City of Waukesha, Wisconsin

Clean Water Plant

Facility Plan Amendment

August 2018

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Acronyms and Abbreviations

CWP	City of Waukesha Clean Water Plant
KPI	key performance indicator
mgd	million gallons per day
mg/L	milligrams per liter
MMSD	Milwaukee Metropolitan Sewerage District
O&M	operation and maintenance
RFDS	Return Flow Discharge Site
TSS	total suspended solids
UV	ultraviolet
WDNR	Wisconsin Department of Natural Resources
WPDES	Wisconsin Pollutant Discharge Elimination System
WWTP	wastewater treatment plant

1. Introduction

In June 2016, the City of Waukesha obtained approval from the Great Lakes–St. Lawrence River Basin Water Resources Council (Compact Council). The City anticipates approval from the State of Wisconsin to draw water from Lake Michigan for the City's water supply and to return flow through the Root River, a tributary to Lake Michigan. The City's Clean Water Plant (CWP) provides wastewater treatment for the discharge to the Fox River in Wisconsin, which is tributary to the Illinois River. With a switch to a Lake Michigan water source, the CWP will also provide treatment for water returned to the Great Lakes–St. Lawrence River basin.

A facilities plan was submitted by the CWP in May 2011 and approved by the Wisconsin Department of Natural Resources (WDNR). The plan developed an overall strategy for wastewater management at the CWP for the next 20 years. The plan met the requirements of federal and state regulations related to water quality in the Fox River. As part of the City's Application for Lake Michigan Diversion with Return Flow, a Facility Plan Amendment (October 2013) was included in the Application to accommodate the return flow infrastructure and to meet anticipated return flow permit limits proposed by the WDNR as part of the Application process. With the Compact Council's approval of the Application, some proposed elements of the CWP infrastructure in the 2013 Facility Plan Amendment have changed.

This facility plan amendment provides information supplemental to the 2011 facility plan and 2013 facility plan amendment, to provide evaluation of alternatives and selection for infrastructure needed to meet permit conditions to return flow to the Root River near 60th Street and Oakwood Avenue in Franklin, Wisconsin. This is the same location as that proposed in the Application and included in the Compact Council approval.

2. Background

Several reports were used in preparing this facility plan amendment. Each is described briefly below and included as an appendix.

Wastewater Treatment Plant Facilities Plan, City of Waukesha, Prepared by Strand Associates, Inc., May 2011 (Appendix A)

This is the most recent comprehensive facility plan for the CWP. It was prepared for developing an overall plan for wastewater management at the CWP for the next 20 years. The plan meets the requirements of federal and state regulations related to water quality in the Fox River and to maintain the significant investment the City has made at the CWP. It is the facility plan that was amended in 2013 and is proposed to be amended by this 2018 Facility Plan Amendment.

Facility Plan Amendment, Wastewater Treatment Plant Improvements for Returning Water Withdrawn from Lake Michigan, City of Waukesha, Prepared by CH2M HILL, October 2013 (Appendix B)

The facility plan amendment presented the alternatives analysis and recommendations for providing CWP effluent return flow to Lake Michigan. The amendment considered pumping facilities at the CWP, return flow conveyance piping to the Lake Michigan watershed, effluent limits, and an environmental assessment. It was included with the approved Application.

City of Waukesha Return Flow Plan (Volume 4 of the Application), City of Waukesha, Prepared by CH2M HILL, October 2013 (Appendix C)

In support of the Application for Lake Michigan Diversion with Return Flow, return flow alternatives were evaluated based on their public health and safety, short and long-term environmental impacts, ability to implement, and cost. This report documents the return flow alternatives evaluation and operational plan for returning water to Lake Michigan with a Lake Michigan water supply. It also summarizes impacts to the Fox River within the Mississippi watershed, because the City's CWP discharge to the Fox River will be reduced by the amount of water returned to Lake Michigan.

Wastewater Treatment Plant Improvements Phase II, Drawings and Specifications, City of Waukesha, Prepared by Strand Associates, Inc., issued January 2, 2015 (Appendix D)

The City prepared and submitted final plans and specifications to WDNR including a new ultraviolet (UV) light disinfection facility and return flow pump station. The facilities were designed to pump the CWP effluent to the Lake Michigan watershed. Although the pump station design was complete and approvable by WDNR, a formal construction approval was not issued by WDNR because the Application was not yet approved.

Antidegradation Evaluation for the City of Waukesha Application for a Lake Michigan Water Diversion with Return Flow, City of Waukesha, Prepared by CH2M HILL, May 2015 (Appendix E)

This memorandum provides an evaluation of the Application as it relates to antidegradation requirements included in Wisconsin Administrative Code Chapter NR 207. Antidegradation requirements of NR 207 are imposed on the return flow because the return flow is a discharge to a different surface water from where the City of Waukesha's CWP currently discharges. The return flow will meet all the effluent water quality limits proposed by the WDNR, some of which are set at or below the water quality criterion. Detailed water quality analysis was completed as part of the Application and found that water quality in the Root River would be improved, for parameters such as phosphorus, with the addition of return flow.

The Application proposal also meets the economic, social, and environmental components of the antidegradation analysis because the proposal supports the increase in employment and economic production levels forecasted by regional planning authorities, it invests in a water supply that is cost-effective and resource efficient over its life cycle, and it corrects a public health problem by avoiding use of groundwater sources with radium levels above regulations for potable water and by providing clean, safe and sustainable water that meets all state and federal drinking water standards in a manner that protects environmental, economic, and social health. The proposal also supports correcting an environmental problem through the improvements in water quality in the Root River, while providing environmental benefits to the Root River and Lake Michigan fisheries.

Wastewater Treatment Plant Final Phosphorus Compliance Alternatives Plan, City of Waukesha, Prepared by Strand Associates, Inc., September 2017 (Appendix F)

The compliance alternatives plan provides alternatives and costs for meeting the final phosphorus water quality based effluent limits for the Fox River. The plan is intended to satisfy Wisconsin Pollutant Discharge Elimination System (WPDES) permit and facility plan requirements related to the recommended improvements for compliance with the effluent limits. The plan applies to the permit condition for the Fox River discharge only. It does not reflect the discharge limits for the dual discharges for the Root and Fox Rivers. However, the technology used to meet the Fox River limits is expected to be the same as that for the Root River.

Assessment of Root River Water Quality Improvements with Return Flow—Draft (3-200 D5), Prepared by Great Water Alliance, December 2017 (Appendix G)

This technical memorandum summarizes the analysis by the City of Waukesha for quantifying the improvements to the Root River water quality that result from the return flow discharge. Also included in the analysis are phosphorus treatment technology options and costs to meet various phosphorus limits at the City's wastewater treatment facility CWP.

Waukesha Great Lakes Water Supply Route Study: Oak Creek—Draft (4-100 D1), Prepared by Great Water Alliance, January 2018 (Appendix H)

The route study identifies a preferred route alternative that would be used for return flow to the Root River through the return flow pipeline. The study includes the development of six route alternatives and a scoring evaluation based on economic and non-economic criteria.

Waukesha Great Lakes Water Supply WDNR Supplemental Environmental Impact Report—Draft (3-140 D2), Prepared by Great Water Alliance, March 2018 (Appendix I)

The report provides updated environmental impact information from that submitted during the Application for the water supply and return flow pipelines and facilities.

Waukesha Clean Water Plant Return Flow Dissipative Cooling Application Analysis—Draft (3-200 D7) Prepared by Great Water Alliance, December 2017 (Appendix J)

The report supports the WPDES application to return flow to the Root River for effluent temperature discharge requirements for a dissipative cooling evaluation.

3. Existing Facility Plan: Unchanged Items

In preparing this document, the previous elements of the approved facilities plan and amendment were reviewed to determine whether they needed revisions. It was determined that most of the items in those plans remain adequate and are not modified or changed with this 2018 facility plan amendment. The facility plan and facility plan amendment included considerable background information related to service areas, flow and load projections and evaluations of existing and future treatment facilities. Accordingly, the following items remain unchanged.

3.1 Existing Wastewater Conveyance Facilities

The facility plan developed projections of infiltration/inflow in the collection system as needed to plan for peak flow management at the CWP. The facility plan amendment does not modify or change the evaluations and recommendations presented in the facility plan.

3.2 Wasteload and Flow Forecasts

The facility plan developed wastewater flow and loading projections for evaluating future treatment facility capacity and needs. Data from current conditions were used together with population forecasts and development trends to project design flows and loads for the CWP through 2030. This 2018 facility plan amendment does not modify or change the evaluations and recommendations presented in the facility plan.

3.3 Evaluation of Existing Facilities

The facility plan evaluated the ability of the CWP unit processes to treat projected future flows and loadings while meeting the anticipated future requirements of the WPDES permit. The plan also evaluated the compliance of the existing facilities with the WDNR NR110 design standards and other applicable design criteria. The evaluation focuses on the rated capacity, age, reliability, and other factors related to operating and maintaining the facilities. The 2018 facility plan amendment does not modify or change the evaluations and recommendations presented in the facility plan.

3.4 Treatment Process Alternative Evaluations

The facility plan included alternatives evaluations for the following unit processes:

- Preliminary treatment and influent pumping
- Primary clarification
- Roughing filters
- Activated sludge system
- Final clarification
- Coagulation basins and chemical feed systems
- Effluent filtration
- UV disinfection and effluent reaeration
- Biosolids management and biogas utilization

Recommended improvements to these unit processes that have been implemented include phosphorus treatment improvements to the chemical feed systems, UV disinfection and effluent reaeration, and improvements to the biosolids management such as installation of a new digester, biogas storage, centrate equalization, and solids dewatering. The CWP has been monitoring biogas production and continues to evaluate options for use of biogas.

This 2018 facility plan amendment does not modify or change the evaluations and recommendations presented in the facility plan or 2013 amendment, except for treatment processes that are part of the return flow plan. These include phosphorus removal, treated effluent return flow pumping and conveyance, reaeration at the Root River discharge site, and the return flow outfall to the Root River.

4. Water Quality and Discharge Permit Requirements

No changes in design flows from those documented in the 2011 CWP Facility Plan are planned for the CWP. The permitted average annual design flow of the CWP is 14 million gallons per day (mgd). The 2011 CWP Facility Plan projected a year 2030 average annual design flow of 11.65 mgd. All CWP effluent will continue to be discharged to the Fox River until part of the flow is discharged to the Root River after a Lake Michigan water supply is commenced.

4.1 Design Flow to the Root River

Based on the Diversion Approval, return flow to the Root River will provide a water balance based on the previous year's average daily water demand. Between 2010 and 2017, the City's annual average water demand varied from 5.83 mgd in 2017 to 6.97 mgd in 2011. It is possible that water conservation measures together with high precipitation years could result in a year with less than 5.83 mgd demand, however 5.83 mgd was the lowest annual average water demand observed in recent past. While these provide historic water demand, escalating the water demand accounting for growth in the City and to be consistent with the Diversion Approval, a future annual average water demand of 8.2 mgd is used as a design value.

Analyses were completed using the historic water demands and CWP flows between 2010 and 2017 to evaluate the return flow pumping schemes and the City's ability to meet a daily return flow of the previous year's average daily water demand. The results of this analysis were used to escalate the return flow pumping requirements for the future 8.2 mgd design water demand and for estimating an annual average, maximum day, and 7-day rolling average return flow rates. Section 5.2 discusses the return flow pumping requirements. The results for the annual average, maximum day, and 7-day rolling average return flows are as follows:

- Annual average return flow rates from historic conditions range between 100 and 113 percent of the previous year's average water demand. Applying these percentages to the future water demand of 8.2 mgd, to escalate the return flow pumping requirements to meet the future water demand, results in a design annual average return flow rate between 8.2 mgd (100 percent of 8.2 mgd) and 9.3 mgd (113 percent of 8.2 mgd).
- Maximum day return flow rates from historic conditions ranged from 100 to 135 percent of the previous year's average daily demand. Applying these percentages to the future water demand of 8.2 mgd results in a design maximum day return flow rate between 8.2 and 11.1 mgd.
- The 7-day rolling average return flow rate from historic conditions ranged from 100 to 124 percent of the previous year's average daily demand. Applying these percentages to the future water demand of 8.2 mgd results in a design 7-day rolling average return flow rate between 8.2 and 10.2 mgd.

4.2 Design Flow to the Fox River

The permitted average annual design flow of the CWP is 14 mgd. The 2011 CWP Facility Plan projected a year 2030 average annual design flow of 11.65 mgd. CWP annual average effluent flow has averaged roughly 9.4 mgd in recent years and was as low as 8.18 mgd in 2015. Historically 100 percent of the effluent has discharged to the Fox River. The Diversion Approval has impacts on the Fox River because return flow to the Root River will decrease CWP flow to the Fox River by an equal amount. Based on the historic water demands noted above in Section 4.1, flow to the Fox River initially would decrease between 5.83 mgd (100 percent of 5.83 mgd water demand) to 7.88 mgd (113 percent of 6.97 mgd water demand) over a calendar-year period. Applying the 113 percent to the design 8.2 mgd water demand could result in as much as a 9.3 mgd annual average flow diverted away from the Fox River in the future.

An upper design flow to the Fox River can be estimated using the permitted design flow for the CWP and assuming a low return flow to the Root River. It is possible that water conservation measures together with high precipitation years where water demand would be low, could result in a year with less than 5.83 mgd water demand. For example, if the annual average water demand of the previous year were as low as 5 mgd and the current year CWP flow is the permitted design average flow of 14 mgd, then the upper range of the design average flow to the Fox River would be 9 mgd (i.e., 14 mgd minus 5 mgd).

Conversely, a lower design flow to the Fox River can also be estimated. Based on current historical annual average CWP flow of 9.4 mgd and a decrease between 5.83 mgd and 7.88 mgd, initial effluent flow to the Fox River may be between 1.5 and 3.6 mgd. Annual average flow to the Fox River could be even less than this in a low flow year like 2015 when CWP effluent averaged 8.18 mgd. For example, if flow to the Fox decreased 7.88 mgd when CWP flow was this low then the annual average flow to the Fox River would be 0.3 mgd.

Combining the lower and upper ranges yields an approximate range for design annual average flow to the Fox River between 0.3 to 9 mgd. Because return flow is not expected to commence until roughly 2023, which is near the end of the next 5-year permit term, the CWP design average flow of 14 mgd should be used for Fox River effluent limit calculations. This is consistent with past Fox River limit calculations.

Dry and wet weather flows exceeding the flow diverted to the Root River will continue to be discharged to the Fox River. Peak day and peak hour flows to the Fox River are anticipated to be reduced by no more than the diversion to the Root River, and could be unchanged from the CWP facility plan design peak flows to the Fox River if the return flow pump station was not being operated, such as for maintenance, CWP operation considerations, or in unforeseen circumstances. Consequently, peak CWP flows to the Fox River as reported in the CWP facility plan should continue to be used where relevant.

4.3 Fox River Water Quality Based Effluent Limits

No changes or revisions are planned to the CWP facility plan that documents future regulatory requirements for discharge to the Fox River and other CWP operations. As stated in the CWP facility plan and section 3.2.1.6 of the WDNR permit, the Fox River phosphorus limit will be 0.075 milligrams per liter (mg/L) as a 6-month average. There are no significant changes anticipated in the Fox River discharge permit, currently within renewal with the WDNR.

4.4 Root River Water Quality Based Effluent Limits

Water quality based effluent limits for effluent discharged to the Root River are documented in the 2013 facility plan amendment and preliminary draft limits were calculated by the WDNR during the Application. The WDNR used assumed values for the 7-day average 10-year low flow (7Q10), and 7-day average, 2-year low flow (7Q2) in the limit calculations. A 13 mgd return flow rate was used based on early variations in return flow management. These river flow and return flow values have since been updated where the U.S. Geological Survey has updated river flows, resulting in an increased river flow, and return flow rates have decreased as noted in above sections. These two items could result in higher final effluent limits expected for the Root River. This would result in conservative facility planning because this 2018 Facility Plan Amendment will retain the preliminary calculated values documented in 2013, except where noted.

4.4.1 5-Day Biochemical Oxygen Demand

The BOD_5 preliminary calculated effluent limits are slightly stricter than the current effluent limits, but the limits are above the CWP performance. Consequently, no CWP improvements are expected for compliance with BOD_5 limits.

May–October	5.8 mg/L, weekly average
November–April	10 mg/L, weekly average based on not being greater than current BOD_5 limits for the Fox River

4.4.2 Dissolved Oxygen

The preliminary calculated dissolved oxygen (DO) effluent limits are slightly stricter than the current effluent limits. The limit is anticipated to be 7 mg/L daily minimum effluent DO level based on the DO used for determining limitations for BOD_5. The CWP has installed new reaeration facilities to meet discharge requirements to the Fox River, however additional modeling completed since the Application has demonstrated that reaeration will be required near the outfall to the Root River. Consequently, facilities are included in this 2018 Facility Plan Amendment for Root River return flow reaeration.

4.4.3 Total Suspended Solids

The preliminary calculated total suspended solids (TSS) limit is 10 mg/L as a weekly average. This is the same as the current total suspended solids limits to the Fox River and is well above the CWP performance and the performance needed to meet effluent phosphorus limits. Consequently, no CWP improvements are anticipated for compliance with total suspended solids limits.

4.4.4 Ammonia-Nitrogen

A preliminary calculated daily maximum ammonia-nitrogen limit was calculated the same as for the Fox River, which is 24 mg/L, applicable in the months of November through April. The preliminary calculated weekly and monthly limits for discharge to the Root River (Table 1) are similar to the current Fox River permit limits. The final effluent limits are anticipated to be less strict than these and very similar to the limits within the current Fox River permit because the return flow rates are less and Root River flow rates are greater than those used by WDNR in the draft limit calculations included in the Application. The CWP has completed biosolids improvements, including centrate equalization, which have improved the effluent ammonia-nitrogen quality. Consequently, no CWP improvements are anticipated for compliance with ammonia-nitrogen limits.

Table 1. Average Ammonia-Nitrogen Limits

Months	Weekly	Monthly
May–September	3.2 mg/L	1.4 mg/L
October	9.3 mg/L	3.8 mg/L
November–March	10.5 mg/L	4.3 mg/L
April	6.5 mg/L	2.6 mg/L

4.4.5 Fecal Coliform

Administrative code NR 210 specifies an effluent standard of 400 counts per 100 mL as a maximum monthly geometric mean. Since the Root River is not classified as a public water supply, this requirement would apply for the months May through September. The CWP replaced the disinfection system in 2016 to meet these criteria for the Fox River discharge. Consequently, no CWP improvements are anticipated for compliance with fecal coliform limits for the Root River. The WDNR is developing E. coli standards and the CWP is anticipated to meet future limits with the 2016 disinfection improvements.

4.4.6 Total Phosphorus

The Root River has an impairment because phosphorus concentrations are above the water quality criterion of 0.075 mg/L. Because of the impairment, a limit of 0.075 mg/L, equal to the water quality criterion, as a 6-month average (May–October and November–April averaging periods), and 0.225 mg/L monthly average, were deemed appropriate as documented in the 2013 facility plan amendment (Appendix B). An evaluation was conducted to evaluate whether lower return flow phosphorus concentrations could improve Root River water quality to satisfy requirements of the WDNR technical review completed during the Diversion Approval and NR 217.13(b). An Assessment of Root River Water Quality (Appendix G) dated December 15, 2017, was submitted to the WDNR evaluating in-stream total phosphorus concentration and in-stream chlorophyll *a* for a range of CWP effluent total phosphorus from 0.075 mg/L to 0.044 mg/L. The evaluation demonstrated only marginal reductions in in-stream total phosphorus and even smaller reductions in in-stream chlorophyll *a* as CWP effluent phosphorus was reduced from 0.075 mg/L to 0.044 mg/L. The evaluation further demonstrated that below 0.060 mg/L, the improvement diminished more significantly and the costs greatly increased. Providing treatment below a 0.060 mg/L effluent limit is not cost-effective. Furthermore, the treatment technology has not been demonstrated to meet such low limits reliably. Therefore, a phosphorus criterion of 0.060 mg/L 6-month average (May–October and November–April averaging periods) and 0.18 mg/L monthly average are anticipated. The compliance date is expected to be 2022 based on a 9-year compliance schedule and the schedule for transitioning to Lake Michigan water supply and Root River discharge.

The CWP has extensively evaluated phosphorus treatment technologies as part of the Phosphorus Compliance Plans required in the current permit. The treatment alternatives to provide effluent quality for meeting a 0.060 mg/L limit in the Root River are included in this 2018 facility plan amendment. The tertiary treatment technology and compliance date for meeting the Root River limit will be the same for meeting a Fox River discharge limit of 0.075 mg/L.

4.4.7 Mercury

The CWP has been successful in its mercury minimization program where effluent levels have been below the preliminary calculated monthly limits of 1.3 nanograms per liter for many years. Consequently, no CWP improvements are needed or included in this 2018 facility plan amendment.

4.4.8 Copper

Copper effluent limits are not necessary or proposed for the Root River. Consequently, no CWP improvements are anticipated in this 2018 Facility Plan Amendment.

4.4.9 Chloride

A Final Chloride Report dated December 22, 2017, was submitted to the WDNR documenting alternatives to achieve compliance with anticipated water quality based effluent limits ranging from 395 mg/L to 400 mg/L as a weekly average. Removal of chlorides at the CWP was not considered feasible because chlorides are dissolved ions that cannot be removed using cost-effective treatment technologies. Processes capable of removing chlorides have not been applied to wastewater for chloride compliance because they would require a prohibitive capital investment, have a high annual electric cost, and generate a large volume of reject stream that would require disposal. Therefore, chloride removal technologies are not evaluated in this 2018 facility plan amendment.

The recommended alternative involves optimizing residential, commercial, and industrial water softeners before the switch to the Lake Michigan water supply and a second phase of adjusting the source water hardness on water softeners after the switch. It is expected that a significant reduction in CWP effluent chloride concentration can be made before the switch to the Lake Michigan water supply, but consistent compliance with projected weekly average chloride limit is not expected until the second phase of softener adjustments.

4.4.10 Temperature

A dissipative cooling analysis and request form was completed as part of the December 2017 CWP permit renewal application (Appendix J). The analysis concluded that dissipative cooling is an acceptable means for addressing thermal concerns in the Root River. Building facilities to cool the effluent, such as cooling towers, is not needed to protect the biology of the Root River and it would be cost prohibitive. Consequently, no CWP improvements are included in this 2018 facility plan amendment.

4.4.11 Antidegradation

The City completed an antidegradation evaluation (Appendix E) as part of the Application and Diversion Approval. This analysis concluded that the Application meets the economic, social, and environmental basis (administrative code NR207.04(c)) for antidegradation because it supports the increase in employment and economic production levels forecasted by regional planning authorities, it invests in a water supply that is cost-effective and resource efficient over its life cycle, and it corrects a public health problem by avoiding use of groundwater sources with radium levels above regulations for potable water and by providing clean, safe and sustainable water that meets all state and federal drinking water standards in a manner that protects environmental, economic, and social health. The Application also supports correcting an environmental problem by improving water quality in the Root River while providing environmental benefits to the Root River and Lake Michigan fisheries.

Administrative code NR 207.04(d) requires the new discharge to evaluate five control alternatives that that are relevant to the discharge and could prevent the discharge of an indicator parameter. Indicator parameters proposed by WDNR include mercury, ammonia, chloride, copper, temperature and TSS.

The five control alternatives include using conservation measures, recycling measures, construction of treatment processes or operational changes, source reduction measures and other pollution minimization alternatives. Of the five alternatives, three are relevant to some parameters of the return flow discharge, including using conservation measures, source reduction measures, and treatment processes or operational changes.

Conservation Measures

The City has an aggressive water conservation program that minimizes water use in the City. This in turn minimizes influent flows and loadings to the CWP and supports minimizing effluent discharges.
The water conservation program is the most aggressive in the State, it was a critical component of the Diversion Approval, and it is a critical program in the City because the success of the program will allow the City to provide a safe and reliable drinking water while operating within the constraints of the Diversion Approval. The water conservation program continues to be adapted, with WDNR approval, as the City implements the plan and strategic investments are implemented to maximize their impact on reducing water use. For this reason, conservation is implemented to the extent it is feasible and across the entire City water service area. Any potential additional conservation is not cost-effective.

Source Reduction Measures

Source reduction programs within the City are specifically implemented for copper (through corrosion control in the drinking water), chlorides, and mercury. These programs have been successful where a chloride reduction program is under way, mercury concentrations are below the water quality criterion, and copper concentrations are not high enough to be of concern in the CWP effluent where no effluent limits are proposed by WDNR. The chloride and mercury source reduction programs are some of the most aggressive in the State and have been approved by the WDNR during prior WPDES permit applications for the Fox River. The source reduction programs minimize effluent loadings and include measurable steps that continue to reduce source loading to the CWP and in the CWP effluent. The primary purpose of the source reduction programs is to minimize loadings to the CWP at the source, because downstream treatment alternatives at the CWP are very expensive, energy intensive and therefore, have not been installed on municipal wastewater treatment plants in the State.

Treatment Processes and Operational Changes

Dissipative cooling will provide the necessary controls for temperature in the Root River (see Section 4.4.10), where temperature limits are not anticipated to be necessary. Even if necessary, constructing temperature facilities for the Root River discharge, such as chillers, is cost-prohibitive and has not been implemented in the State for a municipal wastewater discharge.

Ammonia at the CWP is minimized because the CWP is a nitrifying treatment plant and the CWP has recently completed a centrate storage facility as part of the digester and solids handling improvement projects. This was completed after the 2013 Facility Plan Amendment and the WDNR draft permit limits. The centrate storage facility equalizes digester centrate to reduce spikes during recycling within the CWP. This has resulted in a significant drop in ammonia spikes and very consistent effluent ammonia concentrations. Further reductions of ammonia may occur, because addition oxidation may occur in the long return flow pipeline. Treatment alternatives could include a fixed film process downstream of the secondary treatment, however the technology is very expensive, the CWP is constrained on space in the location of the treatment operations, and there are no other known treatment plants in the State that have this process when ammonia levels are as low as the CWP's. Consequently, additional treatment alternatives for ammonia are not cost-effective.

The CWP historically has had very low effluent TSS concentrations. This is primarily because the CWP has effluent filters, and to achieve low phosphorus concentrations, very low TSS is needed. Although preliminary calculated TSS effluent limits are strict, it is anticipated that the tertiary treatment necessary for compliance with the lower Root River phosphorus limit (0.060 mg/L) will result in a low effluent TSS concentration. In fact, the CWP TSS effluent consistently has quality much better than the preliminary calculated Root River TSS limits. Additional facilities to be constructed for TSS treatment, beyond those that will be required for phosphorus treatment, would include reverse osmosis or membranes. This alternative is very expensive, is energy intensive, and would not significantly improve Root River water quality. Consequently, a treatment alternative specific for TSS would not be cost-effective. This is consistent with other actions within the State, whereby total maximum daily loads for phosphorus have required municipal treatment plants to have very low TSS limits, instead of TSS total maximum daily loads driving low effluent limits.

Treatment alternatives for copper, mercury, and chlorides could include reverse osmosis or membranes, but these technologies are very expensive and energy intensive, and they have not been installed for chlorides or mercury discharges at municipal wastewater treatment plants in the State. A membrane system produces a highly concentrated liquid reject byproduct that must be disposed of. This would add to the operational complexity and costs. For these reasons, a treatment alternative is not cost-effective.

4.5 Effluent Sampling Location

The primary sampling location for both the Fox and Root River discharges will be the current flow proportional composite sampling location in the effluent chamber after the UV disinfection system and before the Parshall flume. This sampling location (Figure 1) is representative of the effluent characteristics for both discharge locations. Grab samples collected for the Fox River discharge will continue to be collected from the effluent drop box downstream of the Parshall flume. Grab samples collected for the Root River discharge will be collected at the composite sampling location, except for DO and temperature.

During the first permit term, DO and temperature will be monitored at the Root River discharge site after reaeration. The location of reaeration at the Root River discharge site is shown in the Treatment Process Alternative Evaluations section (Figure 10). It is expected that once a correlation has been demonstrated between the effluent temperature at the CWP and the effluent temperature at the Root River discharge site that temperature monitoring at the Root River discharge site may be eliminated in subsequent permits. It is also expected that consistent demonstration of compliance with the DO limit using a static reaeration structure will allow the elimination of DO monitoring at the Root River discharge site in subsequent permits. With a reduction in effluent monitoring at the Root River discharge site, all compliance sampling and monitoring would be completed at the CWP.

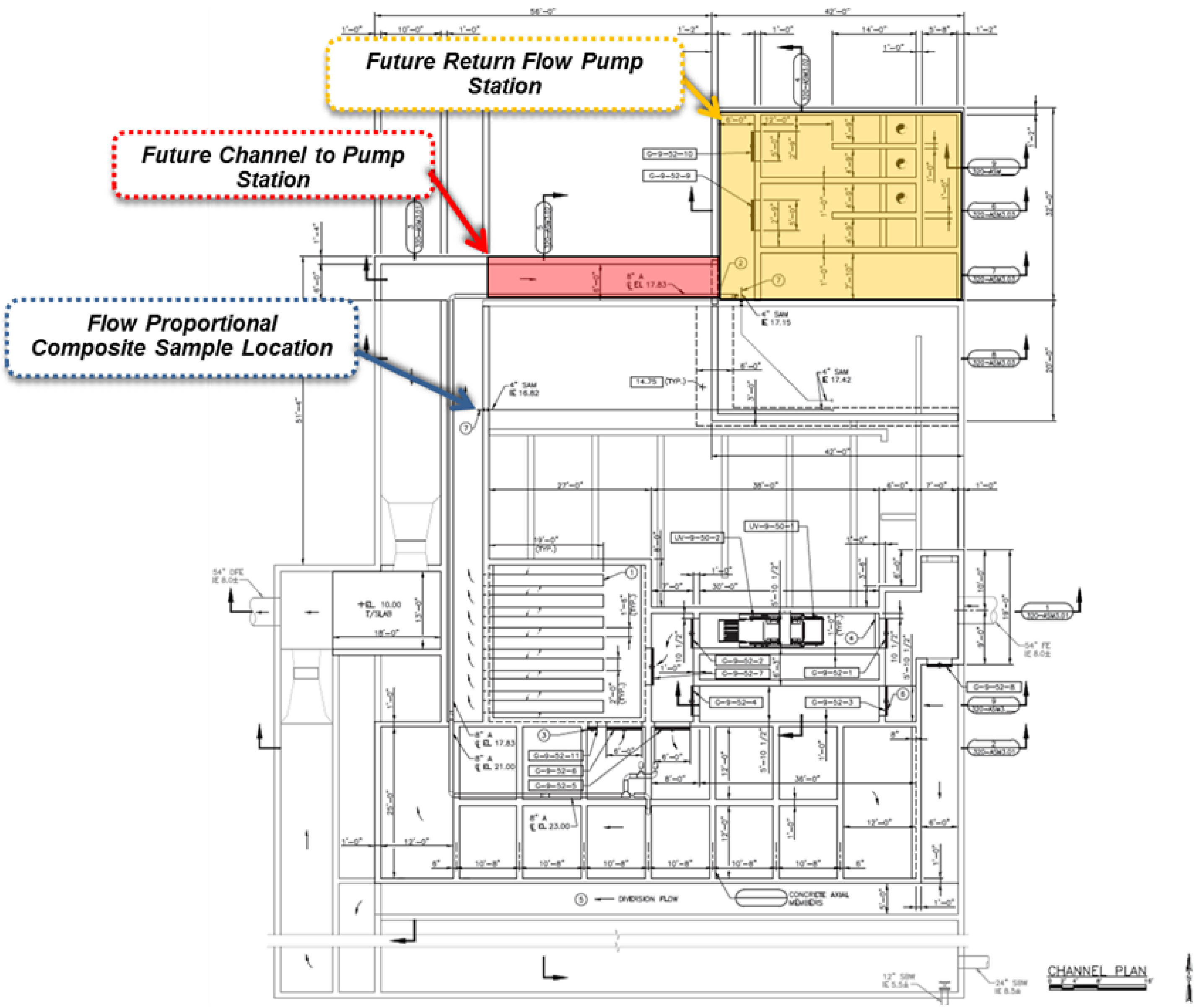

Figure 1. Effluent Sampling Location (Background image provided by Strand Associates.)

4.6 Effluent Flow Measurement

Effluent flow to the Root River will be measured by flowmeter at the CWP downstream of the split between the Fox and Root River discharges. Effluent flow to the Fox River will be measured with the existing or a new flowmeter to the Fox River, or by calculating the difference between an upstream flowmeter and the new return flowmeter. The Fox River metering will be determined during detailed design of the facility improvements and site layout.

5. Treatment Process Alternative Evaluations

This section discusses alternatives development and evaluation for treatment processes that are part of the return flow project. The treatment processes are phosphorus removal, treated effluent return flow pumping and conveyance, reaeration at the Root River discharge site, and the outfall.

5.1 Phosphorus Removal

5.1.1 Design Criteria for Fox River Discharge

As described in the facility plan and refined through the 2017 Final Phosphorus Compliance Alternatives Plan (Appendix F), a new 15 mgd tertiary treatment facility was proposed for compliance with a 0.075 mg/L 6-month average and 0.225 mg/L monthly limit for discharge to the Fox River.

5.1.2 Alternatives Analysis for Fox River Discharge

The facility plan evaluated expansion of the existing dual media filtration facility, membrane filtration, Blue PRO® chemically impregnated fluidized sand filtration, and ACTIFLO® ballasted flocculation and settling. Expansion of the dual media filtration was ruled out because, although expansion could solve the hydraulic capacity limitation of the existing filters, it was deemed incapable of reliably meeting the 0.075 mg/L 6-month average permit limit. Membrane treatment was ruled out because its estimated life-cycle cost was almost double that of ACTIFLO. ACTIFLO was recommended over Blue PRO because ACTIFLO had a lower net present worth due to lower capital costs and slightly lower operating costs. Another advantage of ACTIFLO is a smaller tank footprint and building size compared to those of Blue PRO. The facility plan noted that because phosphorus compliance technologies and strategies continue to evolve, additional evaluation of alternatives should occur before final selection.

The 2017 Final Phosphorus Compliance Alternatives Plan evaluated Blue PRO reactive filtration, ACTIFLO, Veolia Disk Filtration, CoMag®, and the CLEARAS Water Recovery System. Watershed alternatives were also evaluated and ruled out for the reasons noted.

5.1.3 Cost Estimates for Fox River Discharge Alternatives

Table 2 summarizes the costs that were adapted from the 2017 Final Phosphorus Compliance Alternatives Plan submitted to the WDNR to adjust for the current discount rate of 3.875 percent published by the WDNR and to provide costs in May 2018 dollars. All costs assume meeting a 0.075 mg/L 6-month average limit.

Table 2. Cost Comparison for CWP Phosphorus Removal Alternatives (0.075 mg/L limit)

	Blue PRO	ACTIFLO	CoMag	Rapid Mix, Flocculation, Disc Filtration
Total Capital	$12,680,000	$9,565,000	$7,889,000	$8,211,000
Operation and Maintenance (O&M) ($/yr)	$512,000	$555,600	$529,000	$658,000
20-Year Present Worth	$19,256,000	$16,840,000	$14,815,000	$16,926,000

Present worth was not developed for CLEARAS because of the high capital cost and uncertainty regarding pricing of the resulting biomass, which would have a substantial impact on the total present worth of the alternative. Veolia Disc Filtration, although close in cost to ACTIFLO, was not recommended for further consideration based on its slightly higher present worth. The two ballasted flocculation and settling alternatives, CoMag and ACTIFLO, had the lowest present worth costs. Therefore, ballasted flocculation and settling was the recommended alternative. The City is pilot testing CoMag to refine facility and chemical usage cost estimates.

5.1.4 Design Criteria for Root River Discharge

The facility plan and Final Phosphorus Compliance Alternatives Plan selected a 15 mgd capacity for the ballasted flocculation and settling system. The typical diurnal peak flow was assumed to be 15 mgd during average daily flow. A hydraulic peaking factor will be considered during detailed design, and it is not expected to impact facility cost.

As noted in Section 4, the anticipated effluent phosphorus limit for the Root River is a 0.060 mg/L 6-month average (May–October and November–April averaging periods) and a 0.180 mg/L monthly average. Based on the results of an ACTIFLO pilot at the CWP, CWP performance targeting low effluent phosphorus over the last couple of years with ferric chloride addition and effluent filtration, laboratory analyses of soluble nonreactive phosphorus, and jar and CoMag pilot testing by Evoqua, the same technology—ballasted flocculation and settling—is recommended for the 0.060 mg/L 6-month average limit anticipated for the Root River discharge.

5.1.5 Cost Estimates for Root River Discharge Alternatives

The capital cost estimate given in Table 2 would not be expected to change because of a 0.060 mg/L limit versus the 0.075 mg/L limit that costs were based on, but the chemical and associated sludge production costs are expected to be greater for the 0.060 mg/L limit. The additional costs were estimated and are documented in the Assessment of Root River Water Quality Improvements with Return Flow report (Appendix G). The estimated additional annual operating cost was $170,000 per year. This equates to a 20-year present worth of an additional $2,852,000.

5.1.6 Environmental

Environmental considerations for the phosphorus facilities are documented in the Environmental Impact Report (Appendix I). The facility plan and Final Phosphorus Compliance Alternatives Plan include the phosphorus facilities to meet the permit limits for the Fox River. The same facilities will be used for the Root River. Environmental considerations for the phosphorus facilities were included in the facility plan and are all within the developed areas of the CWP site. Additional environmental analyses are not needed for this facility.

5.2 Treated Effluent Return Flow Pumping

5.2.1 Previous Evaluations of Alternatives

Eight alternatives were considered for providing return flow to the Lake Michigan basin as part of the 2013 Facility Plan Amendment. Two alternatives were considered that included return flow to the Milwaukee Metropolitan Sewerage District (MMSD) with an equalization tunnel and pump station located outside the CWP site. These alternatives were not evaluated in detail because of significantly greater costs and operational issues. The remaining alternatives considered a pump station only at the CWP because City-owned land is available, and it provides the least challenges for operation, maintenance, and implementation (compared to an offsite pump station location). The Application proposed, and the Diversion Approval granted, a return flow alternative that included a pump station at the CWP.

5.2.2 2014 Pump Station Design

After the 2013 Facility Plan Amendment was completed, a detailed design of the pump station was performed in 2014 whereby design documents were submitted and approved by WDNR as part of the UV upgrades design (Appendix D). The pump station design was complete and approvable by WDNR, but a formal construction approval was not issued because the Diversion Application was not yet approved. Since the Diversion Approval, the pump station design concept is still relevant to the return flow requirements and it is the basis of this 2018 facility plan amendment. Figure 2 is a plan of the 2014 pump station design.

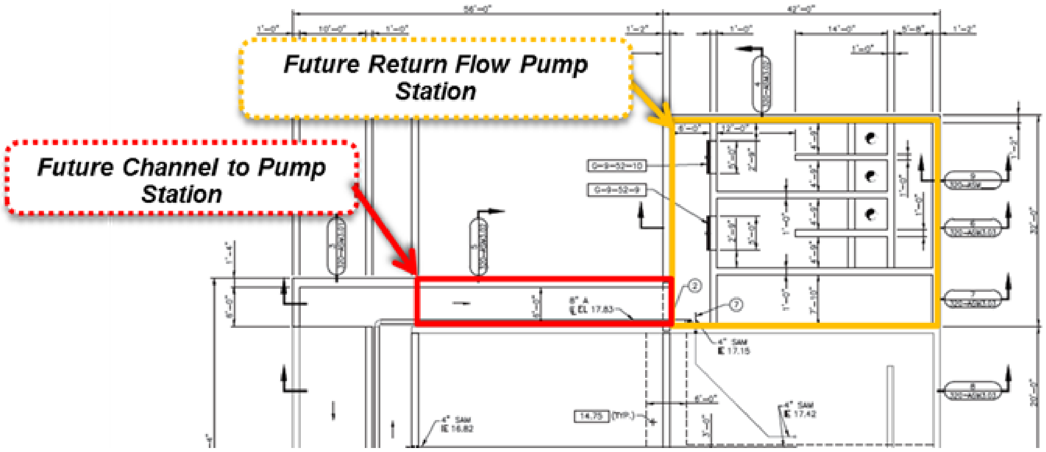

Figure 2. Pump Station Design Plan—2014 (Background image provided by Strand Associates.)

5.2.3 Pump Station Design Criteria

Return Flow Rates Assumed in the 2013 Facility Plan

The 2013 facility plan amendment and the Application stated the following regarding the return flow management plan:

- “Discharge to the Fox River would only occur when wastewater treatment plant (WWTP) flow exceeds 16.7 mgd, as discussed in The City of Waukesha Return Flow Plan (Volume 4 of the Application).”
- “When WWTP flow is 16.7 mgd or less, the pump station would pump all the flow. When WWTP flow exceeds 16.7 mgd, the excess flow would crest the channel to the Fox River outfall.”

The 16.7 mgd pump station capacity was based on maximum day water demand, which was the assumed return flow management plan at the time.

Return Flow Rates Assumed in the 2014 Return Flow Pump Station Design

The required return flow rate had not been determined as of the 2014 design. Because of the uncertainty in required pump station capacity, the pumps were not included in the 2014 design and the dimensions of the 2014 pump station design were conservatively sized to accommodate a pumping rate of up to 26.2 mgd.

Updated Return Flow Rates

Effluent flow rates from the CWP were simulated between 2011 and 2017 to evaluate how various return flow management scenarios could affect return flow rates and meeting Diversion Approval requirements. The 15-minute flow data from 2012–2014 and 2017 were nearly complete, and they offered various flow conditions from the recent past. For example, 2012 was a very dry year, during which meeting the Diversion Approval requirements would have been more challenging. The relative significance of the 2012 drought is demonstrated by the following points:

- 2012 was the 12th driest year since 1895 in Wisconsin according to the year-to-date precipitation total through September 2012 (source Midwest Regional Climate Center).
- June precipitation in much of southeastern Wisconsin, including Waukesha County, was 10 to 25 percent of the mean calculated for the period of 1981 to 2010 (source Midwestern Climate Center).
- 2012 was comparable to a drought cycle last experienced in the 1950s (source National Oceanic and Atmospheric Administration).

The remaining years that were analyzed were not extreme, and 2017 represents the most recent data for evaluating how the CWP would perform under various return flow management scenarios. The CWP did not have complete 15-minute flow data for 2011 and 2015–2016 because of age of the data (2011), construction at the CWP, and CWP changes in flow logging software (2015–2016). Thus, these 3 years were not considered in analyses.

Using the 2012–2014 and 2017 data set, required maximum instantaneous return flow rates (based on 15-minute flow records) were calculated to be 6.9 mgd in 2017 to 11.0 mgd in 2014. Escalating these flow rates for anticipated future growth, the maximum instantaneous return flow rates to meet the Diversion Approval were calculated as 9.3 to 12.6 mgd. For the purposes of this amendment, a maximum return flow rate of 12.6 mgd is used.

Pump Size and Wet Well Configuration Considerations

The 2014 pump station design provided space for four pumps and two isolatable wet wells (Figure 3). The updated range of return flow rates being considered as part of this facility plan amendment does not significantly affect the structure configuration, size and function.

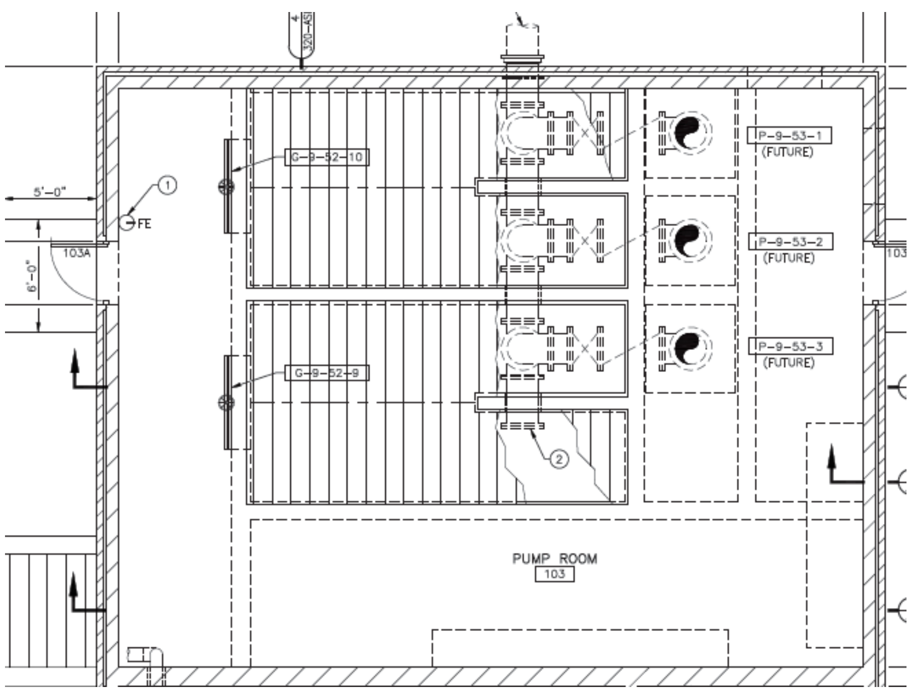

Figure 3. Return Flow Pump Station (*Image provided by Strand Associates)*

One approach with a four-pump pump station would be to design four equal capacity pumps with one serving as a spare. This approach would require three 4.2 mgd pumps for a firm capacity of 12.6 mgd and a total capacity of 16.8 mgd. This would provide 8.4 mgd capacity per wet well in a two wet well configuration. Another four-pump pump station approach would be to design one larger and one smaller pump per wet well. An example would be a 3.3 mgd pump and a 6 mgd pump per wet well which would provide a firm capacity (defined as one of the largest pumps out of service) of 12.6 mgd and a total capacity of 18.6 mgd. This requires more total pumping capacity but provides 9.3 mgd per wet well.

A higher capacity per wet well could increase operational flexibility to take one wet well out of service for maintenance while still meeting Diversion Approval requirements. An alternative to providing larger pumps to allow for a wet well to be taken out of service for maintenance would be providing a means to isolate each individual pump bay. These details, along with refinements to the facility dimensions, will be determined during design.

5.2.4 RFPS Cost Estimate

Table 3 summarizes the pump station cost estimate (May 2018) with the current discount rate of 3.875 percent published by the WDNR.

Table 3. Cost Estimate for Return Flow Pump Station

Total Capital	$11,833,000
O&M ($/yr)	$473,000
20-Year Present Worth	$18,337,700

5.2.5 Environmental

The pump station is located within the developed areas of the CWP site. From *Table 3-1. Preliminary Wetland Impact Summary for Facilities* of Section 3.3.4 of the Environmental Impact Report (Appendix I), there are no wetlands near the preliminary RFPS site layout. The impacts include some tree removal, though no impacts to forested areas are expected. No other environmental impacts are expected for the pump station.

5.3 Treated Effluent Return Flow Conveyance Routing

5.3.1 Return Flow Routing in Application

The Application (Appendix C) included several alternatives for providing return flow to the Lake Michigan basin. These included return flow directly to Lake Michigan, to a tributary to Lake Michigan through either Underwood Creek or the Root River, or to Lake Michigan through the MMSD. The Application included the following return flow alternatives:

- Alternative 1: Return Flow to Underwood Creek—Return treated wastewater effluent to Underwood Creek in Waukesha County, a tributary to Lake Michigan through the Menomonee River in Milwaukee.
- Alternative 2: Return Flow to Root River—Return treated wastewater effluent to the Root River in Milwaukee County, a tributary to Lake Michigan in Racine.
- Alternative 3: Return Flow Direct to Lake Michigan near Milwaukee and Oak Creek—Return treated wastewater effluent directly to Lake Michigan.
- Alternative 4: Return Flow Direct to Lake Michigan near Racine—Return treated wastewater effluent directly to Lake Michigan.
- Alternative 5: Return untreated wastewater to the MMSD for treatment and return to Lake Michigan.
- Alternative 6: Return treated wastewater to the MMSD for treatment and return to Lake Michigan.

Additional sub-alternatives were evaluated in the Application for return flow through MMSD, which included variations of treatment and conveyance options. Routes for each alternative were developed for the Application and each were evaluated for cost, environmental, operational, and maintenance impacts.

Return flow to Lake Michigan through the Root River was the Application proposed alternative, and the Diversion Approval specified the return flow through the Root River. The return flow discharge site outfall location at 60th Street and Oakwood in Franklin was selected by identifying parcels that were larger than five acres in size and adjacent to the Root River downstream of Grange Avenue. Grange Avenue was chosen because a return flow was considered near this location during earlier drafts of the Application, and considering downstream locations increased the opportunities for land owner coordination with the City. The selection process was refined further with secondary evaluation criteria including:

- Parcel size
- Root River frontage

- Watershed area
- Existing stormwater issues
- Adjacent development
- Distance from Waukesha to minimize pipeline costs

The most limiting factor in site selection was first identifying parcels that included Root River frontage. Once these parcels were identified, environmental, land use compatibility, economic impacts, and other factors were considered in site selection. Many property owners were not willing sellers, however the City contacted several property owners and through negotiations with one, an Offer to Purchase the parcel located at 60th Street and Oakwood Road in the City of Franklin was reached (Figure 4).

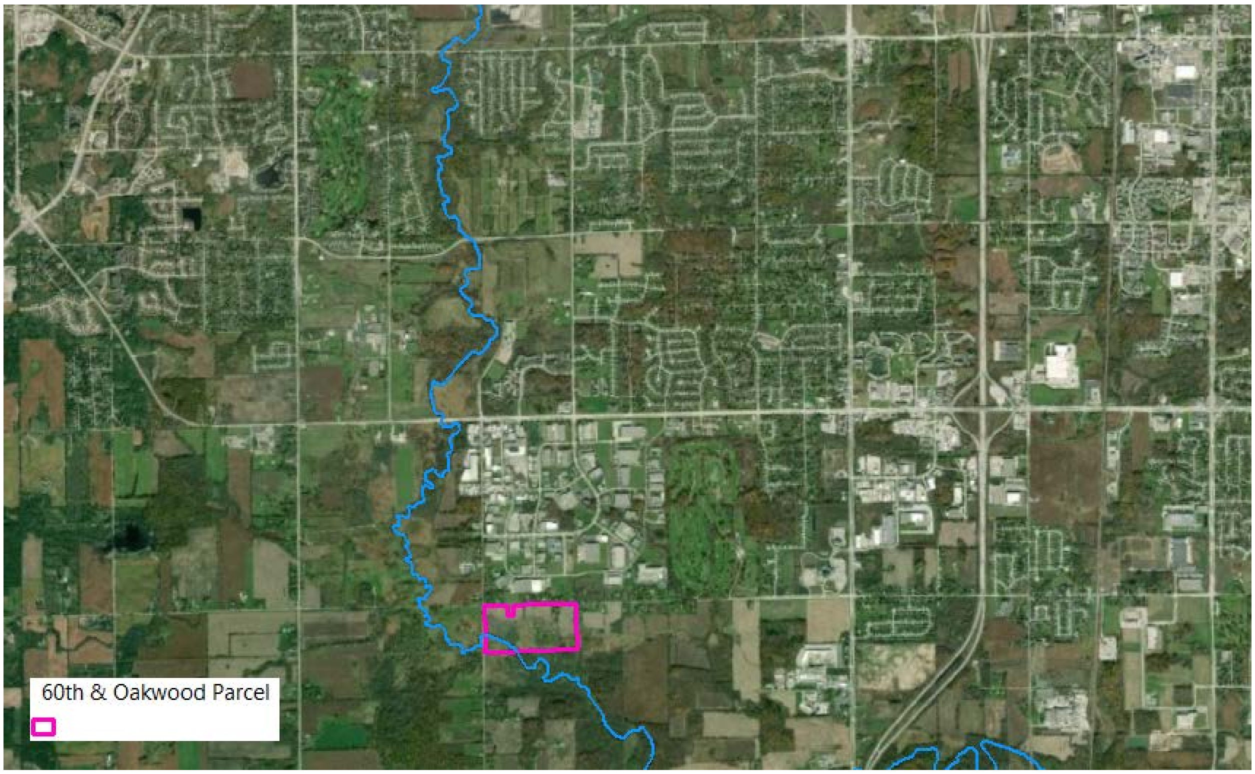

Figure 4. Parcel at 60th Street and Oakwood Road in the City of Franklin

5.3.2 Detailed Route Study for Root River Return Flow Discharge Site

With the Diversion Approval specification of the discharge site and the existing location of the CWP, a detailed route study was completed that evaluated multiple routes for conveying return flow from the CWP to the return flow discharge site at 60th Street and Oakwood (Route Study: Oak Creek (DEL 4-100 D1); see Appendix H). The return flow route study was completed in conjunction with a water supply pipeline route study, Route Study: Oak Creek (Oak Creek Route Study), where the City's water supply was originating from the City of Oak Creek. The water supply has since changed to a City of Milwaukee supply, however the return flow routes remain as documented in the Oak Creek Route Study.

The detailed return flow route study (as documented in the Oak Creek Route Study) is summarized in the following subsections. Full documentation is included in Appendix H.

5.3.3 Route Alternative Development

The study included the development and evaluation of six return flow route alternatives. Evaluation and comparison of the six route alternatives identified three preferred route alternatives for a more detailed evaluation. The following subsections describe the process used in identifying three route alternatives and the process for completing the Oak Creek Route Study to identify a preferred route. Note that each route alternative includes both the return flow pipeline and the water supply pipeline oriented to an Oak Creek water supply connection.

Preliminary Route Alternatives Evaluation

To identify the initial six route alternatives, data were reviewed and potential corridors identified within the route study area. Route alternatives were developed to limit duplication of overlapping corridors. Potential corridors were eliminated to avoid recent or planned regional transportation projects to the extent possible. The original route alternative included in the Application (referred to as the "Application Route") was removed from evaluation as it includes corridors identified with new or planned roadway construction. From the evaluation, six route alternatives remained for further consideration. These route alternatives were numbered from Route Alternative 1, representing the northeastern route alternative, to Route Alternative 6, representing the southwestern (Figure 5).

To reduce the number of route alternatives from six to three, the six route alternatives were evaluated and compared based on economic and non-economic evaluation criteria. Class 5 capital cost estimates were prepared in accordance with the Association for the Advancement of Cost Engineering's Recommended Practice No. 18R-97 to provide a means for comparing route alternatives on an economic basis. Cost estimates for Route Alternatives 1, 5, and 6 were higher than for Route Alternatives 2, 3, and 4. Route alternatives also were compared on the basis of non-economic evaluation criteria. Non-economic evaluation criteria included characteristics or special requirements associated with each route alternative. Based on the economic and non-economic evaluation, Route Alternatives 2, 3, and 4 were selected for further evaluation.

Refinement of Route Alternatives

Route Alternatives 2, 3, and 4 were further refined with a desktop analysis in several east-west corridors to minimize pipeline length, public impact, and easement requirements, and to improve accessibility and avoid wetlands, areas of suspected high risk contaminated material sites, and planned regional transportation projects. This included study areas along Ryan Road between 92nd and 112th Streets for Route Alternatives 2, 3, and 4, between Moorland Road and Racine Avenue for Route Alternatives 2 and 3 and between Racine Avenue and Route 164 for Route Alternative 4. Route sub-alternatives were identified in each study area and evaluated based on economic and non-economic evaluation criteria. Figure 6 shows selected Route Alternatives 2, 3, and 4.

5.3.4 Comparison of Route Alternatives 2, 3, and 4

Cost estimates are presented for Route Alternatives 2, 3, and 4. Estimates are classified as Class 3 according to with the Association for the Advancement of Cost Engineering's Recommended Practice No. 18R-97. Cost estimates are in May 2018 dollars and include bonds and insurance at 3 percent, mobilization and demobilization at 5 percent, contingency at 20 percent, and contractor overhead and profit at 15 percent. Manufacturer quotes, RS Means, and Southeastern Wisconsin bid tabs were used to develop the unit cost information in effort to provide the best available information for each item.

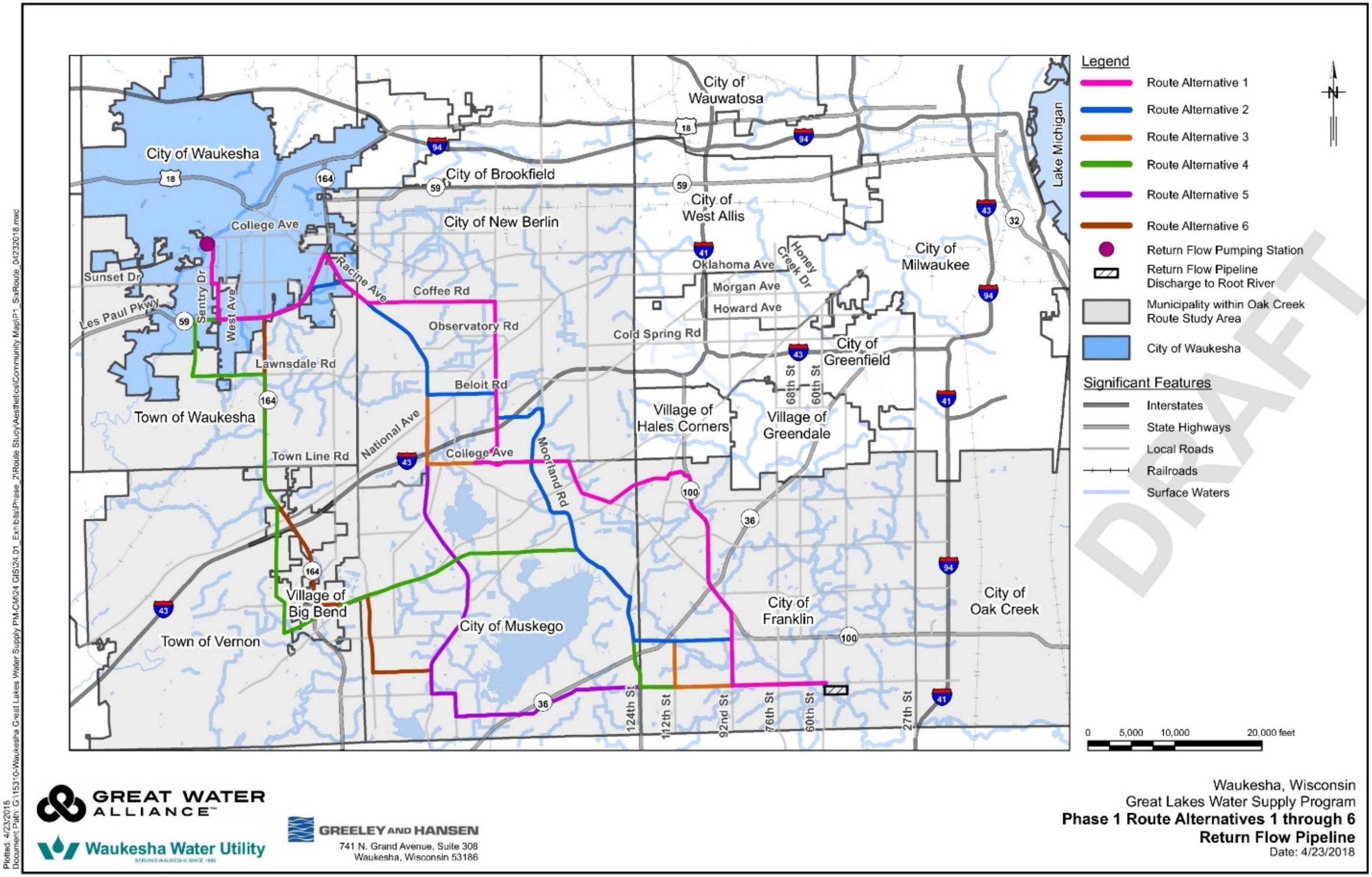

Figure 5. Phase 1 Route Alternatives 1 through 6—Return Flow Pipeline

5.3.5 Alternatives Cost Estimates

Table 4 summarizes the cost estimates for Route Alternatives 2, 3, and 4. Operation and maintenance costs also were to provide preliminary opinions of annual costs and the present worth cost of each Return Flow Pipeline route alternative. The present worth cost was calculated for a 20-year planning period using the current discount rate of 3.875 percent published by the WDNR. The O&M costs consider pipeline flushing and locating services. The O&M costs exclude pipeline replacement, which is not anticipated within the 20-year planning horizon.

Table 4. Route Alternatives 2, 3, and 4 Cost Comparison

Item	Route Alternative 2	Route Alternative 3	Route Alternative 4
Total Capital	$91,200,000	$94,400,000	$106,400,000
O&M ($/yr)	$106,737	$110,400	$124,442
20-Year Present Worth	$92,600,000	$95,800,000	$108,000,000

It was determined that the cost estimates for Route Alternatives 2 and 4 have greater risk of increasing due to additional pipeline length that may be associated with rerouting based on stakeholder feedback received.

Preferred Route Alternative

Route Alternatives 2, 3, and 4 (Figure 6) were further evaluated using a process guided by the Envision Rating System for Sustainable Infrastructure. The evaluation was a comprehensive impact assessment that assigned a score to the alternatives based on economic and non-economic evaluation criteria. The evaluation included key performance indicators (KPIs) developed to integrate the City's vision for its new water supply system into the design process and provide a basis for developing metrics to evaluate and compare alternatives.

Data and information from the economic and non-economic evaluation were used to develop metrics for the KPIs. These metrics, in conjunction with input and feedback obtained during open house meetings with stakeholders, were quantified as metrics and assigned to corresponding KPIs.

The highest weighted KPIs were schedule, system reliability, life-cycle cost, and ease of construction. Route Alternative 4 scored less preferably than the other alternatives in all of these metrics and nearly every other KPI and KPI metric. The low scoring of Route Alternative 4 is principally attributed to the longer total pipeline length, longer trenchless requirements, and constructability concerns through the electrical transmission utility corridor along the City of Muskego Recreational Trail. Route Alternative 4 could have greater impacts to the environment, including potential impacts to wetlands, waterways, and endangered resources, and has greater anticipated energy consumption than other alternatives. Route Alternative 4 has a higher capital and present worth cost estimate than Route Alternatives 2 and 3. Route Alternative 4 is located along corridors with more planned regional transportation projects and has stakeholder feedback concerns that may require pipeline rerouting, which could further elevate capital costs. Considering all factors, Route Alternative 4 is less preferable than Route Alternatives 2 and 3.

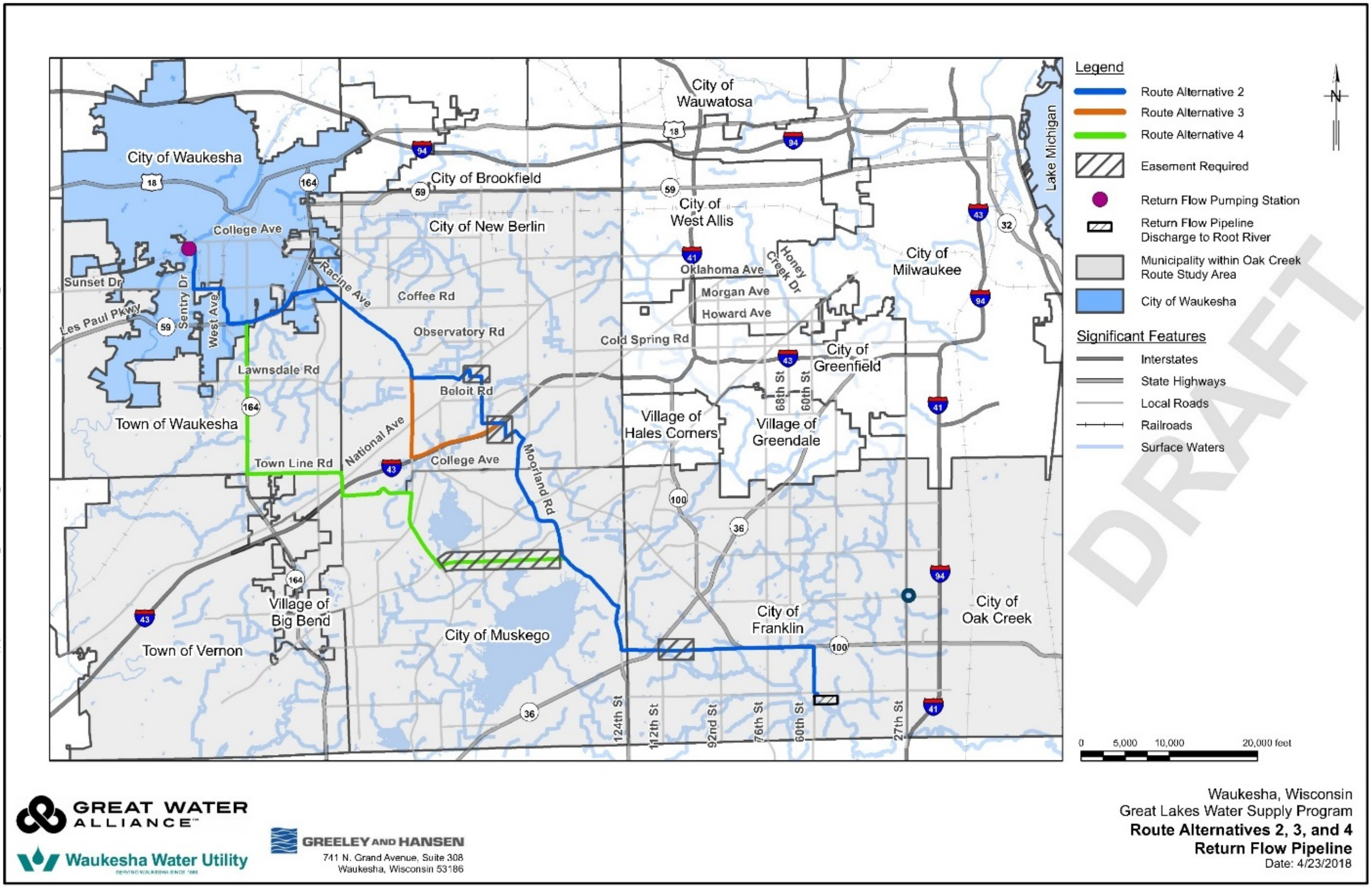

Figure 6. Route Alternatives 2, 3, and 4—Return Flow Pipeline

Although Route Alternatives 2 and 3 scored comparably, Route Alternative 2 runs through more narrow corridors that would cause greater public impacts and maintenance of traffic requirements than Route Alternative 3. Route Alternative 2 requires easements that have stakeholder concerns. Route Alternative 2 has a shorter total pipeline length and slightly lower capital and present worth cost than Route Alternative 3 but has a risk of rerouting that could result in longer total pipeline length due to stakeholder concerns. This could increase the capital cost of Route Alternative 2.

Route Alternative 3 requires fewer easements, reduces public impacts and maintenance of traffic requirements, traverses fewer near-term planned regional transportation projects, and received more favorable stakeholder feedback. An analysis of the environmental impacts of each alternative is documented in the Environmental Impact Report, submitted to WDNR in March 2018 (Appendix I).

Considering economic and non-economic evaluation criteria, Route Alternative 3 (Figure 7) is the preferred return flow route.

5.3.6 Return Flow Pipeline Design Criteria

Design criteria assumptions used for the Return Flow Pipeline are as follows:

- The maximum steady state design pressure will be set at 225 psi. This will eliminate the need for using a pipe with pressure class above 250 psi. Pressures in excess of 250 psi require thicker pipe walls and nonstandard, more robust valves, which would increase cost and complexity of design.
- The Return Flow Pipeline will be operated as a force main upstream of the high elevation point of the Great Lakes Surface Water Divide and a gravity system downstream of the high elevation point. The Return Flow Pipeline will be designed with the ability to transition entirely to a force main in the future, however this will require additional infrastructure at the return flow discharge site. This infrastructure is not included in this facility plan amendment and will be considered during detailed design.
- A maximum velocity of seven feet per second is desirable for preliminary pipeline sizing of the force main to maintain head losses within reasonable tolerance and conserve energy of pumped flows during normal operations.
- Minor friction losses, or head losses due to entry and exits, valves, bends, and fittings comprise a small portion of the system’s dynamic head loss and have not been considered in detail.
- Hydraulic transients will be evaluated during detailed design to confirm operating conditions when a vertical alignment has been developed.

Table 5 summarizes the design criteria.

5.3.7 Environmental

Environmental impacts for the return flow pipeline are documented in the Oak Creek Route Study (Appendix H) and the Environmental Impact Report (Appendix I).

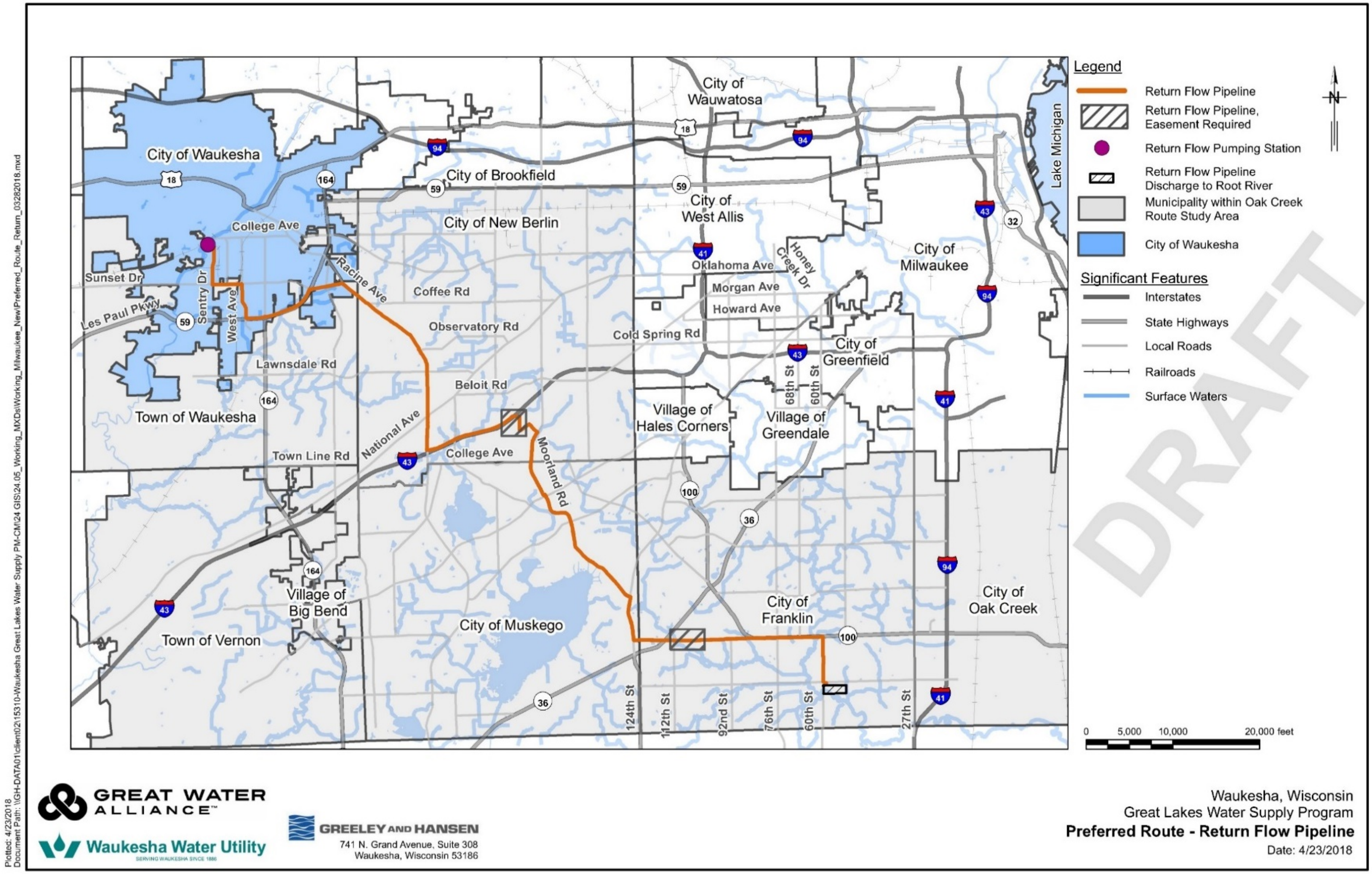

Figure 7. Preferred Route for Return Flow Pipeline

Table 5. Return Flow Pipeline Design Criteria

Description	Design Value
Return Flow Rate	
Minimum Hour, mgd	0
Initial Average Day, mgd	6.6
Future Average Day, mgd	8.2
Maximum Hour, mgd	13.6[a]
Return Flow Pipeline	
Material	Ductile iron, steel pipe, or PCCP
Diameter	30 in.
Design Capacity	12 mgd[a]
Maximum Steady State Design Pressure	225 psig
Minimum Depth of Cover	6.5 ft
Valves	
Isolation Valve	
Type	Butterfly valve
Installation	Direct-bury, except where regulations require vaults
Air Release	
Type	Air relief valve and combination air vacuum relief/air relief valve with surge check
Flushing	
Type	Blowoff assembly
Pipeline Connection	Rolled tee
Special Crossings	
Wetlands and Waterways	Horizontal Directional Drilling
Roads, Highways, or Railroads	Jack and bore method

[a]13.6 mgd was an assumed peak hour flow before a 12.6 mgd firm pump station capacity was established per Section 5.2.3.

[b]12 mgd was an assumed design capacity flow before a 12.6 mgd firm pump station capacity was established per Section 5.2.3.

5.4 Return Flow Reaeration

The CWP provides effluent reaeration to meet a WPDES DO permit limit of 6.7 mg/L in September and 7.0 mg/L the rest of the year before discharge to the Fox River. Effluent reaeration is the final step in the treatment process and uses blowers and diffusers to dissolve oxygen into the effluent. The return flow pump station will be downstream of the effluent reaeration system. Aerated effluent will be pumped to the return flow discharge site (RFDS) for discharge into the Root River. Within the force main, oxygen can be consumed through oxidation of residual BOD and ammonia. Consumption of oxygen within the force main will require replenishment of oxygen to the anticipated 7.0 mg/L Root River permit limit before discharge to the river. Feasible alternatives for reaeration include stair step and low profile cascade aeration and oxygen diffusion. Sizing criteria for reaeration alternatives were established based on DO depletion in the force main. An economic and non-economic comparison was used to select a preferred alternative.

5.4.1 Design Criteria

Dissolved Oxygen Dissolved oxygen (DO) in the return flow discharge is anticipated to be a regulated constituent included in the CWP WPDES Permit. The minimum DO concentration of the return flow that can be discharged to the Root River is anticipated to be 7.0 mg/L as noted in Section 4.2.2.
The reaeration system will be designed to replenish the oxygen depleted in the return flow pipeline to above the permitted concentration.

A model was created for the 2013 facility plan amendment using force main length, return flow rate, temperature, BOD_5 concentration, and initial oxygen concentration. The model indicated that a DO concentration of 7.48 mg/L at the start of the force main would be necessary for a DO concentration of 7.0 mg/L at the RFDS. While the 2013 facility plan amendment accounted for heterotrophic oxidation of organic matter (BOD_5), it did not account for autotrophic aerobic oxidation of ammonia. Ammonia oxidation requires 4.57 mg O_2/mg ammonia consumed compared to 1.1 mg O_2/mg BOD_5 consumed. Therefore, a new model incorporating both BOD_5 and ammonia was created to simulate oxygen depletion in the return flow force main using the WATS model.

1. Basis of Simulation—The 98th percentile for BOD from 2011 through 2016 and the highest day ammonia since improvements placed into operation in June of 2016 as described below were used.
2. BOD_5—The Clean Water Plant monitors effluent BOD_5 daily. From 2011 through 2016, effluent quality has been exceptional with BOD_5 concentrations below the test detection limit roughly 97 percent of the time. The 98th percentile for BOD_5 used in the WATS model is 2.8 mg/L.
3. Ammonia—Ammonia is also monitored daily at the CWP. However, effluent ammonia data for 2011 through 2016 are not representative of current and future conditions. Improvements to the solids handling system were completed and placed into operation in June 2016. The improvements included centrate storage that equalizes the high ammonia return flow to the secondary treatment process. Since centrate equalization has been in operation, the peak effluent ammonia concentration was 0.58 mg/L, which was used in the WATS model.
4. Simulation Results—The WATS model simulation started with an initial DO concentration of 7.0 mg/L, which corresponds to the DO permit limit at the Fox River. A 7.0 mg/L starting DO is a conservative approach. Since July 2016 when improvements to the post-aeration system at the CWP began operation, the average effluent DO concentration has been 9.19 mg/L. The DO has dropped below 8.0 mg/L only twice since July 2016. The WATS model simulates that the selected ammonia and BOD_5 concentrations can result in 3.65 mg/L DO consumption over the length of the return flow pipeline. At the RFDS the DO concentration would be 3.35 mg/L assuming the modeled oxygen consumption and a starting DO concentration of 7.0 mg/L. The effluent reaeration system at the RFDS will be required at a minimum to raise a peak flow of 13 mgd from a starting DO concentration of 3.35 mg/L to final DO concentration of 7.0 mg/L.

Discharge Monitoring

Immediately following effluent reaeration, the return flow will be monitored for DO and temperature. Dissolved oxygen probes can include an integrated temperature sensor allowing the use of a single probe. Luminescent oxygen probes are commonly used and require minimal maintenance. Maintenance is limited to the replacement of the sensor cap every two years. Monitoring data from the sensor will be communicated to the CWP through either a radio or cellular transmitter.

Freeze Protection

Freeze protection is not anticipated to be required based on successful operation of the aeration technologies being considered in similar northern climates. However, provisions for installing freeze protection will be further considered during detailed design.

5.4.2 Reaeration Alternatives Analysis

The return flow site slopes from the northern site border (Oakwood Road) to the south (Root River). Location of the reaeration system will be constrained by a residence on the west half of the site along Oakwood Road and the flood plain to the south. The selected reaeration system will be located above the 100-year flood elevation to ensure access and operation during flood conditions. The reaeration system alternatives that were evaluated were:

1. Reaeration with a concrete step cascade aerator
2. Reaeration with a low profile proprietary cascade aerator
3. Reaeration with pure oxygen injection

Alternative 1—Reaeration with a Concrete Step Cascade Aerator

Cascade aeration is a series of concrete steps that causes turbulence as the effluent flows down the structure (Figure 8). Step sizes typically range from 6 to 12 inches tall and 12 to 24 inches deep. The total height of the structure and number of steps were calculated using the Barrett equation and are dependent upon the oxygen deficit and the relationship of the target DO concentration to the saturation concentration. Dissolved oxygen within the return flow pipeline may be reduced to 3.35 mg/L because of remaining BOD and ammonia. Raising the DO concentration from 3.35 mg/L back to 7 mg/L requires a drop of 17 feet and a total of seventeen 1-foot tall steps (Table 6). The top of the structure would be roughly 16 feet above grade and require a stairway to access the top. The bottom of the 17-foot drop would be at the 100-year flood elevation of 682.20 feet to enable performance when the Root River is flooded. The width of the structure was determined by the return effluent flow rate. At a return flow rate of 13 mgd, the required step width is 26 feet. Cascade aeration is feasible because of the head available in the return flow pipeline. Excess energy from the force main would be dissipated in an influent chamber ahead of the cascade aeration steps. The influent chamber would be the width of the cascade steps and distribute the treated effluent over the length of the top step. An effluent chamber at the end of the cascade aerator steps would collect the effluent and discharge it to the Root River through a pipe. The effluent chamber would form a pool where DO and temperature will be measured.

Table 6. Cascade Aeration Design Summary

Parameter	Step Cascade	Low Profile
Minimum Influent DO	3.35 mg/L	0.0 mg/L
Target Effluent DO	7.0 mg/L	7.0 mg/L
Total Drop	17 ft	2 ft
Step Height	12 in.	—
Total Steps	17	—
Step Depth	24 In.	—
Width	26 ft	22 ft
Length	33 ft	28 ft

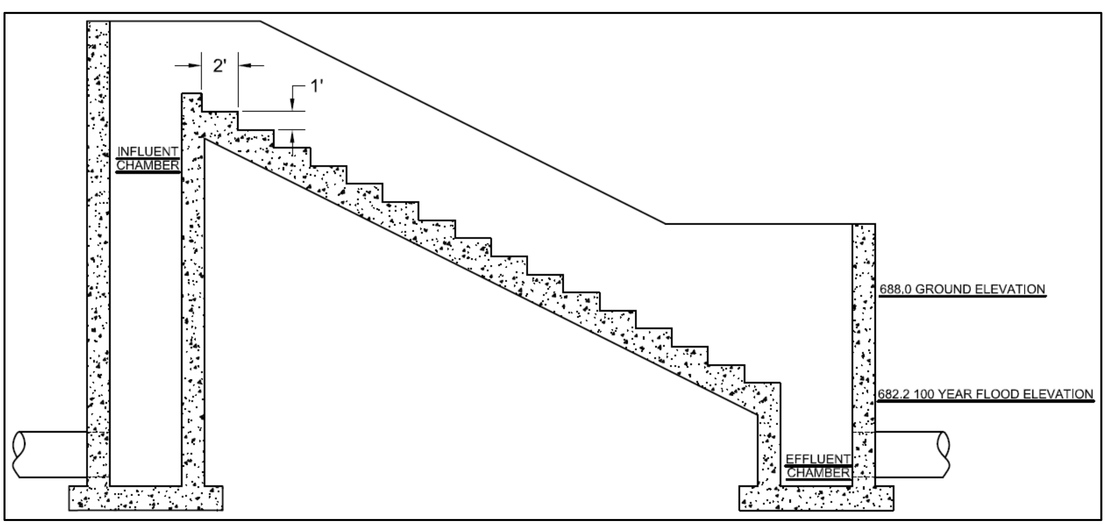

Figure 8. Cross Section of Concrete Step Cascade Reaeration

Alternative 2—Reaeration with Low Profile Proprietary Cascade Aerator

Proprietary cascade aeration equipment can provide the required aeration to meet the discharge limit but with far less drop. Jim Myers & Sons is a manufacturer with successful installations. JMS equipment (Figure 9) forms channels with a series of trapezoidal plates and weirs constructed from stainless steel. The influent arrangement controls the number of channels in service to ensure adequate velocity to create turbulence and entrain air. The equipment is mounted to a concrete structure with influent and effluent chambers similar to those of the concrete step cascade aerator except the influent chamber would not be as tall. The JMS equipment has a footprint of roughly 22 by 28 feet, excluding the influent and effluent chambers. JMS aerators are conservatively designed to raise influent DO from 0.0 mg/L as a standard rather than an assumed starting DO greater than 0. Raising the DO 7 mg/L requires a drop of only 2 feet. The drop to raise the DO 7 mg/L is significantly less than the 17-foot drop to raise the DO concentration a total 3.65 mg/L in the concrete step cascade aerator. The low profile aerator can be placed at grade with a 3.5-foot handrail or wall to prevent people falling into the structure. A security fence will surround the reaeration structure to prevent public access. JMS recommends washing the aerator with a hose twice per year.

Figure 9. JMS Low Profile Cascade Aerator (photo courtesy of JMS)

Alternative 3—Reaeration with Pure Oxygen Injection

Dissolved oxygen can be replenished by injecting oxygen into the return flow force main. Oxygenation systems operate by pumping a side stream portion of the return flow from the force main through an oxygen transfer vessel. Gaseous oxygen is injected into the top of the vessel or influent pipe, allowing for an oxygen transfer efficiency of 90 to 95 percent. The superoxygenated wastewater is then directed back into the force main. Figure 10 is a superoxygenation system illustration by ECO2 Technologies.

Oxygen for the superoxygenation system can be either purchased or generated onsite. Purchased oxygen will be in the liquid form from suppliers such as AirProducts or Praxair. Main components of the system are the storage tank and vaporizer to convert oxygen from liquid to gas. Liquid oxygen is delivered to the site in 6,000-gallon tanker trucks. Gaseous oxygen may also be generated onsite using a vacuum swing adsorption system. In a vacuum swing adsorption system, air is compressed with a positive displacement blower and introduced into an adsorber vessel. Within the vessel, nitrogen is

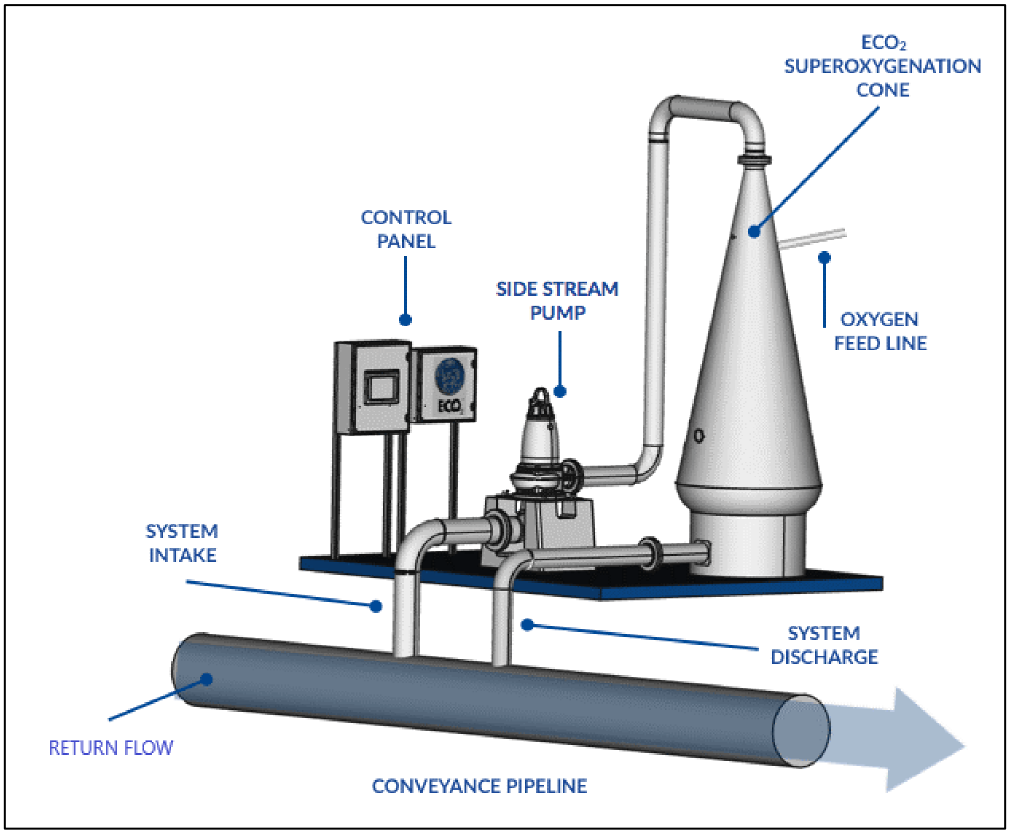

Figure 10. ECO2 Technologies Oxygenation System (illustration courtesy of ECO2 Technologies)

absorbed onto Zeolite media and the oxygen passes through. Nitrogen is rejected from the media and vessel by decreasing pressure in the vessel and reversing the compressor direction.

The return flow site is remote from the CWP. Mechanical equipment will require maintenance and frequent monitoring at the site, and additional energy that is not necessary for the two cascade aeration alternatives. Therefore, the reaeration with pure oxygen injection alternative was not evaluated further.

5.4.3 Alternatives Cost Estimates

Cost estimates were developed for the concrete step (Alternative 1) and low profile (Alternative 2) cascade aerators. The cost estimates include the structures and instrumentation and mechanical equipment within the structures. Capital costs (May 2018 dollars) for both alternatives are roughly $580,000 (Table 7). The costs are within $4,000 and therefore equal within the accuracy of the cost estimate. Concrete costs under Alternative 1 are higher than under Alternative 2 because of the larger footprint and additional height. Alternative 2 includes the cost of the aeration equipment that offsets the higher concrete and stairway cost in Alternative 1.

O&M costs are expected to be the same for each alternative at $6,150 annually (Table 7). Labor accounts for most of the cost and includes a weekly trip to inspect the reaeration system. Electricity is required for site lighting and the DO monitoring instruments. Neither alternative involves the use of mechanical equipment powered by electricity. The telemetry cost is for a cellular connection to the DO instrumentation. O&M costs were calculated based on the following unit costs:

- Labor: $50/hour
- Electricity: $0.08/kilowatt-hour
- Data Line Fee: $50/month

A 20-year net present value was calculated using the capital and O&M costs of each alternative using the current discount rate of 3.875 percent published by the WDNR. The 20-year net present value is roughly $660,000 (Table 7) for either alternative.

Table 7. Cost Comparison for Return Flow Reaeration Alternatives

	Alternative 1: Concrete Step Cascade Aerator	Alternative 2: Low Profile Cascade Aerator
Capital		
Sitework	$39,060	$26,910
Concrete	$202,140	$115,420
Metals	$13,150	—
Equipment	—	$113,530
Instrumentation and Controls	$15,750	$15,750
Allowances	$40,510	$40,740
Contractor Markups	$65,540	$65,910
Contingency (25%)	$98,310	$98,860
Total Construction	$491,540	$494,300
Engineering/Administration	$102,240	$102,810
Total Capital	$576,700	$579,900
O&M ($/yr)		
Labor	$5,200	$5,200
Electricity	$350	$350
Telemetry	$600	$600
Total	$6,150	$6,150
20 Year Present Worth	$661,200	$664,400

In addition to the life-cycle costs, non-economic considerations were evaluated. Table 8 lists some of the major non-economic advantages and disadvantages of each alternative. A "+" denotes where an alternative has an advantage over the other alternative and a "-" where the alternative is at a disadvantage. When both alternatives have a "+" in a category, the systems are considered equal. Both systems are considered equal on life-cycle costs and O&M complexity. Alternative 2 has the advantage in four categories and is the preferred option based on non-economic criteria.

5.4.4 Recommended Reaeration Alternative

Economic and non-economic evaluations were performed for the concrete step and the low profile proprietary cascade aerators. The concrete step aeration system requires a larger structure, and the low profile aerator requires the purchase of the cascade aeration system. Their costs are similar, resulting in the alternatives being equal in capital cost, O&M cost, and 20-year net present value. The non-economic evaluation considered oxygen transfer, O&M complexity, odors, reliability, and aesthetics/space requirements. The alternatives were equal when looking at O&M complexity. However, the low profile proprietary cascade aeration system held the advantage in all the other categories. Because the alternatives were equal in cost and the low profile proprietary aeration system had more advantages in the non-economic evaluation, Alternative 2 is the recommended alternative (Table 8).

Table 8. Criteria for Return Flow Reaeration Selection

Criteria	Alternative 1: Concrete Step Cascade Aeration		Alternative 2: Low Profile Proprietary Cascade Aeration	
Life-Cycle Costs	Capital cost is low. O&M cost is low. Does not use mechanical equipment requiring electrical input or daily O&M.	+	Capital cost is low. O&M cost is low. Does not use mechanical equipment requiring electrical input or daily O&M.	+
Oxygen Transferred	17-foot drop needed to aerate from 3.35 mg/L to 7.0 mg/L	–	2-foot drop needed to aerate from 0.0 mg/L to 7.0 mg/L. Permit limit expected to be met even if starting DO was less than modeled.	+
O&M Complexity	System is simple to operate and maintain. Visual inspection once per week. No mechanical equipment required. Periodic cleaning is only anticipated maintenance.	+	System is simple to operate and maintain. Visual inspection once per week. No mechanical equipment required. Periodic cleaning is only anticipated maintenance.	+
Odors	Relies on turbulence for aeration that may release earthy odors associated with effluent. Difficult to cover to contain odors. Berm and vegetation can be used to direct away odors from residence.	–	Relies on turbulence for aeration that may release earthy odors associated with effluent. Could be covered to contain odors. Berm and vegetation can be used to direct odors away from residence.	+
Reliability	Highly reliable. No mechanical equipment to fall apart. The expected minimum starting DO of 3.35 mg/L is required for permit compliance.	–	Highly reliable. Can raise DO from 0 mg/L to 7 mg/L. No mechanical equipment to fail.	+
Aesthetics/Space Requirements	Largest space requirement. Tall structure that will have highest visual impact. Aesthetic improvements may be expensive.	–	Smallest space requirement. Height can be limited to 4-feet above grade limiting visual impact on site.	+

5.4.5 Environmental

The location of the reaeration structure is independent of the alternative chosen, with a similar footprint for all alternatives. Wetlands were surveyed at the RFDS in fall of 2017 as part of the EIR (Appendix I) investigation of environmental impacts for the Great Lakes Water Supply Program. The structure will be sited outside the regulatory 100-year floodplain and outside any surveyed wetlands at the RFDS.

5.5 Return Flow Discharge Site

Downstream of the reaeration structure, discharge will flow into a 24-inch pipe using the same pipe material as the return flow pipeline.

5.5.1 Return Flow Discharge Site Facilities Cost Analysis

Table 9 (following page) summarizes the preliminary cost analysis of facilities at the RFDS using the recommended reaeration structure alternative. Costs are in May 2018 dollars with the current discount rate of 3.875 percent published by the WDNR.

5.5.2 Environmental

The siting of the outfall structure will consider minimizing disturbance to existing natural assets, such as riparian vegetation, to maintain habitat and water quality. Overall depths of conveyance pipes will be at least 4 feet to provide adequate cover for freeze protection and equipment traffic. Conveyance pipe depths will account for continued land disturbance from agricultural activities.

Depths of the outfall structures will employ optimum slope and minimum pipe depth criteria and be sited below the Root River ordinary high-water mark as much as possible. At the outfall and headwall location, erosion control measures will be employed along the shoreline and scour protection measures at the base of the outfall structures to minimize bank soil migration and river sedimentation. Natural, vegetated solutions are recommended for erosion control measures. Figure 11 shows the locations of all structures on the RFDS. A review of affected environments is provided below.

Table 9. Cost Estimate for Return Flow Discharge Site Facilities

Capital	
Preferred Reaeration Structure	$579,930
Conveyance Pipe and Outfall	$650,000
Total Capital	$1,343,200
O&M ($/yr)	
Preferred Reaeration Structure	$6,200
Conveyance Pipe and Outfall	Included above
Total	$6,200
20-Year Present Worth	$1,315,100

Figure 11. Return Flow Discharge Site Facilities Locations

Physical

The physical resources affected at the RFDS are documented in Appendix I and include:

- Wetlands—The RFDS has farmed wetlands located on the site that will be affected by the conveyance piping and proposed outfall structure.
- Lakes—There will be no lands classified as lakes that will be affected by the proposed project.
- Rivers—The proposed project will provide improved treatment plant phosphorus removal to the discharge. The proposed discharge will improve low-flow conditions in the Root River and improve the downstream fisheries, as noted in the Application (Appendix C).
- Shorelands—The proposed outfall structure will affect Root River shoreland temporarily during construction and permanently where structures will be constructed. The permanent wetland acreage affected by the project is the same for shoreland impacts.
- Floodplains—The RFDS was reviewed for potential floodplain impacts and is outlined in red on the Federal Emergency Management Agency map panel number 55079C0226E in Figure 12. Most of the parcel is within a Zone AE. Zone AE areas are subject to a 1 percent or greater annual chance of flooding in any given year (100-year floodplain). The northern part of the site, where the return flow facilities will be, is in the shaded Zone X. Zone X areas are subject to within a 0.2 percent (500-year floodplain) to 1 percent annual chance of flooding in any given year. The 100-year floodplain elevation at the return flow facilities area is 682.2 feet, the 500-year elevation is 684.4 feet. All structures at the site will have the top of their grade floor located above the 100-year floodplain. For below-grade structures, the top slab will be located above the 100-year floodplain.
- Groundwater—Groundwater elevations may be affected during construction, but there will be no long-term impact on groundwater as a result of this project.

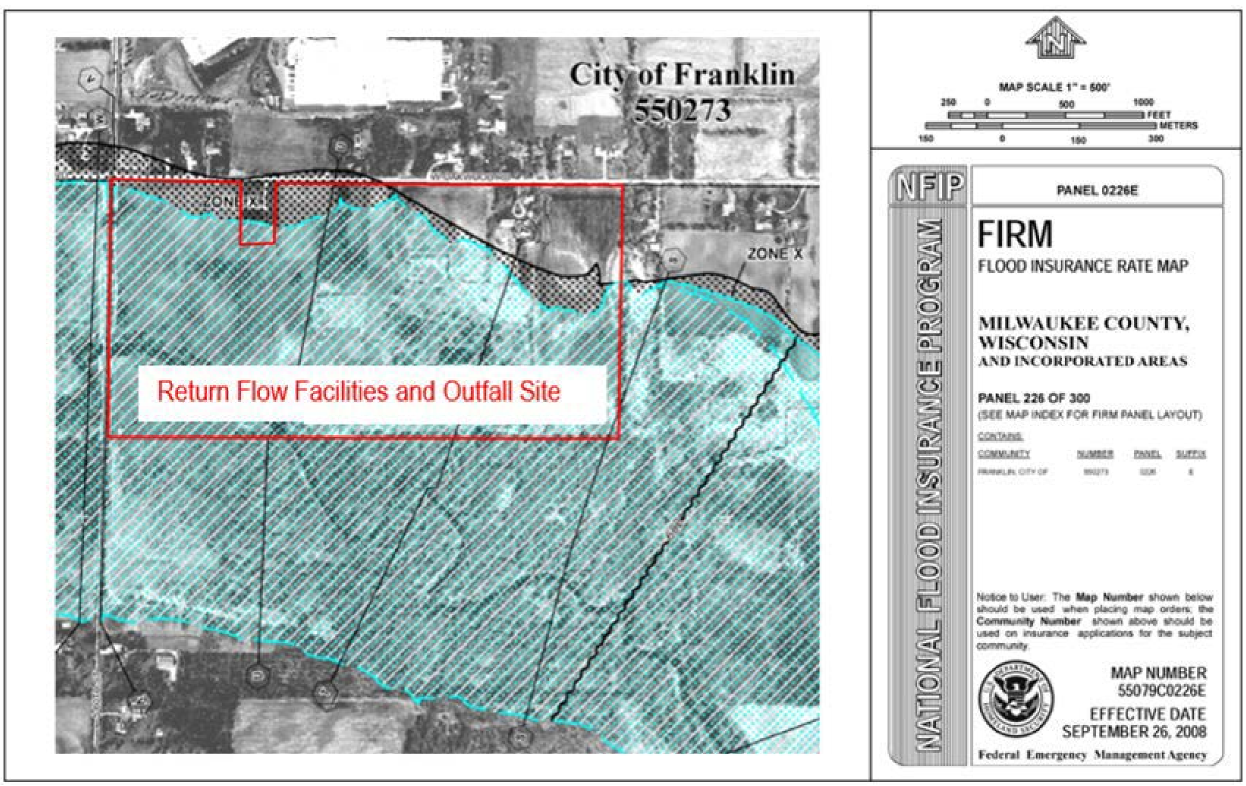

Figure 12. Federal Emergency Management Agency FIRM 55079C0226E

Biological

A desktop evaluation of rare, threatened, and endangered species was performed. The evaluation was conducted through a review of recent and historical aerial photographs, WDNR National Heritage Inventory data, and the U.S. Fish and Wildlife Service Information Planning and Consultation data and endangered species county data. The survey found no rare, threatened, or endangered species.

Cultural

The cultural resources affected at the RFDS are documented in Appendix I and include:

- Zoning and Land Use—The RFDS is located at the southeast corner of West Oakwood Drive and South 60th Street in Section 35, Township 5N, Range 21E of the 4th Principal Meridian. The address associated with the site is 5207 West Oakwood Road, Franklin. The roughly 78-acre parcel is used for residential and agricultural purposes. The parcel slopes from north to south and the lower elevations include wetlands and floodplains. Access to the site for residential and agricultural purposes is provided by an entrance from West Oakwood Drive. The parcel resides within city limits of Franklin. The City of Franklin zoning map (Figure 13) designates the property as primarily R2—Estate Single-Family Residence District and FW—Floodway District, with smaller areas designated as C-1—Conservation Easement and FC—Floodplain Conservancy District. They are not expected to be affected by the proposed improvements. The return flow facilities, except for the outfall piping and structures, will be within zone R-2. The remainder of the parcel is within zone FW.
- Archaeological—A desktop review and field investigation was performed for cultural, archaeological, and historical resources. The assessment reviewed the site for the potential presence of archaeological sites or historic structures. This was accomplished by reviewing the State of Wisconsin's Historic Preservation Database. Archaeological sites 47MI180 and 47MI241 were found to overlap parts of the parcel. Site 47MI180 is in the northwest corner of the parcel. Site 47MI241 overlaps part of the southwest edge of the parcel. A Phase I Archaeological Survey of the site was conducted in 2017 and satisfies survey requirements for regulatory compliance and meets the standards for archaeological survey as outlined in the Guide for Public Archaeology in Wisconsin. Preliminary findings indicate a portion of the site is classified as a disturbed historical site just north of the Root River and just east of 60th Street. The outfall conveyance piping will avoid crossing any archaeological areas identified at the RFDS.
- Economic Setting—The RFDS is primarily agricultural and floodplain. Further development is not expected in this location.

Other Resource Features

Milwaukee County administers the Root River Parkway, a recreational corridor that is part of the Milwaukee County Park System. Milwaukee County defines a recreational corridor as a trail at least 15 miles long within areas of scenic, scientific, historic, or other cultural interest. Recreational corridors provide opportunities for linear outdoor recreation activities. Franklin supports the expansion of the Root River Parkway with a trail system located along the southern border of the Root River which passes through the Return Flow Facilities site. The design of facilities at this site will support and avoid impacts to these Root River Parkway expansion efforts.

Figure 13. City of Franklin Zoning Map

6. Selection of Recommended Alternative

The recommended plan is to return treated effluent flow from the CWP to the Root River, a tributary to Lake Michigan. The facilities recommended to accomplish this plan are summarized in the following sections.

6.1 Phosphorus Removal

The anticipated effluent phosphorus limit for the Root River is a 0.060 mg/L 6-month average (May–October and November–April averaging periods) and a 0.180 mg/L monthly average. Two ballasted flocculation and settling alternatives, CoMag and ACTIFLO, were evaluated and had the lowest present worth cost as compared to other alternative technologies (Blue PRO reactive filtration, Veolia Disk Filtration, and the CLEARAS Water Recovery System). Based on the results of an ACTIFLO pilot and CoMag jar testing and an ongoing pilot at the CWP, the ballasted flocculation and settling is recommended for the 0.060 mg/L 6-month average limit anticipated for the Root River discharge.

The City is pilot testing CoMag to verify performance and further refine facility and chemical usage costs for the ballasted flocculation and settling alternative.

6.2 Return Flow Pump Station

A return flow pump station is recommended to be constructed at the CWP site. The pump station would include space for four pumps and two isolatable wet wells or individually isolatable pump bays.

One approach includes four equally sized pumps with one serving as a spare. This approach would require three 4.2 mgd pumps for a firm capacity of 12.6 mgd and a total capacity of 16.8 mgd. This arrangement would provide 8.4 mgd capacity per wet well in a two wet well configuration. A second approach includes one larger and one smaller pump per wet well. An example would be a 3.3 mgd pump and a 6 mgd pump per wet well that would provide a firm capacity (defined as one of the largest pumps out of service) of 12.6 mgd and a total capacity of 18.6 mgd. The final decision will be determined during design.

6.3 Return Flow Conveyance

Six pipeline route alternatives were developed and evaluated for returning treated effluent flow from the CWP to the Root River (Appendix H). The preferred pipeline route is Alternative 3 (Figure 6) and consists of roughly 27 miles of 30-inch pipe.

6.4 Return Flow Reaeration

The CWP provides effluent reaeration to meet a WPDES DO permit limit of 6.7 mg/L in September and 7.0 mg/L the rest of the year before discharge to the Fox River. Oxygen in the CWP effluent is projected to be consumed from residual BOD_5 and ammonia when it is pumped through the long return flow conveyance pipe for discharge to the Root River. Oxygen replenishment is required to reliably meet the anticipated permit limit of 7.0 mg/L. The recommended reaeration alternative is a low profile proprietary cascade aerator. The aerator is designed to raise influent DO from 0.0 mg/L to the target discharge concentration of 7.0 mg/L. Raising the DO to 7 mg/L requires a drop of 2 feet. The drop is significantly less than the 17-foot drop to raise the DO concentration a total 3.65 mg/L in a concrete step cascade aerator.

6.5 Return Flow Discharge Site

The return flow discharge site is recommended to include the return flow reaeration facility, a sampling and monitoring station for temperature and DO, and pipeline from the reaeration structure to the outfall at the Root River.