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July 17, 2018

Kelly Zylstra, P.E.
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Subject: Great Lakes Water Supply Program
Task 6-240 D1 Preliminary Design Report
GWA PM DEL 052

Dear Ms. Zylstra:

In accordance with Task 4-300 Route Study and Pipelines and Task 6-200 Pump Stations, Storage, and Chemical Treatment of our Agreement, we are hereby delivering via the Great Water Alliance SharePoint site the 6-240 D1 Preliminary Design Report. The deliverable has incorporated comments that were received and discussed on the initial draft.

The purpose of this deliverable is to codify design decisions that have been made to date for the Program with the City of Milwaukee as the water supplier. The Preliminary Design Report presents the decisions of meetings and workshops, describes the subsequent design development, and identifies the recommended design concepts for major components of the Program.

Yours very truly,

Greeley and Hansen LLC
[redacted]

Catharine M. Richardson, P.E.
Program Manager

CMR/kmb
Encl (1): 6-240 D1 Preliminary Design Report (electronic version)

Great Lakes Water Supply Program

GREAT WATER ALLIANCE

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6-240 D1 Preliminary Design Report

July 2018

Waukesha Water Utility
SERVING WAUKESHA SINCE 1886

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PROGRAM TEAM MEMBER CONSULTANTS:

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EXECUTIVE SUMMARY

Background

The Waukesha Water Utility (WWU) provides water treatment and distribution services to the City of Waukesha (Waukesha) and isolated portions of the Town of Waukesha and City of Pewaukee. WWU owns and operates a system of wells that pump groundwater from the St. Peter Sandstone aquifer for treatment and then to WWU's distribution system. The St. Peter Sandstone aquifer, which has been the primary source of drinking water for not only Waukesha, but for communities throughout the Midwest, is being depleted in Southeast Wisconsin. This is due in large part to a natural layer of shale rock that restricts groundwater recharge. Depletion of the St. Peter Sandstone aquifer has also caused increases in the concentrations of radium and other contaminants. As a result, Waukesha needs a long-term, sustainable alternative to its existing water supply to protect public health.

After a lengthy study and public engagement, the Wisconsin Department of Natural Resources (WDNR), Department of Justice (DOJ), and Great Lakes-St. Lawrence River Basin Water Resources Council (Compact Council) unanimously approved Waukesha's Application for Lake Michigan Diversion with Return Flow (Application) to source water from Lake Michigan and return the required amount of flow to the Great Lakes-St. Lawrence River Basin via the Root River. WWU is implementing a program to transition Waukesha's water supply from groundwater to Lake Michigan water, now known as the Great Water Alliance (Program). The purpose of the Program is to plan, design, construct, and commission infrastructure with a 100-year useful life necessary to transition Waukesha's water supply.

The Program is the first for a community in a county straddling the Great Lakes-St. Lawrence River Basin to access Great Lakes water through the Great Lakes-St. Lawrence River Basin Water Resources Compact (Compact). Successful implementation of the Program will set industry precedents for solving water quality and water scarcity challenges for at-risk water supplies in other Great Lakes communities eligible to receive Great Lakes water through the Compact.

Purpose

The purpose of this Preliminary Design Report (PDR) is to summarize the activities that have occurred and document the conclusions that have been made through meetings and workshops for the preliminary design of the Program. The PDR was developed in conjunction with two (2) independent route studies. Draft Route Study: Oak Creek (4-100 D1) was developed to determine the Return Flow Pipeline Route and Draft Route Study: Milwaukee (4-100 D2) was developed to determine the route for the Water Supply Pipeline Route. The route studies detail the procedure for establishing the preferred routes. The PDR and both route studies will be the used to develop the permit applications required for Public Service Commission (PSC), WDNR, and United States Army Corps of Engineers (USACE) and are required before Program construction can begin.

1. PSC Type 2 Application for Certificate of Authority
2. A joint WDNR and USACE Chapter 30/Chapter 281.36 and Section 404 Wetlands and Waterways Impact Individual Permit Application (also referred to as the "Individual Permit").

Both permits will be submitted to the PSC, the WDNR, and the USACE for approval.

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Preliminary Design Report Notes and Assumptions

Due to the Program being in the early stages of development and ongoing field investigations, assumptions were made in order to progress the design. Below is a list of assumptions that were made in developing this PDR.

1. The background information for site and pipeline alignment PDR drawings were created using Geographical Information System (GIS) and aerial photographs. No certified field survey or utility location services were included in the preparation of the PDR drawings.
2. PDR drawings are preliminary and are not for construction. See Appendix E for PDR drawings for each Contract Package.
3. The Program has been organized into five (5) Contracts Packages for the purposes of this PDR.
   - CP1 – Water Supply Pumping Station
   - CP2 – Water Supply Pipeline
   - CP3 – Booster Pumping Station, Storage and Chemical Facilities
   - CP4 – Return Flow Pumping Station
   - CP5 – Return Flow Pipeline and Outfall

   The final number of Contract Packages, the extent of each Contract Package, and the elements contained within each Contract Package will be further refined during design. The Contracting Strategy Report (7-200 D1) will be developed to provide a recommendation on the number and extent of the Contract Packages.
4. Horizontal alignments for the Water Supply and Return Flow Pipelines were completed using the following information from GIS: tax parcel and right-of-way information, delineated wetlands and floodplains, and utility information, including water and sewer, within the Waukesha. A review of surface level utilities was used to align the pipelines to minimize utility impacts. Horizontal pipeline alignments are preliminary and will be refined after certified field survey and utility locating services has been completed. The Contract Documents will include property lines and right-of-way lines as provided by a certified land surveyor.
5. The limits of wetland delineation shown on the drawings are from GIS and the WDNR Wisconsin Wetland Inventory. Field investigations are ongoing, including wetland delineation, and certified wetland limits will be included in Contract Documents during design.
6. Road and rail pipeline crossings that are anticipated to require special crossings are identified on the PDR drawings. Wetland and waterway pipeline crossings that are anticipated to require special crossings are identified on the PDR drawings. The special crossings were identified in order to develop the Opinion of Probable Construction Cost for the pipelines. The assumptions made to develop the special crossings are:
   a. Road and Rail: Significant road and rail crossings are assumed to be steel casing pipe installed by the jack and bore method. The actual type, quantity, location, and length of road and rail special crossings will be refined during design based on the completion of field investigations, refinement of the horizontal alignment, discussions with WWU, and the requirements of local authorities regarding road closure statues and maintenance of traffic requirements.
   b. Wetlands and Waterways: Significant wetland and waterway crossings are assumed to be installed using the horizontal directional drilling method. The actual type, quantity, location, and length of wetlands and waterways special crossings will be refined during design based on the completion of field investigations,

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refinement of the horizontal alignment, discussions with WWU, the requirements of local authorities regarding classification of wetlands and waterways, and the permitting procedure and duration associated with obtaining approval for open cut installation of pipeline through a wetland and/or waterway.

7. For the Booster Pumping Station (BPS), the chemical type and dosage are to be determined from the results of the water quality and pipe loop testing that is ongoing. For the purposes of this PDR, assumptions were made on the chemical type and dosage in order to determine the approximate size of the BPS and develop the Opinion of Probable Construction Cost.
8. The maximum flow rate for Return Flow Pumping Station (RFPS) is assumed to be 12 million gallons per day. The flow rate is under negotiation with WDNR and the final design capacity of the RFPS will be refined dependent on the final requirements set forth by WDNR.

Program Overview

The following subsection identifies the Program Elements needed to transition Waukesha's water supply as part of the Program.

Program Elements

Key Program Elements associated with Waukesha's water supply transition were identified. The Program Elements are listed below, following the flow path along the water supply and return flow systems as shown in Figure ES - 1.

1. Water Connection at Water Supplier: A connection will be required to draw water from the Milwaukee Water Works (MWW) distribution system.
2. Water Supply Pumping Station (WSPS): A WSPS will be required to provide the head necessary to convey water to Waukesha through the Water Supply Pipeline. The WSPS will be owned and operated by MWW, and designed to MWW standards and preferences.
3. Water Supply Pipeline and Appurtenances: A Water Supply Pipeline will be needed to convey water from the water supplier to Waukesha.
4. Water Reservoirs: Water reservoirs will be required between the WSPS and Waukesha to attenuate demands and provide for storage. An air break is envisioned upstream of the water reservoirs to prevent backflow from the water reservoirs in the event of Water Supply Pipeline failure.
5. Booster Pumping Station (BPS): A BPS will be required to provide the head necessary to convey flow from the water reservoirs to WWU's distribution system.
6. Chemical Feed Facilities: Chemical feed facilities will be required to provide the ability to adjust water quality characteristics, such as residual disinfectant and corrosion inhibitor levels.
7. Water Connection to Waukesha: A connection will be required to supply WWU's distribution system. A Water Supply Control Building (WSCB) will be required upstream of the connection to maintain discharge pressures to within desirable ranges for WWU's distribution system.
8. WWU Distribution System Improvements: WWU's distribution system is currently supplied by geographically disperse groundwater wells. The new water supply will feed the distribution system from one connection point. Therefore, improvements could be required at future demand conditions to accommodate the pressure distribution resulting from the new water supply.
9. Return Flow Pumping Station (RFPS): A RFPS will be required to provide the head necessary to convey highly treated effluent from Waukesha's Clean Water Plant to the Root River. The RFPS will be owned and operated by Waukesha's Department of Public Works, and designed to satisfy their standards and preferences.

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10. Return Flow Pipeline and Appurtenances: A Return Flow Pipeline will be required to convey highly treated effluent from the RFPS to the Root River.
11. Return Flow Facilities at Root River: Facilities at the Root River outfall are anticipated to provide a means for discharging highly treated effluent to the Root River. A reaeration structure is anticipated to be required to provide dissolved oxygen adjustment prior to discharge to meet regulatory requirements.

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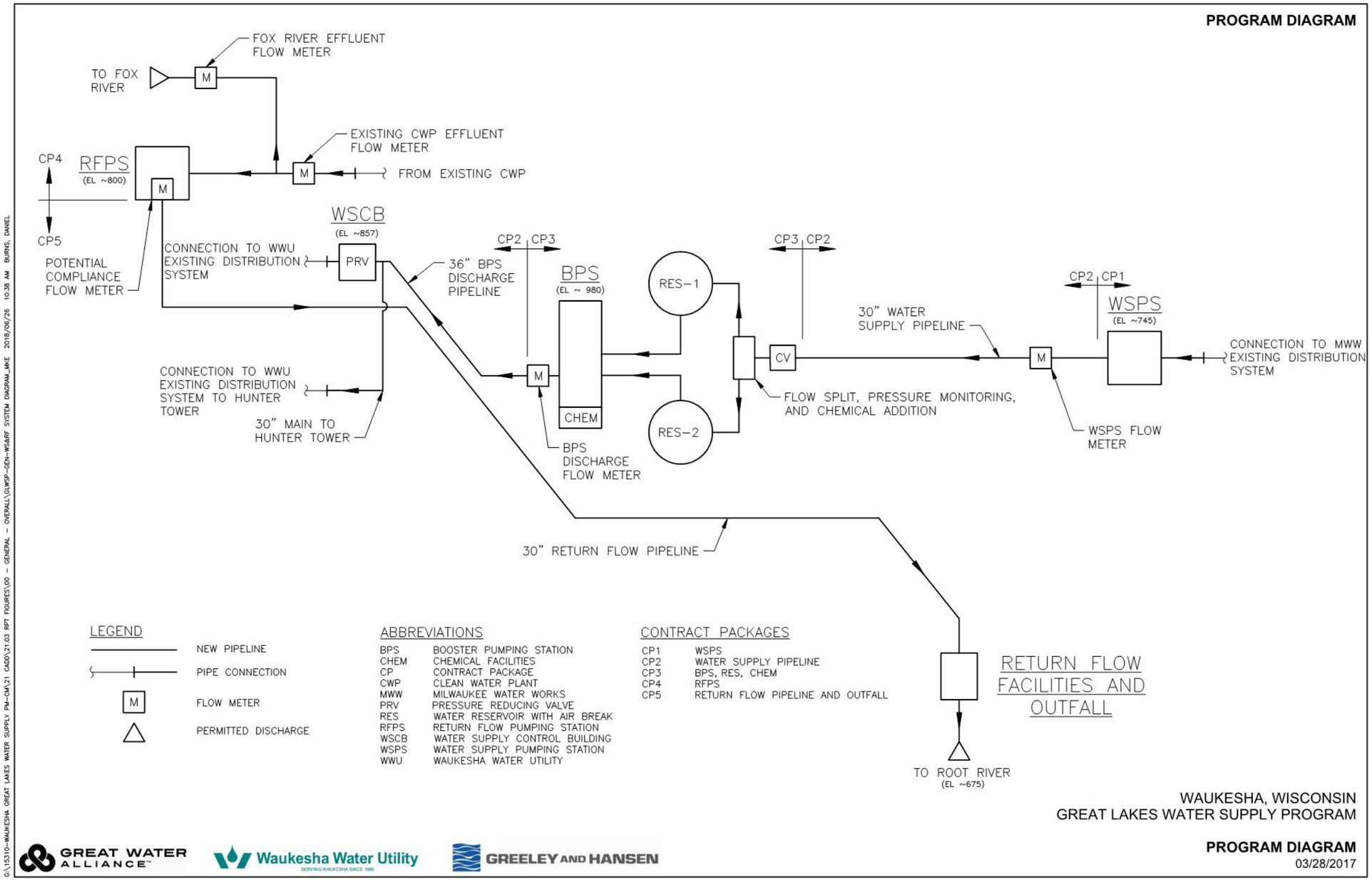

Figure ES - 1 Program Diagram

The Program Elements listed below are undefined due to permit requirements that are yet to be defined for discharge to the Root River.

1. Necessary Clean Water Plant (CWP) Improvements (Exclusive of RFPS)
2. Other Program Elements

Program Sustainability Goals

When Waukesha's Application was approved by the Compact Council, Waukesha's Mayor released a statement that closed with a commitment to "provide a safe sustainable water supply for the people of the City of Waukesha." This pledge of civic duty extends from Waukesha's local government, to WWU and on to the Program. Quality and resilient engineering required to fulfill this design necessitates sustainable thinking that extends the design life of the Program Elements and establishes that the new infrastructure will be able to meet the future needs of the community.

To track the cumulative benefit of sustainability initiatives pursued or committed to, the Program is being evaluated using the Envision rating system by the Institute for Sustainable Infrastructure. This rating system provides a holistic framework for measuring the net benefit of investments made in the social, economic, and environmental well-being of the communities served by the infrastructure. The rating system measures sustainability in five categories: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Resiliency.

Route Studies

This PDR was developed in conjunction with two (2) independent route studies. Draft Route Study: Oak Creek (4-100 D1) was developed to determine the route for the Return Flow Pipeline and Draft Route Study: Milwaukee (4-100 D2) was developed to determine the route for the Water Supply Pipeline. The route studies detail the procedure for establishing the preferred routes. Multiple preliminary route alternatives within each study were evaluated with respect to specific economic and non-economic evaluation criteria developed with input from WWU. Specific tasks consisted of collecting and reviewing pertinent data, conducting field reconnaissance, performing desktop assessments, conducting public Open House meetings, incorporating stakeholder feedback from the public Open House meetings, completing steady state hydraulic analyses, and preparing conceptual opinions of probable construction cost. The selected Water Supply and Return Flow Pipeline routes are displayed in Figure ES - 2.

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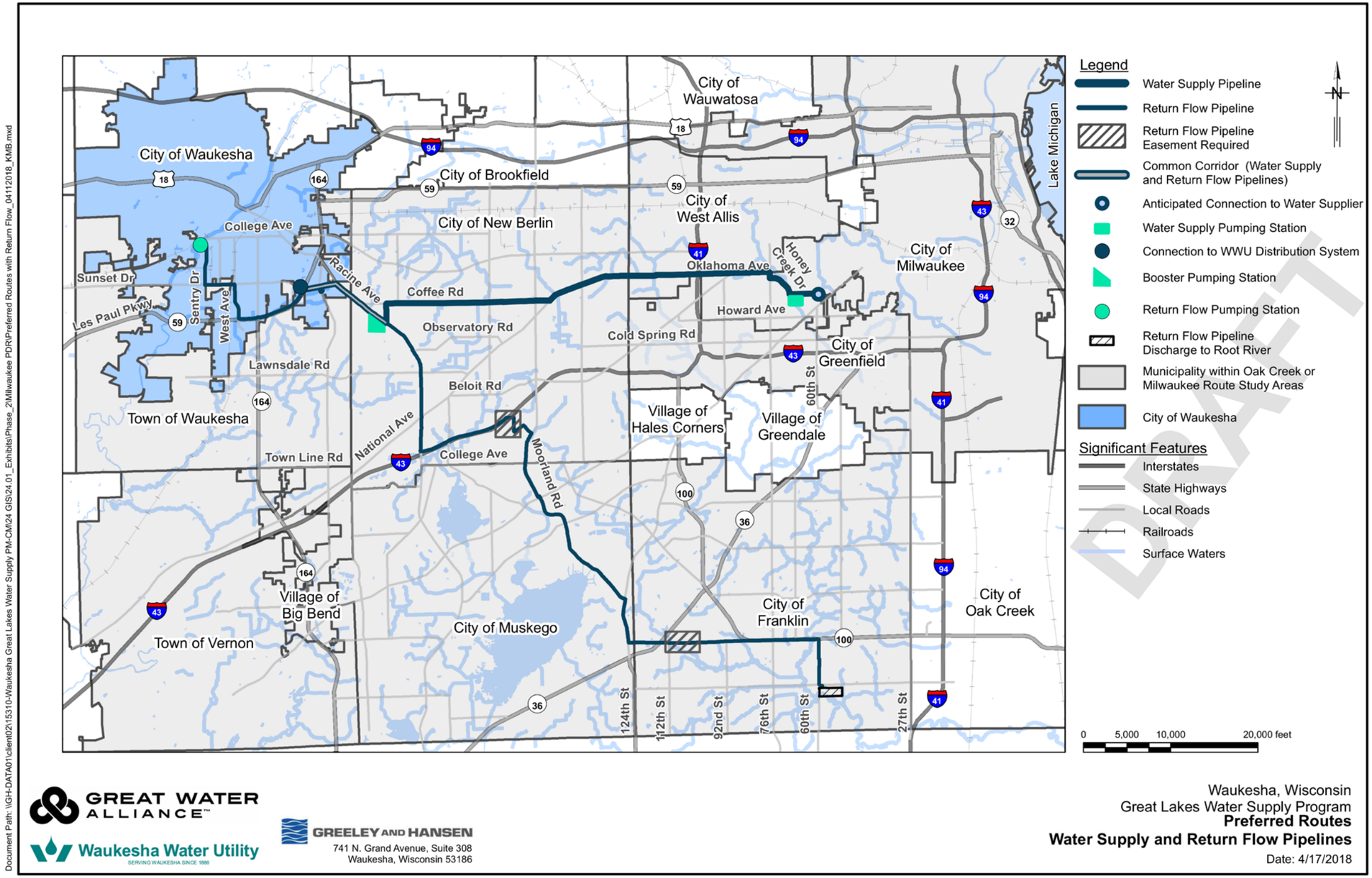

Figure ES - 2 Pipeline and Return Flow Pipeline Routes

Program Permitting

Acquiring the necessary permits and approvals is critical in order to meet the Program schedule. More than 80 permits and approvals required by local, state, and federal authorities are anticipated as part of the Program. The permits and approvals that have the most significant impact on the Program schedule and the authority having jurisdiction are listed below:

- Clean Water Plant Wisconsin Pollutant Discharge Elimination System Permit Renewal – WDNR
- CWP Facilities Plan Amendment – WDNR
- Supplemental Environmental Impact Report – WDNR
- Type 2 Application for Certificate of Authority and Wetland and Waterway Impact Permits – PSC, WDNR, USACE
- Construction Plan Reviews – WDNR
- Local Construction Permits – Local municipalities in which construction is taking place

Program Basis of Design

The Program basis of design is separated into the water supply system and return flow system basis of design, summarized in Table ES - 1 and Table ES - 2, respectively.

Table ES - 1 Water Supply System Basis of Design

Description	Design Values
Water Supply Flow Rate	
Minimum Hour Demand, MGD	1.2
Minimum Day Demand, MGD	3.1
Average Day Demand, MGD	8.2
Maximum Day Demand, MGD	13.6
Peak Hour Demand, MGD	19.0
Water Supply Pumping Station	
Number of Water Supply Pumps	5
Water Supply Pump (Number 1)	
Flow per Pump, MGD	2
Head, feet	300
Motor Size, horsepower	132
Variable Frequency Drive	Yes
Water Supply Pumps (Number 2 through 5)	
Flow per Pump, MGD	4.4
Head, feet	300
Motor Size, horsepower	275
Variable Frequency Drive	Yes
Firm Capacity (Largest Pump Out of Service), MGD	15.2

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Description	Design Values
Installed Capacity, MGD	19.6
Water Supply Pipeline	
Material	Ductile Iron or Steel Pipe
Diameter, inches	30 and/or 36
Maximum Steady State Design Pressure, psig	225
Minimum Design Pressure, psig	35
Minimum Depth of Cover, feet	6'-6"
Booster Pumping Station	
Booster Pumps	
Number of Booster Pumps	4
Flow per Pump, MGD	5.25
Head, feet	145
Motor Size, horsepower	250
Variable Frequency Drive	Yes
Jockey Pumps	
Number of Jockey Pumps	2
Flow per Pump, MGD	2.75
Head, feet	130
Motor Size, horsepower	100
Variable Frequency Drive	Yes
Firm Capacity (Largest Pump Out of Service), MGD	15.75
Installed Capacity, MGD	21.00
Reservoirs	
Number of Reservoirs	2
Volume per Reservoir, MG	9.0
Diameter, feet	210
Total Effective Storage Level, feet	35
Material	Precast Prestressed Concrete
Mixing System	Recirculation Line and Pumps
Chemicals	
Sodium Hypochlorite	Disinfection
Liquid Ammonium Sulfate	Disinfection
Blended Phosphate	Corrosion Inhibitor

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Table ES - 2 Return Flow System Basis of Design

Description	Design Values
Return Flow Rate	
Minimum Hour, MGD	0.0
Initial Average Day, MGD	6.6
Future Average Day, MGD	8.2
Maximum Hour, MGD	12.0
Return Flow Pumping Station	
Return Flow Pumps	
Number of Return Flow Pumps	4
Flow per Pump, MGD	4
Head, feet	278
Motor Size, horsepower	300
Variable Frequency Drive	Yes
Firm Capacity (Largest Pump Out of Service), MGD	12.0
Installed Capacity, MGD	16.0
Return Flow Pipeline	
Material	Ductile Iron, Steel Pipe, or PCCP
Diameter, inches	30
Design Capacity, MGD	13.6
Installed Capacity, MGD	20.1
Maximum Steady State Design Pressure, psig	225
Minimum Depth of Cover, feet	6'-6"
Return Flow Facilities and Outfall	
Receiving Body	Root River
Water Quality Improvements at Return Flow Facilities	Cascade Aeration via Reaeration Structure

Program Opinion of Probable Construction Cost

A Class 3 Opinion of Probable Construction Cost (OPCC) has been prepared in accordance with the Association for the Advancement of Cost Engineering's (AACE's) Recommended Practice No. 18R-97. Costs were developed in mid-2017 dollars at an Engineering News-Record Construction Cost Index (ENR CCI) value of 10,942. A contingency of 20% was used. Unit cost information used various resources in effort to provide the best available information for each item, including manufacturer quotes, RS Means, and local Southeast Wisconsin bid tabs.

Table ES-3 represents the overall Program construction costs broken out by Program Element.

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Table ES - 3 Summary of Program Costs

Element No.	Program Element Description	($ Million)
1	Water Connection at Water Supplier	0.0(1)
2	Water Supply Pumping Station at Water Supplier	0.0(1)
3	Booster Pumping Station at Minooka Park	12.8
4	Water Reservoirs at Minooka Park	13.0
5	Water Supply Pipeline and Vaults	34.6
6	Chemical Feed Facilities	0.3
7	Water Connection at Waukesha	1.2
8	Waukesha Water Distribution System Improvements	0.0(2)
9	Return Flow Pumping Station	4.1
10	Return Flow Pipeline and Vaults	65.4
11	Facilities at Root River	1.7
12	Necessary CWP Improvements (Exclusive of Return Flow Pumping Station)	0.0(2)
13	Other Elements	0.0
	Construction Subtotal	133.1
	Bonds and Insurance (at 3%)	4.0
	Mobilization / Demobilization (at 5%)	6.7
	Contingency (at 20%)	26.6
	Contractor Overhead and Profit (at 15%)	20.0
	Construction Total	190.4
	Engineering	36.5
	Permitting, Legal, and Administration	-
	Engineering Services During Construction	7.5
	Construction Management	16.5
	Program Total	250.9
	Permitting, Legal, and Administration (Application)	6.8
	Permitting, Legal, and Administration (Program)	5.8
	Distrubition System Improvements	22.8
	Lake Michigan Water Diversion Total	285.3

1. Paid for by Milwaukee Water Works.
2. Will be completed outside of Program Scope.

Program Schedule

The Program Schedule has been developed in coordination with WDNR, PSC, Wisconsin Department of Transportation, local municipalities, and other regulatory and governing agencies. The Contract Package construction sequencing, as shown in Figure ES - 3 Program Schedule, will include construction of facilities, operational testing and commissioning to meet regulatory deadlines.

Key Program milestones and dates are as follows:

- October 2016 – Program initiation
- September 2018 – PSC Type 2 Application for Certificate of Authority and a joint WDNR and USACE Chapter 30/Chapter 281.36 and Section 404 Wetlands and Waterways Impact Individual Permit Application

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- August 2020 – Program construction initiation
- May 1, 2022 –DOJ Stipulation Program construction 50% completion
- August 2023 – Program startup and transitioning completion
- September 1, 2023 – DOJ Stipulation full water supply transition

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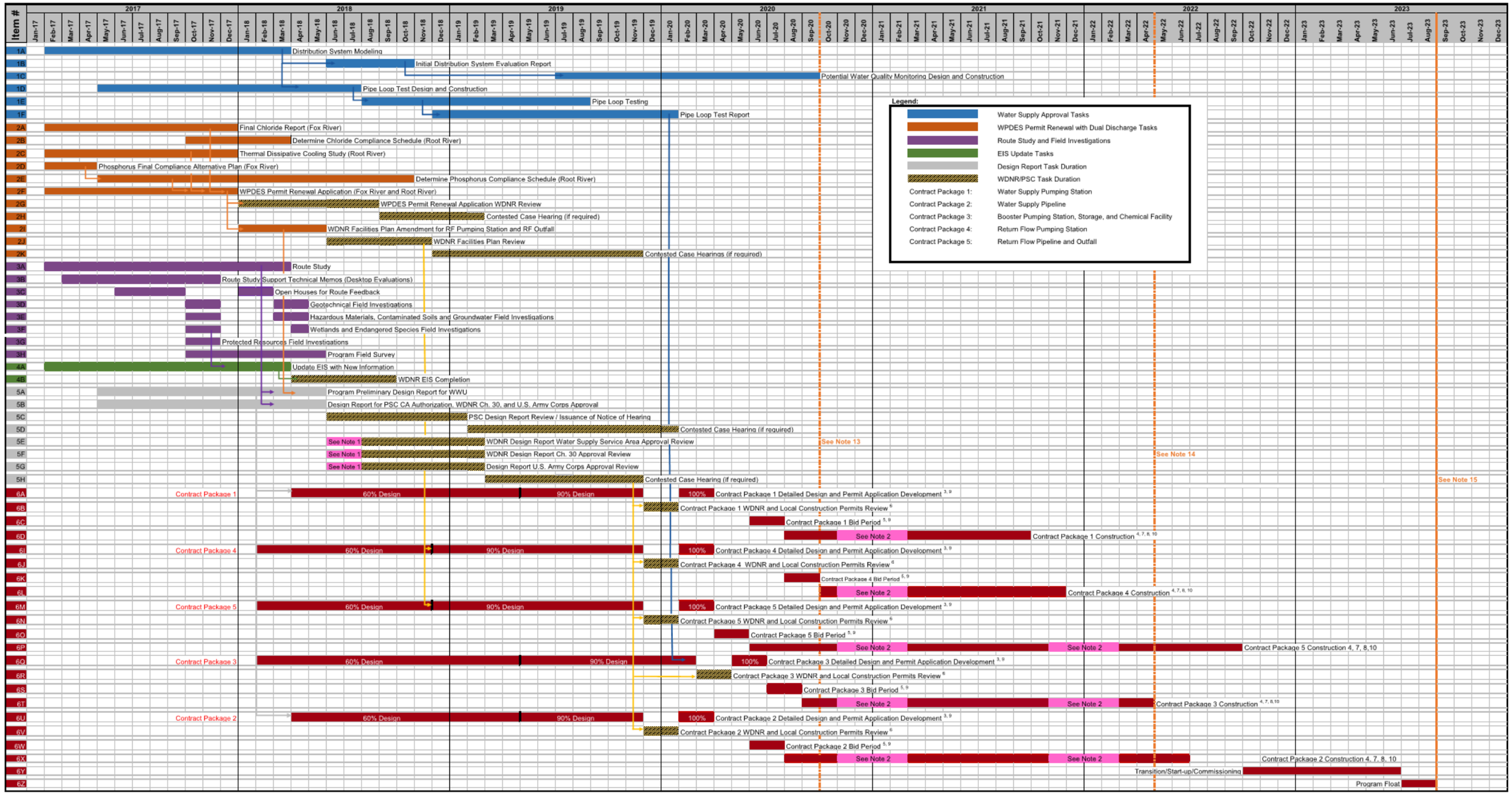

Figure ES - 3 Program Schedule

SECTION 1 Introduction

1.1 Background

The Waukesha Water Utility (WWU) provides water treatment and distribution services to the City of Waukesha (Waukesha) and isolated portions of the Town of Waukesha. WWU owns and operates a system of wells that pump groundwater from the St. Peter Sandstone aquifer for treatment and then to WWU's distribution system. The St. Peter Sandstone aquifer, which has been the primary source of drinking water for not only Waukesha, but for communities throughout the Midwest, is being depleted in Southeast Wisconsin. This is due in large part to a natural layer of shale rock that restricts groundwater recharge. Depletion of the St. Peter Sandstone aquifer has also caused increases in the concentrations of radium and other contaminants. As a result, Waukesha needs a long-term, sustainable alternative to its existing water supply to protect public health.

In 2009, the Department of Justice (DOJ) issued a Stipulation Order to WWU to enforce state and federal drinking water radionuclide standards. Following study efforts and public engagement, Waukesha submitted in 2010 and resubmitted in 2013, the Application for Lake Michigan Diversion with Return Flow (Application) to the Wisconsin Department of Natural Resources (WDNR). In the Application, Lake Michigan water was determined to be the only sustainable source of water that protects both the environment and public health. WDNR concurred that Waukesha's proposal met the criteria of the Great Lakes-St. Lawrence River Basin Water Resources Compact (Compact) and submitted the Application to the Great Lakes-St. Lawrence River Basin Water Resources Council (Compact Council) for review.

The Compact Council was established in 2008 when the Compact became federal and state law in the United States. The Compact Council is comprised of eight governors from the Great Lakes states: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin. The purpose of the Compact is to provide a legal precedent through which to manage and protect the Great Lakes-St. Lawrence River Basin per the governors' pledge with the premiers of the Canadian provinces of Ontario and Quebec.

In its Final Decision, dated June 21, 2016, the Compact Council unanimously approved Waukesha's Application to source water from Lake Michigan and the required return flow to the Great Lakes-St. Lawrence River Basin via the Root River. WWU subsequently commissioned a team of consultants to implement a program to transition Waukesha's water supply from groundwater to Lake Michigan water which later became known as the Great Water Alliance (Program). The purpose of the Program is to plan, design, construct, and commission infrastructure with a 100-year useful life necessary to transition Waukesha's water supply.

The Program is the first for a community in a county straddling the Great Lakes-St. Lawrence River Basin to access Great Lakes water through the Compact. Successful implementation of the Program will set industry precedents for solving water quality and water scarcity challenges for at-risk water supplies in other Great Lakes Communities eligible to receive Great Lakes water through the Compact.

Refer to Figure 1-1 for a vicinity map of the Program area.

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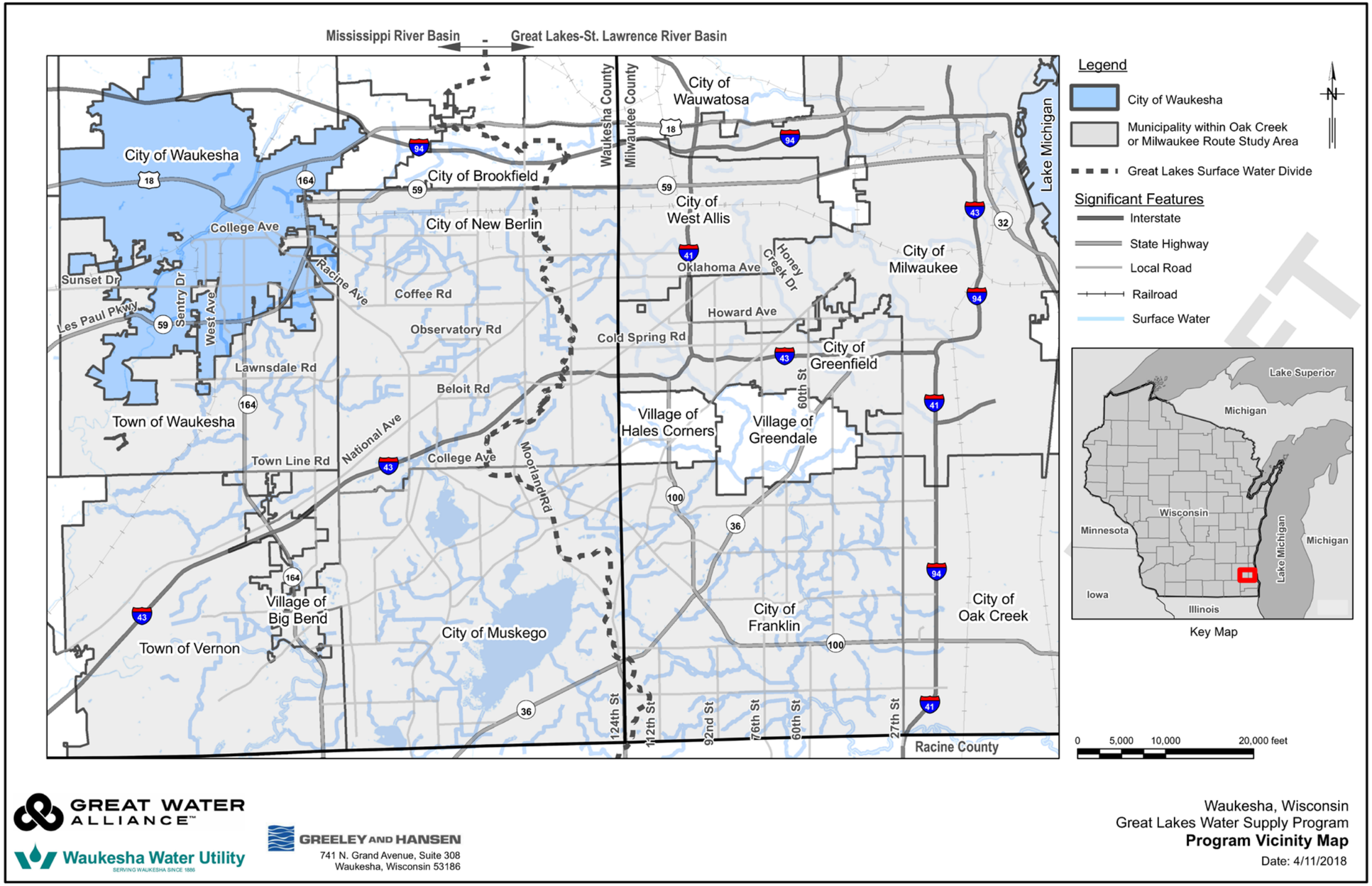

Figure 1-1 Program Vicinity Map

1.2 Preliminary Design Report Purpose

The purpose of this Preliminary Design Report (PDR) is to summarize the activities that have occurred and document the conclusions that have been made through meetings and workshops for the preliminary design of the Program. The PDR was developed in conjunction with two (2) independent route studies. Draft Route Study: Oak Creek (4-100 D1) was developed to determine the Return Flow Pipeline Route and Draft Route Study: Milwaukee (4-100 D2) was developed to determine the route for the Water Supply Pipeline Route. The route studies detail the procedure for establishing the preferred routes. The PDR and both route studies will be the used to develop the permit applications required for Public Service Commission (PSC), WDNR, and United States Army Corps of Engineers (USACE) and are required before Program construction can begin.

1. PSC Type 2 Application for Certificate of Authority
2. A joint WDNR and USACE Chapter 30/Chapter 281.36 and Section 404 Wetlands and Waterways Impact Individual Permit Application (also referred to as the "Individual Permit").

Both permits will be submitted to the PSC, the WDNR, and the USACE for approval.

1.3 Preliminary Design Report Goals and Objectives

The PDR defines the infrastructure necessary to supply Waukesha with a new, sustainable water supply from Milwaukee Water Works in the City of Milwaukee and to return highly treated effluent to the Root River. The PDR addresses these areas by including the following items:

- Details of the proposed hydraulic components of the design
- Proposed site layout and equipment selection
- Summary of technical information by discipline (civil/site, structural, architectural, process mechanical, mechanical, plumbing, electrical, and instrumentation and control (I&C))
- Preliminary operational descriptions for the water supply and return flow systems and a preliminary operator/machine interface philosophy
- Preliminary drawings titled as Draft Preliminary Design Report Drawings for civil/site, structural, architectural, process mechanical, mechanical, plumbing, electrical, and I&C for each Program Element
- Preliminary Opinion of Probable Construction Cost and Operation and Maintenance Costs for the Program

1.4 Preliminary Design Report Organization

This PDR summarizes the preliminary design decisions to transition Waukesha's water supply. It identifies next steps and challenges associated with the next phase of design and construction. The information contained herein documents design preferences and provides a basis for continued design efforts. To accomplish these objectives, the PDR sections were arranged to provide the background and general information relevant to the WWU system and the water supplier, followed by the technical sections of the new facilities and pipeline that make up the overall system. The technical sections are arranged to follow the flow of water from Lake Michigan to Waukesha and back to Lake Michigan via the Root River. The PDR has been organized into the following sections:

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- Executive Summary
- Section 1 Introduction
- Section 2 Program Overview
- Section 3 Regulatory and Permitting Conditions
- Section 4 General Basis of Design
- Section 5 Existing Facilities
- Section 6 Water Supplier
- Section 7 Water Demand
- Section 8 Water Distribution System Modeling
- Section 9 Water Supply Pumping Station Design
- Section 10 Water Supply and Return Flow Pipeline Design
- Section 11 Booster Pumping Station and Reservoir Design
- Section 12 Return Flow Pumping Station Design
- Section 13 Return Flow Facilities Design
- Section 14 Opinion of Probable Construction Cost and Operation and Maintenance Costs
- Section 15 Program Construction Schedule

1.5 Preliminary Design Report Notes and Assumptions

Due to the Program being in the early stages of development and ongoing field investigations, assumptions were made in order to progress the design to this level. Below is a list of assumptions that were made in developing the PDR.

1. The background information for site and pipeline alignment PDR drawings were created using Geographical Information System (GIS) and aerial photographs. No certified field survey or utility location services were included in the preparation of the PDR drawings.
2. PDR drawings are preliminary and are not for construction. See Appendix E for PDR drawings for each Contract Package.
3. The Program has been organized into five (5) Contracts Packages for the purposes of this PDR.
   - CP1 – Water Supply Pumping Station
   - CP2 – Water Supply Pipeline
   - CP3 – Booster Pumping Station, Storage and Chemical Facilities
   - CP4 – Return Flow Pumping Station
   - CP5 – Return Flow Pipeline and Outfall

   The final number of Contract Packages, the extent of each Contract Package, and the elements contained within each Contract Package will be further refined during design. The Contracting Strategy Report (7-200 D1) will be developed to provide a recommendation on the number and extent of the Contract Packages.
4. Horizontal alignments for the Water Supply and Return Flow Pipelines were completed using the following information from GIS: tax parcel and right-of-way information, delineated wetlands and floodplains, and utility

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information, including water and sewer, within Waukesha. A review of surface level utilities was used to align the pipelines to minimize utility impacts. Horizontal pipeline alignments are preliminary. The horizontal and vertical alignments will be designed in 60% design after certified field survey and utility location services have been completed. The Contract Documents will include property lines and right-of-way lines as provided by a certified land surveyor.

5. The limits of wetland delineation shown in the drawings are from GIS and the WDNR Wisconsin Wetland Inventory. Field investigations are ongoing, including wetland delineation, and certified wetland limits will be included on Contract Documents during design.
6. Road and rail pipeline crossings that are anticipated to require special crossings are identified on the PDR drawings. Wetland and waterway pipeline crossings that are anticipated to require special crossings are identified on the PDR drawings. The special crossings were identified in order to develop the Opinion of Probable Construction Cost for the pipelines. The assumptions made to develop the special crossings are:
    a. Road and Rail: Significant road and rail crossings are assumed to be steel casing pipe installed by the jack and bore method. The actual type, quantity, location, and length of road and rail special crossings will be refined during design based on the completion of field investigations, refinement of the horizontal alignment, discussions with WWU, and the requirements of local authorities regarding road closure statues and maintenance of traffic requirements.
    b. Wetlands and Waterways: Significant wetland and waterway crossings are assumed to be installed using the horizontal directional drilling method. The actual type, quantity, location, and length of wetlands and waterways special crossings will be refined during design based on the completion of field investigations, refinement of the horizontal alignment, discussions with WWU, the requirements of local authorities regarding classification of wetlands and waterways, and the permitting procedure and duration associated with obtaining approval for open cut installation of pipeline through a wetland and/or waterway.
7. For the Booster Pumping Station, the chemical type and dosage are to be determined from the results of the water quality and pipe loop testing that is ongoing. For the purposes of this PDR, assumptions were made on the chemical type and dosage in order to determine the approximate size of the Booster Pumping Station and develop the Opinion of Probable Construction Cost.
8. The maximum flow rate for Return Flow Pumping Station is assumed be 12 million gallons per day. The flow rate is under negotiation with WDNR and the final design capacity of the Return Flow Pumping Station will be refined dependent on the final requirements set forth by WDNR.

1.6 Preliminary Design Report Timeline

The timeline and next steps for the PDR and subsequent permitting documents are as follows:

- The PDR will be submitted at the end of April 2018. Design review workshops will be held with WWU in May 2018 to review the design concepts of the Program, respond to any questions or comments from WWU, and gain consensus on the preliminary design. The PDR will be updated to respond to any comments from the WWU and the revised PDR will be submitted in June 2018.
- Field investigations are scheduled to be completed by August 2018.
- The PSC Type 2 Application for Certificate of Authority and joint WDNR and USACE Chapter 30/Chapter 281.36 and Section 404 Wetlands and Waterways Impact Individual Permit Application will be submitted to the agencies in September 2018.

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SECTION 2 Program Overview

The following subsection identifies the Program Elements needed to transition the City of Waukesha's (Waukesha's) water supply as part of the Great Water Alliance (Program). The sustainable tools, meetings, workshops, and reference documents used to support preliminary design of the Program Elements are summarized.

2.1 Program Elements

Key Program Elements associated with Waukesha's water supply transition were identified. The Program Elements are listed below following the flow path along the water supply and return flow systems and are shown in Figure 2-1.

1. Water Connection at Water Supplier: A connection will be required to draw water from the Milwaukee Water Works (MWW) distribution system.
2. Water Supply Pumping Station (WSPS): A WSPS will be required to provide the head necessary to convey water to Waukesha through the Water Supply Pipeline. The WSPS will be owned and operated by MWW, and designed to MWW standards and preferences.
3. Water Supply Pipeline and Appurtenances: A Water Supply Pipeline will be needed to convey water from the water supplier to Waukesha.
4. Water Reservoirs: Water reservoirs will be required between the WSPS and Waukesha to attenuate demands and provide for storage. An air break is envisioned upstream of the water reservoirs to prevent backflow from the water reservoirs in the event of Water Supply Pipeline failure.
5. Booster Pumping Station (BPS): A BPS will be required to provide the head necessary to convey flow from the water reservoirs to WWU's distribution system.
6. Chemical Feed Facilities: Chemical feed facilities will be required to provide the ability to adjust water quality characteristics, such as residual disinfectant and corrosion inhibitor levels.
7. Water Connection to Waukesha: A connection will be required to supply WWU's distribution system. A Water Supply Control Building (WSCB) will be required upstream of the connection to maintain discharge pressures to within desirable ranges for WWU's distribution system.
8. WWU Distribution System Improvements: WWU's distribution system is currently supplied by geographically disperse groundwater wells. The new water supply will feed the distribution system from one connection point. Therefore, improvements could be required at future demand conditions to accommodate the pressure distribution resulting from the new water supply.
9. Return Flow Pumping Station (RFPS): A RFPS will be required to provide the head necessary to convey highly treated effluent from Waukesha's Clean Water Plant (CWP) to the Root River. The RFPS will be owned and operated by Waukesha's Department of Public Works, and designed to satisfy their standards and preferences.
10. Return Flow Pipeline and Appurtenances: A Return Flow Pipeline will be required to convey highly treated effluent from the RFPS to the Root River.

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11. **Return Flow Facilities at Root River:** Facilities at the Root River Outfall are anticipated to provide a means for discharging highly treated effluent to the Root River. A reaeration structure is anticipated to be required to provide dissolved oxygen (DO) adjustment prior to discharge to meet regulatory requirements.

The Program Elements listed below are undefined due to permit requirements that are yet to be defined for discharge to the Root River.

12. Necessary CWP Improvements (Exclusive of RFPS)
13. Other Program Elements

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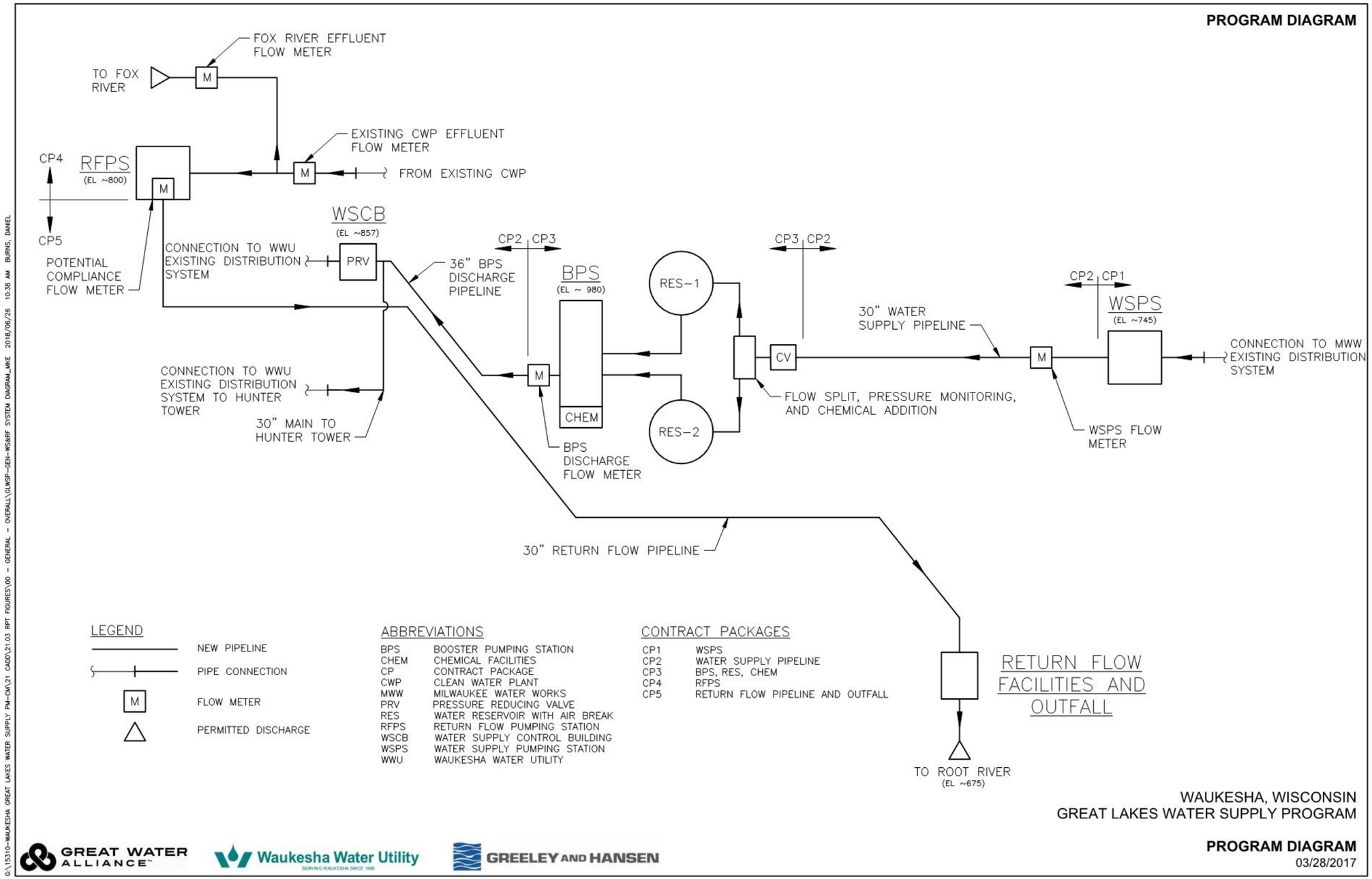

Figure 2-1 Program Diagram

2.2 Contract Packages

The Program Elements have been grouped into Contract Packages to allow for construction to progress at multiple locations concurrently, thereby providing for schedule control and compression opportunities. Contract Package optimization would allow local contractors in Southeast Wisconsin to successfully bid and construct various Program Elements, while sourcing national contractor(s) to supplement a greater breadth and depth of experience in constructing water infrastructure of this magnitude. Grouping the Program Elements into smaller Contract Packages allows the Program to apply for loans and use State Revolving Funds (SRFs).

The Contract Packages are being determined as part of the Draft Contracting Strategy Report (7-200 D1) developed in coordination with WWU. For the purposes of this Preliminary Design Report (PDR), the Contract Packages have been defined as listed in Table 2-1 and shown in Figure 2-1.

Table 2-1 Contract Package Summary

Contract Package		Program Element No.[1]
No.	Title	
1	Water Supply Pipeline Station	2
2	Water Supply Pipeline Station	1, 3, 7
3	Booster Pumping Station, Storage and Chemical Facilities	4, 5, 6
4	Return Flow Pumping Station	9
5	Return Flow Pipeline and Outfall	10, 11

Notes:
1 It is anticipated that work associated with Program Element No. 8 (WWU Distribution System Improvements) will be completed separately from the Program.

2.3 Sustainability

When Waukesha's Application for Lake Michigan Diversion with Return Flow (Application) was approved by the Great Lakes-St. Lawrence River Basin Water Resources Council (Compact Council), Waukesha's Mayor released a statement that closed with a commitment to "provide a safe sustainable water supply for the people of the City of Waukesha." This pledge of civic duty extends from Waukesha's local government to WWU and on to the Program. Quality and resilient engineering required to fulfill this design necessitates sustainable thinking that extends the design life of the Program Elements and establishes that the new infrastructure will be able to meet the future needs of the community. The following subsections summarize how the Program is considering sustainability in the design of Program Elements.

2.3.1 Background

Consistent with the Program's vision of getting it right the first time and building it to last, the Program seeks opportunities to advance sustainability. At its core, the Program mitigates the environmental harm caused by an open-loop water cycle that siphons water from the Great Lakes–St. Lawrence River Basin via overburdened aquifers and then discharges that water into the Mississippi River Basin via the Fox River. The Program closes the loop by

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withdrawing water from Lake Michigan at its surface and then returning it back to the source. Beyond this basic premise, the Program is governed by a highly collaborative and regionally-minded approach to protect the Great Lakes–St. Lawrence River Basin and foster the social, economic, and environmental sustainability of Southeast Wisconsin. Not only does the Program protect the overall health of the residents within WWU's service area, it also drives economic stability by establishing a reliable water source. Further, the Program eliminates Waukesha's reliance on aquifers for drinking water, allowing the aquifers to recharge with time, beginning to restore the predevelopment hydrologic network of springs, rivers and wetlands and the natural habitats that depend on them.

2.3.2 Envision

Increasingly, investors in infrastructure select projects that have broad community support, are managed by strong leadership using good governance mechanisms, and are not associated with environmental policies perceived as harmful. To track the cumulative benefit of sustainability initiatives pursued or committed to, the Program is being evaluated using the Envision rating system by the Institute for Sustainable Infrastructure. This rating system provides a holistic framework for measuring the net benefit of investments made in the social, economic, and environmental well-being of the communities served by the infrastructure. The rating system measures sustainability in five categories: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Resiliency.

The Program utilizes the Envision rating system as a planning guide for conducting sustainable and holistic design. Envision evaluates, grades, and gives recognition to infrastructure projects that make exemplary progress and contributes to the long-term sustainability of the communities they serve. As part of this process, design alternatives will continue to be evaluated using a series of Key Performance Indicators (KPIs). The KPIs are used to assist in determining preferred design alternatives. KPIs are criteria that remain constant with constant weights, but the alternatives and the metrics for each KPI change based on the decision that is being evaluated. The KPI definitions were developed to be broad enough to apply to all aspects of the Program and act as universal weighing criteria. WWU staff weighed the KPIs from one (to represent a less significant or lower perceived impact to the Program and public) to ten (to represent a more significant or higher perceived impact to the Program and public). The weights were linearly scaled such that the sum of all weights produced a value of 100. The KPIs are listed by descending weights in Table 2-2 alongside their definitions which are aligned with the sustainability guidelines from the Envision rating system by the Institute for Sustainable Infrastructure.

Table 2-2 Key Performance Indicator Summary

Key Performance Indicator	Definition	Weight
System Reliability	Using robust design strategies, preventive maintenance and intuitive configurations, Program Elements are dependable and resilient.	19
Life Cycle Cost	Pursue strategies that reduce long-term operational and maintenance costs.	15.5
Schedule	Complete the Program in a timeframe that mitigates negative impacts on the affected communities' quality of life.	14
Ease of Construction	Avoid sites that require intensive efforts to preserve or restore existing environmental conditions and utilities, integrate infrastructure, or access with construction equipment.	11
Public Acceptability	The Program vision and goals align with those of the affected communities, and the implementation of the Program expands the skills, capacity, mobility, and health of a community while mitigating negative impacts.	6.5

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Key Performance Indicator	Definition	Weight
Capital Cost	Minimize financial impact on the affected communities with consideration of factors such as resource conservation, ease of infrastructure integration, and avoiding site development that requires additional efforts to preserve existing site conditions.	6
Effects on Ability to Finance	Through triple bottom line (TBL) analysis of social, economic, and environmental impacts, Program Elements have been mitigated for risk and resiliency, helping enhance support for infrastructure investment.	6
Future Expansion	Implement designs and other measures that allow for the expansion of the Program to incorporate Compact Council approved future connections and increased flow without requiring additional infrastructure and capital expenditure.	6
Operational Flexibility	Reduce vulnerabilities by creating an adaptable design that can function in a variety of social, economic, and environmental conditions with monitored systems that allow ease and consistency of operation.	6
Environmental Impact	Measures are taken to preserve the natural world through avoidance, monitoring, restoration, and negative impact mitigation; resources are conserved during the construction and operation of the Program; there is a concerted effort to preserve the ambient conditions that affect quality of life of the affected communities, such as noise, light, air quality, wetlands, and waterways.	5
Cost Sharing Potential	Thorough infrastructure integration and commitment to synergistic opportunities, the cost of Program Elements is potentially shared by a broader community.	5

2.3.3 Triple Bottom Line Approach

The KPIs will continue to be implemented as weighting criteria to evaluate design alternatives in a Triple Bottom Line (TBL) Matrix shown in Table 2-3. This TBL Matrix both assists in decision making and documenting decisions made during the design process as needed.

Table 2-3 Triple Bottom Line Evaluation

Criteria		Weighting	Maximum Possible Score	Route Alternative		
				M1	M2	M3
1	Social and Community Goals					
1.1	Schedule	14.0	5	-	-	-
1.2	Public Acceptability	6.5	5	-	-	-
1.3	Operational Flexibility	6.0	5	-	-	-
1.4	Future Expansion	6.0	5	-	-	-
2	Economic Goals					
2.1	System Reliability	19.0	5	-	-	-
2.2	Life Cycle Cost	15.5	5	-	-	-
2.3	Ease of Construction	11.0	5	-	-	-
2.4	Capital Cost	6.0	5	-	-	-
2.5	Effects on Ability to Finance	6.0	5	-	-	-
2.6	Cost Sharing Potential	5.0	5	-	-	-

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Criteria	Weighting	Maximum Possible Score	Route Alternative		
			M1	M2	M3
3 Environmental Goals					
3.1 Environmental Impact	5.0	5			
Net TBL Score[1]	100	500	-	-	-
Percent of Max Possible Score		-	-%	-%	-%

Notes:
1 Net TBL Score = Sum of sub-criteria score x Weighting for each Alternative. Net TBL Scores were rounded to nearest whole number.

Route alternatives for the Water Supply and Return Flow Pipelines were evaluated using the KPIs and the TBL Matrix shown in Table 2-3. Refer to the Draft Route Study: Oak Creek (4-100 D1) and Draft Route Study: Milwaukee (4-100 D2) for how the TBL Matrix was utilized to support identifying the preferred routes for the Return Flow and Water Supply Pipelines, respectively.

2.3.4 Goals

In keeping with the Program vision, incremental steps towards sustainability are being pursued where feasible:

- Improvement to Community Quality of Life: Through documented collaboration with regional stakeholders, the Program strives to achieve the maximum benefit from capital investments made.
- Integration of Infrastructure: Regional assets were identified that if restored or improved would contribute to the overall economic well-being of the community.
- Reduction in Energy-use and Greenhouse Gases (GHG): When compared to viable alternatives, the Program requires less energy.
- Restoration of Wetlands: By switching to Lake Michigan water, aquifers will recharge and the hydrological conditions can be improved. In addition, protective measures are proposed wherever construction activities encroach on sensitive landscapes.
- Resiliency: The Program pursues a design approach to provide new infrastructure with a 100-year useful life. This approach promotes flexibility and resiliency to serve future generations of Waukesha residents.

WWU is pursuing a Platinum Award within the Envision rating system – the superlative level of achievement commensurate with WWU's goal of "getting it right." The Program is on track to meet this objective, targeting more than 50% of the total points available as shown in Figure 2-2.

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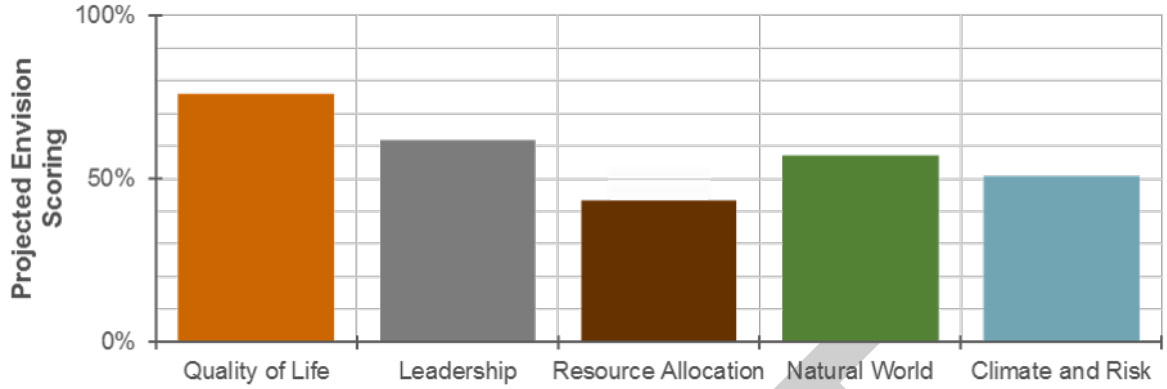

Figure 2-2 Envision Targeted Score of the Program, by Category

Sustainable practices have been and will continue to be implemented throughout the Program. Each design section of this PDR contains a subsection summarizing the sustainable approaches identified and/or utilized in preliminary design.

2.4 Meetings and Workshop Process

Meetings and workshops were held with WWU to discuss Program objectives, receive input regarding the development of planning and design concepts, review findings, and discuss and incorporate suggestions by WWU. Recommendations based upon input from WWU were prepared. The following meetings and workshops were held during Phase 2 related to the design of Program Elements. These meetings and workshops that contributed to the development of the design are organized by Tasks 4, 5, and 6 as shown below.

Refer to Appendix A for the meeting and workshop summaries.

Task 4: Route Studies and Pipelines

- 4-100 M-01 Route Study – Alternative Routes Review Meeting, March 2, 2017
- 4-100 M-02 Route Meeting: Ryan Road Sub-Alternatives and Criteria Weighting with Envision, May 18, 2017
- 4-100 M-03 Route Study Meeting: Preferred Return Flow Route, August 3, 2017
- 4-100 M-04 Route Study Meeting: Water Supply Route Development, November 30, 2017
- 4-100 M-05 Route Study Meeting: Preliminary Preferred Water Supply Route, February 16, 2018
- 4-100 M-06 Route Study Meeting: Preferred Water Supply Route, April 6, 2018
- 4-100 W-01 Preliminary Route Alternatives Report Workshop, February 2, 2017
- 4-100 W-02 Alternate Supply Route Review Workshop, April 19, 2017
- 4-100 W-03 Route Study: Oak Creek Review Workshop, November 21, 2017
- 4-300 M-01 Preliminary Design Meeting: Pipeline Materials, Isolation Valves, and Energy Recovery, June 28, 2017
- 4-300 M-02 Preliminary Design Meeting: Pipeline Appurtenances and Corrosion Control, September 7, 2017
- 4-300 M-03 WDNR Pipeline Horizontal Separation Meeting, October 17, 2017
- 4-300 M-04 DuPage Water Commission Lessons Learned Meeting and Facility Tour, October 20, 2017
- 4-300 M-05 McWane Ductile Iron Plant Tour, November 13, 2017
- 4-300 M-06 US Pipe Ductile Iron Plant Tour, March 7, 2018

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- 4-300 M-07 American Cast Iron Pipe Co. Ductile Iron Plant Tour, March 8, 2018
- 4-300 M-08 American Cast Iron Pipe Co. Steel Plant Tour, March 9, 2018
- 4-300 M-09 WDNR Pipeline Pressure Class Meeting, April 5, 2018

Task 5: Distribution System and Water Quality
- 5-100 M-01 Distribution System Model Calibration Meeting, April 27, 2017
- 5-100 M-02 Distribution System Connection Meeting (the meeting was scheduled, but did not occur)
- 5-100 M-03 Distribution System Connection Meeting, September 7, 2017
- 5-100 M-04 Distribution System Hydraulic Model Meeting, September 27, 2017
- 5-100 M-05 Distribution System Hydraulic Model Meeting, October 13, 2017
- 5-210 M-01 Pipe Loop Plan Review, April 20, 2017

Task 6: Pumping Stations, Storage, and Chemical Treatment
- 6-100 M-01 Clean Water Plant Tour and Meeting, April 28, 2017
- 6-100 M-02 Flow and Pipeline Sizing Considerations Meeting, May 4, 2017
- 6-100 M-03 Water Supply Facilities Tour and Operational Meeting, May 17, 2017
- 6-100 M-04 Water Supply Facilities Site Selection Meeting, May 23, 2017
- 6-100 M-05 Oak Creek Meeting and Tour, June 7, 2017
- 6-100 M-06 Waukesha County Department of Parks and Land Use Meeting, July 19, 2017
- 6-100 M-07 BPS Operation and Discharge Pipeline Evaluation Meeting, August 2, 2017
- 6-100 M-08 Pleasant Prairie Utility Department, Sheridan Road Booster Station Tour, August 16, 2017
- 6-200 M-01 BPS Site and Building Meeting, June 29, 2017
- 6-200 M-02 Water Supply Facilities Tour – Electrical and Mechanical Meeting, July 13, 2017
- 6-200 M-03 Water Supply Facilities SCADA, Electrical and Mechanical Meeting, August 17, 2017
- 6-200 M-04 Water Supply Facilities Site and Building Meeting No. 2, August 31, 2017
- 6-200 M-05 Milwaukee Facilities and Pipeline Kickoff Meeting, January 17, 2018

2.5 Reference Documents

The Program uses information from previous reports and studies provided by WWU and Waukesha's Department of Public Works to aid in making design decisions. These documents are referenced in this subsection.

2.5.1 Application and Final Decision

The following documents were referenced with regards to the Application process for this Program.

- City of Waukesha Application for a Lake Michigan Diversion with Return Flow, October 2013
- Compact Council Final Decision, June 21, 2016

2.5.2 Technical Memoranda

The following technical memoranda were used as reference for this Program.

- Water Model Update and Capital Improvement Planning Technical Memorandum No. 1 – Existing Water System, March 2012

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- Water Model Update and Capital Improvement Planning Technical Memorandum No. 2 – Field Testing and Model Calibration, March 2012
- Water Model Update and Capital Improvement Planning Technical Memorandum No. 3 – Deficiency Analysis, System Evaluation, and Recommendations, March 2012
- Water Model Update and Capital Improvement Planning Technical Memorandum No. 4 – Hydraulic Model Documentation, March 2012
- Water Demand Projections – Response to DNR Technical Memorandums, February 2014

2.5.3 Studies and Reports

The following studies and reports were used as reference for this Program.

- Waukesha Utility Master Plan, February 1993
- Water Utility Master Plan Update, February 2000
- Northwest Pressure Zone Study, March 2005
- Water System Master Plan, May 2006
- Pressure Analysis Report, December 2010
- Wastewater Treatment Plant Facilities Plan, May 2011
- City of Waukesha Water Supply Report, February 2012
- Waukesha Wastewater Treatment Plant (WWTP) Improvements Preliminary Design Report, November 2012
- Changes to Water Supply Infrastructure and Environmental Impacts with a Hypothetical Low Water Demand, February 2014

2.5.4 Drawings

The following drawings were used as reference for this Program.

- Wastewater Treatment Plant Improvements, Phase II, January 2, 2015
- Les Paul Parkway (S.T.H. 164/59) Water Main Project – Phase 2, December 22, 2015

2.6 Abbreviations

Common abbreviations used in this PDR are summarized as follows.

AACE	Association for the Advancement of Cost Engineering
AASHTO	American Association of State Highway and Transportation Officials
ADD	Average Daily Demand
AHI	Architecture History Inventory
ARI	Archaeological Report Inventory
ARV	Air Release Valve
ASCE	American Society of Civil Engineers
ASI	Archaeological Site Inventory
ASTM	American Society for Testing and Materials

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AWWA	American Water Works Association
BEP	Best Efficiency Point
BMP	Best Management Practices
BPS	Booster Pumping Station
CFM	Cubic Feet per Minute
CM	Construction Management
CWP	Clean Water Plant
DIP	Ductile Iron Pipe
DIPRA	Ductile Iron Pipe Research Association
DOJ	Department of Justice
DOT	Department of Transportation
DPLU	Department of Parks and Land Use
DWI	Digital Wetland Inventory
EIS	Environmental Impact Statement
ENR CCI	Engineering News-Record Construction Cost Index
FEMA	Federal Emergency Management Agency
FRP	Fiberglass Reinforced Plastic
GIS	Geographic Information System
GPS	Global Positioning System
HDD	Horizontal Directional Drilling
HDPE	High-Density Polyethylene
HGL	Hydraulic Grade Line
HI	Hydraulic Institute
HSC	Horizontal Split-Case
HVAC	Heating, Ventilating, and Air Conditioning
HWL	High Water Level
I&C	Instrumentation and Control
I/O	Input/Output
KPI	Key Performance Indicators
MAU	Make-Up Air Unit
MDD	Maximum Day Demand
MG	Million Gallons
MGD	Million Gallons per Day
MOT	Maintenance of Traffic
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NHD	National Hydrography Dataset
NHI	National Heritage Inventory
NPSHA	Net Positive Suction Head Available
NPSHR	Net Positive Suction Head Required
NRCS	Natural Resources Conservation Service
OHWM	Ordinary High Water Mark
OIT	Operator Interface Terminal
OPCC	Opinion of Probable Construction Cost
OSHA	Occupational Safety and Health Association

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PCCP	Pre-stressed Concrete Cylinder Pipe
PDR	Preliminary Design Report
PDIT	Pressure Differential Indicating Transmitter
PLC	Programmable Logic Controller
PM	Program Management
POR	Preferred Operating Range
PRV	Pressure Reducing Valve
PSC	Public Service Commission
PSIG	Pounds per Square Inch, Gauge
PSV	Pressure Sustaining Valve
PVC	Polyvinyl Chloride
RFPS	Return Flow Pumping Station
RTE	Rare, Threatened, and Endangered
RTU	Roof Top Unit
SCADA	Supervisory Control and Data Acquisition
SEWRPC	Southeastern Wisconsin Regional Planning Commission
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
SWPPP	Stormwater Pollution Prevention Plan
TBD	To be Determined
TBL	Triple Bottom Line
TCP	Temperature Control Panels
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Services
USGS	United States Geological Survey
UV	Ultraviolet
VFDs	Variable Frequency Drives
VT	Vertical Turbine
WDNR	Wisconsin Department of Natural Resources
WHPD	State of Wisconsin's Historic Preservation Database
WisDOT	Wisconsin Department of Transportation
WPDES	Wisconsin Pollutant Discharge Elimination System
WSCB	Water Supply Control Building
WSP	Water Supply Pumps
WSPS	Water Supply Pumping Station
WTP	Water Treatment Plant
WWU	Waukesha Water Utility

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SECTION 3 Regulatory and Permitting Conditions

3.1 Regulatory Milestones

Permits applications will be completed when the appropriate level of detail for each permit or approval is available based on the design schedule.

The permit and approval requirements are summarized in chronological order in the timeline Figure 3-1. The relationships between the permits and the design deliverables are shown in Figure 3-2. Figure 3-2 also summarizes the expected submittal date and review period, application authors, reviewing agencies, and content of each permit and approval.

The Department of Justice (DOJ) issued a Stipulation Order to Waukesha Water Utility (WWU) to enforce state drinking water radionuclide standards in 2009. The Stipulation Order required Waukesha's water quality to achieve complete compliance with the radionuclide standards by June 30, 2018. The original Stipulation Order was amended in 2017. Per the amended Stipulation Order, the Program will need to complete Waukesha's water supply transition by no later than September 1, 2023. If the Program Manager and the Construction Manager cannot certify that all Program construction is under contract and 50% complete as of May 1, 2022, bidding and construction of interim radium treatment for Waukesha's current water source will be required in order to meet the state drinking water radionuclide standards.

3.2 Permits and Approvals during Design and Construction

The following subsections describe each permit and approval and their relationship to the overall Program.

3.2.1 Wisconsin Pollutant Discharge Elimination System Permit

The Wisconsin Department of Natural Resources (WDNR) regulates the discharge of pollutants to waters of the state through the Wisconsin Pollutant Discharge Elimination System (WPDES) Program. Waukesha's Clean Water Plant (CWP) WPDES permit contains the following requirements:

- Water Quality Monitoring Requirements
- Discharge Flow Limits
- Effluent Concentration Limits
- Implementation Plans
- Special Reports
- Reporting Requirements
- Return Flow Requirements
- Compliance Schedules relevant to the CWP
- Sampling Requirements

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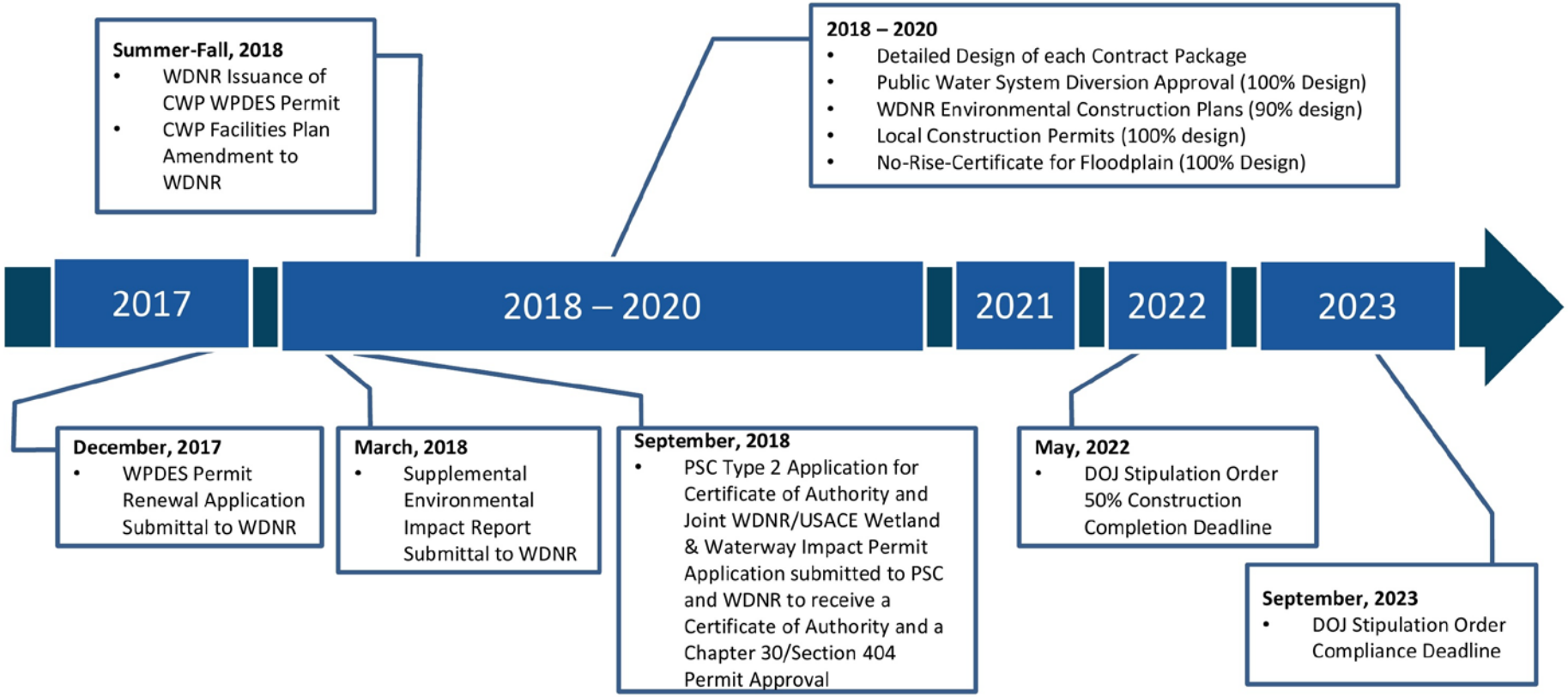

Note:
CWP = Clean Water Plant
PSC = Public Service Commission
USACE = United States Army Corps of Engineers
WDNR = Wisconsin Department of Natural Resources
WPDES = Wisconsin Pollutant Discharge Elimination System

Figure 3-1 GWA Permitting Timeline

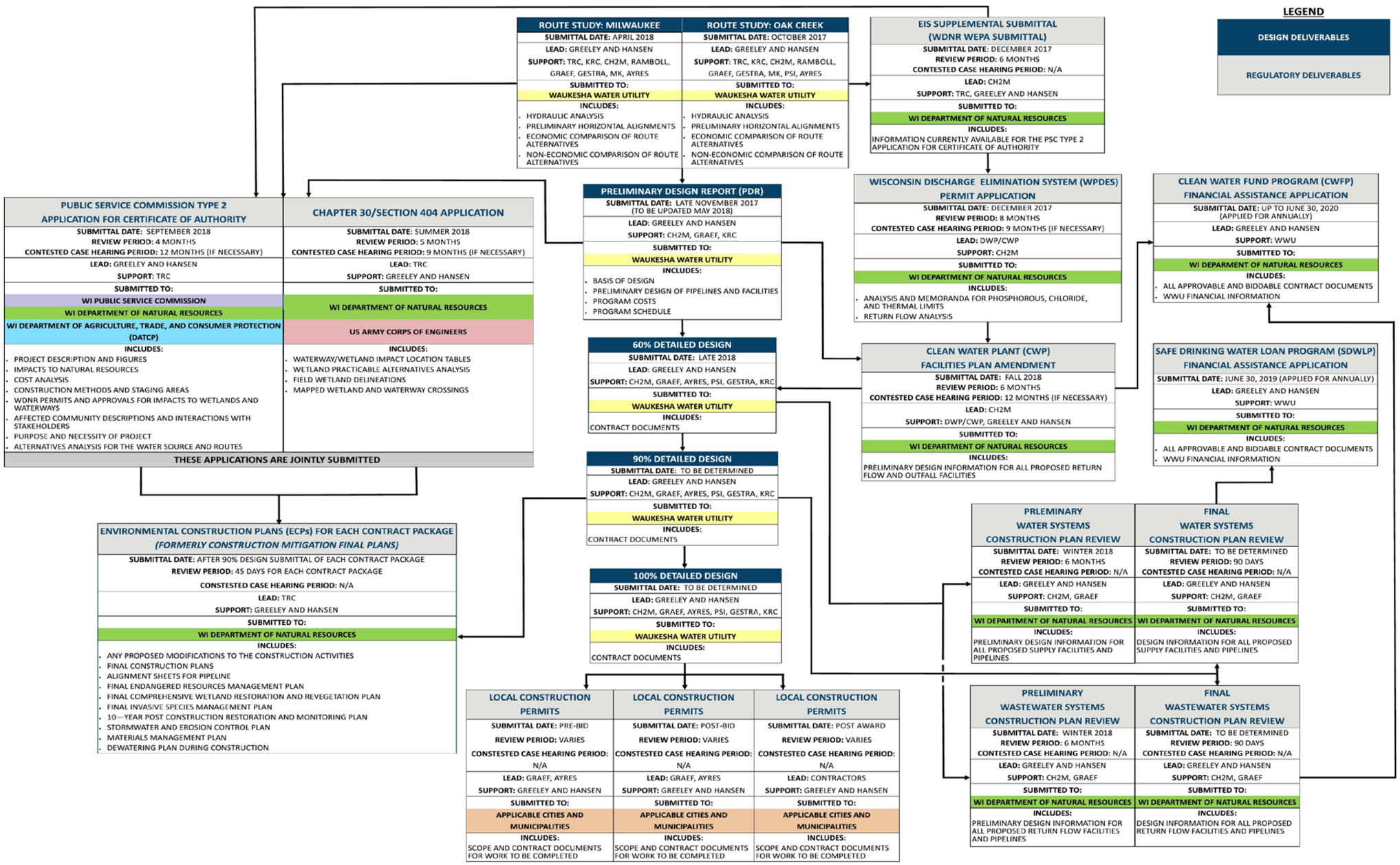

Figure 3-2 Permitting and Design Deliverables Flow Chart

WPDES permits are issued for a five-year term, and renewal applications are typically submitted six months before the end of the preceding permit term. The CWP's current WPDES permit expires on June 30, 2018. A renewal application was submitted to the WDNR in December 2017. The application for the upcoming term anticipated that the WDNR would issue a WPDES permit that includes discharge limits for both the new return flow discharge to the Root River and the existing discharge to the Fox River. The CWP will be required to maintain compliance with permitted discharge limits to each river.

3.2.2 Environmental Impact Statement Supplemental Submittal

The WDNR completed a preliminary final Environmental Impact Statement (EIS) as part of the Application for Lake Michigan Diversion with Return Flow that was submitted to the Great Lakes-St. Lawrence River Basin Water Resources Council (Compact Council). The preliminary final EIS included an analysis of the environmental impacts and benefits of the Program and other supply alternatives which had been included in a previous Environmental Impact Report prepared during the Application process. A preliminary draft EIS was prepared by the WDNR in June 2015. Public comments were received and a preliminary final EIS was issued in January 2016. A supplemental Environmental Impact Report was submitted to the WDNR in March 2018 to finalize the EIS with updated environmental impacts based on the preferred return flow route, a preliminary water supply route, and facility locations. The current preferred route alternative and all environmental impacts will be presented to WDNR in the Wetlands and Waterways Permit Application.

3.2.3 Clean Water Plant Facilities Plan

Before infrastructure improvements can be made to the CWP, the WDNR must approve an amendment to the CWP's existing Facilities Plan (also referred to as the "CWP Facilities Plan Amendment"). The most recent improvements to the CWP were included in a Facilities Plan submitted in 2011. The Return Flow Pumping Station (RFPS), Outfall location, and any additional treatment improvements for the Program, including enhanced phosphorus removal, will be defined in a CWP Facilities Plan amendment that is anticipated to be submitted to the WDNR in July 2018. This CWP Facilities Plan Amendment will reflect any updates that will be made to the CWP as part of the Program.

3.2.4 Public Service Commission Certificate of Authority and WDNR Chapter 30 Wetlands and Waterways Permit Applications

In September 2018, a Public Service Commission (PSC) Type 2 Application for Certificate of Authority and a joint WDNR and United States Army Corps of Engineers (USACE) Chapter 30/Chapter 281.36 and Section 404 Wetlands and Waterways Impact Individual Permit Application (also referred to as the "Individual Permit") will be submitted to the PSC, the WDNR, and the USACE in order to receive a Certificate of Authority and Chapter 30/Chapter 281.36 and Section 404 (Wetlands and Waterways) permit approval. The Department of Agriculture, Trade and Consumer Protection (DATCP) will also review information from the submittal to issue an Agricultural Impact Statement. Water supply projects that include over 3 miles of 8-inch diameter or larger pipe require a Type 2 Water Projects Certificate of Authority (CA) application that is reviewed by the PSC. WDNR and the PSC have consolidated the application process to allow for a single Design Report submission for the CA application. The Design Report will include a description for the need for Program, Practicable Alternatives Analysis (PAA), cost estimates, habitat assessments, biological surveys, and a wetlands and waterways impact analysis. The agencies will issue an overall approval of the Program using this submittal. Detailed designs and final Contract Documents will be required in Environmental Construction Plans for each Contract Package before construction can start as a requirement in the WDNR Chapter 30 Wetlands and Waterways permit issuance.

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The Program must institute practices and designs that minimize or mitigate impacts on endangered species, surface waters, and wetlands in order to meet the requirements set by the Wisconsin Chapter 30 Navigable Waters, Harbors, and Navigation statutes. The Program has completed an Endangered Resources review to document possible impacts to rare, threatened, and endangered (RTE) species. The Program will mitigate and/or minimize potential construction impacts to areas of high quality, rare, or important wetlands, rivers, or habitat features (e.g., bat hibernacula or bird rookeries) and areas where state or federal RTE species occur or may occur. The permit application requires a detailed PAA documenting how environmental impacts were avoided or minimized by the Program design. The presence of high quality habitat features and endangered species may affect the time of year that construction will be allowed in certain areas.

3.2.5 Construction Documents Reviews

The WDNR requires all water and wastewater projects that may affect the quantity or quality of water delivered or treated by an existing water or wastewater system to undergo a thorough technical evaluation before construction can begin. Preliminary design information for the Water Supply and Return Flow pipelines and their associated facilities will be submitted to WDNR at the completion of 60% Design to solicit preliminary feedback. Updated Contract Documents will be submitted to WDNR for final review after completion of 90% Design.

3.2.6 Financial Assistance Applications

The Safe Drinking Water Loan Program (SDWLP) and the Clean Water Fund Program (CWFP) are federal-state partnerships developed to provide financial support to municipal water systems by providing fixed interest rate long-term loans to assist with the funding of water infrastructure projects. In order to maintain eligibility to apply for financial assistance through the programs, WWU will submit an Intent to Apply (ITA) to WDNR each fiscal year until the start of construction, and applications for the SDWLP and CWFP will be prepared and submitted the fiscal year before construction is scheduled to begin. The application packages will include the construction documents that will have been reviewed and approved by WDNR for the Water Supply and Return Flow pipelines and their associated facilities as well as any requested WWU financial information. WWU plans to apply for Water Infrastructure Finance and Innovation Act (WIFIA) funds to fund a portion of the Program.

3.2.7 Environmental Construction Plans

Environmental Construction Plans (ECPs) will be submitted to the PSC and WDNR before Program construction begins as a requirement in the Chapter 30 Wetlands and Waterways permit. The ECPs will be used by the WDNR to review the final environmental impacts and contract drawings of the Program. ECPs for each Contract Package will be submitted to WDNR as each 90% design submittal is completed. The ECPs will include construction drawings containing wetland pre-construction elevation data, final sequencing plans, and additional measures to avoid or minimize waterway or wetland impacts. They will also include pipeline alignment plan and profiles, construction workspace and temporary workspace details, a final endangered resources management plan, a final comprehensive wetland restoration and revegetation plan, and a final invasive species management plan.

3.2.8 Public Water System Diversion Approval Request

A Public Water System Diversion Approval request will be submitted to the WDNR before Program construction begins. The Public Water System Diversion Approval requires that the Program obtain all federal, state, and local permits and approvals necessary to construct and operate a diversion of Lake Michigan water. The WDNR will then

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issue a Public Water System Diversion Approval that will include all conditions of the Compact Council Final Decision.

3.2.9 Local Construction Permits

Local construction permits for each municipality must be completed before construction begins. The permits will be acquired in three phases: pre-bid, post-bid, and post-award. The contractor for each Contract Package will be required to apply for permits through the local municipality prior to the start of construction and can include Grading and Erosion Control Permits, Excavation Permits, Right-of-Way Permits, and Stormwater Management Permits, among others.

3.2.10 FEMA No-Rise-Certificate for Floodplain

The Root River Outfall in the City of Franklin (Franklin) is located in a floodplain categorized as both Zone AE and A floodway. Zone AE refers to areas subject to inundation by a 1%-annual-chance flood event (also referred to as the 100-year-storm) and is determined by hydrologic and hydraulic calculations. The floodway includes the channel of the river and the portion of the floodplain adjoining the channel that is reasonably required to efficiently convey the flood flow of the river. The Federal Emergency Management Agency (FEMA) Letter of Map Revision (LOMR) process is triggered when development in a Zone AE floodplain raises the base flood elevation or the height of the 1% - annual-chance flood. Franklin's Floodplain Zoning Ordinance does not permit developments that increase the flood elevation upstream or downstream by 0.01 feet or more without an amendment to the zoning ordinance or the official floodplain zoning maps. The hydraulic model used to determine the existing flood elevations is being amended to predict the outfall structure's effects on the flood elevation and to mitigate flood elevation rise to achieve a No-Rise-Certificate. If necessary, a LOMR will be pursued.

3.2.11 Hazardous Materials, Contaminated Soil and Groundwater Management

The Program has developed a Contaminated Soil and Groundwater Management Plan (Management Plan) to meet the permitting requirements for Hazardous Materials, Contaminated Soil and Groundwater Management issued by the WDNR. These permits include a written Field Screening Protocol for Contaminant Testing in case contaminated materials are encountered on-site. Contaminated soil and groundwater field investigation reports are required to be submitted to WDNR for approval after field investigations are complete. If contaminated materials are found during construction, then the Program will be required to follow specified procedures detailed in the Management Plan for disposal and handling of materials.

3.2.12 Stormwater Management Permit

The WDNR will require Stormwater Management Permits for each Contract Package. These permits are different from the local stormwater permits in that they are delineated only by Contract Package and not by municipality. The WDNR requires comparisons of the existing and proposed hydrologic conditions and site conditions along each construction site. The Stormwater Management Plans will include protocols and best management practices (BMP) to address the construction stormwater management and erosion control, as well as the post-construction stormwater management.

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3.2.13 Public Lands Field Archaeological Permits

Public Lands Field Archaeological Permits were received from the Wisconsin State Historical Society granting the Program authorization to perform archaeological investigations on specific public properties. Permits were obtained for the CWP and the Booster Pumping Station location. Additional permits for any public land on the Supply Route will be attained if necessary. The Program will provide the results of a State of Wisconsin Historic Preservation Database (WHPD) cultural resources search and the field investigation results for the entire project construction area to the WDNR after investigations along the Supply Route are complete. Each archaeological, historical, or sacred resource (cultural resources) from the WHPD that are found in areas of Program-related construction must be listed. The design and construction process will attempt to minimize or avoid any potential effects on identified cultural resources.

3.3 Expected Permit Requirements after Construction

The permits and approvals for the operation of the pipeline and facilities are dependent on conditions set forth by the Compact Council Final Decision. Some of these conditions will need to be considered during the design and permitting process of the Program while other conditions of the Compact Council Final Decision will require long-term permit considerations. These requirements are as follows:

- The Compact Council Final Decision requires Waukesha to return the previous year's average day demand (ADD). This was established such that a volume of water returned to the Lake Michigan (via the Root River) must be approximately equal to the volume of water withdrawn from the basin. WWU must complete an annual report that documents the amount of water diverted and returned to the Lake Michigan basin and submit the report to the Regional Body (WDNR) and the Compact Council. Discussions with WDNR on the exact permit condition language are ongoing.
- The Compact Council Final Decision requires Waukesha to continue to implement and enforce all elements of its current water conservation and efficiency plan. The water conservation and efficiency plan must be updated at a minimum of once every ten years.
- The Compact Council Final Decision allows Waukesha to maintain the existing deep aquifer groundwater wells, but strictly for emergency use only. State and federal water quality discharge standards of the Clean Water Plant effluent will need to be met during those periods if the deep aquifer wells are used for emergency purposes.
- The Compact Council Final Decision requires Waukesha to implement a comprehensive pharmaceutical and personal care products recycling program to encourage the future reduction of such products into its wastewater.
- The Compact Council Final Decision requires that Waukesha implement a plan to monitor the Root River. An ongoing Pre-Return Flow Data Collection Plan is currently monitoring conditions of the Root River. A Post-Return Flow Root River Data Collection Plan will be implemented to identify changes to the Root River as a result of the return flow in order to adapt the return flow to more effectively promote habitats and the environment.
- Water quality standards will need to be met for both discharges to the Fox and Root River in accordance with the CWP WPDES discharge permit(s).
- The Compact Council Final Decision requires the water supply quality complies with The National Safe Drinking Water Act (SDWA) and the state and federal drinking water radionuclide standards, which will be monitored by WWU and regulated by the WDNR.

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- NR 151.121-128 list the WDNR's post-construction stormwater maintenance performance standards and NR 216.47(5) requires provisions for long-term maintenance of the permanent BMPs. Waukesha will be responsible for maintaining the landscaping and runoff and erosion control BMPs at each of the facilities associated with the new water supply, including those outside of its municipal boundaries: the Water Supply Pumping Station (WSPS) and the Booster Pumping Station (BPS). Plans or agreements addressing stormwater management for the facilities outside of the Waukesha municipal boundaries will be agreed upon with WDNR and the local municipalities.

3.4 State Revolving Loan Fund Program

In order to maintain eligibility for financial assistance through the Safe Drinking Water Loan Program (SDWLP) and the Clean Water Fund Program (CWFP), the Program will adhere to the regulations described in the following subsections.

3.4.1 American Iron and Steel

Section 608 of the Federal Water Pollution Control Act regulates the Program materials' origins by requiring recipients of SDWLP and CWFP to use exclusively iron and steel products made in the United States. These products include lined or unlined pipes and fittings, manhole covers and other municipal castings, hydrants, tanks, flanges, pipe clamps and restraints, valves, structural steel, reinforced precast concrete, and construction materials. There are exceptions to this requirement based on public interest, material availability, and cost, however it is not anticipated that these exceptions will be pursued.

3.4.2 Davis-Bacon and Related Acts

The Davis-Bacon and Related Act is a federal law establishing requirements for labor rates for public projects receiving federal funding. Contractors and subcontractors will be required to pay their laborers employed under the contract no less than the locally prevailing wages and fringe benefits for corresponding work on similar projects in the area.

3.4.3 Wisconsin Environmental Policy Act

The Wisconsin Environmental Policy Act (WEPA) is a state law designed to encourage environmentally sensitive decision-making by state agencies. Typically the act applies only to state agencies. However, WEPA applies to the Program given that its actions involve state agency regulation and funding. The Program will be WEPA compliant through steps such as evaluating relevant environmental information and using this information in the decisions made. The Program will also look at appropriate alternatives to the particular course of action being proposed.

3.5 Water Quality

Water supplied by the Program will need to comply with state and federal drinking water standards. Data on the water quality in the distribution system from before and after the water supply transition will be reviewed to determine how the transition is working and to provide early warning for potential water quality changes. Pipe loop testing will be performed by running water from Milwaukee through a pipe loop test apparatus of service lines and pipes from WWU's distribution system to determine water quality changes and corrosion inhibitor reactions. Testing will be performed using corrosion inhibitor chemicals.

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3.5.1 Lead and Copper

Lead and copper are drinking water contaminants caused by corrosion in service lines and internal building plumbing. Corrosion control treatment will be reviewed and continued in order to prevent lead and copper from reaching action level concentrations, in accordance with NR 809.54 of the Wisconsin Administrative Code. The lead action level is exceeded if the concentration of lead in more than 10% of tap water samples collected during any monitoring period is greater than 0.015 mg/L. The copper action level is exceeded if the concentration of copper in more than 10% of tap water samples collected during any monitoring period is greater than 1.3 mg/L.

3.5.2 Disinfection Byproducts

The disinfection treatment processes will be controlled to optimize the use of disinfectants to minimize the amount of disinfection byproducts generated. The water in the distribution system will be treated in order to meet the residual disinfectant levels set forth in NR 809.561 of the Wisconsin Administrative Code.

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SECTION 4 General Basis of Design

This section presents design criteria that are typical for most, or all, Great Water Alliance (Program) Elements. The purpose of this section is to provide a single location for common elements in an effort to reduce repetition of this information throughout this Preliminary Design Report (PDR). For example, codes and standards that are applicable to multiple Program Elements are addressed herein. Information that is unique to a specific Program Element is located in the element-specific section of this PDR.

4.1 Codes and Standards

Design of the Program Elements will be in accordance with statutory regulations, local codes, and standards, including all latest amendments and associated guidance documents, where applicable. In case of conflict between design criteria and the codes and standards, the most stringent requirements will govern. Additional codes, standards, and guidelines may be identified during design.

The Wisconsin Department of Safety and Professional Services and the State Legislature has been engaged in rulemaking to update its Commercial Code Package, the Wisconsin Administration Code Chapters 361 to 366. On March 16, 2018, the Wisconsin Department of Safety and Professional Services approved the adopted code package and made it effective from May 1, 2018. As part of the updated code package includes the 2015 International Building Code (IBC) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 – 2013.

4.1.1 Codes

Codes are the standards that are enacted into law by local, regional, or national authorities having jurisdiction. The following codes are utilized for the design of the Program Elements:

- 2009 International Building Code (IBC), with Wisconsin Amendments
- 2009 International Existing Building Code (IEBC), with Wisconsin Amendments
- 2009 International Energy Conservation Code (IECC), with Wisconsin Amendments
- 2009 International Fuel Gas Code (IFGC), with Wisconsin Amendments
- 2009 International Mechanical Code (IMC), with Wisconsin Amendments
- American Concrete Institute (ACI), Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary
- City of Waukesha Code Book
- International Society of Automation (ISA)
  - ISA 5.1 – Instrumentation Symbols and Identification
  - ISA 5.2 – Binary Logic Diagrams for Process Operations
  - ISA 5.3 – Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems
  - ISA 5.4 – Instrument Loop Diagrams
  - ISA 51.1 – Process Instrumentation Technology

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- Milwaukee Code of Ordinances - Volume 2
- Municipal Code of the City of Franklin, Part II
- Municipal Code of the City of Greenfield
- Municipal Code of the City of New Berlin, Part II
- Municipal Code of the City of Muskego
- Municipal Code of the City of West Allis
- National Electrical Safety Code (NESC), 2012
- Waukesha County Code of Ordinances
- Wisconsin Administrative Code, Department of Natural Resources (NR)
  - Chapter NR 809 – Safe Drinking Water
  - Chapter NR 810 – Requirements for the Operation and Maintenance of Public Water Systems
  - Chapter NR 811 – Requirements for the Operation and Design of Community Water Systems
- Wisconsin Administrative Code Public Service Commission (PSC)
  - Chapter PSC 114.002 – Wisconsin State Electrical Code, Volume 1
- Wisconsin Administrative Code, Department of Safety and Professional Services (SPS)
  - Chapter SPS 316.002 - Electrical
  - Chapter SPS 360 – Erosion Control, Sediment Control and Storm Water Management
  - Chapter SPS 361 – Administration and Enforcement
  - Chapter SPS 362 – Buildings and Structures SPS 363 Energy Conservation
  - Chapter SPS 363.0302 – Energy Conservation
  - Chapter SPS 364 – Heating, Ventilating, and Air Conditioning
  - Chapter SPS 365 – Fuel Gas Appliances
  - Chapter SPS 366 – Existing Buildings
  - Chapter SPS 360 – 366 Appendices A and B

4.1.2 Standards

Standards are technical procedures and guidelines that specify minimum design requirements. Following standards are utilized for the design of the Program Elements:

- American Institute of Steel Construction (AISC)
  - Steel Construction Manual, thirteenth edition
  - Code of Standard Practice, latest edition
- American National Standards Institute (ANSI)/Hydraulic Institute (HI) Pump Standards
- American Society of Civil Engineers (ASCE)

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  - Minimum Design Loads for Buildings and Other Structures (ASCE 7-05), 2005
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
  - ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings, 2007
  - Handbook of Fundamentals
- American Society for Testing and Materials (ASTM)
- American Water Works Association (AWWA)
  - AWWA – C104-16 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings
  - AWWA – C150-14 Thickness Design of Ductile-Iron Pipe
  - AWWA – C151-17 Ductile-Iron Pipe, Centrifugally Cast
  - AWWA – C-200-17 Steel Water Pipe – 6 In. (150 mm) and Larger
  - AWWA – C-205-12 Cement-Mortar Protective Lining and Coating for Steel Water Pipe – 4 In. (100 mm) and Larger
  - AWWA – C301-14 Prestressed Concrete Pressure Pipe, Steel-Cylinder Type
  - AWWA – C304-14 Design of Prestressed Concrete Cylinder Pipe
  - AWWA – C500-09 Metal Seated Valves for Water Supply Service
  - AWWA – C652-11 Disinfection of Water Storage Facilities
  - AWWA – D107-16 Composite Elevated Tanks for Water Storage
  - AWWA – Cyber Security Guidance and Tool
  - AWWA – D110-04 Wire and Strand Wound Circular Prestressed Concrete Water Tanks
  - AWWA/ASCE/Water Environment Federation (WEF) – Guidance for the Physical Security of Water Utilities
  - AWWA – Process Control System Security Guidance for Water Systems
- American Welding Society (AWS)
  - AWS D1.1 Structural Welding - Steel
- Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers
  - Recommended Standards for Wastewater Facilities, 2014 (10 States Standards)
- Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers
  - Recommended Standards for Water Works (10 States Standards)
- Institute of Electrical and Electronics Engineers (IEEE)
  - IEEE 519 - IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
  - IEEE 802.3 – 10/100/1G Ethernet Networks
  - IEEE C37.20.1 - IEEE Standard for Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit Breaker Switchgear

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  - IEEE C57.12.28 - IEEE Standard for Pad-Mounted Equipment - Enclosure Integrity
- National Sanitation Foundation (NSF) / American National Standards Institute (ANSI)
  - 60 - Drinking Water Treatment Chemicals- Health Effects
  - 61 - Drinking Water System Components-Health Effects ASHREA 90.1-2007 – Effective December 2011
- National Electrical Manufacturers Association (NEMA
  - NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
  - NEMA ICS - 2 Controllers, Contactors and Overload Relays Rated 600 V
  - NEMA MG 1 Motors and Generators
  - NEMA PB 2 Deadfront Distribution Switchboards
- National Fire Protection Association (NFPA)
  - NFPA 1 Fire Protection and Safety Code – Effective November 2014
  - NFPA 13 Installation of Sprinkler Systems, 2007
  - NFPA 14 Installation of Standpipe and Hose Systems, 2007
  - NFPA 20 Installation of Stationary Pumps for Fire Protection, 2007
  - NFPA 30 Flammable and Combustible Liquids
  - NFPA 37 Installation and Use of Stationary Combustion Engines and Gas Turbines
  - NFPA 70 National Electrical Code (NEC), 2011
  - NFPA 70E Electrical Safety in the Workplace
  - NFPA 72 National Fire Alarm and Signaling Code
  - NFPA 79 Electrical Standard for Industrial Machinery
  - NFPA 101 Life Safety Code, 2009
  - NFPA 110 Emergency and Standby Power Systems, 2010
  - NFPA 400 Hazardous Materials Code
  - NFPA 430 Storage of Liquid and Solid Oxidizers
  - NFPA 820 Fire Protection in Wastewater Treatment and Collection Facilities
- Occupational Safety and Health Administration (OSHA) Section 1910 General Industry
- Precast Concrete Institute Design Handbook
- Standard Specifications for Sewer and Water Construction in Wisconsin, sixth edition December 22, 2003
- Steel Deck Institute Design Manual, 2016
- UL 508 – Industrial Control Equipment
- UL 845 – Motor Control Centers
- UL 891 – Switchboards

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4.2 Sustainability

The Basis of Design includes details about the efforts to incorporate sustainability into the design that are common to the facilities in the Program. The Envision Rating System, developed by the Institute for Sustainable Infrastructure, will be used as a guide to optimize sustainable design on the Program. The efforts to incorporate sustainability into the design are outlined in the following subsections using the Triple Bottom Line (TBL) approach, focusing on the social, economic, and environmental considerations in the design.

4.2.1 Social

In order to maintain and enhance the quality of life in the communities that the Program will be located in, several sustainable mechanisms will be employed in the design and construction of the Program. These will include minimizing noise, preserving views and local character, and balancing the need for safety and wayfinding while minimizing light pollution. The use of sound attenuating screens, dampers, and strategic siting will minimize noise and vibration from interior equipment. The exterior lighting will be set to low levels with LED fixtures to meet OSHA requirements and reduce light pollution in order to preserve the night sky. This will be balanced with the Program-wide wayfinding approach discussed in Section 4.5.9. Site design will consider the local character of the region and stakeholder input will be solicited to better integrate the structures.

Safety is also an important consideration in the Program design. Fire safety will be considered in the design of the structures, and fire resistant materials will be used for construction. Fire alarms at each facility will be monitored remotely and locally to provide faster response to a fire event. The resiliency of the Program is further bolstered by the protective functions built into the Instrumentation and Controls design which is described in Section 4.9.2.4.

4.2.2 Economic

The economic considerations of the Program focus on resiliency and energy efficiency. The electrical system at each facility will be designed for durability and to perform (with maintenance) for the expected service life of the Program. Security measures will include lockable doors, key card access, intrusion detection equipment, and video monitoring systems for site protection. The general energy efficiency design strategies are described in Section 4.7.2.6. The use of energy efficient variable frequency drives (VFD) and motors will greatly reduce the energy required for pumping. The Program will pursue independently commissioned energy-consuming systems and program-wide supervisory control and data acquisition (SCADA) systems. Daylighting will be employed where practicable to off-set artificial lighting loads. Economic development will be promoted in the Program's region by utilizing locally-sourced materials when obtainable, as described in Section 4.5.6.

4.2.3 Environmental

A Life Cycle Assessment was conducted for the Program. Section 4.2.4 describes how the chosen path for the Program has an environmental impact reduction compared to another viable alternative that was used as a benchmark. The Program will be designed to further minimize environmental impacts by utilizing recycled content for the materials, implementing environmentally friendly landscaping, and utilizing clean or renewable energy where possible. Section 4.5.6 describes how the Program has targeted 20% reclaimed or recycled content in its materials. Native plants will be used to promote biodiversity and eliminate the need for pesticides, fertilizers, and watering. Natural gas can be used as the primary source of heating for the Facilities where available. The use of natural gas generates fewer emissions than most other sources of energy.

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4.2.4 Life Cycle Assessment

To document achievement under multiple credits of the Envision Rating System, it is useful to perform a comprehensive analysis of the Program's environmental impact. To that end, a preliminary lifecycle assessment was conducted along several Key Performance Indicators (KPIs). The boundary of the analysis included the Program Elements such as new pipelines, new facilities, new equipment along with modifications to existing Waukesha Water Utility (WWU) and City of Waukesha facilities. The impact of the net increase in energy required to divert 8.2 MGD from Lake Michigan and return an equivalent amount via the Root River was also calculated. This assessment accounted for cradle-to-grave impacts from activities associated with extraction of natural resources used in building materials, the manufacture and transport of those materials, construction activities, facility maintenance, and the increased energy required to operate the facilities within the system boundary. Figure 4-1 is a diagram of the life-cycle assessment system boundary.

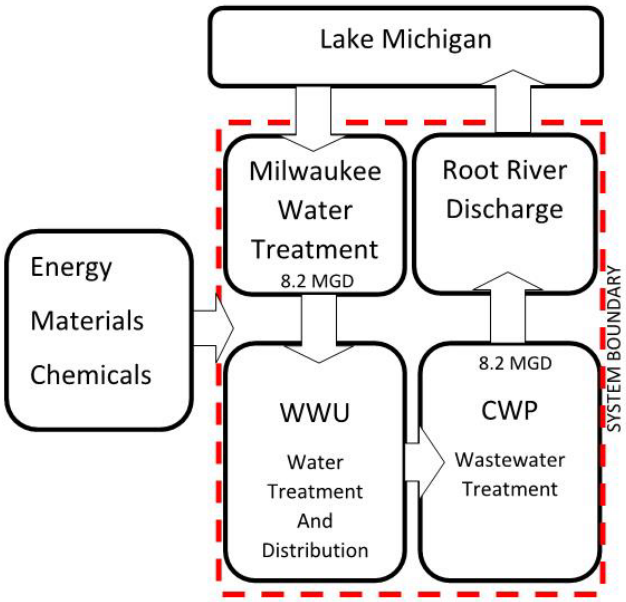

Figure 4-1 Life Cycle Assessment System Boundary

The assessment also accounted for the deconstruction and disposal of the materials at the end of the Program's lifespan, which was set at 100 years. The methodology of the analysis followed International Organization for Standardization (ISO) 14040 and 14044 standards. These results were then compared to the Program benchmark as shown in Table 4-1.

In order to establish an appropriate benchmark, the Program team looked at viable alternatives. In 2015, the Wisconsin Department of Natural Resources requested information on energy and greenhouse gas emissions for water supply and return flow alternatives considered in the City of Waukesha Lake Michigan Application. The results were presented in the technical memorandum, *Waukesha Energy Usage and Air Emissions Clarification*. The Program team selected as the benchmark the alternative which derived water from Lake Michigan at the City of Racine and discharged it to Lake Michigan at the Milwaukee Metropolitan Sewerage District (MMSD) South Shore Wastewater Treatment Plant Discharge. Improvements realized by the Program are mainly attributed to a more efficient route configuration and thus reduced energy consumption. For most categories, the improvements are

proportional to the reduction in energy used. However, a decrease in ozone depletion potential was estimated at 7%. This disproportionate reduction reflects the influence of refrigerants commonly found in a building's climate control system. Reductions in environmental KPIs correlate to an overall improvement in sustainable outcome as illustrated in Table 4-1. Estimates of environmental loads were derived through proprietary software (Tally®) utilizing industry standard databases and modeling principles.

Table 4-1 Estimates of Environmental Loads over Life of the Project (100 years)

Environmental KPI	Benchmark	Program	% Impact
Acidification Potential (Tons SO_2 equivalent)	9,050	8,061	-11%
Eutrophication (Tons N equivalent)	411	366	-11%
Global Warming Potential (Tons CO_2 equivalent)	2,358,001	2,101,163	-11%
Ozone Depletion Potential (Lbs. CFC-11 equivalent)	1.68	1.56	-7%
Smog Formation Potential (Tons O_3 equivalent)	67,870	60,606	-11%

4.3 Civil/Site

The Program goals for civil/site design include minimizing impacts to the environment and surrounding community, maximizing lifespan of components, and providing safe facilities. As such, the design will seek to minimize traffic impacts, noise, and light pollution. Building styles will blend in with local character, and facility placement will maintain existing views where possible. Durable materials will be specified, and safety features will be part of the design.

Desktop analyses were performed and field investigations are being conducted at facility locations to identify any historical or cultural impacts, wetland interference, environmental impacts, and effects on endangered and threatened species habitat. Utility coordination will be conducted to determine the location of and need for electrical, natural gas, potable water, and sanitary services.

All elevations indicated or specified refer to the following datum:

- Horizontal: Wisconsin State Plane Coordinate System, South Zone, NAD27
- Vertical: National Geodetic Vertical Datum of 1929 (NGVD29)

Each Program Element location has unique site characteristics. Detailed information about the civil/site civil design criteria including site improvements, site layout and site accessibility, surface restoration, stormwater management, grading and erosion control plans, floodplain analysis, permitting evaluation, and utilities are located in the element specific sections.

4.4 Process

Process components for the facilities include water supply piping, process piping, and pumping system. Redundancy, reliability, and ease of maintenance were discussed during meetings and workshops with WWU and other municipalities with ownership and maintenance responsibilities, and are being incorporated into the design.

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Each Program Element has unique process requirements. Therefore, process design criteria specific to the Program Elements can be found in the element specific sections.

4.4.1 Equipment Installation and Removal

Design considerations for the removal and installation of equipment for maintenance, upgrade, or replacement is required. Different types of lifting mechanisms can be used and various factors have been considered when selecting the type of lifting equipment best suited for each facility. Such factors include weight and dimension of load, height of lift, distances/areas of movement, clearance, cost, process layout, building limitations, and frequency of use.

The following lifting mechanisms were considered for equipment removal and installation:

- Bridge Crane
- Gantry Crane
- Monorails
- Exterior Crane and Roof Hatch

This section provides a general description of those lifting mechanisms. Each facility has unique requirements and design criteria specific to the facilities can be found in the element-specific sections.

Bridge Crane: Bridge cranes are hoist mechanisms with the ability to move along three axes, two perpendicular axes and one vertical. Bridge cranes operate on an elevated runway system that can span the majority of the room's footprint and can provide a greater degree of load positioning than other types of cranes. Bridge cranes with capacities needed for the Program Elements are available and can limit the obstructions on the floor due to their overhead design. Bridge cranes require additional structural elements to accommodate their loads and higher ceilings to accommodate the crane itself.

The effective use of bridge cranes requires an understanding of the equipment and piping layout requirements to allow vertical and horizontal movement of the equipment to and from a laydown area. Heating, ventilating, and air conditioning (HVAC) facilities, as well as electrical and fire protection facilities, must be located to not interfere with movement of the crane and hoisted equipment. Laydown space sufficient for all components should be provided and designed to support the equipment load. A remote-controlled motorized bridge, trolley and hoist are used to improve ease of operation. Bridge crane runway systems can be directly integrated into the building frame or use a separate structural support system offset from the walls. Hoist mechanisms must be load-rated and periodically load-tested for safety.

Bridge cranes have high capital and maintenance costs due to their complexity, level of integration into the building, and location. Depending upon how the crane is structurally supported, the overhead loading of the crane requires either a more robust building frame or additional reinforcement in the base slab.

Gantry Crane: Gantry cranes are mobile stand-alone floor-supported cranes fitted with height adjustments. The cranes can travel along a set of tracks but are more often equipped with wheels. The crane rail is supported by two A-frame legs and the available floor space and clearance around equipment may limit the crane maneuverability. Due to their mobility, gantry cranes can be rented as needed or dismantled and stored.

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Gantry crane wheels transfer loads to the floor and require floor slabs to be designed to handle the crane and equipment loads. Use of gantry cranes may reduce the design complexity of the facility. Gantry cranes can be more difficult to operate than other lifting mechanisms and motorized units are available to improve general operability. However, motorized gantry cranes have wheels that do not swivel and may be difficult to navigate around equipment. Manual cranes have greater flexibility but become increasingly difficult when moving loads as large as 10 tons. Some manufacturers recommend individual gantry cranes be provided for each pipe and pump segment. The runways adjacent to each pump will need to be clear of obstruction and properly spaced to accommodate the crane.

Gantry cranes generally have the lowest capital cost and require fewer design considerations. The costs of increasing the building footprint to accommodate the floor space needed around equipment and reinforcing the floor slab to handle the equipment load need to be considered.

Monorails: Monorail cranes are similar to bridge cranes except that they provide movement only on the vertical and horizontal axis defined by the monorail. Monorails are efficient for use where equipment has to move repeatedly over a fixed path. Monorails are generally attached to ceiling structures and can be designed to telescope beyond the edge of building. The use of monorails may require additional laydown space for removal of the equipment.

Depending on the horizontal dimensions of a pump, a single monorail may not be able to handle lifting both the pump and motor separately as there would be potential for either component to swing when the monorail is not directly above the load. Such arrangements may need additional lifting mechanisms, such as a monorail or gantry crane, to safely remove and install equipment. The monorail will require a higher ceiling and a laydown space along the monorail path. Multiple monorails can be connected by switches to a single perpendicular monorail track to use one common laydown space. Increasing the number of components will increase the maintenance cost and the level of complexity for integration with the building design. If the monorail is supported by the building structure, the overhead loading of the crane will require a more robust building frame.

Roof Hatch and External Crane: The use of an external crane to lift equipment vertically out of and into the facility will require the building to be equipped with a roof hatch or skylight located directly above the equipment. In addition, adequate space must be provided such that the equipment can be easily removed.

The use of an external crane will require sufficient clearance outside the building for the crane boom to maneuver around the exterior of the building, and proper placement of structural components, utility piping, and equipment inside the building to avoid interference with the hoisted equipment, as well as equipment to be removed located adjacent to the exterior wall. Site grading and layout must be designed to accommodate a crane. Equipment removal will require a recurring fee for crane equipment instead of an initial capital cost for a permanent crane.

4.5 Architectural

4.5.1 General

The architecture of each facility plays an important role in the overall success of the Program. To achieve an aesthetically satisfying solution, each facility's design considers the history, spatial configuration, micro-climate, and other contextual elements specific to each site.

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WWU is committed to an approach that extends the useful life of the facilities and provides for the needs of the community. As such, the architectural components of the proposed facilities focus on safety, ease of use, low maintenance, reliability, and long-term flexibility.

The proposed facilities advance the Program's sustainability goals by maintaining important views and cultivating a character that fits the communities in which they are located. These architectural criteria informed the standards, principles, and design strategies used to carry out the development of design documents for the following structures:

1. Booster Pumping Station
2. Water Supply Control Building

The Water Supply Pumping Station (WSPS) and Return Flow Pumping Station (RFPS) are not subject to the design criteria within Section 4.5. The WSPS will be owned, and operated by Milwaukee Water Works (MWW) and designed by MWW per their standards and preferences. The RFPS will be owned by City of Waukesha Public Works Department and operated by Clean Water Plant (CWP) staff and designed per their standards and preferences.

4.5.2 Codes, Standards, and References

All facilities will comply with the design requirements of the codes listed in Section 4.1 and their respective Wisconsin Amendments.

The Department of Safety and Professional Services has been engaged in rulemaking to update Wisconsin Administration Code Chapters 361 to 366. As part of the updates, the State will adopt the 2015 IBC and ASHRAE 90.1 – 2013 in May of 2018.

4.5.2.1 Wisconsin Commercial Building Code

The following are highlights of the Wisconsin Commercial Building Code (Building Code) which aid in determining the main characteristics of the facilities for further code compliance. Cited sections and tables refer to specific sections in the code.

4.5.2.1.1 Occupancy

In accordance with Building Code Section 306.2, the facilities are assigned Factory Industrial F-2 Low-hazard occupancy.

However, per Building Code Section 304, the toilet, janitor and sampling rooms are assigned Group B Business occupancy. Per Building Code Section 306.1, rooms containing the switchgear, transformers, dry-cell type batteries, and other electrical equipment are assigned Factory Industrial F-1 Moderate-hazard occupancy. Rooms containing toxic or corrosive chemicals stored in excess of the maximum allowed per control area as prescribed in Tables 307.1 (1) and 307.1 (2) are assigned High Hazardous H-4 occupancy. This hazardous assignment extends to areas where wet-cell batteries are stored.

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4.5.2.1.2 Type of Construction

To achieve an economical and flexible facility, fire resistance requirements for building elements have been designated in accordance with Construction Type II-B, Non-combustible building. This approach takes advantage of the inherent fire-resistive quality of materials such as steel and concrete while significantly reducing the need for fire sprinklers and other fire protection systems. As such, except as required by other sections of the Building Code, the primary structural frame, bearing walls, floors, and ceilings do not require fire-resistive coatings beyond being non-combustible in accordance with Table 601.

4.5.2.1.3 Area and Height Limitations

Factory Industrial F-2 Low-hazard occupancies in Type II-B construction are limited to three stories (or 55 feet) and a maximum area of 23,000 SF. None of the facilities are anticipated to exceed 23,000 SF.

4.5.2.1.4 Fire Protection Systems

Building Code Section 903 specifies requirements for automatic sprinkler systems. Since maximum areas established under Chapter 5 – General Building Heights and Areas, are not exceeded, sprinkler systems are generally not required. In addition, Section 903.2 exempts areas where electrical equipment would be stored. However, Section 903.2.5 mandates the installation of a sprinkler system in High Hazard H Occupancies.

Per Building Code 903.2.11.1, stories without openings require sprinklers under certain circumstances. For basements greater than 1,500 SF, one of the following conditions must be met:

- Provide an opening below grade that leads to an exterior stairway.
- Provide an opening above adjacent grade – 20 square feet opening / 50 lf there is a wall on at least one side
- It is anticipated that these conditions will not be met, and sprinklers will be required in basements.

Building Code Section 905 stipulates requirements for Standpipe Systems. Per 905.3.1, Class III standpipes are to be installed where the floor level of the highest story is located more than 30 feet above or below fire department vehicle access. Therefore, Class III standpipes are not required.

Building Code Section 905.4 mandates the installation of a Class I standpipe hose connection in all required stairways at each level above or below grade. Therefore, Class I standpipe hose connections will be provided.

Building Code Section 906 stipulates requirements for portable fire extinguishers. Section 906.1 indicates extinguishers are required in Group F and Group H occupancies. Per 906.1.5, fire extinguishers are to be located per the International Fire Code.

Building Code Section 907 stipulates the requirements for fire alarm and detection systems. However, Section 907.2.2 indicates that Group B occupancy loads of the proposed building is less than the set thresholds. Therefore, the code does not require fire alarms system for this application.

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4.5.3 Architectural Design Approach

4.5.3.1 Walls

The primary building enclosure system will be masonry cavity walls which will aid in moisture control and insulation to meet building performance requirements. The insulation type can vary but will likely use polyisocyanurate to meet energy code requirements for the walls and roofs. Polyisocyanurate has a higher R value per inch then other insulation materials. Thickness of insulation will vary based on the other materials used within the building envelope.

4.5.3.1.1 Exterior Walls

To promote durability and longevity, the exterior of each structure will be finished with face brick and cast stone. Single wythe construction does not meet energy code. Split Face Block can be investigated as an option for the façade of the cavity walls construction.

4.5.3.1.2 Interior Partition Walls

The typical wall construction will be 8-inch concrete masonry units (CMU) with cast-in-place concrete walls located where required for structural performance.

4.5.3.2 Roof Construction

The roof system for the buildings will consist of standing seam metal panels attached to the roof structure which is planned to be metal decking. The roof system will meet a UL Class A rating for severe fire exposure and satisfy wind uplift requirements for the area.

4.5.3.3 Doors and Frames

Typically exterior doors, including roll up doors and their frames, will be aluminum. Oversized double doors will be provided to remove building equipment. Exterior doors in the electrical areas will be sized to remove 90-inch tall motor control center sections.

Six-inch diameter concrete-filled, painted bollards will be provided to protect service entries and any other mounted equipment.

Fiberglass reinforced plastic (FRP) doors and frames will be used where required for both fire rated construction and corrosion resistance in hazardous and chemical storage areas.

4.5.3.4 Finish Hardware

All doors will have heavy-duty stainless steel locksets. The function of such hardware will be appropriate for the door's use. Stainless steel panic hardware will be used where required for egress.

Double doors will be provided with one active leaf, coordinators and edge bolts.

Security access will be provided via electronic locks coordinated with building systems and local municipalities for personnel who might require access to the facilities.

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4.5.3.5 Windows and Translucent Wall Panels

All frames and mullions for both windows and translucent wall panels will be aluminum. Insulated double pane high efficiency low E type glazing will be used for openings which provide a view to the opposite side. Translucent Wall Panels will be used for openings for access to natural lighting.

4.5.3.6 Louvers

Typically louver frames, blades, and drainage channels will be aluminum. FRP will be used where required for corrosion resistance in hazardous and chemical storage areas.

4.5.4 Interior Finishes

Interior finishes in the building will be as follows:

1. Flooring with concrete slab and clear coat sealant
2. Painted concrete masonry unit and cast in place concrete walls
3. Painted precast concrete plank ceilings
4. Metal structural ceilings with intumescent fire resistant coating

4.5.4.1 Signage

Signage will be provided per the appropriate authorities, agencies, and the code for applicable areas.

4.5.4.2 Exterior Lighting

Lighting will satisfy functional and security needs while not creating light pollution in the form of point sources of direct glare which are visible from a distance. Fixtures will be low level, directional, high efficiency LED light fixtures, which illuminate immediate areas, selected for efficiency and cutoff.

4.5.4.3 Railings

Where required along open walkways and stairs, railings will be of welded construction and made of aluminum tubes. FRP will be used where required for corrosion resistance in hazardous and chemical storage areas.

4.5.5 Recycled Content and Locally-Sourced Materials

In order to reduce the use of virgin materials and the amount of waste sent to landfills, the Program has targeted using materials made from 20% reclaimed or recycled content. This target corresponds to an enhanced level of achievement in the Envision Rating System's recycled materials credit category. This is primarily achieved through the use of concrete with fly ash, slag, and recycled aggregate. In addition, steel, aluminum, glass, and other materials that are typically made with a high percentage of recycled content are incorporated where practical.

To further reduce the Program's environmental impact, regional and locally-sourced materials are indicated when obtainable. This approach reduces the carbon footprint associated with the transportation of materials while promoting economic development in the surrounding communities.

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4.5.6 Landscaping and Site Lighting

Fertilizers and pesticides contribute to non-point-source pollution and eutrophication in local water ways. To minimize the use of fertilizers, landscaping will incorporate plant species indigenous to the area and employ an integrated pest management strategy. Indigenous plants tend to be more hardy and drought tolerant than exotic plant species. The use of indigenous plants in the landscape will reduce the amount of water required for irrigation. The design team will coordinate with local officials to identify habitats and select landscaping strategies that protect and preserve habitat biodiversity.

In addition to strategic planting choices, careful site lighting encourages biodiversity by reducing the negative environmental impacts of light pollution. Therefore, site lighting will be deployed in a manner that reduces light pollution and helps preserve the night sky.

4.5.7 Daylighting

The facilities will incorporate the benefits of daylighting where practical. It is well-documented that worker productivity increases in naturally lit work-spaces that provide a visual connection to the exterior. The use of daylighting offsets artificial lighting loads to reduce the building's overall energy consumption, but it is important to consider glare and solar heat loads. Excessive solar heat loads may result in increased energy usage for cooling, and glare may undermine worker productivity by creating visual discomfort. To control for both, a combination of light shelves, projected roof eaves, and high-performance window systems will be evaluated during final design.

4.5.8 Minimize Noise and Vibration

Excessive noise and vibration have negative health consequences for employees and can diminish the quality of life for the surrounding community. Table 4-2 identifies the equipment with the greatest risk for generating unwanted noise and vibration and the corresponding engineering controls.

Table 4-2 Noise and Vibration Control Measures

Equipment	Location	Control Measure
Vertical Turbine Pumps and Motors	Interior	Foundation design, isolation pads, acoustic sound dampening panels
Generators	Exterior	Sound attenuation enclosures, strategic siting, mufflers
Transformers	Exterior	Sound attenuation screens, strategic siting
HVAC Equipment	Exterior	Higher efficiency equipment, dampers

4.5.9 Access Management, Safety, and Wayfinding

Regulatory signage will be provided in accordance with OSHA, NFPA, Wisconsin Department of Transportation (WisDOT), and as required by the authorities having jurisdiction. In addition, identification and directional signage will be developed through an integrated wayfinding approach that is intuitive and consistent with local design standards. In addition to standardized signage, the building and site design will be configured to improve wayfinding and safety. For example, safety is increased and vandalism reduced where public entrances are well lit and lines of sight to them are not obstructed. Industrial buildings experience fewer work-related injuries where pedestrian and worker access aisles are clearly marked.

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4.5.10 Preserve Views and Local Character

Facilities will be designed to preserve views and fit in with the local character. For example, at the Booster Pumping Station (BPS), priority will be given to the rural nature of the vicinity, and thus the horizontality of the structure will be emphasized. In all cases, local design standards will be employed where present. Stakeholder input will be solicited in order to preserve community identity to the greatest extent practical.

4.6 Structural

4.6.1 General

The structural design will be performed in compliance with the State of Wisconsin Building Code, all applicable local codes and ordinances, and construction industry standards. WSPS, BPS, Water Supply Control Building (WSCB), RFPS, and Return Flow Facilities are considered essential facilities. An occupancy category of IV is required to calculate all wind, snow, and seismic loads.

4.6.2 Design Criteria

The design and building specifications will comply with the 2009 IBC and the 2005 ASCE Minimum Design Loads for Buildings and Other Structures (ASCE 7-05). The Department of Safety and Professional Services has been engaged in rulemaking to update Wisconsin Administration Code Chapters 361 to 366. As part of the updates, the State will adopt the 2015 IBC and ASHRAE 90.1 – 2013 in May of 2018.

4.6.3 Design Loads

4.6.3.1 Live Loads

Live loads are in Table 4-3.

Table 4-3 Live Loads

Slab	Live Load
First Floor Slabs on Grade, psf	150
Supported Slabs, psf	250

4.6.3.2 Soil Loads

The unit weight of compacted granular soil fill is 125 pcf. The internal friction angle used for determining lateral loads will be 30 degrees.

4.6.3.3 Wind Loads

Wind loads for each structure will be calculated using the criteria in Table 4-4 and an importance factor of 1.15 for the essential facility occupancy category.

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Table 4-4 Wind Loads

Criteria	Value
Local Wind Speed, miles per hour (mph)	90
Exposure Category	C
Directionality Factor	0.85
Topographic Factor	1.0

The base wind pressure is 1,702 psf and will be modified at each facility based on the size, height, and configuration of the structure.

4.6.3.4 Snow Loads

Snow loads for each structure will be calculated using the criteria in Table 4-5 and an importance factor of 1.20 for the essential facility occupancy category.

Table 4-5 Snow Loads

Criteria	Value
Ground Snow Load, psf	30
Thermal Factor	1.0
Exposure Factor	1.0

The base snow load is 25.2 psf and will be modified at each facility based on the configuration of the roof structure.

4.6.3.5 Seismic Loads

Seismic loads for each structure will be calculated using the criteria in Table 4-6 and an importance factor of 1.50 for the essential facility occupancy category.

Table 4-6 Seismic Loads

Criteria	Value
Spectral Response Accelerations	
Ss, g	0.122
S1, g	0.045
Spectral Response Coefficients	
SDS, g	0.119
SD1, g	0.072
Seismic Response Coefficient	
Cs	0.090
Response Modification	
R	2

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Criteria	Value
Assumed Soil Site Class	D
Seismic Design Category	A

4.6.3.6 Soil Loads

Soil design criteria is not available for any of the building structures at this time and will be determined during design. An allowable soil bearing pressure of 3,000 psf has been used to develop the preliminary foundation design. Backfill against foundation walls and retaining walls will be a granular material with an internal friction angle of 30 degrees.

4.6.3.7 Unit Weights

Unit weights of materials are in Table 4-7.

Table 4-7 Unit Weights

Material	Unit Weight
Concrete, pcf	150
Steel, pcf	490
8-inch Hollow Masonry, psf	45
8-inch Solid Masonry, psf	85
12-inch Hollow Masonry, psf	60
12-inch Solid Masonry, psf	121
8-inch Precast Plank, psf	60
10-inch Precast Plank, psf	67
12-inch Precast Plank, psf	77

4.6.4 Load Combinations

Load combination will be in accordance with the ASCE 7-05 Minimum Design Loads for Buildings and Other Structures

4.6.5 Materials of Construction

Pressures for the materials of construction are in Table 4-8.

Table 4-8 Materials of Construction

Category	Pressure
Concrete	
Footings, psi	3,000
Slabs on Ground, psi	3,500
Foundation Walls, psi	4,000
Reinforcing Steel	
Rebar: American Society for Testing and Materials (ASTM) A615, Grade 60, Fy, ksi	60

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Category	Pressure
Structural Steel	
W-Shapes: ASTM A992, Grade 50, Fy, ksi	50
Rectangular HSS ASTM A500 Grade B, Fy, ksi	42
Angles and Plates: ASTM A36, Fy, ksi	36
Channels: ASTM A36, Fy, ksi	36

4.6.5.1 Concrete Design and Construction

Concrete design will be in accordance with the 2009 ACI Building Code Requirements for Structural Concrete. All concrete structures containing water will be designed in accordance with the 2006 ACI Code Requirements for Environmental Engineering Concrete Structures.

Concrete mixes used for foundations will be designed with a minimum of 40% cement replacement with fly ash. Walls and columns will have a minimum cement replacement of 30% fly ash. The maximum length of pour will be 40 feet. Crack inducers will be within 10 feet of all corners. All concrete exposed to weather will be air entrained a minimum of 5.5%.

Interior floor slabs will require a hard trowel finish and will have a minimum cement replacement of 10% floor slabs will contain a minimum of 5 pounds per cubic yard of macro polypropylene fibers. Floor control joints will be cut as soon as concrete does not ravel. The maximum size of panels is 15 feet by 15 feet.

4.6.5.2 Precast Concrete Plank Design

Precast concrete plank will be selected and detailed in accordance with the Precast Concrete Institute Design Handbook.

4.6.5.3 Masonry Design

Masonry design will be in accordance with the 2008 ACI Building Code Requirements for Masonry Structures (ACI 530). Masonry lintels will be precast masonry with steel angle lintels for the face brick. Unreinforced masonry will be designed for an allowable compressive strength of 1,350 psi. Reinforced masonry will be selected to achieve an allowable compressive strength of 2,000 psi.

4.6.5.4 Structural Steel Design

Structural steel will be designed, fabricated, and erected in accordance with the AISC “Steel Construction Manual” thirteenth edition and the “Code of Standard Practice” latest edition.

All welding will comply with the American Welding Society, Structural Welding Code (AWS D1.1). All bolted connections will be made with ASTM – A325 bolts. All bolted connections not listed on the design drawings will be made with double angles and will support 1/2 the allowable uniform load capacity of the beam.

Steel decking will be designed in accordance with the SDI Design Manual 2016.

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4.7 Electrical

This section describes the electrical design criteria for the power, lighting, grounding, bonding, and electronic safety and security systems of the Program.

4.7.1 Codes and Standards

The design of the facilities' electrical systems will be based on the codes and standards listed in Section 4.1.

4.7.2 Design Criteria

Engineering decisions relating to electrical systems in general will be guided by the following design criteria in subsequent subsections. Electrical design criteria specific to the facilities can be found in facility-specific sections of this PDR.

4.7.2.1 Life Safety

The electrical design will be centered on safety for personnel and the public by incorporating proven design concepts in compliance with NFPA standards. The latest industry consensus standards and recommended practices will be followed in the selection and application of materials and equipment. Hazards to be mitigated through design include fire, electric shock, arc flash, and chemical exposure.

4.7.2.2 Reliability

The power distribution system for the facilities will be designed to reliably deliver electrical power to the facility equipment and to isolate faults with minimum disturbance to unaffected portions of the distribution system. Redundancy will be incorporated so that the failure of a single component is unlikely to lead to a failure of the system. Major distribution system components will be designed with "2N" redundancy where each component is mirrored by a full-capacity redundant component. For operation during outages of the utility power sources, standby power will be delivered from an on-site generator system.

Standby generator systems used for pumping will meet the requirements of the Wisconsin Administrative Code (NR 811.27) and will be capable of supporting average daily demand (ADD) flows. Specific standby system sizing criteria is located in facility-specific section of this PDR.

4.7.2.3 Durability

Each electrical system will be designed to perform reliably for the expected service life of the associated process systems. Routine maintenance of electrical systems will be required. Materials and equipment selected will be suitable for the environment and conditions of service where they are installed.

In general, electrical, instrumentation, and control equipment will be installed in dedicated electrical rooms. These electrical rooms will be heated, air conditioned, and filtered for corrosive air substances in order to extend equipment operating life and to lower equipment maintenance and servicing costs.

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4.7.2.4 Operation and Maintainability

The electrical system design will incorporate the features listed below to facilitate operation and maintenance activities:

- Equipment working clearances meeting or exceeding requirements of the National Electric Code (NEC) and other applicable standards
- Sufficient spaces around equipment to allow for repair or replacement of critical components without disruption to other critical components of the system
- Design to mitigate arc flash hazard through reduction of incident energy and by including features to reduce maintenance activities with an arc flash risk
- Design for future modifications with continued operation
- Design to allow many maintenance activities to be safely performed without requiring a full outage, thus encouraging regular maintenance and enhancing service life and availability

4.7.2.5 Area Classification

Area classifications are expected as follows:

- No flammable vapors, dusts or fibers are anticipated to occur within the facility area.
- Damp, wet, and corrosive areas will be defined in the Contract Specifications and referenced on the Contract Drawings.
- Materials and equipment selected will be appropriate for the environment in which they will be applied and compatible with other materials in close contact.

4.7.2.6 Energy Efficiency and Renewable Energy Use

4.7.2.6.1 General

The design of the facilities will incorporate the features listed below to emphasize energy efficiency:

- Energy conservation will be universally implemented in the design and operation of the facilities.
- Premium efficiency motors, transformers, light-emitting diode (LED) type lighting, and energy efficient equipment will be specified where available. Means for monitoring and managing energy will be built into major electrical equipment and control systems.
- Electrical utilization equipment and associated controls will comply with the 2009 IECC, with Wisconsin amendments.
- Transformers will be selected to exceed Department of Energy (DOE) 2016 efficiency requirements.
- Wiring will be sized for a voltage drop not exceeding the limits in ASHRAE Standard 90.1.
- Major distribution equipment (Switchgear, Switchboards, Motor Control Centers) will include digital power metering with power quality monitoring. Meters will measure voltage, current, power, reactive power, power factor and harmonic content. Metering will include event and trend logging, and will report to SCADA.

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- Pumps will be controlled by VFD to meet flow requirements more efficiently. Pump operation will be monitored and controlled closely through the VFDs by a network.

4.7.2.6.2 Renewable Energy Use

There are federal and state grants and tax credits for the installation of renewable energy technology that could help to offset capital cost. An evaluation has not been performed to determine the return on investment of renewable energy technology at any of the facilities. If requested by WWU, the use of renewable energy technology will be further evaluated. This practice also provides clean energy while also reducing greenhouse gas (GHG) emissions.

Wisconsin currently has a grant network for these technologies, and federal Investment Tax Credit and Production Tax Credits may also be available. Additionally, alternate financing methods such as leasing renewable generation equipment and Power Purchase Agreements (PPAs) can be examined as a way of decreasing capital costs and liabilities. PPAs may be evaluated and entered into independently of facility design decisions.

4.7.2.7 Identification and Labeling System

To facilitate operations, maintenance, and future improvements, a system of identification and labeling will be used for all electrical distribution equipment, conduit, cables, boxes/enclosures, and utilization equipment. Labels will be permanently affixed with expected durability suitable for the service life of the system and composed of materials compatible with the environment. Markings will be selected for legibility under the anticipated service conditions.

Labeling conventions will comply with applicable codes and standards and will be developed in coordination with identification systems for process, heating, HVAC, instrumentation and control (I&C) systems.

4.7.3 24.9-kilovolt Switchgear

24.9-kilovolt electrical service equipment will be fused padmounted outdoor switchgear meeting IEEE C57.12.28 and the requirements of We Energies. Switchgear will be configured for manual source transfer between multiple We Energies primaries.

4.7.4 480-Volt Switchgear

Where electrical service equipment will be 480-Volt switchgear, it will be metalclad drawout switchgear with drawout power circuit breakers meeting IEEE C37.20.1. Switchgear will be arranged in a Main-Tie-Tie-Main configuration to allow tie breaker servicing with reduced risk for arc flash. Switchgear control power will be derived from nickel-cadmium batteries. Batteries are included to allow electric operation of switchgear circuit breakers during a full utility outage prior to the startup and synchronization of standby generators.

Where standby generators will be included, the generator system will be connected to a breaker at the switchgear central tie bus to allow for powering one switchgear main bus from the utility, while the other is powered from the generator. Automatic source transfer controls will be provided. A separate feed-in circuit breaker at the tie bus will be provided for connection of a towable standby generator set to be used during outages or maintenance operations involving the fixed generators or paralleling switchgear.

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Surge Protection Devices (SPDs) will be installed for surge and lightning protection at major power distribution equipment including the new switchgear. SPDs will be installed external to the switchgear to avoid collateral damage to equipment should the surge devices fail actively. SPDs will be equipped with surge counters.

4.7.5 480-Volt Distribution Switchboard

480-Volt equipment other than the main process loads will be powered through a distribution switchboard.

The switchboard will be constructed to meet UL 891 and NEMA PB 2. The switchboard will be arranged in two sections in a Main-Tie-Tie-Main configuration with a cable connection between tie circuit breakers. Transfer between sources will be manual with a mechanical key interlock system to control switching sequence. The switchboard will be in a front-accessible NEMA 1 floor-mounted enclosure defined in NEMA 250. Each switchboard main bus will be rated to carry the entire load of the switchboard for single-ended operation when the tie breakers are closed and one of the main circuit breakers provides power to both main horizontal buses. Main buses will be tin plated copper bars rated and sized as required in accordance with NEMA temperature rise standards for this class of equipment based on a 40 °C ambient temperature. All bus work will be suitably braced to withstand the maximum available system short circuit current. Uninsulated copper grounding bus with lugs for connections to the plant grounding system will be installed continuously across the bottom of each switchboard section.

Main incoming and tie circuit breakers will be provided with a ground fault protection system. The ground fault setting will be adjustable. Rated interrupting capacities at 480-Volt will be suitable to interrupt the maximum available system short circuit current. Key interlocks will be provided to prevent paralleling of incoming feeders.

Switchboards will be provided with external surge protection devices on each bus.

4.7.6 480-Volt Motor Control Centers (MCC)

480-Volt MCCs will be constructed and installed in accordance with NEMA ICS - 2 and UL 845. Each MCC will have UL labels for the entire structure and for each vertical section. The MCCs will consist of a totally enclosed, dead front, gasketed, self-supporting and freestanding NEMA 12 structure defined in NEMA 250. The MCCs, including internal interlock and controller wiring, will be NEMA Class II, Type B defined in NEMA ICS - 2, factory assembled. MCC lineups will be designed for incoming sections and bus tie sections in the center of the lineup and feeder sections on the ends for future expansion. Adequate electrical workspace for future MCC expansion will be provided.

A main horizontal bus will be provided across each structure, and each of the main buses will be connected together through a tie breaker. The main horizontal buses will be rated to carry the entire load on the combined main buses of the MCC for single ended operation when the tie breaker is closed and one of the main circuit breakers provides power to both main horizontal buses. Main buses will be tin plated copper bars rated and sized as required in accordance with NEMA temperature rise standards for this class of equipment based on a 40°C ambient temperature. All bus work will be suitably braced to withstand the maximum available system short circuit current. An uninsulated copper grounding bus with lugs for connections to the plant grounding system will be installed continuously across the bottom of each MCC.

Main incoming and tie circuit breakers will be mechanically key interlocked and will be provided with a ground fault protection system, which will be adjustable. Rated interrupting capacities at 480-Volt will be suitable to interrupt the maximum available system short circuit current. Key interlocks will be provided to prevent paralleling of incoming

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feeders. Motor starters will be enclosed in individual compartments. Each starter will be equipped with an individual control power transformer to derive the 120-Volt for the unit's control circuit. Control devices will be industrial type, heavy duty, oil tight, and arranged for flush panel mounting with legend plates. Rated interrupting capacities at 480-Volt will be suitable to interrupt the maximum available system short circuit current.

4.7.7 Outdoor Pad Mounted Medium Voltage Transformers (Primary Voltage Above 480-Volts)

Outdoor oil-filled power transformers rated for operation at the required distribution voltages will be provided. The transformers will be self-cooled units with a 55°C rise and an 80°C maximum hotspot rise. The transformers will have sidewall mounted, high-voltage and low-voltage bushings. The transformers will have a primary disconnect switch and a secondary circuit breaker for protection. The insulation system must allow continuous loading at 112% of 55°C at rated power with a temperature rise of 65°C. The transformers will have an externally operated, no-load tap changer with four ±2.5% full-capacity taps, two above and two below the rated high voltage, with provision for padlocking the tap changer. The transformers will be installed on concrete pads with oil collection and drainage systems. The transformer systems will have the following accessories: oil thermometer, liquid level gauge, pressure vacuum gauge, and pressure relief valve.

4.7.8 Low-Voltage Transformers (Primary Voltage 480-Volt and Below)

General Purpose indoor transformers for low voltage power and lighting will be dry type, rated for 480-Volt and 208-/120-Volt operation. Windings will be encapsulated, Class H insulation and will be mounted in sheet metal enclosures suitable for wall or floor mounting. Transformers will have efficiencies meeting or exceeding DOE 2016 requirements.

4.7.9 Motors

Motors less than 1 horsepower (HP) will be 120-Volt, single phase. Motors 1 HP or more will be 480-Volt, 3-phase. An exception will be made for chemical feed pumps allowing them to be 3-phase regardless of HP.

Motors will be specified as energy efficient, high power factor type meeting the requirements of NEMA MG 1-2011, Part 12. Motors will be “NEMA premium efficiency”, where available. Motors that are not used with VFDs will be rated for 1.15 service factor for direct on line service with NEMA Class F insulation without exceeding NEMA Class B temperature rise. Motors will be specified to have suitable output torque and speed characteristics to start and operate the driven equipment under design load conditions without exceeding motor nameplate ratings. Motor starting conditions will be evaluated under utility and generator power conditions.

Motors used with VFDs will be premium efficiency, inverter duty rated with 1.00 service factor for inverter duty and NEMA Class H insulation. Motors controlled by VFDs will comply with NEMA MG 1 Part 31. Inverter duty rated motors will be designed for use with pulse width modulated drives. Inverter duty rated motors will include a shaft grounding brush to prevent arcing and early degradation of the bearings. Each motor will be selected according to application and environmental conditions.

Motors serving main process pumps will include winding temperature sensors and anti-condensation heaters. Non-reverse ratchets and vibration monitoring are standard options typically provided on motors driving vertical turbine (VT) pumps and will be included if requested by WWU or Clean Water Plant (CWP).

Local lockable service disconnects will be provided within sight of each motor.

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4.7.10 Variable Frequency Drives

VFD installations will meet the voltage and current harmonic distortion at the point of common coupling as outlined in IEEE Standard 519 and line reactors will be included where required. The VFDs will utilize pulse width modulated insulated gate bipolar transistor technology.

To improve cooling and ventilation and extend VFD life, VFDs will not be installed inside programmable logic controller (PLC) enclosure cabinets or MCC cabinets. VFDs will be installed as standalone units in conditioned and cooled spaces. VFD enclosures will be NEMA 12. VFDs will be equipped with Ethernet IP communications for monitoring of VFD parameters (e.g. voltage, current, power, etc.) by the SCADA system.
VFDs will be provided with internal bypass contactors to allow for operation at full speed with reduced energy consumption.

4.7.11 Wires and Cables

Wires and cables will be in accordance with applicable IEEE and NEMA standards and UL listed. Conductors will be Class B copper. Aluminum wire will not be utilized. Wires and cables will be banded with an identifying number and color coded at each end termination and at each connection point in junction boxes.

4.7.11.1 Low Voltage Power and Control Cables

Wires will be stranded type, except No. 12 and No. 10 AWG which may be solid for lighting fixture and convenience receptacle wiring. 600-Volt wire for power, control, grounding, and lighting conductors will be soft drawn or annealed copper conductor with 98% minimum conductivity, meeting requirements of ASTM B3. The minimum wire size for power and lighting circuits will be No. 12 AWG; control circuits will be No. 14 AWG. Low voltage circuits will be wired with 600-Volt insulated conductors, sized for the actual load to be served, temperature rating of 75°C in wet or dry locations. Insulation for 600-Volt copper conductors will be cross-linked polyethylene compound, Type XHHW-2. Cable outer jacketing will be polyvinyl chloride pipe (PVC).

4.7.12 Panelboards

Lighting panels will be rated 208Y/120V, 3-phase, 4-wire service. Power distribution panels will be rated for 480V, 3-phase, 3-wire service. Power distribution and lighting panels will be dead-front type with automatic, thermal magnetic, trip-free, and nonadjustable bolt-on branch circuit breakers. Panelboards will be wall mounted with enclosures suitable for the environment where installed. Each panelboard will be provided with an external surge protection device.

4.7.13 Lighting System

Lighting sources will be high efficiency LEDs. Fixtures will be qualified by the Design Lights Consortium for their application. Illumination levels will be designed to meet Illuminating Engineers Society of North America (IESNA) guidelines at the end of fixture service life.

Lighting fixtures will be suitable for the environment where installed such as indoor, outdoor, wet, corrosive, or other exposures. Outdoor lighting fixtures will be designed to eliminate light pollution outside the project limits.

Lighting controls will comply with IECC requirements and will include occupancy and daylight sensing where required. Manual override will be included with all automatic controls.

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Illumination levels will be designed to the following IESNA maintained average foot-candle illumination values as noted in Table 4-9.

Table 4-9 Illumination Levels

Area	Maintained Average Foot-Candles (FC)
Pumping Rooms	30
Electrical Rooms	50
Mechanical Rooms	30
Vestibules	50
Toilets	30

4.7.13.1 Emergency Lighting

Emergency egress and exit lights will be provided per NFPA 101 requirements and International Building Code requirements. LED type emergency egress and exit lights will have individual unit batteries. Emergency lights will be wired to local lighting circuits.

Required emergency lighting will be provided through emergency battery units with LED lamps and batteries selected for a minimum duration of 90 minutes. Battery units will be provided for a minimum of two foot-candle illuminance along the egress path.

Exterior lighting fixtures at each building entrance will be provided with integral battery sources for operation during a utility power outage.

4.7.14 Wiring Devices

Lighting switches will be general-use, snap-type switches. Switch enclosures and covers will be suitable for the environment where installed.

Flush receptacles will be single or duplex grounding type with terminals rated 20 amperes, 125-Volts. Receptacles in wet, damp, or outdoor areas will be of the ground fault circuit interrupter type with weatherproof covers. Weatherproof covers will be clear polycarbonate, lockable, and hinged “While in Use” style for damp, wet and outdoor areas. Receptacles for corrosive areas will be housed in NEMA 4X enclosures and will be have appropriate covers similar to weatherproof receptacles. Receptacles in classified areas will be specified to be suitable for the appropriate area classification.

Welding receptacles will be provided as required. These receptacles will include a plug ground contact to engage with the receptacle ground contact before phase contacts engage. Upon plug withdrawal, the ground contact will remain engaged until after the phase contacts disengage.

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4.7.15 Raceways

Dedicated raceways and boxes maintain segregation of wiring systems originating from different utility service buses. Segregation of all raceways of different service voltages will be maintained, and separate raceways for control, instrumentation, power, and communication wiring will be provided. Raceways will be sealed where they emerge from ductbanks, penetrate the building envelope, and at other boundaries between different environmental classifications.

4.7.15.1 Exposed Conduits

Conduits will be run exposed indoors, except in architecturally finished areas where they may be concealed.
In non-corrosive, above grade, indoor areas, conduits will be rigid galvanized steel. Flexible, liquid tight, non-metallic conduit will be used for final connection to equipment subject to vibration or adjustment (e.g. motors, transformers, etc.) in non-hazardous areas.

In corrosive, outdoor, and below grade areas, PVC coated rigid galvanized steel conduits will be used.

4.7.15.2 Underground Electrical Ducts

All raceways installed underground, except lighting branch circuits, will be encased in concrete ductbanks. Power raceways will be PVC Schedule 40. Communication raceways will be rigid galvanized steel conduit.

4.7.15.3 Equipment Enclosures

The recommended enclosure types for the new electrical equipment will be based on the location and the conditions to which the equipment is exposed. Table 4-10 shows the recommended enclosure types for various locations.

Table 4-10 Recommended Enclosure Types

Area	Enclosure Type	Notes
General Indoor	NEMA 12	-
General Outdoor	NEMA 3R	-
Wet Locations	NEMA 4X	316 Stainless Steel with Sealed Seams
General Corrosive Areas	NEMA 4X	316 Stainless Steel with Sealed Seams
Hazardous Locations	NEMA 7	Cast Iron with Threaded Connections and Ground Joint Surfaces

4.7.15.4 Boxes

Terminal, junction, and pull boxes will be installed as required by code, for serviceability, or operational convenience. Surface mounted terminal, junction, and pull boxes will be complete with mounting lugs, threaded hubs, and gasketed covers. PVC coated boxes will be used in areas requiring PVC coated conduits.

4.7.15.5 Surge Protection

Local SPDs will be installed for surge and lightning protection at major power distribution equipment including each new switchgear, switchboard, MCC, and distribution/lighting panelboards. SPDs will be installed external to the

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respective equipment to avoid collateral damage to equipment should the surge devices fail actively. SPDs will be equipped with surge counters.

4.7.15.6 Arc Flash Protection

OSHA requires identification of required Personal Protective Equipment (PPE) on electrical equipment for persons performing operation and maintenance at, or near, electrical equipment. PPE labels are required to alert the operators of the appropriate level of PPE to wear when approaching or working around this equipment. Equipment not properly identified is subject to OSHA issued fines.

An engineering study is required to identify the appropriate PPE and will include a professionally certified arc flash study, fault study, and protective device coordination study. A preliminary power systems study will be prepared during design. The final study will be completed by the contractor during construction on the basis of actual equipment provided and the final system layout.

Power distribution system configuration will be designed to reduce potential arc flash hazard where possible and where it will not compromise continuity of service or add undue complexity.

4.7.15.7 Grounding System

A complete grounding system consisting of electrodes and conductors will be provided.

The grounding system will be provided in accordance with NEC and applicable ANSI and IEEE Standards. Low voltage raceways will include an insulated grounding conductor, except signal raceways. The grounding system will conform to applicable requirements of the NEC Article 250. Accessible connections to structural members will be by exothermic welding process or by bolted connector. Connections to equipment or ground bus will be by bolted connectors. Ground system test wells will be provided for the building ground system. The ground rods in test pits will be enclosed in a soil pipe filled with crushed rock.

4.7.15.8 External Ground Ring

Bare copper cable conductor and copper-clad steel ground rods will ring applicable structures. Grounding loop conductors will be bare annealed copper conductors suitable for direct burial. Ground conductors will be #4/0 unless sized otherwise on Contract Drawings. Buried and concealed ground connections will use exothermic welding.

4.7.15.9 Bonding

A building ground bus bar will be installed in the new electrical equipment room and will be bonded to the proposed new grounding system. Two grounding connections will be provided from transformers and MCCs to the ground loop. Motor frames 50 HP and above will be bonded to the building ground bus bar. For grounding of other pieces of electrical equipment, a grounding conductor installed at the raceway feeding that piece of equipment will be used. Grounding conductors will completely inter-connect ground rods, ground grid, substation, switchgear and MCC ground buses, other distribution equipment, and other groundable equipment. Shielded medium voltage power cable and shielded low voltage VFD power cable will be grounded at each termination and splice location, wherever the shield is exposed. Separately derived equipment or sensitive electronic equipment, including VFDs and PLC cabinets, will be bonded to the building ground bus bar.

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4.7.15.10 Lightning Protection

A complete NFPA 780 Class II (for structures under 75 feet) lightning protection system will be provided for the facilities using NFPA 780 Class I lightning protection materials. The lightning protection systems will comply with NFPA 780 Standard for the Installation of Lightning Protection Systems. The lightning protection system conductors will be fabricated from copper of a grade suitable for commercial electrical work and generally designated as being 95% conductive when annealed with a tin plating for corrosion protection.

Strike air terminal devices will be provided for all parts of a structure that are likely to be damaged by direct lightning flashes. Strike air terminal devices will be placed at intervals dictated by the design applicable for the structure. Air terminals will be Type 316 stainless steel. Down conductors will be installed in PVC conduit. The conduits will be concealed in exterior walls. The grounding systems will be interconnected to provide a common ground potential.

4.7.16 Fire Alarm System

A digital, addressable fire alarm and detection will be installed in each facility as required. It is not anticipated that every facility will require a fire alarm and detection system. The fire alarm system will include smoke detectors, heat detectors, manual sending stations, notification appliances, and an annunciator at the main entry. The system will be designed to NFPA 72 standards. Fire alarm devices will be designed for environmental conditions wherever they are installed. The alarm system status will be monitored remotely according to NFPA and local fire department requirements. The fire alarm status will also be monitored locally by SCADA.

4.7.17 Access Control and Security Systems

Intrusion detection, closed circuit television security, and electronic access control will be provided for the facilities. System type and performance requirements will be selected for interoperability with electronic safety and security systems at existing facilities operated by WWU.

4.7.18 Equipment Disconnect Switches

Heavy duty, non-fused, disconnect switches will be installed adjacent to all process equipment with motors and/or moving parts. This will provide a convenient and local means for equipment isolation. This will assist operations staff in the service, maintenance, repair, or emergency shutdown of equipment. Disconnects will be lockable to accommodate lock-out/tag-out procedures.

4.8 Mechanical

4.8.1 General

This section presents the design criteria for HVAC, plumbing, and fire protection systems associated with the Program. The requirements outlined in this section are to provide information for the design approach. The design criteria specific to the facilities can be found in Program Element specific sections of this PDR.

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4.8.2 Codes and Standards

The mechanical design will be based on the codes and standards listed in Section 4.1. The Wisconsin Department of Safety and Professional Services (SPS) provides amendments to the International Building Code. A brief description of the application of each code is presented below:

- 2009 IECC, with Wisconsin Amendments as noted under SPS 363 – Energy Conservation:
  - Climate zone classification for Waukesha
  - Outdoor and indoor design conditions for HVAC systems
  - Minimum equipment efficiency compliance for HVAC equipment
  - Energy recovery requirements for HVAC equipment
  - Economizer requirements for HVAC equipment
  - Minimum ductwork and piping insulation requirements

- 2009 IMC, with Wisconsin Amendments as noted under SPS 364 – Heating, Ventilating, and Air Conditioning:
  - Minimum ventilation rate requirements for areas not covered under NFPA 820
  - Smoke and fire prevention in air distribution systems
  - Acceptable location for the installation of HVAC equipment and devices
  - Requirements for supply and exhaust ductwork construction
  - Requirements for exhaust ductwork and outlet locations for systems conveying environmental air, contaminated flues and flammable vapors

- 2009 IFGC, with Wisconsin Amendments as noted under SPS 365 – Fuel Gas Appliances.
  - Natural gas piping sizing
  - Acceptable natural gas piping materials and installation
  - Venting of HVAC and Plumbing gas-fired equipment
  - Venting of natural gas distribution systems
  - Underground natural gas piping requirements

- Wisconsin Plumbing Code, SPS 382 – Design, Construction, Installation, Supervision, Maintenance and Inspection of Plumbing
  - Combined and dedicated potable water supply systems
  - Domestic water systems and equipment
  - Plumbing fixtures
  - Sanitary and waste piping requirements
  - Storm piping requirements

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  - Combined and dedicated storm and waste water disposal systems

- Wisconsin Department of Natural Resources, Chapter NR 811 – Requirements for the Operation and Design of Community Water Systems
  - HVAC specific requirements for application on clean water and wastewater treatment facilities

- NFPA 1 – Fire Code 2012, with Wisconsin Amendments as noted under SPS 314 – Fire Prevention.
  - Fire department exterior connections and alarms requirements
  - Space hazard classification and requirements
  - Wet pipe sprinkler and stand-pipe systems
  - Fire pump sizing and application

4.8.3 Heating, Ventilating, and Air Conditioning System

The HVAC system capacities will be calculated based on the location of Waukesha (43.01 °N, 88.23 °W), the code required outdoor conditions, building construction materials, and interior heat loads. The equipment selection will meet the requirements of IECC for climate zone 6A for minimum energy performance compliance.

4.8.3.1 Equipment Selection Criteria

Ventilation systems that incorporate outside air louvers with automatic dampers and exhaust fans will be provided for areas where the summer design indoor temperature can be maintained 10 °F above the outside air temperature. Heating in these areas will be accomplished by unitary heating equipment, gas fired or electrical, as available and as required for each application.

Air handling units with direct expansion cooling coils and indirect gas fired sections will be designed for areas where the indoor temperature should be maintained at or below 80°F in the summer. The air handling unit will be installed indoors with a remote condensing unit at grade level if sufficient space in a mechanical room is available. If this configuration is not possible, a self-contained air handling unit will be specified to be installed outside at grade level or on the roof. A combination of an air handling unit and a dehumidification system will be specified in spaces that have high levels of humidity and requires a higher level of control. Desiccant and refrigerant type dehumidifiers will be studied on a case by case basis, and the most economic and reliable system will be specified depending on the application.

A duplicate standby unit of the same type and capacity will be provided for a system serving spaces that require redundancy (100% back-up). This unit will operate when the lead unit fails.

4.8.3.2 Energy Sources

Natural gas will be used as the primary source of heating, if available. There will be no central heating or cooling plants. Chilled/hot water or steam piping distribution systems will not be considered as a source of heating and cooling. Unitary heating equipment or terminal heating devices could be either gas fired or electric depending on the classification of the space served. Cooling will be provided by electrically operated compressors at the condensing

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units serving the air handling systems. The most efficient heating and cooling equipment will be specified in order to reduce energy consumption and achieve sustainability goals.

4.8.3.3 Exterior Design Conditions

Table 4-11 shows the outdoor temperature conditions for Waukesha based on the requirements established in Chapter SPS 363 of the Wisconsin Energy Conservation Code.

Table 4-11 Outdoor Temperature Design Conditions

Season	Dry Bulb (ºF)	Wet Bulb (ºF)
Winter	-10	N/A
Summer	89	77

4.8.3.4 Interior Design Conditions

The indoor parameters that drive the selection and size of the HVAC system are ventilation requirements and indoor space temperatures. Minimum ventilation rates will be maintained at all times as regulated by codes and standards. The indoor minimum and maximum temperature conditions in process areas are normally based on best engineering practices to prevent freezing in the winter and overheating in the summer.

4.8.3.4.1 Ventilation

Interior spaces will be designed in compliance with NFPA 820 for minimum ventilation requirements for all areas covered under this standard. All other spaces will comply with the minimum ventilation requirements established in the IMC with Wisconsin amendments and ASHRAE Standard 62.1.

4.8.3.4.2 Temperature

The minimum indoor temperature for areas protected by sprinkler systems will require compliance with NFPA 13. Normally unoccupied spaces will be designed to maintain the minimum and maximum indoor temperatures adequate to provide uninterrupted operation of any mechanical or electrical equipment. Normally occupied spaces will be designed to meet ASHRAE Standards 55 and 62.1. Table 4-12 summarizes the minimum ventilation and temperature requirements for the most common spaces on this Program.

4.8.3.5 Systems and Equipment

The HVAC design will specify systems and equipment that are reliable for uninterrupted operation of each area in the facility. Rooms containing critical electrical equipment will have a higher level of protection to enable the electrical systems to operate even when the leading HVAC equipment serving those spaces fails. A higher level of protection will mean having a duplicate standby air conditioning unit to operate when it happens (100% back-up). This PDR will analyze each space independently to determine the most appropriate system for the application.
The design will focus on specifying indoor HVAC equipment and avoid locating equipment on the roofs, however depending on the architecture of each space some roof equipment may be required. Locating the equipment indoors will ease serviceability and preventive maintenance procedures.

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In general, each area or group of spaces having the same indoor conditions will be served by a dedicated air handling system. When required, mechanical cooling and heating will be generated by the dedicated air system serving each space by means of direct expansion for cooling and natural gas for heating. Additionally, depending on the level of corrosion protection required and the predominant relative humidity in the space, the mechanical design may incorporate dehumidification units to maintain adequate indoor conditions.

Table 4-12 Indoor Ventilation and Design Requirements

Space	Winter Design Temp (ºF)	Summer Design Temp (ºF)	Minimum Ventilation Rate (ACH[1])
Pumping Rooms	50	Ambient + 10 °F	N/A[2]
Mechanical/Fire Rooms	60	Ambient + 10 °F	N/A[2]
MCC/VFD/Electrical/Switch Gear Rooms	60	80	N/A[2]
I&C Rooms	60	80	N/A[2]
Battery Rooms	60	80	N/A[2]
Chemical Rooms	65	80	1 CFM/sq ft
Pipe Gallery (Basement)	60	Ambient + 10 °F	N/A[2]
Laboratories (Normally Occupied)	70	75	N/A[2]
Toilet Rooms	60	Ambient + 10 °F	75 CFM/TF[3]
Janitor Closets	60	Ambient + 10 °F	75 CFM/Sink

Notes:
1. ACH – Air Changes per Hour
2. N/A – Not Applicable
3. CFM/TF – Cubic Feet per Minute per Toilet Fixture

4.8.3.6 Air Distribution System

The air handling units, exhaust fans, return fans, and terminal air systems will supply or exhaust air to the serviced spaces through a ducted distribution network. At this time, it is anticipated that low pressure (± 2 in. water column) ductwork systems will be utilized. Type 316 stainless steel or FRP ductwork will be specified in areas with chemicals, where the potential of corrosion is high. Galvanized steel ductwork will be specified in spaces not directly exposed to corrosive environments.

Exposed ductwork conveying conditioned air will be specified with thermal external insulation to prevent heat loss or gain and condensation. All other supply ductwork will only be insulated near outdoor penetrations or as needed to prevent condensation. All ductwork located outside will be insulated and field jacketed for protection.

Exhaust and return ducts will not be insulated unless they carry high temperature gases or have a lower temperature than the ambient. The location of air inlets and outlets will be studied for each space to provide for adequate air circulation and contaminants removal.

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4.8.3.7 Gas Distribution System

A low pressure (up to 2 pounds per square inch gauge (psig)) natural gas distribution network will be designed and specified for each facility if gas is available. Natural gas will be provided from a connection to a municipal gas main at the street, and it will be specified with a main regulator and meter. When medium gas pressure is not available from the municipality at the facility location, gas pressure boosters will be specified to increase pressure and maintain proper operation of heating and HVAC equipment. Gas piping connections at each equipment will have its own pressure regulator and shut-off valve for ease of maintenance. Above grade gas piping will be specified to be of black steel pipe construction. When underground installation is required the piping will be protected, buried, and identified.

4.8.3.8 Control System

The HVAC control system will be a direct digital control system with local temperature control panels (TCP) for monitoring and control and supervised by the plant's SCADA system. The direct digital control system will be able to operate under BACNet or LonWorks communication protocols and will be provided with data acquisition and storage for trend log analysis and HVAC equipment troubleshooting.

Major HVAC equipment, such as air handling units, dehumidification units, and roof top units, will have built-on control panels provided by their manufacturer. These systems will be provided with the manufacturer recommended sensors to perform the design sequence of operation as stand-alone systems. Small HVAC equipment, such as supply fans, exhaust fans, and dampers, will be interlocked with field provided sensors and controllers to achieve the sequence of operation. Additionally, all systems requiring smoke detection will have sensing devices hard-wired interlocked with the main fire alarm panel.

The local TCP will receive signals from all controlled devices to provide for sequencing of operations performed per design documents and will report alarms and system failures to the SCADA system. The SCADA system will not have control capability over the HVAC system, only alarm monitoring.

4.8.4 Plumbing System Design

4.8.4.1 Domestic Water System

Domestic water lines will be provided to new facilities from a connection to the main municipal line where available. The new domestic water lines will include shut off valves and a water meter. Storage type high-efficiency condensing gas-fired water heaters will store water at 150 °F. The domestic hot water distribution temperature will be set at 120 °F for common plumbing fixtures. For emergency eyewash and showers stations, tempered water at about 80 °F will be provided with a thermostatic mixing valve.

Potable water will be provided to all plumbing fixtures, plumbing equipment, internal and exterior hose bibs, and emergency eyewash/showers. Internal hose bibs will be provided in spaces requiring wash down including backflow preventers. Exterior hose bibs (wall hydrants) will be provided for maintenance of landscaped areas around the building and where required to clean outdoor mechanical equipment. Exterior hose bibs will be provided with frost protection and backflow preventers. Domestic hot and cold water distribution piping will be copper and will be insulated to prevent heat loss and freezing. Grey water systems are being considered within the Program during design.

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4.8.4.2 Sanitary and Storm Water Systems

Separated sanitary and storm systems will be specified. All sanitary piping will be vented through the roof. Floor drainage will be specified in all spaces where required by code. Sanitary piping will be sloped at a minimum rate of 1/8-inch per foot to produce a cleansing velocity of 2 feet per second. Equipment drains and area drains will be provided and coordinated during design. All floor drains and plumbing fixtures connected to the sanitary drainage system will be provided with traps and vents. Floor drains subject to evaporation will be equipped with trap primers to maintain the water seal. Sanitary and storm piping will be PVC. Vent piping will be PVC. Below grade piping will be hub and spigot and above grade piping will be hubless.

The roof drainage will be provided above critical equipment rooms by scuppers with downspouts to grade and specified under architectural work. In all other locations, roof drain and over-flow roof drains will be provided. Storm drain piping will be PVC, hub and spigot, and sloped per code requirements.

In facilities with basement galleries that require floor drains, an area well with an ejector pump system for drainage evacuation will be included.

4.8.4.3 Plumbing Fixtures

Emergency showers and eyewashes (safety stations) will be provided no farther than 50-feet from hazardous locations. Low-flow plumbing fixtures will be specified to reduce water consumption. Water closets and urinals will be specified with manual valves including low/high flush options, and lavatories will be specified with powered proximity sensors with automatic mixing valves.

4.8.5 Fire Protection Systems

If a fire suppression system is required by code due to the size of the facility or processes within the facility (i.e. chemical storage and addition), the fire protection system will be in compliance with the Wisconsin Fire Prevention code, NFPA 820, and all other applicable NFPA codes to provide a safe and reliable design. A new combined water main for domestic and fire prevention will be required. Depending on the classification of the space, the facility would need a wet pipe fire suppression system, fire extinguisher cabinets, or a combination of both. Where required by NFPA, the wet system would either be a sprinkler system and/or a stand-pipe system. Fire sprinkler systems will be specified with the required control devices and double check detector valve assembly for backflow prevention.

All fire protection devices including sprinklers, automatic valves, smoke and fire detectors will be monitored by the fire alarm panel which will be specified under Electrical work. The fire alarm panel, test header, outside electric bell and the Siamese connection will be specified in compliance with the local Fire Prevention Code.

4.8.5.1 Fire Pump Requirement

Each individual facility will be evaluated to determine the need for a fire pump based on the city water reported pressure and the minimum pressure required per NFPA 13 and 14 at the furthest sprinkler head or hose.

4.8.6 System Efficiency

The HVAC and plumbing systems will be designed to optimize Envision credits. Heating and ventilation systems will be designed according to the TBL approach. This approach considers WWU's preferences when selecting design

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alternatives while giving a basis for why certain systems are incorporated into the design. The alternatives included in the TBL analysis are designs that potentially benefit the Program's Envision certification goal. The TBL analysis determined that gas or electric heating will be used, rather than using a condensing boiler system.

4.8.7 Reduced Energy Consumption

Energy consumption will be evaluated against a baseline design, using parameters set be the International Building Code and the International Energy Conservation Code. A reduction in energy consumption directly correlates to a reduction in operational expenses as well as a reduction in GHG.

4.8.8 Flood Alleviation

The HVAC, plumbing, and fire protection equipment will be located in areas to protect from flooding.

4.9 Instrumentation and Controls

This section describes the design criteria for the instrumentation and process control systems and the safety and security systems of the Program's facilities. To meet WWU's sustainability goals, independent commissioning will be pursued on energy-consuming systems and the program-wide SCADA systems. To the greatest extent practical, SCADA and building-systems controls will include logging and trending capabilities to facilitate long-term analysis of energy use and ensure continued performance within energy conservation goals.

The process controls described in this section are general in nature, with specific equipment design criteria defined in Program Element specific sections. Applicable codes and standards are listed Section 4.1.

4.9.1 General Design Principles

The design of the instrumentation and controls systems will be guided by the general design principles in the following subsections.

4.9.1.1 Reliability

The control systems will be designed to reliably monitor and control the facility equipment with the ability to restore monitoring and control if equipment or communication failures occur. Redundancy will be incorporated to ensure that the failure of a single component will not lead to a failure of the system.

4.9.1.2 Durability

The process control system will be based on implementation of latest electronic technology. The equipment will be designed to provide a reliable, redundant system at the time of installation. Since the life of electronic components varies based on environmental conditions, the instrumentation and process control equipment will be installed, where possible, in dedicated electrical rooms which will be heated, air conditioned, and filtered for corrosive air substances. This will help to extend equipment operating life and lower equipment maintenance and servicing costs.

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4.9.1.3 Operation and Maintainability

The control system design will incorporate features to facilitate maintenance and operation activities. Equipment working clearances will meet or exceed requirements of the NEC and other applicable standards. Sufficient space will be provided around equipment to allow for repair or replacement of critical components without disruption to other critical equipment of the system. Design will allow many maintenance activities to be safely performed without requiring a full outage, thus encouraging regular maintenance and enhancing service life and availability.

4.9.2 System Control and Monitoring

4.9.2.1 General Requirements

The system design will be integrated, programmable logic control system which responds to local and remote set-point commands and mode selection. Unless noted otherwise, operation of equipment will be remote via PLCs. The control system will be designed, programmed, and installed in order to accomplish control of equipment on-site in a safe and efficient manner.

The PLCs will be networked to share information in multiple locations and provide interface through the human-machine interface (HMI) system to allow monitoring and control. The system data will be provided to the WWU data historian, a database software application that logs time-based process data, for retrieval and reporting. The need to modify the capacity of the data historian will be determined during design. To maintain compatibility with existing control systems, new PLCs will be Allen Bradley MicroLogix.

Control systems will be designed to be fail-safe. Upon loss of control signal or control or motive power, the control system and devices will fail to the position that prevents or minimizes the likelihood for equipment damage or personnel injury.

4.9.2.2 Control Philosophy

Under normal operating conditions, PLCs will be the primary means of control. The PLCs will implement analog and digital logic functions to bring all automatically operated equipment from startup to the desired operating conditions, and back to complete shutdown. They will also include all interlock and control functions to sustain any postulated transient condition.

The PLC will provide the control of the equipment and the operator interface will be through the HMI software. The HMI is a graphical computer interface to accept operator commands and display real time process status information. The HMI receives its data from each of the network PLCs.

The operator will have the capability to intercept the auto mode and to control manually (subject to safety and protection constraints). Primary operator interface will be provided through displays on consoles and local panel displays located near the equipment.

Redundant components, such as pumps, will have a standby mode included in the control logic. The selection of the lead or standby equipment will be done by the PLC. If the redundant equipment is in the standby mode when the operating equipment is tripped, or a process parameter or equipment status indicates that the operating equipment has failed, the standby equipment will start automatically. An alarm will alert operators that the standby equipment has started.

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4.9.2.3 Control Functions

The primary purpose of the PLCs will be to maintain control over system processes. The objective will be to obtain maximum efficiency, longest equipment life, and minimum environmental effects while meeting applicable national and industrial safety codes.

The response time of the control actions will be sufficient to maintain control over the process under all operating scenarios. This response time will include consideration of delay and dead times, both internal and external to the PLCs, and will be selected based on the process requirements. Generally, the PLCs will scan and process all control functions within one second and can be adjusted to less time, if required.

The control system will alarm upon a loss of valid data and transfer the corresponding closed loop control from auto to manual control.

4.9.2.4 Safety and Protection Functions

Protective functions will be designed to prevent failure to trip and false trips. Protective actions may be initiated based on unsafe pressure detection, unsafe level detection, or operator intervention through the HMI. The applicable safety codes governing each process system/equipment will be followed.

The system and process sensors will be provided with sufficient redundancy such that the testing, failure or loss of a single component will not cause a protective function to be disabled. Triple redundant switches/transmitters will be provided for critical trips. Certain equipment trips, such as pump vibration or winding temperature, and noncritical equipment trips, single or dual redundant switches/transmitters will be used.

4.9.2.5 General Equipment Control Philosophy

Control of equipment will include manual control for maintenance, emergency, or abnormal conditions and remote manual or automatic control from PLC/SCADA for normal conditions. Manual control will also be available for startup and testing.

4.9.2.5.1 Local Control

All equipment will have local manual control capabilities at or near the equipment for emergency or abnormal operation, maintenance, and testing. When the Local-Off-Remote selector switch is in the local position, the local manual control will be enabled, and the remote control from the PLC/SCADA will be disabled. Local manual controls will also include hardwired interlocks for personnel safety and equipment protection from unsafe conditions, such as motor overloads. In general, control interlocks with other equipment will not be provided in the LOCAL mode. However, equipment protection and personnel safety interlocks will be provided in the LOCAL mode.

4.9.2.5.2 Off Mode

When the Local-Off-Remote switch is in the off position, the equipment will not be capable of running.

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4.9.2.5.3 Remote Control

When the Local-Off-Remote switch is in the Remote position, the process or equipment is controlled from the PLC/SCADA and manual local controls, except the emergency stop function, are disabled. The PLC will control the equipment in either a PLC Manual or PLC Auto mode as follows:

- PLC Manual: Operator will be able to issue start/stop or open/close commands and/or adjust the capacity of equipment manually through the operator interface terminal (OIT) at the PLC Panel or from any SCADA operator workstation.
- PLC Auto: The automatic control strategy will be executed in the PLC which controls the equipment automatically based on sequence interlocks for start/stop function and operator entered setpoints for variables such as pump speed, flow, or level. Startup and shutdown will be automatic for interlocked equipment.

4.9.3 Control System

4.9.3.1 System Architecture

Each process control facility will have at least one PLC processor networked into the SCADA system, and each facility will have spare pre-programmed PLC for fast switch out backup. Each processor will be single (non-redundant) application. Monitoring locations (no control required) may be provided with networked remote input/output (RIO).

The PLCs will be designed to maintain a high degree of availability, supported by fault tolerant system architectures. The redundancy scheme for systems, if applicable and implemented, will be such that no single component failure, except for non-redundant input/output (I/O) devices (PLC hardware and field devices), will cause a failure or interruption of control and monitoring functions.

The PLCs will be designed such that failure of non-redundant I/O devices will not cause damage to the equipment, and control logic would start backup systems or revert to alternate control strategies wherever possible to minimize operational upset. Similar measurements or outputs connected with similar process equipment units will be partitioned on separate I/O modules. Partitioning will be such that one module or card failure will affect only one part of a redundant system.

Local vendor-supplied unit control panels (UCPs) will be data linked through the ethernet network to the corresponding PLC and integrated into the SCADA system. Critical signals will be hardwired to the corresponding PLCs.

4.9.3.2 Human-Machine Interface

Operator interface with controls will be accomplished via HMI. The same SCADA will be utilized for main communication and control between the WWU PLC and the BPS PLC. Limited information will be shared between the BPS PLC and the Water Supply Pumping Station (WSPS) PLC and between the CWP PLC and the WWU PLC.

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4.9.3.3 Communications Network

The data highway will be star topology to connect to the PLC controllers, I/O servers, HMIs, third party equipment datalink interfaces, and data historian. The maximum cable length will be 300 feet for a copper cable and 6,000 feet for multimode fiber optic cables.

The I/O Ethernet network will be connected as star topology and will be independent from the PLC/HMI network. Long distance communication via wireless radio transmission will be considered where fiber optic connection is not feasible.

4.9.3.3.1 Fiber Optic Cables

Fiber optic cable use will be governed by the following criteria:

1. Multimode unless distance requires single mode
2. ST connectors will be specified
3. Run fiber optic cables wherever communication signals run outside of buildings or within a building if electrical interference is a concern
4. Fiber optic cables routed in cable trays will be run in inner duct
5. Fiber optic patch panels located or mounted with all fibers terminated available for use
6. Pre-terminated fiber optic patch cords will be used for jumpering and connecting end devices to the fiber optic patch panels
7. Fiber optic cables run outside of buildings to be a minimum of 12 strands

4.9.3.3.2 Signal Cables

Digital control signals will use, at a minimum, #14 cable. Analog control signals will use, at a minimum, 2-conductor #16 shielded cable and cables for Ethernet communication will be CAT 6.

4.9.3.4 Conduit

Each copper and fiber optic data highway cable will be routed in a separate cable raceway or conduit. Refer to the Electrical subsection for specific information regarding conduit design.

4.9.3.5 System Security

Each facility will include security measures, including access control. Video monitoring systems will be included for some facilities as determined during design. Building security will be provided through use of lockable doors and key card access. Intrusion detection equipment, including door switches and digital video cameras will be furnished to allow real time monitoring and alarming at remote locations. All networking equipment will be located in either key lockable rooms or locked enclosures for added protection.

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4.9.3.6 Power Supply Considerations

The PLCs will include all power supply conditioning necessary to accommodate normal variations in electrical supply to the systems. Redundant power supplies will be provided with PLC processor cabinets.

Each PLC cabinet will accept 120 VAC power feeds. Where redundant power feeds are utilized, the PLC system will auctioneer power feeds to guard against a loss in the primary power supply. As a minimum, one of the power feeds will be from the uninterruptable power supply (UPS) source.

Each power feed and each power supply utilized for control will be monitored in the PLC and PLC RIO panels. Convenience outlets and cabinet lighting will be powered from 120 VAC feeds independent of the control and PLC power feeds. Convenience outlet and lighting power feeds will not be monitored in the PLC RIO panel.

4.9.3.7 Control Locations and Panels

Control panels located outdoors will be NEMA 4X stainless steel, with no front of panel devices. All control elements will be located inside the panel behind a dead front cover. Control panels located indoors will be standard cabinets which will be free standing, rated NEMA 12, with front of panel devices, and front access. Where room air conditioning is not available, enclosures with louvers, forced ventilation, or air conditioners will be furnished as required to prevent temperature build-up to protect equipment.

For security, enclosures will have hinges inside, and will use recessed or flush mount locks to reduce the risk of tampering or damage.

Control panels may be equipped with status indication lights, and RESET pushbuttons to reset hardwired lockout functions related to equipment protection, personnel safety, and emergency stop control. These cabinets will have removable doors with handles, and will contain Ethernet communication modules, I/O modules, and power supplies. The PLC I/O field cables will be wired to prefabricated interface wiring modules. In process areas and outdoors cable entry will be through the bottom of the cabinet. Fuse holders will be supplied with blown fuse indication. Convenience receptacles will be provided in all PLC panels.

The as-shipped control systems will have a predetermined percent spare wired I/O provided for each I/O type and a predetermined percent spare slots and unwired terminations space in each I/O cabinet. Actual percentages to be determined.

4.9.3.8 Input/Output

120-Volt AC digital signals will be partitioned together and in separate panels, where possible, depending on signal quantities. I/Os will be segregated so that 24-Volt DC signals will be routed away from 120-Volt AC signals, in separate enclosures if possible, with signs mounted on panel to mark 120-Volt AC areas.

Analog and digital I/O card types will be standardized. Analog signals will be wired to fused terminal blocks. The use of universal transient barriers to protect analog signals from surges and transients will be specified accordingly during design.

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4.9.3.9 Logic

The PLC will perform all logic for calculations and alarm triggers.

4.9.3.10 Data Historian

A data historian software will be used to record trends and historical information for future reference. The data historian package will be procured and integrated into the PLC network and will be hosted on an independent server from the HMI application. Inputs, outputs, PLC calculated values, events, and alarms will be routed to the Historian.

The data historian system will allow information from multiple inputs (both analog and digital) to be retained for a predetermined amount of time onto a server. A report generator will be available for critical facility data and all required environmental reporting.

The data historian will allow data to be retrieved and manipulated for technical reports and troubleshooting. Access to modifying information will be limited to authorized personnel.

The data historian will have a minimum predetermined percentage of spare points available. Storage capacity will be sized to provide a minimum of predetermined amount of years of archived data. This information will be stored in a manner that it can be retrieved in an orderly fashion by authorized personnel and copied as a database for use. This information will be accessible on-site and off-site, by authorized personnel.

4.9.3.11 Instrumentation

Analog output signals from field instrumentation, except resistance temperature detectors (RTDs), to the control systems will be 4-20 mA DC signals. Instrumentation will be either field powered or loop powered from the control system. Field powered analog signals will be true “isolated from ground” signals.

All instruments and analyzers will employ noise protection in the system design. Instrument tags will be permanently attached to the devices. If this is not possible, the instrument tag will be fastened to the instrument with stainless steel wire. The wired instrument tag will be supplied as 3/4 inch by 3 inch, stainless steel tags. Tag thickness will be 1/16 of an inch and stamped with instrument tag number. Tag number characters will be 3/8 inch in height. Instrument tags will match facility standards.

Instrumentation located in a hazardous area will be rated for the hazard classification associated with the area. Instrumentation or instrument tubing located outside that is subject to malfunction due to freezing will be heat traced and insulated. Process instrumentation will vary by process area as shown in Table 4-13.

4.9.4 Project Operational Philosophy

The water supply and return flow system for the Program will consist of several process areas and will include three (3) separate stakeholders associated with the control and monitoring functions of the overall system. The stakeholders will include WWU, CWP, and the MWW who will exchange operational data accordingly to ensure the overall operation of the Program.

The process systems are described in detail in Program Element specific sections of this PDR.

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Table 4-13 Process Instrumentation by Area

Measurement	Type	Technology	Application
Liquid Flow	Transmitter	Magnetic Flow Meter, Venturi Meter	System Flow
Liquid Level	Transducer	Submersible Pressure Transducer	Tank or Reservoir Level Wet Well Level Chemical Tank Level
Liquid Pressure	Transmitter	Pressure Transmitter	Pump Suction and Discharge Pressure
Liquid Pressure	Gauge	Pressure Gauge	Pump Suction and Discharge Pressure
Liquid Low Pressure	Switch	Pressure Switch	Pump Seal Water Line Pressure
Liquid Level	Switch	Float	Tank/Reservoir High Level Alarm
Temperature	Transmitter	Transmitter w/ integral RTD	Room or enclosure Temperature
Valve Open/Closed Status	Switch	Limit Switch	Valve Position
Pump/Motor Temperature	Sensors	RTD	Pump Bearing, Motor Winding and Bearing
Pump/Motor Vibration	Sensors	Accelerometer	Motor Winding and Bearing
Chlorine	Analyzer	Amperometric	Chlorine Residual
Low Vacuum (*)	Switch	Vacuum Switch	Vacuum Pump Low Vacuum
Liquid Level (*)	Switch	Probe	Vacuum Break Tank High Water
Smoke Detection	Switch	-	Smoke Detection

Notes:
* Required if vacuum priming system provided

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SECTION 5 Existing Facilities

5.1 General

Waukesha Water Utility's (WWU's) distribution system is comprised of groundwater supply, treatment, ground level reservoirs (reservoirs), elevated storage tanks (towers) and conveyance assets. The drinking water that supplies this system is drawn from ten deep and shallow groundwater aquifer supply wells. This groundwater is treated at the individual well facilities or at the Saylesville Water Treatment Plant before entering the distribution system. All treated groundwater except Well 3 is pumped to WWU's 12 reservoirs and towers. Well 3 is treated and pumped directly into WWU's distribution system.

Waukesha Water Utility's (WWU's) distribution system is comprised of groundwater supply, treatment, ground level reservoirs (reservoirs), elevated storage tanks (towers), and conveyance assets. The WWU distribution system includes approximately 326 miles of water mains across ten pressure zones throughout the City of Waukesha (Waukesha) and limited outlying areas. A system of booster pumping stations and pressure reducing valve (PRV) stations maintain system pressure to provide a reliable water supply across WWU's service area. The boundary of WWU's service area as approved under the Great Lakes-St. Lawrence River Basin Water Resources Compact (Compact) is shown in Figure 5-1.

The drinking water that supplies this system is drawn from ten deep and shallow groundwater aquifer supply wells. Three deep wells are treated with hydrous manganese oxide (HMO) to gain compliance for radionuclides. One of these deep wells, Well 3, pumps directly to the distribution system following treatment. Another of these deep wells, Well 10, following treatment is pumped directly in the Hillcrest reservoir via a dedicated transmission main. The last of these three wells, Well 8, following treatment is pumped into the ground storage facility on Saylesville. Two shallow wells, Well 11 and Well 12, also pump to the treatment plant at Well 8 and then into the same reservoir. Well 13, the last of the shallow wells, is pumped into a reservoir that is integrated into its wellhouse. The other wells, all deep wells, are non-compliant for radionuclides. All of the non-compliant wells, when used, pump to reservoirs at their locations with the exception of Well 7, which pumps directly into the system.

The most recent evaluation of WWU's distribution facilities was completed in 2012. Since the completion of that evaluation, the following larger diameter infrastructure improvement projects have been completed:

- Installation of the 24-inch water main on Les Paul Parkway from Dolphin Court to Sunset Drive that partially replaced an existing 16-inch main.
- Installation of a 24-inch water main from Wisconsin Avenue, across the Fox River, to connect to the 20-inch main on Mountain Avenue.
- Installation of a 16-inch water main on East Avenue from College Avenue to Sunset Drive.
- Installation of a 16-inch water main on Moreland Boulevard from Madison Street to Michigan Avenue.

Southeastern Wisconsin Regional Planning Commission (SEWRPC) defined the planning area for the Waukesha sanitary sewer collection system as all of Waukesha, the Town of Waukesha, as well as parts of Brookfield, New Berlin, Muskego, Pewaukee, Delafield, Genesee, Mukwonago, Wales and Vernon. The wastewater is conveyed to Waukesha's Clean Water Plant (CWP) where it undergoes preliminary, primary, secondary, and tertiary treatment before being discharged to the Fox River.

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5.2 Water Supply and Distribution

WWU's water supply and distribution system is regulated by the drinking water and groundwater quality standards/advisory levels established by the Wisconsin Department of Natural Resources (WDNR) and United States Environmental Protection Agency (USEPA), Safe Drinking Water Act (SDWA). These standards can be found in Appendix B under Table B-1 Drinking Water and Groundwater Quality Standards/Advisory Levels, Table B-2 Drinking Water and Groundwater Quality Public Welfare/Secondary Standards, Table B-3 National Primary Drinking Water Regulations and Table B-4 National Secondary Drinking Water Regulations. The water supply source for Waukesha is treated groundwater from deep and shallow aquifer supply wells constructed to depths up to 2,100 feet below grade. The groundwater is disinfected with sodium hypochlorite, which is used to create free chlorine residual. WWU monitors and controls the distribution system using supervisory control and data acquisition (SCADA). This allows WWU staff to control equipment and monitor remote stations across the distribution system. WWU's distribution system consists of water main ranging from 4 inches in diameter up to 24 inches in diameter as shown in Figure 5-1. The locations of the existing facilities are shown in Figure 5-2.

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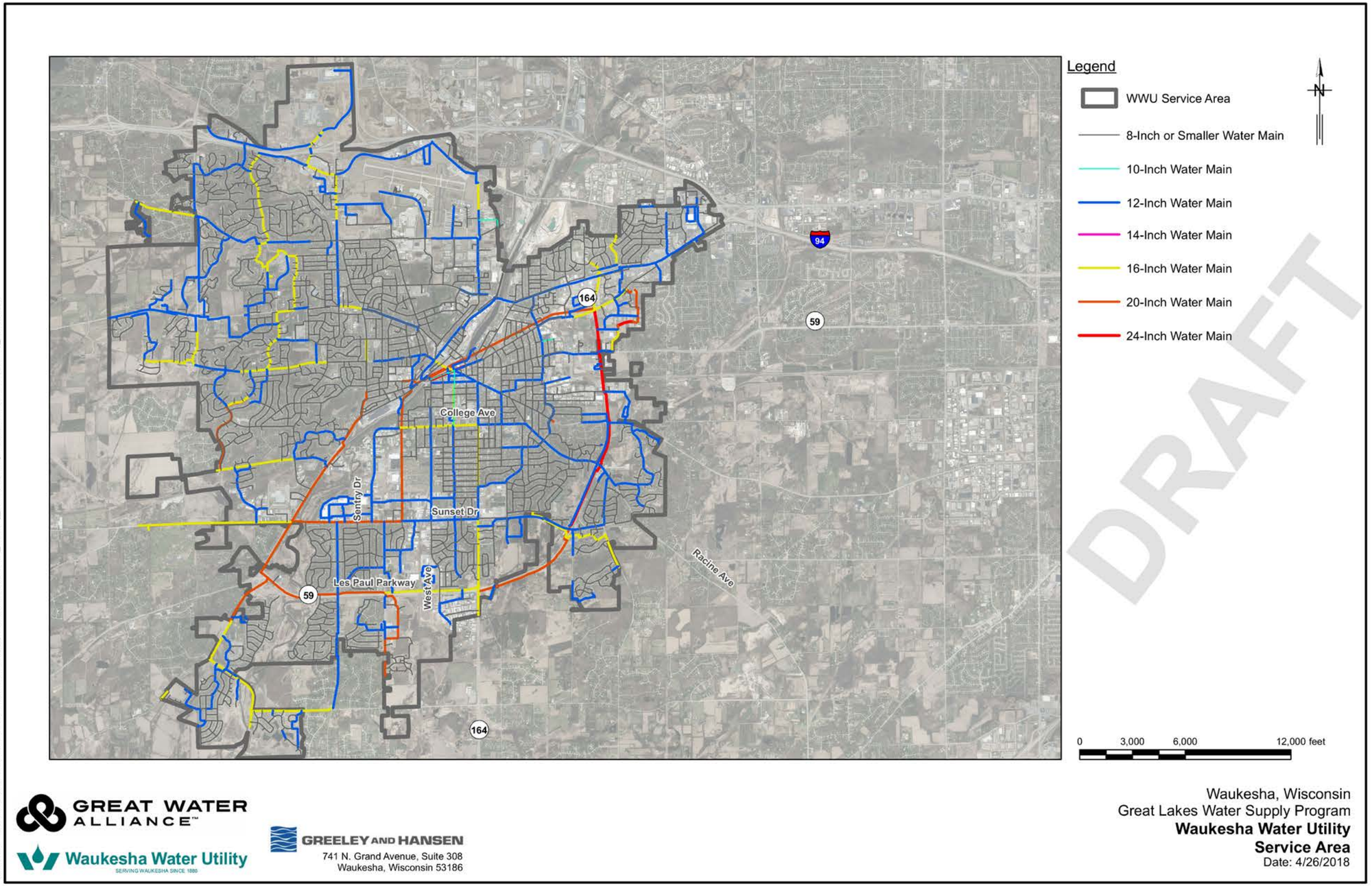

Figure 5-1 Waukesha Water Utility Service Area

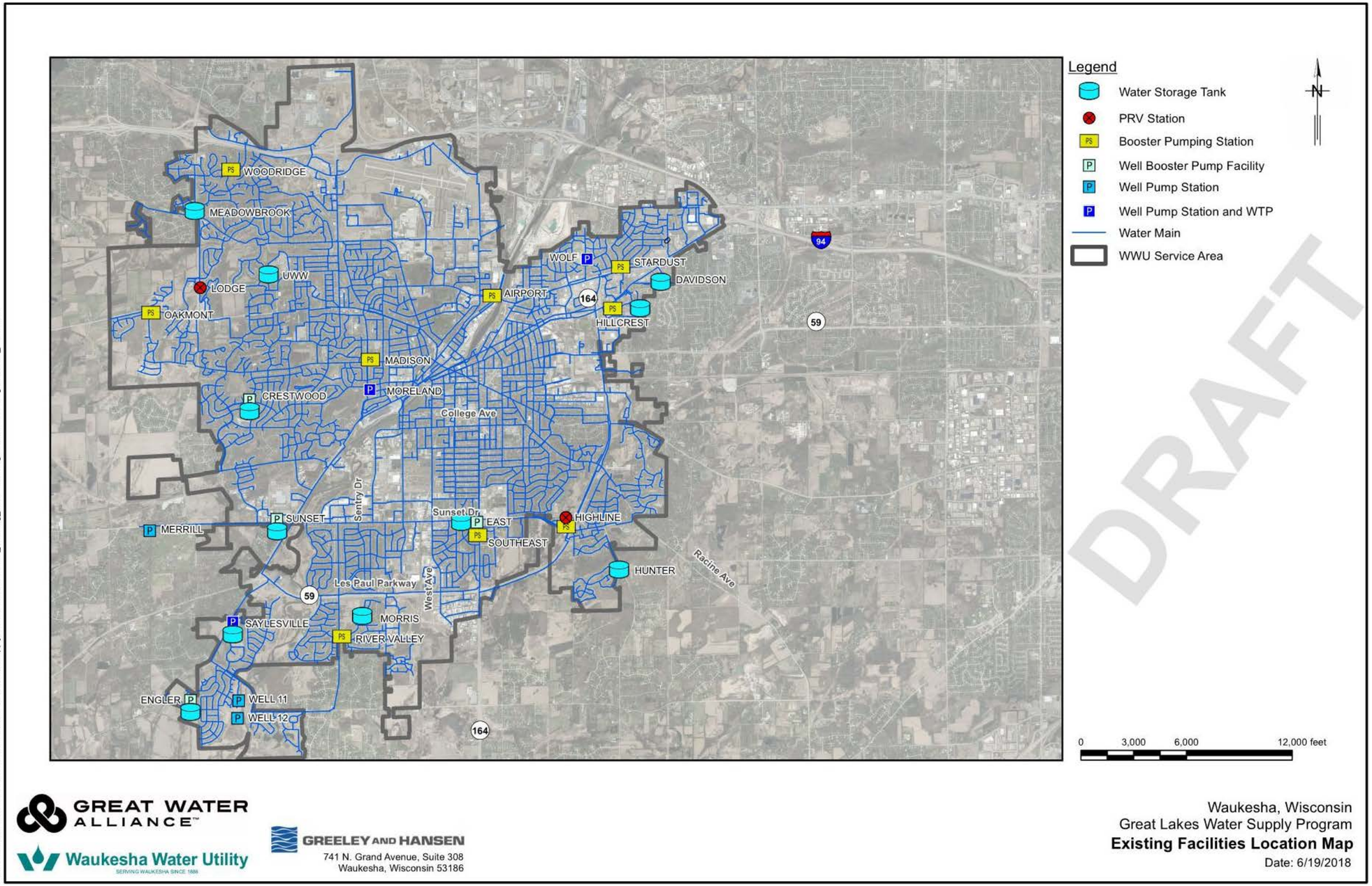

Figure 5-2 Existing Facilities Location Map

A schematic diagram detailing the operations of the equipment and facilities utilized by WWU is provided in Figure 5-3.

The distribution system is divided into ten pressure zones, to maintain adequate pressure throughout the distribution system and provide effective storage within each zone. The effective storage is the volume of water above the lowest operating water level in a given reservoir or tower. The total storage for each pressure zone is the sum of the effective storage volumes of all reservoirs and towers located within the pressure zone.

The existing pressure zones and respective total storage volumes are provided in Table 5-1. The extents of the pressure zones are displayed in Figure 5-4.

Table 5-1 Pressure Zones and Storage

Pressure Zone	Total Storage (MG)
Central(1)	11.5
South Central	0.1
Southeast	0.4
Reduced Southeast(2)	0.0
Northeast	0.3
Hillcrest(2)	0.0
Northwest	1.0
Reduced Northwest(2)	0.0
Oakmont(2)	0.0
Pebble Valley	0.3

Notes:
1 Storage in Central Zone is from facilities at Engler, Saylesville, Sunset, East, Baxter, and Hillcrest.
2 There is no storage due to low demand and the small area of the pressure zone.
3 Hillcrest has two hydro pneumatic tanks for onsite storage

Well 1 was abandoned in 2004, Well 2 was temporarily abandoned and the well pump was removed in 2012, and Well 4 is temporarily abandoned with no pumps inside. Five of the supply well facilities contain booster pumps as well as reservoirs (well booster pump facilities), and one supply well facility contains booster pumps, a ground-level reservoir, and a water treatment plant (WTP). Details about the supply well facilities are provided in Table 5-2.

WWU utilizes booster pumping stations in addition to booster pumps within the supply well facilities to maintain levels in towers and reservoirs, as well as maintain system pressures throughout the pressure zones. Information about the booster pumping stations is provided in Table 5-3.

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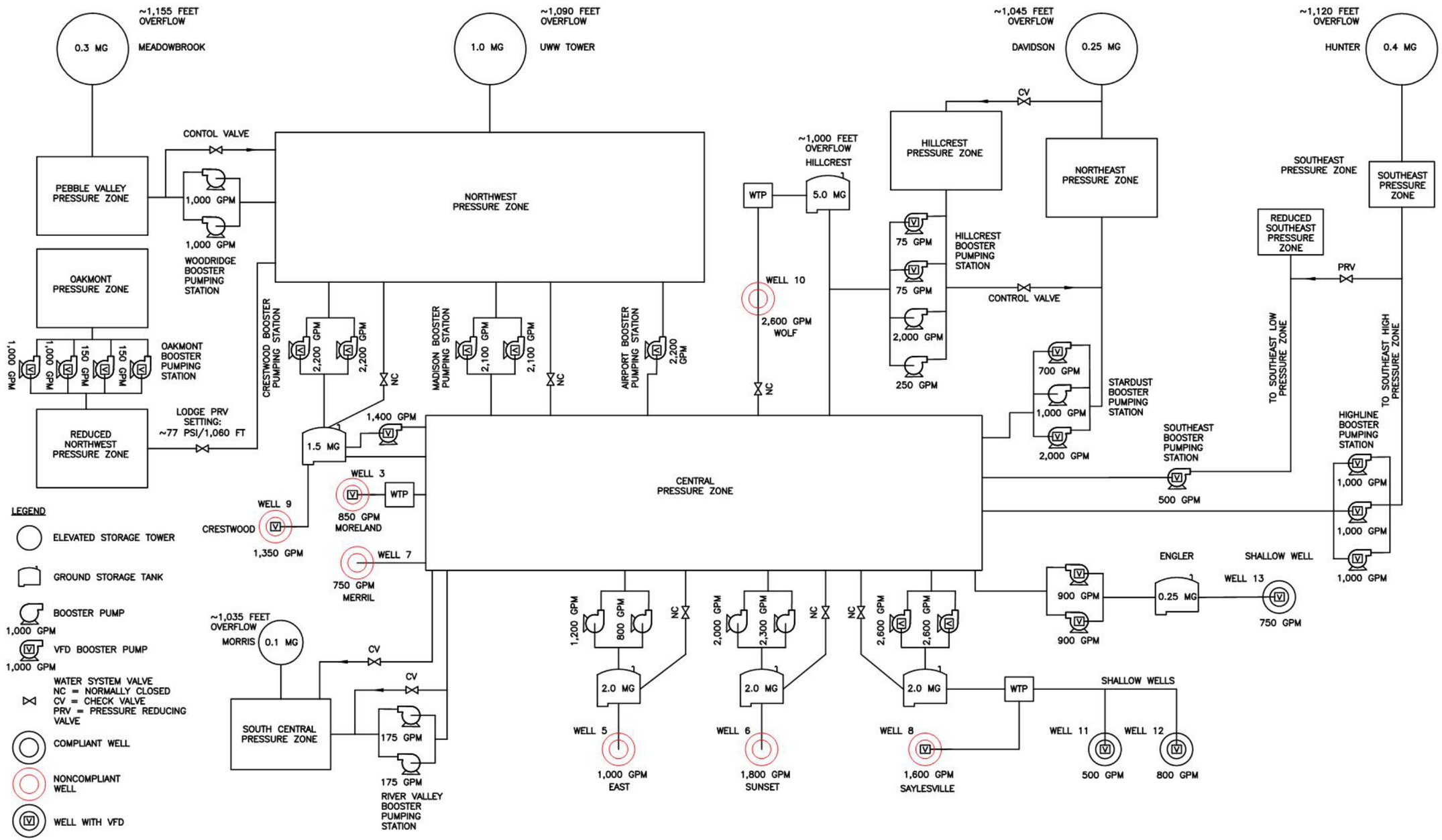
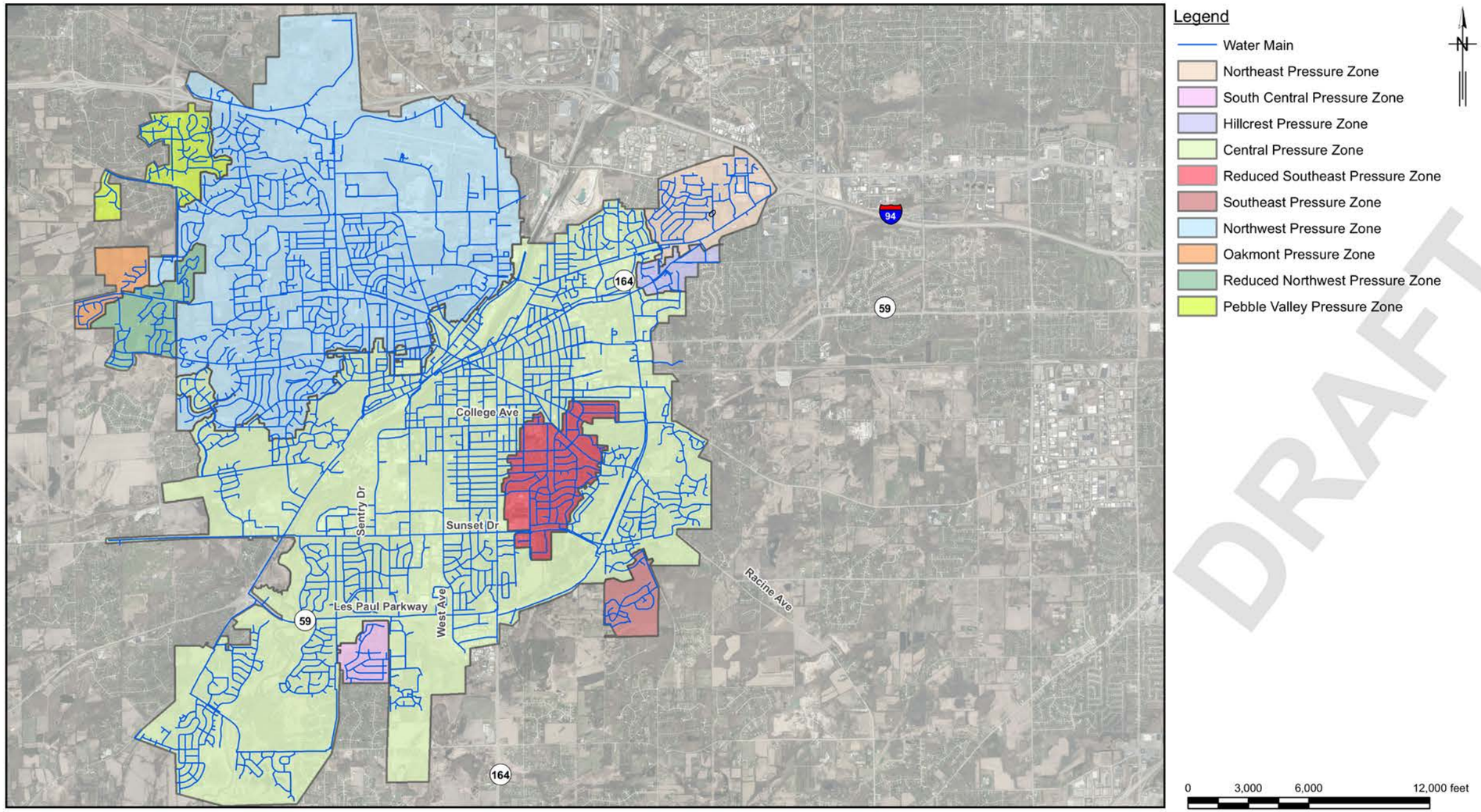


Figure 5-3 Facilities Operations Schematic Diagram



GREAT WATER ALLIANCE
Waukesha Water Utility
GREELEY AND HANSEN
741 N. Grand Avenue, Suite 308
Waukesha, Wisconsin 53186

Waukesha, Wisconsin
Great Lakes Water Supply Program
Pressure Zone Extents Map
Date: 4/26/2018

Plotted: 4/26/2018
Document Path: G:\15310-Waukesha Great Lakes Water Supply PM-CM\24 GIS\24.05_Working_MXDs\Existing Facilities\Pressure Zones_CDB.mxd

Figure 5-4 Pressure Zones Extents Map

Table 5-2 Supply Well Facilities

Well No.	Facility Name	Location (Pressure Zone)	Year Constructed	Depth (feet)	Specific Capacity (gpm/ft)	Well Output (gpm)	Booster Pumping Station (Y/N)	Ground Level Reservoir (Y/N)	Reservoir Capacity (MG)	Effective Storage (MG)	Pump Function (Well/Booster)	VFD (Y/N)	Pump Type	Manufacturer	Pump HP	Flow (gpm)	Pump TDH (feet)	Operational (Y/N)
Well 1[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Well 2[1]	Baxter	-	1927	1835	-	-	-	-	-	--[4]	-I -	N	-	-	-	-	-	N
Well 3[2]	Moreland	Central	1930	1995	6.5	950	N	N	-	-	Well	Y	Submersible	Goulds	250	850	737	Y
Well 4[1]	Newhall	-	1945	1995	-	-	-	-	-	-	-	-	-	-	-	-	-	N
Well 5[2]	East	Central	1953	14.25	10.3	1091	Y	Y	2.0	0.96	Well	N	Vertical Turbine	Goulds	250	1000	680	Y
											Booster		Horizontal Centrifugal	ITT-AC	40	800	140	Y
											Booster		Horizontal Centrifugal	American	75	1200	180	Y
Well 6[2]	Sunset	Central	1959	15.17	21.8	1984	Y	Y	2.0	1.21[6]	Well	N	Submersible	Byron Jackson	400	1800	600	Y
											Booster		Horizontal Centrifugal	American Marsh	150	2000	185	Y
											Booster		Horizontal Centrifugal	A-C	150	2300	195	Y
Well 7[2]	Merrill	Central	1963	1658	7.4	680	N	N	-	-	Well	N	Submersible	Centrilift	200	750	760	Y
Well 8[2]	Saylesville	Central	1968	28.25	23.4	1650	Y	Y	2.0	1.64[6]	Well	Y	Submersible	Centrilift	350	1600	598	Y
											Booster		Horizontal Centrifugal	Fairbanks Morse	150	2600	167	Y
											Booster		Horizontal Centrifugal	Fairbanks Morse	150	2600	167	Y
Well 9	Crestwood	Northwest	1973	19.00	5.6	1350	Y	Y	1.5	0.96[6]	Well	Y	Submersible	Centrilift	350	1350	761	Y
											Booster		Horizontal Centrifugal	Fairbanks Morse	150	2200	175	Y
											Booster		Horizontal Centrifugal	Fairbanks Morse	150	2200	175	Y
											Booster		Horizontal Centrifugal	Fairbanks Morse	50	1400	86	Y
Well 10[2]	Wolf	Central	1980	2145	17	2800	N	N	-	-	Well	N	Submersible	Centrilift	700	2600	870	Y
Well 11	Well 11	Central	2006	124	3.5	300	N	N	-	-	Well	Y	Submersible	Grundfos	40	500	220	Y
Well 12	Well 12	Central	2006	144	10.8	655	N	N	-	-	Well	Y	Submersible	Grundfos	50	800	200	Y
Well 13[2]	Engler	Central	2008	105	10.7	750	Y	Y	0.25	--[4]	Well	Y	Vertical Turbine	Goulds	30	750	97	Y
											Booster		Horizontal Centrifugal	Fairbanks Morse	100	900	220	Y
											Booster		Horizontal Centrifugal	Fairbanks Morse	100	900	220	Y

Notes:
TDH = Total Dynamic Head
1. Well is temporarily abandoned.
2. Chlorine, fluoride, and silicate addition at facility. At Wells 6 and 7 chemicals are added, but not on a regular basis.
3. Effective Storage information not provided.
4. Effective storage of reservoir based on a water depth of 7-feet.
5. Effective storage of reservoir based on a water depth of 6-feet.

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Table 5-3 Booster Pumping Stations

Booster Station ID	Pumps From (Pressure Zone)	Pumps To (Pressure Zone)	No. of Pumps	VFD (Y/N)	Pump Type	Manufacturer	Horsepower	Flow (gpm)	Pump TDH (feet)
Airport Booster Station	Central	Northwest	1	Y	Horizontal Centrifugal	American Marsh	125	2200	193
Madison Booster Station	Central	Northwest	2	Y	Vertical Centrifugal	Aurora	125	2100	178
					Vertical Centrifugal	Aurora	125	2100	178
Woodridge Booster Station	Northwest	Pebble Valley	2	N	Horizontal Centrifugal	Weinman	40	1000	120
					Horizontal Centrifugal	Weinman	40	1000	120
Oakmont Booster Station	Reduced Northwest	Oakmont	4	Y	Horizontal Centrifugal	Aurora	7.5	150	100
					Horizontal Centrifugal	Aurora	7.5	150	100
					Horizontal Centrifugal	Aurora	40	1000	122
					Horizontal Centrifugal	Aurora	40	1000	122
River Valley Booster Station	Central	South Central	2	N	Horizontal Centrifugal	Aurora	5	175	54
					Horizontal Centrifugal	Aurora	5	175	34
Hillcrest Booster Station	Central	Hillcrest/ Northwest	4	Y- Pumps 1 & 2 N- Pumps 3 & 4	Variable Speed	Grundfos	15	75	175
					Variable Speed	Grundofs	15	75	175
					Horizontal Centrifugal	Aurora	75	2000	114
					Horizontal Centrifugal	Aurora	15	250	148
Stardust Booster Station	Central	Northeast	3	Y- Pumps 1 & 3 N- Pump 2	Horizontal Centrifugal	Aurora	15	700	60
					Horizontal Centrifugal	Aurora	30	1000	90
					Horizontal Centrifugal	Aurora	60	2000	80
Southeast Booster Station	Central	Southeast	1	Y	Vertical Centrifugal	A-C	40	500	125
Highline Booster Station	Central	Southeast	3	Y	Horizontal Centrifugal	Peerless	50	1000	135
					Horizontal Centrifugal	Peerless	50	1000	135
					Horizontal Centrifugal	Peerless	50	1000	135

Notes:
TDH = Total Dynamic Head
VFD = Variable Frequency Drive

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In addition to the six reservoirs at the supply well facilities described in Table 5-2, WWU utilizes Hillcrest Reservoir and five additional towers. The Hillcrest Reservoir and five towers are described in Table 5-4.

Table 5-4 Standalone Reservoirs and Towers

Storage Unit ID	Storage Unit Type	Year Constructed	Construction Material	Pressure Zone	Diameter (feet)	Head Range (feet)	Overflow Elevation (feet USGS)	Capacity (MG)
Hillcrest Reservoir	Ground Level Reservoir	1978	Pre-stressed Concrete	Central	180	26	1000	5.0
UWW Tower	Elevated Storage Tank	2008	Composite	Northwest	81	30	1090	1.0
Meadowbrook Tower	Elevated Storage Tank	1999	Steel	Pebble Valley	47	32.5	1155	0.3
Morris Tower	Elevated Storage Tank	1998	Steel	South Central	30	27.5	1035	0.1
Davidson Tower	Elevated Storage Tank	1968	Steel	Northeast	43.67	31.3	1045	0.3
Hunter Tower	Elevated Storage Tank	1998	Steel	Southeast	50	37.5	1120	0.4

To maintain lower system pressures within the Reduced Northwest and Reduced Southeast Pressure Zones, WWU's distribution system utilizes two PRV stations. The PRV stations contain PRVs that lower the system pressure at the inlet to pressure zones that require lower system pressures. The PRV stations are described in Table 5-5.

Table 5-5 PRV Stations

PRV Station	No. Valves	Valve Number	Manufacturer	Valve Size (in)	Min. System flow (gpm)	Max. System flow (gpm)	Description
Lodge	3	1	Cal-Val	2.5	2	300	Reduces system pressure from Northwest Pressure Zone to Reduced Northwest Pressure Zone
		2	Cal-Val	12	300	7000	
		3	Cal-Val	1	1	55	

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PRV Station	No. Valves	Valve Number	Manufacturer	Valve Size (in)	Min. System flow (gpm)	Max. System flow (gpm)	Description
Highline	2	1	Cal-Val	8/2	1	3100	Reduces system pressure from Southeast Pressure Zone to Reduced Southeast Pressure Zone
		2	Cal-Val	8/2	1	3100	

5.3 Water Supply Operating Procedures

5.3.1 Central Pressure Zone

The following facilities provide pressure regulation, groundwater supply, storage, and distribution operations within the Central Pressure Zone: Hillcrest Reservoir, Well 3, Well 5, Well 6, Well 7, Well 8, Well 9, Well 10, Well 11, Well 12, and Well 13. Pumping operations within the Central Pressure Zone are controlled by the water level within the Hillcrest Reservoir. The maximum level of Hillcrest Reservoir is 26 feet and the minimum level is 15.6 feet. A low alarm for Hillcrest Reservoir is activated if the water level falls to 15 feet. Well 3 starts pumping when the water level of Hillcrest Reservoir falls to 22 feet and continues pumping until the water level rises to 25.2 feet. Well 10 starts pumping when the water level of Hillcrest Reservoir falls to 19.5 feet and continues pumping until the water level reaches 25 feet. The system turns one pump on at either Saylesville (Well 8) or Engler (Well 13) if the water level at Hillcrest Reservoir varies more than 0.22 feet in 20 minutes. The booster pumps are controlled based on a rate of gain control feedback loop.

5.3.2 South Central Pressure Zone

The following facilities provide pressure regulation, storage, and distribution operations for the South Central Pressure Zone: Morris Tower, River Valley Booster Pumping Station, and two check valves to the Central Pressure Zone. The booster pumps start pumping when the water level in the Morris Tower falls to 13 feet and stop pumping when the water level in the Morris Tower reaches 21 feet. Pump 1 at the River Valley BPS operates five days a week while Pump 2 operates two days a week. A low-level alarm for Morris Tower is activated if the water level falls to 10 feet. The check valves open when the hydraulic grade line (HGL) in the Central Pressure Zone is greater than in the South Central Pressure Zone. This can occur during certain operational conditions of the River Valley BPS.

5.3.3 Southeast Pressure Zone

The following facilities provide pressure regulation, storage, and distribution operations for the Southeast Pressure Zone: Hunter Tower, Highline BPS, and one pump at the East Booster Pumping Station. The booster pumps start pumping when the water level in the Hunter Tower falls to 27 feet and stop pumping when the water level in Hunter Tower reaches 38 feet. A low-level alarm for Hunter Tower is activated if the water level falls to 20 feet.

5.3.4 Reduced Southeast Pressure Zone

The following facilities provide pressure regulation and distribution operations for the Reduced Southeast Pressure Zone: Hunter Tower, Highline PRV Station, and the East BPS. Operations within the Reduced Southeast Pressure Zone are controlled by the pressure set point in the Highline PRV Station. Head from the Hunter Tower is reduced to a lower level via the Highline PRV station. The Highline PRV Station normally operates between 93 pounds per

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square inch (psi) and 96 psi. The East BPS pump dedicated to the Reduced Southeast Pressure Zone starts pumping when pressure falls to 65 psi at the inlet and stops pumping when the pressure reaches 75 psi. A low-level alarm is activated if pressure in the zone falls to 70 psi.

5.3.5 Northeast Pressure Zone

The following facilities provide pressure regulation, storage, and distribution operations for the Northeast Pressure Zone: Davidson Tower, Stardust BPS, and Hillcrest BPS. The booster pumps start pumping when the water level in Davidson Tower falls to 22 feet and stop pumping when the water level in Davidson Tower reaches 30 feet. Automatic control valves located in the Hillcrest Booster Pumping Station switch the discharge between the Northeast and Hillcrest Pressure Zones, allowing the Hillcrest Booster Pumping Station to supply the Stardust Booster Pumping Station as needed.

5.3.6 Hillcrest Pressure Zone

Pressure regulation and distribution operations within the Hillcrest Pressure Zone are provided by the Hillcrest BPS. The two larger pumps in the Hillcrest BPS are controlled by via pressure in two hydropneumatic tanks, while the two smaller pumps operate on VFD's, with one always running. Automatic control valves switch the discharge between the Northeast and Hillcrest Pressure Zones as needed.

5.3.7 Northwest Pressure Zone

The following facilities provide pressure regulation, storage, and distribution operations for the Northwest Pressure Zone: UWW Tower, Madison BPS, Crestwood BPS, and Airport BPS. The booster pumps start pumping when the water level in the UWW Tower falls to 21 feet and stop pumping when the water level reaches 29.5 feet. The pump running sequence is: Madison BPS, Crestwood BPS, and then Airport BPS with a single pump operating at each facility. A low-level alarm for UWW Tower is activated if the water level falls to 17 feet.

5.3.8 Reduced Northwest Pressure Zone

Pressure regulation operations within the Reduced Northwest Pressure Zone are provided by the Lodge PRV Station. The Lodge PRV Station reduces the pressure at the inlet of the Reduced Northwest Pressure Zone from 90 psi to 75 psi.

5.3.9 Oakmont Pressure Zone

Pressure regulation and distribution operations with the Oakmont Pressure Zone are provided by the Oakmont BPS. Pumping operations within the Oakmont Pressure Zone are controlled by the outlet pressure from the Oakmont BPS. The discharge pressure from the Oakmont BPS is set at 90-91 psi. The pumping sequence for the four pumps in the Oakmont BPS is as follows:

- If the outlet pressure drops to 88 psi, the second booster pump is turned on. If the pumps are able to maintain 90 psi for 5 minutes, the second booster pump is turned off.
- If the outlet pressure drops below 85 psi, the third booster pump (1,000 gpm) is turned on.
- If the outlet pressure drops below 80 psi, the fourth booster pump (1,000 gpm) is turned on.

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5.3.10 Pebble Valley Pressure Zone

The following facilities provide pressure regulation, storage, and distribution operations for the Pebble Valley Pressure Zone: Meadowbrook Tower and Woodridge BPS. The booster pumps start pumping when the water level in the Meadowbrook Tower falls to 10.5 feet and stop pumping when the water level reaches 25.5 feet. A low-level alarm for Meadowbrook Tower is activated if the water level falls to 20 feet.

5.4 Clean Water Plant

5.4.1 Overview

The CWP is owned and operated by Waukesha. The CWP is fed by a network of 260 miles of sanitary sewers and 42 lift stations. The CWP serves residential, industrial, commercial, and public institutions. Rated for an average daily flow of 14 million gallons per day (MGD), the CWP had an average flow of 8 MGD in 2016 with a peak hourly flow of 22 MGD. Raw wastewater undergoes preliminary, primary, secondary, and tertiary treatment. A flow diagram of the CWP treatment processes is presented in Figure 5-5. Treated effluent is discharged to the Fox River, a tributary of the Mississippi Watershed Basin. The original CWP was constructed in 1890. Major upgrades occurred in 1917, 1928, 1947, 1967, 1980, 1991, 2002, and 2015.

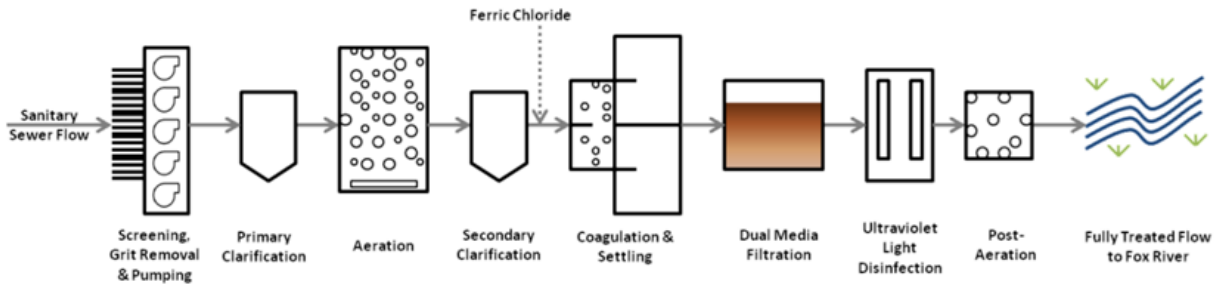

Figure 5-5 Current Flow Diagram of Waukesha's CWP

Preliminary Treatment and Influent Pumping:
Influent wastewater flows through coarse bar screens before passing through two, 1/4-inch continuous belt mechanical fine screens and then through two vortex grit removal tanks. Five primary influent pumps discharge into a distribution box to allow gravity flow to the primary clarifiers.

Primary Treatment:
Four 80-foot square primary clarifiers receive flow from the influent pumps. Solids (primary sludge) are settled and collected in the primary clarifiers and are sent to the anaerobic digesters. Floating materials including oil, grease, and scum are skimmed off the top of the water surface. Effluent from the primary clarifiers is pumped to a splitter box, where it is mixed with return activated sludge (RAS).

Secondary Treatment:
Biological treatment occurs in six parallel activated sludge tanks. Air is provided by 700 horsepower (hp) blowers and fine pore diffusers. The mixed liquor flows by gravity to four 120-foot diameter secondary clarifiers where solids are settled and partially recycled to the activated sludge tanks as RAS.

The wasted sludge is pumped to two dissolved air flotation tanks to be thickened and then pumped along with primary sludge to two 90-foot diameter anaerobic digesters, one 55-foot diameter anaerobic digester, and one egg-shaped anaerobic digester. The digesters are mixed using gas bubble mixers, and the biogas produced is used to sustain a boiler that heats the digesters and three surrounding structures. The digestate is pumped to aboveground liquid storage tanks and dewatered in the Dewatering Building.

Tertiary Treatment:
Secondary effluent from the final clarifiers flows by gravity into coagulation basins where ferric chloride is added for chemical phosphorus settling and removal. Blowers provide mixing as flow enters four mixing basins and exits to rectangular settling basins. Under high flow conditions, secondary effluent can be bypassed directly to disinfection. Flow from these basins flows by gravity to eight dual media filters, where additional suspended solids are removed. This filtered effluent flows to the ultraviolet disinfection system where any remaining pathogens are inactivated during the disinfection season (May through September). The effluent is then aerated to increase dissolved oxygen concentration and discharged to the Fox River.

5.4.2 Permit Summary

The CWP's effluent discharge is regulated by the WDNR as a part of the Wisconsin Pollutant Discharge Elimination System (WPDES) program. Each individual discharger is provided with a permit that specifies concentration limits, load limits, or parameter requirements for pollutants. The permit also sets the requirements for monitoring, special reports, and compliance schedules. The CWP WPDES Permit No. WI-0029971-08-0 will expire June 30, 2018, after which the permit will be renewed for an additional five year period. Table 5-6 summarizes the effluent limits in the current permit.

Table 5-6 Permitted Effluent Limits

Parameter	Limit Type	Limits	Notes
BOD_5 Total	Weekly Average	8.2 mg/L to 10 mg/L	--
Suspended Solids, Total	Weekly Average	10 mg/L	--
pH Field	Daily Maximum Daily Minimum	9.0 SU 6.0 SU	--
Nitrogen, Ammonia (NH_3-N), Total	Monthly Average	2.0 mg/L to 7.0 mg/L	Varies by month
Dissolved Oxygen	Daily Minimum	6.7 mg/L to 7.0 mg/L	--
Phosphorus, Total	Monthly Average	0.7 mg/L	--
Fecal Coliform	Geometric Mean	400#/100 mL	May to September Limit
Chloride	Weekly Average	690 mg/L[1]	--
Metals (various)	Monitoring	--	--
Temperature	Monitoring	--	--

Notes:
1 690 mg/L is the interim chloride discharge limitation. A chloride target value of 440 mg/L is used as the benchmark goal for discharge into the Fox River for 2017.

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SECTION 6 New Water Supply

6.1 Water Supply Source Location

As described in Section 1, Waukesha Water Utility (WWU) will be transitioning from groundwater wells to Lake Michigan water. The City of Milwaukee (Milwaukee) has agreed to supply water via the Milwaukee Water Works (MWW) distribution system to the City of Waukesha (Waukesha).

6.2 Milwaukee Water Works System

The MWW provides potable water to Milwaukee and is sold wholesale to 11 communities that include Village of Brown Deer, Village of Butler, Village of Greendale, Village of Menomonee Falls, City of Mequon, Milwaukee County Grounds, City of New Berlin, Village of Shorewood, Village of Thiensville, City of Wauwatosa, and City of West Allis.

The MWW treats Lake Michigan water at the Linnwood Water Treatment Plant, which has a maximum capacity of 275 million gallons per day (MGD) and the Howard Avenue Water Treatment Plant, which has a maximum capacity 105 MGD. MWW's average daily pumpage was 97 MGD in 2016. Both plants treat water with similar technologies. The typical treatment train is as follows:

- The water is treated with ozone as the primary disinfectant to destroy microorganisms that cause disease, reduce taste and odor compounds and control disinfection byproducts formation.
- Particulate matter is then removed through a series of chemical and physical processes such as coagulation, flocculation, settling, and biologically active filtration.
- After filtration, a liquid form of chlorine is used as a secondary disinfectant. A phosphorous compound is added to control pipe corrosion. Fluoride is also added at this stage.
- Before pumping to the distribution system, MWW adds ammonia to change the free chlorine to chloramine in order to produce a more persistent disinfectant.

Treated water is stored in underground tanks and flows by gravity to pumping stations and then into the distribution system. The distribution system consists of water mains ranging in diameter from 4 inches to 60 inches. Pumping stations maintain pressure in the distribution system. Reservoirs, tanks, and towers are used to store water to meet demand during peak usage.

6.3 Water Supplier Water Quality

The levels detected of regulated contaminants from the 2016 Distribution System Water Quality Report published by the MWW are summarized in Table 6-1. MWW water quality either meets or exceeds all federal and state drinking water health standards.

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Table 6-1 MWW Water Quality Summary

Substance	Highest Level Detected	Highest Level Allowed	Source
Antimony	0.16 µg/L	6 µg/L	Natural deposits
Arsenic	0.5 µg/L	10 µg/L	Natural deposits
Atrazine	0.02 µg/L	3 µg/L	Herbicide
Barium	0.019 mg/L	2 mg/L	Natural deposits
Bromate	7.6 µg/L	10 µg/L	Byproduct of drinking water disinfection
Chlorine, total	2.00 mg/L	4 mg/L	Residual of drinking water disinfection
Chlorite	0.004 mg/L	1.0 mg/L	Byproduct of drinking water disinfection
Copper (2014 Results)	130 µg/L	1,200 µg/L (Action Level)	Corrosion of household plumbing systems
Fluoride	0.69 mg/L	4 mg/L	Natural deposits, water treatment additive
Haloacetic Acids (9), Total	6.4 µg/L	60 µg/L	Byproduct of drinking water disinfection
Lead (2014 Results)	21 µg/L	15 µg/L (Action Level)	Natural deposits and corrosion of household plumbing system
Nitrate, as N	0.70 mg/L	10 mg/L	
Nitrite, as N	0.024 mg/L	1 mg/L	
Radionuclides			Natural deposits
Gross Alpha Particles, excluding Ra + U	3.42±1.99 pCi/L	15 pCi/L	
Gross Alpha Particles	3.6±2.0 pCi/L		
Gross Beta Particles	4.0±1.9 pCi/L	50 pCi/L	
Radium 226	0.20±0.18 pCi/L	5 pCi/L	
Radium 228	1.4±0.7 pCi/L	5 pCi/L	
Radium, combined (226+228)	1.51±0.71 pCi/L	5 pCi/L	
Uranium	<0.0010 mg/L	30 mg/L	
Trihalomethanes, Total	9.1 µg/L	80 µg/L	Byproduct of drinking water disinfection
Turbidity	0.33 NTU 1-day maximum	<0.3 NTU 95% of the time	Natural deposits

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6.4 Water Supplier Pipe Loop Testing

A Pipe Loop Test Plan has been developed to test the impact of Lake Michigan water on WWU's distribution system pipes, water quality, and lead/copper corrosion control program. The Pipe Loop Test Plan and testing are moving forward. Testing will begin in the summer of 2018 and operate for one year, the results of which will help to determine the following:

1. The type and dose of chemicals to be added to drinking water purchased from MWW to maintain water quality for Waukesha customers.
2. The type and dose of chemicals to be added to drinking water purchased from MWW to meet state and federal water quality regulations.
3. The impact of drinking water purchased from MWW on existing pipe scale.

The pipe loop test will evaluate the impact of sodium silicate and phosphoric acid as primary corrosion control chemicals on two types of pipes present in the WWU distribution system:

1. Cast iron pipes, harvested from existing service laterals
2. Copper pipes with lead/tin solder joints, harvested from an existing home

The results of the pipe loop testing will be used to make water chemistry adjustment recommendations that minimize the potential for undesirable water quality within the system when Lake Michigan water is introduced to the WWU distribution system. The recommendations from the pipe loop testing work will not guarantee actual water quality that will be observed in the distribution system, as it is not possible to simulate all conditions found in the distribution system in the pipe loop testing program. Ongoing monitoring of the WWU distribution system post Lake Michigan supply will be required to determine if additional adjustments to water chemistry are required.

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SECTION 7 Water Demand

Historical Waukesha Water Utility (WWU) water demands and the Approved Diversion determined by the Great Lakes-St. Lawrence River Basin Water Resources Council (Compact Council), were reviewed to determine flow rates through the water supply and return flow systems. This section reviews the various demands and establishes flow rates used in preliminary design.

7.1 Existing Demands

7.1.1 Historical Demands

Twenty-nine calendar years from January 1, 1988 through December 31, 2016 of daily pumped flow data was reviewed as provided by WWU. Figure 7-1 shows the 30-day moving average overlaid upon the daily pumped flow data with a linear trend line. The 30-day moving average is the average of the previous 30 days of daily pumped flow data, which is typically used in statistical analysis to review trends over long intervals. As shown, the water demand exhibits a decreasing trend. This trend may be attributed to conservation measures, as well as distribution system improvements. Conservation measures include conservation water rates, public education on the benefits of water conservation, and a rebate program for more efficient water fixtures.

Annual precipitation since 1988 as reported by the Midwestern Regional Climate Center is also shown above the plot of daily pumped flow in Figure 7-1. The annual average rainfall for Waukesha according to the data is 33.9 inches per year. Drought years have been identified as years with an annual precipitation of less than 30 inches and were 1988, 1989, 1994, 2003, 2005, and 2012.

7.1.2 Probability and Exceedance Analysis

Notable dates within the time frame of the analyzed data include the start of water conservation in 2006 and a recent drought year in 2012. The dataset was separated into groups which include the entire dataset, post-conservation data, and post-2012 drought data to allow for comparison of flows. The water demand has exhibited a decreasing trend within the entire dataset and between data groups. Data from the post-conservation period has been used to reflect possible demand conditions used for analysis and design due to the distinct demand decrease after 2006. Statistical values for datasets are outlined in Table 7-1.

Table 7-1 Demand Statistical Values

Item	Demand Statistical Values (MGD)		
	Entire Dataset (1988-2016)	Post-Conservation (2007-2016)	Post-2012 Drought (2013-2016)
Minimum	3.1	3.1	3.1
90% Exceedance	6.1	5.6	5.3
Mean	7.6	6.7	6.3
Median	7.4	6.6	6.2
10% Exceedance	9.3	7.8	7.2
Maximum	15.2	10.8	10.1
Standard Deviation	1.3	0.9	0.7

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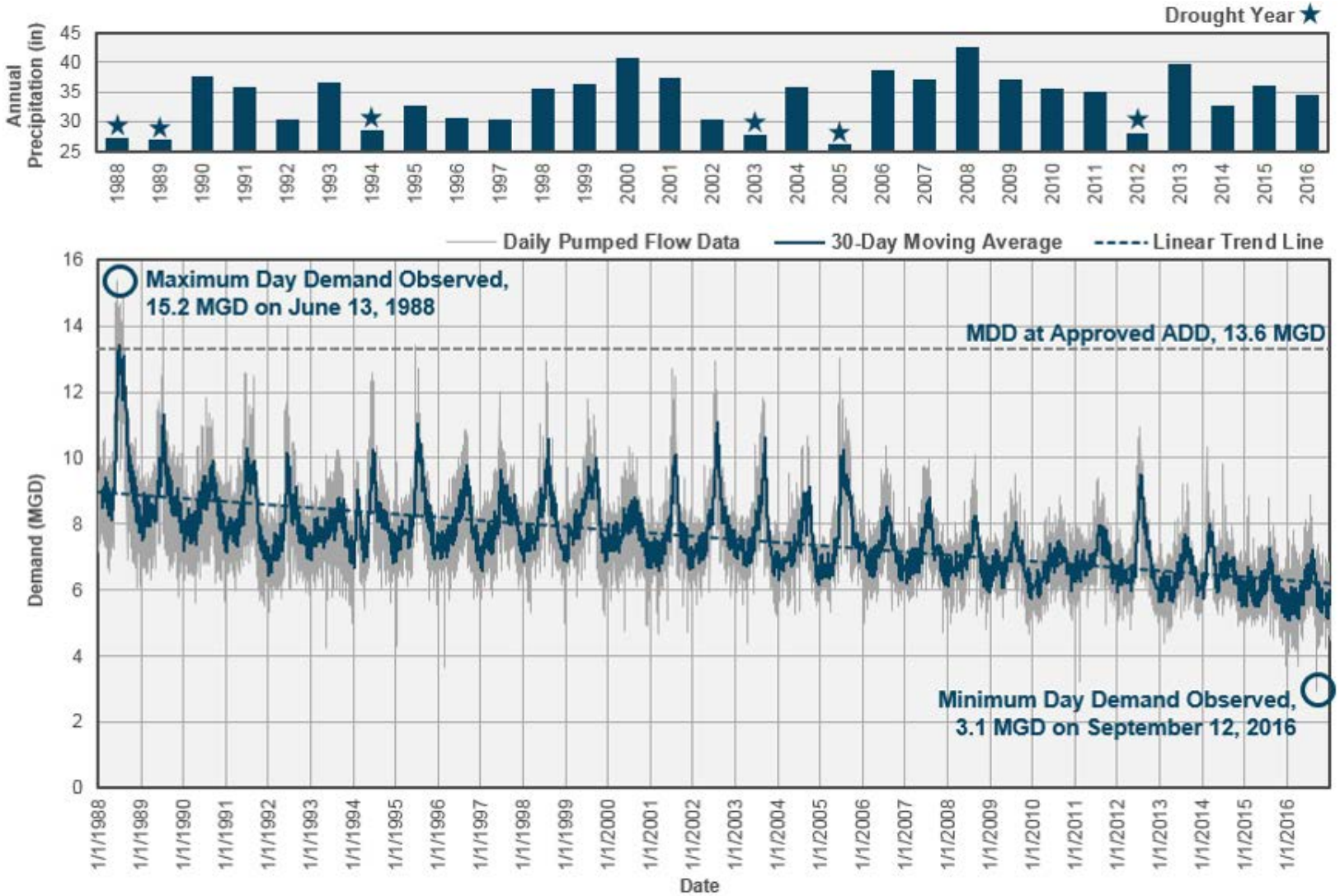

Figure 7-1 29-Year Waukesha Water Demand History, January 1, 1988 through December 31, 2016

A probability and exceedance analysis was performed to determine the likelihood of various day demands. Values with less than 10% exceedance correspond to high flow quantities and lower frequencies of occurrence. These low exceedance values have been examined to provide information on possible upper limits for pumping service.

Figure 7-2 displays results of a probability and exceedance analysis for the post-conservation period spanning the last 10 years from January 2007 through December 2016. Flow values above 7.8 million gallons per day (MGD) occurred less than 10% of demand days and only exceeded 9.2 MGD less than 1% of demand days. The median day demand observed over the last 10 years is 6.6 MGD. The minimum day demand value observed of 3.1 MGD indicates the possible lower bound of demand, and the maximum day demand (MDD) value observed of 10.8 MGD indicates the possible higher bound of demand that may be expected.

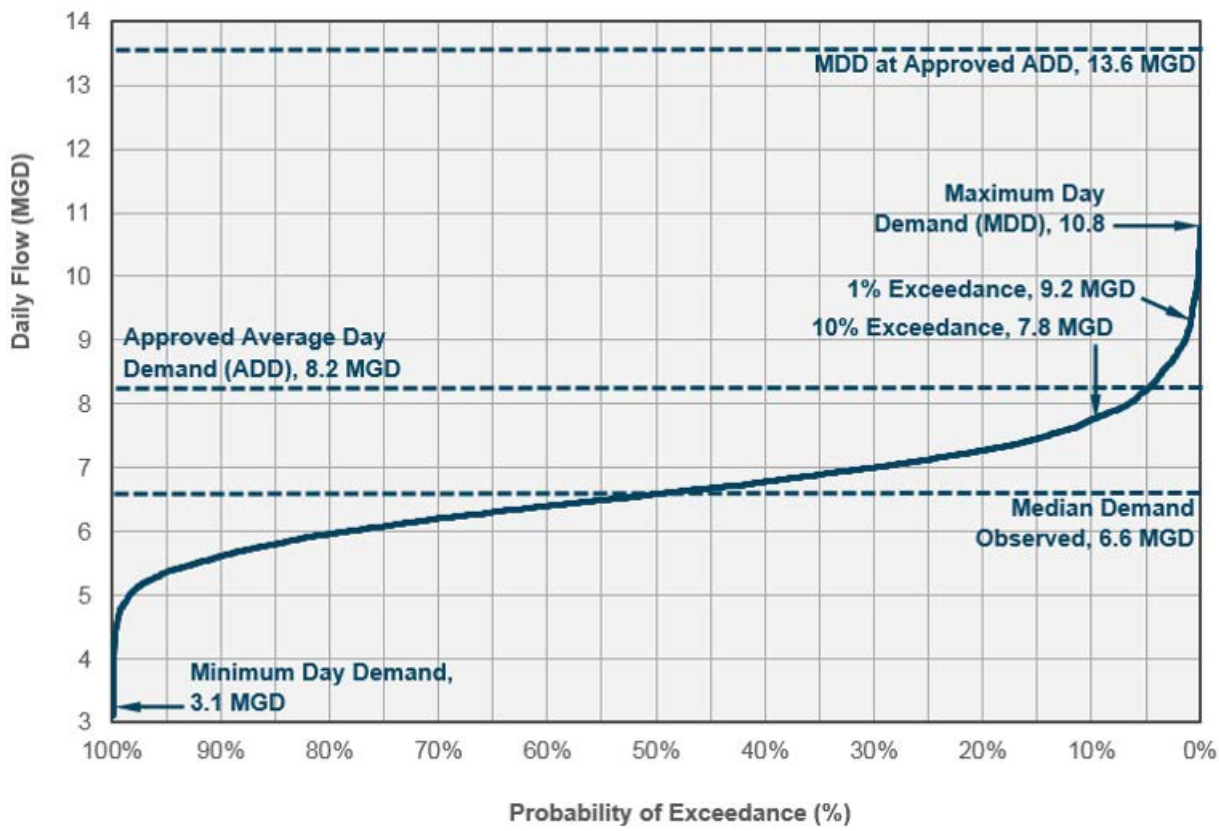

Figure 7-2 10-Year Waukesha Water Probability and Exceedance Analysis, January 1, 2007 through December 31, 2016

Figure 7-3 shows a frequency plot of the daily pumped flow observed over the last 10 years. As shown, 95% of day demands range between 5 and 8.5 MGD. The demand demonstrates a predominantly normal distribution that favors a slight positive skewness. A normal distribution indicates day demands above and below the median day demand are comparably likely.

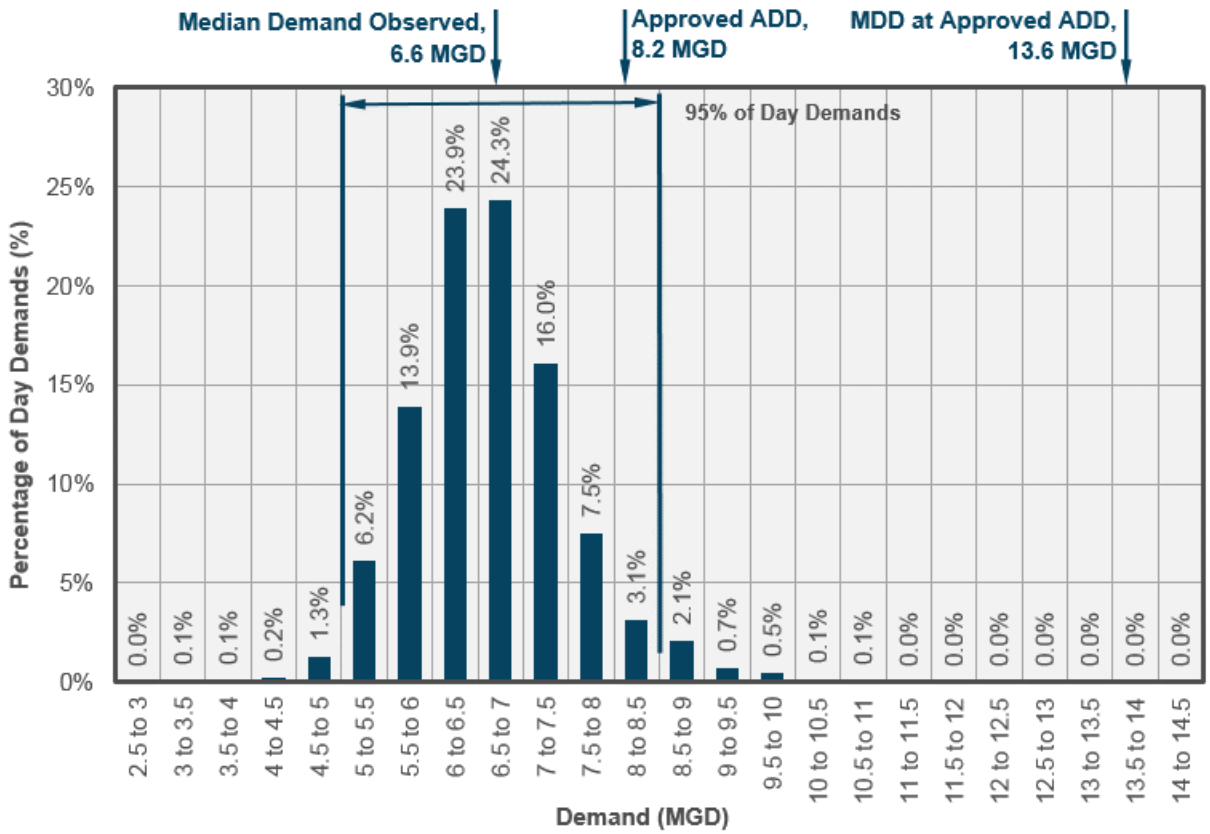

Figure 7-3 10-Year Waukesha Water Demand Frequency, January 1, 2007 through December 31, 2016

7.1.3 Diurnal Demand

The diurnal demand has been developed as a basis for determining flow requirements associated with supplying Waukesha's peak hour demand (PHD). Two years of WWU instantaneous flow data from October 2014 through September 2016 was analyzed to develop the diurnal demand curve. This data is consistent with that used for distribution system modeling in Task 5 of the Great Water Alliance (Program).

The diurnal demand was calculated by performing a water balance on the distribution system. The instantaneous demand was calculated as the sum of the flow supplied and the differential tank flow in each pressure zone. The flow supplied was calculated as the flows through the wells and booster pumping stations in WWU's distribution system. The differential tank flow was calculated as the difference between the flow out of the tank and the flow into the tank. The instantaneous water demand was averaged for each hour of the day from October 2014 through September 2016 to develop a system-wide diurnal demand curve for Waukesha. Distribution system modeling efforts also developed diurnal demand curves for each pressure zone throughout WWU's distribution system.

The system-wide diurnal demand for WWU's distribution system is shown in Figure 7-4, with zero on the x-axis corresponding to midnight. The primary y-axis presents the diurnal demand in MGD, while the secondary y-axis on the right presents the diurnal demand in dimensionless form relative to the average demand observed.

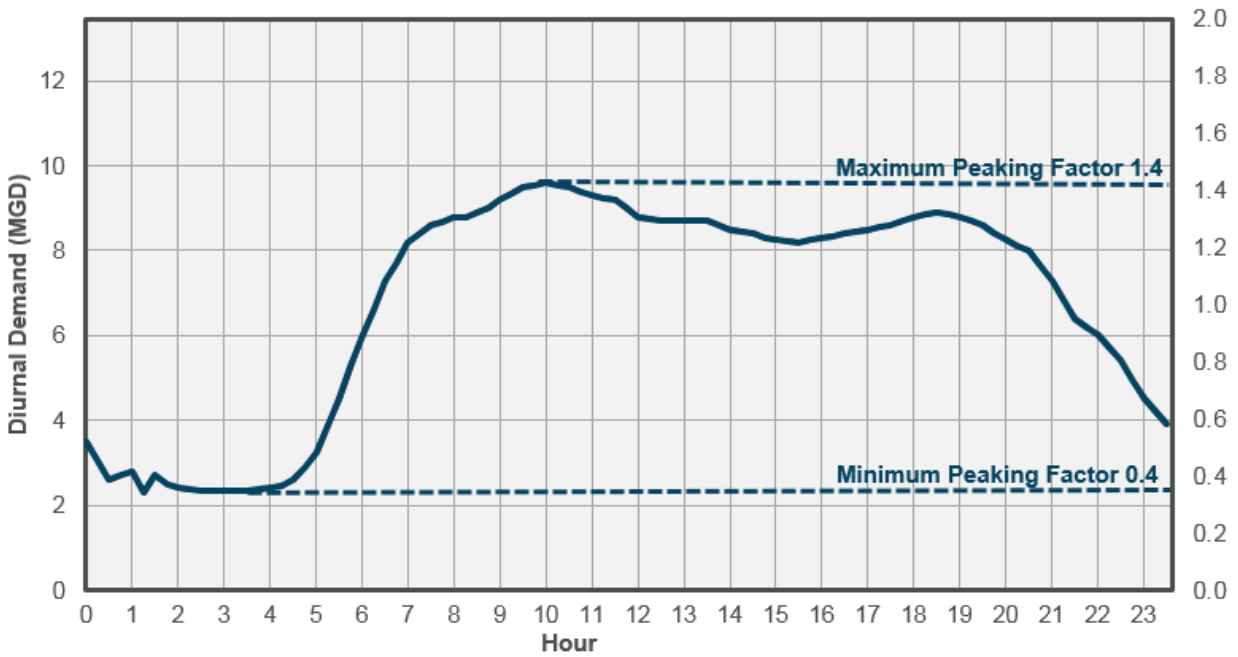

Figure 7-4 Diurnal Demand Curve

As shown, the diurnal demand consists of a variation of a typical diurnal pattern with a minimum flow in the early morning hours as well as two peaks, at midmorning and early evening. The dimensionless diurnal demand ranges from a minimum factor of 0.4 to a maximum factor of 1.4. The diurnal demand curve provides information on potential demand variations used to determine pumping rate possibilities for delivery by the Booster Pumping Station (BPS), while taking into account attenuation by existing storage throughout WWU's distribution system. Existing storage will serve to attenuate flow rates supplied by the BPS to within a 15-20% band.

7.2 Future Water Demands

7.2.1 Application Demands

Waukesha applied for a new diversion of Great Lakes water from Lake Michigan at an average day demand (ADD) of 10.1 MGD. This was based on a projected ADD at full build-out of the Southeastern Wisconsin Regional Planning Commission (SEWRPC) service area, estimated at year 2050. The demand amount includes a 1.2 MGD industrial water demand growth as stated in the Technical Memorandum, Water Demand Projections – Response to DNR dated February 2014. The 10.1 MGD value is in the middle of the projected range of the demand envelope used to estimate demands in the future and also includes a 1 MGD reduction in water use from conservation.

7.2.2 Approved Diversion

In its Final Decision, the Compact Council approved an ADD of 8.2 MGD as a diversion amount consistent with the Great Lakes-St. Lawrence River Basin Water Resources Compact (Compact). The Application, Volume 2, Appendix A, Table 4 calculated that the MDD would be 1.66 times the ADD to a 95% confidence level. For the approved ADD, this would correspond to a 13.6 MGD MDD. These demand conditions are summarized in Table 7-2.

Table 7-2 Demand Conditions per Approved Diversion

Demand Condition	Demand (MGD)
Approved ADD	8.2
MDD at Approved ADD	13.6

7.3 Demands Evaluated

The historical water demands were compared to the Approved Diversion by the Compact Council to determine the selected water demands and flow rates to be used for planning and design. The demands were selected to account for a large range of anticipated flows. The MDD of 13.6 MGD associated with the approved ADD has been compared to historical water demands. A day demand of 13.6 MGD has not been exceeded in over 24 years. Demands over the last 10 years are below 13.6 MGD, including those observed during the 2012 drought year. As a result, the 13.6 MGD MDD associated with the Approved Diversion of 8.2 MGD will be used for the upper bound for design. The median day demand observed over the last 10-years has been used to represent Waukesha's existing demand and a demand within the range of day demands comparable to those upon commissioning. The minimum day demand observed provides the lower bound for design. The selected water demands used in this Preliminary Design Report (PDR) are summarized below.

- Minimum Hour Demand: 1.2 MGD (0.4 [minimum peaking factor] x 3.1 MGD minimum day demand)
- Minimum Day Demand: 3.1 MGD (minimum demand observed, January 1988 to December 2016)
- Existing Day Demand: 6.6 MGD (median demand observed, January 2007 to December 2016)
- Average Day Demand (ADD): 8.2 MGD (approved ADD)
- Maximum Day Demand (MDD): 13.6 MGD (MDD associated with the approved ADD)
- Peak Hour Demand (PHD): 19.0 MGD (1.4 [maximum peaking factor] x 13.6 MGD MDD associated with the approved ADD)

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SECTION 8 Distribution System Evaluation

8.1 Introduction

Waukesha Water Utility's (WWU's) distribution system is currently supplied by groundwater wells geographically dispersed throughout the distribution system. The new water supply from the City of Milwaukee will feed WWU's distribution system through a connection to the Central Pressure Zone. This change will alter the flow patterns and pressure residuals within the distribution system. A hydraulic model has been utilized to simulate the conditions within the distribution system and the effects of the new water supply connection. The results were used to identify the distribution system improvements needed to accommodate the new water supply, and to identify a preferred operational strategy for the Booster Pumping Station (BPS).

8.2 Hydraulic Model Update and Calibration

As part of the Great Water Alliance (Program), the 2012 model has been updated to incorporate system changes that have occurred between 2012 and 2016. The model has been used to identify system improvements, provide recommendations, and evaluate system operation for the new water supply. The model update consisted of reallocating water demands using 2016 billing and water use data available from WWU, incorporating newly constructed and planned improvements, and updating the diurnal demand curves. The model update and calibration process is presented in the Draft Model Update and Calibration Technical Memorandum (5-110 D1).

8.3 Hydraulic Modeling Evaluation Methodology

The calibrated model was used in evaluation of a series of alternatives to determine the preferred configuration and operation of new water supply facilities, and to identify distribution system improvements needed to accommodate the new water supply.

- Water Supply Delivery Alternatives evaluated the preferred configuration of storage and booster pumping between the new water supply and WWU's distribution system. The initial evaluations were based on an assumed single connection point at the intersection of Les Paul Parkway and Racine Avenue.
- Distribution System Connection Alternatives evaluated the preferred water supply delivery alternative with distribution system connection alternatives to determine the preferred connection location.
- BPS Control Strategies evaluated the preferred control element for the BPS and to maintain acceptable pressures at the preferred distribution system connection point. Flow and head data were also generated at the connection point for use in developing system curves for the BPS, which are presented in Section 11.

These evaluations were presented to WWU during the following meetings and workshops:

- 5-100 M-01 Distribution System Model Calibration Meeting, April 27, 2017
- 5-100 M-02 Distribution System Connection Meeting (the meeting was scheduled, but did not occur)
- 5-100 M-03 Distribution System Connection Meeting, September 7, 2017
- 5-100 M-04 Distribution System Hydraulic Model Meeting, September 27, 2017
- 5-100 M-05 Distribution System Hydraulic Model Meeting, October 13, 2017

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The following sections summarize the evaluations and results of the meetings and workshops. The hydraulic modeling evaluations are presented in the Draft Distribution System Evaluation and Improvement Identification Technical Memorandum (5-120 D1).

8.4 Evaluation of Water Supply Delivery Alternatives

Water supply storage will be required between the Water Supply Pumping Station (WSPS) and WWU's distribution system to provide capacity for equalization storage (based on diurnal demand and peak hour), operational storage (for operation of WSPS), and emergency storage. A BPS will be required to provide additional head if the storage is located at elevations insufficient to supply WWU's distribution system and to fill existing storage facilities (Central Pressure Zone reservoirs) within the distribution system by gravity.

The calibrated model has been used to evaluate the storage and pumping station configuration alternatives and to identify a preferred configuration that serves the distribution system in a cost-effective manner. The alternatives are comprised of a blend of storage and pumping configurations as described below.

- Alternative 1 – Ground Level Reservoir and BPS with Direct Connection to Central Pressure Zone: Alternative 1 is comprised of a ground level reservoir(s) and a BPS located in Minooka Park in the City of New Berlin. Flow would be conveyed from the WSPS to a pressure sustaining valve (PSV) located upstream of an air break. The PSV would maintain a minimum pressure of 35 pounds per square inch (psi) in the Water Supply Pipeline upstream of a ground level reservoir(s). The flow would be conveyed through an air break and into the reservoir(s). The BPS would draw from the reservoir and provide the head necessary to supply WWU's distribution system. The BPS would operate based on levels in the Hillcrest Reservoir located in the Central Pressure Zone of WWU's distribution system.

- Alternative 2 – Standpipes with PRV Station at Connection to Central Pressure Zone: Alternative 2, includes standpipes operated at water levels capable of supplying WWU's distribution system by gravity, eliminating the need for a BPS. This would be the simplest method of conveying water to the distribution system. However, to maintain a minimum pressure of 35 psi in the Water Supply Pipeline from the site to the connection point, all effective storage would need to be placed above an elevation of 1,060 feet, or 80 feet above grade. Preliminary discussions with manufacturers indicated that in order to provide the anticipated required storage, four standpipes would be required. Flow would be conveyed from the WSPS to each standpipe. An air break would be more difficult to achieve in the standpipe due to its height. A PRV Station would be placed downstream of the standpipes near the connection point to the Central Pressure Zone to control head within the Central Pressure Zone and to maintain adequate pressure on the Water Supply Pipeline. The Hillcrest Reservoir may require modifications to allow it to fill and drain from the new water supply.

- Alternative 3 – Ground Level Reservoir and BPS with PRV Station at Connection to Central Pressure Zone: Alternative 3 includes a ground level reservoir(s) and a BPS with a PRV Station located at the connection to the Central Pressure Zone. The BPS would operate based on a control element (CE) to maintain pressures in excess of 35 psi in the Water Supply Pipeline. The CE could consist of a pressure transducer for pressure control or a tower (elevated tank) to maintain level in the tank. Similar to Alternative 2, a PRV Station would be required to control pressure in the Central Pressure Zone and to maintain adequate pressure in the BPS Discharge Pipeline.

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The alternatives were evaluated and compared in the Draft Distribution System Evaluation and Improvement Identification Technical Memorandum (5-120 D1) and Alternative 3 was selected as the preferred alternative. Preliminary engineering was based on ground level reservoir(s) and a BPS at the preferred BPS Site B-10.1 (refer to Section 11 for site locations and site screening details) along with a PRV Station located within proximity to the connection to the Central Pressure Zone. Note that the Water Supply Pipeline downstream of the BPS is referred to as the BPS Discharge Pipeline, while the PRV Station is referred to as the Water Supply Control Building (WSCB) hereafter.

8.5 Evaluation of Distribution System Connection Alternatives

In order to identify a preferred connection location to WWU's distribution system, connection alternatives were developed and evaluated. The hydraulic model was used as a tool to evaluate the distribution system and determine if improvements are required for each of the connection alternatives. Each connection alternative utilizes Water Supply Delivery Alternative 3 and the preferred site for the BPS / reservoir facility at BPS Site B-10.1 (refer to Section 11 for details regarding the site screen process and location). Each connection alternative contains the BPS Discharge Pipeline that routes to the WSCB, which will house pressure reducing valves (PRVs) used for controlling pressure in the Central Pressure Zone and maintaining pressure in the pipeline. The following subsections describe the evaluation of the distribution system connection alternatives.

- Alternative 1 – One Connection on Les Paul Parkway (Sunset Drive): Alternative 1 is comprised of a single connection at the intersection of Sunset Drive and Les Paul Parkway. The BPS Discharge Pipeline would be routed to the WSCB that would be located on the same site as Highline Booster Pumping Station owned by WWU. The piping downstream of the WSCB would connect to WWU's Central Pressure Zone near the intersection of Sunset Drive and Les Paul Parkway.

- Alternative 2 – Two Connections on Les Paul Parkway (Sunset Drive and Racine Avenue): Alternative 2 is comprised of a connection at the intersection of Les Paul Parkway and Sunset Drive and another connection at the intersection of Les Paul Parkway and Racine Avenue. The BPS Discharge Pipeline would be routed to a WSCB, which would be located on the northeast corner of Minooka Park. From the WSCB, the piping would then split to the two connection points on Les Paul Parkway.
- Alternative 3 – One Connection on Les Paul Parkway (Racine Avenue): Alternative 3 would be comprised of a connection at the intersection of Racine Avenue and Les Paul Parkway. The BPS Discharge Pipeline would be routed to a WSCB that would be located on the northeast corner of Minooka Park. The piping downstream of the WSCB would connect to WWU's distribution system at the intersection of Racine Avenue and Les Paul Parkway.
- Alternative 4 – One Connection on Les Paul Parkway (East Avenue): Alternative 4 would be comprised of a connection at the intersection of Les Paul Parkway and East Avenue. The BPS Discharge Pipeline to the WSCB located near the connection point would be routed from the BPS south on Swartz Road to Beeheim Road, then west on Beeheim Road to Guthrie Road, then south on Guthrie Road to Lawnsdale Avenue, then west on Lawnsdale Avenue to Hwy 164, and then north on Hwy 164 to Les Paul Parkway. The WSCB would be located upstream of the connection point to WWU's distribution system.

The alternatives were evaluated and compared in the Draft Distribution System Evaluation and Improvement Identification Technical Memorandum (5-120 D1) and Alternative 1 was selected as the preferred alternative.

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Preliminary engineering was based on a connection to the Central Pressure Zone at the intersection of Les Paul Parkway and Sunset Drive.

8.6 Evaluation of BPS Control Strategies

After the preferred water supply delivery configuration was selected and the Central Pressure Zone connection location determined, BPS control strategies were evaluated using the hydraulic model. These evaluations were conducted using Water Supply Delivery Alternative 3 and Distribution System Connection Alternative 1.

- Strategy 1 – Level at Hunter Tower (Level): Strategy 1 includes utilizing water levels in Hunter Tower to operate pumps at the BPS. Hunter Tower would be hydraulically connected, via the BPS Discharge Pipeline, to the WSCB to feed the Central Pressure Zone. The PRVs would be set to reduce pressure from the BPS Discharge Pipeline to that within the operating range of the Central Pressure Zone.
- Strategy 2 – Pressure Transmitter at BPS (Pressure): Strategy 2 includes utilizing pressure set points at the BPS to control operation of the pumps. The BPS would be set to maintain the minimum pressure of 35 psi in the BPS Discharge Pipeline between the BPS and the connection to the Central Pressure Zone. The PRVs would be set to reduce pressure from the pipeline to within the operating range of WWU's Central Pressure Zone.

The two strategy options were evaluated and compared in the Draft Distribution System Evaluation and Improvement Identification Technical Memorandum (5-120 D1) and Strategy 1 was selected as the preferred strategy. Preliminary engineering proceeded utilizing Hunter Tower as the primary CE for the BPS. Flexibility will also be incorporated to allow WWU to switch between level control and pressure control as necessary. The Highline Booster Pumping Station will be maintained to provide water to the Southeast Pressure Zone in the event that pressure control is utilized.

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SECTION 9 Water Supply Pumping Station Design

9.1 Overview

The Water Supply Pumping Station (WSPS) will convey potable water from the water supplier to the reservoirs at the Booster Pumping Station (BPS) located at Minooka Park. The City of Milwaukee is the water supplier and will provide potable water through the Milwaukee Water Works utility (MWW). The WSPS will be owned and operated by MWW. Figure 9-1 is a simplified diagram of the WSPS in reference to other facilities along the Water Supply Pipeline.

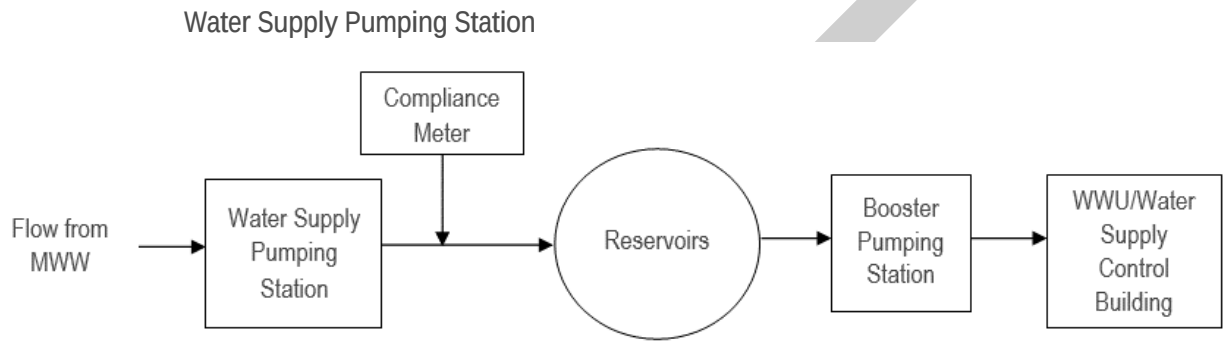

Figure 9-1 Water Supply Pumping Station Diagram

The WSPS will be a prefabricated building designed, constructed and owned by the MWW. This section discusses the process design elements of the WSPS and design elements of the supporting disciplines: civil, structural, architectural, mechanical, electrical, instrumentation and controls (I&C) and construction.

9.2 Site Location

9.2.1 Site Screening

During the Milwaukee Facilities and Pipeline Kickoff Meeting (6-200 M-05) held at Waukesha Water Utility (WWU) on January 17, 2018, the potential points of connection to the MWW potable water distribution system were discussed. Initially, the intersection of Howard Avenue and 60th Street was selected as a potential alternative for the connection point because an existing trunk main runs beneath 60th Street.

The WSPS location will be located near the connection point and will have a maximum foot print of 16,000 square feet (0.4 acres) plus setback to meet the required hydraulic capacity to serve WWU. Potential sites for the WSPS were evaluated within a distance of 1/4, 1/2, 3/4, and 1-mile from the connection point. A total of ten sites were evaluated. A summary of the sites is presented in Table 9-1. Figure 9-2 displays the location alternatives on an aerial image.

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Table 9-1 Water Supply Pumping Station Site Location Summary

Site Location	Intersection	Size (acres)	Land Use Description	Floodplain	Remarks
1	Howard Avenue and 60th Street	0.3	Commercial	No	Private property. Not for sale.
2	Howard Avenue and 60th Street	2.9	Park	No	Property is a park owned by Milwaukee County.
3	Forest Home Avenue and 58th Street	7.8 (total) 3.1 (open space)	Residential	No	Property includes a church and the open space is used for functions during the summer. Forest Home Avenue was recently repaved.
4	Plainfield Avenue and 54th Street	8	Residential	No	Property is owned by Milwaukee School District.
5	Plainfield Avenue and 51st Street	3.5	Cemetery	No	Site location is outside City of Milwaukee limits.
6	Cold Spring Road and 76th Street	25.9	Commercial	No	Site location is outside City of Milwaukee limits.
7	Cold Spring Road and 60th Street	2.2 (total) 1.3 (open space)	Residential	Yes	Owned by City of Milwaukee.
8	Oklahoma Avenue and 76th Street	0.3	Commercial	No	Property is within an active commercial area.
9	Morgan Avenue and 68th Street	2.1	Commercial	Yes	The preferred location, See Section 9.2.2
10	Oklahoma Avenue and 68th Street	2.2 1.4 (open)	Commercial	No	Property is within an active commercial area.

Site Locations 1 through 8 were reviewed during the Milwaukee Facilities and Pipeline Kickoff Meeting (6-200 M-05). Site Locations 1 and 4 presented property acquisition obstacles, and Site Locations 5 and 6 are located outside Milwaukee's city limits. Therefore, Site Locations 1, 4, 5 and 6 were eliminated, leaving Site Locations 2, 3, 7 and 8 as feasible alternatives.

During the WSPS Pump Station Meeting (6-200 M-08), held at Milwaukee on February 2, 2018, Site Locations 9 and 10 were added as feasible alternatives. Site locations 3 and 10 presented property acquisition obstacles, Site Location 7 is within the 100-year floodplain, and Site Location 8 does not provide sufficient space. Therefore, Site Locations 3, 7, 8, and 10 were eliminated, thereby leaving Site Locations 2 and 9 as feasible alternatives.

Land acquisition obstacles and zoning complications eliminated Site Location 2 from further consideration. Site Location 9 is the preferred site location. Therefore, a consensus was reached to update the connection point to the intersection of Morgan Avenue and 60th Street due to the proximity to Site Location 9.

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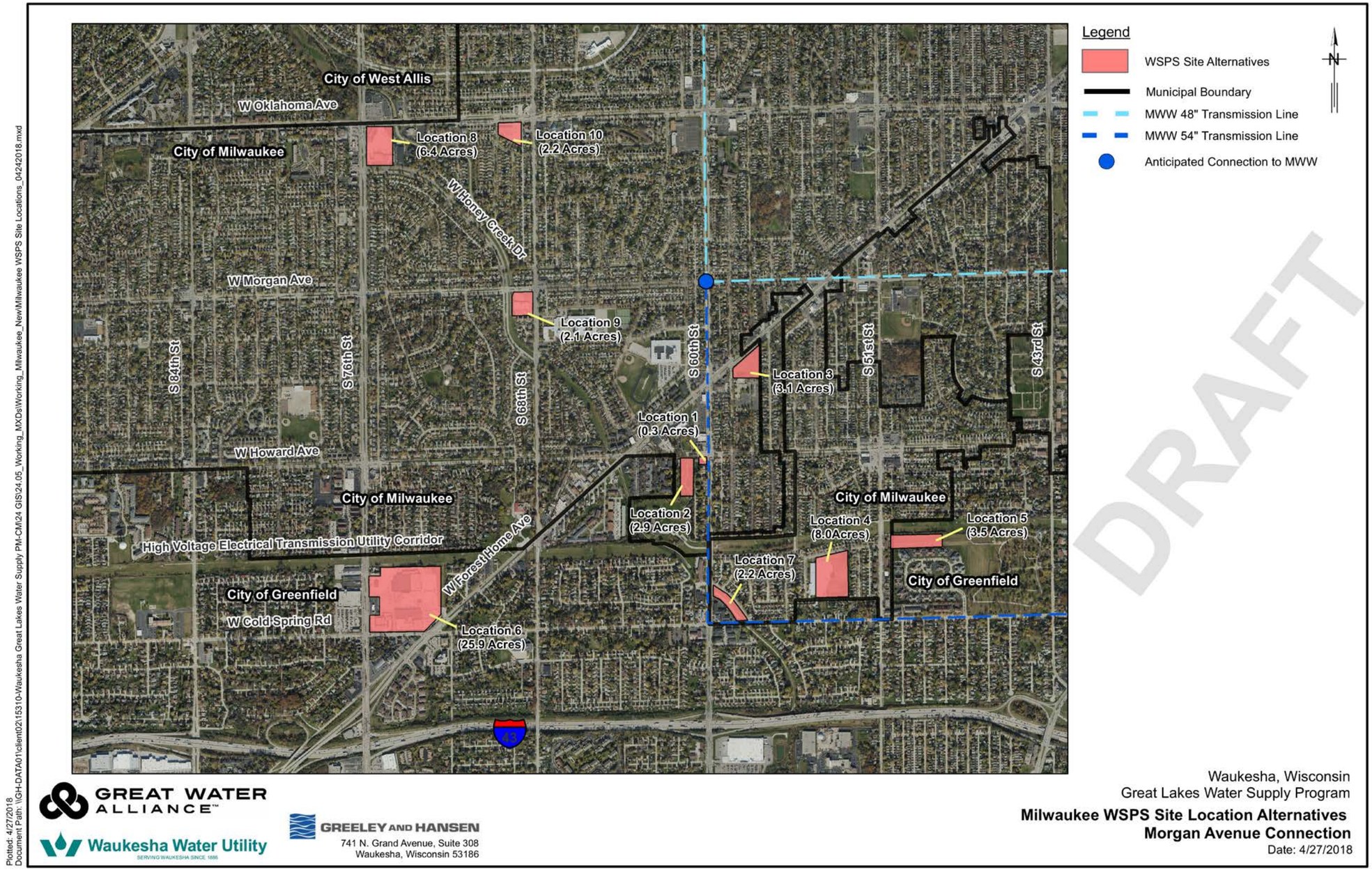

Figure 9-2 Water Supply Pumping Station Site Alternatives

9.2.2 Preferred Water Supply Pumping Station Site

Site Location 9 is shown in Figure 9-3. This site was preferred due to its proximity to the Water Supply Pipeline. According to Milwaukee County tax information, the parcel is owned by JMC Properties and is approximately 2.1 acres in size with 1 acre of open space. The open space could be used by MWW for local distribution system improvement.

Figure 9-3 Water Supply Pumping Station and Connection to MWW Distribution System

9.3 Civil/Site

This section identifies the site and civil engineering requirements for the WSPS. The following subsections present information on the data collection and desktop reviews along with the proposed improvements and associated requirements.

9.3.1 Data Collection

Desktop analyses were performed to support the site screening process and determine the viability of the preferred site. These assessments included review of land use and surface features, and aspects of the site associated with floodplains, zoning, and environmental analysis. The following subsections present information about the data collection, desktop reviews, and field investigations, along with the proposed improvements and associated requirements.

9.3.1.1 Desktop Analysis

Land Use and Surface Features: The site is located at the southwest corner of the intersection of Morgan Avenue and 68th Street. It is currently utilized as a commercial area, Morgan Office Park. Current business at Morgan Office Park are: Allstate office, Southeastern Oneida Tribal Services, American Indian Council office, and Church of Scientology. The site address is 6801 West Morgan Avenue, Milwaukee, Wisconsin. As previously indicated, the parcel is approximately 2.1 acres in size with 1 acre of open space. The southern portion of the site includes a building with access from Wedgewood Drive.

Zoning: The site is zoned as NS-2 which is Neighborhood Shopping Commercial. Subchapter 6: Commercial Sites of Milwaukee's zoning code indicates that sites classified as NS-2 provide for residential uses as well as commercial uses to serve a neighborhood.

Environmental: As part of the Draft Route Study: Milwaukee (4-100 D2), a Phase I Environmental Site Assessment was performed within a 1/4-mile wide corridor centered along the Water Supply Pipeline route alternatives to assess the potential of encountering contaminated soil and groundwater during construction. A desktop review of readily available information was completed along and adjacent to the right-of-way of the route alternatives, and properties were identified as potential contaminated sites. Site Location 9 was not identified as a site with a high potential to encounter contamination.

A desktop evaluation of wetlands and waterways along the Water Supply Pipeline route alternatives was conducted as part of the Draft Route Study: Milwaukee (4-100 D2). The evaluation included a review of maps and aerial imagery including the Wisconsin Department of Natural Resources (WDNR) Wisconsin Wetland Inventory (WWI) maps, United States Geological Services (USGS) topographical maps, Natural Resource Conservation Service (NRCS) soil maps, and recent and historical aerial photographs. Utilizing these resources, potential wetlands and waterways were identified within 50 feet from the right-of-way and mapped on recent aerial photographs. As a result of this evaluation, it was concluded that Honey Creek, which is located along the west side of Site Location 9, was not classified as a WWI wetland.

Floodplain and Floodway: Site Location 9 was evaluated for potential floodplain impacts. The site is located on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) panel number 55079C0151E. As shown in Figure 9-4, the Floodplain limits extend onto the west side of the site but will not have a significant impact on the WSPS.

9.3.2 Site Improvements

The conceptual site plan for the WSPS is shown in Figure 9-5. The site plan includes a prefabricated pumping station with an area of 140 feet by 115 feet, an area for electrical and mechanical equipment, and an open space for potential future expansion for local demand. Grading at the WSPS will facilitate positive drainage of rainfall runoff away from the structure. The WSPS site will be provided with required utility services including electrical, fiber optic, natural gas, potable water, fire protection, process piping, and sanitary sewer services.

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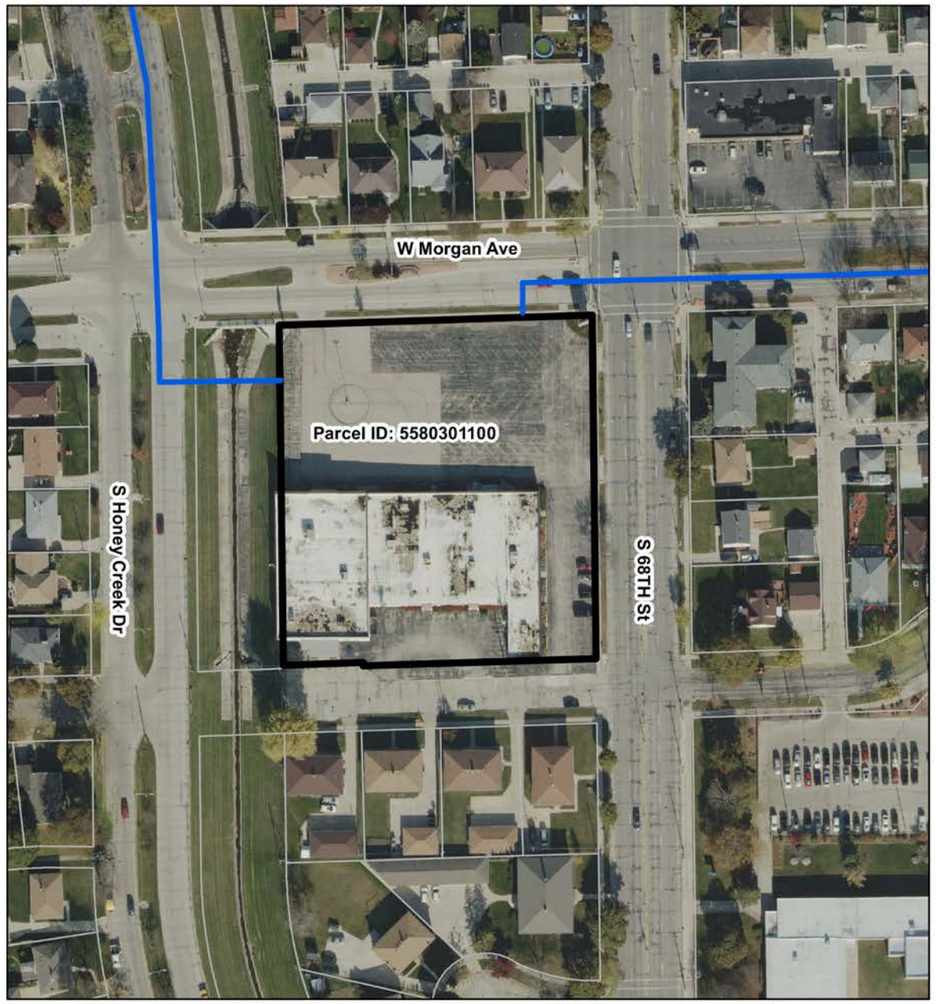
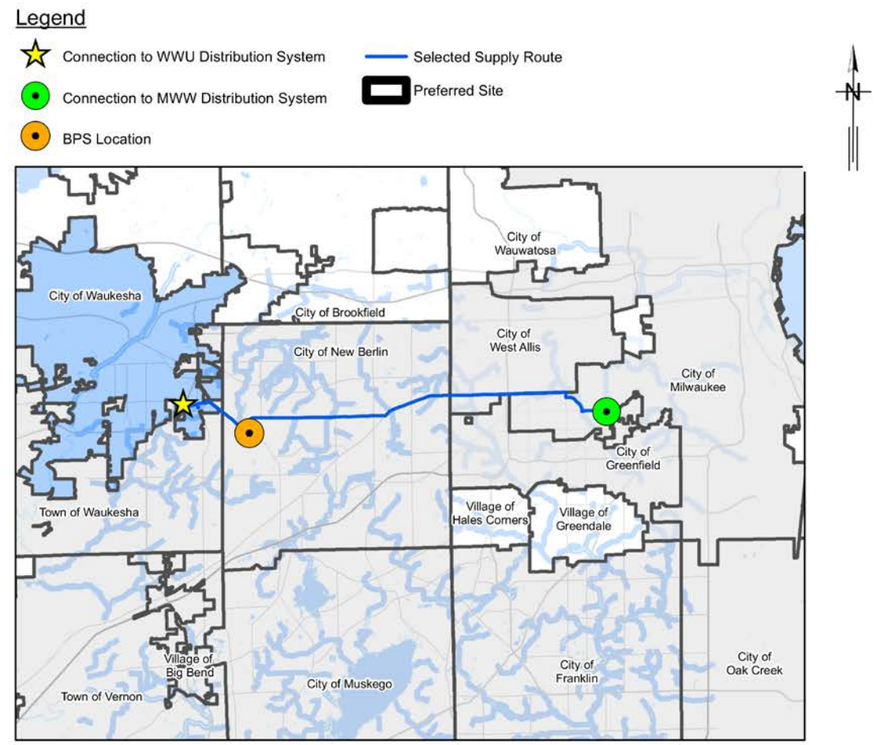


Water Supply Pump Station Alternative - Site Locaiton 9



Key Map

Parcel Information

Location:	Milwaukee
Parcel ID:	5580301100
Owner:	JMC Properties Loc120 LLC
Owner Address:	7430 Harwood Ave, #100, Wauwatosa, WI
Acreage:	2
Zoning:	NS2, Neighborhood Shopping Commercial
Land Use:	Commercial
Last Sale Date:	N/A
Sale Price:	N/A

Legal Description

WEDGEWOOD KPARK IN SW 1/4
SEC 15-6-21 BLOCK 1 (ALL EXC S 3' OF W 75')
& VAC SERVICE STS ADJ & VAC RT
TURN BYPASS ADJ TO SERVICE STS

GREAT WATER ALLIANCE™
Waukesha Water Utility
SERVING WAUKESHA SINCE 1886

GREELEY AND HANSEN
741 N. Grand Avenue, Suite 308
Waukesha, Wisconsin 53186

Waukesha, Wisconsin
Great Lakes Water Supply Program
Water Supply Pumping Station Preferred Site Location
Date: 4/27/2018

Plotted: 4/27/2018
Document Path: G:\115310-Waukesha Great Lakes Water Supply PM-CM\11 Task 6-Facilities\6-200 Design Reports\6-200 Design Report\Section 9 Water Supply Pumping Station Design\Milwaukee\GIS Figures\WSPS_MKE_Site.mxd

Figure 9-4 Preferred Water Supply Pumping Station Site

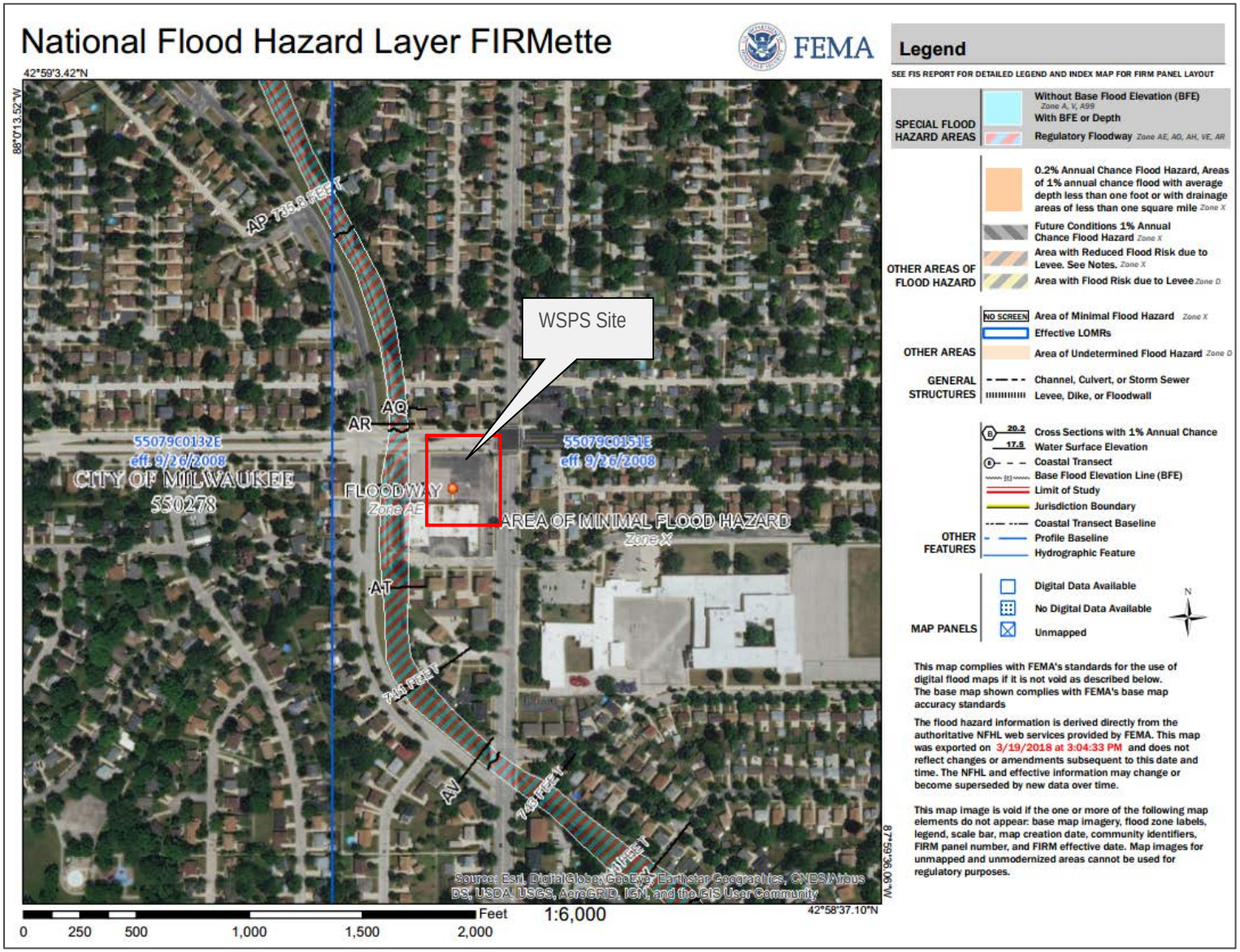


Figure 9-5 FEMA National Flood Hazard Layer FIRMette

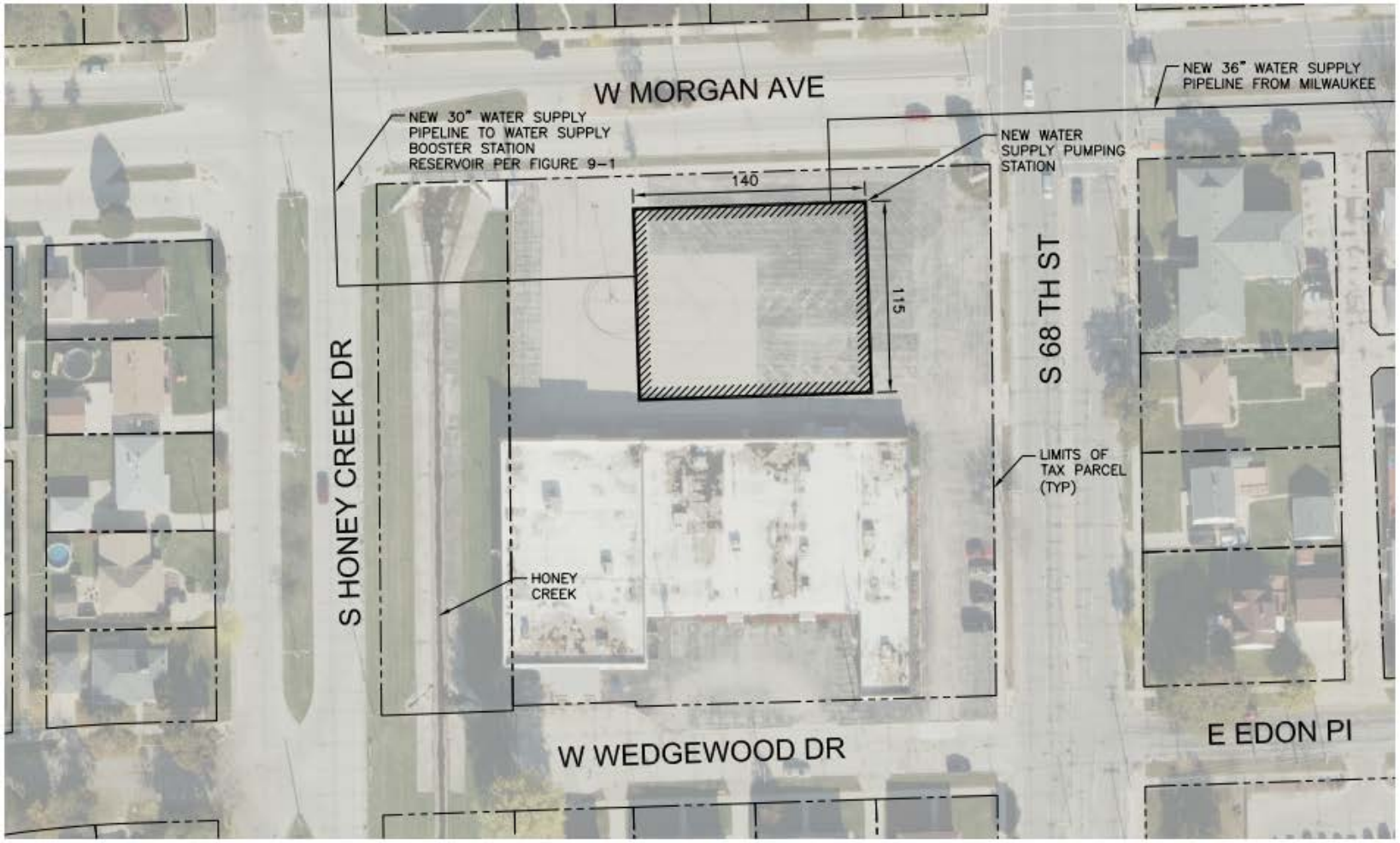


Figure 9-6 New Water Supply Pumping Station Site Plan

9.4 Structural

9.4.1 General

The structural design will be performed in compliance with the State of Wisconsin Building Code, applicable local codes, ordinances and construction industry standards. The WSPS is considered an essential facility. An occupancy category of IV is required to calculate wind, snow and seismic loads.

The design and building specifications shall comply with the 2009 International Building Code (IBC) and the 2005 American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures (ASCE 7-05).

Concrete design shall be in accordance with the 2009 American Concrete Institute Building Code Requirements for Structural Concrete.

9.4.1.1 Water Supply Pumping Station

A prefabricated pumping station will be used for the WSPS. These units are supplied with their own enclosure including floors, walls doors and roof. Inside the enclosure are the pumps and piping. A concrete foundation will be coordinated and constructed prior to the delivery of the WSPS.

Foundation: The foundation for this WSPS will be an eight-inch wide perimeter foundation wall on a 2-foot wide, 12-inch deep footing. Grade beams will be provided under each of the five pump stands.

Backfill: Backfill against foundation walls and retaining walls will be a compacted granular material with an internal friction angle of 30 degrees.

Geotechnical: The soil design criteria are not available for the building at this time. Field investigation will be completed when the site has been purchased. No geotechnical report is available for this facility at this time. An assumed soil bearing capacity of 3,000 pounds per square foot (psf) was used for this report and the design of the span footing. A lateral resistance of 40 psf per foot of depth was used for a granular backfill.

9.5 Architectural

9.5.1 General

The WSPS architectural design will comply with any local requirements of authorities having jurisdiction over the facility. A roof hatch will be located above each pump to facilitate removal of the pump by an exterior crane. The architectural design will accommodate requirements of MWW, using the options that are available from the prefabricated building supplier of the WSPS.

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9.6 Process Mechanical

The purpose of the WSPS is to pump water to the BPS through the Water Supply Pipeline. The WSPS requires a building to house the pumps, piping, valves, meters, and associated accessory equipment to boost the water from MWW to the BPS. This subsection describes the design of the pumping system.

A summary of the basis of design is presented in Table 9-2.

Table 9-2 Water Supply Pumping Station Basis of Design

Description	Design Values
Flow Rate	
Minimum Day Demand, MGD	3.1
Average Day Demand, MGD	8.2
Maximum Day Demand, MGD	13.6
Water Supply Pumps	
Number of Water Supply Pumps	5
Water Supply Pump (Number 1)	
Flow per Pump, MGD	2
Head, feet	300
Motor Size, horsepower	132
Voltage, Volts	480
Variable Frequency Drive	Yes
Water Supply Pumps (Number 2 through 5)	
Flow per Pump, MGD	4.4
Head, feet	300
Motor Size, horsepower	275
Voltage, Volts	480
Variable Frequency Drive	Yes
Firm Capacity (Largest Pump Out of Service), MGD	15.2
Installed Capacity, MGD	19.6
Suction Header	
Diameter, inches	36
Maximum Operating Pressure, psi	100
Minimum Operating Pressure, psi	35
Discharge Header	
Diameter, inches	36
Maximum Operating Pressure, psi	187
Minimum Operating Pressure, psi	104

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9.6.1 Flow Range and Capacity Requirements

Demand Conditions: The WSPS demand conditions are summarized in Section 7 and are restated in Table 9-3. The WSPS design must meet flow conditions between the existing conditions and the Approved Diversion.

Table 9-3 Water Supply Pumping Station Demand Conditions

Parameter	Existing Conditions – Historical Data Analysis	Approved Diversion
Minimum Day Demand (MGD)	3.1	-
Average Day Demand (MGD)	6.6*	8.2
Maximum Day Demand (MGD)	10.8**	13.6

Notes:
* Value is median post conservation per Table 7-1
** Value is maximum post conservation per Table 7-1

The BPS reservoirs will be supplied with flow from the WSPS, the only asset that will supply water to the City of Waukesha (Waukesha). This single supply source will require that the design of the WSPS include a factor of safety to provide excess capacity. During the WSPS Pump Station Design Meeting (6-200, M-08) held on February 2, 2018 a consensus was reached that the hydraulic capacity of the WSPS will be a maximum of 15.0 million gallons per day (MGD) with 24 hour operation to provide the required excess capacity. The storage capacity at the reservoirs allows for complete WSPS shutdown, maintenance or pipe replacement. WSPS shutdowns will be coordinated with WWU and MWW. Table 9-4 summarizes the design parameters for the WSPS.

Table 9-4 Water Supply Pumping Station Design Parameters

Design Parameter	Design Value
Minimum Day Demand (MGD)	3.1
Average Day Demand (MGD)	8.2
Maximum Day Demand (MGD)	13.6
Pumping Duration (Hrs per day)	24.0
Pumping Station Capacity (MGD)	15.0

The WSPS design accommodates the minimum day demand based on Waukesha historical data, the average daily demand (ADD) and maximum day demand (MDD) per the Approved Diversion.

Pressure Requirements: As will be discussed in further detail in Section 10, the Program has set the maximum steady state design pressure as 225 pounds per square inch (psi) to provide a buffer for the 250 psi rated piping and appurtenances. A minimum pressure of 35 psi must be sustained in the Water Supply pipeline connecting the WSPS and Reservoirs located at the BPS per WDNR regulations. The design maximum and minimum pressure shown in Table 9-5.

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Table 9-5 Pipeline Pressure Requirements

Parameter	Pressure (psi)
Maximum Pressure	225
Minimum Pressure	35

9.6.2 Pump Design and Selection

The WSPS will be a prefabricated pumping station similar in design and operation to other MWW pumping stations. The prefabricated system can be configured in a small foot print while allowing for maintenance and operation. Pump design and selection are based on the flow range and capacity requirements described in Section 9.6.1 and the WSPS design parameters outlined in Table 9-4. Pump size, pump configuration, and pumping operations are designed to accommodate these parameters.

9.6.2.1 Pump Size and Configuration

During the WSPS Pump Station Meeting (6-200 M-08) the number and size of Water Supply Pumps (WSP) were discussed with WWU and MWW. A consensus was reached that the total of five pumps will meet the WSPS flow conditions and required capacity shown in Table 9-4. Four pumps will be duty pumps utilized to pump flow to the Reservoirs with the fifth serving as a standby pump. Three of the duty pumps will have a capacity of 4.4 MGD while the fourth pump will have a capacity of 2.0 MGD. Pumps will be configured with variable frequency drives (VFDs) and will have a similar pump and motor arrangement. Table 9-6 shows the pump sizes, totaling a firm capacity of 15.2 MGD.

Table 9-6 Pump Sizing

Pump No.	Capacity (MGD)
WSP – 1	2.0
WSP – 2	4.4
WSP – 3	4.4
WSP – 4	4.4
WSP – 5 (Standby)	4.4
Installed Capacity	19.6
Firm Capacity	15.2

9.6.3 Pumping Hydraulics

Pumping hydraulics were performed to determine the pressure required to pump to the reservoirs at the BPS. The total head required is the sum of the static and dynamic head. The static head is the pressure required to lift the liquid from the water supply pump discharge pipe centerline to the reservoirs. The dynamic head is the pressure to overcome the resistance to flow in the Water Supply Pipeline to the reservoirs and includes losses due to pipe friction and turbulence in various fitting.

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The pump curves were provided by MWW for pump sizes with sufficient head range to meet the system curve head requirements. The design of the Water Supply Pumps is based on the existing pressures at the selected site. The WSPS is to provide a minimum flow of 2 MGD at 250 feet of total head and maximum flow of 15 MGD at 390 feet total head.

9.6.4 Station Piping

The piping plan view provided by MWW is shown in Figure 9-8.

Piping Material: The pipe material will be selected, specified, and installed per MWW standards for prefabricated pumping stations.

Suction Header: The suction header from the MWW will enter the WSPS below grade and be 36-inch diameter within the WSPS. Each of the five Water Supply Pumps will include a pump suction pipe connected to the suction header.

Discharge Header: Individual pump discharge piping for each of the five pumps will connect to the 36-inch diameter discharge header. The discharge header will then reduce to a 30-inch pipeline outside of the WSPS. The discharge header piping will be specified for 250 PSI.

9.6.5 Pump System Appurtenances

Figure 9-8 shows the flow diagram based on the piping arrangement provided by MWW for the WSPS.

Isolation Valves: Isolation valves will be provided to allow isolation of individual pumping units while the WSPS remains operational. Valves typically used for fully-open or fully-closed operation can be used for isolation purposes. The valve types typically considered for water service isolation include butterfly and gate valves. The MWW piping arrangement and flow diagram shows butterfly valves for isolation.

Check Valves: Check valves on the pump discharge piping will be utilized to control the starting and stopping of the pump to dissipate excess pressure surges encountered in the discharge pipeline. Figure 9-7.

Air Release Valves (ARVs): ARVs automatically maintain the performance of the piping by releasing air pockets that form within highpoints of the pressured pipeline. The valves operate by opening against internal pressure, venting air from the pipeline until the air pocket is depleted and water rises through the valve casing pushing up a float switch closing the air vent. An ARV will be located on the top of the suction header.

Surge Protection: A surge relief valve will be installed on the discharge header upstream of the compliance meter to minimize pressure surges or water hammer. Surge relief valves release water from the system to an exterior splash pad to alleviate system pressure.

Metering: A compliance meter will be located at a separate Meter Vault. The location of the meter vault will be finalized during design.

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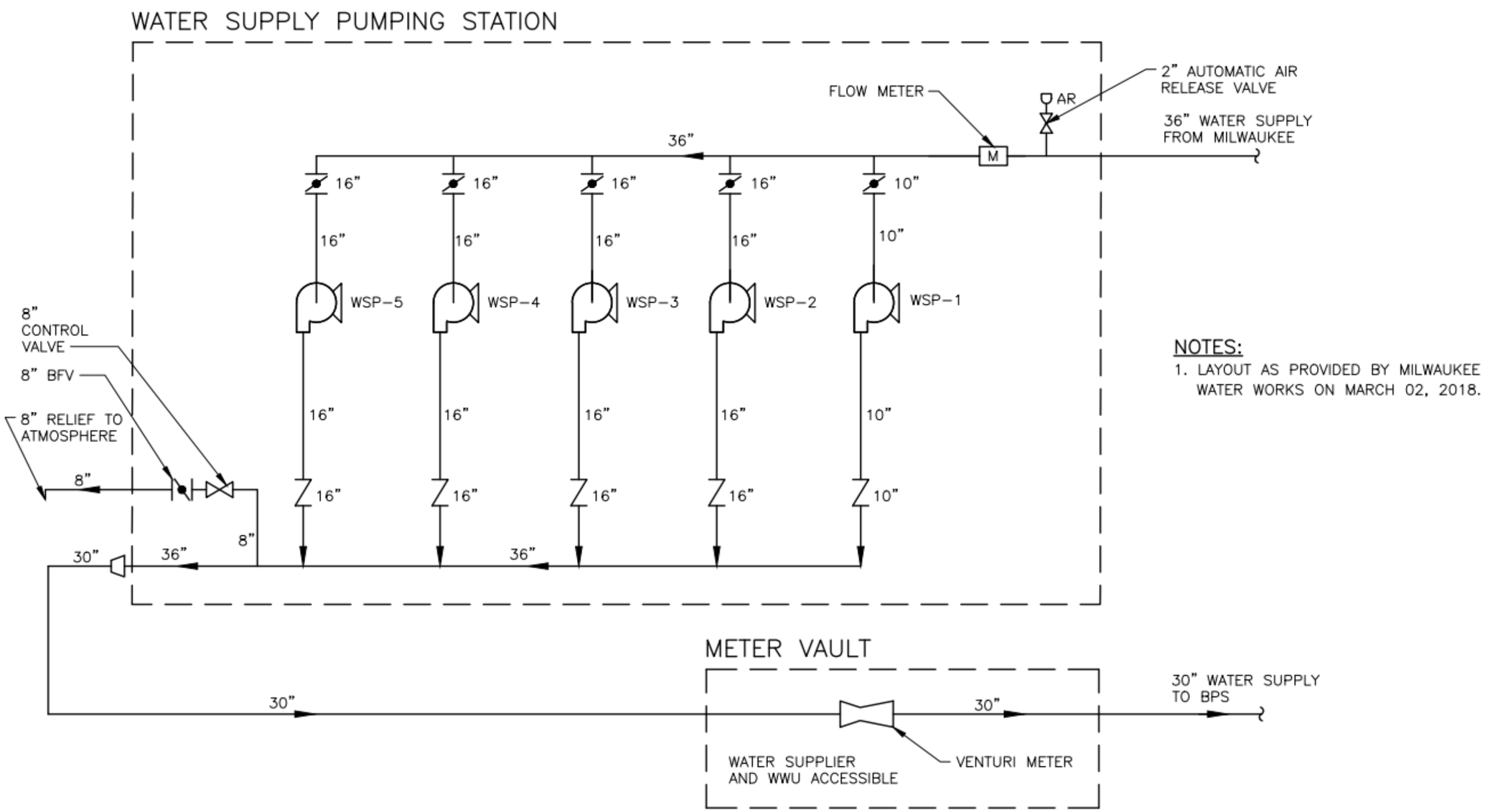

Figure 9-7 Water Supply Pumping Station Plan View

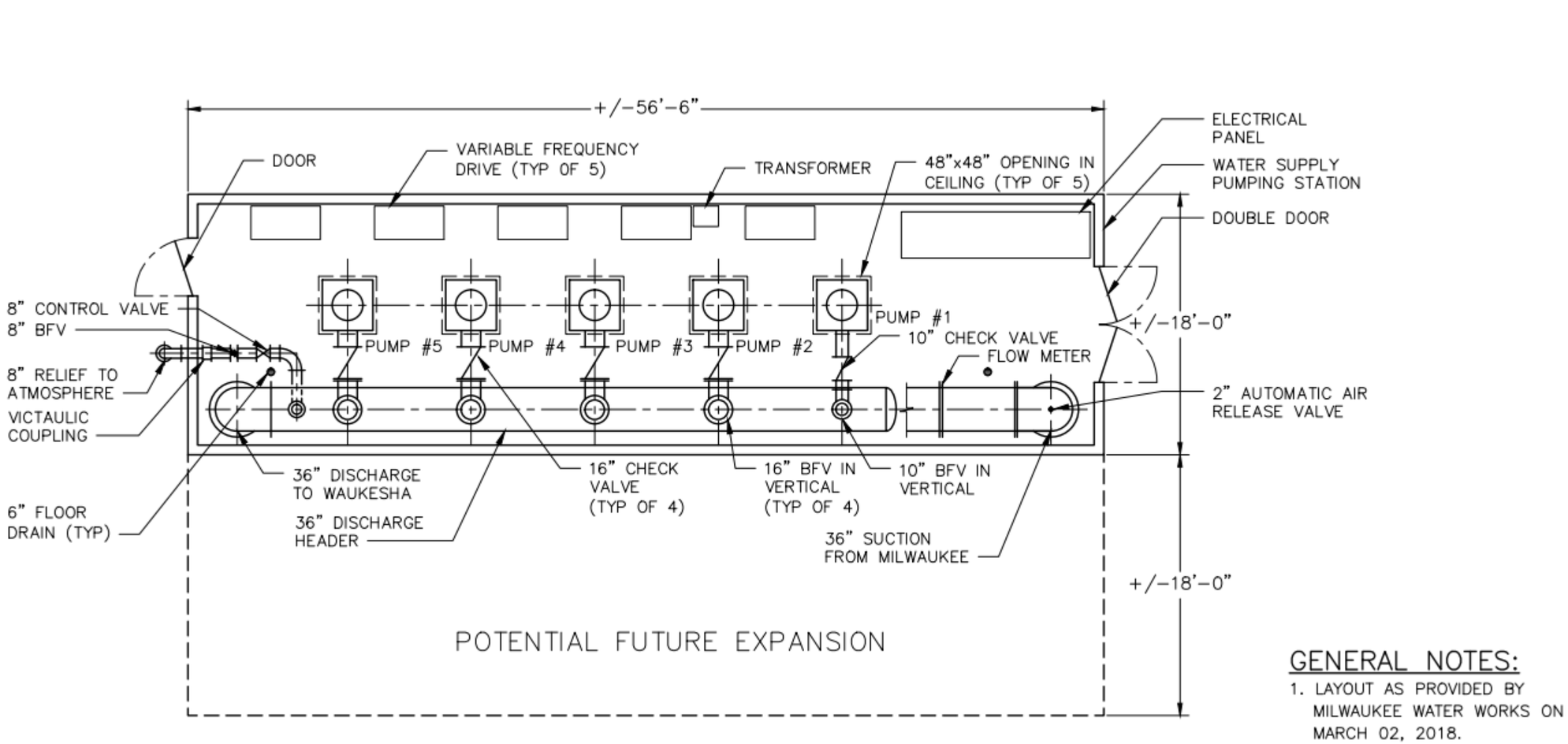

Figure 9-8 Water Supply Pumping Station Flow Diagram

9.7 Mechanical

9.7.1 General

The heating and ventilating system included with the prefabricated building will be specified to accommodate ambient temperatures and operating requirements required by MWW.

9.8 Electrical

9.8.1 General

The electrical systems included with the prefabricated building will be specified to meet MWW requirements.

9.8.2 Source of Utility Power

The WSPS will be served by We Energies, either at 24.9 kilovolts (kV), rate CP1, or at 480 volts, rate CG3. Service will be derived from existing overhead distribution facilities located at the site to new switchgear. If service is obtained at 24.9 kV, a pad mount transformer will be provided to supply 480-volt power to WSPS loads.

9.8.3 Standby Power Source

In the event of failure of the utility power, standby power will be provided by an on-site standby generator system consisting of a single diesel-fueled generator set in a weather-protected, sound-attenuated enclosure with a sub-base diesel fuel tank. The generator system will be sized to support pumping operation for ADD flow as required under the Wisconsin Administrative Code.

9.9 Instrumentation and Controls

9.9.1 General

The control facilities for the WSPS will include the instrumentation and controls equipment necessary to accomplish the operation of the WSPS and a Meter Vault. Monitoring of the flow rate and pressure will be shared by MWW to WWU via fiber optic, radio wave communication, or a combination of both.

9.10 Construction

The WSPS will be a prefabricated pumping station that will be delivered and assembled on-site. The construction and startup of the WSPS will be coordinated with other Program Elements to minimize impact to the Program schedule.

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SECTION 10 Water Supply and Return Flow Pipeline Design

10.1 Purpose and Overview

As part of the Great Water Alliance (Program), a Water Supply Pipeline will be required to convey potable water from the water supplier to the City of Waukesha (Waukesha). The Water Supply Pipeline consists of five segments. Figure 10-1 is a diagram of the overall water supply system infrastructure. MWW will own and operate the Water Supply Pipeline located within the City of Milwaukee. The portion of the Water Supply Pipeline MWW will own and operate begins at the connection point to the MWW distribution system and extends downstream approximately 2.8 miles. This is shown as Segment 1 and the downstream remainder of the 2.8 miles along Segment 2.

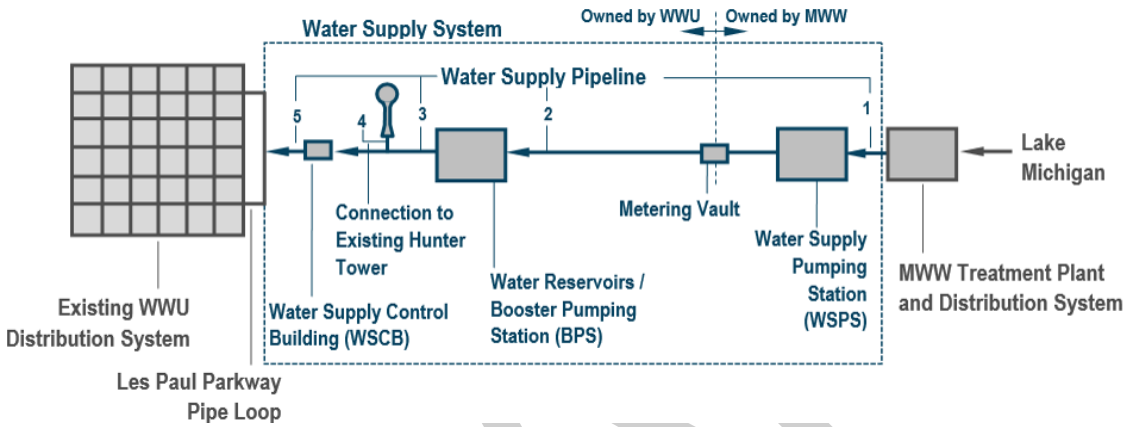

Figure 10-1 Water Supply System Infrastructure Diagram

The Return Flow Pipeline will be required to achieve a net zero water balance in the Great Lakes-St. Lawrence River Basin by conveying highly treated effluent from the Return Flow Pumping Station (RFPS) to Return Flow Facilities prior to discharge to the Root River, which ultimately discharges to Lake Michigan. WWU will own and operate the Return Flow Pipeline. Figure 10-2 includes a diagram of the return flow system infrastructure.

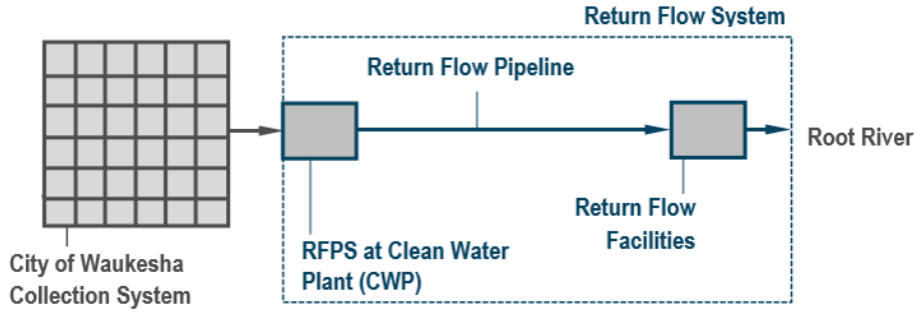

Figure 10-2 Return Flow System Infrastructure Diagram

The purpose of this section is to describe the data collected, constraints and criteria, calculations, and the rationale used to develop the preliminary design of the Water Supply and Return Flow Pipelines. As design elements of both the Water Supply and Return Flow Pipelines are comparable, they have been combined into this one section.

10.2 Pipeline Routes

A Draft Route Study: Oak Creek (4-100 D1) was submitted to Waukesha Water Utility (WWU) in January 2018 that identified a preferred Return Flow Pipeline route. A Draft Route Study: Milwaukee (4-100 D2) was submitted to WWU in April 2018 that identified a preferred Water Supply Pipeline route. Refer to the Draft Route Study: Oak Creek (4-100 D1) and the Draft Route Study: Milwaukee (4-100 D2) for details. Figure 10-3 shows an overview of the preferred routes for the Water Supply and Return Flow Pipelines that were used as a basis for preliminary design.

10.3 Regulatory Constraints

The standards and regulations set forth by the Great Lakes-St. Lawrence River Basin Water Resources Council (Compact Council), Wisconsin Department of Natural Resources (WDNR), Public Service Commission (PSC), Wisconsin Department of Transportation (WisDOT), the Wisconsin Standard Specifications, WWU Specifications, and each of the municipalities traversed by the pipelines have been used to guide design. Refer to Section 4 for a summary of the regulatory requirements per regulatory entity. The regulated parameters are listed below:

- Flow: The annual average flows conveyed by both the Water Supply and Return Flow Pipelines will not exceed requirements set forth by the Compact Council.
- Pipeline Materials: Water Supply Pipeline materials will meet Wisconsin Administrative Code NR 811.69 and WWU Specifications. Return Flow Pipeline materials will meet Wisconsin Administrative Code NR 110.13(5)(g).
- Pressure: The pressure in the Water Supply Pipeline will be subject to standards set forth in Wisconsin Administrative Code NR 811.70 and PSC Subchapter VIII "Operating Requirements", particularly PSC 185.82 "Pressure Standards".
- Wetlands and Waterways Crossing: The Water Supply and Return Flow Pipelines will be designed to minimize impacts to wetlands and waterways, per Wisconsin Administrative Code NR 30. The WDNR's Chapter 30 "Wetlands and Waterways" permit approval requires justification for unavoidable impacts to wetlands and waterways and proof that there are no other alternatives that could be selected and still meet the purpose and need.
- Trenchless Installation: Both pipelines will require trenchless pipe installation at various locations. The installation will follow the protocol set forth in Wisconsin Standard Specifications and/or the given transportation authority.
- Rare, Threatened, and Endangered (RTE): Construction schedule may be impacted by the presence of RTE species at the construction site. Construction cannot be performed in certain seasons depending on the type of RTE species, if any, that are present. The Program will submit endangered resource reviews in conjunction with habitat assessments to the WDNR in accordance with Wisconsin Administrative Code NR 27 and PSC 4.20.
- Construction Season: Methods and timing of construction could be affected by seasonal restrictions. During the winter, special consideration will be required for asphalt, cold patches, and slower work rates.
- Open Cut Installation: The open cut trench for both the pipelines will follow the Occupational Safety and Health Association (OSHA) standards for trench excavations (Section 1926 Subpart P also issued under 29 Code of Federal Regulations (CFR) Part 1911) that are greater than four feet (typical for all sizes/dimensions) in depth and the Standard Specifications for Sewer & Water Construction in Wisconsin, 6th Edition.
- Restoration: The paved surfaces above the trenches for the Water Supply and Return Flow Pipelines will be restored to meet WisDOT or local standards, including backfill requirements. The landscaped surface above the trench will be restored to existing conditions and comply with local ordinances and standards, including erosion control measures as necessary.

Each subsection herein describes the applicable design standards or regulations used in evaluating and developing the preliminary design of the Water Supply and Return Flow Pipelines.

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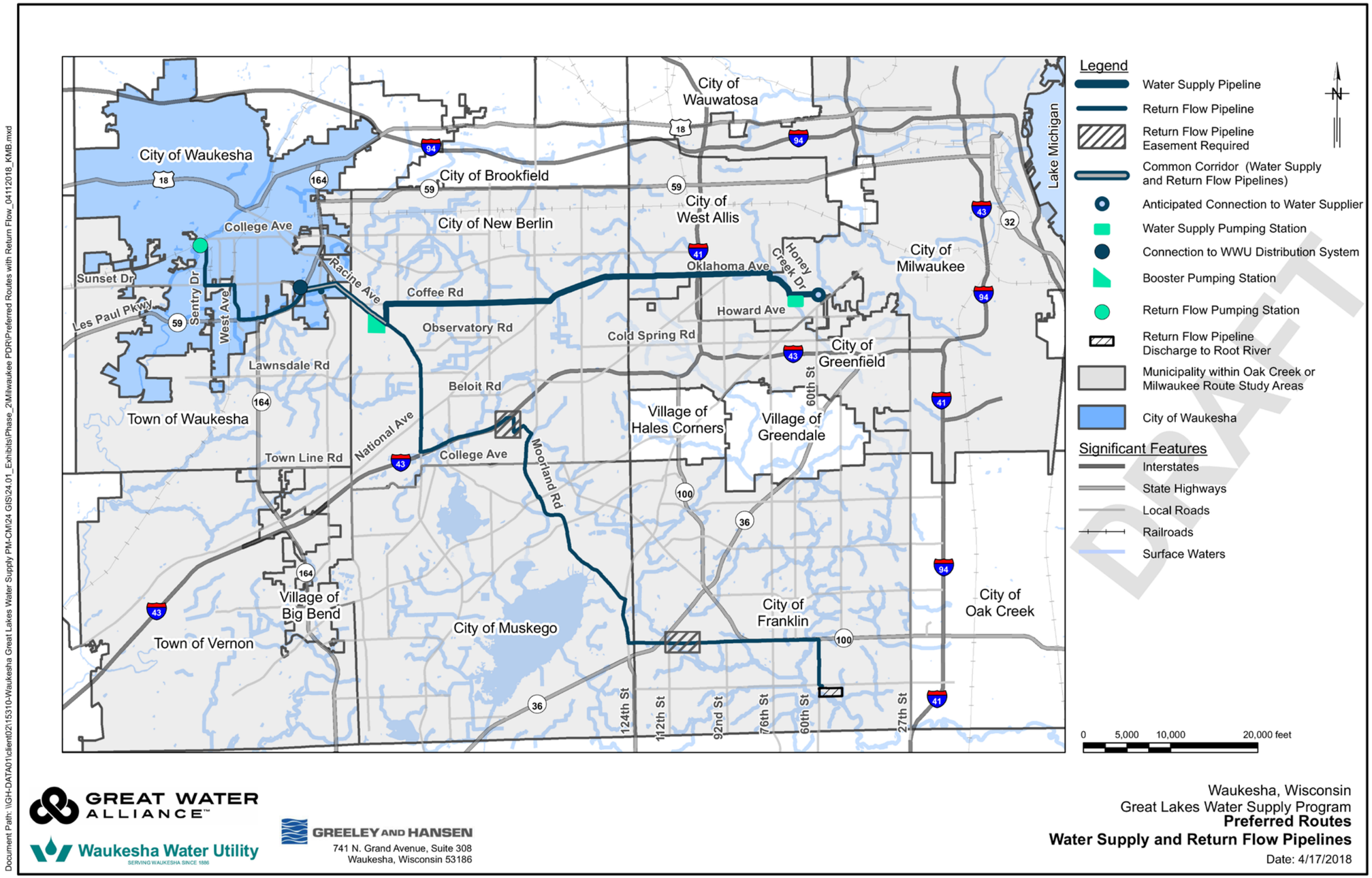

Figure 10-3 Preferred Routes – Water Supply and Return Flow Pipelines

10.4 Civil/Site

10.4.1 Data Collection

The data gathered and reviewed as part of this Preliminary Design Report (PDR) is summarized in Table 10-1 and includes geographic information system (GIS) database files, aerial photography, documents, contract drawings/diagrams, geotechnical database files and hazardous waste or contaminated site database files. The datum for GIS database files throughout the Program is the North American Datum 1927 (NAD 27). Utility information for water infrastructure and property lines have been obtained in the form of municipality GIS files, field investigation, and utility coordination as discussed later in this section.

Table 10-1 Data Sources Summary

Data	Source	Description
GIS Database Files	City of Milwaukee	Tax parcels and right-of-way lines
	City of New Berlin	Tax parcels and right-of-way lines
	City of Greenfield	Tax parcels and right-of-way lines
	Milwaukee County	Public / private water map, public land holdings, tax parcels, right-of-way lines, railroads, parks, municipal boundaries, and topographic contours
	City of Waukesha	Water, storm, sanitary
	Waukesha County	Public / private water map, storm, sewer service areas, county highway pavement conditions, average daily traffic, soils, trails, buildings, rail, parcels, municipal boundaries, and topographic contours
	City of West Allis	Tax parcels and right-of-way lines
Aerial Photography	Program	Aerial photography (photographed in Fall 2016 and Fall 2017), wetlands, floodplain/floodway, water bodies, and digital elevation model
Documents	Other	Pipe catalogues and data from comparable project experience
	RS Means	RS Means data
	City of Waukesha / WWU	Bid tabs, budget, audited financial statements, PSC annual reports and housing statistics
		Waukesha Return Flow Plan
		Waukesha Supply Service Area Plan
	WisDOT	Bid tabs
Contract Drawings / Diagrams	City of Milwaukee	South 60th Street roadway project
	City of Waukesha	Les Paul Water Main Project – Phase 2 Bid Set
		January 2, 2015 Wastewater Treatment Plant Improvements, Phase II
Geotechnical, Wetland, Waterway, and Protected Resources Database Files	MMSD	Soil boring logs
	NRCS	Soils, groundwater, wetlands
	SEWRPC	Bedrock, groundwater
	USDA	NRCS – SURGO Database – Web soil survey data
	USGS	Wetlands, waterways
	WDNR	Well Construction Reports, Wetland Indicator Soils Data, DWI, NHI database
	WHPD	ARI, ASI, and AHI
	WisDOT	Highway Structures Information System
Hazardous Waste / Contaminated Site	ERIS	Contaminated sites identification
	WDNR	Superfund sites, groundwater and soil contamination sites, dry clean environmental sites, and open and closed sites

Notes:

- AHI = Architecture and History Inventory; ARI = Archaeological Report Inventory; ASI = Archaeological Sites Inventory; DWI = Digital Wetland Inventory; ERIS = Environmental Risk Information Services; MMSD = Milwaukee Metropolitan Sewerage District; NHI = National Heritage Inventory; NRCS = National Resource Conservation Service; PSC = Public Service Commission; SEWRPC = Southeastern Wisconsin Regional Planning Commission; SSURGO = Soil Survey Geographic Database; USDA = United States Department of Agriculture; USGS = United State Geological Survey; WDNR = Wisconsin Department of Natural Resources; WisDOT = Wisconsin Department of Transportation

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10.4.2 Desktop Analyses

Desktop analyses were completed as part of the route studies to identify a preferred route, as well as gather information in preparation for preliminary design. Preferred routes were selected based on economic and non-economic evaluations as well as stakeholder feedback received during public Open House Meetings held within each municipality the preferred route traversed. The desktop analyses are listed below. Refer to the Draft Route Study: Oak Creek (4-100 D1) and the Draft Route Study: Milwaukee (4-100 D2) for details regarding the Return Flow and Water Supply Pipelines, respectively.

Non-Economic Evaluation Criteria

- Total pipeline length
- Special crossings
- Geotechnical conditions
- Contaminated materials
- Wetlands
- Waterways
- Endangered resources
- Cultural resources
- Agricultural resources
- Maintenance of traffic requirements
- Recent and planned regional transportation projects
- Stakeholder feedback
- Real property and easement requirements
- Constructability

Economic Evaluation Criteria

- Class 4 opinions of probable construction cost (OPCCs)
- Life cycle pumping cost

10.4.3 Field Investigation

Field investigations were not performed for the development of the PDR. Field investigations are being performed for various tasks of the Program for the next phase of design, including site survey, geotechnical soil borings, contaminated materials, wetlands and waterways, cultural resources, endangered resources, and agricultural resources investigations. These investigations are described in detail within this section.

Site Survey: The site survey is being conducted within corridors and proposed permanent easements along the pipelines. The Plat of Survey and Alta Survey for easements will be provided to WWU upon completion. The topographic survey data will be incorporated into the design of the horizontal and vertical alignments of the pipelines.

Geotechnical: The geotechnical field investigations are being conducted and consist of soil borings at increments of approximately 1,000 feet to a minimum depth equivalent to two pipeline diameters below the planned invert elevation. Additional borings are being taken at the beginning and/or ending points of select special crossings. The investigations will provide information on the suitability of soils for pipeline appurtenances and structures and will be considered in the design. Geotechnical field investigation tasks include the following items:

- Soil samples (and water samples, if applicable) for corrosion parameters testing.

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- Soil samples to test for hazardous materials to determine if soil is clean or contaminated.
- Standard Penetration Test (SPT) borings drilled to 25-feet below grade (or shallower where bedrock is encountered) and a temporary piezometer and in-situ falling head permeability test every mile, sealed with bentonite if conditions require and plugged with grout.
- Pavement borings at approximately one-mile increments to determine thickness of pavement and subgrade.
- Seasonal high groundwater level will be determined at approximately one-mile increments.
- Soil environmental parameter analysis for corrosion control investigations at approximately 2,000-foot intervals, consisting of sulfate, chloride, pH, redox potential and conductivity.
- Compaction testing on suitable soils to be used for trench backfill.

Findings from the geotechnical field investigations will be reviewed, and pipeline design will coordinate with the findings from the geotechnical investigations. The findings will be used to constrain dewatering, pipeline construction, trenching, and trench safety information.

Contaminated Materials: The contaminated materials investigation is being completed in conjunction with the geotechnical field work. A focused Phase II Environmental Audit is being performed along the pipeline alignments to identify the extent of impacts from known or likely sources of contamination that could affect the design, construction costs for remediation, Program schedule, and/or any other aspect needed for due diligence. Contaminated materials sampling is being coordinated with geotechnical investigations.

Wetlands and Waterways: Field investigations for wetland and waterways are being conducted along the pipelines to confirm findings from the desktop analyses. Wetland delineations are being performed to verify mapped and photo interpreted wetlands along the corridors of the pipelines and within proposed permanent easements. The horizontal alignments will be further developed in design to avoid wetland impacts to the extent feasible.

Endangered Resources: Field investigations for endangered resources are being conducted along the pipelines to confirm findings from desktop analyses. The presence of endangered resources in proximity to the pipelines could dictate time of year constraints for construction, pipeline horizontal alignments, and/or work space areas near sensitive areas.

Cultural Resources: A Phase I Archaeological Survey is being conducted in areas where prior Phase I Archaeological surveys have not been conducted for anticipated land disturbing activities associated with the Program. The proposed archaeological survey is being performed in accordance with survey requirements for regulatory compliance and the standards for archaeological survey as outlined in the Guide for Public Archaeology in Wisconsin. The fieldwork is being conducted during favorable weather conditions, which includes absence of snow, frozen ground, saturated soils, or similar conditions that would restrict or prohibit the digging of soil pits and screening of soils.

If prehistoric or pre-modern historic period artifacts are recovered, or if there is other evidence of an archaeological site, standard procedures will be followed to gather preliminary information on size of site, location, and, if possible, cultural affiliation. The locations and limits of any archaeological site will be recorded, and a measured sketch map will be produced showing the location of all finds. The finds will be photographed, and general notes will be taken concerning site location and condition. Global positioning system (GPS) readings will also be taken for each site.

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Following archaeological fieldwork, any artifacts or materials that are recovered and removed from the field context will be returned for processing. The artifact collections will be cleaned and catalogued, and, along with accompanying data, studied to determine site age, nature, and site integrity. Based on this information and the results of background research, recommendations will be made concerning the potential NRHP eligibility and appropriate treatment for each resource that is necessary.

Agricultural Resources: The corridors anticipated to be utilized by the pipelines may contain wooded tracts of land, residential or commercial areas, or agricultural fields. Surface collection is being employed within any agricultural field sites at five meter intervals as recommended in the Guide for Public Archaeology in Wisconsin, as long as ground visibility is greater than 25%. Note that the industry standard is to utilize metric units for some of the dimensions used for field investigations. Shovel testing is being used in areas where the ground surface is obscured by vegetation. It is anticipated that the majority of the identified sites will require shovel testing. Shovel tests would be conducted at 15-meter intervals. Each shovel test will consist of a hand-dug hole about 35 centimeters in diameter excavated to a subsoil that is devoid of cultural artifacts, usually not greater than 45-centimeters deep. All removed soil will be screened through quarter-inch mesh hardware cloth for uniform artifact recovery.

10.4.4 Utility Coordination

Utility coordination was initiated as part of preliminary design. Known utilities within corridors and proposed permanent easements of the pipelines are summarized in Table 10-2.

Table 10-2 Utility Source Descriptions

Utility	Description
ANR Pipeline	Gas
AT&T Distribution	Telecommunications/Fiber Optic
AT&T Transmission	Telecommunications/Fiber Optic
City of Franklin	Sanitary, storm, and water
City of Milwaukee	Storm, traffic signals, and water
City of Muskego	Sanitary, storm, and water
City of New Berlin	Sanitary and water
City of Waukesha	Sanitary, storm, and water
City of West Allis	Sanitary, storm, and water
Level 3 Communications	Telecommunications/Fiber Optic
Midwest Fiber Network	Telecommunications/Fiber Optic
Milwaukee County DPW	Traffic Signals
Milwaukee Metropolitan Sewerage District	Sanitary and gas
New Berlin Utility	Sanitary, storm, and water
Sprint Nextel	Telecommunications/Fiber Optic
TDS Metrocom	Telecommunications/Fiber Optic
Time Warner Cable	Telecommunications/Fiber Optic
Waukesha County DPW	Traffic signals
We Energies	Traffic signals, Electric, and gas
West Shore Pipe Line	Petroleum
Windstream	Telecommunications/Fiber Optic
WisDOT	Equipment and storm

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A standard utility coordination process is being followed for the pipelines within right-of-way corridors and proposed permanent easements to identify the presence and locations of existing utilities. The process is summarized below.

1. A design ticket, which is a form to request as-built information from utilities, was submitted to the third party utility communication firm, Diggers Hotline. A list of utility companies was received that may have utilities in proximity to the Water Supply and Return Flow Pipelines.
2. Route location maps and utility information requests were sent to the utilities listed on the design ticket from Step 1 (certified mail, return receipt requested) to supply as-built drawing information of the respective utility. The information has been stored in a Program Information database and logged to confirm all required utilities along the pipelines have been properly identified. If these utilities do not reply, they will be re-contacted. Utilities typically respond with general or approximate locations for their specific utilities.
3. In the development of base plan sheets, general locations will be documented from Step 2 and merged with utility information received from the surveyor during field investigations.
4. It is possible that the as-built information supplied by utilities will be inaccurate due to misidentified utilities or outdated as-built information. Thus, after 60% plans are developed, the plans will be shared with the utility companies with a request to mark their utilities on the plan sheets. The design will be updated as necessary to coordinate with existing utilities.
5. Subsurface Utility Engineering (SUE) will be performed to obtain X, Y, and Z coordinates of critical vertical crossings identified in Step 4, and the vertical alignment will be updated as necessary. SUE will be utilized during design where the pipelines are crossing utilities without manholes, vaults, or any structure that can be utilized to interpret the given utility's vertical alignment. SUE is typically performed by a contractor or surveyor by excavating a small hole via a vacuum truck.

10.4.5 Typical Sections

Typical sections of the pipelines were developed from review of applicable municipal and state standards and previous experience in Southeast Wisconsin as described in the Draft Route Study: Oak Creek (4-100 D1) and the Draft Route Study: Milwaukee (4-100 D2). Typical sections were used to evaluate whether right-of-way corridors and space constrained areas would be capable of accommodating the pipelines. The typical sections are provided in Appendix E, Drawing Sheet CP3 for pipelines located within and beyond the Common Corridor, or corridors containing both the Water Supply and Return Flow Pipelines.

10.4.6 Preliminary Horizontal Alignments

Preliminary horizontal alignments were developed in both the Draft Route Study: Oak Creek (4-100 D1) and the Draft Route Study: Milwaukee (4-100 D2) to support determining the preferred route for both the Water Supply and Return Flow Pipelines. The preliminary horizontal alignments are included in Appendix E, Drawing Sets CP2 and CP5 and include minor refinements that have been completed as the design continues to evolve.

The design assumptions included in this PDR are based on the preferred routes recommended by the respective route studies. As design progresses from the preliminary horizontal alignments established in the route studies (and as shown in this PDR) through design, the pipeline alignments will be modified based on newly acquired field information. Factors that will affect alignment include, but are not limited to the following:

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- Updated OPCCs
- Updated overall system hydraulics
- Constructability including schedule, sequence and duration
- Limits of construction relative to roads, traffic and other factors
- Existing utilities based on field surveys
- Right-of-way lines and property lines based on field surveys
- Wetland delineations based on field surveys
- Subsurface conditions based on geotechnical field investigations
- Areas of contaminated soils based on field investigations
- Easement acquisition

The above factors will influence both the horizontal and vertical alignments of the pipeline, including establishing locations of horizontal and vertical fittings, areas of pipe curvature, depth of bury, and where alignments will be located within or outside of pavement. This, in turn, will influence the exact locations, lengths, and depths of special crossings, the number of pipeline appurtenances required such as isolation valves, air valves, and blow-off assemblies, special backfill material such as flowable fill under pavement, and the available limits of construction. The factors will also influence design aspects of the pipelines such as pressure class, lengths of restrained joints, the need for bonded joints, specialized gaskets, and special corrosion protection requirements.

Efforts will be made as design progresses to:

1. Utilize pipe curvature or deflected pipe joints (in both the horizontal and vertical alignments) in lieu of fittings as it improves hydraulics, eliminates the cost of the fittings, and reduces the overall length of restrained joints required. This includes replacing pipe jogs that may currently be shown on the horizontal alignments using dual 45 degree bends with pipe curvature and deflected pipe joints.
2. Minimize depth of pipeline cover where possible to minimize construction costs, while meeting the requirements for depth of bury.
3. Balance the number of pipeline high points (ARVs) and low points (blow-off facilities) as it relates to cost associated with appurtenance costs, additional excavation costs, and maintenance costs.
4. Minimize the number and overall length of special crossings, specifically across roads at “non-intersections” to minimize construction cost and reduce overall construction schedule. A balance will be established between designing special crossings at 90 degree angles to roads to minimize the overall length of the special crossing versus the hydraulic benefits of crossing at a 45 degree angle. The cost for the required restrained joints for the different options will also be considered.
5. Minimize the number of special crossings across waterways by working with the permitting agency to allow open-cut crossings where possible.
6. Strategically locate special crossing pits to minimize disruption to traffic and local stakeholders and to minimize unnecessary fittings and or pipe deflections associated with the pit locations.
7. Balance the length of pipeline within pavement areas versus outside of pavement areas to minimize costs related to special backfill requirements and pavement restoration versus utility conflicts, wetland encroachment, and constrained work areas.

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10.4.7 Surface Restoration

Surface restoration will occur throughout the length of the Water Supply and Return Flow Pipelines for grading and drainage, sidewalks, landscaping, and pavement. In general, the surface will be restored to existing conditions per the requirements of the given jurisdiction. Each municipality traversed by the Water Supply and Return Flow Pipelines has different requirements for surface restoration.

- Grading and Drainage: All disturbed areas will be replaced to existing grade or improved to promote drainage as required. If areas of poor drainage are discovered during design, discussions with the municipality stakeholders will take place to determine the appropriate course of action.
- Sidewalks: Municipal standards will be followed in segments along the Water Supply and Return Flow Pipelines where sidewalks will be restored.
- Landscaping: Municipal standards will be followed in segments along the Water Supply and Return Flow Pipelines where landscaping will be disturbed. Where practical, landscaping strategies that eliminate the need for pesticides and fertilizers and that minimize the need for irrigation will be incorporated.
- Pavement: The governing municipal standards will be followed in segments along the Water Supply and Return Flow Pipelines where pavement will be restored. Materials with high solar reflectance will be provided where practical.
- Protection of Slopes and Existing Structures and Foundations: In areas where slopes are impacted either on or adjacent to work being completed, construction will follow the procedures outlined in Section 10.8. Design of the pipelines will utilize adequate distances and practices from the existing structures and foundations so as to not disturb existing structures during construction.

10.4.8 Trenchless Requirements

Where the pipelines will cross a waterway, major roadway, or railroad, a special crossing will be required. Preliminary horizontal alignments have been developed as part of this PDR using special crossing design standards and previous construction experience in Southeast Wisconsin. Two trenchless construction methods have been considered in preliminary design, which include the jack and bore and horizontal directional drilling (HDD) methods. These methods are being utilized based on the capabilities of each process, which are described below.

- The jack and bore method is completed by inserting a casing pipe through the earth with hydraulic jacks, which are typically positioned at the rear of an auger machine. The jack and bore method is completed from a bore pit where installation begins and a receiving pit where installation ends. Once the casing pipe is installed, a carrier pipe is installed inside the casing pipe. This method is unguided to line and grade unless a steering head is used. The jack and bore method is typically used to avoid traffic disruptions at the surface or provide structural support to on-grade facilities such as railroads. The bore length is typically between 100 and 300 feet. For preliminary design, the jack and bore method has been used to cross highways, larger roads, and railroads.
- HDD is a method of soil drilling that is steerable and completed in a two-stage process. The HDD machine is typically setup on the ground surface with an inclined carriage adjusted to an angle between five and 20 degrees with the ground. The process begins with a pilot bore with drilling rods, which have a diameter ranging from one to five inches. The second step involves enlarging the pilot hole by back reaming to the correct diameter, which may require multiple passes with different size back reamers. The pilot hole is typically reamed to a diameter one and a half times larger than the pipe to ensure the pipe can be pulled into place without causing large frictional forces that could lead to collapse of the bore hole. The pipe is installed once the back reaming process

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is complete. Work space for this method will also be required on both ends of the trenchless crossing. HDD is used when there are long lengths of pipe being installed that is beyond the capacity of the jack and bore method. For preliminary design, HDD has been selected to cross certain streams, rivers, and wetlands to reduce impacts to these natural resources. Design will consider the cost-effective use of the jack and bore method for shorter waterway crossings.

Design standards were reviewed for municipalities where trenchless construction is anticipated. Local municipalities do not have explicit regulations on special crossings. Thus, the Wisconsin Administrative Code NR 811.76 for surface water crossings and Wisconsin Administrative Code NR 811.77 for common casing crossings underneath highways were utilized, along with WisDOT and Canadian National standards. Refer to the Draft Route Study: Oak Creek (4-100 D1) and the Draft Route Study: Milwaukee (4-100 D2) for a summary of applicable standards and summary tables of anticipated special crossings, including the trenchless crossing method, crossing and location, permit requirements, and potential schedule implications. Refer to the Appendix E, Drawing Set CP2 and CP5 for sheets of the preliminary horizontal alignments that demonstrate the anticipated locations of the trenchless construction.

10.5 Structural

10.5.1 Design Criteria

The pipelines will be designed in accordance with the Wisconsin Specifications for Water and Sewer Construction and Wisconsin Administrative Code NR 811. Pipeline rated pressures will be in excess of those anticipated through steady state and transient hydraulic modeling. The materials of construction, backfill and bedding requirements, and manholes and vaults are described below.

10.5.2 Materials of Construction

Structural support for pipeline appurtenances will be comprised of concrete. Vaults and manholes would be comprised of either pre-cast or reinforced concrete. Recycled materials will be used where practical.

10.5.3 Bedding and Backfill Requirements

To provide adequate support for all pipe materials the pipe will be laid on a layer of, and backfilled with, pipe bedding material. Pipe bedding material is defined as gravel, crushed stone, limestone screenings, or other granular or similar material as approved that can be readily and thoroughly compacted to 95% of the maximum dry density obtainable by American Society for Testing and Materials (ASTM) D 1557. The pipe bedding will be installed six to 12 inches below the pipe invert and 12 inches above and on either side of the pipe for any pipe material as described in Section 10.4.5. Pipe bedding may be further evaluated during design taking into account the specific pipe material selected and the specific loads applied. Bedding and backfill will be placed in accordance with the Wisconsin Specifications for Water and Sewer Construction.

Pipe laying will occur in dewatered trenches with a stable bottom. If unsuitable soil is discovered at the trench bottom, the unsuitable material will be removed and replaced with pipe bedding material. The amount of this additional excavation will depend on recommendations from the geotechnical investigations.

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10.5.4 Manholes and Vaults

The manholes required for air release or vacuum release valves will be precast concrete. Precast concrete manholes are economical and commonly used in the industry. They are designed by the precast supplier to meet the more stringent loading requirements of the structure being placed in the roadway regardless of location. A concrete pad will be required for the larger diameter manholes. Smaller manholes are generally provided with a solid bottom base piece. The soil bearing under a manhole is generally less than 1,000 pounds per square foot (psf) with the full truck tire loading. Pipeline structures will be designed for a minimum 100 psf surcharge. If geotechnical testing shows the soil to be inadequate for the low applied pressure, soil improvement methods may be required. Structures located under the roadway will be designed for an American Association of State Highway and Transportation Officials (AASHTO) HS-20 truck loading surcharge. Manhole rims will be designed to support the weight of a dual wheel AASHTO HS-20 truck.

10.6 Process Mechanical

Process mechanical features of the Water Supply and Return Flow Pipelines have been defined to a preliminary design level. These features include pipeline materials, corrosion control, pipeline sizes (i.e. nominal diameters), and appurtenances. The following sections describe the method used in developing the preliminary design of process mechanical features of the Water Supply and Return Flow Pipelines.

A summary of the basis of design is presented in Table 10-3.

Table 10-3 Water Supply and Return Flow Pipelines Basis of Design

Description	Design Values
Water Supply Flow Rate	
Minimum Hour Demand, MGD	1.2
Minimum Day Demand, MGD	3.1
Average Day Demand, MGD	8.2
Maximum Day Demand, MGD	13.6
Peak Hour Demand, MGD	19.0
Water Supply Pipeline	
Material	Ductile Iron or Steel Pipe
Diameter, inches	30 and/or 36
Maximum Steady State Design Pressure, psig	225
Minimum Design Pressure, psig	35
Minimum Depth of Cover, feet	6'-6"
Return Flow Rate	
Minimum Hour, MGD	0.0
Initial Average Day, MGD	6.6
Future Average Day, MGD	8.2
Maximum Hour, MGD	12.0

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Description	Design Values
Return Flow Pipeline	
Material	Ductile Iron, Steel Pipe, or PCCP
Diameter, inches	30
Design Capacity, MGD	13.6
Installed Capacity, MGD	20.1
Maximum Steady State Design Pressure, psig	225
Minimum Depth of Cover, feet	6'-6"
Valves	
Isolation Valve	
Type	Butterfly Valve
Installation	Direct-bury, except where vaults are required by regulations
Air Release	
Type	ARV, Combination AVR/ARV, Combination AVR/ARV with Surge Check
Flushing	
Type	Blow-off Assembly
Pipeline Connection	Rolled Tee
Special Crossings	
Wetlands and Waterways	HDD
Roads, Highways, or Railroads	Jack and Bore Method

10.6.1 Assumptions and Criteria

10.6.1.1 Water Supply System

Assumptions and criteria have been used for the water supply system to support the preliminary design of the Water Supply Pipeline as follows:

- MWW Distribution System
  - The connection to MWW's distribution system will be located near 60th Street and Morgan Avenue.
- Water Supply Pipeline, Owned by MWW
  - MWW will own and operate the upstream two miles of pipeline.
  - The portion of pipeline to be owned by MWW will be constructed of Class 55 Ductile Iron Pipe (DIP).
  - MWW distribution system pressures are within the allowable operating pressure of Class 55 DIP.
  - The minimum steady state design pressure is 35 pounds per square inch (psi) which exceeds the minimum allowable steady state pressure of 20 psi per the PSC, Subchapter VIII – Operating Requirements, PSC 185.82 – Pressure Standards and the WDNR, Subchapter NR 811.70 – Water Main Design.

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  - A maximum velocity of seven feet per second (fps) is desirable for preliminary pipeline sizing to maintain head losses within reasonable tolerance and conserve energy during normal operations.

- WSPS
  - The firm capacity of the WSPS will be 15 million gallons per day (MGD) as determined in coordination with MWW.
  - The WSPS will be located southwest of the intersection of 68th Street and Morgan Avenue.
  - MWW will be capable of conveying the firm capacity of the WSPS.
- Water Supply Pipeline, Owned by WWU
  - WWU will own and operate the Water Supply Pipeline, except the first approximately 2.8-mile portion owned and operated by MWW.
  - 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 non-standard, more robust valves, which would increase cost and complexity of design.
  - The minimum steady state design pressure is 35 psi which exceeds the minimum allowable steady state pressure of 20 psi per the PSC, Subchapter VIII – Operating Requirements, PSC 185.82 – Pressure Standards and the WDNR, Subchapter NR 811.70 – Water Main Design.
  - A maximum velocity of seven fps is desirable for preliminary pipeline sizing to maintain head losses within reasonable tolerance and conserve energy during normal operations.
  - Minor friction losses, or head losses due to entry and exits, valves, bends, and fittings have not been factored into design calculations at this time. Further hydraulic calculations will be completed during design as the horizontal and vertical alignments are set.
  - Hydraulic transients will be evaluated separately in design to confirm operating conditions when a vertical alignment has been developed and has not been considered as part of this PDR.
- Water Reservoirs / BPS
  - The water reservoirs and BPS will be located on Parcel NBC 1224994 owned by the Waukesha County Department of Parks and Land Use as discussed during the Water Supply Facilities Site Selection Meeting (6-100 M-04) held on May 23, 2017 and the BPS Site and Building Meeting (6-200 M-01) held on June 29, 2017 with WWU.
  - The BPS will operate to meet the diurnal demand of Waukesha.
  - The water reservoirs and BPS operational configuration is shown in Figure 10-4 as discussed during the BPS Operation and Discharge Pipeline Evaluation Meeting (6-100 M-07) held on August 2, 2017 with WWU. Flow will be conveyed from the WSPS to a Pressure Sustaining Valve (PSV) upstream of an air break in the water reservoirs. The PSV will maintain a minimum pressure of 35 psi in the Water Supply Pipeline upstream of the water reservoirs. The BPS will draw from the water reservoirs and provide the head necessary to supply WWU's distribution system.
  - Hunter Tower is an existing elevated storage tank located near Sunset Drive in WWU's Southeast Pressure Zone. The BPS will operate based on levels in the Hunter Tower to maintain pressures higher than 35 psi in the Water Supply Pipeline downstream of the BPS as discussed during the Distribution System Hydraulic Model Meeting (5-100 M-04) held on October 13, 2017 with WWU. A spur from the Water Supply Pipeline

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on Guthrie Drive will be utilized to facilitate the connection to an existing 16-inch water main that is hydraulically connected to Hunter Tower. Improvements required to the 16-inch water main to accommodate the new connection will be determined in design.

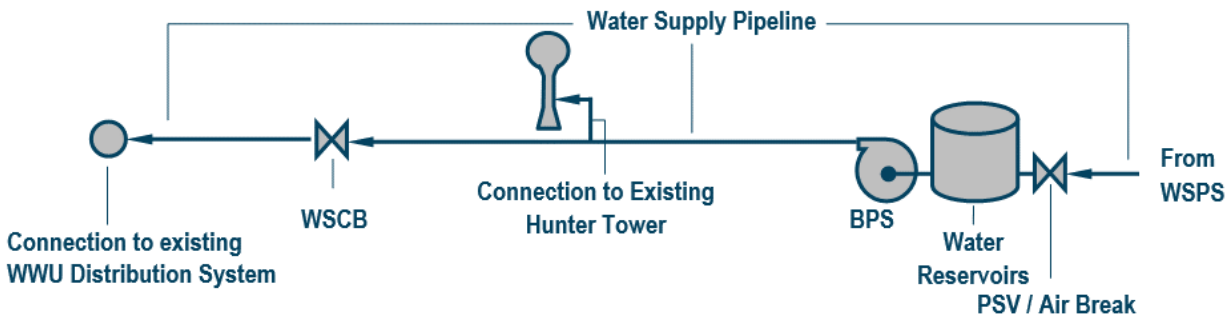

Figure 10-4 Water Supply System Diagram, Water Reservoirs to Waukesha Water Utility Distribution System Connection

- Water Supply Control Building (WSCB)
  - The WSCB will be located on Parcel WAKC 1349999 owned by WWU on the northwest quadrant of the intersection of Sunset Drive and Les Paul Parkway, as per the Distribution System Hydraulic Model Meeting (5-100 M-04) held on October 13, 2017 with WWU. The WSCB is shown in Figure 10-4.
  - The WSCB will house pressure reducing valves (PRVs). The PRVs will reduce pressures in the Water Supply Pipeline to within a desirable range for WWU's distribution system.
- WWU Existing Distribution System
  - The Water Supply Pipeline will connect to WWU's existing distribution system near the intersection of Sunset Drive and Les Paul Parkway at a 24-inch trunk main as discussed during the Distribution System Hydraulic Model Meeting (5-100 M-04) held on October 13, 2017 with WWU.

10.6.1.2 Return Flow System

Assumptions and criteria have been used for the return flow system to support the preliminary design of the Return Flow Pipeline as follows:

- RFPS
  - The discharge to the Root River via the Return Flow Pipeline will be located on Parcel 9489998001 at the southeast corner of the intersection of 60th Street and Oakwood Road in the City of Franklin.
  - Flows conveyed to Waukesha through the Water Supply Pipeline will be offset by an equal discharge to the Root River through the Return Flow Pipeline. Preliminary scenarios for managing the return flow to the Root River relative to diurnal flow variations of the CWP and for managing a preliminary minimum flow of CWP effluent to the Fox River have been used to select a tentative RFPS flow range of 2 to 12 MGD.
  - The RFPS will be located north of the Ultraviolet (UV) Disinfection Facility at the CWP per the Waukesha Department of Public Works plan set titled Wastewater Treatment Plant Improvements, Phase II and dated January 2, 2015.
  - The hydraulic horsepower (hp) required by the pumps at the RFPS shall not exceed 400 hp.

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- Return Flow Pipeline
  - 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 non-standard, 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 Global High Point, Great Lakes Surface Water Divide, between the RFPS and the Root River, and a force / gravity main downstream of the Global High Point. The Return Flow Pipeline will be designed with the ability to transition entirely to a force main in the future.
  - A maximum velocity of seven fps 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 have not been factored into design calculations at this time. Further hydraulic calculations will be completed during design as the horizontal and vertical alignments are set.
  - Hydraulic transients will be evaluated separately in design to confirm operating conditions when a vertical alignment has been developed and has not been considered as part of this PDR.
- Return Flow Facilities
  - An air break is required above the 100-year flood elevation of the Root River to reduce the potential for hydraulic connection between the return flow system and the Root River.
  - The 100-year flood elevation of the Root River at the point of discharge is 682.20 feet per the Federal Emergency Management Agency (FEMA) Flood Insurance Study No. 55079CV004A.

Hydraulic conditions will be updated based on the final Return Flow Management Plan and will continue to be refined and coordinated with facility design in Task 6 of the Program.

10.6.2 Pipeline Material Evaluation

Pipeline materials were evaluated for the Water Supply and Return Flow Pipelines based on economic and non-economic evaluated criteria and to identify the preferred pipeline materials for further consideration in design. The following five pipeline materials were evaluated:

- DIP
- Steel Pipe
- Pre-stressed Concrete Cylinder Pipe (PCCP)
- Polyvinyl Chloride (PVC) Pipe
- High-Density Polyethylene (HDPE) Pipe

The following subsections present an overview of the pipeline material alternatives, advantages and disadvantages, and preferred pipeline materials identified in preliminary design. Note that this evaluation does not apply for the portion of Water Supply Pipeline that will be owned and operated by MWW, which will be comprised of Class 55 DIP.

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10.6.2.1 Material Regulations

The following regulations were assessed during the pipeline material evaluation.

- Wisconsin Department of Natural Resources (WDNR NR811)
- Recommended Standards for Water Works and Wastewater Facilities, Part 8 for Water Works and Chapter 30 for Wastewater Facilities (Ten States Standards)
- Standard Specifications for Sewer and Water Construction in Wisconsin, Part III, IV, and VIII, Sixth Edition (WI Standard Specifications)
- Specifications for Water Main and Service Lateral Materials and the Installation of Water Main and Appurtenances for Waukesha Water Utility, Chapter 4, 5, and 6, 2014 (WWU Specifications)

Table 10-4 displays the pipeline materials included in each regulatory entity's requirements. An "X" denotes the given entity accepts use of the material.

Table 10-4 Material Regulatory Requirements

Regulations and Guidance Documents	DIP	Steel Pipe	PCCP	HDPE Pipe	PVC Pipe
WDNR NR 811	X	X	X	X	X
Ten States Standards	X	X	X	X	X
WI Standard Specifications	X	X	X	X	X
WWU Specifications	X			X	

WWU specifies either DIP or HDPE pipe for water main with nominal diameters of 16 inches and larger, while the other regulations and guidance documents also allow the use of steel pipe, PCCP, HDPE pipe, or PVC pipe. Pipeline materials were discussed during the Preliminary Design Meeting: Pipeline Materials, Isolation Valves, and Energy Recovery (4-300 M-01) held on June 28, 2017. It was determined that DIP, steel pipe, PCCP, HDPE pipe, and PVC pipe would be evaluated to determine the preferred pipeline materials for the Water Supply and Return Flow Pipelines. The following subsections review and compare each of the materials for the purposes of identifying preferred pipeline materials for consideration in design.

10.6.2.2 Ductile Iron Pipe

DIP is commonly used for pressurized potable water main in Southeast Wisconsin. DIP is typically available in nominal diameters ranging from four to 64 inches. Ductile iron bends, tees, and miscellaneous fittings in this size range are readily available. Open-cut methods are common for DIP installation, but DIP can be used in trenchless construction via the jack and bore method or HDD. HDD lengths are limited based on pipeline size and weight. DIP is resistant to temperature changes and has relatively high tensile and compressive strengths. DIP is an effective material for providing structural resistance to impacts and shocks caused by live loads (such as surface traffic) or pressure fluctuations due to variable flows during operations. DIP joints can either be restrained or unrestrained. Both restrained and unrestrained joints are typically push-on joints, which allow faster installation. DIP is more amenable to tapping in comparison to PCCP and HDPE pipe. Comparatively, DIP and has a higher roughness coefficient than materials such as HDPE pipe, which increases headloss and pumping power requirements. The material is less susceptible to deformation during freight, storage, and installation. Maintenance savings are anticipated in

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comparison to composite materials, such as PCCP, where repairs can be more complex. WWU and local contractors have more familiarity with DIP than other materials.

Due to DIP's predominantly metallic composition, corrosion protection is typically required to extend the materials life. Industry standard corrosion protection is polyethylene encasement. Polyethylene encasement slows the rate of corrosion by providing a barrier between oxygen-rich environments and the pipe. A properly encased pipe provides a barrier for the transport of oxygen from the ambient, oxygen-rich soil and groundwater, thereby limiting oxidation (i.e. corrosion) to the amount of oxygen in the annular space between the polyethylene wrap and the pipe wall after installation. If encasement is poorly applied in the field, localized corrosion may occur. Adverse soil conditions may require additional corrosion protection measures to provide for a longer service life. When DIP is installed in proximity to other utilities with impressed current cathodic protection systems or adjacent to electrical transmission power lines, additional corrosion protection would be required relative to non-metallic materials. DIP has the potential to bleed power from nearby electrical lines, and utilities have charged for power losses in some instances. Refer to Section 10.6.3.2 for corrosion control considerations for DIP.

Table 10-5 summarizes the advantages and disadvantages of DIP.

Table 10-5 Advantages and Disadvantages of DIP

Advantages	Disadvantages
• Resistant to impacts and shocks • Push-on restrained and unrestrained joints available • High tensile strength • Amenable to future connections or taps • Less susceptible to deformation during freight, storage and installation • WWU familiarity with material and preferred by most contractors • Multiple manufacturers provide competitive pricing	• Corrosion protection required • Industry standard corrosion protection (polyethylene encasement) mitigates corrosion (does not eliminate corrosion) • Additional corrosion protection may be required in areas with other cathodically-protected utilities, adverse soil conditions, or stray electrical currents • Potential to bleed power from electrical grid near electrical lines • Higher roughness coefficient creates higher headloss and increases pumping power requirements • Increased bedding requirements which increases installation cost

10.6.2.3 Steel Pipe

Spiral-welded steel pipe (steel pipe) is commonly used in large diameter pipeline applications. Steel pipe is available in nominal diameters from six inches to over 120 inches. Steel pipe unrestrained joints are typically rubber gasket push-on joints, while restrained joints are lap-welded. Lap-welded joints require a longer installation time and a greater effort in quality control and quality assurance than joints of other materials that are assembled with mechanically locking restraints. Some contractors prefer to only weld steel pipe joints and not use any rubber gasket joints in larger diameter steel pipe application to expedite installation. Open-cut methods are common for steel pipe installation, but steel pipe can accommodate trenchless construction with the jack and bore method or HDD. HDD with steel pipe typically allows longer lengths as compared to other materials because of the high tensile strength of steel pipe and that the pipe segments can be welded together. Steel pipe is available in up to 50-foot lengths, which can decreases the number of joints and minimize potential joint failure points. Comparatively, Steel pipe and has a

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higher roughness coefficient than materials such as HDPE pipe, which increases headloss and pumping power requirements. Steel pipe is resistant to temperature changes and has high tensile and compressive strengths. Maintenance savings are anticipated in relation to composite materials, such as PCCP, where repairs may be more challenging to address. Steel pipe is more amenable to tapping compared to PCCP and HDPE pipe.

Due to steel pipes predominantly metallic composition, corrosion control is required. Bonded coatings and bonded joints with cathodic protection are the industry standard for corrosion control. When steel pipe is installed in proximity to other utilities with impressed current cathodic protection systems or adjacent to electrical transmission power lines, additional corrosion protection may be required relative to non-metallic materials. Steel pipe has the potential to bleed power from nearby electrical lines, and utilities have charged for power losses in some instances. The advantages of the longer lay lengths available may not be useful in urban environments where there are many existing utilities. In addition, the material requires additional care during transportation, storage, and installation due to its minimal pipe thickness. Steel pipe is not commonly installed in Southeast Wisconsin and local contractors may not be familiar with installation practices and standards. Refer to Section 10.6.3.3 for corrosion control considerations for steel pipe.

Table 10-6 summarizes the advantages and disadvantages of steel pipe.

Table 10-6 Advantages and Disadvantages of Steel Pipe

Advantages	Disadvantages
• Material cost • High tensile strength • Resistant to temperature changes • Multiple manufacturers provide competitive pricing • Commonly used for larger transmission main projects • Availability in 50-foot lengths for fewer joints and expedited installation • Push-on unrestrained joints available	• Corrosion protection via bonded coatings, bonded joints and cathodic protection required • Potential to bleed power from electrical grid near electrical lines • Advantage of longer laying lengths may not be useable in urban environments • Higher roughness coefficient creates higher headloss and increases pumping power requirements • Increased bedding requirements which increases installation cost • Additional care during transportation • Unfamiliarity by contractors

10.6.2.4 Pre-Stressed Concrete Cylinder Pipe

PCCP is composed of a concrete core, a thin steel cylinder, steel pre-stressing wire, and a mortar coating. PCCP is commonly available from 16- to 46-inch nominal diameter pipe and has been historically used for transmission main material. PCCP is installed with a spigot ring gasket and can only be installed utilizing open-cut and jack and bore methods. Joints for PCCP can either be restrained or unrestrained. Both restrained and unrestrained joints are typically push-on joints, which allow faster installation. With high compressive strength, PCCP can provide structural resistance to impacts and shocks caused by live loads (such as surface traffic) or pressure fluctuations due to variable flows during operations. Comparatively, PCCP pipe and has a higher roughness coefficient than materials such as HDPE pipe, which increases headloss and pumping power requirements. Unlike DIP and steel pipe, PCCP has a non-ferrous outer material which can decrease the potential for corrosion and therefore does not require external secondary corrosion protection.

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Because PCCP relies on a composite of materials for strength, it requires care in manufacturing and installation. Installation time is longer than DIP because joints are typically coated with cement mortar in the field. Tapping into PCCP can be difficult as special care is required to maintain tension in the severed pre-stressed wires and to seal against the steel cylinder. Unlike metallic pipeline materials, breaks in PCCP can be catastrophic and can rupture. If deemed necessary based on soil conditions, corrosion control for PCCP can include polyethylene encasement or cathodic protection. Refer to Section 10.6.3.4 for corrosion control considerations for PCCP.

Table 10-7 indicates the advantages and disadvantages of PCCP.

Table 10-7 Advantages and Disadvantages of PCCP

Advantages	Disadvantages
• Material cost • Push-on restrained and unrestrained joints available • Historically used for transmission main material • Can accommodate high pressures and urban alignments to avoid obstacles • Does not generally require additional external corrosion protection barrier (polyethylene encasement) • Minimal bedding requirements which reduces installation cost	• Longer installation time than DIP • More difficult to repair or implement connections/tapping after installation • Composite material requires additional care/effort during design and installation • Less desirable failure mode than metallic pipelines (rupture vs. leaks) • Higher roughness coefficient creates higher headloss and increases pumping power requirements

10.6.2.5 High-Density Polyethylene Pipe

HDPE pipe is a high density polyethylene thermoplastic pipe constructed from petroleum. HDPE is becoming a more popular material throughout the industry, especially in trenchless installations or highly corrosive soils. HDPE pipe is commonly used in pressurized water applications. HDPE pipe is virtually inert and inherently corrosion resistant, requiring no additional coatings or linings in areas of corrosive soils or stray currents, but may not be an appropriate material for soils that are contaminated with materials that can degrade HDPE pipe. Due to its composition, HDPE pipe does not pose risk of bleeding power from an electrical utility in proximity to power lines. HDPE pipe is smoother than DIP, PCCP, and steel pipe and has a low roughness coefficient, which reduces headloss and decreases pumping power requirements. Joints for HDPE pipe are butt fusion welded, which inherently restrains every joint, making the material attractive for use in HDD. Due to its flexibility, HDPE pipe may require fewer fittings than other pipe materials.

Compared to other materials, HDPE pipe is more susceptible to becoming overstressed due to surges, earthwork, shifting soils, or live loads, which can decrease its lifespan. HDPE pipe is also more buoyant than other pipe materials and can be susceptible to upheaval in areas with high groundwater tables, if sufficient cover is not provided. Most municipal maintenance staff are also not commonly trained to heat fuse joints and, therefore, this material is not as common for open cut installations where future connections or repairs may be required. Because HDPE pipe is non-metallic, certain common pipeline locating methods are not feasible and therefore, requires a tracer wire to be installed concurrently in order for the HDPE pipe to be locatable. HDPE pipe is also less amenable to tapping for future connections.

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HDPE pipe is commonly available with nominal diameters ranging from four to 48 inches, but size availability varies based on the pressure rating required. Due to the required thickness of HDPE pipe walls to reach the required pressure ratings, plastic pipe, such as HDPE pipe, have pressure rating classes based on their dimension ratio (DR), where DR is the ratio of the outside diameter (OD) to the pipe minimum wall thickness. Therefore, higher DRs have lower pressure ratings compared to lower DRs. HDPE pipe's inner diameter (ID) is smaller in comparison to other materials for the same nominal diameter which increases the pumping requirements to pump the same amount of flow. HDPE pipe is normally specified as Ductile Iron Pipe Size (DIPS), where the HDPE pipe OD matches the DIP OD. Using DIP ODs allow convenient connections to ductile iron fittings and valves. However, DIPS HDPE pipe is not available in the DR9 (250 psi) wall thickness above 24-inch nominal diameter, but is available in DR11 (200 psi) wall thickness through 36-inch nominal diameter. HDPE pipe is available with ODs equivalent to steel pipe, known as Iron Pipe Size (IPS), in a DR9 thickness in 30- through 36-inch nominal diameter and in DR11 wall thickness through 42-inches. Table 10-8 summarizes the available DIPS and IPS for HDPE pipe.

Table 10-8 HDPE Pipe Thickness and Pressure Ratings for DIPS and IPS

Nominal Diameter (inch)	250 psi (DR 9)		200 psi (DR 11)	
	Minimum Wall Thickness (inch)	Average ID (inch)	Minimum Wall Thickness (inch)	Average ID (inch)
DIPS				
24	2.87	19.72	2.35	20.83
30	Not Available	Not Available	2.91	25.83
36	Not Available	Not Available	3.48	30.92
42	Not Available	Not Available	Not Available	Not Available
IPS				
24	2.67	18.35	2.18	19.34
30	3.35	22.93	2.73	24.22
36	4.00	27.52	3.27	29.06
42	Not Available	Not Available	3.82	33.91

Table 10-9 summarizes the advantages and disadvantages of HDPE pipe.

Table 10-9 Advantages and Disadvantages of HDPE Pipe

Advantages	Disadvantages
• Low surface roughness coefficient • Inert to corrosion • All fused joints, which are inherently restrained • High strength-to-weight ratio, but lower overall strength than DIP, Steel pipe, and PCCP • May require fewer fittings, flexible • Lower leakage risks • Excellent option for trenchless installation • Durable	• Small ID to OD ratio • WWU unfamiliar with maintenance techniques • Buoyancy concern in areas of high water table • Requires tracer wires to be locatable • Fluctuating loads and pressures can reduce lifespan (long-term yield) • Increased bedding requirements which increases installation cost

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10.6.2.6 Polyvinyl Chloride Pipe

PVC pipe is a plasticized, synthetic material. This pipe typically has bell and spigot gasketed joints and can be installed with unrestrained and restrained joints, either by open-cut or trenchless methods. Unrestrained joints for PVC pipe are push-on joints, which allow for faster installation compared to HDPE pipe. Restrained joints above 24 inches require external mechanical restrained joints such as mega-lug. PVC pipe is resistant to corrosion and chemical degradation by acids, alkalis, salt solutions, and other chemicals, but susceptible to degradation by polar solvents such as ketones and aromatics. The interior of PVC pipe is smoother than DIP, PCCP, and steel pipe and has a lower roughness coefficient, similar to HDPE pipe. Open-cut methods are common for PVC pipe installation, but it can accommodate trenchless construction with the jack and bore method or HDD using fused PVC joints. Fusible PVC pipe would be typically used for HDD segments but is not recommended given the high pressures along the pipeline. It is easier to tap PVC pipe compared to PCCP and HDPE pipe. PVC pipe material costs are competitive with DIP but vary based on the petroleum market.

Similar to HDPE pipe, PVC pipe is more buoyant than other pipe materials and can be susceptible to upheaval in elevated groundwater conditions. PVC pipe requires exterior joint restraints for thrust control, which are subject to corrosion, but are available with coatings and can be encased in polyethylene sheeting. PVC pipe typically uses ductile iron fittings, which also require corrosion protection. As a result of its elasticity, PVC pipe has demonstrated long-term yield and decreased lifespan due to fluctuating load or pressure conditions, as well as valve and pumping operations. Because PVC pipe is non-metallic, certain common pipeline locating methods are not feasible and therefore, requires a tracer wire to be installed concurrently in order for the PVC pipe to be locatable. In comparison to HDPE pipe, PVC pipe is more rigid and is, thus, more susceptible to become overstressed due to live loads such as traffic. PVC pipe bell and spigot have allowable leakage, similar to DIP.

PVC pipe is typically available in nominal diameters ranging from six to 48 inches, but available sizes may vary based on pressure ratings similar to HDPE pipe. Due to the required thickness of PVC pipe walls per pressure ratings, PVC pipe's ID is smaller for the anticipated OD in comparison to DIP, but larger than the ID for HDPE pipe. The lower roughness coefficient leads to very similar capacities to that of DIP for same size comparisons. Table 10-10 shows the upper limit of available pipe sizes. Similar to HDPE pipe for DIPS, there is no 250 psi rated PVC pipe with an ID greater than or equal to 30-inches nominal diameter. PVC ODs are provided as DIPS to allow for convenient connections to ductile iron fittings and valves

Table 10-10 PVC Pipe Thickness and Pressure Ratings

	235 psi (DR 18)		200 psi (DR 21)	
Nominal Diameter (inch)	Minimum Wall Thickness (inch)	Average ID (inch)	Minimum Wall Thickness (inch)	Average ID (inch)
24	1.4	22.8	1.2	23.2
30	1.8	28.3	1.5	28.8
36	Not Available	Not Available	1.8	34.4
42	Not Available	Not Available	Not Available	Not Available

Table 10-11 summarizes the advantages and disadvantages of PVC pipe.

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Table 10-11 Advantages and Disadvantages of PVC Pipe

Advantages	Disadvantages
• Low surface roughness coefficient • High abrasion and chemical resistance (internal and external) • Fast installation rate • Lightweight	• External devices required for joint restraint • Buoyancy concern in areas of high water table • Requires tracer wire to be locatable • Not available with high pressure ratings of above 235 psi at larger pipe diameters

10.6.2.7 Hydraulic Analysis of Pipeline Materials

A hydraulic analysis was performed to evaluate the feasibility of using each material along the length of the Water Supply and Return Flow Pipelines based on the sizes and pressure ratings available. Refer to Sections 10.6.4.3 and 10.6.5 for a more detailed analysis of pipeline sizing and steady state operation conditions for the water supply and return flow systems.

Four pipeline nominal diameters were included for the comparison, including 24-, 30-, 36-, and 42-inch pipe. Pipeline IDs for each material accounted for interior linings that are anticipated for each material, where DIP and steel pipe require cement-mortar linings. Table 10-12 provides an overview of the average IDs for each material per pressure rating and nominal diameter.

Table 10-12 Pipeline Material Inner Diameter (ID)

Pipeline Material	Pressure Rating (psi)	Average ID per Nominal Diameter (inches)			
		24	30	36	42
DIP	250	24.81	30.91	37.11	Not applicable
Steel Pipe	250	24.00	30.00	36.00	
PCCP	250	24.00	30.00	36.00	
HPDE Pipe	200	19.37	24.22	29.06	33.91
	250	18.35	22.93	27.52	Not available
PVC Pipe	200	23.20	28.80	34.40	
	235	22.80	28.30	Not available	

Steady state hydraulics were modeled through the pipelines using Hazen-Williams roughness coefficients (i.e., "C" values) recommended by manufacturers of each material as summarized in Table 10-13.

Table 10-13 Hazen-Williams Roughness Coefficients (C) for Pipeline Materials

Pipeline Material	Hazen Williams,C[1]
DIP	140
Steel Pipe	140
PCCP	140
HPDE Pipe	150
PVC Pipe	150[2]

Notes:
1. C as reported by December 2016 *Hydraulic Analysis of Ductile Iron Pipe* by DIPRA, Table 2 except where otherwise noted.

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2. DIPRA reported C values of 155-165. C value of 150 used based on engineering judgment.

Hydraulics through aged pipeline materials as well as minor losses have were not considered for the purpose of comparing pipeline materials. The hydraulic analysis of pipeline materials are discussed in the following subsections for the Water Supply and Return Flow Pipelines.

10.6.2.7.1 Water Supply Pipeline

Hydraulics related to pipeline materials for the Water Supply Pipeline was evaluated from the WSPS to the BPS, which is the segment of Water Supply Pipeline anticipated to have the maximum steady state modeled pressures due to its higher static head and longer pipeline length. The horizontal alignment of the Water Supply Pipeline was built into an InfoWater model of the water supply system, and model runs were simulated for each pipeline material. The WSPS was simulated at a throughput of 15 MGD and pressures were maintained above the minimum steady state design pressure of 35 psi.

To determine the feasibility of materials limited by size at higher pressure ratings, HDPE and PVC pipes were modeled at the largest diameter associated with the maximum rated pressure available for each material. This included a 36-inch nominal diameter HDPE pipe rated at 250 psi and a 30-inch nominal diameter PVC pipe rated at 235 psi. Pipe material nominal pipe size and ID are shown in the title of each plot. DIP, steel pipe, and PCCP were modeled at the average ID for 36-inch nominal diameters rated as shown in
Table 10-12 for 250 psi for comparison with HDPE and PVC pipes.

Steady state hydraulic grade lines (HGLs) and pressure profiles are shown in Figure 10-5 for the materials evaluated. Steel pipe and PCCP are shown on the same graph since their IDs and C values are equivalent. As shown, each material evaluated for the given pipe size has a pressure class available to deliver the maximum throughput anticipated of 15 MGD. The higher head loss observed in HDPE and PVC is attributed to the smaller IDs associated with these materials.

10.6.2.7.2 Return Flow Pipeline

Hydraulics for pipeline materials for the Return Flow Pipeline was evaluated from the RFPS to the Return Flow Facilities. The horizontal alignment of the Return Flow Pipeline was built into an InfoWater model of the return flow system and scenarios were created for each pipeline material. The RFPS was simulated at a throughput of 13.6 MGD to encompass the range of maximum flows anticipated pending finalization of the Return Flow Management Plan. In order to simulate the maximum foreseeable pressure within the Return Flow Pipeline, a scenario for operating the pipeline as a force main was created. A control valve upstream of the Outfall was modulated to maintain a pressure pipeline.

Due to the lower flow and head requirements anticipated for the Return Flow Pipeline, 30-inch nominal diameter pipelines have been preliminarily modeled for all materials evaluated. The rated pressures for all pipelines were kept at 250 psi for this evaluation, except for PVC pipe that has a maximum rated pressure of 235 psi available.

Steady state HGLs and pressure profiles are shown in Figure 10-6 for the materials evaluated. DIP, steel pipe, PCCP, HPDE and PVC pipe are all within rated pressures at a 30-inch nominal diameter. HDPE pipe exceeds the maximum rated pressure available for that material. The higher head loss is attributed to the smaller IDs associated with these materials. Thus, HDPE pipe would require a larger pipe size than the other materials.

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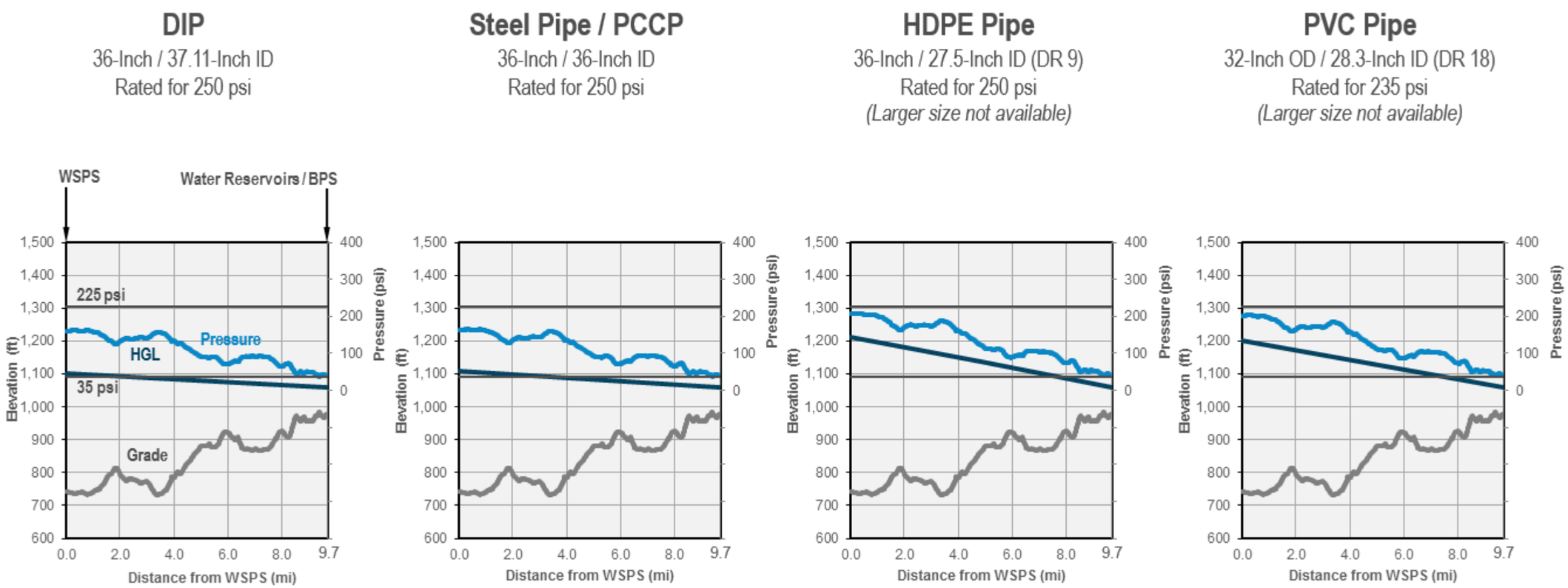


Figure 10-5 Water Supply Pipeline, Modeled HGLs, and Pressures per Pipeline Material

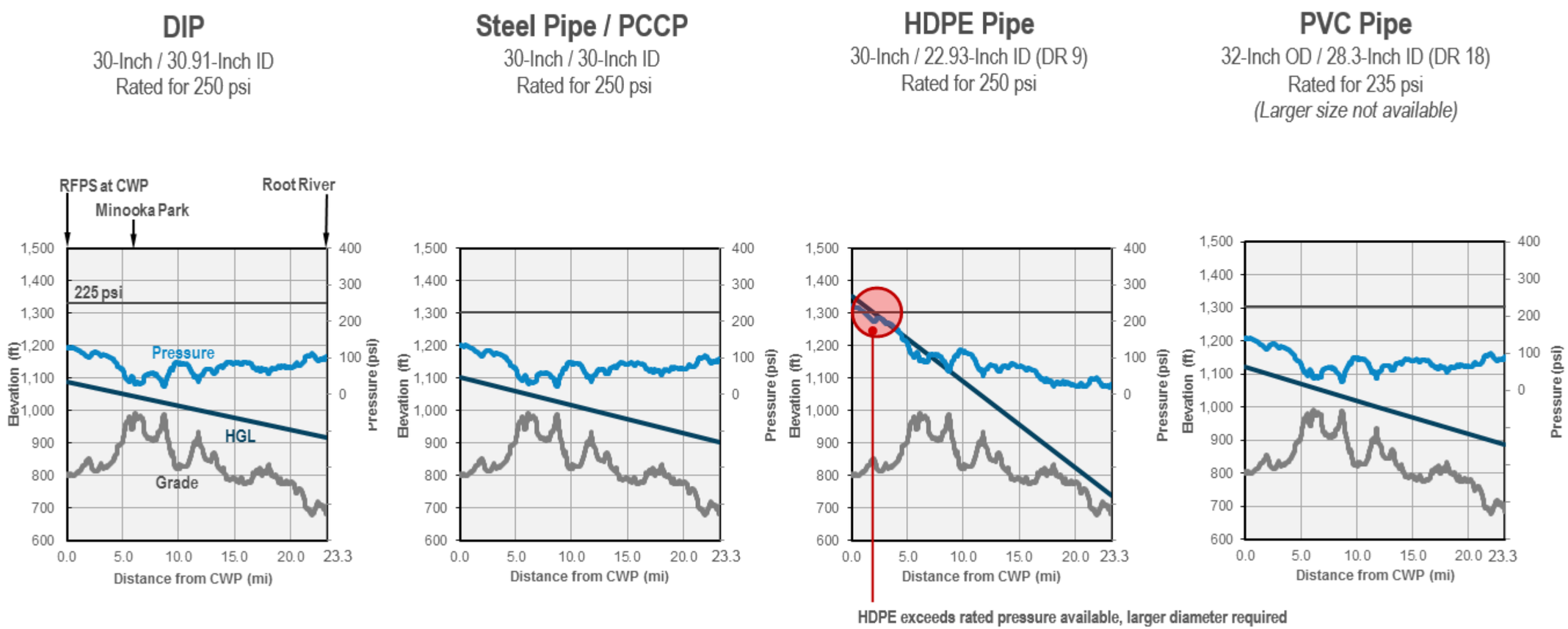


Figure 10-6 Return Flow Pipeline, Modeled HGLs, and Pressures per Pipeline Material

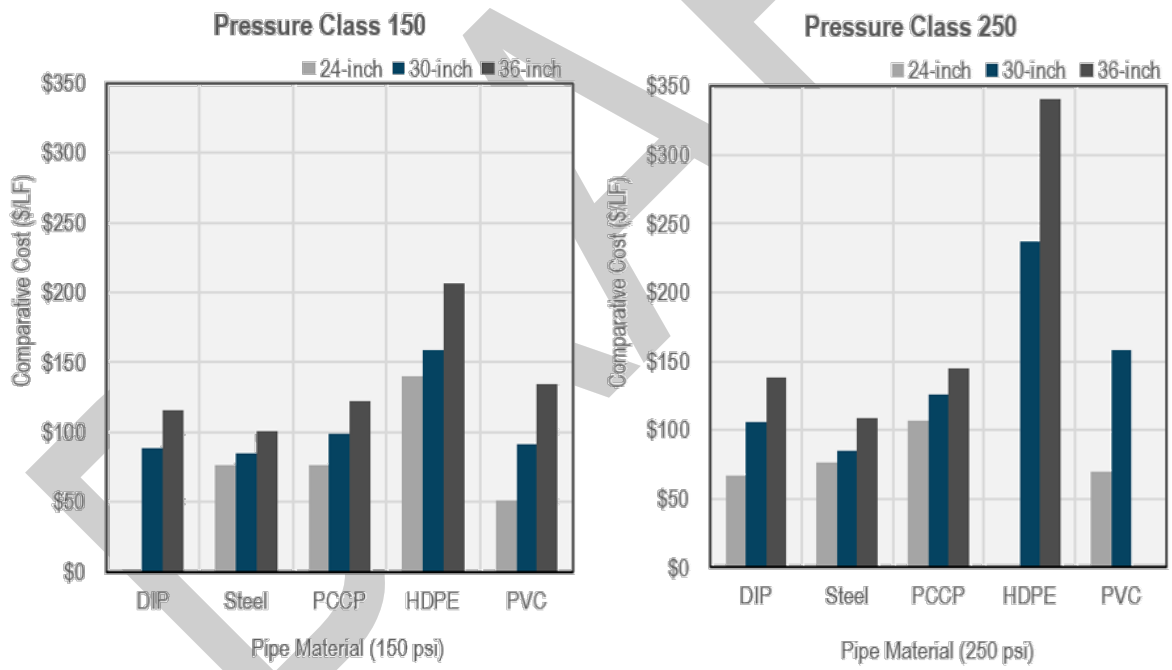
10.6.2.8 Evaluation of Pipeline Materials

Pipeline materials have been evaluated on the basis of an array of economic and non-economic evaluation criteria as discussed in the above and following subsections.

10.6.2.8.1 Economic Evaluation

Raw pipe material costs were gathered for economic evaluation from local vendors and suppliers such as McWane Ductile, American Cast Iron Pipe Company, US Pipe, HD Supply, Northwest Pipe Company, and Forterra. Raw pipe material costs do not include installation, but include transportation to the job site. From the hydraulic analysis of pipeline materials, pressure ratings between 150 and 250 psi and nominal diameters of 24, 30, and 36 inches are in the range of the maximum steady state pressures anticipated for the Water Supply and Return Flow Pipelines. Therefore, costs were acquired for pipeline materials at nominal diameters of 24, 30, and 36 inches rated for 150 and 250 psi, with the exception of PVC pipe, which is available with a maximum rating of 235 psi. Costs for PVC were acquired for available nominal diameters of PVC at a pressure rating of 235 psi.

The material costs are summarized in the graphs on Figure 10-7. Design will consider value engineering of pipeline rated pressures, which will be confirmed with transient modeling.



Notes:
1. DIP cost estimates from McWane Ductile and American Cast Iron Pipe Company
2. Steel pipe cost estimates from American Cast Iron Pipe Company and Northwest Pipe Company
3. PCCP pipe cost estimate from Forterra
4. HDPE Pipe cost estimates from HD Supply
5. PVC Pipe cost estimate from HD Supply.
6. Data unavailable for 24-inch HDPE at 250 pressure class, 24-inch DIP at 150 psi pressure class, and 36-inch PVC at 250 psi pressure class

Figure 10-7 Pipeline Material Economic Evaluation

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As shown, HDPE is more expensive than DIP, steel pipe, and PCCP at the pressure ratings required for the Water Supply and Return Flow Pipelines. PVC is more expensive than DIP, steel pipe and PCCP at the higher pressure rating for a 30-inch pipe and is unavailable at a 36-inch pipe. This is attributed to the thicker pipe walls required for HDPE and PVC pipes to achieve higher pressure ratings. It should be noted that costs for HDPE and PVC pipe vary with the petroleum market. The petroleum market is experiencing a period of depressed prices and, therefore, prices for HDPE and PVC pipe have potential to increase relative to those shown on
Figure 10-7.

10.6.2.8.2 Non-Economic Evaluation

Pipeline materials were also compared based on an array of non-economic evaluation criteria. Non-economic evaluation criteria are characteristics or special requirements associated with each pipeline material. Although they are not assigned a cost value, these criteria are of critical importance in determining appropriate pipeline materials.

Table 10-14 shows a summary of the non-economic evaluation for the pipeline materials.

Table 10-14 Pipeline Material Non-Economic Evaluation Criteria Evaluation

Criteria	Pipeline Material Alternatives				
	DIP	Steel Pipe	PCCP	HDPE Pipe	PVC Pipe
Product Availability	Yes	Yes	Yes	No High Pressure Class	
Rate of Installation	Faster	Moderate	Slower	Moderate	Faster
Average Length of Pipe (ft)	18 to 20	20 to 40	16 to 20	Varies	18 to 20
Open Cut / HDD Deflection	Moderate	Moderate	Moderate	Higher	Moderate
Available Construction Methods(1)	Open Cut/HDD	Open Cut/HDD	Open Cut	Open Cut/HDD	Open Cut
Level of Maintenance	Moderate	Moderate	Lower	Lowest	Lowest
Mode of Failure	Leak	Leak	Rupture	Joint Failure	Crack
Ease of Tapping	Yes	Yes	No	No	Yes
Surface Roughness	Moderate	Moderate	Moderate	Lower	Lower
Material Thickness for 250 psi	Thinner	Thinnest	Standard	Very thick	Thicker
Industry Standard Corrosion Protection	Polywrap	Exterior Coat, Bonded Joints, Cathodic Protection	None or Polywrap	Corrosion Resistant	
WWU Specifications	Yes	No	No	Yes	No

Notes:
All materials can be installed via the jack and bore method.

The non-economic evaluation criteria have each been assigned a score from one (to represent a less favorable alternative for the established criteria) to three (to represent a more favorable alternative for the established criteria). The resulting scores have been compiled to produce a total score for each material. Materials with the higher total scores represent more preferred materials.

The non-economic evaluation criteria and scores are shown in Table 10-15. As shown, DIP scored more preferably than other materials on a non-economic basis.

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Table 10-15 Pipeline Material Non-Economic Evaluation Criteria Scoring

Criteria	Pipeline Material Alternatives				
	DIP	Steel Pipe	PCCP	HDPE	PVC Pipe
Product Availability	3	3	3	1	1
Rate of Installation	3	2	1	2	3
Average Length of Pipe	2	3	2	3	2
Open Cut / HDD Deflection	2	2	2	3	2
Available Construction Methods	3	3	2	3	2
Level of Maintenance	1	1	2	3	3
Mode of Failure	3	3	1	1	1
Ease of Tapping	3	3	1	1	3
Surface Roughness	2	2	2	3	3
Material Thickness for 250 psi	3	3	2	1	1
Corrosion Protection	2	2	2	3	3
WWU Specifications	3	1	1	3	1
Total	30	28	21	27	25

10.6.2.9 Selected Pipeline Materials

Pipeline materials were evaluated based on economic and non-economic evaluation criteria during the Preliminary Design Meeting: Pipeline Materials, Isolation Valves, and Energy Recovery (4-300 M-01) held on June 28, 2017. The following subsections review and select materials for further consideration in design.

10.6.2.9.1 Installation in Right-of-Way and Easements

The majority of the Water Supply and Return Flow Pipelines will be installed along right-of-way, with short segments installed in easements. Preliminary steady state hydraulic modeling indicates each pipe material evaluated is feasible as solo pipeline materials for the Water Supply Pipeline. HDPE, however, may require a larger nominal pipe size than other materials due to significantly thicker pipe walls restricting the ID. HDPE and PVC pipes have demonstrated decreased lifespan due to fluctuating load or pressure conditions, as well as valve and pumping operations. In terms of designing a water supply system with a 100-year useful life, HDPE and PVC pipes may fall short. In addition, WWU staff are not as familiar or readily equipped to repair HDPE pipe. Economic evaluation of pipeline materials indicate HDPE pipe has higher material costs than DIP, steel pipe, and PCCP for comparable sizes at anticipated pressure ratings required. Material costs for HDPE and PVC pipes vary with the petroleum market. The petroleum market is experiencing a period of depressed prices and, therefore, prices for HDPE and PVC pipes have the potential to increase. Considering economic and non-economic factors, HDPE and PVC pipes are not preferred materials for either the Water Supply or Return Flow Pipelines.

An ideal pipeline material would allow for quick installation performed by contractors who are familiar with the material in order to keep duration of construction and traffic disturbance to a minimum. An ideal pipeline material would also allow for quick repairs performed by personnel familiar with the material. DIP is available with push-on joints, which reduces the installation time and is also an effective material for providing structural resistance to impacts and shocks caused by live loads such as surface traffic. DIP is also less susceptible to deformation during freight, storage, and installation and, therefore, has less risk of unintended consequences caused by poor installation. Local contractors in Southeast Wisconsin have more familiarity with DIP than other pipeline materials, and WWU has indicated they have successfully operated and maintained DIP in their distribution system. Given these factors, it is recommended that design proceed with DIP for the Water Supply and Return Flow Pipelines.

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PCCP is more complicated to engineer, fabricate, install, inspect, and maintain than DIP. Although PCCP provides a similar structural integrity to DIP, PCCP's composite material provides more opportunities for failure and more consequential modes of failure that could result in longer repair times and increased maintenance concerns than DIP. Waukesha needs a long-term sustainable alternative to its existing water supply. Pipeline materials that could pose a risk to the constant delivery of water are not preferred. Considering the criticality of a sustainable water supply, PCCP is not a preferred material for the Water Supply Pipeline. However, from the economic evaluation for raw material and transportation costs to the job site, PCCP has the opportunity to be cost competitive. As discussed in Section 10.6.1.2, the preliminary design of the Return Flow Pipeline assumes that flows conveyed to Waukesha must be offset by an equal discharge to the Root River on a daily basis. The assumption provides a Return Flow Pipeline preliminary sizing that can accommodate any anticipated outcome of the Return Flow Management Plan. However, discussions with the WDNR have indicated that the quantity returned may only require to match last year's water demand on an annual basis. In this scenario, longer repair times would be less critical for the Return Flow Pipeline than the Water Supply Pipeline. Considering economic factors, it is recommended that design proceed to allow competitive bidding of PCCP for the Return Flow Pipeline.

Similar to PCCP, steel pipe requires more effort to install and inspect than DIP. WWU has less familiarity with operating and maintaining steel pipe, and local contractors have less experience installing steel pipe. From the economic evaluation of pipeline materials, steel pipe has the opportunity to be cost competitive with DIP. Steel pipe can also provide a similar installed structural integrity and service life to DIP. The fact that steel pipe is typically installed with a bonded coating, bonded joints, and cathodic protection system to prevent corrosion provides a long service life regardless of soil conditions. Although familiarity with material is desired to reduce repair time during operations, steel pipe's mode of failure is comparable to that of DIP and is anticipated to be less intensive to repair than PCCP. In addition, installation of steel pipe will provide local contractors the opportunity to become more familiar with the material for future repair scenarios. Given these factors, it is recommended that design proceed to allow competitive bidding of steel pipe for the Water Supply and Return Flow Pipelines.

10.6.2.9.2 Installation in Trenchless Crossings

The Water Supply and Return Flow Pipelines will require installation of piping in certain locations using trenchless construction. The material for these trenchless segments should be durable and provide a long service life. Where casings are jacked and bored under highways and railways, any of the selected pipe materials can be utilized. For HDD, the preferred piping material is HDPE pipe, although steel pipe or DIP can be used if it is determined that conditions preclude the use of HDPE pipe.

10.6.2.9.3 Selected Pipeline Material Summary

Pipeline materials were reviewed and evaluated for the Water Supply and Return Flow Pipelines. WWU has indicated that they have successfully installed, operated, and maintained DIP in their distribution system. Local contractors have familiarity with installing and repairing DIP. Based on this and other considerations, it is recommended design proceed for DIP. However, steel pipe and PCCP have the opportunity to foster cost competition with DIP, while HDPE pipe may be preferable for trenchless requirements installed via HDD.

It is recommended that design proceed to allow competitive bidding of the following materials:

- Water Supply Pipeline

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  - DIP
  - Steel Pipe
  - HDPE Pipe, for HDD trenchless crossings only

- Return Flow Pipeline
  - DIP
  - Steel Pipe
  - PCCP
  - HDPE Pipe, for HDD trenchless crossings only

Pipe manufacturer tours were held with representatives from the manufacturers, WWU staff, and the Program's pipeline design team. The tours held to date include the following items. Additional tours and/or meetings will be held with pipe manufacturers as design progresses.

- 4-300 M-05 McWane Ductile Iron Plant Tour, November 13, 2017
- 4-300 M-06 US Pipe Ductile Iron Plant Tour, March 7, 2018
- 4-300 M-07 American Cast Iron Pipe Co. Ductile Iron Plant Tour, March 8, 2018
- 4-300 M-08 American Cast Iron Pipe Co. Steel Plant Tour, March 9, 2018

The tours are being used to gain further knowledge regarding the pipe material fabrication, testing, and transportation processes, quality control processes, manufacturing capacity, and design recommendations. Information gained during these tours are being used to further refine the pipeline design.

10.6.3 Pipeline Corrosion Evaluation

Corrosion control alternates were evaluated for preferred pipeline materials. Pipeline corrosion is the deterioration of a pipeline material that results from an electrochemical reaction with the environment. Pipeline corrosion can occur in one of two forms: galvanic or electrolytic corrosion. Galvanic corrosion occurs where soil characteristics such as moisture, oxygen, chlorides, sulfates, pH, and soil resistivity directly impact the exterior of the pipeline. Electrolytic corrosion occurs from direct current from an outside source such as cathodically-protected gas lines by induced current or electrical transmission lines, which cross or run parallel to the pipeline. Corrosion control may consist of reducing or preventing corrosion by creating a barrier between the pipe and the corrosive environment and/or providing anodes or impressed current to protect the pipe. Generally, each material will require corrosion control, but the required systems cannot be determined until soil conditions are defined by soil borings and laboratory testing. Regulations and different types of corrosion control for each pipeline material considered for competitive bidding are presented in the following sections. Since HDPE pipe is inert and not subject to corrosion, it has not been included.

10.6.3.1 Corrosion Control Regulations

Regulations were reviewed during the pipeline corrosion control evaluation. Wisconsin Standard Specifications, Section 4.4.4 and WWU Specifications, Chapter 6.7 requires that DIP be installed with eight mil, or eight thousandths of an inch, polyethylene encasement in accordance with American Water Works Association (AWWA) C105. There are no specific regulations for corrosion control regarding steel pipe and PCCP.

10.6.3.2 DIP Corrosion Control Alternatives

There are typically four corrosion control alternatives for DIP – polyethylene encasement, zinc coating, optional bonded coating with bonded joints and monitoring, and cathodic protection that includes bonded coating and bonded joints. These alternatives are described below in the order of corrosion control each provides, starting with the least effective alternative. All alternatives include polyethylene encasement.

- Polyethylene Encasement is the industry standard for corrosion control of DIP and required for all installations per AWWA C105 and Section 4.4.4 of the Wisconsin Standard Specifications. Polyethylene encasement economically provides a significant level of corrosion control when installed correctly. Polyethylene encasement limits the amount of corrosion to the material within the annular space between the encasement and pipe wall. An enhanced polyethylene encasement, known as V-Bio, is becoming more popular in the industry as it further reduces the potential of corrosion induced by anaerobic bacteria in the annular space between the pipe wall and the encasement.
- Zinc Coating is used as a sacrificial anode and is analogous to cathodic protection. The corrosion protection consists of a zinc-based coating with the addition of a polyethylene encasement per AWWA C105 standards. The zinc coating functions as a sacrificial anode and corrodes preferentially to iron, producing zinc salts that adhere to the DIP. The corroded zinc byproducts serve as a secondary corrosion protectant.
- Optional Bonded Coating with Bonded Joints and Test Stations verifiably monitors corrosion and would allow WWU to react to corrosion occurring during operations in a targeted, cost-effective manner. In this method, the DIP could also be provided with a bonded coating to protect from corrosive soil or groundwater conditions with the addition of a polyethylene encasement per AWWA C105 standards. The pipe would be made electrically continuous by providing copper cable jumpers across each joint. Monitoring stations would be installed to allow corrosion to be tested for during operations along the pipeline so that corrosion can be cost-effectively targeted as it is observed in specific segments.
- Cathodic Protection with Bonded Coating and Bonded Joints verifiably prevents corrosion and is the most dependable corrosion control method. In this method, the DIP is provided with a bonded coating to protect from corrosive soil or groundwater conditions with the addition of a polyethylene encasement per AWWA C105 standards. The pipe is made electrically continuous by providing copper cable jumpers across each joint. The pipe is also provided with a cathodic protection system, which can be a passive magnesium anode system or an active impressed current system.

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Table 10-16 summarizes corrosion control alternatives for DIP.

Table 10-16 DIP Corrosion Control Alternatives

Polyethylene Encasement	Zinc Coating	Optional Bonded Coating with Bonded Joints and Test Stations	Cathodic Protection including Bonded Coating and Bonded Joints
• Economically provides a significant level of corrosion control when installed correctly • Corrosion protection/mitigation is not verifiable • Care required to avoid large tears or improper overlaps	• Zinc is a sacrificial anodic coating • Provides extra protection for pipe • May only slightly prolong life of pipe	• Bonded coating is optional. If Zinc was used, refer to items under "Zinc Coating". • Allows for corrosion to be cost-effectively targeted during operations.	• Verifiably prevents corrosion • Requires periodic maintenance • More expensive

10.6.3.3 Steel Pipe Corrosion Control Alternatives

There are typically three corrosion control alternatives for steel pipe: polyurethane coating, tape coating, and cathodic protection including bonded coating and bonded joints. These alternatives are described below in the order of corrosion control each provides, starting with the least effective alternative.

- Polyurethane Coating with Bonded Joints and Test Stations is commonly used for water transmission mains and provides high dielectric properties. Polyurethane coating is further detailed in AWWA C222.
- Tape Coating with Bonded Joints and Test Stations has a four layer system including one liquid adhesive layer, one corrosion protection system, and two mechanical protection layers in accordance with AWWA 214.
- Cathodic Protection with Bonded Coating and Bonded Joints verifiably prevents corrosion and is the most dependable corrosion control method. In this method, the steel pipe is provided with a polyurethane or tape wrap coating to protect the pipe from corrosive soil or water conditions. The pipe is made electrically continuous by providing copper cable jumpers across each pipe joint. The pipe is also provided with a cathodic protection system, which can be a passive magnesium anode system or an active impressed current system. This is the industry standard for buried steel pipe installation.

Table 10-17 summarizes corrosion control alternatives for steel pipe.

Table 10-17 Steel Pipe Corrosion Control Alternatives

Polyurethane Coating	Tape Coating	Cathodic Protection Including Bonded Coating and Bonded Joints
• AWWA C222 • Commonly used for water transmission mains • High dielectric properties	• AWWA 214 • Four layer system: • One liquid adhesive layer • One corrosion protection layer • Two mechanical protection layers • Minor gouges are self-healing	• Verifiably prevents corrosion • Requires periodic maintenance • Steel pipe cost estimates typically include bonded coating • More expensive

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10.6.3.4 Prestressed Concrete Cylinder Pipe Corrosion Control Alternatives

As previously stated, PCCP is only being considered for the Return Flow Pipeline. Unlike DIP and steel pipe, PCCP does not have a metallic outer surface; therefore, corrosive soils may not impact the outer layer of PCCP in the same manner as it would impact the outer metallic surface of DIP and steel pipe. Unless the soil conditions are corrosive to concrete, PCCP typically does not require corrosion protection. Because of the low cost and added protection, PCCP is often specified with polyethylene encasement. If soil conditions are such that monitoring of the pipeline is recommended, the pipeline may be made electrically continuous by bonding the joints and test stations may be installed. This will facilitate future installation of cathodic protection if monitoring shows deterioration of the prestressing wires in the pipe. These alternatives are described below.

- Polyethylene Encasement economically provides a level of corrosion control when installed correctly.
- Bonded Joints and Test Stations would be installed if recommended based on soil conditions, so that the pipe could be monitored and easily retrofitted with cathodic protection in the future. This would likely be limited to certain areas based on soil conditions.

Table 10-18 summarizes corrosion control alternatives for PCCP.

Table 10-18 PCCP Corrosion Control Alternatives

Polyethylene Encasement	Test Stations and Bonded Joints
• Economically provides a significant level of corrosion control when installed correctly • Corrosion protection/mitigation is not verifiable • Care required to avoid large tears or improper overlaps	• Facilitates corrosion monitoring of the pipe • Facilitates future retrofit of cathodic protection • More expensive

10.6.3.5 Cathodic Protection

There are two types of cathodic protection: galvanic anodes and impressed current. Galvanic (or sacrificial) anodes is a passive system where buried anodes create a galvanic cell with soil that generates current to protect the pipeline by having a natural potential that is more negative than the pipeline. Since the anodes are not connected to a power source, they need to be replaced over the lifetime of the pipe depending on soil conditions. Sacrificial anodes are commonly used in the water and sewer industry. Table 10-19 summarizes advantages and disadvantages of sacrificial anodes.

Table 10-19 Sacrificial Anodes Overview

Advantages	Disadvantages
• Does not require external power source • Less liable to cause interaction with neighboring facilities • Engineered to specific applications • Protection can be verified • Potentially lower capital cost than impressed current when cathodic protection is used over shorter lengths of pipeline, such as utility crossings	• Sacrificial anodes and/or wiring may need to be replaced over pipe lifetime depending on soil conditions (15- to 40-year average) • Industry standard is to monitor system every five years and make repairs if necessary

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Impressed current is similar to sacrificial anodes, but applies current to the pipeline via electronic devices powered by the electric utility, typically a direct current (DC) power source. The power source generates large potential differences enabling more current to flow to the pipeline being protected. Impressed current is used in applications where the potential difference between the sacrificial anode and pipeline is not enough to generate sufficient current for cathodic protection to occur. Impressed current is commonly used in the gas and petroleum markets, particularity in rural applications, and has been used on long transmission mains. Table 10-20 further discusses the advantages and disadvantages of impressed current.

Table 10-20 Impressed Current Overview

Advantages	Disadvantages
• Fewer anodes are needed compared to sacrificial anode protection • Potentially lower capital cost than sacrificial anodes for large projects where cathodic protection is used along the entire pipeline • Can be remotely monitored with suitable communications infrastructure • Adjustable output to variations in soil conditions over time • Engineered to specific applications	• Electrical source required • Rectifiers will require replacement (50 year average) • Anode lifetime is typically 50 years

10.6.3.6 Monitoring Corrosion

If cathodic protection is required for the pipeline, then test stations will be provided to facilitate monitoring corrosion activity throughout the pipeline. Test stations can be installed without cathodic protection to monitor corrosion that may develop along the pipeline after start-up to target segments of the pipe, thereby cost-effectively managing corrosion. Test stations are typically located approximately every 1,000 feet. Additional stations may be needed at protected utility crossings. In order to perform routine testing, there must be electrical continuity throughout the pipeline via bonded joints.

10.6.3.7 Pipeline Corrosion Control Cost Analysis

A cost evaluation for corrosion control alternatives was performed for DIP, steel pipe, and PCCP. Table 10-21 shows the installed pipe cost. Installed costs were estimated for 36-inch nominal diameter pipe rated at 250 psi in an urban area. Pipe material costs, excluding labor and equipment cost for installation, were provided by McWane Ductile, American Cast Iron Company, Northwest Pipe Company, and Forterra.

Table 10-21 Pipe Material Installed Cost Evaluation

Pipeline Material	Estimated Cost per Unit ($/LF)
DIP	$487
Steel	$447
PCCP	$448

Notes:
1. DIP raw material cost estimates from McWane Ductile and American Cast Iron Pipe Company.
2. Steel raw material cost estimates from American Cast Iron Pipe Company and Northwest Pipe Company.
3. PCCP raw material cost estimate from Forterra.

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Table 10-22 illustrates the additional cost for each corrosion control alternative per linear foot. Costs included labor and material only. Polyethylene encasement and zinc coating cost estimates were provided by McWane Ductile and bonded coating and bonded joints with test station cost estimates were provided by Corrosion Control Inc. Raw material costs for steel pipe included bonded coatings; therefore, steel pipe's installed cost did not include additional costs for bonded coatings.

Table 10-22 Corrosion Control Alternatives Cost Evaluation

Evaluation Item	Estimated Cost ($/LF)
Polyethylene Encasement	$3.00
Zinc Coating	$16.00
Bonded Coating and Bonded Joints with Test Station	$26.00
Bonded Joints with Test Station for Steel Pipe	$4.25

Figure 10-8 evaluates the installed cost plus the corrosion control alternative for each pipeline material.

Pipeline materials were discussed during the Preliminary Design Meeting: Pipeline Appurtenances and Corrosion Protection (4-300 M-02) held on September 7, 2017 and the DuPage Water Commission Lessons Learned Meeting and Facility Tour (4-300 M-04). The type of corrosion protection for each pipeline material will be dependent on the soil conditions and will be determined in design. Corrosion monitoring of the pipelines is recommended to detect potential pipeline corrosion.

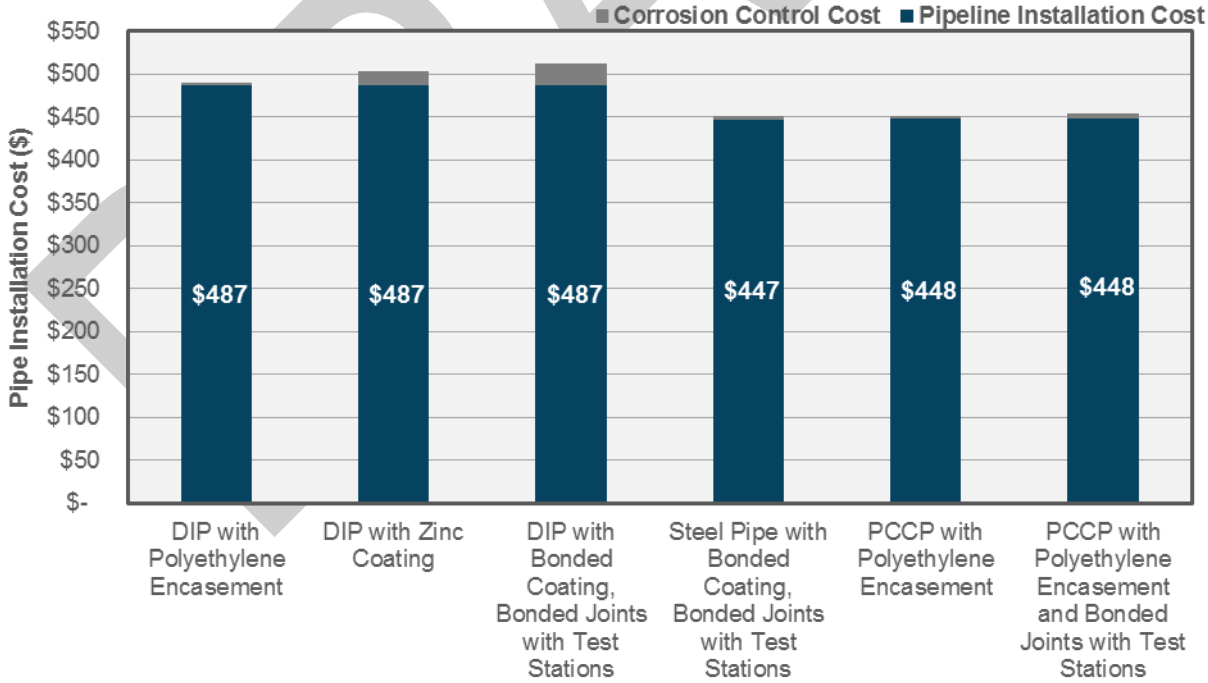

Figure 10-8 Corrosion Control Cost Evaluation

10.6.4 Roughness Coefficients

10.6.4.1 Roughness Coefficient Alternatives

Two roughness coefficients have typically been used in characterizing major head losses from flow conveyance in a pressure pipe. These include the following coefficients.

Hazen-Williams Roughness Coefficient (referred to as "C")

Darcy-Weisbach Friction Factor (referred to as "f")

The Hazen-Williams formula is typically used to model full-pipe flow, where C has been used to account for major friction losses. The Hazen-Williams formula can be expressed as:

$$Q = 1.318CR_h^{0.63}S^{0.54}A$$

in which Q is flow rate, A is conveyance area, S is the slope of the HGL, and R_h is hydraulic radius (calculated as A divided by wetted perimeter, P_w). Methods using the Hazen-Williams formula typically use a constant value for C based on the material and age of a given pipe. The Hazen-Williams formula and its use of C is analogous to Manning's formula and its use of Manning's n generally used in open channel applications.

The Darcy-Weisbach formula has typically been used to model open channel or full-pipe flow and has also been used in branches of engineering other than civil engineering. The Darcy-Weisbach formula can be expressed in terms of headloss as:

$$h_f = f\frac{L}{D_h}\frac{V^2}{2g}$$

in which h_f is major head loss, L is length, g is acceleration due to gravity, and D_h is hydraulic diameter (or, equivalently, $4R_h$). Unlike methods using Manning's or the Hazen-Williams formulae, methods using the Darcy-Weisbach formula have typically not assumed a constant value of f for a given conveyance material and age. Rather, f has been determined as a function of relative roughness (from both hydraulic diameter and absolute roughness of the conveyance material) and Reynolds Number (or Re, determined from velocity, kinematic viscosity, and hydraulic diameter). Variants of this method have used a diagram of *f versus Re* per relative roughness initially presented in the November 1944 *Friction Factors for Pipe Flow* by Lewis F. Moody or the Colebrook-White formula to determine f for the given flow condition. C and f were considered in characterizing the major head losses through the Water Supply and Return Flow Pipelines.

10.6.4.2 New and Aged Pipe

Pipeline age was evaluated to project the increase in major head losses in the Water Supply and Return Flow Pipelines over a 100-year useful life. Regulations and guidance documents typically provide a recommended value or range of values for roughness coefficients. Roughness coefficients for mains conveying either water or wastewater as provided by regulations and guidance documents and manuals of practice include the following items.

- Ten States Standards
  - Water: Recommended Standards for Water Works, 2012 Edition (Ten States Standards - Water)

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  - Wastewater: Recommended Standards for Wastewater Facilities, 2014 Edition (Ten States Standards - Wastewater)
- WDNR
  - Water: Requirements for the Operation and Design of Community Water Systems, Wisconsin Department of Natural Resources Chapter (WDNR NR 811)
  - Wastewater: Sewerage Systems, Wisconsin Department of Natural Resources Chapter (WDNR NR 110)
- State of Wisconsin
  - Water and Wastewater: Standard Specifications for Sewer and Water Construction in Wisconsin (Wisconsin Standard Specifications)
- WWU
  - Water: Specifications for Water Main and Service Lateral materials and the Installation of Water Main and Appurtenances for Waukesha Water Utility, 2014 (WWU Specifications)

From the review, it was determined that applicable regulation and guidance documents and manuals of practice all characterize roughness coefficients or ranges of roughness coefficients in the form of C for pressure pipe. Although values for C vary based on pipeline material, pipeline age, and the type of fluid being conveyed, the regulation and guidance documents and manuals of practice do not distinguish between pipeline age and material. Table 10-23 summarizes each regulations and guidance documents or manual's standard value or range of values for C.

Table 10-23 Regulations for Hazen-Williams Roughness Coefficients (C)

	Hazen-Williams Roughness Coefficient, C	
Entity/Manual	Water	Wastewater
Ten States Standards	Not Provided	120
WDNR	140	100 to 125
WI Standard Specifications	Not Provided	Not Provided
WWU Specifications	120	Not applicable

As shown in Table 10-23, the regulations and guidance provide lower C values for pipelines conveying wastewater. The Return Flow Pipeline will convey highly treated effluent with low suspended solids, organics, and nutrient contents. As a result, roughness coefficients through the Return Flow Pipeline are anticipated to be comparable to that of the Water Supply Pipeline, rather than that of a raw sewage force main.

C values provided by regulations and guidance documents and manuals of practice were compared to flow test data for pipes after years of service. A study performed by the Ductile Iron Pipe Research Association (DIPRA) titled *Cement-Mortar Linings for Ductile Iron Pipe* and dated March 2017 summarized the flow testing results performed on cement-mortar lined DIP. Preferred materials for the Water Supply and Return Flow Pipelines include DIP, steel pipe, and PCCP. All of these materials include an interior considered to have comparable C values to those observed for cement-mortar lined DIP. The pipes tested were water main located in 20 cities across the United States. The water mains ranged in nominal diameter from six to 36 inches and were in service from five to 77 years at the time of flow testing. Due to the highly treated water quality characteristics of the Return Flow Pipeline, these flow test results have been considered applicable to the Return Flow Pipeline, as well as the Water Supply Pipeline. Figure 10-9 shows the flow test results overlaid upon C values provided by regulations and guidance documents and manuals of practice for the Water Supply and Return Flow Pipelines. A trend line of flow test data as a function of the power of pipeline age was overlaid upon each figure.

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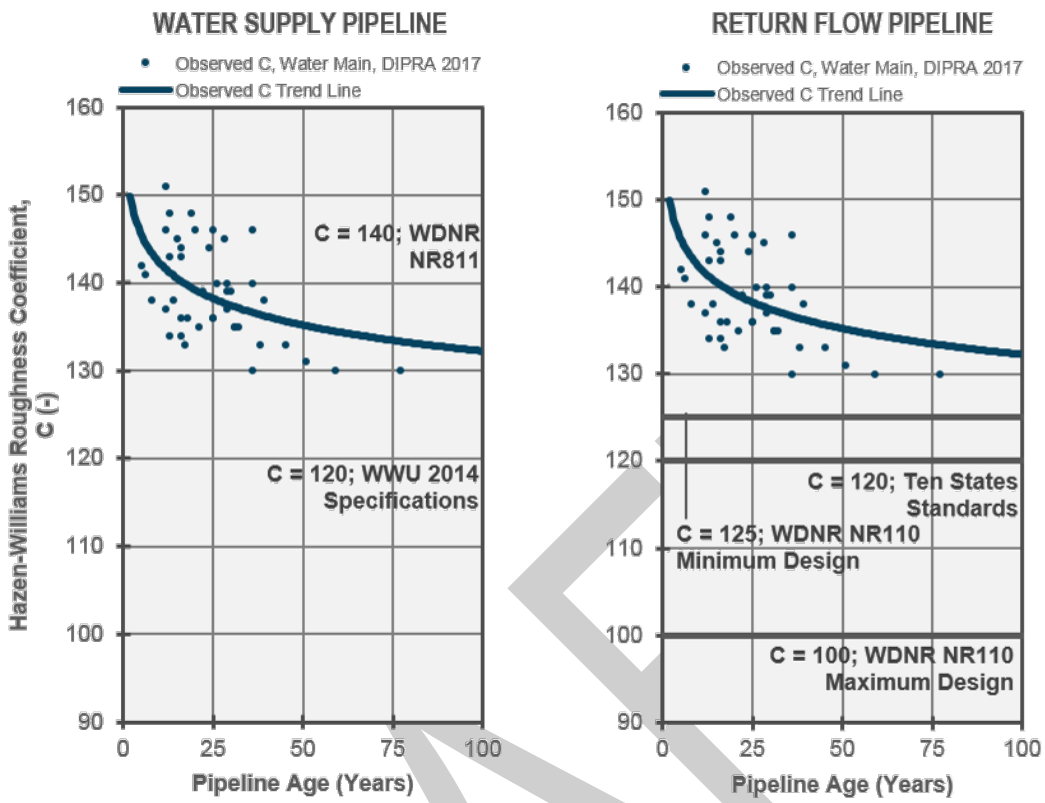

Figure 10-9 Hazen-Williams Roughness Coefficient Analysis with Pipeline Age

As shown in Figure 10-9, flow tests conducted by DIPRA on cement-mortar lined main demonstrate C values range from 150 (newer main) to 130 (older main). The trend line developed and extended through a 100-year useful life appear to approach a C value of 130. For the Water Supply Pipeline, WWU specifies a C value of 120, while NR 811 specifies a C value of 140. Many design guidelines utilize C = 140 for new water main, but that is typically for distribution system piping (i.e. 12 inches or smaller). The referenced DIPRA article calculated C values based on flow tests, where all pipe greater than or equal to 30 inches had a C value between 146 and 151. The steady state hydraulic analysis should evaluate the full range of operating conditions anticipated for the purpose of sizing the pipeline and pumping facilities. Flow testing data indicate a new pipeline could have C values as high as 150. Thus, C values of 120 and 150 have been used to characterize major head losses along the Water Supply Pipeline.

For the Return Flow Pipeline, Ten States Standards recommends a C value of 120, while WDNR NR 110 provides a range of C values from 100 to 125. It should be noted that these C values are for force mains conveying raw sewage. Given that the Return Flow Pipeline will convey highly treated effluent, C values near 100 have been determined to be unnecessarily conservative and not reflective of anticipated major head losses during the Return Flow Pipeline's useful life. The Return Flow Pipeline will convey fluid that has been anticipated to generate comparable hydraulic conditions to that of the Water Supply Pipeline. Thus, C values of 120 and 150 have been used to characterize major head losses along the Return Flow Pipeline for preliminary design. The values are within the range provided by WDNR NR 110 as well as the recommended C value by Ten States Standards.

Given the above, the following C values were used for modeling steady state hydraulics through the pipelines:

- New: C = 150, for either the Water Supply and Return Flow Pipelines
- Aged: C = 120, for either the Water Supply and Return Flow Pipelines

10.6.4.3 Roughness Coefficient Evaluation

The Hazen-Williams formula has a limited range of applicability. It is generally accepted that the Darcy-Weisbach formula, where major head loss is determined as part of the calculation method as a function of Reynolds Number and absolute roughness, is more accurate than the Hazen-Williams formula. The American Society of Civil Engineers (ASCE) November 2003 *Hydraulic Design of Large-Diameter Pipes* published in the Journal of Hydraulic Engineer noted that the use of Hazen-Williams formula "can have very detrimental effects on pipe design." The ASCE Pipelines 2011 publication titled *Common Pitfalls in Hydraulic Design of Large Diameter Pipelines: Case Studies and Good Design Practice* noted that errors using Hazen-Williams formula could exceed 40% for mains larger than 60-inches nominal diameter. Even though diameters for this Program are far smaller than 60-inches, major head losses were calculated for both the Hazen-Williams and Darcy-Weisbach formulae for the range of flows anticipated for new and aged materials along the water supply and return flow systems. The evaluation is summarized in Table 10-24.

Table 10-24 Difference in Major Head Losses (Hazen-Williams – Darcy-Weisbach)

Pipeline Segment	New Pipe (psi [ft]) C = 150, ε = 0.42 mf(1)		Aged Pipe (psi [ft]) C = 120, ε = 0.63 mf(1)	
	DIP 37.11-inch ID/ 30.91-inch ID	Steel Pipe / PCCP 36.00-inch ID/ 30.00-inch ID	DIP 37.11-inch ID/ 30.91-inch ID	Steel Pipe / PCCP 36.00-inch ID/ 30.00-inch ID
High Flows				
Water Supply Pipeline, 30-inch Nominal Diameter, 15 MGD				
WSPS to BPS	-6.2 [-14.4]	-7.5 [-17.4]	11.5 [26.7]	13 [29.9]
Water Supply Pipeline, 36-inch Nominal Diameter, 19 MGD PHD				
BPS to Waukesha	-0.6 [-1.4]	-0.8 [-1.7]	1.4 [3.3]	1.6 [3.7]
Return Flow Pipeline, 30-inch Nominal Diameter, 12 MGD (Equivalent to RFPS Firm Capacity)				
RFPS to Root River	-7.2 [-16.6]	-8.6 [-20.0]	16.3 [37.7]	18.4 [42.5]
Low Flows				
Water Supply Pipeline, 30-inch Nominal Diameter, 3.1 MGD Minimum Day Demand				
WSPS to BPS	-0.2 [-0.4]	-0.2 [-0.5]	0.8 [2.0]	1.0 [2.3]
Water Supply Pipeline, 36-inch Nominal Diameter, 1.2 MGD Minimum Hour Demand				
BPS to Waukesha	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
Return Flow Pipeline, 30-inch Nominal Diameter, 1.2 MGD (Equivalent to Minimum Hour Demand)				
RFPS to Root River	-0.1 [-0.2]	-0.1 [-0.2]	0.3 [0.7]	0.3 [0.8]

Notes:
1. *Pump Station Design* by Sanks, Section Edition, Appendix B, Table B-5
- ε = Absolute roughness, mf = millifeet

As shown, the Hazen-Williams formula provides a larger band of potential operating heads than the Darcy-Weisbach formula. The steady state hydraulic analysis should evaluate the full range of operating conditions anticipated for the purpose of sizing the pipeline and pumping facilities. C values for new and aged pipe were determined from field testing data produced by manufacturers and supported by values stipulated by regulations and guidance documents and literature. It was determined that steady state hydraulics will be modeled by using the Hazen-Williams formula.

10.6.5 Pipeline Size

10.6.5.1 Water Supply Pipeline Size, Segment 2 – WSPS to BPS

InfoWater was used to size the Water Supply Pipeline. The water supply system was configured into the InfoWater model from the WSPS to the BPS. The WSPS was operated at a throughput of 3.1 to 15.0 MGD and a PSV at the

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water reservoirs upstream of the BPS was set to maintain the minimum steady state design pressure of 35 psi. The evaluation used a C value of 120 to provide a pipeline size capable of conveying the full range of heads anticipated throughout the 100-year useful life of the Water Supply Pipeline. Three pipeline nominal diameters were evaluated, including 24, 30, and 36-inch diameters, based on maintaining pressures within an acceptable range of from 35 through 225 psi and at velocities of less than seven fps. Table 10-25 summarizes maximum steady state modeled pressures and velocities observed along the pipeline for each nominal diameter and demand condition.

Table 10-25 Water Supply Pipeline Size, Segment 2 – WSPS to BPS

Pipeline Material	Nominal Diameter (in)	ID (in)	Velocity (fps)	Major Head Loss (ft/100 ft)	Maximum Pressure (psi)
Minimum Day Demand, 3.1 MGD					
DIP	24	24.81	1.43	0.035	153
	30	30.91	0.92	0.012	148
	36	37.11	0.64	0.005	147
Steel Pipe	24	24.00	1.53	0.042	154
	30	30.00	0.98	0.014	148
	36	36.00	0.68	0.006	147
Existing Day Demand, 6.6 MGD					
DIP	24	24.81	3.04	0.140	175
	30	30.91	1.96	0.050	156
	36	37.11	1.36	0.020	150
Steel Pipe	24	24.00	3.25	0.170	181
	30	30.00	2.08	0.060	157
	36	36.00	1.44	0.020	150
ADD, 8.2 MGD					
DIP	24	24.81	3.78	0.214	191
	30	30.91	2.43	0.074	161
	36	37.11	1.69	0.030	152
Steel Pipe	24	24.00	4.04	0.252	199
	30	30.00	2.58	0.085	163
	36	36.00	1.80	0.035	153
MDD, 13.6 MGD					
DIP	24	24.81	6.27	0.547	263
	30	30.91	4.04	0.188	185
	36	37.11	2.80	0.077	161
Steel Pipe	24	24.00	6.70	0.643	284
	30	30.00	4.29	0.217	191
	36	36.00	2.98	0.089	164
WSPS Firm Capacity, 15.0 MGD					
DIP	24	24.81	6.93	0.656	287
	30	30.91	4.46	0.225	193
	36	37.11	3.10	0.092	164
Steel Pipe	24	24.00	7.40	0.771	313
	30	30.00	4.74	0.260	200
	36	36.00	3.29	0.107	168

Notes:
1. Cells shaded red are greater than the maximum steady state design pressure criterion of 225 psi or the maximum velocity of seven fps.
2. Cells shaded orange are close to the maximum steady state design pressure criterion of 225 psi or the maximum velocity of seven fps.

As shown in Table 10-25, although a 24-inch nominal diameter would be sufficient to convey the ADD for either DIP or steel pipe, the size would produce pressures in excess of the maximum steady state design pressure criterion at flows greater than the ADD that would be likely to occur over a typical year with an average demand comparable to the ADD. In consideration of the Program's vision that the Water Supply Pipeline will be designed for a 100-year useful life, a 24-inch pipeline would be insufficient.

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A 30-inch nominal diameter pipeline between the WSPS and BPS is capable of conveying the firm capacity of the WSPS within acceptable pressure and velocity limits. A 36-inch nominal diameter also can sufficiently convey the demand requirements, but would result in a higher capital investment than a 30-inch nominal diameter with no apparent benefit to WWU. As such, a 30-inch nominal diameter pipe is the more preferable size for the Water Supply Pipeline to satisfy the demand conditions approved by the Compact Council, accommodate the WSPS firm capacity, and pursue the Program's vision for designing infrastructure with a 100-year useful life. The size and maximum pressures will be confirmed in design through transient analysis.

10.6.5.2 BPS Discharge Pipeline Size, Segment 3 – BPS to WSCB

InfoWater was also used to simulate the hydraulics of the BPS Discharge Pipeline from the BPS to the WSCB. WWU's distribution system was configured into the InfoWater model for the new water supply system. The diurnal demand was extrapolated to the selected demands anticipated. The BPS was simulated by an interim pump curve capable of producing a relatively constant throughput, while existing system ground storage was utilized to dampen the peak hour demand (PHD). The modeled head and flow at the water supply connection to WWU's distribution system near the intersection of Sunset Drive and Les Paul Parkway are summarized in Table 10-26.

Table 10-26 Distribution System Modeling Results, Waukesha Connection HGL

Demand	Minimum Hour Rate		Peak Hour Rate	
(MGD)	Flow (MGD)	HGL (ft)	Flow (MGD)	HGL (ft)
3.1	1.2	991	4.3	991
6.6	2.6	991	9.2	1,004
8.2	3.3	991	11.5	1,006
10.8	4.4	991	15.0	1,015
13.6	5.4	991	19.0	1,026

Three pipeline nominal diameters were selected to size the BPS Discharge Pipeline between the BPS and WSCB, including 24-, 30- and 36-inch diameter pipe. The pipeline diameters were evaluated based on maintaining pressures within an acceptable range of 35 through 225 psi and at velocities of less seven fps. Table 10-27 summarizes maximum steady state modeled pressures and velocities observed from the BPS to WSCB for the full range of anticipated flows from the Minimum Hour Demand to the PHD. All scenarios used a C value of 120 to provide a nominal diameter that will be capable of conveying the range of flows anticipated throughout the 100-year useful life. The Minimum Hour Demand utilized Hunter Tower at its minimum level of 26.5 feet, while the PHD utilized Hunter Tower at its maximum level of 36.5 feet to represent the operating range of anticipated heads.

As shown, a 24-inch diameter pipeline would result in velocities in excess of seven fps. Thus, a 24-inch pipeline is not preferred. Both 30- and 36-inch nominal diameter pipelines result in comparable hydraulic conditions with an acceptable range for anticipated flows. A 36-inch nominal diameter pipeline would require a higher capital investment. However, the range of heads required by the system curve generated from a 30-inch pipeline is too large for a single set of pumps per available manufacturer pump curves. The BPS would likely require an additional set of pumps to satisfy higher demand conditions, such as the PHD. For these reasons, a 30-inch nominal diameter BPS Discharge Pipeline is not recommended. A 36-inch nominal diameter BPS Discharge Pipeline between the BPS and WSCB is the preferred size to accommodate the anticipated flows. The maximum pressures and pipe size will be confirmed in design through a transient analysis.

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Table 10-27 BPS Discharge Pipeline Size, Segment 3 – BPS to WSCB

Pipeline Material	Nominal Diameter (in)	ID (in)	Velocity (fps)	Major Head Loss (ft/100 ft)	Maximum Pressure (psi)	BPS Head Required (ft)
Minimum Hour Demand, 1.2 MGD						
DIP	24	24.81	0.55	0.006	114	128
	30	30.91	0.36	0.002	114	128
	36	37.11	0.25	0.001	114	128
Steel Pipe	24	24.00	0.59	0.007	114	128
	30	30.00	0.38	0.002	114	128
	36	36.00	0.26	0.001	114	128
Peak Hour Demand, 19.0 MGD						
DIP	24	24.81	8.77	1.016	109	228
	30	30.91	5.65	0.348	115	168
	36	37.11	3.92	0.143	117	149
Steel Pipe	24	24.00	9.37	1.194	115	244
	30	30.00	6.00	0.403	115	173
	36	36.00	4.17	0.166	116	151

Notes:
1. Cells shaded red are greater than the maximum steady state design pressure criterion of 225 psi or the maximum velocity of seven fps.

10.6.5.3 Water Supply Pipeline Spurs, Segments 1, 4, and 5

Three of the Water Supply Pipeline segments are comprised of spurs, including Segments 1, 4, and 5. Segment 1 will serve as the suction piping for the WSPS and, thus, was sized for the WSPS's firm capacity. Segment 4 will be located along Guthrie Road to facilitate the connection to Hunter Tower, while Segment 5 will be located downstream of the WSCB to connect to the WWU distribution system. Segments 4 and 5 are located downstream of the BPS and, thus, were sized for the PHD. The length of these segments are shorter than other segments and, thus, sizing of these spurs is based on velocity. Pipeline sizes and velocities for the PHD are summarized in Table 10-28.

Table 10-28 Water Supply Pipeline Size, Segments 1, 4, and 5 – Spurs

Pipeline Material	Nominal Diameter (in)	ID (in)	Velocity (fps)
Segment 1, WSPS Firm Capacity, 15.0 MGD			
DIP	24	24.81	6.93
	30	30.91	4.46
	36	37.11	3.10
Segments 4 and 5, Peak Hour Demand, 19.0 MGD			
DIP	24	24.81	8.77
	30	30.91	5.65
	36	37.11	3.92
Steel Pipe	24	24.00	9.37
	30	30.00	6.00
	36	36.00	4.17

Notes:
1. Cells shaded red are greater than the maximum steady state design pressure criterion of 225 psi or the maximum velocity of seven fps.
2. Cells shaded orange are close to the maximum steady state design pressure criterion of 225 psi or the maximum velocity of seven fps.

As shown, a 24-inch diameter pipeline would result in velocities in excess of seven fps for all anticipated materials for Segments 4 and 5. A 24-inch diameter pipe is also close to exceeding the seven fps velocity criterion for Segment 1.

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It was determined a 24-inch pipeline is insufficient to serve Waukesha's needs. A 30-inch diameter pipe is recommended for Segments 1, 4, and 5.

10.6.5.4 Return Flow Pipeline Size

10.6.5.4.1 Operational Alternatives

The Great Lakes Surface Water Divide serves as a Global High Point along the Water Supply and Return Flow Pipelines. The Return Flow Pipeline is required to operate as a force main upstream of the Global High Point. However, the portion of the Return Flow Pipeline downstream of the Global High Point could be operated as either a force main or gravity main. The two operational alternatives were compared to determine the most cost-effective solution. The alternatives are described below and shown in Figure 10-10 and Figure 10-11.

- Force Main: The elevation difference between the Global High Point and the discharge elevation to the Root River is much greater than the head required to convey the anticipated flows. Thus, operating the Return Flow Pipeline as a force main would allow the potential for energy recovery of the remaining static head available with hydroelectric turbines. In order to operate the Return Flow Pipeline as a force main, control valves located at the Outfall site would also be required to supplement the head loss induced by the turbines and sustain pressures in the Return Flow Pipeline downstream of the Global High Point. For the purposes of this evaluation, the control valves and turbines would be located in an above grade structure, referred to as the Return Flow Control Building (RFCB) at the Outfall site.
- Force / Gravity Main: Operating the Return Flow Pipeline as a gravity main would not require the RFCB. The operational configuration would preclude energy recovery.

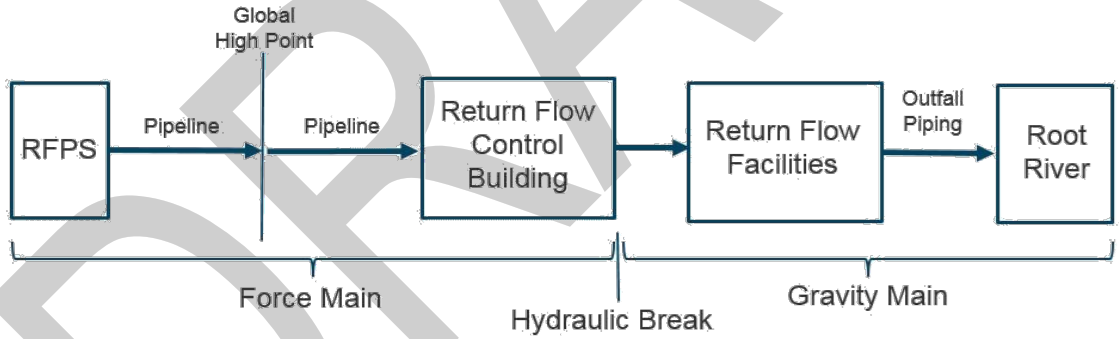

Figure 10-10 Return Flow Pipeline Operated as a Force Main

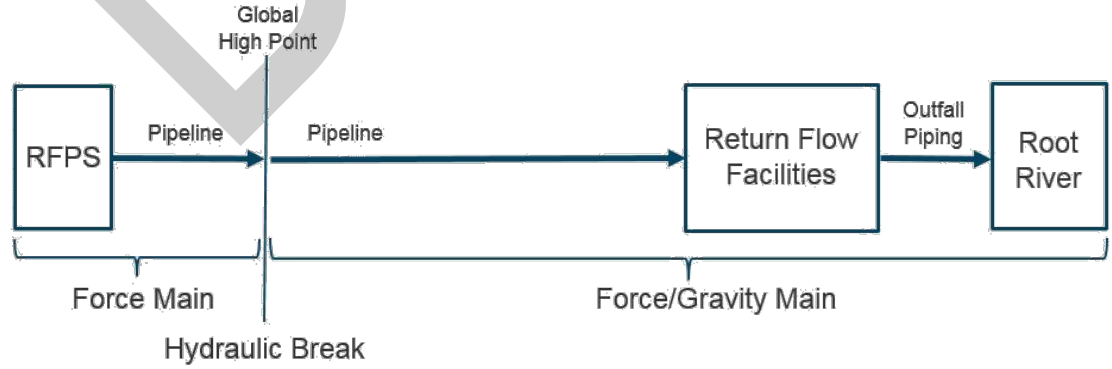

Figure 10-11 Return Flow Pipeline Operated as a Force / Gravity Main

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Table 10-29 provides a comparison of the major elements affecting both capital, operation and maintenance costs associated with the return flow system for the force main and force / gravity main operational alternatives.

Table 10-29 Return Flow System Operational Comparison

Force Main	Force / Gravity Main
Requires a Return Flow Control Building	No Return Flow Control Building required
Requires back-pressure valves	No back-pressure valves required
Requires a control strategy for maintaining pressure in the system	No control strategy required
Requires maintenance and operation of a Return Flow Control Building and Outfall	Minimal maintenance required at Outfall location
Velocity in pipeline is within a reasonable range	Segments of pipe with high velocity (>15 fps) requires mitigation
Energy recovery is an option	Energy recovery is not an option

The advantage of operating the system as a force main is energy recovery of the head available. However, the RFCB with energy recovery would increase the capital, operational and maintenance costs of the return flow system. A disadvantage of operating the system as a force / gravity main is high velocity flow in steeply-sloped pipeline segments flowing partially full. Risks of higher velocities will need to be managed in design by adjusting the slope of the pipeline or coating the pipeline with an epoxy liner to mitigate scour. An evaluation for recovering energy was conducted to confirm economic justification of the preferred alternative.

10.6.5.4.2 Energy Recovery Evaluation

The following assumptions and criteria were utilized to evaluate the cost impacts of energy recovery:

- The Return Flow Pipeline would be 30 inches in diameter.
- The net head available for energy recovery would change over time based on the pipeline roughness coefficient increasing over time.
- The sell back rate for recovered energy would be constant over the 100-year useful life of the pipeline at the current rate of $0.0425/kWhr.
- The turbine would be out of service for one month each year for maintenance.
- The average minimum nighttime flow would be 3.1 MGD for eight hours. The average flow for the remaining 16 hours would be the flow necessary to meet the ADD for the day. The ADD was assumed to increase 1.0 MGD for two consecutive 20-year increments and remain constant thereafter.
- A Turgo style turbine would be designed for a water-to-shaft efficiency of 75-89% for 2-12 MGD.
- A generator efficiency of 93% would be achievable.

A lifecycle cost evaluation was used to support investment decision-making by using information on anticipated costs incurred throughout the life of the assets. Net Present Value (NPV), internal rate of return (IRR) and the breakeven point was calculated to provide an indication of the desirability of investing in infrastructure to recover energy. This cash flow analysis has been performed to calculate the NPV with a discounted cumulative cash flow curve for the payback time of the investment. The analysis required a minimum of three components: revenue, investment cost, and annualized costs. For the force main alternative (i.e., with energy recovery), these components have been refined to include periodic replacement costs, depreciation, and taxes. NPV factor values, including inflation and

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discount rates, were applied for the useful life of Program infrastructure through 2121. An annual inflation factor of 3.00% and a discount rate of 8.00% was used. Inflation represents the increasing costs of goods or decrease in the purchasing value of money. The discount rate represents the value of money in today's dollars compared to the future due to its ability to produce immediate benefits as risks may occur in the future, ranging from 3% to 13% as cited in both the state of Wisconsin and National guidance documents. The inflation rate and discount rate were multiplied together to reflect the time value of money of costs incurred over the 100-year life cycle. This multiplied factor is called an NPV factor which is a gradient applied to cost components such as revenue, initial, and annualized costs over the 100-year life cycle. Present costs are provided in tables and used as initial inputs which are translated into present worth by multiplying corresponding NPV factors to annual cash flows. Cost components and calculations follow WDNR guidance for Clean Water State Revolving Fund (CWSRF) and Section 602(b)(13) of the Federal Water Pollution Control Act for present worth analysis and alternative assessment. The lifecycle analysis assumed the following values in Table 10-30. Indicator values are summarized in Table 10-31.

Table 10-30 Lifecycle Cost Calculation Assumptions

Parameter	Value
Revenue from Energy Recovered ($/year)	$47,500 to $51,500 times multiplier
Initial Capital Cost Incremental Cost beyond Status Quo ($)	$1.2M
Equipment Replacement Cost	$1,000 to 256,600 quantities at 5 year intervals
Capital Depreciation As specified by Wisconsin Public Service Commission (%)	2.25
Estimated Utility Revenue Tax (%)	25
Operation and Maintenance Costs ($/year)	$21,300

Table 10-31 Lifecycle Cost Analysis Summary

Indicator	Value for $1.2M Capital No Energy Rate Multiplier	Value for $1.2M Capital Energy Rate Multiplier of 5.5
20-Year NPV ($)	-$1.43M	$25,600
IRR (%)	No Return Achieved	9%
Breakeven Point (year)	No Breakeven Point	2037

Based on current energy pricing, energy recovery is not cost-effective due to a long payback period. Based on the results of this energy evaluation and the increased capital, operation and maintenance costs associated with the RFCB with energy recovery alternative it is recommended to proceed with operating the Return Flow Pipeline as a force / gravity main. Per discussions with WWU, the Return Flow Pipeline will be designed so as to have the capability of being operated as a force main in the future.

10.6.5.5 Return Flow Pipeline Size

InfoWater was used to size the Return Flow Pipeline. The return flow system was configured into an InfoWater model from the RFPS to the Outfall. Due to the fact that the Return Flow Management Plan is still being developed, the Return Flow Pipeline was sized to convey a maximum throughput anticipated of 13.6 MGD. The RFPS was operated at a throughput of 13.6 MGD and a PSV was included at the Outfall to simulate to maintain a pressure pipeline. The Return Flow Pipeline will be designed for the maximum anticipated pressures which occur when the pipeline is operated as a force main condition. The evaluation used a C value of 120 to provide a pipeline size capable of

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conveying the full range of heads anticipated throughout the 100-year useful life. Three pipeline nominal diameters were evaluated, including 24, 30, and 36-inch diameters, based on maintaining pressures within an acceptable range up to 225 psi and at velocities of less than seven fps. Table 10-32 summarizes maximum steady state modeled pressures and velocities observed along the pipeline for each nominal diameter and demand condition.

Table 10-32 Return Flow Pipeline Sizing

Pipeline Material	Nominal Diameter (in)	ID (in)	Velocity (fps)	Major Head Loss (ft/100 ft)	Maximum Pressure (psi)
Maximum Day Demand, 13.6 MGD					
DIP	24	24.81	6.27	0.547	257
	30	30.91	4.04	0.188	124
	36	37.11	2.80	0.077	112
Steel Pipe/PCCP	24	24.00	6.70	0.643	308
	30	30.00	4.29	0.217	141
	36	36.00	2.98	0.089	109

As shown in Table 10-32, a 24-inch nominal diameter would result in pressures in excess of the maximum steady state design pressure of 225 psi for the pipeline materials evaluated. In consideration of the Program's vision that the Return Flow Pipeline will be designed for a 100-year useful life, a 24-inch pipeline would be insufficient. A 30-inch nominal diameter pipeline between the RFPS and Outfall is capable of conveying the MDD within acceptable pressure and velocity limits. A 36-inch nominal diameter also can sufficiently convey the demand requirements, but would result in a higher capital investment with no apparent benefit to WWU. As such, a 30-inch nominal diameter pipe is the more preferable size for the Return Flow Pipeline to satisfy the demand conditions approved by the Compact Council, accommodate the RFPS firm capacity, and pursue the Program's vision for infrastructure with a 100-year useful life. The size and maximum pressures will be confirmed in design through transient analysis.

10.6.6 Steady State Hydraulics

10.6.6.1 Water Supply Pipeline Steady State Hydraulics

Steady state hydraulics along the Water Supply Pipeline were summarized with HGLs. Based on the firm capacities of the facilities and pipeline sizes identified above. The HGLs were determined at the C value anticipated upon startup (i.e. C = 150) as shown in Figure 10-12 and at the aged C value anticipated over a 100-year useful life (i.e. C = 120) as shown in Figure 10-13. The ground profile has been developed using GIS data received. The steady state modeled pressures for DIP and steel pipe are within an acceptable range between 35 and 225 psi and at acceptable velocities below seven fps. The static head and major head losses were used to determine the pump head required at the WSPS and BPS in Section 8.1 and Section 11, respectively.

10.6.6.2 Return Flow Pipeline Steady State Hydraulics

Steady state hydraulic conditions along the Return Flow Pipeline were summarized with HGLs. The Return Flow Pipeline was simulated for both the force / gravity main and force main alternatives. The Return Flow Pipeline was simulated with 30-inch pipe for DIP, steel pipe, and PCCP. The HGLs were determined at C = 150 as shown in Figure 10-14 and at C = 120 as shown in Figure 10-15. Steel pipe and PCCP are shown on the same graph since their IDs and C values are equivalent, which results in equivalent hydraulic conditions. The steady state operating pressures are within an acceptable range of less than 225 psi and velocities below seven fps. The static head and major head losses have been used to determine the pump head required at the RFPS in Section 12.

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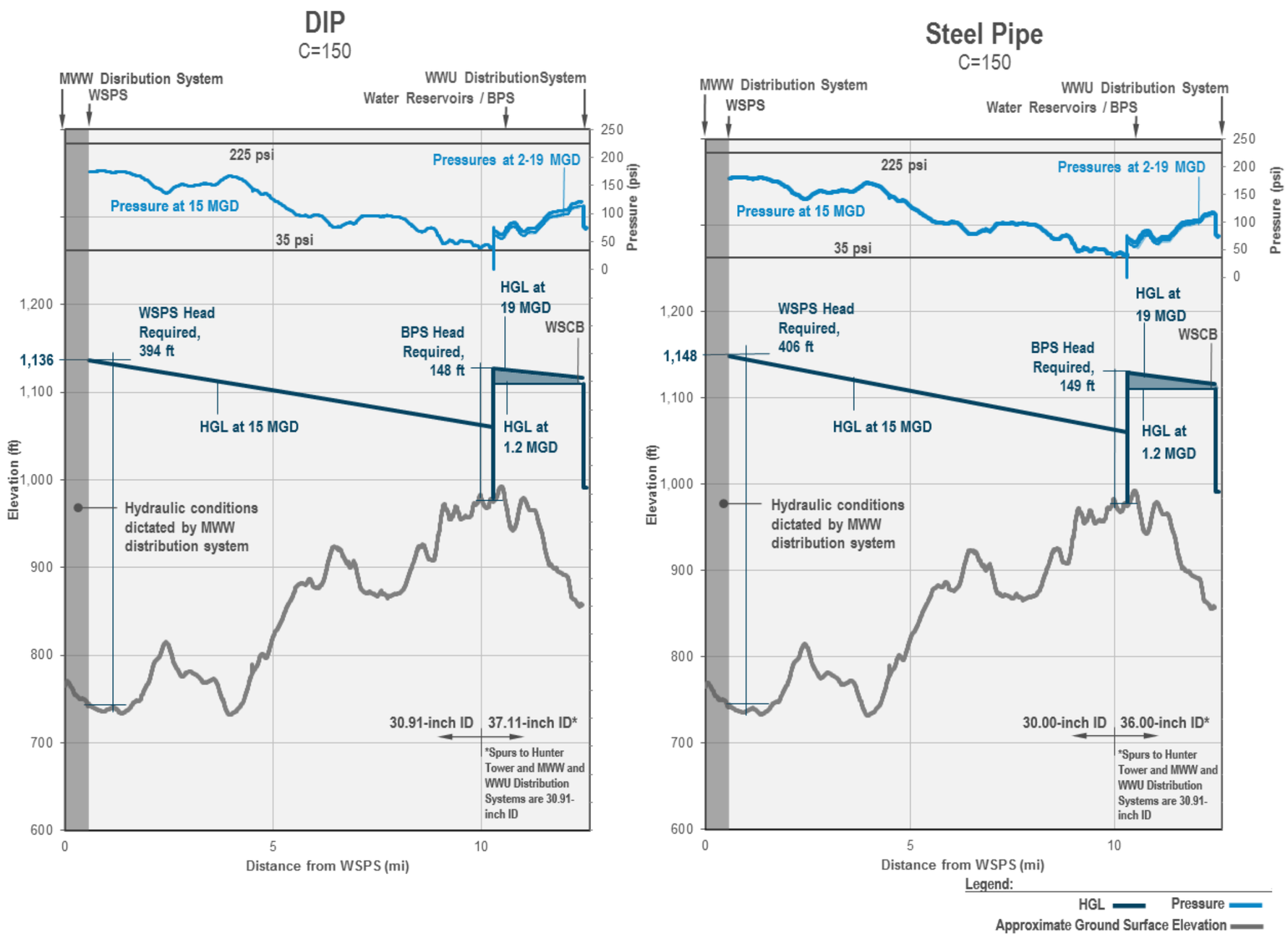

Figure 10-12 HGL and Pressure for New Water Supply Pipeline

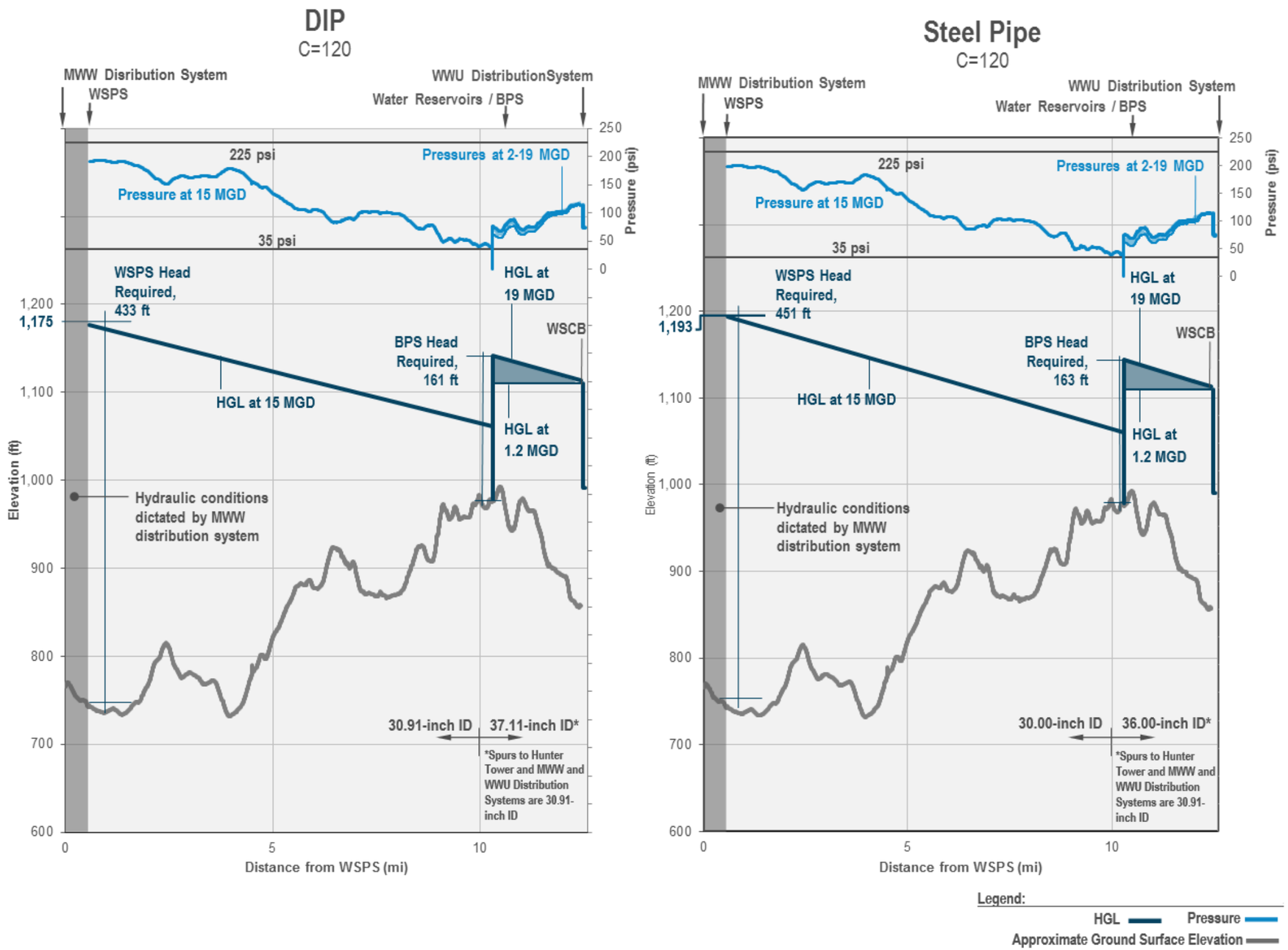

Figure 10-13 HGL and Pressure for Aged Water Supply Pipeline

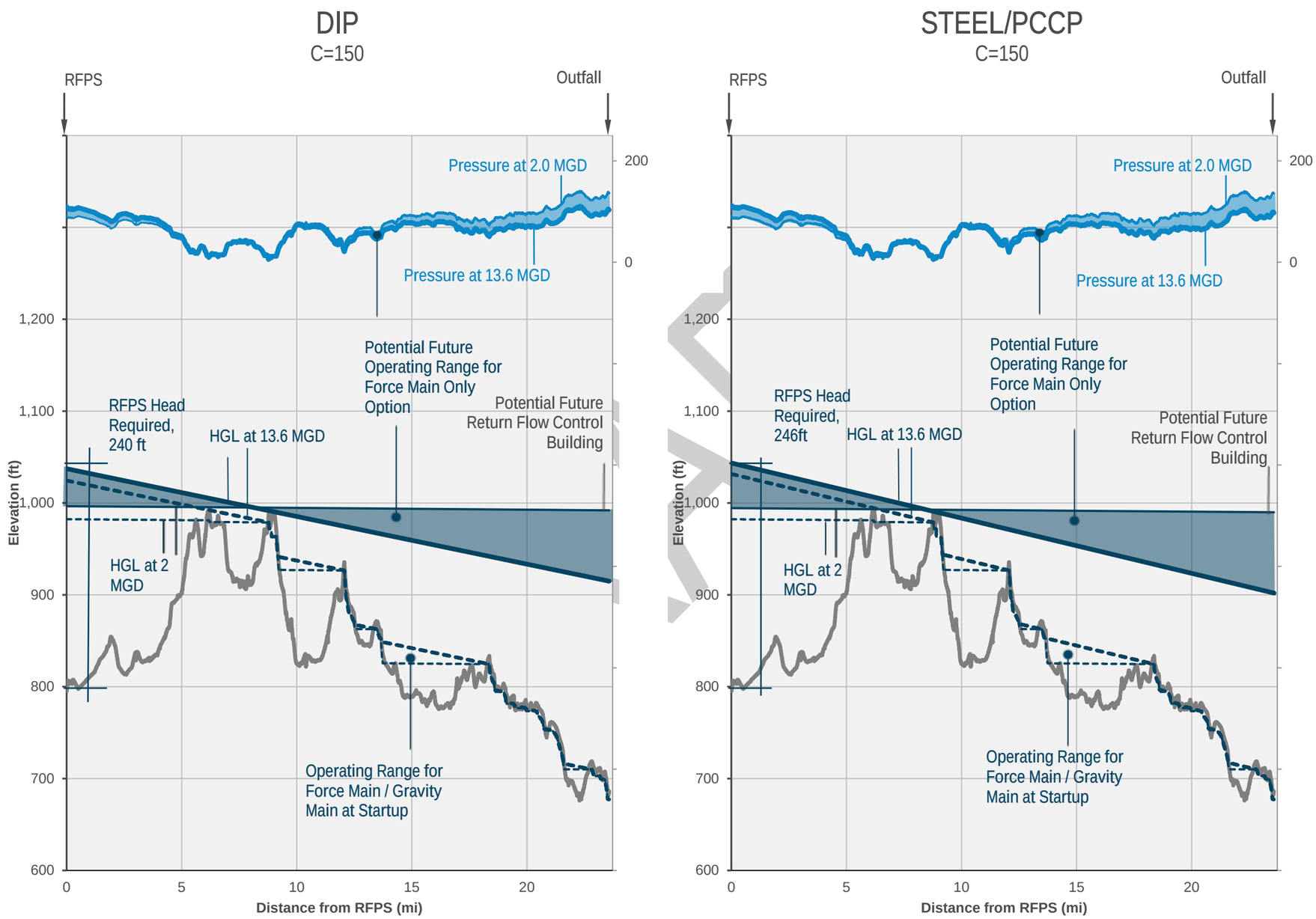

Figure 10-14 HGL and Pressure for New Return Flow Pipeline

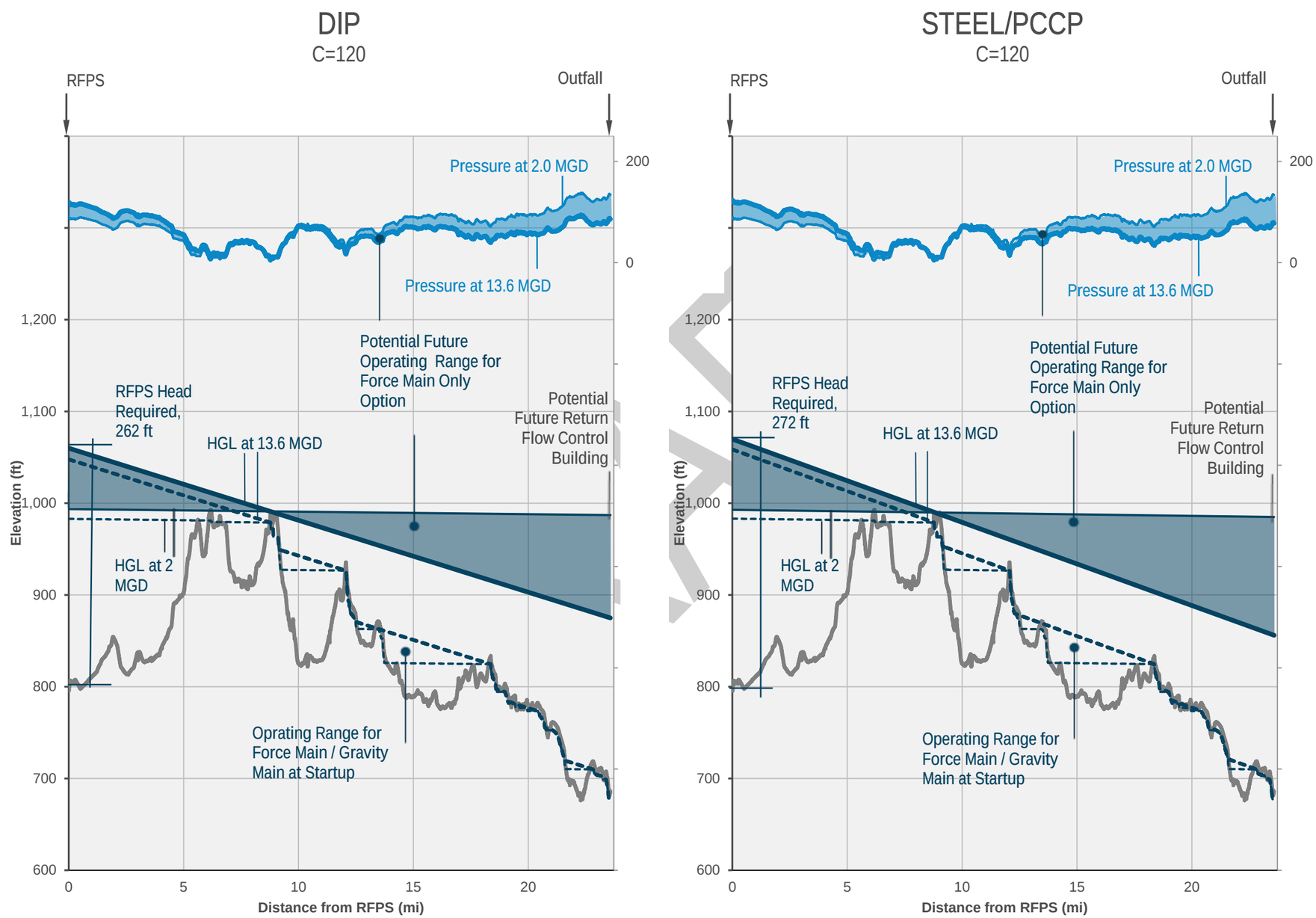

Figure 10-15 HGL and Pressure for Aged Return Flow Pipeline

10.6.7 Pipeline Appurtenances

This section evaluates the different valves and appurtenances necessary for optimal performance of the Water Supply and Return Flow Pipelines. There are four types of valves and appurtenances, which are essential components to the Water Supply and Return Flow Pipelines.

- Isolation Valves are used to isolate a section of the pipeline to perform maintenance and repairs and play a vital role in the startup of the pipeline.
- Air Valves are used to exhaust air during filling of the pipeline or during startup, to admit large volumes of air to prevent a vacuum condition during draining of the pipeline, and to allow the release of small air pockets that develop due to low pressures or a rise in temperature.
- Blow-Off Assemblies are used for draining and flushing of the pipeline during maintenance.
- Meters are used for metering water usage sold to WWU from MWW.

Although sizes may differ for these appurtenances for the Water Supply and Return Flow Pipelines, the general details and configuration of these appurtenances are consistent for both pipelines. As such, the appurtenances were evaluated for both pipelines concurrently.

The following regulations and standards were assessed during the pipeline appurtenances evaluation.

- Wisconsin Department of Natural Resources (WDNR NR811)
- Recommended Standards for Water Works and Wastewater Facilities (Ten States Standards)
- Standard Specifications for Sewer and Water Construction in Wisconsin, Sixth Edition (Wisconsin Standard Specifications)
- Specifications for Water Main and Service Lateral Materials and the Installation of Water Main and Appurtenances for Waukesha Water Utility, 2014 (WWU Specifications)
- American Water Works Association

10.6.7.1 Isolation Valves

The purpose of this section is to evaluate types of isolation valves for the Water Supply and Return Flow Pipelines based on feasibility. Four types of isolation valves were initially considered including the following valve types.

- Butterfly Valves
- Gate Valves
- Ball Valves
- Plug Valves

Butterfly valves and gate valves are commonly used in the water and wastewater industry. Ball valves are not generally utilized for isolation valves on water transmission mains and are typically more expensive than gate valves. Plug valves are commonly used in the wastewater industry, but are more expensive than gate valves. Based on the economic evaluation, applicability to large diameter pipelines, and product availability, ball and plug valves were determined to be less preferable and were not further evaluated as means of providing isolation for the Water Supply

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and Return Flow Pipelines. For means of isolation for the Water Supply and the Return Flow Pipelines, butterfly and gate valves were taken into further consideration. These valves are evaluated and compared further in the following subsections.

10.6.7.1.1 Evaluation of Isolation Valves

Butterfly valves are commonly used for large diameter pipeline applications because they offer a lighter, more compact design compared to gate valves. Gate valves provide a lower head loss than butterfly valves because the "gate," or disc, is out of the direction of flow. Table 10-33 summarizes the advantages and disadvantages of using butterfly and gate valves.

Table 10-33 Evaluation of Isolation Valves

Valve	Advantages	Disadvantages
Butterfly Valve	Lighter in weight Compact size Lower torque Lower capital cost	Higher head loss
Gate Valve	Lower head loss	Heavier in weight Larger size Higher torque Higher capital cost

The valves were evaluated based on an economic evaluation. Head losses were taken into consideration when evaluating costs for each type of valve. Since butterfly valves have a higher head loss than gate valves, a lifecycle cost estimate was performed to determine whether the lower cost of butterfly valves would be outweighed as compared to gate valves when considering additional pumping costs due to higher head losses. Head losses were calculated by accounting for the minor loss coefficients at the firm capacity of the WSPS, or 15 MGD. According to AWWA, butterfly valves have a minor loss coefficient of 0.43 (K = 0.43) and gate valves have a coefficient of 0.10 (K = 0.10). Head loss can then be converted into power by the below equation:

$$\mathrm{HP_W} = \frac{\mathrm{Q} \times \mathrm{h}}{3960}$$

where HP_w = water horsepower, Q = flow rate in gallon per minute (gpm), and h = head loss in feet. Water horsepower can then be converted into power, in kilowatts, by using the below equation:

$$\mathrm{Power\ (kW)} = 0.746 \times \mathrm{HP_w}$$

Using the Primary Service Energy Charge of $0.075/kWhr, the annual monetary savings in electricity would lead to a less than significant savings of $2,800 over a 20-year period when using a gate valve rather than a butterfly valve. Therefore, it was determined the monetary savings from head loss is negligible and the capital cost of each valve is greater than lifecycle cost. Capital costs for gate valves are more expensive than butterfly valves. The lifecycle cost evaluation is summarized in the graph in Figure 10-16. Energy costs are added to the capital costs provided by Kennedy Valve and are shown in grey.

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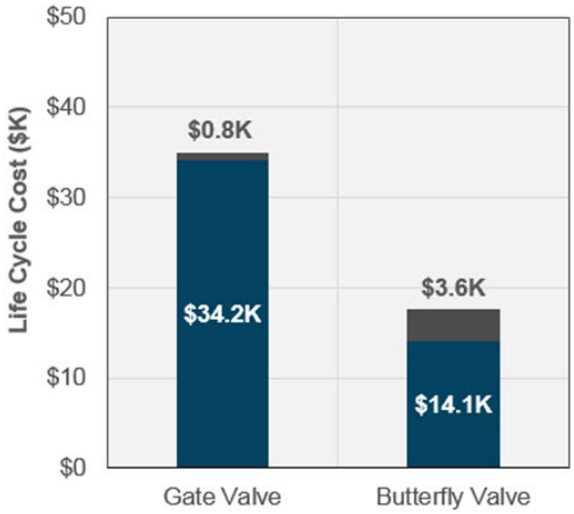

Figure 10-16 36-inch Isolation Valve Cost Estimate

10.6.7.1.2 Selected Isolation Valve

Isolations valves were evaluated during the Preliminary Design Meeting: Pipeline Materials, Isolation Valves, and Energy Recovery (4-300 M-01) held on June 28, 2017. Based on economic and non-economic considerations, it was determined that butterfly valves will be used as a means of isolation for the Water Supply and the Return Flow Pipelines.

10.6.7.1.3 Isolation Valve Regulations

Section 4.7 of the WWU Specifications indicates all valves 16 inches and larger will be rubber seated butterfly valves. All other regulations indicated in Section 10.6.7 do not specify the type of isolation valve required. Isolation valves will be placed approximately one per two miles and at both ends of HDD locations.

10.6.7.1.4 Isolation Valve Details

Isolation valves can be installed in either a valve vault or direct buried and provided with a valve box for the operator. Installation of valve vaults allows for ease of maintenance access for the valve, but may require freeze protection and a means to drain groundwater that may accumulate in the vault. Direct buried valves with valve boxes are more cost-effective and are more common for water utilities, but maintenance on the valve requires excavation. WWU specifies valves to be installed with valve boxes per Section 4.8 of the WWU Specifications. Typical valve vaults and valve box sections are provided in the Wisconsin Standard Specifications for butterfly valves in File No. 39 – Butterfly Valve & Box, File No. 40A – Standard Vault for Butterfly Valves.

Isolation valve details were reviewed during the Preliminary Design Meeting: Pipeline Materials, Isolation Valves, and Energy Recovery (4-300 M-01) held on June 28, 2017 with WWU. It was determined that isolation valves will be direct buried to reduce capital cost and additional maintenance associated with vaults. Upstream of waterway crossings, WDNR requires the installation of isolation valves in valve vaults. Therefore, isolation valves will be located in valve vaults only where required by WDNR. Isolation valve details are shown in Appendix E, Drawing Sheet C1.

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10.6.7.2 Air Valves

Air entrainment can reduce pipeline capacity, which can lead to lower pumping efficiency and, potentially, air binding of the system. There are multiple types of air valves used in the water and wastewater industry to provide air management in pipelines. Each valve type is described below.

- Air Release Valve (ARV): ARVs exhaust small pockets of accumulated air that collect at high points. Air pockets may continue to collect air to the point of air locking the system or allowing large pockets of air to travel in the system creating velocity surges. Reducing pockets of entrapped air will improve overall efficiency and reduce the possibility of damage from surges and water hammer in the system. ARVs have a small orifice and are typically furnished in inlet sizes from 0.5 to six inches.
- Air Vacuum Valve (AVV): AVVs vent large quantities of air during pipe filling and admit large quantities of air when pressure in the pipeline drops below atmospheric pressure, which occurs during draining. AVVs prevent air locks in the pipeline during filling by expelling the air present in the pipe as filling progresses. AVVs prevent a vacuum from forming in the pipeline by allowing large volumes of air to be quickly admitted into the pipeline to match the flow rate during draining, pipe break, or transient condition. They are typically installed downstream of pumps and at high points in the system. It is important to note that AVVs are normally closed based on normal operating pressure and will not relieve small amounts of air. Therefore, ARVs are used in combination with AVVs to allow venting of entrained air that has been released from the fluid. AVVs have a larger orifice and are available in inlet sizes from 0.5 to 30 inches.
- Combination Air Valve (CAV): CAVs combine the functions of an ARV with an AVV into one unit. Therefore, there is an economic benefit when both valve types are needed at the same location. CAVs contain both a small orifice for air release and a large orifice for large air release/vacuum into one assembly. Some applications will require an ARV and AVV to be manifolded together to provide benefits of both with a wider selection than what is offered with a single-body design. Single body CAVs are available in inlet sizes from one to eight inches, where dual body CAVs are available from one to 36 inches.
- Vacuum Relief/Air Inlet Valve (AVR): AVRs immediately admit large quantities of air when pressures become negative to prevent a vacuum from forming. When system pressure returns to positive, the valve closes air tight. This type of valve is installed at locations where vacuum conditions are known or predicted to occur by transient modeling. A vacuum condition has the potential to cause transient surge pressures if the vacuum cavity collapses and potentially could cause the pipeline to collapse. AVRs are available in inlet sizes from 0.5 to 42 inches.
- Combination Vacuum Relief Valve (CVR): CRVs combine the functions of an AVR and an ARV with a dual body design. CRVs are installed in locations when both functions are required to protect the pipeline from vacuum conditions and have the added benefit of controlling air exhausted through the valve in a controlled manner to prevent surges. CRVs are available in inlet sizes from three to 42 inches.
- Surge check valves have also been used in combination with the above to avoid slamming of AVVs when exhausting large quantities of air.

10.6.7.2.1 Selected Air Valves

After evaluating each air valve and its relative function, it was determined that AVVs or AVRs would not be required for solo applications along the Water Supply and Return Flow Pipelines. From design experience, it was determined that the pipelines would utilize three types of valves to manage air and mitigate transients along the pipelines.

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The overview of the air valves is shown in Table 10-34.

Table 10-34 Overview of Selected Air Valves

ARV	Combination AVR / ARV	Combination AVV with ARV and Anti-Slam Surge Check Valve
• Automatically exhausts small pockets of accumulated air • Located at high points where air pockets accumulate	• Automatically allows large quantities of air into the pipeline on negative pressure • Slowly vents air	• Air vacuum valve allows air to enter pipe on vacuum conditions • ARV automatically vents small quantities of air during routine operation • Often used with anti-slam check valve

10.6.7.2.2 Air Valve Regulations

Regulations from regulations and guidance documents in Section 10.6.7 were evaluated for design of the air valves and are shown in Table 10-35.

Table 10-35 Air Valve Regulations

Entity	Section	Regulation
WWU Specifications	4.12	• In accordance with File No. 41 Air Release Vault and File No. 42 Air Release Assembly (Valve Box Type) of the WI Standard Specifications
WDNR NR811	811.72	• If possible, air relief assemblies will not be located in areas subject to flooding or high groundwater • Drains from valves will not be connected to storm or sanitary sewer and will be drained to pits underground or ground surface
Ten States Standards	8.5, 8.6	• Open end of air relief pipe should be extended at least one foot above grade and screened with a downward facing elbow • Drains from valves will not be connected to storm or sanitary sewer and will be drained to pits underground or ground surface

Each of the three selected air valves will be located along the pipeline based on particular criteria and designed to satisfy applicable standards. These criteria are summarized in Table 10-36.

Table 10-36 Air Valve Locations

Valve Type	Application
ARV	High points, but design pipeline to avoid unnecessary high points. Where required, minimum 2-inch air pipe per 2014 WWU Specifications. • Provide screened gooseneck • Gasketed, watertight, bolted manhole cover and lid • Terminate vent 24 inches above grade where required
Combination AVR / ARV	Size and location based on results from transient modeling. Same specification requirements as ARVs per NR 811.72 and 2014 WWU Specifications.
Combination AVV with ARV and Anti-Slam Surge Check Valve	Size and location based on results from transient modeling. Same specification requirements as ARVs per NR 811.72 and 2014 WWU Specifications.

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10.6.7.2.3 Air Valve Details

Air valve details have been developed in accordance with WWU preferences and application regulations. The air valves are located in vaults and provided with a screened gooseneck, as per Wisconsin Administrative Code NR 811.72. The air valves will vent through goosenecks within the air valve manholes or above grade where required. The manholes will be secured with gasketed, bolted down, water tight covers, as per NR 811.72. Manual, direct-buried air valves are being considered for secondary high points to reduce the number of vaults required. Per WWU Specifications, air piping will be a minimum of two inches in diameter.

Air valve details were reviewed during the Preliminary Design Meeting: Pipeline Materials, Isolation Valves, and Energy Recovery (4-300 M-01) held on June 28, 2017. The DuPage Water Commission Lessons Learned Meeting and Facility Tour (4-300 M-04) was held with the DuPage Water Commission and WWU to discuss feedback from operations of a water system similar to that envisioned for this Program. The DuPage Water Commission indicated that it was useful to be able to access the inside of their pipelines during maintenance and repairs. The details were updated per feedback provided by WWU to allow access to the inside of the pipelines. The air valve details are shown in Appendix E, Drawing Sheet C2. These details will continue to be refined in coordination with WWU and transient modeling results in design. Air valves determined to be critical for normal operations of the pipelines will be provided with redundancy during design.

10.6.7.3 Blow-Off Assemblies

The purpose of this section is to evaluate appurtenances that will provide means to drain the pipeline during startup, routine maintenance, or emergency repairs. The two types of appurtenances that were evaluated include blow-off assemblies and flushing hydrants. Both blow-off assemblies and flushing hydrants provide means of draining the Water Supply or Return Flow Pipeline, but there are advantages and disadvantages to each alternative. The following subsection evaluates the regulatory requirements for each appurtenance alternative.

10.6.7.3.1 Evaluation of Blow-Off Assemblies

Blow-off assemblies offer a larger outlet size for flushing to facilitate faster draining compared to flushing hydrants and are commonly used for transmission mains. The primary advantage for blow-off assemblies for large transmission mains is there is no risk for potential unintended use. Flushing hydrants, which are commonly used for distribution systems only, provide the potential for unintended use.

Advantages and disadvantages of blow-off assemblies and flushing hydrants are summarized in Table 10-37. Note that flushing for chlorination and testing are comparable for both alternatives.

Table 10-37 Advantages and Disadvantages of Flushing Appurtenances

Blow-Off Assembly	Flushing Hydrant
Advantages • Outlets available larger than six inch to facilitate draining • Below grade for freeze protection and avoiding damage • Eliminates potential for unintended use and confusion of whether local communities along pipelines can utilize transmission main Disadvantages • None	Advantages • Compatible with standards for hoses and pumpers • Multiple nozzles on one hydrant providing more control over maximum draining velocity Disadvantages • Accessible by outside entities (fire service expected) • Typical appurtenance for distribution systems not transmission main

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10.6.7.3.2 Selected Blow-Off Assembly

The flushing alternatives were reviewed during the Preliminary Design Meeting: Pipeline Materials, Isolation Valves, and Energy Recovery (4-300 M-01) held on June 28, 2017. It was determined that blow-off assemblies are preferred as it limits the potential for access by outside entities.

10.6.7.3.3 Blow-Off Assembly Regulations

There were no specific regulations on types of flushing appurtenances regarding entities from Section 10.6.7. Design regulations for flushing appurtenances are shown in Table 10-38.

Table 10-38 Flushing Regulations

Entity	Section	Regulation
WDNR NR811	811.71 and 811.72	• Flushing hydrants will allow frost-proof operation; flushing will be pumped prior to freezing weather • No direct connections to storm or sanitary drains • Blow-off assemblies must drain to the ground surface or absorption pits that are not subject to flooding

10.6.7.3.4 Blow-Off Assembly Details

Blow-off assembly details have been developed in accordance with WWU preferences and application regulations. The blow-off assemblies could connect to the pipelines via special fitting or rolled tee. It was determined that rolled tees will be used to connect the blow-off assemblies to the pipelines. Rolled tees are more field adaptable than special fittings. The piping for the assembly includes a valve used to manually modulate flow control. The assembly then terminates at grade to a blind flange connection, which will allow different sized hoses to be connected to the pipelines for draining. Per Wisconsin Administrative Code NR 811.72, the details were developed without direct connections to storm drains or sanitary sewers and are drained to the ground surface. Adsorption pits will be designed if ponding is expected in proximity to the blow-off assembly, as per NR 811.72.

Blow-off assembly details were reviewed during the Preliminary Design Meeting: Pipeline Materials, Isolation Valves, and Energy Recovery (4-300 M-01) held on June 28, 2017. The isolation valve details are shown in Appendix E, Drawing Sheet C1.

10.6.7.4 Metering Vault

Meters will be utilized to measure the volume of flow WWU will purchase from MWW in perpetuity. The metering building is envisioned to be located in a below grade vault along the Water Supply Pipeline. A site location will be identified in design. The meters will consist of two trains consistent of either horizontally stacked meters or a meter and a bypass. The metering and vault configuration will be finalized in design in coordination with MWW.

The Return Flow Pipeline will have a compliance meter located at either the RFPS or Outfall site. If the compliance meter is located at the Outfall site, it is envisioned to be located below grade in a vault.

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10.6.7.5 Pipeline Appurtenances Location Methodology

The changes in elevation and hydraulic transients will dictate the location and the number of appurtenances. Transient modeling and surge analysis will be performed to optimize locations of all appurtenances in design. Table 10-39 shows the recommended location methodology for each pipeline appurtenance that will be completed in design.

Table 10-39 Location Methodology

Pipeline Appurtenance	Location Methodology
Isolation Valves	• Preclude long drain time (less than 6 hours) • Approximately every one to two miles
ARVs	• High points • Design will be optimized to consider cost-effective use of ARVs and high points
Combination Air Valves	• Locate at high points, as dictated by transient analysis
Combination Vacuum Relief Air Valves	• Locate at high points, as dictated by transient analysis
Blow-Off Assemblies	• At low points between isolation valves • Approximately every one to two miles

The Water Supply and Return Flow Pipelines will be designed to manage air and hydraulic transients. In order to minimize the rise and fall of the pipeline elevations, which could result in additional air valves, the pipelines may need to be buried deeper. This increases the cost of installation through additional cut and fill, but can eliminate the need for additional air valves. During design, the vertical alignment will be optimized to balance cut and fill with additional appurtenances. A representation of this design methodology is shown in Figure 10-17. All light blue elements depict the air valves needed when installing the pipeline based on topography. The light blue hollow circles represent air release valves. The dark blue elements depict the air valves needed when the pipeline's vertical alignment has been optimized to reduce the need for air valves.

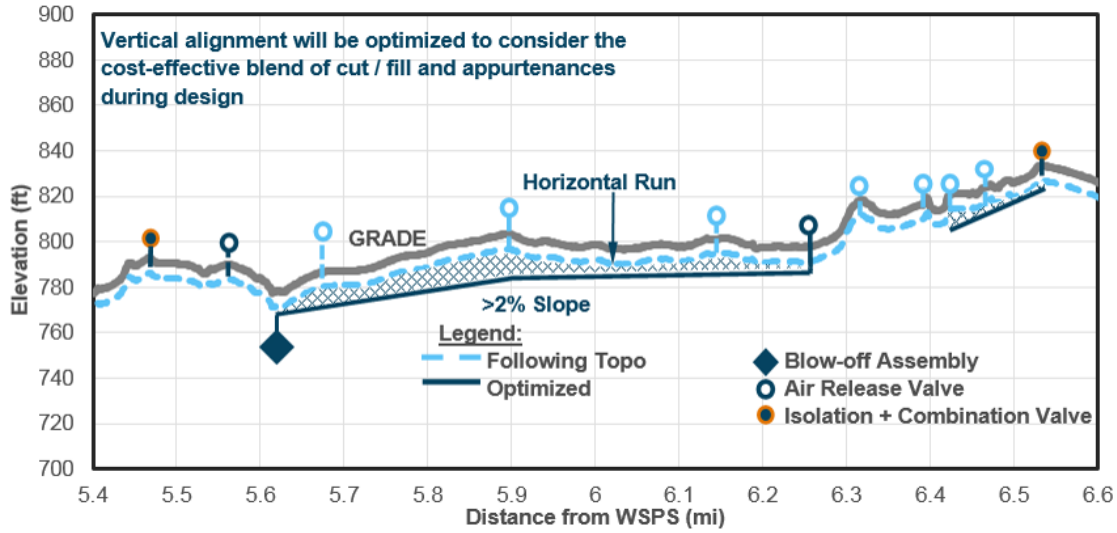

Figure 10-17 Optimization of Pipeline Appurtenances

The design method was reviewed during the Preliminary Design Meeting: Pipeline Materials, Isolation Valves, and Energy Recovery (4-300 M-01) held on June 28, 2017. It was determined that the vertical alignment will be optimized to balance cut and fill with additional appurtenances.

10.6.8 Restrained Joints

10.6.8.1 Purpose

The purpose of this section is to describe the method that will be used to calculate restrained joint lengths during design. Restrained joints will be installed on both the Water Supply and Return Flow Pipelines in order to resist movement from forces exerted by fluid flow within the pipelines. Thrusts occur in pressurized pipe in locations such as pipe bends, valves, and fittings where placement of restrained joints balance thrust. The expression to represent thrust is:

$$\mathrm{T} = 2\mathrm{PA}\sin\left(\frac{\Delta}{2}\right)$$

where T=thrust force, P=internal pressure, A=internal area, and Δ=angle of bend. Figure 10-18 demonstrates a free body diagram of the thrust force vectors at a typical bend along the Water Supply or Return Flow Pipelines.

At valves, outlets, or bulkheads, the expression becomes T=PA, as the direction of forces act parallel to the pipeline. The forces resisting thrust include frictional forces against the pipeline and soil bearing forces. Restrained joints allow for final balance of forces against thrust and prevent movement of fittings. The length of the restrained joints determine the frictional force accumulated to achieve force balance.

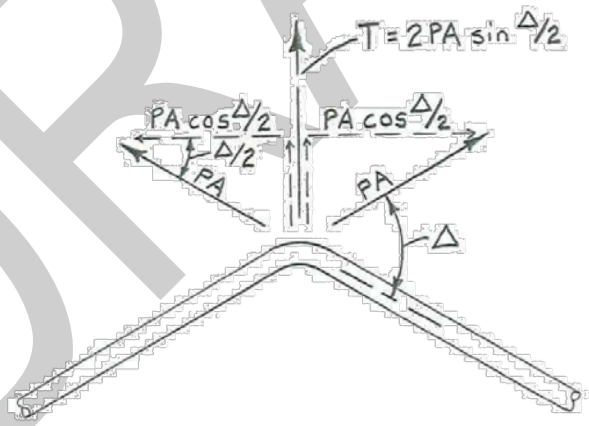

Figure 10-18 Thrust Force Vectors

10.6.8.2 Approach

For the purposes of preliminary design, pressures have been calculated at one-mile increments along the pipeline, with each increment classified as rural or urban to assign a value for buried depth. Potential joint locations and angles have been identified along the preliminary pipeline horizontal alignments based on typical DIP fittings, and the calculations were performed for restrained joint lengths for each of these locations. Two scenarios have been calculated including groundwater level at grade and groundwater below the invert of the pipe, and two different C

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values representing pipe internal friction forces. Groundwater level at grade represents the maximum buoyant condition and groundwater below the invert of the pipe represents maximum friction condition against the pipe. A factor of safety of 1.5 has been applied for the condition with groundwater below the invert of the pipe. Pipeline materials considered for analysis include DIP and steel pipe for the Water Supply Pipeline and DIP, steel pipe, and PCCP for the Return Flow Pipeline. Calculation assumptions are summarized in Table 10-40.

Table 10-40 Restrained Joint Calculation Assumptions

Parameter	Value
Return Flow Pipe Diameter (in)	30
Water Supply Pipe Diameter (in)	30 and/or 36
Natural Soil Buoyant Density (lb/ft^3)	65
Compacted Buoyant Density (lb/ft^3)	70
Friction Angle (degrees)	35
Soil friction factor to Pipeline	0.35
Soil Cover Depth for Rural, Urban (ft)	6.5, 9.0
Standard Length of Pipelines (ft)	18

Higher pressures result in greater pipeline friction, which result in longer restrained joint lengths. Operations and hydraulic control points can affect which C values generate the highest pressures that dictate restrained joint lengths. In designing restrained joint lengths, greater pipeline pressures will require a greater length of restrained joints at fittings and valves. The design will continue to be developed to utilize the hydraulic conditions that are anticipated to require the greatest length of restrained joints for design.

10.7 Water Supply Control Building

10.7.1 Overview

The purpose of the WSCB is to house valves required to maintain pressures at the connection to WWU's distribution system near the intersection of Sunset Drive and Les Paul Parkway within a desirable range. The BPS will provide the head necessary to operate based on levels in the Hunter Tower, which is an existing elevated storage tank in WWU's distribution system. The water supply connection to WWU's distribution system is located in the Central Pressure Zone that is operated based on the Hillcrest Reservoir with overflow levels over 100 feet lower than levels in the Hunter Tower. Therefore, the WSCB will require PRVs to discharge from the water supply system at heads within a desirable operating range for Waukesha's Central Pressure Zone. A diagram of the Water Supply System downstream of the BPS is illustrated in the diagram in Figure 10-19.

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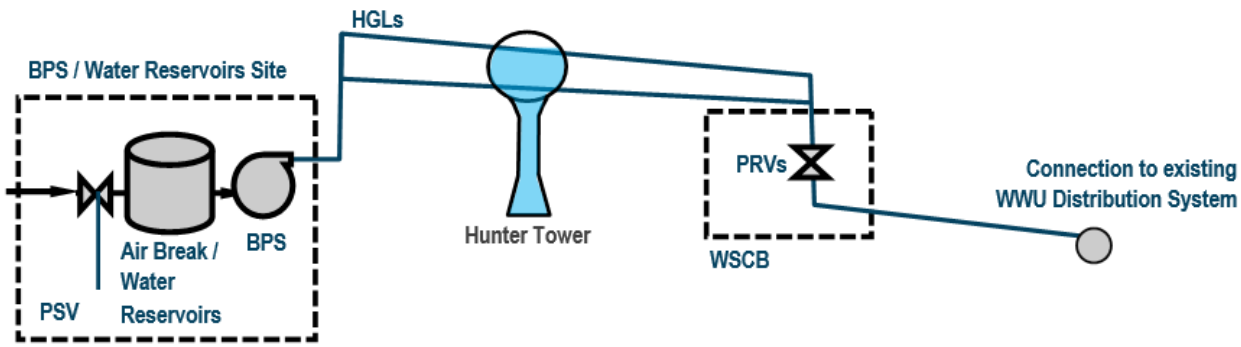

Figure 10-19 Water Supply System Diagram Downstream of BPS

The water supply connection to WWU's distribution system is located near the intersection of Les Paul Parkway and Sunset Drive. WWU operates an existing booster pumping station, referred to as the Highline BPS, just northwest of the intersection on Parcel WAKC1349999. An evaluation was conducted to determine a building alternative that would be preferable for the WSCB from the following alternatives:

1. Alternative 1: Locate the valves and piping in a new, standalone structure adjacent to the Highline BPS.
2. Alternative 2: Locate the valves and associated piping in the interior of the existing Highline BPS.
3. Alternative 3: Expand the Highline BPS to the north and locate the new valves and piping in the expansion.
4. Alternative 4: Locate the valves in a below grade vault.

The alternatives were discussed with WWU. It was determined that Alternative 4, which would involve locating the valves in a below grade vault, is not preferred due to groundwater infiltration concerns, the need for confined space entry, and additional safety challenges for WWU's operations staff.

Alternative 2, which would involve locating the valves in the Highline BPS, would require piping modifications in the Highline BPS and would require the Highline BPS to be out of service for a period of time. The alternative would also require significant structural modifications. There would also be limited space for maintenance. As a result, it was determined locating the valves in the existing Highline BPS is not preferred.

The remaining two alternatives, Alternatives 1 and 3, were further evaluated. Comparative costs were developed for Alternatives 1 and 3. It was determined that Alternative 3, which would involve expanding the Highline BPS, would result in significant modifications to the existing roof structure. This would require a larger capital investment than Alternative 1 with a standalone building. Therefore, it was determined that the design would proceed with the WSCB as a new standalone building located on Parcel WAKC1349999.

The following section discuss the design for the WSCB in detail, including civil, structural, architectural, mechanical, electrical, and instrumentation and controls (I&C). Refer to the Appendix E, Drawing Set CP2 for the WSCB site plan. A proposal will be presented to and approved by the Waukesha Plan Commission during design before any use permits are granted.

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10.7.2 Civil/Site

This section reviews the site and civil engineering requirements for the WSCB. The selected site of the WSCB was chosen due to its proximity to the connection to the WWU distribution system, ease of access for maintenance activities, and cost savings associated with its location on a site that WWU already owns. The following subsections present information on data collection, desktop reviews, and field investigations, along with the proposed improvements and associated requirements for the WSCB site in Waukesha.

10.7.2.1 Data Collection

Desktop analyses and field investigations were used to collect information on the WSCB site to support design. These assessments included review of land use and surface features, floodplains, zoning, environmental, wetland and waterway, archaeological, and RTE species. Field investigations were conducted for the Program to obtain information to support preliminary design and design activities. Not all of the field investigations for the WSCB site were able to be completed prior to this PDR. Findings from field investigations will be incorporated into design.

10.7.2.2 Desktop Analysis

Land Use and Surface Features: The selected site of the WSCB is located at the northwest corner of Les Paul Parkway and Sunset Drive. The parcel, owned by WWU, is the same location as the WWU's Highline BPS. The access drive begins in the southwest corner intersecting Sunset Drive and extends northeast before turning west to the parking area along the western edge of the parcel adjacent to the Highline BPS. The northern edge of the parcel is a small wooded area, and the remaining area is grass. We Energies has an easement within the parcel for large power lines. The WSCB will be constructed in the northwest corner of the parcel to provide sufficient space between the facilities.

Zoning: The site for the WSCB is zoned as an institutional area. According to Waukesha's Municipal Zoning Code, there should be a minimum front setback of 25 feet from the right-of-way. In addition, all principle buildings should have a side setback of not less than 10 feet and a rear setback of not less than 40 feet, as shown in Table 10-41.

Table 10-41 Zoning Requirements

Reference	Description	Requirement	
22.42(4)	I-1 Institutional District	Use L: Utility substations, municipal wells, pumping stations and towers provided that the use is not less than fifty feet from any lot line.	
22.42(5-7)	Site Development Standards For I-1	Minimum Lot Dimensions	
		Lot Area (sq ft)	10,000
		Lot Width (feet)	75
		Minimum Setbacks (feet)	
		Front	25
		Side (each)	10, each side
		Rear	40
		Shore Setback from OHW Mark	75
		Wetland Buffer	--
		Wetland Setback	--
		Maximum Height	None, 20 for accessory structures

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Environmental: Desktop evaluations for environmental impacts will be performed during design. This assessment will identify any potential and recognized environmental conditions at the selected WSCB location. The analysis will review environmental regulatory documents, Sanborn fire insurance maps, and historical aerial photographs purchased from Environmental Data Resources, Inc.

Wetland and Waterway: A wetland and waterway desktop review on the WSCB location was conducted. The review included analysis of digital wetland inventory (DWI) data purchased from WDNR, USGS Topographic Maps, the USDA's Web Soil Survey maps, recent aerial imagery, and county GIS topographic data. The wetlands were then classified using the Wisconsin Wetland Inventory Classification System, and emergent wetlands were further divided into two subcategories, including natural and agricultural. Applicable waterways at each location were evaluated using the USGS NHD. There are no anticipated wetlands to be impacted on the site.

Floodplain and Floodway: A desktop review was conducted to determine if the WSCB site is within any known floodplain or floodway. The review included a GIS analysis of FEMA's Special Flood Hazard Areas (SFHA). Areas that fall within the FEMA SFHAs are subject to the National Flood Insurance Program's (NFIP) floodplain management regulations and are required to purchase flood insurance. The FEMA map panel that shows the site is 55133C0327G and is shown in Figure 10-20. As shown, the WSCB site is not located within any of the FEMA SFHAs.

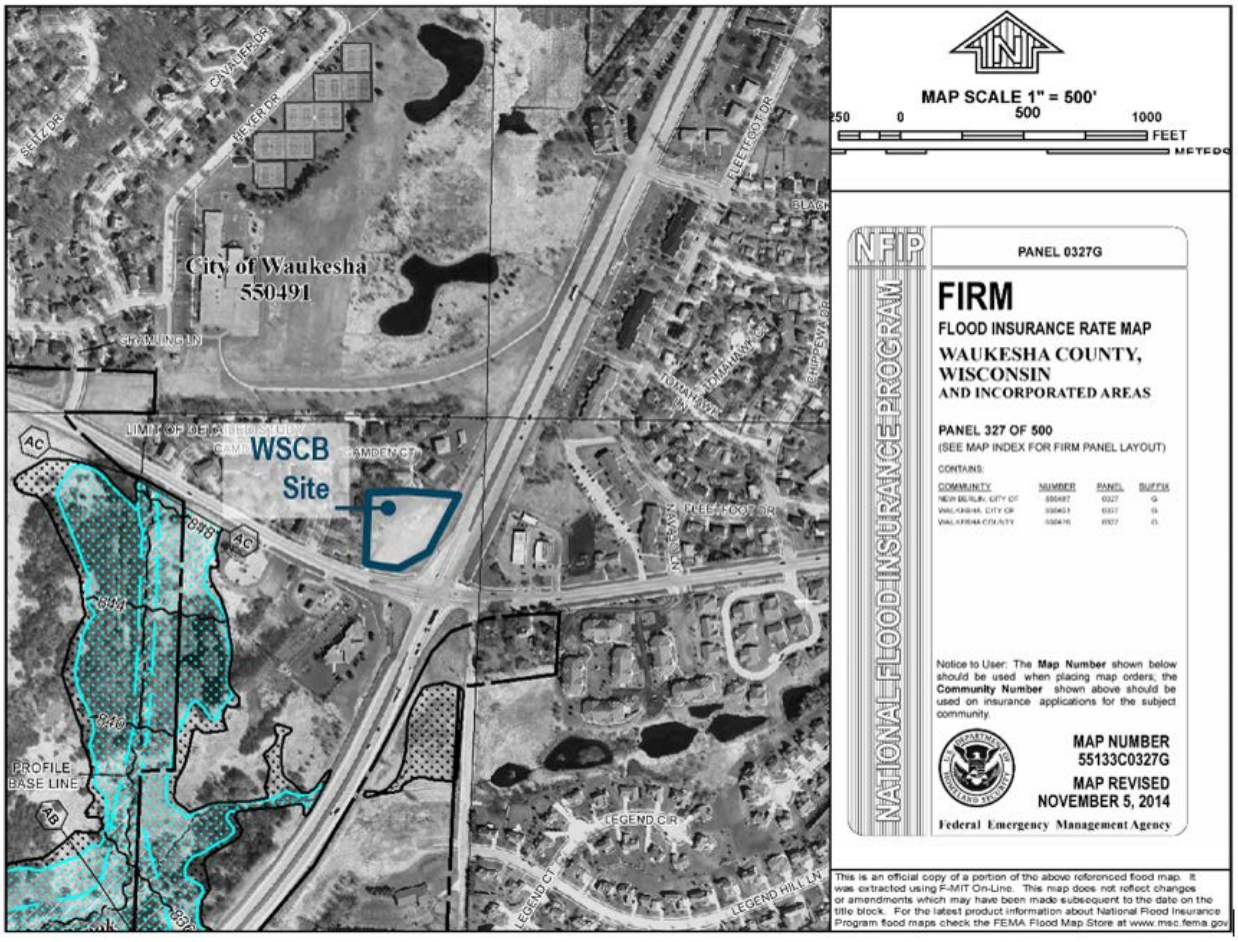

Figure 10-20 FEMA Floodplain Map Panel No. 55133C0327G

Archaeological: A desktop review for cultural, archaeological, and historical resources was performed. The assessment reviewed the site for the potential presence of archaeological sites and/or historic structures by reviewing the State WHPD.

As seen in Figure 10-21, the desktop review of the WSCB site did not find evidence of any potential cultural, archaeological, or historical resources that would be impacted. The green cross hatched area that runs through the site indicates that the area was previously studied, but no findings were reported. Field investigations will be performed to confirm the results of the desktop analysis prior to land transfer or a purchase agreement for the subject property.

Figure 10-21 Archaeological Desktop Analysis Map

Endangered/Threatened Species: A desktop evaluation of RTE species for the site will be conducted. The evaluation consists of reviewing up to date records such as recent and historical aerial photographs, WDNR NHI data, the USFWS IPaC data, and the USFWS endangered species county data. Utilizing these resources, potential RTE species and natural communities within the selected site and an associated one-mile buffer for terrestrial species, and two-mile buffer for aquatic species will be identified and mapped on aerial photographs. The results will be utilized to assess and prevent impacts to RTE species.

10.7.2.3 Field Investigation

Field investigations will be performed in design. Field investigations will include site survey, wetland and waterway investigations, geotechnical soil borings, and hazardous materials investigations. These investigations are described in detail in the following subsections as they apply to the WSCB site.

Survey: A survey will be completed within the WSCB site boundaries during design. Since WWU owns this property, a more limited survey will be required to locate property boundaries, features, and topography.

Wetlands and Waterways: Field investigations for wetland and waterways will be conducted on the site to confirm any wetlands or waterways identified from the desktop analysis. The WSCB footprint will be further developed in design to avoid wetland impacts to the extent feasible.

Archaeological: A Phase I Archaeological Survey of the WSCB site will be conducted during design in areas of proposed improvements. The proposed archaeological survey will satisfy survey requirements for regulatory compliance, and will meet the standards for archaeological survey as outlined in the Guide for Public Archaeology in Wisconsin.

Endangered and Threatened Species: A comprehensive field review will be performed during design to evaluate the presence of RTE species habitat at the site. Species-specific studies or incidental take permits may be required by the WDNR if the proposed improvements are not able to avoid locations of potential habitat.

Geotechnical: Geotechnical field work will be completed at the site during design. The geotechnical report will provide information on the suitability of soils for the structure located on-site and will be incorporated into the design.

Hazardous Materials Investigation: The Phase I Assessment and associated soil testing will occur in conjunction with the geotechnical work if deemed necessary from preliminary investigations. The Phase 1 Assessment will be performed prior to the land transfer or a purchase agreement for the subject property. This work will be completed in design.

10.7.2.4 Site Improvements

This section describes specific codes and ordinances applicable to the WSCB. The conceptual site plan is discussed along with the features and utilities shown in Appendix E, Drawing Set CP2.

10.7.2.4.1 Site Layout

A conceptual site layout was developed to determine the feasibility of the site to house the WSCB. Once selected, the site layout was further developed. Architectural aspects of the site were considered, as described in Section 10.7.4. The final preliminary site layout is presented in Appendix E, Drawing Set CP2.

10.7.2.4.2 Site Accessibility

A new access drive will connect to the existing access road at the Highline BPS suitable for heavy-load trucks and cranes. Adequate ingress, egress, and set-up space for heavy-load trucks and cranes to the WSCB will be provided. The proposed access way will be designed for an AASHTO load rating of HS-20. Bridging or reinforcement over piping will be provided as required. If required, turning radii at curves and roadway intersections will be designed for a

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minimum of 50 feet to provide access for heavy-load trucks and cranes. The new access way leading up to the WSCB will be a minimum of 15 feet in width. Signage and/or appropriate physical restrictions will be provided at access points to the light-duty roadway.

10.7.2.4.3 Surface Restoration

Surface conditions, where affected, will be restored to original conditions.

Grading and Drainage: The existing site topography will be maintained as feasible. Downspouts and drainage from WSCB will be routed to grade and will not be connected directly to storm sewers. Grading at the WSCB will be designed to facilitate positive drainage of rainfall runoff away from the WSCB and Highline BPS. In general, grade will be sloped away from the building walls and equipment at a minimum pitch of 1.0%. The grading for earthen slopes will be no steeper than three feet horizontal to one foot vertical to the extent possible. Top of floor elevation for equipment foundations will be a minimum of six inches above the finished high point of grade or paving elevations. Erosion control measures will be in place during construction per local ordinances and standards, and any dewatering will be properly routed to meet WDNR requirements.

Paving and Sidewalks: The governing municipal standards for concrete and asphalt pavement will be followed for the areas where the access drive is extended to the edge of right-of-way. Concrete or asphalt pavement from the right-of-way within the privately owned WWU property will be designed as appropriate.

Landscaping: Existing mature trees will be retained where feasible. A tree survey may be required. Seeding will be required in all areas disturbed by construction and any additional areas indicated by WWU. Plantings will be provided at locations directed by WWU to replace the plantings removed during construction. Where practical, landscape strategies that eliminate the need for pesticides and fertilizers, while minimizing need for irrigation will be incorporated.

10.7.2.4.4 Stormwater Management

The site at the WSCB is both predeveloped near the Highline BPS, and undistributed with a wooded area on the northern edge of the site. Stormwater runoff from the proposed building and access walkway to the WSCB will drain to grade and utilize the existing best management practices (BMPs) at the site. A detailed stormwater analysis will be performed during design, including calculation and documentation of the pre- and post-development runoff, storage, and infiltration using TR-55 Curve Numbers and other continuous simulation-modeling methods.

The results of the stormwater analysis will be utilized to develop a stormwater management plan, assess whether existing BMPs can handle the additional load, and design additional BMPs if necessary. The stormwater management plan and the design of stormwater management BMPs will be developed in accordance with the guidelines and performance standards outlined in Chapters NR 151, NR 216, and NR 811 of the Wisconsin Administration Code.

10.7.2.4.5 Utilities

New utilities considered for the WSCB include potable water for fire protection, process piping, electrical, fiber optic, and natural gas. Each utility was evaluated to determine the necessary connections and improvements to existing utilities.

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Electric: Electric service will be delivered to the WSCB through a single underground feeder from the Highline BPS, as described in Section 10.7.7.

Fiber Optic: Fiber optic service will provide communications for the Program. It is anticipated that this service will be new and connect all Program Elements. Radio will be considered only for communication if fiber optic is not feasible in downtown Waukesha. This utility is discussed in detail in Section 10.7.8

Natural Gas: Natural gas service will be provided as described in Section 10.7.6.3.

Potable Water: Potable water for the domestic water supply at the WSCB will be provided by the Water Supply Pipeline from the BPS to WWU. This pipe will be under constant pressure as the pumping station is anticipated to operate continuously.

Fire Protection: Fire protection will be provided to the WSCB as described in Section 10.7.6. Fire protection will also be provided by hydrants. The location and spacing of the hydrants will be coordinated with the fire department.

Process Piping The 36-inch nominal diameter Water Supply Pipeline will enter the WSCB on the east side of the building and exit on the north side of the building. A 30-inch nominal diameter pipeline will exit the WSCB and then head east toward the intersection of Les Paul Parkway and Sunset Drive and connect to WWU's distribution system. More detailed information on process piping is included in Section 10.7.5.

Storm Sewer: As indicated above, a stormwater analysis will be completed during design for the WSCB that will examine pre- and post-development conditions at the site. Post-development conditions will be analyzed with and without BMPs. This will determine the necessary size and location for storm sewers or water retention, if needed.

10.7.3 Structural

Foundation: A geotechnical investigation will be performed to determine subsurface conditions for the WSCB. An assumed soil bearing capacity of 3,000 psf was used for the preliminary design.

Bedding and Backfill: Bedding under internal slabs on grade will be eight inches of compacted granular soil. Backfill against foundation walls and retaining walls will be a compacted granular material with an internal friction angle of 30 degrees.

Floor System: The slab on grade floor will be seven-inch concrete reinforced with macro polypropylene fibers.

Roof System: The sloped roof with overhangs will be constructed of 10-inch steel beams with 1-1/2-inch metal deck. These beams will be supported on concrete columns partially buried in the masonry walls.

Wall System: The eight-inch masonry will be used as shear walls. Reinforcing will be designed as required for lateral loads. Lintels will be reinforced concrete with separate steel angles for the face brick.

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10.7.4 Architectural

10.7.4.1 General

The WSCB will adhere to the aesthetic direction given by WWU as described in Section 4. The structure will complement the existing structures on-site, which most notably includes a hip style shingled roof with a dormer at the front.

10.7.4.2 Site Conditions

As illustrated in Figure 10-22, the WSCB will be located adjacent to the existing Highline BPS at the northwest corner of Les Paul Parkway and Sunset Drive in Waukesha. The site is bisected by a utility easement for the electrical utility. The site is bordered on the north and west sides by residential developments. A dense group of trees block the view from the north.

Figure 10-22 Site Diagram

10.7.4.3 Building Aesthetics

As illustrated in Figure 10-23, the WSCB will be a masonry clad structure with minimal fenestration and louvers provided for ventilation. The roof of the WSCB will be a pitched to match the existing structure. The building aesthetics will be subject to approval from the Waukesha Plan Commission.

10.7.4.4 Structural System

The WSCB will be built using load bearing masonry walls and a framed roofing system.

10.7.4.5 Codes, Standards, and References

The design will adhere to Chapter 22, Zoning Code of Waukesha as well as those listed in Section 4.

10.7.4.6 Space Allocation

The WSCB will be a single room building located adjacent to an existing pumping station. The building will include all process, mechanical, electrical, and instrumentation equipment.

10.7.4.7 Materials

The building will follow the guidelines of Section 4 for materials and technology except as listed below.

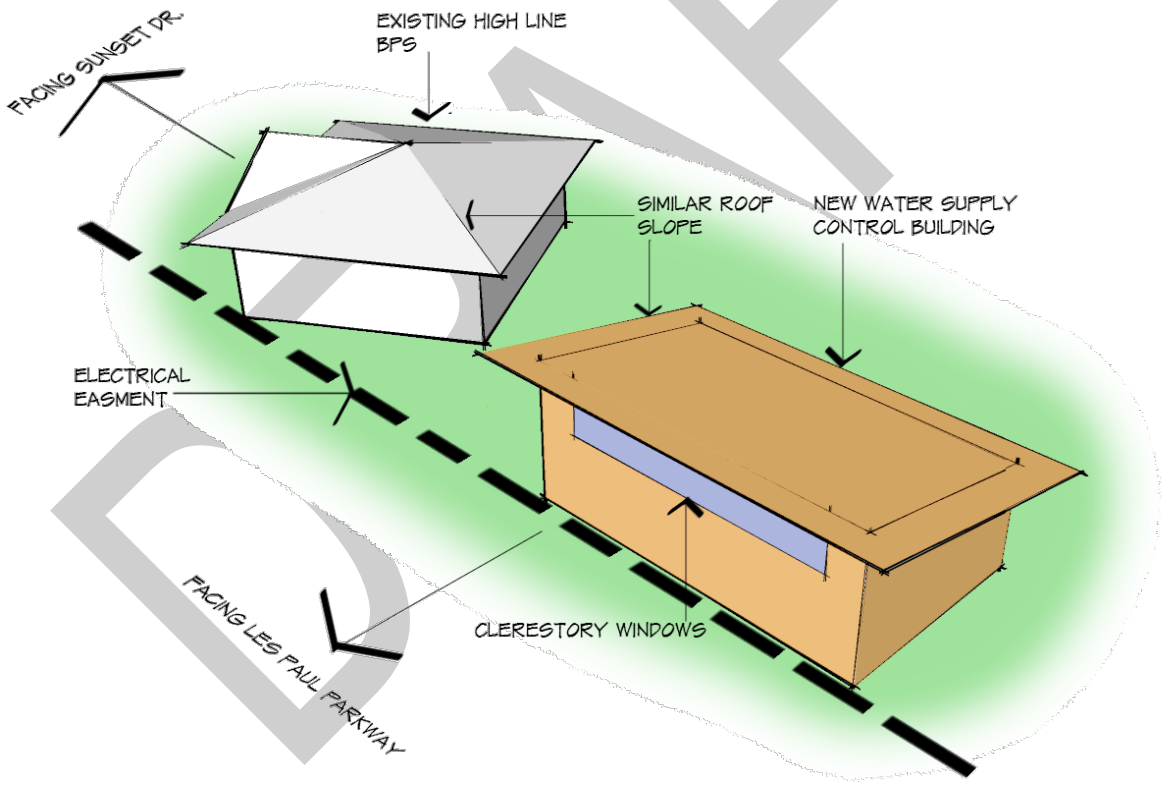

Figure 10-23 Conceptual Building Sketch

10.7.5 Process Mechanical

10.7.5.1 Hydraulics

To control pressures in the system, the WSCB will house PRVs similar to the Cla-Val Hytrol Valve. This valve will maintain a constant downstream pressure, regardless of fluctuating demand. The pressure reducing feature produces discharge pressures comparable to that of WWU's distribution system. This valve will include a surge relief pilot to protect the valves in the event of hydraulic transients. Two of these valves will be included in a horizontally stacked configuration to provide a level of redundancy in the event of failure. The valve has been preliminarily sized to be capable of handling a wide range of flows, including the 19 MGD PHD. Per manufacturer recommendation and in order to support WWU's future needs, the PRV is recommended to be 18-inches in diameter.

10.7.5.2 Piping and Valves

Within the WSCB, pipeline appurtenances will be installed to control system pressure upstream of the distribution system connection. These appurtenances have been chosen for their design features, reliability, maintainability and cost. A plan and section view of the WSCB is included in Appendix E, Drawing Sheet CP2-M2.

All buried pipe near the WSCB is anticipated to be restrained. All interior piping in the WSCB will be flanged. Reducers were oriented to consider air management. Isolation valves within the WSCB will provide means to shut off flow for maintenance of the PRVs. Four, 18-inch butterfly valves will be installed and will be actuated with a geared hand wheel actuator. The hand wheel actuators will be positioned for operational convenience and safety. Within the WSCB, the pipe and joints will be supported from the floor with concrete supports. Joints will be located to facilitate maintenance and removal of the appurtenances.

10.7.6 Mechanical

10.7.6.1 General

This section presents the basis of design for heating, ventilating, and air conditioning (HVAC) and plumbing systems associated with the WSCB. The requirements outlined in this section are a subset to Section 4, detailing the design approach for HVAC and plumbing at the WSCB. The design for the HVAC and plumbing systems for this Program will be based on the following concepts and regulations.

10.7.6.2 Heating, Ventilating, and Air Conditioning System

For HVAC design criteria, refer to Section 4.8 for details.

10.7.6.3 Systems and Equipment Serving Process Areas

A Water Supply Facilities SCADA, Electrical and Mechanical Meeting (6-200 M-03) was held on August 17, 2017. The purpose of the meeting was to discuss and gain consensus on HVAC design alternatives for the Program facilities. As discussed during the meeting, the WSCB area will be designed to maintain 50°F in the winter. The summer design temperature will be 10°F above ambient. As discussed during the Water Supply Facilities Tour – Electrical and Mechanical Meeting (6-200 M-02) held on July 13, 2017, the WSCB will also be designed to accommodate the portable dehumidification units (Hi-E Dry) for when excessive condensation occurs. The WSCB will be conditioned with a combination of exhaust fans and outside air intake louvers in the summer. Heating will be

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accomplished by either electric or gas fired unitary heating equipment. The mechanical design will specify room temperature sensors for automatic operation of the outside air dampers and exhaust fans. These sensors will report back to the local temperature control panels (TCP) to allow control and monitoring. The TCP will report critical alarms to the supervisory control and data acquisition (SCADA) system.

10.7.6.3.1 Exterior Design Conditions

Refer to Section 4.7 for exterior design conditions.

10.7.6.3.2 Air Distribution System

There will be no ductwork distribution systems in the WSCB.

10.7.6.3.3 Gas Distribution System

For general gas distribution system description, refer to Section 4 for details.

10.7.6.3.4 Control System

For HVAC Control System description, refer to Section 4 for details.

10.7.6.3.5 Plumbing System Design

Plumbing system design including domestic and stormwater, and plumbing fixtures, are described in Section 4.

10.7.6.3.6 Fire Protection Systems

A fire alarm system will be specified under electrical work. It will include fan shut down where required by Code. Smoke detectors will be monitored at a fire alarm control panel. Fire alarm signals will be monitored by the corresponding TCP associated with the HVAC system. All alarms will be sent to the SCADA system and to the local fire department.

10.7.6.3.7 Reduced Energy Consumption

For the reduced energy consumption description, refer to Section 4 for details.

10.7.6.3.8 Flood Alleviation

For the flood alleviation HVAC and plumbing system descriptions, refer to Section 4 for details.

10.7.7 Electrical

10.7.7.1 General

This section presents the basis of design for electrical systems associated with the WSCB. The requirements outlined in this section are a subset to Section 4, detailing the design approach for electrical systems. The design for the electrical systems for the WSCB will be based on the concepts and regulations contained herein.

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10.7.7.2 Bulk Electrical Distribution

Electric service will be delivered to the WSCB at 240/120-Volts, single-phase and will enter through a single underground feeder from the Highline BPS. The service equipment will be a 100-Amp panelboard meeting the criteria in Section 4.7.

10.7.7.3 Source of Utility Power

Electrical power will be derived from the existing service at the Highline BPS. A subfeed circuit breaker will be provided in the existing panelboard at the Highline BPS motor control center.

10.7.7.4 Interior Lighting

Interior lighting fixtures will use LED sources and vapor tight enclosures. Lighting fixtures will meet the criteria in Section 4.7.

10.7.7.5 Convenience Receptacles

Standard 20-Amp, 120-Volt receptacles will be located throughout the interior of the WSCB for service use. A minimum of one per wall for general use and one adjacent to each piece of equipment will be provided.

Standard 20-Amp, 120-Volt receptacles with weatherproof while-in-use covers will be provided at the exterior of the building for service use. One will be located at each piece of HVAC equipment, the electric service equipment, and each door.

10.7.7.6 Reliability and Standby Power

The PRVs do not require electrical power to function. Only instruments will require reliable power for continuity of monitoring. Critical instrumentation and telecommunications system loads will be powered through an uninterruptible power supply (UPS).

10.7.7.7 Emergency Lighting

Required emergency lighting will be provided through emergency battery units with LED lamps and batteries selected for a minimum 90-minute duration. Battery units will be located to provide a minimum two-foot-candle illuminance along the egress path.

Exterior lighting fixtures at the WSCB entrance will be provided with integral battery sources for operation during a utility power outage.

10.7.7.8 Conduit

All interior conduit will be rigid galvanized steel with cast fittings. Exterior conduit will be PVC pipe, encased in reinforced concrete duct banks.

10.7.7.8.1 Enclosures

Enclosures will be a dust tight, metallic National Electrical Manufacturers Association (NEMA) 12.

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10.7.7.8.2 Grounding System

A complete grounding system will be provided, refer to Section 4.7 for more details.

10.7.8 Instrumentation and Controls

The purpose of the WSCB is to provide pressure reduction downstream of the building. The control scheme within the WSCB involves programmable logic controller (PLC) interaction with the PRVs, as well as pressure instrumentation for monitoring and alarming.

10.7.8.1 Programmable Logic Controller

The monitoring and alarming within the WSCB will be accomplished via a standard microprocessor-based PLC and input/output (I/O) modules for instrumentation and network link to remote control systems. The WSCB will have a spare pre-programmed PLC for fast switch out backup.

The WSCB PLC will be located within the WSCB. Operator interface with the PLC will consist of an operator interface terminal (OIT), which will provide graphic interface, diagnostics, trending, alarms, and status displays.

The WSCB PLC will communicate with other program PLCs for remote monitoring, with the BPS via fiber optic connection, and with WWU via wireless radio.

10.7.8.2 Pressure Control

Water Supply Pipeline pressure downstream of the WSCB will be reduced by the PRVs within the building, with valve interaction with the PLC. The operator will have the capability to input pressure setpoints into the control system via operator station interaction remotely or locally.

Pressure control will be accomplished via the WSCB PLC by PID type control loops using pressure feedback from pressure indicating transmitters located directly downstream from each valve. A remote pressure setpoint can be entered through the control system. A manually operated isolation valve will be located upstream and downstream of each PRV.

10.7.8.2.1 Pressure Control Operation Protocol

The PRVs will maintain a constant pressure downstream of the WSCB. The control will respond to slight variations in downstream pressure to reposition the main valve to maintain the pressure setpoint.

The valve electronic control system will work in conjunction with the PRVs by receiving transmitted signals and activating dual solenoid pilots to direct hydraulic pressure within the system to position and regulate the valve. The controller will compare the feedback signal from the pressure indicating transmitters to the setpoints. The control system activates when deviation exceeds the deadband, actuating the solenoid controls to modulate the valve percent open. Valve control will incorporate time delays to minimize fluctuations in position or rapid cycling.

Pressure indicating transmitters with 4-20 mA analog output will be located directly upstream and downstream of each valve. Alarms will be generated in the control system for high and high-high pressure measurements downstream of the PRVs.

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10.7.8.3 Site Security

The WSCB security system will include site monitoring equipment and building access control. The site will be monitored by closed circuit television, and monitoring equipment will consist of cameras around key points of the building. Physical access to the WSCB will be monitored and controlled via electronic access at the main entrances.

10.8 Construction

The purpose of this section is to describe aspects of construction contractors will incorporate into their construction plans. Certain aspects will be specified or required as part of permits; many aspects are the individual contractor's means and methods and will be determined by them.

10.8.1 Sequence of Construction

Sequencing of construction will be required to coordinate with other Program Elements, minimize impacts to the schedule, and maintain access. A sequence of construction will be prepared during design.

10.8.2 Hours of Construction

Hours of construction will be coordinated with WWU, Waukesha, other municipalities traversed by the pipelines, Waukesha County, and Milwaukee County. Although in general it is anticipated that the hours of construction will be from 6:00 a.m. to 7:00 p.m., construction near residents, such as at the WSCB, may require a later start time of 7:00 or 8:00 a.m.

10.8.3 Contractor Staging

To minimize disruption and create efficient workflow, the contractor will develop a staging plan. The majority of the Water Supply and Return Flow Pipeline construction will occur in active roadway corridors and near existing residences or businesses.

Maintenance of traffic (MOT) plans will be developed during design. Traffic control will be required in active work areas near roadways to create a barrier between the construction and the public. This will include the use of detours, lane closures, flaggers, and temporary striping or signage.

It is anticipated that some designated construction storage and staging areas may be identified during design and access provided to contractors for their use during construction. The contractors may also identify and obtain permission for their own staging or storage areas apart from those that may be offered by WWU as part of the bid packages. These areas may be utilized by the contractors to store equipment and materials. Options for areas to be included in the bid packages include government or publicly owned land. Requirements concerning documentation of permissions for any contractor-obtained private property used for staging will be detailed in the construction specifications. The contractors will be responsible for any on-site construction trailers, local utilities such as electric and telephone, fencing, and security. Areas obtained by WWU may include multiple contractors for each designated site, with restrictions, such as stormwater control, access point designation, and conditions identified or specified in the bid documents.

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10.8.4 Construction Site Security

The contractor will be responsible for staging area security. The staging area will be secured with temporary fencing, gates, lights, cameras, etc. as required. Gates and access doors will be locked in order to only allow access for contractor, its sub-contractors, owner and their representatives.

10.8.5 Haul Route and Site Access

Haul routes and access point locations will utilize erosion and sediment controls including a stabilized construction entrance and/or wheel wash. The contractor must keep roadways free from debris at all times.

10.8.6 Erosion and Sediment Controls

The Contract Documents will require applicable erosion and sediment controls by preparing and submitting a Storm Water Pollution Prevention Plan (SWPPP) per the most recent requirements of NR 216.46 of the Wisconsin Pollution Discharge Elimination System (WPDES). The bid documents will include applicable local details and specifications for erosion and sediment controls.

The construction plans will identify and indicate required wetlands or waterway jurisdictional lines and buffers and require that these areas be protected during the contract work. Minimization and avoidance of impacts during design will be provided near existing wetlands and/or waterways by use of construction methods such as HDD. Work within roadside drainage ditches will require erosion and sedimentation controls as described in the erosion and sediment controls plan. Fine grading and restoration will return the ditch profile to existing conditions or greater to promote ditch drainage. Site reporting and monitoring will follow the most recent requirement of NR 216.48 of the WPDES. Typical recurring site reports include weekly inspections or after every 0.5-inch rain event. Additional reports including occurrences of non-compliance must be documented and submitted to the WDNR.

10.8.7 Dewatering Plan

A contractor-prepared dewatering plan will be required by the Contract Documents. Soil borings will be provided to the contractor for information to facilitate bidding and aid in the development of a dewatering plan. The Contract Documents will require the contractor to perform geotechnical work during bidding and construction as needed to properly bid and construct the work. Dewatering will progress with the work and follow all applicable erosion and sediment control details and specifications provided by the local municipality or regulating agency. Dewatering will discharge to existing roadside drainage ditches in order not to impede stormwater runoff.

10.8.8 Excavation Methods

The contractor will be required by the Contract Documents to have sheeting and shoring designed by a professional engineer licensed in the State of Wisconsin. It is anticipated that the pipeline excavations will require the use of a trench box or sheeting/shoring.

10.8.9 Material Management Plan

Stockpile Area: The Contract Documents will require stockpiling of suitable materials during construction for use as pipe bedding or backfill. Unsuitable materials will be the responsibility of the contractor for hauling and disposal. Stockpiles will be kept within the limits of construction or the contractors own site.

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On-Site Suitable Material: Approved excavated materials from the site may be reused on-site as fill or backfill. Unsuitable material will be disposed of off-site at appropriately licensed disposal facilities.

Disposable Non-Contaminated Materials: Materials characterized as non-contaminated materials and either excess or not suitable for construction will be disposed of per NR 500-538 of the Wisconsin Administrative Code. The contractor will also coordinate with local disposal agencies and follow all local, county, and state limitations and regulations.

Disposal of Contaminated Materials: Any contaminated materials discovered during construction will be removed and disposed of in accordance with all applicable local, State, and Federal regulations. The cost for disposal of unforeseen contaminated materials will be further evaluated during design after field investigations have been completed. The approach for unforeseen contaminated materials will most likely include unit prices for removal in the contract specifications and will be refined during design.

10.8.10 Coordination with Planned Regional Transportation Projects

The Contract Documents will identify special conditions and required coordination with other projects, including planned transportation projects. Regional transportation projects planned by local municipalities or transportation authorities before and during construction may affect the phasing and schedule of Program construction. Planned regional transportation projects that overlap with corridors utilized by the Water Supply and Return Flow Pipelines that are anticipated before Program construction can affect Program schedule, cost, and permitting. Additional risks include added costs and schedule delays that may arise if the planned regional transportation project is delayed. In cases where the planned regional transportation project overlaps with pipeline corridors, the pipeline design may require adjustment to minimize or avoid conflicts such that rebuilding of new infrastructure is minimized or eliminated. Where regional transportation projects are planned during Program construction that overlap with pipelines, opportunities exist to take advantage of potential synergies, such as sharing maintenance of traffic and surface restoration costs, between the two projects.

The planned regional transportation projects that overlap pipeline corridors and which will be considered during final design are summarized below:

- The Milwaukee County DOT completed a roadway maintenance and resurfacing project along Ryan Road from 92nd to 112th Streets in 2017. The project is located in the area of the Return Flow Pipeline. A meeting was held on April 19, 2017 with WWU and the Milwaukee County DOT, and it was determined the pipeline will be located outside the edge of pavement within this corridor to eliminate impacts to the new road. Route sub-alternatives were identified and a preferred sub-alternative was selected. A preliminary horizontal alignment was developed and shared with the Milwaukee County DOT as part of the Milwaukee County Meeting (3-500 M-01) held on September 6, 2017 that demonstrated the alignment beyond the edge of pavement. The Milwaukee County DOT determined the horizontal alignment to be acceptable.
- WisDOT completed a maintenance and resurfacing project along Loomis Road from County Highway Y to Route 100 in 2017. This roadway project is located in the area of the Return Flow Pipeline. The schedule of Program construction is such that construction will not affect this roadway project.
- New Berlin completed reconditioning of Beloit Road between Moorland Road and National Avenue in 2017. The Water Supply and Return Flow Pipelines are not anticipated to utilize this corridor.

- Muskego is planning a pavement replacement project along Moorland Road from Janesville Road to McShane Drive. This roadway project is located in the same corridor as the Return Flow Pipeline. The Moorland Road pavement replacement project will be expected to be completed by 2018. The horizontal alignment of the Return Flow Pipeline has been developed beyond the edge of pavement to eliminate the need to rebuild the road.
- New Berlin is planning a roadway expansion project on Moorland Road from College Avenue to Grange Avenue. Moorland Road will be expanded from two lanes to four lanes. The existing roadway will be utilized as the northbound lanes. The existing landscaped parkway area between the west edge of pavement and sidewalk on the west side of the roadway will be developed to become the new southbound lanes. This roadway project will be located in the same corridor as the Return Flow Pipeline. The project is expected to be constructed in 2018 before Program construction begins. Modifications to the preliminary horizontal alignment and/or trenchless construction methods will need to be developed to eliminate the need to rebuild the road once final plans for this planned regional transportation projects are made available.
- WisDOT is planning a reconstruction project to expand to additional lanes along Ryan and St. Martins Road from 60th Street to Loomis Road. This project will be located in proximity to the Return Flow Pipeline. The roadway reconstruction and expansion project is expected to be completed by 2021 or 2022. Since the schedule of this roadway reconstruction project is aligned with the schedule of the Program's construction, there is a potential to coordinate construction along this corridor so that both projects may proceed without delays and take advantage of potential concurrent construction schedules.
- WisDOT is planning a bridge rehabilitation project along Interstate 43 from Route 164 to Beloit Road. This bridge rehabilitation project is located in the area of the Return Flow Pipeline. The Interstate 43 bridge rehabilitation project is expected to be completed by 2022. The horizontal alignments of the Return Flow Pipeline has been planned to be a sufficient distance away from the roadway as to not have either construction project impede the other.

10.8.11 Coordination with Other Contract Packages

Coordination with all other Contract Packages will be needed during pipeline design and construction. The required coordination will be determined during design and any constraints to be considered by the bidders included in the bid documents. Refer to Section 15 for anticipated Program construction schedule.

10.9 Sustainability

The route studies were the first step in designing the Water Supply and Return Flow Pipelines. The route studies included economic analyses, non-economic analyses, and Triple Bottom Line (TBL) evaluations that incorporated sustainable aspects into the identification of the preferred routes for the Water Supply and Return Flow Pipelines. To track the cumulative benefit of all sustainability initiatives pursued or committed to, the Program was assessed using the Envision rating system by the Institute for Sustainable Infrastructure. This rating system provides a holistic framework for measuring the net benefit of investments made in the social, economic, and environmental well-being of the communities served by the infrastructure. Details about the efforts to further incorporate sustainability into the preliminary designs presented in this section of the Water Supply and Return Flow Pipelines are outlined in the following subsections using the TBL approach, focusing on the social, economic, and environmental considerations in the design.

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10.9.1 Social

In order to maintain and enhance the quality of life and better integrate the pipelines into the existing infrastructure, several social initiatives are being employed in the design and construction of the Water Supply and Return Flow Pipelines. They include Contract Package size, site restoration, and communication with stakeholders and utilities.

The Water Supply and Return Flow Pipes have been separated into multiple smaller Contract Packages to increase the prospect of bids from local contractors. The potential involvement of local contractors in the Program can provide Southeast Wisconsin's construction industry with valuable experience, while also equipping the region with the experience to maintain the pipelines in the future.

The majority of the pipelines will be located in right-of-way, and all landscaping and infrastructure above the trench will be restored to existing conditions. Where required, restoration will be updated to meet local permits, as described in Section 10.4.7.

This design requires extensive communication and collaboration with residents, municipalities, and other entities. The Program encourages stakeholder involvement in the design process by holding Open House Meetings and documenting stakeholder input; this process is described in the Draft Route Study: Oak Creek (4-100 D1) and Draft Route Study: Milwaukee (4-100 D2). The pipelines will be integrated with existing infrastructure in the right-of-way by coordinating with local municipalities to mitigate impacts on existing utilities. Additionally, the jack and bore or HDD methods for trenchless pipe installation will be utilized to cross major intersections to minimize traffic disruption and waterways to minimize disturbance to wetlands or surface waters. These instances of infrastructure integration are both captured in Section 10.4.8.

10.9.2 Economic

The economic considerations of the Water Supply and Return Flow Pipeline designs focus on resiliency and efficient construction and maintenance. As discussed earlier, the limited size of the Contract Packages encourages local contractor participation. This will both develop local capabilities and familiarize the contractors with the Program so that these contractors will be better suited to perform effective maintenance on the pipelines when necessary.

With a 100-year design life, risks to the functionality of the pipelines during operations have been considered in the design. The Water Supply and Return Flow Pipelines will traverse areas of corrosive soils and areas suspected to contain contaminated materials. Soil borings and contaminated material field investigations have been initiated along the pipeline alignments to delineate subsurface conditions. The pipelines will be designed for corrosion control based on the field investigation data obtained. If contaminated soil or groundwater is encountered, procedures to address such situations will be designed to reduce the potential for contaminants that can degrade pipeline gaskets and appurtenances.

Pipelines and appurtenances will be locally and/or regionally manufactured to the extent feasible in an effort to reduce the energy used in the transport of materials and to contribute to the economic well-being of the region. The majority of iron and steel materials in the Program will be produced in the United States. The recycling of excavated material as backfill will be implemented where appropriate in order to reduce the quantity of excavated materials required for hauling and disposal. These practices are discussed further in Sections 10.6 and 10.5.3, respectively.

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10.9.3 Environmental

The Water Supply and Return Flow Pipelines are designed to minimize environmental impacts by providing protection for RTE species communities and surface waters contiguous to the construction site. An endangered species assessment was conducted and found that the pipelines potentially cross RTE species communities. The pipeline design will continue to be developed to include the required and recommended measures for construction within and in proximity to a potential RTE community, as described in Sections 10.3. Impacts to floodplains and waterways will be mitigated by the trenchless construction, as described in Section 10.4.8.

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SECTION 11 Booster Pumping Station and Reservoir Design

11.1 Overview

The purpose of the Booster Pumping Station (BPS) is to store, treat, and pump potable water received from the water supplier via the Water Supply Pipeline and convey that water to the Waukesha Water Utility (WWU) distribution system. To perform these functions, the BPS has been designed to meet the full range of anticipated demands from WWU. The on-site reservoirs, fed by the Water Supply Pumping Station (WSPS), provide a delineation between the Milwaukee Water Works (MWW) and WWU systems and provide emergency storage. Chemicals will be added to the water prior to the reservoirs and/or after the pumps in order to maintain potable water quality standards. Figure 11-1 shows a simplified diagram of the BPS in reference to other facilities along the Water Supply Pipeline.

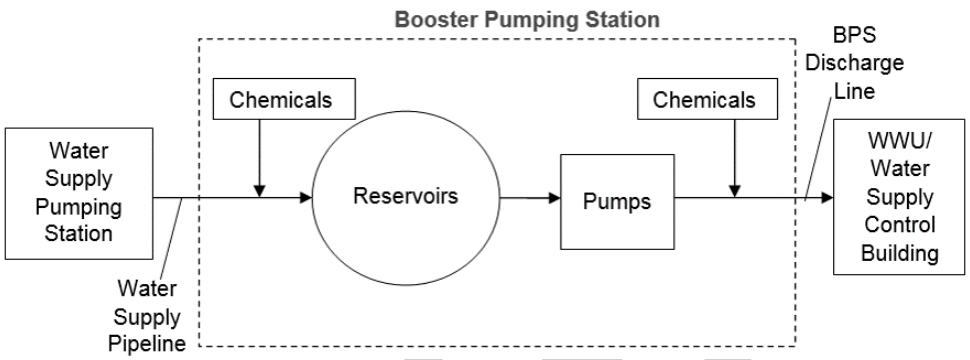

Figure 11-1 Booster Pumping Station Diagram

This section discusses the process design elements of the BPS shown in Figure 11-1 and design elements of the supporting disciplines: civil, structural, architectural, mechanical, electrical, and instrumentation and controls (I&C).

11.2 Site Location

WWU does not own a site that can support the BPS, therefore a new site was selected. The site selection was performed in conjunction with the preferred route selection process and is described in the following sections.

11.2.1 Site Screening

Screening for a potential BPS site consisted of field reconnaissance, desktop analysis, evaluation, and comparison of the possible sites. Pipeline and site hydraulic features and issues were identified for each site.

Site visits were completed to perform a visual review with regard to existing site conditions, open space, and adjacent lands. Upon completion of the field reconnaissance, the list of potential sites was narrowed, and a desktop analysis was conducted on the remaining sites to provide information to be used for comparing and ranking. The desktop analyses evaluated the following subject areas:

- Hazardous Materials
- Archaeological
- Wetlands and Waterways

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- Floodplain and Floodway
- Site Size and Elevations

The BPS site recommendations and the conceptual layouts were presented to WWU during the BPS Site and Building Meeting (6-200 M-01) held on June 29, 2017, with the preferred site being B-10. Upon further evaluation of the area around Site B-10, additional locations adjacent to the site were identified and considered. The new locations were assigned designations as B-10.1 (southwest corner of South Swartz Road and South Racine Avenue) and B-10.2 (southeast corner of South Swartz Road and South Racine Avenue) of which B-10.1 was preferred due to its ownership by the Waukesha County Department of Parks and Land Use (DPLU). The preferred site is situated in Minooka Park and land transfer can be effectively coordinated between DPLU and WWU. Figure 11-2 shows the preferred Site B-10.1.

Site B-10.1 contains a wetland that separates Site B-10.1 into two potential areas for the BPS. Both areas of Site B-10.1 were considered. The area located to the west of the wetland was designated as Site B-10.1A and the area to the east of the wetland was designated as Site B-10.1B.

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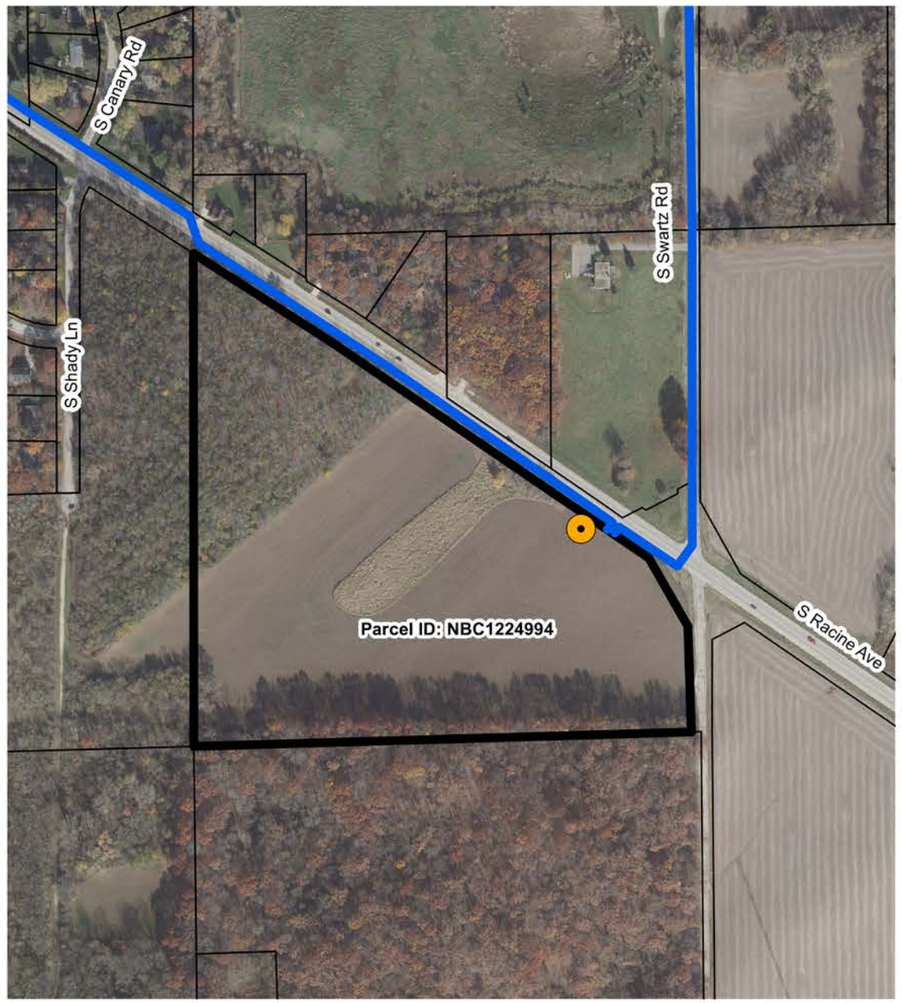
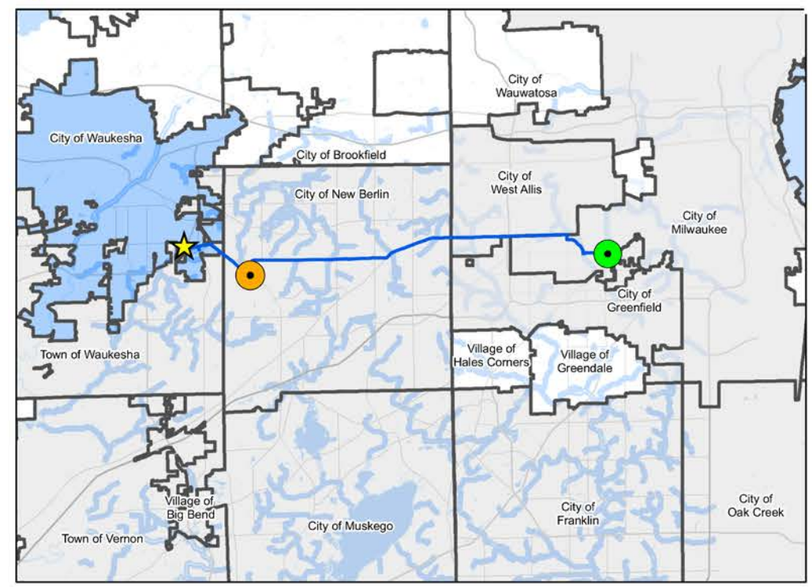


Booster Pumping Station and Reservoirs Site

Legend

- Connection to WWU Distribution System
- Connection to MWW Distribution System
- BPS Location
- Selected Supply Route
- Preferred Site



Key Map

Parcel Information

Location:	City of New Berlin
Parcel ID:	NBC1224994
Owner:	Waukesha County Park & Planning Dept
Owner Address:	1320 Pewaukee Road
Acreage:	27
Zoning:	Parks and Recreation
Land Use:	Agricultural
Last Sale Date:	N/A
Sale Price:	N/A

Legal Description

PT W.50 SE.25 SEC 18 T6N R20E LYING S OF RACINE RD 27 AC R2012 I189

GREAT WATER ALLIANCE™
Waukesha Water Utility
GREELEY AND HANSEN
741 N. Grand Avenue, Suite 308
Waukesha, Wisconsin 53186

Waukesha, Wisconsin
Great Lakes Water Supply Program
Booster Pumping Station Preferred Site Location
Date: 4/27/2018

Plotted: 4/27/2018
Document Path: G:\15310-Waukesha Great Lakes Water Supply PM-CM\11 Task 6-Facilities\6-200 Design Reports\6-200 Design Report\Section 11 Booster Pumping Station and Reservoir Design\GIS Figures\BPS_Site_3292018.mxc

Figure 11-2 BPS Site B-10.1

11.2.2 Preferred Booster Pumping Station Site

Conceptual site plans were prepared for Sites B-10.1A and B-10.1B and reviewed with WWU. Due to a number of site constraints present with Site B-10.1A such as wetland limits and environmental corridor location, Site B-10.1B was selected as the preferred site. The advantages of Site B-10.1B include flexibility for site components, building layouts, site access, and hydraulics. The reservoirs can be located away from South Racine Avenue, a major arterial, to reduce the visual impact of the reservoirs. The building can be located toward South Racine Avenue and incorporate architectural aspects that are visually appealing.

A meeting was held with DPLU to review the initial conceptual site plan for the preferred site on July 19, 2017. DPLU accepted the conceptual site plan for Site B-10.1B, which is shown in Figure 11-3.

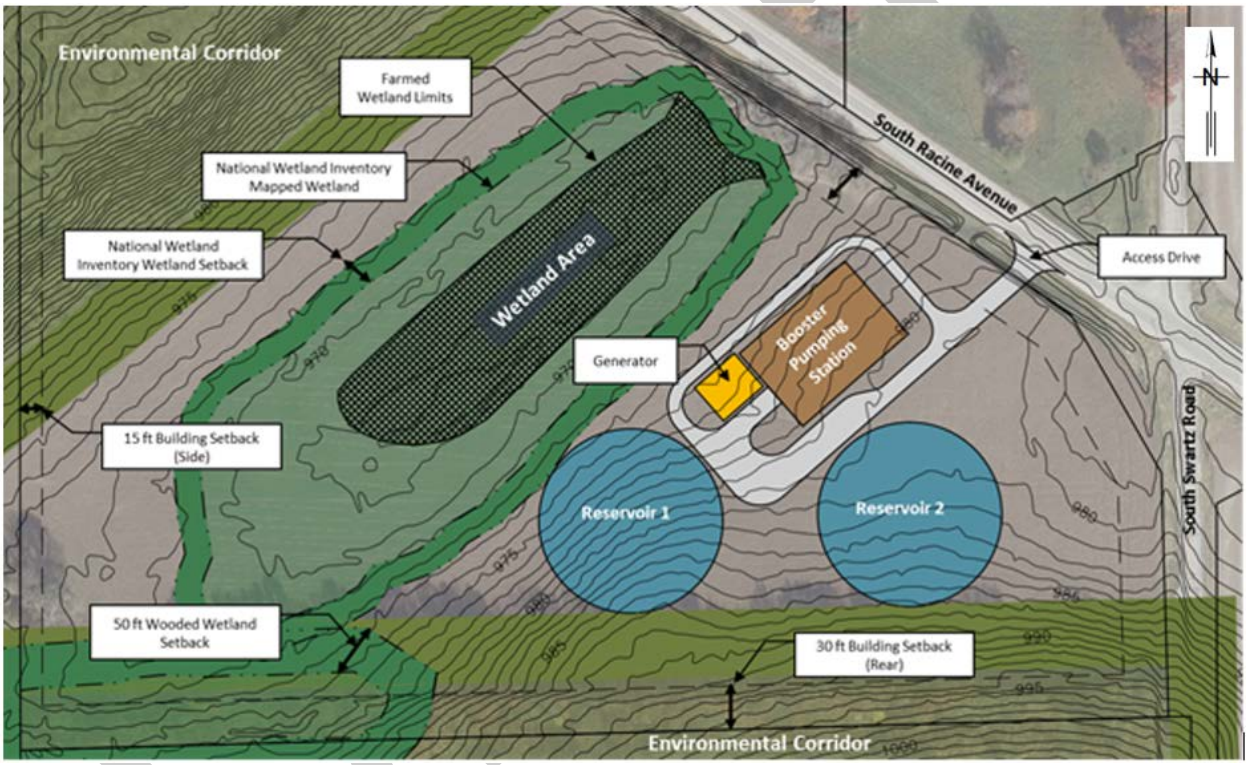


Figure 11-3 Conceptual Site B-10.1B Plan

Follow-up meetings will be held with the DPLU as the design progresses and the site layout is refined.

11.3 Civil/Site

This section identifies the civil/site engineering requirements for the BPS. The following subsections present information on data collection, desktop reviews, and field investigations, along with the proposed improvements and associated requirements.

11.3.1 Data Collection

Desktop analyses were performed to support the site screening process and determine the viability of the preferred site. These analyses included review of land use and surface features, aspects of the site associated with zoning, environmental, wetland and waterway, floodplain and floodway, archaeological, and rare, threatened, and endangered (RTE) species.

Field investigations were conducted to obtain information to support preliminary design and design activities. The following subsection describes the investigations completed and to be completed during design. Field investigations include surveys, wetlands and waterways, geotechnical borings, and hazardous materials.

11.3.1.1 Desktop Analysis

Land Use and Surface Features: The site is located at the southwest corner of Racine Avenue and Swartz Road and is situated in part of the west half of the southeast quarter of Section 18, Township 6N, Range 20E of the 4th Principal Meridian. The address associated with the site is 3675 South Racine Avenue, New Berlin, Wisconsin. According to the Waukesha County Tax Assessor, the parcel is owned by the Waukesha County Park and Planning Department and is used for agricultural purposes. Adjacent properties are a mixture of residential and agriculture uses. Figure 11-4 shows an aerial of the existing site (shown in red) and its location within Minooka Park (shown in green hatch).

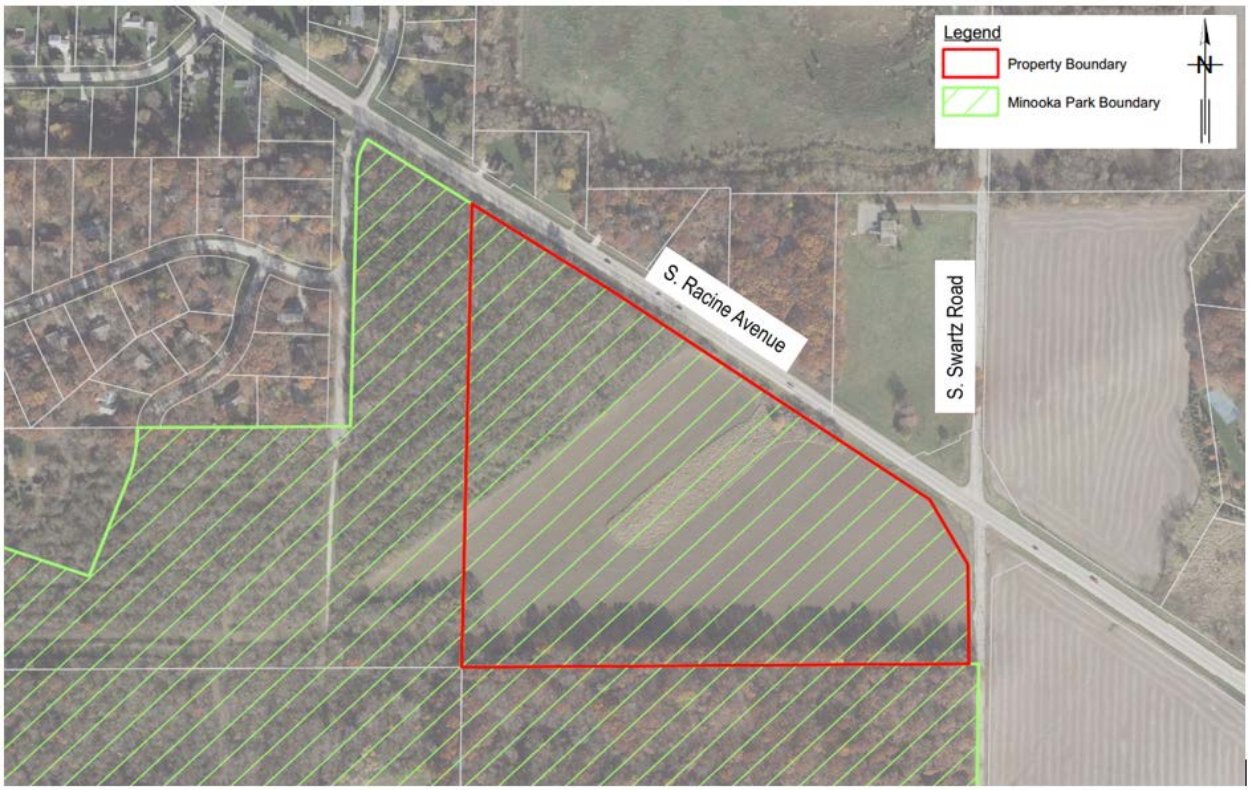


Figure 11-4 Existing Site Aerial

The parcel is approximately 27 acres. Approximately four acres of the site consists of a wetland area located in the center of the site and six acres of environmental corridor on the west side of the site with the remaining acreage being used for agriculture. The parcel gently slopes towards the wetland. The wetland does not have an outlet,

therefore, water impounded in the wetland either infiltrates or evaporates. Swales are located along the north and east sides of the site, which are bound by Racine Avenue and Swartz Road, and can be described as roadside ditches. Access to the site for agricultural equipment is provided by an entrance from Racine Avenue.

Zoning: Site B-10.1B is owned by DPLU and leased as farm land. The site is located within the City of New Berlin's (New Berlin) planning area and is zoned as P-1, Park and Recreation District. New Berlin's City Code defines this district as:

> *"The P-1 Park and Recreation District is intended to provide areas where open space and outdoor recreational needs of the citizens can be met without the undue disturbance of natural resources and adjacent uses. When applied to privately owned recreational lands, this district is intended to avoid the conversion of such lands to other urban uses without adequate public review and approval. The district should be used for areas designated as parks in the adopted New Berlin Comprehensive Plan."*

It should be noted that the Zoning Ordinance indicates that Essential Services are permitted in P-1 Districts. However, per Zoning Section 275-70, the definition of Essential Services is limited to the utilities necessary for the exercise of the principal use or service of the principal structure, but does not include buildings. The BPS does not meet the definition of an Essential Service. Therefore, it is recommended that the BPS be developed as a Conditional Use in a P-1 District. Table 11-1 shows the minimum setbacks for the P-1 District in accordance with New Berlin City Code Chapter 275, Article IV, Zoning.

Table 11-1 Zoning Information

Reference	Description	Requirements	
275-36		Institutional and Recreational / Park Districts	
275-36.B(2)	P-1 Park and Recreation District	Used for areas designated as parks in the adopted New Berlin comprehensive plan	
TBL 275-36-1	Uses For P-1	Utilities Essential Services	Conditional Principal
TBL 275-36-2	Site Development Standards For P-1	Minimum Lot Dimensions	
		Lot Area (sq ft) Essential Services	None None
		Minimum Setbacks (feet)	
		Front Side (Each) Rear Ordinary High Water Mark Wetland Maximum Height	50 50 50 50 10 / 30 35
TBL 275-36-3	Lot Coverage (Percentage)	Maximum Coverage By:	
		Building Impervious Surfaces Open Space And Landscaping	None None None

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Environmental: The site was not identified by Environmental Data Resources, Inc. (EDR) in any of the researched databases. This indicates that the site does not have a history of environmental issues. The EDR search did identify areas in the vicinity of the site on one or more of the environmental databases. Based on the relative distance between the database identified properties and the site and/or the reported site status, the identified areas are not expected to impact the site. The desktop analysis of the site did not find evidence of any recognized environmental conditions at the subject site.

As a prerequisite to land acquisition and to confirm the results of the desktop analysis, a Phase I Environmental Assessment (ESA) was completed. Based on the information reviewed from November 9 through November 16, 2017, no recognized environmental conditions, as defined by the All Appropriate Inquiry (AAI) ASTM Standard E-1527-13, were identified at the site. Due to the results of the Phase I ESA, a Phase II ESA is not recommended or required.

Environmental Corridors: Southeastern Wisconsin Regional Planning and Commission (SEWRPC) categorizes environmental corridors as primary environmental corridors, secondary environmental corridors, and isolated natural resource areas. The site contains isolated natural resource areas on the northwest, west, and south of the BPS site as shown in Figure 11-5. It is the intent of the Program to limit or eliminate disturbance to these areas.

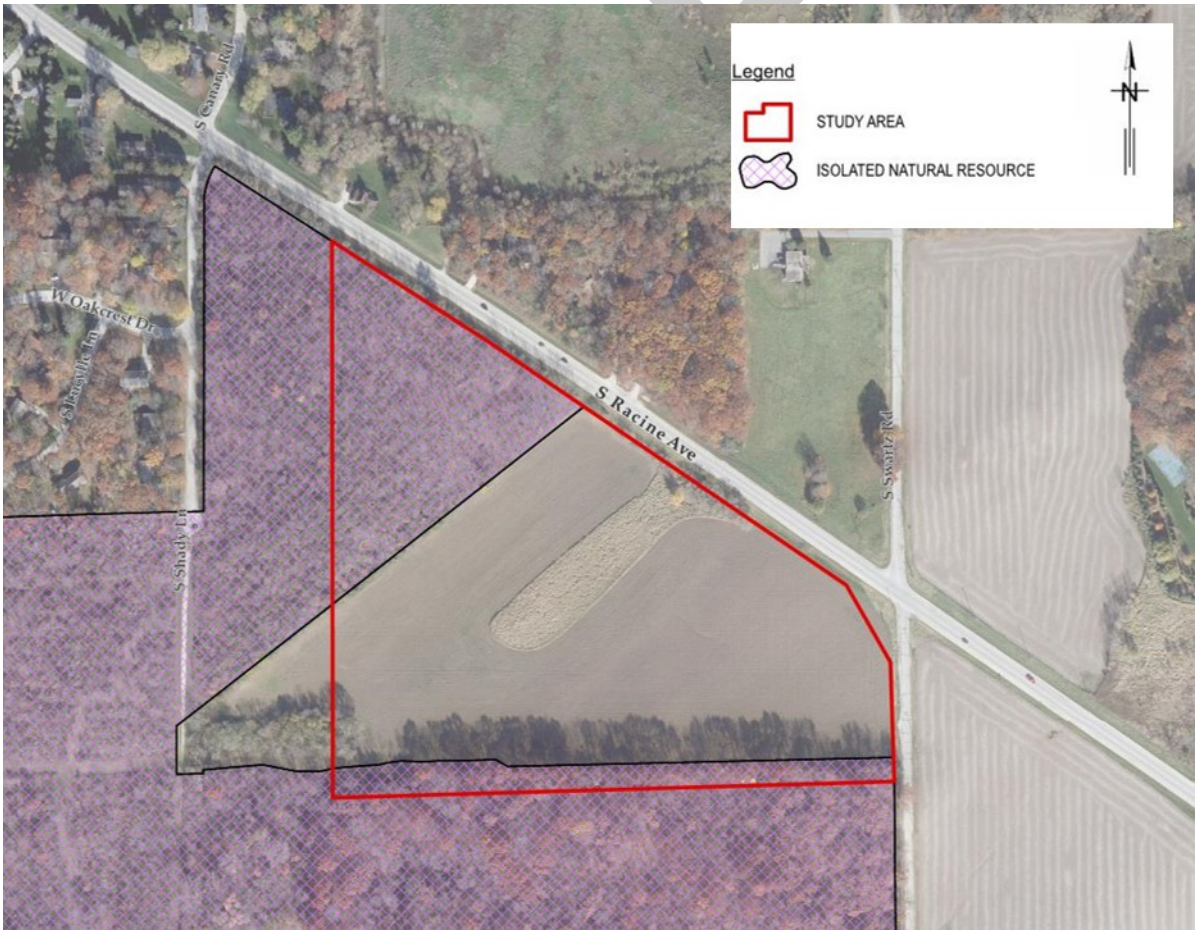

Figure 11-5 Environmental Corridors Map

Wetland and Waterway: A wetland and waterway desktop review on the BPS site location was conducted. The review included analysis of digital wetland inventory (DWI) data from Wisconsin Department of Natural Resources (WDNR), United States Geological Survey (USGS) Topographic Maps, Natural Resources Conservation Service (NRCS) Soils maps from the United States Department of Agriculture (USDA), Google Earth street view, recent aerial imagery, and county geographic information system (GIS) topographic data. The wetlands were then classified using the Wisconsin Wetland Inventory Classification System and emergent wetlands were further divided into the subcategories: natural and agricultural. Applicable waterways at each location were evaluated using the national hydrography dataset (NHD) from the USGS. The wetlands are identified in Figure 11-6 and are listed by their land area coverage in units of acres.

As shown in Table 11-1, New Berlin requires either a 10 or 30 foot setback for wetlands. The following information is presented in the New Berlin Zoning Ordinance:

Wetland Setback

a. *All impervious surfaces will be set back a minimum of 30 feet. However, where at least one of the following conditions is met, the minimum setback is 10 feet:*
    i. *The lot is vacant and is part of a platted residential subdivision that was recorded before October 9, 2001.*
    ii. *The building permit for the principal structure located on the lot was issued before October 9, 2001.*
b. *Grading may be allowed within the wetland setback upon approval by the Director. The applicant will demonstrate appropriate erosion control practices as approved by the City and/or the Wisconsin Department of Natural Resources (WDNR).*
c. *Landscaping may be allowed within the wetland setback upon approval by the Director. The applicant will demonstrate appropriate erosion control practices as approved by the City and/or the WDNR.*

New Berlin requires a 30 foot setback of any impervious surfaces from the delineated wetland limits. The conditions identified in the zoning ordinance for the 10 foot setback are not applicable. Grading and landscaping is allowed within the wetland buffer as approved by New Berlin. It is the intent of the Program to limit wetland disturbance and provide a 30 foot wetland buffer around the delineated wetland limits.

In addition to the setback requirements, the wetland does not positively drain to any other location by storm sewer or culvert. This will require consideration when defining water levels for impoundment and discharge to the wetland.

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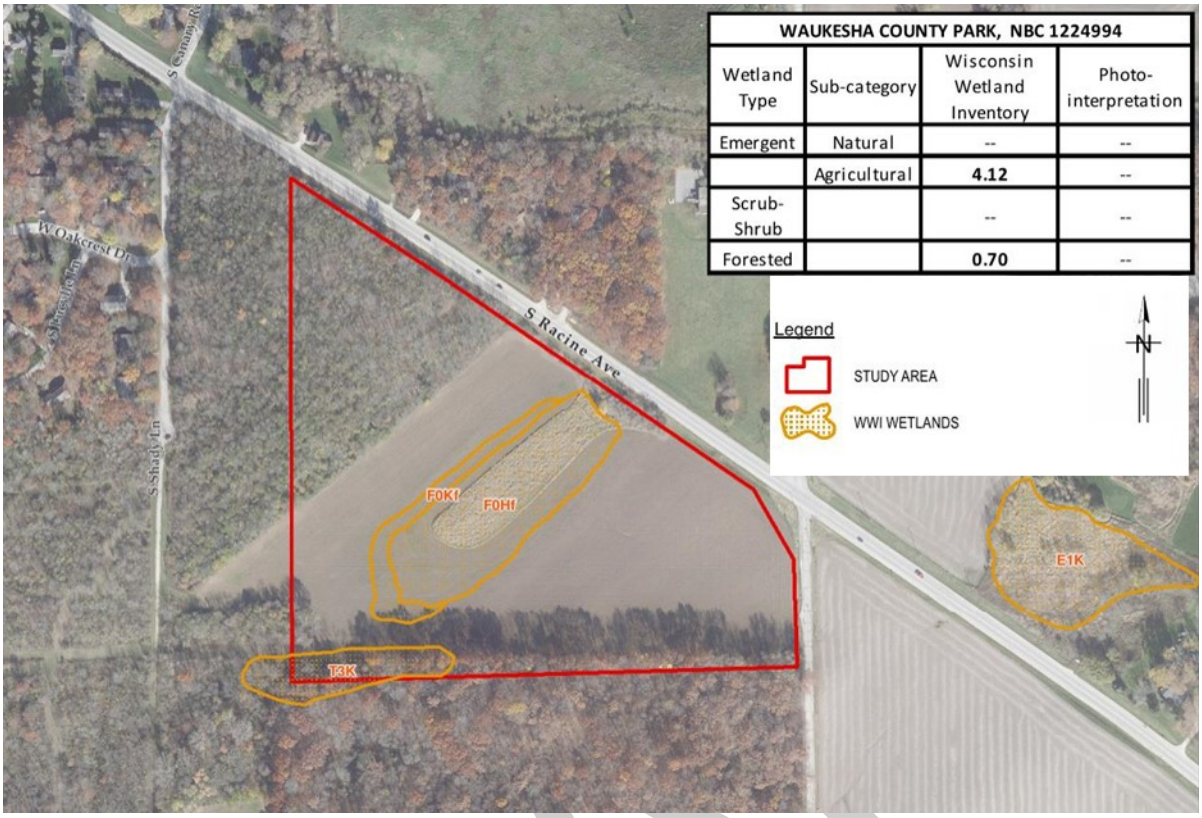

WAUKESHA COUNTY PARK, NBC 1224994			
Wetland Type	Sub-category	Wisconsin Wetland Inventory	Photo-interpretation
Emergent	Natural	--	--
	Agricultural	**4.12**	--
Scrub-Shrub		--	--
Forested		**0.70**	--

Figure 11-6 BPS Wetlands Map

Floodplain and Floodway: The site was reviewed for potential floodplain impacts and is outlined in red on the Federal Emergency Management Agency (FEMA) map panel number 55133C0331G in **Figure 11-7**. There are no mapped or defined floodplain limits on the site, however, there is a wetland on site, which does not drain via culvert or storm sewer. Instead, water is stored in the wetland until it can infiltrate or evaporate. An ordinary high water mark (OHWM) for the wetland will be determined during design with all structures being located above this elevation.

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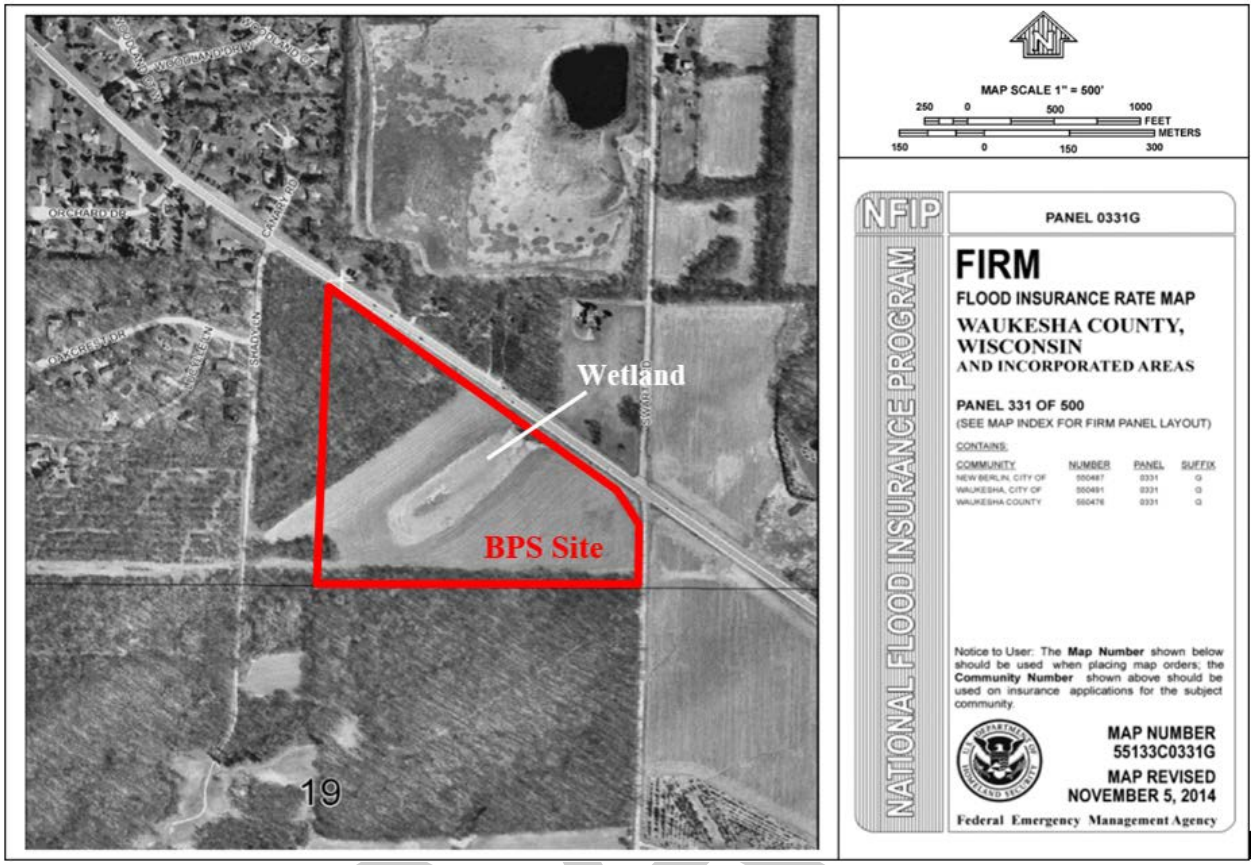

Figure 11-7 FEMA Floodplain Map Panel #55133C0331G

Archaeological: A desktop review for cultural, archaeological, and historical resources was performed. The assessment reviewed the site for the potential presence of archaeological sites and/or historic structures. This was accomplished by reviewing the State of Wisconsin's Historic Preservation Database (WHPD).

As seen in Figure 11-8, the desktop review of the site did not find evidence of any potential cultural, archaeological, or historical resources that would be impacted. The green cross hatched area on the south side of the site indicates that the area was previously studied but no findings were reported. Field investigations will be performed to confirm the results of the desktop analysis prior to land transfer or a purchase agreement for the site.

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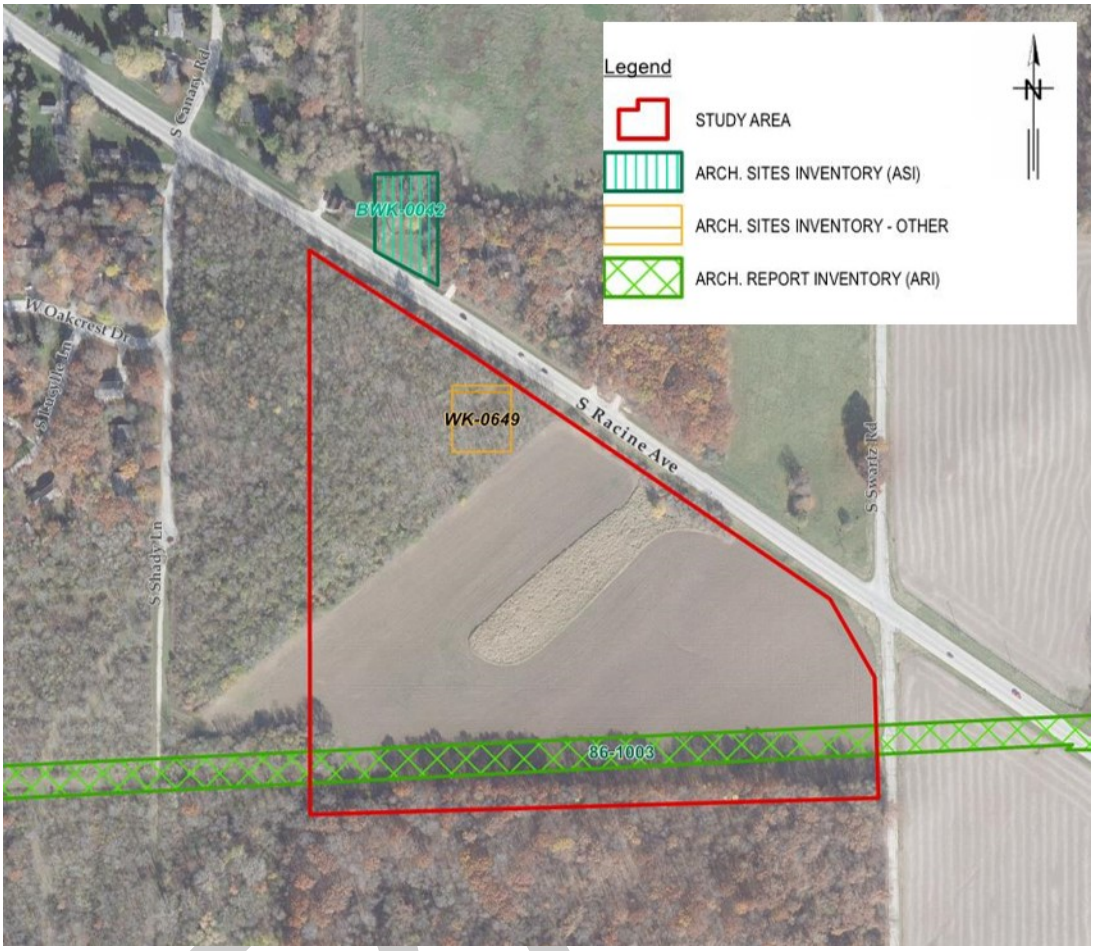

Figure 11-8 Archaeological Desktop Analysis Map

Historical Significance: A sign is located in the northeast corner of the site as shown in Figure 11-9. This sign was erected by the Waukesha County Historical Society Museum (WCHSM) in 2004 to commemorate the influence and historic significance of Cornfalfa Farm to the region. Cornfalfa Farm was owned by the Swartz family, who was notable for a number of products, and held a copyright for the Cornfalfa Farm name. Coordination was held with the WCHSM to determine the significance of the sign to the Program. A letter was received from the Historical Society dated August 23, 2017, which provided the following statement:

> *"The placement of the historical marker is incidental, and in no way implies any restriction of land use or inhibits use of the land. WCHSM works with local citizens, businesses, and other interested community groups to raise funds for the erection of historic markers. Should a marker need to be relocated WCHSM is to be notified with sufficient advance notice, and permitted to make arrangement to find a new location for the marker."*

It is the intent of the Program to coordinate with the WCHSM to determine whether the sign needs to be relocated to a new location to better serve the community.

Figure 11-9 Historical Marker Sign

Endangered and Threatened Species: A desktop evaluation of RTE species for the site was performed. The evaluation was conducted via a desktop review of recent and historical aerial photographs, the WDNR National Heritage Inventory (NHI) data, the United States Fish and Wildlife Service (USFWS) Information Planning and Consultation (IPaC) data, and the USFWS endangered species county data. Utilizing these resources, potential RTE species and natural communities, collectively referred to as element occurrences (EOs), were identified and mapped on recent aerial photographs located in 4-130 D3, taken in Fall 2017.

The RTE species evaluation was conducted in August 2017. The study area included the full parcel, with an associated one-mile buffer for terrestrial species, and two-mile buffer for aquatic species.

The RTE evaluation results identified the Poweshiek skipperling, northern long-eared bat, and eastern prairie-fringed orchid. Field investigations were conducted in fall of 2017. For the northern long-eared bat, it is possible that seasonal tree clearing may be required along the south property line to accommodate site improvements. To date, however, there are no known bat roosts or hibernacula.

11.3.1.2 Field Investigations

Field investigations for the Program began in mid-2017. The site is currently used for agricultural purposes and crops are planted and located on-site. In order to reduce impact to the crops, field investigations that would create land

disturbing activities were planned to be conducted after the crop harvest in the fall of 2017. Field investigations that would not create land disturbing activities were completed earlier. Field investigations for the BPS are scheduled to be completed by mid-2018. The status of the field investigations are described below:

Survey: The survey field work was completed after crop harvest to allow access to the site. If required, Land/Easement Acquisition Documents will be provided to WWU as needed to facilitate land acquisition.

Geotechnical: The geotechnical field work was scheduled and completed after crop harvest to allow the use of drill rigs and other equipment on-site. The geotechnical report will provide information on the suitability of soils for structures to be located on the site and will be incorporated into the design.

Wetlands and Waterways: A wetland delineation of the site was performed on September 29, 2017. Appendix E, Drawing Sheet CP3-C1 shows the delineated wetland and a 30-foot buffer around the wetland limits. This wetland and waterway delineation was conducted in accordance with the guidelines of the 1987 Corps of Engineers Wetland Delineation Manual (Environmental Laboratory, 1987) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manuals (Northcentral and Northeast Region (Version 2.0, 2012)) and in general accordance with WDNR guidelines. The wetland and waterway delineation report will be included in an appendix of the wetland and waterway permit application prepared in July 2018.

Archaeological: A Phase I Archaeological Survey of the site was conducted in 2017 in areas of the proposed improvements. The survey was conducted in accordance with the Guide for Public Archaeology in Wisconsin (Dudzik et al. 2012) and the Secretary of the Interior's Standards & Guidelines for Archaeology and Historic Preservation. The archaeological survey satisfies survey requirements for regulatory compliance and meets the standards for archaeological survey as outlined in the Guide for Public Archaeology in Wisconsin. The report will be included in an appendix of the wetland and waterway permit application prepared in July 2018.

Endangered and Threatened Species: A field review for endangered and threatened species was performed in fall 2017 to evaluate potential RTE species habitat at the site. The report will be included in an appendix of the wetland and waterway permit application prepared in July 2018.

Hazardous Materials Investigation: A Phase I Environment Site Assessment has been performed in November 2017 in conformance with the scope and limitations of ASTM Practice E 1527-13. This assessment did not reveal evidence of recognized environment conditions. Based on the Phase I results, a Phase II investigation is not required.

11.3.2 Site Improvements

The following subsections describe specific codes and ordinances applicable to the BPS site. The evolution of the site plan is discussed along with the features and utilities proposed in the preliminary design drawings.

11.3.2.1 Site Layout

A conceptual design was competed to determine the feasibility of the site during the site screening process. Once the site was selected, the site was further developed. The preliminary site layout is presented in Appendix E, Drawing Sheet CP3-C2.

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The BPS will be located near the north side of the parcel, east of the wetlands, and adjacent to Racine Avenue. The reservoirs are located toward the south of the site, perpendicular to Swartz Road. The methodology for selecting this arrangement is presented in Section 11.6. The BPS, reservoirs, and impervious surfaces will be located outside the wetland buffer area. Retention/detention ponds will be located along the Racine Avenue. Space reserved for septic fields is shown adjacent to the wetland. A perimeter fence will be provided around the structures on-site to provide security. An access slide gate to the BPS will be provided at the north side of site on the access drive from Racine Avenue.

11.3.2.2 Site Accessibility

Racine Avenue is classified as a county trunk highway, which requires an access permit in order to construct an access driveway to the site. Additionally, a utility permit is required for construction within the county highway's right-of-way.

The access drive and paved areas will be suitable for heavy-load trucks, tanker trucks, and cranes. The chemical rooms are located on the east side of the BPS, allowing for ease of access for all chemical deliveries. An overhead door is also located on the east side of the building, providing direct access to the most heavily used part of the building.

Adequate ingress, egress, and set-up space for heavy-load trucks and cranes to the BPS site will be provided. All proposed roadways will be designed for an American Association of State Highway and Transportation Officials (AASHTO) load rating of HS-20. Bridging or reinforcement over piping will be provided as necessary. Turning radii at curves and roadway intersections will be designed to provide access for heavy-load trucks and boom crane trucks. The new paved areas leading up to and adjacent to the BPS will be a minimum of 20-feet in width. Any secondary roadways required on-site for light to medium traffic will be a minimum of 16-feet in width. Signage and/or appropriate physical restrictions will be provided at access to all light-duty roadways.

11.3.2.3 Surface Restoration

Surface conditions, where disturbed, will be restored to original conditions on-site at the end of construction.

Grading and Drainage: The existing drainage areas on-site will be maintained to the extent possible. Grading at the BPS site will be designed to facilitate positive drainage of rainfall runoff away from building walls and equipment at a minimum slope of 1.0%. The grading for earthen slopes on-site will be no steeper than three feet horizontal to one foot vertical (3:1). Finished floors of structures will be above finished adjacent grade. Two retention/detention ponds will be constructed on-site for stormwater management. As shown on Appendix E, Drawing Sheet CP3-C2, one retention/detention pond will be to the north of the BPS near the existing wetland and the other will be to the east of the BPS near the intersection of Racine Avenue and Swartz Road.

Paving and Sidewalks: The team will coordinate with the City of New Berlin on the minimum requirements for pavement design. These standards will be compared with WWU standards and the more stringent requirements will take precedence. Sidewalks a minimum of 5-feet in width will be constructed around the BPS to provide access to all facility entrances.

Landscaping: Existing mature trees will be retained where feasible. A tree survey may be required during design. Seeding will be required in all areas disturbed by construction and any additional areas as requested by WWU.

Plantings and landscaping features to be incorporated into the site will be coordinated with WWU, New Berlin, and Waukesha County. Selection will take maintenance and trimming into consideration.

Since the majority of the BPS site is currently used for agricultural purposes, surface restoration will include grass plantings within the fenced limits and native plantings or wetland plantings as applicable outside the fenced limits.

11.3.2.4 Stormwater Management

A preliminary stormwater analysis was conducted to determine whether it is feasible to meet the New Berlin and WDNR stormwater requirements for post-construction performance (New Berlin City Code Chapter 275-55.1 post-construction stormwater management and Wisconsin Administrative Code Natural Resources (NR) 151.121-128, respectively). Due to the site's environmental sensitivity and space constraints, it is anticipated the site will be required to meet the WDNR and New Berlin standards for total suspended solids (TSS), peak discharge, infiltration, and protective areas around the adjacent wetland.

Release rates were determined for both pre- and post-development conditions. Table 11-2 shows the three runoff rates considered by New Berlin. Stormwater best management practices (BMPs) will be implemented to reduce the post-development runoff rates to be no greater than the corresponding pre-development runoff rates, or to the maximum extent practicable.

Table 11-2 City of New Berlin Peak Discharge Rates

Post-Development		Pre-Development
1-year, 24 Hour Storm Runoff Rate	≤	1-year, 24 Hour Storm Runoff Rate
2-year, 24 Hour Storm Runoff Rate	≤	2-year, 24 Hour Storm Runoff Rate
100-year, 24 Hour Storm Runoff Rate	≤	10-year, 24 Hour Storm Runoff Rate

It was assumed that all of the stormwater runoff will be directed to proposed retention/detention ponds on-site, and the preliminary analysis showed that the New Berlin runoff standards can be met with the use of ponds and BMPs. The preliminary analysis showed that the New Berlin runoff standards can be met with retention/detention ponds and BMPs. These may be included along the north property line as retention/detention pond systems or swales. Permeable pavement in the parking lot and along the access drive will be considered in order to further reduce the peak discharge runoff rate.

New Berlin and WDNR set the standard for stormwater infiltration on-site in New Berlin City Code Chapter 275-55.1 post-construction management and Wisconsin Administrative Code NR 151.124 infiltration performance standards, respectively. The BPS site is categorized as moderately impervious (40-80%), corresponding to the post-development infiltration volume being at least 75% of the pre-development infiltration volume for the average annual rainfall, or the maximum extent practicable. Wisconsin Administrative Code NR 151 requires approximately 178,000 gallons of storage on-site. The on-site retention/detention basins and additional BMPs described in this section will be considered to further improve the post-development infiltration volumes.

During design, an in-depth stormwater analysis will be performed for the site that will examine pre- and post-development conditions. The analysis will assess peak discharge, infiltration, protective areas, and TSS in the runoff using TR-55 Curve Numbers and other continuous simulation-modeling methods. The analysis will also determine

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the OHWM elevation, hydroperiod, and the infiltration rate in the adjacent wetland. These variables will affect the hydraulics of the on-site retention/detention ponds and their release rates.

The stormwater management plan and the design of stormwater BMPs will be developed in accordance with the aforementioned regulations. Storm sewers will be sized according to local ordinance to safely and effectively convey stormwater runoff to the designed treatment practices. In addition, inlets will be sized according to local ordinance standards so as to reduce ponding in the post-development condition. Regulatory investigations will be undertaken to meet Waukesha County and New Berlin standards.

11.3.2.5 Utilities

Electrical and natural gas utilities were contacted to coordinate existing utilities in order to define service location points for the BPS. Both electrical and natural gas utilities are owned by We Energies near the BPS site. Information received from We Energies during utility coordination is discussed below. Site utilities and piping considered for the BPS and reservoirs include electric, fiber optic, natural gas, potable water (domestic water supply and fire protection), process piping, storm sewer, and sanitary sewer. Each utility was evaluated to determine the necessary connections and improvements required to the existing utilities.

Electric: Electric service in the vicinity of the site is provided by We Energies. Three phase overhead electric lines are located along the east side of Swartz Road. Through coordination with We Energies, it is anticipated that electric service will be provided from the overhead lines located along Swartz Road. On-site electrical conduit and duct banks will be located as described in Section 11.8.

Fiber Optic: Fiber optic service will provide communications for the Program. It is anticipated that this service will be new and connect all Program Elements. This utility is discussed in detail in Section 11.10.

Natural Gas: Natural gas service in the vicinity of the site is provided by We Energies. A 20-inch high pressure (650 pounds per square inch (psi)) gas main runs east/west along the south property line of the site. A 6-inch low pressure (60 psi) gas main is located along the south side of Racine Avenue which terminates approximately 560 feet west of Swartz Road. We Energies has indicated that the 6-inch main has capacity to serve a natural gas generator at the BPS. Natural gas will be routed to the BPS as shown in Appendix E, Drawing Sheet CP3-C3.

Potable Water: Per Wisconsin Administrative Code NR 811.25.8, all pumping stations, pump houses, and water treatment plants will be provided with potable water and lavatories, except for unoccupied automatic stations or if such facilities are available elsewhere. Potable water service will be provided to this site to support lavatories, maintenance activities, and fire protection. A single occupant lavatory will be provided in the BPS. Potable water for the domestic water supply at the BPS will be provided by the discharge pipe from the BPS to WWU. This pipe will be under constant pressure as the pumping station is anticipated to operate continuously or be hydraulically connected to an elevated tank.

Fire Protection: Fire protection will be provided internally to the building as described in Section 11.7. Fire protection will also be provided by hydrants on-site. The location and spacing of the hydrants will be coordinated with the local fire department.

Process Piping: The 30-inch Water Supply Pipeline enters the BPS on the east side of the building and leaves the BPS on the south side as two separate 30-inch pipes (one for each reservoir) that are routed to the reservoirs. There

is a 30-inch pipe leaving each reservoir that is routed back to the BPS as the supply line to the booster pumps. A 30-inch BPS discharge pipeline exits the west side of the BPS and turns north to Racine Avenue. The supply and discharge piping will each include a valve vault with a single isolation valve on the north side of the BPS to allow for isolation of the building from the rest of the system in case of emergencies when entering the building is not feasible. The valve vaults will be sized to provide space for future connections as well as any space required for sampling connections.

Storm Sewer: Storm sewers will be utilized to convey runoff to the retention/detention ponds and ultimately to the wetland. A stormwater analysis will be completed during design for the BPS site that will examine pre- and post-development conditions at the site and will determine the necessary sizes and location for storm sewers on-site. Due to the use of the site and heavy vehicles, reinforced concrete pipe will be used for storm sewer. Flared end sections with grating will be provided at pipe entrances.

Sanitary Sewer: The BPS will be an unmanned facility with periodic maintenance activity and the anticipated lavatory will have one toilet and a janitor's room with sink. As the sanitary flow for the facility will vary, it is assumed that 3.5 gallons per working day will be generated that takes maintenance activities into consideration. Chemical analyzers will be located in the BPS to control chemical dosing for the finished water. The chemical analyzers require continuous flow at approximately 0.5 gallons per minute (gpm) for 24 hours a day. This water will be recycled internally and will not produce a waste stream. The total average day flow at the BPS is therefore 3.5 gpd per working day or 2.5 gpd on average over 7 days/week.

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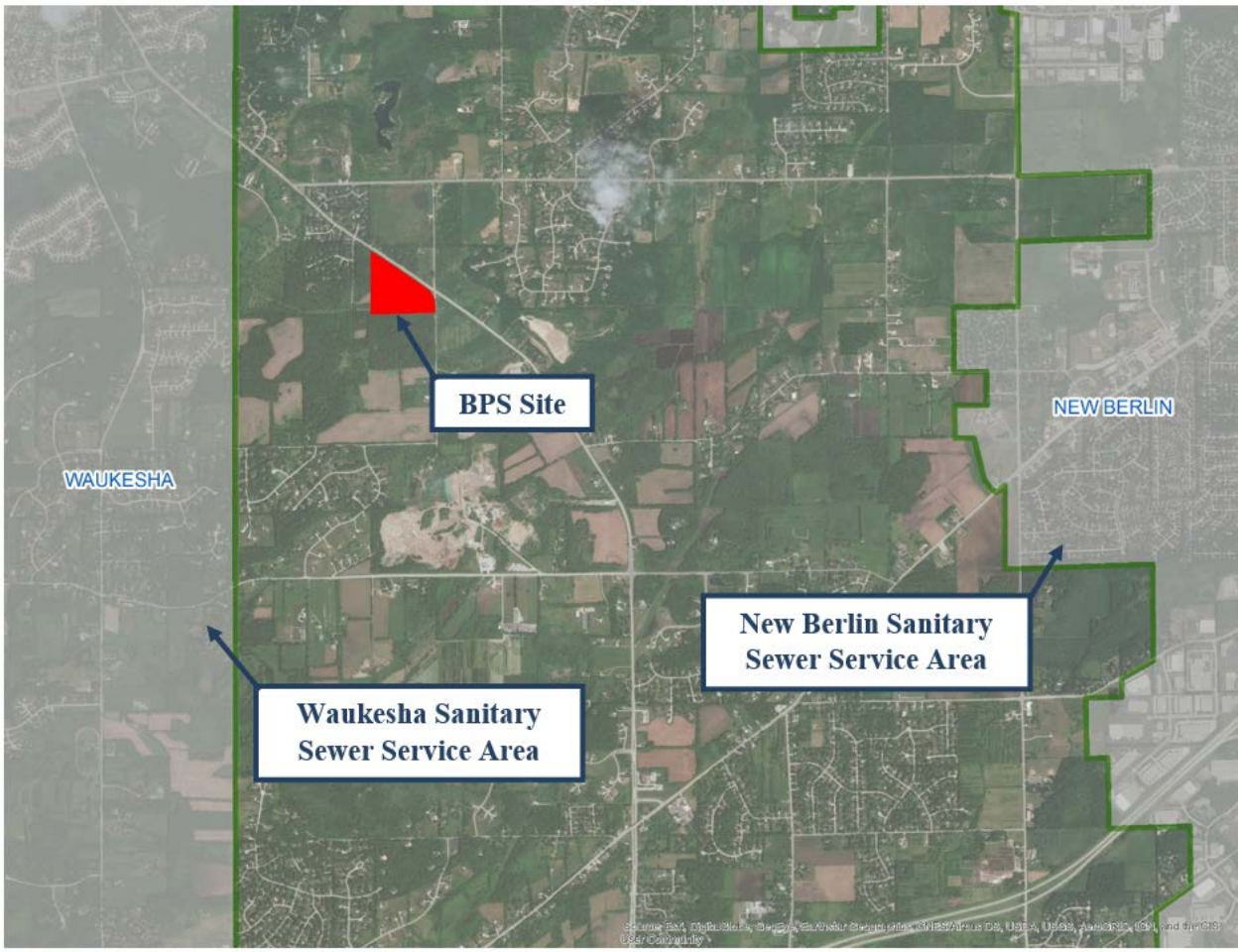

Figure 11-10 SEWRPC Waukesha and New Berlin Sewer Service Area Map

The available sanitary options are:

- On-site lift station and forcemain
- On-site septic field
- Off-site septic field
- Sewage holding tank

On-site Lift Station and Forcemain: An on-site lift station will collect the sanitary flow and discharge through a 4-inch forcemain to the sewer connection in either New Berlin or Waukesha service area. The forcemain will share the same trench as the Return Flow Pipeline to reduce the installation cost. The cost associated with this option for the anticipated flow is high compared to the other options.

On-site Septic Field: On-site treatment was examined as a single chamber septic tank paired with a drain field. Two types of drain fields were evaluated: absorption trenches and sloping sand mounds. Absorption trenches and mound systems are similar to each other in function as both filter and treat liquid effluent from septic tanks. However, mound systems can be used in instances of unsuitable soil conditions for conventional absorption trenches and may require a dosing chamber with pumps between the septic tank and drain field. Preliminary calculations showed that there is

sufficient area on-site to accommodate the footprint of the septic tank and absorption trenches option, but may not have space for the septic tank and sloping sand mounds system. Based on a desktop analysis using the USDA's NRCS soil survey data, the soil on-site is rated as very limited for use as septic tank absorption fields. According to the New Berlin City Code Chapter 267-12, percolation tests should be performed to determine whether or not soil conditions will support a septic field system or other on-site sewage treatment system. If suitable soils for a septic system are found on-site, then a septic tank with absorption trenches may be feasible.

Off-site Septic Field: If the soils at the BPS site are not suitable to support a drain field or mound system, then sites near the BPS site could be evaluated for feasibility of a system. The Waukesha County Ordinance allows for an easement of an off-site parcel to be utilized to construct a private sewage system.

Sewage Holding Tank: If the above described systems are not feasible on-site or off-site, then a sewage holding tank may be required. In accordance with the Waukesha County Department of Health and the New Berlin Plumbing Code, a sewage holding tank may be placed only if soil conditions do not support on-site sewage treatment. The holding tank would require periodic cleaning and disposal of the waste at a septic receiving location.

The described systems were evaluated and compared based on the following criteria.

1. Life Expectancy: The estimated service life until a complete replacement of the system.
2. Maintenance: Since the BPS will be unmanned with periodic maintenance, a high level of effort to sustain the sanitary options' operations are not desirable due to added costs and labor.
3. Reliability: Reliability of the system is important to effectively treat or convey sanitary flow, protect the environment, and minimize repair and replacement costs.
4. Flexibility: The ability of the system to be modified or accept additional flow.
5. Comparative Capital Cost: The comparative capital cost indicates the cost to construct the system, neglecting common components, with a higher cost being less desirable.

The criteria were assigned a score from one (to represent a less favorable alternative for the established criteria) to three (to represent a more favorable alternative for the established criteria). The resulting scores were compiled to produce a total score for each option. Options with the higher total scores are preferred. Table 11-3 shows the summary of the comparison and scoring.

Table 11-3 Sanitary Options Comparison

Criteria	Sanitary Service Alternatives (Score)			
	On-Site Lift Station and Forcemain	On-Site Septic Field	Off-Site Septic Field	Sewage Holding Tank
Life Expectancy	3	2	2	2
Maintenance	2	3	3	1
Reliability	2	2	2	1
Flexibility	3	2	1	1
Comparative Capital Cost	1	3	2	3
Total	12	12	10	8

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Based on the scoring matrix, the on-site lift station and forcemain as well as the on-site septic field options are preferred. Based on WWU's preference, the on-site septic field is the preferred sanitary option. Comparatively, the cost for an on-site lift station and forcemain would be more than ten times higher than the cost for an on-site septic field or sewage holding tank options. Field investigations during design will determine the permeability of the soil in order to size the septic field. The sanitary flow and on-site treatment options will be further evaluated after field investigations have been completed. To be conservative, the on-site lift station and forcemain option was assumed for the opinion of probable construction cost.

11.4 Structural

11.4.1 Site

Retaining Walls: Retaining walls will be required to accommodate site grading and finished floor elevations of structures. Cantilevered concrete walls will be used on the uphill cut walls and mechanically stabilized earth (MSE) walls can be used on the downslope fill walls.

11.4.2 Water Storage

Two prestressed precast reservoirs will be used for water storage. The design of the reservoirs, including the walls, roof, and foundation, will be provided by the reservoir supplier. Refer to Section 11.6 for the process design of the reservoirs.

Foundation: A geotechnical investigation will be performed and provided to the reservoir supplier to determine the substructure design of the reservoirs. The geotechnical investigation will be completed during design.

11.4.3 Booster Pumping Station

Foundation: A geotechnical investigation is currently underway to determine subsurface conditions for the BPS site. An assumed soil bearing capacity of 3,000 pounds per square foot (psf) was used for the preliminary design.

Bedding and Backfill: Bedding under internal slabs on grade will be 8 inches of compacted granular soil. Backfill against foundation walls and retaining walls will be a compacted granular material with an internal friction angle of 30 degrees.

Floor System: The supported first floor will be constructed of cast in place concrete beams with a 6-inch concrete one-way slab.

Roof System: The roof over the Pumping Room will be constructed with steel trusses and purlins. The trusses will be supported on the columns used to support the crane girders.

Wall System: The lateral force system on the lower roof portion will be masonry shear walls. The lateral force system on the high roof will be braced frames along the crane rails and masonry shear walls perpendicular to the crane rails.

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11.4.4 Equipment Removal

Equipment removal options were evaluated and are presented in Section 11.6.2.

11.5 Architectural

11.5.1 Site Layout and Planning

11.5.1.1 Existing Site Configuration

As illustrated in Figure 11-11, the parcel is bordered on the south by a heavily wooded area of Minooka Park, on the northwest by a strip of wetlands, on the east by Swartz Road, and Racine Avenue runs diagonally along the northeast edge. Racine Avenue is a county trunk highway, connecting Interstate 43 to Waukesha. Swartz Road is a secondary road due to its short length. As such, the site is oriented toward Racine Avenue as the front.

The parcel gently slopes from the woods on the south towards a swale along Racine Avenue. There is a narrow access point over the swale on Racine Avenue. Swartz Road follows the slope described above and allows the parcel to be easily accessed from the east. Currently the parcel is used for agricultural purposes, and the adjacent properties are a mixture of residential and farm land.

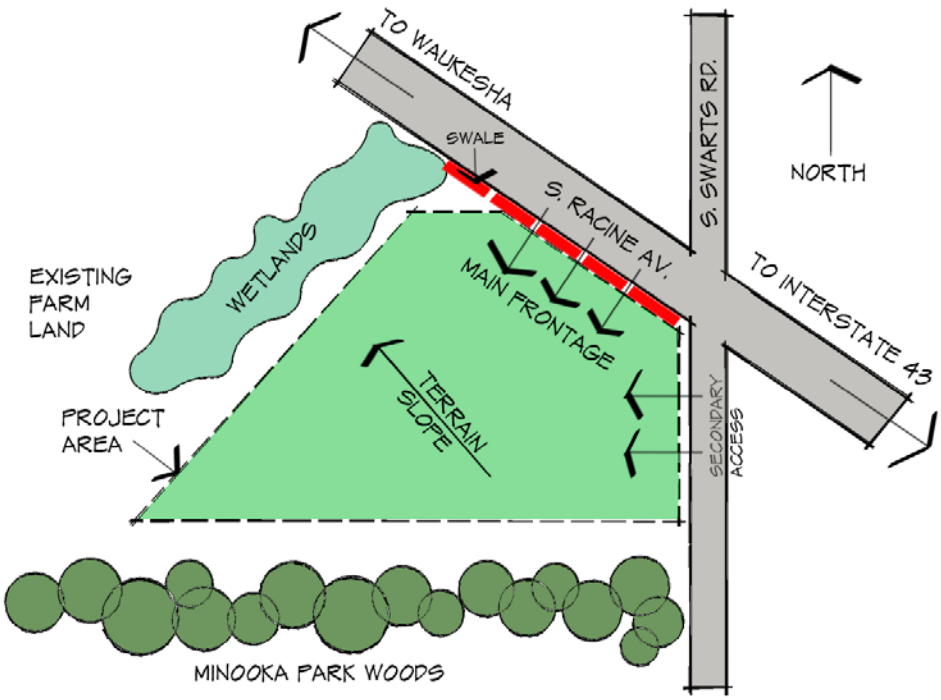

Figure 11-11 Architect's Sketch of Site Conditions

11.5.1.2 Proposed Land Plan

The BPS will be located near the north side of the parcel, east of the wetlands, and will extend along Racine Avenue. The reservoirs will be located along the south property line, which is considered to be the back of the BPS site. This location will aid in diminishing the prominence of the reservoirs on-site. Access to the BPS will be from Racine Avenue.

The placement of the building avoids the adjacent wetlands and therefore keeping the natural hydrology of the site intact. This reduces the negative impacts of stormwater on nearby infrastructure while maintaining an important habitat for local plants and animal species. Nuisance noise from equipment located outside of the building can be surrounded with sound-attenuating screens and walls. This approach protects critical equipment from vandalism. Entry to the BPS will be controlled by a perimeter fence and slide gate with electronic access. Alternatives for entry, including access password or phone/surveillance access, will be further evaluated with WWU. Electronic surveillance is also proposed along the perimeter of the site.

11.5.2 Building Characteristics

11.5.2.1 Structural System

The foundation of the BPS will be cast-in-place concrete. At the Pumping Room, the structure will be a braced steel frame supporting a steel truss roof and crane girders. This approach provides a lightweight roof system capable of economically spanning the large room. Other areas of the BPS will utilize load-bearing masonry and the finished floor will be 6 inches above adjacent grade and 24 inches above flood or impounded water levels.

For more specific information on structural systems, refer to Section 11.4.

11.5.2.2 Building Enclosure

The exterior walls of the BPS will be clad in brick and cast stone and the roof will be finished with a standing seam metal system. In combination with the building's massing, these finishes were selected to subtly relate to WWU's Well 8 facilities and to adhere to the prairie style reviewed and approved by WWU. The fenestration formalizes this appearance by including a series of clerestory windows that provide natural light to the Pumping Room. These clerestory windows are protected by projected roof eaves that emphasize the horizontality of the structure and prevents excessive glare and solar heat gain. This approach takes advantage of one of the prairie style elements to creatively and economically enhance the building's overall appearance and provides a more weather resistant solution for roof penetrations.

11.5.3 Codes, Standards, and References

The design will adhere to the following, as well as those listed in Section 4.

- New Berlin City Code Chapter 275, Article IV, Zoning.

11.5.4 Space Allocation

As illustrated in Figure 11-12, the BPS is made up of five primary space functions: process areas, personnel areas, mechanical areas, electrical areas, and chemical areas.

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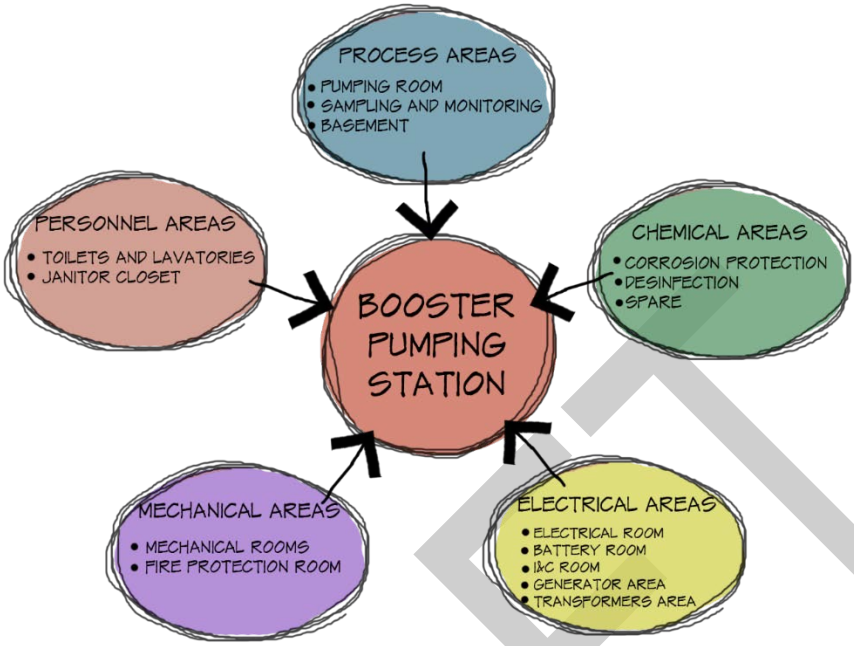

Figure 11-12 Spatial Grouping Diagram

Table 11-4 Space Allocation Table

	Occ.	Area (sq ft)	Ext Access	Natural Lighting	Sprinklered
Process Areas					
Pumping Room	F-2	3,500	Y	Y	N
Sampling and Monitoring Room	F-2	200	N	N	N
Basement	F-2	4,600	N	N	Y
Chemical Areas					
Chemical Room No. 1	H-4	820	Y	N	Y
Chemical Room No. 2	H-4	630	Y	N	Y
Chemical Room No. 3	H-4	580	Y	N	Y
Electrical Areas					
Electrical Room	F-1	900	Y	N	N
Battery Room	F-1	150	Y	N	Y
I & C Room	F-2	150	N	N	N
Transformer Area	--	--	--	--	--
Generator Area	--	--	--	--	--
Mechanical Areas					
Mechanical Room	F-2	1,800	Y	N	N
Fire Protection Room	F-2	650	Y	N	N
Personnel Areas					
Toilet	F-2	70	N	N	N
Janitor Closet	F-2	50	N	N	N
Circulation and Egress Areas					
Stair – A	F-2	400	Y	N	Y
Stair – B	F-2	400	Y	N	Y
Total		14,900			

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11.5.4.1 Process Areas

The process areas will make up the core of the building function and all other spaces will be complementary or will provide support to these areas directly or indirectly. The main process areas will be the Pumping Room, the Sampling and Monitoring Room, and the Basement under the Pumping Room.

Pumping Room: This space will be the largest in the building and will account for about 25% of the total building area. All other spaces will be organized around it. Maintenance of pumps and equipment will be critical to the layout of the Pumping Room, the height and width of which will provide adequate clearance for equipment removal. A roll up door will be provided at the rear of the Pumping Room to permit a truck to back up partially into the space. A staging area will be located in front of this door and an access aisle will be proposed along one side of the Pumping Room. This design will allow a bridge crane or other lifting mechanism to move equipment with minimal interference. Floor doors and grated openings will be provided to facilitate the removal of parts and equipment from the Basement. Access to other important areas within the building, such as the Electrical and Mechanical Rooms, will be provided through the Pumping Room.

Sampling and Monitoring Room: This room will be used for sampling and monitoring. To facilitate these tasks, a stainless steel sink and countertop will be provided. The Sampling and Monitoring Room will be enclosed with masonry partitions to reduce noise. Windows will be provided to allow a line of sight to the Pumping Room.

Basement: This space will be located directly under the Pumping Room and contains piping, valves, and other appurtenances.

11.5.4.2 Chemical Areas

Chemicals will be stored in a designated area to ensure worker safety and efficient material handling. Access to the chemical filling stations will not be permitted while the facility is unattended. Therefore, chemical filling stations will be located within the building, and each will be accessed from the exterior via a secured door.

The Chemical Rooms will be separated from the rest of the building by fire rated walls as required by the 2009 International Building Code, with Wisconsin Amendments (IBC). These areas are classified as hazardous by IBC and have specific requirements based on the type and amounts of chemicals stored. Showers, eye wash stations, and other personal protective devices are to be provided as required. It is expected that in the future, the chemical storage tanks may need to be replaced or swapped out. Either double doors, removable roof panels, or knockout walls will be provided to facilitate removal of the chemical storage tanks.

11.5.4.3 Electrical Areas

The Electrical Room, Battery Room, and Instrumentation and Control Room are grouped together and arranged in such a way that they are close to the exterior electrical equipment. Fire rated walls between these spaces and means of egress will be provided as required by IBC.

Electrical Room: IBC allows electrical rooms to not be sprinklered if the room is dedicated only to house electrical equipment, is not used to store any items, and is protected from other spaces by fire rated walls.

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Battery Room: This room will be provided with direct access to the exterior. Automatic smoke detection will be provided as required by the International Building Code Section 907.2.23. An emergency eyewash and shower station will be provided in accordance with Occupational Safety and Health Association (OSHA) regulations.

Instrumentation and Control Room: In addition to Instrumentation and Control equipment, this room will have a small desk for operators. This room will be isolated from the Pumping Room by masonry partitions to reduce noise. Windows will be strategically located to provide a line of sight to the Pumping Room.

Transformer and Generator Area: Located outside of the building, this area can be surrounded by sound-attenuating screen walls that complement the building's architectural style. This approach will reduce nuisance noise, protect critical equipment from vandalism, and improve the visual aesthetics of the building.

11.5.4.4 Mechanical Areas

Mechanical rooms will be located close to the spaces they are serving to minimize duct travel distances and avoid potential conflict with roof structural members.

Mechanical Room: This room will house the mechanical equipment for the building. Because of the large electric loads associated with the mechanical equipment, it will be located close to the Electrical Room. The room is planned as a long rectangle to facilitate the placement of air handling units next to intake louvers and for ease of maintenance.

A double door opening to the outside will be provided to facilitate maintenance or removal of equipment.

Fire Protection Room: The requirement and size of a Fire Protection Room will be coordinated with New Berlin during design. If required by New Berlin, this room will have direct access from the exterior for fire department use in case of an emergency. Access to this room will be through the Pumping Room.

11.5.4.5 Personnel Areas

Personnel areas for this building are minimal. A single occupant toilet room for staff convenience and a janitor closet with a utility sink and storage for cleaning supplies will be provided. Both rooms will be located off of the Pumping Room.

11.5.4.6 Circulation and Egress Areas

Building circulation, or the means by which equipment and spaces are accessed, is critical to the safe and efficient layout of the BPS. Rooms within the BPS will be positioned to interconnect, allowing extraneous corridors and hallways to be minimized. Work areas and access aisles will be demarcated to enhance worker safety. Figure 11-13 illustrates the required and preferred room adjacencies that informed the layout of the BPS.

Egress is the means by which occupants exit a building in an emergency. The egress requirements at the BPS were reviewed to verify compliance with IBC. Each room will be provided with no less than the minimum number of exits required by IBC. Doors and exits will be located in a manner that assures egress travel distances do not exceed the maximum prescribed by IBC. Egress from the basement to exits at grade will be provided by two stairways, each enclosed by fire-rated masonry.

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11.5.5 Contextual Aesthetics

To relate the BPS more fully to its surroundings, design motifs that reference the unique character of the site and region are proposed. For example, the site was once one of Wisconsin's flagship farms, Swartz's Cornfalfa Farm. Thus, it is proposed that the building subtly incorporate agrarian décor elements on friezes, column capitals, and elsewhere to make reference to the corn and alfalfa that were once harvested there and blend into the surrounding landscape. The building design will be coordinated with New Berlin during the zoning and permitting process. The BPS will adopt many of the characteristics associated with that style, including low-sloped roofs, large cantilevers that emphasize horizontality, brick columns, and clerestory buildings among others.

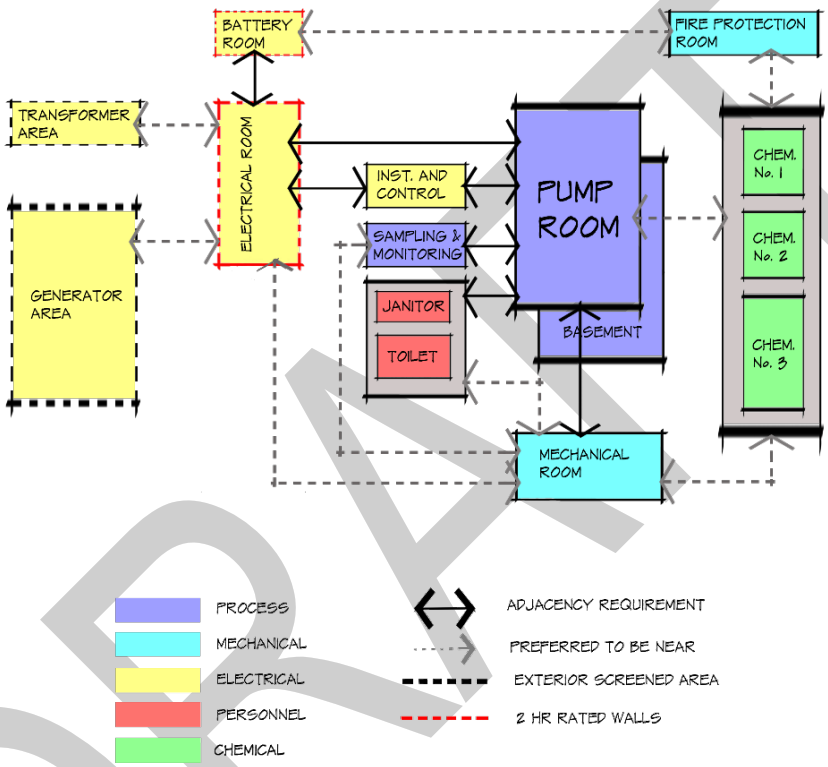

Figure 11-13 Adjacency Diagram

The landscaping around the BPS will also help commemorate the uniqueness of the site. Anticipated plants include those identified by SEWRPC as indigenous to the region. Additional landscape strategies will include painting the reservoir tanks a neutral color and surrounding them with a heavily vegetated berm of native plants that meet requirements of the code and require minimal maintenance. A vehicular access road around the reservoirs is proposed and will be paved in a permeable material to reduce stormwater runoff.

11.5.6 Materials and Technology

The building will follow the guidelines of Section 4 for materials and technology.

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11.6 Process Mechanical

The purpose of the BPS is to store, treat, and pump water to the WWU distribution system through the Water Supply Control Building (WSCB) and WWU Distribution System Central Pressure Zone. This requires reservoirs to store water that is delivered from the WSPS. The BPS also requires a building to house the pumps, piping, valves, meters, and associated accessory equipment to boost the water from the reservoirs to the WSCB. Chemical addition is provided to supplement the chloramine residual to desired concentration and to add corrosion inhibitor to the finished water. This subsection describes the design of the reservoirs, pumping system, and chemical feed system. Due to the progress of the water quality evaluation and pipe loop testing, certain assumptions were made regarding the type and concentration of chemicals used. These assumptions were made in order to size the BPS and develop the opinion of probable construction cost. Evaluations for each chemical and preliminary design for storage and pumping requirements for each are presented herein.

The results of the pipe loop testing, distribution system modeling, and input from WWU will help to further define anticipated water quality and residuals within the distribution system and refine the selection of chemicals during design.

A summary of the basis of design is presented in Table 11-5.

Table 11-5 Booster Pumping Station Basis of Design

Description	Design Value
Demands	
Minimum Hour Demand, MGD	1.2
Minimum Day Demand, MGD	3.1
Average Day Demand, MGD	6.6
Maximum Day Demand, MGD	10.8
Peak Hour Demand, MGD	15.1
Site	
Area, acres	27
Booster Pumps	
Booster Pumps	
Number of Booster Pumps	4
Flow per Pump, MGD	5.25
Head, feet	145
Motor Size, horsepower	250
Voltage, volts	480
Variable Frequency Drive	Yes
Jockey Pumps	
Number of Jockey Pumps	2
Flow per Pump, MGD	2.75
Head, feet	130
Motor Size, horsepower	100

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Description	Design Value
Voltage, volts	480
Variable Frequency Drive	Yes
Firm Capacity (Largest Pump Out of Service), MGD	15.75
Installed Capacity, MGD	21.0
Control Element	
Primary	Hunter Tower Level
Secondary	BPS Discharge Pipeline Pressure
Booster Pump Suction Header	
Pipe Material	Ductile Iron
Diameter, inches	30
Maximum Operating Pressure, psi	25
Minimum Operating Pressure, psi	10
Booster Pump Discharge Header	
Pipe Material	Ductile Iron
Diameter, inches	30
Maximum Operating Pressure, psi	75
Minimum Operating Pressure, psi	40
Storage Reservoirs	
Number of Reservoirs	2
Volume per Reservoir, MG	9.0
Total Volume, MG	18.0
Operational Storage (15% of Total), MG	2.7
Equalization Storage (Based on MDD), MG	1.9
Emergency Storage (Based on 2 days at ADD), MG	13.4
Reservoir Diameter, feet	210
Total Effective Storage Level, feet	35
High Water Level, feet	35
Low Water Level, feet	2
Material	Precast Prestressed Concrete
Mixing System	Recirculation Line and Pumps
Chemicals	
Disinfection – Chloramine Production	
Sodium Hypochlorite Design Criteria	
Design Demand, MGD	8.2
Required Chlorine Concentration, mg/L	3.0
Initial Strength, %	12.5
Design Strength, %	10.9

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Description	Design Value
Density, lb/gal	10.0
Daily Usage, gpd	188
Desired Storage Capacity, days	30
Required Storage Capacity, gallons	5,700
Number of Bulk Storage Tanks	2
Capacity of each Bulk Storage Tank, gallons	3,000
Total Capacity of Bulk Storage Tanks, gallons	6,000
Number of Day Tanks	1
Capacity of Day Tank, gallons	400
No. of Feed Pumps	3
No. of Feed Pumps Operating	1
Feed Rate	
Maximum Demand, gph	18.2
Minimum Demand, gph	1.2
No. of Transfer Pumps	2
Transfer Pump Flow Rate, gpm	40
Liquid Ammonium Sulfate Design Criteria	
Design Demand, MGD	8.2
Ammonia as Nitrogen Concentration, mg/L	0.75
Strength, %	38
Density, lb/gal	10.4
Daily Usage, gpd	636
Desired Storage Capacity, days	30
Required Storage Capacity, gallons	1,900
Number of Bulk Storage Tanks	2
Capacity of each Bulk Storage Tank, gallons	1,000
Total Capacity of Bulk Storage Tanks, gallons	2,000
Number of Day Tanks	1
Capacity of Day Tank, gallons	130
No. of Feed Pumps	2
No. of Feed Pumps Operating	1
Feed Rate	
Maximum Demand, gph	5.9
Minimum Demand, gph	0.4
No. of Transfer Pumps	2
Transfer Pump Flow Rate, gpm	15
Corrosion Inhibitor	

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Description	Design Value
Blended Phosphate Design Criteria	
Design Demand, MGD	8.2
Total Phosphate Concentration, mg/L	2.0
Strength, %	34
Density, lb/gal	11.3
Daily Usage, gpd	402
Desired Storage Capacity, days	30
Required Storage Capacity, gallons	1,100
Number of Bulk Storage Tanks	2
Capacity of each Bulk Storage Tank, gallons	550
Total Capacity of Bulk Storage Tanks, gallons	1,100
Number of Day Tanks	1
Capacity of Day Tank, gallons	80
No. of Feed Pumps	2
No. of Feed Pumps Operating	1
Feed Rate	
Maximum Demand, gph	3.5
Minimum Demand, gph	0.2
No. of Transfer Pumps	2
Transfer Pump Flow Rate, gpm	10

11.6.1 Reservoirs

The reservoirs are required to provide storage at the BPS site for emergency, attenuation between different pumping rates of the WSPS and the BPS, and operational volume for the WSPS to conduct filling operations. This subsection evaluates the types of reservoirs and provides recommendation for the size, quantity, type, and features of the reservoirs.

11.6.1.1 Reservoir Capacity

An evaluation was performed to identify the capacity of the reservoirs needed for the system. The following volumes were accounted for in this evaluation:

- Operational
- Equalization
- Emergency

These three volumes define the effective storage and do not include the dead storage and freeboard of the reservoirs.

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Operational Storage: Operational storage is the volume that supports operation of the WSPS pumps between the water levels that the WSPS pumps turn on and off. The difference in volume between the high and low water levels for operation of WSPS determine this volume. For systems with new potable water supplies, a typical industry standard of 15% of the total storage is used for preliminary sizing. The operational storage volume will be coordinated with MWW and updated as information for control of the WSPS is finalized.

Equalization Storage: Equalization storage defines the volume required to balance the difference in flow from the WSPS pumping rate with the diurnal demand of the WWU distribution system. To calculate the required equalization storage, the cumulative differential volume between the supply and the demand was calculated. MWW has indicated that the preferred method of conveyance will be at a steady rate over 24 hours. Discharge from the BPS was based on the diurnal demand curve for Waukesha. Figure 11-14 graphically illustrates how the volume for the equalization storage was determined.

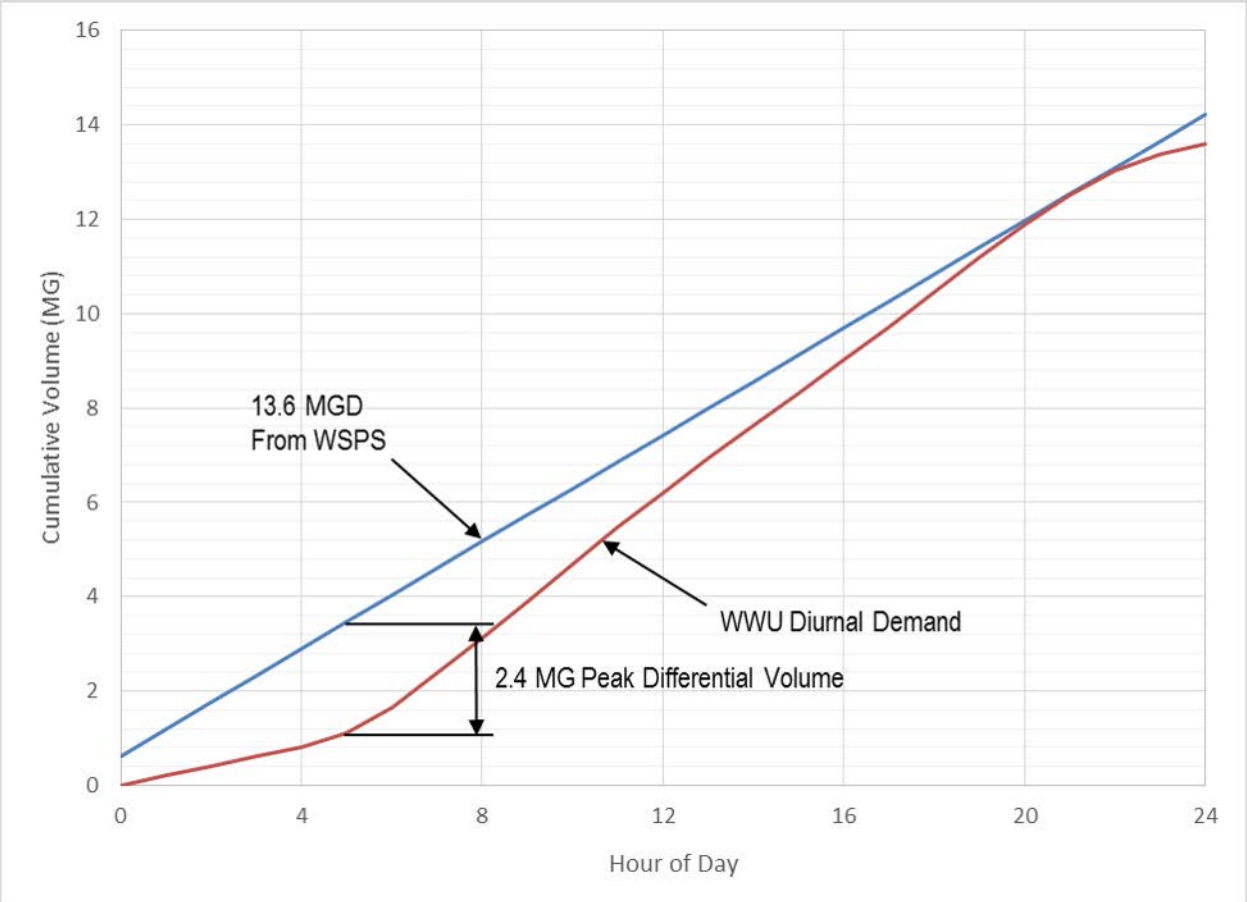

Figure 11-14 Equalization Storage Diagram (13.6 MGD)

The demand and associated equalization storage is summarized in Table 11-6. As shown in the table, larger day demands result in larger volumes of required equalization storage.

Table 11-6 Equalization Storage Volumes

Demand	Equalization Storage (MG)
Minimum Day Demand (3.1 MGD)	0.6
Existing Day Demand (6.6 MGD)	1.2
Average Day Demand (8.2 MGD)[1]	1.4
Existing Maximum Day Demand (10.9 MGD)	1.9
Maximum Day Demand (13.6 MGD)[1]	2.4

Notes:
Based on Approved Diversion amount of 8.2 MGD and peaking factors defined in Section 7.

Emergency Storage: Emergency storage provides water for events such as Water Supply Pipeline breaks, loss of service from the WSPS, power outages, and equipment failures upstream of the reservoirs. Wisconsin Administrative Code NR 811.62 requires a minimum reservoir storage of one average day demand (ADD) under normal operating conditions. Other systems in the region that receive water from a single supplier provide two days of ADD. As a conservative approach and based on conversations with WWU, up to two days but not less than one day of ADD will be provided as emergency storage. In the event of an emergency, this target volume will provide ample time for WWU's emergency backup well system to start-up. The emergency storage volume is 13.2 million gallons (MG) for the Existing Day Demand of 6.6 MG ADD and 16.4 MG for the ADD based on the Approved Diversion of 8.2 MG ADD.

Fire protection for Waukesha was evaluated but not included in the reservoir volume allocation as the existing storage in the WWU distribution system provides sufficient volume. Dead storage at the bottom of the reservoir will be required to facilitate hydraulics and will be evaluated after the inlet, outlet, and drain design is finalized during design.

Based on these assumptions, Table 11-7 was produced to show the storage requirement associated with the existing demands and the demands associated with the Approved Diversion.

Table 11-7 Preliminary Storage Volumes

Storage Type	Volume Associated with the Existing Demands (MG)	Volume Associated with the Approved Diversion (MG)
Operational Storage (15% of Total)	2.7	3.3
Equalization Storage (Based on MDD)	1.9	2.4
Emergency Storage (2xADD)	13.2	16.4
Total	17.8	22.1

Based on Table 11-7, 17.8 MG of storage is estimated for the existing demands to provide two days of volume for emergency storage plus the additional volumes for equalization and operational storage. For the volume associated with the Approved Diversion, 22.1 MG is estimated. As a starting point and in order to not oversize the reservoirs for the existing demands, an effective volume of 18.0 MG was selected. A visual representation of the proposed storage volumes associated with the existing demands is presented in Figure 11-15.

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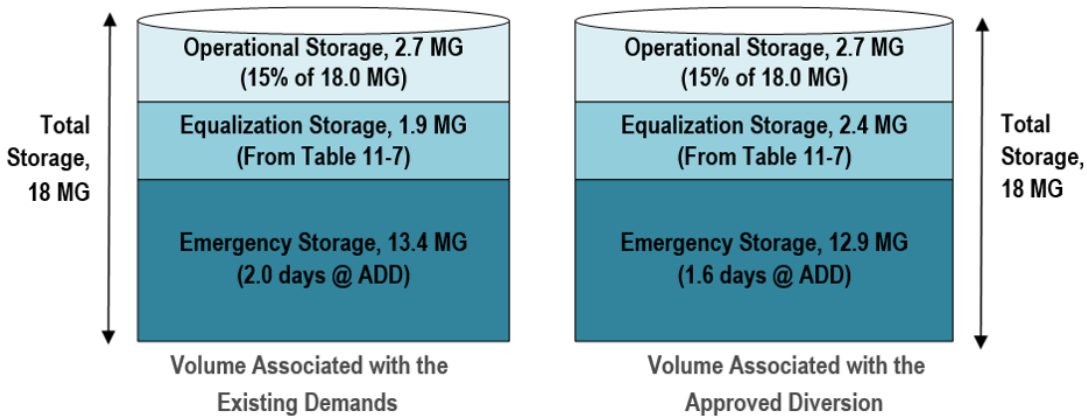

Figure 11-15 Total Reservoir Storage Diagram

The Central Pressure Zone also contains emergency storage. This storage can be included in the available emergency volume for the system and adds to the volumes described above for the reservoirs. This volume is evaluated in the Distribution System Evaluation and Improvement Identification Technical Memorandum (5-120 D1).

11.6.1.2 Reservoir Type Evaluation

After determining the required capacity for the reservoirs, the following evaluation was performed to select an appropriate reservoir type. Reservoir parameters, including the quantity, configuration, shape, and material, were determined.

Number of Reservoirs: The total effective volume of 18.0 MG was used for preliminary design based on the volume calculations in Section 11.6.1.1. In order to provide a level of redundancy and allowance for tank cleaning and maintenance, a minimum of two tanks at 9.0 MG each were selected.

Configuration: Three storage configurations were evaluated for the reservoirs: underground, at grade, and elevated. After initial evaluation, the elevated storage configuration was eliminated due to the size limitation of elevated storage and the large storage volume required. Evaluation between underground and at grade structures considered the regulatory requirements, anticipated groundwater level, soil conditions, and hydraulics. Underground storage reservoirs are allowed in Wisconsin, but Wisconsin Administrative Code NR 811.63 requires that the floor or sump of the underground storage be placed a minimum of two feet above the groundwater table. For at grade reservoirs, Wisconsin Administrative Code NR 811.63 recommends that the lowest elevations of floors or sump floors be placed at or above the ground surface. At grade reservoirs were selected based on the evaluation of the regulations, site constraints, and hydraulics.

Shape: Two reservoir shapes, circular and rectangular, were evaluated for at grade storage. Circular reservoirs have a more uniform stress distribution than rectangular reservoirs, which have higher stress concentrations in the corners. Rectangular reservoirs also frequently experience sediment deposits in the corners as flow currents are disturbed by the sharp 90-degree bends. Circular reservoirs were identified as the preferred shape to ensure consistent flow and mixing throughout the reservoir and reliable structural integrity through uniform stress distribution.

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Material: Four material types were evaluated for the reservoirs and are listed below:

- Bolted steel
- Welded steel
- Cast-in-Place (CIP) concrete
- Precast Prestressed (PCPS) concrete

The criteria used to evaluate these materials included eight factors:

1. Design Complexity: The complexity involved for design of the reservoirs.
2. Rate of Installation: The rate at which the reservoirs are constructed and put into operation. This was considered an important factor as construction is not anticipated to occur rapidly during the winter months.
3. Capacity: Since two 9.0-MG reservoirs are being considered, the selected material must be able to support this volume.
4. Maintenance: Factors related to the upkeep of reservoirs and the life cycle costs were also considered. Reservoir materials requiring excessive upkeep and maintenance are not desirable because of costs and labor required for maintenance.
5. Life Expectancy: The estimated time frame for the reservoirs' operational lives and until the reservoirs need to be replaced.
6. Durability: Corrosion resistance and the overall robustness of materials was evaluated since the reservoirs will be exposed to harsh winters and warm summers.
7. Aesthetics: The options for reservoir aesthetics were also considered since this project will be visible to the community from the roadway.
8. Cost: The initial capital cost of construction for each reservoir material type is considered based on discussions with manufacturers.

Each of the material types is briefly discussed below.

Bolted Steel:
Bolted steel reservoirs are designed per American Water Works Association (AWWA) D100-59 Standard Specifications for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks for Water Storage (D100) and consist of steel panels that are coated by the manufacturer during production. Completed panels are shipped to the project site and bolted together with gaskets to erect the reservoir. Bolted steel reservoirs have a higher potential of leaking because of the numerous bolted connections and are less durable to impact and ice damage. Wisconsin, especially during the winter, is a harsh environment and frequent icing is anticipated. Installation of bolted steel tanks can begin when materials arrive, an experienced team is required to erect the structure. Maintenance requirements include regular inspection to identify cracks or chips and panel replacement when required. Life expectancy is estimated to be 30 years, depending on the frequency of maintenance and upkeep. Maximum capacity is approximately 5 MG. The external aesthetics can be modified by various coatings and by adding colors to the steel panels. Initial capital cost for this reservoir material type benefits from low cost materials and expedited construction.

Welded Steel:
Design and construction of a welded steel reservoir also conforms to AWWA D100. Welded steel reservoirs are comprised of manufactured steel panels that are treated with an appropriate coating to prevent corrosion. Depending on the site location, welded steel reservoirs may require cathodic protection to maximize their useful life. Finished steel panels are delivered to the project site and the entire reservoir structure is welded together. Regular maintenance to control corrosion and periodic recoating of the reservoir is required to prevent structural damage from occurring. Life expectancy of welded steel reservoirs depends on maintenance, but can extend to 50 years of useful life. The most common capacity is under 5 MG while structures have been built as large as 30 MG. There are various coatings that can be applied externally to welded steel reservoirs for a range of aesthetic options. Overall capital cost for welded steel reservoirs is influenced by the amount of labor required to weld the reservoir.

Cast-in-Place (CIP) Concrete:
CIP concrete tanks are constructed in place with forms. Concrete poured into each form and allowed to cure and achieve strength before moving on to the next section. This method applied to reservoir construction requires each piece of the reservoir to be poured on-site and appropriately sequenced so that the finished product is a singular, integrated structure. On-site concrete pours ensure that all steel reinforcement is entirely encased, which provides a high degree of assurance for the corrosion resistance of the reservoir. Construction of CIP concrete reservoirs is the longest duration of the four alternatives since the structure must cure for approximately 28 days after the pour. Concrete structures require minimal maintenance, exterior painting is completed as needed and interior cleanings occur per state regulations and utility operating standards. Life expectancy for CIP concrete reservoirs is estimated to be approximately 75 years depending on maintenance. CIP concrete reservoirs can be constructed with capacity ranges exceeding of 50 MG. Exterior aesthetics for concrete reservoir are limited to painting or installation of architectural façades such as brick walls. Capital cost of CIP concrete reservoirs is higher due to the amount of material required for construction and the long duration necessary for installation.

Precast Prestressed (PCPS) Concrete:
PCPS concrete is precast in standard panel shapes and sizes for the purposes of reservoir construction and follows AWWA D110 Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks. The manufacturing process ensures that all steel reinforcement is completely encased in the panels. This quality control provides a high degree of assurance for the corrosion resistance of the reservoir. PCPS concrete panels are constructed at the project site or delivered to the site ready for installation. As panels are ready for installation, the reservoir is constructed. Once standing, high strength steel wire is wound around the reservoir to place the reservoir into compression to enhance its overall strength. Concrete structures require minimal maintenance, exterior painting is completed as needed and interior inspection and cleanings occur per state regulations and utility operating procedures. Life expectancy for PCPS concrete reservoirs is anticipated to be over 75 years with the oldest structure of this type still in operation since 1936. Capacity can exceed 50 MG for PCPS concrete reservoirs. Exterior aesthetics are limited to painting or installation of architectural façades such as brick walls. PCPS concrete reservoirs have a fast rate of installation due to the efficient panel manufacturing process which allows for lower overall initial capital cost of the reservoirs.

Based on the eight criteria discussed, each of the four material types were evaluated and assigned a score in Table 11-8. The criteria were assigned a score from one (to represent a less favorable alternative for the established criteria) to three (to represent a more favorable alternative for the established criteria). The resulting scores were compiled to produce a total score for each material. Materials with the highest total score represent preferred type and materials.

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Table 11-8 Reservoir Material Comparison

Criteria	Reservoir Material Alternatives			
	Bolted Steel	Welded Steel	CIP Concrete	PCPS Concrete
Design Complexity	3	3	1	3
Rate of Installation	3	2	1	2
Maximum Capacity	1	3	3	3
Life Expectancy	1	2	3	3
Corrosion Resistance	2	2	3	3
Level of Maintenance	1	2	3	3
Aesthetics	1	2	3	3
Initial Cost	3	2	1	2
Total	15	18	18	22

From this evaluation, bolted steel was eliminated as a potential option because the maximum capacity available is insufficient. Generally, the benefits of concrete compared to steel include a more durable and resilient material while the drawbacks include higher material costs. Concrete has the benefit of higher corrosion resistance because of encased reinforcement and a greater anticipated life expectancy. In addition, the overall level of maintenance of a concrete structure is generally less than that of comparable steel structures. There are also more options for external aesthetics when compared to steel reservoirs.

Concrete reservoirs exhibit more benefits to the operation and maintenance requirements of a water reservoir for WWU. The benefits of PCPS concrete reservoirs compared to CIP concrete are that they are manufactured in an assembly setting that expedites the installation process and provides uniform quality inspection. The drawbacks of CIP concrete reservoirs are the duration of time needed for the entire reservoir structure to cure as one piece and the higher capital costs. Therefore, PCPS concrete is selected as the preferred reservoir type and material.

Two 9.0-MG, at grade, circular PCPS concrete reservoirs will be provided with a total effective storage of 18.0 MG.

11.6.1.3 Reservoir Design

The PCPS concrete reservoirs will be designed to meet applicable regulations and site and system design parameters, such as hydraulics and site considerations.

Reservoir Dimensions: The total volume of 18 MG was used for preliminary design with a total volume of 9 MG each. Several combinations of reservoir diameter to side water depth (SWD) were developed to compare the feasibility and capital cost differential. The reservoir footprint is connected to site grading and preparation. After evaluation, two 210-foot diameter reservoirs were selected with SWD of approximately 35 feet. The SWD will be comprised of the height of the operational storage as roughly 5.3 feet, the height of the equalization storage as 3.7 feet, and the emergency storage as 26.0 feet. The dimensions and SWD associated with the existing demands are summarized in Figure 11-16.

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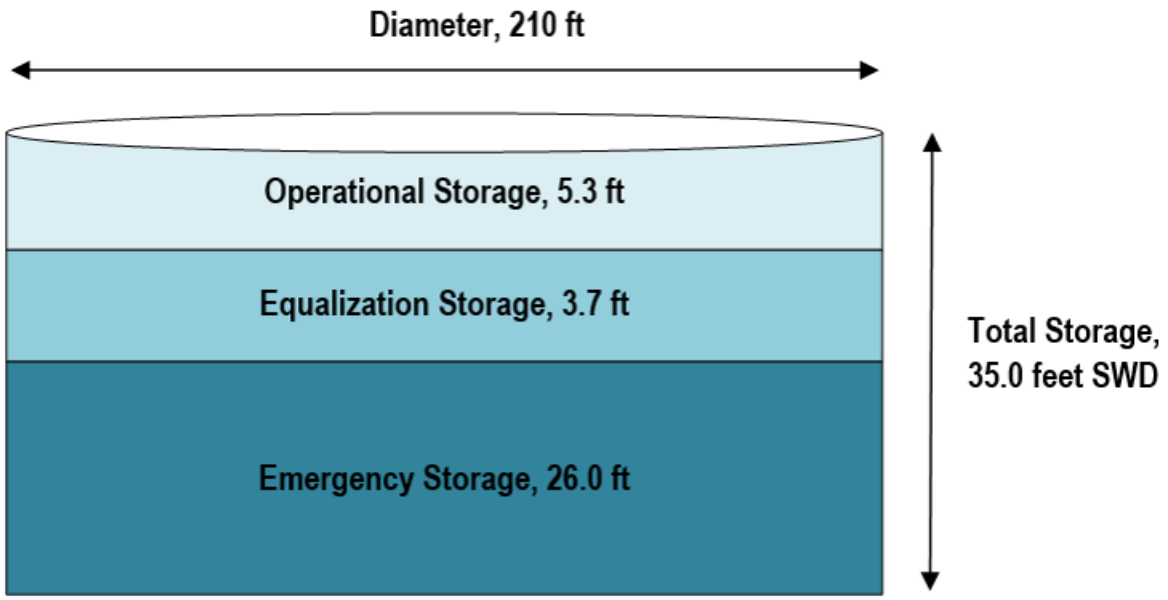

Figure 11-16 Reservoir Depths Associated with Existing Demand

Inlet and Outlet Piping: Each reservoir will be served by a separate inlet and outlet pipe that will enter through the floor approximately 22.5 degrees apart and, respectively, feed to and draw from the reservoir at opposite sides of the reservoir to prevent short circuiting.

The inlet piping passes through BPS before connecting to the reservoir. All piping at the site located underground will be installed below the frost line. Starting at the reservoir floor, the inlet piping will rise approximately 3-feet and be directed to the opposite side of the reservoir as shown in Appendix E, Drawing Sheet CP3-M5. The inlet piping will rise approximately 36-feet, placing it 6-inches above the high water level (HWL). Above the HWL, the inlet piping will turn slightly and end at a bend. The angle will be determined during design. Water will discharge from the inlet piping through a free Outfall that allows water to cascade from the top of the reservoir to the water surface during filling operations providing an air-break from the WSPS and the reservoirs.

The outlet will be located to minimize the distance between the reservoir and the BPS. An anti-vortex plate will be installed to decrease water turbulence and prevent vortexing as water enters the outlet pipe. The outlet pipe will be placed approximately 6-inches above the floor of the reservoir to reduce the amount of sediment or debris that may be carried to the outlet. A small percentage of the reservoir will be unable to exit the outlet pipe due to its raised height, which will result in the reservoir's dead space. The required dead space will be further evaluated during design.

A sump will be provided in the floor next to the at grade access manway to drain the remaining water (dead storage) from the reservoir. A portable submersible pump would be placed in the sump and discharge to the nearby stormwater manhole that leads to the retention/detention ponds. A permit is required to discharge water in the method described above and will be pursued during design.

Mixing System:
Mixing within the reservoir is required to maintain a uniformly distributed chloramine residual and to prevent short circuiting, water age issues, and freezing. Two methods of reservoir mixing were evaluated:

- Hydrodynamic mixing
- Mechanical mixing

Hydrodynamic mixing consists of water flowing through specialized nozzles along a pipe header in a reservoir. This method utilizes the jet velocity and momentum of the incoming water to create a flow regime. The system is designed such that the jet through the nozzles fully mix the reservoir within a set amount of time. The hydrodynamic mixing system would be installed during reservoir construction. This mixing system components within the reservoir do not require routine maintenance, however, the recirculation pumps located in the BPS will require routine maintenance. The initial capital cost of hydrodynamic mixing systems is higher than other options but the system provides greater flexibility for operation and maintenance. The life expectancy of the nozzles is 30 years or greater.

Due to the need for an air break between the supply from MWW and the reservoirs, a recirculation line from the pump suction line at the BPS would be installed to supply flow and pressure for the mixing system. Two recirculation pumps located at the BPS would supply sufficient mixing pressure. A third, swing pump would be installed to maintain water quality if a pump is down for maintenance. The recirculation line's discharge in the reservoir could either be a single vertical pipe that spans the reservoirs' height or a single horizontal pipe spanning the reservoirs' diameter along the floor. Both options would discharge from nozzles along the pipe per the manufacturer's specifications.

An example of a Tideflex hydrodynamic mixing system is shown in Figure 11-17.

Figure 11-17 Tideflex Hydrodynamic Mixing System

Mechanical mixing blends water through electric submersible mixers. The quantity, size, and power of mixers are determined based on the reservoir volume and flow in and out of the reservoir. Mechanical mixers do not rely on the water entering the reservoir for mixing. Installation of the mixers could be done through the roof access hatch by lowering and placing the devices with chains. The chains would also be used in case of maintenance by lifting the mixer and lowering it to the ground outside the reservoir. Alternatively, if an at grade manway were provided, the mixers could be installed and maintained through the manway when the reservoirs are empty. Electrical wiring from a power source would feed from the top of the reservoir to supply power to the mixers. The mixers typically use motors less than 5 horsepower (hp). The capital cost of mechanical mixers is less than that of hydrodynamic mixing systems

but operation and maintenance are more challenging. The life expectancy of mechanical mixers is five to seven years.

Figure 11-18 shows an example of a PAX Water Technologies impeller mechanical mixer.

Figure 11-18 PAX Mechanical Mixer

Table 11-9 Mixing Reservoir Comparison

	Hydrodynamic Mixing	Mechanical Mixing
Initial Cost	Higher	Lower
Complexity	Less complex with chemical feed No additional power, sample or chemical lines to reservoir	More complex, sample, power and chemical lines to reservoir
Reliability	Can maintain water.quality. with pump out of service	Loose water quality in tank if mixer is down
Maintenance	Easier to maintain equipment located in building	More difficult to maintain, units removed through roof of reservoir in the elements
Life Expectancy	Header and nozzles 30-yrs Pumps 20-yrs	Mixers 5 to 7-yrs

As shown in Table 11-9 the hydrodynamic mixing system provides benefits of little to no maintenance within the reservoir and high life expectancy. For this reason the hydrodynamic mixing system was selected for preliminary design. The mixing system will be further refined in design to provide complete mixing and ensure even chloramine distribution in the reservoir. Since the reservoir water levels and operation schedule have not yet been finalized, consideration will be made to maintain water quality in the reservoir under all potential operating conditions.

Air-Break: The reservoirs are intended to provide a separation between MWW's system and the WWU distribution system. In order to accomplish this, an air-break will be utilized to eliminate the direct connection to the reservoirs and backflow potential. The selection of the hydrodynamic mixing system with the recirculation line dictated the recommended air-break since the supply line will not be directly connected to the reservoir mixing system. A free fall discharge from the supply line is the most economical type of air-break. There will be minimum maintenance with this type of air-break.

Overflow: During rare operating conditions where the flow rate of water entering the reservoir exceeds the storage capacity and outlet flow, water will overflow above the HWL elevation. The reservoir will be constructed with an

overflow weir that will capture the excess water and pass it through an overflow pipe. The weir and overflow pipe will be sized to pass water out of the reservoir at a rate that exceeds the maximum anticipated supply flow rate. Once the overflow pipe exits the reservoir near the base of the wall, a weighted flap valve with a mesh screen will be installed horizontally to prevent any debris, insects, or animals from entering the overflow pipe. Refer to Appendix E, Drawing Sheet CP3-M7 for the overflow detail. Overflow water will be directed to the retention/detention ponds.

Reservoir Appurtenances: The PCPS concrete reservoir will have a free spanning dome roof with an access hatch and interior ladder to enter and exit the reservoir from the top. The roof will have a minimum slope of 0.015 feet per foot to facilitate drainage per Wisconsin Administrative Code NR 811.64. An exterior ladder, equipped with safety equipment, will provide access to the roof.

A "mushroom style" frost proof roof vent will be constructed with the opening 24 inches above the roof and covered with 24 mesh corrosion resistant screens. AWWA D110 has set pressure operation boundaries for roof vents so that the air inflow rate is equal to the maximum tank outflow rate at pressure differentials not exceeding 2.0 inches of water column. The pressure boundaries provide proper operation of the reservoir vents during all operational scenarios. Per Wisconsin Administrative Code NR 811.64 the skirted sides of the mushroom cap will cover the screens when viewing the cap from the side. An example of the mushroom style frost proof roof vent typically used by DN Tanks is shown in Figure 11-19.

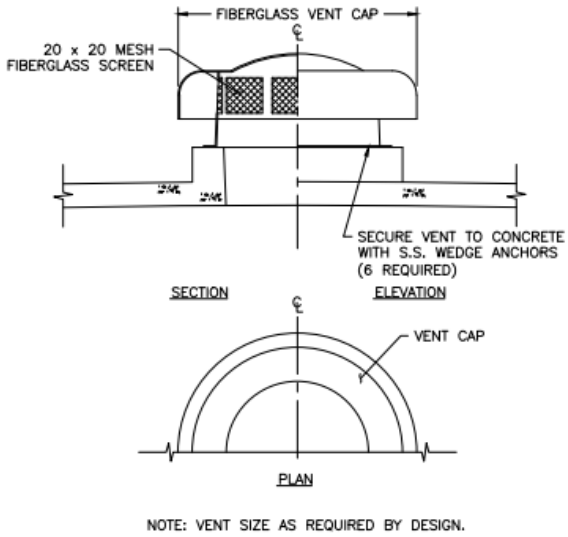

Figure 11-19 Mushroom Style Frost Proof Roof Vent

An exterior ladder, equipped with safety equipment, will provide personnel with access to the roof. A walkway between the exterior ladder, access hatch, and vent will be provided with a slip resistant coating and railings where appropriate. Liquid level indicators will be provided and are discussed in Section 11.9.6.

An at grade manway hatch will provide access to the interior of the reservoir from the ground level when the reservoir is empty. The importance of an at grade manway hatch is two-fold. First, it allows for safe and easy access by personnel when the reservoir is drained compared with descending from the roof access. Second, it will allow the dead storage water to be drained out easily with a portable submersible pump. The at grade manway hatch can only be opened when the reservoir is empty and will have multiple locks. An example of an at grade manway hatch typically used by DN Tanks is shown in Figure 11-20.

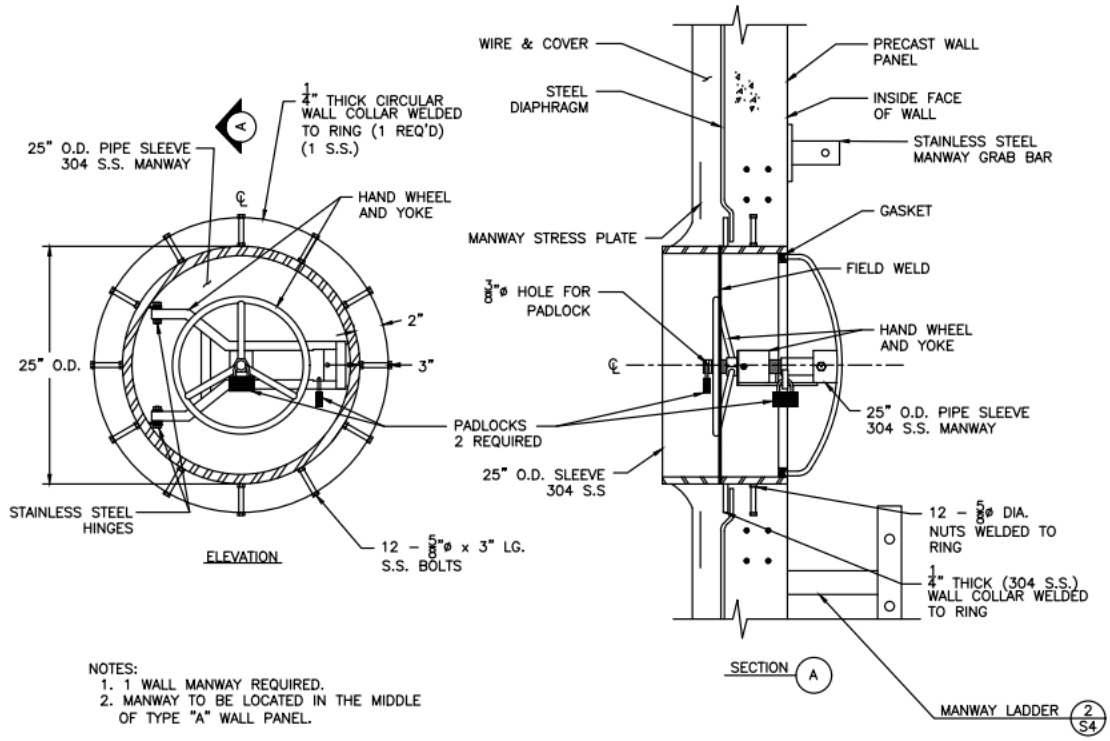

Figure 11-20 At Grade Access Manway Hatch

Aesthetics and Façade: The reservoir aesthetics will be coordinated with WWU and New Berlin. The details of the aesthetics and façade are described in the Section 11.5.

Inspection and Disinfection: It is anticipated that inspection and disinfection of the reservoir will occur at five year intervals, and a full drain down of the reservoir will be required every ten years or after every other inspection per Wisconsin Administrative Code NR 810.14. Following drain down inspections, the reservoir must be disinfected. The methods and materials for disinfection of water storage facilities are detailed in AWWA C652-11 Disinfection of Water Storage Facilities. There are three recommended methods to disinfect the tank without entering it: 1) chlorination of the full storage facility such that at the end of the appropriate retention period, the water will have a free chlorine residual of not less than 10 mg/L; 2) spraying of all storage facility water-contact surfaces with a solution of 200-mg/L available chlorine; 3) a two-step process of chlorinating the bottom portion of the storage facility with 50-mg/L available chlorine followed by filling to overflow and maintaining a free chlorine residual of at least 2 mg/L for 24 hours. WWU traditionally uses Method 2 or Method 3 from AWWA C652-11. After disinfection is complete, the disinfection water is required to be tested before it can be released to the distribution system.

11.6.2 Booster Pumping System

11.6.2.1 Distribution System Modeling Results

The distribution system modeling for the connection of new water supply to the existing distribution system is described in Section 8. This subsection summarizes the results of the modeling, which determine the operational parameters for the BPS.

Hunter Tower Connection: The use of Hunter Tower as a control element was modeled to provide static head on the Water Supply Pipeline at a minimum of 35 psi along Racine Avenue. The BPS will be operated to maintain the water level in the Hunter Tower. The water level in the Hunter Tower currently varies between elevation (EL) 1,119, which is one foot below the set overflow elevation and EL 1,109, the water level for 70% full volume.

Central Pressure Zone Connection: The new BPS Discharge Pipeline will be connected to the Central Pressure Zone downstream of the WSCB at Sunset Drive and Les Paul Parkway. Pressure reducing valves (PRVs) will be located in the WSCB and utilized to maintain the operating pressure in the Central Pressure Zone at the downstream side of the valve. This is required as the HGL of Hunter Tower is significantly higher than the Central Pressure Zone. The PRV will operate to allow Hillcrest Reservoir to operate on the system.

BPS Operation: The BPS will supply water from the reservoirs to the Central Pressure Zone. The BPS will operate based on the level in Hunter Tower as stated above. A PRV will be located at the WSCB in order to regulate the pressure in the Central Pressure Zone. When the Hunter Tower is out of service for maintenance and repair, the BPS will have the ability to maintain a pressure set point on the discharge line to ensure adequate pressure provided to the central and southeast pressure zones under all operating conditions. Operational flexibility will be maintained to allow Hunter Tower and the Southeast Pressure Zone to be fed by the Highline Booster Pumping Station.

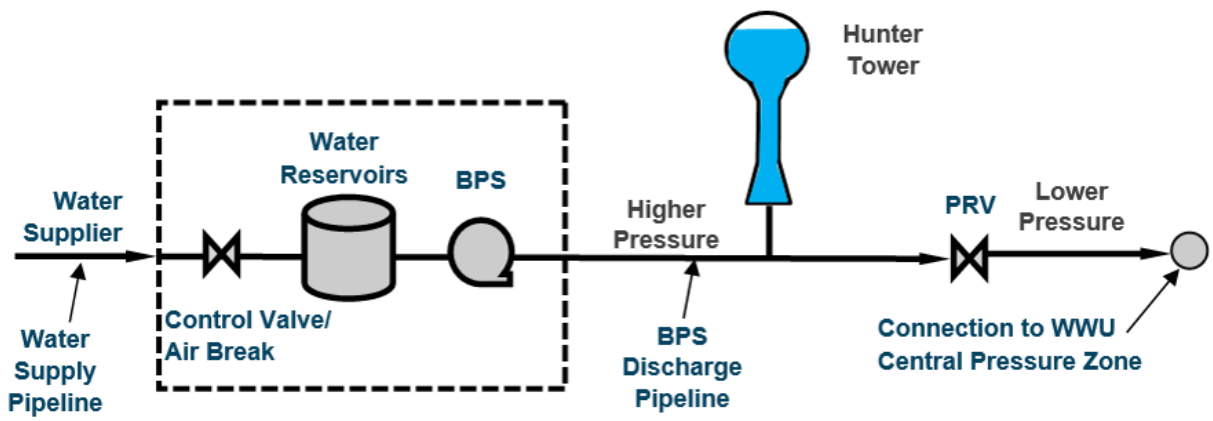

Figure 11-21 Diagram of System

11.6.2.2 Flow Range and Capacity Requirements

The BPS will be the sole source of water for the Waukesha and will need to meet the diurnal demand of the distribution system. The BPS will be designed to meet the existing conditions and have the flexibility to increase capacity as needed to meet future demands associated with the maximum withdrawal allowed by the Approved Diversion. The demand conditions are summarized in Section 7 and presented in Table 11-10.

Table 11-10 Waukesha Water Utility Demand Conditions

Parameter	Existing Demand Conditions – Historical Data Analysis (MGD)	Demand Associated with Approved Diversion (MGD)
Minimum Hour Demand (MHD)	1.2 (1)	1.5 (1)
Minimum Day Demand (Min.DD)	3.1	3.8 (2)
Average Day Demand (ADD)	6.6	8.2
Maximum Day Demand (MDD)	10.8	13.6 (3)
Peak Hour Demand (1.4xMDD)	15.1 (4)	19.0 (4)

Notes:
1. Determined by a peaking factor of 0.4 from the diurnal curve established in Section 8
2. Determined by the existing conditions Min.DD/ADD factor of 0.46
3. Determined by MDD/ADD peaking factor of 1.66 established in Section 7
4. Determined by a peaking factor of 1.4 from the diurnal curve established in Section 8

The distribution system model was used to confirm the diurnal demand. The model confirmed with the minimum hour and maximum hour range of flow described in Table 11-10. The modeled minimum hour was typically 25% of the minimum day demand and the peak hour was typically 25% higher than the MDD. The model also showed that the use of Hunter Tower and ground storage within the distribution system buffers the required peak flow from the BPS.

11.6.2.3 Hydraulic Considerations

HGLs and Elevations: The operating pressure of the BPS is determined based on the system curves developed in Section 11.6.2.2. The pertinent design HGLs and elevations are presented in Table 11-11.

Table 11-11 Booster Pumping Station Design HGLs and Elevations

Location	Hydraulic Grade Line (HGL), feet
Reservoir Minimum Water Level (HGL, feet)	980.0
Reservoir Maximum Water Level (HGL, feet)	1,015.0
Booster Pump Room Floor Elevation (HGL, feet)	980.5
Hunter Tower Minimum Water Level (HGL, feet)	1,109.0
Hunter Tower Maximum Water Level (HGL, feet)	1,119.0

Net Positive Suction Head (NPSH): In order for proper pump performance and service life, sufficient suction head must be provided. NPSH is defined as the total available suction head minus the required suction head as defined by the pump manufacturer for proper operation. The key factors impacting the NPSH are atmospheric pressure, lowest water level in the reservoir, head loss between reservoir and the pump, and the pump datum elevation. Table 11-12 presents the NPSH at the pump room finished floor.

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Table 11-12 NPSH at Pump Room Finished Floor

Parameter	Value
Reservoir Minimum Water Level Elevation, feet	980.0
Booster Pump Room Floor Elevation, feet	980.5
NPSH available at Booster Pump Room Finished Floor, feet	17.5

Notes:
1. NPSH calculated for flow of 19 MGD.
   The pump NPSH datum are different for different types of pumps and therefore will be one of the key factors in the selection of pump type. The NPSH available must be greater than the NPSH required by the pump at the desired flows in order to preclude the damaging effects of cavitation and provide the performance as shown on the pump curve. The ratio of NPSH available to NPSH required is recommended by the Hydraulic Institute (HI) Standard 9.6.1 at a minimum ratio of 1.1 for water pumps used for this application.

11.6.2.4 Pump Design and Selection

Pump design and selection are based on the flow range and capacity requirements described in Section 11.6.2.2 and BPS design flows outlined in Table 11-10. Pump type, pump size, pump configuration, and pumping operations are designed to accommodate these parameters.

11.6.2.4.1 Pump Type

The following are two types of pumps commonly used for potable water supply and were selected for evaluation:

Axial split-case dry-pit style with the shaft centerline oriented horizontally, commonly known as horizontal split-case (HSC) dry-pit style and referred to below as HSC pumps

Lineshaft-driven vertical turbine style referred to below as vertical turbine (VT) pumps

Each pump type have been evaluated in terms of site requirements, priming requirements, NPSH, hydraulic efficiencies, ease of maintenance, and spatial requirements.

Horizontal Split-Cased Pumps: A HSC pump at WWU's Airport Booster Station similar to the ones considered for this application is shown in Figure 11-22. It is preferable to install HSC pumps on the main floor of a building for access and maintenance. The pump and motor are mounted on a common base supported by a concrete equipment pad. A single double-suction impeller would be sufficient to produce the flow and head required. Suction and discharge piping would enter and exit the main floor through the basement, where header pipes would be located. The pump and motor are typically oriented perpendicular to the suction and discharge lines but require a large amount of space to accommodate clearances around equipment. Other orientations are available but may not be suitable for all flow and head conditions. The NPSH datum for HSC pumps is at the centerline of the shaft, which is approximately 4-feet above the main floor. In order to achieve Hydraulic Institute (HI) standards for NPSH, the minimum water level in the reservoir must be at least 5-feet above the pump room main floor, which requires additional grading to be performed on site and increases the overall height and visibility of the reservoirs. If flooded suction conditions are not achievable, each pump will be equipped with a vacuum priming system to flood the pump impeller prior to starting the pump.

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Figure 11-22 Horizontal Split Case Pump at WWU's Airport Booster Station

Vertical Turbine Pumps: Photos of typical VT pump installation at Pleasant Prairie Pumping Station at Pleasant Prairie, WI from the site visit conducted on August 16, 2017, similar to the ones considered for this application are shown in Figure 11-23. VT pumps can be installed over clear wells or in a barrel (also known as a can) that is hard piped. Since the reservoirs are above grade, the VT pumps will need to be installed in a barrel and hard piped. The motor and pump discharge would be installed on the main floor of the BPS with the barrel and suction port located in the basement. The pump and motor would be mounted on a common base supported by a concrete equipment pad attached to the main floor slab. Each pump would include pump bowls arranged in series on a common shaft to produce the flow and head required. Since the suction port for the barrel is located in the basement, all header and individual pump suction piping would be located below the main floor. The pump discharges above the main floor and would have a discharge pipe and then turn and enter the basement to a common discharge header. The NPSH datum for VT pumps is at the impeller eye of the first stage which, is approximately 10-feet below the main floor. In order to achieve HI standards for NPSH, the minimum water level in the reservoir could be same as the Pumping Room main floor which allows for minimal site grading and minimizes the overall height and visibility of the reservoirs.

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Motor and Pump Discharge on Main Floor

Pump Elements and Barrel in the Basement

Figure 11-23 Vertical Turbine Pump

Recommendations: The hydraulic efficiencies of these two pump types are similar. The pump and motor base can be smaller for VT pumps than HSC pumps, reducing the area required for the base as well as the spacing between the pump discharge piping and ultimately, the BPS. HSC pumps can be fully worked on from the Pumping Room whereas only the motors of the VT pumps are accessible from the Pumping Room. VT pumps provide more flexibility for site grading and reservoir design due to the NPSH requirements. In addition to NPSH constraints, final site grading and reservoir design may necessitate the addition of a vacuum priming system for the HSC pumps. The VT pumps offer cost savings in the pump equipment, building, reservoir, and site work. Due to the number of benefits the VT pumps offer over the HSC pumps, VT pumps are preferred for this application.

11.6.2.4.2 Pump Size and Number

In order to select the size and number of pumps, many factors were evaluated, including, range of flow, level of redundancy, operational flexibility and planning for the future. The flow data provided by WWU from 2012 to 2016 was used to select the number and size of the pumps. In order to determine the number and size of pumps, hourly data is needed since the pumping station will need to supply flow based on the diurnal curve of the demand on any given day. The hourly flow data for the existing conditions was determined applying the diurnal curve (refer to Section 7) to each day of the data set received by WWU from 2012 to 2016. The data was then placed in ascending order to produce the cumulative percentile curve shown in Figure 11-24.

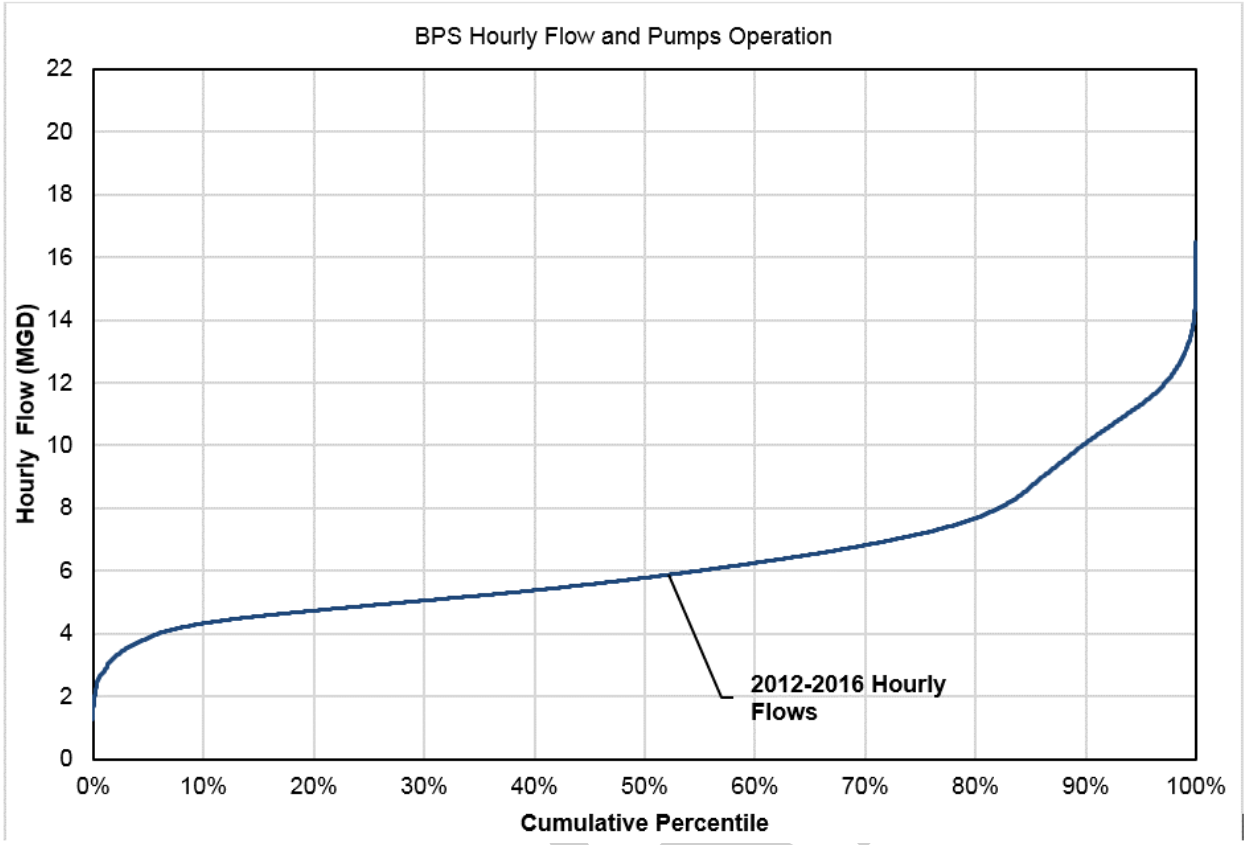

Figure 11-24 Flow Cumulative Percentile Curve

Figure 11-24 shows that for the existing conditions data set, 80% of the hourly flow (between 10% and 90%) is within a range of approximately 4.25 MGD – 10.1 MGD. One pump sized at 6 MGD can provide flow for half of the data set. In order to limit the number of pumps installed, pump sizes between 5 and 6 MGD were evaluated.

To determine the number of pumps, the level of redundancy was evaluated. Pumping stations must be able to supply the firm capacity with one of the largest pumping units out of service. This is often referred to as an N+1 configuration, with "N" being the number of pumps to provide the firm capacity. To evaluate the number of pumps required, the largest peak hour flow value from the data set of 15.75 MGD was divided by the top and bottom range of the targeted pump sizes (5 and 6 MGD). This yields values of 2.6 and 3.1 and centers on the whole number 3 which is the number of pumps to provide the firm capacity for the station. To provide a firm capacity of 15.75 MGD, each pump is rated for 5.25 MGD. When the value of 3 is used "N", the total number of pumps is 4. The total station capacity with all 4 pumps in operation is then 21.0 MGD.

Based on the analysis, for the Existing Demand Conditions, this selection will provide operational flexibility over a wide range of flow. Typical turn down on a pump is 50%, which yields a pumped low flow of 2.63 MGD. Based on the hourly flow data, the probability of the flow being below this value is 0.5%. Flows below the capacity of a pump can be accommodated with recirculation lines or jockey pumps, if necessary. Further, two pumps at rated capacity will satisfy the flow demand over 90% of the operating time. Table 11-13 summarizes the pumping capacities compared to the probability of occurrence in the data set and the linear percent of the design peak hour demand (PHD).

Table 11-13 Existing Conditions Pumping Capacity

No. Pumps Operating	Existing Conditions Capacity	Percent of Time Flow in Data Set is Below Pumping Capacity (%)	Percent of Design Peak Hour Demand (15.1 MGD) (%)
One Pump (Low Flow) (MGD)	2.63	0.5%	17%
One Pump (MGD)	5.25	36%	35%
Two Pumps (MGD)	10.50	91%	70%
Three Pumps (N or Firm Capacity) (MGD)	15.75	100%	104%
Four Pumps (N+1 or Installed Capacity) (MGD)	21.00	NA	140%

In the future, it may be necessary to increase the BPS capacity to accommodate increased demand or growth. The PHD associated with the Approved Diversion of 8.2 MGD ADD is 19.0 MGD. This would require an additional 3.25 MGD of installed capacity. Two options to increase capacity would be to replace two of the pumps with higher capacity pumps or all four pumps. Table 11-14 shows the pump selection for existing conditions and options for the future.

Table 11-14 Options for Increasing Pumping Capacity

Pump No.	Existing Conditions	Future Option 1 – Replace 2 Pumps	Future Option 2 – Replace All Pumps
BP - 1 (MGD)	5.3	8.5	6.4
BP – 2 (MGD)	5.3	5.3	6.4
BP – 3 (MGD)	5.3	5.3	6.4
BP – 4 (MGD)	5.3	8.5	6.4
Firm Capacity (MGD)	15.8	19.0	19.0
Installed Capacity (MGD)	21.0	27.5	25.4

Option 2 allows greater flexibility for phasing the pumps in over time and allows for use of the existing pump barrels, discharge piping, etc. This will be further considered during design and in discussion with WWU.

11.6.2.4.3 Pumping Hydraulics

Pumping hydraulics were analyzed to maintain water levels in Hunter Tower. Flow and head curves were developed for the system based on modeling performed and described in Section 8. The total head is the sum of the static and dynamic heads. The static head is the water level elevation difference between Hunter Tower and the reservoirs. The dynamic head is the head required to overcome the resistance to flow in the pipeline and includes losses due to pipe friction and turbulence in various fittings.

Two system curves were developed based on the water levels in the reservoirs, the water levels in Hunter Tower, and pipe friction losses that represent age of pipe.

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- System Curve 1: This represents the minimum anticipated system curve. It accounts for the minimum static conditions with the reservoirs full and Hunter Tower at 70% full (1,109 feet). It also accounts for a pipe roughness coefficient consistent with new pipe.
- System Curve 2: This represents the maximum anticipated system curve. It accounts for the maximum static conditions with the reservoirs at low level and Hunter Tower full. It also accounts for a pipe roughness coefficient consistent with old pipe.

The parameters used to develop the system curves are presented in Table 11-15.

Table 11-15 BPS System Curve Parameters

Parameter	System Curve 1	System Curve 2
Reservoir Water Level, feet	1015	980
Hunter Tower Water Level, feet	1109	1120
Hazen-Williams C	150	120
Total Static Head, feet	94	129
Dynamic Head (@ 15.1 MGD), feet	13	16
Total Head, feet	107	145

These two curves represent the anticipated boundaries of the full operating range of the pumps and were used for selecting and validating pump curves. The system curves and pump curve (for one of the selected pumps) are shown in Figure 11-25. Pump curves are shown for one, two, and three pumps operating at full speed in parallel. The one pump curve also shows anticipated operation at reduced speed capacity.

Pump Operating Range

Design characteristics for both performance and service life of pumps are optimized near a rate of flow designated as the best efficiency point (BEP). Operating a pump continuously or for a long duration outside the preferred/allowable operating range affects the power consumption and life of pump components. Based on the HI Standard 9.6.3, the preferred operating region (POR) for VT pumps selected by manufacturer for the booster pumping application is 70% and 120% of flow at BEP. These operating ranges are shown in Figure 11-25.

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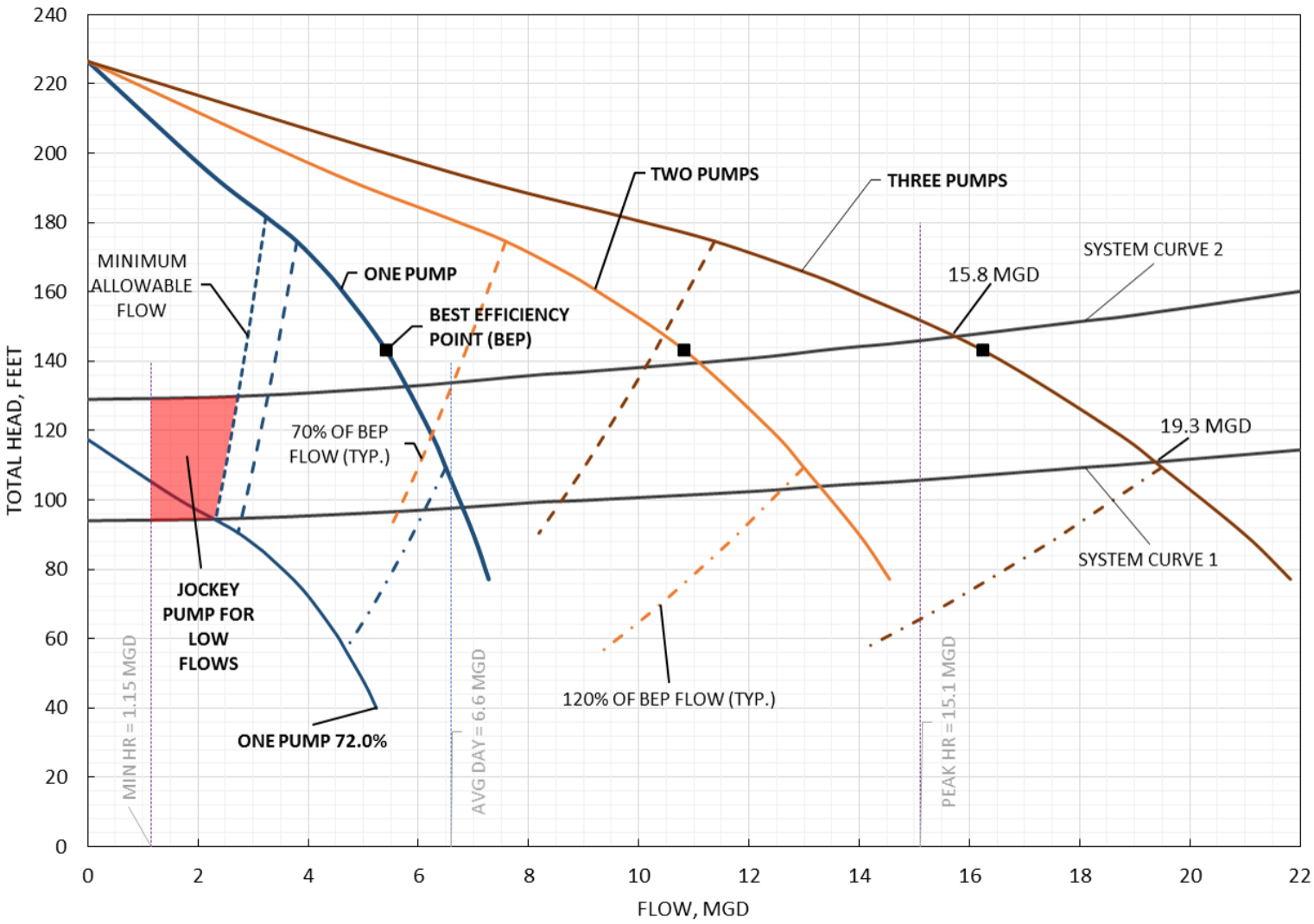

Figure 11-25 System Curves and Existing Conditions Pump Curves

The allowable operating region (AOR) is a wider range and typically determined by the pump manufacturer for their specific individual pump. Normal operating conditions should be located in the pump's POR and infrequent operating conditions could be located in the pump's AOR. Note that all of the flow conditions shown in Figure 11-25 fall within the POR for the pumps except for the low flow conditions which needs to be satisfied when the station is operating to maintain a pressure set point (Hunter Tower offline).

Based in Figure 11-25, the operating range for the pump selection along System Curve 1 is from 2.3 MGD to 19.3 MGD and the operating range for the pump selection along System Curve 2 is from 2.6 MGD to 15.8 MGD. The firm capacity of the station with three pumps in operation is expected to be between 15.8 MGD and 19.3 MGD, contingent to the operating levels in Hunter Tower and the reservoirs. Operationally, the levels could be optimized and coordinated with the MWW to provide greater throughput in the summer months.

Low Flow Condition

When the BPS is operating to maintain levels in Hunter Tower, pumps will be started and stopped as needed. When Hunter Tower is offline for maintenance, the BPS must be able to operate to maintain a pressure set point leaving the BPS. Pump manufacturers had provided the allowed minimum continuous stable flow, the low range of AOR for the selected pumps. The minimum continuous stable flow for pumps from different manufacturers varied from 1.75 MGD to 3.23 MGD. Therefore, the selected booster pumps would not satisfy the minimum hour demand of 1.2 MGD even running at reduced speed. To satisfy the low flow conditions, either the flow above 1.2 MGD could be recirculated to meet the minimum stable flow condition of the pump or a jockey pump of smaller capacity could be used.

Jockey Pumps

The use of a jockey pump was discussed with WWU and selected to satisfy the minimum flow conditions. A two pump system with one operating and one stand-by would be installed in the basement of the BPS. The pumps would operate between 1.1 MGD and 2.75 MGD with head between 90 feet and 130 feet. These pumps would be horizontal centrifugal type for ease of installation and maintenance as NPSH is not a constraint when located in the basement. The corresponding flow at the BPS rated maximum head of 145 feet is lower than the minimum stable continuous flow for these pumps and therefore the jockey pumps would not be able to contribute to the stations firm capacity. However, if the station was operated to maintain a pressure set point at a head that is achievable by the jockey pumps, then they could be operated in parallel to the booster pumps and contribute to the capacity of the station. Another benefit to the jockey pumps is that they could be used to top off Hunter Tower at a low rate to reduce the risk of overflow.

11.6.2.5 Station Piping

The piping arrangement is shown in Appendix E, Drawing Sheet CP3-M2 and CP3-M3. The main supply pipe, booster pumps suction and discharge headers, individual booster pump discharge, and related appurtenances will be located at the basement under the Pumping Room. Individual booster pump suction will be located in the Pumping Room.

The laying lengths and pipe velocities meet the requirements of the HI Standard 9.6.6 Pump Piping requirements. All water piping will have flanged joints. Piping will have breakout fittings to allow quick dismantling for maintenance or replacement of piping and equipment. The location and design of breakout fittings will be developed during design. The pipe support location and design will be developed during design. The design goal will be to locate the pipe supports to avoid any unsupported piping element while any equipment or piping element is removed for replacement

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or maintenance. Valves will be supported by supports on either side of the valve as required to allow for removal of the valve.

Piping Material: The two pipeline materials considered for the station main water piping are ductile iron pipe (DIP) and steel pipe. DIP would have multiple flanged fittings and pipe spool pieces resulting in higher cost compared to steel pipe. DIP has been selected for preliminary design to represent the most conservative design with laying lengths and space requirements. DIP is the preferred material for WWU due to familiarity at existing facilities. Steel pipe may be evaluated for the design at WWU's discretion.

Reservoir Supply Line: The 30-inch Water Supply Line from WSPS will enter the basement area at the east side wall and will continue along the north wall of the basement. It will have a reservoir supply meter to measure flow to the BPS. Two 24-inch reservoir supply lines branching off of the 30-inch pipeline after the flow meter will supply water to the reservoirs and will have pressure control valves, which will maintain a minimum pressure in the Water Supply Pipeline. After pressure control valves, both 24-inch pipelines will have an interconnection and isolation valves which will allow flexibility of splitting flows to the reservoirs and will also allow connecting reservoirs to each other. After the interconnection, the two reservoir supply lines will exit the BPS building at the south wall of the basement.

Suction Header: A 30-inch pump supply line from each reservoir will enter the south wall of the basement and will have interconnection. The 30-inch pump suction header will be connected to the interconnection. Suction header will be on the floor and will have tee connections to each individual overhead pump suction pipes.

Discharge Header: Individual booster pumps will pump through their control valve, flow meter and discharge piping into a common 30-inch discharge header all located at the Pumping Room. The discharge header will run towards south and then will be connected to the 30-inch BPS discharge line in the basement which will exit the building and supply the WSCB. The BPS Discharge Line will include a flow meter to measure the combined flow leaving the station. The 30-inch discharge line will be connected to the 36-inch BPS Discharge Line along Racine Avenue.

Bypass Connection: The BPS will have a station bypass connection to allow the WSPS to directly supply water to the WSCB in the event that the BPS needs to be removed from service. This will be accomplished by extending 30-inch Reservoir Supply Line after tee connections for 24-inch Reservoir Supply Lines to the 30-inch BPS discharge line.

Dead Ends: Dead ends are sections of piping that can have stagnant water due to lack of water circulation. Dependent on the number of pumps operating, dead ends can occur in the suction and discharge header. These dead ends can result in increased water age and provide environment for bacteria to grow. To keep water fresh throughout BPS piping, a recirculation line will be installed to connect the pressurized discharge header to the suction header. The recirculation pipe will be sized to recirculate minimum volume of water at a dead end to eliminate adverse water age.

11.6.2.6 Pump System Appurtenances

Isolation Valves: Valves typically used for fully-open or fully-closed operation can be used for isolation purposes. The valve types typically considered for water service isolation include butterfly and gate valves. Butterfly valves were selected as isolation valves due to suitability, ease of operation, short face-to-face dimension, light weight, and economic affordability for sizes 12-inch diameter and larger. Many of WWU's facilities currently use butterfly valves for isolation purposes.

Butterfly valves meeting AWWA C504 will be specified. The size, location, and shaft orientation of the butterfly valves will be reviewed with the specified manufacturers to avoid any excessive vibration of the valve and fluttering of the disc. If potential signs of disc vibration or cavitation occur with butterfly valves, gate valves will be used in its place.

Providing extensions to the Pumping Room for manual operators of isolation valves in the Basement will be evaluated during design. Valves used to direct flow or require more frequent use will be evaluated for electric actuators during design.

Control Valves: The reservoir supply line will have a control valve. The primary function of the control valve will be to sustain a minimum pressure of 35 psi at the highest point of the Water Supply Pipeline from WSPS to BPS. Any other functions such as control of flow to reservoirs will depend on how water is conveyed from the water supplier and will require input from the water supplier. A control valve will be selected during design.

A motorized pump control valve will be installed on the discharge of all booster pumps and jockey pumps. Pump control valves provide adjustable opening and closing times to protect pumps against potential hydraulic transients. The hydraulic transient analysis will be performed and will govern the design and selection of the pump control valve.

Air Release Valves: ARVs automatically maintain the efficiency of the piping by releasing air pockets that form within highpoints of the pressured pipeline. The valves operate by opening against internal pressure, venting air from the pipeline until the air pocket is depleted and water rises through the valve casing pushing up a float switch closing the air vent. An ARV will be located on the top of the spool piece immediately downstream of each pump expansion joint and on the discharge header upstream of the BPS discharge meter. The design and selection of the ARV will performed during design in conjunction with the hydraulic transient analysis.

Surge Protection: A surge relief valve will be installed on the discharge header to minimize pressure surges and water hammer. Surge relief valves release water from the system to an exterior splash pad to alleviate system pressure. Surge relief valves will be selected upon completion of the transient analysis.

During the Water Supply Facilities Site and Building Meeting No. 2 (6-200 M-04) held on August 31, 2017, initial evaluation was performed for the possibility to return surge flow into the supply line for the reservoirs to eliminate the wasted water outside. Based on a preliminary evaluation, water quality and pressure effects on BPS piping are key concerns for wasting water from the surge line to the supply line. The surge protection system should not have any downstream valves that prevent effective functions and should be configured to allow testing to ensure functionality. Further evaluation during design equipment will determine the ability to convey the water to the supply line.

Pressure Gauges: Pressure gauges will be installed on the reservoir supply line upstream and downstream of the flowmeter and pressure sustaining control valve, at the pump supply line prior to the individual pump suction headers, upstream and downstream of the booster pumps, downstream of discharge flowmeter, and the surge relief line. The locations of pressure gauges are shown in Appendix E, Drawing Sheet CP3-N1 and CP3-N2. WWU utilizes 1-inch normal pipe thread (NPT) taps for all instrumentation and gauges and prefers that weldolets be provided on pipe by the fabricator. Photos of typical gauge connections at WWU's facilities are shown in Figure 11-26.

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Sample Tap Connection

Gauge Connection

Gauge, Transmitter, and Tap Connection

Figure 11-26 Typical Gauge Connection at WWU's Facilities

Metering: During the Water Supply Facilities SCADA, Electrical and Mechanical Meeting (6-200 M-03) held on August 17, 2017, pipeline metering locations were discussed and consensus was gained to use a Venturi meter (discussed in Section 11.10) on the Water Supply Pipeline to provide similar accuracy as the Compliance Meter for WWU at the WSPS. WWU indicated preference to have individual magnetic flowmeters on each booster pump to monitor pump performance.

11.6.2.7 Equipment Removal

The BPS will require lifting mechanisms to lift and move pumps, motors, valves, and other ancillary equipment for maintenance, upgrade, or replacement. Different types of lifting mechanisms can be used to remove and install equipment at the BPS. Various factors for selecting the type of lifting mechanisms best suited for the use in the BPS include weight and dimension of the load, the height of the lift, distances/areas of movement required, clearance, cost, process layout, building limitations, and frequency of use. Table 11-16 provides the range of weights and frequency that equipment may need to be removed from the facility for repair, replacement, or upgrade.

Table 11-16 BPS Equipment List

Equipment	Life Expectancy	Weight (lbs)	Removal Requirement
Pumps	20+ years	3,500	Refurbishment / Replacement Only
Motors	20+ years	3,000	5 to 10 years for maintenance
Valves	20+ years	3,700	Refurbishment / Replacement Only
Pump Control Valve – Ball Valve (if used)	20+ years	6,300	Refurbishment / Replacement Only
Pipe (heaviest fitting)	20+ years	3,700	Replacement Only
Venturi Meter	20+ years	3,100	Replacement Only

The hoisting system will be designed for a 5-ton capacity. The equipment considered for this application are as follows:

- Bridge Crane
- Gantry Crane
- Monorails
- Roof Hatch and External Crane

Descriptions and design considerations for lifting mechanisms are provided in Section 4.

Removal Equipment Recommendation: A bridge crane is recommended for equipment removal at the BPS due to the versatility, greater degree of movement, and load positioning of the crane. Both a monorail and gantry crane application will require individual crane units for each booster pump and its discharge piping and have limited movement pathways for the equipment. This is limited by the floor space for the gantry and the track path for the monorail. The gantry and monorail options have similar or higher cost to that of the bridge crane. The bridge crane reduces risk of injury to the operator by providing the most control over movement of hoisted equipment.

VT pumps are typically furnished with barrel, pump unit, and discharge head as an integral assembly and might be required to be removed as one piece. Lifting the long VT pump assembly using the bridge crane would require higher bridge crane, resulting in an increase in the height of the Pumping Room. To install the bridge crane at a higher location for removal of VT pump assembly will cost approximately $150,000. The pump assembly that would be require to be removed is estimated to occur once every five years which is likely more often than they would actually be removed. Use of an external rental crane and removal through roof hatches will cost approximately $12,000 for every five years and will be a cost effective option than installing the bridge crane at higher location. The recommendation of using an external rental crane for removal of VT pump assembly through roof hatches and using bridge crane for all other equipment was discussed with WWU and selected for the design.

11.6.3 Chemical Feed

This subsection provides information on the type of chemicals anticipated to be used at the BPS. At a minimum, it is anticipated that disinfectants and corrosion inhibitors will be required. The chemical feed system is an ongoing evaluation and will continue to be updated in design in conjunction with the water quality evaluation and pipe loop testing.

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11.6.3.1 Milwaukee Water Quality

Based on published data, the chemicals that are currently added to MWW's water system are detailed in Table 11-17

Table 11-17 Chemical Addition to MWW's Water System

Chemical	Purpose
Ozone	Primary Disinfectant
Aluminum Sulfate (Alum)	Coagulant
Liquid Chlorine	Secondary Disinfectant
Ammonia	Form Chloramine
Fluoride	Dental Health
Orthophosphate	Corrosion Inhibitor

Similar to many large water utilities, MWW forms chloramines, also known as combined chlorine, as their secondary disinfectant. The exact type of corrosion inhibitors and pH adjustment that MWW uses were not available at the completion of this report. Refer to Section 6 for more information on MWW's finished water quality.

11.6.3.2 Chemical Evaluation and Discussion

Due to the current state of the water quality evaluation and pipe loop testing, certain assumptions were made regarding the type and concentration of chemicals used. These assumptions were made in order to size the BPS and develop the opinion of probable construction cost. Evaluations for each chemical and preliminary design for storage and pumping requirements for each are presented herein.

The results of the pipe loop testing, distribution system modeling, and input from WWU will help to further define anticipated water quality and residuals within the distribution system and refine the selection of chemicals during design.

This section describes the preliminary chemical selection process for chloramine, corrosion inhibitors, and pH adjustment.

11.6.3.2.1 Disinfection

Chlorination (free chlorine) and chloramination (combined chlorine) are common disinfection practices for potable water. There are advantages to using each type of disinfection, but it is recommended to utilize chloramination for this application based on the following items:

- Finished water from MWW will have chloramines present.
- Chloramines provide a stable, long lasting residual disinfectant that has the potential to reach the edges of the distribution system.
- Chloramines have a low oxidation potential and produce significantly lower levels of trihalomethanes (THMs) and other disinfection by-products (DBPs).

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- Chloramines effectively minimize taste and odor concerns in the distribution system since chloramine residual lasts longer compared to free chlorine.

The reaction between chlorine and ammonia forms various chloramine compounds, including monochloramine, dichloramine, and trichloramine. Monochloramine is the preferred chloramine compound for potable water disinfection. The formation of dichloramine and trichloramine can be minimized by adding a specific weight ratio of chlorine to ammonia in order to control pH levels. The preferred chlorine to ammonia mass ratio is between 3:1 and 5:1.

Chlorine: Sodium hypochlorite and chlorine gas were considered. Sodium hypochlorite has become more common as there is lower potential for health risks and injuries to operators compared to chlorine gas. WWU currently uses sodium hypochlorite as their primary disinfectant. Due to safety concerns of chlorine gas and WWU's current familiarity with their disinfectant, sodium hypochlorite is selected as the preferred source of chlorine at the BPS.

Ammonia: Anhydrous ammonia, ammonium hydroxide (aqua ammonia), and liquid ammonium sulfate (LAS) were considered for ammonia solutions to dose with sodium hypochlorite to form chloramines. Anhydrous ammonia is injected as a gas and requires an ammoniator to monitor and control the ammonia flow. Aqua ammonia is the most hazardous of the three chemicals, where LAS is widely accepted as a safe, stable and effective source of ammonia. Unlike aqua ammonia, LAS has a long storage life and does not degrade rapidly over time. Therefore, LAS is the preferred source of ammonia solution to form chloramines.

11.6.3.2.2 Corrosion Inhibitor

A corrosion inhibitor will need to be dosed at the BPS and possibly other locations within WWU's distribution system to limit corrosion and loss of pipe scale. Pipe loop testing will be performed, that will define the preferred chemical(s). In order to size the BPS, select equipment and develop the opinion of probable construction costs, assumptions were made on the type and concentration of the chemical, since the results of this evaluation are not yet available.

Although Waukesha currently uses sodium silicate as their corrosion inhibitor, a phosphate blend is used by many communities who treat and distribute Lake Michigan water. Published information and coordination with chemical providers in southeast Wisconsin indicate that a 60:40 polyphosphate/orthophosphate ratio blend is typical of communities who treat Lake Michigan water. Therefore, a 60:40 ratio blend, is assumed for preliminary design.

11.6.3.2.3 Fluoride

MWW adds fluoride to its finished water and it is anticipated that levels will be sufficient for distribution to WWU. Results on source water quality and pipe loop testing will be available during design and the need for boosting fluoride will be further evaluated.

11.6.3.2.4 pH Adjustment

pH adjustment may be required if sufficient alkalinity is not present in the source water. Space for a small system has been incorporated into the layout of the BPS. Results on source water quality and pipe loop testing will be available during design and the need for pH adjustment will be further evaluated.

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11.6.3.3 Chemical Feed and Storage

The regulations and design criteria for each of the preferred chemicals are described in this section.

11.6.3.3.1 Sodium Hypochlorite System

Sodium hypochlorite will have the flexibility of being injected to the reservoirs and/or after the booster pumps. Primary mode of operation will be to monitor the residual in the reservoir and adjust feed rates accordingly. Injection to the BPS Discharge Header will allow for an alternate dosing location that also provides the ability to perform a free chlorine treatment of the distribution system. In order to size equipment, it was assumed that the water received from MWW contains minimal chlorine residual. This is a conservative assumption and it is anticipated that some residual will be present and defined in design.

The sodium hypochlorite system will be located in a separate room. A filling station will be provided inside the room along with a transfer station and eyewash station. The sodium hypochlorite room will have its own independent heating, ventilating, and air conditioning (HVAC) system as described in Section 11.8. The instrumentation and control system for sodium hypochlorite is described in Section 11.9.

Regulations: Wisconsin Administrative Code Wisconsin Administrative Code NR 811 requirements were evaluated for sodium hypochlorite design and are summarized in Table 11-18.

Table 11-18 Sodium Hypochlorite Standards and Regulations

Evaluation Item	Wisconsin Administrative Code Wisconsin Administrative Code NR 811
Bulk Storage Requirements	Minimum of 30 days, Maximum 45 days
Day Tank Storage Requirements	Minimum 24 hours
Containment Volume	Largest tank volume
Protection	Out of direct sunlight

Wisconsin Administrative Code NR 811 requires enough on-site storage for 30-days of chemical supply. Sodium hypochlorite storage can be designed for up to 45-days of chemical supply but no longer, as its concentration decreases over time.

System Design: Since the residual chlorine concentration in the water from MWW is unknown, it is assumed there will be minimal residual, but there will be no initial chlorine demand. Wisconsin Administrative Code NR 811 requires a minimum total combined chlorine concentration level of 1.0 mg/L at the entry point to the distribution system and detectable throughout the distribution. United States Environmental Protection Agency (USEPA) regulations require chloramine concentrations to be below 4 mg/L. According to the American Water Works Association and American Society of Civil Engineers manual *Water Treatment Plant Design, Fourth Edition*, most utilities provide a chloramine residual between 2.5 and 3.5 mg/L at their facilities. A chloramine residual of 3.0 mg/L will be used at the BPS with a Cl_2:NH_3-N ratio of 4:1 for monochloramine production.

Sodium hypochlorite is a corrosive liquid that requires the use of a chemical-feed pump and injection system to provide the desired mixing. According to Wisconsin Administrative Code NR 811, sodium hypochlorite storage is required for a minimum of 30-days. Storage time greater than 30-days will result in increased degradation of sodium

hypochlorite and is not recommended. Generally, the rate of sodium hypochlorite decomposition will increase from higher concentrations, higher temperatures, lower pH, and exposure to sunlight. For design, it was assumed that the sodium hypochlorite room temperature is 80°F with a concentration of 10.9%, which is the average concentration of 12.5% solution over 30-days, as shown in Figure 11-27.

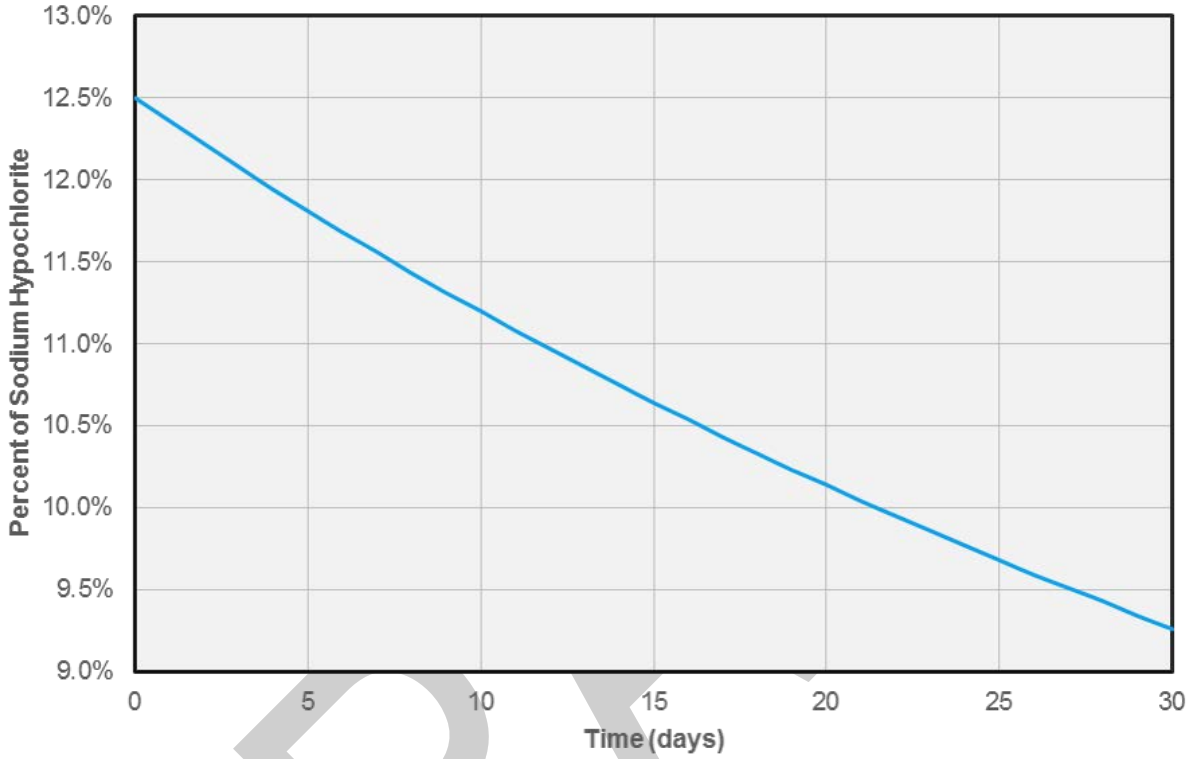

Figure 11-27 Sodium Hypochlorite Degradation

Table 11-19 shows the design criteria for sodium hypochlorite.

Table 11-19 Sodium Hypochlorite Design Criteria

Description	Flow Range		
	Minimum Demand	Average Demand	Maximum Demand
Design Demand, MGD	1.2	8.2	19
Required Chlorine Concentration, mg/L	3.0	3.0	3.0
Initial Strength, %	12.5	12.5	12.5
Design Strength, %	10.9	10.9	10.9
Density, lb/gal	10.0	10.0	10.0
Daily Usage, gpd	28	188	435
Desired Storage Capacity, days	-	30	-
Required Storage Capacity, gallons	-	5,700	-

Description	Flow Range		
	Minimum Demand	Average Demand	Maximum Demand
Number of Bulk Storage Tanks	-	2	-
Capacity of each Bulk Storage Tank, gallons	-	3,000	-
Total Capacity of Bulk Storage Tanks, gallons	-	6,000	-
Number of Day Tanks	-	1	-
Capacity of Day Tank, gallons	-	400	-
No. of Feed Pumps	3	3	3
No. of Feed Pumps Operating	1	1	1
Feed Rate, gph	1.2	7.8	18.2
No. of Transfer Pumps	2	2	2
Transfer Pump Flow Rate, gpm	40	40	40

Pumps: Two transfer pumps will transfer sodium hypochlorite from the bulk storage tank to the day tank. The transfer pump capacities are designed to transfer sodium hypochlorite in a fast, but safe flow rate. The sodium hypochlorite transfer pumps are designed for a flow rate of 40 gpm and can fill the day tank in approximately ten minutes. They will also provide the ability to fill exterior or mobile tanks that WWU can use to transfer chemicals to other facilities.

Two chemical feed pumps will be used for maintaining the residual at the reservoirs by injecting into the mixing system, and a third chemical feed pump will be used for injecting at the BPS Discharge Header. The flow rate for each pump ranges from 1.2 to 18.2 gallons per hour (gph).

Storage: The total volume of storage is based off of the anticipated ADD for a 30-day supply. Two vertical bulk storage tanks were selected for redundancy and size requirements. In accordance with Wisconsin Administrative Code NR 811, a day tank is provided to reduce the amount of chemical dosed in the water supply from the bulk storage tanks if there was a system malfunction. The day tank was sized based on meeting a MDD for a 30-hour duration. The MDD of 13.6 MGD was used to ensure there would be enough capacity in the day tank to treat high demand days without the need to refill. The total storage capacity was calculated to be 5,700 gallons for a 30-day supply.

11.6.3.3.2 Liquid Ammonium Sulfate

LAS will also have the flexibility of being injected to the reservoirs and/or after the booster pumps. The primary mode of operation will be to monitor the chloramine residual in the reservoir and adjust feed rates accordingly. Injection to the BPS Discharge Header will allow for an alternate dosing location that provides the ability to add more ammonia if the water quality is past break point chlorination. In order to size equipment, it was assumed that the water received from MWW contains minimal chlorine residual. This is a conservative assumption and it is anticipated that some residual will be present and defined in design.

The LAS system will be located in a separate room from the other chemical rooms within the BPS. A filling station will be provided inside the room along with a transfer station and eyewash station. The LAS room will have its own

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independent HVAC system as described in Section 11.7. The instrumentation and control system for LAS is described in Section 11.9.

Regulations: Wisconsin Administrative Code NR 811 was evaluated for LAS design. Table 11-20 summarizes the standards and requirements.

Table 11-20 Liquid Ammonium Sulfate Regulations

Evaluation Item	Wisconsin Administrative Code NR 811
Bulk Storage Requirements	Minimum of 30-days, Maximum 60-days
Day Tank Storage Requirements	Minimum 24 hours
Containment Volume	Largest tank volume

According to Wisconsin Administrative Code NR 811, there must be enough on-site storage for 30-days of chemical supply and can be provided for up to 60-days of supply.

System Design: A chloramine residual of 3.0 mg/L will be used at the BPS with a Cl_2:NH_3-N ratio of 4:1 for monochloramine production. This equates to a finished water concentration of 0.75 mg/L as NH_3-N to achieve the target dose. Table 11-21 shows the design criteria for LAS.

Table 11-21 Liquid Ammonium Sulfate Design Criteria

Description	Flow Range		
	Minimum Demand	Average Demand	Maximum Demand
Design Demand, MGD	1.2	8.2	19
Ammonia as Nitrogen Concentration, mg/L	0.75	0.75	0.75
Strength, %	38	38	38
Density, lb/gal	10.4	10.4	10.4
Daily Usage, gpd	9	61	141
Desired Storage Capacity, days	30	30	30
Required Storage Capacity, gallons	-	1,900	-
Number of Bulk Storage Tanks	-	2	-
Capacity of each Bulk Storage Tank, gallons	-	1,000	-
Total Capacity of Bulk Storage Tanks, gallons	-	2,000	-
Number of Day Tanks	-	1	-
Capacity of Day Tank, gallons	-	130	-
No. of Feed Pumps	2	2	2
No. of Feed Pumps Operating	1	1	1

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Description	Flow Range		
Feed Rate, gph	0.4	2.5	5.9
No. of Transfer Pumps	2	2	2
Transfer Pump Flow Rate, gpm	15	15	15

Pumps: Two transfer pumps will transfer LAS from the bulk storage tank to the day tank. The transfer pumps are designed for a flow rate of 15 gpm and can fill the day tank in less than 15 minutes. They will also provide the ability to fill exterior or mobile tanks that WWU can use to transfer chemicals to other facilities.

Two chemical feed pumps will be used for maintaining the residual at the reservoirs and a third chemical feed pump will be used for injecting at the BPS Discharge Header. The flow rate for each pump ranges from 0.4 to 5.9 gph.

Storage: The total volume of storage is based off of the anticipated ADD for a 30-day supply. Two vertical bulk storage tanks were selected for redundancy and size requirements. In accordance with Wisconsin Administrative Code NR 811, a day tank is provided to reduce the amount of chemical dosed in the water supply from the bulk storage tanks if there was a system malfunction. The day tank was sized based on meeting a MDD for a 30-hour duration. The MDD of 13.6 MGD was used to ensure there would be enough capacity in the day tank to treat high demand days without the need to refill. The total storage capacity was calculated to be 1,900 gallons for a 30-day supply.

11.6.3.3.3 Blended Phosphate System

Blended phosphate will be injected to the BPS Discharge Header. Dosing will be based on flow to the distribution system. In order to size equipment, it was assumed that the water received from MWW does not contain any blended phosphate residual. This is a conservative assumption and it is anticipated that some residual will be present and defined in design.

The blended phosphate system will be located in a separate room from the other chemical rooms within the BPS. A filling station will be provided inside the room along with a transfer station and eyewash station. The blended phosphate room will have its own independent HVAC system as described in Section 11.7.2. The instrumentation and control system for blended phosphate is described in Section 11.9.

Regulations: Wisconsin Administrative Code NR 811 was evaluated for blended phosphate design. Table 11-22 summarizes the standards and requirements.

Table 11-22 Blended Phosphate Regulations

Evaluation Item	Wisconsin Administrative Code NR 811
Bulk Storage Requirements	Minimum of 30-days, Maximum 60-days
Day Tank Storage Requirements	Minimum 24 hours
Containment Volume	Largest tank volume

According to Wisconsin Administrative Code NR 811, there must be enough on-site storage for 30-days of chemical supply and storage can be provided for up to 60-days of supply.

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System Design: Since the residual phosphate concentration in the water from MWW is unknown, it is assumed there will be no residual. Wisconsin Administrative Code NR 811 regulations state that the total phosphate concentration cannot exceed 10 mg/L. There is no minimum concentration required. It is common practice to dose blended phosphates between 0.5 mg/L to 4.0 mg/L as total phosphate. Other Lake Michigan communities typically dose blended phosphates between 1.0 mg/L to 2.0 mg/L as total phosphate. To be conservative, a blended phosphate concentration of 2.0 mg/L will be utilized, but pipe loop testing will confirm the appropriate type and dosage.

Table 11-23 shows the design criteria for blended phosphate.

Table 11-23 Blended Phosphate Design Criteria

Description	Flow Range		
	Minimum Demand	Average Demand	Maximum Demand
Design Demand, MGD	1.2	8.2	19
Total Phosphate Concentration, mg/L	2.0	2.0	2.0
Strength, %	34	34	34
Density, lb/gal	11.3	11.3	11.3
Daily Usage, gpd	5	36	83
Desired Storage Capacity, days	30	30	30
Required Storage Capacity, gallons	-	1,100	-
Number of Bulk Storage Tanks	-	2	-
Capacity of each Bulk Storage Tank, gallons	-	550	-
Total Capacity of Bulk Storage Tanks, gallons	-	1,100	-
Number of Day Tanks	-	1	-
Capacity of Day Tank, gallons	-	80	-
No. of Feed Pumps	2	2	2
No. of Feed Pumps Operating	1	1	1
Feed Rate, gph	0.2	1.5	3.5
No. of Transfer Pumps	2	2	2
Transfer Pump Flow Rate, gpm	10	10	10

Pumps: Two transfer pumps will transfer blended phosphate from the bulk storage tank to the day tank. The transfer pumps are designed for a flow rate of 10 gpm and can fill the day tank in less than 10 minutes. They will also provide the ability to fill exterior or mobile tanks that WWU can use to transfer chemicals to other facilities.

Two chemical feed pumps will be used for dosing at the BPS Discharge Header, where one pump will be on standby. The online pump is anticipated to be flow-paced. The flow rate for each pump ranges from 0.2 to 3.5 gph.

Storage: The total volume of storage is based off of the anticipated ADD for a 30-day supply. Two vertical bulk storage tanks were selected for redundancy and size requirements. In accordance with Wisconsin Administrative Code NR 811, a day tank is provided to reduce the amount of chemical dosed in the water supply from the bulk storage tanks if there was a system malfunction. The day tank was sized based on meeting a MDD for a 30-hour

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duration. The MDD of 13.6 MGD was used to ensure there would be enough capacity in the day tank to treat high demand days without the need to refill. The total storage capacity was calculated to be 1,100 gallons for a 30-day supply.

11.6.3.4 Monitoring and Control

As previously stated, sodium hypochlorite and LAS will be monitored and controlled in the reservoirs. Chloramine sampling and monitoring will be required at locations described below:

- At the Reservoir Supply Line to determine the background levels for chloramine in the water received from MWW.
- At the BPS Suction Header to determine that levels are maintained in the reservoirs. Feed rates for chlorine and ammonia will be adjusted based on the sampled levels.
- At the BPS Discharge Header to verify the chloramine levels heading to the distribution system are within the required limits.

Sample lines will be routed to chlorine analyzers to determine free chlorine, total chlorine, free ammonia, and pH levels. It is very important to monitor free chlorine, total chlorine, and free ammonia in order to understand where the chlorine residual lies on the chloramine curve. Chemical feed system controls are further discussed in Section 11.9.

11.7 Mechanical

11.7.1 General

This section presents the basis of design for HVAC, plumbing and fire protection systems associated with the BPS. The requirements outlined in this section are a subset to Section 4, detailing the design approach for HVAC, fire protection, and plumbing at the BPS. The design for the HVAC, plumbing, and fire protection systems for the Program will be based on the concepts and regulations contained herein.

11.7.2 Heating, Ventilating, and Air Conditioning System

For HVAC design criteria, refer to Section 4 for more details.

11.7.2.1 Systems and Equipment Serving Electrical Areas

The HVAC design for the BPS will consist of cooling-only direct expansion split system air conditioning units for electrical equipment areas (Battery Room, Electrical Room, and I&C Room). The split systems will have condensing units located outside at grade level. Each system will have a duplicate air conditioning unit in place. This will ensure that all sensitive electrical equipment is protected in the event of failure of the lead unit. The total number of HVAC systems designed and installed for the BPS will be dependent upon the final space layout. The systems will be specified with a combination of return and outside air dampers to allow for economizer mode operation when outdoor temperature is favorable to cool the spaces without the need of compressor power in order to reduce operational costs. Heating for these areas will be provided by dedicated electric unit heaters.

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An indoor space temperature of 80°F in the summer and 60°F in the winter will be maintained in the electrical equipment areas. Thermostats in the room and air flow sensors will be provided to control heating, cooling, and fan operation. These sensors and thermostats will report back to the temperature control panels (TCP) to allow monitoring. High and low temperature alarms will initiate remote and local alarms when temperature rises above or falls below the set point. 4-20 ma analog temperature sensors with a range of 20°F to 120°F will be provided (Water Supply Facilities SCADA, Electrical, and Mechanical Meeting (6-200 M-03) held on August 17, 2017). The supervisory control and data acquisition (SCADA) system will receive critical alarms from the TCP and it will not control the HVAC system. For SCADA system description see Section 11.9.

Additionally, the Battery Room will be designed with a dedicated exhaust fan and air conditioned supply from the nearest system to provide minimum code ventilation requirements as noted in Section 4.

11.7.2.2 Systems and Equipment Serving Process Areas

The Pumping Room will be designed to maintain 50 to 55°F during winter when occupied and will maintain a temperature of 50°F when unoccupied (Water Supply Facilities SCADA, Electrical and Mechanical Meeting (6-200 M-03) held on August 17, 2017). The design temperature during the summer will be +10°F above ambient to a maximum of 104°F. The maximum outdoor temperatures are based on International Energy Conservation code 2009 and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) weather data. The process pumping area will also be designed to accommodate the portable dehumidification units (Hi-E Dry) when excessive condensation occurs (Water Supply Facilities SCADA, Electrical and Mechanical Meeting (6-200 M-03) held on August 17, 2017). The Pumping Room will be conditioned in the summer with a combination of in-line exhaust fans and outside air intake louvers. Heating will be accomplished by gas fired unitary heating equipment. The mechanical design will specify room temperature sensors for automatic operation of the outside air dampers and exhaust fans. These sensors will report to the local TCP to allow control and monitoring. The TCP will report critical alarms to the SCADA system.

The basement underneath the Pumping Room will be heated using gas fired unit heaters.

11.7.2.3 Systems and Equipment Serving Chemical Storage Areas

Chemical storage rooms require continuous ventilation at a minimum rate of 2 cubic feet per minute (CFM) per square foot and an indoor temperature between 65°F and ambient plus 10ºF, not to exceed 104ºF, to ensure chemicals maintain their properties while in storage. Temperature set points are per material safety data sheet and International Mechanical Code 2009 requirements. Ventilation, heating, and cooling will be further evaluated during design for the chemical storage rooms. Design considerations include an indoor central station make-up air unit (MAU) with gas heating and direct expansion (DX) cooling sections located in the Mechanical Room. Remote condensing units will be located outside the mechanical room at grade level. The MAUs will be sized for 100% of the total design cooling load. Supplemental heating, if needed, will be provided by gas-fired or electric unit heaters. Demand control ventilation will be provided when rooms are occupied, if required per code. At this time, listed chemical storage materials are not required to have increased ventilation rates when occupied.

Each chemical storage room will be provided with dedicated spark-resistant exhaust fans to continuously ventilate the room. A variable air volume system with dedicated terminal air units can be used to improve the storage rooms' indoor temperature and will be analyzed during design. Room thermostats will interlock the operation of each

exhaust fan with their corresponding terminal unit. A TCP will control and monitor the operation of the HVAC systems and will report critical alarms to the SCADA systems.

11.7.2.4 Systems and Equipment Serving Mechanical Equipment, Toilet, and Janitor Closet Areas

The Fire Protection Room, Toilet and Janitor Closet will be designed for 10°F above ambient temperature in the summer and 60°F in the winter. Cooling will be achieved with a combination of outside air intake louvers with automatic dampers and exhaust fans. Heating will be provided by unitary gas fired heating equipment. Room thermostats will interlock the operation of the exhaust fans and outside air dampers.

11.7.2.5 Exterior Design Conditions

For exterior design conditions, refer to Section 4 for more details.

11.7.2.6 Air Distribution System

Galvanized ductwork will be specified in the non-corrosive areas and designed in accordance with the latest Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) HVAC Duct Construction Standard for Metal and Flexible Ducts. Type 316 stainless steel or FRP ductwork will be specified within the chemical storage areas and designed in accordance with the reference standard listed above. Exposed ductwork conveying conditioned air at a temperature below the ambient will be specified with thermal external insulation to prevent heat gain and condensation. All other supply ductwork will only be insulated near outdoor penetrations or as needed to prevent condensation. All ductwork located outside will be insulated and field jacketed for protection. Exhaust and return ducts will not be insulated in rooms they serve. The location of air inlets and outlets will be studied for each space to ensure that adequate air circulation and contaminants removal are addressed for each space.

11.7.2.7 Gas Distribution System

For the gas distribution system description, refer to Section 4 for more details.

11.7.2.8 Control System

For the HVAC Control System description, refer to Section 4 for more details.

11.7.3 Plumbing System Design

For plumbing system design including storm and wastewater systems, as well as plumbing fixtures, refer to Section 4 for more details.

11.7.4 Fire Protection Systems

The design will specify a wet fire suppression system per International Fire Code with amendments from Wisconsin Administrative Code. The basement area as well as the Battery Room will be provided with sprinkler coverage. A Class 1 standpipe system will be provided within all egress stairways.

To comply with the code requirements for the standpipe, a fire pump will be required. The wet fire sprinkler system will be specified with the required control devices and double check detector valve assembly for backflow prevention.

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A fire alarm system will be specified under electrical work. It will include air handling smoke detection and fan shut down where required by code. Smoke detectors will be monitored at a fire alarm control panel. Fire alarm signals will be monitored by the corresponding TCP associated with the HVAC system. All alarms will be sent to the SCADA system and to the local fire department.

11.7.5 Reduced Energy Consumption

For reduced energy consumption description, refer to Section 4 for more details.

11.7.6 Flood Alleviation

For flood alleviation HVAC and plumbing system descriptions, refer to Section 4 for more details.

11.8 Electrical

11.8.1 General

This section presents the basis of design for electrical systems associated with the BPS. The requirements outlined in this section are a subset to Section 4, detailing the design approach for electrical systems. The design for the electrical systems for the BPS will be based on the concepts and regulations contained herein.

11.8.2 Source of Utility Power

The BPS will be powered by a single utility feed with sufficient capacity to support design loads. Provisions to accommodate a second utility feed will be provided. The feasibility of a second source from a separate substation will be evaluated during design.

11.8.2.1 Utility Connection

A single 24.9-kilovolt (kV), 3-phase electric utility service will be provided by We Energies from their existing overhead circuit on Racine Avenue. The BPS facility will be powered at 480 volts, through a padmounted transformer located on site. The 24.9-kV primary circuit installation will be by We Energies.

An option is provided to allow for a second utility feed either as part of this design or as a future addition. We Energies has indicated that a dedicated reserve line could be extended from the vicinity of Cleveland Avenue and Johnson Avenue, approximately two miles from the BPS site. The optional second utility feed is not included in the opinion of probable construction cost.

Site space for a second padmounted transformer will be reserved. Services from the transformers will enter the BPS through separate concrete-encased duct banks.

11.8.3 Standby Power Source

In the event of a failure or power outage from the utility, standby power will be provided by an on-site natural gas-fueled generator.

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The generator system will be sized to support pumping operation for ADD flow as required under the Wisconsin Administrative Code. The generator will be furnished in a weather-protected, sound-attenuated enclosure. The generator will be located outdoors, adjacent to other outdoor electrical equipment.

Batteries are included to allow electric operation of switchgear circuit breakers during a full utility outage prior to the startup of standby generators. Booster pump discharge valve motor operators will also require a standby power source capable of responding in advance of generator availability. The main switchgear battery system will be sized to support operation of these valves during a power failure.

11.8.4 480-Volt Main Switchgear

480-Volt electrical service equipment will be metal-clad draw-out switchgear, meeting the criteria described in Section 4.

The standby generator will be connected to a central tie bus to allow for powering one switchgear main bus from utility, while the other is powered from the generator. Automatic source transfer controls will be provided. A spare feed-in circuit breaker at the tie bus will be suitable for connection of a towable standby generator set to be used during outages or maintenance operations involving the fixed generator.

The main booster pump motor controllers will be connected to the 480-Volt switchgear.

11.8.5 Distribution Switchboard

480-Volt equipment other than the booster pumps will be powered through a distribution switchboard meeting the criteria described in Section 4.

11.8.6 Electrical Load Study

A load study will be completed in coordination with the BPS pumping system operational parameters, and will analyze the operating characteristics of the electrical system. This load study will determine the required electrical capacity for the new and future pumping systems, during all design basis operating scenarios, including regular service and maintenance activities. Additionally, the load study will demonstrate that the station's electrical power systems have adequate capacity to meet the power requirements of the new and future pumping systems.

11.8.7 Motors

All motors will be as described in Section 4. Motors serving water booster pumps will include winding temperature sensors and anti-condensation heaters.

11.8.8 Variable Frequency Drives

All booster pump motors will be controlled by variable frequency drives (VFDs). Refer to Section 4 for more details.

11.8.9 Low-Voltage Transformers

Low-voltage power for lighting, appliances, and receptacles will be derived from indoor dry-type transformers meeting the criteria described in Section 4.

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11.8.10 Panelboards

Low-voltage power for lighting, appliances, and receptacles will be distributed through panelboards. Refer to Section 4 for more details.

11.8.11 Grounding System

A complete grounding system will be provided, refer to Section 4 for more details.

11.8.11.1 External Ground Ring

The BPS will include an external grounding ring buried outside the building foundation. Refer to Section 4 for more details.

11.8.11.2 Bonding

A building ground bus bar will be installed in the new electrical equipment room and will be bonded to the grounding system and to yard piping and duct banks. Equipment will be bonded to the grounding system. Refer to Section 4 for more details.

11.8.12 Lightning Protection

A complete lightning protection system will be provided for the BPS. For lightning protection system description, refer to Section 4 for more details.

11.8.13 Fire Alarm System

A digital, addressable fire alarm and detection system will be installed in the BPS. For the fire alarm and detection system description, refer to Section 4 for more details. The alarm system status will be monitored remotely according to local fire department requirements.

11.9 Instrumentation and Controls

11.9.1 General

The control scheme within the BPS and the reservoirs involves programmable logic controller (PLC) interaction with flow meters, pump control valves, booster pump VFDs, the chemical monitoring and metering system, and other instrumentation, such as pressure indicating transmitters, level indicating transmitters, magnetic type flow meters, and valve limit switches.

11.9.2 Programmable Logic Controller

The monitoring and control within the BPS will be accomplished via a standard microprocessor-based PLC and input/output (I/O) modules using instrumentation and network links to remote control systems and other control devices. The pumping station will be furnished with manufacturer standard instrumentation and packaged controls to allow operators to monitor and control the system equipment. The BPS will have a spare pre-programmed PLC for fast switch out backup.

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Operator interface with the BPS PLC system will consist of an operator interface terminal (OIT). The OIT will provide operator control of the process through graphic interface, diagnostics, trending, alarms, and status displays. The control system, including the PLC, OIT, and network equipment, will be located in the Instrumentation and Controls Room within the BPS.

The BPS PLC will communicate with other Program PLCs for remote monitoring: with the WSCB via fiber optic connection; with the WSPS via fiber optic connection; with the RFPS via wireless radio; and with WWU via wireless radio.

11.9.3 Metering Systems

11.9.3.1 Reservoir Supply Meter

The reservoir supply meter will consist of a flanged, Venturi type meter with differential pressure instrumentation for flow calculation. The construction materials for the meter will consist of stainless steel, including body, throat, and flanges. Analog pressure differential indicating transmitter (PDIT) will be used to convert high and low pressure readings from the meter into a 4-20mA output signal. The meter output will be trended and recorded. The need for single or dual PDITs, based on flow ranges, will be evaluated during design.

The reservoir supply meter will be located on the supply line to the reservoirs in the Basement of the BPS. The placement of the meter will be horizontal. A manually operated isolation valve will be located at the inlet and outlet sections of the meter for maintenance purposes.

A required straight pipe run clearance distance of ten pipe diameters will be considered directly upstream of the meter to provide a uniform flow profile in order to maintain standard measurement accuracy. A straight pipe run clearance distance of five pipe diameters will be considered directly downstream of the meter. The meter design will be based on a pipe diameter of 30 inches, and standard ANSI class 150 flanges.

The metered flow at the Reservoir Supply Line will be relayed to the supplier in order to control the Water Supply Pumps.

11.9.3.2 Process Meters

Flow indicating transmitters with 4-20mA analog output will monitor flow at the discharge piping of each booster pump, at the main discharge header downstream of the booster pumps, and at the mixing/recirculation line. The flow meters will be a flanged and magnetic type. The meter output will be trended and recorded. The placement of the meters will be horizontal.

A straight pipe run clearance distance of five pipe diameters will be considered directly upstream of each meter to provide a uniform flow profile in order to maintain standard measurement accuracy. A straight pipe run clearance distance of two pipe diameters will be considered directly downstream of each meter.

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11.9.4 Pump Control

The booster pumps will be controlled by the PLC, in either automatic or manual mode, with hardwired interlock between the pumps and their VFD, and Ethernet datalink connection between the VFDs and the PLC. Pump startup and shutdown will be based on either Hunter Tower level, pipeline pressure, flow demand, or reservoir levels. In the case of low water level measurement in the reservoirs, an alarm will be generated to allow operators to take appropriate corrective action. If the level in the reservoir continues to decrease, a low-low water level will be reached which will shut down the operating booster pumps to protect the pumps from damage. High level at Hunter Tower and high and low BPS Discharge pressure are just a couple of the conditions that will also initiate shut down procedures. The booster pumps will have local control stations that will provide limited control capabilities.

11.9.4.1 Pump Discharge Interlock

A pump control valve will be located at the discharge piping of each booster pump. The control valve will be controlled via PLC logic with hardwired interlock between the valves and the pumps VFDs, and Ethernet datalink connection between the VFDs and the PLC. The purpose of each control valve is to provide pump protection by isolating the pump from the discharge header when the pump is not running, as well as to reduce the potential for water hammer by starting and stopping the pump against a closed valve. The control valve allows the pump discharge flow to be regulated to protect the pump from reverse rotation and water hammer.

The control logic for each control valve will be interlocked with its corresponding pump control logic. For pump startup, the booster pump will be started with its corresponding control valve in the closed position. As soon as the pressure at the pump discharge reaches and maintains a predetermined setpoint for a predetermined amount of time, the control valve will be released to fully open at a designed adjustable speed. Prior to pump stop, the associated control valve will be in the closed position at a designed adjustable speed to prevent pump reverse rotation as well as to reduce water hammer. In addition, a pump tripped status or a power failure will automatically initiate a control valve close command.

11.9.4.2 Pump Monitoring and Protection

Pump monitoring and protection will include temperature and vibration monitoring and alarming, as well as discharge pressure protection interlock. Vibration and temperature monitoring will be included for motor bearings and pump bearings.

High vibration or temperature detection for a predetermined amount of time will generate an alarm in the PLC. High-high vibration and temperature detection will be hardwired to the pump starter, and detection of either for a predetermined amount of time will generate both an alarm and a pump protection stop.

High pressure detection at a booster pump discharge piping for a predetermined amount of time will generate an alarm in the PLC. High-high discharge pressure detection for a predetermined amount of time will generate both an alarm and a pump protection stop.

11.9.5 Chemical Feed System

The chemical feed system will include monitoring and control of flow from the chemical storage tanks as well as control of chemical metering pumps. The system will consist of equipment and appurtenances such as, but not limited to, storage tanks, day tanks, transfer pumps, metering pumps, safety shower and eyewash stations, and

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necessary instrumentation for monitoring and control. Combination unit emergency shower and eyewash stations will be furnished in each of the chemical rooms. The emergency shower and eyewash station units will be equipped with flow switches that will alert the operators when the emergency unit is activated.

11.9.5.1 Disinfection System

The disinfection system control will consist of the monitoring and control of flow from the sodium hypochlorite and LAS storage tanks to the day tanks, and from the day tanks to the injection points. The system will operate with two sodium hypochlorite bulk storage tanks and two LAS bulk storage tanks in service. Submersible pressure transducers will monitor the sodium hypochlorite and LAS levels in each bulk storage tank.

Sodium hypochlorite and LAS injection will be paced based on residual chlorine concentration in the reservoirs. The output of the sodium hypochlorite and LAS metering pumps will be automatically adjusted based on the measured chloramine residual and the target concentration. Operators will be able to adjust the dose within SCADA.

11.9.5.2 Corrosion Inhibitor System Control

The corrosion inhibitor system control will consist of the monitoring and control of flow from the blended phosphate storage tanks to the day tank and from the day tank to the injection point. The system will operate with two bulk storage tanks in service. Submersible pressure transducers will monitor the liquid level in the bulk storage tanks.

Blended phosphate injection will be paced based on metered flow rate in the BPS Discharge Header and the selected finished water concentration. The output of the blended phosphate metering pumps will be automatically adjusted based on the measured water flow and the target concentration. Operators will be able to adjust the dose within SCADA.

11.9.6 Instrumentation

11.9.6.1 Level Instrumentation

Level indicating transmitters with submersible level sensors will continuously monitor the water level at each water reservoir. Level measurement will consist of submersible hydrostatic type pressure transducer and remote junction/desiccant box, and remote mounted external display/adjustment unit. Alarms will be generated in the control system for low-low, low, high, and high-high reservoir levels. The level will be relayed to the supplier in order to control the Water Supply Pumps.

11.9.6.2 Pressure Instrumentation

Pressure indicating transmitters with 4-20mA analog output will monitor pressure at the BPS suction and discharge headers. Alarms will be generated in the PLC for low-low, low, high, and high-high pressure measurements.

Pressure gauges will provide local pressure indication at the suction and discharge headers as well as at each booster pump suction and discharge piping.

The pressure at the Reservoir Supply Line will be relayed to the supplier in order to control the Water Supply Pumps.

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11.9.7 Site Security

The BPS site security system will include site monitoring equipment and building access control. The site will be monitored by closed circuit television, and monitoring equipment will consists of cameras around key points of the BPS. Entry to the facility will be controlled by a perimeter fence and an access slide gate with electronic access. Alternatives for entry, including access password or phone/surveillance access, will be further evaluated with WWU.

11.10 Construction

This section describes the anticipated scope of construction that the selected contractor will incorporate into their site specific plan. The majority of these items will be determined by contractor means and methods. The goal of this section is to highlight some of the major activities that will be constant throughout the BPS construction. Activities will include construction of the BPS structure and adjacent reservoirs, general utility work, applicable site grading, paving activities, and general site work.

11.10.1 Sequence of Construction

Sequencing of construction will be required to coordinate with other Program Elements, minimize impacts to the schedule, and maintain access to the site. A sequence of construction will be prepared during design.

During construction, it may be necessary to isolate sections of utilities to make new connections for the new facilities or to perform startup and testing. Operational shutdowns will be identified during design to the extent possible, coordinated with WWU, and incorporated into the Contract Documents.

11.10.2 Hours of Construction

Hours of construction will be coordinated with WWU, Waukesha County, and New Berlin. In general, it is anticipated that the hours of construction will be from 6:00 a.m. to 7:00 p.m.

11.10.3 Contractor Staging

To minimize ground disturbance and create efficient workflow, an effective staging plan will be developed. The contractor will be constrained by adjacent active roadways, drainage ditches, and an existing wetland.

Traffic controls will be implemented in active work areas near roadways to create a barrier between the construction and the public. Generally this will include the use of detours, lane closures, flaggers, and temporary striping or signage.

Designated areas on-site will be utilized by the contractor to store equipment and materials. This area may also incorporate a construction trailer. The trailer will likely require utilities such as electric and telephone. Sanitary facilities will also be provided. These staging areas will be coordinated in advance of construction.

The contractor will locate material on-site in designated storage areas or buildings. Material will be stored neatly and as directed by the manufacturer. Fill or aggregate material will be stored in dry, well-drained areas to prevent mixing with the substrate.

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11.10.4 Site Security

The contractor will be responsible for site security. The site will be secured with temporary fencing, gates, lights, cameras, etc., as required. Gates and access doors will be locked in order to only allow access for contractor, its sub-contractors, owner, and their representatives.

11.10.5 Haul Route and Site Access

Haul routes and access point locations will utilize erosion and sediment controls including a stabilized construction entrance and/or wheel wash. The contractor must keep roadways free from debris at all times. Site access will utilize existing drives or future access drives. These locations will follow Wisconsin Department of Transportation (WisDOT), county, and local permitting guidelines. Parking will be provided on-site for workers and visitors to the site. Any disturbed areas used as haul routes or site access not intended to be used as future driveways or roadways will be restored to existing conditions.

11.10.6 Erosion and Sediment Controls

The Contract Documents will require applicable erosion and sediment controls by preparing and submitting a site specific Storm Water Pollution Prevention Plan (SWPPP) as part of the Stormwater Management Plan submitted to WDNR for approval prior to construction. The SWPPP will adhere to the requirements and standards set forth by NR 216.46 and NR 151.11 of the Wisconsin Administrative Code. The bid documents will include applicable local details and specifications for erosion and sediment controls. Additional provisions will be provided at the limits of construction to further protect the Fox River watershed as needed.

The construction plans will identify and show required wetlands jurisdictional lines and buffers, and require that these areas be protected during the contract work. Site reporting and monitoring will follow the most recent requirement of NR 216.48 of the Wisconsin Administrative Code, per Wisconsin Pollutant Discharge Elimination System (WPDES) Permit No. WI-SO67831-5. Typical recurring site reports include weekly inspections or after every 0.5-inch rain event.

11.10.7 Dewatering Plan

A contractor-prepared dewatering plan will be required by the Contract Documents. Soil borings will be provided to the contractor for information to facilitate bidding and aid in the development of a dewatering plan. The Contract Documents will require the contractor to perform geotechnical work during bidding and construction as needed to properly bid and construct the work.

Dewatering discharge should generally be kept on-site and should follow all applicable erosion and sediment control details and specifications provided by the local municipality or regulating agency. Attention will be given to work within existing roadside drainage ditches so as not to impede stormwater runoff. Any flow experienced will be diverted or maintained to avoid upstream impact. Additional protective measures will be taken to ensure site activities do not negatively impact the wetland. Any dewatering discharge that is found to be contaminated will be managed according to Section 11.10.9.

11.10.8 Excavation Methods

The contractor will be required by the Contract Documents to have sheeting and shoring designed by a professional engineer licensed in the State of Wisconsin. It is anticipated that the pipeline excavations would require the use of a

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trench box or sheeting/shoring and structure excavations will require sheet and shoring. Subsurface conditions will dictate the excavation methods likely to be used.

The contractor will be required to protect slopes, existing structures and foundations in accordance with:

- Slope stabilization and protection methods
- OSHA requirements
- Temporary erosion control measures
- Local, county, and state permit requirements
- Erosion control measures
- Dewatering plan
- Grading or surface water drainage plan

11.10.9 Material Management

Stockpile Area: Materials to be used on-site or disposed of off-site will be stockpiled during construction and will be kept within the limits of construction. Stockpile areas will be neatly shaped and free to drain, protected from erosion using silt fencing, seeding and mulching, or other control methods in accordance with the Program requirements. Staging areas will be determined during design.

On-Site Suitable Material: Suitable materials excavated from the site may be reused on-site as fill or backfill as approved by the Engineer. Unsuitable material will be disposed of off-site at appropriately licensed disposal facilities approved by WWU.

Disposal of Non-Contaminated Materials: Materials characterized as non-contaminated materials will be disposed of per NR 500-538 of the Wisconsin Administrative Code. The contractor will also coordinate with local disposal agencies and follow all local, county, and state dump limitations and regulations.

Disposal of Contaminated Materials: A Program-wide Soil and Groundwater Management Plan will be submitted to WDNR as part of the permitting process. The approved plan will guide the Program with respect to the handling and management of contaminated media while also minimizing construction delays and the associated costs of material management.

11.10.10 Coordination with Other Construction Contracts

Coordination with Contract Package 2 (Water Supply Pipeline Segments) and Contract Package 5 (Return Flow Pipeline and Outfall) will be needed during construction of the BPS. Constraints will be identified during design and included in the Contract Documents.

11.11 Sustainability

Sustainability can be defined as meeting the demands of the present without compromising resources for the future. The location of the BPS was heavily influenced by the hydraulic efficiency and feasibility of the system. The site is suitable for maintaining hydraulic efficiency, but there are several sensitive features around the site: a farm, a wetland, an environmental corridor, and a historical marker. For this reason, an environmentally conscious design is important for the sustainability goals of the BPS. The Envision Rating System, developed by the Institute for

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Sustainable Infrastructure, will be used as a guide to optimize sustainable design on the Program. This section outlines the details about the efforts to incorporate sustainability into the BPS design using the Triple Bottom Line (TBL) approach and focusing on the social, economic, and environmental considerations in the design.

11.11.1 Social

In order to maintain and enhance the quality of life in the surrounding area, several sustainable mechanisms will be employed at the BPS site: noise pollution mitigation, preservation of local character, and preservation historical resources. The BPS site is located in Minooka Park which is owned by Waukesha County. The nature trails in Minooka Park are a popular attraction and a valued asset to the community. To preserve the natural characteristics of Minooka Park's trails, the noise from equipment located outside of the building will be contained by sound attenuating screens and walls. Section 11.5.1.2 describes how the reservoirs will be located behind the BPS, farther from Racine Avenue, to make the BPS site more subtle, minimizing impacts to the community's aesthetic. The site bears a sign that serves as a historical marker for the Swartz family's Cornfalfa Farm that was erected by the WCHSM. In an effort to preserve a historic icon and local character, the design team will work with the WCHSM to temporarily relocate the sign during construction to mitigate any risks to the integrity of the historical marker and better serve the public.

11.11.2 Economic

The economic design considerations of the BPS and site focus on efficient resource allocation and resiliency. The facility site screening process, discussed in Section 11.2.1, was conducted to select a site absent of visible vulnerabilities to future risks. The reservoirs at the BPS site provide emergency storage for Waukesha. In the case of a failure in the supply line or maintenance to the WSPS, water would be drawn from the emergency storage tanks to supply potable water to Waukesha. Resiliency was a critical aspect of the pump design and the layout of the BPS, described in Sections 11.6.2 and 11.10.4. Flow and pressure will be monitored, both on-site and remotely, to maintain regulatory compliance in the system, as discussed in Sections 11.9.3 and 11.9.6. Monitoring flows will provide insight into pump performance and allow early identification of reduced efficiency so that it may be corrected. The water levels in the reservoirs are monitored and interlocked with the WSPS and the BPS for pump start up and shutdown based on the reservoirs' level demand. MWW will have the ability to maintain a level setpoint within the reservoir on a schedule coordinated with WWU. This will allow them to provide water on a flexible schedule that can be optimized. The pumps have the ability to be controlled either automatically or manually, as described in Section 11.9.4. Sustainable resource allocation will be facilitated through the use of energy efficient equipment and energy systems monitoring. The motors for the pumps in the BPS will be equipped with VFDs for efficient energy use in operations; the pumps are assessed in Section 11.8.7. The ability to remotely monitor and operate the facility saves energy in transportation to the site for routine status checks at the facility.

11.11.3 Environment

The BPS is designed to minimize environmental impacts by providing protection for the adjacent wetlands, managing stormwater, promoting biodiversity, and assessing the suitability of surficial features on the site for development. During construction, erosion and sediment controls will be implemented, as discussed in Section 11.10.6, to protect the wetland on-site. Development on steep grades (>20%) was avoided to control runoff velocity and prevent erosive flows. All precipitation on site will drain to grade or to a basin in order to maintain stormwater infiltration levels that are comparable to the predevelopment levels. Permeable pavement, designed to support loads incurred during facility maintenance, will be considered for the access drive and the paved areas around the BPS. The BMPs employed to preserve the adjacent wetland are further discussed in Section 11.3.2. The design team will work with landscape

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architects to develop a landscaping plan that employs native species to promote biodiversity, requires minimal maintenance, and does not call for the use of pesticides or fertilizers. SEWRPC environmental corridors are located on the south and west sides of the BPS site. Planting native species along the south property line, adjacent to the environmental corridor, will be evaluated during design to promote biodiversity and serve as a local corridor to the wetlands. Section 11.4.3 describes the soil load assessment at the site used to determine whether the geology was suitable for the structures.

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SECTION 12 Return Flow Pumping Station Design

12.1 Overview

The purpose of the Return Flow Pumping Station (RFPS) and Return Flow Pipeline is to convey highly treated effluent to the Root River in an amount equal to the previous year's withdrawal from Lake Michigan. To perform this function, the RFPS has been designed to meet the full range of anticipated withdrawal based on the following:

- Range of treated effluent flow anticipated from City of Waukesha's (Waukesha's) Clean Water Plant (CWP)
- Range of permitted discharge flow anticipated for the Fox River
- Range of anticipated water losses in-transit to the Return Flow Facilities
- Permitted effluent quality anticipated for the new Outfall

Permitting requirements are described in Section 3 of this Preliminary Design Report (PDR). Figure 12-1 below shows a simplified diagram of the RFPS in reference to the CWP and other facilities along the return flow pipeline.

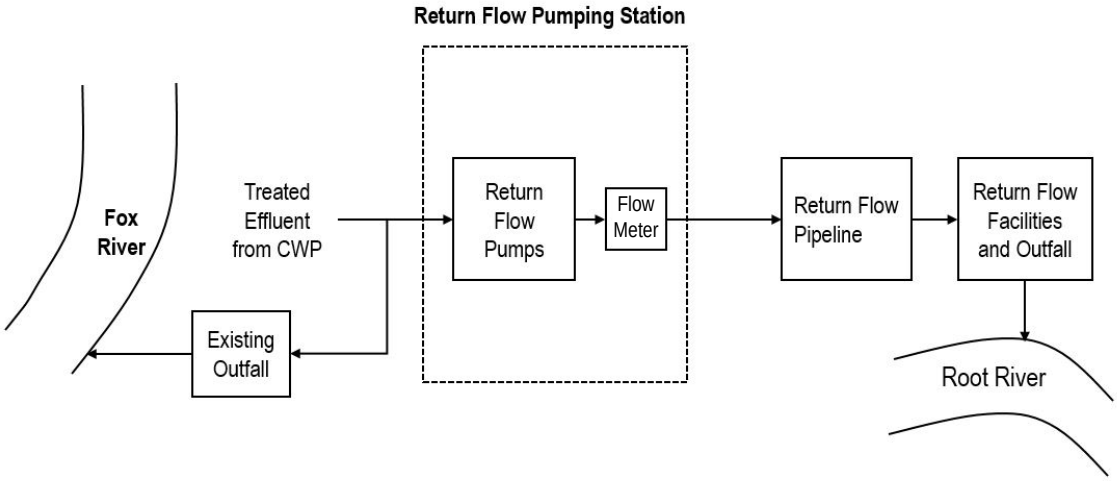

Figure 12-1 Return Flow Pumping Station Diagram

This section discusses the process design elements of the RFPS and design elements of the supporting disciplines; civil, structural, architectural, mechanical, electrical, and instrumentation and controls (I&C).

12.2 Site Location

12.2.1 Site Screening

The location for the RFPS required no site screening since the Great Water Alliance (Program) decided that the RFPS would be located at Waukesha's CWP. By locating the RFPS close to the liquid to be pumped, the distance the CWP effluent would flow by gravity and the depth of the RFPS are minimized, thereby minimizing the cost of the conveyance and pumping facilities.

12.2.2 Preferred Return Flow Pumping Station Site

The preferred RFPS site at the CWP is adjacent to the existing Ultraviolet (UV) Disinfection Facility's effluent channel that conveys treated effluent to the Fox River as shown in Figure 12-2. That location was shown in contract drawings prepared by others for the CWP in January 2015 and discussed with CWP during the RFPS Preliminary Design Review Meeting No. 1 (6-200 M-09) held on February 13, 2018.

12.3 Civil/Site

This section identifies the civil and site engineering requirements for the RFPS. The following subsections present information on the data collection, desktop reviews, and field investigations along with the proposed improvements and associated requirements.

12.3.1 Data Collection

Desktop analyses were performed to determine the viability of the site for the RFPS. These analyses included reviews of land use and surface features, aspects of the site associated with zoning, environmental, wetland and waterway, floodplain and floodway, archeological, and endangered and threatened species.

Field investigations were conducted and are ongoing to obtain information to support design activities. This Section describes the investigations completed and to be completed during design. Field investigations include surveys, wetlands and waterways, geotechnical borings, and hazardous materials.

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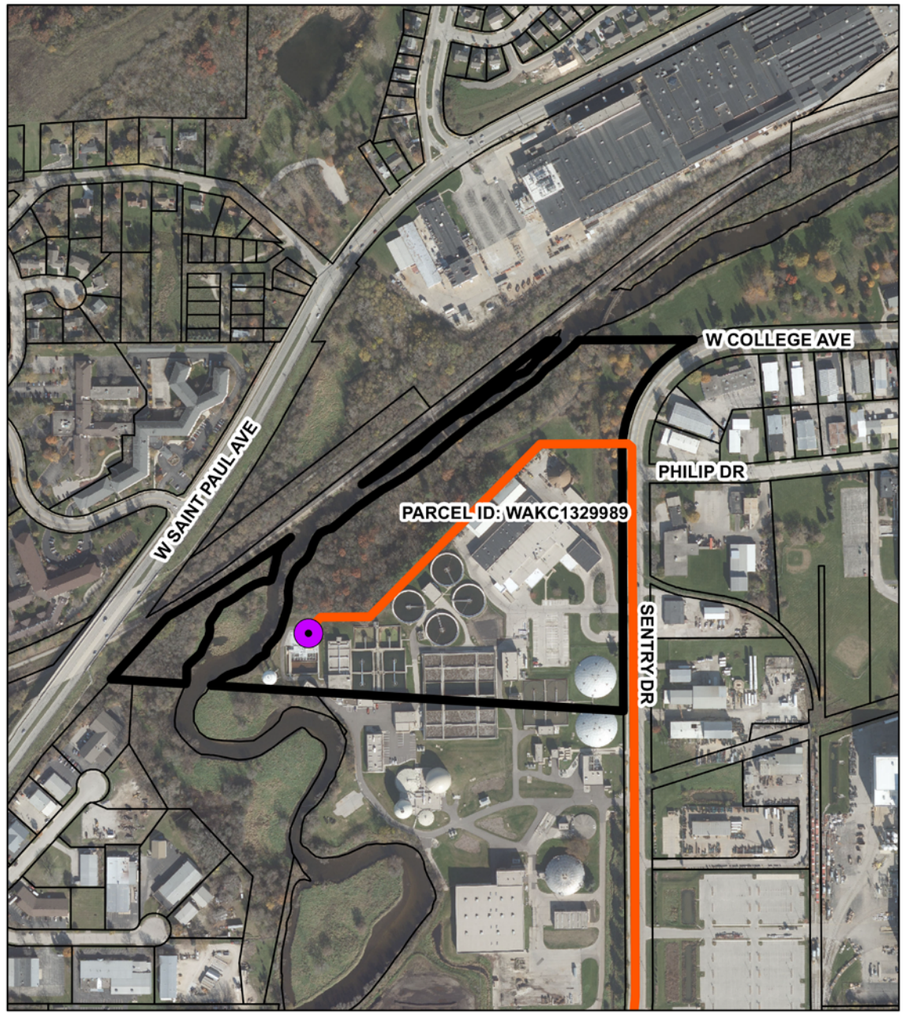
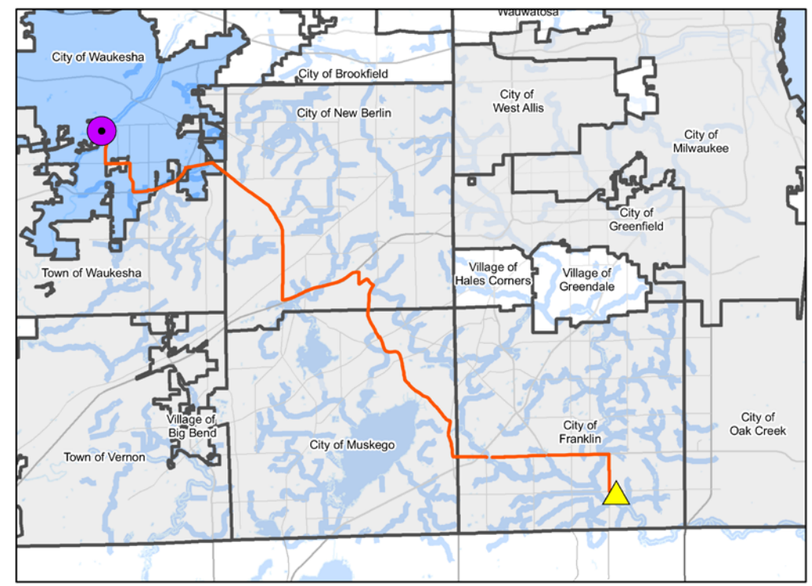


Return Flow Pump Station Site Location

Legend

- Return Flow Pumping Station
- Return Flow Facilities
- Selected Return Flow Route
- RFPS Parcel Limits



Key Map

Parcel Information

Location:	City of Waukesha
Parcel ID:	WAKC1329989
Owner:	City of Waukesha
Owner Address:	201 Delafield St
Zoning:	General Industrial District
Land Use:	General Industrial District
Last Sale Date:	N/A
Sale Price:	N/A

Legal Description

PT NE1/4 SEC 9 T6N R19ECOM N LI PHILIP DR &E
LI SENTRY DR, N88 10'5WON N LI PHILIP EXT100'
TO W LI SENTRY, S138'40 W 352' M/L TOSW LI 25' RR
EASEMENT & BEG,S1 38'40 W 310' M/LTO
N LI SEWAGE TREATMENT
PLANT PROP, W200' M/L,S 90' M/L, W 145' M/L,
N 205' M/L, W 935' M/L TONE BANK FOX R,
N & E ALG BANK 1660' M/L TO W LI 25' RR, S 160' M/L,
S 410' M/L, SE 320' M/L TO BEG18 AC M/L V927 DEEDSP517

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Waukesha, Wisconsin
Great Lakes Water Supply Program
Return Flow Pumping Station
Date: 4/27/2018

Plotted: 4/27/2018
Document Path: G:\15310-Waukesha Great Lakes Water Supply PM-CM\11 Task 6-Facilities\6-200 Design Reports\6-200 Design Report\Section 13 Return Flow Facilities Design\GIS Figures\RFPS_Site.mxd

Figure 12-2 Return Flow Pumping Station Site Location

12.3.1.1 Desktop Analysis

Land Use and Surface Features: An aerial view of the site is shown in Appendix E, Drawing Sheets CP4-C1 and CP4-C2. Record drawings of previous CWP improvements show details of the existing facilities. A portion of the west side of the site consists of floodplain. The parcel slopes from the east and south sides of the site towards the floodplain. Access to the site is provided by the CWP entrance from Sentry Drive and CWP access drives.

Zoning: The RFPS site is zoned by the City of Waukesha Code Book, CH 22: Zoning Ordinance as M-2, which is General Industrial District. The requirements for M-2 zones are described in Table 12-1.

Table 12-1 Zoning Information

Code Reference	Description	Requirement	
22.39	M-2 General Industrial District	Provide for manufacturing and industrial development of a more general and less restrictive nature than the M-1 Limited Manufacturing District in those areas where the relationship to surrounding land use would create fewer problems of compatibility.	
22.39 (5-7)	Site Development Standards for M-2	Minimum Lot Dimension	
		Lot Area (sq ft)	None
		Lot Width	None
		Minimum Setbacks (feet)	
		Front	25 from row
		Side (each)	10
		Rear	25
		Shore setback from Ordinary Highwater Mark	75
		Maximum Height	None

Environmental: The site was not identified by Environmental Data Resources, Inc. (EDR) in any of the researched databases which indicates that the site does not have a history of environmental issues. The desktop analysis of the site did not find evidence of any recognized environmental conditions at the subject site.

As a prerequisite to land acquisition and to confirm the results of the desktop analysis, a Phase 1 Environmental Assessment was completed. Based on the information reviewed from November 9 through November 16, 2017, no recognized environmental conditions (RECs), as defined by the All Appropriate Inquiry (AAI) ASTM Standard E-1527-13) were identified at the site. Due to the results of the Phase 1 ESA, a Phase II ESA is not recommended or required.

Wetland and Waterway: A wetland and waterway desktop review of the RFPS site was conducted. The review included analysis of digital wetland inventory (DWI) data from Wisconsin Department of Natural Resources (WDNR), mapped hydric soils, and recent aerial imagery. No wetlands were identified inside the fenced portion of the Site. Wetlands were identified outside the fenced portion of the site on the northwest side of the Site Applicable waterways were evaluated using the national hydrography dataset (NHD) from the U.S. Geological Survey and none were identified on the site.

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Floodplain and Floodway: The RFPS site was reviewed for potential floodplain impacts. The site is located on the Federal Emergency Management Agency (FEMA) map panel numbers 55133C0194G and 55133C0307G as shown in Figure 12-3 and Figure 12-4, respectively. As shown, the site location is within a Zone AE. Zone AE areas are subject to a 1% or greater annual chance of flooding in any given year. Floodplain limits extend onto the site, but will not have a significant impact on the RFPS. The site appears to be outside the floodway limits. The 100-year floodplain appears to be between elevation 796 and 797. The elevation and limits will be verified during design. New structures at the site will have the top of their grade floor located above the 100-year flood level.

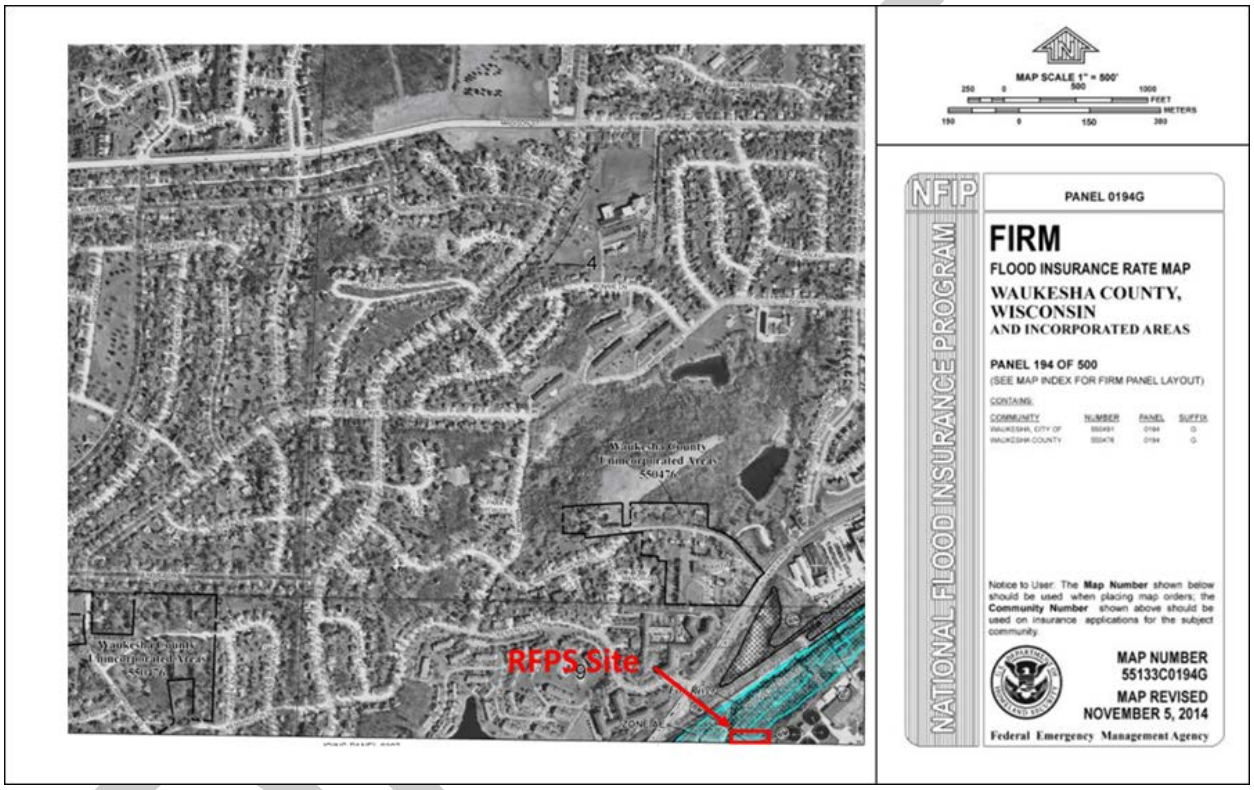

Figure 12-3 FEMA Floodplain Map Panel #55133C0194G

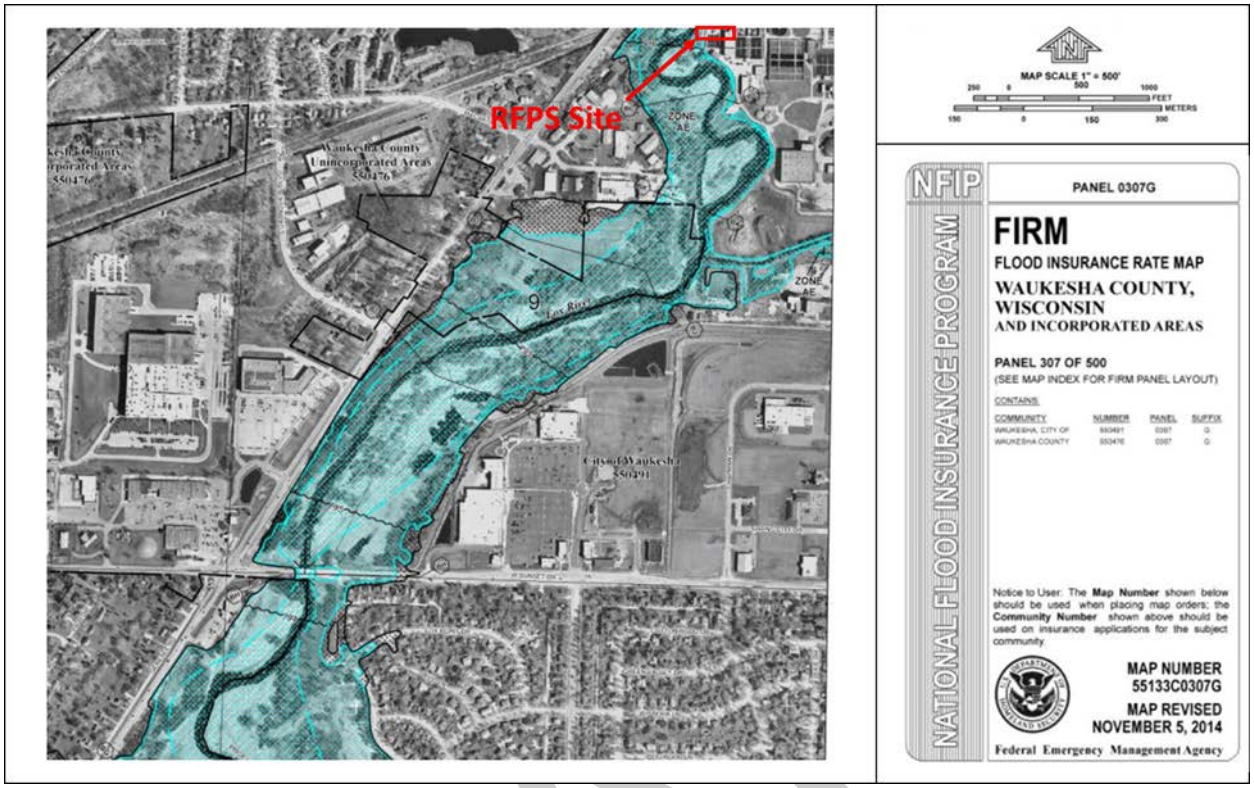

Figure 12-4 FEMA Floodplain Map Panel #55133C0307G

Archaeological: The RFPS site is located at an active clean water plant and no cultural, archaeological, or historical resources are anticipated.

Endangered and Threatened Species: A desktop evaluation of rare, threatened, and endangered (RTE) species for the site was conducted via a desktop review of recent and historical aerial photographs, the WDNR National Heritage Inventory (NHI) data, the United States Fish and Wildlife Service (USFWS) Information Planning and Consultation (IPaC) data, and the USFWS endangered species county data. Utilizing these resources, potential RTE species and natural communities, collectively referred to as element occurrences, were identified and mapped on aerial photographs. The results will be utilized to assess and prevent impacts to RTE species.

12.3.1.2 Field Investigations

Field investigations for the Program began in mid-2017. Field investigations for the RFPS were coordinated with CWP personnel and are scheduled to be complete by mid-2018. The status of the field investigations are described below.

Survey: A topographic survey has been completed and will be incorporated into the design.

Geotechnical: Geotechnical field work and a geotechnical report have been completed. The geotechnical report provides information on the suitability of soils for structures to be located on the RFPS site and will be incorporated into the design.

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Wetlands and Waterways: A wetland delineation of the site was performed in September and October of 2017. This wetland and waterway delineation was conducted in accordance with the guidelines of the 1987 Corps of Engineers Wetland Delineation Manual (Environmental Laboratory, 1987) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manuals (Northcentral and Northeast Region (Version 2.0, 2012)) and in general accordance with Wisconsin Department of Natural Resources guidelines. The wetland and waterway delineation report will be included in an appendix of the wetland and waterway permit application prepared in July 2018.

Archaeological: A Phase I Archaeological Survey outside the fenced portion of the RFPS along the northwest side of the RFPS site was conducted during design in areas of proposed improvements. The survey was conducted in accordance with the Guide for Public Archeology in Wisconsin (Dudzik et al. 2012) and the Secretary of the Interior's Standards & Guidelines for Archaeology and Historic Preservation. The archaeological survey satisfies survey requirements for regulatory compliance and meets the standards for archaeological survey as outlined in the Guide for Public Archaeology in Wisconsin. The report will be included in an appendix of the wetland and waterway permit application prepared in July 2018.

Endangered and Threatened Species: A desktop review was conducted summer 2017 by evaluating recent and historical aerial photographs, the WDNR Natural Heritage Inventory (NHI) data, and informal USFWS Information Planning and Consultation (IPaC) data. A field review was performed fall 2017 to evaluate potential RTE species habitat at the site. The report will be included in an appendix of the wetland and waterway permit application prepared in July 2018.

Hazardous Materials Investigation: A Phase 1 Environmental Site Assessment has been performed in conformance with the scope and limitations of ASTM Practice E 1527-13. This assessment did not reveal evidence of recognized environment conditions. Based on the Phase 1 results, a Phase II investigation is not required.

12.3.2 Site Improvements

This section describes specific codes and ordinances applicable to the site. The conceptual site plan is discussed along with the features and utilities proposed in the preliminary design drawings.

12.3.2.1 Site Layout

The proposed site layout is presented in Drawing Sheet CP4-C3. The RFPS is located immediately north of the existing UV Disinfection Facility and within the existing CWP perimeter fence.

12.3.2.2 Site Accessibility

The existing access drives within the CSP include an access drive extending along the west side of the UV Disinfection Facility and ending at the north side of those facilities. The access drive located north of the UV Disinfection Facility will be reconfigured to accommodate the RFPS. The new paved areas leading up to and adjacent to the RFPS will be a minimum of 14 feet in width and designed for an American Association of State Highway and Transportation Officials (AASHTO) load rating of HS-20.

It is estimated that a boom truck crane with a 10-ton lifting capacity and a 45-feet long boom will be required to access the pumping equipment within the RFPS. Turning radii needed to accommodate the cranes will be

incorporated in the design. Radii of existing access drives will be reviewed during design and modifications needed for crane access will be incorporated during design.

12.3.2.3 Surface Restoration

Surface conditions, where disturbed, will be restored to original conditions on-site at the end of construction.

Grading and Drainage: The existing site topography will be maintained as feasible. Drainage from the RFPS structures will discharge to grade. Grading at the RFPS will be designed to facilitate positive drainage of rainfall runoff away from the structures. In general, grade will be sloped away from the building walls and equipment at a minimum pitch of 1%. The grading for earthen slopes will be no steeper than three horizontal to one vertical. Finished floors of structures will be above adjacent finished grade. Surface runoff from areas around the structures will drain across the new access drive or sidewalk to the lawn.

Paving and Sidewalks: An access drive extending along the west and north sides of the RFPS will connect to the existing access drive. The existing access drive will be widened where practical to accommodate turning requirements of heavy-duty trucks and boom truck cranes. Sidewalks will be constructed on the east side of the RFPS to provide access to the east building entrance from both the existing sidewalk on the east side of the existing MCC/Blower Building and the new access drive. New sidewalks will be a minimum of five feet in width. In areas of disruption, sidewalks will be restored to the original footprint.

Landscaping: Seeding will be provided in all areas disturbed by construction. Existing mature trees will be retained where feasible.

12.3.2.4 Stormwater Management

The site at the CWP is largely developed and surrounded by previously disturbed and impervious surfaces. Stormwater runoff from the new sidewalks and access drive will utilize the existing best management practices (BMPs) at the site. A detailed stormwater analysis will be performed during design, including calculation and documentation of the pre- and post-development runoff, storage, and infiltration using TR-55 Curve Numbers and other continuous simulation-modeling methods.

The results of the stormwater analysis will be utilized to develop a stormwater management plan, assess whether the existing CWP stormwater system described in Section 12.3.2.5 can handle the additional load, and design additional BMPs if necessary. The stormwater management plan and the design of stormwater management BMPs will be developed in accordance with the guidelines and performance standards outlined in Chapters NR 151, NR 216, and NR 811 of the Wisconsin Administration Code. The Program will consider incorporating a protective area into the site to treat runoff if it would otherwise discharge directly into the Fox River adjacent to the site.

12.3.2.5 Utilities

Site utilities and piping considered for the RFPS include potable water, non-potable water, fire protection, process piping, storm sewer, sanitary sewer, electrical, fiber optic, and natural gas. Each utility was evaluated to determine the necessary connections and improvements to existing utilities.

Electrical: The CWP is powered by two independent 24.9-kV primary feeders from We Energies. These feeders enter the CWP from an overhead service at the Fox River and an underground service on Sentry Drive. The existing

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CWP electrical service does not have sufficient capacity to support the RFPS. New electrical facilities will be as described in Section 12.8 and as shown in Appendix E, Drawing Sheet CP4-E2.

Fiber Optic: Fiber optic service will provide communications for the Program. It is anticipated that this service will be new and connect all Program Elements. This utility is described in Section 12.9.

Natural Gas: Natural gas service is provided by We Energies. The natural gas is distributed to existing CWP facilities on the site by a network of 2-, 4-, and 6-inch pipes. A 4-inch pipe is located near the west and north sides of the Filter Building. A 2-inch pipe branches off the 4-inch pipe and extends to the east side of the UV Disinfection Facility. New natural gas facilities will be as described in Section 12.7.

Potable Water: Potable water service is provided to the CWP by WWU. An 8-inch water supply enters the plant at Sentry Drive and passes through a backflow preventer before being distributed throughout the plant. The 8-inch pipe extends to near the southeast corner of the UV Disinfection Facility and a 1.5-inch branch extends to the south side of the MCC/Blower Building. The existing CWP includes lavatory and toilet facilities which are sufficient for personnel providing maintenance for the RFPS. No lavatory or toilet facilities will be located within the RFPS.

Non-Potable Water: The CWP non-potable water system includes a 4-inch flushing water pipe outside each side of the UV Disinfection Facility that serves multiple yard hydrants. The existing 4-inch pipe will be replaced as necessary to accommodate the proposed structures. The RFPS includes multiple wall hydrants and hose bibbs. The RFPS water system could be served by either the existing potable or non-potable water system. The water supply system will be selected during design.

Fire Protection: Fire protection will be provided internal to the RFPS as described in Section 12.7. Fire protection outside the building will be provided by the water system owned and operated by the CWP. The location, spacing and type of hydrants will be coordinated with the fire department and the CWP.

Process Piping: A 24-inch return flow pipe will exit the RFPS on the north side of the building and connect to the 30-inch diameter Return Flow Pipeline as shown in Appendix E, Drawing Sheets CP4-M2 and CP4-M3. A new 8-inch Effluent pipe, equipped with a flowmeter and motor-actuated throttling valve, will be used to convey the appropriate flow to the Fox River as shown in Appendix E, Drawing Sheet CP4-M3.

Storm Sewer: A 4-inch storm sewer serves the existing MCC/Blower Building and adjacent grade level slab. The sewer discharges to grade at the north edge of the CWP. Stormwater runoff from the Effluent Channels and RFPS will discharge to that storm sewer and the downstream segment of the sewer will be replaced with a 6-inch pipe as shown in Appendix E, Drawing Sheet CP4-C4.

Sanitary Sewer: The CWP sanitary sewer system serves multiple buildings and discharges to a 30-inch raw wastewater pipe that drains to the headworks facilities. The MCC/Blower Building located at the UV Disinfection Facility includes floor drains connected to a 4-inch sanitary sewer that discharges to the wastewater basin located at the south end of the UV Disinfection Facility. The RFPS will be an unmanned facility with periodic maintenance activity. The RFPS will require sanitary service for the floor drains and those drains will discharge by gravity to the existing 4-inch sanitary sewer serving the MCC/Blower Building.

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12.4 Structural

12.4.1 Return Flow Pumping Station

Foundation: A geotechnical investigation was performed to determine subsurface conditions for the RFPS. A soil bearing capacity of 3,000 pounds per square foot was used for the preliminary design.

Bedding and Backfill: Bedding under internal slabs on grade will be 8-inch thick compacted granular soil. Backfill against foundation walls and retaining walls will be a compacted granular material with an internal friction angle of 30 degrees.

Floor System: The slab on grade floor system will be 5-inch thick concrete reinforced with macro polypropylene fibers.

Roof System: The roof system will be 12-inch thick precast planks.

Wall System: The 8-inch masonry will be used as shear walls. Wall reinforcement will be designed as required for lateral loads. Lintels will be reinforced concrete with separate steel angles for the face brick.

12.4.2 Equipment Removal

Equipment removal options were evaluated and are presented in Section 12.6.5.

12.5 Architectural

12.5.1 General

The RFPS will vary in design from the other structures of the Program because it is located within the property of the CWP. Therefore, the RFPS will match the existing masonry buildings on the site, the roofs of which are flat precast planks supported by load-bearing masonry. Other design influences include siting, maintenance, access to natural light, and efficient use of structural systems.

12.5.2 Site Conditions

As illustrated in Figure 12-5, the RFPS will be located on the north side of the existing buildings. Access to the RFPS will be from an existing access road to the west. The building site is bordered by a publicly-owned wooded area to the north, the Fox River to the west, the Filter Building and waste treatment tanks to the east, and the UV Disinfection Facilities, including the MCC/Blower Building, to the south.

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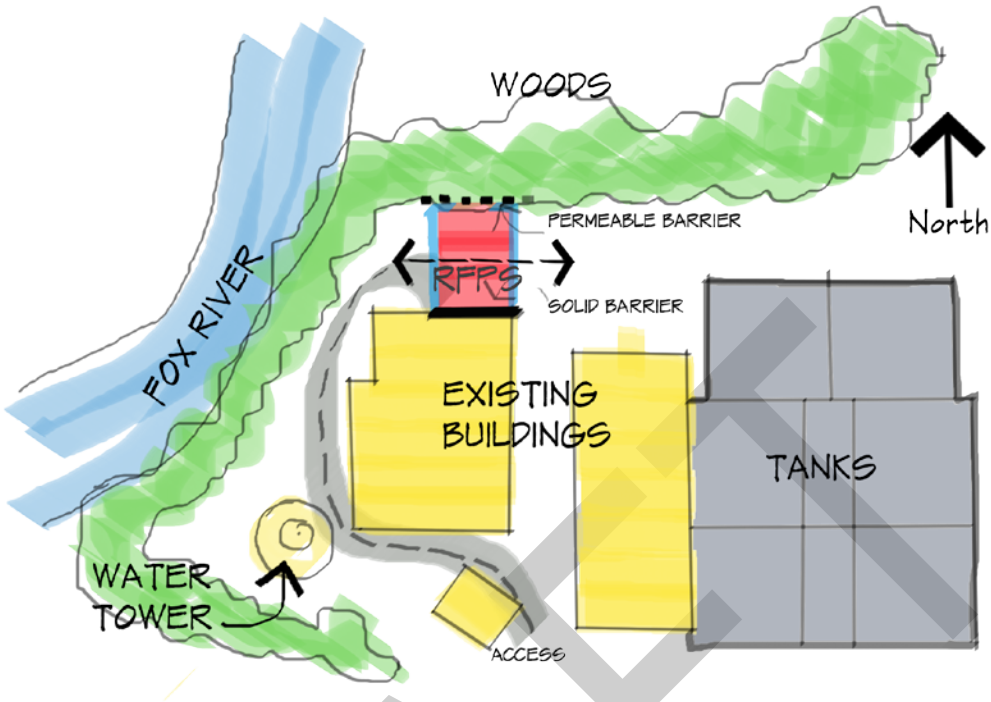

Figure 12-5 Site Conditions

12.5.3 Building Aesthetics

The RFPS is not visible from any major road or neighborhood. As the RFPS will abut the existing MCC/Blower Building, efforts will be made to ensure the new construction matches the existing. This will be achieved by using the same cladding materials as those used on the MCC/Blower Building, primarily brick with cast stone trim and metal copings. The access route to the RFPS will run east to west due to limitations from the existing buildings to the south and the wooded area to the north. Openings for ventilation will be located along the east and west facades. To control solar heat gain and visual glare, the roof of the RFPS will extend beyond the building façade as a horizontal plane. This approach will help further integrate the RFPS with the existing building. See Figure 12-6 for a conceptual rendering of the RFPS.

12.5.3.1 Structural System

The RFPS's main structural system will be a cast-in-place concrete structural foundation with load bearing concrete masonry unit walls supporting a precast hollow core plank roof. This follows the design of the adjacent MCC/Blower Building.

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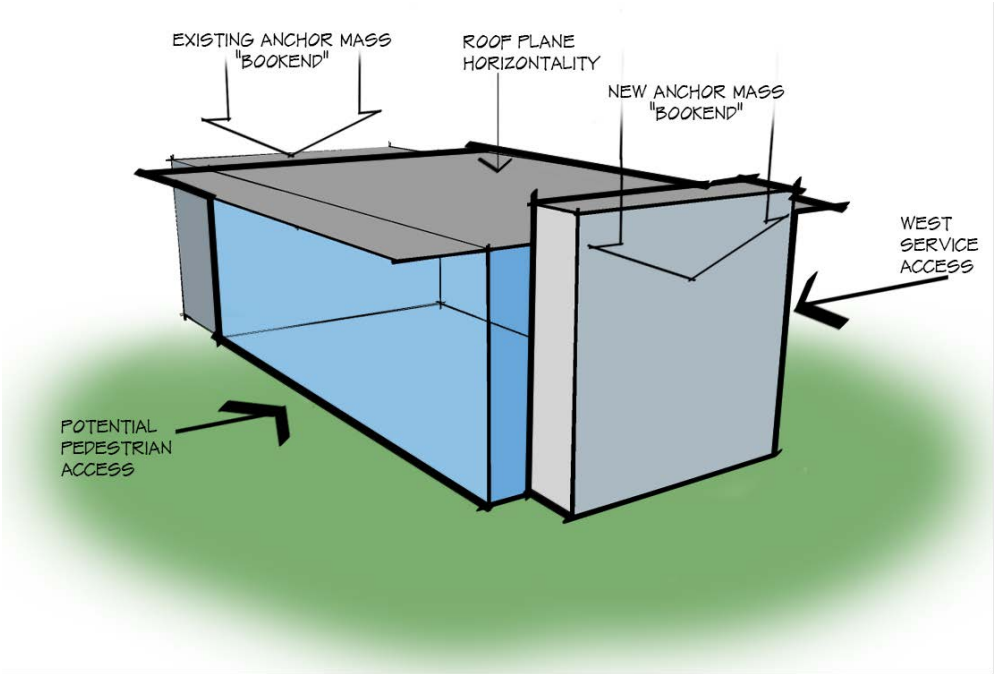

Figure 12-6 Building Massing

12.5.4 Codes, Standards and References

The design will adhere to those codes, standards and references listed in Section 4 of this document and the following:

- City of Waukesha Code Book, CH 22: Zoning Ordinance

During design, the RFPS design elements outside of the building will be coordinated with Waukesha's Planning Department and submitted to the Plan Commission for their approval.

12.5.5 Space Allocation

The RFPS will be a two room building located next to the existing MCC/Blower Building located on top of the UV Disinfection Facility. Table 12-2 shows the space allocation for the RFPS.

Table 12-2 Space Allocation

Space Name	Occ. Group	Area (sq ft)	Exterior Access	Natural Lighting	Sprinklered
Pumping Room	F-2	1,000	Y	N	N
Electrical Room	F-1	500	Y	N	N
Generator Area	--	--	--	--	--
	Total	1,500			

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12.5.5.1 Pumping Room

The Pumping Room will be the primary area within the structure and will provide space for ancillary functions such as metering. The room will be located to the north of the UV Disinfection Facility, partially above proposed channels. Primary access to the space will be from the west, near a proposed turnaround area. A roof hatch will be located above each pump to facilitate removal of the pump by an exterior crane. Space will be provided for a flow meter along the discharge header. The Pumping Room classification is F-2 and such classifications are not required to be sprinklered.

12.5.5.2 Electrical Room

The Electrical Room will be located at an elevation that keeps critical equipment above the 100-year flood. The Electrical Room will be separated from other areas by fire rated walls. The Electrical Room classification is F-1, and F-1 spaces are generally required by code to be sprinklered. However, the building code exempts F1 Occupancy Groups from the requirement for automated fire sprinklers where only electrical equipment is located and therefore the Electrical Room will not be sprinklered.

12.5.5.3 Mechanical Equipment

Wall and roof mounted equipment will be utilized to maintain environmental conditions at the RFPS.

12.6 Process Mechanical

The purpose of the RFPS is to pump water to the Root River through the Return Flow Pipeline. The RFPS requires a building to house the pumps, piping, valves, meters, and associated accessory equipment to boost the water from the CWP to the Root River. This subsection describes the design of the pumping system.

A summary of the basis of design is presented in Table 12-3.

Table 12-3 Return Flow Pumping Station Basis of Design

Description	Design Values
Flow Rate	
Minimum Hour, MGD	0.0
Initial Average Day, MGD	6.6
Future Average Day, MGD	8.2
Maximum Hour, MGD	12.0
Return Flow Pumps	
Number of Return Flow Pumps	4
Return Flow Pumps	
Flow per Pump, MGD	4.0
Head, feet	278
Motor Size, horsepower	300
Voltage, volts	480

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Description	Design Values
Variable Frequency Drive	Yes
Firm Capacity (Largest Pump Out of Service), MGD	12.0
Installed Capacity, MGD	16.0
Discharge Header	
Pipe Material	Ductile Iron
Diameter, inches	18
Maximum Operating Pressure, psi	123
Minimum Operating Pressure, psi	80

12.6.1 Flow Range and Capacity Requirements

In response to Waukesha's Application for Lake Michigan Diversion with Return Flow, the Compact Council approved a diversion of 8.2 MGD average daily demand (ADD) to meet the projected final build out of Waukesha. The existing ADD is 6.6 MGD based on the historical data analysis described in Section 7. The Final Decision requires Waukesha to discharge to the Root River, which ultimately discharges into Lake Michigan, a volume of water approximately equal to the volume of water withdrawn from Lake Michigan.

More specifically, as described in Section 2.1, the Final Decision included the following findings and conditions:

- The Applicant will return up to the previous year's average daily withdrawal amount per day and, therefore, a volume of water approximately equal to the volume of water withdrawn from Lake Michigan will be returned to the Lake Michigan watershed.
- The Applicant must return to the Root River, a Lake Michigan tributary, a daily quantity of treated wastewater equivalent to or in excess of the previous calendar year's average daily diversion. On any days when the total quantity of treated wastewater is insufficient to meet this target, all treated wastewater must be returned to the Root River.

The daily water pumpage rate has been compared to the daily CWP treated effluent rate for the six year period of 2011 through 2016. Annual average water pumpage ranged from 6.0 to 7.0 million gallons per day and the annual average effluent flow ranged from 8.2 to 10.8 million gallons per day. The minimum daily effluent flow was 6.3 MGD. In some years, especially during droughts, there were days that a quantity of treated effluent equivalent to the previous calendar year's average daily diversion would not have been met even when returning 100% of the CWP treated effluent to the Root River. Discussions are ongoing with WDNR to allow flexibility to meet the previous year's ADD by considering the range of flows that make up the prior year ADD and regarding a minimum flow of CWP treated effluent to the Fox River at all times. Minimum permitted flow rates of 0.5 and 1.0 MGD, as well as no such flow rates, are currently being considered.

The CWP influent and treated effluent flow rates vary throughout each day. During the period of 2011 through 2016, the maximum recorded influent and treated effluent flows were 55.0 and 54.7 MGD, respectively. The minimum recorded influent flow was 4.1 MGD except for a short period in August 2013 when the flow approached zero for less than one hour due to maintenance activities. The treated effluent flow declined to less than 2 MGD 37 days per year on average, generally for less than one-quarter hour but for multiple hours during six days in 2014 through 2015. The short duration low flow events appear to coincide with dry weather conditions and the operation of filter backwash

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pumps after the diurnal effluent flow dropped below 6 MGD. All operational circumstances that resulted in treated effluent flow rates being significantly less than the corresponding influent flow rates will be evaluated further during design to better understand and accommodate the future circumstances that may produce similar conditions.

Multiple scenarios for managing the return flow to the Root River relative to the diurnal flow variations, both with and without a minimum flow to the Fox River, have been evaluated. Based on maintaining a selected minimum rate of flow to the Fox River, scenarios evaluated include the following:

- Match treated effluent flow, up to the RFPS firm capacity, throughout the day while discharging a selected minimum flow to the Fox River
- Match treated effluent flow, up to the RFPS firm capacity, until a daily quota is met and then reduce to a lower constant flow rate for the remainder of the day, all while discharging a selected minimum flow to the Fox River
- Match treated effluent flow, up to the RFPS firm capacity, during off peak hours and then reduce to a lower constant flow rate for the remainder of the day, all while discharging a selected minimum flow to the Fox River

Based on the above scenarios and discussions with the WDNR, a firm pumping capacity of 12 MGD has been selected to accommodate all ADD flows of up to 8.2 MGD while maintaining a minimum flow of 1 MGD to the Fox River. Flow to the Fox River or Root River may need to be interrupted to accommodate occasions when CWP treated effluent flow is inadequate to meet the required flow rates. Pending the results of future discussions with WDNR, a minimum return flow rate of 2 MGD to the Root River has been tentatively selected for the RFPS. One pump would cycle on and off when the CWP effluent flows are less than 2 MGD.

12.6.2 Pump Design and Selection

Pump design and selection are based on the RFPS flow range and capacity requirements described in Section 12.6.1 of a 12 MGD firm capacity with a minimum flow rate of 2 MGD. Pump size, number of pumps, pump type, and pumping operations are designed to accommodate these parameters.

12.6.2.1 Pump Size and Number

Four pumps are considered to be the most effective arrangement for the capacity requirements. The selected size of each pump is 4 MGD with variable frequency drives (VFDs) to meet the minimum flow condition and to provide the pumping rates needed to accommodate the return flow management plan.

The RFPS will have the ability to operate up to three of the four pumps at all times with the fourth pump serving as a standby pump. This capability will allow any one of the four pumps to be taken out of service at any time for maintenance or repair without jeopardizing the required capacity of the RFPS.

The RFPS wet well will be arranged in two halves. Wet well facilities will be covered with aluminum planks where practical to facilitate access. Stop logs and sluice gates will be provided to isolate wet well halves to accommodate periodic manual cleaning after removing the aluminum planks.

12.6.2.2 Pump Type

The following two types of pumps commonly used for wastewater treatment plant highly treated effluent were selected for evaluation:

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- Lineshaft-driven vertical turbine style referred to below as vertical turbine (VT) pumps
- Axial split-case dry-pit style with the shaft centerline oriented horizontally, commonly known as horizontal split-case dry-pit style and referred to below as HSC pumps

The advantages and disadvantages of utilizing each type to pump the CWP highly treated effluent have been evaluated in terms of priming requirements, hydraulic efficiencies, ease of maintenance, and spatial requirements.

The CWP effluent flows by gravity from the weir troughs controlling the liquid level in the UV Disinfection Facility to the effluent flume that measures the flow to the Fox River. The maximum water surface of the treated effluent is at Plant Datum Elevation 16.9, which is below the existing grade level of Elevation 18.5. The space available for the RFPS is limited as shown in Appendix E, Drawing Sheet CP4-C3.

Vertical Turbine Pumps: Vertical Turbine (VT) pumps would be arranged with the pump inlet located below the building's grade floor and below the liquid surface, thereby making the pump fully primed and ready to start at any time. Each pump would include multiple pump bowls arranged in series on a common shaft to produce the head required. The major elements of the pump unit would consist of a pump bowl unit with a bell type suction and multiple impellers housed in multiple bowls, impeller shaft, suction column, discharge elbow and motor. The suction bell would be equipped with a basket type strainer to prevent entrance of damaging material. The grade floor would be located sufficiently high to protect the pump discharge head and motor from flooding due to water levels as high as the 100-year flood. The pump discharge head would be anchored to the grade floor and the motor would be mounted vertically immediately above the pump discharge head.

Horizontal Split-Case Pumps: For horizontal split-case (HSC) pumps, all pump elements would be located above the building's grade floor and the liquid surface. The pump and motor would be mounted on a common base supported by a concrete equipment pad attached to the floor slab. A single double-suction impeller would be sufficient to produce the head required. Each pump would be equipped with a vacuum priming system to flood the pump impeller prior to starting the pump. Each pump would include suction piping to convey the treated effluent from the wet well to the pump suction. Suction piping located near the pump would be oriented horizontally in order to locate the pump isolation valve above the grade floor. Further upstream, the suction piping would be oriented vertically and extend below the liquid surface.

Recommendation: The hydraulic efficiencies of these two types of pumps are similar. HSC pumps are easier to maintain than VT pumps. However, the VT pumps would be fully primed and ready to start at any time, have a smaller dimensional footprint than the HSC pumps, and can accommodate the spacial limitations of the site. Thus, the VT pumps are recommended for the RFPS. Plan views of the below grade and above grade structures are shown in Appendix E, Drawing Sheets CP4-M2 and CP4-M3, respectively.

12.6.2.3 Pumping Hydraulics

System head curves represent the calculated pressure to sustain flow from the water source, which is the wet well at the CWP, to the discharge of the return flow pipeline into the Return Flow Facilities. Figure 10-14 presents the grade elevations and hydraulic grade line (HGL) at 12 MGD along the return flow pipeline. The total head is the sum of the static and dynamic head. Due to the nature of the topography along the route, the static head is the pressure to lift the liquid from the pump bays to the pipeline highpoint at Minooka Park. The dynamic head is the pressure to overcome the resistance to flow in the return flow pipeline to the Return Flow Facilities and includes losses due to pipe friction and turbulence in various fittings.

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Two system curves were developed based on the water level in the pump bay and pipe friction losses that represent the varying age of pipe. System curve SC1 represents the head required to convey flow at the high water level (HWL) in the pump bays for a newly installed pipe. System curve SC2 represents the head required to convey flow at the minimum operating water level in the wet well with increased friction losses caused by increased roughness in an older pipe. Pipe friction losses were calculated using the Hazen Williams equation with C=120 for aged pipe and C=150 for new pipe. Table 12-4 below presents the minimum and maximum wet well liquid surface elevations, pipeline elevation at the highpoint, dynamic headloss from the wet well to the Return Flow Facilities, and total head for the pump station capacity of 12 MGD based on the 30-inch Return Flow Pipeline size distribution addressed in Section 10.

If required in the future, the RFPS firm capacity could be increased to approximately 20 MGD without exceeding the pressure rating of the return flow pipeline by upgrading the return flow pumps and electrical equipment. Concrete wet well pump bay widths and initial filler walls selected for the initial and future pump capacities during design will meet the Hydraulic Institute (HI) standards.

Table 12-4 RFPS System Curve Parameters

Parameter	Low	High
Pipeline at Highpoint, Elevation	984	984
Wet Well Liquid Surface, Elevation	797	793
Total Static Head, feet.	187	191
Hazen-Williams (C)	150	120
Dynamic Headloss (@ 12 MGD), feet.	60	88
Total Head, feet.	246	278

Pump performance curves are shown as an example Figure 12-7. Curves are shown for one, two and three pumps operating at full capacity, as well as one pump operating at reduced speed.

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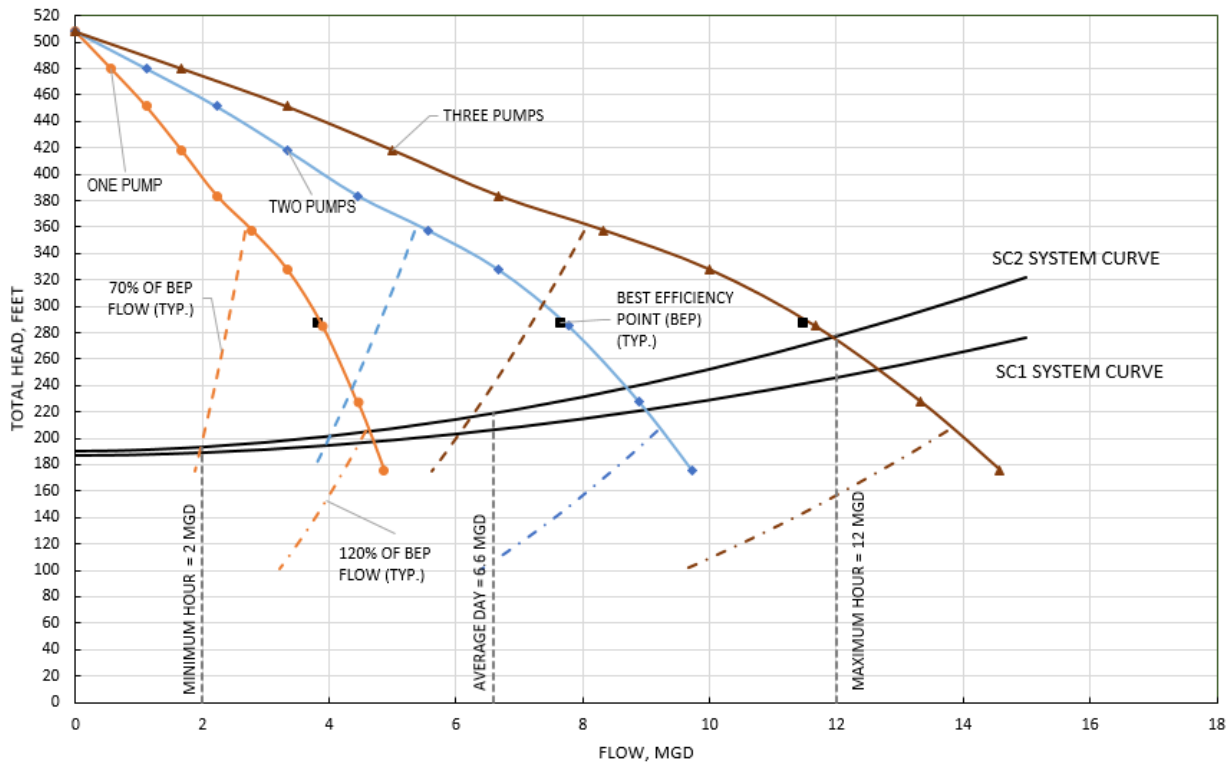

Figure 12-7 RFPS Pump and System Curves

The HI Standard 9.6.3 defines the preferred operating ranges (POR) for clean water pumps of this style and size as 70% to 120% of the pump's best efficiency point (BEP). This range will provide acceptable service life and performance. The POR are shown as dashed lines and the ranges are based on the 70 and 120% operating limit criteria. The lines are shown to represent the flexibility of operating range with VFDs and that the pump sizing, configuration, and operations will meet RFPS requirements.

Net positive suction head available (NPSHA) is defined by the HI as "the total suction head of liquid absolute determined at the suction nozzle and referred to datum, less the absolute vapor pressure of the liquid in head of liquid pumped". NPSHA must be greater than the net positive suction head required (NPSHR) by the pump at the desired flows in order to preclude the damaging effects of cavitation and provide the performance as shown on the pump curve. In practice, the NPSHA must exceed the NPSHR by a margin in order to obtain the desired performance and service life. The margin is expressed as the ratio of NPSHA/NPSHR. The HI has defined recommended NPSHA/NPSHR ratios in HI Standard 9.6.1. The standard recommends a minimum ratio of 1.1 for water pumps that are greater than 100 brake horsepower per stage and equipped with stainless steel or aluminum bronze impellers. Pumps specified during design will have sufficient NPSH margin and meet the HI standard.

12.6.3 RFPS Station Piping

The piping arrangement is shown in Appendix E, Drawing Sheet CP4-M2. The individual return flow pump discharge piping, the discharge header, and related appurtenances will be located in the Pumping Room.

The laying lengths and pipe velocities meet the HI 9.6.6 Pump Piping requirements. All piping within the RFPS will have flanged joints and include breakout fittings to allow quick dismantling for maintenance or replacement of piping and equipment. The location and design of breakout fittings will be developed during design. The pipe support location and design will be developed during design. The general philosophy will be to locate the supports to avoid any unsupported piping element while any equipment or piping element is removed for replacement or maintenance. Valves will be supported by supporting adjacent piping.

Piping Material: The piping in the RFPS will be ductile iron pipe (DIP).

Discharge Header: The four return flow pumps will pump through their discharge piping into the 18-inch discharge header located along the north wall of the Pumping Room. Downstream of the pump discharge connections, the discharge header will connect to the 18" return pipe located above the discharge header to accommodate the upstream straight run requirements of the return flowmeter. Downstream of the flowmeter and 18" RFPS isolation valve, the 18" return pipe will increase to 30" prior to penetrating the Pumping Room floor for connection to the buried 30" Return Flow Pipeline outside the building.

12.6.4 Pump System Appurtenances

Isolation Valves: Isolation valves will be provided on the pump discharge piping to allow isolation of individual pumping units while the RFPS remains operational. Valves typically used for fully-open or fully-closed operation can be used for isolation purposes. The valve types typically considered for treated effluent isolation include butterfly and gate valves. Butterfly valves were selected as isolation valves due to suitability, ease of operation, short face-to-face dimension, light weight, and economic affordability for sizes 12-inch diameter and larger. The type and arrangement of actuators for butterfly valves will be evaluated during design. Large valves will be equipped with manual operators arranged for use of portable electric operators or with electric actuators. Butterfly valves meeting American Water Works Association (AWWA) C504 will be specified. During design, the size, location, and shaft orientation of the butterfly valves will be reviewed with the specified manufacturers to avoid any excessive vibration of the valve and fluttering of the disc.

Control Valves: A motorized pump control valve will be installed on the discharge of all four return flow pumps. Pump control valves provide adjustable opening and closing times to protect pumps against potential hydraulic transients. A hydraulic transient analysis will be performed during design. The analysis will govern the location, type, design, and selection of the pump control valve.

Air Valves: An air valve will be located on the top of the spool piece immediately downstream of each pump expansion joint and on the top of the horizontal return pipe immediately upstream of the downturned elbow as shown in Appendix E, Drawing Sheet CP4-M2. The air valves will automatically maintain the efficiency of piping by releasing air pockets that form within highpoints of pressurized piping and automatically prevent a vacuum from forming by admitting air when pressure in the piping drops below atmospheric pressure. The design and selection of the air valve will be performed during design in conjunction with the hydraulic transient analysis.

Surge Protection: Pumping stations discharging into long pipelines have potentials for surges. The selection and design of the surge protection system will depend on the expected severity of the surges. A hydraulic transient analysis will be performed during design. The analysis will govern the design of the surge protection system.

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Pressure Gauges: Pressure gauges will be located immediately downstream of each return flow pump, as well as downstream of the Return Flow Pipeline flowmeter. General pressure gauge locations are shown in Appendix E, Drawing Sheet CP4-N1.

Return Flow Metering and Sampling: During the Water Supply Facilities SCADA, Electrical and Mechanical Meeting (6-200 M-03) on August 17, 2017, return flow pipeline metering and sampling locations were discussed, including potential benefits of locating the return flow meter and sampling at the RFPS. One possible location for the meter is in the Pumping Room as shown in Appendix E, Drawing Sheet CP4-M2. WDNR subsequently indicated a preference that the sampling location be the existing facilities located upstream of the RFPS. Final type and location of the equipment will be determined during design.

Fox River Flow Metering: The CWP discharge to the Fox River is currently measured by a parshall flume rated for more than 55 MGD. As described in Section 12.6.1, discussions are ongoing with WDNR regarding a minimum flow rate of 0.5 or 1.0 MGD to the Fox River when the RFPS is in operation. To accurately measure and control such flow, a new 8-inch effluent pipe located below the floor of the existing flume will convey CWP treated effluent downstream of the existing flume. The effluent pipe will be equipped with a motor operated throttling valve and magnetic flow meter to measure and control the rate of discharge to the Fox River when the remainder of the treated effluent is being pumped by the RFPS. One possible location for the meter and throttling valve is a new Meter Vault as shown in Appendix E, Drawing Sheets CP4-M1 and CP4-M3. The WDNR requirements regarding minimum flow to the Fox River and the final location of the corresponding equipment, including provisions for access, will be determined during design.

12.6.5 Equipment Removal

The RFPS will require lifting mechanisms to lift and move pumps, motors, valves, and other ancillary equipment for maintenance, upgrade, or replacement. Different types of lifting mechanisms can be used to remove and install equipment at the RFPS. Various factors for selecting the type of lifting mechanisms best suited for use in the RFPS include weight and dimension of the load, the height of the lift, distances/areas of movement required, clearance, cost, process layout, building limitations, and frequency of use. Table 12-5 provides the range of weights and frequency that equipment may need to be removed from the facility for repair, replacement, or upgrade.

Table 12-5 RFPS Equipment List

Equipment	Life Expectancy	Weight (lbs)	Removal Requirement
Pumps	20+ years	3,400	Replacement; Maintenance every 5 to 10 years
Motors	20 years	2,500	Replacement; Maintenance every 5 to 10 years
Isolation Valves	20+ years	400	Replacement Only
Pump Control Valves	20+ years	3,000	Replacement Only
Pipe	20+ years	3,000	Replacement Only
Flow Meter	20+ years	1,000	Replacement Only

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The lifting mechanisms considered for these conditions are as follows:

- Gantry Crane
- Monorails
- External Crane

Descriptions and design considerations of the lifting mechanisms are provided in Section 4.

12.6.5.1 Removal Equipment Recommendation

Multiple roof hatches and an external crane is the recommended option for the pumps and pump motors. A gantry crane is recommended for the smaller equipment and piping. Both of the lifting systems will be designed for a 2-ton capacity.

12.7 Mechanical

12.7.1 General

This section presents the basis of design for heating, ventilating, and air conditioning (HVAC), plumbing, and fire protection systems associated with the RFPS.

12.7.2 Heating, Ventilating, and Air Conditioning System

General HVAC design criteria are described in Section 4.8.

12.7.2.1 Systems and Equipment Serving Electrical Areas

At the RFPS, the design will consist of a self-contained cooling-only roof top unit (RTU) for the Electrical Room. The RTU will be provided with a full back-up. This will ensure that all sensitive electrical equipment is protected in the event of failure of the main system. The RTUs will be specified with full economizer mode to operate when outdoor temperature is favorable to cool the space without the need of compressor power in order to reduce operational costs. Heating for this space will be provided by electric unit heaters.

An indoor space temperature of 80 °F in the summer and 60 °F in the winter will be maintained in the Electrical Room. Thermostats in the room and air flow sensors will be provided to control heating, cooling, and fan operation. These sensors and thermostats will report back to the local temperature control panels (TCP) to allow control and monitoring. Space high and low temperature alarms initiating remote and local alarms when temperature rises above or falls below the set point. 4-20ma analog temperature sensors with a range of 20 °F to 120 °F will be provided (Water Supply Facilities SCADA, Electrical and Mechanical Meeting (6-200 M-03) on August 17, 2017). The supervisory control and data acquisition (SCADA) system will receive critical alarms from the TCP, but will not control the HVAC system. For SCADA system description, refer to Section 12.9.

12.7.2.2 Systems and Equipment Serving Process Areas

The HVAC system for the process area will be designed to maintain 60 ºF in the winter with a drift point temperature of 50 ºF when unoccupied. The design space temperature in the summer will be +10 °F above ambient. The process

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area will be designed to accommodate portable dehumidification units (Hi-E Dry) when excessive condensation occurs (Water Supply Facilities SCADA, Electrical and Mechanical Meeting (6-200 M-03) on August 17, 2017). The process pumping area will be conditioned with a combination of in-line exhaust fans and outside air intake louvers. Heating will be accomplished by gas fired unitary heating equipment. The mechanical design will specify room temperature sensors for automatic operation of the outside air dampers and exhaust fans. These sensors will report to the local TCP to allow control and monitoring. The TCP will report critical alarms to the SCADA system.

12.7.2.3 Exterior Design Conditions

Refer to Section 4.8 for exterior design conditions.

12.7.2.4 Air Distribution System

Refer to Section 4.8 for air distribution system description.

12.7.2.5 Gas Distribution System

Natural gas is available at the site. During design, the existing piping size will be reviewed to confirm that there is sufficient capacity for the proposed gas-fire unit heaters and emergency generator.

12.7.2.6 Control System

Refer to Section 4.8 for HVAC Control System description.

12.7.3 Plumbing System Design

Refer to Section 4.8 for plumbing system design including storm and wastewater systems, as well as plumbing fixtures.

12.7.4 Fire Protection Systems

A fire alarm system will be specified under electrical work. It will include air handling smoke detection and fan shut down where required by Code. Where smoke detectors are installed, they will be monitored at a fire alarm control panel. Fire alarm signals will be monitored by the corresponding TCP associated with the HVAC system. All alarms will be sent to the SCADA system and to the local fire department.

12.7.5 Reduced Energy Consumption

For reduced energy consumption description, refer to Section 4.8 for more details.

12.7.6 Flood Alleviation

For HVAC and plumbing system flood alleviation description, refer to Section 4.8 for more details.

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12.8 Electrical

12.8.1 General

The electrical power distribution system configuration for the RFPS will be modeled after the future provisions depicted in the January 2015 Phase II Improvements documents and include features of the design approach applied elsewhere within the existing CWP. The RFPS will be isolated electrically from the existing CWP power distribution systems due to insufficient capacity to support RFPS loads.

12.8.2 Source of Utility Power

The CWP is powered by two independent 24.9-kilovolt primary feeders from We Energies. These feeders enter the plant from an overhead service at the Fox River and an underground service on Sentry Drive to a primary service switchgear south of the digester complex. From this switchgear, circuits are extended in loop configuration to CWP facilities. The existing loop circuits do not have sufficient capacity to support RFPS loads.

New service for the RFPS will be obtained from We Energies by extending both existing primary circuits in new, dedicated ductbanks to new service equipment.

12.8.2.1 Utility Connection

We Energies services will be extended to a new padmounted primary switchgear dedicated to the RFPS. Utility metering will be provided at the new primary switchgear. Detailed coordination with We Energies is required to determine a suitable location for the primary switchgear.

Service at 24.9 kV will be extended to two new padmounted transformers adjacent to the RFPS. Each transformer will be sized to carry the full RFPS load, allowing for single-ended operation during an outage of one transformer. Secondary cables in ductbank will extend from the transformers to the RFPS Electrical Room.

12.8.3 Standby power source

In the event of failure of the utility power source, standby power will be provided by an on-site natural gas-fueled generator. The generator will be furnished in a weather-protected, sound-attenuated enclosure adjacent to the RFPS.

Generator power will be interconnected to the RFPS power system through an Automatic Transfer Switch integrated into the service equipment. The Automatic Transfer Switch will be service-entrance rated at 480-volts, 1600 A and composed of two mechanically-interlocked power circuit breakers and associated controls. Output of the transfer switch will feed the service motor control center.

Generator size will be selected during design based on operating the pumping equipment to accommodate ADD flow.

12.8.4 480-Volt Service Motor Control Center

The 480-volt electrical service equipment will be a service-entrance-rated motor control center, rated 1600 A with two incoming utility main circuit breakers and a generator main circuit breaker. Integral automatic transfer controls will

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automate the generator connection during an outage. For motor control center description, refer to Section 4.7 for more details.

The motor control center will contain feeder units to power VFDs serving each of the return flow pumps, electromechanical starters for HVAC fans, and feeder units for lighting and other building loads.

12.8.5 Electrical Load Study

A load study will be completed during design to analyze the operating characteristics of the electrical system. The load study will determine the required electrical capacity for the pumping systems during all design basis operating scenarios, including regular service and maintenance activities.

12.8.6 Motors

Motors serving the return flow pumps will include winding temperature sensors, anti-condensation heaters, non-reverse ratchets and vibration monitoring. Refer to Section 4 for more details on motors.

12.8.7 Variable Frequency Drives

The return flow pumps will be controlled by VFDs. Refer to Section 4.7 for more details on motors.

12.8.8 Low-voltage transformers

A low voltage dry-type distribution transformer will serve 120- and 208- volt building loads.

12.8.9 Panelboards

Low-voltage power for lighting, receptacles, instruments and appliances will be distributed through panelboards. Refer to Section 4.7 for more details.

12.8.9.1 External Ground Ring

The pumping station will include an external grounding ring buried outside the building foundation. For external ground rings description, refer to Section 4.7 for more details.

12.8.9.2 Bonding

A building ground bus bar will be installed in the Electrical Room and will be bonded to the proposed new grounding system and to the existing grounding system at the UV Disinfection Facility. Equipment will be bonded to the grounding system, refer to Section 4.7 for more details.

12.8.10 Lightning Protection

A lightning protection system will be provided for the RFPS. For lightning protection system description, refer to Section 4.7 for more details.

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12.8.11 Fire Alarm System

A digital, addressable fire alarm and detection system will be installed in the RFPS. For fire alarm and detection system description, refer to Section 4.7 for more details.
The alarm system will be integrated with the existing fire alarm system at the CWP and the fire alarm status will be monitored locally by SCADA.

12.9 Instrumentation and Controls

12.9.1 General

The control scheme for the RFPS involves programmable logic controller (PLC) interaction with a flow meter, pump control valves, VT pumps and VFDs, and other instrumentation, such as pressure indicating transmitters, level detection elements, and valve limit switches.

12.9.2 Programmable Logic Controller

The Monitoring and Control within the RFPS will be accomplished via a standard microprocessor-based PLC and input/output (I/O) modules using instrumentation and network links to remote control systems and other control devices. The RFPS will be furnished with manufacturer standard instrumentation and packaged controls to allow operators to monitor and control the system equipment. To maintain compatibility with existing control systems, new PLCs will be Allen Bradley MicroLogix. The RFPS will have a spare pre-programmed PLC for fast switch out backup.

Operator interface with the RFPS PLC will consist of an operator interface terminal (OIT). The OIT will provide operator control of the process through graphic interface, diagnostics, trending, alarms, and status displays. The control system, including the PLC, OIT, and network equipment, will be located in the Pumping Room of the RFPS.

The RFPS PLC will communicate with other Program PLCs for remote monitoring: with the return flow meter via fiber optic connection; with the CWP via fiber optic connection; with the Booster Pumping Station (BPS) via wireless radio; and with WWU via wireless radio.

12.9.3 Return Flow Meter

The return flow meter within the RFPS will consist of a flanged, magnetic type flow meter with flow indicating transmitter. The analog flow indicating transmitter (FIT) will be used to convert readings from the meter into a 4-20mA output signal. The meter output will be trended and recorded.

The return flow meter will be located on the 18-inch return pipe within the RFPS. The placement of the meter will be horizontal. A manually operated isolation valve will be located downstream of the meter for maintenance purposes.

A required straight pipe run distance of five pipe diameters will be considered directly upstream of the meter to provide a uniform flow profile in order to maintain standard measurement accuracy. A required straight pipe run distance of two pipe diameters will be considered directly downstream of the meter.

The return flow meter design will be based on a pipe diameter of 18-inches, flow rates between 0 and 12 MGD, and standard ANSI Class 150 flanges.

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12.9.4 Pump Control

The return flow pumps will be controlled via the RFPS PLC, in either automatic or manual mode. PLC connections include a hardwired interlock between the pumps and their VFD, and an ethernet datalink connection between the VFDs and the PLC. Pump startup and shutdown will be based on maintaining either a flow rate at the common discharge or level in the return flow pump bays. The return flow pumps will have local control stations that will provide limited control capabilities.

12.9.4.1 Pump Discharge Interlock

A pump control valve will be located in the discharge piping of each return flow pump. The pump control valve will be controlled via PLC logic with hardwired interlock between the valves and the pumps VFDs, and ethernet datalink connection between the VFDs and the PLC. The purpose of each pump control valve is to provide isolation from the return header when the return flow pump is not running, as well as to reduce the potential for pressure transients by starting and stopping the pump against a closed valve.

Prior to pump stop, the associated control valve will be slowly placed in the closed position to reduce the potential for pressure transients.

12.9.4.2 Pump Monitoring and Protection

Pump monitoring and protection will include temperature and vibration monitoring and alarming, as well as discharge pressure protection interlock. Vibration and temperature monitoring will be included for motor bearings and pump bearings.

High vibration or temperature detection for a predetermined amount of time will generate an alarm in the PLC. High-high vibration and temperature detection will be hardwired to the pump starter, and detection of either for a predetermined amount of time will generate both an alarm and a pump protection stop.

High pressure detection at a return flow pump discharge piping for a predetermined amount of time will generate an alarm in the PLC. High-high discharge pressure detection for a predetermined amount of time will generate both an alarm and a pump protection stop.
Instrumentation

12.9.4.3 Level Instrumentation

Level indicating transmitters with submersible level sensors will continuously monitor the water level at each return flow pump bay. During the RFPS Preliminary Design Review Meeting No. 1 (6-200 M-09) on February 13, 2018, CWP staff indicated they prefer the submersible style sensor for wet well applications. Level measurement will consist of submersible hydrostatic type pressure transducer and remote junction/desiccant box, and remote mounted external display/adjustment unit.

Alarms will be generated in the control system for low-low, low, high, and high-high pump bay levels. Pump bay level measurements will be interlocked with the return flow pumps for pump startup and shutdown, as well as pump speed control.

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12.9.4.4 Pressure Instrumentation

Pressure indicating transmitters with 4-20 mA analog output will monitor pressure at the 18-inch return pipe, as well as at each return flow pump discharge pipe. Alarms will be generated in the PLC for low-low, low, high, and high-high pressure measurements.

Pressure gauges will provide local pressure indication at the 18-inch return pipe, as well as at the discharge piping of each return flow pump.

12.9.4.5 Fox River Flow Instrumentation

In addition to the return flow meter described in Section 12.9.3, a flow indicating transmitter with 4-20 mA analog output will monitor flow at the proposed treated effluent piping extending from the existing effluent channel to the Fox River Outfall. The flow meter will be a flanged, magnetic type. The meter output will be totalized, trended, and recorded. The placement of the meter will be horizontal.

A required straight pipe run distance of five pipe diameters will be considered directly upstream of the meter to provide a uniform flow profile in order to maintain standard measurement accuracy. A required straight pipe run distance of two pipe diameters will be considered directly downstream of the meter.

An open channel flowmeter will monitor the flow at the existing effluent channel downstream of the UV disinfection weir troughs. The open channel flowmeter will consist of area-velocity transducers used in conjunction with a level transmitter. The meter will use the transit time difference of ultrasonic sound pulses to measure the open channel flow velocity. The ultrasonic pulses will be transmitted upstream and downstream across the channel at an angle, with the difference in the sonic wave transit time being directly proportional to the liquid velocity.

12.9.4.6 Site Security

Site security will be based on the existing security program at the CWP.

12.10 Construction

The purpose of this section is to describe the anticipated scope of construction that the selected contractor will incorporate into their site specific plan. The majority of these items will be determined by individual contractor means and methods. This section highlights some of the major activities that will be constant throughout the RFPS construction. Activities will include construction of the RFPS structures as an extension of the existing UV disinfection facility, general utility work, applicable site grading and paving activities, and general site work.

12.10.1 Sequence of Construction

Sequencing of construction will be required to coordinate with other Program Elements, minimize impacts to the schedule, and maintain access to the site. A sequence of construction will be prepared during design.

During construction, it may be necessary to isolate sections of utilities to make new connections for the new facilities or to perform startup and testing. Operational shutdowns will be identified during design to the extent possible, coordinated with WWU and CWP, and incorporated into the Contract Documents.

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12.10.2 Hours of Construction

The hours of construction of the RFPS will be coordinated with CWP staff.

12.10.3 Contractor Staging

To minimize ground disturbance and to create efficient workflow, an effective staging plan will need to be developed. Existing site constraints will include the Fox River to the northwest and coordination with existing CWP maintenance and operations as to not impede CWP performance.

Designated on-site areas will be utilized by the contractor to store equipment and materials. This area may incorporate an on-site construction trailer that will use local utilities such as electric, telephone, water, and sewer. These designated areas will be coordinated for the Contract Package and may include multiple contractors for each designated site.

12.10.4 Construction Site Security

The contractor will be responsible for site security. The site will be secured with temporary fencing, gates, lights, or cameras. if required. Gates and access doors will be locked in order to only allow access for contractor, its sub-contractors, owner and their representatives.

12.10.5 Erosion and Sediment Controls

The Contract Documents will require applicable erosion and sediment controls by preparing and submitting a Storm Water Pollution Prevention Plan (SWPPP) per the most recent requirements of NR 216.46. The bid documents will include applicable local details and specifications for erosion and sediment controls. Additional provisions will be provided at the limits of construction to further protect the Fox River as needed.

The construction drawings will identify and show required wetlands jurisdictional lines and buffers, and require that these areas be protected during the contract work. Site reporting and monitoring will follow the most recent requirement of NR 216.48. Typical recurring site reports include weekly inspections or after every 0.5-inch rain event. Additional reports including occurrences of non-compliance will be documented and submitted to the WDNR.

12.10.6 Dewatering Plan

The contractor's dewatering plan will be determined by means and methods and may not be needed in all areas. A contractor-prepared dewatering plan will be required by the Contract Documents. Soil borings will be provided to the contractor for information to facilitate bidding and aid in the development of a dewatering plan. The Contract Documents will require the contractor to perform geotechnical work during bidding and construction as needed to properly bid and construct the work. Dewatering discharge will generally be kept on-site and will follow all applicable erosion and sediment control standards and specifications provided by the local municipality or regulating agency. Additional protective measures will be taken to ensure site activities do not negatively impact the Fox River.

12.10.7 Haul Route and Site Access

Haul routes and access point locations will be determined during design and will utilize erosion and sediment controls including a stabilized construction entrance and/or wheel wash. The contractor will be required to keep roadways

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and plant service roads free from debris at all times. Site access will utilize existing drives or future access drives. Disturbed areas used as haul routes or site access and not intended to be used as future driveways or roadways will be restored to existing conditions.

12.10.8 Excavation Methods

The contractor will be required by the Contract Documents to have sheeting and shoring designed by a professional engineer licensed in the State of Wisconsin. It is anticipated that the pipeline excavations will require the use of a trench box or sheeting/shoring and structure excavations will require sheet and shoring. Subsurface conditions will dictate the excavation methods likely to be used.

The contractor will be required to protect slopes, existing structures and foundations in accordance with:

- Slope stabilization and protection methods
- Occupational Safety and Health Association (OSHA) requirements
- Temporary erosion control measures
- Local, county and state permit requirements
- Erosion control measures
- Dewatering plan
- Grading or surface water drainage plan

12.10.9 Material Management Plan

Stockpile Area: Materials to be used on-site or disposed of off-site will be stockpiled during construction within limits of construction. Stockpile areas will be shaped and free to drain, protected from erosion using silt fencing, seeding and mulching, or other control methods in accordance with the Program requirements. Staging areas will be determined during design.

On-Site Suitable Material: Approved excavated materials from the site may be reused on-site as fill or backfill.

Disposal of Non-Contaminated Materials: Materials characterized as non-contaminated materials will be disposed of per NR 500-538 of the Wisconsin Administrative Code. The contractor will coordinate with local disposal agencies and follow all local, county, and state dump limitations and regulations.

Disposal of Contaminated Materials: A Program-wide Soil and Groundwater Management Plan will be submitted to WDNR as part of the permitting process. The approved plan will guide the Program with respect to the handling and management of contaminated media while minimizing construction delays and the associated costs of material management.

12.10.10 Coordination with Other Construction Contracts:

Coordination with Contract Package 5 (Return Flow Pipeline and Outfall) will be needed during construction of the RFPS. Constraints will be identified during design and included in the Contract Documents.

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12.11 Sustainability

Sustainability, as described in the preceding sections, can be defined as meeting the demands of the present without compromising the resources for the future. The return flow to the Lake Michigan basin is the facet of the Program that makes the water diversion inherently sustainable. The RFPS is located at a predeveloped site at the CWP facilities, and is located at the interface of the built and natural worlds. Resilient, space efficient, and environmentally conscious design is important for the sustainability of the RFPS. Details about the efforts to incorporate sustainability into the design of the RFPS are outlined in the following section using the Triple Bottom Line (TBL) approach, focusing on the Social, Economic, and Environmental considerations in the design.

12.11.1 Social

The RFPS will be located at the CWP and it will have minimal impact on the surrounding area. The architecture of the RFPS building and the surrounding landscaping will be designed in a manner consistent with the existing CWP, as discussed in Section 12.5.3.

12.11.2 Economic

The economic design considerations of the RFPS focus on resiliency and efficient use of energy and space. The RFPS site has a small footprint at the end of the treatment train in order to better integrate the RFPS and the Return Flow Pipeline with the existing infrastructure. Section 12.6.2.2 describes how the limited amount of space available made VT pumps more favorable. The motors for the pumps in the RFPS will be equipped with VFDs in order to more efficiently use energy in operations as described in Section 12.8.6. The instrumentation, described in Section 12.9, includes monitoring the wet well water level and the pressure at the pump discharge to maintain favorable conditions for operations. The temperature and vibration of the pump, motor, and bearings will be monitored to assess the state of the equipment. Resiliency was a critical aspect of the pump station layout and design as described in Section 12.6.2 and 12.6.3. A standby power source will be incorporated into the design so that the RFPS is consistently available for operation. Section 12.8.2 describes the Automatic Transfer Switch integrated into the RFPS power system that will facilitate the transition to the standby power in the event of failure of the utility power source. This, in conjunction with the grade floor located above the 100-year flood level described in Section 12.3.1.1, contribute to the resiliency of the pump station.

12.11.3 Environmental

The RFPS is designed to minimize environmental impacts such as developing on a greyfield site, planting native species, avoiding adverse geology, minimizing soil disturbance, and a robust return flow management plan. The RFPS is located at the CWP, thereby utilizing a site that has already been developed and avoiding additional environmental impact to natural areas. The CWP will consider maintaining a minimum flow to the adjacent Fox River, to which the CWP currently discharges its entire effluent flow, in order to minimize impacts due to reduced flow and preserve surface water functions downstream. The potential scenarios for managing the flow to the two Outfalls, at the Root River and the Fox River, are described in Section 12.6.1. Additionally, monitoring the quality of the treated effluent at the site will help the CWP operators assess the quality of the treated effluent discharged at the Root River. Section 12.6.4 describes the sampling facilities that will help monitor compliance with the WPDES permit.

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SECTION 13 Return Flow Facilities Design

13.1 Overview

The purpose of the Return Flow Facilities and Outfall are to receive and discharge highly treated effluent from the City of Waukesha's (Waukesha's) Clean Water Plant (CWP) to the Root River. The Return Flow Facilities and Outfall will provide additional treatment and possibly include flow metering and sampling facilities to meet the Wisconsin Department of Natural Resources (WDNR) permit requirements. This section discusses the process design elements for the Return Flow Facilities and Outfall and design elements of the supporting disciplines: civil, electrical, and instrumentation and controls (I&C). The following three components of the Return Flow Facilities and Outfall are recommended:

1. Reaeration Structure
2. Outfalls to the Root River (Outfall Piping)
3. Potential Metering and Sampling Facilities

Figure 13-1 shows a diagram of those components in reference to the overall Return Flow system.

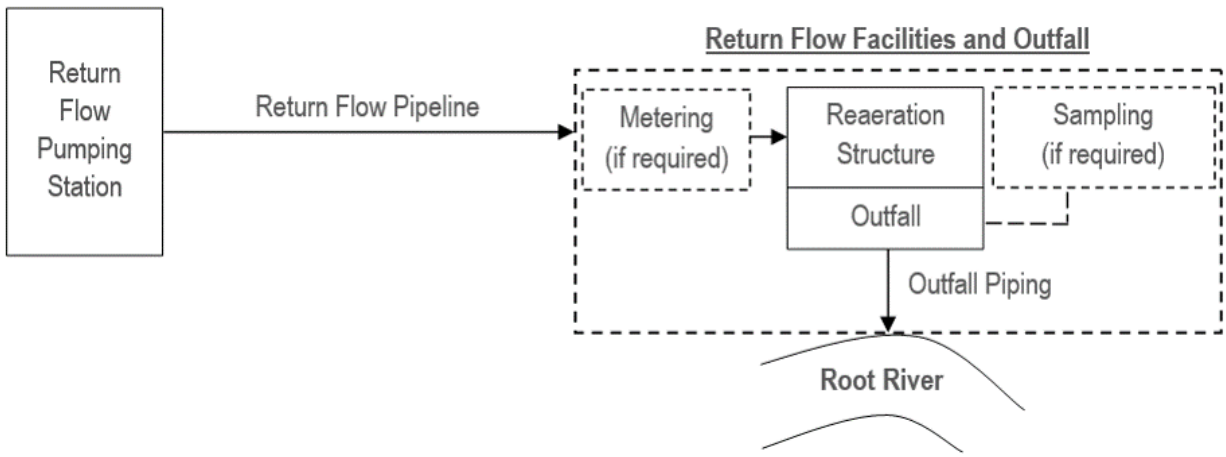

Figure 13-1 Return Flow Facilities and Outfall Diagram

The permit requirements for the Return Flow system are described in Section 3 and the Return Flow Pumping Station (RFPS) design elements are described in Section 12. The basis for the range of flows selected for the RFPS and downstream facilities pending are addressed in Section 12.6.1. Section 10 describes the Return Flow Pipeline design elements.

13.2 Site Location

13.2.1 Site Screening

During the application period for the "Lake Michigan Diversion with Return Flow" (Application), the Waukesha Water Utility (WWU) started acquisition of land within the City of Franklin (Franklin) for the Outfall as shown in Figure 13-2. The Application indicated that discharging into the Root River at that location would provide benefits to the river's ecosystem and the public. This site was selected as the preferred site to return highly treated effluent to Lake Michigan. Negotiations with the land owner are ongoing.

13.2.2 Preferred Return Flow Facilities and Outfall Site

The preferred site for returning treated effluent to Lake Michigan is of adequate size to accommodate the Reaeration Structure and other potential Return Flow Facilities and Outfall shown in Figure 13-1 and described in Section 13.4. All Return Flow Facilities will be located at the Outfall site to avoid acquisition of additional property.

13.3 Civil/Site

This section identifies the civil/site engineering requirements for the Return Flow Facilities. The following subsections present information about the data collection, desktop reviews and field investigations, along with the proposed improvements and associated requirements.

13.3.1 Data Collection

Desktop analyses were performed to determine the viability of the site. These analyses included reviews of land use and surface features, zoning, utility easements and setbacks, adjacent land uses, natural resources, environmental, environmental corridors, recreational corridors, wetland and waterway, floodplain and floodway, archeological, and endangered and threatened species. Field investigations were conducted to obtain information to support design activities. This section describes the investigations completed and to be completed during design. Field investigations include surveys, geotechnical borings, wetlands and waterways delineation, and hazardous materials sampling.

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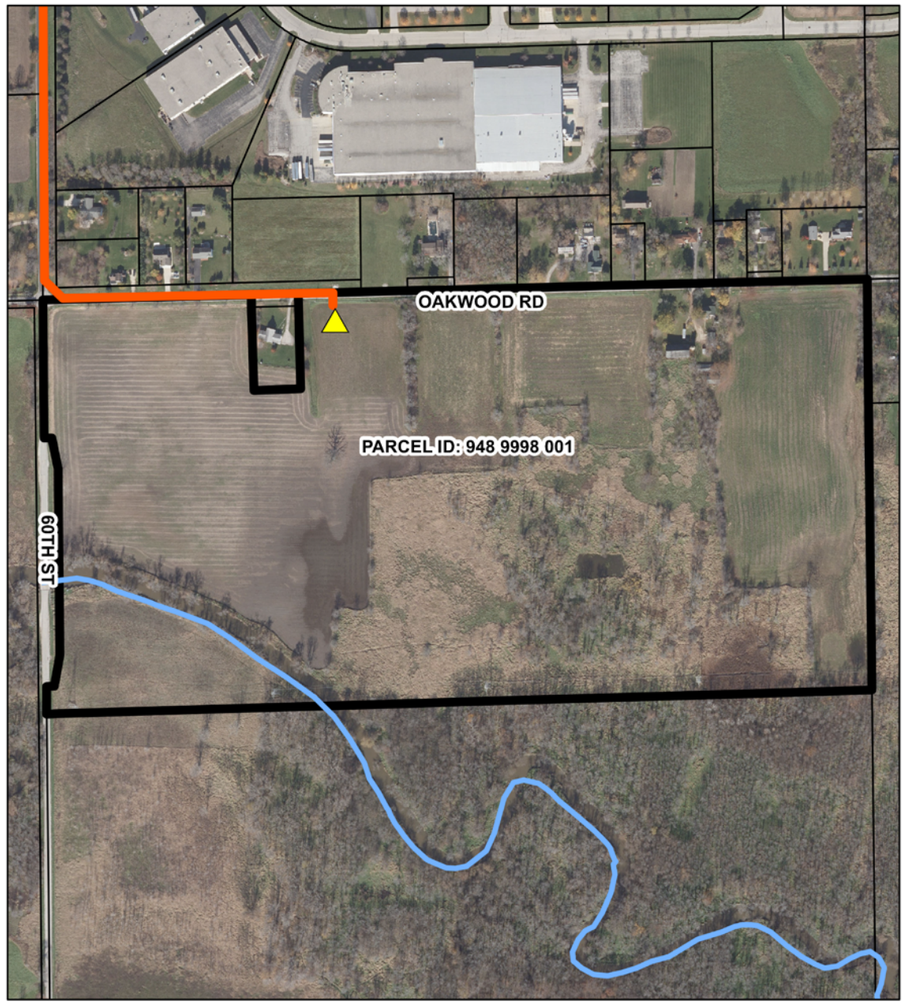
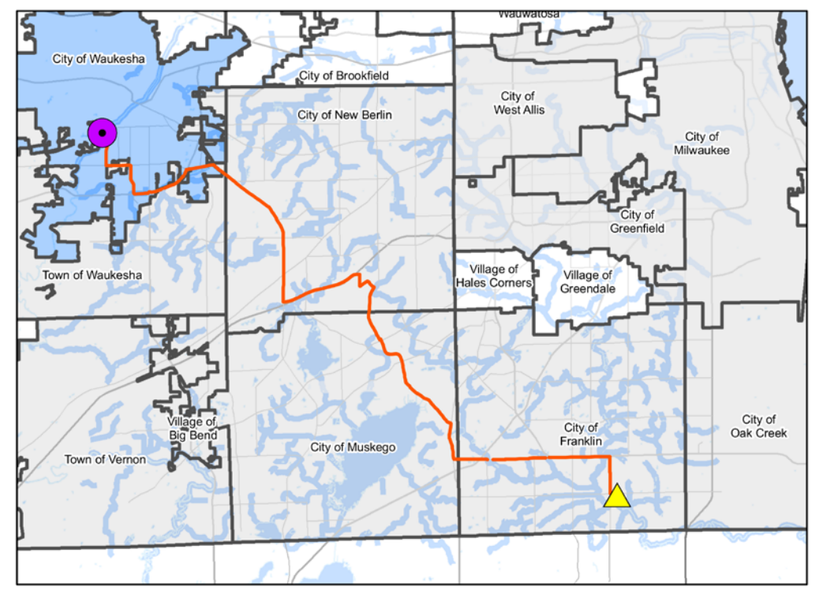


Return Flow Facilities and Outfall Location

Legend

- Return Flow Pumping Station
- Return Flow Facilities
- Selected Return Flow Route
- Return Flow Facilities and Outfall Parcel Limits



Key Map

Parcel Information

Location:	City of Franklin
Parcel ID:	948 9998 001
Owner:	Judith Gyuro, Laona Grudzielanek
Owner Address:	5207 W Oakwood Rd
Acreage:	78
Zoning:	R-2 & FW
Land Use:	Agricultural and Residential
Last Sale Date:	N/A
Sale Price:	N/A

Legal Description

THE NORTH 1/2 OF NORTHWEST 1/4 OF SECTION THIRTY-FIVE (35). TOWNSHIP FIVE (5) NORTH. RANGE TWENTY-ONE (21) EAST, IN THE CITY OF FRANKLIN, COUNTY OF MILWAUKEE, STATE OF WISCONSIN. EXCEPT THAT PORTION CONVEYED TO THE CITY OF FRANKLIN, IN WARRANTY DEED RECORDED JANUARY 24, 1984, REEL 1606, IMAGE 1324, DOCUMENT NO. 5687973, AND EXCEPT CERTIFIED SURVEY MAP NO. 2810 RECORDED IN REEL 926, PAGE 371. CONTAINS 78.4 ACRES, MORE OR LESS.

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Waukesha, Wisconsin 53186

Waukesha, Wisconsin
Great Lakes Water Supply Program
Return Flow Facilities and Outfall Location
Date: 4/27/2018

Plotted: 4/27/2018
Document Path: G:\15310-Waukesha Great Lakes Water Supply PM-CM\11 Task 6-Facilities\6-200 Design Reports\6-200 Design Report\Section 13 Return Flow Facilities Design\GIS Figures\Outfall_SiteFigure_DAB.mxd

Figure 13-2 Return Flow Facilities and Outfall Site Location

13.3.1.1 Desktop Analysis

Site Land Use and Surface Features: The site is located at the southeast corner of West Oakwood Road and South 60th Street in Franklin and is situated in part of Section 35, Township 5N, Range 21E of the 4th Principal Meridian. The address for the site is 5207 West Oakwood Road, Franklin, Wisconsin. The parcel is approximately 78 acres. The parcel is used for residential and agricultural purposes. The parcel slopes from north to south and the lower elevations include wetlands and floodplains of the Root River. Access to the site for residential and agricultural purposes is provided by an entrance from West Oakwood Road.

Zoning: The parcel resides within the city limits of Franklin. The City of Franklin zoning map provided in Figure 13-3 primarily designates this property as R2 – Estate Single-Family Residence District and FW – Floodway District with smaller areas designated as C-1 – Conservation Easement and FC – Floodplain Conservancy District, which are not expected or impacted by the proposed improvements. The location of the Return Flow Facilities and Outfall, except for the Outfall Piping discharge locations, are within zone R-2. The remainder of the parcel is located within zone FW.

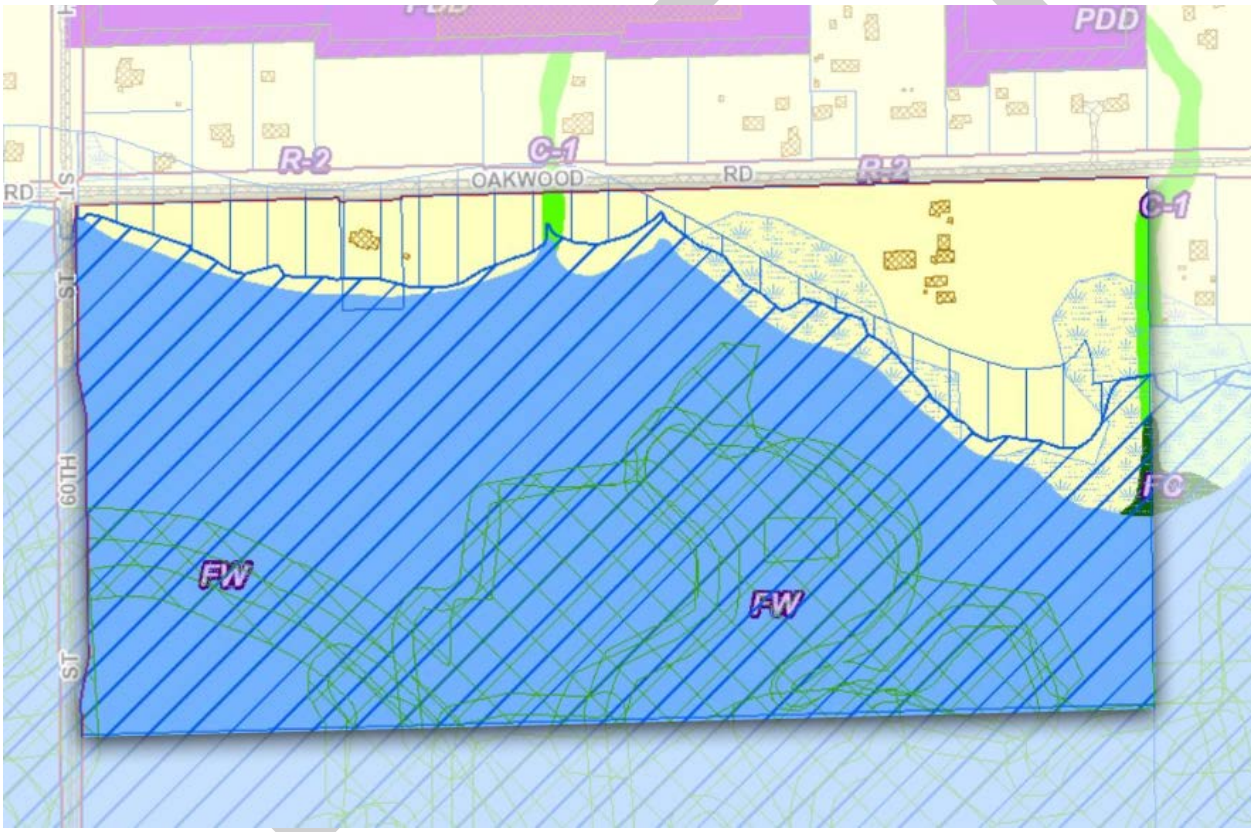

Figure 13-3 Zoning Map

R2 – Estate Single-Family Residence District – This designation requires buildings setbacks of 40 feet.

FW – Floodway District – Floodways and unnumbered "A" Zones on Federal Emergency Management Agency (FEMA) flood maps. Structures require locating outside of the Floodway District.

C-1 – Conservation Easement – No infrastructure improvements planned within C-1.

FC – Floodplain Conservancy District – Floodplain-designated lands which are located outside FEMA-designated floodways and unnumbered "A" Zones on FEMA flood maps. No infrastructure improvements within FC.

A zoning designation change may not be required due to existing zoning designations classifying utilities as a permitted use, however, it is recommended to confirm designations with Franklin.

Existing Utilities and Required Setbacks: We Energies maintains an overhead electrical line easement that stretches the entire length of the site along West Oakwood Road and the southern boundary of the site, as shown in Figure 13-4.

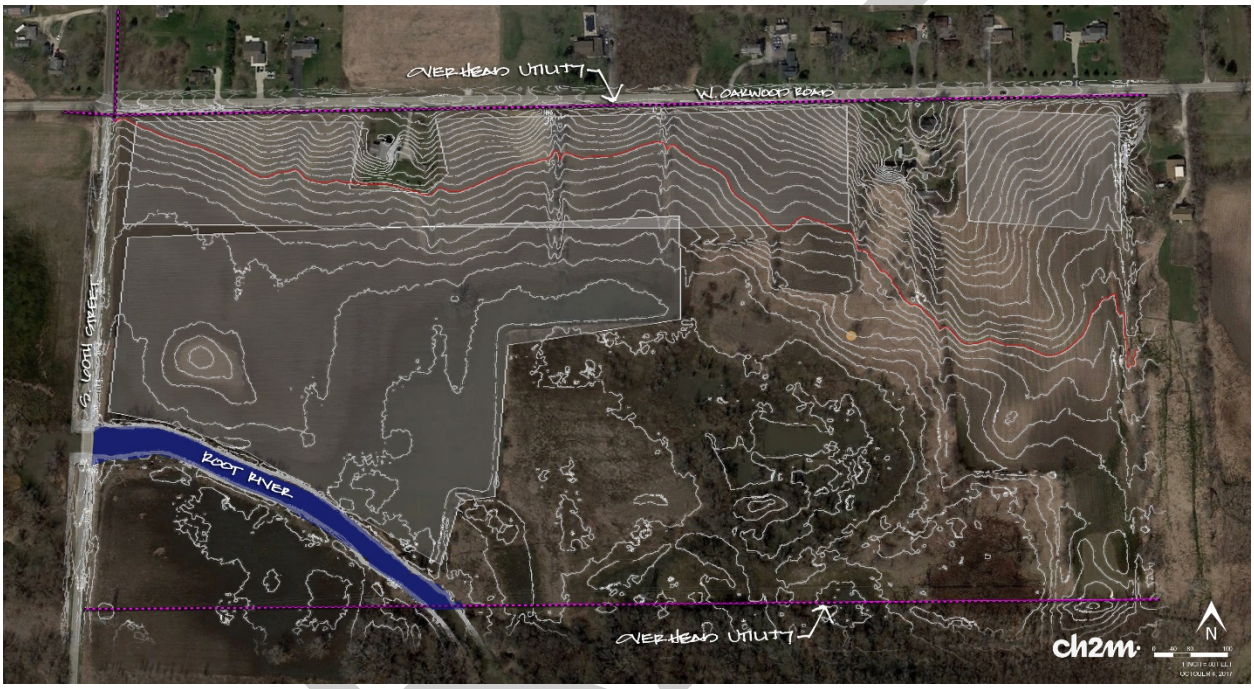

Figure 13-4 Overhead Electrical Utility Easements

The easement located along West Oakwood Road impacts some siting requirements of proposed buildings or structures. The following setbacks are required when siting infrastructure:

Overhead Utility – West Oakwood Road
Fences: N/A
Buildings (sheds, garages, etc.): 7.5 feet (horizontal), 13.5 feet (vertical)
25'-30' Ht. Trees (buffer): 30 feet (horizontal)
40'+ Ht. Trees (buffer): 50 feet (horizontal)
Other vegetation retaining walls: 14 feet (horizontal)

Utility Poles – West Oakwood Road
Fences: 4 feet (horizontal) No attaching to pole
Buildings (sheds, garages, etc.): 3 feet (horizontal)
25'-30' Ht. Trees (buffer): 30 feet (horizontal)
40'+ Ht. Trees (buffer): 50 feet (horizontal)
Other vegetation retaining walls: 4 feet (horizontal)

It is recommended that siting structures and potential future buildings consider setbacks to fulfill the building zoning requirement and the required We Energies setback to incorporate any potential vegetative screening of trees between the We Energies easement and required zoning building setback. It is unknown at this time whether a vegetative screen will be required for any potential future buildings, it is recommended that siting of structures incorporate sufficient space for vegetative screening. The proposed Reaeration Structure should be sited to incorporate a 40-foot setback from the We Energies setback to accommodate larger trees if needed in the future for screening.

Existing Land Uses: Existing land uses are agricultural and residential as shown in Table 13-1. Agricultural activities will continue in the future and improvements on-site are supporting these uses. Table 13-1 shows surrounding land uses to consider when siting proposed structures and potential buildings.

Table 13-1 Existing Land Use

Direction	Land Use(s)	Land Owner
North	Residential	Private
South	Recreational/Open Space	Milwaukee County
East	Residential	Private
West	Recreational/Open Space	Milwaukee County

Existing Natural Resources and Site Inventory: The constructed wetland has the following natural resource types as defined by the Natural Resource Protection Plan by Franklin:

Shore Buffers – Defined as the undisturbed land area, including undisturbed natural vegetation within 75 feet landward of the ordinary high water mark of navigable waters such as lakes, ponds, and streams and parallel to that ordinary high water mark. Shore buffers do not include area of land adjacent to streams enclosed within a current drainage structure such as a pipe or culvert. On the site, the shore buffers run parallel to the Root River and are expected to have the only permanent environmental impact from the Return Flow Facilities. The overall size of the impact will be determined during design.

Shoreland Wetland – Defined as a wetland that is located within a shoreland area, lands lying within one thousand (1000) feet of a lake, pond, or flowage or three hundred feet from a river or stream, or to the landward side of the floodplain areas. A wetland is defined as an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions. There are approximately 45 acres of wetlands presently on the Return Flow Facilities and Outfall site, 24 acres of which are presently disturbed through agricultural activities or farmed. The remaining wetland acreage is considered undisturbed or existing.

Floodlands – Lands, including channels, floodways, and floodplain fringe of a given reach, which are subject to inundation by the flood with a given recurrence frequency. The 100-year flood recurrence interval is used for zoning regulation.

Stream – A course of running water, either perennial or intermittent, flowing in a channel. The Root River is considered a stream on the Return Flow Facilities and Outfall site.

Woodlands (mature or young) – An area or stand of trees with a total combined canopy covers 1 acre for mature, and 0.5 acre for young, with at least 50% of which is composed of canopies of trees have a diameter at breast height (DBH) of at least 10 inches for mature, and 3 inches for young woodlands. Mature woodland can be considered a

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grove consisting of eight or more individual trees with a DBH of at least 12 inches whose combined canopies cover at least 50% of the area encompassed by the grove. From aerial imagery and site visit viewing, there are trees concentrated within the undisturbed existing wetland and within the shoreland area of the Root River. Further tree surveys will be needed to determine whether areas of the site fall under these woodland categories. Trees will be protected as much as possible as the design progresses.

Environmental: A preliminary site screening environmental desktop review of the Return Flow Facilities and Outfall site was conducted. The review identified potential environmental conditions at the proposed Return Flow Facilities and Outfall location. Environmental regulatory documents, Sanborn fire insurance maps, and historic aerial photographs have been reviewed. Limited site reconnaissance was performed as part of this assessment. No recognized environmental conditions (RECs), (as defined by the All Appropriate Inquiry (AAI) ASTM Standard E-1527-13), were identified at the site.

Environmental Corridors: Southeastern Wisconsin Regional Planning and Commission (SEWRPC) identifies environmental corridors as primary environmental corridors, secondary environmental corridors, and isolated natural resource areas. The site is located in a Primary Environmental Corridor. The Root River Watershed Restoration plan recommends that open spaces, such as primary environmental corridors, be preserved and expanded through native landscaping and small wetlands, woodlands, and prairies.

Recreational Corridors: 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 that is located 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 and Outfall site. The design of facilities at this site will support and avoid impacts to these Root River Parkway expansion efforts.

Wetland and Waterway: A wetland and waterway desktop review of the Return Flow Facilities and Outfall site was conducted. The review included analysis of digital wetland inventory (DWI) data from WDNR, United States Geological Survey (USGS) Topographic Maps, Natural Resources Conservation Service (NRCS) Soils maps form the United States Department of Agriculture (USDA), Google Earth street view, aerial photographs, and county geographic information system (GIS) topographic data. The wetlands were then classified using the Wisconsin Wetland Inventory (WWI) Classification System and emergent wetlands were further divided into the subcategories: natural and agricultural. At the site, the one WWI identified wetland abuts additional wetlands identified by photo interpretation and site visits. The identified wetlands are shown in Figure 13-5.

The Return Flow Facilities and Outfall will not directly disturb any natural wetlands. Site elements that affect agricultural wetlands will be mitigated per Wisconsin state and federal regulations.

Waterways at the Return Flow Facilities and Outfall site were evaluated using the National Hydrography Dataset (NHD) from the USGS. The Root River was identified as the only waterway on the site.

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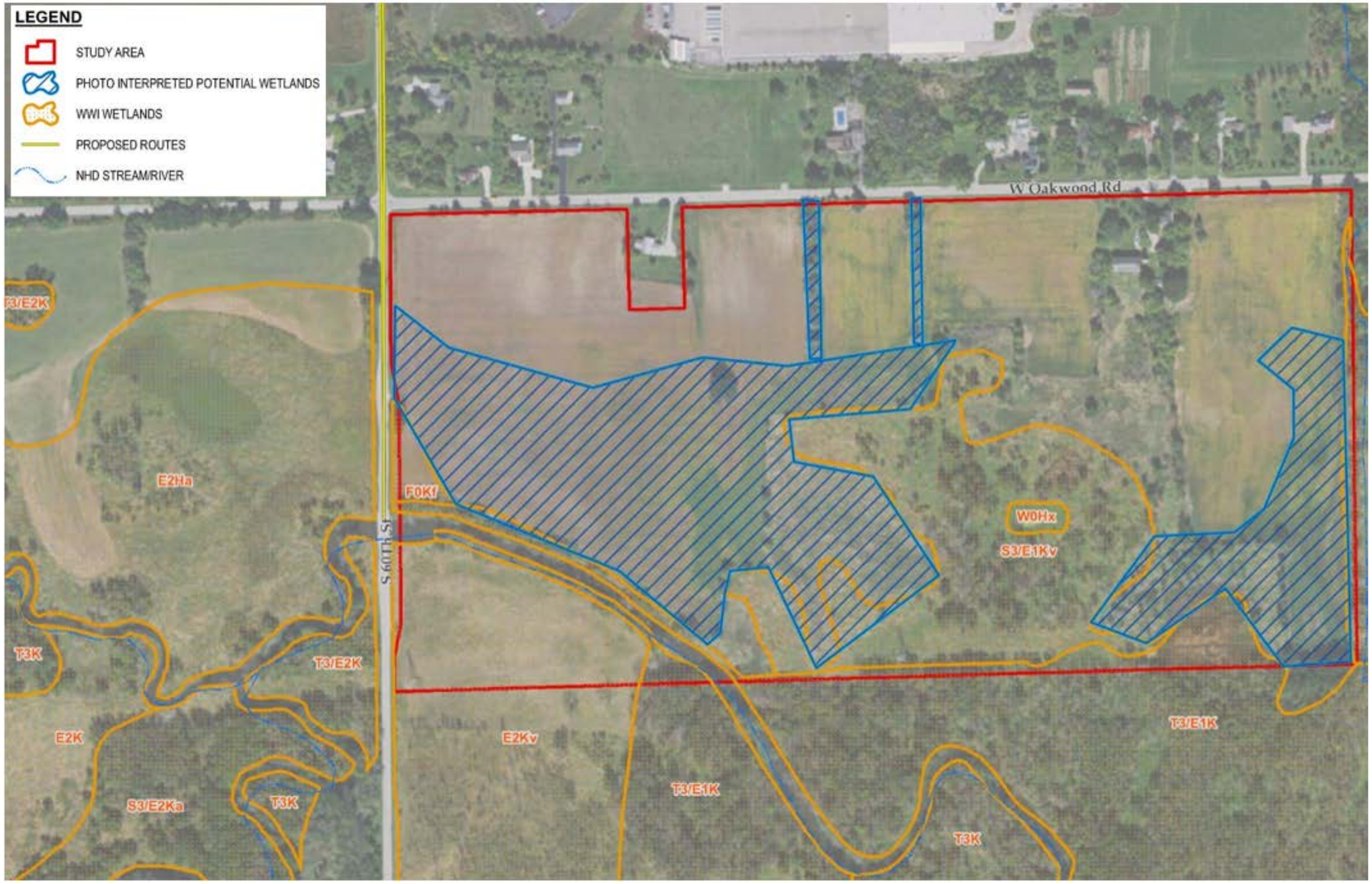

Figure 13-5 Return Flow Facilities and Outfall Wetlands Map

Floodplain and Floodway: The site was reviewed for potential floodplain impacts and is outlined in red on the FEMA map panel number 55079C0226E in Figure 13-6. The majority of the parcel is within a Zone AE. Zone AE areas are subject to a 1% 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 located is in the shaded Zone X. Zone X areas are subject to within a 0.2 percent (500-year floodplain) to 1% annual chance of flooding in any given year. The 100-year and 500-year floodplain elevation at the Return Flow Facilities and Outfall site is 682.2 and 684.4, respectively. At a minimum, all structures at the site will have the top of the grade floor located above the 100-year floodplain and for any below grade structures the top of the top slab will be located above the 100-year floodplain.

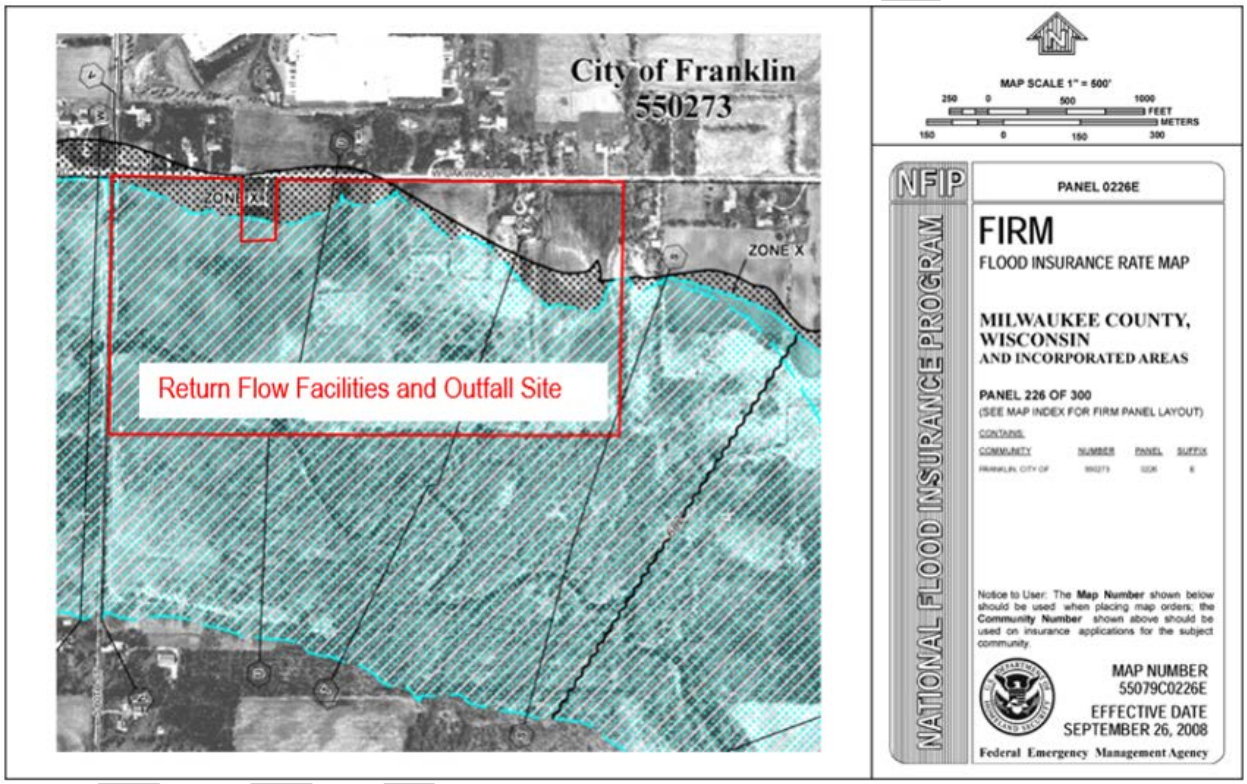

Figure 13-6 FEMA Floodplain Map Panel #55079C0226E

Archaeological: A desktop review for cultural, archaeological, and historical resources was performed. The desktop review of the site looked for the potential presence of archaeological sites or historic structures. This was accomplished by reviewing the State of Wisconsin's Historic Preservation Database (WHPD). Two archaeological sites were found to overlap parts of the site, 47MI180 and 47MI241. Site 47MI180 is located in the northwest corner of the Return Flow Facilities and Outfall site. Site 47MI241 overlaps a portion of the southwest edge of the Return Flow Facilities and Outfall site. To avoid potential impacts to the two sites, the Outfall Piping will avoid crossing these areas.

Endangered and Threatened Species: A desktop evaluation of rare, threatened, and endangered (RTE) species was performed. The evaluation was conducted via a review of recent and historical aerial photographs, the WDNR National Heritage Inventory (NHI) data, the United States Fish and Wildlife Service (USFWS) Information Planning and Consultation (IpaC) data, and the USFWS endangered species county data. Utilizing these resources, potential

RTE species and natural communities, collectively referred to as element occurrences (EOs), were identified and mapped on aerial photographs.

The RTE species evaluation was conducted in August 2017. The study area included the full Return Flow Route and associated parcels, with an associated one-mile buffer for terrestrial species, and two-mile buffer for aquatic species.

The Return Flow Route contains 32 EOs and three listings of federal RTE species including: the Poweshiek skipperling, northern long-eared bat, and eastern prairie-fringed orchid.

13.3.1.2 Field Investigations

Field investigations for the Program began in mid-2017. The site is used for agricultural purposes. In order to reduce impact to the crops, field investigations that would create land disturbing activities were planned to be conducted after crop harvest in the fall of 2017. Field investigations that would not create land disturbing activities were completed earlier. Field investigations for the site have been performed with no disturbances or negative effects on wetlands or waterways. Field investigations for the Return Flow Facilities and Outfall are scheduled to be completed by mid-2018. The status of the field investigations are described below.

Survey: The survey field work was completed after crop harvest to allow access to the site. If required, Land/Easement Acquisition Documents will be provided to WWU.

Geotechnical: The geotechnical field work was completed after the crop harvest to allow the use of drill rigs and other equipment on-site. The geotechnical report will provide information on the suitability of soils for structures to be located on the site and will be incorporated into the design.

Wetlands and Waterways: A wetland delineation of the site was performed in the fall of 2017. The delineated wetland is shown in Appendix E, Drawing Sheet CP5-C2 and in Figure 13-7. This wetland and waterway delineation was conducted in accordance with the guidelines of the 1987 Corps of Engineers Wetland Delineation Manual (Environmental Laboratory, 1987) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manuals (Northcentral and Northeast Region (Version 2.0, 2012) and in general accordance with WDNR guidelines. The wetland and waterway delineation report will be included as an appendix to the Chapter 30/Section 404 Wetlands and Waterways Permit Application to WDNR.

Archaeological: A Phase I Archaeological Survey of the site was conducted in 2017 in areas of the proposed improvements. The survey was conducted in accordance with the Guide for Public Archaeology in Wisconsin (Dudzik et al. 2012) and the Secretary of the Interior's Standards & Guidelines for Archaeology and Historic Preservation. The archaeological survey satisfies survey requirements for regulatory compliance and meets the standards for archaeological survey as outlined in the Guide for Public Archaeology in Wisconsin. Preliminary results indicate a portion of the site is classified as a disturbed historical site. Artifacts have been discovered in two locations within the property as shown in Figure 13-7. An isolated find exists towards the East and an area containing artifacts on the northern side of the Root River towards the west of the property has been identified. The report will be included as an appendix to the Chapter 30/Section 404 Wetlands and Waterways Permit Application to WDNR.

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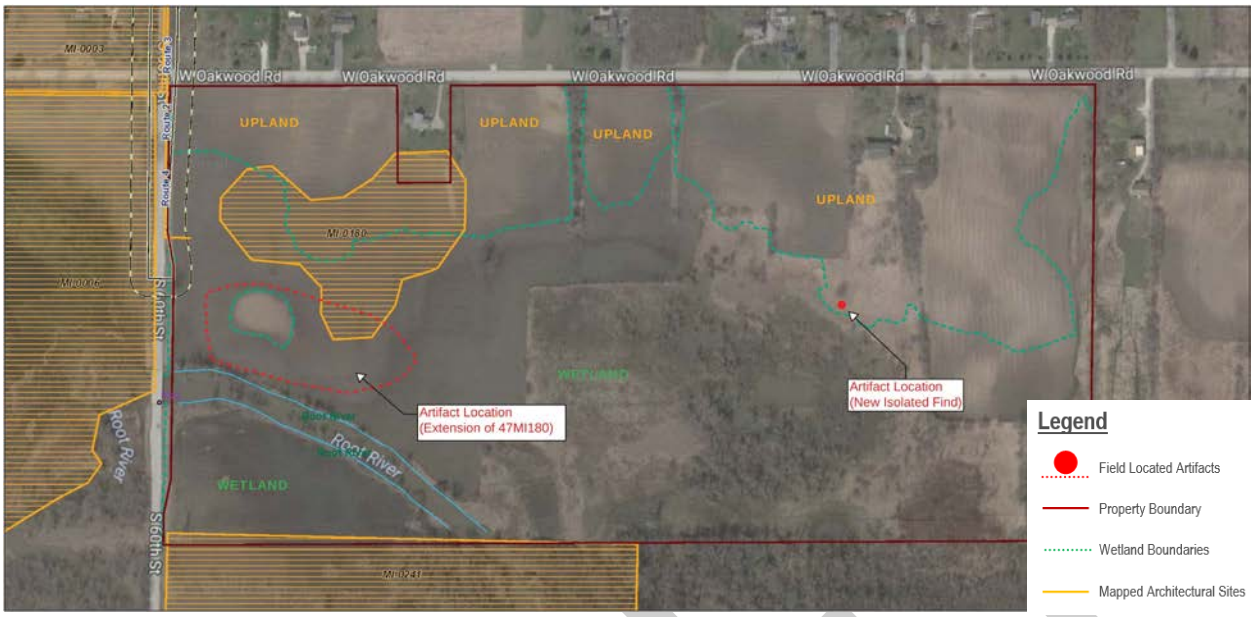

Figure 13-7 Wetland and Archaeological Site Location Map

Endangered and Threatened Species: A field review for endangered and threatened species at the site is not planned at this time.

Hazardous Materials Investigation: A hazardous materials field investigation at the site is not planned at this time.

13.3.2 Site Improvements

This section describes specific codes and ordinances applicable to the Return Flow Facilities and Outfall site. The evolution of the site plan is discussed along with the features and utilities proposed in the preliminary design drawings.

13.3.2.1 Site Layout

A conceptual design was performed to determine the feasibility of the site during the site screening process. The site layout was further developed and the preliminary site layout is presented in Appendix E, Drawing Sheets CP5-C1 through CP5-C4.

As shown on Appendix E, Drawing Sheet CP5-C2, the Reaeration Structure and, if required by WDNR, the Meter Vault and Sampling Structure, will be located near the north side of the parcel and outside the 100-year floodplain. These potential facilities are included in the opinion of probable construction cost. The Outfall Piping will extend south from the Reaeration Structure to the Root River.

13.3.2.2 Site Accessibility

Adequate ingress, egress, and set-up space for heavy-load trucks and cranes to the Return Flow Facilities and Outfall site will be provided. The access drive will connect to West Oakwood Road. Turning radii at curves and the roadway intersection will be designed to provide access for heavy-load trucks and cranes.

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13.3.2.3 Surface Restoration

Surface conditions, where disturbed, will generally be restored to original conditions on-site at the end of construction. Surface restoration for the Outfall Piping are described in Section 13.4.2.

Grading and Drainage: The existing drainage areas will be maintained to the extent possible. Grading at the Return Flow Facilities and Outfall site will be designed to facilitate positive drainage of rainfall runoff away from the access drive and facilities at a minimum slope of 1%. The grading for earthen slopes on-site will be steeper than three feet horizontal to one foot vertical.

Paving and Sidewalks: Access drives and paved areas will be designed for an American Association of State Highway and Transportation Officials (AASHTO) load rating of HS-20. The City of Franklin standards for concrete and asphalt pavement will be followed.

Landscaping: The current land use is agricultural with no existing landscaping. Planting and landscaping features will be in accordance with Franklin design standards and while attempting to minimize to reduce WWU maintenance.

13.3.2.4 Stormwater Management

Franklin's Stormwater Quality and Quantity Management Applicability Ordinance Section 15-8.0604 states that development disturbing five or more acres must follow water quality management requirements, and increasing impervious surface area by one-half acre must follow water quantity requirements. The estimated site disturbance surface area is not finalized at this time. The estimated disturbance area and impervious surface area increase will be estimated during design once the Return Flow Facilities and Outfall requirements are finalized. However, it is anticipated that the estimate will be below the limits of the water quality and water quantity management requirements, thereby precluding the need to implement stormwater management practices for the Return Flow Faculties and Outfall site.

13.3.2.5 Utilities

Electrical and natural gas utilities were contacted to coordinate existing utilities in order to define service location points for the Return Flow Facilities and Outfall. Both electrical and natural gas utilities are owned by We Energies. Information received from We Energies during utility coordination is described below. Site utilities and piping considered for the site include electric, fiber optic, natural gas, potable water (domestic water supply and fire protection), process piping, storm sewer, and sanitary sewer. Each utility was evaluated to determine the necessary connections and improvements required to the existing utilities.

Electric: Electrical service in the vicinity of the site is provided by We Energies. Three phase overhead electric lines are located along the south side of West Oakwood Road. On-site electrical conduit and duct banks will be as described in Section 13.5.

Fiber Optic: Fiber optic service will provide communications for the Program. It is anticipated that this service will be new and connect all Program Elements.

Natural Gas: Natural gas service in the vicinity of the site is provided by We Energies. A 6-inch gas main is located nearby on 60th Street. The Return Flow Facilities and Outfall are not anticipated to require natural gas service.

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Potable Water: Potable water service in the vicinity of the site is provided by Franklin and is located approximately 0.7 miles east on West Oakwood Road. The Return Flow Facilities and Outfall are not anticipated to require potable water service.

Fire Protection: Fire protection is not required for the Return Flow Facilities and Outfall.

Process Piping: The 30-inch Return Flow Pipeline will enter the Return Flow Facilities and Outfall site along West Oakwood Road and connect to the Reaeration Structure as shown in Appendix E, Drawing Sheet CP5-C4. Outfall piping from the Reaeration Structure to the Outfall structures located at the Root River shoreline will be as described in Section 13.4.2 and as shown in Appendix E, Drawing Sheet CP5-C2.

Storm Sewer: The Return Flow Facilities and Outfall are not anticipated to require storm sewers.

Sanitary Sewer: Sanitary sewer service in the vicinity of the site is provided by Franklin and is located approximately 0.4 miles north on South 60th Street. The Return Flow Facilities and Outfall are not anticipated to require sanitary sewer service.

13.4 Process Mechanical

The preliminary design of the Return Flow Facilities and Outfall has been summarized in the form of a basis of design provided in Table 13-2.

Table 13-2 Return Flow Facilities and Outfall Basis of Design

Description	Design Values
Return Flow Rate	
Minimum Hour, MGD	0.0
Initial Average Day, MGD	6.6
Future Average Day, MGD	8.2
Maximum Hour, MGD	12.0
Return Flow Facilities and Outfall	
Receiving Body	Root River
Water Quality Improvements at Return Flow Facilities	Cascade Aeration via Reaeration Structure

13.4.1 Reaeration Structure

A reaeration structure will be located before the Outfall with a potential Meter Vault, and Sampling Structure, prior to discharging to the Root River, as shown in Appendix E, Drawing Sheets CP5-C2 through CP5-C4. Using a series of downward stepped elevations or terraces, cascade aeration will be used at the Reaeration Structure to encourage turbulence to reaerate the highly treated effluent prior to discharging to the Root River. Equipment maintenance for operation is not expected for the structure. Terrace sizes should typically range from a 6 to 12-inch rise with a 12 to 24-inch run. The reaeration structure will be sited outside the 100-year flood plain. An influent chamber will be designed to accept and distribute treated effluent over the first terrace and an effluent chamber sited after the bottom

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terrace to collect and discharge effluent through to a 30-inch pipe. The effluent chamber will be designed to pool to measure dissolved oxygen levels. WDNR regulatory requirements will determine the ultimate sizing of the reaeration structure. The process mechanical features of the Reaeration Structure and Outfall including conveyance to the Root River, will be determined during design based on permit requirements currently under negotiations with WDNR.

13.4.2 Outfalls and Associated Piping

After the Reaeration Structure, discharge will flow into a single pipe of the same pipe material as the Return Flow Pipeline and a single Outfall structure to the Root River as shown in Appendix E, Drawing Sheet CP5-C2. If dissipative cooling is not achieved with one single Outfall structure, the plan has optionally sited three (3) additional Outfall structures to be constructed at a later phase further providing conditions for temperature reductions through dissipative cooling. The siting of Outfall structures will consider minimum disturbance to existing natural assets such as riparian vegetation to maintain habitat and water quality. Overall depths of Outfall pipes have a minimum of 6.5 feet to preclude freezing. Outfall pipe depths account for continued land disturbance from agricultural activities.

Depths of the Outfall structures will use optimum slope and minimum pipe depth criteria and sited below the Root River ordinary high-water mark as much as possible. At Outfall and headwall locations, 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.

Site restoration will occur after constructing the Outfall structure and associated conveyance piping. Table 13-3 contains recommended site restoration approaches by existing site condition area:

Table 13-3 Site Restoration Approaches

Existing Site Condition	Construction Expected to Impact	Recommended Restoration Method
Farmed Wetland, or an area of land that holds water seasonally at a minimum that could support wetland vegetation but continuous disturbed or cleared from existing agricultural activities	45-foot wide work area along 30-inch pipe route	Construction impacts are expected to be short in duration. Depending on time of year, grades will be restored to predevelopment conditions and cover crop seed will be broadcast with erosion control measures. Cover crop species such as red-top millet or oats will be considered depending on the time of year and proposed agricultural activities
Non-Farmed Wetland, or an area of land that holds water seasonally at a minimum which is not disturbed by land clearing activities and maintains continuous vegetated cover regardless of existing wetland vegetation species	None	None
100-Year Flood Plain	45-foot wide work area along 30-inch pipe route, along with Outfall structures	Grades will be restored to predevelopment conditions as much as possible

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Existing Site Condition	Construction Expected to Impact	Recommended Restoration Method
Root River Shoreline or Riparian Environment	45-foot wide work area along 30-inch pipe route, along with Outfall structures	Restoration of shoreline areas will meet or exceed WDNR's shoreland management program requirements within areas disturbed resulting from construction activities. The shorelands area may increase compared to predevelopment conditions depending on WDNR requirements as well as areas maintaining optimum soil depths over proposed conveyance pipes

13.4.3 United States Geological Survey River Gage Structure

The existing USGS River Gage Structure (Gage Structure) will be relocated from its current location on the south side of the Root River to the north side to collect accurate river condition data and prevent interference from the highly treated effluent mixing with river flows. The new location of the Gage Structure is expected to move a minimum of 100 feet upstream from the proposed Outfall structures near the South 60th Street Bridge for access as shown in Appendix E, Drawing Sheet CP5-C2. The Gage Structure will be raised at or above the 100-year flood plain. Utilities are not expected for the Gage Structure as it will operate solely from solar power facilities located clear of obstructions and shadows. If the Gage Structure requires samplers, pumps, refrigeration, and filters, utilities may need consideration.

13.4.4 Potential Metering or Sampling Facilities

During the Water Supply Facilities SCADA, Electrical and Mechanical Meeting (6-200 M-03) on August 17, 2017, return pipeline metering and sampling locations were discussed, including potential benefits of locating the return flow meter and sampling at the RFPS. If WDNR requires the equipment, its final location will be determined during design. Since the metering and sampling facilities are associated with the quantity and quality of the water entering the Root River, respectively, the facilities will be located at the Return Flow Facilities and Outfall site if not located at the RFPS or CWP. If the meter is located at the Return Flow Facilities and Outfall site it will be housed in a vault located upstream of the Reaeration Structure and provisions for equipment maintenance will be determined during design. If WDNR requires water quality parameters to be monitored at the Return Flow Facilities and Outfall, a prefabricated stainless steel Sampling Structure would be utilized to house an auto sampler and PLC. Section 13.6.3 addresses additional details.

13.4.5 Future Return Flow Control Building

In the future, if WWU desired to operate the Return Flow Pipeline as a pressurized force main, the Return Flow Control Building (RFCB), could be located near the intersection of South 60th Street and West Oakwood Road. The building could be located outside of the 100-year flood plain and front West Oakwood Road.

13.4.6 Permit Requirements for Temperature Limits

The Return Flow Facilities and Outfall will meet sub-lethal thermal temperature limits through dissipative cooling as required by WDNR. Additional measures may be required to meet WDNR permit requirements once constructed and testing of the system commences.

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13.4.7 Potential Constructed Wetlands

Constructed wetlands may be employed to decrease temperatures beyond dissipative cooling of the highly treated effluent. Preliminary modeling on effluent temperatures using historical data indicate temperatures at or above non-thermal limits in November. With temperatures near regulated levels, wetlands will decrease effluent temperatures below regulated levels.

Constructed wetlands should be designed to work with existing contours to minimize cost and balance cut and fill. Existing site conditions should allow enough wetland area to cool effluent temperatures to regulated levels, with the average width of the wetlands (water surface area with earthwork) of 100 feet allowing flow paths running east and west. Constructed wetlands should be designed with shallow, vegetated areas approximately 1 – 2 feet in depth, along with deeper zones to maintain flows and facilitate cooling. Deep zones vary from 4 – 6 feet. The site slopes 5 – 7% or more in some areas, allowing for a primarily gravity-fed wetland system designed in a series of steps or tiers going north to south.

Additional soil tests may indicate the need for lining constructed wetlands as the design progresses. While there is a groundwater well adjacent to the site, the well has not been located in the field and the constructed wetlands are not expected to be sited within 250 feet of groundwater wells. The presence of groundwater wells would prompt the required use of wetland liners if the wetlands are sited within 250 feet of a groundwater well.

To minimize environmental impacts incurred through earthwork and piping, constructed wetlands should be sited in the upland areas as much as possible. This will impact the existing farmed wetlands only.

Regulators and plan reviewers will classify constructed wetlands as separate from existing wetlands as they are not hydraulically connected to the existing wetlands and only used for cooling. Constructed wetlands designed to mimic habitat wetlands can support local flora and fauna and used as a public recreation amenity. Public involvement and coordination with the Franklin are recommended to define goals for the constructed wetland beyond cooling.

Reaeration technology is recommended after discharge from the wetland due to low dissolved oxygen through a constructed wetland and allow a minimum 7 mg/L of required dissolved oxygen levels before reaching the Root River.

13.5 Electrical

13.5.1 Source of Power

If required, electric power will be provided by We Energies from the existing overhead circuit on West Oakwood Road through a pole-mounted transformer owned by We Energies.

13.5.2 Bulk Electrical Distribution

The Sampling Structure, if required, will be equipped with electrical service at 240/120 volts, single-phase entering through a single underground feeder to a meter fitting at the structure's exterior. The service equipment will be a 100-amp panelboard, furnished with the Sampling Structure prefabricated building.

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13.5.3 Electrical Equipment Mounting

Electrical equipment will be installed a minimum of three feet above the 100-year flood elevation. Raceways entering structures from outdoors or below grade will be sealed to prevent passage of floodwaters.

13.5.4 Electrical Distribution and Branch Circuits

Electrical wiring to lighting and convenience receptacles within the Sampling Structure, if it is required, will be furnished with the prefabricated building. 120-volt power circuits will be extended to serve instrumentation and control equipment. Outdoor 120-volt convenience receptacles will be located at the Reaeration Structure and Sampling Structure exterior.

13.6 Instrumentation and Controls

13.6.1 Programmable Logic Controller

The control strategy for the Return Flow Facilities and Outfall will involve PLC interaction with the meter in the Meter Vault and the auto sampler in the Sampling Structure, if both structures are required. If required, monitoring at the Return Flow Facilities and Outfall will be accomplished through a standard microprocessor-based PLC panel and input/output (I/O) modules using instrumentation and network links to remote control systems. If required, the Return Flow Facilities will be furnished with manufacturer standard instrumentation and packaged controls.

The Return Flow Facilities and Outfall PLC will communicate with the RFPS PLC for remote monitoring through fiber optic connection.

13.6.2 Auto Sampler System

If the auto sampling facilities are required, the auto sampler system instrumentation will be determined during design.

13.6.3 Compliance Meter

If required, the Compliance Meter will consist of a flanged, Venturi type flow meter with differential pressure instrumentation for flow calculation. The analog pressure differential indicating transmitter (PDIT) will be used to convert high and low pressure readings from the Venturi meter into a 4-20 mA output signal. The meter output will be trended and recorded for compliance. The need for single or dual PDITs, based on flow ranges, will be evaluated during design. The compliance meter design will be based on a pipe diameter of 18 inches, a discharge flow between 0 and 12 MGD, and standard ANSI Class 150 flanges.

The compliance meter will be located within a Meter Vault at the Return Flow Facilities and Outfall site, upstream from the Reaeration Structure. The placement of the compliance meter will be horizontal. A straight pipe run clearance distance of ten pipe diameters will be considered directly upstream of the meter to provide a uniform flow profile in order to maintain standard measurement accuracy. A straight pipe run clearance distance of five pipe diameters will be considered directly downstream of the meter.

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13.7 Construction

This section describes the anticipated scope of construction that the selected contractor will incorporate into their site specific plan. The majority of these items will be determined by contractor Means and Methods. The goal of this section is to highlight some of the major activities that will be constant throughout the Return Flow Facilities and Outfall construction. Activities will include construction of the reaeration structure, a Meter Vault and Sampling Structure if required, Outfall piping, USGS Gage Structure, applicable site grading and paving activities, and site work.

13.7.1 Sequence of Construction

Sequencing of construction will be required to coordinate with other Program Elements, minimize impacts to the schedule, and maintain access to the site. A sequence of construction will be finalized during design.

During construction it may be necessary to isolate sections of utilities to make new connections for the new facilities or to perform startup and testing. Operational shutdowns will be identified during design to the extent possible, coordinated with WWU, and incorporated into the Contract Documents.

13.7.2 Hours of Construction

Hours of construction will be coordinated with WWU, Waukesha County, and Franklin. The hours of construction will not be earlier than 6:00 a.m. or after 7:00 p.m.

13.7.3 Contractor Staging

To minimize ground disturbance and create efficient workflow, an effective staging plan will be developed. The contractor will be constrained by adjacent active roadways, drainage ditches, and an existing wetland.

Traffic control will be implemented in active work areas near roadways to create a barrier between the construction and the public. This will include the use of detours, lane closures, flaggers, and temporary striping or signage.

Designated areas on-site will be utilized by the contractor to store equipment and materials. These areas may incorporate a construction trailer. The trailer will require utilities such as electric and telephone. Sanitary facilities will be provided. These staging areas will be coordinated in advance of construction.

The contractor will locate material on-site in designated storage areas or buildings. Material will be stored neatly and as directed by the manufacturer. Fill or aggregate material will be stored in dry, well-drained areas to prevent mixing with the substrate.

13.7.4 Construction Site Security

The contractor will be responsible for site security. The site will be secured with temporary fencing, gates, lights, cameras, etc. as required. Gates and access doors will be locked in order to only allow access for contractor, its sub-contractors, owner and their representatives.

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13.7.5 Haul Route and Site Access

Haul routes and access point locations will utilize erosion and sediment controls, including a stabilized construction entrance and/or wheel wash. The contractor must keep roadways free from debris. Site access will utilize existing drives or future access drives. These locations will follow Wisconsin Department of Transportation (WisDOT), county, and local permitting guidelines. Parking will be provided on-site for workers and visitors to the site. Disturbed areas used as haul routes or site access not intended to be used as future driveways or roadways will be restored to existing conditions.

13.7.6 Erosion and Sediment Controls

The Contract Documents will require applicable erosion and sediment controls by preparing and submitting a site specific Stormwater Pollution Prevention Plan (SWPPP) as part of the Stormwater Management Plan submitted to WDNR for approval prior to construction. The SWPPP will adhere to the requirements and standards set forth by NR 216.46 and NR 151.11 of the Wisconsin Administrative Code. The bid documents will include applicable local details and specifications for erosion and sediment controls. Additional provisions will be provided at the limits of construction to further protect the Root River as needed.

The construction plans will identify and show required wetlands jurisdictional lines and buffers, and require that these areas be protected during the contract work. Site reporting and monitoring will follow the most recent requirement of NR 216.48 of the Wisconsin Administrative Code, per WPDES Permit No. WI-SO67831-5. Typical recurring site reports include weekly inspections or after every 0.5-inch rain event. Additional reports including occurrences of non-compliance must be documented and submitted to the WDNR.

13.7.7 Dewatering Plan

A contractor-prepared dewatering plan will be required by the Contract Documents. Soil borings will be provided to the contractor for information to facilitate bidding and aid in the development of a dewatering plan. The Contract Documents will require the contractor to perform geotechnical work during bidding and construction as needed to properly bid and construct the work.

Dewatering discharge should be kept on-site and should follow applicable erosion and sediment control details and specifications provided by the local municipality or regulating agency. Attention will be given to work within existing roadside drainage ditches so as not to impede stormwater runoff. Flow will be diverted or maintained to avoid upstream impact. Additional protective measures will be taken to ensure site activities do not negatively impact the Root River.

Dewatering discharge that is found to be contaminated will be managed according to Section 13.7.9.

13.7.8 Excavation Methods

The contractor will be required by the Contract Documents to have sheeting and shoring designed by a professional engineer licensed in the State of Wisconsin. It is anticipated that the pipeline excavations will require the use of a trench box or sheeting/shoring and structure excavations will require sheet and shoring. Subsurface conditions will dictate the excavation methods likely to be used.

The contractor will be required to protect slopes, existing structures and foundations in accordance with:

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- Slope stabilization and protection methods
- Occupational Safety and Health Association (OSHA) requirements
- Temporary erosion control measures
- Local, county and state permit requirements
- Erosion control measures
- Dewatering plan
- Grading or surface water drainage plan

13.7.9 Material Management

Stockpile Area: Excavated materials that will be used as backfill will be stockpiled during construction and will be kept within the limits of construction. Stockpile areas will be neatly shaped and free to drain, protected from erosion using silt fencing, seeding and mulching, or other control methods in accordance with the project requirements. Staging areas will be determined during design.

On-Site Suitable Material: Suitable materials excavated from the site may be reused on-site as fill or backfill as approved by the design engineer or onsite representative. Unsuitable material will be disposed of off-site at appropriately licensed disposal facilities approved by entity having jurisdiction.

Disposal of Non-Contaminated Materials: Materials characterized as non-contaminated materials will be disposed of per NR 500-538 of the Wisconsin Administrative Code. The contractor will coordinate with local disposal agencies and follow local, county, and state dump limitations and regulations.

Disposal of Contaminated Materials: A Program-wide Soil and Groundwater Management Plan will be submitted to WDNR as part of the permitting process. The approved plan will guide the Program with respect to the handling and management of contaminated media while minimizing construction delays and the associated costs of material management.

13.8 Sustainability

The Return Flow Facilities and Outfall will be adjacent to environmentally sensitive areas as determined in the Application. Details of incorporating sustainability criteria into design of the Return Flow Facilities and Outfall are outlined in the following section using the triple bottom line approach focusing on the social, economic, and environmental aspects of the design.

13.8.1 Social

The Return Flow Facilities and Outfall site will have minimal impacts to the surrounding local character with its small footprint. Its proximity to the floodplain is not appropriate for residential or commercial development. The Return Flow Facilities and Outfall site is located near the Root River Parkway, a recreational corridor part of the Milwaukee County Park System (Park). The trails in the Park are a valued asset to the community. SEWRPC has developed a plan to extend the trail in the Root River Parkway recreational corridor around the Return Flow Facilities and Outfall site. The design of the Return Flow Facilities and Outfall has taken this into account and will not impact these efforts.

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13.8.2 Economic

The economic considerations of the Return Flow Facilities and Outfall focus on efficient use of space and resiliency. The Return Flow Facilities will be located outside of the floodplain above the 100-year flood elevation in order to minimize risk exposure. Electrical equipment will be located at a minimum, 3 feet above the 100-year flood elevation.

13.8.3 Environmental

The Return Flow Facilities and Outfall will be designed to minimize environmental impacts by monitoring the effluent, promoting biodiversity and health of the adjacent Root River. A Post-Return Flow Root River Data Collection Plan will be implemented to identify changes to the Root River affected by the return flow in order to adapt the return flow for improving habitat and the environment. The Root River serves as a Primary Environmental Corridor for wildlife movement with consistent flow and good water quality as important features for the River's resident aquatic species.

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SECTION 14 Program Cost

14.1 Opinion of Probable Construction Cost

14.1.1 Methodology

A Class 3 Opinion of Probable Construction Cost (OPCC) has been prepared in accordance with the Association for the Advancement of Cost Engineering's (AACE's) Recommended Practice No. 18R-97. Costs were developed in mid-2017 dollars at an Engineering News-Record Construction Cost Index (ENR CCI) value of 10,942. A contingency of 20% was used. Unit cost information used various resources in effort to provide the best available information for each item, including manufacturer quotes, RS Means, and local Southeast Wisconsin bid tabs.

The diagram shown in Figure 14-1 demonstrates the projected accuracy of the Program cost opinions as the Program progresses per AACE guidance. The Program cost opinion in this document represents a Class 3 Program Opinion of Probable Cost at 10-40% of full Program definition as shown in blue in Figure 14-1.

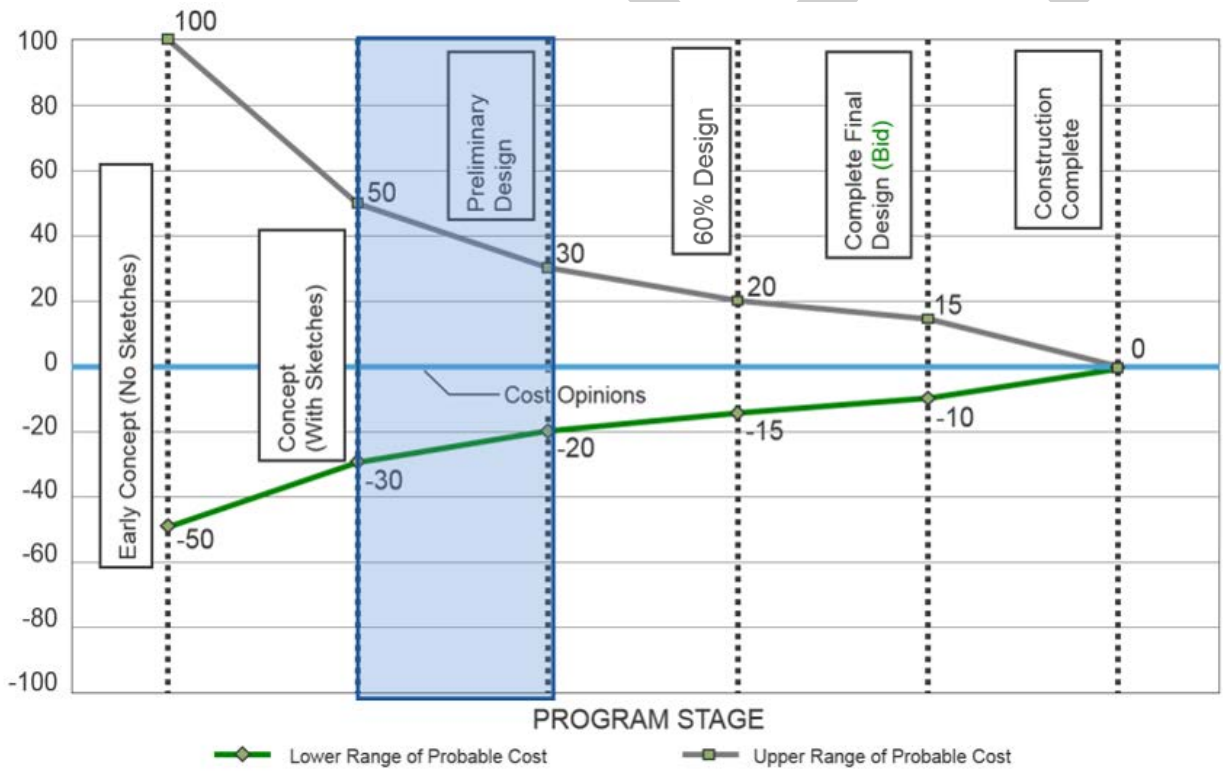

Figure 14-1 Cost Opinion Accuracy Diagram

14.1.2 Summary of Opinion of Probable Construction Cost

Table 14-1 provides a cost for each Program Element. Program Elements that are part of the Program, but are paid for, by entities outside of the Program, have been included for reference. The full OPCC for each Program Element is provided in Appendix C. The OPCC is organized by Program Element, as described in Section 2.

Table 14-1 Summary of Program Costs

Element No.	Program Element Description	($ Million)	Source Notes
1	Water Connection at Water Supplier	0.0	Milwaukee Water Works paying for full construction costs
2	Water Supply Pumping Station at Water Supplier	0.0	Milwaukee Water Works paying for full construction costs
3	Booster Pumping Station at Minooka Park	12.8	
4	Water Reservoirs at Minooka Park	13.0	
5	Water Supply Pipeline and Vaults	34.6	Milwaukee Water Works paying for first two miles of Water Supply Pipeline
6	Chemical Feed Facilities	0.3	
7	Water Connection at Waukesha	1.2	
8	Waukesha Water Distribution System Improvements	0.0	Included in Lake Michigan Water Diversion Total
9	Return Flow Pumping Station	4.1	
10	Return Flow Pipeline and Vaults	65.4	
11	Facilities at Root River	1.7	
12	Necessary CWP Improvements (Exclusive of Return Flow Pumping Station)	0.0	
13	Other Elements	0.0	
	Construction Subtotal	133.1	
	Bonds and Insurance (at 3%)	4.0	
	Mobilization / Demobilization (at 5%)	6.7	
	Contingency (at 20%)	26.6	
	Contractor Overhead and Profit (at 15%)	20.0	
	Construction Total	190.4	
	Engineering	36.50	Engineering contract upper limit
	Permitting, Legal, and Administration	-	Not included in Program costs, see Lake Michigan Water Supply Total below
	Engineering Services During Construction	7.5	Engineering services during Construction contract upper limit
	Construction Management	16.5	
	Program Total	250.9	
	Permitting, Legal, and Administration (Application)	6.8	Provided by WWU as cost incurred during the Application process
	Permitting, Legal, and Administration (Program)	5.8	Provided by WWU as anticipated costs
	Distrubition System Improvements	22.8	Provided by WWU as cost incurred and as anticipated DSI cost. Costs to be developed upon completion of distribution model.
	Lake Michigan Water Diversion Total	286.3	

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The Program costs are funded from a variety of revenue streams that ultimately pay the cost of the project, maintenance, or other needs. This includes sources such as appropriations, user fees, private donations, and other partner contributions. Including but not limited to; State and Federal Grants, Private Sector Grants, and primarily, the Clean Water Fund Program (CWFP) and the Safe Drinking Water Loan Program (SDWLP). The CWFP and SDWLP are administered jointly by the Department of Natural Resources (DNR) and the Department of Administration (DOA).

14.2 Operation, Maintenance and Replacement

Operation, maintenance and replacement (OM&R) costs have been developed to provide preliminary opinions of annual and Net Present Value (NPV) costs for the Program Elements. The OM&R costs are for Program Elements that either WWU or the City of Waukesha Department of Public Works (DPW) will own, operate and maintain. The full calculations for OM&R costs are provided in Appendix D.

14.2.1 OM&R Cost Assumptions

The key assumptions used to develop the OM&R costs include the following items.

- General:
  - NPV Gradient Series (NPV) utilized a 20-year planning period, which is consistent with Wisconsin Department of Natural Resources (WDNR) guidance on monetary analysis in NR 110, and an 8% Discount Rate and 3% Inflation Factor.
  - WWU provided existing facilities' electrical and natural gas costs from 2015 to 2017. These numbers were adjusted using the Construction Cost Index to convert to 2017 dollars and averaged to provide a baseline with which the Program OM&R costs can all be compared in 2017 dollars. Chemical costs were provided from 2017 and are used in the OM&R cost comparison.
  - When the Program is complete and the new system is operational, some of the existing facilities will have reduced OM&R costs due to the wells only being required for emergency backup operation, facilities being removed from service and other reduced load or ancillary costs that are being born by the new Program facilities. WWU provided assumptions that are reflected in the OM&R costs as to which existing facilities would remain in service, have reduced operations or not be utilized after the new water supply is operational.
  - OM&R costs associated with the Water Supply Pumping Station are not included in this comparison as they will be built into the wholesale water rate per the Water supplier contract held by WWU and Milwaukee Water Works.
  - Chloramine disinfection operations training costs were not included. Training will be included during construction as part of start-up services.
- Electrical:
  - A rate of $0.08/kWh for electrical unit costs was used.
  - Electrical costs for Program Elements were based on supplying an average day demand of 6.6 MGD for the Booster Pumping Station (BPS) and 6.6 Million Gallons per Day (MGD) for the Return Flow Pumping Station (RFPS). Miscellaneous electrical loads (such as lighting) that have not been designed were approximated based on not exceeding the 2009 International Energy Conservation Code (IECC) with Wisconsin Amendments and converted to horsepower (hp) for inclusion in the spreadsheets.
- Natural Gas:
  - A rate of $0.06/therm for gas unit cost was used.

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  - The BPS natural gas use calculations were based on the 2009 IECC with Wisconsin Amendments and modeled in Trace700, a program that calculates the heating and cooling loads.
  - The Water Supply Control Building (WSCB) and RFPS natural gas use estimates were based on heat loss per volume calculations. The gas usage estimate involved calculating the cubic feet of air movement and determining the BTU's required to heat that air volume within the building.

- Chemical:
  - The existing facilities' anticipated chemical cost reduction is based on 70% reduced chemical use at existing facilities. It is assumed that some of the existing facilities may be required to boost chloramine levels in the system to maintain sufficient residual disinfection. Water quality modeling and pipe loop testing to be performed as part of design will be used to define final chemical requirements and costs.
  - Chemical quantities for the BPS were based on supplying an average day demand of 6.6 MGD.

- Maintenance:
  - Maintenance costs are annual and are fairly consistent between years.
  - Costs for the Program Elements were provided for equipment, materials, consumables and labor on daily (D), weekly (W), monthly (M), quarterly (Q), semi-annually (SA) or annually (A).
  - Maintenance costs for the daily (D) frequency are based on five working days in a week.
  - Where Program Element maintenance costs occur less frequent than an annual basis (every two years, five years, etc.), the costs are prorated on an annual basis.
  - A labor rate of $120 per hour for WWU operators was applied for all Program Elements where WWU operations staff perform the maintenance activities.
  - Contract maintenance was assumed for lawn mowing, grounds keeping, internal road maintenance, and building tuckpointing. Contract maintenance utilized a labor rate of $100 per hour per laborer.
  - For the Program Elements, generator testing was assumed to be performed once per week, with two operators present. The fuel consumption cost was based on 0.07 gal/kWh, the associated generator rating, and a diesel fuel unit cost at $3.00/gallon.
  - Fiber optic service for the Program Elements is expected to be maintenance free over the 20-year planning period; therefore, those costs are not included in the OM&R cost comparison.
  - WWU standard practice requires two operators to perform pipeline maintenance activities.
  - Corrosion control testing for the pipelines was assumed to occur every five years. This activity was prorated on an annual basis.
  - $10,000 has been allocated for utility locating services for the Water Supply Pipeline and $15,000 for the Return Flow Pipeline. Coordination with USIC, LLC, an underground utility damage prevention company, will continue during design to refine locating service costs.

- Replacement:
  - Replacement costs are maintenance for larger costs or those that occur infrequently.
  - Costs are provided for replacement at 5, 10, 15, and 20-year frequencies as applicable. NPV costs were calculated based on the costs incurred at those intervals over the 20-year planning period. Annual costs were calculated based on the total NPV cost divided by the sum of the gradient series present worth factors.
  - Pipeline replacement is not anticipated within the 20-year planning period.
  - Human Machine Interface (HMI) software replacement is assumed to occur every 10-years with PLC hardware and associated software replacement every 20 years.
  - Test station replacement costs assume test stations will be located at 1,000-foot intervals along the pipelines, and that 10% of the test stations will require replacement every five years.

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- Anode replacement costs assume that anodes will be required at 10% of the test station locations along the pipelines after initial corrosion testing is performed after around five years of operations. Each anode is assumed to be comprised of five, 20-pound magnesium bags with a life expectancy of 30 years.

14.2.2 Summary of Annual OM&R Costs

The average operating budget for the existing facilities for the years 2015 to 2017 in 2017 dollars was $974,200. Based on the assumptions provided by WWU, there will be an anticipated reduction in cost at the existing facilities of $813,000 after the new water supply is operational. The anticipated cost to operate and maintain the existing facilities when the Program is complete is $161,200 on an annual basis.

The Program facilities OM&R cost requirements were developed for each of the following, using the previously stated assumptions:

- Water Supply Control Building
- Water Supply Pipeline
- Booster Pumping Station
- Return Flow Pumping Station
- Return Flow Pipeline
- Return Flow Facilities and Outfall

Calculations of the OM&R costs for each facility are presented in Appendix D. The anticipated total annual OM&R costs for the Program facilities is $1,325,300. Table 14-2 provides a summary of the existing facilities and Program facilities costs. The total of the existing facilities costs, anticipated existing facility cost reduction, and Program facility costs is $1,486,500.

Table 14-2 Summary of Annual OM&R Costs

Description	Cost ($)
Existing Facilities OM&R Cost	$974,200
Existing Facilities OM&R Cost Reduction	($813,000)
Existing Facilities OM&R Post Program, Subtotal	$161,200
Program Facilities and Pipelines Cost	$1,325,300
Great Lakes Water Supply Total OM&R Post Program Costs	$1,486,500

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SECTION 15 Program Schedule and Contract Package Sequencing

15.1 General

The Great Water Alliance (Program) Program Schedule with Contract Package sequencing has been developed in coordination with Wisconsin Department of Transportation, Wisconsin Department of Natural Resources (WDNR), local municipalities, and other various regulatory and governing agencies. The schedule during design has helped influence agency submittal dates in effort to remain on the critical path.

The Program Schedule will continue to be developed through design, updated and monitored throughout construction to provide clarity to Waukesha Water Utility, the Program Manager, and Construction Manager the current status of the Program. Additionally, each independent Contract Package can have progress tracked to remain compliant with regulatory requirements and achieve funding deadlines as part of the Safe Drinking Water Loan Program and Clean Water Fund Program as discussed in Section 3.

The Contract Package Construction sequencing is shown in Figure 15-1 will include construction of facilities, operational testing and commissioning to meet regulatory deadlines. Items on the critical path will be monitored during design and coordinated during construction to ensure Program compliance with mandatory completion dates and agreed Program budgets.

The Program has been strategically developed into multiple Contract Packages. Separate Contract Packages provide clarity to governing agencies for funding requirements. This topic is critical due to the numerous agencies involved with the design, permitting, and ownership of each Program Element. Separate Contract Packages allow more flexibility with bid review and procurement. The intention with a project of this magnitude was to provide reviewing agencies smaller packages for review in effort to not overwhelm and delay procurement and compliance prior to the start of construction. Additionally, multiple Contract Packages also allow greater flexibility for local resources, taking into consideration current and future state projects and private developments in the area (Foxconn). Another intent for separate Contract Packages is to attract larger, national contractors, as well as local contractors to promote a mix of experience and expertise. A diverse combination of contractors will provide flexibility with bonding capacity and personnel capacity.

Construction is scheduled to begin in mid-2020. The anticipated Contract Package Construction sequencing has been forecasted with consideration given to Public Service Commission (PSC) and WDNR agency reviews and possible contested case durations. The sequencing is summarized in Table 15-1.

Table 15-1 Contact Package Construction Sequencing Overview

Contract Package		Start	Duration	End
No.	Title	(Month Year)	(months)	(Month Year)
1	Water Supply Pumping Station	August 2020	14	October 2021
2	Water Supply Pipeline	August 2020	23	June 2022
3	Booster Pumping Station, Storage and Chemical Facilities	September 2020	18	February 2022
4	Return Flow Pumping Station	October 2020	14	November 2021
5	Return Flow Pipeline and Outfall	June 2020	28	September 2022
-	Program Startup and Transitioning	September 2022	11	August 2023

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As the Program progresses through permitting and design, the Program Schedule will be updated. The Construction Documents for bidding will detail coordination and construction constraints as well as milestones. These constraints and milestones, along with other factors, will be monitored using the Critical Path Method (CPM) throughout construction until the completion of the Program. The schedule will be monitored and updated as during construction to mitigate and avoid schedule slippage to ensure the Program will be complete and operational by September 2023.

15.2 Contract Package Sequencing

The extent of each contract Package for this Preliminary Design Report (PDR) have been set as described in Section 2. The number and extent of each Contract Package are being determined as part of the Draft Contracting Strategy Report (7-200 D1) being developed in coordination with WWU. For the purposes of this Preliminary Design Report (PDR), the schedule was developed with five Contract Packages. Contract Package 5 possesses the longest duration and will be bid first as to not delay the overall Program construction completion. Generally, pipeline Contract Packages possess longer durations and require an earlier bid time to meet the Program construction completion milestones.

Limited operational testing of the facilities may be accomplished prior to the completion of the connecting pipelines; however, full operational testing will need to be deferred until after the connecting pipelines are constructed and commissioned.

Existing facility operations for MWW, WWU and the city of Waukesha will be maintained at all times by facility owner. Any connection of new facilities to existing systems will be coordinated in order to minimize impact.

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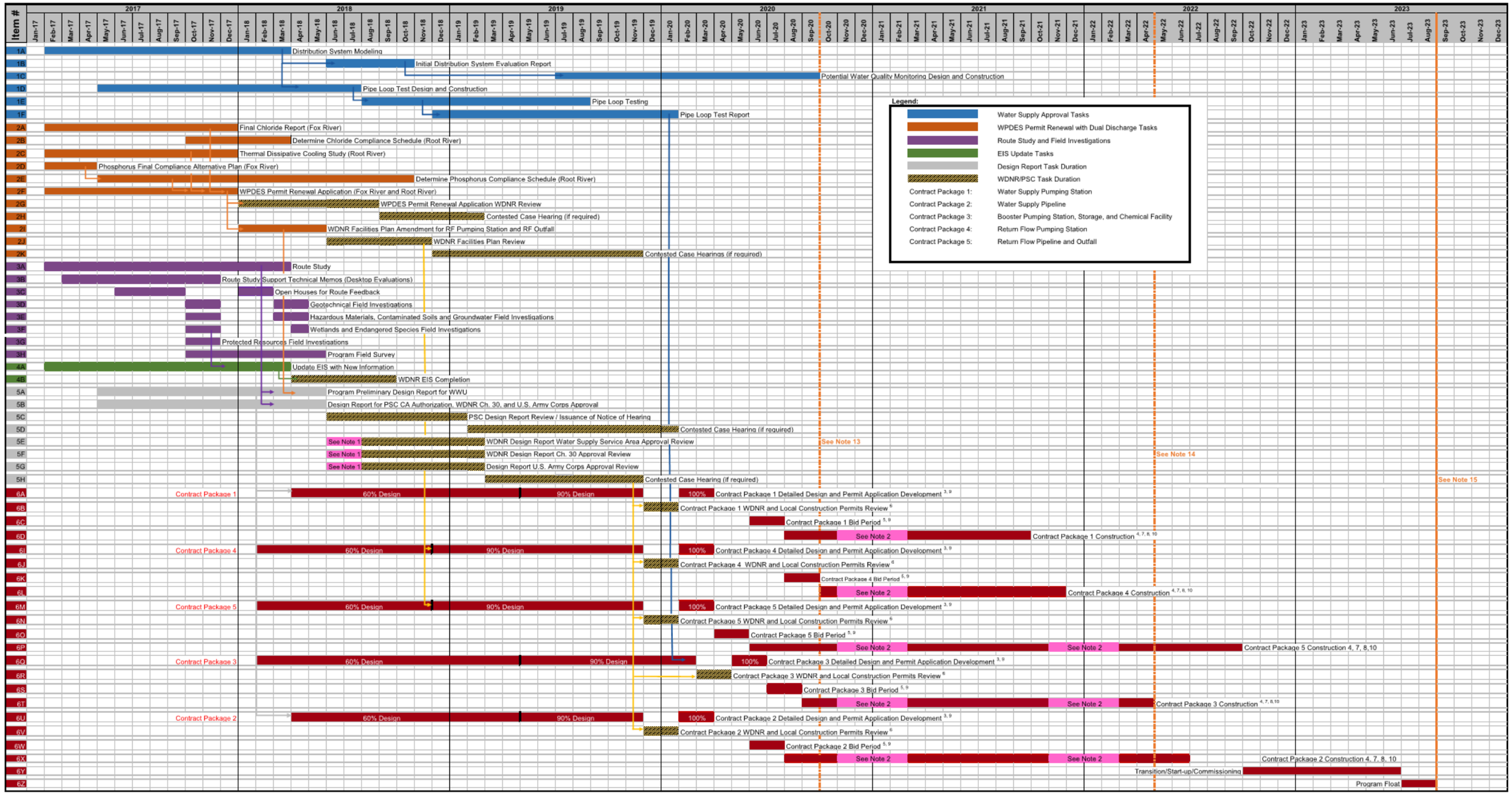

Figure 15-1 Program Schedule

Appendix A – Meeting Minutes

Appendix B – Drinking Water Regulatory Standards

Appendix C – Opinion of Probable Construction Cost

Appendix D – Operation, Maintenance and Replacement Cost

Appendix E – Preliminary Design Report Drawings (Bound Separately)

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