FEASIBILITY REPORT

WATER SUPPLY AND TREATMENT OPTIONS FOR PFAS AND NITRATE REMOVAL

August 2, 2023

Prepared for:
City of Hastings
101 4TH Street East
Hastings, MN 55033

WSB PROJECT NO. 022905-000

August 2, 2023

Mr. Ryan Stempski
City Engineer/Public Works Director
City of Hastings
101 4TH Street East
Hastings, MN 55033

Re: Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN
WSB Project No. 022905-000

Dear Mr. Stempski:

Enclosed please find the Feasibility Report for Water Supply and Treatment Options for PFAS and Nitrate Removal for the City of Hastings. The primary purpose of this study was to evaluate various water supply and treatment alternatives and provide recommendations on the most feasible and cost-effective option. The City's computer model of the water distribution system was updated and employed in the analysis. Costs were estimated for the recommended improvements.

We appreciate City staff's assistance in collecting and reviewing the information presented in this report. Your experience with and knowledge of the system was very helpful. We are available to review this report with you at your convenience.

Sincerely,

WSB

Jon Christensen, PE
Project Manager

Attachments

cc: Steve Nelson, WSB

kkp

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Certification Sheet

I hereby certify that this plan, specification, or 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.

Jon Christensen, PE

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Date: August 2, 2023 Lic. No. 57814

Quality Control Review Completed By:

Steve Nelson, PE

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Date: August 2, 2023 Lic. No. 24388

Executive Summary

The City of Hastings and the Minnesota Department of Health (MDH) have detected per- and polyfluoroalkyl substances (PFAS) in the City of Hastings raw water supply, in addition to Nitrate which was already known to be present. The PFAS concentrations and forthcoming national and state drinking water regulations have prompted the City to begin evaluating water supply and treatment options.

The Hastings water supply system currently includes six wells, one water treatment plant (WTP), two water towers, one ground storage tank, a booster station, and several pressure reducing valve stations. All of the City's wells are in the Jordan aquifer which has been impacted by PFAS contamination.

The Minnesota Veterans Home of Hastings owns and operates a separate community water system that also uses Jordan wells that are vulnerable to PFAS contamination. They have expressed interest in interconnecting with and receiving water, treated for PFAS removal, from the Hastings water system.

This study considers four water supply and treatment options for PFAS and Nitrate removal:

1. Blend Existing Wells to Dilute Below Limits
2. Construct Deeper Mt. Simon-Hinckley Wells
3. Purchase Treated Water from St. Paul Regional Water Services (SPRWS)
4. Implement Water Treatment

Blending is not feasible based on the PFAS concentrations relative to forthcoming EPA Maximum Contaminant Levels (MCLs) and MDH health-based guidance values. Constructing deeper Mt. Simon-Hinckley wells is not feasible because of a moratorium on the use of that aquifer and the Radium concentrations in its water. Purchasing treated water from SPRWS is not feasible due to the prohibitive distance and cost to connect and loss of control over water quality and water rates.

The only feasible option is to implement water treatment for the removal of PFAS. The most common treatment technologies for PFAS removal are granular activated carbon (GAC) and ion exchange (IX). IX for PFAS removal would require a pilot study. It is assumed IX would only be used for Nitrate removal.

GAC is a proven treatment process for PFAS removal and is pre-approved by MDH and the 3M Settlement Conceptual Drinking Water Supply Plan. The efficacy of particular GAC media should be evaluated with a rapid small scale column test (RSSCT).

Based on the projected water demands from the 2018 Water System Study, the City should plan to install a new Well No. 9 around the year 2026. The City's hydraulic model of the water distribution system was updated based on recent water use data and to include Well No. 9 and recent watermain improvements. The model was used to evaluate whether any treated watermain improvements would be needed after reconfiguring the water supply from wells to several water treatment plants. The hydraulic results are within acceptable ranges, however some segments at Sites 1 and 3 are candidates for future upsizing.

The estimated capital costs for the proposed improvements are $69 million, and the estimated annual operation and maintenance costs for the proposed facilities are approximately $800,000 to $1,000,000 (increasing over time).

1. Introduction

The City of Hastings and the Minnesota Department of Health (MDH) have detected per- and polyfluoroalkyl substances (PFAS) in the City of Hastings raw water supply, in addition to Nitrate which was already known to be present. The PFAS concentrations and forthcoming national and state drinking water regulations have prompted the City to begin evaluating water supply and treatment options.

1.1 Authorization

The City hired WSB to complete a feasibility study for water supply and treatment options for PFAS and Nitrate removal in April 2023.

1.2 Study Scope

This study includes identification and consideration of water supply and treatment alternatives, review of treatment technologies, review of water distribution system options based on computer modeling, and cost estimates.

1.3 Background

PFAS are a family of manmade chemicals used in products like non-stick cookware, microwave popcorn bags, firefighting foam, and other consumer products. They do not break down in the environment and are transported through the flow of surface and groundwaters. MDH has established health-based guidance values for six species of PFAS used to calculate a Health Risk Index (HRI), also referred to as Health Index (HI) or Hazard Index (HI), which is a unitless sum of measured PFAS concentrations divided by each of their respective health-based guidance values. The HRI is recommended to be maintained below 1.0.

From MDH sampling of Hastings raw water in recent years, three of seven sampling locations had quarterly running average HRI's between 0.5 and 1.0, and four of seven had running averages between 0.0 and 0.5. There has been one sample in one well that exceeded the HRI of 1.0, but its running average remains below 1.0.

PFAS related guidance values, regulations, and laboratory methods have been rapidly developing in recent years. In March 2023, the EPA proposed draft National Primary Drinking Water Regulation Maximum Contaminant Levels (MCLs) for six species of PFAS as detailed in *Table 1.1* below. The EPA's proposed MCLs are lower than existing MDH guidance values, and if established would result in higher HRIs and stricter treatment triggers and thresholds. MDH is also currently reviewing its health-based guidance values for PFOA and PFOS and has indicated that they will likely be lowered later in 2023 to values similar and potentially lower than the EPA Proposed MCLs.

Table 1.1 – EPA Draft MCLs for PFAS (proposed in March 2023)

Compound	Abbreviation	Proposed MCL
Perfluorooctanoic acid	PFOA	4.0 ng/L
Perfluorooctane sulfonate	PFOS	4.0 ng/L
Perfluorononanoic acid	PFNA	HRI 1.0 (unitless)
Perfluorohexane sulfonate	PFHxS	
Perfluorobutane sulfonate	PFBS	
Hexafluoropropylene oxide dimer acid	HFPO-DA*	

**Commonly and hereafter referred to as GenX*

2. Existing System

Hastings water system facilities related to Supply, Treatment, Storage, and Distribution System Pressure Zones are summarized in *Tables 2.1-2.4* below and shown on the attached *Figure 1*.

Table 2.1 – Supply

Well No.	Unique ID	Aquifer	Year	Depth (ft)	Casing Diameter (in)	Capacity (gpm)
3	206333	Jordan	1956	299	16	1,200
4	207993	Jordan	1961	400	16	1,200
5	207639	Jordan	1970	355	24	1,200
6	207643	Jordan	1972	332	24	1,200
7	509053	Jordan	1989	285	24	1,200
8	686266	Jordan	2006	280	24	1,200
					Total Capacity	**7,200**
					Firm Capacity	**6,000**

Table 2.2 – Treatment

WTP No.	Location	Capacity (gpm)	Wells	Target	Processes
1	1300 N Frontage Rd	1,600	3, 5	Nitrate	Ion Exchange, Chemical Addition

Table 2.3 – Storage

Name	Zone	Volume (MG)	High Water Level (ft)	Year
4th Street Tower	Main	0.75	1,016	1985
Industrial Park Tower	Main	1.0	1,016	1997
Ground Storage Tank	Low	1.0	902	1998
Total		**2.75**		

Table 2.4 – Pressure Zones

Pressure Zone	Supply	Storage (MG)	Approx. HGL* (ft)
Main	Wells 4, 6, 8, Booster Station	1.75	1,016
Low	Wells 3, 5, 7, and 3 PRVs	1.0	902
Reduced	2 PRVs	0.0	930

**HGL = hydraulic grade line*

Minnesota Veterans Home of Hastings

The Minnesota Veterans Home of Hastings located at 1200 East 18th Street on the eastern side of the city currently owns and operates its own community water system. The system serves approximately 180 people and supplies an average of 18,000 gallons per day (gpd). Historical average day demands have reached as high as 20,000 gpd. The maximum day demand was assumed to be 40,000 gpd per the system's MDH inventory report.

The Veterans Home water system facilities related to Supply, Treatment, Storage, and Distribution System are summarized below:

Supply – The system is supplied by three wells:

1. One primary Jordan well,
2. A second backup Jordan well, and
3. A third emergency Mt. Simon well.

   The Jordan wells are vulnerable to PFAS contamination. The Mt. Simon well has measurable Radium concentrations and is not considered a feasible long-term supply.

Treatment – The raw well water is treated via chemical addition. The Veterans Home does not have treatment for PFAS. PFAS treatment would be less cost effective for a system of its size.

Storage – Storage for equalization and fire-fighting is provided by one 250,000-gallon water tower.

Distribution System – Treated water is pumped into the Veterans Home distribution system.

   The system pressure is based on the water tower's high water level (HWL) elevation of approximately 948 feet plus or minus 5 feet.

The Veterans Home has expressed interest in interconnecting with and receiving water, treated for PFAS removal, from the City of Hastings water system. The feasibility of this interconnection is discussed in greater detail in the water distribution system modeling section.

3. Evaluation of Options

This study considers four water supply and treatment options for PFAS and Nitrate removal:

1. Blend Existing Wells to Dilute Below Limits
2. Construct Deeper Mt. Simon-Hinckley Wells
3. Purchase Treated Water from St. Paul Regional Water Services (SPRWS)
4. Implement Water Treatment

Each of these alternatives are discussed in detail below.

3.1 OPTION 1 – Blend Existing Wells to Dilute Below Limits

The first option is to blend the City's six existing groundwater wells before the point of entry (POE) to dilute the higher concentrations of PFAS and Nitrate from some wells with lower concentrations from others to reach acceptable health levels. This option is not considered feasible for the reasons outlined below.

Hastings draws its drinking water from six wells as detailed above, all in the Jordan aquifer. The historical maximum PFAS HRI Quarterly Running Annual Average (QRAA) and the average Nitrate concentrations over the last ten years for each well are listed in *Table 3.1* below. PFAS concentrations show a gradually increasing trend in most of the City's wells, and in most cases the maximum HRI QRAA has occurred in the last two years. Nitrate concentrations have been more constant over the last ten years, with variation of about one to three milligrams per liter (1-3 mg/L as N) in individual test results.

The raw water from Wells 3 and 5 is already treated at WTP No. 1 for Nitrate removal via ion exchange (IX). Therefore, for the purposes of the blending analysis, the WTP No. 1 PFAS and Nitrate concentrations are used instead of the Well 3 and 5 concentrations.

Table 3.1 – Historical PFAS and Nitrate Concentrations

Well No.	Max. PFAS HRI QRAA	Nitrate (as N) (mg/L)
3	0.48	9.1
4	0.09	4.1
5	0.76	7.7
6	0.29	7.9
7	0.57	5.9
8	0.94	7.7
WTP No. 1	0.47	5.2
Limit	*1.0*	*10.0*

The City's average day demand from 2013-2022 was 2.33 million gallons per day (MGD) (equal to 1,620 gallons per minute (gpm)), and its maximum day demand was 5.10 MGD (3,540 gpm). To meet the City's existing max day water demand, the City must have three wells operating at a time (1,200 gpm per well), and sound management (i.e., Firm Well Capacity) also requires having a fourth well to be available as a backup during maintenance, or in the event of an emergency. Therefore, blending scenarios must include a minimum of four wells.

As mentioned previously, the EPA announced draft MCLs for six species of PFAS in March 2023. PFOA is the one of particular concern for the City of Hastings. The draft MCL for perfluorooctanoic acid (PFOA) is 0.004 micrograms per liter (µg/L). If established, five of the City's six wells (and WTP No. 1) would already exceed this limit based on the most recent quarterly running PFOA concentrations shown in *Table 3.2* below.

Table 3.2 – Historical PFOA Concentrations

Well No.	PFOA QRAA Concentration (µg/L)	EPA Draft MCL (µg/L)
3	0.010	0.004
4	0.002	
5	0.016	
6	0.005	
7	0.007	
8	0.022	
WTP No. 1	0.011	

Rapidly evolving laboratory science is expected to continue leading to lower PFAS detection limits and regulatory limits. It is appropriate for Hastings to plan for tightening PFAS limits.

The historical PFOA concentrations relative to the EPA's draft MCLs demonstrate a strong likelihood that blending will not be a feasible option for the City. Under the proposed MCLs, the only usable well would be Well No. 4, which can only supply 1,200 gpm and cannot satisfy the City's existing max day demand (let alone future demand) on its own.

In addition, MDH is expected to release new health-based guidance values for PFOA and PFOS in 2023 and has indicated that they will be more stringent (lower) than current MDH values, and potentially even lower than the EPA Draft MCLs. Therefore, even if EPA relaxed its MCL for PFOA to the point that the City could use more of its wells, MDH's new guidance values for PFOA and PFOS will increase the HRIs and could push certain wells above 1.0 and trigger health risk advisories, again making those wells unusable without treatment.

In addition to the regulatory concerns that make blending unfeasible, other challenges include:

- Controlling of PFAS and Nitrate concentrations at the Point of Entry (POE) to the distribution system and at the consumer's tap would require complex system controls and monitoring, including but not limited to:
    - Control and monitoring of the time each well pump is operated.
    - Control and monitoring of the pumps and pressure reducing valves between pressure zones.
- Trends of historical PFAS concentrations indicate that there is reasonable likelihood that the PFAS concentrations in the City's aquifer could increase over time. This compounds the impact of stricter MCLs and guidance values anticipated in the future.
- Blending would not remove PFAS from the environment like treatment. The overall mass of PFAS in the environment, due to present natural resource damage, would remain unimproved.

3.2 OPTION 2 – Construct Deeper Mt. Simon-Hinckley Wells

The second option is to construct and pump from deeper Mt. Simon-Hinckley wells instead of the Jordan wells that are currently being used by the City. This option is also not considered feasible as outlined below.

The Mt. Simon-Hinckley Aquifer is the deepest bedrock formation in the Twin Cities and is significantly deeper than the Jordan Aquifer. This aquifer is confined and less susceptible to surficial contaminants. Per the Dakota County Hydrogeologic Atlas Plate 6 Bedrock Hydrogeology, "The Mt. Simon-Hinckley is the deepest high-yield aquifer available to Dakota County. It underlies the entire county and, under natural conditions, is hydraulically isolated from the Prairie du Chien-Jordan aquifer."

New Mt. Simon-Hinckley wells can potentially be drilled, although it is very uncommon for the DNR to approve them. The State of Minnesota currently has a moratorium that restricts the use of the Mt. Simon-Hinckley Aquifer in the Twin Cities Metropolitan Area. Therefore, the DNR does not issue appropriation permits to cities to pump groundwater from this aquifer when alternative water sources or interconnections with nearby public water systems exist. The City would be required to apply for and receive a variance from the DNR before this option could be fully analyzed. There is no guarantee that the DNR would issue a variance for these wells to Hastings. Variances have only been provided when a public water system has no other water supply options.

The 3M Settlement Conceptual Drinking Water Supply Plan dated August 2021 notes that, "To date, 11 Mt. Simon wells have been sampled for PFAS. PFBA was detected in five of the wells, ranging in concentration from 8 through 27 parts per trillion. MDH's [health risk limit] for PFBA is currently 7,000 parts per trillion." Despite only low concentrations of PFBA (among the smallest and most mobile PFAS) encountered in the Mt. Simon to date, this suggests that the aquifer is not immune to long-term contamination.

Additionally, the Mt. Simon-Hinckley Aquifer is likely to contain concentrations of radium that exceed the EPA MCL of 5.0 pCi/L for combined Radium 226/228. MDH's Distribution of Radium in Minnesota Drinking Water Aquifers report dated December 2010 shows concentrations of combined Radium 226/228 from 5.0 to 10.0 pCi/L and in excess of 10.0 pCi/L in the Mt. Simon aquifer along the Mississippi River near Hastings. Radium would require new treatment systems (ion exchange, reverse osmosis, hydrous manganese oxide filtration, lime softening, or other) that would add significant capital and operations and maintenance costs on top of the cost of well construction.

Constructing and pumping water from deeper Mt. Simon-Hinckley wells is not feasible because of the permitting moratorium, long-term contamination risk, and probable radium treatment requirements and costs.

3.3 OPTION 3 – Purchase Treated Water from SPRWS

The third option analyzed is to purchase water on a wholesale basis and receive treated water from St. Paul Regional Water Services (SPRWS) via new transmission watermains. This option is also not feasible as detailed below. SPRWS water comes from the Mississippi River, a chain of lakes in the Northeast Metro, and backup groundwater wells. The raw water is treated at the McCarrons Water Treatment Plant (WTP). The main treatment processes include lime softening, flocculation, sedimentation, and filtration. SPRWS has a large and complex distribution system which delivers water to the City of St. Paul and surrounding communities.

The existing SPRWS trunk watermains are very far from the Hastings water distribution system. A potential connection point to the SPRWS system is an existing 30-inch diameter watermain at the West Side Reservoir along Imperial Drive in West St. Paul (West Side Pressure Zone). The existing trunk watermains in the southeastern portion of the SPRWS system are too small for connection based on the approximate transmission main sizing below. The potential connection point would require approximately twenty-mile-long transmission watermains through several intervening cities and townships.

An interconnection to the SPRWS system would need to supply enough water to meet the City's future maximum day demands. The City's Water System Study dated June 2018 lists a projected 2040 max day water demand of 8.24 MGD. To minimize velocities and headloss at that flow rate over the twenty-mile distance, the transmission watermains would need to be 30-inch to 36-inch diameter. Dual transmission watermains would be recommended for redundancy. The cost to acquire land or easements, construct, and maintain dual transmission watermains of this size over twenty miles is prohibitive. The relative hydraulic grade lines of the SPRWS and Hastings systems and the hydraulics along the transmission watermains have not been analyzed due to the prohibitive distance and costs associated with this option.

Purchasing treated water from SPRWS has several other significant disadvantages:

- The City would lose control over its water rates, and existing water rates would increase. The City would need to collect enough revenue from water users in the City to cover the cost of purchasing water from SPRWS, as well as to maintain its own existing water distribution system (water towers, watermains, hydrants, valves, and meters) within the City.
- The City would lose control over its water quality. Purchasing water from another entity would relinquish this control to others, and the City would not be able to directly address water quality changes.
- SPRWS has indicated that this type of interconnection would likely only be feasible in the context of regional water supply to multiple cities in the area.
- Surface waters, such as the Mississippi River which supplies SPRWS, are more susceptible to hazardous material spills and emerging contaminants which can jeopardize the water supply or require more costly treatment.
- The long-term reliability of the Mississippi River as a water source would be a concern. In the event of a historic drought or an intentional or unintentional contamination event, SPRWS would likely not have enough backup capacity in their groundwater wells to continue to serve all their customers.

Although this option has the advantages that the City would no longer be responsible for treatment and residents with home water softeners could save salt, equipment, and maintenance costs since SPRWS softens its water, the disadvantages detailed above are far greater and this option is not feasible.

3.4 OPTION 4 – Implement Water Treatment

The fourth alternative is to remove PFAS and Nitrate from the raw water at water treatment plants (WTPs) to meet EPA MCLs and MDH health-based guidance values. This was deemed to be the only feasible option. The quantity, locations, and types of WTPs are discussed below.

The City already treats the raw water from Wells 3 and 5 for Nitrate removal via ion exchange (IX) at WTP No. 1. The raw water from the remaining wells receives chemical addition at each well house, as required to provide safe aesthetically pleasing water to Hastings customers.

PFAS concentrations, regulations, and removal are the focus of this study, in order to address the damage caused to Hasting's natural resource by PFAS contamination. Regardless of the PFAS treatment technology(s) selected, Hastings will still need to deliver safe aesthetically pleasing drinking water to its customers; so iron, manganese, fluoride, disinfectant residual, and nitrate levels in the finished water will remain important.

PFAS cannot be removed via simple chemical addition, conventional rapid sand filtration, or biological filtration. The most common treatment technologies for PFAS removal are granular activated carbon (GAC) and ion exchange (IX), and these two technologies are discussed in greater detail below.

Membrane separation processes such as reverse osmosis (RO) and nanofiltration (NF) remove PFAS from the membrane permeate stream but also concentrate the PFAS present in the raw water into a concentrate stream rejected by the membranes (i.e. the membrane reject stream). It is not acceptable to send this PFAS laden concentrate (the membrane reject stream) to the sanitary sewer, because this would just "kick the PFAS pollution can" down the road to the wastewater treatment facilities. Treating the PFAS laden membrane reject stream would add substantial costs, such that the total treatment costs would be well above that associated with the GAC and IX treatment technology solutions. Thus, membrane separation processes are deemed to be an unfeasible treatment technology for PFAS removal in Minnesota.

The potential treatment technologies are summarized in *Table 3.3* below.

Table 3.3 – Treatment Technologies

Treatment Technology	PFAS	Nitrate	Relative Cost
Chemical Addition	No	No	Low
Conventional Filtration	No	No	Medium
Biological Filtration	No	Yes	Medium
Granular Activated Carbon (GAC)	Yes	No	Medium
Ion Exchange (IX)	Partial*	Yes	Medium
Reverse Osmosis (RO)	Yes/No**	Yes	High
Nanofiltration (NF)	Yes/No**	Yes	High

**IX removal efficiencies vary by resin and target PFAS species. IX resin is also susceptible to iron and manganese fouling and competition or interference amongst target contaminants as described in more detail below.*
*** Membrane (RO and NF) would remove PFAS from the membrane permeate stream but would also produce a PFAS laden membrane reject stream that cannot be sent to the sanitary sewer.*

Among the six compounds of PFAS currently monitored by the City and MDH, PFOA is the largest contributor to the City's HRIs as demonstrated in *Table 3.4* below. In other words, PFOA is the constituent whose concentrations have been closest to MDH's health-based guidance values. Any GAC media or IX resin selections should take this into account.

Table 3.4 – Relative PFAS Concentrations

Well No.	PFAS MDH HRI QRAA (unitless)	PFOA Portion of HRI QRAA	PFOS Portion of HRI QRAA	Other PFAS Portion of HRI QRAA
3	0.48	59%	7%	34%
4	0.09	46%	0%	54% (PFBA 45%)
5	0.72	64%	5%	31%
6	0.23	68%	11%	21%
7	0.57	35%	45%	20%
8	0.93	68%	19%	13%

Granular Activated Carbon (GAC)

GAC is a treatment technology that relies upon carbon granules (media) that have been activated to contain many small pores and cavities to provide a high surface area and many favorable adsorption sites for the removal of targeted constituents from the water being treated. In the context of PFAS removal, the cavities within the carbon provide many adsorption sites for the PFAS molecules to adsorb to and stick to. There are several types of commercially available GAC media and treatment systems. Activated carbon is also available in powdered, extruded, bead, woven, and other forms, but GAC has proven the most effective for PFAS removal.

GAC treatment systems have shown a greater than 90% removal rate for a wide range of PFAS. Studies have indicated that the removal rate for short chain PFAS, such as PFBA, diminishes at shorter contact times – typically expressed as empty bed contact time (EBCT). The removal rate can also be impacted by high concentrations of natural organic matter (NOM) which competes for adsorption area.

GAC treatment systems are widely used in municipal water treatment. In the East Metro, the Cities of Cottage Grove, Oakdale, and St. Paul Park have installed interim GAC WTPs under the 3M Settlement. GAC filter systems are typically operated with pairs of filters in a lead/lag series and media replacement (or in some cases, swapping of the lead/lag vessels) once PFAS breaks through the lead vessel and is detected in the effluent of the lead vessel. The spent or exhausted GAC filter media must be periodically replaced and regenerated or disposed of.

It should be noted, *the GAC PFAS removal facilities in the East Metro replace all of the media (in both the lead and lag GAC vessels) as soon as PFAS is detected in the effluent of the lead vessel.*

Ion Exchange (IX)

IX uses a reversible interchange of ions (negatively charged anions in the case of Nitrate removal) that takes place on ion exchange resin beads. The IX resin is periodically recharged with a saturated solution of the original anion, typically brine containing chloride. There are many types of commercially available IX resins designed to target particular solute ions or contaminants.

IX treatment system efficiency can be affected by competing solute ions present in the raw water. Notably, Nitrate has a stronger affinity for IX resins than PFAS, and individual PFAS species have varying affinities. Therefore, Nitrate will have greater removal efficiencies than PFAS, and certain PFAS species will have greater removal efficiency than others. The effectiveness of a particular IX resin for the removal of particular solute ions would need to be tested and demonstrated with a pilot study.

The City of Cottage Grove conducted a pilot study in 2020-2022. The study included five different treatment columns: one GAC column, two different IX columns, and two different GAC then IX columns. The IX columns experienced iron and manganese fouling in the first weeks of operation and pretreatment was added for the remainder of the pilot. GAC was less susceptible to fouling. IX performed better than GAC for perfluorosulfonic acids (PFAS species ending in “S”), and IX and GAC performed similarly for perfluorocarboxylic acids (PFAS species ending in “A”). PFOA is the largest contributor to the Hastings PFAS HRIs.

Treatment Train

GAC is a proven treatment process for PFAS removal and is pre-approved by MDH and the 3M Settlement Conceptual Drinking Water Supply Plan. The efficacy of particular GAC media should be evaluated with a rapid small scale column test (RSSCT), where the source water is flowed through a miniature filter column with ground media to simulate a sufficient number of bed volumes to predict removal efficiency and breakthrough point. *The RSSCT can help evaluate the efficacy of particular media with particular source water and particular PFAS targets, for example whether Hastings Well No. 7 with relatively higher PFOS concentrations warrants a different GAC media selection than the other wells.*

Nitrate removal efficiency with GAC depends on many factors such as the particular GAC media, the pH of the raw water, and the contact time between the water and media. Further bench or pilot scale study would be needed to predict the Nitrate removal efficiency. It is recommended that Hastings assume that IX will be necessary as a Nitrate removal treatment process in addition to the PFAS removal GAC process. The approximate land area for IX treatment has been evaluated and accounted for in the WTP site evaluation.

Pretreatment

Pretreatment may be required upstream of the IX and GAC filter vessels to remove iron and manganese and thereby prevent fouling or clogging of the filer beds. If pretreatment is necessary, it offers the benefit of extending the useful life of the resin or media. The longer lifespan means less long-term changeout costs.

The need for pretreatment will be further evaluated once additional iron and manganese test results for all of the City's wells become available later in 2023.

Treatment Summary

Implementing treatment offers the City the following benefits:

- GAC removes PFAS from the environment since the spent media covered in PFAS is typically disposed of or regenerated at an incineration facility that mineralizes or breaks down the PFAS into innocuous molecules. This reduces the amount of PFAS that exists in the environment.
- Removing PFAS from the aquifer would reduce risk to other users of the aquifer located downstream of Hastings.
- The City would maintain complete control of its water supply, water quality, and water rates without being dependent on another water utility.
- The City would be able to pump each of its wells as needed to meet the City's water demands, without cumbersome control and monitoring of which wells are running for how long and in which pressure zone.
- GAC, and to a limited extent IX, would also remove natural organic compounds, taste and odor compounds, and synthetic organic chemicals.

There are also a few disadvantages to note:

- New WTPs require additional operator training and time to operate and maintain the treatment systems.
- Treatment would involve a significant up-front capital expenditure.
- Treatment would require ongoing operation and maintenance costs (especially media or resin replacement costs).
- The City's water supply would be solely reliant on its groundwater sources, although the same is true for the existing wells.

4. Projected Water Demands

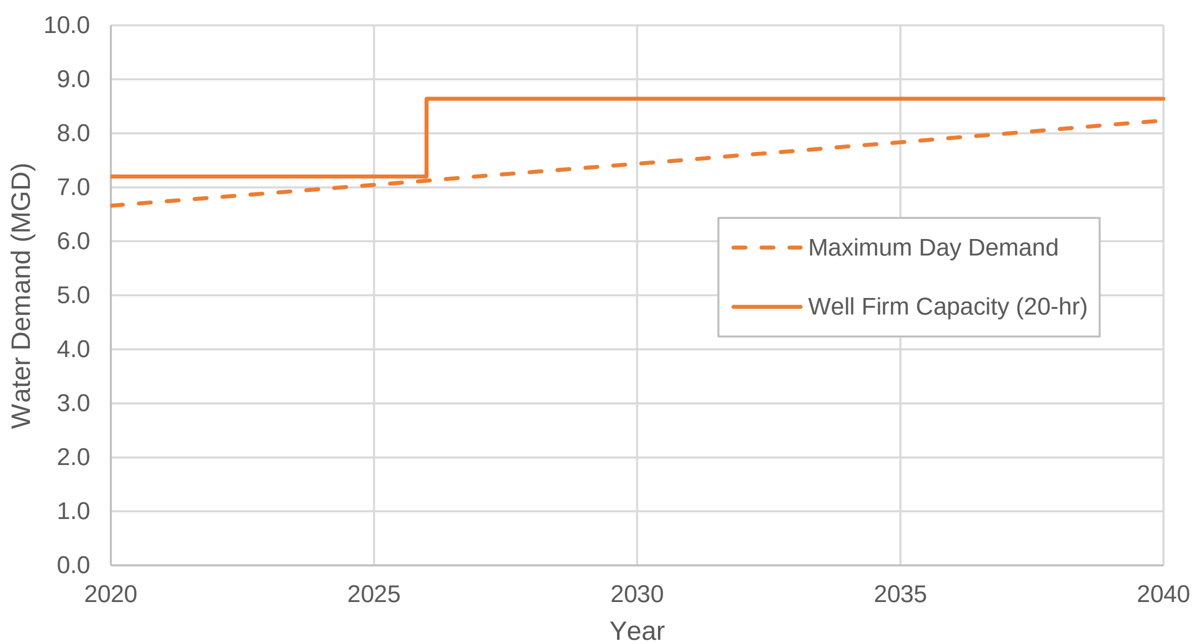
The projected water demands from the 2018 Water System Study are summarized in *Table 4.1* below. Based on recent historical data averaged over 2013 to 2022, the City's total per capita water demand and maximum day peaking factor have decreased slightly, but not to the extent that they warrant revised projections. Therefore, the projected water demands from the 2018 Water System Study were used in this analysis for consistency and to be conservative.

Table 4.1 – Projected Water Demands

Year	Population	Total Per Capita Water Demand (gpcd)	Average Day Demand (MGD)	Maximum Day Demand (MGD)
2030	26,000	110	2.86	7.44
2040	28,800	110	3.17	8.24

The City's well firm capacity, which is its capacity with the largest well out of service, is recommended to meet or exceed maximum day demand. Based on the projected maximum day demand and the existing well firm capacity using a 20-hour water supply period, the City should plan to install Well No. 9 around the year 2026. This water supply trigger is shown graphically in *Figure 2* below. The addition of Well No. 9 is incorporated in the water distribution system modeling and WTP site analysis.

Figure 2 - Water Supply Trigger Chart
City of Hastings, MN



5. Water Distribution System Modeling

The City of Hastings has a hydraulic model of its existing and future water supply systems that was last updated in 2017 to 2018 in support of the 2018 Water System Study. The model was updated for this analysis to include recent water demands based on historical water use data from 2013 to 2022, recent watermain improvements, and the Minnesota Veterans Home of Hastings water demands and skeletonized system. The updated model was used to analyze the system hydraulics and necessary improvements for implementing treatment.

Notable watermains already in place that can be used with the WTPs include dual 12-inch diameter raw and treated watermains between Wells 3 and 5 and a single 12-inch diameter raw watermain most of the distance between Wells 6 and 8. These watermains are shown on *Figures 3* and *4*. The modeling assumes these watermains will remain in service.

One Central WTP

It is typically more cost effective to construct WTPs at central locations that can receive water from multiple wells so long as the wells are located near enough to one another and the distribution system is adequately sized for the change in hydraulics. The feasibility and costs associated with pumping all of the City's wells to a single central WTP site were evaluated. The Well No. 3 site was determined to be the best candidate for a single central WTP based on the following criteria:

- Near the interface between pressure zones
- Near the ground storage tank (only storage serving the Low Zone) and booster station
- Near large diameter trunk watermains
- City-owned property (or property that can be easily acquired)
- Sufficient area of vacant land

Changing the locations of significant inflow into a water distribution system, such as at wells versus WTPs, often requires watermain improvements to maintain acceptable hydraulic conditions in the system. This includes limiting pressure surges to about five to ten pounds per square inch (5-10 psi), velocities to five feet per second (5 ft/s), and headloss gradients to ten feet per thousand feet (10 ft / 1,000 ft).

One method to maintain existing hydraulic conditions, when existing are already acceptable, is to provide treated watermains from WTPs back to wells so that treated water continues to enter the system at the same location. However, this can be overly conservative and result in unnecessary cost. Therefore, modeling was completed to determine what watermain improvements are truly needed in conjunction with a single central WTP.

The most taxing or intensive hydraulics that will be experienced by the system within the lifespan of this study are the future maximum day demand conditions which require six wells to be pumping simultaneously to keep pace with demand. Therefore, these conditions were used to determine the minimum trunk watermain improvements necessary to achieve acceptable hydraulic conditions in the system. The necessary improvements are shown in *Figure 12* and include upsizing the raw and treated watermains between the WTP and the Ground Storage Tank and Booster Station and upsizing the trunk distribution watermains on the Main Zone side of the Booster Station. Additional High Service Pumps (HSPs) in an expanded Booster Station will also be necessary to return treated water up to the Main Zone at the max day demand rate of that zone.

The estimated life cycle costs for this scenario, including the trunk watermain upsizing and high service pumps, are included in the next section.

Three Decentralized WTPs

Based on the locations of the existing Hastings production wells and pressure zones, it is more feasible to construct WTPs at three different sites with each treating raw water from two to three wells as summarized in *Table 5.1* below. The sites are shown on *Figure 9* and are numbered chronologically based on the anticipated order of construction. The estimated life cycle costs for this preferred scenario are also included in the next section.

Table 5.1 – WTP Sites

Site	Wells	Capacity (gpm)
1	6, 8	2,400
2	3, 5, 7	3,600
3	4, Future 9	2,400

This decentralized configuration with three WTPs offers the following qualitative advantages:

- The construction of the facilities can be phased. The WTPs can be built and placed into service in sequence, with priority given to wells with higher PFAS concentrations (in this case Site No. 1 for Wells No. 6 and 8).
- The WTPs will run independently. If an issue at one WTP requires it to be taken out of service, the others can continue to operate and supply treated water. This improves operational flexibility and resiliency.
- The wells can continue to pump into the existing pressure zones as they do currently without the need for “double pumping” a portion of the flow back up to the Main Zone and the resulting additional watermain and booster station upsizing.
- The existing distribution watermains near each site are adequately sized to accommodate the change in hydraulics, as described below.

The modeling of hydraulics near each individual WTP site assumed the maximum pumping rate through the WTP at that site as the worst-case scenario. One special case is WTP Site No. 2 where it is assumed that the existing 12-inch diameter treated return line from Well No. 3 to Well No. 5 will remain in service to convey a portion of the flow to the booster station to be pumped to the Main Zone. The hydraulic modeling results are summarized in *Table 5.2* below.

Table 5.2 – Modeling Results

Site	Pressure Surge (psi)	Velocity (ft/s)	Headloss Gradient (ft / 1,000 ft)
1	3 – 7	4.4	7.8
2	< 1	1.8	2.6
3	2 – 4	4.0	7.8

The following are general observations for each site based on the results in *Table 5.2*:

1. Site No. 1 will experience hydraulic conditions approaching the AWWA recommended limits in the existing 12-inch diameter watermain in Spiral Blvd between Great River Rd and Well No. 6. That segment is a candidate for future upsizing to 16-inch diameter.
2. Site No. 2 will experience acceptable hydraulic conditions in the nearby water distribution system whether Well No. 7 is pumped to this site or not. The existing 12-inch diameter treated return line from Well No. 3 to Well No. 5 should remain in service to convey a portion of the flow to the booster station to be pumped to the Main Zone. Short segments of on-site watermain will require reconfiguration or upsizing, to be determined during preliminary design.
3. Site No. 3 will experience hydraulic conditions approaching the AWWA recommended limits in the existing 12-inch diameter watermain in Northridge Dr from Stonegate Rd to Wyndham Hill Dr. That segment is a candidate for future upsizing to 16-inch diameter.

Minnesota Veterans Home of Hastings

Based on topography and existing water tower elevations, the Veterans Home site will require its own pressure zone. The ground elevations within the Veterans Home site vary from about 740 to 820 feet. Based on the Low Zone high water level (HWL) of 902 feet, static pressures off that zone would vary from 35 to 70 psi. Dynamic pressures at some locations would fall below the minimum working pressure of 35 psi, so integration with this zone is not feasible. In addition, looped interconnections under the Vermillion River would be costly.

Based on the Main Zone HWL of 1,016 feet, static pressures off that zone would vary from 85 to 120 psi. Pressures above 80 to 90 psi are excessive, so supply from the Main Zone will require pressure reducing valve (PRV) stations at each interconnection location. There are several potential interconnection locations with existing watermains south of the site as shown on *Figure 10*. The existing Veterans Home water tower with a HWL of 948±5 feet can remain in service for equalization and fire protection within the new pressure zone.

A “skeletonized” or simplified version of the Veterans Home distribution system, water tower, and potential interconnection watermains with PRVs were added to the City’s water model. The pressures during maximum day demand would be similar to existing and vary from 40 to 81 psi. The available fire flows at a residual pressure of 20 psi at the main junctions in the skeletonized system would vary from 3,600 to 6,700 gpm. AWWA recommends an available fire flow of 3,500 gpm for large multi-use buildings, which would be satisfied in this case.

6. Estimated Costs

Because of the significant obstacles and disadvantages that make the first three of the four water supply and treatment alternatives not feasible as discussed in the sections above, the life cycle costs for those alternatives were not analyzed in detail. For the treatment alternative, the costs for both the Central WTP and Decentralized WTPs scenarios were developed for comparison.

The estimated cost to implement treatment is summarized in *Table 6.1* below and detailed in *Appendix C*. The costs are 30-year life cycle costs including the initial capital cost and 30-year operation and maintenance (O&M) costs. The initial capital costs include a 20% construction contingency (greater than usual due to recent economic instability, supply chain issues, and labor shortages) and 25% indirect costs such as administration, legal, and engineering.

The raw watermain costs are based on the improvements shown on *Figures 3* to *9* and *11* to *12* and directional drilling to the greatest extent possible to minimize easement or property acquisition, surface disturbance, and restoration costs. The WTP costs are based on IX and GAC pressure filters with a vehicle lane for resin and media changeouts and chemical feed systems for fluoride and chlorine. The 30-year costs include rehabilitation costs for each WTP at ten-year intervals. Rehabilitation work includes replacing coatings, valves, chemical feed, mechanical, and electrical.

The costs for the watermain improvements associated with the Veterans Home Site on *Figure 10* are not yet included, but they can be added upon request.

Table 6.1 – Summary of Estimated Costs

Description	Central WTP Estimated Cost	Decentralized WTPs Estimated Cost
Watermain Improvements	$25,130,000	$3,600,000
IX Treatment	$21,300,000	$29,280,000
GAC Treatment	$23,740,000	$35,480,000
Total Capital Costs	**$70,170,000**	**$68,900,000**
Total 30-Year Life Cycle Costs	**$98,870,000**	**$98,060,000**

7. Conclusions and Recommendations

Of the four water supply and treatment options considered in this report, the only feasible option is to implement treatment. Treatment should include GAC for PFAS removal and IX for Nitrate removal.

Treatment scenarios for a single central WTP versus three decentralized WTPs were compared. Three decentralized WTPs are more feasible and offer several qualitative advantages. Therefore, it is recommended to pursue the WTP sites identified in Figures *3* to *9*.

The efficacy of particular GAC media should be confirmed with a rapid small scale column test (RSSCT), in particular for Well No. 7 which has relatively higher PFOS concentrations compared to the other wells. The RSSCT and its funding should be coordinated with state agencies ahead of design to allow time for sampling and testing.

Changing the point of entries into the water distribution system from the wells to the WTPs will alter the hydraulic conditions in the system near those locations. The updated computer model of the water distribution system indicates that the hydraulic conditions with the decentralized WTPs will be within acceptable ranges. However, there are segments of existing 12-inch diameter trunk watermains at Sites 1 and 3 that are candidates for future upsizing to 16-inch diameter.

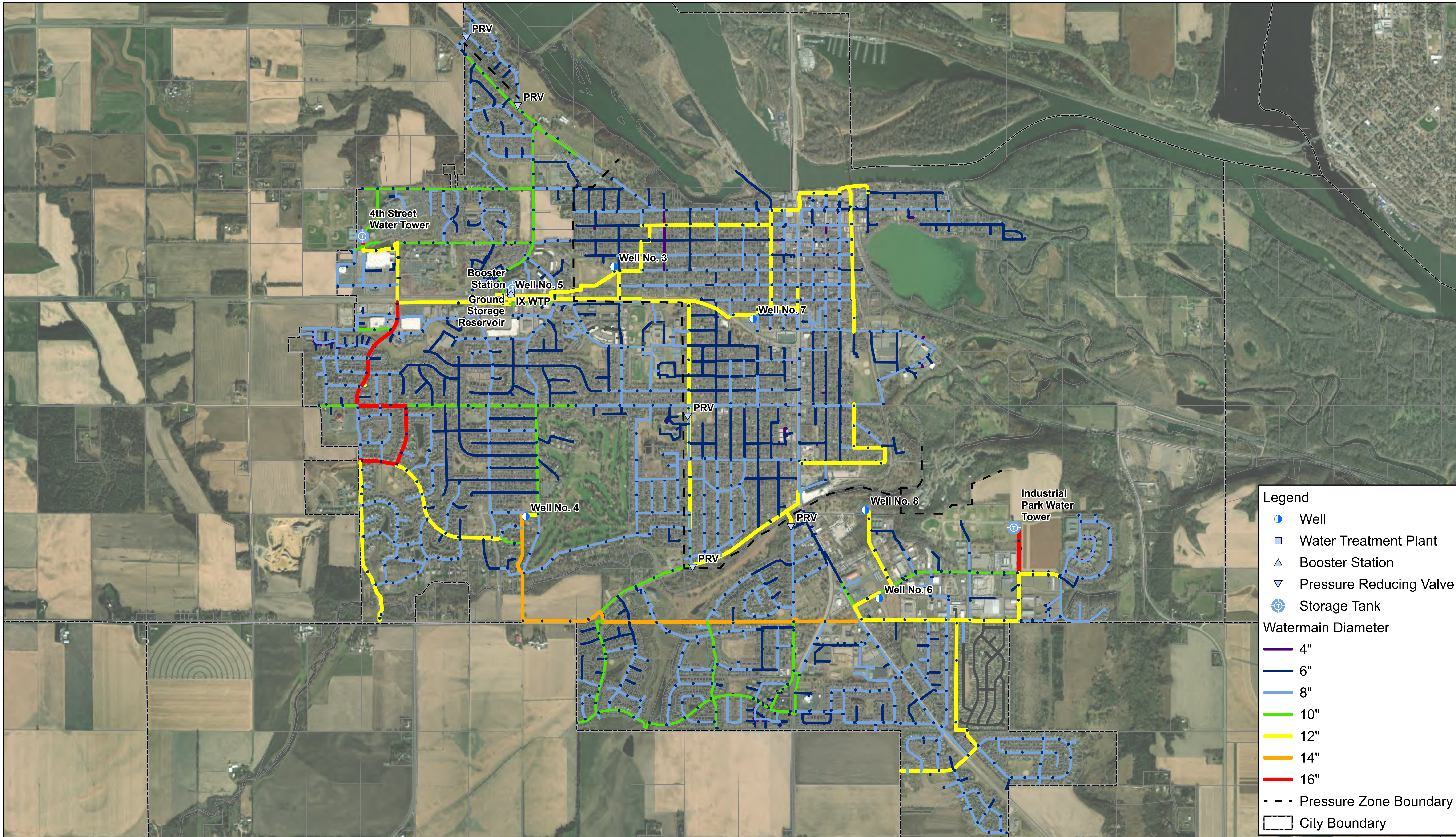
Based on the Veterans Home ground elevations and water tower HWL in relation to the Hastings pressure zone HGLs, interconnection(s) between the Veterans Home system and the Hastings system will require the creation of a new Veterans Home pressure zone with pressure reducing valve stations at each interconnection. The model indicates that the existing Veterans Home water tower provides acceptable pressures and available fire flows.

The analysis in this report should be revisited and updated when additional iron and manganese results become available for all of the City’s wells, and as EPA and MDH update their respective PFAS limits.

It is recommended that the City of Hastings engage with state agencies and funding sources to begin the RSSCT testing and then design and construction of the water treatment and distribution improvements detailed in this report. The estimated capital costs for the proposed improvements are $69 million, and the estimated annual operation and maintenance costs for the proposed facilities are approximately $800,000 to $1,000,000 (increasing over time).

Appendix A

Figures



Document Path: K:\022905-000\GIS\Maps\Hastings\Fig 1 - Existing Water Supply System Date Saved: 8/2/2023

Figure 1 - Existing Water Supply System

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

N

0 2,200 Feet

1 inch = 2,200 feet

wsb

Figure 2 - Water Supply Trigger Chart
City of Hastings, MN

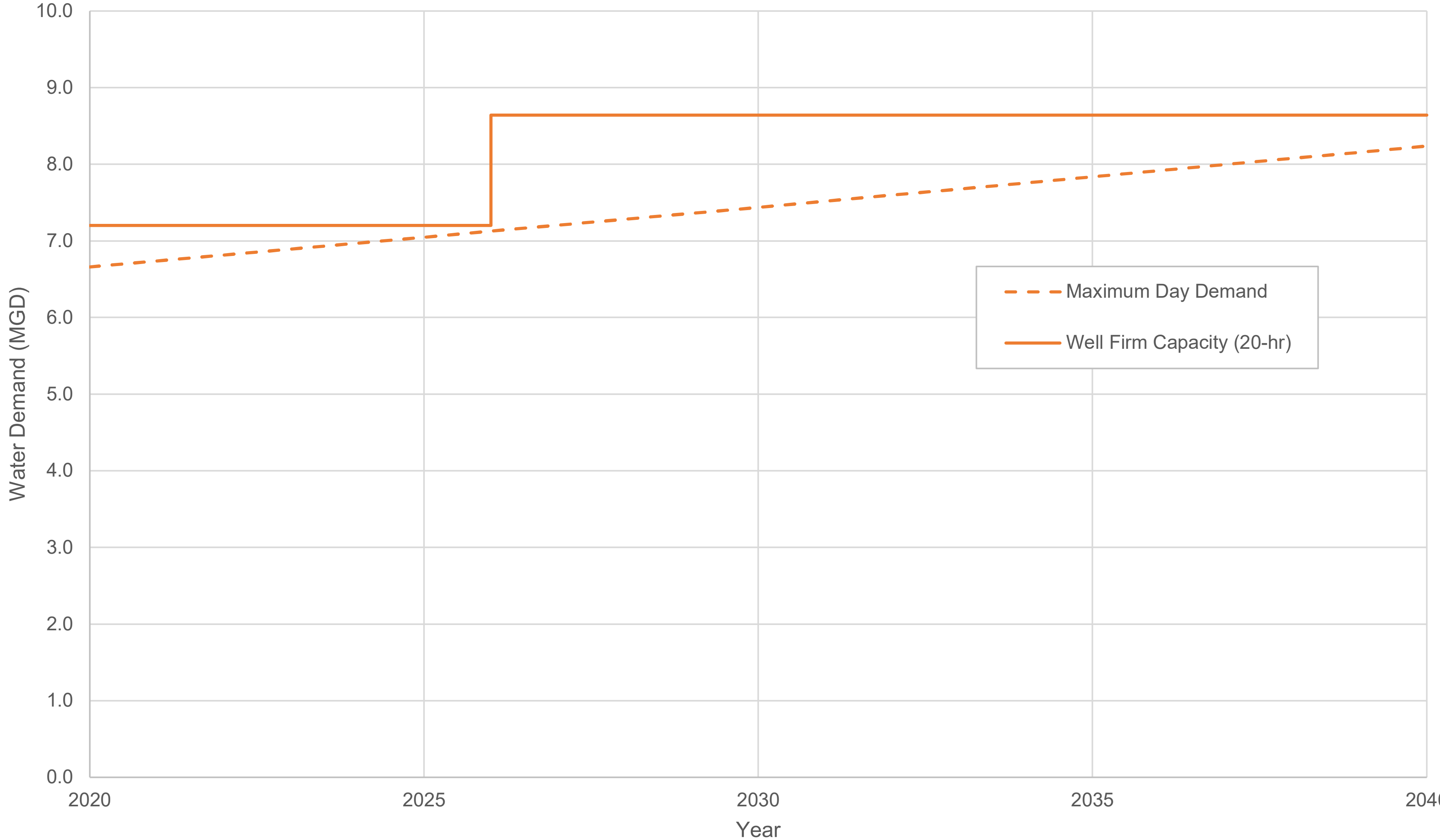


Figure 3 - Proposed WTP Improvements - Site No. 1

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

N
0 500 Feet
1 inch = 500 feet

Document Path: K:\022905-000\GIS\Maps\Hastings\Fig 3 - Proposed WTP Improvements - Site 1 Date Saved: 8/2/2023

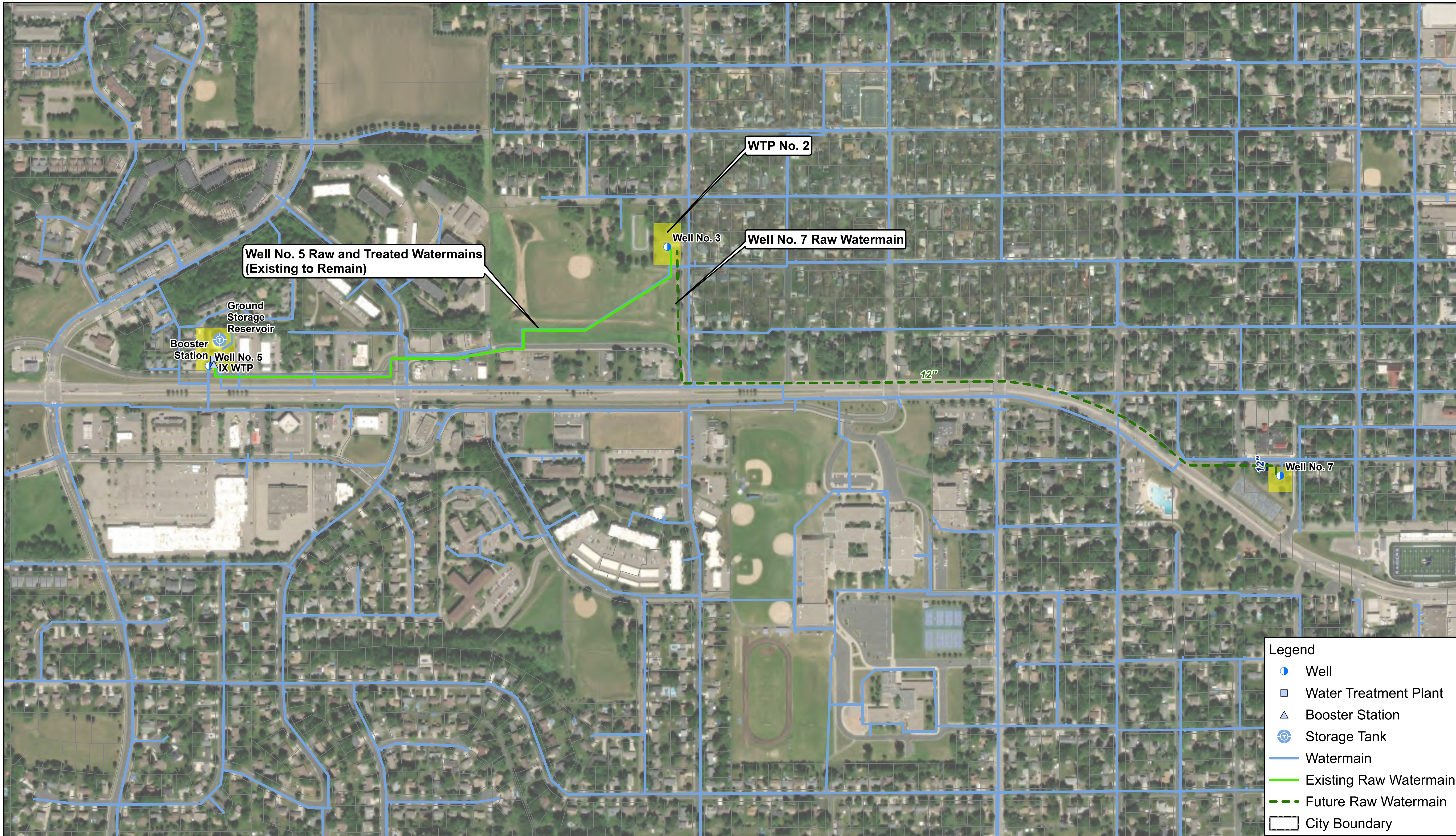
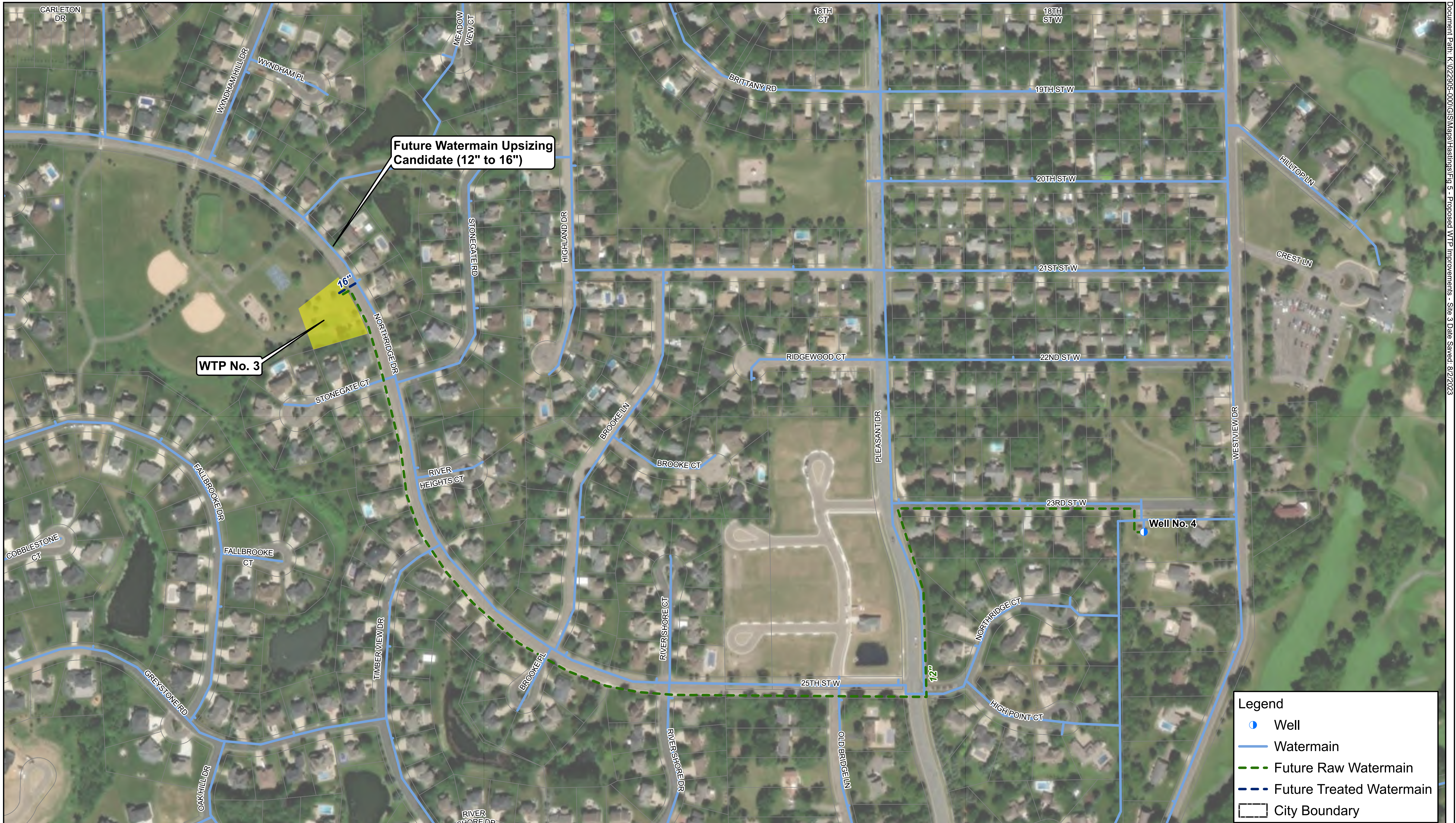


Figure 4 - Proposed WTP Improvements - Site No. 2

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

N
0 500 Feet
1 inch = 500 feet



Hastings Minnesota, Since 1857

Figure 5 - Proposed WTP Improvements - Site No. 3

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

wsb

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Since 1857 Hastings MINNESOTA

Figure 6 - Proposed WTP Sites - Site No. 1

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

N

0 50 Feet
1 inch = 50 feet

wsb

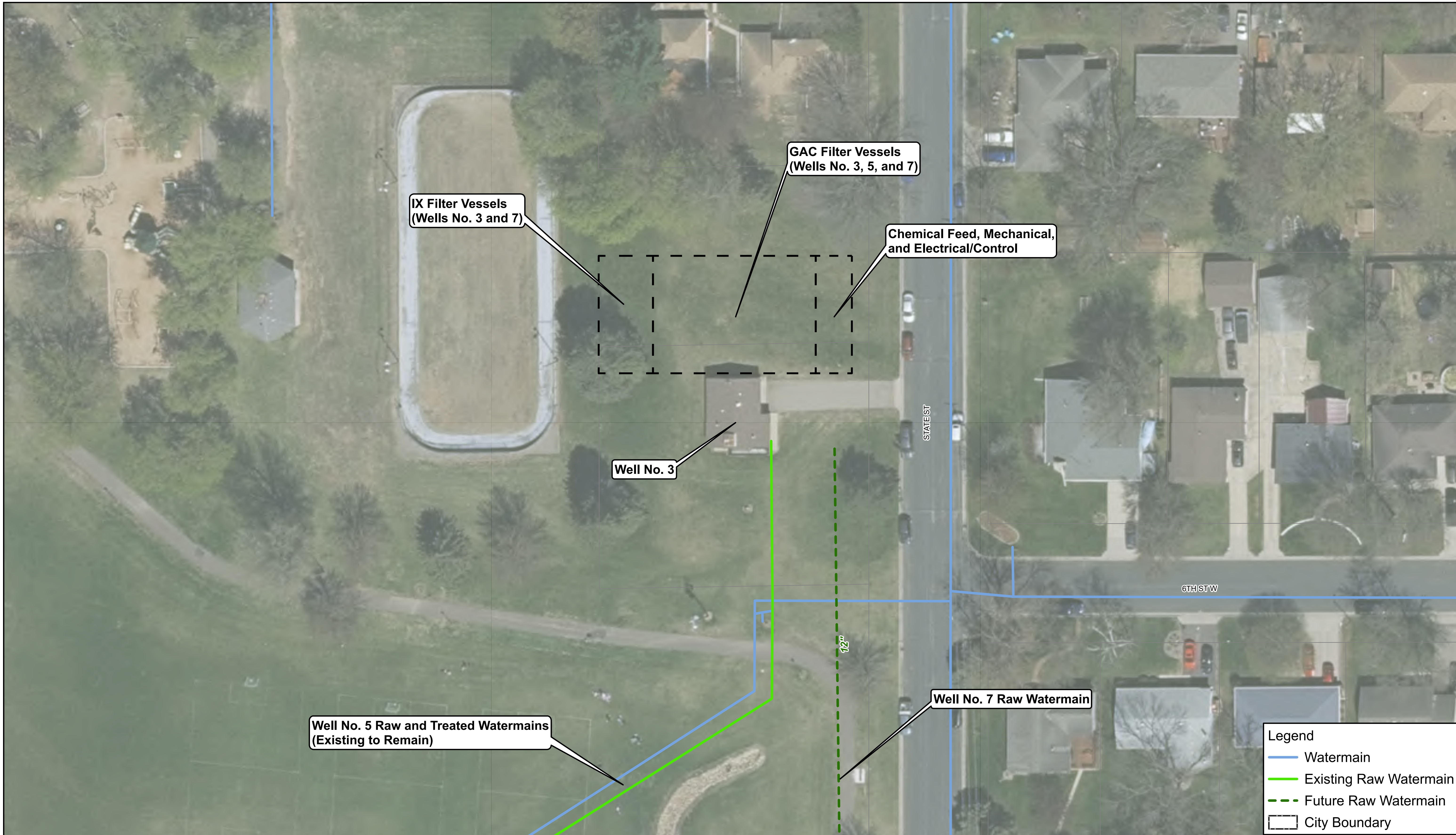
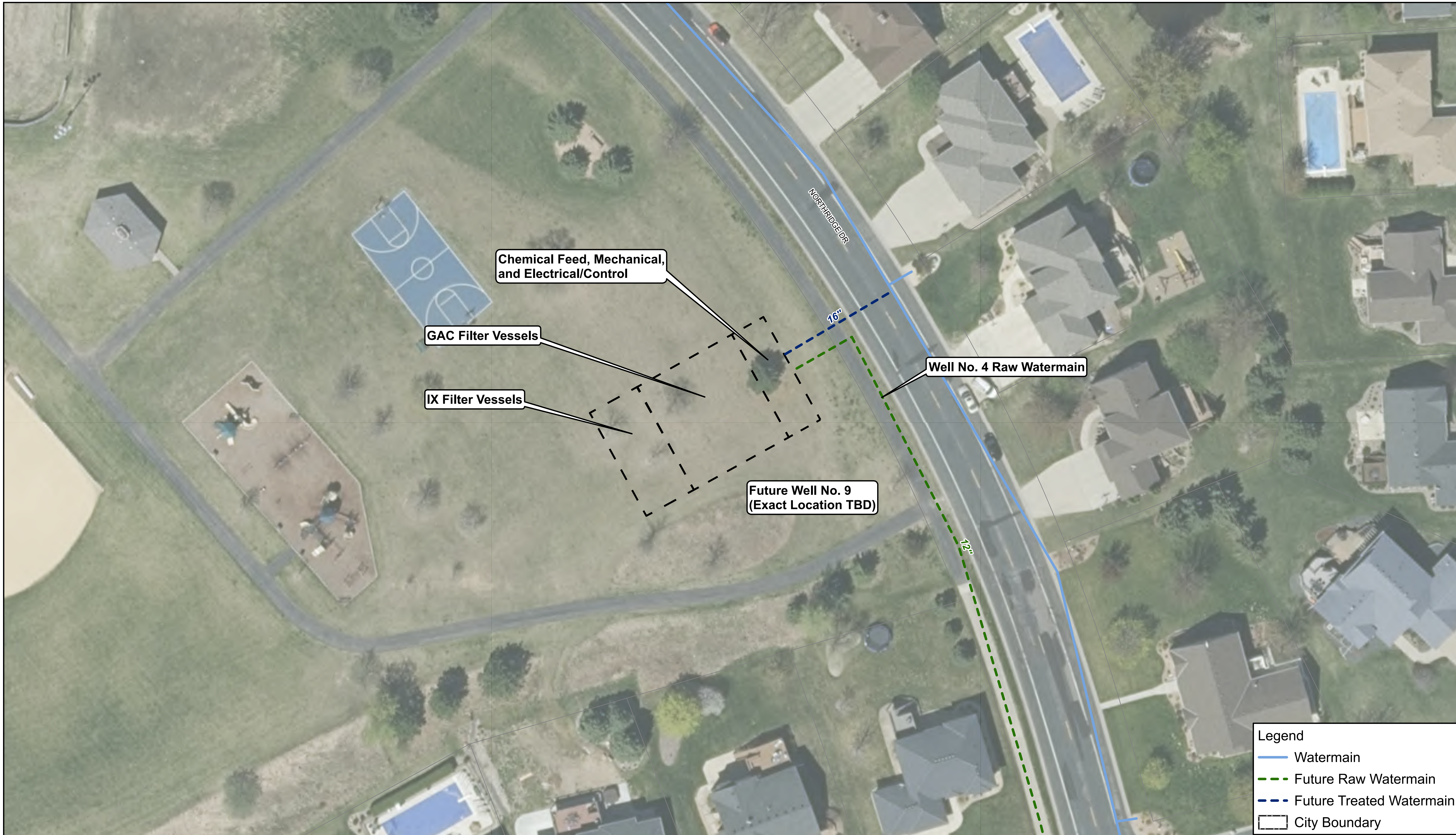


Figure 7 - Proposed WTP Sites - Site No. 2

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

Document Path: K:\022905-000\GIS\Maps\Hastings\Fig 7 - Proposed WTP Sites - Site 2 Date Saved: 8/2/2023

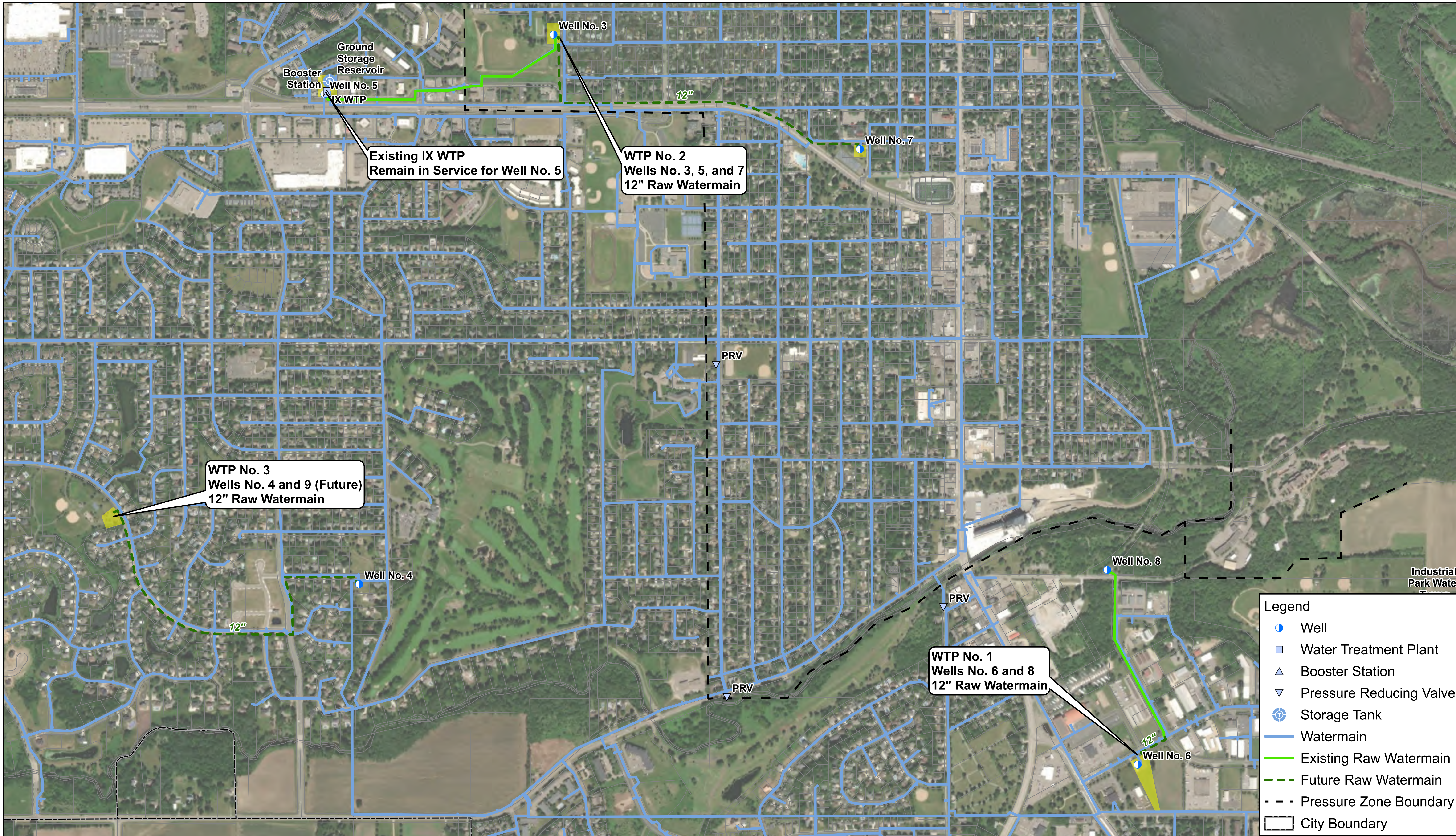


Document Path: K:\022905-000\GIS\Maps\Hastings\Fig 8 - Proposed WTP Sites - Site 3 Date Saved: 8/2/2023

Figure 8 - Proposed WTP Sites - Site No. 3

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

N
0 50 Feet
1 inch = 50 feet

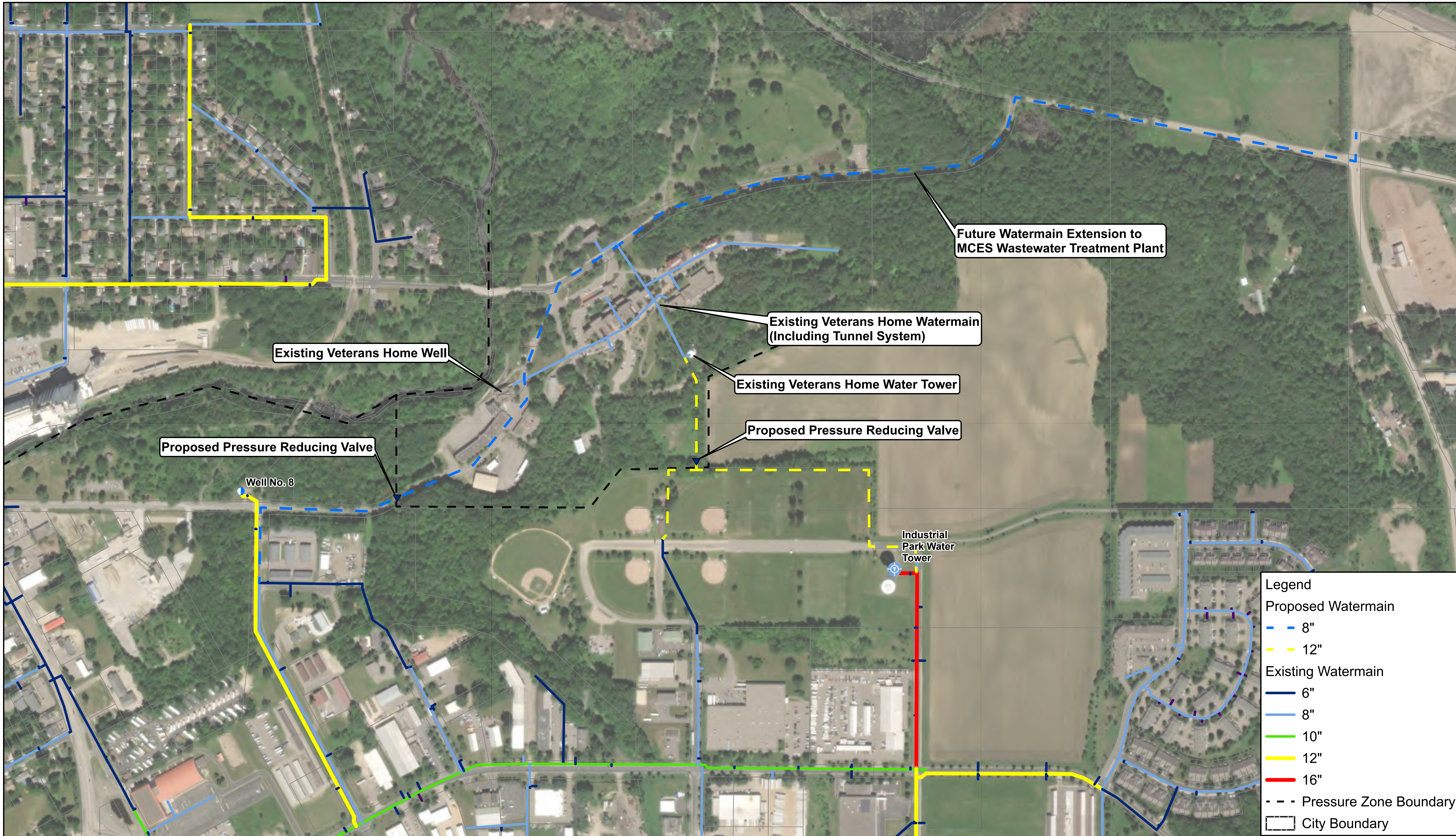


Document Path: K:\022905-000\GIS\Maps\Hastings\Fig 9 - Proposed WTP Phasing Date Saved: 8/2/2023

Figure 9 - Proposed WTP Phasing

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

N
0 500 Feet
1 inch = 1,000 feet

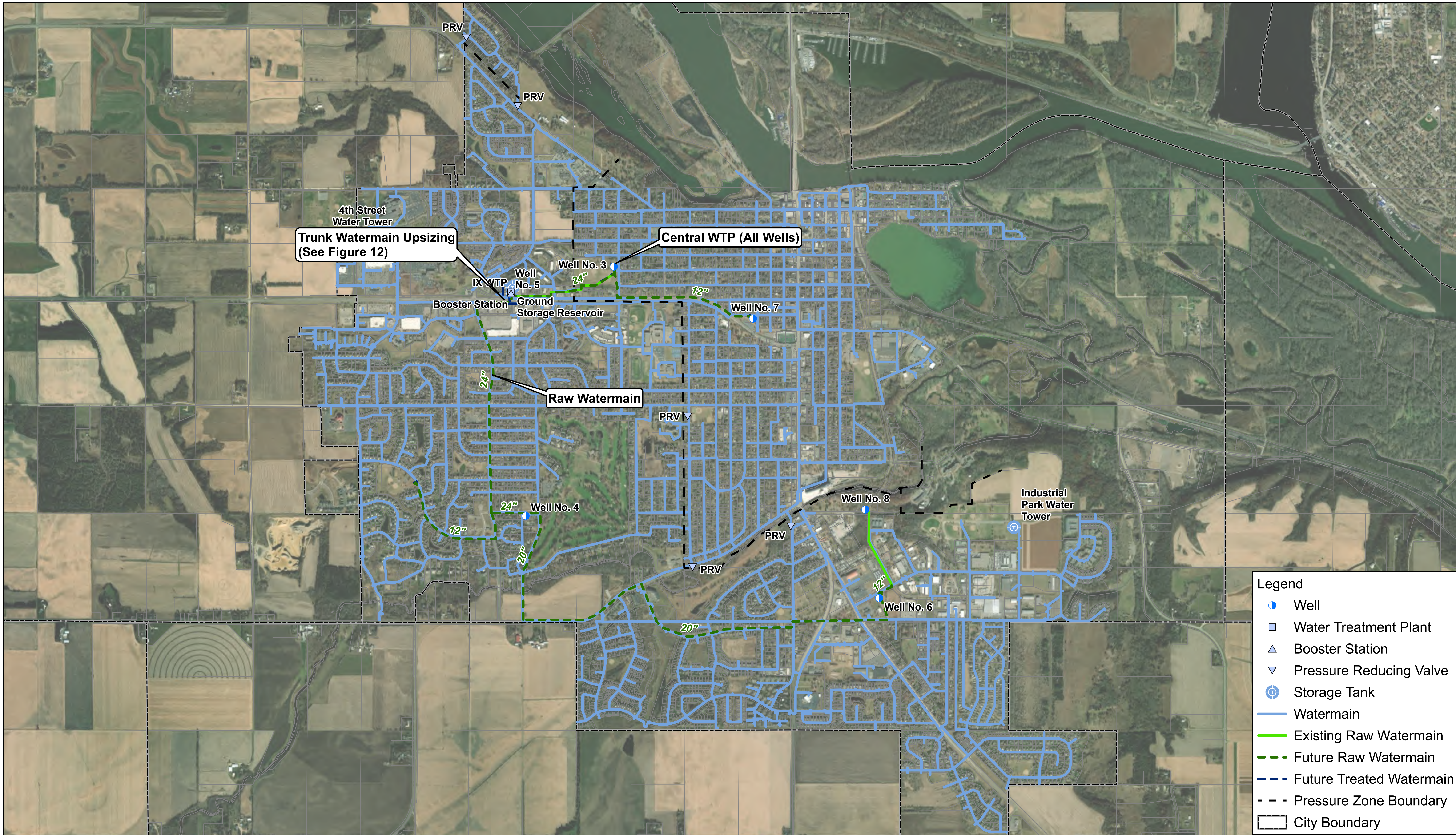


Document Path: K:\022905-000\GIS\Maps\Hastings\Fig 10 - Veterans Home Site Date Saved: 8/2/2023

Figure 10 - Veterans Home Site

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

N
0 500 Feet
1 inch = 500 feet



Document Path: K:\022905-000\GIS\Maps\Hastings\Fig 11 - Central WTP Improvements Date Saved: 8/2/2023

Since 1857 Hastings MINNESOTA

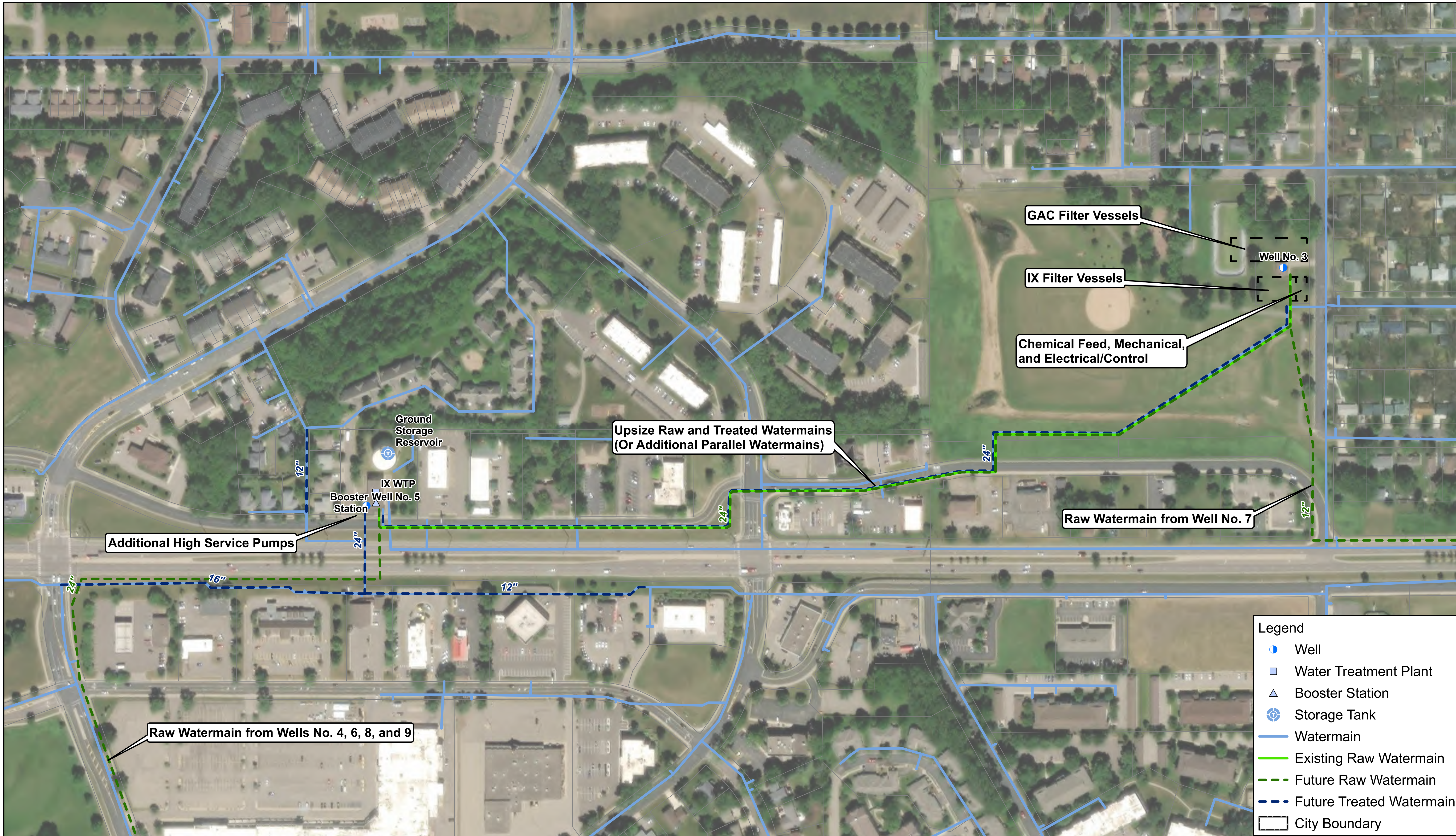
Figure 11 - Central WTP Improvements

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

N

0 2,200
Feet
1 inch = 2,200 feet

wsb



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Hastings Minnesota, Since 1857

Figure 12 - Central WTP Site

Water Supply and Treatment Options for PFAS and Nitrate Removal
City of Hastings, MN

N
0 250 Feet
1 inch = 250 feet

wsb

Appendix B

Historical PFAS Data

Well No. 3
Historical PFAS Concentrations
City of Hastings

	Measured Concentrations (µg/L)							
Date	**PFOS**	**PFOA**	**PFBS**	**PFBA**	**PFHxS**	**PFHxA**	**Health Risk Index (HRI)**	**HRI Quarterly Running Annual Average (QRAA)**
10/25/2022		0.01	0.0021	0.34	0.0029	0.007	0.45	0.48
7/25/2022		0.011	0.0023	0.3	0.0029	0.0074	0.48	0.45
10/25/2021	0.00099	0.0096	0.0021	0.37	0.0027	0.0072	0.51	0.45
9/2/2021	0.0011	0.0084	0.0019	0.33	0.0024	0.0069	0.47	0.33
4/20/2021	0	0.008	0.0014	0.29	0.0019	0.0054	0.35	0.28
3/18/2021	0	0.0099	0.0021	0.36	0.0029	0.008	0.46	0.24
2/21/2019	0	0	0	0.32	0	0	0.05	0.14
9/21/2017	0	0.007	0	0.32	0	0.0078	0.28	0.14
9/28/2015	0	0	0	0.3	0.007	0	0.19	0.09
6/3/2014	0	0	0	0.33	0	0	0.05	0.05
5/30/2013	0	0	0	0.34	0	0	0.05	0.06
5/24/2012	0	0	0	0.39	0	0	0.06	0.06
7/27/2011	0	0	0	0.47	0	0	0.07	0.06
3/18/2011	0	0	0	0.39	0	0	0.06	0.06
9/24/2010	0	0	0	0.36	0	0	0.05	0.06
3/25/2010	0	0	0	0.4	0	0	0.06	0.06
12/15/2009	0	0	0	0.6	0	0	0.09	0.06
9/23/2009	0	0	0	0.4	0	0	0.06	0.06
6/30/2009	0	0	0	0.4	0	0	0.06	0.06
3/24/2009	0	0	0	0.4	0	0	0.06	0.06
12/24/2008	0	0	0	0.4	0	0	0.06	0.06
9/29/2008	0	0	0	0.4	0	0	0.06	0.06
6/23/2008	0	0	0	0.4	0	0	0.06	0.06
3/28/2008	0	0	0	0.4	0	0	0.06	0.06
9/24/2007	0	0	0	0.4	0	0	0.06	0.06
8/27/2007	0	0	0	0.46	0	0	0.07	0.06
7/24/2007	0	0	0	0.45	0	0	0.06	
6/22/2007	0	0	0	0.39	0	0	0.06	
5/24/2007	0	0	0	0.5	0	0	0.07	

Well No. 4
Historical PFAS Concentrations
City of Hastings

Date	Measured Concentrations (µg/L)						Health Risk Index (HRI)	HRI Quarterly Running Annual Average (QRAA)
	PFOS	PFOA	PFBS	PFBA	PFHxS	PFHxA		
10/25/2022		0.0026		0.23		0.0027	0.12	0.09
7/25/2022		0.0026		0.2		0.0027	0.12	0.07
9/2/2021	0	0.0022	0	0.22	0	0.0025	0.11	0.05
2/21/2019	0	0	0	0.25	0	0	0.04	0.03
9/21/2017	0	0	0	0.24	0	0	0.03	0.02
9/28/2015	0	0	0	0.22	0	0	0.03	0.02
6/9/2015	0	0	0		0		0.00	0.02
12/10/2014	0	0	0		0		0.00	0.02
6/3/2014	0	0	0	0.22	0	0	0.03	0.03
5/30/2013	0	0	0	0.21	0	0	0.03	0.03
5/24/2012	0	0	0	0.21	0	0	0.03	0.03
7/27/2011	0	0	0	0.26	0	0	0.04	0.03
3/18/2011	0	0	0	0.21	0	0	0.03	0.03
12/29/2010	0	0	0	0.21	0	0	0.03	0.03
9/24/2010	0	0	0	0.18	0	0	0.03	0.03
6/17/2010	0	0	0	0.2	0	0	0.03	0.03
3/25/2010	0	0	0	0.2	0	0	0.03	0.03
12/15/2009	0	0	0	0.2	0	0	0.03	0.03
9/23/2009	0	0	0	0.2	0	0	0.03	0.03
6/30/2009	0	0	0	0.2	0	0	0.03	0.03
3/24/2009	0	0	0	0.2	0	0	0.03	0.03
12/24/2008	0	0	0	0.2	0	0	0.03	0.03
9/29/2008	0	0	0	0.2	0	0	0.03	0.03
6/23/2008	0	0	0	0.2	0	0	0.03	0.03
3/28/2008	0	0	0	0.2	0	0	0.03	0.03
12/27/2007	0	0	0	0.2	0	0	0.03	0.03
11/26/2007	0	0	0	0.2	0	0	0.03	0.03
10/29/2007	0	0	0	0.2	0	0	0.03	0.03
9/24/2007	0	0	0	0.2	0	0	0.03	0.03
8/27/2007	0	0	0	0.2	0	0	0.03	0.03
7/24/2007	0	0	0	0.22	0	0	0.03	0.03
6/22/2007	0	0	0	0.19	0	0	0.03	0.03
5/24/2007	0	0	0	0.2	0	0	0.03	0.03
4/26/2007	0	0	0	0.2	0	0	0.03	0.04
3/23/2007	0	0	0	0.2	0	0	0.03	0.04
2/26/2007	0	0	0	0.3	0	0	0.04	
1/22/2007	0	0	0	0.3	0	0	0.04	
1/9/2007	0	0	0	0.2	0	0	0.03	

Well No. 5
Historical PFAS Concentrations
City of Hastings

	Measured Concentrations (µg/L)							
Date	**PFOS**	**PFOA**	**PFBS**	**PFBA**	**PFHxS**	**PFHxA**	**Health Risk Index (HRI)**	**HRI Quarterly Running Annual Average (QRAA)**
10/25/2022		0.018	0.0036	0.56	0.0036	0.012	0.77	0.72
7/25/2022		0.013	0.0026	0.28	0.0026	0.008	0.53	0.74
10/25/2021	0.0013	0.018	0.0038	0.49	0.0037	0.012	0.85	0.76
9/2/2021	0.0012	0.015	0.0032	0.46	0.0033	0.011	0.73	0.66
4/20/2021	0.001	0.02	0.0029	0.42	0.003	0.0095	0.84	0.60
2/18/2021	0.00095	0.013	0.0026	0.34	0.0028	0.0092	0.61	0.50
1/31/2019	0	0.01	0	0.64	0	0.014	0.45	0.36
9/21/2017	0	0.013	0	0.53	0	0.013	0.51	0.39
9/28/2015	0	0.012	0	0.53	0	0	0.42	0.44
6/3/2014	0	0	0	0.55	0	0	0.08	0.37
5/30/2013	0	0.015	0	0.66	0	0.009	0.57	0.38
5/24/2012	0	0.019	0	0.6	0	0.011	0.68	0.26
7/27/2011	0	0	0	0.69	0	0.014	0.17	0.11
3/18/2011	0	0	0	0.63	0	0	0.09	0.09
9/24/2010	0	0	0	0.61	0	0	0.09	0.09
6/17/2010	0	0	0	0.62	0	0	0.09	0.10
3/25/2010	0	0	0	0.7	0	0	0.10	0.10
12/15/2009	0	0	0	0.7	0	0	0.10	0.10
9/23/2009	0	0	0	0.8	0	0	0.11	0.09
6/30/2009	0	0	0	0.7	0	0	0.10	0.09
12/24/2008	0	0	0	0.6	0	0	0.09	0.07
9/29/2008	0	0	0	0.4	0	0	0.06	
6/23/2008	0	0	0	0.7	0	0	0.10	
3/28/2008	0	0	0	0.3	0	0	0.04	

Well No. 6
Historical PFAS Concentrations
City of Hastings

	Measured Concentrations (µg/L)								
Date	**PFOS**	**PFOA**	**PFBS**	**PFBA**	**PFHxS**	**PFHxA**	**Health Risk Index (HRI)**	**HRI Quarterly Running Annual Average (QRAA)**
10/25/2022		0.0055		0.17		0.0027	0.19	0.23
7/25/2022		0.0052		0.14		0.0025	0.18	0.25
10/25/2021	0.00093	0.0054	0.00097	0.18	0.00088	0.0027	0.28	0.27
9/2/2021	0.00082	0.0052	0.00084	0.16	0.00083	0.0024	0.26	0.21
4/20/2021	0.001	0.006	0	0.19	0	0	0.27	0.19
3/18/2021	0.00093	0.0055	0.00096	0.17	0.00086	0.0029	0.29	0.13
2/21/2019	0	0	0	0.19	0	0	0.03	0.06
9/21/2017	0	0.0049	0	0.2	0	0.0027	0.18	0.05
9/28/2015	0	0	0	0.17	0	0	0.02	0.01
6/9/2015	0	0	0		0		0.00	0.08
12/10/2014	0	0	0		0		0.00	0.09
6/3/2014	0	0	0	0.19	0	0	0.03	0.29
5/30/2013	0	0.009	0	0.25	0	0	0.29	0.29
5/24/2012	0	0	0	0.23	0	0	0.03	0.23
7/27/2011	0	0.027	0	0.32	0	0	0.82	0.22
3/18/2011	0	0	0	0.19	0	0	0.03	0.03
9/24/2010	0	0	0	0.16	0	0	0.02	0.03
6/17/2010	0	0	0	0.18	0	0	0.03	0.03
3/25/2010	0	0	0	0.3	0	0	0.04	0.03
12/15/2009	0	0	0	0.2	0	0	0.03	0.03
9/23/2009	0	0	0	0.2	0	0	0.03	0.03
6/30/2009	0	0	0	0.2	0	0	0.03	0.03
3/24/2009	0	0	0	0.2	0	0	0.03	0.03
12/24/2008	0	0	0	0.2	0	0	0.03	0.03
9/29/2008	0	0	0	0.2	0	0	0.03	0.03
6/23/2008	0	0	0	0.26	0	0	0.04	0.03
3/28/2008	0	0	0	0.2	0	0	0.03	0.03
12/27/2007	0	0	0	0.2	0	0	0.03	0.03
11/26/2007	0	0	0	0.1	0	0	0.01	0.02
10/29/2007	0	0	0	0.2	0	0	0.03	0.03
9/24/2007	0	0	0	0.2	0	0	0.03	0.03
8/27/2007	0	0	0	0.16	0	0	0.02	0.03
7/24/2007	0	0	0	0.18	0	0	0.03	0.03
6/22/2007	0	0	0	0.27	0	0	0.04	0.03
5/24/2007	0	0	0	0.2	0	0	0.03	0.03
4/26/2007	0	0	0	0.2	0	0	0.03	0.03
3/23/2007	0	0	0	0.2	0	0	0.03	0.03
2/26/2007	0	0	0	0.3	0	0	0.04	
1/22/2007	0	0	0	0.2	0	0	0.03	
1/9/2007	0	0	0	0.2	0	0	0.03	

Well No. 7
Historical PFAS Concentrations
City of Hastings

	Measured Concentrations (µg/L)							
Date	**PFOS**	**PFOA**	**PFBS**	**PFBA**	**PFHxS**	**PFHxA**	**Health Risk Index (HRI)**	**HRI Quarterly Running Annual Average (QRAA)**
10/25/2022	0.0036	0.0067		0.16	0.0027	0.0044	0.53	0.57
7/25/2022	0.004	0.0069	0.0016	0.13	0.0029	0.0046	0.58	0.56
10/25/2021	0.0039	0.0074	0.0016	0.17	0.003	0.0047	0.60	0.57
9/2/2021	0.0037	0.0065	0.0015	0.15	0.0027	0.0046	0.55	0.43
4/20/2021	0.004	0.007	0.0013	0.14	0	0.004	0.52	0.33
3/18/2021	0.004	0.0078	0.0016	0.19	0.0032	0.0052	0.63	0.21
2/21/2019	0	0	0	0.18	0	0	0.03	0.05
9/21/2017	0	0.0037	0	0.17	0	0.0037	0.15	0.04
9/28/2015	0	0	0	0.16	0	0	0.02	0.01
6/9/2015	0	0	0		0		0.00	0.01
12/10/2014	0	0	0		0		0.00	0.02
6/3/2014	0	0	0	0.17	0	0	0.02	0.03
5/30/2013	0	0	0	0.21	0	0	0.03	0.03
5/24/2012	0	0	0	0.17	0	0	0.02	0.03
7/27/2011	0	0	0	0.2	0	0	0.03	0.02
3/18/2011	0	0	0	0.18	0	0	0.03	0.02
12/29/2010	0	0	0	0.15	0	0	0.02	0.02
9/24/2010	0	0	0	0.14	0	0	0.02	0.03
6/17/2010	0	0	0	0.16	0	0	0.02	0.02
3/25/2010	0	0	0	0.2	0	0	0.03	0.03
12/15/2009	0	0	0	0.2	0	0	0.03	0.03
9/23/2009	0	0	0	0.1	0	0	0.01	0.02
6/30/2009	0	0	0	0.2	0	0	0.03	0.02
3/24/2009	0	0	0	0.2	0	0	0.03	0.02
12/24/2008	0	0	0	0.1	0	0	0.01	0.01
9/29/2008	0	0	0	0.1	0	0	0.01	0.01
6/23/2008	0	0	0	0.1	0	0	0.01	0.01
3/28/2008	0	0	0	0.1	0	0	0.01	0.01
12/27/2007	0	0	0	0.1	0	0	0.01	0.02
11/26/2007	0	0	0	0.1	0	0	0.01	0.02
10/29/2007	0	0	0	0.1	0	0	0.01	0.02
9/24/2007	0	0	0	0.2	0	0	0.03	0.02
8/27/2007	0	0	0	0.16	0	0	0.02	0.02
7/24/2007	0	0	0	0.18	0	0	0.03	0.02
6/22/2007	0	0	0	0	0	0	0.00	0.02
5/24/2007	0	0	0	0.2	0	0	0.03	0.03
4/26/2007	0	0	0	0.2	0	0	0.03	0.03
3/23/2007	0	0	0	0.2	0	0	0.03	0.02
2/26/2007	0	0	0	0.2	0	0	0.03	
1/22/2007	0	0	0	0.2	0	0	0.03	
1/9/2007	0	0	0	0	0	0	0.00	

Well No. 8
Historical PFAS Concentrations
City of Hastings

	Measured Concentrations (µg/L)							
Date	**PFOS**	**PFOA**	**PFBS**	**PFBA**	**PFHxS**	**PFHxA**	**Health Risk Index (HRI)**	**HRI Quarterly Running Annual Average (QRAA)**
10/25/2022	0.003	0.027	0.0022	0.18	0.0032	0.0051	1.11	0.93
7/25/2022	0.0024	0.02	0.0017	0.14	0.0025	0.0037	0.84	0.87
10/25/2021	0.0028	0.02	0.0021	0.18	0.0029	0.0044	0.89	0.80
9/2/2021	0.0024	0.021	0.0016	0.15	0.0025	0.0039	0.87	0.72
4/20/2021	0.003	0.02	0.0016	0.15	0.0025	0.004	0.88	0.68
2/18/2021	0.0017	0.012	0.0012	0.12	0.0019	0.0028	0.54	0.63
2/21/2019	0	0.02	0	0.22	0	0	0.60	0.72
9/21/2017	0	0.022	0	0.2	0	0.0038	0.68	0.86
9/28/2015	0	0.023	0	0.2	0	0	0.69	0.88
6/9/2015	0	0.0324	0		0		0.93	0.94
12/10/2014	0	0.0405	0		0		1.16	0.92
6/3/2014	0	0.025	0	0.18	0	0	0.74	0.94
5/30/2013	0	0.031	0	0.26	0	0	0.92	0.76
5/24/2012	0	0.029	0	0.2	0	0	0.86	0.54
7/27/2011	0	0.042	0	0.25	0	0	1.24	0.33
3/18/2011	0	0	0	0.22	0	0	0.03	0.03
12/29/2010	0	0	0	0.21	0	0	0.03	0.03
9/24/2010	0	0	0	0.17	0	0	0.02	0.46
6/17/2010	0	0	0	0.21	0	0	0.03	0.46
3/25/2010	0	0	0	0.2	0	0	0.03	0.46
12/15/2009	0	0.06	0	0.28	0	0	1.75	0.46
9/23/2009	0	0	0	0.2	0	0	0.03	0.03
6/30/2009	0	0	0	0.2	0	0	0.03	0.03
3/24/2009	0	0	0	0.2	0	0	0.03	0.39
12/24/2008	0	0	0	0.2	0	0	0.03	0.39
9/29/2008	0	0	0	0.2	0	0	0.03	0.39
6/23/2008	0	0.05	0	0.2	0	0	1.46	0.39
3/28/2008	0	0	0	0.2	0	0	0.03	0.60
12/27/2007	0	0	0	0.2	0	0	0.03	0.60
11/26/2007	0	0	0	0.2	0	0	0.03	1.04
10/29/2007	0	0.08	0	0.2	0	0	2.31	1.04
9/24/2007	0	0	0	0.26	0	0	0.04	0.47
8/27/2007	0	0.061	0	0.26	0	0	1.78	0.47
7/24/2007	0	0	0	0.26	0	0	0.04	0.04
6/22/2007	0	0	0	0.22	0	0	0.03	
5/24/2007	0	0	0	0.3	0	0	0.04	
4/26/2007	0	0	0	0.4	0	0	0.06	

WTP No. 1 (Wells 3 and 5)
Historical PFAS Concentrations
City of Hastings

Date	Measured Concentrations (µg/L)						Health Risk Index (HRI)	HRI Quarterly Running Annual Average (QRAA)
	PFOS	PFOA	PFBS	PFBA	PFHxS	PFHxA		
10/25/2022		0.014	0.0028	0.41	0.0032	0.0096	0.60	0.47
7/25/2022		0.013	0.0026	0.29	0.0028	0.0084	0.54	0.32
10/25/2021	0.00092	0.015	0.0031	0.4	0.0033	0.011	0.70	0.20
2/28/2019	0	0	0	0.15	0	0	0.02	0.02
2/25/2019	0	0	0	0.16	0	0	0.02	0.02
2/21/2019	0	0	0	0.34	0	0	0.05	
6/9/2015	0	0	0		0		0.00	
12/10/2014	0	0	0		0		0.00	

Appendix C

Cost Estimate

Alternative: One Central WTP
Capital, Operation and Maintenance Costs
City of Hastings, MN
WSB Project No. 022905-000

		Capital																O&M				
		Demo/Seal					New Construction						Renovation/Rehab									
Year	**Projected Volume Pumped and Treated (gal)**	ID	Ground Storage Reservoir (GSR)	Tower (T)	Well (W)	Water Treatment Plant (WTP)	ID	Raw Water Lines (RWL), Finished Water Line (FWL) & High Service Pump (HSP)	Tower (T)	Well (W)	Ion Exchange (IX)	Granular Activated Carbon (GAC)	ID	Tower (T)	Well (W)	Ion Exchange (IX)	Granular Activated Carbon (GAC)	**IX Resin Changeout Costs**	**GAC Media Changeout Costs**	**Added Chemical Costs**	**Added Labor Costs**	**Added Pumping Costs**
2020	934,932,900																	$0	$0	$0	$0	$0
2021	945,829,610																	$0	$0	$0	$0	$0
2022	956,726,320																	$0	$0	$0	$0	$0
2023	967,623,030																	$0	$0	$0	$0	$0
2024	978,519,740						IX, GAC, RWL, FWL	$12,871,860			$7,051,279	$7,912,705						$0	$0	$0	$0	$0
2025	989,416,450	IX				$100,000	IX, GAC, HSP	$550,000			$7,051,279	$7,912,705						$0	$0	$0	$0	$0
2026	1,000,313,160																	$83,264	$657,984	$0	$17,664	$50,176
2027	1,011,209,870																	$84,171	$665,152	$0	$17,664	$50,722
2028	1,022,106,580																	$85,078	$672,319	$0	$17,664	$51,269
2029	1,033,003,290																	$85,985	$679,487	$0	$17,664	$51,816
2030	1,043,900,000						HSP					$80,000						$86,892	$686,655	$0	$17,664	$52,362
2031	1,055,142,000																	$87,828	$694,049	$0	$17,664	$52,926
2032	1,066,384,000																	$88,764	$701,444	$0	$17,664	$53,490
2033	1,077,626,000																	$89,700	$708,839	$0	$17,664	$54,054
2034	1,088,868,000																	$90,635	$716,234	$0	$17,664	$54,618
2035	1,100,110,000												IX, GAC			$705,128	$791,270	$91,571	$723,628	$0	$17,664	$55,182
2036	1,111,352,000																	$92,507	$731,023	$0	$17,664	$55,746
2037	1,122,594,000																	$93,443	$738,418	$0	$17,664	$56,309
2038	1,133,836,000																	$94,378	$745,813	$0	$17,664	$56,873
2039	1,145,078,000																	$95,314	$753,207	$0	$17,664	$57,437
2040	1,156,320,000																	$96,250	$760,602	$0	$17,664	$58,001
2041	1,167,562,000																	$97,186	$767,997	$0	$17,664	$58,565
2042	1,178,804,000																	$98,122	$775,392	$0	$17,664	$59,129
2043	1,190,046,000																	$99,057	$782,786	$0	$17,664	$59,693
2044	1,201,288,000																	$99,993	$790,181	$0	$17,664	$60,257
2045	1,212,530,000						HSP					$80,000	IX, GAC			$987,179	$1,107,779	$100,929	$797,576	$0	$17,664	$60,821
2046	1,223,772,000																	$101,865	$804,971	$0	$17,664	$61,385
2047	1,235,014,000																	$102,800	$812,365	$0	$17,664	$61,948
2048	1,246,256,000																	$103,736	$819,760	$0	$17,664	$62,512
2049	1,257,498,000																	$104,672	$827,155	$0	$17,664	$63,076
2050	1,268,740,000																	$105,608	$834,549	$0	$17,664	$63,640
2051	1,279,982,000																	$106,543	$841,944	$0	$17,664	$64,204
2052	1,291,224,000																	$107,479	$849,339	$0	$17,664	$64,768

Construction Costs (sum of highlighted area)	**$43,449,828**
Contingency (20%)	**$8,689,966**
Indirect Costs (Engineering, Legal, and Administration) (25%)	**$13,034,948**
Land and/or Easement Acquisition	**$5,000,000**
Total Capital Cost	**$70,174,742**
30-Year Cost Including O&M	**$98,866,646**

***Legend**
IX, GAC = IX and GAC treatment at Central WTP for All Wells, split over two years

Alternative: Three Decentralized WTPs
Capital, Operation and Maintenance Costs
City of Hastings, MN
WSB Project No. 022905-000

		Capital																		O&M				
		Demo/Seal					New Construction						Renovation/Rehab									
Year	Projected Volume Pumped and Treated (gal)	ID	Ground Storage Reservoir (GSR)	Tower (T)	Well (W)	Water Treatment Plant (WTP)	ID*	Raw Water Lines (RWL) & Finished Water Line (FWL)	Tower (T)	Well (W)	Ion Exchange (IX)	Granular Activated Carbon (GAC)	ID	Tower (T)	Well (W)	Ion Exchange (IX)	Granular Activated Carbon (GAC)	IX Resin Changeout Costs	GAC Media Changeout Costs	Added Chemical Costs	Added Labor Costs	Added Pumping Costs
2020	934,932,900																	$0	$0	$0	$0	$0
2021	945,829,610																	$0	$0	$0	$0	$0
2022	956,726,320																	$0	$0	$0	$0	$0
2023	967,623,030																	$0	$0	$0	$0	$0
2024	978,519,740						IX1, GAC1, RWL1, FWL1	$172,610			$6,626,400	$6,758,400						$0	$0	$0	$0	$0
2025	989,416,450						IX2, GAC2, RWL2, FWL2	$771,620			$6,626,400	$10,137,600						$0	$0	$0	$0	$0
2026	1,000,313,160						IX3, GAC3, RWL3, FWL3	$790,650			$6,626,400	$6,758,400						$83,264	$657,984	$0	$37,632	$0
2027	1,011,209,870																	$84,171	$665,152	$0	$37,632	$0
2028	1,022,106,580																	$85,078	$672,319	$0	$37,632	$0
2029	1,033,003,290																	$85,985	$679,487	$0	$37,632	$0
2030	1,043,900,000																	$86,892	$686,655	$0	$37,632	$0
2031	1,055,142,000																	$87,828	$694,049	$0	$37,632	$0
2032	1,066,384,000																	$88,764	$701,444	$0	$37,632	$0
2033	1,077,626,000																	$89,700	$708,839	$0	$37,632	$0
2034	1,088,868,000												IX1, GAC1			$331,320	$337,920	$90,635	$716,234	$0	$37,632	$0
2035	1,100,110,000												IX2, GAC2			$331,320	$506,880	$91,571	$723,628	$0	$37,632	$0
2036	1,111,352,000												IX3, GAC3			$331,320	$337,920	$92,507	$731,023	$0	$37,632	$0
2037	1,122,594,000																	$93,443	$738,418	$0	$37,632	$0
2038	1,133,836,000																	$94,378	$745,813	$0	$37,632	$0
2039	1,145,078,000																	$95,314	$753,207	$0	$37,632	$0
2040	1,156,320,000																	$96,250	$760,602	$0	$37,632	$0
2041	1,167,562,000																	$97,186	$767,997	$0	$37,632	$0
2042	1,178,804,000																	$98,122	$775,392	$0	$37,632	$0
2043	1,190,046,000																	$99,057	$782,786	$0	$37,632	$0
2044	1,201,288,000												IX1, GAC1			$463,848	$473,088	$99,993	$790,181	$0	$37,632	$0
2045	1,212,530,000												IX2, GAC2			$463,848	$709,632	$100,929	$797,576	$0	$37,632	$0
2046	1,223,772,000												IX3, GAC3			$463,848	$473,088	$101,865	$804,971	$0	$37,632	$0
2047	1,235,014,000																	$102,800	$812,365	$0	$37,632	$0
2048	1,246,256,000																	$103,736	$819,760	$0	$37,632	$0
2049	1,257,498,000																	$104,672	$827,155	$0	$37,632	$0
2050	1,268,740,000																	$105,608	$834,549	$0	$37,632	$0
2051	1,279,982,000																	$106,543	$841,944	$0	$37,632	$0
2052	1,291,224,000																	$107,479	$849,339	$0	$37,632	$0

Construction Costs (sum of highlighted area)	**$45,268,480**
Contingency (20%)	**$9,053,696**
Indirect Costs (Engineering, Legal, and Administration) (25%)	**$13,580,544**
Land and/or Easement Acquisition	**$1,000,000**
Total Capital Cost	**$68,902,720**
30-Year Cost Including O&M	**$98,055,457**

***Legend**
IX1, GAC1 = IX and GAC treatment at Site No. 1 for Wells No. 6 and 8
IX2, GAC2 = IX and GAC treatment at Site No. 2 for Wells No. 3, 5, and 7 (Well No. 5 use existing IX)
IX3, GAC3 = IX and GAC treatment at Site No. 3 for Wells No. 4 and 9