Draft Water System Plan Update

Prepared for
City of Blaine, Minnesota

February 2018

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Certifications

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Michelle A. Stockness PE #: 45155	Date

I hereby certify that the water system model and analysis was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Name PE #: Number	Date

Acronyms

Acronym	Description
AWWA	American Water Works Association
C/I/I	Commercial/Institutional/Industrial
CIP	Capital Improvement Plan
DNR	Department of Natural Resources
EPA	Environmental Protection Agency
GIS	Geographic Information System
GPCD	Gallons per capita per day
GWMA	Groundwater Management Area
HSP	High Service Pump
MDH	Minnesota Department of Health
MGD	Million gallons per day
MG	Million gallons
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MPARS	MN/DNR Permitting and Reporting System (new electronic permitting system)
MRWA	Minnesota Rural Waters Association
NFPA	National Fire Protection Association
NOAA	National Oceanic and Atmospheric Administration
SWP	Source Water Protection
TOC	Total organic carbon
VFD	Variable Frequency Drive
VOC	Volatile organic compound
WHP	Wellhead Protection
WSS	Water Supply and Sanitation
WT1	Water Tower 1
WT2	Water Tower 2
WT3	Water Tower 3
WT4	Water Tower 4
WT5	Water Tower 5
WTP1	Water Treatment Plant 1
WTP2	Water Treatment Plant 2
WTP3	Water Treatment Plant 3
WTP4	Water Treatment Plant 4

Definitions

Average Daily Demand	The total amount of water pumped during the year divided by 365 days
Maximum Daily Demand	The highest amount of water used for one day within a single year
Peak Day Demand	The maximum demand occurring in a given period
Peaking Factor	Maximum day demand divided by average day demand
Residential Per Capita Demand	Water delivered to residents during the year divided by the population served divided by 365 days
Total Per Capita Demand	The total amount of water pumped during the year divided by the population served divided by 365 days
Total Water Pumped	The cumulative amount of water withdrawn from all water supply sources during the year.
Total Water Delivered	The sum of residential, commercial, industrial, institutional, water supplier services, wholesale and other water delivered.
Unaccounted Water	Unaccounted for water use is the volume of water withdrawn from all sources minus the volume of water delivered.

1.0 Executive Summary

This report is intended to provide the city with a comprehensive analysis of their existing drinking water supply system, estimate future water system demands, and recommend improvements for the system through the year 2040. The City of Blaine's (City) population has grown steadily from 2005 when approximately 50,000 people were connected to the system, and is projected to continue to grow at a consistent rate through 2040 when it is projected to reach 87,300 residents. The population of Lexington, a neighboring City that Blaine supplies water to, is not included in the existing and projected population numbers. The existing water system contains a total of 21 supply wells, with a firm pumping capacity of 30.7 million gallons per day (MGD). The system contains four towers and a ground storage reservoir, with an adjusted combined storage capacity of 9.2 million gallons (MG). In 2016, the average daily demand was 6.9 MGD and the maximum daily demand was 13.3 MGD. By the year 2040, the average day demand is projected to be 10.21 MGD, with a peak day demand of 21.89 MGD. To meet this demand the city will need to add an additional treatment plant, additional water storage, as well as trunk watermain.

The City monitors water quality at each of their supply wells, treatment plants, and throughout the distribution system. Water quality results for treatment plant effluent have historically met both the primary and secondary drinking water standards. The City expects to continue to operate each of the treatment plants and future treatment plant so plant effluent continues to meet these water quality standards.

The existing distribution system is comprised of over 300 miles of watermain, ranging from 2.5 inches to 24 inches in diameter. The distribution system contains fifteen interconnections with the City of Lexington, in addition to the seven interconnections with the Cities of Circle Pines, Coon Rapids, Lino Lakes, Mounds View, and Spring Lake Park. The City does not have any plans to install additional interconnections, although steps are being taken to improve water quantity metering with the City of Lexington.

Hydraulic water system modeling results for the existing and future system reveal the distribution system generally meets the required velocity, pressure, and available fire flow recommendations for average day, peak day, and peak day with fire flow scenarios. A few locations were identified with lower pressures and reduced fire flow, however overall the system performance is acceptable.

Water conservation is a growing focus, where the City has several water conservation and efficiency measures already in place. The City is proactively improving their water system, and provides multiple educational efforts throughout the year, and enforces several water conservation ordinances. In addition to these existing water conservation measures, the City is also planning to start conducting leak detection monitoring for all City lines on a 3 to 4 year cycle to help identify leaks and reduce unaccounted water.

2.0 Background

In 2016, the City had a population of approximately 64,000 people. The population is expected to increase by approximately 23,000 people to 87,300 by the year 2040. In order to ensure the City continues to meet the demands of its growth, this plan was developed to analyze the existing system and determine future system requirements related to infrastructure and conservation efforts.

The report is broken down as follows:

- Section 3.0 Water System Criteria for Analysis
- Section 4.0 Existing Water System
- Section 5.0 Proposed Future Water System
- Section 6.0 Water Conservation and Efficiency Measures
- Section 7.0 Conclusions and Recommendations

Recommendations from Ten State Standards, Minnesota Department of Health (MDH), Minnesota Department of Natural Resources (DNR), primary and secondary drinking water standards, American Water Works Association (AWWA) Minnesota fire and building codes, and National Fire Protection Association (NPFA) requirements were used to evaluate system performance and infrastructure requirements related to water supply, storage, distribution, and water quality, which are discussed in Section 3.0.

The City's existing system is discussed in Section 4.0. The current population and historical demands are included, as well as information related to water quality and the City's infrastructure: supply wells, treatment plants, storage structures, and distribution system. An existing system model was developed and calibrated utilizing this information to help with planning.

Information from the existing system was used in addition to projected populations, demands, and land use maps to evaluate future system requirements, which are covered in Section 5.0. Trigger charts were developed to show when additional wells, treatment plants, and storage structures will be needed to meet growing demands. The water system model was updated to evaluate system performance and determine the requirements for future infrastructure needs.

In addition to future infrastructure needs, conservation efforts currently being implemented by the City are included in Section 6.0 of the plan as well as new efforts the City is planning to undertake to help improve water conservation. Conclusions and recommendations associated with new water conservation efforts, future infrastructure, and operations and maintenance (O&M) are included in Section 7.0.

3.0 Water System Criteria for Analysis

The following sections describe the criteria used to evaluate the water system performance and future infrastructure recommendations.

3.1 Water Quantity and Supply

Per Ten State Standards recommendation 3.2.1.1, the water supply capacity shall equal or exceed the design maximum day demand with the largest producing well out of service. For this study we have included the following additional assumptions when considering supply: Well 7 is not included in the base supply calculations since it may be abandoned in the future. In addition to this, Well 15, which is owned by Lexington, is also excluded from firm pumping supply calculations.

3.2 Water Quality and Treatment

The Primary Drinking Water Regulations and Secondary Drinking Water Regulations were used to evaluate water quality. These regulations are administered by the Minnesota Department of Health (MDH) and EPA.

3.3 Distribution System

The performance of the distributions system was evaluated using the following parameters per MDH, American Water Works Association (AWWA) and Ten State Standards Recommendations:

- Minimum pressure (PSI): 35 psi
- Minimum recommended pressure (PSI): 50 psi
- Maximum recommended pressure (PSI): 80 psi
- Maximum recommended pipeline headloss (ft/1,000 ft): 10 feet
- Maximum velocity (feet per second [FPS]): 10 fps
- Minimum pressure during fire flow (PSI): 20 psi

3.4 Storage Volume

Per Ten State Standards recommendation 7.0.1, the minimum storage capacity (or equivalent capacity) for systems not providing fire protection shall be equal to the average daily consumption. This requirement may be reduced when the source and treatment facilities have sufficient capacity with standby power to supplement peak demands of the system.

3.5 Fire Flow Requirements

The Insurance Services Office (ISO) report from September 28, 2009 indicates that the basic fire flow for the City is 3,000 gpm. The ISO requirements vary throughout the City depending on building construction and location. The Minnesota Fire Code states that the minimum required fire flow for residential areas is 1,000 gpm and the minimum required fire flow for other building types is 1,500 gpm.

3.6 Building Code

Water infrastructure facilities should meet current building codes and NFPA requirements.

3.7 MN DNR Benchmarks

The Minnesota Department of Natural Resources (DNR) recommends the following for public water supply systems in Minnesota, as outlined in their Water Supply Plan Template, Part 3B:

- Objective 1: Reduce unaccounted water (non-revenue) water loss to less than 10% (Unaccounted for water is the difference between the metered volume pumped and the volume delivered to customers.)
- Objective 2: Achieve less than 75 gpcd residential water use
- Objective 3: Achieve at least 1.5% annual reduction in non-residential per capital water use
- Objective 4: Achieve a decreasing trend in total per capita demand
- Objective 5: Reduce the ratio of maximum day (peak day) to the average day demand to less than 2.6

3.8 Partnership for Safe Drinking Water

The Partnership for Safe Water (Partnership) is an alliance of six drinking water organizations with a goal to improve the quality of water delivered to customers by optimizing water system operations. The Partnership goals go above and beyond minimum regulatory standards. Goals as outlined by the Partnership include the following:

- Disinfectant residual: optimized systems shall use secondary disinfection for all supply with free chlorine between 0.2 mg/L and 0.4 mg/L for 95% of the routine readings each month
- Pressure: An optimized system shall maintain a minimum pressure of 20 psi and a minimum pressure of 35 psi under monthly average day demands.
- Main break frequency: The optimization goal for main break frequency annually is a maximum of 15 for each 100 miles of distribution pipelines.

4.0 Existing Water System

4.1 Population

The City's population for 2016 is estimated at 63,900 according to the 2010 U.S. Census. From 2005-2016, the population served has increased at a consistent rate, increasing on average by approximately 1,400 people per year. Historical values for population served were obtained from the City's 2016 Department of Natural Resources (DNR) Water Supply Plan (Barr, 2016). Not all City residents are served by the City's water system, but for planning purposes, the City has decided to assume the entire population will be served by the water system in future, meaning total population is equivalent to population served. Lexington's population, estimated at 2,068 people for 2014 according to the 2015 Metropolitan Council Thrive 2040 System Statement is **not** included in the historical or existing Blaine population served.

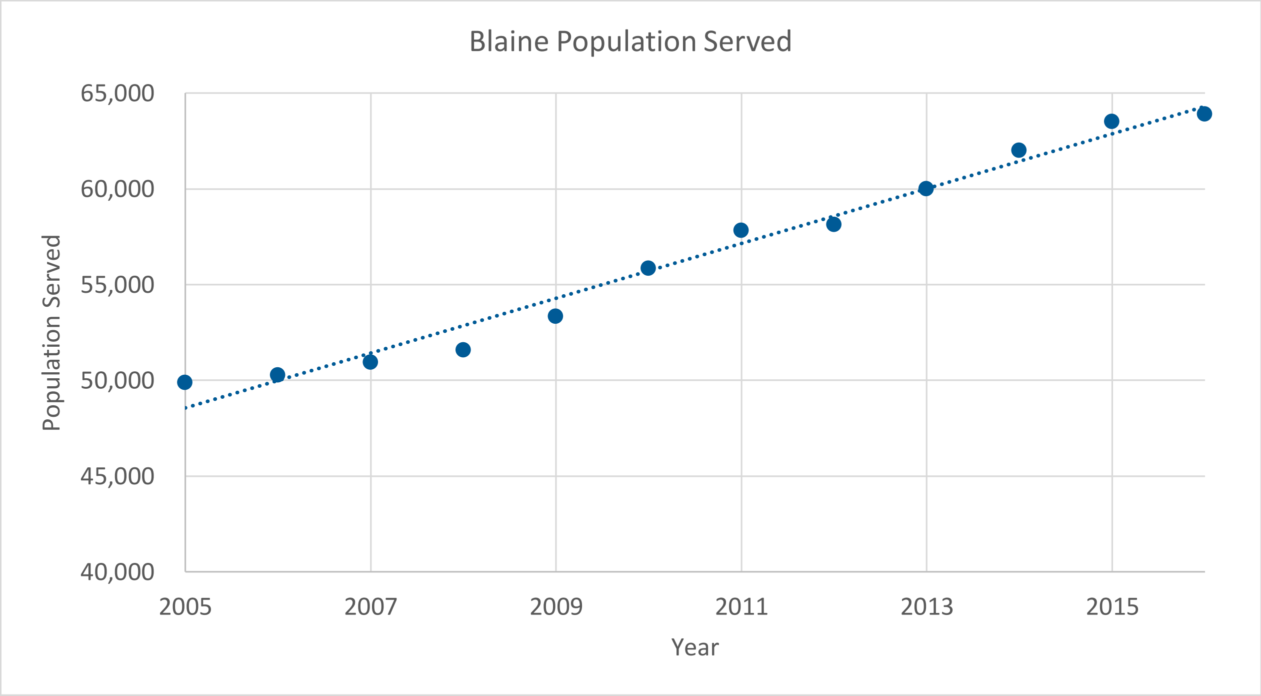

Figure 4-1 Historical Population Served

4.2 Demands

Demands for 2016 were consistent with historical demands, with an average day demand of 6.24 MGD and a peak day demand of 13.31 MGD. The City of Blaine utility billing tracks water use by the following categories: residential, commercial, water supply and sanitation (WSS), and institutional water usage. The gallons delivered in 2016 for each category, along with the number of connections per category, are included in the following table.

Table 4-1 2016 Water Use per Customer Category

Category	Gallons Delivered (Gallons)	No. of Connections	Water Use (gpcd)
Residential	1,591,512,512	18,698	68.2
Commercial	629,467,863	818	n/a
WSS	270,910	1	n/a
Institutional	56,245,020	64	n/a
Total:	**2,277,496,305**	**19,581**	**97.6**

The total percentage of water delivered in 2016 for each customer category is displayed in the following figure. Residential use made up nearly 70 percent of water delivered while commercial use was just below 28 percent.

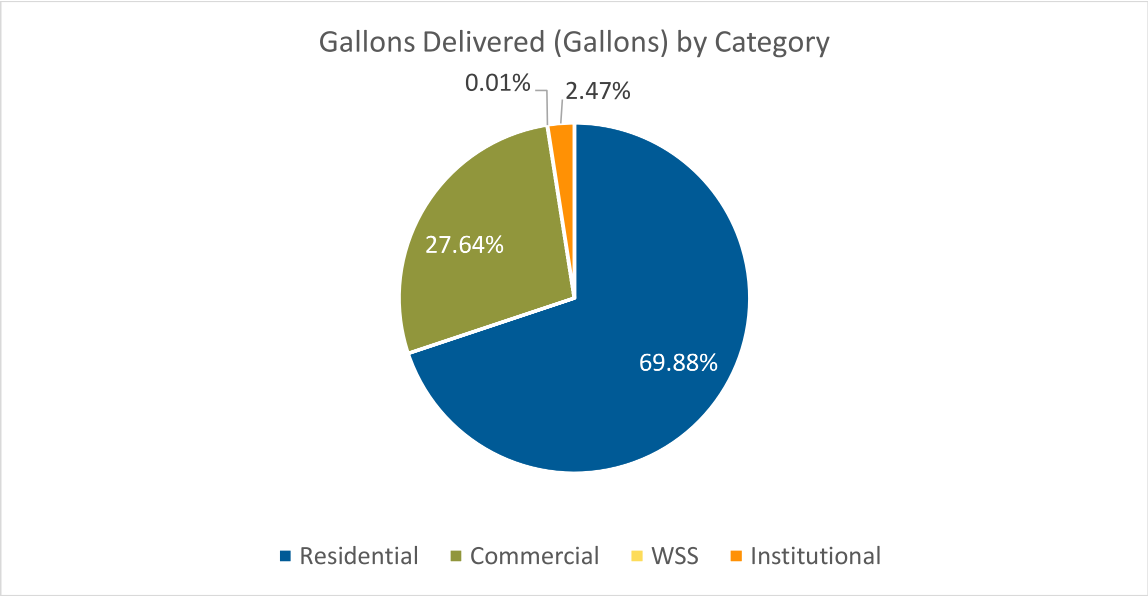

Figure 4-2 2016 Percentage of Gallons Delivered per Customer Category

Historical water demands were obtained from the City's 2016 DNR Water Supply Plan (Barr, 2016). On a daily basis, the City has reported that peak water usage begins around 5:00 PM and ends around 2:00-3:00 AM. The average daily demand, max daily demand, and peaking factors from 2005-2016 are listed in the following table.

Table 4-2 Historical Water Demand 2005-2016

Year	Average Daily Demand (MGD)	Average Daily Demand (gpcd)	Peak Daily Demand (MGD)	Peak Daily Demand (gpcd)	Peaking Factor
2005	6.1	122	10.2	205	1.7
2006	6.9	138	16.2	322	2.3
2007	7.0	137	17.9	352	2.6
2008	6.8	131	17.2	334	2.5
2009	7.3	137	17.2	323	2.3
2010	7.3	131	14.8	266	2.0
2011	7.0	122	11.1	194	1.6
2012	7.7	132	11.9	205	1.6
2013	6.9	115	18.9	316	2.8
2014	6.4	103	13.2	214	2.1
2015	6.4	101	13.3	210	2.1
2016	6.2	98	13.3	208	2.1
Ten Year Average (2007-2016	**6.9**	**119**	**14.9**	**262**	**2.2**
DNR Water Supply Plan Average (2010-2015)	**6.9**	**117**	**13.9**	**234**	**2.14**

The following two figures show how the City's water demand is influenced by climate, where warmer years with more days above 90 degrees Fahrenheit and lower annual precipitation totals tend to have higher max daily demands, likely due to increased irrigation, and years with higher precipitation and fewer days above 90 degrees Fahrenheit tend to have lower max daily demands. The temperature and precipitation data shown in these figures was collected from the National Oceanic and Atmospheric Administration (NOAA), which tracks historical temperature and precipitation data. The temperature and precipitation data represents data collected in the Twin Cities Area from 2005-2016.

Recent years, between 2014 and 2016 have experienced cooler summers with higher precipitation, which has resulted in lower average and maximum daily demands. Warmer summers with less precipitation will likely reoccur which will result in increased water demands. This will need to be considered when determining future infrastructure requirements. This would suggest considering using higher average and peak day projections, such as those from 2006 and 2007, when considering future infrastructure needed.

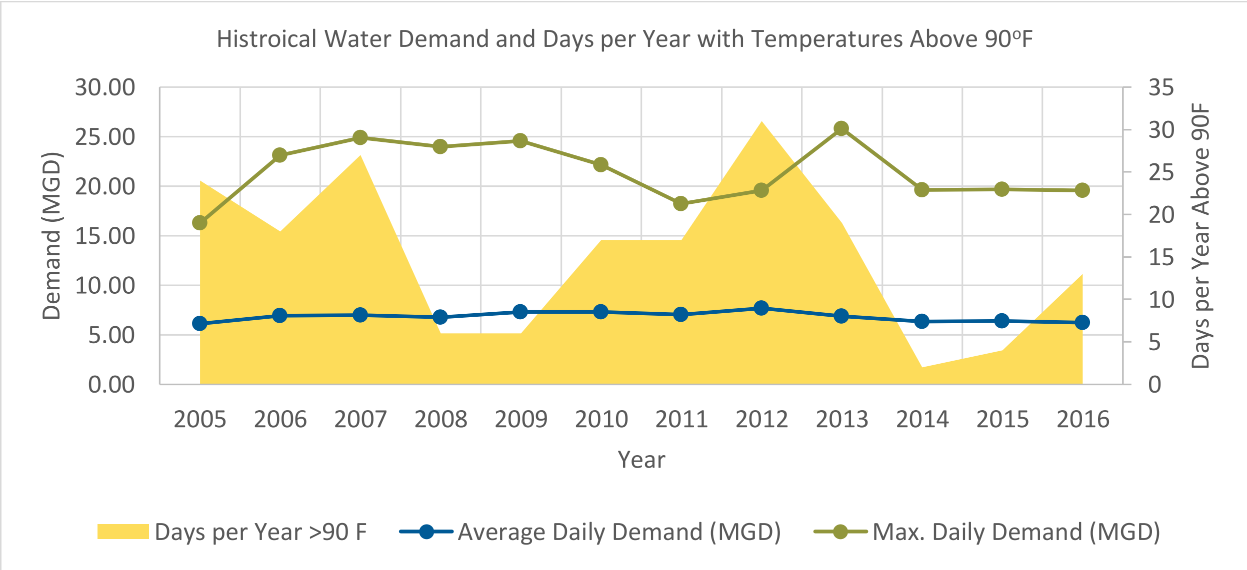

Figure 4-3 Historical Water Demand and Number of Days per Year with Temperatures above 90 degrees Fahrenheit, 2005-2016

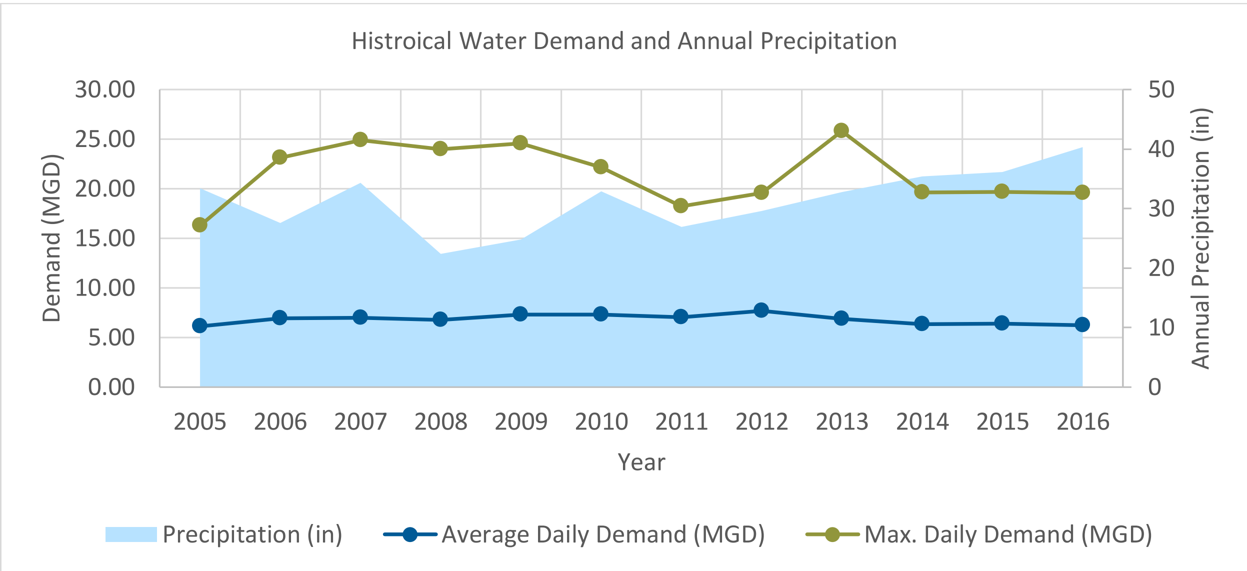

Figure 4-4 Historical Water Demand and Annual Precipitation Totals, 2005-2016

4.3 Existing Water Supply

The City's potable water is currently supplied by 21 wells drawing from the Quaternary, Jordan, and Tunnel City-Wonewoc aquifers. The City has recently installed four new wells, Wells 18-21 in the northeast portion of the City; these wells will be discussed further in Section 5.3. Out of the 21 wells currently in service, seven supply water to one of the three water treatment plants. The remaining fourteen wells are used seasonally to meet peak day demand during warm summer months. Well 15 is owned, maintained, and operated primarily by the City of Lexington. Blaine has the ability to monitor and control Well 15 when it is used to supply water to Blaine during summer months.

All active-use wells that supply water to the City's treatment plants contain backup emergency power, while the seasonal wells do not. The seasonal wells would each require a portable backup generator in the event of a power failure. The following table includes information on the City's 21 wells. A functional description including information on the well controls is included in Appendix A.

Table 4-3 Blaine Supply Wells

Well Name	Year Installed	Capacity	Usage	Location	Emergency Power Source
Well 1	1959	800	Seasonal	Wellhouse	No
Well 2	1960	800	Seasonal	Wellhouse	No
Well 3	1960	1,000	Active Use – Supply Water Treatment Plant 1 (WTP1)	Submersible Well	Yes
Well 4	1964	1,000	Active Use – Supply WTP1	Submersible Well	Yes
Well 5	1966	480	Seasonal	Wellhouse	No
Well 6	1968	1,000	Active Use – Supply Water Treatment Plant 3 (WTP3)	Submersible Well	Yes
Well 7	1969	1,000	Seasonal	Wellhouse	No
Well 8	1971	1,000	Seasonal	Wellhouse	No
Well 9	1972	600	Seasonal	Wellhouse	No
Well 10	1971	1,050	Seasonal	Wellhouse	No
Well 11	1974	1,000	Active Use – Supply WTP3	Submersible Well	Yes
Well 12	1976	2,000	Active Use – Supply Water Treatment Plant 2 (WTP2)	Submersible Well	Yes
Well 13	1977	1,000	Active Use – Supply WTP2	Submersible Well	Yes
Well 14	1978	1,000	Seasonal	Wellhouse	No
Well 15*	1966	1,000	Seasonal	Wellhouse	Yes
Well 16	1986	1,200-1,500	Seasonal	Wellhouse/ booster	No
Well 17	2006	2,000	Active Use – Supply WTP2	Submersible Well	Yes
Well 18	2017	1,700	Future supply to WTP4	Submersible Well	Future
Well 19	2017	1,400	Future supply to WTP4	Submersible Well	Future
Well 20	2017	1,500	Future supply to WTP4	Submersible Well	No
Well 21	2017	800	Future supply to WTP4	Submersible Well	No

*The City of Lexington owns, operates, and maintains Well 15, which is also referred to as Lexington Well 1. Blaine has the ability to monitor and control Well 15 when it is used to supply water to Blaine during summer months.

The system schematic, shown in the following figure, shows the configuration of the water supply wells. The schematic has also been included in Appendix B.

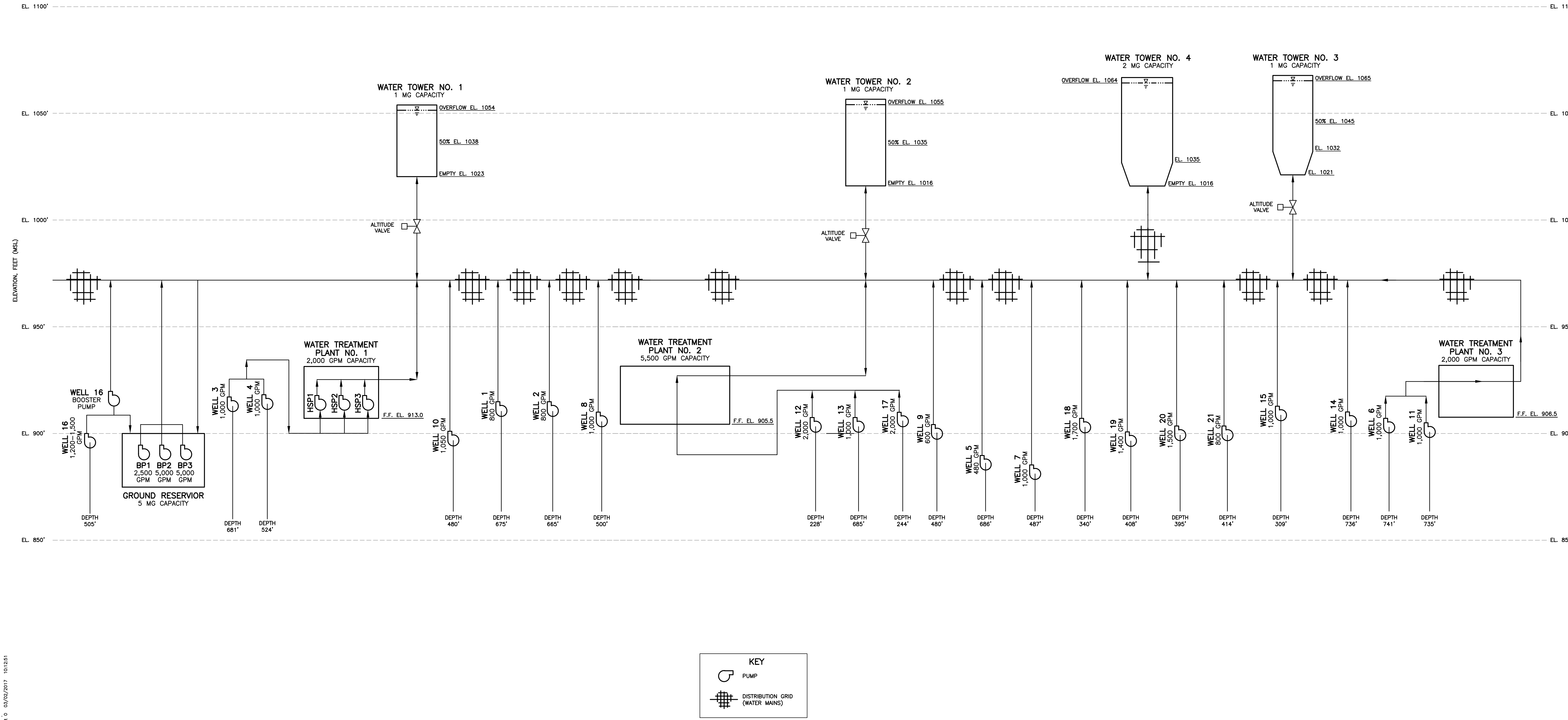

Figure 4-5 City System Schematic

CITY WATER SYSTEM SCHEMATIC
CITY OF BLAINE

CADD USER: Rick Gustner FILE: M:\ADEPTWORK\RJG\23021056_PFD-COMBINED.DWG PLOT SCALE: 1:2.6911 PLOT DATE: 2/14/2018 10:57 AM
rig M:\AdeptWork\RJG\23021056_PFD-02.dwg Plot at 0 03/02/2017 10:12:51

4.3.1 Existing Total Well Capacity

This includes the total combined capacities of Wells 1-21, with the exception of Wells 7 and 15 which were not included in the combined total. The future of Well 7 is currently being evaluated due to elevated arsenic levels. Well 15 was also not included since it is owned by the City of Lexington. Excluding these two wells from the total capacity makes the trigger chart slightly more conservative, where the total combined capacity is 21,330 gpm or 30.7 MGD, which is approximately 2.9 MGD lower than the actual available well capacity.

4.3.2 Existing Firm Well Capacity

Firm well capacity is defined as the total well capacity with the largest capacity well offline. The largest capacity City wells, Wells 12 and 17, can pump 2,000 GPM. Similar to the total well capacity explained above, the firm well capacity trend includes the total combined capacities of Wells 1-21, with the exception of Wells 7 and 15. Well 17 was also excluded since it's one of the highest capacity wells. When a City has more than 10 wells, which is the case for Blaine, the firm well capacity is modified to exclude an additional high capacity well. Because Wells 7 and 15 are already excluded from the trend, Well 12 remained included in the firm well capacity trend. Existing firm well capacity is 19,330 gpm or 27.8 MGD.

4.3.3 Existing Water Quantity and Supply Issues

Barr staff met with treatment plant operators in June 2017 to discuss issues related to the water system. A memo summarizing the meeting and ranking the top ten issues discussed is included in Appendix C. One of the issues the operators mentioned was related to Well 14, a seasonal well that runs approximately three months out of the year. This well has recently started experiencing flow issues, where it is now pumping significantly less than it has historically been capable of pumping. The City is planning to perform maintenance and rehabilitate this well as an attempt to restore the well's pumping capacity.

4.4 Existing Water Quality

Treatment of the well water provides the City of Blaine with quality water that complies with both the Primary Drinking Water Regulations and Secondary Drinking Water Regulations. This section will cover the water quality results for the well water, treatment plant effluent, and distribution system.

4.4.1 Historical Groundwater Quality

Historical water quality results for Wells 1-21 are listed in Appendix D. Water quality results provided by the City and also included in the City's previous 2002 Water System Plan (Progressive Consulting Engineers, 2002) that exceed, or nearly exceed, either a primary or secondary drinking water standards will be discussed in this section. The primary and secondary standards that will be discussed are listed in the following table.

Table 4-4 Relevant Primary and Secondary Drinking Water Standards

Contaminant	Primary or Secondary?	Maximum Contaminant Limit (MCL)	Maximum Contaminant Level Goal (MCLG) (If Applicable)
Iron (µg/L)	Secondary	300	-
Manganese (µg/L)	Secondary	50	-
1,2-dichloroethane (DCA) (µg/L)	Primary	5	0.0
Arsenic (µg/L)	Primary	10	-
di(2-ethylhexyl)phthalate (µg/L)	Primary	6	0.0
Turbidity (NTU)	Primary	5	-

Well 1

Well 1 has historically had elevated sample results for iron and manganese. Sample information included in the 2002 Water System Plan shows the iron concentration above the secondary drinking water standard at 340 µg/L. Manganese results were measured at nearly three times the secondary drinking water standard at 142 µg/L. Well 1 is only used seasonally, and is blended in the distribution system with filtered water from the treatment plants to alleviate issues associated with the higher levels noted.

Well 2

Well 2 has historically had elevated sample results for manganese. Sample information included in the 2002 Water System Plan shows a manganese concentration above the secondary drinking water standard at 129 µg/L. Well 2 is only used seasonally, and is blended in the distribution system with filtered water from the treatment plants to alleviate issues associated with the higher levels noted.

Well 3

Well 3 has historically had elevated sample results for 1,2-dichloroethane (1,2-DCA), iron, and manganese. 1,2-DCA has a Maximum Contaminant Level (MCL) of 5 µg/L and an MCLG of 0 µg/L. A sample collected from Well 3 on August 30, 2016 was analyzed and found to have a 1,2-DCA concentration of 5 µg/L, which exceeds the MCLG and is equivalent to the MCL.

Samples collected in July 2013 resulted in an iron concentration twice the secondary drinking water standard at 602 µg/L and manganese measured at levels nearly eight times the secondary drinking water standard at 372 µg/L.

Groundwater from Well 3 is routed to WTP1, where iron and manganese concentrations are reduced to levels below the secondary drinking water standard. WTP1 also has an air stripper column that is used to remove compounds such as 1,2-dichloroethane.

Well 4

Well 4 has had elevated sample results for both iron and manganese. Samples collected in July 2013 resulted in an iron concentration nearly three times the secondary drinking water standard at 1440 µg/L and manganese measured at levels nearly ten times the secondary drinking water standard at 492 µg/L. Groundwater from Well 4 is routed to WTP1, where iron and manganese concentrations are reduced to levels below the secondary drinking water standard.

Well 5

Well 5 has historically had elevated sample results for iron and manganese. Sample information included in the 2002 Water System Plan shows an iron concentration above the secondary drinking water standard at 338 µg/L and a manganese concentration above the secondary drinking water standard at 89.7 µg/L. Well 5 is only used seasonally, and is blended in the distribution system with filtered water from the treatment plants to alleviate issues associated with the higher levels noted.

Well 6

Well 6 has historically had elevated sample results for iron and manganese. Sample information included in the 2002 Water System Plan shows an iron concentration above the secondary drinking water standard at 389 µg/L and a manganese concentration above the secondary drinking water standard at 353 µg/L. Groundwater from Well 6 is routed to WTP3, where iron and manganese concentrations are reduced to levels below the secondary drinking water standard.

Well 7

Well 7 has elevated sample results for arsenic, di(2-ethylhexyl)phthalate, manganese, and iron. The MCL for arsenic is 10 µg/L. Water analyzed from Well 7 consistently has elevated arsenic levels, around 10 µg/L, sometimes exceeding 10 µg/L. A sample collected on August 3, 2010 was analyzed and arsenic was measured at 10.4 µg/L.

Di(2-ethylhexyl)phthalate has an MCL of 6 µg/L and a MCLG of 0 µg/L. According to the United States Environmental Protection Agency (EPA), di(2-ethylhexyl)phthalate is commonly used as a plasticizer for polyvinylchloride (PVC), rubber, cellulose, and styrene. While analyzed samples do not exceed the MCL, they are elevated and exceed the MCLG. A sample collected on July 11, 2016 had a di(2-ethylhexyl)phthalate concentration of 2.7 µg/L.

Well 7 has historically had elevated sample results for iron and manganese. Sample information included in the 2002 Water System Plan shows an iron concentration above the secondary drinking water standard at 404 µg/L and a manganese concentration above the secondary drinking water standard at 279 µg/L.

Well 7 is rarely used even as a backup seasonal well. The well water does not pass through either of the treatment plants, and is instead pumped directly to the distribution system and blended in the distributions system with filtered water from the three treatment plants. The City is currently in the process of determining options for how Well 7 should be handled in the future.

Well 8

Well 8 has historically had elevated sample results for iron and manganese. Sample information included in the 2002 Water System Plan shows an iron concentration above the secondary drinking water standard at 2390 μg/L and a manganese concentration above the secondary drinking water standard at 106 μg/L. Well 8 is only used seasonally, and is blended in the distribution system with filtered water from the treatment plants to alleviate issues associated with the higher levels noted.

Well 9

Well 9 has historically had elevated sample results for iron. Sample information included in the 2002 Water System Plan shows a manganese concentration above the secondary drinking water standard at 680 μg/L. Well 9 is only used seasonally, and is blended in the distribution system with filtered water from the treatment plants to alleviate issues associated with the higher levels noted.

Well 10

Well 10 has historically had elevated sample results for iron and manganese. Sample information included in the 2002 Water System Plan shows iron concentrations above the secondary drinking water standard at 1230 μg/L and a manganese concentration above the secondary drinking water standard at 83.6 μg/L. Well 10 is only used seasonally, and is blended in the distribution system with filtered water from the treatment plants to alleviate issues associated with the higher levels noted.

Well 11

Well 11 has had elevated sample results for iron and manganese. Samples collected in July 2013 resulted in an iron concentration two times the secondary drinking water standard at 604 μg/L and manganese measured at levels nearly ten times the secondary drinking water standard at 495 μg/L. Water from Well 11 is routed to WTP3, where iron and manganese concentrations are reduced to levels below the secondary drinking water standard.

Well 12

Well 12 has historically had elevated sample results for manganese. Sample information included in the 2002 Water System Plan shows a manganese concentration above the secondary drinking water standard at 408 μg/L. Water from Well 12 is routed to WTP2, where manganese concentrations are reduced to levels below the secondary drinking water standard.

Well 13

Well 13 has had elevated sample results for iron. Samples collected in July 2013 resulted in an iron concentration two times the secondary drinking water standard at 768 μg/L. Water from Well 13 is routed to WTP2, where iron concentrations are reduced to levels below the secondary drinking water standard.

Well 14

Well 14 has historically had elevated sample results for iron and manganese. Sample information included in the 2002 Water System Plan shows an iron concentration above the secondary drinking water standard at 445 µg/L and a manganese concentration above the secondary drinking water standard at 80.4 µg/L. Well 14 is only used seasonally, and is blended in the distribution system with filtered water from the treatment plants to alleviate issues associated with the higher levels noted.

Well 15

Well 15 has historically had elevated sample results for manganese. Sample information included in the 2002 Water System Plan shows a manganese concentration above the secondary drinking water standard at 1680 µg/L. Well 15 is only used seasonally, and is blended in the distribution system with filtered water from the treatment plants to alleviate issues associated with the higher levels noted.

Well 16

Similar to Well 7, Well 16 has di(2-ethylhexyl)phthalate concentrations above the MCLG of 0 µg/L but below the MCL of 6 µg/L. Water analyzed from Well 16 on June 9, 2009 was analyzed for di(2-ethylhexyl)phthalate and found to have a concentration of 1 µg/L. This is below the MCL; however, it is above the MCLG and should continue to be monitored.

Well 16 has also historically had elevated sample results for iron and manganese. Sample information included in the 2002 Water System Plan shows an iron concentration above the secondary drinking water standard at 697 µg/L and a manganese concentration above the secondary drinking water standard at 202 µg/L. Well 16 is only used seasonally, and is blended in the distribution system with filtered water from the treatment plants to alleviate issues associated with the higher levels noted.

Well 17

Well 17 has had elevated sample results for iron and manganese. Samples collected in July 2013 resulted in an iron concentration above the secondary drinking water standard at 405 µg/L and manganese measured at levels nearly ten times the secondary standard at 488 µg/L. Water from Well 17 is routed to WTP2, where iron concentrations are reduced to levels below the secondary drinking water standard.

Well 18

Well 18 has had elevated sample results for iron, manganese, and turbidity. Samples collected in September 2017 resulted in iron and manganese concentrations above the secondary drinking water standard at 565 µg/L and manganese measured at levels nearly eight times the secondary standard at 350 µg/L. Turbidity exceeded the primary drinking water standard of 5 NTU where the sample had a turbidity of 5.8 NTU. Well 18 is currently used as a seasonal well, where water is blended in the distribution system with filtered water from the treatment plants. Once WTP4 is constructed, water from Well 18 will be routed to the plant, where iron, manganese, and turbidity will be reduced to levels below the secondary drinking water standard.

Well 19

Well 19 has had elevated sample results for iron and manganese. A sample collected in January 2017 resulted in an iron and manganese concentrations above the secondary drinking water standard at

397 μg/L and manganese measured at nearly three times the secondary standard at 149 μg/L. Well 19 is currently used as a seasonal well, where water is blended in the distribution system with filtered water from the treatment plants. Once WTP4 is constructed, water from Well 19 will be routed to the plant, where iron and manganese will be reduced to levels below the secondary drinking water standard.

Well 20

Well 20 has had elevated sample results for manganese. A sample collected in January 2017 resulted in a manganese concentrations above the secondary drinking water standard at 763 μg/L. Once WTP4 is constructed, water from Well 20 will be routed to the plant, where manganese will be reduced to levels below the secondary drinking water standard.

Well 21

Well 21 has had elevated sample results for manganese. A sample collected in March 2017 resulted in a manganese concentrations above the secondary drinking water standard at 456 μg/L. Once WTP4 is constructed, water from Well 21 will be routed to the plant, where manganese will be reduced to levels below the secondary drinking water standard.

4.4.2 Existing Treatment Plant Effluent Water Quality

The treatment plant effluent did not exceed any of the Primary Drinking Water Regulations or Secondary Drinking Water Regulations. The water quality results for WTP1, WTP2, and WTP3 can be found in Appendix E.

4.4.2.1 WTP1 Air Stripper

In 2006, a packed column air stripper was constructed with new WTP1 as part of a superfund project to treat 1,2-dichloroethane (1,2-DCA) that was found in Wells 2 and 4. The air stripper was designed to treat up to 2,000 gpm, with a maximum design influent 1,2-DCA concentration of 16 ug/L, and a maximum effluent concentration of <1 ug/L, with an operating cycle of 24 hours per day, 7 days per week.

Treated water from WTP1 has been analyzed for 1,2-dichloroethane several times, and the highest measured result was collected on May 27, 2014 where concentrations were measured at 1.6 μg/L, which is below the 5 μg/L MCL but still above the 0 μg/L. The sample results for WTP1 are included in Appendix E, and show that between 2007 and 2017, there were a total of 13 samples analyzed for 1,2-dichloroethane. Out of the 13 samples analyzed, four samples had non-detects below 0.2 μg/L and 9 samples had measurable concentrations that ranged between 0.59 μg/L and 1.6 μg/L. All 1,2-DCA concentrations are below the action level, but above the goal of 0 μg/L.

The City may want to review water quality sampling as well as evaluate the performance of the air stripper column to determine if 1,2-DCA concentrations can be consistently be reduced to non-detectable levels. A file review and discussion with regulatory agencies would also be helpful.

4.4.3 Distribution Water Quality

The water quality results for the distribution system contain results for a total of 321 sample collected between 2007 and 2017, and can be found in Appendix F. Out of the 321 samples collected, there were water quality issues for 22 samples where copper concentrations were measured above the MCL of 1,300 µg/L. These samples were all collected between June 6, 2007 and March 12, 2009. The highest copper result was measured at 2,060 µg/L on March 31, 2008. All the sample results for lead fell below the MCL of 15 µg/L; however, the highest lead result was measured at 14 µg/L.

The EPA Lead and Copper Rule (LCR) requires systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb or copper concentrations exceed an action level of 1.3 ppm in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion. The 22 samples with water quality issues represents 6.8% of the 321 total samples collected, which is below the action percentage for copper. And no samples exceeded the lead MCL.

To improve water quality, city staff worked with the MDH to provide additional sampling and corrosion controls measures. Modifications have been made to the treatment process to add phosphate to help reduce corrosion in the distribution system. The copper and lead samples collected after March 12, 2009 have all been below the MCL and action levels.

When distribution samples show elevated results nearing or exceeding the MCL, the City should work with the MDH to ensure safe drinking water to users.

4.4.4 Existing Water Quality Issues

City staff have identified several locations within the distribution system that repeatedly struggle with water quality issues. Appendix G contains a water system schematic that identifies the location of the water quality issues discussed throughout this section. These issues are also discussed in the Water System Issue Memo included in Appendix C.

4.4.4.1 Discoloration – Southeast

In the southeast corner of the City, the water has been identified as having both a brown and green tinge. The City has repeatedly flushed the lines in this area; however, the City continues to receive complaints where flushing the lines does not appear to be resolving the water discoloration issue.

Arrow Cryogenics is located in the south side of town and uses approximately 900,000 gallons of water per month. They have contacted the City about water quality issues related to discolored water.

The City is planning to conduct ice pigging in this portion of town during 2018 to help clean the watermains and resolve the water discoloration issues.

4.4.4.2 Residual Chlorine – South

The south side of the City has been having difficulty maintaining residual chlorine. This may be due to having WTP1 offline during 2017, where all the water being supplied to the south side of town is coming down from the north side of town. Residual chlorine has been measured as low as 0.25 mg/L on the south side of town. The MDH recommends that the free chlorine residual in the distribution system should not drop below 0.2 mg/L or exceed 4.0 mg/L. While the residual is low, it is still in the recommended range.

4.4.4.3 Low Turnover – Southeast

Weston Woods Townhomes, a private system, located in the southeastern most portion of town struggles with issues related to stagnant water. It was recommended that the development invest in a pressure valve so they could tie into the Circle Pines water system; however, the decision was made to tie into the Blaine water system instead. The townhomes have struggled with stagnant water since construction. Because this is a private system, the development will have to decide if they want to take steps to resolve this issue.

4.5 Treatment

The City currently has three separate treatment plants that utilize pressure filters to remove iron and manganese from the raw groundwater to meet secondary drinking water standards. In addition to iron and manganese removal, the treatment plants provide disinfection through chlorine addition and prepare the water for distribution. WTP1 contains an air stripper used for volatile organic compound (VOC) removal and pH adjustment.

WTP1 and WTP2 both have permanent backup generators that can be used in the event of a power failure. WTP3 can be powered with a portable generator that is stored at Public Works. The generator for each treatment plant also supplies backup power to the treatment plant supply wells.

The City's seasonal wells are used primarily during summer months to meet the additional demands. Water treatment for each seasonal well consists of chlorine gas disinfection, fluoride addition, and phosphate addition for corrosion control.

The following table includes information on each of the three treatment plants.

Table 4-5 Existing Treatment Plants

Treatment Plant	Year Installed	Treatment Capacity (GPD)	Treatment Type	Treatment Method
WTP1	2006	2,880,000	Iron, manganese, and 1,2-dichlorethane removal. Chlorine and fluoride addition.	Pressure filters and air stripper column
WTP2	2006	7,920,000	Iron and manganese removal. Chlorine and fluoride addition.	Pressure filters
WTP3	2008	2,880,000	Iron and manganese removal. Chlorine and fluoride addition.	Pressure filters

4.5.1 Existing Treatment Issues

The City has identified several issues related to the operation and reliability of their treatment plants and wellhouses that are discussed below. These issues are also summarized in the Water System Issue memo included in Appendix C.

4.5.1.1 Treatment Plant Operations, Capacity

The City has been experiencing operational issues at each of the treatment plants where each plant has been struggling with reduced capacity. During the spring of 2017, the original Filtronics Electromedia was changed out at each plant and replaced with Pyrolusite, with the exception of a single filter in WTP3. Following the media change out, WTP1 needs pH adjustment in order to prevent precipitation in the tower since the air stripping tower has a higher pH. In addition to addressing capacity issues, the existing water treatment plants should be assessed and reviewed to determine necessary equipment upgrades to improve reliability and operations, including security and corrosion issues.

4.5.1.2 Wellhouse Issues

The City's wellhouses have reached their useful service life, and are in need of upgrades to their electrical, controls, chemical feed systems, and buildings to manage the risk of infrastructure failures. During the spring of 2017, one of the wellhouses had a chlorine gas leak from the feed tubing. The City has preliminary plans to make improvements to the wellhouses to bring them up to current code and to increase system reliability, which will be discussed in Section 5.5.

4.6 Distribution System

The City's distribution system is comprised of approximately 318 miles of watermain that range in size from 2.5 inches to 24 inches. The west and east sides of the City are connected by three separate watermains: a 12-inch watermain that runs along the southern border of the City, a 20-inch watermain that is located near the center of the City, and a 16-inch watermain in the northern portion of the City. The City's distribution system is shown on the following figure.

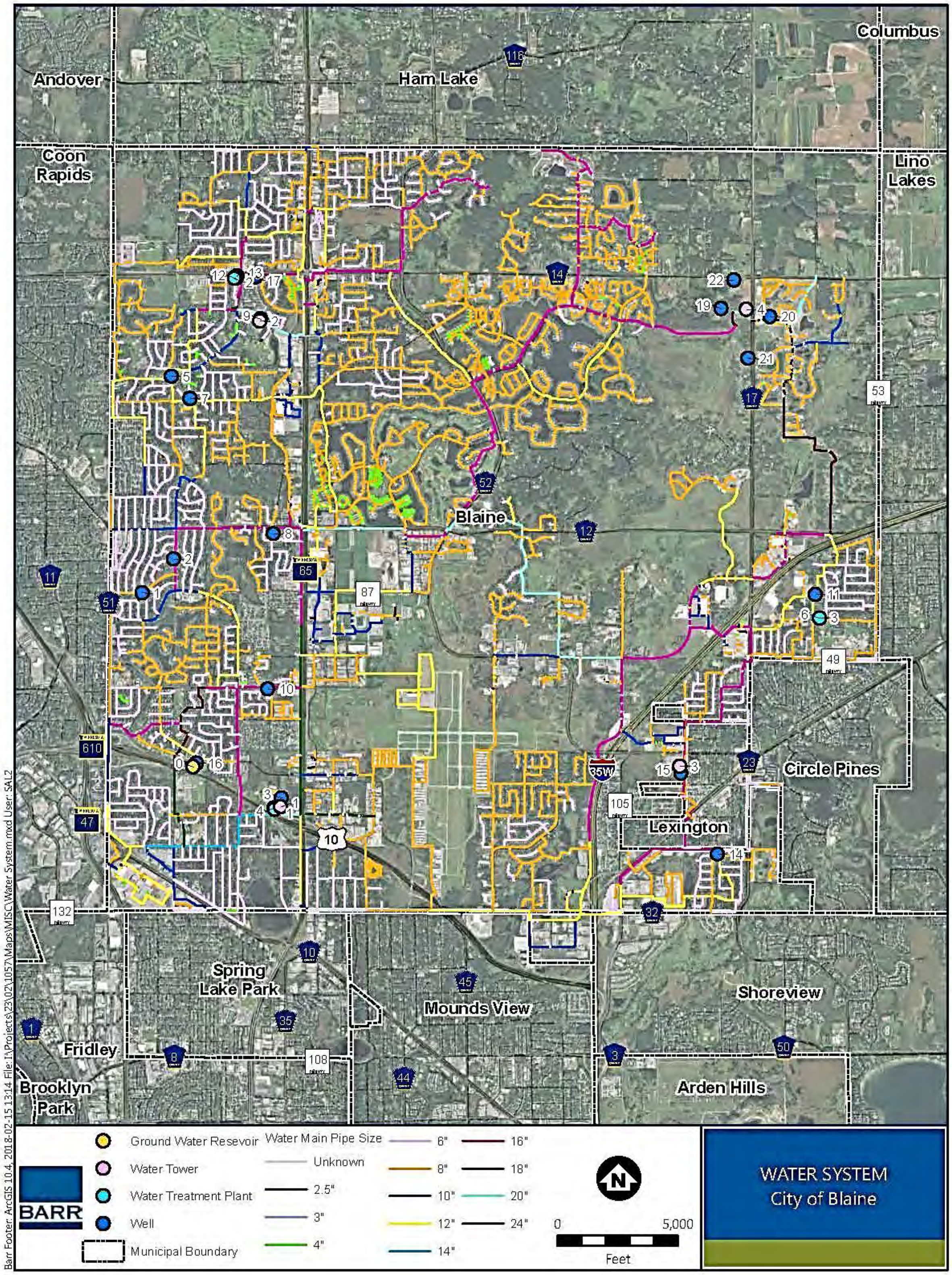

Figure 4-6 City Water System Map

4.6.1 Hydraulic Model Existing Distribution System

Hydraulic water system models are useful tools used to simulate a City's distribution system. They are used to identify issues within the system, such as areas with pressure and pipelines that may be undersized. The model can be used to help determine capital improvements to resolve issues within the water system identified by the model, such the need for additional supply or upsizing watermains.

A new hydraulic model was developed for the City using Innovyze's Infowater version 12.3. GIS files from the City containing information on existing watermain size and location were imported into the model. Location, elevation, and capacity related to the water storage structures and supply wells were manually entered into the model in addition to pump curves for each of the supply wells. Operational setpoints were entered based on conversations with the city operators and SCADA data. A figure identifying all the information uploaded into the existing system model is included in **Appendix E**.

Demands were allocated into the model utilizing demands initially projected for 2017 along with a land use map for the existing system. The projected 2017 demands were used in the model as they were slightly higher than recent years, making them more conservative yet still below the high average day demand experience in 2012 and the high peak day demand experienced in 2013. The model was calibrated with hydrant flow data that was collected on July 14, 2017 between the hours of 8:20 AM and 2:20 PM. The existing system was examined for average day demand and max day demand scenarios.

4.6.1.1 Existing System Average Day

To represent typical operation, the average day demand was modeled with the storage tanks near full capacity, with each of the water treatment plants on, along with Well 10. The following table summarizes the model results. Pressure, flow velocity, hydraulic grade line, and headloss figures for the existing system average day can be found in **Appendix H.**

Table 4-6 Existing System Average Day Model Results

Parameter	Results	Within Acceptable Range?*
Average Day Demand	7.54 MGD	NA
Junction Pressure	54-74 psi	Yes
Pipe Velocity	<5 fps	Yes
Hydraulic Grade Line	1,049-1,066 ft	Yes
Headloss in Pipes	<7 ft/1,000 ft	Yes

* Criteria for analysis discussed in Section 3.0.

In this average day scenario, the pressures throughout the system ranged from 54 psi to 74 psi, which are within the desirable range of 50 psi to 80 psi. The hydraulic grade line ranged from 1,049 ft to 1,066 ft, with the lower spot in the southwest portion of the City. The hydraulic grade line is used to determine where headloss occurs, with the lower area indicating headloss. The flow velocities in the pipes all fell below 5 fps, which is within the preferred range of less than 10 fps. The headloss in the pipes was below 7 ft/1,000 ft, which is also within the preferred range of less than 10 ft/1,000 ft of headloss.

4.6.1.2 Existing System Maximum Day

The max day scenario for the existing system was modeled with the storage tanks half full and all wells active. In this scenario, Well 16 was pumped to the reservoir and the 2,500 gpm booster pump pumped water from the reservoir to the distribution system; therefore, the booster pump directly between Well No. 16 and the distribution system was not activated. The following table summarizes the model results. Pressure, flow velocity, hydraulic grade line, and headloss figures for the existing system maximum day can be found in Appendix H.

Table 4-7 Existing System Maximum Day Model Results

Parameter	Results	Within Acceptable Range?*
Maximum Day Demand	16.15 MGD	NA
Junction Pressure	41-65 psi	Yes
Pipe Velocity	<10 fps	Yes
Hydraulic Grade Line	1,017-1,098 ft	NA
Headloss in Pipes	17 ft/1,000 ft	No

* Criteria for analysis discussed in Section 3.0.

For this scenario, the pressures ranged from 41 psi to 65 psi. Some pressures fell below the desired range, but remained above the 35 psi minimum desired pressure. The hydraulic grade line ranged from 1,017 ft to 1,098 ft, with the lower elevations being in the central part of the City from the north to the south. The location of the low elevation between the average daily and maximum daily scenarios is due to the difference in wells that are operating, since the City has wellhouses located throughout the City. The majority of pipeline velocities were maintained below 5 fps, however there were several small pipe sections located around WT3 and WTP2 that had velocities in the range of 5-10 fps. The majority of the pipes had a headloss below 10 ft/1,000 ft, however there are two small pipe sections that have a headloss above 10 ft/1,000 ft, which is due to larger diameter pipes that connect to or become smaller diameter pipes. These pipes can be replaced with larger diameter pipes to avoid this issue.

Another model was run with one of the 2,500 booster pumps and a 5,000 gpm booster pump turned on. Under existing average day demand, pressures were generally 50-60 gpm in the system. Under existing maximum day demand, pressures were lowered to 40-50 psi in some areas of the city. These pressures are still within acceptable limits. Figures showing these model runs are in Appendix H.

4.6.1.3 Existing System Fire Flow

The maximum day scenario was also examined for available fire flows, as this is when the flow will be constricted most and therefore indicates what would be available during the more limiting situation. The ISO Report for the City of Blaine indicates that the basic fire flow for the City is 3,000 gpm, which is used to determine the number of engine companies the City needs. The fire flow requirements for the City will vary from location to location, depending on building type and square footage according to the Minnesota Fire Code. The Minnesota Fire Code states that the minimum required fire flow for residential areas is 1,000 gpm and the minimum required fire flow for other building types is 1,500 gpm. The following table summarizes the model results. The existing system maximum day available fire flow figure can be found in Appendix H.

Table 4-8 Existing System Maximum Day Fire Flow Model Results

Parameter	Results	Within Acceptable Range?*
Maximum Day Demand	16.15 MGD	NA
Fire Flow Requirement Used in Model	3,000 gpm	NA
Lowest available fire flow	500 gpm	No

* Criteria for analysis discussed in Section 3.0.

Fire flows for the existing system ranged from 500 to 5,000+ gpm. While the model indicates fire flows above 5,000 gpm were present in the system, flows above this value are not considered realistic. Generally the available fire flow is within the acceptable range, however there are a few areas with lower available fire flows around 500 gpm which tend to occur at dead-end lines and loops with small diameter pipes.

4.6.1.4 Water Age Analysis

The hydraulic model software used to model a high level water age analysis for the distribution system. The water age analysis shows that the average water age for all junctions (service connections) is 1.3±0.3 days. The average maximum water age is 2.5±0.7 days and the absolute maximum water age found in the system was 3.3 days. This was done by running a month long simulation at average daily demands, therefore with maximum daily demands the water age should be reduced. The Water Industry Database (AWWA 1992) indicates an average distribution system retention time of 1.3 days and a maximum retention time of 3.0 days based on a survey of more than 800 U.S. utilities. Blaine's system is within these parameters.

To more accurately model water age, an extended period simulation model would be required. Historical billing data tied to parcel location is needed in addition to detailed operational information such as tower level, flowrates, and pump controls. This information would be used within the model and also be used to develop an accurate diurnal pattern that represent how water consumption fluctuates throughout the day. Testing for chlorine residuals throughout the system is another way to determine areas with higher water age, as older water generally has lower chlorine residuals. They City may want to consider conducting a detailed water quality analysis to determine specific improvements for water age and water quality in areas with known issues.

4.6.2 Interconnections

Blaine's distribution system has several interconnections with surrounding cities. The following table summarizes the location and metering capabilities for each interconnection. All interconnections are intended for emergency use with the exception of the interconnection with the City of Lexington. There are fifteen interconnections with the City of Lexington; however, none of these interconnections are currently metered. The City of Lexington determines water usage based on their customer water meters billing. At the end of the year, Lexington informs the City how much water was transferred from the City to Lexington customers. The following year, the City pumps an equivalent amount of water from Well 15 during summer months. The City is currently planning to install flow meters on all the Lexington interconnections so they have a more reliable method for tracking water transferred between the two cities.

Table 4-9 Interconnections with Surrounding Cities

City Name	Interconnection Location	Metered	Usage	Operation
Circle Pines	Lexington Ave NE and Woodland Road	6" - Metered	Emergency	Manual
Circle Pines	North Road and Pine Drive	6" - Metered	Emergency	Manual
Coon Rapids	North of 126th Ave and University	6" - Unmetered	Emergency	Manual
Coon Rapids	109th Ave and University Ave	6" - Metered	Emergency	Manual
Lexington	15 connections	Not Metered	Summer Months	Open
Lino Lakes	Elm Street and Sunset Ave	6" – Metered	Emergency	Manual
Mounds View	85th Ave and Hastings Street	6" - Metered	Emergency	Manual
Spring Lake Park	85th Ave and Central Street	6" - Metered	Emergency	Manual

4.6.3 Watermain Maintenance

To replace aging or vulnerable infrastructure, the City has started replacing cast iron watermains with either ductile iron or PVC watermains. In the event of a failure, the City will repair the watermains and then fully replace them with either ductile iron or PVC during planned road construction.

4.6.4 Existing Distribution System Issues

The distribution system experiences several issues primarily related to water pressure, undersized watermains, and the Lexington Interconnection. The following sections will discuss existing issues the City is aware of. Issues related to the distribution system are also summarized in the Water System Issue memo included in Appendix C.

4.6.4.1 Watermain breaks

The City does not report any reoccurring watermain breaks or excessive breaks per year. On an annual basis, the City performs approximately 8 to 12 watermain repairs. According to a statistic from the AWWA, which is discussed in section 3.0, the average annual number of leaks is nine per 100 miles of watermain. AWWA provides a goal of 20 breaks per 100 miles of watermain. The Partnership for Safe Water goal is no more than 15 breaks per 100 miles of watermain. The City has approximately 318 miles of watermain, which means they have approximately 3 leaks per 100 miles of watermain, which is below average and meets excellence goals.

4.6.4.2 Pressure Issues

As explained earlier, the City's distribution system is capable of meeting recommended pressures; however, there are several areas within the City where low pressures have been reported by residents. Residents located between 109th Ave NE and Territorial Road NE and University Ave NE and Jefferson St NE have commonly reported low pressure issues. While the model shows the pressure in this area still falls within the acceptable range, between 50-60 psi according to model results for the existing average day, the existing max day model results show some portions of this area have pressures that are between 40-50 psi. The Water System Issue Map, included in Appendix G, identifies the location of the low pressure complaints.

High pressure issues also have been reported to occur in the north end of town when WT1 is full and the 2,500 GPM Reservoir Booster Pump is running. The existing average day model results show a small area on the northwest side of town where the pressures range between 70-80 psi in the area around 125th Ln NE. This area of town is also at a higher elevation. Pressures are still in an acceptable range according to model results, however pressures are at the high end of the range. The Water System Issue Map, included in Appendix G, identifies the location of the higher pressures experienced in the north end of the City.

The cause of the low and high pressures in this area should be further investigated, and may be due to a hydraulic constraint such as inadequate looping, undersized watermain, or inadequate cross connections across the distribution system.

4.6.4.3 Undersized Watermains

Other issues reported by City staff related to the distribution system deal with watermain sizes. The watermain inlet for WTP2 is sized at 24 inches; however, the watermain outlet is significantly smaller at 16 inches. Also, the watermain leaving WT1 that crosses under Highway 65 is also reported as being undersized at 18 inches. Undersized watermains result in high velocities and reduced flow.

The existing maximum day headloss figure shows higher headloss for the WTP2 effluent pipes, where headloss is in the higher range of 5-10 ft/1,000 ft. Similarly, there is a section of pipe near WT1 that cross under Highway 65 that has a headloss range of 5-10 ft/1,000 ft. These headlosses are still within the acceptable range, although it is still higher than in other portions of the City. The Water System Issue Map, included in Appendix G, identifies the location of the undersized watermain.

4.6.4.4 Lexington Interconnection

There are several unknowns related to the Lexington interconnections. Other than relying on the City of Lexington to determine water pumped through the interconnection, the City does not have a means of calculating the amount of water sent between the Cities, although there are plans in place to install flow meters. There are currently 15 open interconnections between the cities. The City plans to install metering to obtain accurate measurement and accounting of water transfer, and to investigate the interconnections further to reduce potential risks and vulnerabilities to the City.

4.7 Storage

The City's water system is comprised of four elevated towers and a single ground storage reservoir. Water Tower 1 (WT1) is located in the southwest portion of the City, immediately next to WTP1. WT1 has a storage capacity of 1 MG. Water Tower 2 (WT2) is located in the northwest corner of town, a few blocks south of WTP2. Similar to WT1, WT2 has a storage capacity of 1 MG. Water Tower 3 (WT3) is located in the southeast corner of town, near the Cities of Circle Pines and Lexington. WT3 has a design capacity of 1 MG; however, it has an adjusted storage volume of 0.7 MG due to the lower overflow elevations of WT1 and WT2. Water Tower 4 (WT4) is located in the northeast corner of town, adjacent to future Water Treatment Plant 4 (WTP4). WT4 has a design capacity of 2 MG, but similar to WT3, it has a reduced operating capacity due to the lower overflow elevations of WT1 and WT2. The operating capacity of WT4 is approximately 1.5 MG. Lexington has a 0.1 MG elevated storage tank located near WT3; however, this storage structure was not included in Blaine's total existing storage capacity.

The Ground Storage Reservoir is located northwest of WT1 in the southwest portion of town. The Ground Storage Reservoir has a capacity of 5.0 MG and is filled with either water from the distribution system, or directly from Well 16. The reservoir is emptied and not used during winter months due to reduced demands. A generator located at the ground reservoir supplies backup power to Well 16, Well 16 Booster Pump, and the three reservoir high service pumps.

The following table summarizes information related to the City's five storage structures. It is important to note that the Lexington tower was not included as part of Blaine's existing storage.

Table 4-10 Blaine Storage Structures

Storage Name	Year Constructed	Storage (MG)	Adjusted Storage (MG)	Overflow Elevation (ft)	Empty Elevation (ft)	Altitude Valve?
WT1	1960	1.0	1.0	1054	1023	Yes
WT2	1972	1.0	1.0	1055	1016	Yes
WT3	1981	1.0	0.7	1065	1021	Yes
WT4	2009	2.0	1.5	1064	1016	No*
Ground Reservoir	1987	5.0	5.0	922	897	N/A
Total	-	**10**	**9.2**	-	-	-

*Plans in place to have altitude valve installed in 2018

The City should consider maintaining a pressure relief point for the water system as a whole. If an altitude valve is planned for Water Tower 4 then a relief point should be added to make sure the system does not over pressurize in the event of a well or treatment plant that continues to run when it should be shutting down. The Ground Storage Reservoir was designed with three booster pumps to pump water from the reservoir into the distribution system. The following table includes the design capacities for each of the three booster pumps.

Table 4-11 Ground Storage Booster Pump Information

Booster Pump Name	Year Installed	Capacity (GPM)
Booster Pump 1 (BP1)	1987	2,500
Booster Pump 2 (BP2)	1987	5,000
Booster Pump 3 (BP3)	1987	5,000

4.7.1 Existing Storage Issues

The City has had ongoing issues related to the booster pumps located at the Ground Storage Reservoir and recently started experiencing issues maintaining water in Tower 4. These issues are discussed below, as well as in the Water System Issue memo included in Appendix C.

4.7.1.1 Ground Storage Booster Pumps

Booster Pump 1 (BP1) has a capacity of 2,500 gpm, and is the only booster pump that is operated. The 5,000-gpm reservoir booster pumps are not operated as it is believed they are oversized and running either one of the 5,000-gpm booster pumps will over-pressurize the distribution system. The high capacity booster pumps are likely intended to provide flow for firefighting. Regardless of this, if the city never uses them they will likely not be turned on even if a fire is being fought. There are also issues with the controls where they are outdated. The City may want to consider conducting an evaluation on the equipment located at the reservoir booster station that includes an evaluation of variable frequency drives (VFD), electrical, controls, pumps, instrumentation, valves, and emergency backup power.

4.7.1.2 Maintaining Adequate Storage Level

During the summer of 2017, the City struggled to maintain adequate storage level in WT4, located in the northeast portion of town. Operators reported that it was difficult maintaining levels above 20% and that the lowest levels occurred between 3:00-6:00 AM. WTP1 remained offline for portions of the summer due to issues with the pressure filter media, which operators believe made maintaining level in Tower 4 difficult.

4.7.1.3 Historical System Failures

During 2017, the City had two occurrences where the water towers went empty and residents did not have adequate water pressure or supply. The occurrences were not related, where the first occurrence was due to a communications failure and the second occurrence was due to a mechanical control panel failure. The City is currently in the process of upgrading their SCADA system to add redundancy and replace aging infrastructure, which will help to maintain adequate supply in the future and prevent similar failures from occurring.

5.0 Proposed Future Water System

5.1 Projected Population

The City's population is expected to increase by approximately 30% percent between 2020 and 2040. Projected populations were obtained from the 2015 Metropolitan Council Thrive 2040 System Statement where populations were estimated for years 2020, 2030, and 2040. Intermediate years were calculated by linear interpolation. The population of Lexington is not included in Blaine's projected population served. Projected population for Blaine is shown on the following figure.

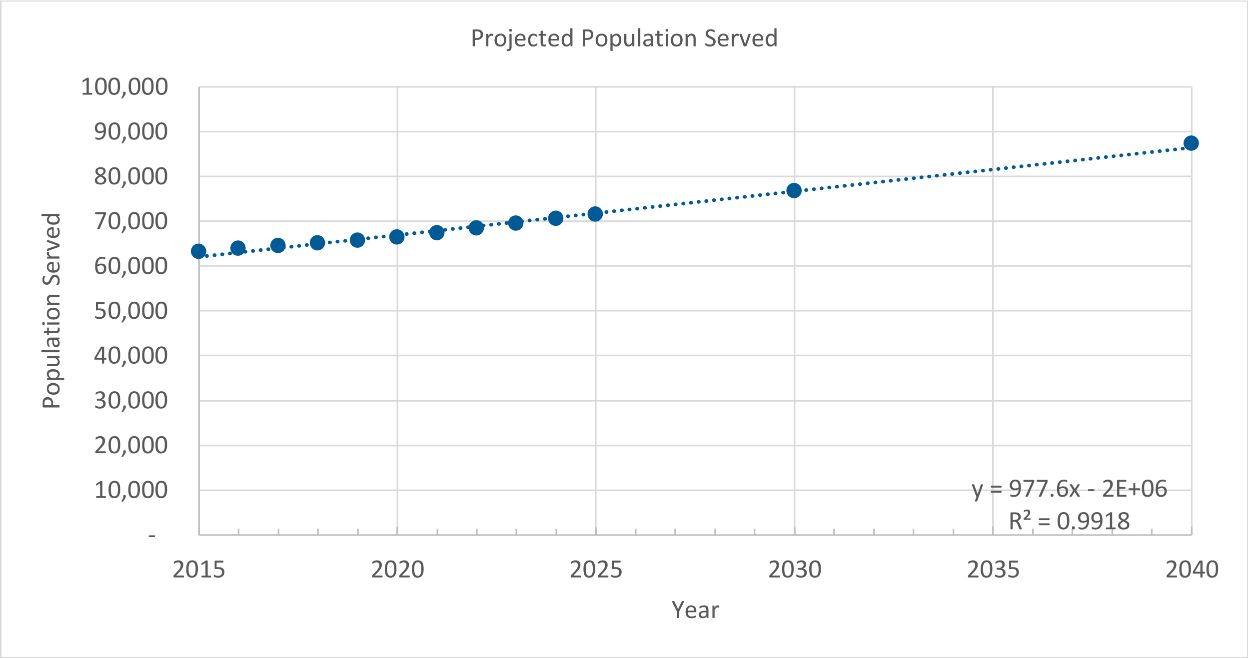

Figure 5-1 Projected Population through 2040

5.2 Future Demands

The average and peak day demands are projected to increase steadily through 2040. The average day demand is projected to reach 10.21 MGD by 2040 and the maximum day demand is projected to reach 21.89 MGD by 2040, according to the Department of Natural Resources (DNR) Water Supply Plan that was submitted in December 2016 (Barr, 2016).

The population and water use projections are outlined in the table below. Note, these projections are different than the draft DNR Water Supply Plan projections that used *population served*. Projections are based on an assumed future use of 117 GPCD, this value is based on the average use from 2010 to 2015. A peaking factor of 2.14 was used to calculate the projected maximum day demand, which is the average peaking factor from 2005 to 2015. Projected demands for the City are shown on the following figure. While the assumed use is in line with recent averages it excludes the highest historic use which occurred in 2006 and 2007. This should be kept in mind when considering future system improvements.

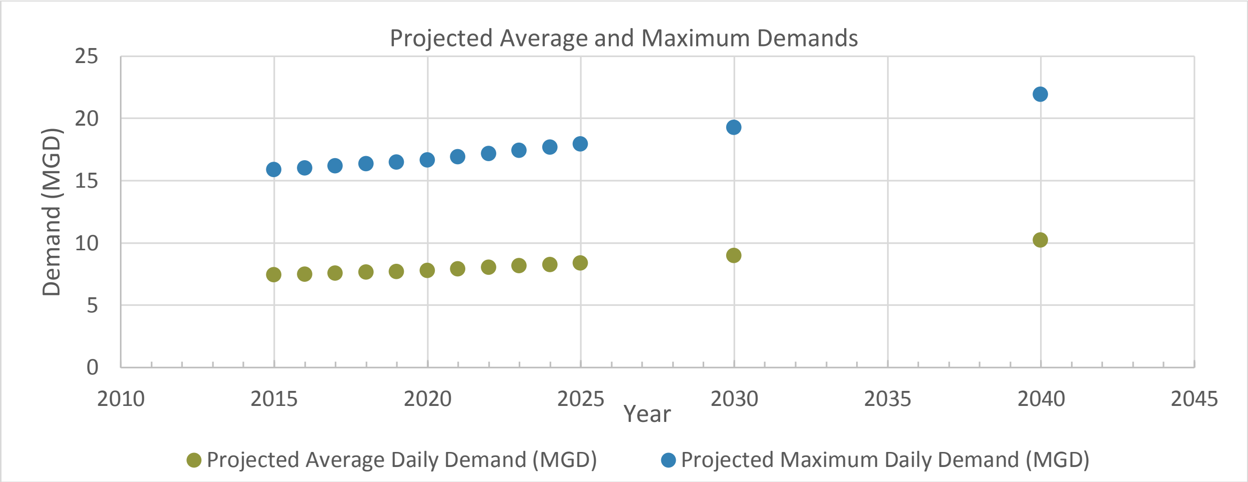

Figure 5-2 Projected Demands through 2040

Table 5-1 Projected Water Demand through 2040

Year	Average Daily Demand (MGD)	Max Daily Demand (MGD)	Peaking Factor (2005-2015 average)
2017	7.54	16.15	2.14
2018	7.61	16.31	2.14
2019	7.68	16.47	2.14
2020	7.76	16.62	2.14
2021	7.88	16.88	2.14
2022	8.00	17.14	2.14
2023	8.12	17.40	2.14
2024	8.24	17.66	2.14
2025	8.37	17.93	2.14
2030	8.97	19.23	2.14
2040	10.21	21.89	2.14

Note that the numbers in Table 5-1 do not match the recent DNR water supply plan since this plan assumes all future residents will be connected to the water system.

Residential development is expected to occur primarily in the northeast portion of town, as shown on the following City land use map. Areas highlighted in pink represent areas that will be redeveloped prior to 2020, while areas highlighted in orange will be redeveloped between 2020 and 2040. The following two land use maps were both used while creating the future system model to determine how future demands should be allocated within the City.

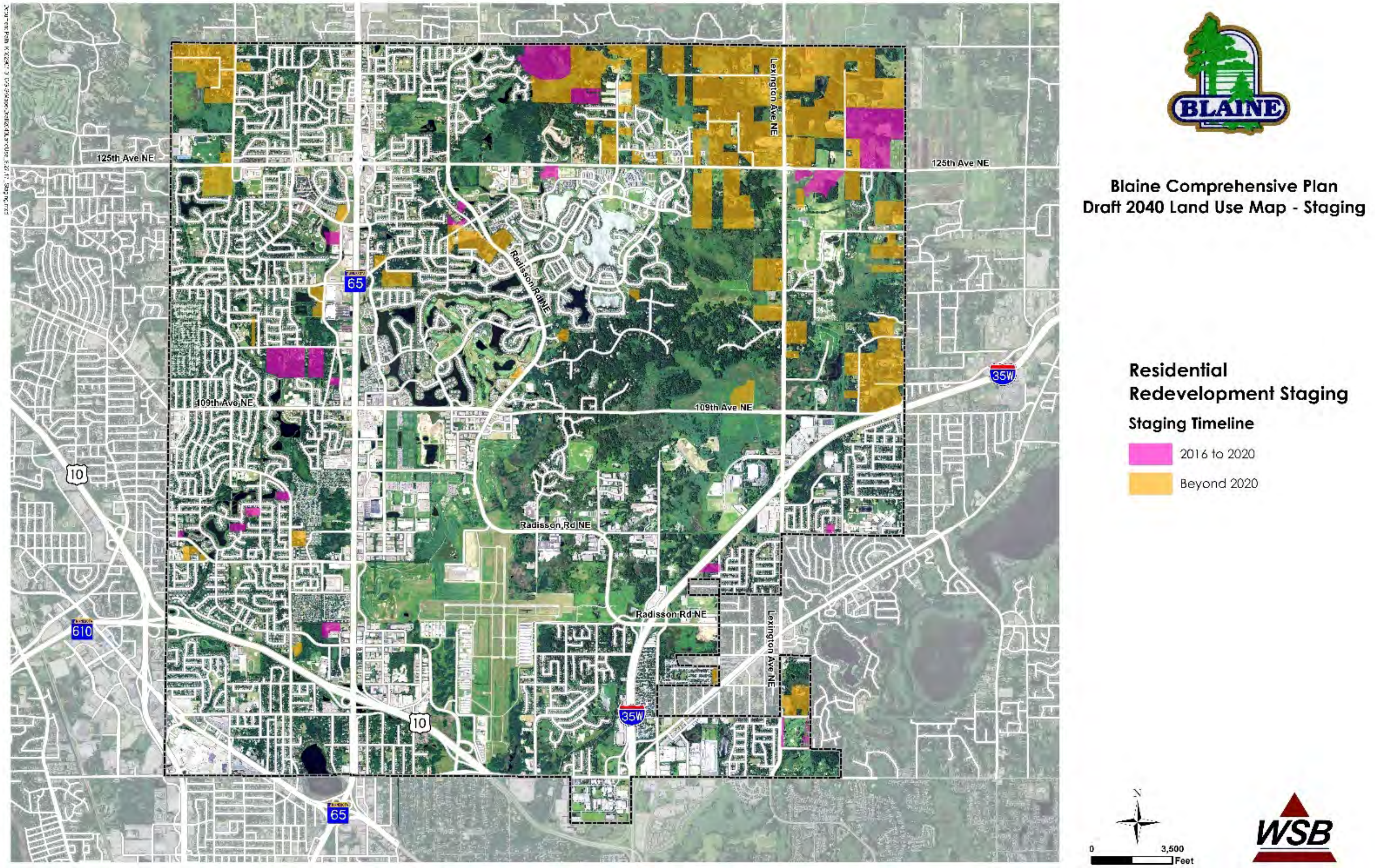

Figure 5-3 **Residential Redevelopment Staging through 2040**

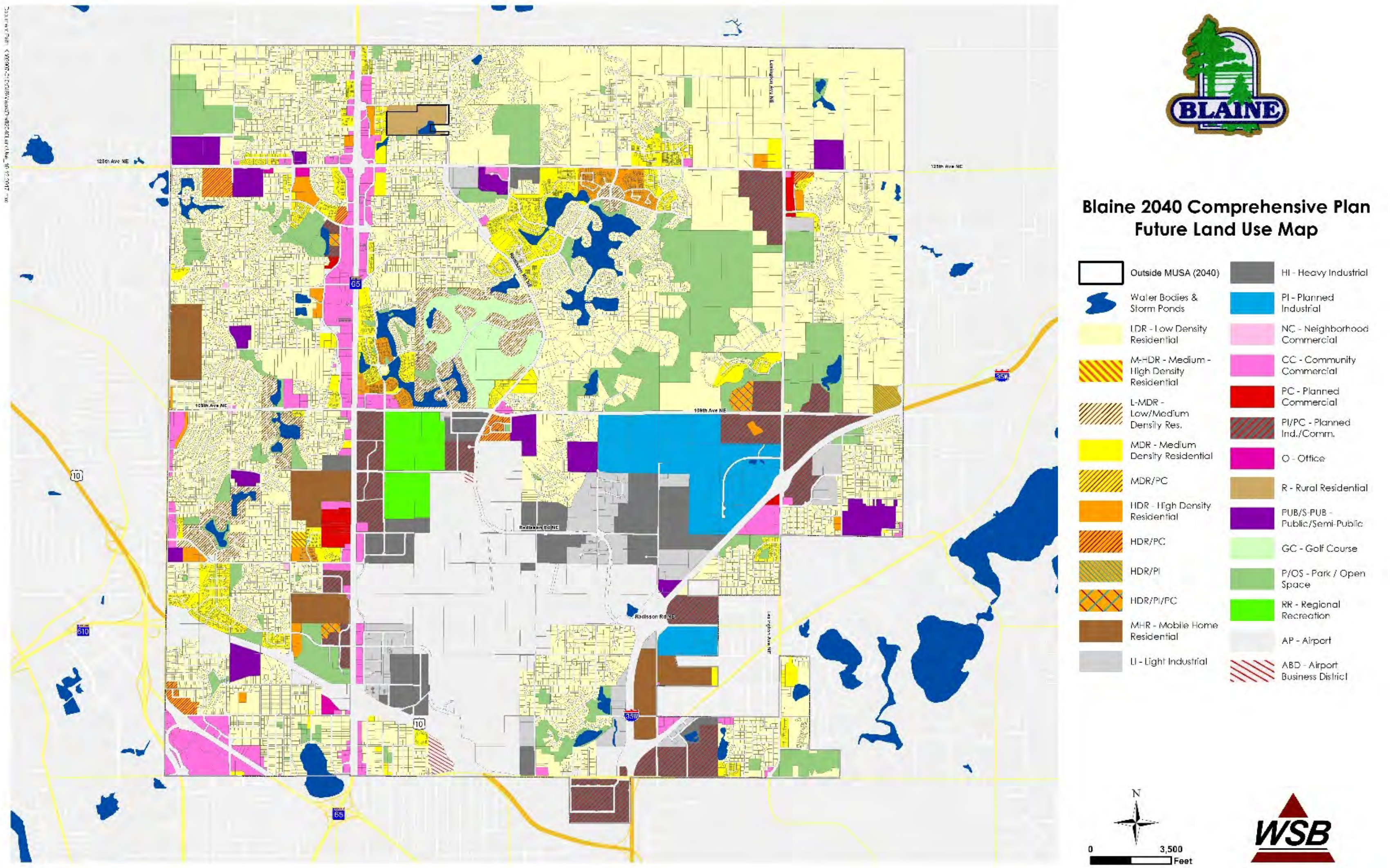

Figure 5-4 Future Land Use Map through 2040

5.3 Future Water Supply

To meet future supply, the City has recently installed four new wells located in the northeast portion of town, Wells 18-21. These wells will be used temporarily as seasonal wells until WTP4 becomes operational. Once WTP4 is operational, these wells will be used to supply water to the new treatment plant. However, more improvements are needed for the future water supply system.

5.3.1 Well Capacity Trigger Chart

Ten State Standards 3.2.1.1 states that firm well capacity should equal the maximum day demand. A trigger chart, shown on the following figure and also included in Appendix I, was created to help identify when additional supply wells are needed based on historical peak day. There are multiple ways you can analyze this data depending on how conservative or risk adverse you want to be. The trigger chart shows trends for several peak day demands experienced by the City over the last fifteen years. Each of the trends are explained below:

Table 5-2 Future Water Demand Alternatives

Category	Name	Description	Value
Well Capacity	Total Well Capacity	Total combined capacities of Wells 1-21, excluding Wells 7 and 15	30.7 MGD
	Firm Well Capacity	Total combined capacities of Wells 1-21, excluding Wells 7 and 15 and minus Well 17 one of the highest capacity wells.	27.8 MGD
Average Day	Minimum Average Day	DNR benchmark recommendation of 75 gpcd	75 gpcd
	2016 average day	Annual average of water demand in 2016	98 gpcd
	Projected 2040 average day	Projected average day use for 2040 per the DNR Water Supply Plan	117 gpcd
	10 year average of average day	10 year average of average day water use (2005-2015)	119 gpcd
	15 year max average day	highest GPCD average day for the last 15 years, 148 gpcd in 2003	148 GPCD
Peaking Factor	10 year average of peaking factor	10 year average of peak day radio (2007-2016)	2.2
	5 year peaking average	5 year average of peak day radio (2010-2015) used in DNR Water Supply Plan	2.14
Peak Day	DNR Minimum Peak Day	lowest calculated GPCD peak day, which is calculated using the residential DNR GPCD average day goal and the 10 year average peaking factor. The residential DNR GPCD goal is 75 GPCD	165 GPCD
	Existing Peak Day	Existing peak day from 2016.	208 GPCD
	Projected 2040 Peak Day	Calculated peak day for 2040, per the DNR Water Supply Plan	251 GPCD
	10 Year Average of Peak Day	Averaging the actual peak day trends for the last 10 years	262 GPCD
	Highest Calculated Max Peak Day	highest calculated GPCD peak day, calculated using highest GPCD average day from the last 15 years and the 10 year average peaking factor (148 gpcd x 2.2)	326 GPCD
	Highest Actual Max Peak Day	the highest actual GPCD peak day from the last 15 years in 2003	388 GPCD (2003)

Total Well Capacity – This trend includes the total combined capacities of Wells 1-21, with the exception of Wells 7 and 15 which were not included in the combined total of **30.7 MGD**. The future of Well 7 is currently being evaluated due to elevated arsenic levels. Well 15 was also not included since it is owned by the City of Lexington. Excluding these two wells from the total capacity trend makes the trigger chart slightly more conservative, where the total combined capacity is approximately 2.9 MGD lower than the actual available well capacity.

Firm Well Capacity – Firm well capacity is defined as the total well capacity with the largest capacity well offline is **27.8 MGD**. The largest capacity City wells, Wells 12 and 17, can pump 2,000 GPM. Similar to the total well capacity trend explained above, the firm well capacity trend includes the total combined capacities of Wells 1-21, with the exception of Wells 7 and 15. Well 17 was also excluded from the trend since it's one of the highest capacity wells. When a City has more than 10 wells, which is the case for Blaine, the firm well capacity is modified to exclude an additional high capacity well. Because Wells 7 and 15 are already excluded from the trend, Well 12 remained included in the firm well capacity trend.

Minimum Average Day – This trend is used to show the lowest calculated GPCD average day, which is calculated using the residential DNR GPCD plus fire flow. The residential DNR GPCD goal is 75 GPCD. This trend includes an average day of **75 GPCD plus fire flow**, and is included on the trigger chart as a bench mark, as the least conservative trend.

Existing 2016 Actual Average Day – The existing average day trend includes actual average day data from 2016. In 2016, the average day was **98 GPCD**. As explained earlier in the report, it's important to remember 2016 was a relatively cool year with limited warm summer days with a considerable amount of rainfall.

Projected 2040 Average Day – This data point is used to show the calculated average day for 2040, utilizing the projections explained in Section 5.2. The 2040 average day plus fire flow is shown as **117 GPCD**.

10 Year Average Day – Averaging the actual average day trends for the last 10 years (2007-2016) results in an average day of 119 GPCD. This trend includes an average day of **119 GPCD.**

Highest Actual Average Day – This trend is used to show the highest actual GPCD average day from the last 15 years plus fire flow. In 2003, the average day well production was **148 GPCD**.

Peaking Factor- 10 year average 10 year average of peak day radio (2007-2016) is **2.2.**

Peaking Factor- 5 year average 5 year average of peak day radio (2010-2015) used in DNR Water Supply Plan is **2.14.**

DNR Minimum Peak Day – This trend is used to show the lowest calculated GPCD peak day, which is calculated using the residential DNR GPCD average day goal and the 10 year average peaking factor. The residential DNR GPCD goal is 75 GPCD. This value was then multiplied by the 10 year average (2007-2016) peaking factor of 2.2, which results in a calculated minimum peak day value of **165 GPCD**. This is included on the trigger chart as a bench mark, as the least conservative trend.

2016 Peak Day – The actual peak day trend includes actual peak day data from 2016. In 2016, the peak day was **208 GPCD**. This trend is included on the trigger chart as a bench mark, and is not used to determine the need for additional wells. As explained earlier in the report, it's important to remember 2016 was a relatively cool year with limited warm summer days with a considerable amount of rainfall.

Projected 2040 Peak Day – This data point is used to show the calculated peak day for 2040, utilizing the projections explained in Section 5.2. The 2040 peak day is calculated at **251 GPCD**.

10 Year Average Peak Day – Averaging the actual peak day trends for the last 10 years (2007-2016) results in an average peak day of **262 GPCD**. This trend is included on the trigger chart as a bench mark, and is not used to determine the need for additional wells.

Highest Calculated Max Peak Day – This trend is used to show the highest calculated GPCD peak day, which is calculated using the highest GPCD average day from the last 15 years and the 10 year average peaking factor. The highest GPCD average day for the last 15 years occurred in 2003, where the average day well production was 148 GPCD. The average day well production was then multiplied by the 10 year average (2007-2016) peaking factor of 2.2, which results in a calculated peak day value of **326 GPCD**. This trend is used to conservatively determine the need for additional wells, but is less conservative than the actual historical peak day well production of 388 GPD.

Highest Actual Max Peak Day – This trend is used to show the highest actual GPCD peak day from the last 15 years. In 2003, the peak day well production was **388 GPCD**. This trend is included on the trigger chart as a bench mark, and is not used to determine the need for additional wells.

The trigger chart shows a firm well capacity trend of 27.8 MGD until the population reaches 85,500 people, which is projected to occur by 2039. When the population reaches 85,500 people, a new well, Well 22, will be required to meet the demands of the City. Additional wells beyond Well 22 will likely not be required until after the City’s population has expanded beyond 88,000 people.

While the trigger chart shows Well 22 is not required until 2037, the City should consider obtaining a well site near future WTP4 as development occurs.

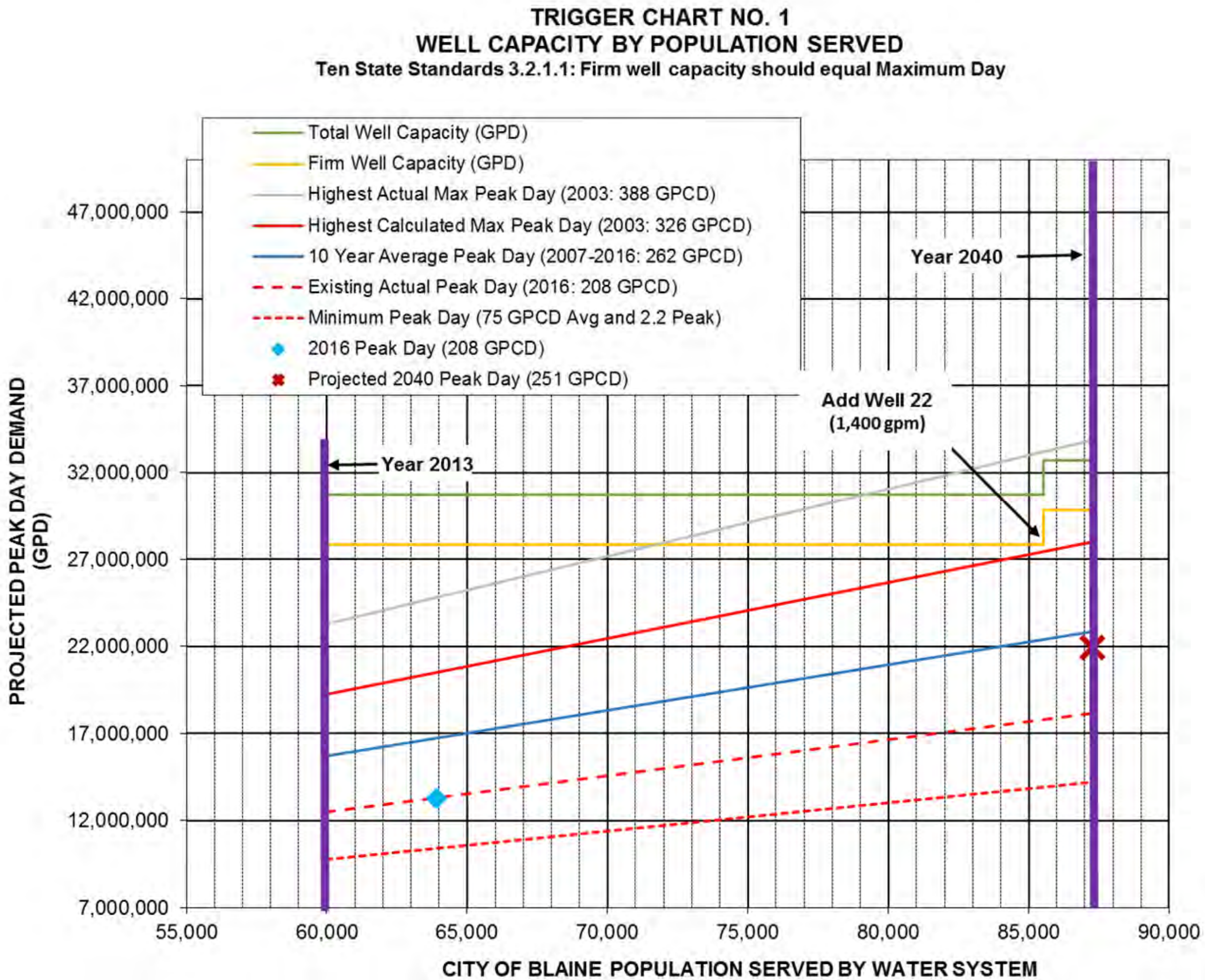

Figure 5-5 **Well Capacity by Population Served**

The following table includes information on future proposed Well 22, which is planned to provide water capacity and redundancy to future WTP4.

Table 5-3 Future Well 22

Well Name	Year Installed	Capacity	Usage	Emergency Power Source
Well 22	Future	1400 gpm	Future – Supply WTP4	Generator

5.3.2 Wellhouse Improvements

To meet city building codes and NFPA requirements, the City's wellhouses need upgrades to their electrical, controls, chemical feed systems, and buildings. The City has preliminary plans to make improvements to the following wellhouses. Details on which wellhouses are being considered, and their construction year, is shown below.

Table 5-4 Wellhouses Needing Rehabilitation

Name	Construction Year
Wellhouse 1	1959
Wellhouse 2	1960
Wellhouse 5	1966
Wellhouse 7	1969
Wellhouse 8	1971
Wellhouse 9	1972
Wellhouse 10	1971
Wellhouse 11	1974
Wellhouse 14	1978
Wellhouse 16	1986

5.4 Future Water Quality

The City will continue to comply with the primary and secondary drinking water standards for the future water treatment system. The City will also continue to address reported water quality issues in the system which are described in Section 3.4 above and displayed in Appendix G.

5.4.1 WTP4 Treatment Plant Effluent Water Quality

The City is planning on constructing WTP4 to treat raw water from the new northeast well field, Wells 18-21. All parameters that exceed either the secondary or primary drinking water standards for Wells 18-21 will be reduced to acceptable levels as the well water is treated in future WTP4. WTP4 will be designed to remove iron and manganese via aeration, chemical oxidation, detention, and gravity media filtration. Water quality concerns associated with high total organic carbon (TOC) will also be addressed within the plant design. Additional chemicals will be added for disinfection and fluoridation, as required by the MDH, as well as chemicals for corrosion control in the distribution system.

5.5 Future Treatment Capacity

Continued development in the northeast portion of the City will require additional treatment. Construction of future WTP4 is currently anticipated to begin in 2019 and will be located near the existing WT4 located at 125th Avenue NE and Lexington Avenue N in Blaine. The 6,000-gpm (8.64 MGD) gravity filtration treatment plant is currently being proposed to treat the groundwater for iron and manganese removal, as well as address the water quality concerns associated with high TOC in order to comply with primary and secondary drinking water standards.

5.5.1 Treatment Plant Capacity Trigger Chart

A trigger chart, shown in the following figure and also included in Appendix I, was created to help show when additional treatment plants are needed based on historical peak day. The trigger chart shows trends for several peak day demands experienced by the City over the last fifteen years, as previously explained in Table 5-2. Each of the new trends for water treatment planning are explained below:

WTP Capacity – This trend includes the total combined capacities of WTP1, WTP2, and WTP3 at 13.68 MGD. The capacity of WTP4 is included in the trend once the population reaches 66,300 people, which is when the total treatment capacity increases from 13.68 MGD to 22.32 MGD.

While the total treatment plant capacity falls below the highest calculated max peak day trend, the 10 year average peak trend is within the design capacity of all four treatment plants. Existing seasonal wells can be used to supplement additional water demand during peak days. The City is planning to investigate the feasibility of additional treatment for their ten seasonal wells with the goal of producing water that meets the secondary drinking water standards year round.

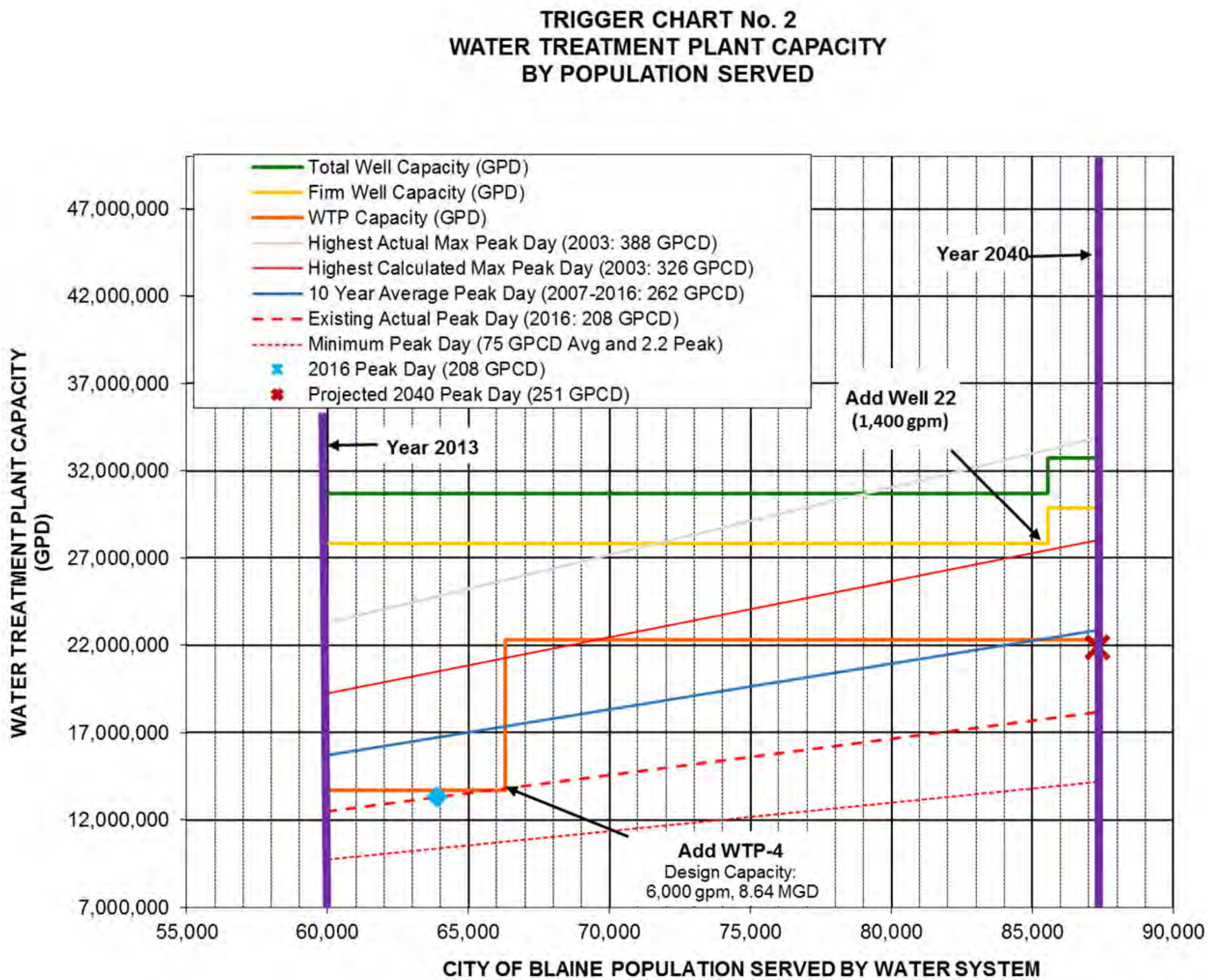

Figure 5-6 **Water Treatment Plant Capacity by Population Served**

5.6 Future Distribution System

With future development and the addition of WTP4, additional watermain will be required throughout the City. A figure identifying watermain used in the future system model is included in Appendix J.

5.6.1 Future System Hydraulic Model

The future system was examined for average day demand and max day demand scenarios. A future land use map, residential development projection map, population projections, and land use density change data provided by the City was used in developing the future system model.

5.6.1.1 Future System Average Day

Similar to the existing system, the future system average day was modeled with the storage tanks near full capacity, with each of the water treatment plants on, along with Well 10. The following table summarizes the model results. Pressure, flow velocity, hydraulic grade line, and headloss figures for the future system average day can be found in Appendix J.

Table 5-5 Future System Average Day Model Results

Parameter	Results	Within Acceptable Range?*
Average Day Demand	10.21 MGD	NA
Junction Pressure	54-75 psi	Yes
Pipe Velocity	<5 fps	Yes
Hydraulic Grade Line	1,049-1,066 ft	NA
Headloss in Pipes	<8 ft/1,000 ft	Yes

* Criteria for analysis discussed in Section 3.0.

In this average day scenario, the pressures throughout the system ranged from 54 psi to 75 psi, which are within the desirable range of 50 psi to 80 psi. The hydraulic grade line ranged from 1,049 ft to 1,066 ft, with the lower spot in the southwest portion of the City. The flow velocities in the pipes all fell below 5 fps, which is within the preferred range of less than 10 fps. The headloss in the pipes was below 8 ft/1,000 ft, which is also within the preferred range of less than 10 ft/1,000 ft of headloss.

5.6.1.2 Future System Maximum Day

The max day scenario for the existing system was modeled similar to the existing system with the storage tanks half full and all wells active. In this scenario, Well 16 was pumped to the reservoir and the 2,500 gpm booster pump pumped water from the reservoir to the distribution system; therefore, the booster pump directly between Well No. 16 and the distribution system was not activated. The following table summarizes the model results. Pressure, flow velocity, hydraulic grade line, and headloss figures for the future system maximum day can be found in Appendix J.

Table 5-6 Future System Maximum Day Model Results

Parameter	Results	Within Acceptable Range?*
Maximum Day Demand	21.89 MGD	NA
Junction Pressure	40-65 psi	Yes
Pipe Velocity	<10 fps	Yes
Hydraulic Grade Line	1,012-1,044 ft	NA
Headloss in Pipes	<17 ft/1,000 ft	No

* Criteria for analysis discussed in Section 3.0.

For this scenario, the pressures ranged from 40 psi to 65 psi. The pressures drops slightly below the desired range, but remain above the 35 psi minimum desired pressure. The hydraulic grade line ranged from 1,012 ft to 1,044 ft, with the lower elevations being in the central part of the City from the north to the south. The majority of pipeline velocities were maintained below 5 fps, however there were several small pipe sections that had velocities that ranged between 5-10 fps. The headloss ranged up to 17 ft/1,000 ft, which is higher than preferred, although the majority of the pipes had a headloss below 10 ft/1,000 ft.

Due to the large area with lower pressures in the range of 40-50 psi, the model inputs were modified to assume one of the 5,000 gpm booster pumps was operational in addition to the 2,500 gpm booster pump. This significantly reduced the portion of town experiencing low pressures in the range of 40-50 psi. Pressure and hydraulic grade line figures for the future system maximum day with the 5,000 gpm booster pump can be found in Appendix J. The City may want to consider the booster station study mentioned earlier in the report in order evaluate necessary improvements at the booster station.

5.6.1.3 Future System Fire Flow

The maximum day scenario was also examined for available fire flows, assuming a basic fire flow requirement of 3,000 gpm. The following table summarizes the model results. The future system maximum day available fire flow figure can be found in Appendix J.

Table 5-7 Future System Maximum Day Fire Flow Model Results

Parameter	Results	Within Acceptable Range?*
Maximum Day Demand	21.89 MGD	NA
Fire Flow Requirement Used in Model	3,000 gpm	NA
Lowest available fire flow	500 gpm	No

* Criteria for analysis discussed in Section 3.0.

Fire flows for the existing system ranged from 500 to 5,000+ gpm. While the model indicates fire flows above 5,000 gpm were present in the system, flows above this value are not considered realistic. Generally the available fire flow is within the acceptable range, however there are a few areas with lower available fire flows which tend to occur at dead-end lines and loops with small diameter pipes.

Modifying the model inputs by assuming one of the 5,000 gpm booster pumps was operational in addition to the 2,5000 gpm booster pump did not significantly improve the available fire flow, where portions of town still had an available fire flow of 500 gpm. The available fire flow figure for the future system maximum day with the 5,000 gpm booster pump can be found in Appendix J.

5.6.2 Future Distribution System

The following table includes a list watermain identified in the model greater than 10 inches in diameter that will be required to supply water to customers through 2040. Figure 5-7 identifies all future watermain used in the 2040 average day and maximum day model. The figure has also been included in Appendix K.

Table 5-8 Future Watermains Identified with Model

Location	Length (ft)	Diameter (in)
Added from 4813 121st Ave NE to Sunset Ave and 121st Ave NE	1,200	10" Watermain
Added from 125th Ln NE and Jefferson St NE to 132nd Ave NE	4,500	12" Watermain
Added from Hupp St NE to Lexington Ave NE and Watermain along Lexington Ave NE	5,600	12" Watermain
Added from Quail Creek Pwky NE to 133rd Ln NE	3,800	16" Watermain
Added from Harper St NE and 131st Ave NE along 131st Ave NE	1,300	16" Watermain
Added from Lever St NE and 131st Ave NE and west to Harper St NE	8,400	20" Watermain
Added along Lever St NE from 125th Ave NE and north to 131st Ave NE	4,600	20" Watermain
Added from 126th Ln NE east and south to 125th Ave NE	2,300	20" Watermain
Added from Lexington Ave NE added from 122nd Ave NE to 133rd Ln NE	7,200	24" Watermain
Added from 125th Ave NE from Lexington Ave NE to 3641 125th Ave NE	3,400	24" Watermain

As WTP4 is constructed, additional watermain will be required to tie the plant into the existing distribution system and supply wells. Figure 5-8 shows the proposed watermain locations and sizes surrounding WTP4.

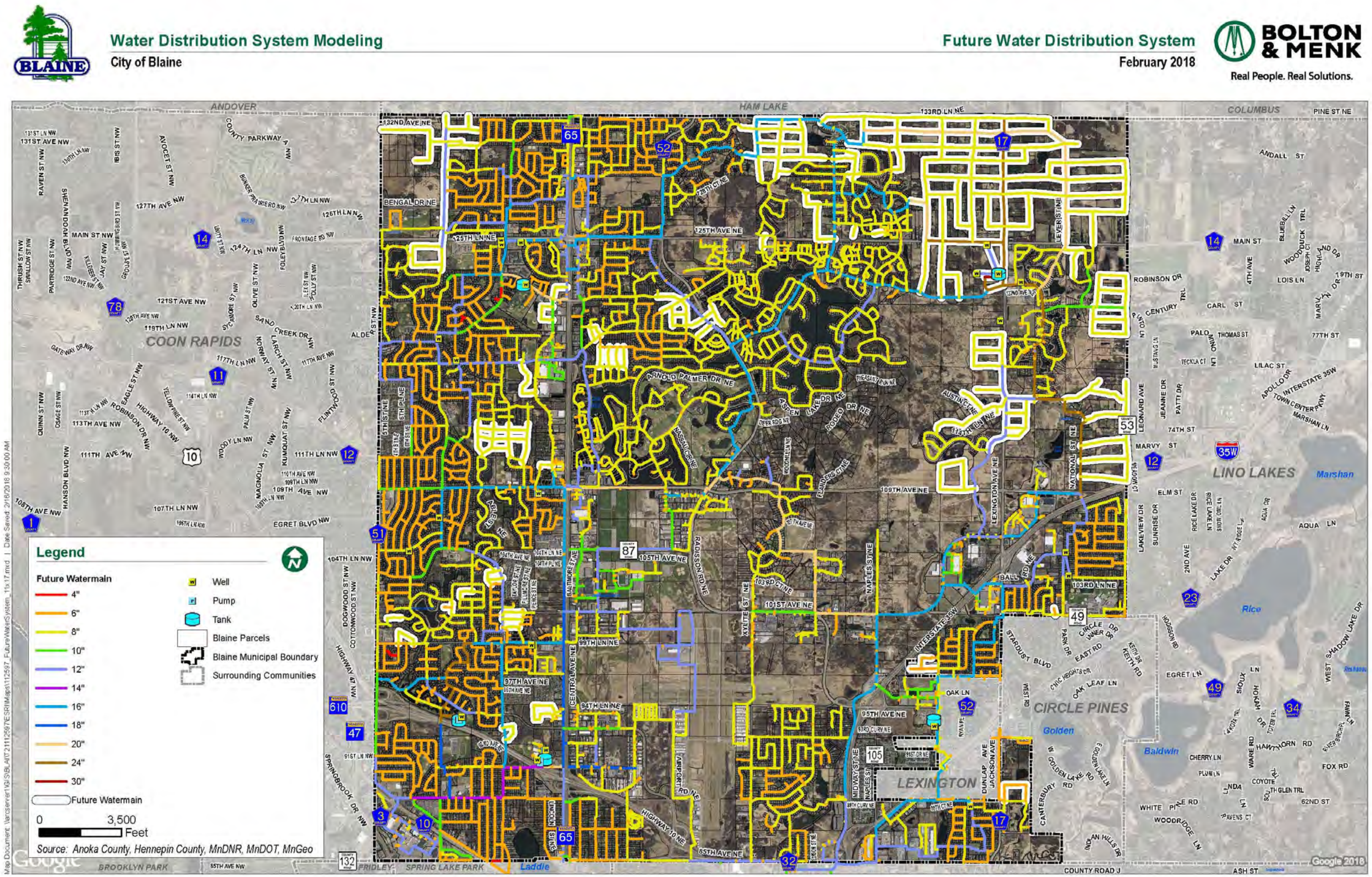

Figure 5-7 **Location of Future Watermain Identified with Model**

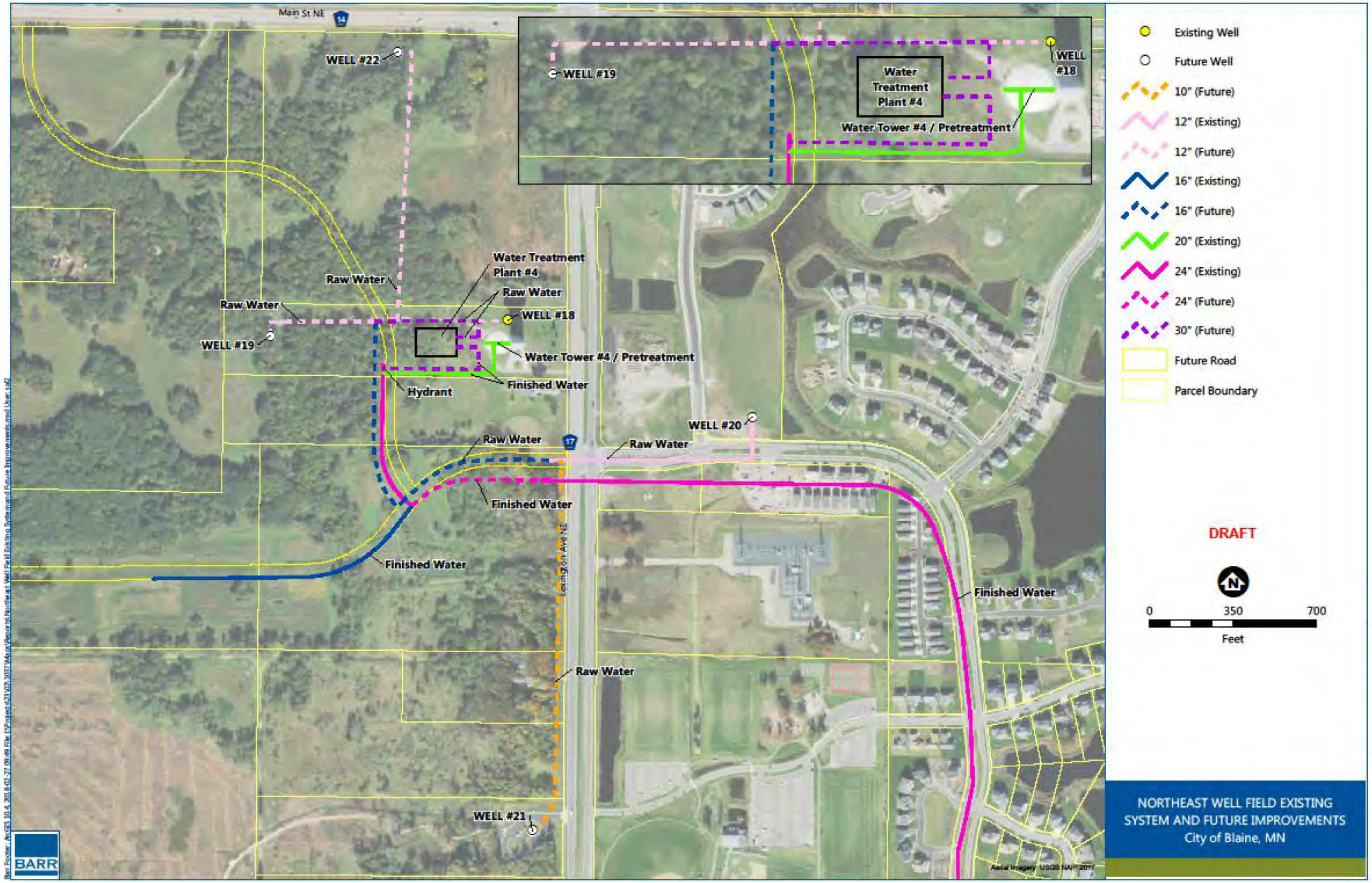

Figure 5-8 **Northeast Well Field Distribution**

5.6.3 Interconnections

The City is currently planning to install flow meters on all the Lexington interconnections so they have a more reliable method for tracking water transferred between the two cities. In addition to installing flow meters, it is recommended to investigate and document the following:

1. Update legal agreement between the cities
2. Document water use and supply between the cities
3. Develop maintenance agreements
4. Implementing alarms in Blaine SCADA

5.7 Future Storage

The proposed WTP4 includes the addition of a clearwell. The clearwell will be used to store water following filtration and provide additional storage capacity for the distribution system. The final size of the clearwell has not been determined, although it is recommended to be a minimum of 380,000 gallons.

5.7.1 Storage Capacity Trigger Chart

Ten State Standards 7.0.1 says storage capacity shall meet average day demand plus fire flow. The trigger chart shown in the following figure, and also included in Appendix I, was created to help show when additional storage may be needed based on historical water usage. The selection of future storage is highly dependent on which average day estimate the City uses for the system. The trigger chart displays trends for several different average day demands experienced by the City plus fire flow, as also outlined in Table 5-2. Each of the new trends related to storage are explained below:

Future Fire flow – Fire flow requirements assumed 3,000 gpm over a two-hour period based on the ISO report from September 28, 2009.

Additional Storage Through 2040 – This trend includes the total combined storage capacities of water towers 1 through 4 and the ground storage reservoir. When the population is below 65,700, the available storage is 9.2 MG. After the population reaches 65,700, the trend shows the need to increase storage volume to 11.6 MG.

Optional Additional Storage – Once the population reaches 76,700, this trend shows an additional optional storage volume of 2.0 MG being added. This will increase the City's available storage to 13.7 MG.

Using the most conservative calculation, the trigger chart below recommends a total of 4.5 MG of storage by 2040, using the highest historical average day of 148 GPCD plus fire flow. While the upper red line is based on the highest historical annual average, it is recommended the City consider if additional storage is required in addition to the new clearwell that will be installed as part of WTP4.

Using the blue line in the trigger chart, which represents the historical 10-year annual average of 119 GPCD, an additional 2.5 MG of storage is recommended.

An alternate approach for determining storage requirements with the trigger chart uses the 2040 projected average and maximum day demand of 10.21 MGD and 21.80 MGD, respectively. Storage requirements are based on the following three parameters:

- Equalization demand – Equal to 25% of the City's maximum daily demand
- Fire demand – Conservative value of 3,500 gpm for 4 hours (higher than requirement listed in recent ISO report)
- Emergency demand – 60% of average daily demand

The following table identifies the recommended storage requirements for the 2040 system using the less conservative approach.

Table 5-9 Future Storage Volume Requirements

Storage Parameter	Future System Recommendation (MG)
Equalization	5.47
Fire Flow	0.84
Emergency	6.13
Recommended Storage	**11.60**
Existing adjusted storage	9.2
Total new storage	**2.4**

Based on the information provided in the table above, and the trigger chart below, the City will likely need to add a minimum additional storage volume of approximately 2.5 MGD by 2040. Between WT3 and WT4, there is approximately 0.8 MG of storage capacity that is not utilized due to the higher overflow elevations of WT1 and WT2. It may be worthwhile for the City to investigate options to utilize this 0.8 MG of existing storage.

Assuming the City moves forward with a solution that allows them to use the existing unavailable storage volume within WT3 and WT4, and the WTP4 clearwell is sized at 0.7 MG, an additional 1.0 MG tower will increase the City's total storage volume to 11.7 MG, which will satisfy the 119 GPCD average day plus fire flow per the trigger chart below, and the alternate calculation above.

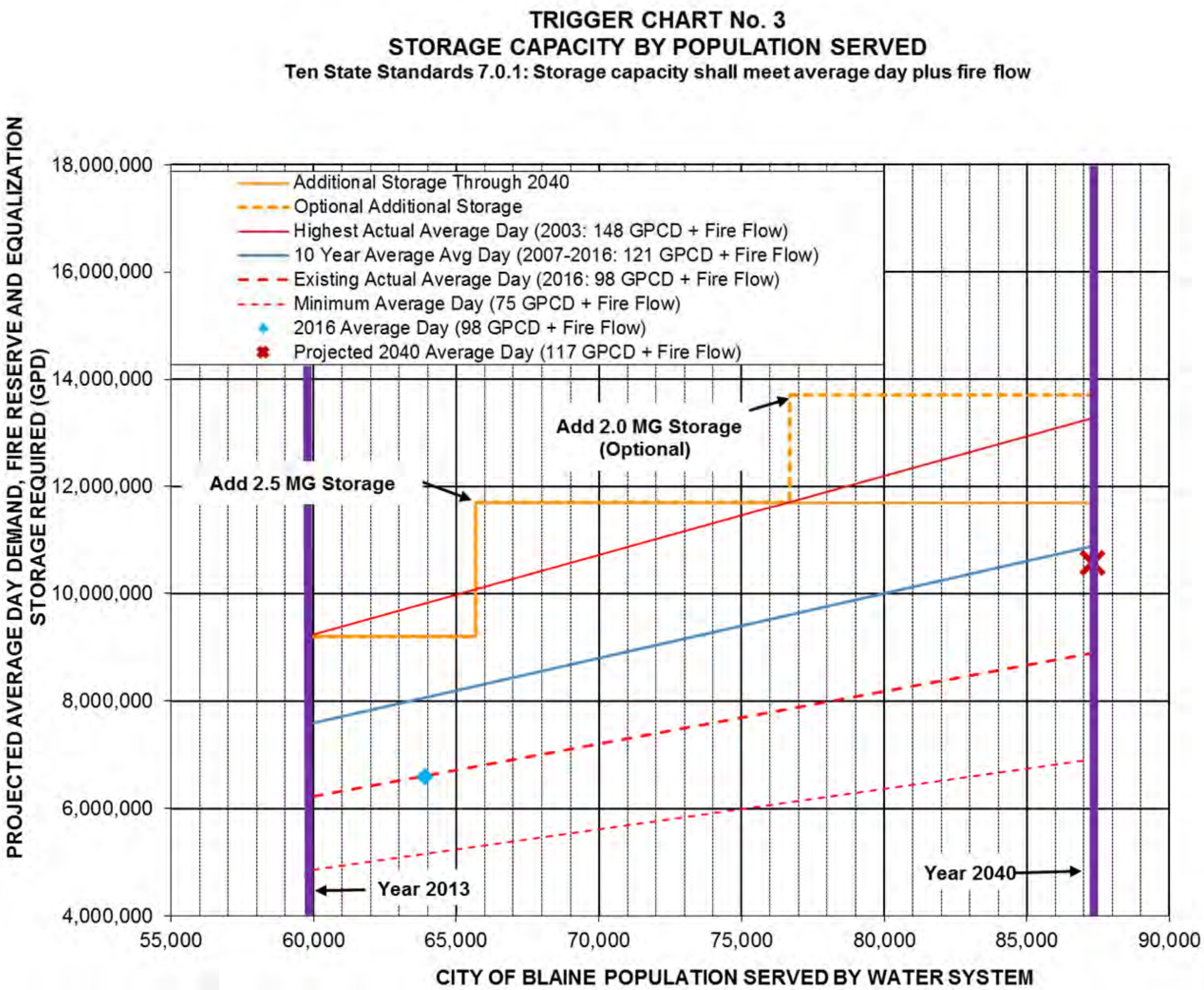

Figure 5-9 **Storage Capacity by Population Served**

6.0 Water Conservation and Efficiency Measures

6.1 Water System Improvements

The City has an ongoing maintenance program that includes their wells, treatment plants, towers, hydrants, flow meters, valves, controls, and watermains. The City has recently started implementing a watermain replacement program where watermains are replaced in conjunction with street reconstruction projects. In addition to planned maintenance, leak repairs and other maintenance is conducted as needed to ensure the reliability of the system.

Leak detection monitoring is an additional step the City can take to help reduce unaccounted water and make system improvements. The City has a new commitment to monitor all of the City lines on a 3-4 year cycle. The annual cost for conducting the leak detection survey has been included in Section 7.0.

6.2 Educational Efforts

Educating customers on water usage to improve water conservation is a key focus for the City. The City has numerous educational efforts to provide residents with information and tools related to water conservation.

6.2.1.1 Direct Customer Mailing

Water bills mailed to residents contain information that includes tips for water conservation. In addition, the City newsletter is used annually to provide information on the City's Consumer Confidence Drinking Water Report. Newsletters are also used to inform residents of hydrant flushing and provide the odd/even irrigation schedule.

6.2.1.2 City Website and Social Media

The City's website includes an entire page related to water use and conservation. The website includes information related to declining aquifer levels and provides facts on the City's specific water usage and how it fluctuates throughout the year. The bottom of the site includes water-saving tips residents can use to help reduce water usage.

The City also has a Facebook page, "City of Blaine, Minnesota, Government." The Facebook page is used throughout the year to provide information related to water conservation.

The Anoka County Wellhead Protection Group provides ongoing educational information including a website called "know the flow" which the City is a member of.

6.2.1.3 Educational Material

Different handouts can be picked up at City Hall. In addition to information related to water conservation, information on testing well water and installing rain gardens is also provided.

6.3 Water Conservation Ordinances and Enforcement

The City revised their sprinkling ordinance for odd/even-day watering on August 18, 2016. The revised ordinance is now enforced throughout the year, and is also restricted between the hours of 10:00 AM and 6:00 PM during summer months. The City Manager has authorized public works personnel and utility personnel to issue citations for sprinkler system violations.

An ordinance to allow appropriation of water from stormwater ponds for private irrigation is allowed if certain criteria specified by the City are met.

New developments are required to have a minimum of four inches of black dirt as topsoil. This is to help grass retain moisture and require less irrigation.

6.4 Lawn Irrigation

The City encourages its residents to install soil moisture meters to determine when lawns actually need watering. In addition, it is also recommended to install water sensors to prevent irrigation systems from turning on when it's raining. Commercial and industrial properties are required to have rain sensors on their lawn irrigation system. The City also encourages residents to inspect their irrigation systems for leaks and make repairs as needed and prevent water waste by making sure sprinklers are adjusted to spray the lawn, not sidewalks or streets. While not a requirement, new developments are asked to consider using stormwater for irrigation.

7.0 Conclusions and Recommendations

The CIP is broken into eight separate parts, which will be discussed throughout this section.

- Water supply
- Treatment
- Storage
- Wellhouse rehabilitation
- SCADA improvements
- Future watermain
- Annual O&M Costs
- Studies

A CIP cash flow, summarizing the decade costs will be incurred, has been included in Appendix L to help with planning and budgeting purposes.

With increasing capital costs associated with future infrastructure, the City may want to consider conducting a rate study to determine modification to customer billing rates. Customer billing rates were last modified on January 1, 2004.

As detailed in the Prioritized Water System Issue Memo included in Appendix C, the following table includes the top ten issues prioritized by the City. The planned steps for addressing each of the issues are included in the table, in the proposed improvements column.

Table 7-1 Top Ten Issues Prioritized by the City on June 6, 2017

Priority	Issue Description	Proposed Improvement
1	Reduced treatment plant capacities	See Table 7-9 below.
2	Water discoloration in the southeast corner of the City	City to investigate water quality issue under general maintenance and operations budgets. City is planning to conduct ice pigging in this portion of town during 2018.
3	Arrow Cryogenics water quality issues	City to investigate water quality issue under general maintenance and operations budgets. City is planning to conduct ice pigging in this portion of town during 2018.
4	5,000 gpm reservoir booster pumps are not used	See Table 7-9 below.
5	Low flow and pressure on east side of city between 109th and Territorial Road and University Ave NE and Jefferson St. NE	Model results show pressures are still within recommended pressure range.
6	High pressure on the north end of town when WT1 is full and 2,500 gpm reservoir booster pump is running	Model results show pressures are still within recommended pressure range.
7	WTP2 Watermain outlet undersized at 16"	Model results show headloss still within recommended range.
8	Well 14 reduced pumping capacity	See Table 7-9 below.
9	Lexington interconnection	See Table 7-9 below.
10	Peak water usage occurring from approximately 5:00 PM to 2:00-3:00 AM	Incorporate into general system planning.

7.1 Water Supply

The Northeast Well Field CIP includes costs associated with the installation of watermains for newly added Wells 18-21. The future watermains will connect wells to future WTP4 and the existing distributions system. The costs associated with future Well 22 are also included in this section along with the costs for temporary chemical feed systems. The total costs and details associated with the Northeast Well Field are included in the following table.

Table 7-2 Northeast Well Field CIP

Item	Item Description	Amount	Totals	Year
Well 18	Watermain: 125-ft of 12-in added west of Lexington Ave. NE, connecting existing Well 18 to future WTP4.	$20,000	$20,000	By 2020
Well 19	Watermain: 500-ft of 12-in connecting Well 19 to future WTP4.	$79,500	$290,000	By 2020
	Watermain: 435-ft of 30-in added west of Lexington Ave. NE connecting Well 19 to future WTP4. The 30-in pipe is where Well 19 connects to raw water from Well 20.	$210,105		By 2020
Well 20	Watermain: 654-ft of 24-in added west of Lexington Ave. NE, connecting the existing Well 20 main to future WTP4.	$284,490	$290,000	By 2020
Well 21	Watermain: 1,600-ft of 12-in added south of the existing Well 20 main, parallel to Lexington Ave. NE.	$254,400	$260,000	By 2020
Well 22	Watermain: 1,200-ft of 12-in added west of/parallel to Lexington Ave. NE, connecting existing Well 18 to future WTP4.	$190,800	$870,000	By 2020*
	Submersible Well (Quaternary well).	$350,000		By 2020*
	Pitiless, pump, motor, controls.	$325,000		By 2020*
Misc.	Watermain: 580-ft of 24-in added west of Lexington Ave. NE, connecting the existing finished watermains. Electric altitude valve install at Tower 4.	$305,700	$310,000	By 2020
Temporary Chemical Feed	Temporary building with chemical feed systems. Building size 10-ft by 15-ft.	$116,200	$120,000	By 2020
	SUBTOTAL		$2,160,000	
	CONTINGENCY (15%)		$324,000	
	ENGINEERING, LEGAL, ADMIN. (20%)		$432,000	
	TOTAL		$2,916,000	

*Well 22 added as soon as 2020 for WTP4 backup

7.2 Treatment

The WTP CIP includes costs associated with the installation of watermains to connect WTP finished water to the existing distribution system along with additional raw watermain piping. The cost for WTP4 is also included in the estimate. The total costs associated with WTP and watermain are included in the following table. More details for this estimate are found in the WTP4 Pilot and Feasibility Study.

Table 7-3 WTP4 CIP

Item	Item Description	Amount	Totals	Year
Watermain	Watermain: 755-ft of 30-in added west of Lexington Ave. NE, directly west of Water Tower No. 4, connecting the future Water Treatment Plant No. 4 influent raw water to the treatment plant and finished water to existing finished watermains	$364,665	$370,000	By 2020
WTP4	Water Treatment Plant 4	$17,900,000	$17,900,000	By 2020
	SUBTOTAL		$18,270,000	
	CONTINGENCY (15%)		$2,740,500	
	ENGINEERING, LEGAL, ADMIN. (20%)		$3,654,000	
	TOTAL		$24,664,500	

7.3 Storage

The Storage CIP includes costs associated with the installation of a new 2.0 MG tower along with maintenance required for the existing storage structures, such as painting.

Table 7-4 WTP4 CIP

Item	Item Description	Amount	Totals	Year
WT5	Water Tower 5 (2.0 MG)	$4,800,000	$4,800,000	By 2020
Tower Painting	Every 20 years, each tower	$1,000,000	$1,000,000	Every 20 Years
	SUBTOTAL		$5,800,000	
	CONTINGENCY (15%)		$870,000	
	ENGINEERING, LEGAL, ADMIN. (20%)		$1,160,000	
	TOTAL		$7,830,000	

7.4 Wellhouse Rehabilitation

The Wellhouse Rehabilitation CIP includes costs associated with replacing buildings, chemical feed, electrical, controls, and HVAC at different wellhouses. The preliminary details and total costs associate with the wellhouse rehabilitation are included in the following table.

Table 7-5 Wellhouse Rehab CIP

Item	Item Description	Amount	Totals	Year
Well 1	Wellhouse 1 Rehab	$500,000	$500,000	By 2020
Well 2	Wellhouse 2 Rehab	$600,000	$600,000	By 2020
Well 5	Wellhouse 5 Rehab	$600,000	$600,000	By 2020
Well 7	Demo of existing building	$50,000	$150,000	By 2020
	Well abandonment	$95,000		
Well 8	Wellhouse 8 Rehab	$900,000	$900,000	By 2020
Well 9	Wellhouse 9 Rehab	$600,000	$600,000	By 2020
Well 10	Wellhouse 10 Rehab	$600,000	$600,000	By 2020
Well 11	Wellhouse 11 Rehab	$400,000	$400,000	By 2020
Well 14	Wellhouse 14 Rehab	$500,000	$500,000	By 2020
Well 16	Wellhouse 16 Rehab	$600,000	$600,000	By 2020
	SUBTOTAL		$5,450,000	
	CONTINGENCY (15%)		$817,500	
	ENGINEERING, LEGAL, ADMIN. (20%)		$1,090,000	
	TOTAL		$7,357,500	

7.5 SCADA Improvements

The SCADA Improvement CIP includes costs associated with improving communication and controls of the water system at each location. The total costs associated with the SCADA system are included in the following table. More details are included in the SCADA Evaluation report.

Table 7-6 SCADA Improvement CIP

Item	Item Description	Amount	Totals	Year
WT1	Water Tower 1 - Hardware	$14,000	$14,000	By 2020
WT3	Water Tower 3 - Hardware	$32,000	$32,000	By 2020
WT4	Water Tower 4 - Hardware	$32,000	$32,000	By 2020
Well 1	Well 1 - Hardware	$28,000	$28,000	By 2020
Well 2	Well 2 - Hardware	$28,000	$28,000	By 2020
Well 5	Well 5 - Hardware	$28,000	$28,000	By 2020
Well 8	Well 8 - Hardware	$28,000	$28,000	By 2020
Well 9	Well 9 - Hardware	$28,000	$28,000	By 2020
Well 10	Well 10 - Hardware	$28,000	$28,000	By 2020
Well 11	Well 11 - Hardware	$28,000	$28,000	By 2020
Well 12	Well 12 - Hardware	$28,000	$28,000	By 2020
Well 13	Well 13 - Hardware	$28,000	$28,000	By 2020
Well 14	Well 14 - Hardware	$28,000	$28,000	By 2020
Well 15	Well 15 - Hardware	$22,000	$22,000	By 2020
Well 16	Well 16 and Ground Storage Reservoir - Hardware	$42,000	$42,000	By 2020
Well 17	Well 17 - Hardware	$16,000	$16,000	By 2020
Well 20	Well 20 - Hardware	$3,000	$3,000	By 2020
Well 21	Well 21 - Hardware	$3,000	$3,000	By 2020
WTP1	Water Treatment Plant 1 - Hardware	$51,000	$51,000	By 2020
WTP2	Water Treatment Plant 2 - Hardware	$46,000	$46,000	By 2020
WTP3	Water Treatment Plant 3 - Hardware	$36,000	$36,000	By 2020
Radio	Radio communication system - Hardware	$196,013	$197,000	By 2020
Other	Cabinet removal, installation, conduit, wiring - Hardware	$54,735	$55,000	By 2020
Software	Software integration	$211,959	$212,000	By 2020
	SUBTOTAL		$1,040,000	
	CONTINGENCY (10%)		$100,000	
	ENGINEERING, LEGAL, ADMIN. (20% Hardware and 10% Software)		$190,000	
	TOTAL		$1,330,000	

7.6 Future Watermain

The Future Watermain CIP contains costs associated with watermain that will be required throughout the City as development continues through 2040. The watermain included in this section have been identified using the future system model. The details and total costs associated with future watermain are included in the following table.

Table 7-7 Future Watermain CIP

Item	Item Description	Amount	Totals	Year
10" Watermain	Watermain: 1,200-ft of 10-in added from 4813 121st Ave NE to Sunset Ave and 121st Ave NE	$191,118	$200,000	By 2040
12" Watermain	Watermain: 4,500-ft of 12-in added from 125th Ln NE and Jefferson St NE to 132nd Ave NE	$712,320	$720,000	By 2040
12" Watermain	Watermain: 5,600-ft of 12-in added from Hupp St NE to Lexington Ave NE and Watermain along Lexington Ave NE	$890,400	$900,000	By 2040
16" Watermain	Watermain: 3,800-ft of 16-in added from Quail Creek Pwky NE to 133rd Ln NE	$805,140	$810,000	By 2020
16" Watermain	Watermain: 1,300-ft of 16-in added from Harper St NE and 131st Ave NE along 131st Ave NE	$268,380	$270,000	By 2040
20" Watermain	Watermain: 8,400-ft of 20-in added from Lever St NE and 131st Ave NE and west to Harper St NE	$1,932,000	$1,940,000	By 2040
20" Watermain	Watermain: 4,600-ft of 20-in watermain added along Lever St NE from 125th Ave NE and north to 131st Ave NE	$1,062,600	$1,070,000	By 2020
20" Watermain	Watermain: 2,300-ft of 20-in watermain added from 126th Ln NE east and south to 125th Ave NE	$515,200	$520,000	By 2040
24" Watermain	Watermain: 7,200-ft of 24-in from Lexington Ave NE added from 122nd Ave NE to 133rd Ln NE	$1,827,840	$1,830,000	By 2040
24" Watermain	Watermain: 3,400-ft of 24-in added from 125th Ave NE from Lexington Ave NE to 3641 125th Ave NE	$860,160	$870,000	By 2040
	SUBTOTAL		$9,130,000	
	CONTINGENCY (15%)		$1,369,500	
	ENGINEERING, LEGAL, ADMIN. (20%)		$1,826,000	
	TOTAL		$12,325,500	

7.7 Annual O&M Costs

The Annual Costs CIP contains costs that will occur on an annual basis. The annual costs assume three wells are rehabilitated per year and that a leak detection survey is conducted on one-third of City lines per year. The details and total costs associated with O&M are included in the following table.

In addition to the costs listed in the table, a draft existing condition and service life assessment has been included in Appendix M. This assessment contains estimated installation dates for major pieces of equipment associated with the water system along with an estimated service life which is based on information provided by the American Society of Civil Engineers (ASCE). The service life assessment should be updated with equipment replacement dates to help plan and budget for future replacements.

Table 7-8 Annual O&M Costs

Item	Item Description	Amount	Totals	Year
Well Rehabilitation	Rehabilitate three wells every year. The costs included here assume all wells have already been brought up to good condition as part of the wellhouse rehab project.	$120,000	$120,000	Reoccurring Annual Cost
Leak Detection Survey	Approximately 300 miles of watermain are monitored on a 3-4 year cycle. (Cost included here is an annual cost for 100 miles of watermain)	$6,000	$10,000	Reoccurring Annual Cost
	SUBTOTAL		$130,000	
	CONTINGENCY (15%)		$19,500	
	ENGINEERING, LEGAL, ADMIN. (20%)		$26,000	
	TOTAL		$175,500	

7.8 Studies

The Studies CIP contains costs associated with the several studies mentioned throughout the report. The details and total costs associated with each study are included in the following table.

Table 7-9 Studies CIP

Item	Item Description	Amount	Totals	Year
Lexington Interconnections	Investigate interconnections with City of Lexington Recommendations to improve/develop SCADA alarms, maintenance agreement, legal agreement).	$20,000	$20,000	By 2020
Water Rate Study	Evaluate required billing rates for water system customers.	$30,000	$30,000	By 2020
Booster Station Rehabilitation	Evaluate requirements to improve reliability and efficiencies of reservoir booster station (inspect electrical, controls, valves, instrumentation, and emergency backup power and determine recommended booster pump capacity).	$20,000	$20,000	By 2020
Well 7 Water Quality	Evaluate the water quality for Well 7 since it contains both arsenic and di(2-ethylhexyl)phthalate.	$10,000	$10,000	By 2020
Well 14 Capacity	Evaluate Well 14 well capacity issues.	$10,000	$10,000	By 2020
WTP1, WTP2, WTP3 rehabilitation Assessment	Determine necessary equipment upgrades to improve reliability and operations, especially in regard to corrosion and security issues.	$15,000	$20,000	By 2020
Distribution Water Quality Analysis	Determine specific instrumentation improvements that would provide the information needed to successfully conduct an accurate water age analysis.	$20,000	$20,000	By 2020
Hydrant Flushing	Optimize current hydrant flushing program to improve water quality.	$5,000	$5,000	2018
Distribution Pressure Analysis	Investigate reoccurring low and high pressure areas in the distribution system.	$10,000	$10,000	By 2020
Resiliency Study	Use new EPA and AWWA J100 guidance to estimate risks and vulnerabilities to the water system.	$20,000	$20,000	By 2020
WT3 and WT4 Capacity	Investigate options to optimize existing towers to add 0.8 MG of storage capacity currently not being used in WT3 and WT4.	$20,000	$20,000	By 2020
WTP1 Water Quality	Evaluate historical water quality data and performance of the existing air stripper for removal of 1.2-dichloroethane (1,2-DCA) including a file review and correspondence with regulatory agencies.	$20,000	$20,000	2018
	SUBTOTAL		$170,000	
	CONTINGENCY (15%)		$25,500	
	ENGINEERING, LEGAL, ADMIN. (20%)		$34,000	
	TOTAL		$229,500	

8.0 References

Barr Engineering Co., 2016. City of Blaine Water Supply Plan, Water Supply System Description and Evaluation, Emergency Preparedness Procedures, and Water Conservation Plan. Prepared for City of Blaine, MN. December 2016.

Progressive Consulting Engineers, Inc., 2002. City of Blaine Water System Plan Update. Rev. February 20, 2002.

Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2012, Recommended Standards for Water Works. Commonly referred to as 'Ten State Standards.'

Minnesota Department of Natural Resources, Water Supply Plan Template, Part 3B, Conservation Objectives and Strategies, Key Benchmarks for DNR.

Metropolitan Council, Master Water Supply Plan, 2015

Partnership for Safe Drinking Water Goals, https://www.awwa.org/resources-tools/water-and-wastewater-utility-management/partnership-for-safe-water.aspx

Appendix A

Functional Description

Appendix B

System Schematic

Appendix C

Prioritized Water System Issues Memo

Appendix D

Existing Wells 1-21 Water Quality Data

Appendix E

Treatment Plant Water Quality Data

Appendix F

Distribution Water Quality Data

Appendix G

Water Issue Map

Appendix H

Existing System Modeling Results

Appendix I

Trigger Charts

Appendix J

Future System Modeling Results

Appendix K

Reconstruction Needs of Water System

Appendix L

CIP Cash Flow

Appendix M

Condition and Service Life Assessment