 1965 and the 96-inch diameter outfall was installed during the project in 2002-2005. There are three 36-inch diffusers at the end of the 72-inch pipe and three 48-inch diffusers at the end of the 96-inch pipe for discharge diffusion.

7.9 Sludge Thickening

Gravity Belt Thickeners: Two gravity belt thickeners located in the Solids Processing Building 165 are used to thicken (WAS) from the secondary activated sludge treatment process. Polymer is added to the WAS to help the thickening process. Thickened WAS is pumped to the digesters. Filtrate drains to the West Drain Pump Station (Structure 138) and is pumped back to the headworks for treatment. Thickener equipment is outlined Table 7-1.

7.10 Anaerobic Digestion and Biogas

Anaerobic Digesters: The WWTP utilizes four one-million-gallon capacity digesters. Both sludge from the primary clarifiers and thickened waste activated sludge (TWAS) are pumped to the digesters. Mechanical mixers keep the organic material in contact with the anaerobic organisms. Tube-in-tube heat exchangers provide heat to ensure that temperature is maintained at 95 degrees Fahrenheit in the digesters. Through anaerobic bacterial action, sludge is decomposed and converted into a more stable product. Methane gas (biogas) is produced as a by-product of this decomposition. Biogas is used as a fuel supply for large internal combustion engine driven blowers and boilers.

One fixed cover tank with a volume of 552,000 gallons is used as part of the sludge dewatering operation. After primary digestion, sludge is transferred to the tank.

Gas Storage Sphere: Biogas 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 sludge heating. Since gas production and usage is not uniform in rate, a gas storage sphere is used for storage or 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, the gas is routed and burned by a flare.

7.11 Sludge Dewatering

Belt Filter Presses: Six two-meter presses are located in Solids Processing Building 165. These continuous stage belt filter presses consist of two polyester cloth belt sets one above another that maneuver through a series of pressure rollers. Sludge is conditioned with a liquid polymer and is fed onto a gravity drainage section of the belts. Following gravity drainage, the sludge is distributed on the lower pressure belt.

After an additional small section of gravity drainage, concentrated sludge comes in contact with the upper belt. The two belts form a wedge which gradually forces removal of water filtrate. The final three rollers form an S-shaped configuration which generates a shear force and creates additional water drainage. The filter belts are continuously washed with water at high pressure. Filtrate and rinse water drainage are pumped back to the headworks of the plant.

Dewatered sludge is conveyed to a truck loadout bays and is hauled by truck to ultimate reuse.

7.12 Ferric Chloride Chemical Feed for Phosphorus Removal

Chemical Feed and Storage for Phosphorus Removal: Phosphorus is removed from wastewater to meet permit requirements which are based on preventing 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 wastewater. Ferric chloride can be fed before primary clarifiers, after primary clarifiers, and prior to Final Clarifiers.

7.13 Plant Water and Heating Systems

Final Effluent Systems: 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.

Tank Drainage System: The tank drainage system consists of the drain system for all the treatment units and the controlled diversion arrangements for these units. Two tank drainage wells and five drainage pumps are provided.

Tank Drainage Pumps: 700 gpm at 30 feet TDH

Heating, Ventilation and Air Conditioning: Hot water for space heating is provided by continuous loop system. The system is provided with multiple pass, horizontal fire tube boilers. Two of the four boilers 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.

7.14 Facility Condition Assessment (See Table 7-2)

AECOM met with RWU staff at the wastewater treatment plant July 18, 2019 to conduct an assessment regarding the condition of the wastewater treatment plant facilities. Site visits were conducted to meet with operations staff to review operational needs identified by RWU staff as well as discuss priority of needs. The following, Table 7-2 summarizes the general assessment of the wastewater treatment plant process systems and facilities. Refer to Appendix F for assessment of buildings and mechanical systems.

Table 7-2. Racine Wastewater Treatment Facility Plan Condition Assessment

P&ID	TAG #	Struct No.	Drawing No.	Equipment	Condition Assessment	Facility Plan Alternatives to Review	Comments
09-N-01				*PROCESS INTERFACE SUMMARY*			
NA		02	02-CF- 2-10	CIVIL FACILITIES			
		02	02-CG- -	CIVIL GRADING	Long term needs for paving	Consider addressing cost for repaving roads	Allow for funding by facility plan project
					Stormwater ponding around Digester B per RWU	Revise grading and provide drainage to correct condition.	
NA		02	02-CP-2 - 11	CIVIL PIPING	No apparent issues.	Consider video inspection of pipe condition?	
NA		**06**	**06-SM-o-1**	**FLOW CONTROL STRUCTURE**	Facility staff note that only one of 5 flow meters to EQ work.	Validate that flow meter replacement is accounted for in CIP and planning	RWU staff note this is covered in CIP planning
NA		07	07-AMH-o-1	SAMPLER BUILDING	Not assessed. No issues noted.	SEPTAGE Sampler upgrade	
NA		08		COMBINATION BOX STRUCTURE	Not assessed. No issues noted.	No upgrades or replacement required	
NA		20	20-SM-1	DIVERSION STRUCTURE	Not assessed. No issues noted.	No upgrades or replacement required	
NA		20	30-SM-2	INFLUENT SIPHON GATE NOS. 1 &2	Not assessed. No issues noted.	No upgrades or replacement required	
NA		20	20-SM-1	DIVERSION STRUCTURE	Not assessed. No issues noted.	No upgrades or replacement required	
NA		25	25-R-1	JUNCTION STRUCTURE	Not assessed. No issues noted.	No upgrades or replacement required	
		30	**30-M-n-3**	**EQ SCREENING BUILDING**	Facility staff noted deficiencies in screen performance / valve access	Improve O&M of EQ Screening	Allocate cost for screen replacement
		40	40-M-n-1	EAST EQUALIZATION BASIN - EQ #1	Concrete in poor condition around perimeter. Facility staff note	Rehabilitate EQ #1 Allocate for costs of surface rehab of coating system and include replacement of concrete around perimeter. Evaluate overall EQ capacity needs and improve peak flow management of collection system and WWTP	Peak flow to plant is limited to 95 MGD per effluent flow metering management in collection system and WWTP is critical issue for Facility Plan. Prepare alternative improvement items when collection system flow inputs provided.
		45	40	WEST EQUALIZATION BASIN - EQ #2	Condition not assessed. No concerns noted by staff		
		47	02-CP-5	DECHLORINATION STRUCTURE	Not assessed. No issues noted.	Review final effluent chlor/dechlor requirements	RWU notes need for more permanent infrastructure at effluent
		50		PRIMARY EFFLUENT JUNCTION STRUCTURE	Not assessed. No issues noted.	No upgrades or replacement required	
		60	02-CP-w-1	SECONDARY EFFLUENT JUNCTION STRUCTURE	Not assessed. No issues noted.	No upgrades or replacement required	
		91	91-PHE-s-1	EFFLUENT METERING STATION	Sampler building is undersized and deficient for required uses	Upgrade Sampler Building 91- design space for needs	
		95	95-PH-s-1	LIQUID CHLORINE BUILDING	Not assessed. No issues noted.	No upgrades or replacement required	
		106	106-SM-01	VACTOR DUMP STATION	Not a true septage receiving station- concrete containment area	Consideration of value of better management of storing, blending, and metering of high strength waste?	*High Strength Waste Receiving Station Option for future?*
		110		***ADMINISTRATION BUILDING***	*Various upgrades requested*	*See Arch/HVAC assessment and cost estimate*	
		120		***CHEMICAL WING***		*See Arch/HVAC assessment and cost estimate*	
09-N-47		***120***		***FERRIC CHLORIDE SYSTEM***	FRP tanks satisfactory per WWTP inspections; no spill containment at truck unloading needs to be addressed and no ramp at dock.	*Upgrade ferric chloride unloading, and spill containment system. Add hydraulic ramp and building loading dock.*	
		125		***LAB***	Replace roof top air handling and make up air system equipment ; laboratory - requested updates to flooring and lab hoods, and utility support systems	*Arch/HVAC assessment and cost allocation*	
		130	130-M-2	PRELIMINARY TREATMENT BUILDING	Building work completed in 2005. No apparent issues.	Consider solar panels for roof	Future consideration
09-N-50	T-13-1-1	130	130-M-2	SODIUM BISULFITE SYSTEM	There is a temporary bisulfite feed line in place; a permanent line should be installed with a flow-paced feed system.	Install bisulfite line extension and add pump controls.	Bisulfite feed system shown on Dwg. 09-N-50. Specific costs not required.
09-N-02	30-GT-11 THRU 12	130	30-SM-2	INFLUENT SIPHON GATE #1 AND #2	Not assessed. No issues noted.		
09-N-02	P-2-3-1	130	30-SME-3	RAW WASTEWATER SAMPLE PUMP	Calibrated process model indicates that sampling is not representative of calibrated mass balance of solids.	Allow for cost to address sampling system design and operation in design phase	*GPS calibrated model showed influent data flow & loading understated.*
09-N-02	FE&FIT 2-1-1 THRU-2	130	30-SME-3	RAW WASTEWATER INFLUENT FLOW METER #1 & #2	*Not assessed- since recently replaced by RWU.*	RWU replaced these flow meters. Dec 2018	*Influent flow data prior to Dec 2018 unreliable*
09-N-02	FCV 2-1-1 THRU-2	130	130-M-1	INFLUENT FLOW CONTROL VALVES #1 & #2	building work completed in 2005. No apparent issues.	Not inspected or assessed at this time	O&M to evaluate hydraulic performance adequacy for future
09-N-03	M-2-12-1 THRU - 4	130	130-M-2	SCREENING	4 - 6-ft wide Vulcan Crawler screens with 1/2-in spacing. Screens appeared to be in good working order - no issues noted. Screens are close to 20 years old. Climber-type screens not as favored as when they were installed.	. No upgrades or replacement required	Replacement not a priority for RWU as in good condition

		130	130-M-2	SCREENING	There isn't adequate access to the drain valves in the screen channels.	No upgrades or replacement required	Plant staff cut hatches in concrete to improve access.
09-N-04	M-2-18-1 THRU -4	130	130-M-2	SCREEN WASH PRESSES AND CONVEYORS	4 - Vulcan units. Washer/presses and conveyor appeared to be in good working order - no issues noted. Equipment is close to 20 years old. [Better discharge guide to conveyor possible?]	No upgrades or replacement required	Replacement not a priority for RWU as in good condition
09-N-05	M-2-27-1 THRU -2	130	130-M-2	DEGRITTERS	2 - Vortex grit units with maximum capacity of 70 MGD. Units appeared to be in good working order - no issues noted. Equipment is close to 20 years old.	No upgrades or replacement required	None
09-N-05	P-2-28-1 THRU -2	130	130-M-1	GRIT PUMPS	2 - recessed impeller pumps; 250 gpm at 32-ft. Pumps appeared to be in good working order - no issues noted. Equipment is close to 20 years old.	No upgrades or replacement required	None
09-N-05	M-2-40-1 THRU -2	130	130-M-2	GRIT CONCENTRATOR	2 - 6-in dia. units; 250 gpm capacity. Units appeared to be in good working order – no issues noted. Equipment is close to 20 years old.	No upgrades or replacement required	None
09-N-05	M-2-29-1 THRU -2	130	130-M-2	GRIT DEWATERING SCREW CONVEYOR	2 - 9-in dia. units. Units appeared to be in working order - plant advises conveyor has been repaired multiple times and needs replacement: bad corrosion.	*Replace grit dewatering screw conveyors with new 316 SS units .*	*Updated per meeting 1/30/20 with B. Bartel. A budgetary cost for complete new units obtained.; PLC and control panels are good and do not need replacement.*
09-N-05	M-2-30-1 THRU -2	130	130-M-2	GRIT WASHER AUTOMATIC LUBRICATOR	Not assessed.	TBD	TBD
09-N-06	M-3-1-1 THRU -6	136	135-M-1 - 2	PRIMARY CLARIFIER #1-6 (WEST BANK)	WWTP maintains records of component replacement and regularly inspects condition	Replace drives on 1,2,3, and 4. Replace GRATING.	A budgetary cost was obtained from a manufacturer, EVOQUA in Appendix.
09-N-07	M-3-1-7 THRU -12	136	136-M-1 - 4	PRIMARY CLARIFIERS #7-12 (EAST BANK)	WWTP maintains records of component replacement and regularly inspects condition Plant staff note difficulty of cleaning Primary Clarifier 10 & 11 due to lack of walkway access	Replace drives on 7,8,9 and 10. Provide walkway between Primary 10 & 11	A budgetary cost was obtained from a manufacturer, EVOQUA in Appendix. Phased replacement costs carried in recommendations will be O&M decision based on inspections
09-N-08	P-3-15-1 THRU-3	137	135-M-1	PRIMARY CLARIFIER TUNNEL - SLUDGE PUMPS	3 - progressing cavity pumps; 215 gpm at 30 psi. Pumps receive sludge from Clarifiers 1-6. Plant staff noted thick primary sludge can be difficult to pump.	Ongoing O&M – engineering to address need to manage thick primary sludge. Rebuild primary sludge pump Nos 1 and 2	Pump system needs to be evaluated to improve efficiency in management of thick primary sludge
09-N-08	FV-3-14-1 THRU-6	137	135-M-1	PRIMARY CLARIFIER TUNNEL - SLUDGE VALVES	No apparent issues.	Ongoing Plant O&M	None
09-N-09	P-3-15-4 THRU-6	137	136-M-1 - 2	PRIMARY CLARIFIER TUNNEL - SLUDGE PUMPS	3 - progressing cavity pumps; 215 gpm at 30 psi. Pumps receive sludge from Clarifiers 7-12. Plant staff noted thick primary sludge can be difficult to pump. Equipment is close to 20 years old.	Ongoing Plant O&M	Pump system needs to be evaluated to improve efficiency in management of thick primary sludge
09-N-09	FV-3-14-7 THRU-12	137	136-M-5	PRIMARY CLARIFIER TUNNEL - SLUDGE VALVES	No apparent issues.	Ongoing Plant O&M	None
09-N-09	FE & FIT 3-21-1	137	136-M-1	PRIMARY SLUDGE FLOW METER	No apparent issues.	Ongoing Plant O&M	None
09-N-10	M-3-23-1 THRU-2	137	136-M-2	PRIMARY CLARIFIER - SCUM EJECTORS	2 - Yeomans pumps; 100 gpm at 50-ft. Scum discharges to the discharge header from the Primary Sludge Pumps. The scum can only be sent to the digesters.	Consider new pump type but such may just create other O&M issues. Recommend upgrading scum piping flexibility and redundancy to allow pumping to more digesters with ability to remove scum from system .	See alternatives evaluation
				EFFLUENT CHANNEL BETWEEN PRIMARY & AERATION	Sole primary effluent channel path to secondary is point of vulnerability for plant.	Discussed feasibility of new 2nd primary clarifier channel . Upgrade will focus on more feasible addition of isolation gates to enable pump drain and inspect	RWU needs vulnerability addressed concern of limitation of sole primary effluent channel
09-N-48	P-12-1-1 THRU -3	138	138-SM-1	WEST DRAIN PUMP STATION	Not assessed. 3 - submersible pumps; 1,400 gpm at 47-ft. No issues noted.	Ongoing Plant O&M	None
09-N-49		125/139	139-M-1	NORTH/SOUTH DRAIN PUMP STATION	Not assessed. No issues noted.	Ongoing Plant O&M	None
				AERATION SYSTEM PERFORMANCE	Existing ceramic diffusers. Plant cleans annually and reported as 90% efficient 5 years ago. Condition needs further evaluation to assess. Calibrated model indicates raw wastewater/ mixed liquor is system has insufficient SRT and some characteristic as well preventing capability to fully nitrify/denitrify wastewater.	Conduct specific/random diffuser performance testing to verify SOTE and fouling. Use data for diffuser replacement evaluation for 2020-2040. Calibrated Mode. Evaluate option of new membrane diffusers and location in tank. however, plant has been pleased with life of existing diffusers.	See results of calibrated process model; fouling factor of 0.6 needs to investigated;
09-N-11	FE & FIT 4-1-1 THRU -4	139		AERATION BASIN RAS DISTRIBUTION FLOW METERS	Data reliability suspect - meters are old technology.	Include cost to replace outdated meters with new magmeters	Replace flow meters with new technology
09-N-11	AIT 4-2-1 THRU -5	139		AERATION BASIN D.O. INSTRUMENTATION	Condition reported as OK and replacement maintained by plant staff as needed.	Not assessed	Plant updates D.O. instrumentation on ongoing basis

09-N-11	G-4-3-1 THRU -4	139		AERATION BASIN GATES	- Plant staff looking for new isolation gates for maintenance	Furnish 2 additional gates in ML effluent channel to isolate flow for maintenance. Replace existing	Insufficient isolation of channel and upgrade of worn existing gates needed
09-N-21		139		AERATION BLOWERS	Gas-driven engines are high maintenance and inefficiently operated - controls need to be upgraded. Air permit impacts engine operation.	Consider replacing engine- driven blowers with new electric motor driven blowers ; Upgrade biogas utilization for facility and site. See alternatives evaluation for issues	See alternatives evaluation - This is the most significant proposed upgrade and impacts biogas utilization. Air permit limitations must be addressed and potentially re-negotiated with DNR.
		139		AERATION BASIN/GALLERY	Some structural leakage issues to be addressed; new metering in piping.	Allocate cost for structural repairs	
09-N-13	M-5-1-1 THRU -5	140	141-M-1	FINAL CLARIFIER #1-6	1. Excessive algae growth at Final Clarifiers per staff 2. Clarifiers have no skimming mechanisms. 3. No way to waste sludge from Final Clarifier No. #2,#4, and #6	1. Consider covers over weirs and launders to control algae growth. Need covers with long wear life. 2. Evaluate means to add sludge wasting to #2, #4, #6	. 1. Included covers as recommended item with further evaluation required. 2. Upgrade piping to WAS pumps to waste from ALL Final Clarifiers.
09-N-13	G-5-3-1 THRU -5	140		FINAL CLARIFIER #1-6 INFLUENT GATES		No upgrades or replacement required	
09-N-13	FIT-5-1-1 THRU -5	140		FINAL CLARIFIER #1-6 EFFLUENT FLOW METERS	No apparent issues.	No upgrades or replacement required	
09-N-14	M-5-1-7 THRU -9	140	140-M-1	FINAL CLARIFIER #7-9	Staff reports excessive algae growth at the Final Clarifiers.	Consider covers over weirs and launders to control algae growth.	A budgetary cost to be obtained from manufacturer. Included as recommended item with further evaluation required
09-N-14	G-5-3-7 THRU -9	140	140-M-1	FINAL CLARIFIER #7-9 INFLUENT GATES	No apparent issues.	No upgrades or replacement required	
09-N-14	FIT-5-1-7 THRU -9	140		FINAL CLARIFIER #7-9 EFFLUENT FLOW METERS	No apparent issues.	No upgrades or replacement required	
09-N-15	P-5-10-1	145	139-M-1	RAS/WAS PUMP STATION WAS PUMP NO. 1	1 - centrifugal pump; 700 gpm at 35-ft. Pump receives sludge from Final Clarifiers #1 & 2. Pump appeared to be in good working order - no issues noted. Pump is over 40 years old. There are issues withdrawing WAS from all of the clarifiers.	Plant would like to consider alternative for a common RAS system and then withdraw WAS from common RAS system. Or consider piping modification to connect pump suction to individual lines from clarifiers to draw WAS from each Final Clarifier.	Specific costs for piping modifications not required.
09-N-15	FE / FIT -5-11-1	145	139-M-1	RAS/WAS PUMP STATION WAS FLOW METER	Not assessed	Replace WAS flow meter	Replace flow meters with new technology
09-N-15	FV-5-11-1	145	139-M-1	RAS/WAS PUMP STATION WAS MODE VALVE	No apparent issues.	No upgrades or replacement required	
09-N-15	FV-5-9-1	145	139-M-1	RAS/WAS PUMP STATION RAS/WAS VALVE #1	No apparent issues.	No upgrades or replacement required	
09-N-15	P-5-12-2 THRU-4	145	139-M-1	RAS/WAS PUMP STATION RAS PUMP NO. 2-4	3 - centrifugal pumps; 3,400 gpm at 20-ft. Pumps receive sludge from Final Clarifiers #1 & 2. Pumps appeared to be in good working order - no issues noted. Pumps age unknown.	Evaluate increasing peak capacity to pump RAS. Consider piping modifications for managing RAS/WAS.	Plant expressed concern that RAS pumps cannot handle peak flow. Allocation included for rebuild and replacement to restore peak capacity.
09-N-15	FE-5-6-1 THRU-2	145	139-M-1	RAS/WAS PUMP STATION RAS FLOW METER NO. 1&2	Plant expressed concern about accuracy of RAS Flow	Upgrade RAS flow metering with new magmeters	
09-N-16	FV-5-9-2	145	139-M-2	RAS/WAS PUMP STATION RAS/WAS VALVE #2	No apparent issues.	No upgrades or replacement required	
09-N-16	P-5-10-5	145	139-M-2	RAS/WAS PUMP STATION WAS PUMP NO. 5	1 - centrifugal pump; 700 gpm at 35-ft. Pump receives sludge from Final Clarifiers #3 & 4. Pump appeared to be in good working order - no issues noted. Pump is over 40 years old. There are issues with drawing WAS from all of the clarifiers.	Add piping to connect pump suction to individual lines from clarifiers to draw WAS from each clarifier.	
09-N-16	P-5-12-6 THRU-8	145	139-M-2	RAS/WAS PUMP STATION RAS PUMP NO. 6-8	3 - centrifugal pumps; 3,400 gpm at 20-ft. Pumps receive sludge from Final Clarifiers #3 & 4.	Evaluate increasing peak capacity to pump RAS.	
09-N-16	FE-5-6-3 THRU-4	145	139-M-2	RAS/WAS PUMP STATION RAS FLOW METER NO. 3&4	Plant expressed concern about accuracy of RAS Flow	Upgrade RAS flow metering with new magmeters	
09-N-17	FV-5-9-3	145	139-M-2	RAS/WAS PUMP STATION RAS/WAS VALVE #3	No apparent issues.	No upgrades or replacement required	
09-N-17	P-5-10-9	145	139-M-3	RAS/WAS PUMP STATION WAS PUMP NO. 9	1 - centrifugal pump; 700 gpm at 35-ft. Pump receives sludge from Final Clarifiers #5 & 6. Pump appeared to be in good working order - no issues noted. Pump is over 40 years old. There are issues with drawing WAS from all of the clarifiers.	Add piping to connect pump suction to individual lines from clarifiers to draw WAS from each clarifier.	
09-N-17	P-5-12-10 THRU-12	145	139-M-3	RAS/WAS PUMP STATION RAS PUMP NO. 10-12	3 - centrifugal pumps; 3,400 gpm at 20-ft. Pumps receive sludge from Final Clarifiers #5 & 6. Pumps appeared to be in good working order - no issues noted. Pumps age unknown.	Evaluate increasing peak capacity to pump RAS.	Plant expressed concern that RAS pumps cannot handle peak flow
09-N-17	FIT 5-6-5 THRU -6	145	139-M-3	RAS/WAS PUMP STATION RAS FLOW METER NO.5&6	Plant expressed concern about accuracy of RAS Flow	Upgrade RAS flow metering with new magmeters	Replace flow meters with new technology
09-N-18	FV-5-18-1 TO 5-20-1	145	139-M-3	RAS/WAS PUMP STATION WAS VALVE NO. 1-3	No apparent issues.		

09-N-18	P-5-10-17	145	145-M-2	RAS/WAS PUMP STATION WAS PUMP #17	1 - centrifugal pump; 700 gpm at 35-ft. Pump receives sludge from Final Clarifiers #7, 8 & 9. Pump appeared to be in good working order - no issues noted. Pump is close to 20 years old. There are issues with drawing WAS from all of the clarifiers.	Add piping to connect pump suction to individual lines from clarifiers to draw WAS from each clarifier.	Specific costs for piping modifications not required.
09-N-18	P-5-12-13 THRU-16	145	145-M-2	RAS/WAS PUMP STATION RAS PUMP NO. 13-16	4 - centrifugal pumps; 4,500 gpm at 35-ft. Pumps receive sludge from Final Clarifiers #7, 8 & 9. Pumps appeared to be in good working order - no issues noted. Pumps are close to 20 years old.	Evaluate increasing peak capacity to pump RAS.	
09-N-18	FIT 5-6-7 THRU 10	145	145-M-2	RAS/WAS PUMP STATION RAS FLOW METER NO. 7-10	Plant expressed concern about accuracy of RAS Flow	Upgrade RAS flow metering to magmeters	Replace flow meters with new technology
09-N-19	M-5-24-1 THRU -2	140	145-M-2	SECONDARY SCUM EJECTOR NO. 1 & 2	2 - Yeomans pumps; 100 gpm at 50-ft. Scum discharges to the discharge header from the Primary Sludge Pumps. The scum can only be sent to the digesters.	Consider new pump type but such may just create other O&M issues. Recommend upgrading scum piping flexibility and redundancy to allow pumping to more digesters with ability to remove scum from system .	See alternatives evaluation
		144		DISTRIBUTION BOX	No apparent issues.	No upgrades or replacement required	
		150		PLANT GENERATOR BUILDING	Sufficient Capacity ; Very Good Condition - No Changes Required for Facility Plan	No upgrades or replacement required	No visible wear and tear during walkthrough.
09-N-20	M-6-1-1 THRU -2	160	160-M-1	UV DISINFECTION SYSTEM NO. 1 AND NO. 2	2 - Trojan Model UV4000 units; 160 lamps per unit. Peak hourly flow rate: 108 MGD. System is close to 20 years old. There are more efficient systems now available.	Replace UV equipment with new, more efficient units.	A budgetary cost to be obtained from a manufacturer.
09-N-20	G 6-2-1 THRU -2	160	160-M-1	UV INFLUENT GATE NO. 1 AND NO. 2	No apparent issues.	Not Assessed	
09-N-20	G-6-3-1	160	160-M-1	UV CONTROLLED DIVERSION GATE	No apparent issues.	Not Assessed	
09-N-20	FV-6-15-1 THRU -2	160	160-M-1	UV EFFLUENT VALVE NO. 1 AND NO. 2	No apparent issues.	Not Assessed	
09-N-20	M-6-9-1	160	91-PHE-s-1	EFFLUENT SAMPLER	No apparent issues.		
09-N-20	G-6-7-1 ; G-6-8-1 &-2	160	162-M-w-1	EFFLUENT BOX GATE NO. 1 THRU NO. 3	See comment	Evaluate site impacts from high lake levels	Plant expressed concern of lake levels impacting operations with leakage into effluent structure?
	SBS	160	02-CP-5	DECHLOR STRUCTURE NO. 47	Not assessed. No issues noted.	Re-evaluate capability for final effluent dechlorination	Plant needs equipment to dechlorinate final effluent
09-N-22		165	165-M-2	GRAVITY BELT THICKENER FEED PUMPS	Sufficient Capacity ; Good Condition - No Changes Required for Facility Plan	Maintain through 2040	
09-N-22		165	165-M-2	GRAVITY BELT THICKENER FEED FLOW METERS	Sufficient Capacity ; Good Condition - No Changes Required for Facility Plan	Maintain through 2040	
09-N-23		165	165-M-2	BELT THICKENER POLYMER SYSTEM	Sufficient Capacity ; Very Good Condition - No Changes Required for Facility Plan	Maintain through 2040	
09-N-24		165	165-M-2	GRAVITY BELT THICKENERS (GBT)	Very Good Condition - Piping does NOT allow for redundancy	Include cost for piping revision to allow for redundancy	Plant expressed concern of limitation imposed by common piping and also inability to equalize distribution of TWAS flow to digesters
09-N-25		165	165-M-2	GRAVITY BELT THICKENERS (GBT)	Very Good Condition - Piping does NOT allow for redundancy	Include cost for piping revision to allow for redundancy	
09-N-26		165	165-M-3	SLUDGE PIPING	High pressure noted to Digester E	Include cost for piping revision to alleviate high pressure	
09-N-38		165	165-M-3	BELT PRESS FEED PUMPS	Sufficient Capacity ; Very Good Condition -		
09-N-39		165	165-M-3	BELT PRESS POLYMER SYSTEM	Sufficient Capacity ; Very Good Condition -	1. Consider cost//benefit of 5 day a week dewatering operation which negatively impacts plant performance vs 7 day BFP operation. Consider equalization of BFP Filtrate storage for managing recycle flow of supernatant/	5 day a week operation negatively impacts plant performance. SEE CALIBRATED PROCESS MODEL.
09-N-40		165	165-M-4	BELT PRESS NO.1	Sufficient Capacity ; Very Good Condition - No Changes Required for Facility Plan	No upgrades or replacement required	
09-N-41		165	165-M-4	BELT PRESS NO.2	Sufficient Capacity ; Very Good Condition - No Changes Required for Facility Plan	No upgrades or replacement required	
09-N-42		165	165-M-4	BELT PRESS NO.3	Sufficient Capacity ; Very Good Condition - No Changes Required for Facility Plan	No upgrades or replacement required	
09-N-43		165	165-M-4	BELT PRESS NO.4	Sufficient Capacity ; Very Good Condition - No Changes Required for Facility Plan	No upgrades or replacement required	
09-N-44		165	165-M-4	BELT PRESS NO.5	Sufficient Capacity ; Very Good Condition - No Changes Required for Facility Plan	No upgrades or replacement required	

09-N-45		165	165-M-4	BELT PRESS NO.6	Sufficient Capacity ; Very Good Condition - No Changes Required for Facility Plan	No upgrades or replacement required	
09-N-46		165	165-M-5-8	SLUDGE CONVEYOR SYSTEM	Sufficient Capacity ; Very Good Condition -	Initial need expressed for weigh scale for BFP Trailers?	Plant request withdrawn
09-N-27		170	170-SM-	DIGESTER "B" MIXING	No apparent issues.		
09-N-35		170	170-SM-	DIGESTER B GAS	1. Digester "B" floating cover was replaced in 2001 upgrade but tilts and a fix is needed. 2. Currently biogas stored and used for blower engines, heating systems or flared in summer	1. Include in assessment of overall digester cover improvements. 2. Re-evaluate Biogas Utilization.	Could be due to snow cover/melt/ice
		171		ACCESS VAULT			
		172		DIGESTER CONTROL BUILDING 1	No apparent issues		
		173		DIGESTER CONTROL BUILDING 2	No apparent issues		
09-N-36		173	173-M-1	DIGESTER "A & D" GAS	Currently biogas stored and used for blower engines, heating systems or flared.in summer	Evaluate Biogas Storage and Utilization	Too much biogas wasted in summer
09-N-31		175	175-SM-	DIGESTER "E"	NEW in 2001 upgraded. Concern expressed by plant operations of difficulty in managing distribution of flow of TWAS to digesters	Allocate cost for painting cover.	Potential study of digester utilization?
09-N-37		180	180-M-1	DIGESTER "E" GAS	Currently 65% methane biogas stored and used for blower engines, heating systems or flared.in summer	Evaluate Biogas Storage and Utilization	Too much biogas wasted in summer. Biogas is directly fed to engines for blowers at 0.6" WC . Biogas is compressed to 50 psi for storage
09-N-30		176	176-M-1	PRIMARY DIGESTER "A"	90 ft dia. with floating cover that was NOT replaced in 2001 upgrade	TBD	Plant staff recommended rehab/paint of cover
09-N-29		177	177-M-1	DIGESTER "D'	Digester "D" floating cover is a depreciated asset - will not last next 25 years. Concern expressed by plant operations of difficulty in managing distribution of flow of TWAS to digesters	Include in assessment of overall digester cover improvements	Address cover type; inspection needed to validate whether repair or replacement required or not.
09-N-32		180	180-M-1	SLUDGE HEATING	No apparent issues other than age of equipment	TBD	Consider replacement cost for A,B,D ?
09-N-33		180	180-M-1	SLUDGE HEATING	No apparent issues other than age of equipment	TBD	
09-N-34		180	180-M-1	SLUDGE HEATING	No apparent issues other than age of equipment	TBD	
		181	181	WASTE GAS BURNER NO. 2	Currently biogas stored and used for blower engines, heating systems or flared.in summer	Address flaring upgrade for planning period in conjunction with biogas utilization upgrade.	Too much biogas wasted in summer. Allocated cost for new flare.
09-N-28		182	182-M-1	DIGESTER "C" - DIGESTED SLUDGE STORAGE	Not mixed; used as digested sludge storage tank for feed	TBD	Consider evaluation of alternative use of Digester C as a means to improve TWAS feed to digesters
		183	183	TUNNELS	Water leakage noted	Allocate funding for structural leak repairs	
09-N-51		185	185-M-1	MAIN EQUIPMENT BUILDING AIR COMPRESSORS	Fair. High vibration and noise negatively impact facility and personnel.	Evaluate alternative of supplementing existing reciprocating air compressors with more efficient rotary screw air compressors in acoustic enclosures.	Excessive vibration and noise noted in Main Equipment building and existing break room
		185	185	MAIN EQUIPMENT BUILDING - Potentially hazardous asbestos materials	Noted asbestos floor tiles and asbestos insulation	Conduct thorough inspection and allocate allowance for removal and replacement of suspect asbestos materials. Assessment to include miles of asbestos pipe insulation throughout the plant.	
		190	190	GAS STORAGE SPHERE- 40 ft DIA.	Structure Not assessed - capacity in summer questioned by WWTP staff . Design is 8 psi to boilers through 4-IN supply piping.	Evaluate as part of biogas utilization upgrade	Too much biogas wasted in summer. Biogas from sphere is NOT CLEANED. Biogas is regulated for 8 psi distribution to hot water boilers or to fill Digester E gas holding cover.
		250	250	GENERATOR BUILDING OFF-SITE	NOT ASSESSED	TBD	
				OTHER NON-PROCESS RELATED ITEMS			
				BACK UP ENGINES	Assets are depreciated and need to be replaced if/as required for specific use	Update deficiencies in back up engines if still required for plant operation	Included in budgeting recommendations
				FIRE ALARM PANELS	Out of date - deficiency needs to be updated for O&M from 2020-2040	Update deficiencies in Fire Alarm Panels	Included in budgeting recommendations
				REPAIR OR REPLACE PROTECTIVE WATER TANKS	Depreciated asset	Upgrade service water plumbing and piping with new backflow prevention principles	Future plumbing project
				ROAD REPAIR AND REPAVING	Not assessed	Anticipated by Plant Staff	Included in budgeting recommendations
				ADDITIONAL GARAGE FOR EQUIPMENT STORAGE	Equipment storage deficiency and additional storage requested by WWTP staff	Needs analysis in future.	Future CIP Planning

8.0 Historical Wastewater Flows and Loadings and Plant Performance

8.1 Purpose

Wastewater treatment plants are designed to achieve effluent compliance for the discharge limits and associated time-periods defined in the effluent discharge permit. Those time periods typically are monthly, weekly, and daily. That means that influent wastewater loading variations must be defined and applied when designing, operating, controlling, and optimizing unit treatment processes. Understanding the time-related-magnitude of loadings is fundamental to successful treatment performance, which is directly related to properly sized processes and systems. Intrinsic to that notion is the balance between the extent (size, cost, complexity, etc.) of the physical treatment facilities and the selected magnitude of the loading criteria and the duration of that loading magnitude. Treatment facilities must be sized and constructed based on probable loading conditions, not on the absolute worst-case, extreme loading circumstances. This is where appropriate data analysis and judicious extraction of information are very important to define cost-effective solutions.

Modeling of the Racine WWTP (See Appendix B WWTP Process Modeling) was a critical step in evaluating existing process performance, oxygen transfer, and potential nutrient removal configurations. This methodology also provided an accurate accounting of primary treatment performance, secondary solids production, nitrification performance, aeration demand, secondary clarifier solids loading, biosolids processing, and recycle streams; all of which can have a significant influence on plant performance.

8.2 Review of Historical Wastewater Data

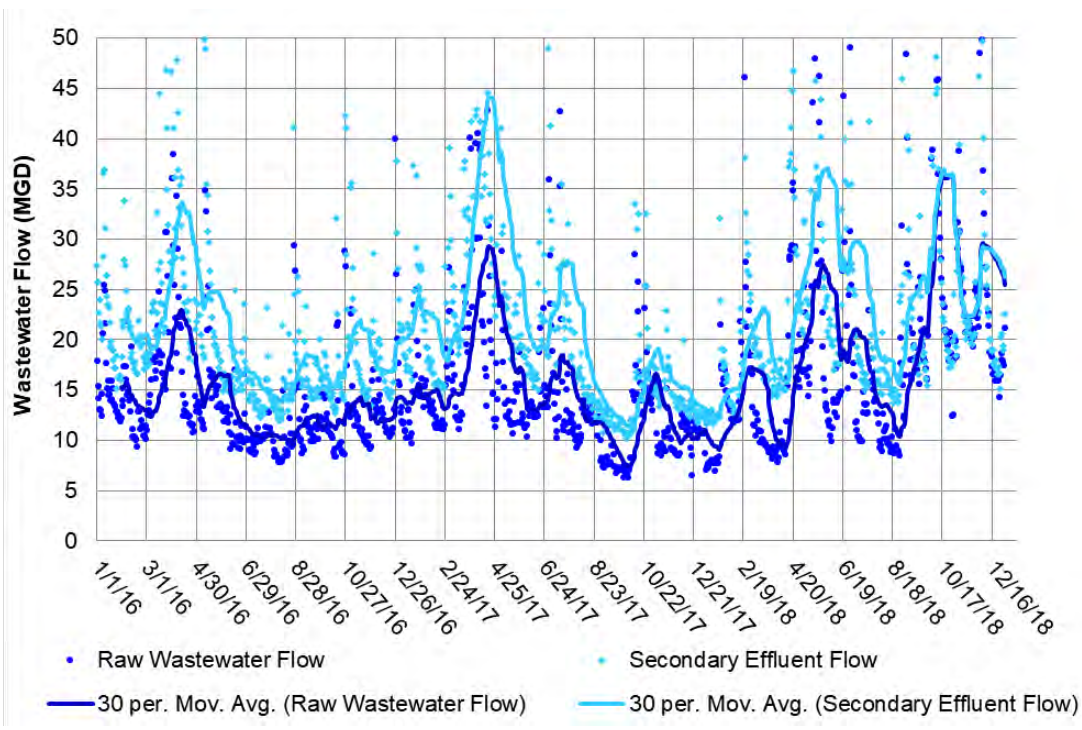
Data from January 1, 2016 through December 31, 2018 were provided by RWU, compiled, and evaluated to investigate the historical raw wastewater (RWW) pollutant loadings. Historical parameters of interest included flow, total suspended solids (TSS), 5-day biochemical oxygen demand (BOD), total Kjeldahl nitrogen (TKN), ammonia (NH4-N), total phosphorus (TP), and orthophosphate (OP). The raw wastewater loadings were computed by integrating the measured raw wastewater flow and pollutant concentrations. To check their validity, they were examined in terms of the service area population. Several different entities, including the Racine County Department of Planning and Development, the Wisconsin Department of Administration, and the Southeastern Wisconsin Regional Planning Commission estimated the service area population at about 136,000. The per-capita flow and loadings were computed by dividing the long-term raw wastewater averages by this population. Table 8.1 illustrates the per-capita flow and loadings and compares them with typical values and ranges where it became evident that the measured raw wastewater loadings were significantly less than typical values. This indicated that either the raw wastewater flow measurement, pollutant concentrations, or both were underreported by flow metering error, sampling, or laboratory methods.

Table 8-1. Long-Term Average and Per-Capita Raw Wastewater Flows and Loadings

Parameter	Unit	Annual Average	*Per-Capita*	*Typical Per-Capita*	*Typical Per-Capita Range*
Flow	(MGD)	16.0	*118*	*130*	*60 - 200*
TSS	(lbs/d)	14,105	*0.10*	*0.20*	*0.13 - 0.33*
BOD	(lbs/d)	14,402	*0.11*	*0.18*	*0.11 - 0.26*
TKN	(lbs/d)	2,520	*0.019*	*0.029*	*0.020 - 0.048*
NH4-N	(lbs/d)	1,591	*0.012*	*0.017*	*0.011 - 0.026*
TP	(lbs/d)	319	*0.0023*	*0.0046*	*0.0023 - 0.0070*
OP	(lbs/d)	160	*0.0012*	*0.0020*	*0.0010 - 0.0030*

Raw wastewater flow is measured just upstream of the bar screens and the secondary effluent is measured just downstream of the UV disinfection system. Neither flow metering location includes wet weather equalized flow. Equalized/settled wet weather flow is managed by controlled diversion around the rectangular primary clarifiers and secondary treatment then combined with secondary effluent downstream of the secondary effluent flow meters. As such, it was recognized that the long-term average raw wastewater and secondary effluent flows should be about equal since the only other flow exit pathway from the plant is in the dewatered cake sludge, which can be considered negligible. The raw wastewater and secondary effluent flow data were investigated by plotting both on the same graph in Figure 8.1. The investigation showed that the secondary effluent flow was about 37% greater than the measured raw wastewater. On a long-term average basis, the measured raw wastewater averaged 16 MGD while the secondary effluent averaged about 22 MGD. RWU had previously identified this discrepancy and subsequently has replaced the raw wastewater flow metering.

Figure 8.1. Comparison of metered raw wastewater and secondary effluent flow



When the long-term average raw wastewater pollutant concentrations were applied to 22 MGD, the per-capita loadings were still coming out less than typical per-capita loadings. For instance, when the long-term average raw wastewater TSS concentration of 106 mg/L was applied to 22 MGD, the loading only came out to about 19,500 lbs/d or about 0.14 lbs/d/capita. The primary influent TSS concentration, however, averaged 146 mg/L. The only sidestream recycles that influenced the primary influent was gravity belt thickener (GBT) filtrate, belt filter press (BFP) filtrate, and hauled waste. As such, the raw wastewater flow and loadings were estimated by flow and mass balance. To carry the task out the primary effluent flow was computed as the secondary effluent flow plus GBT washwater, BFP washwater, and WAS flow. Next primary influent flow was estimated by adding the primary sludge flow. Finally, the raw wastewater flow was estimated as the primary influent flow minus the hauled waste, GBT filtrate, and BFP filtrate. A mass balance around the primary clarifiers, discussed in Appendix B, Section 2.2 confirmed that the measured primary influent loadings were quite reasonable given the primary effluent and primary sludge loadings, and as such, the raw wastewater loadings were estimated as the primary influent minus the hauled waste, GBT filtrate, and BFP filtrate loadings (all of which were quite small). For instance, when these sidestream TSS loadings were subtracted from the long-term average primary influent TSS loading of 27,638 lbs/d, the raw wastewater TSS loading was estimated at 26,601 lbs/d, which is about 4% less than the primary influent. This translated to 0.20 lbs/d/capita, which is in exact agreement with the typical per-capita TSS loading.

The above mass balance procedure was also carried out for the other measured pollutants (BOD, TKN, NH4-N, TP, and OP). Table 8.2 compares the long-term average loadings as measured and as estimated by mass-balance on a per-capita basis where the estimated values were quite reasonable compared to typical values.

Table 8-2. Measured and Estimated Per-Capita Raw Wastewater Flows and Loadings

Parameter	Unit	Raw Wastewater as Measured		Raw Wastewater as Estimated by Mass Balance		*Typical Per-Capita*	*Typical Per-Capita Range*
		Annual Average	*Per-Capita*	Annual Average	*Per-Capita*		
Flow	(MGD)	16.0	***118***	22.0	***161***	***130***	*60 - 200*
TSS	(lbs/d)	14,105	***0.10***	26,601	***0.20***	***0.20***	*0.13 - 0.33*
BOD	(lbs/d)	14,402	***0.11***	23,544	***0.17***	***0.18***	*0.11 - 0.26*
TKN	(lbs/d)	2,520	***0.019***	3,402	***0.025***	***0.029***	*0.020 - 0.048*
NH4-N	(lbs/d)	1,591	***0.012***	2,070	***0.015***	***0.017***	*0.011 - 0.026*
TP	(lbs/d)	319	***0.0023***	384	***0.0028***	***0.0046***	*0.0023 - 0.0070*
OP	(lbs/d)	160	***0.0012***	238	***0.0018***	***0.0020***	*0.0010 - 0.0030*

Lastly, the daily raw wastewater flow and loadings were dynamically estimated by proportionally decreasing the measured primary influent flow and loadings by the apparent long-term average ratio of primary influent to the estimated raw wastewater parameter. This enabled the creation of a 3-year dynamic raw wastewater database for which various information can be extracted. Figures 8.2 through 8.8 illustrate and compare the measured and estimated raw wastewater flow and loadings.

The overall conclusion of this comparison was that the raw wastewater flow and pollutant concentration data was underreported. Plant staff have indicated that the raw wastewater flow metering was corrected in late 2018, which is evident in Figure 8.1 at around October 2018 where the raw wastewater and secondary effluent data lined up. The measured raw wastewater concentration data, on the other hand, still appeared abnormally low through 2018. Since the other sampling data within the plant (primary influent, effluent, etc.) made sense as per the historical data analysis discussed in Appendix B, the laboratory analysis was not deemed questionable, rather, the sampling methodologies seemed the most probable area to investigate.

Figure 8.2. Raw wastewater flow (a) as measured (b) as estimated by flow balance

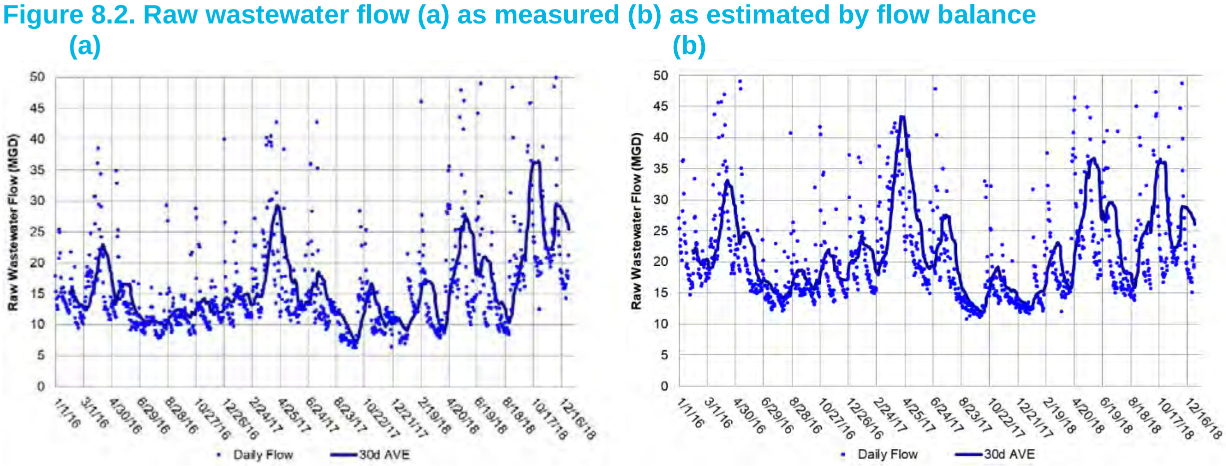


Figure 8.3. Raw wastewater TSS loading (a) as measured (b) as estimated by mass balance

(a) (b)

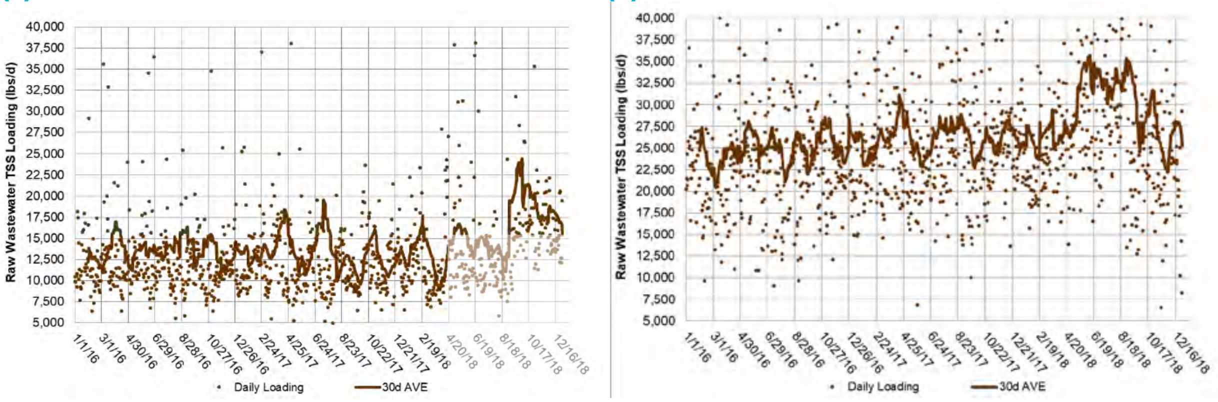


Figure 8.4. Raw wastewater BOD loading (a) as measured (b) as estimated by mass balance

(a) (b)

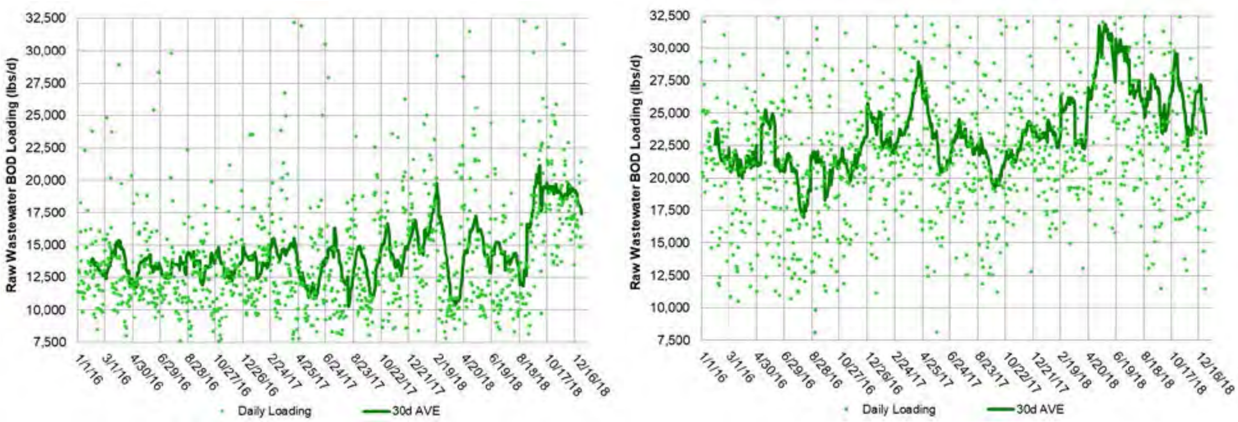


Figure 8.5. Raw wastewater TKN loading (a) as measured (b) as estimated by mass balance

(a) (b)

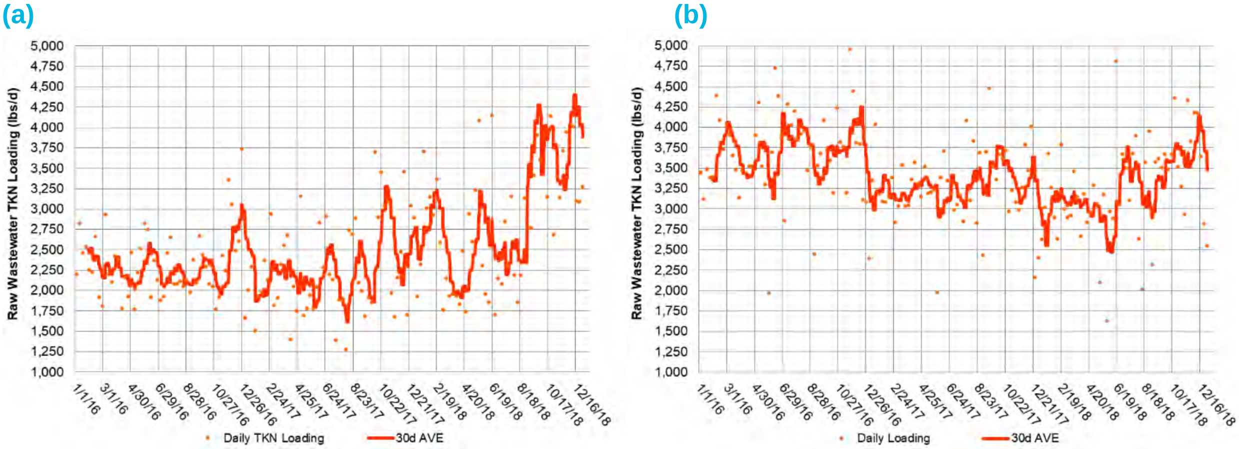


Figure 8.6. Raw wastewater NH4-N loading (a) as measured (b) as estimated by mass balance

(a) **(b)**

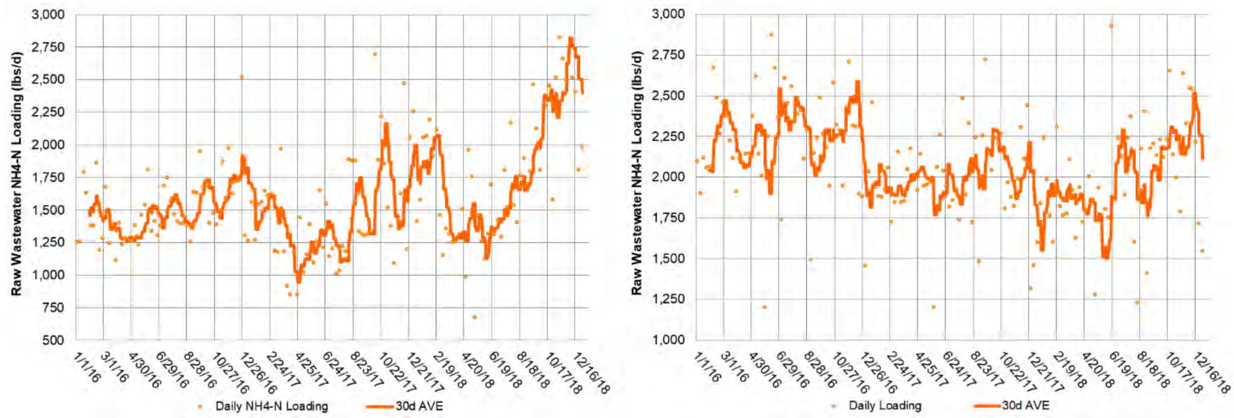


Figure 8.7. Raw wastewater TP loading (a) as measured (b) as estimated by mass balance

(a) **(b)**

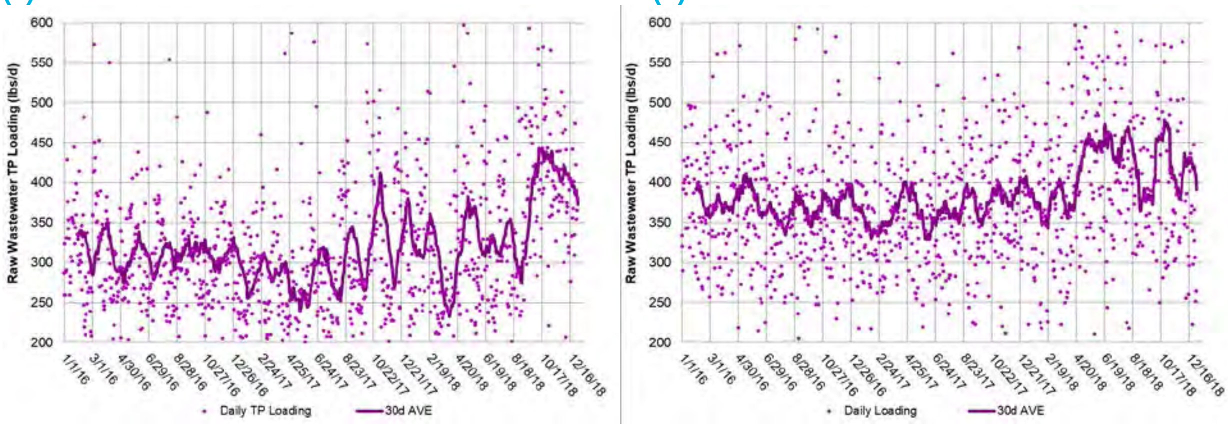
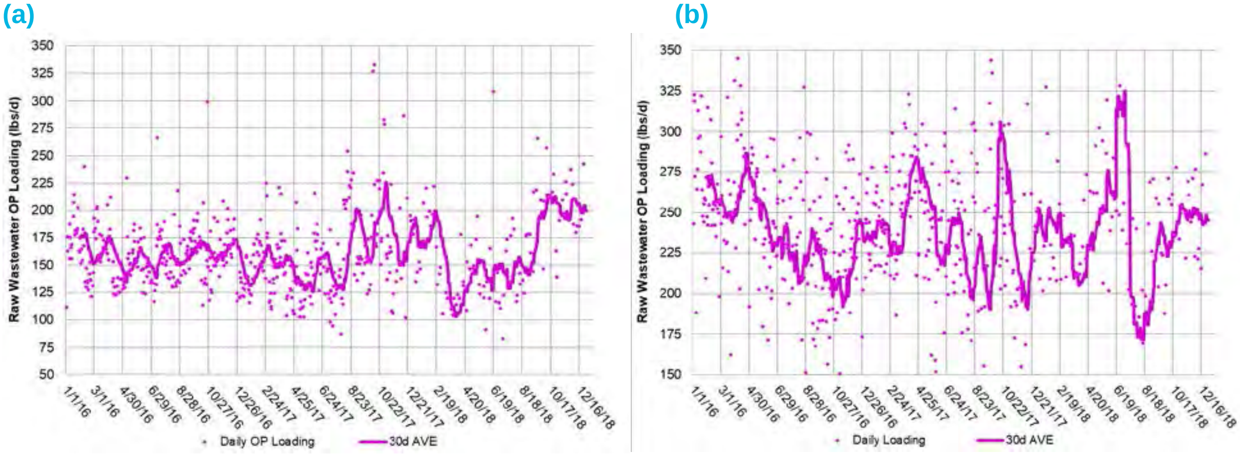


Figure 8.8. Raw wastewater OP loading (a) as measured (b) as estimated by mass balance

(a) **(b)**



Review of the historical daily flow indicated that periods of elevated flowrates were commonly experienced during the early springtime, suggesting a strong influence of snowmelt and spring rain events. Conversely, lower flowrates were typically observed in the middle of summer. These dry-weather periods of flow can help differentiate the respective levels of sanitary flow from snowmelt/rainfall derived. For instance, the wastewater flow during the low flow summer periods were typically on the order of 15 MGD, a fair indication of dry-weather sanitary sewage flow without the influence of rainfall or snowmelt.

8.3 Peaking Factor Analysis

The flow and loading patterns presented in Figures 8.2 through 8.8 were investigated to identify the annual average and maximum monthly average flows and loadings for each year analyzed. Each annually observed maximum month average was normalized by dividing it by the annual average to create a "peaking factor" which can be applied to future conditions that assume similar service area characteristics. While the values of the measured raw wastewater flow and loadings were, for the most part, deemed underestimated, the variability of them were still quantified in terms of the maximum month peaking factors to help select peaking factors for which to evaluate future upgrades. Tables 8.3 through 8.7 summarize the flow and loading conditions that were observed for each year analyzed.

Table 8-3. Historical flows and peaking factors

Year	Measured			Estimated		
	Annual Average	Maximum Month	Peaking Factor	Annual Average	Maximum Month	Peaking Factor
	(MGD)	(MGD)	(---)	(MGD)	(MGD)	(---)
2016	13.8	22.9	1.67	20.3	33.2	1.64
2017	14.7	29.3	2.00	21.3	43.4	2.04
2018	19.6	36.4	1.86	24.2	36.7	1.51
AVE	**16.0**	**29.6**	**1.84**	**22.0**	**37.8**	**1.73**
Selected Peaking Factor:			**1.73**			

Table 8-4. Historical TSS loadings and peaking factors

Year	Measured			Estimated		
	Annual Average	Maximum Month	Peaking Factor	Annual Average	Maximum Month	Peaking Factor
	(MGD)	(MGD)	(---)	(MGD)	(MGD)	(---)
2016	13,523	16,979	1.26	25,092	28,601	1.14
2017	13,244	19,531	1.47	25,941	31,168	1.20
2018	15,549	24,428	1.57	28,775	35,730	1.24
AVE	**14,106**	**20,313**	**1.43**	**26,603**	**31,833**	**1.19**
Selected Peaking Factor:			**1.30**			

Table 8-5. Historical BOD loadings and peaking factors

Year	Measured			Estimated		
	Annual Average	Maximum Month	Peaking Factor	Annual Average	Maximum Month	Peaking Factor
	(MGD)	(MGD)	(---)	(MGD)	(MGD)	(---)
2016	13,499	15,375	1.14	21,645	25,748	1.19
2017	13,732	16,675	1.21	22,836	28,948	1.27
2018	15,979	21,143	1.32	26,158	31,867	1.22
AVE	**14,403**	**17,731**	**1.23**	**23,546**	**28,854**	**1.23**
Selected Peaking Factor:			**1.23**			

Table 8-6. Historical TKN loadings and peaking factors

Year	Measured			Estimated		
	Annual Average	Maximum Month	Peaking Factor	Annual Average	Maximum Month	Peaking Factor
	(MGD)	(MGD)	(---)	(MGD)	(MGD)	(---)
2016	2,322	3,049	1.31	3,688	4,252	1.15
2017	2,251	3,276	1.46	3,278	3,767	1.15
2018	2,979	4,402	1.48	3,243	4,129	1.27
AVE	**2,517**	**3,576**	**1.42**	**3,403**	**4,049**	**1.19**
Selected Peaking Factor:			**1.20**			

Table 8-7. Historical TP loadings and peaking factors

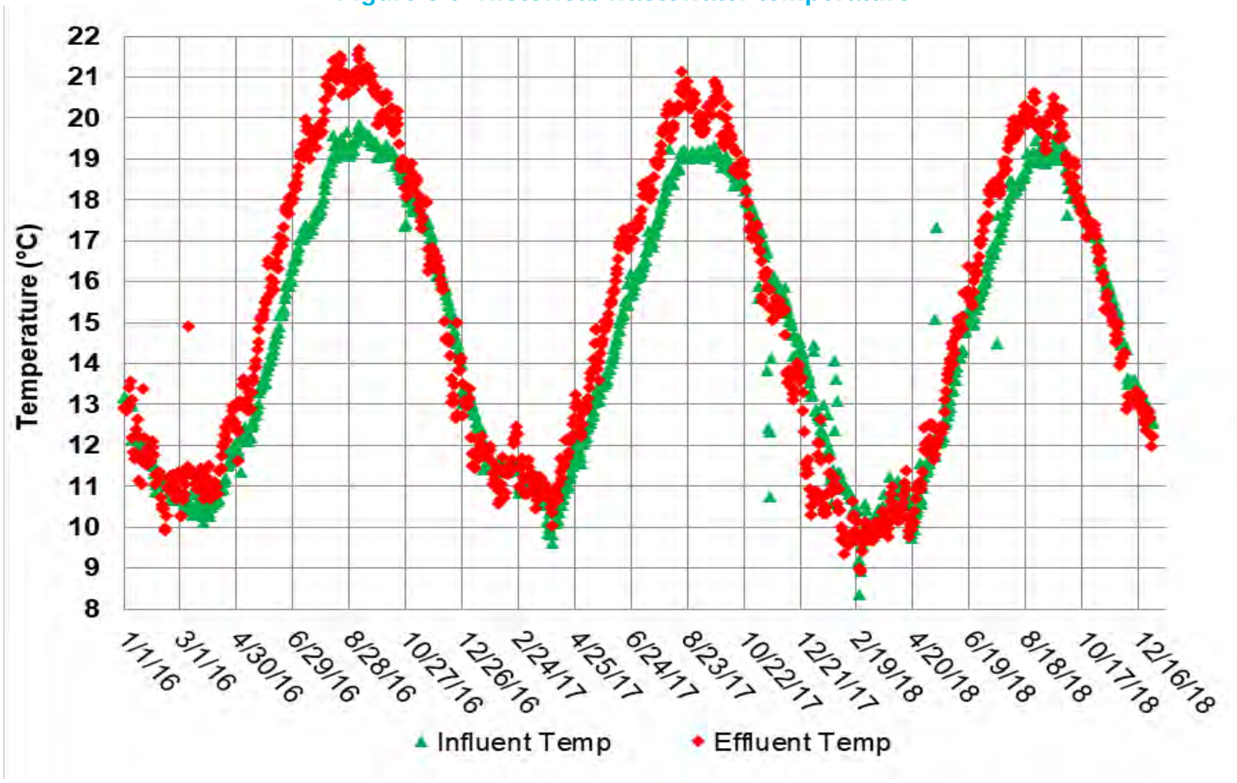
Year	Measured			Estimated		
	Annual Average	Maximum Month	Peaking Factor	Annual Average	Maximum Month	Peaking Factor
	(MGD)	(MGD)	(---)	(MGD)	(MGD)	(---)
2016	313	350	1.12	372	408	1.10
2017	299	413	1.38	368	405	1.10
2018	346	443	1.28	411	478	1.16
AVE	**319**	**402**	**1.26**	**384**	**430**	**1.12**
Selected Peaking Factor:			**1.20**			

The selection of the above peaking factors took into consideration both the estimated and measured peaks, as well as experience in conducting this analysis for several other WWTPs. Also, when selecting peaking factors, it was important to realize that not all pollutant loadings usually peak at the same time. As such, it is not advisable to select the maximum observed peaking factors for all pollutants as this can result in overly conservative designs that can be problematic to operate. Overly conservative designs can also result in expensive facilities with unused idle equipment and mechanical components that cannot be turned down enough to meet most-probable demands, especially if sized for conditions that are forecasted far into the future.

8.4 Raw Wastewater Temperature

Wastewater temperature has a significant influence on process performance. For example, the rate of nitrification decreases about 30% for each 5°C decrease in mixed liquor temperature. A historical investigation of wastewater temperature enables judicious selection of design basis temperatures. Figure 8.9 illustrates the historical daily influent and effluent temperature. Minimum, annual average, and maximum temperatures were respectively identified at 9, 15, and 20°C.

Figure 8.9. Historical wastewater temperature



8.5 Summary of Historical Plant Performance (See Appendix B)

The following summarizes the existing plant performance from historical data analysis discussed in Appendix B.

8.5.1 Primary Treatment Performance

Primary treatment performance is dependent upon the influent characteristics and typically related to the surface overflow rate (SOR) or the clarifier's hydraulic retention time (HRT). Racine's long term historical primary treatment performance of 72% TSS removal and 52% BOD removal was better than typical removals for the observed primary clarifier HRTs.

8.5.2 Secondary Treatment Performance

The secondary treatment system operation was investigated in terms of solids retention time (SRT) and waste activated sludge (WAS) production. The SRT is the length of time that solids remain in the secondary system and is a major parameter that influences solids production in an activated sludge process. Other factors include influent characterization, organic loading, and temperature. The long-term, calibration, and validation period MLSS respectively averaged 1,781 mg/L, 1,930 mg/L and 1,742 mg/L. Racine WWTP has an historic SRT of about 7.8 days

The total activated sludge system volume is about 5.65 MG. The WAS solids production respectively averaged 9,775 lbs/d, 10,304 lbs/d, and 9,628 lbs/d and the secondary effluent solids averaged about 1,036 lbs/d, 1,323 lbs/d and 1,111 lbs/d.

Mixed liquor flows into the clarifiers and is made up of the primary effluent plus the RAS flow. Solids flow out of the clarifier by means of the RAS, WAS, and clarifier effluent.

8.5.3 Nitrification Performance

The existing treatment plant meets effluent ammonia limits in the permit and achieves nitrification occasionally, depending upon weather, as well as flows and loadings. Full nitrification is not required and was not observed; the 30-day average effluent ammonia was typically between 2 and 7 mg/L while the observed aerobic SRT was typically between 7 and 12 days. This observation was somewhat surprising because the observed aerobic SRT was typically greater than the theoretical minimum 7-day threshold needed to provide full nitrification. This observation may warrant further investigation in the future.

Nitrification is more sensitive to SRT and temperature because the nitrifiers growth kinetics are much slower. When the aerobic SRT drops below the minimum time required for nitrifier biomass growth, they cannot be sustained and wash out of the system. The minimum aerobic SRT to completely nitrify varies as a function of nitrifier kinetic coefficients, temperature, and reactor regime (complete-mix vs. plug-flow). For preliminary evaluation purposes, the minimum aerobic SRT was calculated assuming complete-mix reactor conditions.

Based on the aforementioned kinetics, an aerobic zone DO concentration of 2 mg/L, an effluent ammonia of 1 mg/L, and the cold weather design temperature of 9°C, the minimum aerobic SRT was calculated at 7 days. This threshold represents the theoretical minimum aerobic SRT to provide full nitrification during the coldest conditions.

Based on current nitrifier activity, to protect against nitrifier washout, modeling of the aerobic SRT was performed at about 12 days or more. The SRT analysis showed excessive MLSS and SLR parameters for the projected maximum month conditions such that the aeration tank volume and clarifier surface area were increased to provide a conventional MLSS concentration and to prevent the SLR from exceeding 25 lbs/d/ft2. This resulted in a treatment plant expansion inclusive of an additional 2.36 MG of aeration tank volume (four 0.59 MG tanks) and 23,562 ft2 of clarifier surface area (three 100 ft diameter clarifiers).

8.5.4 Phosphorus Removal Performance

The plant has been practicing chemical phosphorus removal with ferric chloride addition to the primary influent for many years to successfully meet its 1.0 mg/L monthly average TP limit. The new permit criteria is 0.86 mg/L. Long term ferric chloride addition is averaging approximately 500 gallons per day or approximately 800 lbs/day Fe^{3+} at 40% concentration of solution added versus a design average day rated capacity dose of approximately 777 gal/day.

8.5.5 Secondary Clarifier Performance

The secondary clarifiers typically operate at surface overflow rates (SOR) of about 400 gpd/ft^2 and solids loading rates (SLR) of about 13 lbs/d/ft^2 with typical effluent TSS of 6 mg/l which is very good performance. The data also showed very good performance of effluent TSS of <10 mg/L with SLR loadings on the order of 20 lbs/d/ft^2.

8.5.6 Anaerobic Digestion Performance

Observed volatile suspended solids (VSS) destruction correlated well with predicted VS destruction in the range of 60-64% and biogas for all datasets fell within commonly accepted performance range of 12-18 cubic feet of biogas per lb. Volatile Solids destroyed.

8.5.7 Biosolids Dewatering Performance

Historical database indicates very good overall capture efficiencies of 95% of solids.

9.0 Design Wastewater Flows and Loadings and Projected Plant Performance

This section summarizes the development of annual average and maximum month conditions for the facility planning period. Basis of Design Conditions

9.1 Existing Plant Flows and Capacity Allocations

It is important to identify the origin of the new wastewater production associated with a plant's service area growth when projecting new additional flow and loadings. For facility planning purposes, a 20-year service envelope was identified for the plant, establishing a design year of 2040. The Racine County Department of Planning and Development, the Wisconsin Department of Administration, and the Southeastern Wisconsin Regional Planning Commission each provided population projections, all of which were around 150,000 for the currently defined service area. The projected population of 150,685 by the Department of Administration was used for evaluating the plant. This translated to a service area expansion of 14,685. New additional flows and loadings associated with this new population have been developed with the application of typical per-capita flow and loadings from Table 8-1. By adding the existing and additional flows and loadings together, Table 9-1 sets forth the design annual average conditions. Use of the peaking factors presented in Table 8-3 through 8-7 allowed for sensible extraction of the design maximum month average conditions based on the projected annual average conditions. Table 9-2 illustrates the annual average and maximum month flow and loadings for the design year of 2040.

Table 9-1. Development of design annual average conditions for 2040

Parameter	Unit		Existing Annual Average Conditions		Additional Annual Average		Design Annual Average Conditions	
Year	(year)		2016 - 2018		Growth to 2040		2040	
Population	(capita)		136,000		14,685		150,685	
Flow	(MGD)		22.0		1.9		23.9	
TSS	(lbs/d)	(mg/L)	26,601	145	2,937	184	29,538	148
BOD	(lbs/d)	(mg/L)	23,544	129	2,643	166	26,188	132
TKN	(lbs/d)	(mg/L)	3,402	18.6	426	27	3,828	19.2
TP	(lbs/d)	(mg/L)	384	2.1	68	4.2	452	2.3

Table 9-2. Projected annual average and maximum month conditions for 2040

Parameter	Unit		Annual Average		Maximum Month Average	
Flow	(MGD)		23.9		41.3	
TSS	(lbs/d)	(mg/L)	29,538	148	38,400	112
BOD	(lbs/d)	(mg/L)	26,188	132	32,211	94
TKN	(lbs/d)	(mg/L)	3,828	19.2	4,593	13.3
TP	(lbs/d)	(mg/L)	452	2.3	542	1.6

This indicates that the existing WWTP with a design average capacity of 36 MGD is sufficient to meet the stated growth projections.

Separate from this analysis, several SSR communities have requested increases in their average daily flow allocations at the WWTP. As discussed earlier, flow allocations are governed by the IGA and are a driver for this planning process. Table 9-3 presents the current average flows, current flow allocations and the requested flow allocations for each community.

Table 9-3. SSR Average Daily Flow Requests

Community	2016-2018 Average MGD[1]	Current Flow Allocation Average Day[2] MGD	Requested/Projected 2040 Flow Average Day MGD
Caledonia	3.60	5.13[3]	9.75[4]
Mount Pleasant	6.06	11.49[3]	19.60[5]
Somers			
Elmwood Park	0.10		
North Bay	0.07		
Sturtevant	1.02	1.78	3.00[6]
Wind Point			
Racine	11.28	17.06	17.06[7]
Total	**22.13**	**35.46**	**49.41**

Sources: 1. Racine Wastewater Utility 2016-18 Annual Reports, calculated
2. Racine Wastewater Utility 2018 Annual Report
3. After 1.0 MGD transfer from Caledonia to Mount Pleasant, 2018
4. E-mail from Anthony Bunkelman to Keith Haas, August 1, 2018
5. E-mail from Anthony Beyer to Keith Haas, October 10, 2018
6. Email from Jeff Seitz to Keith Haas, April 9, 2020
7. No increase in growth projections.

The requests from Mount Pleasant and Caledonia are based on land use plan full buildout conditions, including significant industrial user development, not solely on projected population growth estimates . Mount Pleasant's request also accounts for the 4.0 MGD committed to Foxconn. The majority of the allocation is anticipated to be used only sporadically. Domestic wastewater generated by Foxconn will be sent to RWU for treatment on a regular basis. The requested total of 49 MGD exceeds the rated flow capacity of 36 MGD. For these reasons, this plan includes the concept for a 12 MGD satellite plant to be developed on the former Case New Holland property immediately south of the WWTP. Further details of a future satellite plant are discussed in Section 11.

One of the challenges facing RWU and the SSR communities is that the current IGA is structured to tie peak flow allocations closely to the average daily flow allocations. However, increasing average capacity at the WWTP will not alleviate the peak flow issues discussed in Section 10.

9.2 Summary of Process Modeling Simulations at Design Loadings

The following sections describe process modeling results determined with the calibrated and validated process model (described in detail in Appendix B) at the projected flows and loadings shown in Table 9-2.

9.2.1 Effluent Limits and Simulation Scenarios

In addition to the existing TSS and BOD limits, an update to the plant's effluent permit included a more stringent TP limit of 0.86 mg/L. To evaluate meeting this new limit at the projected flows and loadings, the existing practice of chemical phosphorus removal was simulated. Potential reactor modifications were also investigated and simulated to provide biological phosphorus removal. For most model application simulations, no ammonia or nitrogen limits were assumed, but one set of full nitrification simulations were also carried out with chemical phosphorus removal. The following scenarios were assumed for each set of simulations:

- Annual average flow and loadings at annual average temperature
- Annual average flow and loadings during winter
- Annual average flow and loadings during summer
- Maximum month average flow and loadings during winter
- Maximum month average flow and loadings during summer

9.2.2 Simulation Assumptions

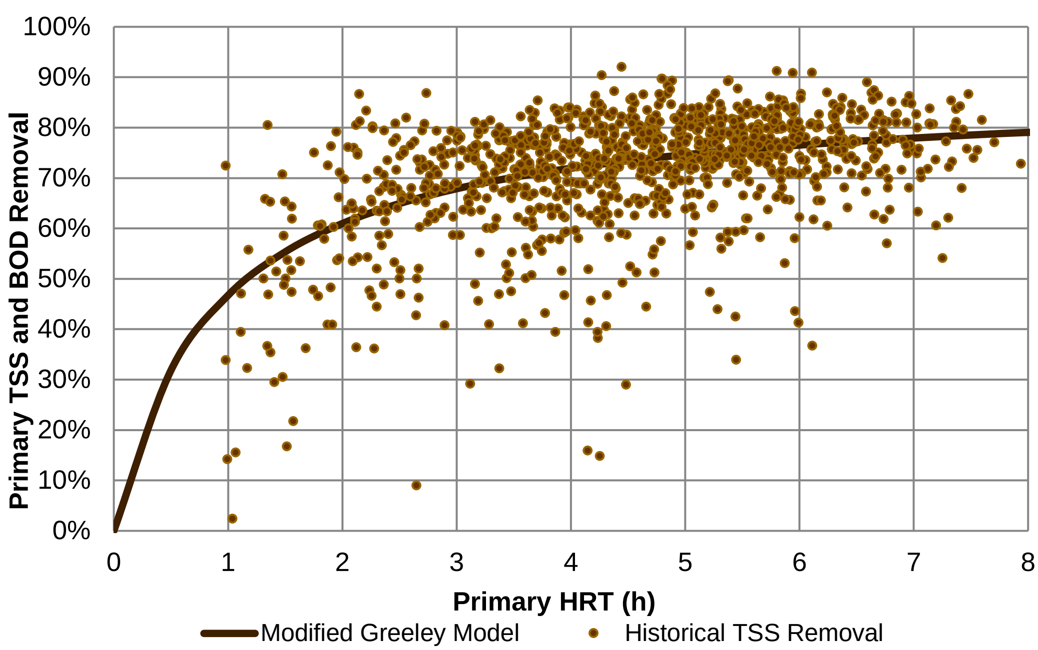
The following assumptions regarding the influent loadings, characterizations, environmental conditions, treatment units online, and operating parameters have been set forth for upgrade scenario simulations; most of which generally reflect the calibration and validation period observations:

- The raw wastewater stoichiometric fractions that achieved dynamic calibration and validation would remain in effect for the scenario simulations. The future annual average and maximum month influent characterization breakdowns have been included as a part of Appendix B, Attachment 3.1.
- Excess influent alkalinity for full nitrification
- All primary clarifiers, aeration tanks, secondary clarifiers, and digesters online
- Primary removal performance governed by a modified Greeley model (discussed later)
- Aeration tank aerobic zones operated at DO set points of 2 mg/L
- RAS rate set at 80% of secondary influent flow
- Secondary clarifier solids loading rate kept under 25 lbs/d/ft2
- Primary sludge set to about 4% solids
- Gravity belt thickener solids capture efficiency set at 95%
- Gravity belt thickened sludge set to 5% solids
- Belt filter press capture efficiency set at 95%
- Belt filter press dewatered sludge cake set to 19.8% solids

9.2.3 Modified Greeley Primary Treatment Model

In projecting future primary performance, a relationship was generated by means of a modified Greeley removal curve that was fitted to the observed solids removal data. Figure 9.1 illustrates the modified solids removal curve along with the historical primary solids removal data where the curve generally passed through the observed removal data. This curve was used in predicting the solids removal (and all particulate components, e.g. particulate BOD, particulate COD, particulate TKN, particulate phosphorus, etc.) when the simulations were carried out.

Figure 9.1. Modified Greeley primary treatment removal model



9.2.4 Chemical Phosphorus Removal

The projected annual average and maximum month average flows and loadings cited in Table 9.2 were employed in essentially running the existing configuration of the plant for the chemical phosphorus removal simulations. For the annual average conditions, the MLSS concentration was adjusted to typical historical values (~1,500 mg/L) which rendered an SRT of about 6 days. The aeration tanks were kept completely aerobic. Full nitrification was evident for the annual average loadings at the summer and annual average temperatures, but only partial nitrification was found for the winter conditions. For the maximum month loadings, the MLSS was set about 2,000 mg/L, which kept the secondary clarifier solids loading rate under the 25 lbs/d/ft^2 threshold. The SRT came out around 5.5 days, which enabled full nitrification during summer and only partial nitrification during winter. The ferric chloride addition required to meet the 0.86 mg/L limit was about 500 gpd for annual average loadings and 440 gpd at maximum month loadings. The slightly less ferric chloride requirement for the higher loadings was because the influent TP concentration was less at the higher loadings. The simulation results are shown in Appendix B, Attachment 4.1.

9.2.5 Biological Phosphorus Removal

The applicability of biological phosphorus removal (BPR) at Racine was investigated. BPR removal usually needs a secondary influent BOD/TP ratio of at least 20 to provide adequate carbonaceous material to drive P release. Historically, the primary effluent BOD/TP averaged about 36 (61 mg/L / 1.7 mg/L). Secondly, it was determined that simply converting the first zone of each aeration tank (first half of each first pass) into an unaerated and mixed zone would provide the proper HRT for a typical A/O process. This conversion would provide about 1.4 hours of HRT at annual average conditions and about 0.8 hours at the projected maximum month conditions. This is particularly convenient because P release typically occurs within an HRT range of about 0.5 to 2.0 hours. As such, the applicability of BPR at Racine appeared quite optimistic.

To model BPR at Racine, the zone 1 DO set point in the aeration tanks object was simply set to zero. The simulations indicated very good BPR performance for all the loading and temperature scenarios considered. The modeled effluent TP concentration was about 0.55 mg/L for all the annual average conditions and about 0.60 mg/L for the maximum month conditions. No ferric chloride addition was needed. Another major benefit that was apparent was a significant decrease in the aeration demand. Relative to the chemical phosphorus removal simulations, the aeration demand in the BPR simulations showed a 25 – 54% reduction, depending upon the loading and temperature conditions. Attachment 4.1 illustrates these results.

While the BPR simulations showed a major reduction in operating cost parameters, e.g. elimination of ferric chloride requirements and a reduction in aeration demand, there is the potential unintended consequences, specifically associated with nuisance struvite formation. Struvite is an insoluble crystalline mineral that can form in anaerobic digesters, sludge piping, and pumps when there is an ample availability of phosphate, ammonia, and magnesium. Due to the storage and removal of phosphate in the WAS and its subsequent conveyance to anaerobic digesters, soluble orthophosphate is typically re-released during digestion making struvite formation possible. There are, however, beneficial struvite harvesting technologies available that can prevent nuisance formation, and at the same time, provide revenue-generating fertilizer production. Such technologies may be appropriate if BPR were implemented by RWU.

9.2.6 Solids Retention Time Sensitivity

Nitrification requires a minimum aerobic SRT to provide time for the growth of nitrifying biomass. Model calibration and validation efforts identified an apparent AOB maximum specific growth rate of 0.7/d. With this finding, an aerobic SRT sensitivity analysis was carried out to identify the minimum aerobic SRT needed to fully nitrify whereby the effluent nitrogen speciation was plotted as the aerobic SRT was varied.

The aerobic SRT sensitivity analysis investigated the effluent ammonia, nitrite, and nitrate as a function of the aerobic SRT under the projected maximum month conditions and the minimum monthly wastewater temperature of 9.0°C. The effluent nitrogen results indicated that nitrification would be absent at aerobic

SRTs of around 7 days or less, partial nitrification would occur between about 7 and 10 days, and full nitrification would occur over 10 days. For design purposes, a slightly greater aerobic SRT of about 12 days or more is recommended to protect against nitrifier washout.

The analysis also investigated the required MLSS concentration and secondary clarifier solids loading rate (SLR) to provide the aerobic SRT in question. Figure 9.2 showed how the MLSS increased and Figure 8.4 showed how the SLR increased as the aerobic SRT increased. For example, at a 12 day aerobic SRT, the MLSS and SLR were respectively predicted at about 3,800 mg/L and 42 lbs/d/ft^2 at the existing aeration tank volume and secondary clarifier surface area. These findings are significant because this MLSS and associated SLR values are beyond the capabilities of the existing secondary system components.

Figure 9.2. Effluent nitrogen and MLSS sensitivity of aerobic SRT at 9.0°C

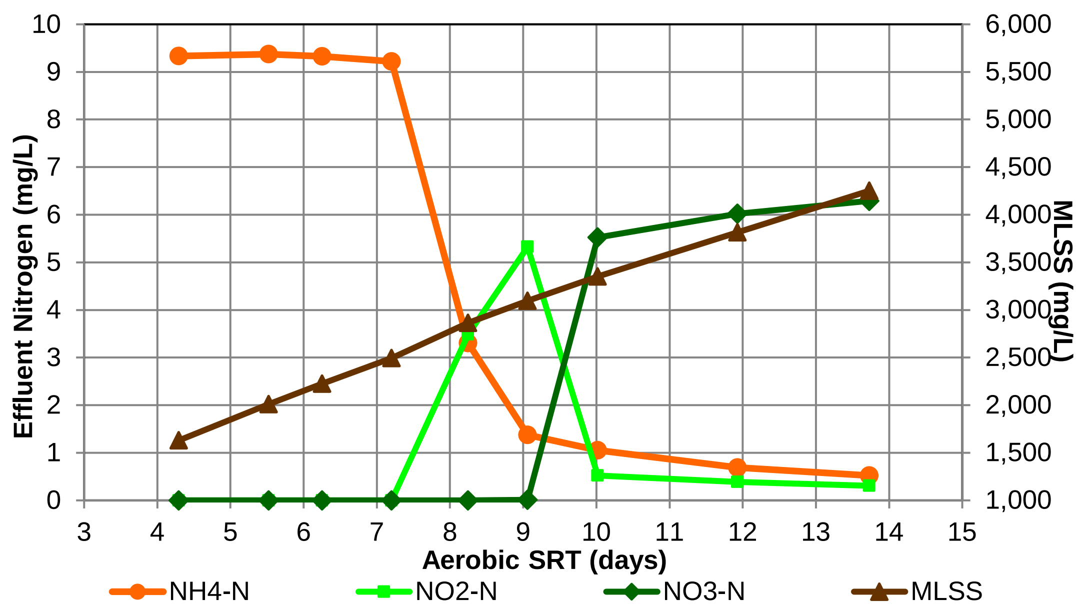
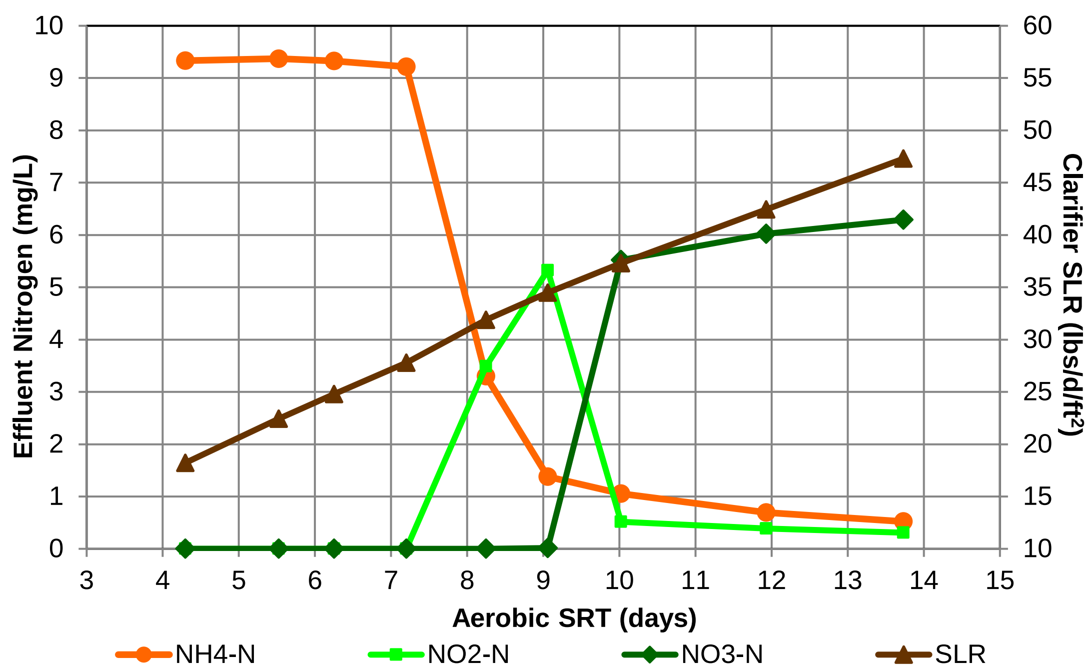


Figure 9.3. Effluent nitrogen and SLR sensitivity of aerobic SRT at 9.0°C



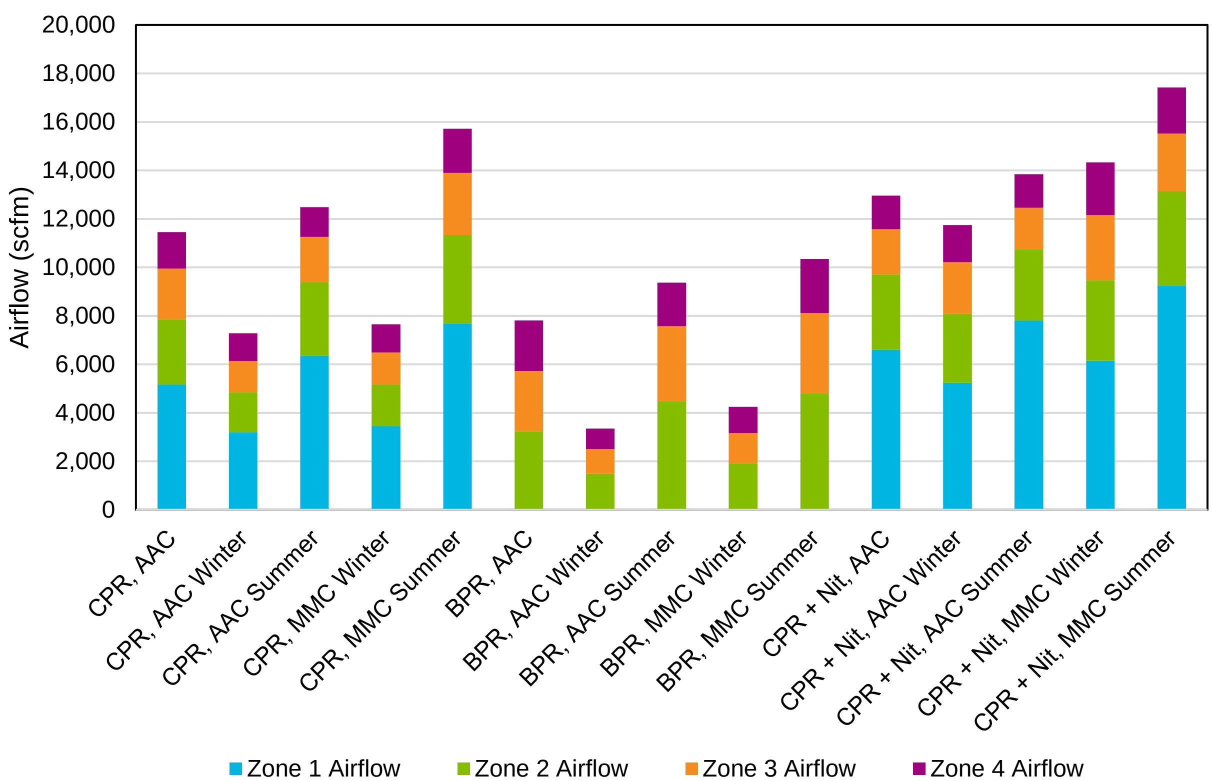
9.2.7 Nitrification and Chemical Phosphorus Removal

To protect against nitrifier washout, the aerobic SRT was maintained at about 12 days or more. Since the above SRT analysis showed excessive MLSS and SLR parameters for the projected maximum month conditions, the aeration tank volume and clarifier surface area were increased to provide a conventional MLSS concentration and to prevent the SLR from exceeding 25 lbs/d/ft^2. This resulted in a treatment plant expansion inclusive of an additional 2.36 MG of aeration tank volume (four 0.59 MG tanks) and 23,562 ft^2 of clarifier surface area (three 100 ft diameter clarifiers). The simulation results are shown in Appendix B, Attachment 4.1 and a conceptual layout of the expansion has been shown in Appendix B, Attachment 4.2.

9.2.8 Aeration Demand

The airflow estimations for the model application scenarios assumed the same alpha factors and diffuser densities employed for the model calibration/validation efforts. The apparent low fouling factor of 0.6, discussed in Appendix B, Section 3.3, however, was increased to 0.9 to reflect mostly clean/new diffusers. Figure 9.4 illustrates the total and airflow per zone for each simulation. As expected, the chemical phosphorus removal (CPR) simulation results indicated the highest airflow during the maximum month conditions (MMC) during summer when full nitrification was in effect and the lowest airflow during annual average conditions (AAC) during winter that showed only partial nitrification. A similar trend was apparent for the biological phosphorus removal (BPR) simulations, however, a significant reduction in airflow was found due to the removal of organic loading in the unaerated zone. The CPR with nitrification (CPR + Nit) simulations showed the highest airflows.

Figure 9.4. Simulated airflow requirements with new diffusers



10.0 Wastewater Conveyance Alternatives Analysis

10.1 General Overview

In this section of the Facilities Plan, conveyance system deficiencies are identified, and improvements intended to mitigate the deficiencies are presented. Alternatives are developed to provide the required hydraulic capacity to handle the projected design year 2040 flows. The design year 2040 wastewater flows developed in Section 9 of this report were routed through a hydraulic model of the Racine interceptor sewer network to identify sewer segments and lift stations not having adequate hydraulic capacity to carry estimated flows. The model was also used to determine the wastewater flows arriving at the wastewater treatment plant.

The wastewater conveyance alternatives presented in this section present the optimum combination of improvements, i.e. interceptor upsizing, lift station improvements, or flow equalization storage for design year 2040. A phased approach to improvements is outlined, prioritizing improvements based on the projected “system build-out” and the anticipated benefit of each proposed improvement.

The impacts of clear water infiltration and inflow (I/I) were evaluated by using the hydraulic model to predict the ratio of wet weather flow to dry weather flow at various locations throughout the sanitary sewer system in the current (year 2020) condition. Where excessive levels of I/I are identified, recommendations for reducing wet weather flows via the Capacity, Management, Operation and Maintenance (CMOM) programs of the individual Sewer Service Recipients (SSRs) are presented.

10.2 Design Storm

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) is the official metropolitan planning organization for the southeastern region of the State. SEWRPC has prepared guidelines to estimate total rainfall depth with a rainfall distribution to develop design storms (https://www.sewrpc.org/SEWRPC/Environment/RainfallFrequency.htm).

SEWRPC has developed hydrologic parameters in Intensity-Duration-Frequency (IDF) equations for computing rainfall intensity for seven counties in Southeastern Wisconsin, including Racine County. These IDF equations are based on the equation expressed by Chow et all, (1988):

$$i = \frac{a}{t^k + b}$$

where i is the rainfall intensity (inches/hour); t is the duration (minutes); a, b, and k are constant parameters.

The constant parameters were determined by SEWRPC using the statistical method of least squares by minimizing the Root Mean Square Error. The 5-year storm parameters are summarized in Table 10-1 for durations up to 24 hours. Based on the IDF equation with the 5-year storm parameters, the calculated total rainfall depth is 2.6 inches for the 5-year, 6-hour storm.

Table 10-1. 5-Year Storm IDF Parameters of Racine County for Durations Up to 24 Hours

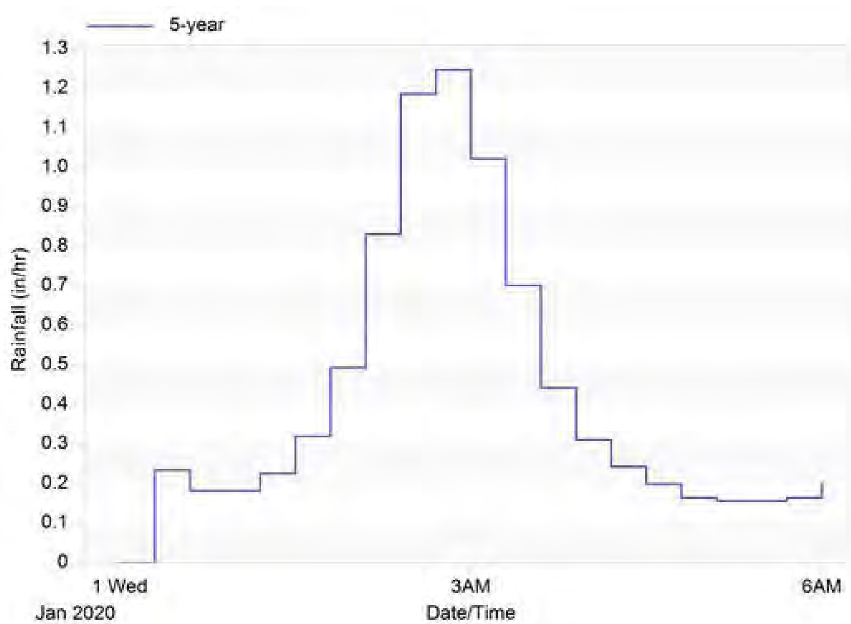
Recurrence (year)	a	b	k
5	79.095	13.289	0.872

SEWRPC also developed a rainfall distribution that is applicable for a range of storm durations and depths. Table 10-2 is a summary of the SEWRPC rainfall distribution cumulative percent of total rain versus percent of total storm time. As a result, the 5-year, 6-hour design storm hyetograph (shown in Figure 10-1 was created by applying the rainfall distribution curve and the total rainfall depth of 2.6 inches. Note that rainfall amounts on the hyetograph are adjusted in 0.3-hour increments.

Table 10-2. SEWRPC Recommended Rainfall Distribution

Percent of Total Storm Time	Cumulative Percent of Total Storm Rain
0	0
5	2.7
10	4.8
15	6.9
20	9.5
25	13.2
30	18.9
35	28.5
40	42.2
45	56.6
50	68.4
55	76.5
60	81.6
65	85.2
70	88
75	90.3
80	92.2
85	94
90	95.8
95	97.7
100	100

Figure 10-1. Rainfall Hyetograph for 5-year, 6-hour Design Storm



The 5-year storm was selected based on discussions with Wisconsin Department of Natural Resources (WDNR). It was agreed that a 5-year design would be used for the level of service, with the 10-year storm to provide an analysis of the incremental impact of higher level of service on facilities planning.

The duration of the design storm was selected based on the time of concentration. This is the time it takes for precipitation falling in a catchment to reach the assessment point. An application with a small service area will have a shorter time of concentration than an application that considers the entire service area, such as flows at the WWTP. A shorter duration storm will have a higher peak intensity, and a smaller depth than a longer duration storm. Additionally, the average time of concentration specified in the hydraulic model is 5.4 hours. Based on these considerations, a duration of 6 hours was selected. Therefore, the 5-year, 6-hour storm event was used as the design storm for the system-wide assessment of the RWU conveyance system, and the 10-year, 6-hour storm was applied to evaluate the incremental impact on facilities planning.

The 5-year, 6-hour and 10-year, 6-hour storm events were modeled to determine how the conveyance system responded in relation to service criteria presented in Section 10.3. These model runs are independent of the current allocation of peak flows based on IGA.

10.3 Service Criteria

A sanitary sewer collection and conveyance system is described as an engineered system of sewers, complete with all appurtenant facilities, sufficient in size, slope and capacity to collect and convey the required wastewater flows to an acceptable point of discharge. Service criteria establish the level of service to be provided by the sanitary sewer system and provide the basis for determining the adequacy of the system. For the purposes of this Facilities Plan, conveyance indicates those major sanitary sewers and interceptors that convey wastewater from each SSR to the WWTP. Collection refers to the sanitary sewers owned and operated by each SSR to serve their municipality. The service criteria for this study are as follows:

1. All gravity sewers must be capable of transporting wastewater flows generated by the 5-year, 6-hour rainfall event (2.6 inches) with limited surcharging. Limited surcharging is defined as surcharging of sewer segments due primarily to head loss associated with wastewater entering and exiting manholes and/or surcharging of interceptors to an elevation no higher than 9 feet below the ground surface.
2. Surcharging of gravity sanitary sewers should be limited to short durations during (and immediately following) the 5-year, 6-hour rainfall event and should not result in the backup of wastewater into basements.
3. Lift stations should be capable of handling wet weather flows generated by the 5-year, 6-hour rainfall event
4. Controlled diversion of untreated wastewater from the sewer system during (and immediately following) all rainfall events up to the 5-year, 6-hour rainfall (2.6 inches), except discharge at existing safety sites, is not allowed in the design year 2040 condition.
5. No significant increase in the volume of Safety Site Discharge resulting from the 5-year, 6-hour rainfall event during the 2040 Design condition from the 2020 condition.
6. Wherever possible, providing flow equalization throughout the overall wastewater conveyance system is preferred over improvements which increase peak flow arriving at the WWTP.

10.4 Analysis of Sanitary Sewer Conveyance System

The conveyance system was evaluated using flow developed for the study area (Section 9) to determine the adequacy of the interceptors and lift stations to meet the service criteria. The analysis was limited to the hydraulic capacity of the interceptors and modeled lift stations. Structural deficiencies of the sewer pipes and lift stations were not evaluated as part of this study. Each of the SSRs have ongoing programs addressing infiltration, inflow, and condition assessments. Ongoing maintenance of those systems are the responsibility of the individual SSR. The lift stations are maintained by the Utility. Identified improvements have been made by Utility staff and addressed as part of ongoing maintenance and capital budget planning.

The following wastewater flow scenarios were evaluated as part of the conveyance system study:

1. Conveyance System Performance: 5-Year, 6-Hour Storm, 2020 Existing Condition
2. Conveyance System Performance: 5-Year, 6-Hour Storm, 2030 Condition
3. Conveyance System Performance: 5-Year, 6-Hour Storm, 2040 Design – Baseline Condition
4. Conveyance System Performance: 5-Year, 6-Hour Storm, 2040 Design – Alternative No. 1 Condition (Evaluation of I/I Reduction Measures in Safety Site 8 Sewershed)
5. Conveyance System Performance: 5-Year, 6-Hour Storm, 2040 Design – Alternative No. 2 Condition (Evaluation of a second option for reduction of surcharging of the Mt. Pleasant/Sturtevant Interceptor)
6. Conveyance System Performance: 5-Year, 6-Hour Storm, 2040 Design – Alternative No. 3 Condition (Evaluation of a second option for reduction of surcharging of the KR Interceptor)
7. Conveyance System Performance: 5-Year, 6-Hour Storm, 2040 Design – Alternative No. 4 Condition (Evaluation of a third option for reduction of surcharging of the KR Interceptor)

Modeling of the 2020 Existing condition DOES NOT include the proposed new Pike River Lift Station because the Pike River Lift Station is not due to be completed prior to completion of this facilities planning report. The Facilities Plan is scheduled to be completed in the summer of 2020. The KR Lift Station was used in the 2020 condition.

Modeling of the 2030 Condition is based on the completion of previously recommended conveyance system improvements proposed for construction by RWU and SSR communities prior to 2030 included in the model. Most of these projects were contemplated prior to the work of this study by the SSR communities. Descriptions of these improvements can be found in Subsection 10.15.

Also, the Storage at Lift Station No. 2 was designed for a different return interval storm and was not being completely utilized during the 2020 condition modeled for this Facilities Plan. For the 2030 conditions modeling, modifications were a made to the Lift Station No. 2 pump start/stop elevations and the operation of the flow equalization basin. In the model, Pumps No. 2 and No. 3 were given higher elevations to start/stop to allow more overflow into the flow equalization storage basin. The flow equalization storage basin was also given an orifice with a flap gate through the weir to allow flow at lower elevations. The flow equalization storage basin at Lift Station No. 2 is fully utilized in the 2030 Condition modeling.

The 2040 Design - Baseline Condition consists of the 2030 Condition improvements plus the improvements proposed between 2030 and 2040. Descriptions of these improvements can be found in Subsection 10.16.

The 2040 Design - Alternative No. 1 Condition was evaluated to determine if I/I reduction in the Safety Site 8 sewershed is a cost-effective approach to reducing surcharging of the interceptor between Lift Station No. 2 and Lift Station No. 1. A description of Alternative No. 1 can be found in Subsection 10.17.

The 2040 Design - Alternative No. 2 Condition was evaluated to determine the cost-effective approach to reducing anticipated surcharging in the Mt. Pleasant/Sturtevant Interceptor north of the Pike River Lift Station in the future. A description of Alternative No. 2 can be found in Subsection 10.17 of this report.

The 2040 Design - Alternatives No. 3 and 4 Conditions were evaluated to determine the cost-effective approach to reducing anticipated surcharging in the KR Interceptor in the future. A description of Alternatives No. 3 and 4 can be found in Subsection 10.17 of this report.

10.5 Population and Flows

Study area population and wastewater flows were developed in Section 9. For a number of sewersheds, peak flows are based on SSR community requests, not the projected population growth. Wastewater flows routed through the interceptor sewer network were modeled to identify conveyance system deficiencies.

10.6 Hydraulic Computer Model

Background

A hydraulic computer model of RWU's sewer service area conveyance system was developed to assist in performing the hydraulic analysis to identify conveyance system deficiencies for past projects. The original model was constructed in the using Pizer's HYDRA and used for the 1998 Racine Wastewater Facility Plan. This model was then converted to a MIKE URBAN collection system model developed by the Danish Hydraulic Institute (DHI). In 2006, this model was used for the Caledonia I-94 Service Area Trunk Sewer Analysis. Following that project, the model was updated and improved to be used for the Storage Optimization Study in 2009. Since 2009, the model had been used to evaluate specific areas in the system that had been identified during the 1998 Facility Plan and the 2009 Storage Optimization Study for storage project and conveyance upgrades.

Introduction

For this project, the MIKE URBAN 2016 was used to evaluate the conveyance system. The Existing Conditions model created during the 2009 Storage Optimization Study was used as the starting point for the collection system model. This model dataset was then reviewed and updated to incorporate available sources of information including, but not limited to, project models (modeled segments of the system used to evaluate conveyance projects in specific area), sanitary sewer as-built drawings, known sewer improvements and field information.

The characteristics of the sanitary sewer system, including length and diameter of sewers segments, pipe roughness coefficients, ground surface elevations, invert elevations, and basic flow data were input into the model.

Information presented in the hydraulic model includes flows generated, maximum velocity, pipe capacity, percent of capacity utilized, hydraulic grade line (HGL) elevations and pipe slope.

Model Updates

A significant effort was required to update the 2009 hydraulic model of the RWU conveyance system. Sixteen (16) projects needed to be added to the original model. Also, the 2009 model utilized a very different rainfall event as the design storm., which does not allow for direct comparison of modeling outputs.

Conveyance system components added to the 2009 version of the model consist of the following;

- TID 5 Interceptor System
- Pike River Lift Station
- 15th Street & Lathrop Avenue relief interceptor (Racine)
- Horlick Avenue Siphons (Racine)
- Osborne Boulevard Interceptor (Racine)
- Kinzie Avenue Interceptor (Racine)
- Blaine Avenue Interceptor (Racine)
- Lift Station No. 2 Storage (Racine)
- Ohio Street In-line Storage (Racine)
- Spring Street/Blaine Avenue Diversion (Racine)
- Hood's Creek Lift Station Storage Basin (Caledonia)
- North Park Lift Station and Forcemain (Caledonia)
- Dunkelow Road Sewer/Easement Sewer (Caledonia)
- CTH KV Lift Station & Forcemain (Caledonia)
- CTH K and Adams Road Interceptor (Caledonia)
- CTH V interceptor (Mount Pleasant)

For the conveyance system components listed above, the following paragraphs detail the work involved to incorporate them.

Pike River Lift Station and TID 5 Interceptor System

The Pike River Lift Station and TID 5 interceptor system was previously modeled for the TID 5 Interceptor Sewer System Improvements Project designed by Foth Infrastructure and Engineering, LLC. (Foth I&E). These components of the conveyance system were imported in the model and updated with current information on the pumps and wet well dimensions based on the bid documents received from Foth I&E.

15th Street & Lathrop Avenue Relief Interceptor

This segment of the sewer was previously modeled for design purposes in a separate model from the 2009 Storage Optimization Study model. For this Facilities Plan, the 15th Street and Lathrop Avenue Relief Interceptor was imported into the system model and updated using record drawings.

Horlick Avenue Siphons and the Osborne Blvd.-Kinzie Ave.-Blaine Ave. Interceptor

This interceptor and siphons connect the Spring Street/Blaine Avenue diversion to the interceptor on the east side of the Root River. The interceptor on the east side of the Root River carries flow from Lift Station No. 2 to Lift Station No. 1, and the Osborne-Kinzie-Blaine interceptor discharges downstream of Lift Station No. 2 before Lift Station No. 1. This conveyance system information was imported from GIS shape files. Due to limited data/plans on the interceptor, the slopes of the pipes were back-calculated using standard slopes and elevations at both ends. This was added because wastewater flowing towards Lift Station No. 2 can be routed through this interceptor during high flow via a high point manhole at the bottom of the Spring Street/Blaine Ave diversion.

Lift Station No. 2 Storage

Originally, this basin had been modeled separately from the RWU master model for project design purposes. The Lift Station No. 2 storage basin design model was imported in the master model. Conveyance system components were updated according and checked with the bid set of plans for the storage system.

Ohio Street In-line Parallel Storage

The In-line/parallel storage located along Ohio Street in Lockwood Park consists of approximately 392’ of 18” PVC, 115’ of 36” PVC, and 750’ of 54” Fiber-Reinforced Plastic Matrix Pipe (FRPMP) feeding two (2) parallel 590’ long 54” FRPMPs. Constructed and put in service March of 2009, the system stores approximately 160,000 gallons. This project had been previously modeled separately from the RWU master model for project design purposes. The project was imported into the master model and updated using record drawings.

Spring Street/Blaine Avenue Diversion

The Spring Street interceptor has a weir in MH Y0030 which diverts low flow downstream through the Blaine Avenue interceptor to MH Y0021 where it continues down Whitter Drive then back up Hawthorne Drive and through Maple Grove Park connecting back into the Spring Street interceptor leading to Lift Station No. 2. This project was previously modeled separately from the RWU master model for project design purposes. It was imported into the master system model.

Hood’s Creek Attenuation Basin

The Hood’s Creek Attenuation Basin was constructed in Caledonia on the north side of Northwestern Avenue at Airline Road. The basin, which stores 1.5 MG, was completed in 2013. This storage basin was inputted into the RWU master model using record drawings.

Dunkelow Road Sewer/Easement Sewer

These sewers were added to the model using record drawings provided by Foth Infrastructure & Engineering (Foth I&E). It was determined these were needed due to a diversion structure on Dunkelow Road that can divert flow to the Hood’s Creek Attenuation Basin.

North Park LS and Force Main

The North Park Lift Station is located on 4 ½ Mile Road on the east side of Caledonia. The forcemain goes from the lift station to the corner of Dodge Street & Michigan Blvd. This project was previously modeled in a future conditions model presented in the October 2009 report titled, “Storage Optimization Study for Racine Wastewater Utility”. It was imported into the existing conditions model and revised to reflect current conditions.

KV Lift Station and Force Main

The KV Lift Station is located on southeast corner of CTH K & V on the west side of Caledonia. The forcemain goes from the lift station to a Mount Pleasant interceptor on CTH V. This lift station and forcemain were added to the model using record drawings provided by Foth Infrastructure & Engineering (Foth I&E).

Conveyance System Model Components Updated/Modified:

Conveyance system model components updated or modified consist of the following;

- Grove Avenue Storage (Racine)
- Echo Lane (Racine)
- LS06 Pump Curves (Racine)
- Dry Weather Flow Generation
- Converted from “Rainfall Derived Infiltration (RDI)” module to “Time-Area + RDI” as described in Subsection 10.5.4.3 of this Facilities Plan.

Grove Avenue Storage

The Grove Avenue storage basin is located underneath a parking lot on Grove Avenue approximately 200’ south of Washington Avenue. The storage basin stores approximately 650,000 gallons. Construction of the basin was completed in March 2007. The basin is filled through a 24” overflow pipe installed in Manhole Z0010 on Washington Avenue. The basin is emptied manually through pumps when downstream conditions allow. This basin was previously modeled for project design purposes. It was imported into the RWU master model and reviewed using record drawings.

Echo Lane

The model was updated using the size, material, and invert elevations of the interceptor on Kinzie Avenue and Echo Lane using record drawings.

Converted Model from “Rainfall Derived Infiltration (RDI) Module” to “Time-Area + RDI”

The RDI module was primarily applied for wet weather responses to predict both inflow and infiltration in the October 2009 Storage Optimization Study. The module in MIKE URBAN, however, is designed to simulate slow responses, which include surface storage, root zone and groundwater infiltration. For inflow, the Time-Area method in MIKE URBAN can be utilized to model fast responses during wet weather events. Using the RDI module to mainly simulate both inflow and infiltration may not be appropriate to produce runoff from sub-catchments. Therefore, converting hydrology modules from RDI only to Time Area + RDI is highly recommended. In this study, both modules are applied to model inflow and infiltration to calibrate the RWU hydrologic and hydraulic model and run wet weather simulations.

Dry Weather Flow Generation

The dry weather flow (DWF) was altered in the model for all the meter areas. In the original model, DWF for the meter areas were inputted in three ways; 1.) residential flow was apportioned by population, 2.) commercial flow was apportioned by drainage area, and 3.) industrial flow was added as a value independent of catchment area or population. This method was changed to facilitate the calibration process to a method called “Wastewater Production Method” which has two components of dry weather flow: sanitary flow (daily dry flow) and baseflow (infiltration) base on the population of any given catchment. So, the dry weather flow is generated by the persons equivalent (PE) in a given catchment multiplied by the diurnal pattern multiplier, then multiplied again by the gallons per capita in its given meter-shed based on the sanitary and base flow numbers.

LS06 Pump Curve

During the calibration, discharge flows from LS06 were found to be higher than metered data. To address this discrepancy, the model pump curves were reduced from 2.808 MGD to 0.96 MGD per pump to better match the metered data.

10.7 Computer Model Calibration

10.7.1 Metered Sites

The RWU conveyance system has various locations with flow meters, conveyance level meters, and safety site discharge meters. The MIKE URBAN conveyance system model was calibrated using metered data from the meter locations in Table 10-3.

Table 10-3. Calibration Meters

Meter Name	Meter Type	Location
WWTP	Flow	WWTP Influent Flow
LS 01	Flow	Lift Station No. 1 East & West Lift Station
LS 02	Flow	Lift Station No. 2 12-inch & 16-inch Forcemain
LS 06	Flow	Lift Station No. 6
M01	Flow	Riverbend Lift Station - Caledonia West Point-of-Entry
M02	Flow	North Park Lift Station (Central Lift Station)
M03	Flow	HWY 32 & Bryn Mawr Avenue
M04	Flow	KR Lift Station
M07	Flow	Spring Street & Spring Valley Drive
M08	Flow	Shirley Avenue & Ohio Street
M09	Flow	Westmore Drive & Green Bay Road
M10	Flow	16th Street & Ostergaard Avenue
M11	Flow	Sturtevant - On Willow Road 1000' North of Durand Avenue
SS LS02	Flow	Lift Station No. 2
SS LS06	Flow	Lift Station No. 6
SS 01	Flow	Augusta Street & Michigan Boulevard
SS 02	Flow	Michigan Boulevard North of Lombard Avenue
SS 03	Flow	LaSalle Street & Carlton Drive
SS 04	Flow	16th Street & Wisconsin Avenue
SS 05	Flow	21st Street & Grove Avenue
SS 06	Flow	Grove Avenue & Washington Boulevard
SS 08	Flow	West 6th Street Siphon
SS 09	Flow	Ontario Street Siphon
SS 10	Flow	Brentwood Drive & Spruce Street
SS 11	Flow	Knoll Place & Norwood Drive
SS 12	Flow	Golf Avenue & Conrad Drive

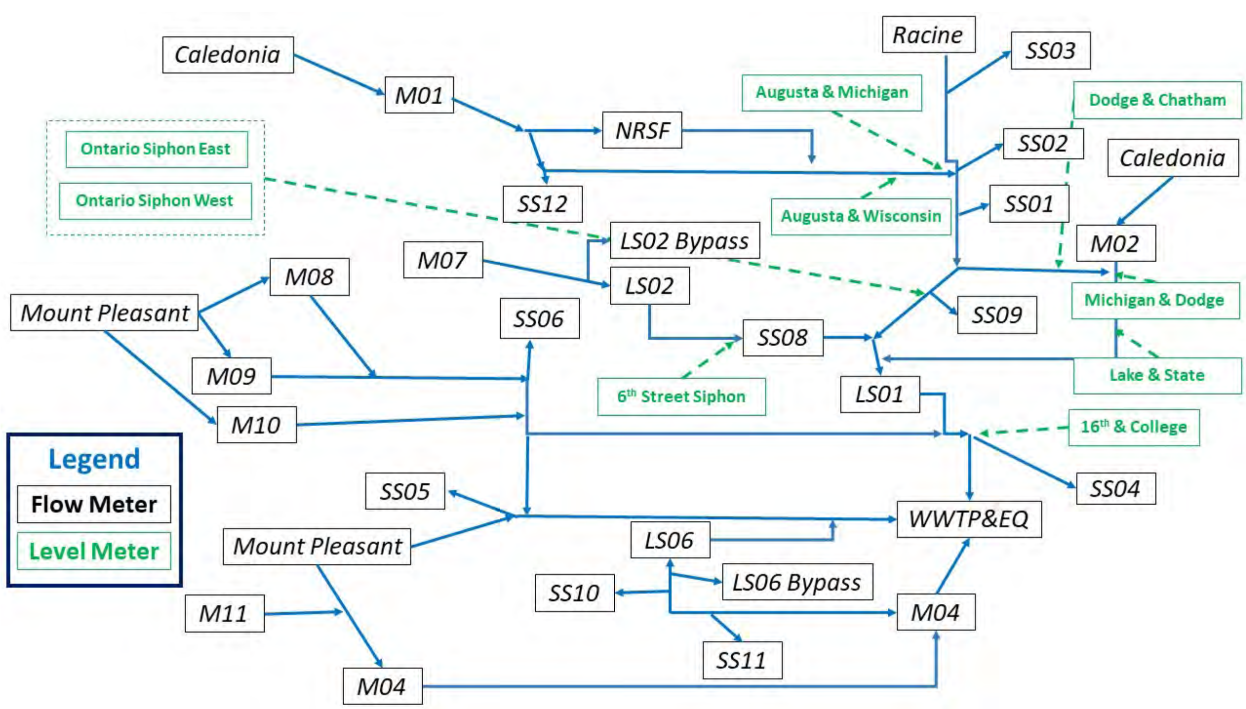
Table 10-4 displays level meters and a flow meters that were considered to be calibrated. However, the data recorded at these points had shown to be unreliable. The data was generally disregarded or used as a spot check when applicable.

Table 10-4. Considered Calibration Points

Meter Name	Meter Type	Location	Comment
16th and College	Level	16th Street & College Avenue	Unreliable/Bad Data
6th Street Siphon	Level	West 6th Street Siphon	Unreliable/Bad Data
Augusta and Michigan	Level	Augusta Street & Michigan Boulevard	Unreliable/Bad Data
Augusta and Wisconsin	Level	Augusta Street & Wisconsin Avenue	Unreliable/Bad Data
Dodge and Chatham	Level	Dodge Street & Chatham Street	Unreliable/Bad Data
Lake and State	Level	Lake Avenue & State Street	Unreliable/Bad Data
Michigan and Dodge	Level	Michigan Boulevard & Dodge Street	Unreliable/Bad Data
Ontario Street Siphon - East Line	Level	Ontario Street Siphon - East Line	Unreliable/Bad Data
Ontario Street Siphon - West Line	Level	Ontario Street Siphon - West Line	Unreliable/Bad Data
NRSF	Flow	Flow to WWTP - Diversion Structure at Northside Remote Storage Diversion	"Manual" Operation

Below is Figure 10-2 displaying a calibration meter schematic which outlines the connectivity of the system.

Figure 10-2. Calibration Meter Schematic



10.7.2 Dry Weather Flow Calibration

The model was first calibrated to dry weather flow (DWF) after the system was updated to reflect current conditions. The period chosen for DWF calibration started on 9/27/2018 and ended on 9/28/2018 for a duration of 24 Hours.

During the calibration three components were used to generate the flows coming from each catchment and create a flow pattern within the meter-sheds. These three components were; 1.) persons equivalents (PEs), 2.) base flow/sanitary flow, and 3.) diurnal patterns.

A diurnal pattern describes how the flow developed for each catchment is allocated in the system throughout the day. To begin this process, catchments were assigned to a specific point in the system that is related to a flow metered location used for calibration. This allows the diurnal patterns developed from the flow meter data to be allocated to each respective catchment and guides decisions made during the calibration process.

In the original model, the model had diurnal pattern averages that did not equal 1,0 which typically indicates that a peaking factor was applied. Therefore, all diurnal patterns for each meter-shed were reconfigured to have an average equal to 1.0 while matching the pattern of the metered data.

A peaking factor is not needed for dry weather flows when calibrating existing catchments for two reasons. The first one is total volume for a meter-shed over the period of the dry weather flow calibration event will be matched by applying a base and sanitary flow for each catchment. The second reason for not utilizing a peaking factor is that the adjusted applied diurnal pattern will match the metered data over the duration of the dry weather period.

As previously noted, dry weather flows in the original model were generated from three sources; residential flow, commercial flow, and industrial flow. The method used to generate dry weather flows was called the Wastewater Production Method outlined in a paper called “Quantifying Base Infiltration in Sewers” by ADS Environmental Services. The dry weather flow consists of two contributors: base flow and sanitary flow. Each of the meter-sheds has a quantity for each specific flow to the meter-shed. Base flow is to simulate the base infiltration, and the sanitary flows are to simulate the daily usages. Each flow has a gallon per capita assigned, and the sanitary flow has a diurnal pattern.

For each catchment in the model, person equivalents (PEs) were assigned to it from multiple past projects. These PEs were reviewed and adjusted accordingly based on the dry weather flow calibration results and GIS aerial mapping. These PEs are then multiplied by the base and sanitary flow gallons per capita, and diurnal pattern multiplier, to simulate the dry weather flow coming out of each catchment.

10.7.3 Wet Weather Calibration

Table 10-5 displays the periods and events chosen to calibrate the model. A variety of rain events with different return intervals were chosen to provide a more accurate calibration. This allows the parameters in the Time-Area + RDI modules to closer represent the fast and slow response runoff.

Table 10-5. Calibration Events

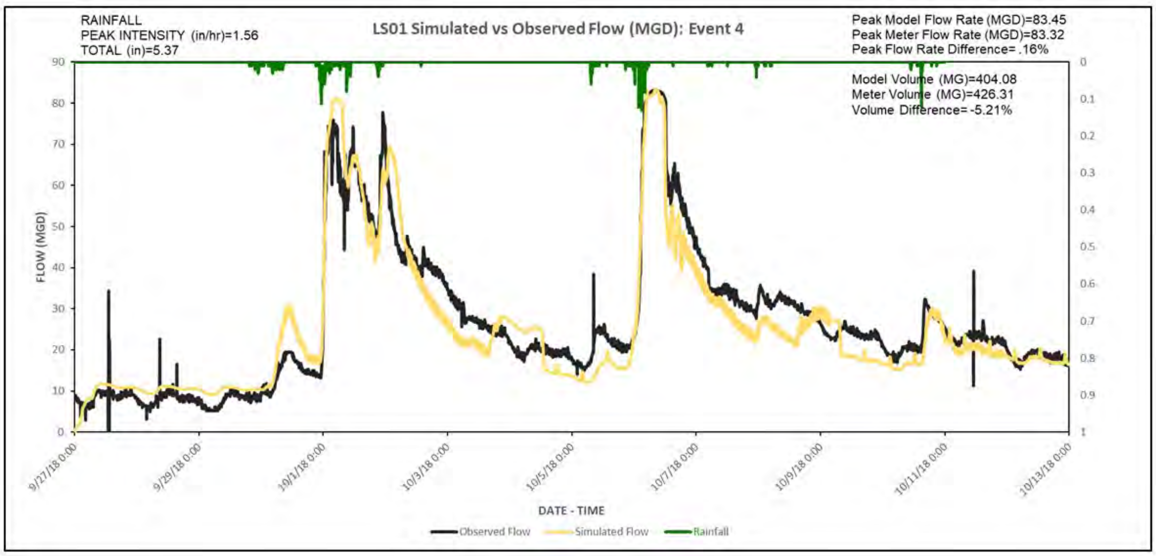
Events	Start	End	Rainfall Depth (in)	Return Interval
1	5/12/2014 17:00	5/13/2014 1:00	2.70	5 Year
2	7/11/2017 0:00	7/16/2017 0:00	2.80	5 Year
3	5/8/2018 0:00	5/19/2018 0:00	3.62	2 Year
4	9/27/2018 0:00	10/13/18 0:00	5.40	10 Year

The model was originally configured to use the RDI module as the primarily source of wet weather responses to predict both inflow and infiltration in the 2009 storage optimization study. The RDI module in MIKE URBAN is designed to simulate slow responses, which include surface storage, root zone and groundwater infiltration. For inflow, Time-Area method in Mike Urban can be utilized to model fast responses during wet weather events. Using the RDI module to mainly simulate both inflow and infiltration may not be appropriate to produce runoff from subcatchments. Therefore, converting hydrology modules from RDI only to Time Area + RDI is highly recommended. In this study, both modules are applied to model both inflow and infiltration to calibrate the hydrologic and hydraulic parameters during the storm simulations.

During the calibration, hydrologic and hydraulic parameters were adjusted for each meter-shed. In the Time-Area module following: impervious percentage, time of concentration, and sometimes initial loss. In the RDI module: area percentage, surface storage (Umax), root zone storage (Lmax), overland coefficient (CQOF), TC overland flow, TC interflow, and thresholds parameters for groundwater recharge, interflow, and overland flow to match the peaks and volumes of the metered data during the rain events.

The model was first calibrated to Event 4, the reason for this was the Event 4 was the most responsive to the hydraulic and hydrologic parameters in the meter-sheds. Once the model was close to matching Event 4, the model was then run using Event 1 for calibration. Event 1 was the least responsive to the hydraulic and hydrologic parameters. The calibration process then continued by simulating Event 1 and Event 4, changing the parameters to match metered data. During this process, Event 2 and Event were simulated to check how it matched using the parameters altered during Event 3 and 4 simulations. This process was continued until meter-sheds were within acceptable tolerances. See Figure 10-3 below displaying calibration results at LS01 during Event 4.

Figure 10-3. Calibration Result at Lift Station No. 1



10.7.4 Future Flows

Future flows for existing catchments were calculated using each community's' 2035 Master Plan land use and the open space analysis using an aerial map in GIS. The open space was compared with the corresponding land use. The four types of the land uses and the corresponding generated flows are displayed in Table 10-6. The acreage identified during the open space analysis was further reduced by 15% for future roads and storm water ponds. The rates below are consistent with previous planning documents developed for projects within the sewer service area, namely: 2003 Interceptor Sewer System Capacity Study for Mount Pleasant, 2006 Trunk Sewer Analysis for Caledonia, 2009 Storage Optimization Study for Racine Wastewater Utility, and the 2018 Facilities Plan for TID 5 Interceptor Sewer System for Mount Pleasant.

Table 10-6. Flows Corresponding to Land Use

Land Use	Gallons per Acre
Residential	1000
Commercial	1200
Commercial/Industrial	1600
Industrial	200

No peaking factors were applied to the existing catchments providing flows in the 2020 condition.

Catchments representing an expansion of the sewer service area were calculated through the same method described above but included a peaking factor of 2.5. These peak flows were provided by Foth I&E, LLC from the facility plan for the Pike River Lift Station.

10.8 Conveyance System Performance: 5-Year, 6-Hour Storm, 2020 Existing Condition

During rainfall events up to the 5-year, 6-hour storm, most RWU interceptor sewers had sufficient capacity to carry estimated wastewater flows under 2020 existing conditions. However, fifteen areas within the interceptor conveyance system did not meet the service criteria established for this Facilities Plan for the 2020 existing condition flows. Those fifteen segments are summarized in Table 10-7 and illustrated on Figure 10-4.

The modeling results for the 2020 existing condition can be found in Appendix C.

Outlet	Qmax MGD	Volume MG
SS 01	2.8128	0.2354
SS 02	5.4362	0.8849
SS 03	0.3193	0.0438
SS 04	0.0006	0.0013
SS 05	0.0006	0.0031
SS 06	0.0019	0.0074
SS 08	6.4774	1.0046
SS 09	3.8146	0.5555
SS 10	< 0.0001	0.0002
SS 11	1.7315	0.5178
SS 12	0.0006	0.0024
SS LS02	< 0.0001	0.0011
SS LS06	0.0006	0.0023
WWTP EQ Basins	64.1900	27.2600
WWTP	95.0000	229.7400

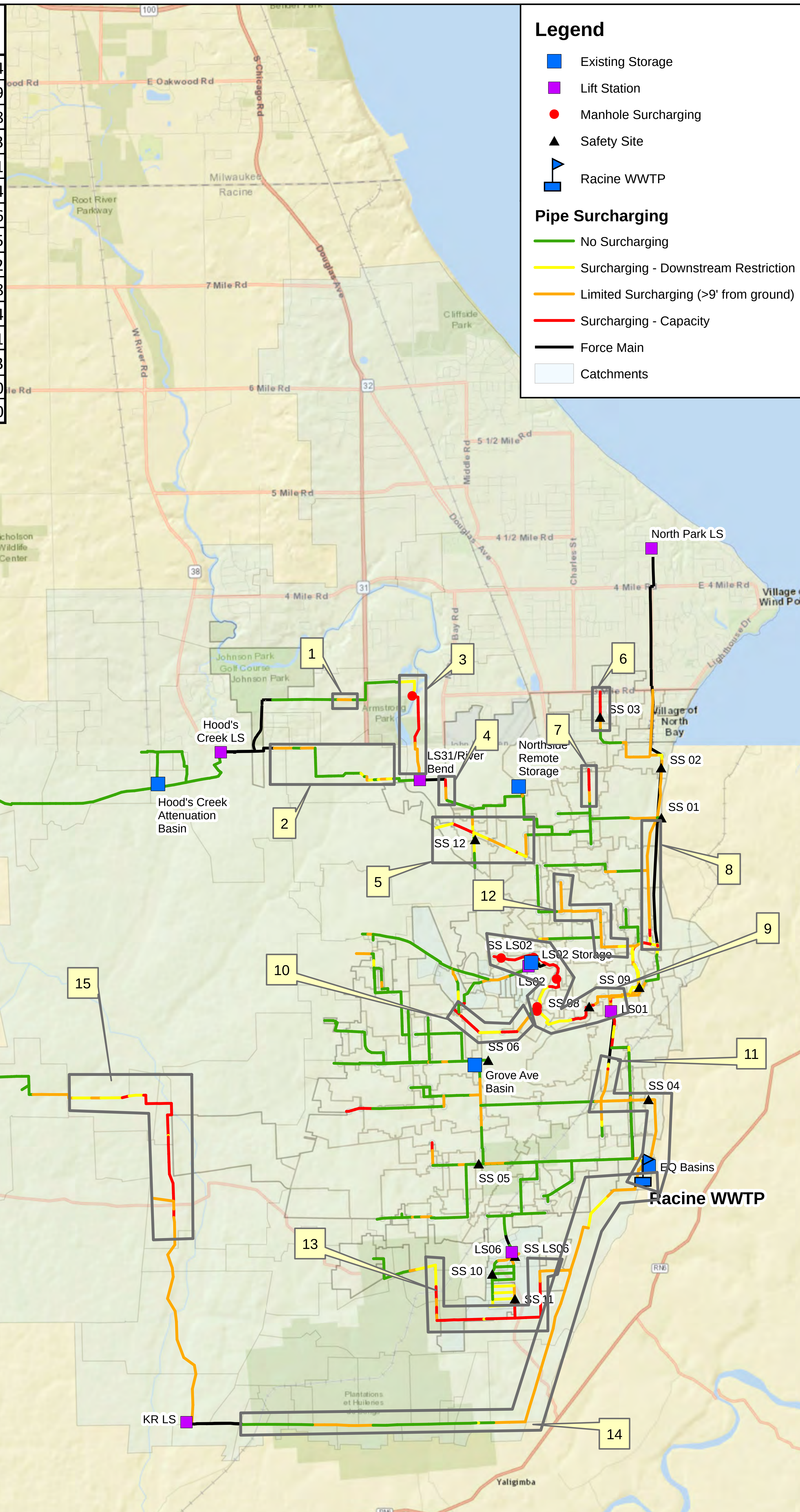


Figure 10-4
2020 Condition Capacity Constraints

AECOM

Drawn By: JFP
Checked By:
Date:
Project #: 60554970

Racine Facilities Plan
Racine Wastewater Utility

Projection:
NAD_1983_2011_StatePlane_Wisconsin_South_FIPS_4803_Ft_US

0 0.5 1 2 Miles

Table 10-7. Capacity Constraints
2020 Existing Condition

Constraint No.	Description	Location	Issue	Comments
1	Hood's Creek Lift Station North Discharge	Northern interceptor receiving discharge from Hood's Creek LS and flowing to LS 31 in the northwest portion of the service area.	Limited surcharge	No improvements proposed because the hydraulic grade line is greater than 9.0 feet from the ground surface in the surcharged segments. This capacity constraint was removed from further consideration.
2	Hood's Creek Lift Station South Discharge	Southern interceptor receiving discharge from Hood's Creek LS and flowing to LS 31 in the northwest portion of the service area.	Limited surcharge	No improvements proposed because the hydraulic grade line is greater than 9.0 feet from the ground surface in the surcharged segments. This capacity constraint was removed from further consideration.
3	Lift Station No. 31 (River Bend) Upstream Interceptor	Caledonia interceptor along Root River north of LS 31.	Surcharged	Improvements considered for this surcharged area included(1): • Underground flow equalization basin • In-line flow equalization piping • Parallel relief sewer
4	Lift Station No. 31 (River Bend) Downstream Interceptor	Discharge point for LS 31 on North Green Bay Road from Buckley Road to Long View Lane.	Surcharged	This constraint is being addressed by the extension of the forcemain from LS 31, under design by Caledonia. The proposed forcemain extension is included in the 2030 condition.
5	Rapids Drive Area Interceptor	This area receives flow from Caledonia from LS 08.	Surcharged	Pipe flowing full in the model with less than 9 feet between top of pipe and ground surface. Although this exceeds the established service criteria in one location, further investigation found no basement backups reported in this area. No improvements proposed at this time. This capacity constraint was removed from further consideration.
6	LaSalle Street Trunk Sewers	LaSalle Street from 3 Mile Road to Shorecrest Drive.	Surcharged	Upgrades to trunk sewers proposed.
7	Geneva Street Interceptor	Geneva Street (South Street to Wolff Street).	Surcharged	Upgrades to interceptor sewers proposed.

**Table 10-7. Capacity Constraints
2020 Existing Condition**

Constraint No.	Description	Location	Issue	Comments
8	Michigan Boulevard Interceptor	Downstream of Augusta Street in the northeast portion of the service area.	Surcharged	Improvements considered for this surcharged area included(1): • Underground flow equalization basin • In-line flow equalization piping • Parallel relief sewer
9	Lift Station No. 2 (Brose Park) Downstream Interceptor to Lift Station No. 1	Interceptor along Root River, downstream of LS 02 and upstream of the 6th St siphon under the Root River.	Surcharged	Improvements considered for this surcharged area included: • Underground flow equalization basin along Root River • Relief Sewer • I / I reduction measures
10	Osborne Blvd./ Kinzie Avenue Interceptors	These interceptors discharge to the interceptor along the Root River upstream of LS 01.	Surcharged	Improvements considered for this surcharged area included(1): • Underground flow equalization basin • In-line flow equalization piping • Parallel relief sewer • Interceptor Up-sizing
11	Lift Station No. 1 Downstream Interceptors discharging to WWTP	These interceptors receive the discharge from the LS 01 west side forcemain.	Surcharged	Flow equalization storage at LS 01 is proposed for mitigation of this surcharge.
12	N. Memorial Drive/Kewaunee St./ Marquette St. Interceptors	North of LS01 in the center portion of the northside of the City of Racine.	Limited surcharge	No improvements proposed because the hydraulic grade line is greater than 9.0 feet from the ground surface in the surcharged segments. This capacity constraint was removed from further consideration.
13	Chicory Road Interceptor	Southwest of the WWTP. This interceptor discharges to the KR Interceptor.	Surcharged	Improvements considered for this surcharged area included(1): • Underground flow equalization basin • In-line flow equalization piping • Parallel relief sewer

Table 10-7. Capacity Constraints
2020 Existing Condition

Constraint No.	Description	Location	Issue	Comments
14	Mount Pleasant/Sturtevant Interceptor	Southwest of the WWTP. This interceptor receives flow from the KR Lift Station.	Limited surcharge	Surcharge is the result of a downstream restriction at the headworks of the WWTP. Flow equalization storage at the Pike River LS is proposed for reduction of this surcharge. A separate study is recommended to determine the extent of basement back-ups occurring along Sheridan Road with the proposed 11.0 MG EQ Storage Basin in service at the Pike River Lift Station.
15	Pike River Interceptor	Receives flow from the KV Lift Station and new TID 5 Interceptors in the southwest corner of the Racine service area.	Surcharged	Improvements considered for this surcharged area included: • Underground flow equalization basin • Interceptor sewer upsizing

(1) The impact on the conveyance system and the estimated cost of each of the alternatives listed below are consider equal for this Facilities Plan. Construction of an underground flow equalization basin was selected for this Facilities Plan. Further consideration of all alternatives will be provided during final design of each separate project.

10.9 Conveyance System Performance: 5-Year, 6-Hour Storm, 2030 Condition

Modeling of the 2030 Condition is based on conveyance system improvements proposed for construction prior to 2030 included in the model. Projects incorporated into the model for the 2030 condition include the following:

1. Pike River Lift Station with New 36-inch Dia. Forcemain from Pike River Lift Station to the Mt. Pleasant/Sturtevant Interceptor

   The Pike River Lift Station Project consists of a new lift station to convey all the flow from the existing Mt. Pleasant/Sturtevant sewer service area plus the new Tax Increment District 5 (TID 5) sewer service area. The total flow capacity of the new Pike River Lift Station will be 40 MGD, expandable to 75 MGD. The site for the new TID 5 Lift Station is just to the north of the existing KR Lift Station along the Pike River. Upon completion of the Pike River Lift Station, the KR Lift Station will be taken out of service. The Pike River Lift Station will discharge to the Mt. Pleasant/Sturtevant Interceptor via a 36-inch diameter force main. The length of the new force main serving the Pike River Lift Station is approximately 5,700 feet.

2. Pike River Flow Equalization Storage

   The existing Pike River Interceptor receives wastewater from the Pike River Lift Station. In order to mitigate surcharging of the Pike River interceptor, flow equalization storage capacity is proposed at the Pike River Lift Station site. Modeling indicates that a flow equalization basin with a capacity of 11.0 MG will reduce interceptor surcharging to acceptable levels. This improvement is based upon full buildout of the area served by the TID 5 interceptor sewers discharging to the Pike River Lift Station. Additional investigation may be required to determine the impacts on the local collection systems.

3. Tax Increment District 5 (TID 5) Interceptor Sewer

   The purpose of the TID 5 Interceptor Sewer System is to provide sanitary sewer service to the development in the southwest corner of the Village of Mount Pleasant. The sewer system also provides an opportunity to serve the Foxconn site in Mount Pleasant and development along I-94, not only in Mount Pleasant, but also in Caledonia.

4. 3.5 MG of Flow Equalization Storage at North Park Lift Station

   Peak wet weather flow from the portion of the Caledonia collection system served by the North Park Lift Station will be attenuated by the proposed North Park Flow Equalization Basin. The modeled 3.5 MG equalization basin reduces surcharging of the downstream interceptor on Michigan Boulevard.

5. Additional 1.5 MG of Flow Equalization Storage at Hood's Creek Lift Station.

   There is an existing 1.5 MG flow equalization basin located at the Hood's Creek Lift Station. The existing equalization basin was constructed in 2013. Peak wet weather flow from the portion of the Caledonia collection system served by the Hood's Creek Lift Station will be attenuated by an additional Hood's Creek Flow Equalization Basin. The modeled additional 1.5 MG equalization basin further reduces surcharging of downstream interceptors.

6. 1.0 MG of Flow Equalization Storage along Chicory Road

   The modeled 1.0 MG flow equalization basin at Chicory Road reduces surcharging of the Chicory Road Interceptor. Additional investigation will be performed after this plan to determine the impacts on the local collections system.

The storage at Lift Station No. 2 was designed for a different return interval storm and was not being completely utilized in the modeling of the 5-year, 6-hour storm event in the 2020 condition. Modifications were a made in the model to the Lift Station No. 2 storage structure and the pump start and stop elevations. Pumps 2 and 3 at the lift station were given a higher elevation to start/stop to allow more overflow at the storage structure. The storage structure was also given an orifice with a flap gate through the weir to allow flow at lower elevations.

Modeling indicates that during rainfall events up to the 5-year, 6-hour storm, most RWU interceptor sewers had sufficient capacity to carry estimated wastewater flows under 2030 conditions with the improvements described above. However, nine areas within the Racine Wastewater Utility interceptor sewer system did not meet the service criteria established for this Facilities Plan in the 2030 condition. Those nine segments are summarized in Table 10-8 and illustrated on Figure 10-5. The modeling results for the 2030 condition can be found in Appendix C.

Outlet	Qmax MGD	Volume MG
SS 01	2.4399	0.1876
SS 02	5.3011	0.8316
SS 03	0.3193	0.0438
SS 04	0.0006	0.0013
SS 05	0.0006	0.0031
SS 06	0.0019	0.0074
SS 08	4.4519	0.7243
SS 09	1.3327	0.0882
SS 10	< 0.0001	0.0002
SS 11	< 0.0001	0.0004
SS 12	0.0006	0.0024
SS LS02	< 0.0001	0.0011
SS LS06	0.0006	0.0023
WWTP EQ Basins	66.0400	24.3000
WWTP	95.0000	254.0000

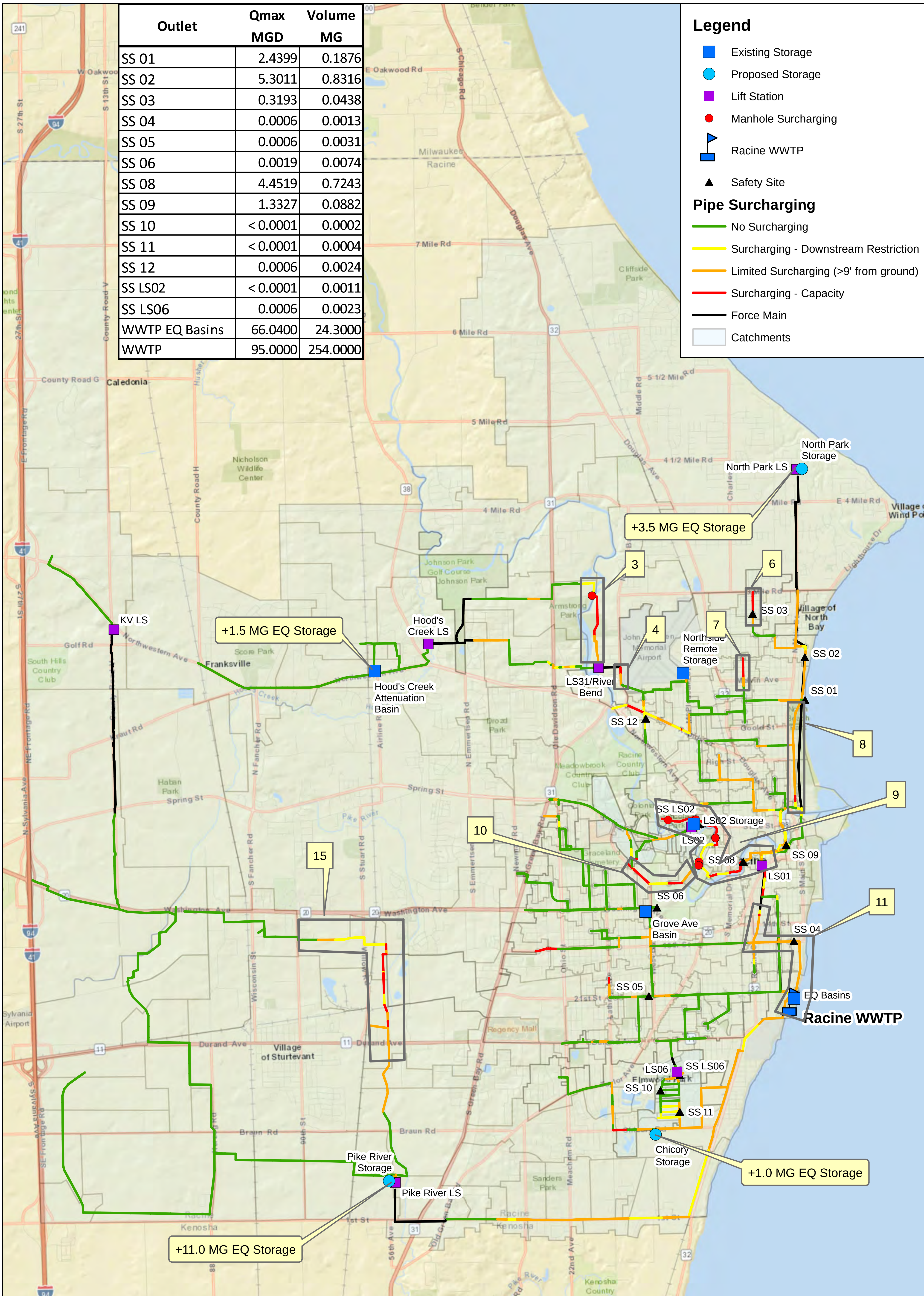


Figure 10-5
2030 Condition Capacity Constraints

AECOM

Drawn By: JFP
Checked By:
Date:
Project #: 60554970

Racine Facilities Plan
Racine Wastewater Utility

Projection:
NAD_1983_2011_StatePlane_Wisconsin_South_FIPS_4803_Ft_US

0 0.5 1 2 Miles

Table 10-8. Capacity Constraints
2030 Condition

Constraint No.	Description	Location	Issue	Comments
3	Lift Station No. 31 (River Bend) Upstream Interceptor	Caledonia interceptor along Root River north of LS 31.	Surcharged	Improvements considered for this surcharged area included(1): • Underground flow equalization basin • In-line flow equalization piping • Parallel relief sewer
4	Lift Station No. 31 (River Bend) Downstream Interceptor	Discharge point for LS 31 on North Green Bay Road from Buckley Road to Long View Lane.	Surcharged	This constraint is being addressed by the extension of the forcemain from LS 31, under design by Caledonia
6	LaSalle Street Trunk Sewers	LaSalle Street from 3 Mile Road to Shorecrest Drive.	Surcharged	Upgrades to trunk sewers proposed.
7	Geneva Street Interceptor	Geneva Street (South Street to Wolff Street).	Surcharged	Upgrades to interceptor sewers proposed.
8	Michigan Boulevard Interceptor	Downstream of Augusta Street in the northeast portion of the service area.	Surcharged	Improvements considered for this surcharged area included(1): • Underground flow equalization basin • In-line flow equalization piping • Parallel relief sewer
9	Lift Station No. 2 (Brose Park) Downstream Interceptor (to Lift Station No. 1)	Interceptor along Root River, downstream of LS 02 and upstream of the 6^{th} St siphon under the Root River.	Surcharged	Improvements considered for this surcharged area included: • Underground flow equalization basin along Root River • Additional flow equalization storage at LS 02 • I / I reduction measures
10	Osborne Blvd. / Kinzie Avenue Interceptors	These interceptors discharge to the interceptor along the Root River upstream of LS 01.	Surcharged	Improvements considered for this surcharged area included(1): • Underground flow equalization basin • In-line flow equalization piping

Constraint No.	Description	Location	Issue	Comments
				• Parallel relief sewer • Interceptor Upsizing
11	Lift Station No. 1 Downstream Interceptors discharging to WWTP	These interceptors receive the discharge from the LS 01 west side forcemain.	Surcharged	Flow equalization storage at LS 01 is proposed for mitigation of this surcharge.
15	Pike River Interceptor	Receives flow from the KV Lift Station and new TID 5 Interceptors in the southwest corner of the Racine service area, including Sturtevant and central Mount Pleasant as well.	Surcharged	Improvements considered for this surcharged area included: • Underground flow equalization basin • Interceptor sewer upsizing

(1) The impact on the conveyance system and the estimated cost of each of the alternatives listed below are consider equal for this Facilities Plan. Construction of an underground flow equalization basin was selected for this Facilities Plan. Further consideration of all alternatives will be provided during final design of each separate project.

10.10 Conveyance System Performance: 5-Year, 6-Hour Storm, 2040 Design – Baseline Condition

Modeling of the 2040 Design - Baseline Condition included conveyance system improvements previously incorporated into the 2030 condition model, plus the following additional projects incorporated into the model for the 2040 Design - baseline condition:

1. 10.0 MG Flow Equalization Storage at Lift Station No. 1

   The modeled 10.0 MG flow equalization storage at Lift Station No. 1 eliminates surcharging of interceptors downstream of the lift station.

   The preliminary design calls for using existing pumps in existing Lift Station No. 1 to convey excessive wet weather flow from the Lift Station No. 1 wet well to a 10.0 MG basin located next to the lift station. When the rainfall event is over, the contents of the basin would flow back into the wet well at a low rate.

2. 1.0 MG Flow Equalization Storage at Lakeview Park.

   The modeled 1.0 MG equalization basin reduces surcharging of the downstream interceptor on Michigan Boulevard.

3. Additional 1.0 MG Flow Equalization Storage at Caledonia-Riverbend Lift Station (LS31).

   The modeled additional 1.0 MG flow equalization basin at Caledonia-Riverbend Lift Station (LS31) reduces surcharging of the interceptor upstream of Lift Station No. 31.

4. Upsizing of the Osborne Boulevard / Kinzie Avenue Interceptor.

   The modeled upsizing reduces surcharging of the interceptor upstream of Lift Station No. 2.

5. Upsizing of the LaSalle Street Trunk Sewer and Geneva Street Interceptor

   The modeled upsizing reduces surcharging of the LaSalle Street trunk sewer and Geneva Street interceptor.

6. 1.65 MG Flow Equalization Storage along Pike River Interceptor

   The modeled 1.65 MG flow equalization basin along the Pike River Interceptor north of the Pike River Lift Station eliminates surcharging of the interceptor.

Modeling indicates that during rainfall events up to the 5-year, 6-hour storm, most of the 2040 Design – the 2020 condition conveyance system with improvements recommended to be completed by 2040, had sufficient capacity to carry estimated 2040 wastewater flows. However, one area within the Racine Wastewater Utility interceptor sewer system did not meet the service criteria established for this Facilities Plan in the 2040 Design baseline condition. The segments are summarized in Table 10-9 and illustrated on Figure 10-6.

Additional investigations of the root causes of the surcharging of the interceptor sewer between Lift Station No. 2 and Lift Station No. 1 are recommended. Data presented in Section 10.11 of this report indicates that peak wet weather flows in the interceptor downstream of Lift Station No. 2 (to the point of discharge to Lift Station 01) are excessive. An analysis of one approach to lowering peak wet weather flow is presented as Alternative No. 1 to the 2040 Design – Baseline Condition. That analysis, involving a foundation drains removal program in the Safety Site 8 sewershed, did not prove to be the answer to effectively lowering the peak flows. The modeling results for the 2040 Design - baseline condition can be found in Appendix C.

Outlet	Qmax MGD	Volume MG
SS 01	0.0000	0.0006
SS 02	1.8601	0.1522
SS 03	< 0.0001	0.0002
SS 04	0.0006	0.0013
SS 05	0.0006	0.0031
SS 06	0.0019	0.0074
SS 08	3.7209	0.4418
SS 09	0.0006	0.0038
SS 10	< 0.0001	0.0002
SS 11	< 0.0001	0.0004
SS 12	0.0006	0.0024
SS LS02	< 0.0001	0.0011
SS LS06	0.0006	0.0023
WWTP EQ Basins	42.7800	9.9700
WWTP	95.0000	253.7600

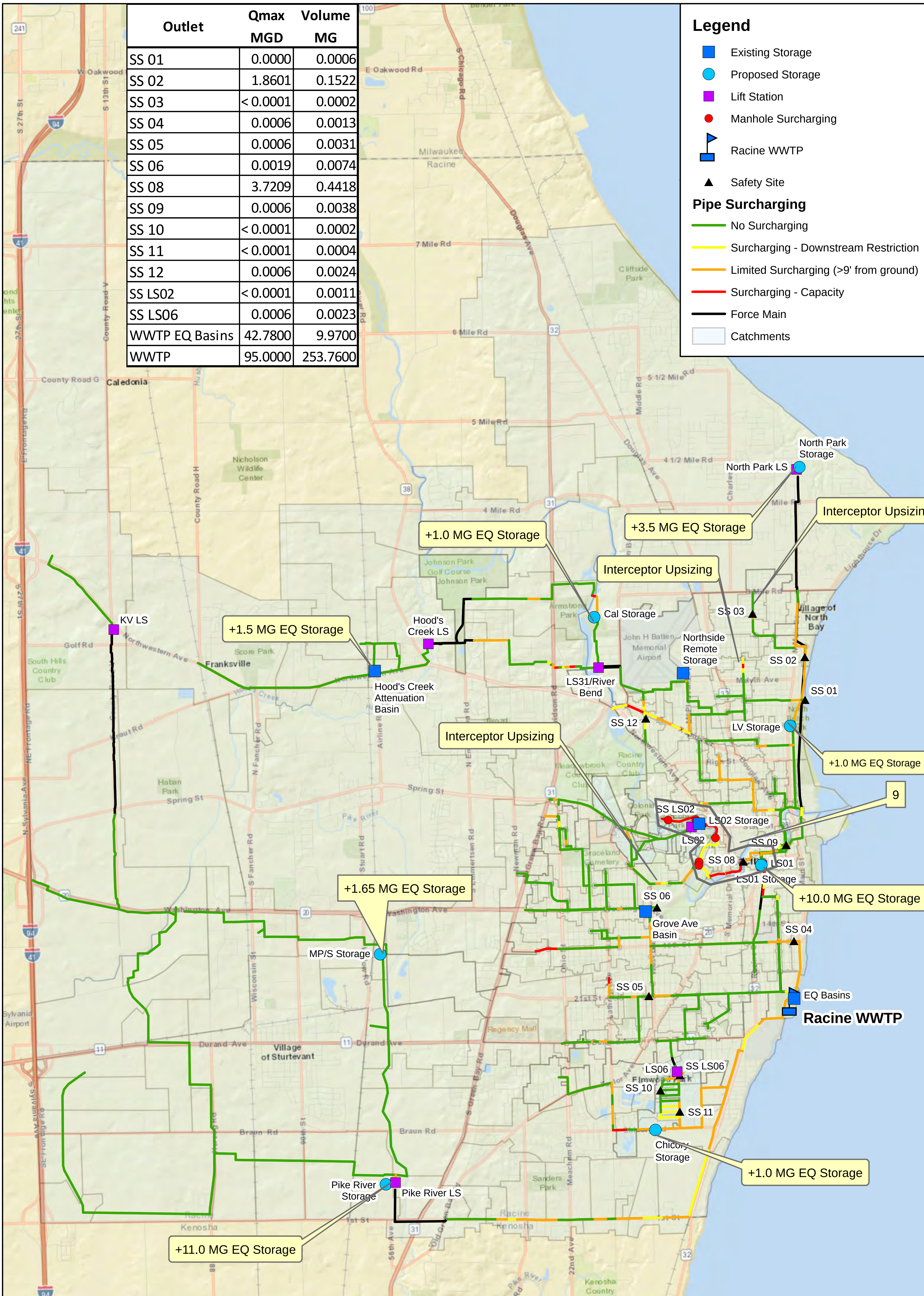


Figure 10-6

2040 Baseline Condition Capacity Constraints

Projection: NAD_1983_2011_StatePlane_Wisconsin_South_FIPS_4803_Ft_US

Drawn By: JFP

Checked By:

Date:

Project #: 60554970

Racine Facilities Plan

Racine Wastewater Utility

Table 10-9. Capacity Constraints
2040 Design – Baseline Condition

Constraint No.	Description	Location	Issue	Comments
9	Lift Station 02 (Brose Park) Downstream Interceptor (to the point of discharge to Lift Station 01)	Interceptor along Root River, downstream of LS 02 and upstream of the 6th St siphon under the Root River.	Surcharged	Improvements considered for this surcharged area included: • Underground flow equalization basin along Root River • Relief Sewer • I / I reduction measures

10.11 Lift Station Performance

Table 10-10 summarizes the lift stations included in the hydraulic model of the Racine wastewater collection system

Table 10-10. RWU Modeled Lift Stations

Lift Station No.	Location	Description	Issue
1	780 Washington Ave (Behind City Hall)	Largest lift station in the collection system. Six (6), 300 HP pumps conveying an average daily flow of 10.5 MGD*.	None
2	2022 Spring St. and Leudtke Ct.	Second largest lift station in the collection system. Three (3), 40 HP pumps conveying an average daily flow of 0.47 MGD*.	None
6	3236 Drexel Ave	Fourth largest lift station in the collections system. Three (3) 15 HP pumps conveying an average daily flow of approximately 0.25 MGD*.	None

*Average daily flow came from the years 2015 through 2018.

The hydraulic model indicates that all lift stations are capable of handling the 5-year, 6-hour storm event under existing (year 2020) conditions and the 2040 Design – condition. Table 10-11 presents a summary of lift station capacities under 5-year, 6-hour storm, 2040 Design – condition.

Table 10-11. Lift Station Capacity
5-Year, 6-Hour Storm 2040 Design Condition

Lift Station No.	Location	Peak Flow (MGD)	Firm Capacity (1) (MGD)	Total Capacity (2) (MGD)	Deficiency (3) (MGD)
1	780 Washington Ave (Behind City Hall)	83.01	90.0	112.0	None
2	2022 Spring St. and Leudtke Ct.	3.35	6.05	9.07	None
6	3236 Drexel Ave	2.96	2.88	4.32	None

(1) Firm capacity is the estimated capacity with the single largest pump out of service.

(2) Total capacity is the estimated capacity with all pumps in service.

(3) Deficiency = Peak Flow – Firm Capacity.

10.12 Infiltration / Inflow Removal

Under existing (year 2020) conditions, the total average flow to the wastewater treatment plant is approximately 22.0 MGD. During the design storm (5-year, 6-hour rainfall), flow to the wastewater treatment plant increases dramatically to in excess of 160.0 MGD. The amount of clear water entering the sewer system has a significant impact on the interceptor and treatment facilities.

The hydraulic model was used to compare wet weather flow generated by the 5-year, 6-hour rainfall event versus average dry weather flow at the safety site locations distributed across the RWU conveyance system. Peak hour to average dry weather flow ratios ranged from 6.4 to 26.5. The peak wet weather to average dry weather ratios shown in Table 10-12 illustrate which sites are experiencing the most amounts of clear water I/I.

Table 10-12. Rations of Peak Wet Weather to Average Dry Weather Flows 2020 Existing Conditions

Safety Site No.	Location	Ratio of Peak Wet Weather to Ave. Dry Weather Flow
SS 01	Augusta Street & Michigan Avenue	8.2
SS 02	Michigan Boulevard & South Street Extended	21.4
SS 03	Carlton Drive & La Salle Street	6.4
SS 04	16th Street & College Avenue	7.7
SS 05	21st Street & Grove Avenue	5.1
SS 06	Washington Avenue & Grove Avenue	7.2
SS 08	East 6th Street Siphon	15.9
SS 09	Ontario Street & 4th Street Siphon	26.5
SS 10	Spruce Street & Brentwood Court	12.4
SS 11	Knoll Place & Norwood Drive	10.9
SS 12	Golf Avenue & Conrad Drive	125.6[1]

1. This peaking factor is an anomaly created by a very low dry weather flow in the SS 12 sewershed in the model. SS 12 was removed from further I/I reduction analysis.

For the design of new wastewater treatment systems, the Wisconsin Administrative Code, Section NR110.15(4)(c) states "when flow or water use records do not exist, the maximum hour design flow shall be estimated by multiplying the average design flow by the appropriate peaking factor". Design peaking factors contained in the Administrative Code range from a high of 5.0 for communities under 1,000 population, to a low of 2.0 for communities with a population greater than 100,000.

Wisconsin Administrative Code, Section NR110.13(c) states, "Sewers shall be designed to carry, when running full, the peak design flows expected from domestic, commercial, industrial and other sources, and infiltration and inflow. Peak design flow shall be established using existing sewage flow or water use records, and records of infiltration and inflow. Where peak flow records are not available, the peak design flow shall be determined by applying one of the following peak flow factors to the average design flow: 1.) 250% of the average design flow for interceptors, main (trunk) sewers, and sewage outfall pipes; or, 2.) 400% of average design flow for submain and branch sewers."

These peaking factors, related to the design of new sewer systems, are included in the hydraulic model for expansion of the Racine sanitary sewer system (new construction).

The Wisconsin Administrative Code defines excessive I/I as, "the quantities of infiltration/inflow which can be economically eliminated from a sewerage system by rehabilitation, as determined in a cost−effectiveness analysis that compares the cost of correcting the infiltration/inflow conditions to the total costs for transportation and treatment of the infiltration/inflow" The Administrative Code does not define excessive I/I based on peaking factors.

For this Facilities Plan, the ratios of peak wet weather flow to average dry weather flow at Safety Sites 02, 08 and 09 are considered to be excessive. The worst case of excessive I/I occurs in the Safety Site 08 sewershed where modeling indicates an 80.9% reduction of the I/I volume would be needed to accomplish a 23% reduction in the peaking factor. (See Table 10-13.) I/I reduction measures should be focused on the Safety Site 02, 08 and 09 sewersheds.

Table 10-13. Revised Peaking Factors Base on I/I Reduction

Safety Site No.	Location		2020 Condition with I/I Reduction	
		Original Peaking Factor	Peaking Factor	Percentage of I/I Reduction Required
SS 02	Michigan Boulevard & South Street Extended	21.4	9.2	64.3%
SS 08	East 6th Street Siphon	15.9	12.2	80.9%
SS 09	Ontario Street & 4th Street Siphon	26.5	10.8	62.0%

RWU, and each of the SSRs served by the Utility, have developed Capacity, Management, Operation and Maintenance (CMOM) programs to assess sanitary sewer collection system conditions (manholes and pipe segments), maintain system capacity, and eliminate backups and overflows.

Key components of these CMOM Programs include:

- Manhole inspections followed by rehabilitation of manholes identified as deficient.
- CCTV inspection of sanitary sewers followed by rehabilitation of sewer segments identified as deficient.
- Smoke testing of sanitary sewers followed by elimination of clear water inflow sources identified.
- Elimination of foundation drain systems discharging to the sanitary sewer system.
- Rainfall and wastewater flow monitoring programs which correlate sewer system and lift station flows to rainfall events to assist in identifying areas experiencing excessive amounts of I/I.

Each of the SSR parties are required to meet peak flow limits under the IGA dated April 25, 2002. Each party is responsible to address its own I/I and is required to document those efforts when their peak flow allocation is exceeded.

Alternative No. 1 to the 2040 Design – Baseline Condition consists of modeling to determine the impact of conducting a foundation drains removal program in the Safety Site 8 sewershed. The results of the Alternative No. 1 modeling can be found in Section 10.17 of this Facilities Plan.

10.13 Safety Site Overflows

One of the Service Criteria established for this Facilities Plan is that there will be no significant increase in the volume of controlled diversion wastewater at Safety Sites during the 2040 Design – Condition 5-year, 6-hour rainfall event. Tables 10-14 and 10-15 summarize overflow information obtained from modeling the 2020 Existing condition and 2040 Design – baseline condition during the 5-year, 6-hour rainfall event. It is noted that overflow volumes occurring at the safety sites significantly decrease under the modeled 2040 Design – baseline conditions compared to the 2020 condition.

Table 10-14. Safety Site Discharge Information, 2020 Existing Condition

Safety Site No.	Location	5-Year, 6-Hour Storm 2020 Existing Condition	
		Volume (MG)	Peak Flow (MGD)
SS 01	Augusta Street & Michigan Avenue	0.2354	2.8128
SS 02	Michigan Boulevard & South Street Extended	0.8849	5.4362
SS 03	Carlton Drive & La Salle Street	0.0438	0.3193
SS 04	16th Street & College Avenue	0.0031	0.0006
SS 05	21st Street & Grove Avenue	0.0031	0.0006
SS 06	Washington Avenue & Grove Avenue	0.0074	0.0019
SS 08	East 6th Street Siphon	1.0046	6.4774
SS 09	Ontario Street & 4th Street Siphon	0.5555	3.8146
SS 10	Spruce Street & Brentwood Court	0.0002	0.0000
SS 11	Knoll Place & Norwood Drive	0.5178	1.7315
SS 12	Golf Avenue & Conrad Drive	0.0024	0.0006
LS 02	Spring Street & Luedtke Court LS #2	0.0011	0.0000
LS 06	Drexel Avenue & Maryland Avenue	0.0023	0.0006
WWTP EQ BASINS		27.2600	64.1900
WWTP		229.7400	95.0000

Table 10-15. Safety Site Discharge Information 2040 Design – Condition

Safety Site No.	Location	5-Year, 6-Hour Storm 2040 Design – Condition	
		Volume (MG)	Peak Flow (MGD)
SS 01	Augusta Street & Michigan Avenue	0.0006	<0.0001
SS 02	Michigan Boulevard & South Street Extended	0.1522	1.8446
SS 03	Carlton Drive & La Salle Street	0.0002	<0.0001
SS 04	16th Street & College Avenue	0.0031	0.0006
SS 05	21st Street & Grove Avenue	0.0031	0.0006
SS 06	Washington Avenue & Grove Avenue	0.0074	0.0019
SS 08	East 6th Street Siphon	0.4418	3.7209
SS 09	Ontario Street & 4th Street Siphon	0.0038	0.0007
SS 10	Spruce Street & Brentwood Court	0.0002	<0.0001
SS 11	Knoll Place & Norwood Drive	0.0004	<0.0001
SS 12	Golf Avenue & Conrad Drive	0.0024	0.0006
LS 02	Spring Street & Luedtke Court LS #2	0.0011	<0.0001
LS 06	Drexel Avenue & Maryland Avenue	0.0023	0.0007
WWTP EQ BASINS		9.9700	42.7800
WWTP		253.7600	95.0000

10.14 Safety Site Discharge – Alternate Peak Storm

To determine how the RWU conveyance system would perform during a rainfall event greater than the 5-year, 6-hour design storm, an alternate peak storm event was modeled. Based on discussions with Wisconsin DNR staff, the 10-year, 6-hour rainfall event was selected as the alternate peak storm. An indicator of the performance of the conveyance system is the volume of wastewater discharged at Safety Sites.

Tables 10-16 and 10-17 summarize Safety Site discharge information obtained from modeling the 2020 Existing condition and 2040 Design condition during the 10-year, 6-hour rainfall event.

As expected, the amount of wastewater volume discharged from Safety Sites and the WWTP controlled diversion during the 10-year, 6-hour storm event significantly decreases in the 2040 Design – Baseline Condition when compared to the 2020 Existing Condition. Further, the Safety Site discharges and WWTP bypass volumes in the 2040 Design – Baseline Condition during the 10-year, 6-hour rainfall event are significantly less than the discharges occurring in the 2020 Existing Condition during the 5-year, 6-hour storm event.

Table 10-16. Safety Site Discharge Information
Alternate Peak Storm 2020 Existing Condition

Safety Site No.	Location	10-Year, 6-Hour Storm 2020 Existing Condition	
		Volume (MG)	Peak Flow (MGD)
SS 01	Augusta Street & Michigan Avenue	0.614	4.080
SS 02	Michigan Boulevard & South Street Extended	1.591	8.215
SS 03	Carlton Drive & La Salle Street	0.082	0.427
SS 04	16th Street & College Avenue	0.001	0.001
SS 05	21st Street & Grove Avenue	0.003	0.001
SS 06	Washington Avenue & Grove Avenue	0.007	0.002
SS 08	East 6th Street Siphon	1.617	9.043
SS 09	Ontario Street & 4th Street Siphon	1.673	7.928
SS 10	Spruce Street & Brentwood Court	0.001	0.780
SS 11	Knoll Place & Norwood Drive	0.690	1.965
SS 12	Golf Avenue & Conrad Drive	0.002	0.001
LS 02	Spring Street & Luedtke Court LS #2	0.001	0.000
LS 06	Drexel Avenue & Maryland Avenue	0.006	0.252
WWTP EQ BASINS		39.86	75.28
WWTP		270.53	95.00

Table 10-17. Safety Site Discharge Information
Alternate Peak Storm 2040 Design - Condition

Safety Site No.	Location	10-Year, 6-Hour Storm 2040 Design - Condition	
		Volume (MG)	Peak Flow (MGD)
SS 01	Augusta Street & Michigan Avenue	0.003	0.131
SS 02	Michigan Boulevard & South Street Extended	0.773	5.993
SS 03	Carlton Drive & La Salle Street	0.011	0.163
SS 04	16th Street & College Avenue	0.001	0.001
SS 05	21st Street & Grove Avenue	0.003	0.001
SS 06	Washington Avenue & Grove Avenue	0.007	0.002
SS 08	East 6th Street Siphon	0.686	5.704
SS 09	Ontario Street & 4th Street Siphon	0.004	0.001
SS 10	Spruce Street & Brentwood Court	0.001	0.781
SS 11	Knoll Place & Norwood Drive	0.018	0.091
SS 12	Golf Avenue & Conrad Drive	0.002	0.001
LS 02	Spring Street & Luedtke Court LS #2	0.001	0.000
LS 06	Drexel Avenue & Maryland Avenue	0.006	0.253
WWTP EQ BASINS		16.500	54.570
WWTP		267.620	95.000

10.15 Proposed Conveyance Improvements – 2030 Condition

Modeling of the 2030 Condition includes conveyance system improvements proposed for construction prior to 2030. These projects are identified by SSR communities. Projects which are planned to be completed by the year 2030 include the following:

1. Pike River Lift Station with New 36-inch Dia. Forcemain from Pike River Lift Station to the Mount Pleasant/Sturtevant Interceptor

   The Pike River Lift Station Project consists of a new lift station to convey all the flow from the existing KR sewer service area plus the new Tax Increment District 5 (TID 5) sewer service area. The total flow capacity of the new Pike River Lift Station will be 40 MGD, expandable to 75 MGD. The site for the new TID 5 Lift Station is just to the north of the existing KR Lift Station along the Pike River. Upon completion of the Pike River Lift Station, the KR Lift Station will be taken out of service. The Pike River Lift Station will discharge to the Mount Pleasant/Sturtevant Interceptor via a 36-inch diameter force main. The length of the new force main serving the Pike River Lift Station is approximately 5,700 feet.

2. Pike River Flow Equalization Storage

   The existing Mount Pleasant/Sturtevant Interceptor receives wastewater from the Pike River Lift Station. In order to mitigate surcharging of the Mount Pleasant/Sturtevant interceptor, flow equalization storage capacity will be provided at the Pike River Lift Station site. Modeling indicates that a flow equalization basin with a capacity of 11.0 MG will reduce Mount Pleasant/Sturtevant Interceptor surcharging to acceptable levels. (Addresses Capacity Constraint No. 14). Note: The expansion of the Pike River Lift Station to 75 MGD capacity will not be necessary if the 11.0 MG flow equalization basin is constructed at the Pike River Lift Station.

3. Tax Increment District 5 (TID 5) Interceptor Sewer

   The purpose of the TID 5 Interceptor Sewer System is to provide sanitary sewer service to the development in the southwest corner of the Village of Mount Pleasant. The sewer system also provides an opportunity to serve the Foxconn site in Mount Pleasant as well as development along I-94, not only in Mount Pleasant but also in Caledonia.

4. 3.5 MG of Flow Equalization Storage at North Park Lift Station

   This EQ basin is proposed to reduce peak flows from the Caledonia area in accordance with Caledonia's SSR agreement with RWU.

5. Additional 1.5 MG of Flow Equalization Storage at Hood's Creek Lift Station.

   There is an existing 1.5 MG flow equalization basin located at the Hood's Creek Lift Station. This equalization basin was constructed in 2013. An additional 1.5 MG of flow equalization storage at Hood's Creek Lift Station will eliminate the Hood's Creek Lift Station North Discharge and South Discharge capacity constraints. (Addresses Capacity Constraints No. 1 & No. 2).

6. 1.0 MG Flow Equalization Storage for Chicory Road Interceptor

   The proposed 1.0 MG flow equalization basin at Chicory Road will reduce surcharging of the Chicory Road Interceptor (Addresses Capacity Constraint No. 13.)

10.16 Proposed Conveyance Improvements – 2040 Design - Baseline Condition

Modeling of the 2040 Design - Baseline Condition included conveyance system improvements proposed for construction prior to 2030 in the model (as described above), plus the following additional projects proposed for completion by 2040:

1. 10.0 MG Flow Equalization Storage at Lift Station 01

   The proposed 10.0 MG flow equalization storage at Lift Station No. 1 will eliminate surcharging of interceptors downstream of the lift station (Addresses Capacity Constraint No. 11).

   The preliminary design calls for using existing pumps in existing Lift Station No. 1 to convey excessive wet weather flow from the Lift Station No. 1 wet well to a 10.0 MG flow equalization basin located next to the lift station. When the rainfall event is over, the contents of the basin would flow back into the wet well at a low rate.

2. 1.0 MG Flow Equalization Storage at Lakeview Park.

   The proposed 1.0 MG equalization basin will reduce surcharging of the downstream interceptor on Michigan Boulevard (Addresses Capacity Constraint No. 8).

3. Additional 1.0 MG Flow Equalization Storage at Caledonia-Riverbend Lift Station (LS31).

   The proposed 1.0 MG flow equalization basin at Caledonia-Riverbend Lift Station (LS31) will reduce surcharging of the interceptor upstream of Lift Station No. 31 (Addresses Capacity Constraint No. 3).

4. Osborne Boulevard / Kinzie Avenue Interceptor Sewer Upgrades.

   The proposed upsizing of the interceptor along Osborne Boulevard and Kinzie Avenue will eliminate surcharging of the interceptor upstream of Lift Station No. 2 (Addresses Capacity Constraint No. 10). The proposed upsizing consists of the following:

   a. 1,700 LF of 18-inch diameter to 24-inch diameter pipe upsized to 30-inch diameter
   b. 3,250 LF of 10-inch diameter to 21-inch diameter pipe upsized to 36-inch diameter
   c. 750 LF of 18-inch diameter to 20-inch diameter pipe upsized to 48-inch diameter

5. Miscellaneous Interceptor and Trunk Sewer Upsizing

   a. LaSalle Street – Total of 2,097 LF upsized (Addresses Capacity Constraint No. 6)

      i. 1,302 LF of 10-inch diameter pipe upsized to 12-inch diameter
      ii. 795 LF of 10-inch diameter pipe upsized to 15-inch diameter

   b. Geneva Street – Total of 2,229 LF upsized (Addresses Capacity Constraint No. 7)

      iii. 1,320 LF of 18-inch diameter pipe upsized to 30-inch diameter
      iv. 909 LF of 21-inch diameter pipe upsized to 30-inch diameter

The above RWU interceptor and City of Racine trunk sewer upsizing projects will be conducted as street and utility reconstruction projects take place across the City of Racine.

6. 1.65 MG Flow Equalization Storage along Pike River Interceptor

The proposed 1.65 MG flow equalization basin along the Pike River Interceptor north of the Pike River Lift Station will eliminate surcharging of the interceptor.

10.17 Conveyance Improvements – 2040 Design - Alternatives

In order to address areas of the RWU collection conveyance system which remain surcharged under the 2040 Design – baseline condition, Alternative No. 1 was evaluated. Also, In order to evaluate the cost-effectiveness of improvements proposed for reducing surcharging of the Pike River and Mt. Pleasant / Sturtevant Interceptors in the 2040 Design – baseline condition, Alternatives No. 2, 3 and 4 were evaluated.

10.17.1 2040 Design – Baseline Condition With Alternative No. 1: 2040 Design – Baseline Condition Plus Infiltration / Inflow (I/I) Reduction In The Safety Site No. 8 Sewershed

The Alternative No. 1 Condition is based on the implementation of a Foundation Drains Removal Program in the Safety Site No. 8 sewershed. The Safety Site No. 8 sewershed has approximately 3,020 properties. Based on actual foundation drain removal programs in other Midwestern cities, it is estimated that 63% of the Safety Site No. 8 sewershed properties have foundation drains connected to sewer laterals which discharge to the interceptor sewer system. Modeling predicts that eliminating the estimated 1,903 foundation drain connections in the Safety Site No. 8 sewershed would result in a 0.48 million gallons per day (MGD) reduction in the rate of wastewater flow arriving at Safety Site No. 8 during the peak of the 5-year, 6-hour storm event. Modeling indicates that the peak wastewater flow rate at the Safety Site No. 8 manhole during the 5-year, 6-hour storm event is 26.3 MGD. Comparing the peak wet weather flow reduction of 0.48 MGD resulting from the elimination of foundation drain discharges in the Safety Site No. 08 sewershed to the peak wastewater flow during the design storm event (26.3 MGD) shows that the foundation drains discharge is less than 2% of the peak flow. Thus, it is predicted that a Foundation Drains Removal Program conducted in the Safety Site No. 8 sewershed would have a minimal impact on surcharging of the interceptor between Lift Station No. 2 and Lift Station No. 1 and would not significantly reduce discharges from Safety Site No. 8 during the design year rainfall event. Addition studies are recommended to determine the most effective use of I/I reduction measures in the Safety Site 8 sewershed.

10.17.2 2040 Design – Baseline Condition With Alternative No. 2: 2040 Design – Baseline Condition Minus The 1.65 Mg Eq Basin North Of Pike River Lift Station Plus Upsizing The Pike River Interceptor

Modeling indicates the Pike River Interceptor will surcharge during the 5-year, 6-hour storm event with full build-out of the area served by the interceptor. The Alternative No. 2 Condition is based on mitigating the anticipated surcharging of the Pike River Interceptor by upsizing the interceptor (or installing a relief sewer) in lieu of installing a 1.65 MG flow equalization basin. The estimated cost of the interceptor upsizing/relief sewer project is $4.1 million.

Comparing the cost of upsizing the Pike River Interceptor (or building a relief interceptor) to the cost of a 1.65 MG flow equalization basin along the interceptor route finds the alternatives similar in capital cost. Design alternatives should be re-evaluated at a later date, as development occurs in the area served by the interceptor.

10.17.3 2040 Design – Baseline Condition With Alternative No. 3: 2040 Design – Baseline Condition Minus The 11.0 Mg Flow Eq Basin At Pike River Lift Station, Plus New 36 Inch Dia. Forcemain From Pike River Lift Station To Racine WWTP

For the Alternative No. 3 Condition, the 11.0 MG flow equalization basin at the Pike River Lift Station is removed from the model and a new 36-inch diameter forcemain is added between the Pike River Lift Station and the headworks of the Racine WWTP. The proposed 1.65 MGD flow equalization basin on the Pike River Interceptor upstream of the Pike River Lift Station is not included in the alternative. Modeling indicates that surcharging of the Mt. Pleasant/Sturtevant Interceptor between the Pike River Lift Station and the WWTP is reduced under this alternative. However, there is no significant difference in the degree of surcharging comparing a new 36-inch diameter forcemain alternative to the 2040 Design – Baseline Condition with 11.0 MG of flow equalization storage at the Pike River Lift Station. The estimated cost of the 36-inch diameter forcemain alternative and the 11.0 MG equalization basin are similar. Since flow equalization at Pike River Lift Station provides the additional benefit of reducing peak flow arriving at the WWTP benefitting the entire system, the recommendation of this Facilities Plan is to provide flow equalization storage at the Pike River Lift Station.

10.17.4 2040 Design – Baseline Condition With Alternative No. 4: 2040 Design – Baseline Condition Minus The 11.0 Mg Flow EQ Basin At Pike River Lift Station, Plus New 36 Inch Dia. Forcemain From Pike River Lift Station To The Case New Holland Industrial Site

For the Alternative No. 4 Condition, the 11.0 MG flow equalization basin at the Pike River Lift Station is removed from the model and a new 36-inch diameter forcemain is added between the Pike River Lift Station and Case New Holland industrial site located southwest of the Racine WWTP.

Modeling indicates that surcharging of the Mt. Pleasant/Sturtevant Interceptor between the Pike River Lift Station and the WWTP is reduced under this alternative. However, there is no significant difference in the degree of surcharging comparing a new 36-inch diameter forcemain to the Case New Holland site alternative to the 2040 Design – Baseline Condition with 11.0 MG of flow equalization storage at the Pike River Lift Station. The estimated cost of the 36-inch diameter forcemain to the Case New Holland site alternative and the 11.0 MG equalization basin are similar.

If construction of a new forcemain from the Pike River Lift Station directly to the Case New Holland site is given further consideration, a flow equalization basin or new WWTP at the former Case New Holland industrial site will need to be constructed to receive the forcemain discharge. The preliminary design and layout of a new 12 MGD WWTP at the Case New Holland site is provided in Subsection 11.17 of this Facilities Plan. The recommendation of this Facilities Plan is to provide flow equalization storage at the Pike River Lift Station, unless a decision is made to construct a new WWTP at the Case New Holland site. If a new WWTP is constructed at the Case New Holland site, it is recommended that a 36-inch diameter forcemain be constructed between the Pike River Lift Station and the new WWTP, with no flow equalization storage provided at the Pike River Lift Station.

10.18 Prioritization and Time Frame of Conveyance Improvements

The conveyance system improvements recommended in this Facilities Plan are intended to serve current flows as well as potential growth in the service area. Whether or not growth occurs and projects proceed to final completion depends on many factors. Timing of projects is also dependent on non-growth related matters, such as WPDES permit requirements.

In the prioritization provided below, projects currently under construction or design were given highest priority, followed by projects related to anticipated growth in the southwest corner of the service area. The next level of priority was given to projects which were recommended in engineering studies conducted on the Caledonia and Mt. Pleasant conveyance systems. The remaining projects were prioritized based on the amount of benefit provided to the overall conveyance system and the anticipated timing of the need for the improvement. Projects were also spread out over the design period (2020 – 2040) to alleviate financial constraints.

Furthermore, it is likely that some conveyance system improvements will be designed and constructed ahead of the time frame provided in this Facilities Plan depending on the needs of the individual SSRs. The project implementation schedule presented in this Facilities Plan is intended to spread out costs over the 20-year planning period, not to dictate the actual schedules for projects designed and constructed by individual SSRs in accordance with their plans for development.

Priority No. 1A: Pike River Lift Station Phase 1 and Forcemains to Mt. Pleasant/Sturtevant Interceptor (at Old Green Bay Road)

	Project Time Frame: Anticipated completion in December 2021.
Priority No. 1B:	Abandonment of KR Lift Station and Interconnection to Pike River Lift Station Project Time Frame: Anticipated completion in mid-2020
Priority No. 1C:	Pike River Lift Station Phase 2 Project Time Frame: 2025 – 2030 Note: The Pike River Lift Station Phase 2 Project will not be necessary if the 11.0 MG flow equalization basin is constructed at the Pike River Lift Station
Priority No. 2A:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 1,2 and 3 from Pike River Lift Station to STH 11 Completed in 2020
Priority No. 2B:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 7 from STH 11 to STH 20 Project Time Frame: Anticipated completion in 2021.
Priority No. 3:	1.0 MG Flow Equalization For Chicory Road Interceptor Capacity Constraint Project Time Frame: 2021 – 2025
Priority No. 4:	3.5 MG Flow Equalization Storage at North Park Lift Station Project Time Frame: 2021 - 2025
Priority No. 5:	Additional 1.5 MG Flow Equalization Storage at Hood's Creek Lift Station. Project Time Frame: 2021 - 2025
Priority No. 6:	11.0 MG Flow Equalization Storage at Pike River Lift Station Project Time Frame: 2025 - 2030
Priority No. 7:	10.0 MG Flow Equalization Storage at Lift Station 01 Project Time Frame: 2030 - 2035
Priority No. 8:	Additional 1.0 MG Flow Equalization Storage at Caledonia 1. (LS 31 Upstream Capacity Constraints) Project Time Frame: 2030 - 2035
Priority No. 9:	1.0 MG Flow Equalization Storage at Lakeview Park. (Michigan Blvd Capacity Constraints) Project Time Frame: 2035 – 2040
Priority No. 10:	Osborne Boulevard/Kinzie Avenue Interceptor Sewer Upgrade Project Time Frame: 2035 – 2040
Priority No. 11:	Miscellaneous Interceptor and Trunk Sewer Upsizing • LaSalle Street Trunk Sewer • Geneva Street Interceptor Project Time Frame: 2035 – 2040
Priority No. 12:	1.65 MG Flow Equalization Storage along Mt. Pleasant / Sturtevant Interceptor Project Time Frame: 2035 – 2040

10.19 Cost Considerations

Below are cost estimates for each conveyance system improvement recommended in this Facilities Plan. Costs were estimated using 2020 pricing. For projects intended for construction in future years, an annual inflation rate of 3.375% was used to adjust to estimated year-of construction costs.

Cost estimates for Priorities No. 1A, 1B, 1C, 2A, and 2B were obtained from Foth I&E, LLC, representing Caledonia and Mt. Pleasant. Costs for Priorities No. 1A and 2A were based on actual bid prices for projects which are currently under construction. Costs for Projects 1B, 1C and 2B are engineers' opinions of probable construction cost.

Estimates of probable construction cost for Priorities 3 through 12 can be found in Appendix D.

Priority No. 1A:	Pike River Lift Station and Forcemains to Mt. Pleasant/Sturtevant Interceptor Est. Project Completion – Dec. 2021 Estimated Project Cost: $32.2 Million ($21.7 Million for Lift Station + $10.5 Million for Forcemain) (2020 Dollars)
Priority No. 1B:	Abandonment of KR Lift Station and Interconnection to Pike River Lift Station Est. Project Completion – Dec. 2021 Estimated Project Cost: $4.4 Million (2020 Dollars)
Priority No. 1C:	Pike River Lift Station Phase 2 Project Time Frame: 2025 - 2030 Estimated Project Cost: $9.3 Million (2020 Dollars) $11.0 Million (2025 Dollars based on 3.375% annual inflation) Note: The Pike River Lift Station Phase 2 Project will not be necessary if the 11.0 MG flow equalization basin is constructed at the Pike River Lift Station. Cost summaries for this Facilities Plan will include the cost of the 11.0 MG EQ Basin and will not include the cost of the Pike River Lift Station Phase 2 Project.
Priority No. 2A:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 1,2 and 3 from Pike River Lift Station to STH 11. Completed in 2020 Estimated Project Cost: $21.2 Million (2020 Dollars)
Priority No. 2B:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 7 from STH 11 to STH 20. Est. Project Completion - 2021. Estimated Project Cost: $9.0 Million (2020 Dollars) 10.6 Million (2025 Dollars)
Priority No. 3:	1.0 MG Flow Equalization For Chicory Road Interceptor Capacity Constraint Project Time Frame: 2021 – 2025 Estimated Project Cost: $2.8 Million (2020 Dollars) - See Table D-4 in Appendix D. $3.3 Million (2025 Dollars based on 3.375% annual inflation) $3.9 Million (2030 Dollars based on 3.375% annual inflation)
Priority No. 4:	3.5 MG of Flow Equalization Storage at North Park Lift Station Project Time Frame: 2021 - 2025 Estimated Project Cost: $6.4 Million (2020 Dollars) - See Table D-2 in Appendix D. $7.5 Million (2025 Dollars based on 3.375% annual inflation) $8.9 Million (2030 Dollars based on 3.375% annual inflation

Priority No. 5:	Additional 1.5 MG of Flow Equalization Storage at Hood's Creek Lift Station. Project Time Frame: 2021 - 2025 Estimated Project Cost: $3.4 Million (2020 Dollars) - See Table D-3 in Appendix D. $4.0 Million (2025 Dollars based on 3.375% annual inflation) $4.7 Million (2030 Dollars based on 3.375% annual inflation)
Priority No. 6:	11.0 MG Pike River Lift Station Flow Equalization Storage Project Time Frame: 2025 - 2030 Estimated Project Cost: $17.9 Million (2020 Dollars) - See Table D-1 in Appendix D. $21.0 Million (2025 Dollars based on 3.375% annual inflation) $25.0 Million (2030 Dollars based on 3.375% annual inflation)
Priority No. 7:	10.0 MG Flow Equalization Storage at Lift Station 01 (LS No. 1 Downstream Interceptor Capacity Constraints) Project Time Frame: 2030 - 2035 Estimated Project Cost: $14.5 Million (2020 Dollars) - See Table D-5 in Appendix D. $17.1 Million (2030 Dollars based on 3.375% annual inflation) $20.2 Million (2035 Dollars based on 3.375% annual inflation)
Priority No. 8:	Additional 1.0 MG Flow Equalization Storage at Caledonia-Riverbend Lift Station (LS31). (LS 31 Upstream Capacity Constraints) Project Time Frame: 2030 - 2035 Estimated Project Cost: $2.8 Million (2020 Dollars) - See Table D-6 in Appendix D. $3.9 Million (2030 Dollars based on 3.375% annual inflation) $4.6 Million (2035 Dollars based on 3.375% annual inflation
Priority No. 9:	1.0 MG Flow Equalization Storage at Lakeview Park. (Michigan Blvd Capacity Constraints) Project Time Frame: 2035 – 2040 Estimated Project Cost: $2.8 Million (2020 Dollars) - See Table D-7 in Appendix D. $4.6 Million (2035 Dollars based on 3.375% annual inflation) $5.4 Million (2040 Dollars based on 3.375% annual inflation
Priority No. 10:	Osborne Boulevard/Kinzie Avenue Interceptor Sewer Upgrade Project Time Frame: 2035 – 2040 Estimated Project Cost: $3.9 Million (2020 Dollars) - See Table D-8 in Appendix D. $6.4 Million (2035 Dollars based on 3.375% annual inflation) $7.6 Million (2040 Dollars based on 3.375% annual inflation
Priority No. 11:	Miscellaneous Interceptor and Trunk Sewer Upsizing • LaSalle Street Trunk Sewer • Geneva Street Interceptor Project Time Frame: 2035 – 2040 Estimated Project Cost: $3.4 Million (2020 Dollars) - See Tables D-9 and D-10 in Appendix D. $5.6 Million (2035 Dollars based on 3.375% annual inflation)

$6.6 Million (2040 Dollars based on 3.375% annual inflation

Priority No. 12:	1.65 MG Flow Equalization Storage along Pike River Interceptor Project Time Frame: 2035 – 2040 Estimated Project Cost: $3.9 Million (2020 Dollars) - See Table D-11 in Appendix D. $6.3 Million (2035 Dollars based on 3.375% annual inflation) $7.4 Million (2040 Dollars based on 3.375% annual inflation

10.20 Conveyance System Improvements Summary

The conveyance system improvements described in this Facilities Plan can be categorized as Near-Term, Mid-Term or Long-Term Conveyance Improvements.

Near-Term Conveyance Improvements consist of projects currently under construction or design. These projects are anticipated to be completed by 2025. Near-Term Conveyance Improvement Projects include the following:

Priority No. 1A:	Pike River Lift Station Phase 1 and Forcemains to Mt. Pleasant/Sturtevant Interceptor (at Old Green Bay Road)
Priority No. 1B:	Abandonment of KR Lift Station and Interconnection to Pike River Lift Station
Priority No. 2A:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 1,2 and 3 from Pike River Lift Station to STH 11
Priority No. 2B:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 7 from STH 11 to STH 20
Priority No. 3:	1.0 MG Flow Equalization for Chicory Road Interceptor Capacity Constraint

The total estimated cost of Near-Term Conveyance Improvements, in 2020 dollars, is $79.2 million.

Mid-Term Conveyance Improvements consist of projects anticipated to be completed between 2025 and 2030. Mid-Term Conveyance Improvements Projects include the following:

Priority No. 4:	3.5 MG Flow Equalization Storage at North Park Lift Station. Based on the May 2020 storm events, this project may be considered a higher priority.
Priority No. 5:	Additional 1.5 MG Flow Equalization Storage at Hood's Creek Lift Station. Based on the May 2020 storm events, this project may be considered a higher priority.
Priority No. 6:	11.0 MG Flow Equalization Storage at Pike River Lift Station

The total estimated cost of Mid-Term Conveyance Improvements, in 2025 dollars, is $21.0 million.

Long-Term Conveyance Improvements consist of projects anticipated to be completed between 2030 and 2040. Long-Term Conveyance Improvements Projects include the following:

Priority No. 7:	10.0 MG Flow Equalization Storage at Lift Station 01
Priority No. 8:	Additional 1.0 MG Flow Equalization Storage at Caledonia-Riverbend Lift Station (LS31). Based on the May 2020 storm events, this project may be considered a higher priority.
Priority No. 9:	1.0 MG Flow Equalization Storage at Lakeview Park.

Priority No. 10:	Osborne Boulevard / Kinzie Avenue Interceptor Sewer Upgrade
Priority No. 11:	Miscellaneous Interceptor and Trunk Sewer Upsizing • LaSalle Street Trunk Sewer • Geneva Street Interceptor
Priority No. 12:	1.65 MG Flow Equalization Storage Along Pike River Interceptor Sewer

The total estimated cost of Long-Term Conveyance Improvements, in 2035 dollars, is $47.7 million.

10.21 Conclusions and Recommendations

Modeling of the 2020 Existing conveyance system during the 5-year, 6-hour rainfall event identified capacity constraints located throughout the system. After identifying all existing capacity constraints, numerous modeling runs were conducted to determine the optimum implementation of improvements to the RWU conveyance system to mitigate anticipated constraints under design year 2040 conditions. Some of the improvements proposed in this Facilities Plan serve specific areas, often at the extremities of the conveyance system. Other projects serve a large geographical area and provide a benefit to the overall RWU service area. All projects are intertwined. Improvements in the extremities of the service area affect the core of the conveyance system and vice versa.

This Facilities Plan prioritizes proposed conveyance system improvements and lays out time frames for implementation. Modeling predicts that implementation of the proposed improvements will significantly reduce surcharging of interceptor sewers and the amount of bypassing occurring at Safety Sites during the 2040 Design condition when compared to the 2020 Existing condition.

Infrastructure improvements presented in this Facilities Plan are intended to prevent surcharging of interceptor sewers, discharge of untreated wastewater at Safety Sites and basement backups. The recommended improvements were not based on the allocation of flows contained in the IGA between RWU and each SSR. The hydraulic model developed for this Facilities Plan can be used to determine future conveyance system needs.

It is recommended that RWU continue implementation of projects currently under design or construction (Near-Term Projects) and begin preliminary design of projects slated for construction in the 2025 – 2030 time frame (Mid-Term Projects). As Near-Term and Mid-Term projects are completed, the hydraulic model of the conveyance system should be used to fine-tune predictions for the 2030 – 2040 time frame based on actual development of the service area. Long-Term Projects should be implemented if growth/development in the RWU service area occurs as predicted in this Facilities Plan.

11.0 Wastewater Treatment Alternatives Analysis

This section discusses and presents an alternatives analysis to resolve system needs identified with RWU in facilities condition assessment and alternatives analysis review meetings. The alternatives address items to remedy deficiencies; many of the issues were standalone items. Other alternatives associated with improving treatment performance or energy efficiency have choices. Each alternative includes a brief description of the proposed upgrade or system, advantages and disadvantages, and associated cost. Recommendations are summarized in Section 13 and implementation planning is discussed in Section 14.

The following is a list of alternatives by unit process using the following numbering system:

UNIT PROCESS NO. – STRUCTURE NO – SEQUENTIAL NO.

Where:

Unit Processes are as numbered in the Process Interface Figure 11-1 (unit process numbers 1 through 14). Structures are as numbered on Site Key Plan Figure 7-1

Table 11-1 provides a summary of the alternatives and needs reviewed in this facility plan. The capital cost total from the estimate worksheets includes markups and escalation factors; therefore, the initial cost in the planning level estimate is for a completed project from design through installation commissioning and not just an equipment vendor quote. Unless the item is a well-defined scope of work with a quote, the typical planning level Capital Cost column in Table 11-1 includes the following factors (which are subjectively used in estimating):

- 30% Contingency (add-on to Equipment and Installation estimates for future scope details and escalation)
- 20% Overhead and Markups (contractor mark ups on equipment and installation)
- 10-15% Engineering (pending scope of design and construction related services of item)

11.1 Wet Weather Optimization

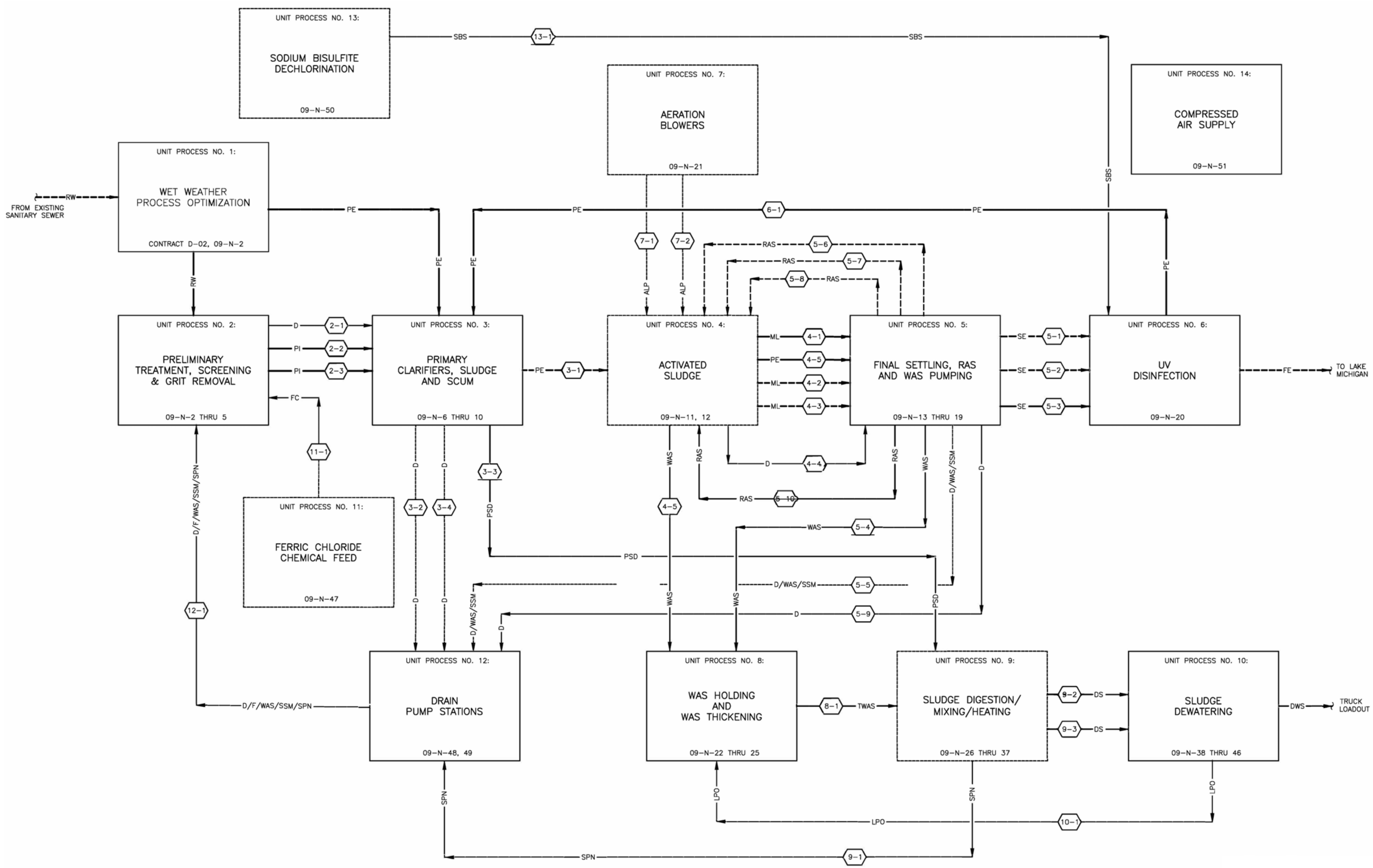
1-30-1 Improve Flow Equalization Facilities

<u>Alternative Description</u>

The existing 4 foot-6 inch wide by approximately 6 foot deep bar screen channel Inv EL 593.5 is approximately thirteen (13) feet above the raw wastewater influent channel elevation in Equalization (EQ) Screening Building 30 (Inv EL 580.5). After each peak flow event, materials like floatables, sand, grit, trash and debris are trapped in the influent channel as there is insufficient velocity to lift all materials in the wastewater through the elevated screening channel resulting in buildup and difficulty in cleanout and maintenance of the deep channel low point in the system.

The existing bar screens are past useful life and costly to maintain. In addition to replacing the bar screens, potential revisions to improve maintenance accessibility and cleanout include the addition of water cannon for flush out of the channel toward a submersible pump which RWU staff have added, as well as relocation of an isolation valve in the EQ basin pump discharge piping that is currently below peak flow water levels in the raw wastewater channel and unsafe for access.

Control of managing wet weather flow at the wastewater treatment plant is limited by gravity hydraulics but will improve with more accurate data. Planning for improving flow measurement with new and additional flow measurement technology will benefit control of opening and closing gates and valves which channel peak flows to treatment or equalization. Also see the alternatives regarding new UV channels and increasing wall height at mixed liquor and final effluent channels for addressing peak flow through the plant.



Projection:

Figure 11-1
Process Interface Summary Diagram

Racine Facilities Plan
Racine Wastewater Utility

Drawn By: JFP
Checked By: MJZ
Date:
Project #: 60554970

Table 11-1. Racine Wastewater Treatment Plant Facility Plan Alternatives Evaluation
Rev Date 07/01/2020

Facility Plan Alternative Number and Name	Capital Cost Estimate $	Annual O&M $	Present Worth of Annual O&M $	Total Present Worth $
GENERAL SITE AND FACILITIES				
G-1 Upgrade road paving	$ 179,000			
G-2 Improve stormwater drainage around Digester B (170) between structures 172 and 185	$ 136,000			
G-3 Inspect metal manstards on building exteriors which are observed to be deteriorating. Finish deterioration may be warranty issue? Refinish or replace.	$ 166,000			
G-4 Upgrade out-of-date Fire Alarm Panels	$ 89,000			
G-5 Upgrade service water plumbing systems	$ 75,000			
G-6 Upgrade back-up engines	$ 143,000			
G-7 Upgrade women's locker rooms	$ 49,000			
G-8 Alternative to add new high strength waste receiving station				
G-139 Structural leakage issue upgrades	$ 36,000			
G-162 Outfall Condition Assessment - STUDY	$ 50,000			
G-185 Inspect Site Pipe insulation for presence of asbestos to enable identification and cost estimate allowance for removal and replacement	$ 50,000			
EQUALIZATION- WET WEATHER OPTIMIZATION				
1-30-1 Improve facilities for O&M of Equalization	$ 1,100,000			
1-30-2 Revise Screening Building with New Channels	$ 1,900,000			
1-40-1 Rehabilitate East Equalization Basin EQ #1	$ 200,000			
ADMINISTRATION BUILDING 110				
110-1 Replace roofs on Administration Bldgs.	$ 685,000			
110-2 Conduct study to evaluate staffing, space, and functionality adequacy to meet needs				
110-2 Replace furnishings & finishes (percent allowance)	$ 251,000			
110-3 Upgrade communications and electronics to support future functionality	$ 69,000			
110-4 Upgrade Men's Restroom- Lobby	$ 49,000			
110-5 Replace HVAC Air Handling Unit	$ 179,000			
CHEMICAL WING BUILDING 110				
120-1 Design and construct truck unloading containment for ferric chloride delivery with/hydraulic ramp	$ 300,000			
120-3 Upgrade Ferric Chloride Tank to dual containment OH fill piping	$ 160,000			
LAB BUILDING 125				
125-1 Consider additional space or allocation for file/records storage.				
125-2 Replace lab hoods	$ 60,000			
125-3 Replace lab floor with more chemical resistant material.	$ 75,000			
125-4 Review alternate locations for storage of gases				
125-5 Evaluate piping and circulation of chemicals and gases through lab from loading dock for improved safety and efficiency.	$ 90,000			
125-6 Replace air handlers and condensing units with rooftop HVAC (2 ea).	$ 269,000			
125-7 Upgrade Lab Fixtures	$ -			
PRELMINARY TREATMENT- 130				
G-130-2 Consider Solar Panels on Preliminary Treatment Building	$ 89,000	$ (12,580)	$ (181,000)	$ (92,000)
2-130-1 Replace Grit Screw Conveyors	$ 498,000			
PRIMARY TREATMENT- 135/136				
3-135/136-1 Primary Clarifier Mechanism Rehab -ALL	$ 3,002,000			
3-136-1A Primary Clarifier Mechanism Rehab - Replacement Years 0-5	$ 850,000			
3-135/136-1B Primary Clarifier Mechanism Rehab - Replacement Years 5-10	$ 940,000			
3-135/136-1C Primary Clarifier Mechanism Rehab - Replacement Years 10-15	$ 875,000			
3.136-2 Add walkway between Primary Clarifier Nos.10-11	$ 110,000			
3-135/136-3 Upgrade Channel Aeration Mixing . Enviromix Proposal	$ 600,000	$ 10,000	$ 144,000	$ 744,000
3-125-1 Replace Channel Aeration Blowers	$ 535,000	$ 50,000	$ 719,000	$ 1,254,000
3-136-4B Upgrade Primary Scum Pumping and Distribution System	$ 130,000			
3-136-5 Provide Redundancy for Primary Effluent Channel	$ 110,000			

Table 11-1. Racine Wastewater Treatment Plant Facility Plan Alternatives Evaluation
Rev Date 07/01/2020

Facility Plan Alternative Number and Name	Capital Cost Estimate $	Annual O&M $	Present Worth of Annual O&M $	Total Present Worth $
SECONDARY TREATMENT- AERATION 139				
4-139-1 Maintain Existing Aeration- Ceramic Diffusers . Evaluate performance and upgrade controls/Replace diffusers as needed	$ 370,000			
4-139-2 Replace Diffuser System with New Ceramic Diffusers and New Piping and Controls	$ 1,750,000	$ (16,604)	$ (239,000)	$ 1,511,000
4-139-3 Replace Diffuser System with New Membrane Diffusers and New Piping and Controls	$ 1,840,000	$ (75,056)	$ (429,000)	$ 1,211,000
4-139-4 Decouple aeration from mixing first 25% of aeration volume to create swing zone for energy efficiency and potential bio-P				
4-139-5 Replace RAS distribution flow meters 1 through 5	$ 222,000			
4-139-6 Add ML Channel Isolation Gates	$ 125,000			
4-139-7 Replace aeration tank MLSS butterfly valves	$ 540,000			
4-139-8 Replace aeration tank inlet gates	$ 120,000			
4-139-9 Convert to Biological Phosphorus Removal				
7-185-1 Upgrade to new high efficiency centrifugal blower system (see 4-139 for various aeration system sizing considerations)	$ 2,200,000	$ (60,056)	$ (863,000)	$ 1,337,000
SECONDARY TREATMENT- FINAL CLARIFICATION 140-145				
5-139-9 Replace RAS Flow Meters 3-7	$ 160,000			
5-139-10 Upgrade RAS Pumps #2-#4-#6-#8-#10-#12 to handle peak flow	$ 180,000			
5-140-1 Evaluate FRP Covers for Weir Launders- Clarifier 7-9 algae growth prevention	$ 275,000			
5-141-1 Evaluate FRP Covers for Weir Launders- Clarifier 1-6 algae growth prevention	$ 524,000			
5-141-1A Evaluate Aluminum Covers for Weir Launders- Clarifier 1-9 algae growth prevention	$ 2,300,000			
5-141-2 Evaluate Means for Pumping Waste Sludge From Final Clarifiers #2, #4, and #6	$ 85,000			
5-141-3 Modify Mixed Liquor Inlet Channel/Effluent Separation Wall at Final Clarifiers #1 – #6	$ 16,000			
5-145-4 Upgrade Secondary Scum Pumping and Distribution	$ 130,000			
5-145-5 Add Final Effluent Reuse as Engine Cooling Water	$ 62,000			
SECONDARY TREATMENT- UV DISINFECTION & EFFLUENT OUTFALL 160-162				
6-91-1 Upgrade Deficient Sampler Building	$ 60,000			
6-160-1 UV Disinfection System Nos. 1 and .2 -STATUS QUO	$ -	$ 485,900	$ 6,985,000	$ 6,985,000
6-160-2 Upgrade UV Disinfection System Nos. 1 and 2 (replace)	$ 4,677,000	$ 128,940	$ 1,853,000	$ 6,530,000
6-160-3 Upgrade UV Disinfection System to 3-Channel System	$ 4,469,000	$ 126,740	$ 1,822,000	$ 6,291,000
6-160-4 Replace Final Effluent Flow Meters (60" Magmeters)	$ 440,000			
6-162-1 – Cover for Effluent Junction Chamber	$ 119,000	$ -	$ -	$ -
6-162-2 – Final Effluent Junction Chamber Solar Panels	$ 30,000			
13-47-1 Upgrade Dechlorination System	$ 95,000			
SOLIDS PROCESSING 165				
8-165-1 Upgrade TWAS piping to digesters	$ 350,000			
10-165-2 Maintain status quo Belt Filter Press Operating Schedule				
10-165-3 Filtrate Equalization Tank	$ 1,960,000			
10-165-4 Consider replacing air handling units with heating system using WWTP hot water loop	$ 200,000			
10-165-5 Improve plumbing supply and drainage on 1st and 2nd floor of Building 165	$ 100,000			
ANAEROBIC DIGESTION & BIOGAS 170-190				
9-170-1 Inspect, evaluate and rehabilitate Digester "B" Cover	$ 276,000			
9-177-1 Replace Digester D Floating Cover	$ 1,843,000			
9-185-1 Biogas Conditioning for H2S (Hydrogen Sulfide Removal)	$ 317,000	$ 7,333	$ 105,000	$ 422,000
9-185-1A Biogas Conditioning for IC Engine (Moisture and VOC/Siloxanes)	$ 1,260,000	$ 10,000	$ 144,000	$ 1,404,000
9-185-2A Biogas CHP Engine Generator- Max Month Biogas with One Unit out of Service	$ 4,500,000	$ (203,000)	$ (2,918,000)	$ 1,532,000
9-185-2B Biogas CHP Microturbines - MAX Month Biogas with One Unit out of service	$ 4,200,000	$ (99,000)	$ (1,423,000)	$ 2,727,000
9-185-2C Biogas CHP - STATUS QUO Facility Plan Needs	$ 550,000	$ 105,000	$ 1,500,000	$ 2,050,000
9-190-1- Increase Gas Storage Capacity	$ 1,256,000			
14-185-3 Upgrade Existing Reciprocating Piston Air Compressors with New Rotary Screw Air Compressors	$ 139,000			

Table 11-1. Racine Wastewater Treatment Plant Facility Plan Alternatives Evaluation
Rev Date 07/01/2020

Facility Plan Alternative Number and Name	Capital Cost Estimate $	Annual O&M $	Present Worth of Annual O&M $	Total Present Worth $
CNH SITE				
G-CNH Lakefront Stabilization/ Erosion Protection	$ 360,000			
G-CNH Install Solar Panels	$ 3,915,000	$ (616,820)	$ (8,866,000)	$ (4,951,000)
G-CNH WWTP- Future Concepts	$ 48,000,000			

Advantage:

Upgrade bar screening and improve accessibility and efficiency of cleaning trapped grit, trash, and debris in low point of EQ basin influent channel and improve equalization system flow measurement.

- **Initial Cost $1.1 Million**

1-30-2 Revise EQ Screening Building 30 and Screens to Accommodate New Channels

As a comparison alternative No. 1-30-1 for the maintenance challenges in keeping influent channels clean would be to redesign the structure and screening system to use proper hydraulic flow through channel. This would require relocating the EQ basin sludge pump system to a new structure to enable revisions to the EQ screen channel with new screens designed to extend to the bottom of the influent channel to eliminate the hydraulic jump to the screens which leaves debris trapped in the low point inlet channel.

This modification requires major changes to the buried withdrawal piping, relocation of all sludge pump piping to a new structure, revisions to demo existing screening channels as well as design and installation of new longer mechanical bar screens for the revised flow through channel.

Advantage:

Provides proper hydraulic design of channels and screens to improve maintenance.

Disadvantage:

Major rework of EQ Screening Structure 30 in addition to cost of new screens as compared to alternative 1-30-1.

- **Initial Cost $965,000**

1-40-1 Rehabilitate East Equalization Basin EQ #1

Original stormwater clarifier (equalization basin) was not upgraded in the last plant upgrade and expansion and is in need of concrete and structural steel surface rehabilitation.

- **Initial Cost $1.9 Million**

11.2 Headworks and Preliminary Treatment

G-8 High Strength Waste Receiving Station

The potential of adding a high strength waste receiving station at the Racine WWTP is an alternative that has drawn some consideration for the future. High strength waste receiving and waste processing in digesters has been implemented with mixed success by other wastewater utilities.

High strength receiving station planning at RWU needs considerations for the following:

- Determination of optimum capacity for truck hauling of anticipated waste vs. frequency of deliveries.
- Location for deliveries and spill containment
- Below grade concrete tanks need special protective coatings or linings for corrosion protection.
- Pumping station and waste distribution
- SCADA: Tank level control and

Benefits:

- Potential revenue source based on market needs for management of high strength waste
- Sustainability measure for the community if RWU were able to accept food waste; especially in the event local industries should lose outlets for disposal of food waste byproducts.
- Potential renewable energy source for increased biogas production in conjunction with future biogas utilization alternatives anticipated during the planning period
- Alternative for management of scum

Concerns:

- Maintenance of tankage, pumping and piping associated with receiving of waste
- Corrosive, odorous nature of waste which if managed improperly could cause structural damage to tanks, piping and digester systems
- Capital cost required to invest in the high strength waste market.

Recommendation

RWU should implement a specific study to determine if there is enough waste in the area to justify the investment for RWU to manage the waste or compete in the marketplace for such waste treatment. The study can further evaluate the design considerations and provide economic analysis of the benefits vs the impact of the concerns.

11.3 Preliminary Treatment

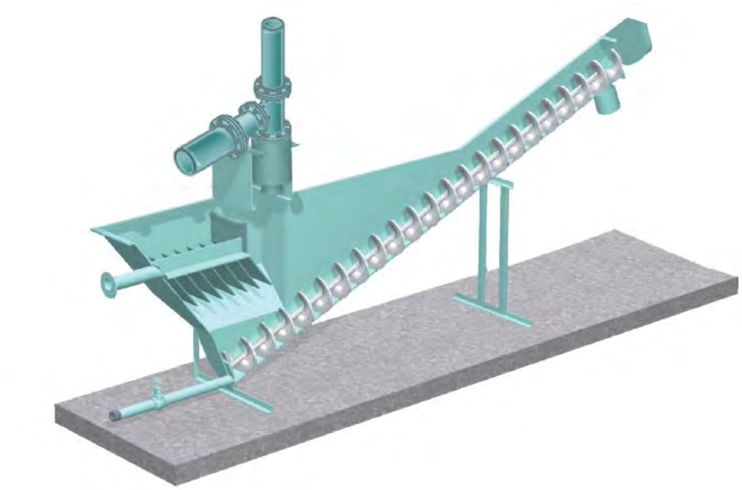
2-130-1 Replace Grit Screw Conveyors

The Grit Screw Conveyors (M-2-29-1,-2) were installed as part of the 2002-2005 upgrade. The conveyors have a capacity of 250 gpm and are 15-ft in length and have screws with a diameter of 9-in. A cutaway drawing of a typical grit screw conveyor is shown in Figure 11-2.

The original painted steel screw conveyors are nearing the end of their useful life and have been repaired multiple times. The screw conveyors need replacing with 316SS materials of construction that will withstand both the abrasion and corrosive conditions. The corresponding lubricators should be replaced as well; however, the existing screw conveyor controls and control panels are in good condition and do not need to be replaced.

- **Initial Cost** **$498,000**

Figure 11-2. Grit Screw Conveyor – Cutaway Drawing



11.4 Primary Treatment

3-135/136-1 – Primary Clarifier Mechanism Replacement

There are 12 primary clarifiers in three general sizes. The different sized clarifiers are as follows:

- Clarifier #1 – 4 - Basin size 34.5-ft x 137.5-ft
- Clarifier #5 – 6 - Basin size 30-ft x 115-ft
- Clarifier #7 – 12 - Basin size 30-ft x 120-ft

The newest of the primary clarifier mechanisms are in Clarifiers #5, #6, #11, and #12. The plant regularly inspects mechanisms and keeps record of operating maintenance. Some of the clarifier drive mechanisms are in need of replacement sooner than others during the planning period. The mechanism manufacturer, Evoqua (formerly Envirex), will assist in recommendations based on inspection reports. The installation of covers over drives should be considered during replacement work to reduce ice build-up. Following is a list of the wear parts typically needing replacement:

- Chains: Flight carry – long, flight carry – cross, and drive
- Drives
- Flights: long and cross
- Wear shoes: return track and floor
- Wear strips: floor attachment and return tracks attachment
- Return tracks (supports to be reused)
- Deflector angles and supports
- Collector bearings –longitudinals: head shaft, upper effluent and lower effluent idler shafts and upper effluent
- Collector bearings – cross collectors: head shaft and idler shaft
- Collector sprockets –longitudinals: head shaft and idler shaft
- Sprockets – cross collectors: head shaft and idler shaft
- Drive sprockets and torque limiters
- Driven sprockets

For conservative budgeting, it is assumed that the clarifier mechanisms will be replaced in sets of four, with the O&M replacement projects scheduled approximately five years apart and managed by RWU. The first mechanism replacement project would be for Primary Clarifiers #7, #8, #9, and #10, the second for Primary Clarifiers #1, #2, #3, and #4, and the third for Primary Clarifiers #5, #6, #11, and #12. The sequencing and timing will be dependent on the condition of the mechanisms during the planning period.

Maintenance Costs

A projection for potential replacing of mechanism components is listed below with actual components and sequence and budgeting based on need for RWU planning purposes only:

- Alternative 3-135/136-1A Primary Clarifiers #7, #8, #9, and #10 - maximum $850,000
- Alternative 3-135/136-1B Primary Clarifiers #1, #2, #3, and #4 - maximum $940,000
- Alternative 3-135/136-1C Primary Clarifiers #5, #6, #11, and #12 - $875,000

3-135-2 Add Walkway Between Primary Clarifier #10 and 11

There are walkways on the walls between the clarifiers except for the wall between Primary Clarifiers #10 and #11. All other clarifiers have walkway access to at least one side of the tank. These walkways provide safe and convenient access for cleaning and maintenance activities. Due to lack of walkway access, it is difficult to clean and maintain Primary Clarifiers #10 and #11.

A 4-ft wide walkway consisting of aluminum grating and handrail should be installed on the wall that separates the two tanks. The walkway would be in two sections: one approximately 90-ft long across the main part of the tanks and another 20-ft section across the effluent weir section of the tanks. The walkways would connect the ends of the tank with the existing transverse (east-west) walkway. The existing handrail on the transverse walkway would need to be removed at the connections to the new walkway.

<u>Advantage:</u>

The walkway would provide safe and convenient access for cleaning and maintenance activities.

- **Cost $110,000**

3-135-3 Upgrade Channel Aeration Mixing

Description of System Alternative

BioMix™ systems provide mixing in liquids by firing short bursts of compressed air through engineered nozzle(s) in the primary influent channel. This compressed air is intermittently fired in fractional second durations to mix the tank. The relatively small surface area of the large gas volumes and their rapid upward velocity enable BioMix™ to provide energy-efficient, effective mixing. A control valve module mounted near the basin, would control the firing of the compressed air through 304SS press-technology piping and 304SS BioMix™ proprietary nozzles. Potentiometers for firing frequency and duration would allow optimally setting the mixing intensity in the channel. Electrical power is required to operate the air compressor and the 120 V power for the control valve.

A proposed BioMix™ system for the Primary Influent Channels would be designed for a "wet installation" while channel is in service (see Figure 11-3 below). New supply header piping would be installed above the liquid surface by affixing the piping to the channel wall using with supplied supports and hardware. A vertical nozzle header would be lowered into the channel which would have a concrete block affixed to the nozzle. The block would be hung above floor of the floor and counter act fluid velocity forces and buoyant forces to restrain the nozzle header. A sway brace support would be affixed to the nozzle header above the liquid surface for added structural rigidity.

Advantage:

A BioMix™ installation would be designed to:

- Significantly reduce power consumption compared to diffused air mixing.
- Replace larger horsepower motor driven PD blowers with smaller 25 HP packaged air compressor unit. (less space/less noise).
- Replace old large painted carbon steel headers and piping with new lighter smaller stainless-steel piping.
- Maintain no mechanical or electrical components in the wastewater.
- Provide non-clogging, self-cleaning in-channel components.
- Allow for minimal scheduled maintenance of other components (compressor, air control valves). in controlled environments.

Disadvantage to Conversion of Channel Mixing Technology

- Demolition of existing blower and coarse bubble diffuser system is required.
- Higher capital cost than alternative No. 3-125-1 which is alternative to replace PD blowers and maintain existing channel mixing.

Figure 11-3. BioMix™ Layout Concepts

- **Initial Cost $600,000**

3-125-1 Replace Channel Aeration Blowers

The existing channel aeration blowers (Hoffman Blowers) have had a long service life; However, if the existing coarse bubble diffused air mixing system is maintained, they will need to be replaced

Consideration should be given to packaging new blowers in sound attenuating enclosures to reduce the noise in the building which requires operating personnel to wear hearing protection throughout the room and corresponding hallway/tunnels.

<u>Advantage to Maintaining Coarse Bubble Diffuser Channel Mixing:</u>

Reuse existing air distribution and coarse bubble diffuser system (less capital intensive than new large bubble mixing system)

<u>Disadvantage to Maintaining Coarse Bubble Diffuser Channel Mixing:</u>

Significantly higher power consumption compared to large bubble mixing technology

- new larger horsepower motor driven PD blowers required as compared with a smaller 25 HP packaged air compressor unit(less space/less noise)

- **Initial Cost $535,000**

3-136-4A Upgrade Scum Pumping System

The existing primary scum pumps are Yeomans ejector pumps which were installed as part of the 2002-2005 plant upgrade. There are two pumps, each with a capacity of 100 gpm at 50-ft. These pumps are nearing the end of their useful life. In addition, other types of pumps have become more common for scum pumping.

It is recommended that the scum pump system be evaluated as part of the review of the systemwide scum management plan. The options for improving the scum removal system include the replacement of the scum pumps, modifications to the scum piping to allow the scum to discharge to multiple locations and the use of the Vactor.

One option would be to replace the existing scum pumps with an alternate type of pump. Two possible pump types are progressing cavity and rotary lobe. Both pump types are positive displacement pumps that are commonly used to pump scum. Typical progressing cavity and rotary lobe pumps are shown in Figures 11-4 and 11-5, respectively.

Piping modifications are preferred by RWU staff over the installation of different style of positive displacement pumping. Pumps bring concerns regarding scum plugging, blockage and increased O&M risks which need to be engineered and managed.

There are other improvements being considered for the primary scum pumping system, including modifications to the discharge piping and the potential for the integral addition of hauled high strength waste. These improvements are discussed in 3-136-4B.

Advantage of Progressing Cavity Pumps vs Other Types:

Progressing cavity pumps are less costly than rotary lobe pumps for the design flow and load conditions.

Disadvantage (Progressing Cavity Pumps):

Progressing cavity pumps have a large footprint as well as design issues to manage risk of pipe blockage. Neither progressive cavity nor rotary lobe type pumps are favored by RWU staff and therefore are not recommended at this time.

Figure 11-4. Typical Progressing Cavity Pump

Figure 11-5. Typical Rotary Lobe Pump

- **Initial Cost** **$100,000.**

3-136-4B Provide Ability to Pump Scum to Digester B and E or Use Vactor for Removal

The Scum Pumps discharge into the piping from the Primary Sludge Pumps which conveys the sludge and scum to the anaerobic digesters. Piping modifications should be made to allow the ability to discharge scum to either Digesters B or E.

Another possible modification that is recommended would be to add a tee in the scum piping upstream of the pumps with a connection for the Vactor, which could then be used to remove the scum. The use of the Vactor instead of the scum pumps would allow the scum to be removed in a shorter period of time. The Vactor could discharge the scum to a dumpster for removal when the scum quality is less than should be sent to the digesters. Scum could also be discharged into a tank which could also receive high-strength waste. When the scum is of a quality that can be sent to the digesters, the valve to the digester feed piping could be opened and the scum pumps used to send the scum to the digesters as in the current operation. This should allow the scum pumping system to function better.

The estimate is a conservative allowance only as piping layouts need to be configured.

- **Initial Cost $130,000**

3-136-5 Provide Redundancy for Primary Effluent Channel

The Primary Effluent Channel is 6-ft wide by 7'-9" high. The likelihood of a situation where the primary effluent channel is unavailable is remote. However, it would have a very severe impact on the treatment facilities, as there is no alternate method of conveying effluent from the primary clarifiers to the aeration tanks. Unfortunately, there are significant interferences which make the construction of a redundant channel very difficult and costly.

A parallel channel adjacent to the existing channel would be approximately 260-ft in length. A channel adjacent to the existing channel is not practical as it would interfere with the plant's electrical feed facilities. Another possible route for the channel would be along the plant road between digesters and the Solids Processing Building. The channel length for this route would be approximately 330-ft. This route would also be impractical due to interferences such as major electric feed lines, the tunnel between the digesters and the Solids Processing Building, and a 12-in diameter water line.

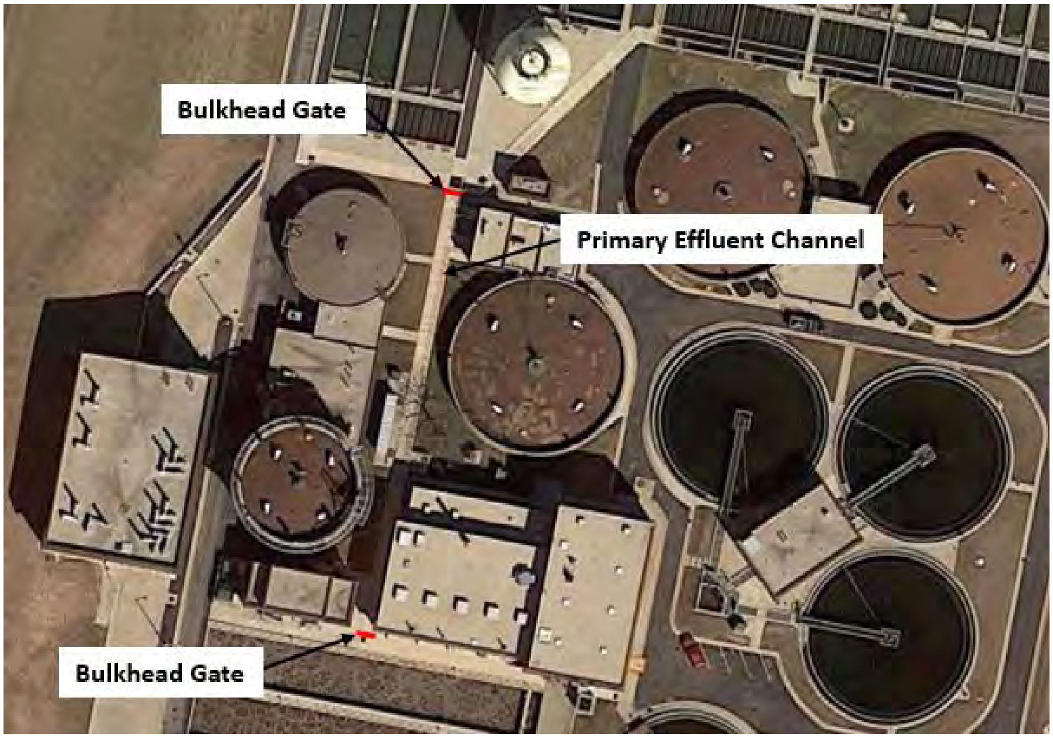
An alternative to installing a redundant channel would be to install facilities to help expedite temporary pumping of primary effluent if the channel were ever to be out of service. This would include installing a bulkhead gate at the upstream entrance to the channel and another at the discharge end of the channel. These gates would allow the channel to be isolated. The locations of the bulkhead gates are shown in Figure 11-6. The gates would both be 6-ft wide by 7'-6" high. The bulkhead gates would be of stainless steel with an in-channel mounted frame and a lifting eye which could be attached to a lifting device.

If, in the future, the plant's electric feed facilities or major electric feed lines were to be moved or altered in a way which would allow the construction of an additional channel, either parallel to the existing channel or along the west plant road, the option of a second channel could be reconsidered.

Advantages: Channel isolation gates would expedite the bypassing of the Primary Effluent Channel. The cost for providing a redundant channel, which would be prohibitively expensive and impractical, would be avoided.

Disadvantages: There would be a need to arrange for temporary pumping equipment and piping, which would cause a delay until bypassing the channel could begin. There would be an operational cost for the rental of bypass pumping equipment.

Figure 11-6. Primary Effluent Channel



- **Cost $110,000**

11.5 Secondary Treatment- Activated Sludge

4-139-1 Maintain existing ceramic diffusers and aeration grid layout

RWU has had positive performance from their existing ceramic diffusers. They are cleaned annually by pressure washing but have not been tested for oxygen transfer efficiency (OTE) in the last 5 years. Plant staff have been pleased with longevity of the ceramic diffusers. The calibrated GPS-X process model indicates, however, that there may be higher fouling factor than originally designed. Dynamic wet pressure (DWP) and off-gas testing is recommended to confirm effectiveness of cleaning and condition of diffusers. If found that cleaning cannot restore design efficiency, diffuser replacement is warranted. Testing can be conducted by Redmon Engineering, Sanitaire, EDI, or other testing firms.

As part of maintenance and upgrades, it is prudent over the planning period to consider the longevity of existing ceramic diffusers for continued service. This alternative considers a case where 10% (equivalent to one pass) of the system diffusers will need to be replaced. Air flow measurement technology has improved and in consideration of the aeration system as a whole, a minimum upgrade should consider new aeration flow meters and controls. This alternative includes the testing and further evaluation of existing ceramic diffusers needed to verify oxygen transfer efficiency and validate performance.

<u>Advantages:</u>

Maintain status quo based on verification of oxygen transfer efficiency with minimal capital investment.

1. When new, ceramic diffusers operate at design head loss of system.
2. No shrink, creep or crack because they are made of fixed ceramic diffusers at Racine have proven to last longer than 7-10 year expected life of membrane diffusers when they are well maintained and may not become fouled. Racine has proven this point in terms of life with annual cleaning and historically minimal loss of transfer efficiency. This likely correlates with the solids concentrations and loadings which do not subject the diffusers to fouling seen in other systems.

Disadvantages:

The existing aeration system is aging and nearing the 20-year expected life of PVC piping and diffuser supports which may degrade over time resulting in weakness. The frequency of pipe leaks and breaks may increase over time as this material continues to degrade. Here are some of the disadvantages of staying with ceramic diffusers to further evaluate before replacing in kind:

1. They are less energy efficient than membranes. Due to fouling, ceramic diffusers end up with higher backpressure, which increases demand on the blowers, which in turn leads to higher power requirements and costs. Even a 10% increase in pressure loss can result in blower energy costs that are 5% to 9% higher.

2. They should not be turned off and have limited turndown range: because their fixed orifices will become fouled in the absence of airflow.

3. They are more expensive to clean if washing does not return efficiency.

- **Potential Capital Cost:** $370,000 (dependent on further evaluation of which if any diffusers need replacement- cost estimate for 10% diffusers and piping plus new aeration flow meters and controls)

4-139-2 Replace all ceramic diffusers in kind.

In response to concerns of longevity of piping and diffuser life over the duration of the planning period, one of the alternatives is a worst-case complete system replacement of the piping/diffuser system with new PVC piping and ceramic diffusers, as well as aeration flow meters and control valves. See the discussion in 4-139-1 and 4-139-3 for advantages and disadvantages.

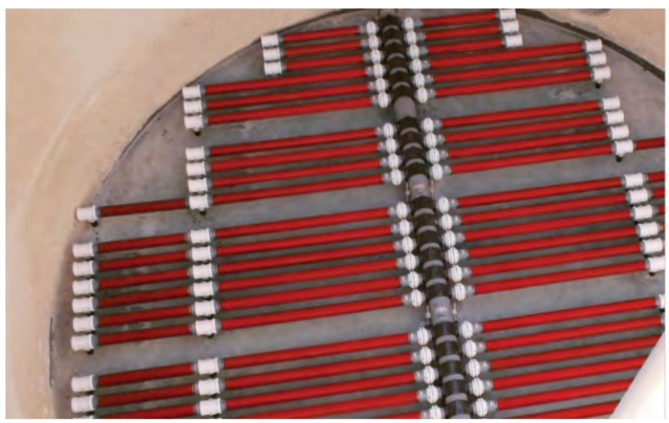
- **Initial Cost:** **Diffuser system equipment price from vendor: $600,000. Total project cost $1.75 million**

4-139-3 Alternative to replace existing ceramic diffusers with new membrane diffusers

As an alternative to maintaining existing ceramic diffusers, membrane technology has proven to be an energy efficient approach for activated sludge aeration. The existing ceramic diffuser system could be replaced with new PVC piping and new polymer-based membrane disc diffusers or membrane panel diffusers (whether EPDM or HDPE or PTFE). See Figures 11-7 and 11-8.

Figure 11-7. Typical Membrane Disc Diffuser

Figure 11-8. Typical Minipanel Membrane Diffuser



Advantages:

New diffusers will eliminate concerns of aging, worn, or fouled diffuser performance and diffusers are the key component in optimizing oxygen transfer and energy efficiency of aeration system.

1. Energy efficiency: because facilities can turn these diffusers off when necessary, RWU would have opportunity save money on energy costs. Because they do not foul and increase backpressure, they also put less strain on the blowers, again leading to reduced energy costs. Focus on Energy grants can offset the capital cost if studies show OTE issues with existing ceramic diffusers that cannot be recovered by cleaning.
2. Greater turndown, and improved efficiency when operating at low airflow. While this has not historically been done with ceramic diffusers, this opportunity exists with new turbo blowers and new membrane diffusers. Here again Focus on Energy grants can offset costs up to $0.04 per kWh saved,

The following features of membrane diffusers have been advantages to other wastewater treatment facilities that need to be considered but may not outweigh the longevity that RWU has achieved in maintaining their ceramic diffusers:

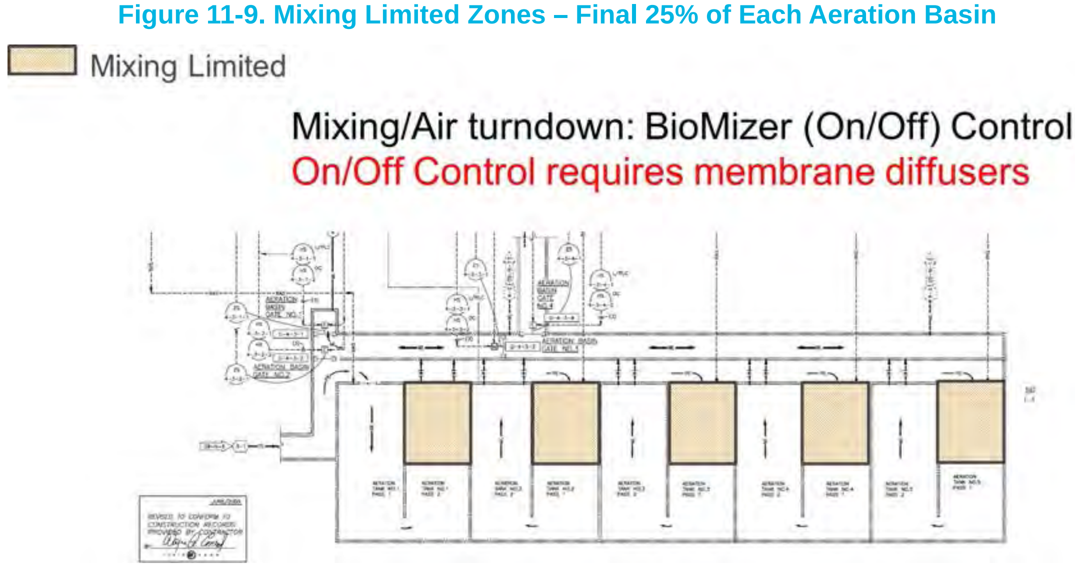
1. Resistance to fouling: particularly when treated with protective coatings membranes resist the buildup of unwanted sludge on their surfaces and pores.
2. Potentially lower maintenance costs**.** due to resistance to fouling which means they should need less frequent cleaning. However, RWU is cleaning ceramic diffusers annually.
3. Ability to handle high loads**,** a high solids concentration and hard water. They can also maintain constant backpressure and high OTE even under these conditions which would become more of an issue if loadings were to increase in future years.
4. Ability to be shutoff: This is because the membrane orifices prevent the backflow of wastewater that would clog their pores and internal structure. For this reason, they work well if Racine were to operate a choosing to turn select diffusers off.

<u>Membrane Diffuser Technology</u>

A new membrane aeration system could enable reduction of aeration energy consumption in conjunction with tighter aeration D.O. or ammonia-based control. One of the key benefits of membrane diffusers is the ability to turn off air. When the air is turned off, the membrane acts as a check valve, preventing backflow of liquid into the air system. In contrast, air cannot be turned off to the existing ceramic diffuser system. If air is turned off to a ceramic diffuser, activated sludge backflows into the diffuser causing plugging and fouling. The ability to turn air off allows for on/off control. This ability has potential in mixing limited zones such as the final 25% of the aeration basin at the Racine WWTP (see Figure 11-9).

RWU notes that air permit limits on engine run-time of the current engine-driven aeration blowers have limited the ability of RWU to manage the aeration system for energy efficiency improvements. New diffusers in conjunction with new electric motor driven blowers with aeration control strategies not limited by engine run-times can enable RWU to achieve significant energy efficiency improvements.

Figure 11-9. Mixing Limited Zones – Final 25% of Each Aeration Basin



Disadvantages:

High capital cost to replace entire diffuser system: In addition to high initial cost to replace the existing ceramic diffuser system, life cycle cost planning needs to incorporate life cycle cost of diffuser replacement anticipated to be within 7-10 years.

- **Initial Cost $1.84 million**

4-139-4 -Conversion to Biological Phosphorus/ Nutrient Removal (BPR/ BNR)

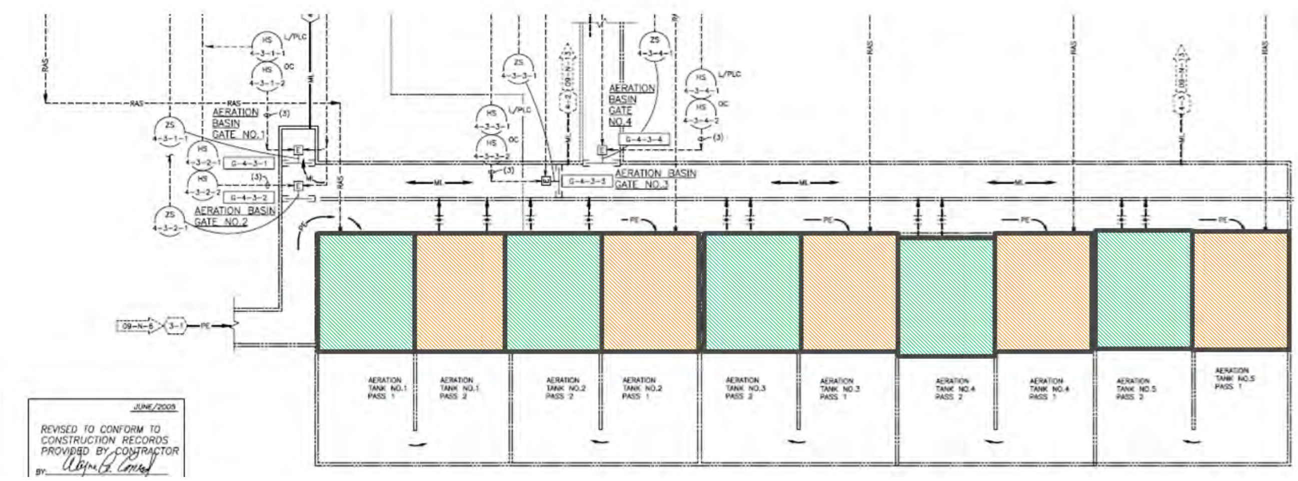
This alternative considers de-coupling aeration from mixing first 25% of aeration tankage to create swing anaerobic zone forenergy efficiency and potential biological phosphorus removal or from last 25% aeration tankage in mixing limited zone.

Mixing

As noted in the GPS modeling evaluation, should biological nutrient removal /biological phosphorus removal (BNR/BPR) become a more viable alternative to chemical phosphorus removal in the future, membrane diffusers provide the ability to achieve control with anaerobic and mixing limited zones better than ceramic diffusers due to the on-off and turn down capabilites.

An anaerobic zone could be created in the first 25% of each aeration tank and a mixing only zone also be created in the last 25% of each of the 5 basins (see Figure 11-10).

Figure 11-10. Decoupling Aeration from Mixing in Aeration Tanks



4-139-9 Convert to Biological Phosphorus Removal (BPR)

As noted in Section 9 BPR, while simulations showed a reduction in operating cost parameters; e.g. potential elimination of ferric chloride requirements and a reduction in aeration demand, there is the potential unintended consequences, specifically associated with nuisance struvite formation. Struvite is an insoluble crystalline mineral that can form in anaerobic digesters, sludge piping, and pumps when there is an ample availability of phosphate, ammonia, and magnesium.

Due to the storage and removal of phosphate in the WAS and its subsequent conveyance to anaerobic digesters, soluble orthophosphate is typically re-released during digestion making struvite formation possible. There are, however, beneficial struvite harvesting technologies available that can prevent nuisance formation, and at the same time, provide revenue-generating fertilizer production. Such technologies may be appropriate if BPR were implemented by RWU.

Potential energy savings for reduced aeration demand will be offset by capital costs required for the unaerated zone in first half of first pass of aeration tanks (5 tanks) The costs include mixers, support bridge, aeration tank divider walls (impacting hydraulics), electrical and controls. Biosolids dewaterability will be impacted by reductions in ferric chloride feed that need to be addressed which may add capital costs for pumps, piping and chemical feed as well.

There is no permit need or incentive to convert to BPR/BNR at this time. Therefore, further evaluation creating anaerobic zone as an alternative will be set aside as a future evaluation.

4-139-5 Replace deficient RAS distribution flow meters 1 through 5

This is a critical control deficiency that needs to be corrected with installation of new magnetic flow meters replacing the existing 16-inch diameter pipeline flow meters.

- **Initial Cost $222,000**

4-139-6 Add Mixed Liquor Channel Isolation Slide Gates

WWTP maintenance staff need the ability to isolate mixed liquor (ML) channel flow to Clarifier #1-6. This alternative includes cost to procure and install two (2) new 72-inch by 96-inch slide gates in the mixed liquor channel to the east and west of the branch channel to isolate Final Clarifier #1-6.

- **Cost $125,000**

4-139-7 Replace MLSS butterfly valves on Aeration Tanks

The original Pratt butterfly valves (36” diameter) are difficult to open and do not seal well. This deficiency needs to be corrected and this alternative is cost allowance for replacing existing valves (chain wheel manual opening) with new valves with pneumatic actuators for opening and closing valves.

- **Cost $540,000**

4-139-8 Replace Aeration Tank Inlet Gates

There are 48-inch by 60-inch gates at the inlet end of each Aeration Tank pass (five total). The gates are nearing the end of their useful life and this deficiency requires planning for replacement. It is recommended that the current five (5) gates be upgraded with new gates.

- **Cost $120,000**

11.6 Final Settling, RAS and WAS Pumping

5-139-9 Replace deficient RAS flow meters 3 through 7

This is a deficiency that needs to be corrected with installation of new magnetic flow meters replacing the existing 14” dia. pipeline flow meters.

- **Initial Cost $160,000**

5-139-10 Improvements To RAS Pumps #2 – #4, #6 – #8 and #10 – #12 To Handle Peak Flows

The nameplate capacities for the two-clarifier RAS/WAS pump systems (Clarifiers #1 – #6) are 3,400 gpm at 20-ft for the RAS pumps (total of nine) and 700 gpm at 35-ft for the WAS pumps (total of three). The pumps appeared to be in good working order. However, due to wear issues, the RAS pumps do not appear to be able to meet their listed nameplate capacities.

The nameplate capacities for the RAS/WAS pump system for Clarifiers #7 – #10 are 4,500 gpm at 35-ft for the RAS pumps (total of four) and 700 gpm at 35-ft for the WAS pump. These pumps appeared to be in good working order and there do not appear to be any issues with the pumps meeting their listed nameplate capacities.

Wisconsin DNR Chapter NR 110.21 states that the rate of sludge return expressed as a percentage of the average flow of sewage shall lie within the limits of a minimum of 15% and a maximum of 75%. Ten States Standards’ range is a minimum of 15% and a maximum of 100%.

The RAS pump capacities and the rates expressed as a percentage of the annual average flow for the sets of RAS pumps are shown in Table 11-2. The percentage of annual average flow rates assume a flow split proportional to the surface areas of the clarifiers so as to maintain the same surface overflow rate for all tanks. The RAS pumping capacities were calculated using the pump nameplate capacity with one pump out of service, per NR 110 requirements. Based on this condition, the total RAS nameplate pump capacity is 48.8 MGD.

Table 11-2. RAS Flowrates.

Clarifiers	RAS Pumps	RAS Pump Capacity (MGD)	Future Annual Average Flow (23.9 MGD)
#1, #2	#2, #3, #4	9.79	204%
#3, #4	#6, #7, #8	9.79	186%
#5, #6	#10, #11, #12	9.79	170%
#7, #8, #9	#13, #14, #15, #16	19.44	241%

Due to the age of the RAS pumps and the wear on the pumps, they appear to operate considerably below their nameplate capacities. In their current condition, the RAS pumps for Final Clarifiers #1 – #6 do not have the capacity to return 100% of the flow at average flows. The swing pumps, which are intended to act as back-up pumps, need to be operated to produce sufficient flow. The lack of capacity is especially significant in the summer when higher RAS flows are needed prevent denitrification in the Final Clarifiers.

The RAS pumps have been rebuilt in the past to return the pumps to their nameplate capacity. It is recommended that the pumps which are operating below their nameplate capacities be rebuilt. Based on the repair records, it appears that seven of the nine pumps need to be rebuilt. If the pumps are returned to their total nameplate capacity of around 48 MGD, the WAS flowrate would be acceptable.

The RAS pumping system for Clarifiers #1 – #6 can be remotely operated by air-operated actuators. Remote operation makes changing which pumps are in operation much easier. It is recommended that the RAS pumping system for Final Clarifiers #7 – #9 be modified so that they can be remotely-operated similar to Clarifiers #1 – #6.

Advantages:

Rebuilding the RAS pumps would be less costly than replacing them in kind.

Disadvantage:

Capital cost to implement upgrade

- **Initial Cost $180,000**

5-140-1 Evaluate Covers Over Weir Launders to Prevent Algae Growth

There is excessive algae growth at the Final Clarifiers. A common method for limiting algae growth in final clarifiers is the installation of covers over the launders. Typical installation of clarifier covers from two different manufacturers are shown in Figures 11-11 and 11-12.

Fiberglass reinforced plastic (FRP) covers generally have a limited life and can look unappealing when they are past their service life or are poorly maintained. Plant personnel have noted an instance of poor appearance of launder covers at another installation. The manufacture of fiberglass covers has improved over the last 20 – 30 years. FRP was previously manufactured by press molding, while the pultruded method is currently more popular. Also, better UV inhibitors are available. These factors should make the poor appearance of launder covers less likely. Aluminum covers are also available, which have a longer service life. However, aluminum covers are significantly more costly than FRP units (see Alt 5-141-1A in Table 11-1).

Advantages:

The covers would reduce algae growth on the weirs and baffle and reduce TSS in the clarifier effluent. Aluminum covers are much less likely to develop a poor appearance.

Disadvantages:

Clarifier covers have the potential to develop a poor appearance. Design work and proven success at other installation is still needed to proceed with an installation recommendation Aluminum covers have a much higher capital cost.

Figure 11-11. Final Clarifier Weir Covers – NEFCO

Figure 11-12. Final Clarifier Weir Covers – Enduro

- **Initial Cost**

Budgetary costs were obtained from the manufacturers of both fiberglass and aluminum covers. . The cost of aluminum covers will be carried in the recommended plan. Aluminum covers for all nine final clarifier launders is estimated as a $2.3 million project.

While algae growth could be reduced by the installation of covers over the launders, further review of the need for covers should be performed. Further evaluation of FRP alternatives is recommended. An option would be to install covers on Final Clarifiers #7 – #9 and evaluate their performance. The capital project cost for FRP launder covers for Final Clarifiers #7 – #9 is estimated at $275,000. The estimated cost for Final Clarifiers #1 – #6 is $524,000. AECOM has included cost to cover all Final Clarifiers in the recommended plan.

5-141-2 Provide Means for Pumping Waste Sludge from Final Clarifiers #2, #4, and #6

There are issues with drawing WAS from all of the clarifiers. There can be difficulties pumping WAS from Final Clarifiers #2, #4, and #6. The suction lines for the WAS pumps for Final Clarifiers #1 – #6 are connected to the suction headers for the RAS pumps for those clarifiers. The identification of WAS pumps, and RAS pumps associated with each final clarifier listed in Table 11.3.

Table 11-3. Final Clarifier WAS and RAS Pumping Information WAS Pumps #1, #5 and #9

Final Clarifiers	WAS Pumps	RAS Pumps
#1 and #2	#1	# 2, #3 and #4
#3 and #4	#5	#6, #7 and #8
#5 and #6	#9	#10, #11 and #12

The suction piping to WAS Pump #1 is connected to the suction header pipe nearer the line from Clarifier #1 than the line from Clarifier #2. Also, there are RAS pump suction lines between the line coming from Clarifier #2 and the suction line for the WAS Pump #1. The piping configuration for WAS Pumps #5 and #9 is similar to that for WAS Pump #1. This piping configuration leads to WAS not being proportionally removed from all clarifiers due to difficulties in drawing sludge from the clarifiers whose connections are farther away from the WAS suction lines (Clarifiers #2, #4, and #6).

The suction piping for WAS Pump #13 is different from the other WAS pumps. The identification of the clarifiers and RAS pumps associated with WAS Pump #13 are listed in Table 11. This RAS/WAS pump system has a separate header for WAS and RAS. It is understood that there are no significant issues with WAS withdrawal from Clarifiers #7, #8 or #9.

Table 11-4. Final Clarifier WAS and RAS Pumping Information

Final Clarifiers	WAS Pump	RAS Pumps
#7, #8, and #9	#13	#14, #15, #16 and #17

It is recommended that piping modifications be made to the suction piping arrangements for WAS Pumps #1, #5 and #9. Instead of being connected to the suction piping header, the WAS suction piping should branch and be directly connected to the piping from the clarifiers. Plug valves capable of remote operation should be located at the connections to the piping from the clarifiers to allow for isolation. The valves could also be used to induce additional head loss to balance flows from each clarifier, if necessary.

Advantages: The WAS piping modifications would allow for sludge to be effectively wasted from all Final Clarifiers and is recommended.

- **Initial Cost $85,000**

5-141-3 Modify Mixed Liquor Inlet Channel/Effluent Separation Wall at Final Clarifiers #1 – #6

At high flows (in excess of 90 MGD), mixed liquor flows to Final Clarifiers #1 – #6 can cause excessive splashing from the mixed liquor channel to the effluent channel. This can degrade the effluent quality from the clarifiers and has been a factor in limiting peak flow to the clarifiers. RWU limits peak flow to approximately 95 MGD to minimize this impact as well as to prevent problems in the UV disinfection channels.

Raising the wall at the section of the tank where mixed liquor enters would stop overflows from occurring. Raising the wall 1’-6” for a length of 10-ft on either side of the inlet (20-ft total) should be sufficient to minimize the discharge of mixed liquor into the clarifier effluent channel. This modification has been previously considered by plant personnel.

Advantages: Raising a portion of the wall between the inlet and effluent channels would allow for higher flows to Final Clarifiers #1 – #6 which would reduce the liquid level in the aeration tanks.

- **Initial Cost $16,000**

5-145-4 Pump Final Clarifier Scum to Holding Tank Instead of Headworks (similar to 3-136-4)

Modifications to the Final Clarifier scum piping could be made similar to those for the primary clarifier scum piping discussed in 3-136-4B. Changes to the piping would allow the Vactor to remove scum and discharge it to a dumpster, like the modifications to the primary scum system previously discussed. As with the primary scum system, the scum pumps could also be used to pump the scum as in the current operation.

Costs for the changes to the secondary scum system would be similar to the costs for the piping modifications to the primary scum system. The estimate is a conservative allowance only as piping layouts need to be configured.

- **Initial Cost $130,000**

5 -145-5– Final Effluent Engine Cooling Pump

Final effluent is pumped to the engines to provide cooling. There is no redundancy for this pumping system. It is recommended that a back-up system be installed adjacent to the existing system. The new system would include piping and valves to allow the two systems to operate independently. This improvement requires further evaluation, particularly when considered in context of the potential changes to the biogas engine system.

- **Initial Cost $62,000**

11.7 UV Disinfection

6-160-1 Maintain UV Disinfection System Nos. 1 and 2) (2 Channel Model UV 4000)

6-160-2 Upgrade UV Disinfection System Nos. 1 and 2 (2 Channel Signa2R)

6-160-3 Upgrade UV Disinfection System Nos. 1 and 2 (3 Channel Signa4R)

The existing UV system consists of two Trojan Model UV4000 units with 160 lamps per unit (320 total lamps). Each unit is installed in a 6-ft wide concrete channel and located in a building. The existing system is close to 20 years old and is nearing the end of its useful life. There are more energy-efficient UV systems available now than when the existing units were installed. Another issue with the existing system is that it is understood that plant flows above approximately 95 MGD cause difficulties with the UV bulbs due to the high velocity. These flows also result in high level alarms at the UV channels.

There are two options for replacing the disinfection system from Trojan. One option would consist of installing three Model Signa4R banks in each of the two existing channels. The other would be to install four Model Signa2R banks in each of three channels. The second option would require the construction of a third channel. The 4R system would require that the bottom of the channels be raised approximately 2-ft. The new UV systems would be supplied with a backup UV transmittance meter. A typical Model Signa2R system is shown in Figure 11-13.

Figure 11-13. Trojan Signa UV System

The equipment cost for the 2R system is approximately $500,000 less than the 4R system. The primary reason for the higher cost of the 4R system is that it has more stainless-steel framework. The 4R systems are also removed from the channel by a different method. The 4R systems tilt out of the channel and the 2R systems are raised vertically out of the channel. The mechanism needed to tilt a 4R system out of the channel needs to be much more powerful. The channel removal mechanisms for the two systems are shown in Figure 11-14.

Figure 11-14. Signa UV Lifting Systems (2R left; 4R right)

The capacity of the 4R system installed in the two existing channels would be 99 MGD. The capacity of the 2R system installed in three channels would be 108 MGD. Both capacities are above the current operating maximum flow of 95 MGD. The 2R system would allow for higher flows should plant flow restrictions be alleviated.

The 2R system banks each have 22 lamps per bank and four banks per channel, which results in a total of 264 lamps. The system has a maximum power draw of 278 kW. The 4R system banks each have 40 lamps per bank and three banks per channel, which results in a total of 240 lamps. This system has a maximum power draw of 283 kW.

Either of the new systems would be much more energy efficient. The maximum duty power draw for either of the new Signa units is about 280 kW. The specification for the existing Model UV 4000 units required a maximum total power consumption of no greater than 896 kW, so the new system's power requirements would be approximately 30 percent of the current system.

<u>Advantages</u>:

The new UV units would use much less power than the existing units. The units would also allow higher flow through the system. The Model Signa2R system would have a higher capacity than the Model Signa4R system.

<u>Disadvantages</u>:

The Model Signa2R system would require the construction of a third channel. The Model Signa4R system has a lower capacity than the Model Signa2R system.

It is recommended that the existing UV disinfection system be replaced with a new system. It is also recommended that a more detailed evaluation of the Model Signa2R and Signa4R systems be performed during the preliminary design. During preliminary design, the advantage or need for a capacity of 108 MGD could also be evaluated.

- **Cost**

Status quo of existing system has the highest operating cost. The initial cost of the Signa2R UV disinfection system is $4,677,000. The cost for the Signa4R UV disinfection system is approximately $ 4,469,000.

6-162-1 – Cover for Effluent Junction Chamber

At the discharge chamber of Structure 160 (UV Structure), disinfected effluent flows over a weir, then discharges into an 84-in diameter outlet pipe. As this is an open structure, there can be algae growth at the discharge chamber, which can require cleaning of the weir and chamber surfaces, as well as negatively impact the effluent quality.

The installation of covers over the chamber could significantly reduce algae growth. Flat covers limit access to hatch locations. A half barrel-type cover system is an option which would still allow access to the chamber. An example of this type of cover system is shown in Figure 11-15.

Advantages:

The covers would reduce algae growth, which would decrease maintenance work and improve effluent quality.

Disadvantages:

The covers would limit access to the discharge chamber and would require some maintenance.

Figure 11-15. Example Half-Barrel Cover Installation

- **Initial Cost $119,000**

6-162-2 – Final Effluent Junction Chamber Solar Panels

The discharge chamber of Structure 160 (UV Structure) is an open structure. The covering of this chamber is under consideration. The cover would have an area of approximately 1,000 square feet. The inclusion of solar panels in the structure cover is an option which could produce electrical power, reducing the plant's dependence on purchased power. The total present worth cost for the solar panels is $24,800. This cost includes the generation of almost $5,000 of electrical power per year. Focus on Energy grants are available for prescriptive solar energy projects; credits will help offset capital cost.

Maintenance accessibility must be effectively provided to warrant implementation of this alternative.

- **Initial Cost $30,000**

11.8 Aeration System- Blowers

7-185-1 Upgrade to new high efficiency centrifugal blower system

The RWU aeration system blowers account for over 50% of the energy consumption at the WWTP. Energy is second only to labor costs in terms of highest operating cost.

The existing aeration system is comprised of three engine driven positive displacement (PD) rotary lobe blowers; two constant speed electric motor driven PD rotary lobe blowers and associated appurtenances (e.g. inlet filter), diffusers, piping, and aeration controls. The equipment is in Building 185 and is 1967 vintage with replacement and overhauls and control upgrades over the years.

The engine-driven PD blowers have been maintained in operation using biogas for fuel. The engine generators have been generally reliable but are not capable of low nitrogen oxide (NOx) emissions or the energy efficiencies of today's lean burn engines. Aeration control and efficiency is negatively impacted by the need to managing engine run time restrictions set by the current air permit.

During the last 20 years, with the increase of power costs, and treatment processes that require wide ranges of airflow, the wastewater industry has moved away from positive displacement (PD) toward high efficiency centrifugal blower technologies for the aeration system.

This option is in conjunction with Biogas Utilization Alternative 9-185-1. Conversion to new electric motor driven blowers must include reconfiguration of biogas utilization away from driving engine blowers to combined heat and power production.

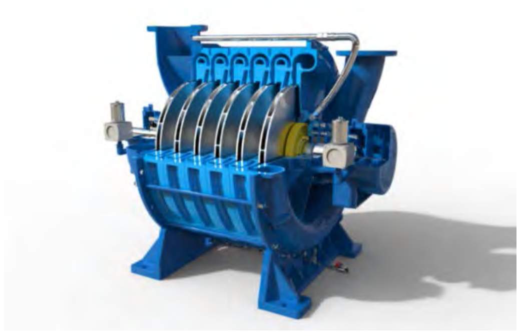
Sustainable aeration blower design must have a holistic approach and consider the entire envelope of environmental conditions and operational considerations[5], which are further discussed in this alternative. Blowers should have the ability to modulate air capacity to meet all varying aeration demands for aerobic biological activated sludge treatment. The blower system design is based on the diffuser selection and performance to meet the aeration requirements for treatment.). Blowers should have the ability to modulate air capacity to meet all varying aeration demands for aerobic biological activated sludge treatment. The blower system design is based on the diffuser selection and performance to meet the aeration requirements for treatment.

There are three centrifugal blower technologies utilized today in the water treatment industry either in lieu of or in conjunction with positive displacement blowers: Multistage, Gearless Turbo and Geared Turbo

Multistage Centrifugal Blowers

This technology consists of a series of impellers mounted on a shaft supported on each end by roller bearings. The blower shaft is directly coupled to a 2-pole motor (3,600 rpm). The casing directs the air (gas) from one stage (impeller) to the next. Each stage increases the air pressure. In the aeration system of a wastewater plant, anywhere from 3 to 9 stages are utilized depending on blower size and discharge pressure requirements.

Figure 11-16. Multistage Centrifugal Blower



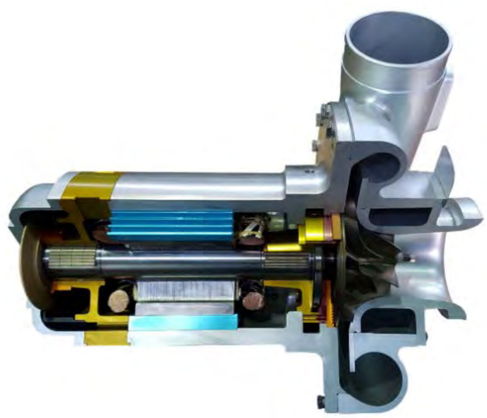
[5] *Water Environment Federation "Liquid Stream Fundamentals: Blowers, copyright 2017 WEF document no. WSEC-2017-FS-025*

Flow modulation for this technology is achieved either through an inlet throttling valve or a variable frequency drive. This technology has been the workhorse for the wastewater industry and for several low-pressure air and gas processes in industrial applications.

Gearless Turbo Centrifugal Blowers

This technology is a direct drive, single-stage blower. The compression work is done with a single impeller rotating at high speed (typ. 20,000 to 40,000 rpm). The impeller is mounted on an integral motor shaft. Blower output is varied via variable frequency drive. This technology is derived from the aeronautical industry and started to be utilized in the aeration system of wastewater treatment plants in the early 2000's and has become more prevalent in the industry over the past 10 years. These bearings do not require lubrication because the blower shaft is either levitated by an air film or positioning magnets to prevent the blower shaft from touching the bearing during high speed operation.

Figure 11-17. Gearless Turbo Blower (Typical blower skid is inside rectangular enclosure)



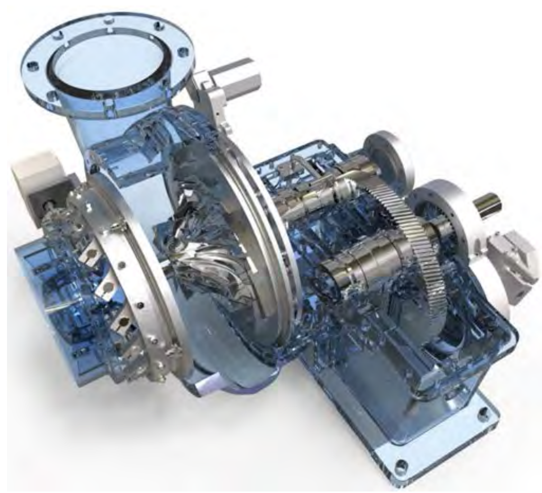
In the last few years, the design of this technology has been improved by certain manufacturers to overcome some of the historical limitations:

- Triple treatment bearing design which allows for life expectancy from 25,000 to 50,000 start/stop cycles and better handling of surge episodes
- Motor cooling shaft mounted fan (opposite to impeller) to evacuate motor heat avoiding blower heat injection – no liquid cooling required
- Above referenced bearing and heat evacuation improvements allows for a HP rating of a single core up to 500 HP
- Non-proprietary component design

Geared Turbo Centrifugal Blowers

This technology is a single-stage blower: the compression work is done with a single impeller rotating at high speed (typ. 10,000 to 20,000 rpm). This technology utilizes a one-step gearbox mounted integral to the blower casing to increase the input motor speed (typ. 2-pole motor operating at 3,600 rpm) to the required impeller speed. This is a constant speed technology that utilizes internal vanes (one set of vanes at the inlet and one set at the impeller discharge) to modulate flow and maximize compression efficiency at different operating conditions. The vanes are automatically positioned by the blower PLC based on required airflow and onboard instrument monitoring inlet temperature and discharge pressure. This technology utilizes pressure-lubricated journal bearings (some manufacturers use ball bearing in smaller frames and on low-speed shaft).

Figure 11-18. Geared Turbo Blower



Environmental Design Conditions:

- Racine site elevation: 590 MSL is appropriate for any of the blower technologies.
- Ambient temperature has hourly, daily and seasonal variations that impact blower performance.
- Relative humidity: higher relative humidity near Lake Michigan has impact on the mass of air.
- Varying flows and loads throughout the day require the blowers to match output to demand.
- Side water depth of the aeration tanks is set and requires 9 psi.
- Air requirements are determined in conjunction with aeration diffuser alternative selected for implementation.

Operational Considerations:

1. Avoid over-aerating under minimum mixing conditions by providing adequate blower turndown.

Table 11-5. Blower Turndown and Efficiency Comparison[6]

Blower Type	Typical Turndown Range (from maximum capacity)	Typical Blower Efficiency
Multistage Centrifugal	20% to 40%	55% to 70%
Single-Stage Integrally Geared	50 to 60%	70% to 78% (dual guide vanes)
High Speed Direct Drive (Turbo)	35 to 55%	65% to 75%
Positive Displacement (Rotary Lobe)	40 to 60%	45% to 65%

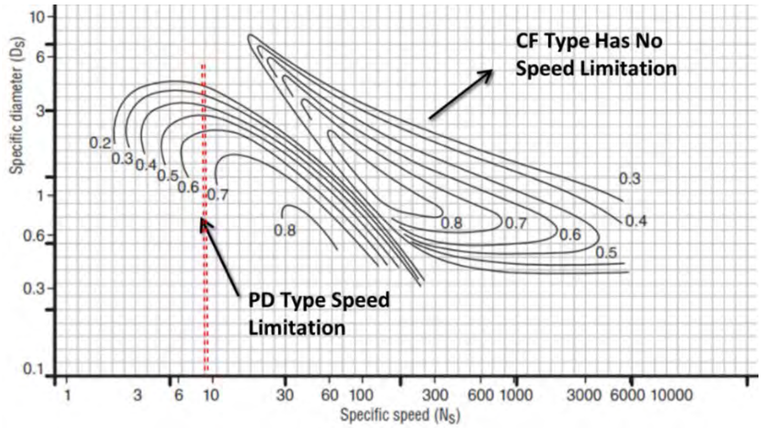
2. Avoid oversizing the system by setting realistic design criteria.

The blower system should be sized to satisfy maximum month diurnal air requirements with the largest one unit out of service.

The chart below (Figure 11-19) details the specific speed that will allow the maximum aerodynamic efficiency possible for a given diameter of impeller or lobe. Centrifugal (CF) “Turbo” type blowers can generally achieve higher compression efficiency than Positive Displacement (PD) type due to the ability to operate at higher speeds and due to the lack of gas (air) recirculation.

[6] *Water Environment Federation “Liquid Stream Fundamentals: Blowers, copyright 2017 WEF document no. WSEC-2017-FS-025*

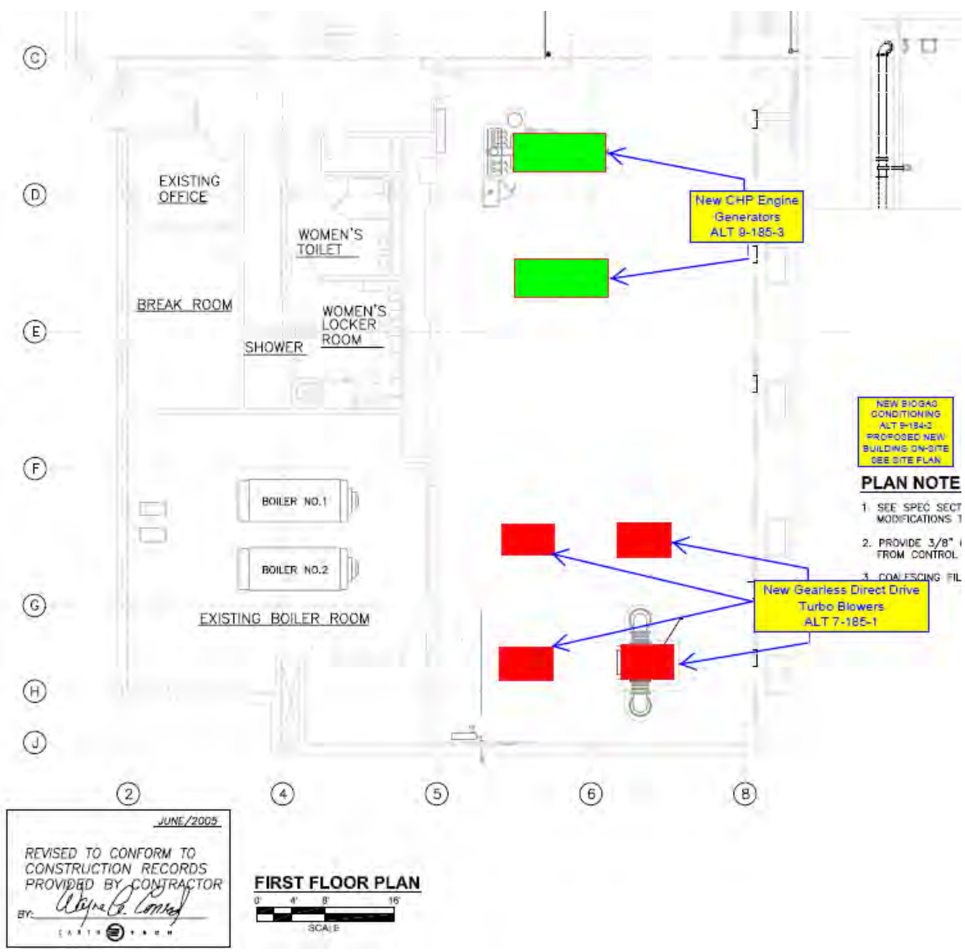
Figure 11-19. Centrifugal Speed vs Positive Displacement Speed Limitations



It may be advantageous to select blowers with small footprint, high turndown and efficiency, and low operating noise as the blowers would.

This alternative considers a selection of gearless turbo blowers in a possible layout configuration shown in Figure 11-20 with new combined heat and power internal combustion engine generators. This concept layout would require major construction sequencing planning to maintain aeration system operation throughout construction there will be significant rework of engine exhaust, and blower intake and supply piping systems with new silencing equipment.

Figure 11-20. Conceptual General Arrangement in Building 185 of Turbo Blowers with CHP IC Engine Generators



<u>Advantages of Turbo Blowers:</u>

- Ease of installation and maintenance
- Small footprint (4.25' W x 6.5' L x 9' H enclosure for 400 HP – 8000 SCFM @ 9 PSIG)
- Integral motor
- Low operating noise (<85 dbA)
- Higher efficiency and turndown with respect to positive displacement blowers and multistage centrifugal blowers which is advantage in life cycle cost comparisons.
- No oil or grease needed

<u>Disadvantage:</u>

- Typically higher capital and O&M cost than PD blower

- **Initial Cost $2.2 million**

11.9 WAS Holding and Thickening

8-165-1 – Upgrade TWAS Piping to Digesters

There are concerns regarding the difficulty in managing distribution of flow of thickened waste activated sludge (TWAS) to digesters. Additional piping and valves can be added to the TWAS line from Building 185 to the digester complex to improve the flow distribution to the digesters. This item is an allowance for upgrading piping configuration to resolve flow distribution concerns and provide redundancy.

- **Initial Cost $350,000**

11.10 Sludge Digestion Mixing and Thickening

11.10.1 Digester Cover Improvements

The newest of the anaerobic digester covers is nearly 20 years old and the covers are nearing the end of their useful lives. However, with the exception of the cover for Digester B, as described below, they are in good condition and function adequately. Due to their age, the replacement of a cover is anticipated during the planning period. The replacement of the cover for Digester D is included below. Before the replacement of a digester cover, inspection of all of the covers will be made to assess structural condition. It is possible that the cover for a different digester may require replacement before Digester D.

9-170-1 – Inspect, Evaluate and Rehabilitate Digester B Cover

There have been some issues with the tilting of the cover of Digester B, which has a diameter of 90-ft. The floating cover for Digester B was replaced with a radial beam-type cover during the last plant upgrade. The mixing system was also replaced with an internal draft tube-type system. The cover has nine vertical slide guides with ultra-high molecular weight (UHMW) polyethylene slide blocks.

A common cause for digester covers tilting and getting stuck is due to issues with the ballast alignment. The radial beam-type covers use submerged ballast blocks for cover stability and to maintain adequate gas pressure. Tilting can occur if the ballast blocks are not balanced. The current installation process is to have each of the ballasts weighed and have the contractor place the ballasts in a specific order to produce a more balanced cover. Even though the ballasts are all typically poured in the same form, there can be some variability in the weights.

Due to the partial shading of the cover, there can be uneven snow loadings. The uneven snow loading can be a potential cause for the cover to tilt. Another possible cause for digester cover tilting is due to issues with mixing system draft tubes. The draft tubes are in two pieces, with one sliding inside the other as the cover moves vertically, based on the tank liquid level. The clearances are necessary tight. If the draft tubes are not plumb or if they have been deformed, there can be issues with the vertical travel. Another possible issue is the clearances of the UHMW blocks in the slide guides. UHMW can expand and contract and there could be issues due to a lack of clearance at the guides.

It is recommended that the ballast blocks be investigated to determine that they properly balanced. It is also recommended that the draft tubes be examined and checked to ensure that they are plumb and that their shapes have not been distorted. If there are issues with either the ballast blocks or draft tubes, these issues should be addressed. Methods of enhancing snow melting on the cover should be assessed if further evaluation indicates that snow loading imbalances result in cover tilting. Partial heat tracing of the cover would be a possible method to enhance snow melting.

Other options for rehabilitation of the digester include the replacement of the cover and changing the mixing method for the tank. The planning level estimate considers need for inspection, evaluation, design engineering, as well as an allowance for the cost of rehabilitation.

- **Cost $276,000**

9-177-1 – Replace Digester D Floating Cover

The mixing system for Digester D was replaced during the last plant upgrade. However, the cover was not replaced. The floating cover at Digester D is a depreciated asset that will not last through the planning period.

Two common types of floating covers available are the radial beam-type and the dual deck, truss-type. The existing Digester D cover has a dual deck. Beam covers are a more economical choice for anaerobic digester covers, as they do not have ceiling plates and have less field weld length than truss covers. Truss covers typically have a longer service life as they feature steel plates on the top and bottom of the trusses to form an attic space, which protects the structural members from corrosion.

Advantages (cover type): The radial beam-type covers generally have lower capital cost than dual deck, truss-type covers.

Disadvantages (cover type): The radial beam-type covers generally do not have as long of a service life compared to dual deck, truss-type covers.

Figure 11-21. Example Radial Beam-Type Floating Digester Cover

Due to the lower capital cost, a radial beam-type cover has been used as basis for the replacement of the Digester D cover. A detailed evaluation of the cover type should be performed as part of a digester cover replacement project.

- **Cost $1,843,000**

11.11 Sludge Dewatering

10-165-2 Maintain Status Quo Filtrate Return Flow to Influent.

The current mode of operating dewatering equipment is press operation Monday through Thursdays to efficiently manage labor cost in conjunction with sludge dewatering needs. As noted in dynamic simulations of performance using the GPS-X model of the plant in the Appendix B report, it appears that the existing operation of the belt filter presses creates effluent spikes in ammonia and phosphorus.

Without an equalization tank, plant operations could reduce ammonia and phosphorus spikes by extending belt filter press operating times from the current weekday schedule. Further evaluation would be needed to calculate effluent performance improvement vs increased operating costs.

10-165-3 – Consider Filtrate Equalization Tank to Equalize Sludge Dewatering Filtrate Return Flow to WWTP Treatment

Due to the operation schedule of the belt filter presses, the dewatering process results in slug loads to the plant. The equalization of the filtrate would reduce these loads to the treatment facilities. This would be beneficial if effluent permit limits for ammonia and phosphorus are stricter in the future.

Under the current operation, filtrate is returned to the Building 130 when the belt filter presses are in operation. The loadings from the belt filter presses have not created any issues with meeting the current permit limits.

The storage tank was sized using the Maximum Month Winter Condition, which was the highest condition for filtrate from the modeling results. Under this condition, the daily filtrate volume is about 200,000 gallons (for 5 days of operation) or 143,000 gallons (averaged over 7 days). The volume of flow included the specified washwater flowrate, assuming the belt filter presses are operating at 75% of maximum capacity. The equalized constant flow rate would be approximately 100 gpm.

The tank volume would need to be approximately 380,000 gallons to equalize the filtrate flow, so it is a constant flow through the week. Tank dimensions of 47-ft diameter by 30 high would produce sufficient volume for the tank. The tank volume could be reduced if the flowrate was increased. With sludge dewatering on the third floor of the Solids Processing Building, a tank height of up to approximately 30-ft would allow for the equalization tank to function without any pumping required. A tank location near the Solids Processing Building and the West Drain Pump Station is shown in Figure 11-22. The tank location would require excavation on the side slope to the west of the plant facilities. The tank would be suitably reinforced to account for the loading.

Advantages: An equalization tank would reduce the slug loads which occur during operation of the BFPs, which would in turn reduce effluent spikes in ammonia and phosphorus.

Disadvantages: There would be continuing maintenance costs for the equalization tank and associated valve and meter. Unless there are changes to the plant's effluent limits there is substantial capital cost that offsets benefit to achieve improved effluent quality that is already meeting effluent water quality requirements.

Figure 11-22. Concept Location for Filtrate Equalization Tank

- **Initial Cost** **$1,960,000**

10-165-4 Consider replacing air handling units with heating system using WWTP hot water loop

The existing heating system for Structure 165 is ineffective and difficult to maintain and operate.

This alternative is to allow for study/design/and construction for system to heat the building with hot water loop from either existing or new WWTP thermal capacity in lieu of existing make up air units. Further engineering is needed to define and size the demand loads and match with appropriate supply capacity. Investigation will need to consider:

- extending hot water loop from existing WWTP boilers;
- providing a new boiler in Structure 165;
- use of thermal capacity from proposed biogas utilization

- **Initial Cost Allowance of $200,000**

11.12 Phosphorus Removal- Ferric Chloride Chemical Feed

120-1 Design and construct truck unloading containment for ferric chloride delivery

As described in Appendix F, the wastewater treatment plant lacks spill containment for truck unloading of ferric chloride deliveries to the plant. This alternative provides an estimate to design and construct concrete spill containment facilities to remedy this deficiency and mitigate the risk of a potential spill from being discharged. The cost estimate assumes new flooring, roof and north wall in Structure 120.

- **Initial Cost $300,000**

120-2 Design and construct hydraulic ramp for truck unloading

A new 10 ton hydraulic lift ramp for truck unloading at the dock has been included in the costs of safety upgrades in Alternative 120-1. This upgrade will mitigate the risks involved in material handling.

120-3 Upgrade ferric chloride tank fill system to avoid unsafe condition of overhead fill piping.

The existing overhead fill piping poses a hazard risk in the event of pipe failure or leak that can be mitigated with installation of dual containment piping and leak detection system. This alternative addresses a new fill system from truck to tank.

- **Initial Cost $160,000**

11.13 Drain Pump Stations

12-47-1 West Drain Pump Station

The West Drain Pump Station receives flow from the following sources:

- Drainage from the primary clarifiers
- Filtrate and drainage and from gravity belt thickeners and belt filter presses
- WAS, scum, and drainage from the aeration tanks
- Digester supernatant

The pump station consists of a wet well which contains three submersible pumps and a valve vault. The capacities of the submersible pumps are each 1,400 gpm at 47-ft. The station discharges to the Bar Screen Influent Channel.

The pump station is approximately 20 years old. No issues have been noted regarding the station and therefore there are no alternative evaluations associated with this process system.

11.14 Sodium Bisulfite Dechlorination

13-47/162-1 Upgrade Dechlorination System

The primary discharge location for the sodium bisulfite feed is Structure 47. As it is more efficient to dechlorinate near the outfall, a temporary line is used to provide sodium bisulfite to Structure 162. However, the chemical addition rate is manually set, and it is difficult to achieve the proper dosage for effective dechlorination.

It is recommended that a permanent 1-in diameter feed line be installed from the Sodium Bisulfite Room in Structure 130 to Structure 162 and that a third flow paced pump with controls be added to the existing duplex feed pump system. The chemical feed system would draw from the existing storage tank.

The new 1-in diameter feed from the Sodium Bisulfite Room to Structure 162 would be approximately 865-ft in length. About 90-ft of this length would be in Structure 130 and the remaining 775-ft would be underground piping.

Advantages: A permanent sodium bisulfite dechlorination system would allow for an efficient and reliable method to dechlorinate the overflow discharge from the EQ Tanks.

- **Initial Cost $95,000**

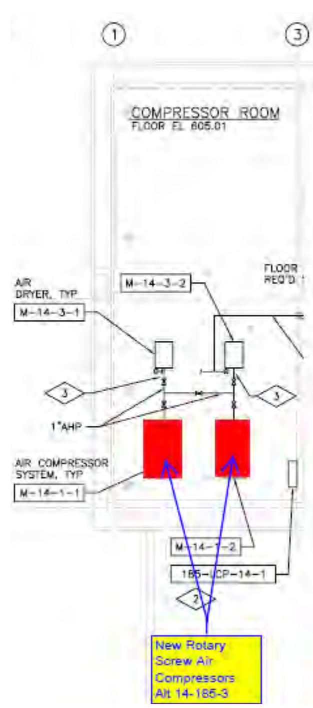
11.15 Compressed Air Supply

14-185-3 Upgrade Existing Reciprocating Piston Air Compressors with New Rotary Screw Air Compressors.

The existing air compressors were installed in the last plant upgrade. During the 2019 plant condition assessment, the vibration and noise of the existing reciprocating air compressors was evident in the nearby hallways and break room, even with the door to the compressor room closed.

Rotary screw air compressor packages have a small footprint with integrated refrigerated dryers and operate with much less vibration and noise generation with 100% duty time. They consume less oil than flooded reciprocating compressors with less oil carryover. Rotary screw compressor packages have proven to be durable and reliable with comparable efficiency to reciprocating air compressors.

Figure 11-23. Rotary Screw Air Compressors in Building 185 Compressor Room



- **Initial Cost $139,000**

11.16 Biogas Utilization

Racine WWTP biogas production currently ranges from 160,000 to 210,000 ft3/day and is projected to increase to max month average of approximately 240,000 ft3/day in the planning period. The plant is designed to use biogas as primary fuel for internal combustion (IC) engines that drive aeration blowers, with the thermal heat recovered for hot water heating. Biogas is also used as fuel for hot water boilers for preheating sludge feed to the digesters.

There are three existing Waukesha internal combustion engines in Building 185 that drive positive displacement blowers. These engines have been the workhorse of the plant activated sludge aeration system. The following problems need to be addressed for efficient biogas management and effective aeration control for the 20-year planning period:

- Existing IC engines need new controls. Engine overhauls will be needed based on run times of the older technology engines.
- Existing IC engine run times are limited by air permit. Since the engines are coupled to blower performance, this restriction causes variability in dissolved oxygen control and corresponding variability in energy and treatment efficiency.
- The plant flares biogas in the summer when biogas production exceeds biogas utilization capacity. With the existing biogas utilization, the plant needs additional biogas storage capacity.

Biogas management can be improved to utilize all of the biogas generated from anaerobic digesters via decoupling aeration control from engine operation. New, energy efficient, cleaner emission, longer life combined heat and power (CHP) technology alternatives will enable obtaining a new air permit with removal of engine run time restrictions. Annual flaring of biogas will not be needed. No additional biogas storage will be required. Overall plant energy efficiency and activated sludge treatment efficiency will be improved.

This section reviews two alternatives for incorporating a new CHP system with new technology to eliminate using engine drivers for blowers. The following alternatives need to be integrated with new aeration blower system Alternative 7-185-1: Biogas CHP.

11.16.1 Biogas CHP Alternative- Internal Combustion Engine (IC) Generators (Alt 9-185-2A)

Combined Heat and Power (CHP) is defined as the simultaneous generation of electricity (power), and useful heat (thermal energy) using fuel energy supplied from digester gas (biogas) to either an engine-generator or microturbine.

CHP System Description:

One of the most important considerations in choosing IC engine technology specifically for CHP is proper sizing, to match both the facility's 'steady' electrical load and the available fuel (digester gas). Oversizing the equipment can result in poor economics due to higher fixed costs and the associated lower equipment load factor.

Biogas conditioning will be needed for moisture, particulate, and siloxane compound removals (See Section 11.17)

Most IC generators can run on either digester gas, natural gas, or a mixture of the two. Since digester gas production rates often vary considerably, providing natural gas as a supplemental or standby fuel is common. Fuel blending is an option. Racine's existing biogas storage will continue to be utilized to manage digester gas utilization while better matching the generator electrical loads.

Current generation digester gas engines offer low first cost, fast start-up, proven reliability when properly maintained, excellent load-following characteristics, and significant heat recovery potential. These current generation systems typically can recover up to 44 percent on a higher heating value (HHV) basis of the thermal energy from the combustion of digester gas for use with heating applications. This includes high grade heat and low-grade heat for hot water.

Additionally, the engine/generator can convert approximately 38 percent of the thermal energy of the digester gas (HHV basis) to the production of electrical power. This means that the overall CHP efficiency is at or above 80 percent, which is significantly better than that of local utility power plants.

Biogas production in the planning period ranges from current average of 181,000 ft^3/day[7] to a projected max month of approximately 243,000 ft3/day in 2040 which correlates to fuel value ranging from 4.5 million BTU/hr to approximately 6 million BTU/hr. At design average biogas production of 217,000 ft^3/day biogas fuel, the options are to provide one CHP system to meet max month biogas production or select a combination of two multiple systems either rated for combined operation to meet maximum month or sized to meet average month with one unit out of service.

For planning purposes only, this alternative evaluated the cost effectiveness of) the high performance, lean burn- low NOx emission, 633 kW Jenbacher JMS 312 cogeneration unit as pictured below in Figure 11-24 (locally represented by Clarke Energy in Waukesha, WI). Actual engine generator sizing, recommended manufacturers to meet specifications, and number of engines requires further evaluation.

The JMS 312 is a 60,000-hour engine life system rated at 5.67 million BTU per hour fuel input value which is between projected average day and future maximum month biogas production at the WWTP.

Figure 11-24. Jenbacher Model JMS 312 GS 480 V Cogeneration Unit for Indoor Installation

At a biogas production of 217,000 ft^3/day biogas fuel, the JMS 312 could operate at 96% of its design capacity (with 85.5% overall efficiency as fueled on biogas with an output rating of 633 kW electrical output at 480 V and 2683 MBTU/hr thermal output based on power input of 5666 MBTU/hr of biogas. The next engine size down the Jenbacher JMS 208 (336 kW) would require two units in operation to meet even average month production and is not a cost-effective offering in comparison to the model JMS 312 (633 kW). The next engine size up to meet max month is the model JMS 316 (835 kW) and would be needed for a single engine system.

The Racine WWTP operations staff has a strong preference to operate with a two-engine CHP system which provides the following options:

- Size each IC engine generator for average biogas production at energy efficient operating point of single CHP unit. Two units can operate in max month biogas production.
- Consider identical engine generator systems which would provide uniformity of components for operation and maintenance spare parts and control.
- Stagger engine run times to extend service intervals between engine overhauls.

[7] *Racine Wastewater Utility 2018 Annual Report issued July 30, 2019*

A two-unit system (600 kW each) would enable RWU to maintain 24/7 CHP operation fueled by projected max month biogas production. Additionally, with each unit sized to match average biogas production, RWU can stagger operation and balance/extend engine life to meet operating cost planning. There are significant advantages to common engine sizing for a dual unit system operation in controlling cost of operation and maintenance.

Synchronizing of the generator with the plant power grid and coordination with the electric power utility is required but can be minimized if the power generation is dedicated to specific plant equipment items such as the aeration blowers and pumps.

Layout Concept

As noted in alternative 7-185-1 for new aeration blowers, two new IC engine generators could ideally be located in place of the easternmost engine driven blowers (See Figure 11-20). Utilities and infrastructure for biogas, cooling water and heat recovery are all located here as well as maintenance accessibility.

Aeration blower system redundancy will be reduced while removing an engine driven blower from service and further evaluation is needed to address the construction sequence phasing which will be needed to maintain aeration control and biogas utilization while converting from engine driven blowers to a new CHP system.

CHP Energy Savings

RWU WWTP annual electrical usage in 2018 was 7.26 million kWh (peak demand of 1862 kW) in the month of June with total electrical cost of $688,595 and estimated $218,533 value of biogas produced [2].

CHP in this alternative would provide continuous 600 kW of electrical output at projected average biogas fuel input of 217,000 ft3/day (38 % of biogas fuel value); equivalent to 5.26 million kWh electrical production annually as well as savings of 380,000 kWh of fuel value not flared in summer. Blowers will require total of 3.68 million kWh electrical power and the net “export” of available power will be approximately 2 million kWh. This equates to approximately $180,000 annual energy savings from electrical power production alone.

Thermal heat recovery opportunity from CHP of this biogas production rate is approximately 2.5 million Btu/hr (47% of biogas fuel value) which is greater than current engine heat recovery and will partially offset need for boilers. The net thermal energy cycle needs further evaluation.

Electrical Power Distribution

RWU WWTP is serviced by the electric utility with 26.4 kV feeders, high voltage switchgear and two 250 MVA 26.4 kV to 4160 kV step down transformers.

The main plant transformers are connected to 2000 kW 4160 V generator for paralleling standby power via load demand controller for feed to the medium voltage switchgear.

A 4160 kV medium voltage switchgear panel services two 4160 V motor aeration blowers as well as six 4160/480 V wye transformers (our rated @ 750/840 kVA and two rated @ 1000/1125 kVA).

Building 185 has a main 480 V power distribution panel that feeds multiple motor control centers, air compressors, and smaller distribution panels.

There are several options for use of biogas for electrical power generation:

One option is to provide step up transformers to the 26.4 kV high voltage switchgear for generated power to be synchronized with incoming line power for use in the facilities electric power grid at the site for potential sale to the utility. A buyback rate option does not have payback currently due to lack of incentive for utility to purchase.

A second option is step up transformers to the 4160 kV medium voltage switchgear for distribution to plant wide power.

A third option is to evaluate the cost effectiveness of 4160 kV engine generator sets vs 480 V electrical output.

A more cost-effective approach may be to provide switchgear and distribution design to specific motor control centers to offset power purchase via continuous on-site generation coordinated with demand loads.

Further study is required to determine the best electrical power utilization plan and define the scope and costs of installation.

Maintenance

New engine generators have preventive maintenance (PM) needs that RWU has experience with in maintaining existing Waukesha IC engines. Factory service protection plans are also available for both preventive maintenance and overhauls. As an example, overhaul costs on the Jenbacher after 60,000 hours range from $300K-$350K. PM packages are available ranging from $8/hr to $20/hr depending on scope of inclusion (PM or complete; and with or without an overhaul during the 60,000 operating hour life cycle). Oil supply and changeout as well as biogas quality would always need to be managed by RWU regardless of whether maintenance service agreements were contracted by the Utility.

Advantages

Improve Air Emissions - Revisit Air Permit

The existing air permit at the site limits engine run times as noted in Alternative 4-185-1.

Technological improvements have enhanced the combustion control systems of today’s engines versus the existing engines on-site, resulting in increased efficiencies and reduced emissions. New lean burn engines essentially flood the combustion chamber with air, nearly doubling the amount of air for fuel combustion. The more diluted mixture reduces peak combustion temperatures, reducing oxides of nitrogen (NOx) emissions which are primary contributors to the formation of ozone and other health problems. The lean burn engine's lower NOx levels, at five to ten percent of the rich burn engine's, and the most efficient engines will emit NOx levels < 0.5 g NOx/bhp-hr.

Currently, the two most significant emissions in terms of air permitting are NOx and CO. Either of these emissions, or both, can be limiting factors when permitting gas engines. It is common for engine manufacturers to set their engine emissions performance based upon NOx output.

With new lean burn engines, RWU can apply to WDNR to revisit the restrictive terms and conditions of the existing Air Permit. Initial discussions have been held with the Utility’s air permitting consultant.

Dispersion modeling will be needed to address the permit application. There is concern that exhaust stacks may be required to disperse emissions at allowable elevations due to the surrounding topography. A study to complete this modeling is included as part of the cost estimate for this alternative.

Significantly Reduce Flaring of Biogas

In conjunction with a new air permit, a biogas storage and CHP system designed for electrical power generation will reduce the flaring of biogas to specific maintenance outages or breakdown. This allows RWU to maximize their use of biogas instead of using the flare as peak shaving of biogas vs aeration system requirements and engine run time limitations. The existing flare is still incorporated into this alternative as a safety measure to prevent venting of biogas.

Increase Overall Plant Energy Efficiency

With simultaneous production of energy from conversion of biogas into both electrical power and thermal energy, RWU can take advantage of decoupling biogas utilization from aeration control as well as offsetting purchase of electrical power.

New lean burn engines are 5-7% more efficient in electrical production than older technology Waukesha engines currently in use.

With CHP optimized at current mass balance, further efficiency increases are possible with more efficiency in digestion and increased biogas production. Based on electrical and thermal efficiencies and least cost present worth analysis, the IC engine generator approach is the preferred CHP methodology to develop into a project.

- **Initial Cost $4.5 million**

11.16.2 Biogas CHP Alternative – Microturbines (Alt. 9-185-2B)

Another CHP technology that has become more common in the wastewater industry is microturbines. Microturbines are small industrial gas turbines. Microturbine capacities using biogas range from 30 to 250 kW, with capacities greater than 200 kW achieved using multiple or multi-pack microturbines. Electricity conversion efficiency is enhanced by use of a recuperation cycle, where most of the exhaust gas heat is used to preheat the combustion air charge. Heat can be recovered in an exhaust gas heat exchanger for hot water digester or facility heating or converted to steam in a heat recovery steam generator.

Microturbines are ideally suited for distributed generation applications due to their flexibility in connection methods, ability to be stacked in parallel to serve larger loads, ability to provide stable and reliable power, and low emissions. In this CHP application, the waste heat from the microturbine would be used to produce hot water heat for the anaerobic digesters and heat building space as is currently done via jacket water heat recovery on the existing IC engines.

11.16.3 Capstone Turbine Corporation

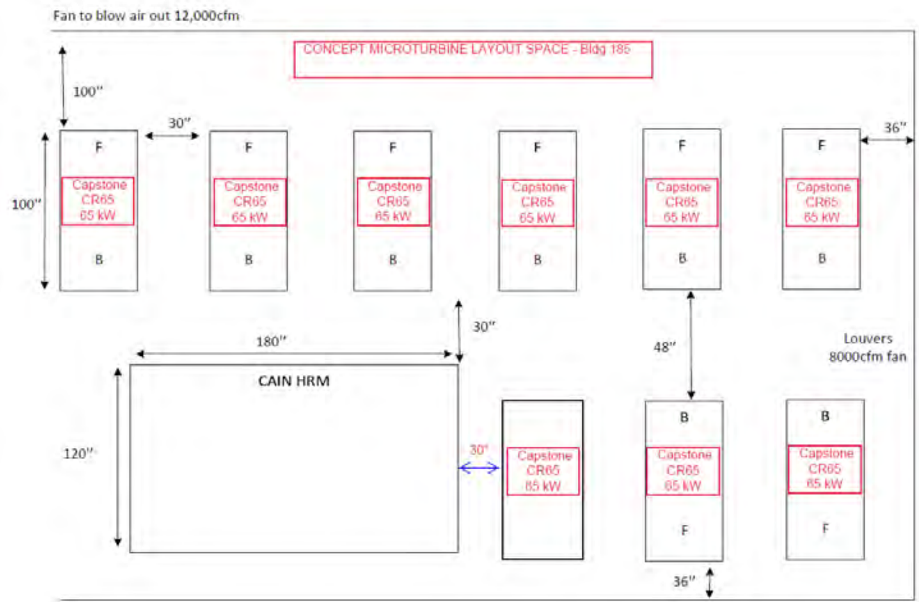
Capstone Turbine Corporation® is a producer of low-emission microturbine systems and was first to market with commercially viable air-bearing turbine technology. The local representative for Capstone is Vergent Power Solutions, Minneapolis, MN.

Layout Concept

Capstone recommends eight 65 kW model to meet the maximum month demand of 240,000 cu ft per day biogas. Therefore, a minimum of nine units would be required to allow for one unit out of service at a time. The larger 200 kW units have not proven to be cost effective due to frequency of overhauls.

The units operate most efficiently in cool ambient temperatures. However, since there is no footprint available to consider outdoor installation, inside Bldg. 185 would be the logical location. Typically, there are two main layout options. One is to put the microturbines in a row and layout the Cain Heat Recovery Module (HRM) heat exchanger at one end for the exhaust recovery header at the very end. The second option is to put the units back to back with the heat exchanger at one end. Ventilation rates must be enough to cool the units when located indoors. Figure 11-25 shows space requirements for microturbines alone in potential Building 185 layout space reconfiguration (does not show blower layouts).

Figure 11-25. Microturbine – Concept Layout Space Requirements in Building 185



Microturbine Efficiencies

Microturbines' electricity conversion efficiency is between 25 to 35 percent. The overall efficiency, including heat recovery, could be as high as 65 to 75 percent. Due to the small clearances and high speed of small rotor blades, fuel gas specifications require near complete removal of all deposit-forming siloxanes in the digester gas. Microturbines have very low emissions and permitting is relatively easy. Microturbines require over 50 psig fuel pressure.

Electrical Power Distribution

The same considerations exist as with engine generator power production.

Air Permitting

The microturbine has the lowest emissions of any combustion technology available. The C65 emits <0.17 lb/MWh NOx based on very lean air-fuel premix prior to continuous combustion in the microturbine. No active treatment or SCR device required. The microturbine never requires any active treatment of emissions. Just as with the IC-engine generator emissions, dispersion modeling will be required for determining point source location/elevation (i.e. a stack for elevating the emissions).

Maintenance

The Janesville, Wisconsin WWTP has operated a microturbine engine generator system with four 65 kW CR units and one 200 kW CR unit since 2013. Plant operations experience is that 65 kW CR units have limited maintenance requirements (mostly on the air inlet end) prior to typical 45,000-hour lifecycle between overhauls. Factory protection plans are available for:

- All planned and unplanned maintenance
- All parts and labor (or parts only options available)
- Performed by factory-trained and certified technicians
- Full remote monitoring and diagnostics
- Fixed pricing during the term for up to twenty years (no inflation rate)

Advantages:

1. Simple design with only one moving part.
2. Use of patented air bearings result in zero friction and no oil changes.

3. Inverter-based power electronics allow for simple interconnection to utility grid.
4. Scalable solutions with superior part load efficiency and ability to automatically synchronize and load follow.
5. Ultra-low emissions with no treatment of exhaust required.
6. Integrated heat recovery to maximize CHP efficiency.
7. Lower lifecycle cost than some IC engines.
8. Comprehensive factory protection plan for up to twenty years (10 yr. plan = $0.015 per KW with one overhaul).

Disadvantages:

1. Thermal recovery and overall efficiency are less than higher end IC engine generators.
2. Multiple units required with all operating means more challenges staggering overhauls. (required at 48,000 hours best case with newest model C65).
3. Larger 200 kW systems have not achieved the design life between overhauls to be cost effective. Microturbines have a higher present worth cost than IC engine generators . Also, given the long term successful RWU experience with IC engine driven blowers, switching to microturbines is not as desirable an alternative.

- **Initial Cost $4.2 million**

11.17 Upgrade Biogas Conditioning

The existing biogas conditioning at RWU consists of moisture removal prior to compression for storage in gas sphere and fueling existing IC engine-driven aeration blowers.

Equipment warranties for new IC engines or new microturbines are dependent on maintaining strict compliance with biogas fuel quality as specified by equipment manufacturers.

RWU biogas analysis from April 26,2019 indicates the following components expressed as a percentage of molecular weight of the biogas:

- Hydrogen <0.1%
- Oxygen 0.33%
- Nitrogen 1.06%
- CO2 36.4%
- Methane 62.1%
- Ethane <0.03%
- CO <0.03%
- H_2S <0.1%
- Silicon & Siloxanes 2.59 ppmv and 3.24 mg/M^3

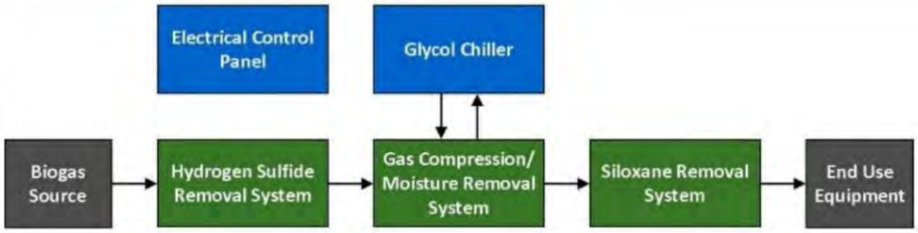
For a design phase, it is also important to test for and quantify the sulfur component speciation and volatile organic compounds which r in the biogas in order to finalize biogas conditioning design and calculate the media usage and life cycle cost. Future testing should also include:

- Sulphur component speciation
- Volatile organic carbons (VOCs)

No matter which CHP technology is employed, the beneficial use of biogas at the Racine WWTP will be improved by providing new biogas conditioning technology. In its most complete form this includes treatment for removal of hydrogen sulfide (H_2S), ammonia (NH_3), water vapor (moisture), and siloxane compounds (siloxanes) for biogas utilization as a fuel.

A simple process flow diagram for a generic CHP system is presented below (Figure 11-26). Digester gas is pretreated for the removal of contaminants before fueling the CHP units. Pre-treatment often consists of H_2S removal, compression, moisture and particulate removal, and siloxane removal. After pre-treatment, the biogas is piped to the CHP units.

Figure 11-26. Biogas Conditioning Systems



Equipment	Mounting	Electrical Classification
Hydrogen Sulfide Removal System	Standalone	Class I, Division 1
Gas Compression/Moisture Removal System	Skid Mounted	Class I, Division 1
Siloxane Removal System	Standalone	Class I, Division 1
Glycol Chiller	Standalone	Unclassified
Electrical Control Panel	Standalone	Unclassified

11.17.1 Biogas CHP Pretreatment

Alternative 9-185-1 Add Hydrogen Sulfide (H2S) Removal System

H_2S can be a by-product of the anaerobic digestion process and can be extremely corrosive to process equipment by virtue of its acidic properties. H_2S is typically problematic at a digester pH of 6 and lower and has not been problematic for Racine. However, the presence of H2S in digester gas adversely affects the quality of combustion emissions. The combustion of H2S produces sulfur dioxide (SO2), which is the most common source of SOx (oxides of sulfur). Therefore, the preventative step of removal of H2S and other sulfur species from the digester gas fuel causes an equivalent reduction in SOx emissions. This is an important air permitting consideration as Racine will be seeking a new air permit in conjunction with CHP planning.

Iron sponge treatment has been commonly used to remove H2S from digester gas. In this process, the saturated digester gas flows through process vessels containing wood chips impregnated with hydrated ferric oxide. The H2S reacts with the ferric oxide to form iron sulfide and water.

This process requires the digester gas to be saturated with water vapor and is therefore typically the first step in the fuel treatment process, before moisture is removed. Media removal and replacement is maintenance intensive. Once exhausted, the nonhazardous, iron sulfide laden, wood chips can be safely disposed of at most municipal landfills.

Newer H2S removal alternatives feature proprietary iron oxide sorbents. These systems include SULFATREAT®, Sulfur-Rite®, and SULFA-BIND®, all of which feature an inorganic substrate to which the proprietary sorbent adheres. Like the iron sponge, these alternative media can typically be regenerated and once exhausted can be safely disposed of at most landfills. Iron sponge media requires process control to prevent exposure to oxygen and subsequent potential for combustion.

Figure 11-27. Hydrogen Sulfide Treatment Vessels

<u>Advantage:</u>

Pretreatment removes source of sulfur in gas stream and prevents fouling more expensive downstream siloxane removal media.

<u>Disadvantage:</u>

Not currently used in biogas pretreatment and adds ongoing O&M cost.

- **Initial Cost of Hydrogen Sulfide Treatment $317,000**

Alternative 9-185-1A Add Moisture and Siloxane Removal System

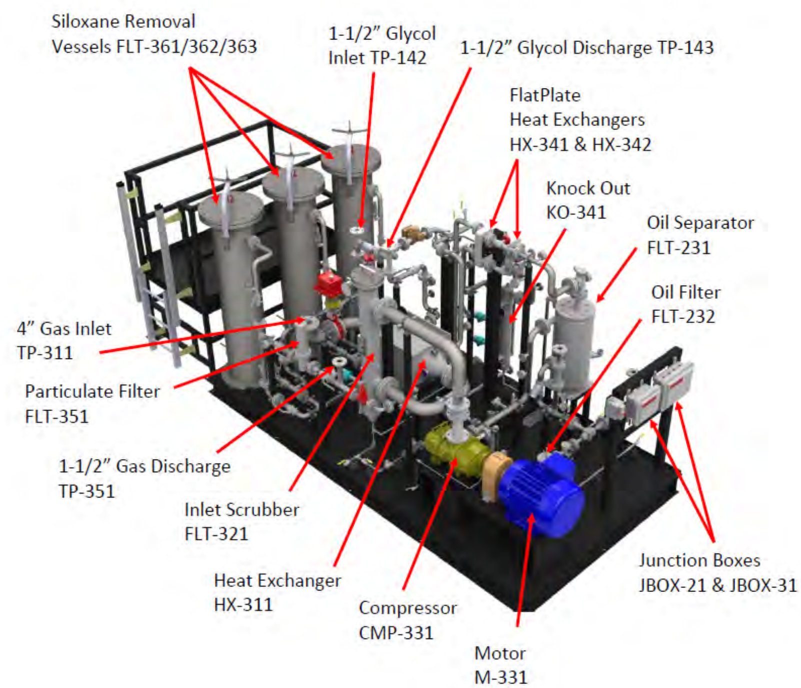
There will also be a minor amount of ammonia in the digester gas in equilibrium with free aqueous ammonia. Water vapor in digester gas can be voluminous and be removed through traditional knock-out pots or condensate traps, coalescing filters, or through temperature adjustments.

Siloxanes are volatile organic compounds used extensively in industrial products such as lubricants and in personal care products. When biogas is combusted as a fuel, silicon compounds in the siloxane oxidize to silica. Silica is extremely abrasive material, sand-like, and deposits of solid silicon dioxide collect within the equipment and can cause both maintenance and performance problems. Therefore, both internal combustion engine and microturbine manufacturers impose warranty and guarantee limits on siloxane concentrations in biogas fuel.

Siloxanes compounds, in addition to other volatile organic compounds (VOC's), can be removed from biogas via carbon absorption or siloxane-specific absorptive media. Testing of biogas is used to determine the concentration of siloxanes and VOC for media selection. Testing is also required protocol during operation to determine when to replace the media before breakthrough occurs.

The common technologies for low concentration H_2S removal may or may not include iron sponge or pelletized iron hydroxide in vessels; these technologies are protection for the more expensive siloxane removal media. Moisture and particulate removal improvements occurs in vessels. Siloxane removal is achieved via biogas flow through absorption media in stainless steel vessels.

Figure 11-28. Moisture and Siloxane Removal Skid



<u>Advantages:</u>

Systems provide contaminant removals needed for efficient operation of CHP.

<u>Disadvantages</u>

Media replacement is ongoing annual maintenance cost to protect engines or microturbines

- **Initial Cost of Moisture and Siloxane Treatment $1.26 million**

11.18 Future Capacity Land Acquisition

Treatment Facilities at the CNH Site

As discussed in Section 9, Mount Pleasant, Caledonia and Sturtevant have made requests for additional average daily flow allocation capacity at the WWTP. The current flow requests total 49 MGD compared to the WWTP rated capacity of 36 MGD. Though the WWTP current average flow is significantly below its rated capacity, RWU is developing a concept for a 12 MGD satellite facility. This facility will be further developed and constructed if flow and load monitoring during the planning period indicates that this project, or an equivalent way to meet the SSR flow requests, is justified.

Due to the current treatment facility's location, there is very limited space for additional treatment processes. Therefore, it is likely that a property acquisition would be necessary for a significant expansion to the plant's treatment capacity. The property occupied by the former Case-New Holland (CNH) test facility, tractor assembly plant, and foundry lies just south of the WWTP along the Lake Michigan Shoreline. This parcel consists of approximately 100 acres formerly developed as an industrial facility. A portion of the CNH property could provide an area for additional plant facilities. This site could provide sufficient area for a 12 MGD treatment facility. The city of Racine is currently in negotiations with CNH to purchase this property.

A preliminary plant layout was developed for a 12 MGD treatment facility on the CNH property. The processes include influent screens, vortex grit removal units, primary clarifiers, activated sludge tanks,

Legend:

Approximate Property Boundary

0' 150' 300' 600'
SCALE

N

AECOM

Figure 11-29
Conceptual 12 MGD Plant Layout

Racine Facilities Plan
Racine Wastewater Utility

Projection:

Drawn By: JFP

Checked By: MJZ

Date:

Project #: 60554970

Final Clarifiers, and a UV disinfection system. A layout for treatment facilities at the CNH property is shown in Figure 11-29.

To comply with NR 110 there also need to be setbacks around the plant property due to the zoning of the areas adjacent to the site. Also, it is assumed that there would be a 150-ft wide strip of land along the top of the lake bluff. The setbacks from areas zoned commercial and residential would be 500-ft. Currently, the areas to the north and south of the site are zoned either residential or commercial. It is assumed that the setback along Sheridan Road would be 100-ft wide to accommodate a berm and fencing to screen the facilities.

The 12 MGD sizing is equivalent to a per capita flow of 100 gallons/capita/day and a population equivalent of 120,000. Using the population equivalent and a peak flow factor of 1.94 based on Figure 1 from Ten States Standards, the peak flow to the facility is estimated to be 23.2 MGD. The average BOD loading to the facility would be 20,400 lb BOD_5/day using a typical BOD loading of 0.17 lbs/capita/day.

Influent flows to the facility would be received at a headworks building which would contain mechanical bar screens and vortex grit units. The building would be approximately 60-ft by 60-ft and have space for three bar screens and two grit tanks, as well as equipment to wash and compact the materials removed from the flow. Three blowers for the air supply to the aeration tanks would also be housed in the building.

Circular tanks and rectangular tanks were considered for the primary clarifiers. To match the existing facilities, rectangular tanks were selected. The sizing of the tankage was based on the following criteria (from Chapter NR 110):

Design Average Flow	1,000 gpd/ft^2
Maximum Hourly Flow	1,500 gpd/ft^2

The total required area of 15,490-ft^2 for the maximum hourly flow governed the sizing of the tanks. Based in this area, primary clarifier tanks with overall surface area dimensions of 110-ft by 145-ft would be required.

The organic loading to the aeration tanks was based on a typical removal rate of 30 percent from the primary clarifiers. This reduced the loading to 14,280 lb BOD_5/day. The sizing of the aeration tanks was based on an organic loading rate of 15 lb BOD_5/day/1,000 ft^3 from Chapter NR 110 (for extended aeration). At this loading rate the total required volume of the aeration tanks is 952,000-ft^3. Assuming a depth of 14-ft, the required surface area is about 68,000-ft^2. This results in aeration tanks with total surface area dimensions of 185-ft by 370-ft.

The sizing of the Final Clarifiers was based on a peak hour flow of 1,000 gpd/ft^2 from Chapter NR 110 (for extended aeration). This resulted in a required total surface area of about 23,230-ft^2. Assuming two Final Clarifiers, the tanks would need to be 122-ft in diameter. As this is significantly larger than the tanks at the existing plant, the option of three tanks was examined. For this option, three 100-ft diameter tanks would be needed. As this size is comparable to the existing tanks, a system of three tanks was selected.

The RAS and WAS pumps would be housed in structures between the Final Clarifiers. The two structures each would be approximately 20-ft by 25-ft. A structure housing the UV equipment and channels would be located adjacent to the Final Clarifiers. The structure would house two channels and be approximately 20-ft by 30-ft. Effluent would be discharged through the outfall sewer at the main WWTP.

The current concept includes pumping the biosolids to the main plant for further processing.

11.18.1 Solar Fields at the CNH Site

Buffer zones around the proposed treatment facilities will be needed due to zoning requirements. These areas would be an ideal location for a solar array to generate power for the WWTP to offset the facility's power requirements.

Recent power requirements from the 2018 Annual Report were reviewed to estimate the WWTP's expected power requirements. A range of potential power production options needed to meet different conditions are shown in Table 11-16.

Also shown in Table 11-5 are the approximate cost and the dimensions of the areas required for the different options. The cost and area requirements are based on typical values used in developing conceptual arrangements. The areas assume rectangular fields with lengths of twice the widths.

The buffer zones around the proposed treatment facilities should be able to accommodate any of the areas listed in Table 11-6. It is recommended that the solar field be sized near the 50th percentile to balance minimizing the purchased power and the intent to not produce surplus power.

Table 11-6. Potential Solar Fields at CNH Site

Condition*	Required Power Production (kW)	Cost	Area Dimensions (ft)
Maximum Month	1002	$4,010,000	300 x 600
75th Percentile	890	$3,558,000	280 x 560
50th Percentile	824	$3,296,000	270 x 540
25th Percentile	769	$3,075,000	260 x 520
Minimum Month	710	$2,839,000	250 x 500

* Based on 2018 electricity usage.

11.18.2 Lake Bank Stabilization Measures at the CNH Site

Lake Michigan is at historic high levels in 2020 as discussed in Section 7. Erosion from wave fronts has reshaped the shoreline and lake bank stabilization measures are needed along the lakefront of this site to protect from further erosion damage and loss. Due to extraordinary shoreline erosion caused by wave action from record high water levels in Lake Michigan, RWU needs to prioritize lake bank stabilization for this property.

Typical measures include placement of layers of large rip-rap rock along the shoreline as well as vegetative measures and storm runoff considerations.

11.19 WWTP Outfall

11.19.1 Outfall Capacity Review

There are two outfall pipes. The outfall pipe from the 1965 addition has a 72-inch diameter. The pipe installed during the 2002-2005 plant upgrade has a 96-inch diameter. Both pipes extend approximately 500-ft into the lake and each have three diffuser discharge ports.

The water level at the plant upstream of the outfall is dependent on the level of Lake Michigan, which is currently relatively high. The maximum recorded Lake Elevation is 584.2. Per information from the US Army Corps of Engineers May 2020 lake level bulletin, the 2020 high lake level is expected to be 582.3.

The hydraulic capacity of the outfalls was reviewed assuming a peak flow of 200 MGD. At this flow, the head loss through the outfalls is estimated to be between 1.0 to 1.5 ft.

11.19.2 Outfall Condition Assessment

The outfall should be inspected as part of future work to assess condition and confirm peak flow capacity.

12.0 Sustainability

RWU and the SSR communities believe sustainability is important to the long-term operation, maintenance, and future expansions of the treatment facility and the conveyance system. The emphasis and desire of each group to value the sustainability of the systems will go only so far. The need to define what sustainability means and how to document sustainability will be critical. The definition of sustainability varies depending on what lens you are viewing a project or action through. The EPA says, "To pursue sustainability is to create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations". The US Green Building Council (USGBC) mission statement states "Our mission is to transform the way building and communities are designed, built and operated, enabling and environmentally and socially responsible, healthy, and prosperous environment that improves quality of life." The critical element is how do you document sustainable practices and the sustainability process. There are two primary tools that are used worldwide to documents the sustainability process for design, construction, and operation. Those tools are ENVISION from the Institute for Sustainable Infrastructure (ISI) and Leadership in Energy and Environmental Design (LEED). The Water Environment Federation (WEF) has also created a manual relating the ENVISION Framework to wastewater projects.

12.1 Documenting Sustainability

Sustainability is not just the end results of a project. Sustainability is the process by which a project is planned, design, constructed, operated, and maintained. As previously stated, there are a couple of tools available that provide a framework to document the process towards a sustainable project or improvement. The first tool is the ENVISION framework.

The ENVISION framework is a series of 64 questions, within 5 categories, that are used to guide and direct decisions, planning, design, and implementation of infrastructure projects. The 5 categories are; Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Resilience. ENVISION provides a checklist that records the answers to the 64 questions, provides documentation for meeting criteria for the levels within each question, and processes or steps that groups can take to increase the sustainability of a project. ENVISION can be used as a guide for anyone wanting to evaluate the sustainability efforts of a project. There is also an option to submit a project for formal review and evaluation for possible ENVISION Ratings and awards. The current version of ENVISION, V3, was released in 2018. Future versions may be available and any use of the ENVISION rating system should check for the most current version.

Similar in to ENVISION, LEED is also a framework used to document sustainability and guide decision making. LEED has specific rating systems for Building Design & Construction, Interior Design and Construction, Building Operation and Maintenance, LEED Zero, among others. Similar to ENVISION, the LEED rating system contains a series of questions that document the process and inputs for a project to determine the scoring associated with the project. This scoring will determine what Certification Level can be awarded to the project. LEED can also be used in a similar fashion to ENVISION and simply as a guide for decision making for future projects. LEED is specific for occupied buildings where ENVSION is primarily setup for infrastructure; i.e. energy, water, waste, transportation, landscape, and IT.

12.2 City and W/WW Utility Sustainability Goals

The City of Racine is currently working with City staff, community members, business partners, and others to create goals and a Mission Statement for the City. The City is also working with the University of Wisconsin Madison to provide a framework for developing the Mission and Vision statements. A high-level goal for the City, and point of emphasis, is to make the WWTP carbon neutral. Details and action items for the goal have yet to be determined. Other goals that the team is reviewing and evaluating are the use of solar, becoming a LEED Certified Community through the US Green Building Council, and green infrastructure among others. Sustainability projects associated with the WWTF Facility Planning are identified below and may assist the City in identifying future goals.

12.3 Potential Sustainability Improvements

This Facility Plan has identified multiple improvements that may improve/ increase the sustainability of the Treatment Facility as a whole, and individual processes within the facility. The following is a list of the potential improvements and some other sustainable practices that could be implemented in future improvements to the WWTP and the conveyance system.

1. Renewable Fuels
   a. Increase efficiency of biogas use at WWTP.
   b. Solar Field at CNH Property.
   c. Add solar panels to the roof of the preliminary treatment building and the cover of the final effluent junction chamber.
2. Energy Efficiency
   a. Aeration blower upgrades to higher efficiency units.
   b. Process upgrades to reduce energy consumption in the aeration process.
   c. More efficient UV disinfection.
   d. Use of high-efficiency motors in equipment replacement.
3. Clean Air
   a. Minimize flaring of biogas.
   b. Cleaner biogas engine exhaust.
4. Clean Water
   a. Improved Dissolved Oxygen (DO) and ammonia controls in the activated sludge process.
5. Other Sustainable Practices
   a. Trenchless construction
   b. Energy efficient motors at pump stations
   c. Green roofs at pump stations
   d. LED lighting where not already implemented.
   e. Green infrastructure

13.0 Recommended Plan

13.1 Prioritization and Time Frame of Conveyance Improvements

The conveyance system improvements recommended in this Facilities Plan are intended to serve current flows as well as potential growth in the service area. Whether or not growth occurs and projects proceed to final completion depends on many factors. Timing of projects is also dependent on non-growth related matters, such as WPDES permit requirements.

In the prioritization provided below, projects currently under construction or design were given highest priority, followed by projects related to anticipated growth in the southwest corner of the service area. The next level of priority was given to projects which were recommended in engineering studies conducted on the Caledonia and Mt. Pleasant conveyance systems. The remaining projects were prioritized based on the amount of benefit provided to the overall conveyance system and the anticipated timing of the need for the improvement. Projects were also spread out over the planning period (2020 – 2040) to alleviate financial constraints.

Furthermore, it is likely that some of the conveyance system improvements will be designed and constructed ahead of the time frame provided in this Facilities Plan depending on the needs of the individual SSRs. The project implementation schedule presented in the Facilities Plan is intended to spread out costs over the 20-year planning period, not to dictate the actual schedules for projects designed and constructed by individual SSRs in accordance with their plans for development.

Priority No. 1A:	Pike River Lift Station Phase 1 and Forcemains to Mt. Pleasant/Sturtevant Interceptor (at Old Green Bay Road) Project Time Frame: Anticipated completion in December 2021.
Priority No. 1B:	Abandonment of KR Lift Station and Interconnection to Pike River Lift Station Project Time Frame: Anticipated completion in mid-2020
Priority No. 2A:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 1,2 and 3 from Pike River Lift Station to STH 11 Project Time Frame: Anticipated completion in 2020.
Priority No. 2B:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 7 from STH 11 to STH 20 Project Time Frame: Anticipated completion in 2021.
Priority No. 3:	1.0 MG Flow Equalization for Chicory Road Interceptor Capacity Constraint Project Time Frame: 2025 - 2030
Priority No. 4:	3.5 MG Flow Equalization Storage at North Park Lift Station Project Time Frame: 2021 - 2025
Priority No. 5:	Additional 1.5 MG Flow Equalization Storage at Hood's Creek Lift Station. Project Time Frame: 2021 - 2025
Priority No. 6:	11.0 MG Flow Equalization Storage at Pike River Lift Station Project Time Frame: 2025 - 2030
Priority No. 7:	10.0 MG Flow Equalization Storage at Lift Station 01 Project Time Frame: 2030 - 2035

Priority No. 8:	Additional 1.0 MG Flow Equalization Storage at Caledonia-Riverbend Lift Station (LS31). (LS 31 Upstream Capacity Constraints) Project Time Frame: 2030 - 2035
Priority No. 9:	1.0 MG Flow Equalization Storage at Lakeview Park. (Michigan Blvd Capacity Constraints) Project Time Frame: 2035 – 2040
Priority No. 10:	Osborne Boulevard/Kinzie Avenue Interceptor Sewer Upgrade Project Time Frame: 2035 – 2040
Priority No. 11:	Miscellaneous Interceptor and Trunk Sewer Upsizing • LaSalle Street Trunk Sewer • Geneva Street Interceptor Project Time Frame: 2035 – 2040
Priority No. 12:	1.65 MG Flow Equalization Storage along Pike River Interceptor Project Time Frame: 2035 – 2040

13.2 Cost Considerations

Below are cost estimates for each conveyance system improvement recommended in this Facilities Plan. Costs were estimated using 2020 pricing. For projects intended for construction in future years, an annual inflation rate of 3.375% was used to adjust to estimated year-of construction costs.

Cost estimates for Priorities No. 1A, 1B, 1C, 2A, and 2B were obtained from Foth I&E, LLC, (representing Caledonia and Mt. Pleasant).

Costs for Priorities No. 1A and 2A were based on actual bid prices for projects which are currently under construction. Costs for Projects 1B, 1C and 2B are engineers' opinions of probable construction cost.

Estimates of probable construction cost for Priorities 3 through 12 can be found in Appendix D.

Priority No. 1A:	Pike River Lift Station and Forcemains to Mt.Pleasant/Sturtevant Interceptor Est. Project Completion – Dec. 2021 Estimated Project Cost: $32.2 Million ($21.7 Million for Lift Station + $10.5 Million for Forcemain) (2020 Dollars)
Priority No. 1B:	Abandonment of KR Lift Station and Interconnection to Pike River Lift Station Est. Project Completion – Dec. 2021 Estimated Project Cost: $4.4 Million (2020 Dollars)
Priority No. 1C:	Pike River Lift Station Phase 2 Project Time Frame: 2025 - 2030 Estimated Project Cost: $9.3 Million (2020 Dollars) Note: The Pike River Lift Station Phase 2 Project will not be necessary if the 11.0 MG flow equalization basin is constructed at the Pike River Lift Station. Cost summaries for this Facilities Plan will include the cost of the 11.0 MG EQ Basin and will not include the cost of the Pike River Lift Station Phase 2 Project.

Priority No. 2A:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 1,2 and 3 from Pike River Lift Station to STH 11. Est. Project Completion - 2020. Estimated Project Cost: $21.2 Million (2020 Dollars)
Priority No. 2B:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 7 from STH 11 to STH 20. Est. Project Completion - 2021. Estimated Project Cost: $9.0 Million (2020 Dollars) $10.6 Million (2025 Dollars)
Priority No. 3:	1.0 MG Flow Equalization For Chicory Road Interceptor Capacity Constraint Project Time Frame: 2025 – 2030 Estimated Project Cost: $2.8 million (2020 Dollars) - See Table D-4 in Appendix D $3.3 million (2025 Dollars based on 3.375% annual inflation) $3.9 million (2030 Dollars based on 3.375% annual inflation)
Priority No. 4:	3.5 MG of Flow Equalization Storage at North Park Lift Station Project Time Frame: 2021 - 2025 Estimated Project Cost: $6.4 Million (2020 Dollars) - See Table D-2 in Appendix D. $7.5 Million (2025 Dollars based on 3.375% annual inflation) $8.9 Million (2030 Dollars based on 3.375% annual inflation)
Priority No. 5:	Additional 1.5 MG of Flow Equalization Storage at Hood's Creek Lift Station. Project Time Frame: 2021 - 2025 Estimated Project Cost: $3.4 Million (2020 Dollars) - See Table D-3 in Appendix D. $4.0 Million (2025 Dollars based on 3.375% annual inflation) $4.7 Million (2030 Dollars based on 3.375% annual inflation)
Priority No. 4:	11.0 MG Pike River Lift Station Flow Equalization Storage Project Time Frame: 2025 - 2030 Estimated Project Cost: $17.9 Million (2020 Dollars) - See Table D-1 in Appendix D. $21.0 Million (2025 Dollars based on 3.375% annual inflation) $25.0 Million (2030 Dollars based on 3.375% annual inflation)
Priority No. 7:	10.0 MG Flow Equalization Storage at Lift Station 01 (LS No. 1 Downstream Interceptor Capacity Constraints) Project Time Frame: 2030 - 2035 Estimated Project Cost: $14.5 Million (2020 Dollars) - See Table D-5 in Appendix D. $17.1 Million (2030 Dollars based on 3.375% annual inflation) $20.2 Million (2035 Dollars based on 3.375% annual inflation)

Priority No. 8:	Additional 1.0 MG Flow Equalization Storage at Caledonia-Riverbend Lift Station (LS31). (LS 31 Upstream Capacity Constraints) Project Time Frame: 2030 - 2035 Estimated Project Cost: $2.8 Million (2020 Dollars) - See Table D-6 in Appendix D. $3.9 Million (2030 Dollars based on 3.375% annual inflation) $4.6 Million (2035 Dollars based on 3.375% annual inflation)
Priority No. 9:	1.0 MG Flow Equalization Storage at Lakeview Park. (Michigan Blvd Capacity Constraints) Project Time Frame: 2035 – 2040 Estimated Project Cost: $2.8 Million (2020 Dollars) - See Table D-7 in Appendix D. $4.6 Million (2035 Dollars based on 3.375% annual inflation) $5.4 Million (2040 Dollars based on 3.375% annual inflation)
Priority No. 10:	Osborne Boulevard/Kinzie Avenue Interceptor Sewer Upgrade Project Time Frame: 2035 – 2040 Estimated Project Cost: $3.9 Million (2020 Dollars) - See Table D-8 in Appendix D. $6.4 Million (2035 Dollars based on 3.375% annual inflation) $7.6 Million (2040 Dollars based on 3.375% annual inflation)
Priority No. 11:	Miscellaneous Interceptor and Trunk Sewer Upsizing • LaSalle Street Trunk Sewer • Geneva Street Interceptor Project Time Frame: 2035 – 2040 Estimated Project Cost: $3.4 Million (2020 Dollars) - See Tables D-9 and D-10 in Appendix D. $5.6 Million (2035 Dollars based on 3.375% annual inflation) $6.6 Million (2040 Dollars based on 3.375% annual inflation)
Priority No. 12:	1.65 MG Flow Equalization Storage along Pike River Interceptor Project Time Frame: 2035 – 2040 Estimated Project Cost: $3.9 Million (2020 Dollars) - See Table D-11 in Appendix D. $6.3 Million (2035 Dollars based on 3.375% annual inflation) $7.4 Million (2040 Dollars based on 3.375% annual inflation)

13.3 Description of Wastewater Treatment Plant Improvements

The recommended alternatives for plant upgrades and operation and maintenance sustainability are summarized in Table 13-1 and Figures 13-1 through 13-4. Recommendations have been categorized as follows for implementation planning discussed in Section 14:

- Upgrade(s) needed to remedy current deficiencies.
- Recommended alternative(s) with further evaluation required to develop scope and refine cost estimates.
- Upgrades recommended as a future improvement.

The following narrative description is based on the recommended alternatives to meet facility needs:

Wet Weather Optimization- 30/40/45

Influent wastewater will continue to flow to the plant equalization screening Structure 30. Currently, flows in excess of 95 MGD are diverted by influent wastewater control valves to equalization to prevent hydraulic peak flow issues from impacting plant operations and treatment efficiency. Peak flows are

Table 13-1. Wastewater Treatment Plant Facility Plan Recommendations
Rev. Date 07/1/2020

Facility Plan Alternative Number and Name	Capital Cost Estimate $	Annual O&M $	Present Worth of Annual O&M $	Total Present Worth $	NEEDS CATEGORIZATION
GENERAL SITE AND FACILITIES	**$ 973,000**				
G-1 Upgrade road paving	$ 179,000				FUTURE IMPROVEMENT
G-2 Improve stormwater drainage around Digester B (170) between structures 172 and 185	$ 136,000				REMEDY CURRENT DEFICIENCY
G-3 Inspect metal manstards on building exteriors which are observed to be deteriorating. Finish deterioration may be warranty issue? Refinish or replace.	$ 166,000				REMEDY CURRENT DEFICIENCY
G-4 Upgrade out-of-date Fire Alarm Panels (Qty 6)	$ 89,000				REMEDY CURRENT DEFICIENCY
G-5 Upgrade service water plumbing systems	$ 75,000				REMEDY CURRENT DEFICIENCY
G-6 Upgrade back-up engines	$ 143,000				REMEDY CURRENT DEFICIENCY
G-7 Upgrade women's locker rooms	$ 49,000				REMEDY CURRENT DEFICIENCY
G-139 Structural leakage issue upgrades	$ 36,000				REMEDY CURRENT DEFICIENCY
G-162 Outfall condition assessment - STUDY	$ 50,000				FURTHER EVALUATION
G-185-8 Inspect site pipe insulation for presence of asbestos to enable identification and cost estimate allowance for removal and replacement	$ 50,000				FUTURE IMPROVEMENT
EQUALIZATION- WET WEATHER OPTIMIZATION	**$ 1,300,000**				
1-30-1 Improve facilities for O&M of EQ Influent Channels	$ 1,100,000				REMEDY CURRENT DEFICIENCY
1-40-1 Rehabilitate East Equalization Basin EQ #1	$ 200,000				REMEDY CURRENT DEFICIENCY
ADMINISTRATION BUILDING 110	**$ 1,233,000**				
110-1 Replace roofs on Administration Bldgs.	$ 685,000				REMEDY CURRENT DEFICIENCY
110-2 Replace furnishings, finishes and	$ 251,000				FUTURE IMPROVEMENT
110-3 Upgrade communications and electronics to support future functionality	$ 69,000				FUTURE IMPROVEMENT
110-4 Upgrade lobby men's restrooms	$ 49,000				FUTURE IMPROVEMENT
110-5 Replace HVAC Air Handling Unit -	$ 179,000				REMEDY CURRENT DEFICIENCY
CHEMICAL WING BUILDING 120	**$ 460,000**				
120-1 Design and construct truck unloading spill containment and provide hydraulic ramp for truck unloading	$ 300,000				REMEDY CURRENT DEFICIENCY
120-3 Upgrade Ferric Chloride Tank to dual containment OH fill piping	$ 160,000				REMEDY CURRENT DEFICIENCY
LAB BUILDING 125	**$ 548,000**				
125-2 Replace lab hoods	$ 60,000				REMEDY CURRENT DEFICIENCY
125-3 Replace lab floor with more chemical resistant material.	$ 75,000				FIURTHER EVALUATION
125-5 Evaluate piping and circulation of chemicals and gases through lab from loading dock for improved safety and efficiency.	$ 90,000				REMEDY CURRENT DEFICIENCY
125-6 Replace air handlers and condensing units with rooftop HVAC (2 ea).	$ 269,000				REMEDY CURRENT DEFICIENCY
125-7 Upgrade Lab Fixtures	$ 54,000				FURTHER EVALUATION
PRELMINARY TREATMENT- 130	**$ 587,000**				
G-130-2 Consider Solar Panels on Preliminary Treatment Building	$ 89,000	$ (12,580)	$ (181,000)	$ (92,000)	FUTURE IMPROVEMENT
2-130-1 Replace Grit Screw Conveyors	$ 498,000				REMEDY CURRENT DEFICIENCY
PRIMARY TREATMENT- 135/136	**$ 3,615,000**				
3-136-1A Primary Clarifier Mechanism Rehab - YEAR 0-5	$ 850,000				REMEDY CURRENT DEFICIENCY
3-135/136-1B Primary Clarifier Mechanism Rehab - YEAR 5-10	$ 940,000				FUTURE IMPROVEMENT
3-135/136-1C Primary Clarifier Mechanism Rehab - YEAR 10-15	$ 875,000				FUTURE IMPROVEMENT
3.136-2 Add walkway between Primary Clarifier Nos.10-11	$ 110,000				REMEDY CURRENT DEFICIENCY
3-135/136-3 Upgrade Channel Aeration Mixing . Enviromix Proposal	$ 600,000	$ 10,000	$ 144,000	$ 744,000	FUTURE IMPROVEMENT
3-136-4 Upgrade Primary Scum Pumping and Distribution System	$ 130,000				REMEDY CURRENT DEFICIENCY
3-136-5 Provide Redundancy for Primary Effluent Channel	$ 110,000				REMEDY CURRENT DEFICIENCY
SECONDARY TREATMENT- AERATION 139	**$ 5,047,000**				
4-139-3 Replace Diffuser System with New Membrane Diffusers and New Piping and Controls	$ 1,840,000	$ (75,056)	$ (429,000)	$ 1,211,000	FURTHER EVALUATION
4-139-5 Replace RAS distribution flow meters 1 through 5	$ 222,000				FURTHER EVALUATION
4-139-6 Add ML Channel Isolation Gates	$ 125,000				REMEDY CURRENT DEFICIENCY
4-139-7 Replace aeration tank MLSS butterfly valves	$ 540,000				REMEDY CURRENT DEFICIENCY
4-139-8 Replace aeration tank inlet gates	$ 120,000				REMEDY CURRENT DEFICIENCY
7-185-1 Upgrade to new high efficiency centrifugal blower system (see 4-139 for various aeration system sizing considerations)	$ 2,200,000	$ (60,056)	$ (863,000)	$ 1,337,000	FURTHER EVALUATION

Table 13-1. Wastewater Treatment Plant Facility Plan Recommendations
Rev. Date 07/1/2020

Facility Plan Alternative Number and Name	Capital Cost Estimate $	Annual O&M $	Present Worth of Annual O&M $	Total Present Worth $	NEEDS CATEGORIZATION
SECONDARY TREATMENT- FINAL CLARIFICATION 140-145	**$ 2,908,000**				
5-139-9 Replace RAS Flow Meters	$ 160,000				FURTHER EVALUATION
5-139-10 Upgrade RAS Pumps #2-#4-#6-#8-#10-#12 to handle peak flow	$ 180,000				REMEDY CURRENT DEFICIENCY
5-140-1A Aluminum Covers for Weir Launders- Clarifier 1-9 algae growth prevention	$ 2,300,000				FURTHER EVALUATION
5-141-2 Evaluate Means for Pumping Waste Sludge From Final Clarifiers #2, #4, and #6	$ 85,000				REMEDY CURRENT DEFICIENCY
5-141-3 Modify Mixed Liquor Inlet Channel/Effluent Separation Wall at Final Clarifiers #1 – #6	$ 16,000				REMEDY CURRENT DEFICIENCY
5-145-4 Upgrade Secondary Scum Pumping and Distribution System (See 3-136-4)	$ 105,000				REMEDY CURRENT DEFICIENCY
5-145-5 Add Final Effluent Reuse as Engine Cooling Water	$ 62,000				FUTURE IMPROVEMENT
SECONDARY TREATMENT- UV DISINFECTION & EFFLUENT OUTFALL 160-162	**$ 5,213,000**				
6-91-1 Upgrade Deficient Sampler Building	$ 60,000				REMEDY CURRENT DEFICIENCY
6-160-3 Upgrade UV Disinfection System to 3-Channel System	$ 4,469,000	$ 126,740	$ 1,822,000	$ 6,291,000	REMEDY CURRENT DEFICIENCY
6-160-4 Replace Final Effluent Flow Meters (60" Magmeters)	$ 440,000				REMEDY CURRENT DEFICIENCY
6-162-1– Cover for Effluent Junction Chamber	$ 119,000				FURTHER EVALUATION
6-162-2 – Final Effluent Junction Chamber Solar Panels	$ 30,000				FURTHER EVALUATION
13-47-1 Upgrade Dechlorination System	$ 95,000				REMEDY CURRENT DEFICIENCY
SOLIDS PROCESSING 165	**$ 2,610,000**				
8-165-1 Upgrade TWAS piping to digesters	$ 350,000				REMEDY CURRENT DEFICIENCY
10-165-3 Filtrate Equalization Tank	$ 1,960,000				FURTHER EVALUATION
10-165-4 Upgrade air handling units with heating system using WWTP hot water loop	$ 200,000				FURTHER EVALUATION
10-165-5 Improve plumbing supply and drainage on 1st and 2nd floor of Building 165	$ 100,000				REMEDY CURRENT DEFICIENCY
ANAEROBIC DIGESTION & BIOGAS 170-190	**$ 8,335,000**				
9-170-1 Inspect, evaluate and rehabilitate Digester "B" Cover	$ 276,000				REMEDY CURRENT DEFICIENCY
9-177-1 Replace Digester D Floating Cover-	$ 1,843,000				FURTHER EVALUATION
9-185-1 Biogas Conditioning for H2S (Hydrogen Sulfide Removal)	$ 317,000	$ 7,333	$ 105,000	$ 422,000	FURTHER EVALUATION
9-185-1A Biogas Conditioning for IC Engine (Moisture and VOC/Siloxanes)	$ 1,260,000	$ 10,000	$ 144,000	$ 1,404,000	FURTHER EVALUATION
9-185-2A Biogas CHP Engine Generator- Max Month Biogas with One Unit out of Service	$ 4,500,000	$ (203,000)	$ (2,918,000)	$ 1,532,000	FURTHER EVALUATION
14-185-3 Upgrade Existing Reciprocating Piston Air Compressors with New Rotary Screw Air Compressors	$ 139,000				FUTURE IMPROVEMENT
CNH SITE	**$ 4,275,000**				
G-CNH Lakefront Stabilization/ Erosion Protection	$ 360,000				REMEDY CURRENT DEFICIENCY
G-CNH Install Solar Panels	$ 3,915,000	$ (616,820)	$ (8,866,000)	$ (4,951,000)	FURTHER EVALUATION
TOTAL	**$ 37,100,000**				

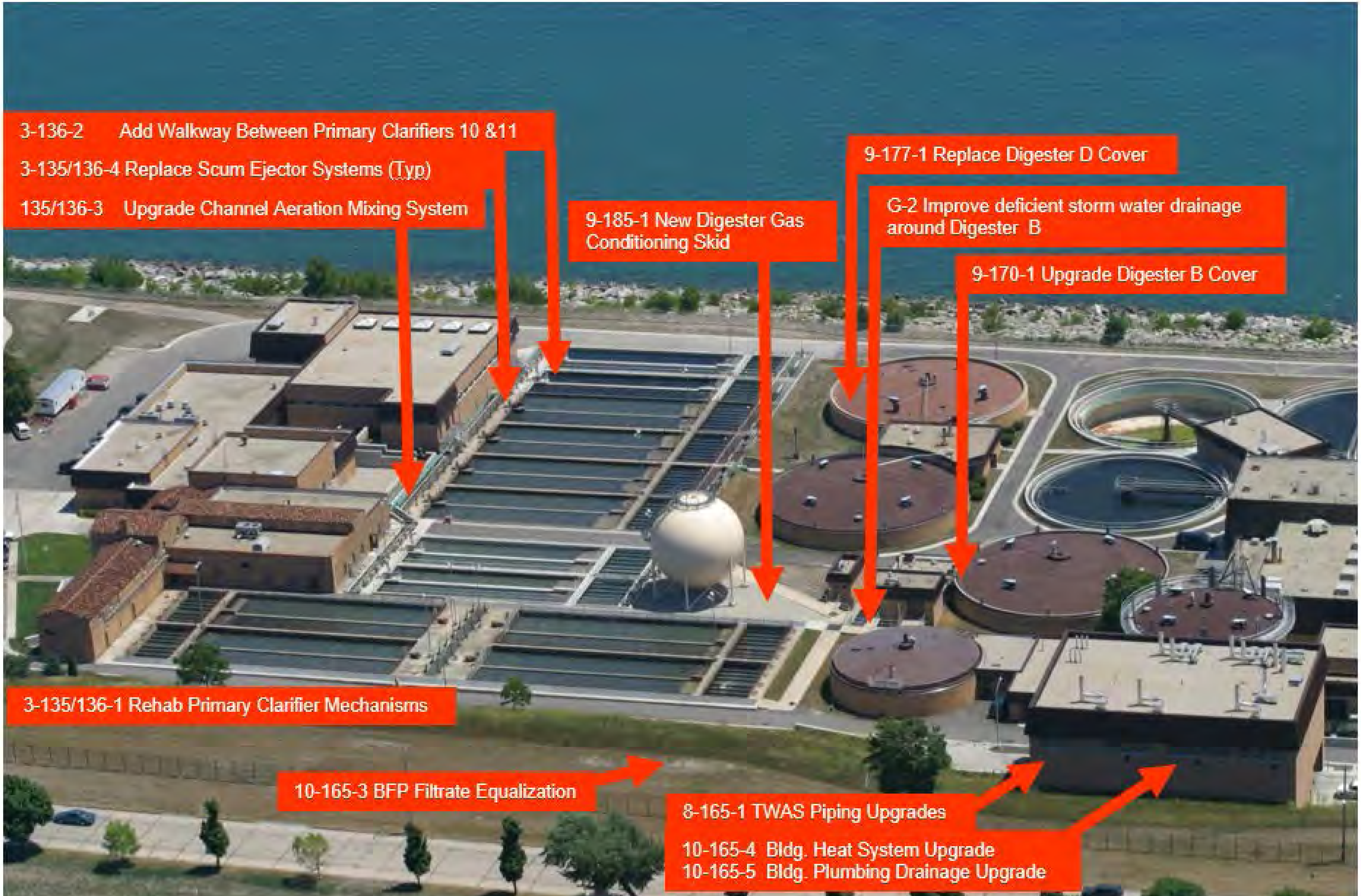
Projection:

Figure 13-1
Racine WWTP Facility Plan Needs

Racine Facilities Plan
Racine Wastewater Utility

[redacted]

Drawn By: JFP
Checked By: MJZ
Date:
Project #: 60554970



Projection:

Figure 13-2
Racine WWTP Facility Plan Needs

Racine Facilities Plan
Racine Wastewater Utility

[redacted]

Drawn By: JFP
Checked By: MJZ
Date:
Project #: 60554970

Projection:

Figure 13-3
Racine WWTP Facility Plan Needs

Racine Facilities Plan
Racine Wastewater Utility

[redacted]

Drawn By: JFP
Checked By: MJZ
Date:
Project #: 60554970

Projection:

Figure 13-4
Racine WWTP Facility Plan Needs

Racine Facilities Plan
Racine Wastewater Utility

[redacted]

Drawn By: JFP

Checked By: MJZ

Date:

Project #: 60554970

managed in the two 2.7-million-gallon equalization basins (Structures 40 and 45) for primary settling and hypochlorite disinfection followed by de-chlorination treatment prior to mixing with plant effluent.

- Equalization Basin 1 will be upgraded to extend life and improve measurement and management of wet weather flows. Additional peak flow measurement of influent will be evaluated to enable better control.
- New bar screens are needed in the equalization screening structure. Miscellaneous improvements are required in Structure 30 to enable maintenance to manage peak flow events and cleanup.

Hydraulic limitations in the plant will be addressed to eliminate or reduce bottlenecks which impact effluent quality during peak flow events.

Preliminary Treatment (130)

Existing preliminary treatment facilities are adequate for design flows and loadings. Upgrades are needed to replace grit screw conveyors which have corroded beyond continued reasonable repair. Opportunity to add solar panels to the roof of treatment Building 130 is a future energy sustainability upgrade.

Chemical Phosphorus Removal (120)

Phosphorus removal will continue based on feeding ferric chloride to the primary influent. The existing ferric chloride storage and feed system has adequate capacity; however, the tank unloading area will be upgraded to provide spill containment for unloading trucks and the overhead tank fill piping will be upgraded to a dual containment piping system. Biological phosphorus is feasible in the future with potential energy savings but will require further evaluation to consider replacing the proven performing technology.

Primary Treatment (135/136)

Primary clarifier tanks are in good structural condition. However, sludge collector mechanism rehabilitation is required during the 20-year planning period and will be phased in based on preventive maintenance inspections. The plant needs a walkway between Primary Clarifier #10-11.

The existing primary channel mixing system with aging blowers and coarse bubble diffusers should be upgraded with an energy efficient channel aeration mixing system.

The scum ejector pump system is problematic and improvements in piping, distribution, and scum management are required Scum management is currently restricted to mixing with primary sludge. Upgrades are needed to allow for options for management of scum either to selected Digester B or E or to a separate / removal and treatment considerations

RWU vulnerability assessments have identified that the single primary effluent channel between the primary and aeration tanks is a critical flow channel that in case of need for repair lacks a very costly to construct redundant channel or other means to maintain flow while a critical structural inspection or repair could be implemented. At a minimum, a means for isolating this connecting channel with gates to allow for temporary bypass pumping can provide a means to mitigate this unlikely but potentially catastrophic risk.

Secondary Treatment - Activated Sludge (139 & 185)

The aeration tanks are adequate size and capacity for projected treatment needs since full nitrification is not required. Diffuser performance testing is recommended to evaluate oxygen transfer efficiency of existing ceramic diffusers. Diffuser system replacement planning will only proceed after further evaluation to allow for least life cycle cost aeration control for the next 20 years.

Aging engine driven blower systems should be replaced with new, more efficient blowers, high efficiency electric motors, and new variable frequency drive systems. New blower sizing would be in conjunction with the selected diffuser technology to allow for improved efficiency in aeration process control.

New aeration tank isolation gates and effluent valves will be provided to replace deficient depreciated assets. RAS pump capacity will be upgraded to manage peak flow activated sludge treatment and new RAS flow meters are needed.

Secondary Treatment - Final Clarification (140-145)

Final Clarifiers are of adequate size and capacity for projected treatment needs. The clarifier scum distribution systems should be upgraded to improve scum management. Waste activated sludge management need to be upgraded to design for pumping sludge directly from clarifier #2-4-6.

New isolation gates should be provided in mixed liquor channels to allow for O&M flexibility and channel separation walls can be raised to allow for better peak flow management and effluent quality in the final clarification process. Opportunities to prevent algae growth in final effluent clarifier troughs and channels with covers can be evaluated further for implementation.

UV Disinfection (160)

The existing UV disinfection system is costly to operate and maintain and needs to be replaced with newer energy-efficient UV system technology. A new 3-channel system merits consideration and can potentially provide advantage to direct replacement with a new 2-channel system. This upgrade will provide an improvement in energy efficiency as well as potentially eliminate a hydraulic bottleneck of the two-channel system that limits operation during peak flows.

The effluent metering system will need to be replaced during the next planning period and the effluent sampler building is undersized for all the technology needs in effluent monitoring.

Solids Processing (165)

Solids dewatering systems are performing well, and dewatered biosolids contract management is in place for maintaining efficient management of biosolids.

Minor improvements in the sludge handling systems are recommended. In the process evaluation, a filtrate equalization tank has been identified as an improvement for further evaluation to prevent slug loadings of ammonia and phosphorus in the filtrate return to the influent that occur with current management of belt filter press operations.

Heating and ventilation and plumbing system upgrades are needed in Building 165 to improve efficiency and reduce operation and maintenance costs.

Anaerobic Digestion and Biogas Utilization (170-190)

Digester cover improvements are needed. Digester B cover system is deficient in operation and along with Digester D cover requires further evaluation for rehabilitation/replacement soon. Thickened waste activated sludge (TWAS) piping modifications are needed to improve equalizing distribution of TWAS to the digesters.

In conjunction with aeration system efficiencies gained by replacement of engine-driven blower systems, RWU can improve biogas utilization and reduce energy costs with an upgrade to a new combined heat and power (CHP) system. Payback is based on:

- New IC engine generator technology that is more efficient (both electrical and thermal efficiencies) than current engines.
- Efficient utilization of on-site electrical power generation to reduce need to purchase from utility.
- De-coupling biogas utilization from the aeration process. RWU will be able to fully utilize available biogas that is currently coupled to aeration control needs and air permit restrictions.
- New low-NOx emission combustion systems. RWU can revisit the air permit that has emission limits which currently restricts engine-operating hours.

- Reduction in flaring of gas. With CHP, need for flaring can be reduce to emergency back-up use only. Improved thermal energy recovery from CHP to continue to provide for digester sludge heat and hot water plant heating needs.

General Site and Administrative Facilities (see also Appendix F)

In the 20 years since the last planning period, the following existing facilities are either past their useful life and need to be replaced or upgraded:

- Fire alarm panels
- Protective water system piping
- Back up engines for electrical power
- Existing pipe insulation
- Protected water backflow prevention systems

Civil /infrastructure needs include improvements to:

- Road paving
- Stormwater drainage around Digester B
- Tunnel structures to address leakage
- Air compression systems

Administration Building 110 needs include:

- Roof replacement
- HVAC air handling unit replacement
- Furnishings upgrades
- Communication and electronics upgrades
- Men’s restroom upgrade

Lab Building 125 needs include

- Metal free lab hoods
- Chemical resistant lab flooring
- HVAC upgrades
- Piping and fixture upgrades

Acquisition of CNH Site Property

The existing Racine WWTP site is fully developed and there is no available space to grow either equalization or treatment capacity. RWU has planned for such potential by acquiring neighboring CNH property.

The premium of acquiring land adjacent to the WWTP offers opportunities for increasing treatment capacity (not available on the fully developed site) should future permitting requirements or requested capacity growth in wastewater treatment needs occur. Land can also be utilized for garage and maintenance facilities, solar power generation for the wastewater treatment plant, and additional equalization tankage.

14.0 Implementation Plan

14.1 Conveyance System Improvements Summary

14.1.1 Recommendations

The conveyance system improvements described in this Facilities Plan can be categorized as Near-Term, Mid-Term or Long-Term Conveyance Improvements.

Near-Term Conveyance Improvements consist of projects currently under construction or design. These projects are anticipated to be completed by 2025. Near-Term Conveyance Improvement Projects include the following:

Priority No. 1A:	Pike River Lift Station Phase 1 and Forcemains to Mt. Pleasant/Sturtevant Interceptor (at Old Green Bay Road)
Priority No. 1B:	Abandonment of KR Lift Station and Interconnection to Pike River Lift Station
Priority No. 2A:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 1,2 and 3 from Pike River Lift Station to STH 11
Priority No. 2B:	Tax Increment District 5 (TID 5) interceptor sewer system for the Village of Mount Pleasant. Phase 7 from STH 11 to STH 20
Priority No. 3:	1.0 MG Flow Equalization for Chicory Road Interceptor Capacity Constraint

The total estimated cost of Near-Term Conveyance Improvements, in 2020 dollars, is $79.2 million.

Mid-Term Conveyance Improvements consist of projects anticipated to be completed between 2025 and 2030. Mid-Term Conveyance Improvements Projects include the following:

Priority No. 4:	3.5 MG Flow Equalization Storage at North Park Lift Station. Based on the May 2020 storm events, this project may be considered a higher priority.
Priority No. 5:	Additional 1.5 MG Flow Equalization Storage at Hood's Creek Lift Station. Based on the May 2020 storm events, this project may be considered a higher priority.
Priority No. 6:	11.0 MG Flow Equalization Storage at Pike River Lift Station

The total estimated cost of Mid-Term Conveyance Improvements, in 2025 dollars, is $21.0 million.

Long-Term Conveyance Improvements consist of projects anticipated to be completed between 2030 and 2040. Long-Term Conveyance Improvements Projects include the following:

Priority No. 7:	10.0 MG Flow Equalization Storage at Lift Station 01
Priority No. 8:	Additional 1.0 MG Flow Equalization Storage at Caledonia-Riverbend Lift Station (LS31). Based on the May 2020 storm events, this project may be considered a higher priority.
Priority No. 9:	1.0 MG Flow Equalization Storage at Lakeview Park.
Priority No. 10:	Osborne Boulevard / Kinzie Avenue Interceptor Sewer Upgrade

Priority No. 11:	Miscellaneous Interceptor and Trunk Sewer Upsizing • LaSalle Street Trunk Sewer • Geneva Street Interceptor
Priority No. 12:	1.65 MG Flow Equalization Storage Along Pike River Interceptor Sewer

The total estimated cost of Long-Term Conveyance Improvements, in 2035 dollars, is $47.7 million.

14.2 Conveyance Summary

Modeling of the 2020 Existing conveyance system during the 5-year, 6-hour rainfall event identified capacity constraints located throughout the system. After identifying all existing capacity constraints, numerous modeling runs were conducted to determine the optimum implementation of improvements to the RWU conveyance system to mitigate anticipated constraints under design year 2040 conditions. Some of the improvements proposed in this Facilities Plan serve specific areas, often at the extremities of the conveyance system. Other projects serve a large geographical area and provide a benefit to the overall RWU service area. All projects are intertwined. Improvements in the extremities of the service area affect the core of the conveyance system and vice versa.

This Facilities Plan prioritizes proposed conveyance system improvements and lays out time frames for implementation. Modeling predicts that implementation of the proposed improvements will significantly reduce surcharging of interceptor sewers and the amount of bypassing occurring at Safety Sites during the 2040 Design condition when compared to the 2020 Existing condition.

Infrastructure improvements presented in this Facilities Plan are intended to prevent surcharging of interceptor sewers, discharges of untreated wastewater at Safety Sites and basement backups during the design year storm. The recommended improvements were not based on the allocation of flows contained in the IGA between RWU and each SSR. The hydraulic model developed for this Facilities Plan can be used to determine future conveyance system needs as development occurs.

It is recommended that RWU continue implementation of projects currently under design or construction (Near-Term Projects) and begin preliminary design of projects slated for construction in the 2025 – 2030 time frame (Mid-Term Projects). As Near-Term and Mid-Term projects are completed, the hydraulic model of the conveyance system should be used to fine-tune predictions for the 2030 – 2040 time frame based on actual development of the service area. Long-Term Projects should be implemented if growth/development in the RWU service area occurs as predicted in this Facilities Plan.

14.3 Wastewater Treatment Plant Improvements Summary

Wastewater treatment plant improvements have been identified as three needs categories:

- Deficiencies requiring immediate repair or replacement.
- Issues requiring further evaluation to determine required repair or replacement for those deficiencies
- Future improvements required for either future aging of existing systems and equipment or as future flows and loads increase.

Based on those needs categories the plan has prioritized the recommended alternatives for implementation.

- Priority level “1” indicates priority projects targeted for near-term implementation.
- Priority levels “2” and “3” indicate projects that can be implemented sometime later during the planning period without jeopardizing plant performance.

14.4 Cost Summary

Table 14-1 provides a summary of the estimated construction costs for the recommended improvements. The recommendations are organized into priority levels 1, 2, and 3 as described above. Cost allocations for deficiencies are based on capacities defined in the IGA. Cost allocations for future improvements will

Table 14-1. Racine Wastewater Treatment Plant Facility Implementation Plan
Rev Date 07/1/2020

Facility Plan Alternative Number and Name	Capital Cost Estimate $	NEEDS CATEGORIZATION	IMPLEMENTATION PRIORITY
PRIORITY LEVEL 1	**$ 23,073,000**		
G-1 Upgrade road paving	$ 179,000	FUTURE IMPROVEMENT	1
G-2 Improve stormwater drainage around Digester B (170) between structures 172 and 185	$ 136,000	REMEDY CURRENT DEFICIENCY	1
G-3 Inspect metal manstards on building exteriors which are observed to be deteriorating. Finish deterioration may be warranty issue? Refinish or replace.	$ 166,000	REMEDY CURRENT DEFICIENCY	1
G-4 Upgrade out-of-date Fire Alarm Panels (Qty 6)	$ 89,000	REMEDY CURRENT DEFICIENCY	1
G-5 Upgrade service water plumbing systems	$ 75,000	REMEDY CURRENT DEFICIENCY	1
G-6 Upgrade back-Up engines	$ 143,000	REMEDY CURRENT DEFICIENCY	1
G-7 Upgrade women's locker rooms	$ 49,000	REMEDY CURRENT DEFICIENCY	1
G-139 Structural leakage issue upgrades	$ 36,000	REMEDY CURRENT DEFICIENCY	1
G-162 Outfall condition assessment - STUDY	$ 50,000	FUTURE IMPROVEMENT	1
G-185-8 Inspect site pipe insulation for presence of asbestos to enable identification and cost estimate allowance for removal and replacement	$ 50,000	REMEDY CURRENT DEFICIENCY	1
G-CNH Lakefront Stabilization/ Erosion Protection	$ 360,000	REMEDY CURRENT DEFICIENCY	1
1-30-1 Improve facilities for O&M of EQ Influent Channels	$ 1,100,000	REMEDY CURRENT DEFICIENCY	1
1-40-1 Rehabilitate East Equalization Basin EQ #1	$ 200,000	REMEDY CURRENT DEFICIENCY	1
110-1 Replace roofs on Administration Bldgs	$ 685,000	REMEDY CURRENT DEFICIENCY	1
110-5 Replace HVAC Air Handling Unit -	$ 179,000	REMEDY CURRENT DEFICIENCY	1
120-1 Design and construct truck unloading spill containment and provide hydraulic ramp for truck unloading	$ 300,000	REMEDY CURRENT DEFICIENCY	1
120-3 Upgrade Ferric Chloride Tank to dual containment OH fill piping	$ 160,000	REMEDY CURRENT DEFICIENCY	1
125-2 Replace lab hoods	$ 60,000	REMEDY CURRENT DEFICIENCY	1
125-5 Evaluate piping and circulation of chemicals and gases through lab from loading dock for improved safety and efficiency.	$ 90,000	REMEDY CURRENT DEFICIENCY	1
125-6 Replace air handlers and condensing units with rooftop HVAC (2 ea).	$ 269,000	REMEDY CURRENT DEFICIENCY	1
2-130-1 Replace Grit Screw Conveyors	$ 498,000	REMEDY CURRENT DEFICIENCY	1
3-136-1A Primary Clarifier Mechanism Rehab - YEAR 0-5	$ 850,000	REMEDY CURRENT DEFICIENCY	1
3.136-2 Add walkway between Primary Clarifier Nos.10-11	$ 110,000	REMEDY CURRENT DEFICIENCY	1
3-136-4 Upgrade Plantwide Scum Pumping and Distribution System	$ 130,000	REMEDY CURRENT DEFICIENCY	1
3-136-5 Provide Redundancy for Primary Effluent Channel	$ 110,000	REMEDY CURRENT DEFICIENCY	1
4-139-3 Replace Diffuser System with New Membrane Diffusers and New Piping and Controls	$ 1,840,000	FURTHER EVALUATION	1
4-139-5 Replace RAS distribution flow meters 1 through 5	$ 222,000	FURTHER EVALUATION	1
4-139-6 Add ML Channel Isolation Gates	$ 125,000	REMEDY CURRENT DEFICIENCY	1
4-139-7 Replace aeration tank MLSS butterfly valves	$ 540,000	REMEDY CURRENT DEFICIENCY	1
4-139-8 Replace aeration tank inlet gates	$ 120,000	REMEDY CURRENT DEFICIENCY	1
7-185-1 Upgrade to new high efficiency centrifugal blower system (see 4-139 for various aeration system sizing considerations)	$ 2,200,000	FURTHER EVALUATION	1
5-139-10 Upgrade RAS Pumps #2-#4-#6-#8-#10-#12 to handle peak flow	$ 180,000	REMEDY CURRENT DEFICIENCY	1
5-141-2 Evaluate Means for Pumping Waste Sludge From Final Clarifiers #2, #4, and #6	$ 85,000	REMEDY CURRENT DEFICIENCY	1
5-141-3 Modify Mixed Liquor Inlet Channel/Effluent Separation Wall at Final Clarifiers #1 – #6	$ 16,000	REMEDY CURRENT DEFICIENCY	1
5-145-4 Upgrade Plantwide Scum Pumping and Distribution System (See 3-136-4)	$ 105,000	REMEDY CURRENT DEFICIENCY	1
6-91-1 Upgrade Deficient Sampler Building	$ 60,000	REMEDY CURRENT DEFICIENCY	1

Table 14-1. Racine Wastewater Treatment Plant Facility Implementation Plan
Rev Date 07/1/2020

Facility Plan Alternative Number and Name	Capital Cost Estimate $	NEEDS CATEGORIZATION	IMPLEMENTATION PRIORITY
6-160-3 Upgrade UV Disinfection System to 3-Channel System	$ 4,469,000	REMEDY CURRENT DEFICIENCY	1
8-165-1 Upgrade TWAS piping to digesters	$ 350,000	REMEDY CURRENT DEFICIENCY	1
9-170-1 Inspect, evaluate and rehabilitate Digester "B" Cover	$ 276,000	REMEDY CURRENT DEFICIENCY	1
9-185-1 Biogas Conditioning for H2S (Hydrogen Sulfide Removal)	$ 317,000	FURTHER EVALUATION	1
9-185-1A Biogas Conditioning for IC Engine (Moisture and VOC/Siloxanes)	$ 1,260,000	FURTHER EVALUATION	1
9-185-2A Biogas CHP Engine Generator- Max Month Biogas with One Unit out of Service	$ 4,500,000	FURTHER EVALUATION	1
10-165-5 Improve plumbing supply and drainage on 1st and 2nd floor of Building 165	$ 100,000	REMEDY CURRENT DEFICIENCY	1
13-47-1 Upgrade Dechlorination System	$ 95,000	REMEDY CURRENT DEFICIENCY	1
14-185-3 Upgrade Existing Reciprocating Piston Air Compressors with New Rotary Screw Air Compressors	$ 139,000	FUTURE IMPROVEMENT	1
PRIORITY LEVEL 2	**$ 11,196,000**		
110-2 Replace furnishings and finishes	$ 251,000	FUTURE IMPROVEMENT	2
110-3 Upgrade communications and electronics to support future functionality	$ 69,000	FUTURE IMPROVEMENT	2
110-4 Upgrade lobby men's restrooms	$ 49,000	FUTURE IMPROVEMENT	2
125-3 Replace lab floor with more chemical resistant material.	$ 75,000	FIURTHER EVALUATION	2
125-7 Upgrade Lab Fixtures	$ 54,000	FURTHER EVALUATION	2
G-130-2 Consider Solar Panels on Preliminary Treatment Building	$ 89,000	FUTURE IMPROVEMENT	2
3-135/136-1B Primary Clarifier Mechanism Rehab - YEAR 5-10	$ 940,000	FUTURE IMPROVEMENT	2
3-135/136-3 Upgrade Channel Aeration Mixing . Enviromix Proposal	$ 600,000	FUTURE IMPROVEMENT	2
5-139-9 Replace RAS Flow Meters	$ 160,000	FURTHER EVALUATION	2
5-140-1A Aluminum Covers for Weir Launders- Clarifier 1-9 algae growth prevention	$ 2,300,000	FURTHER EVALUATION	2
5-145-5 Add Final Effluent Reuse as Engine Cooling Water	$ 62,000	FUTURE IMPROVEMENT	2
6-160-4 Replace Final Effluent Flow Meters (60" Magmeters)	$ 440,000	FUTURE IMPROVEMENT	2
6-162-1 – Cover for Effluent Junction Chamber	$ 119,000	FUTURE IMPROVEMENT	2
6-162-2 – Final Effluent Junction Chamber Solar Panels	$ 30,000	FURTHER EVALUATION	2
10-165-4 Upgrade air handling units with heating system using WWTP hot water loop	$ 200,000	FURTHER EVALUATION	2
9-177-1 Replace Digester D Floating Cover-	$ 1,843,000	FURTHER EVALUATION	2
G-CNH Install Solar Panels	$ 3,915,000	FURTHER EVALUATION	2
PRIORITY LEVEL 3	**$ 2,835,000**		
3-135/136-1C Primary Clarifier Mechanism Rehab - YEAR 10-15	$ 875,000	FUTURE IMPROVEMENT	3
10-165-3 Filtrate Equalization Tank	$ 1,960,000	FURTHER EVALUATION	3
TOTAL	**$ 37,100,000**		
G-CNH WWTP- Future Concepts	*$ 48,000,000*	*FURTHER EVALUATION*	*3*

need to be evaluated as part of a Cost of Service Study or similar analysis. It is anticipated that reallocations and negotiations will be required to define future cost distribution.

14.5 Intergovernmental Agreement Cost Allocations

The cost of improving deficiencies in the current plant will be shared by all SSR Parties in proportion to their unique capacity allocations. Future growth capacity needs requested by the Parties will be shared by the requesting Party in proportion to their unique capacities that have been requested. For example, a community that has not requested additional capacity will likely not pay for any costs associated with new growth related improvements. At the time of this Facility Plan, the SSR parties of Mt. Pleasant, Caledonia, and Sturtevant have gone on record requesting additional capacity in this Facilities Planning effort to meet their current or future needs for growth or for excess flow mitigation.

Following acceptance of this Facilities Plan, the Racine Wastewater Commission will engage the services of a consulting firm to properly allocate the costs of deficiencies and new growth onto the proper current SSR Parties or future SSR parties should any request capacity in the near future. The SSR Parties will than have a chance to study the associated costs and decide whether to move forward with all or some of the improvements in a defined time schedule.

14.6 Funding

Each of the SSRs has the responsibility for their own sewer systems. The existing IGA addresses peak flow capacities and actions required should those values be exceeded. Funding for these improvements are eligible for State Revolving Fund (SRF) funding and the SRF program is likely to be a primary source of design and construction monies for these projects.

Potential other funding sources include development program funds and potential federal economic stimulus programs. Ongoing monitoring of government programs should be done to minimize the financial impact of the required improvements.

RWU has not determined whether it would apply for funding under the Clean Water Fund, and readers of this document should not assume that projects recommended in this Plan would necessarily be financed in whole or in part through the Clean Water Fund. Decisions on financing techniques will be made by the Utility as a part of making actual commitments to proceed with portions of this Plan, which in turn are contingent on a number of factors.

14.7 User Charge

Each SSR is responsible for their respective User Charge. Therefore, this plan cannot address the User Charges for the improvements as negotiations regarding capacity ownership and cost allocations is required. Also, the priority recommended improvements may be phased or otherwise scheduled to minimize User Charge impacts.

The fact that facilities are proposed in this Plan shall not be construed as a consent or acquiescence by the City of Racine or the RWU in any service area expansions, and both the City of Racine and the RWU expressly do not give any such consent or acquiescence by issuance of this Facilities Plan. Further, the fact that facilities are proposed in this Plan shall not be construed as a commitment or agreement by either the City of Racine or the RWU to actually construct any such facilities, which will be determined in subsequent decisions independent of, and outside of, this planning process, and which will be dependent on many factors in addition to facility planning, including WPDES permit requirements, ordinances, wastewater service contracts, and other matters. These same contingencies will also affect the timing and extent of preparation of plans and specifications related to specific construction activities, and the Utility may be precluded from proceeding with some or all of the preparation of plans and specifications if these contingencies are not resolved. This bifurcation of the planning process (to examine potential needs and facilities) from the ultimate decisions to construct specific facilities, is a fundamental premise of RWU in issuing this Facility Plan, and is an integral part of this Facilities Plan which RWU will deem accepted if this Facilities Plan is approved.

14.8 Summary of Public Participation

A public hearing on the Facilities Plan Amendment will be conducted. The substance of this facilities plan will be described with an opportunity given for both oral and written statements by the public. The public hearing transcript will be in Appendix I. The wastewater treatment alternatives, monetary and environmental considerations, as well as the findings and recommendations of the facilities plan will be discussed in detail during the public hearing.