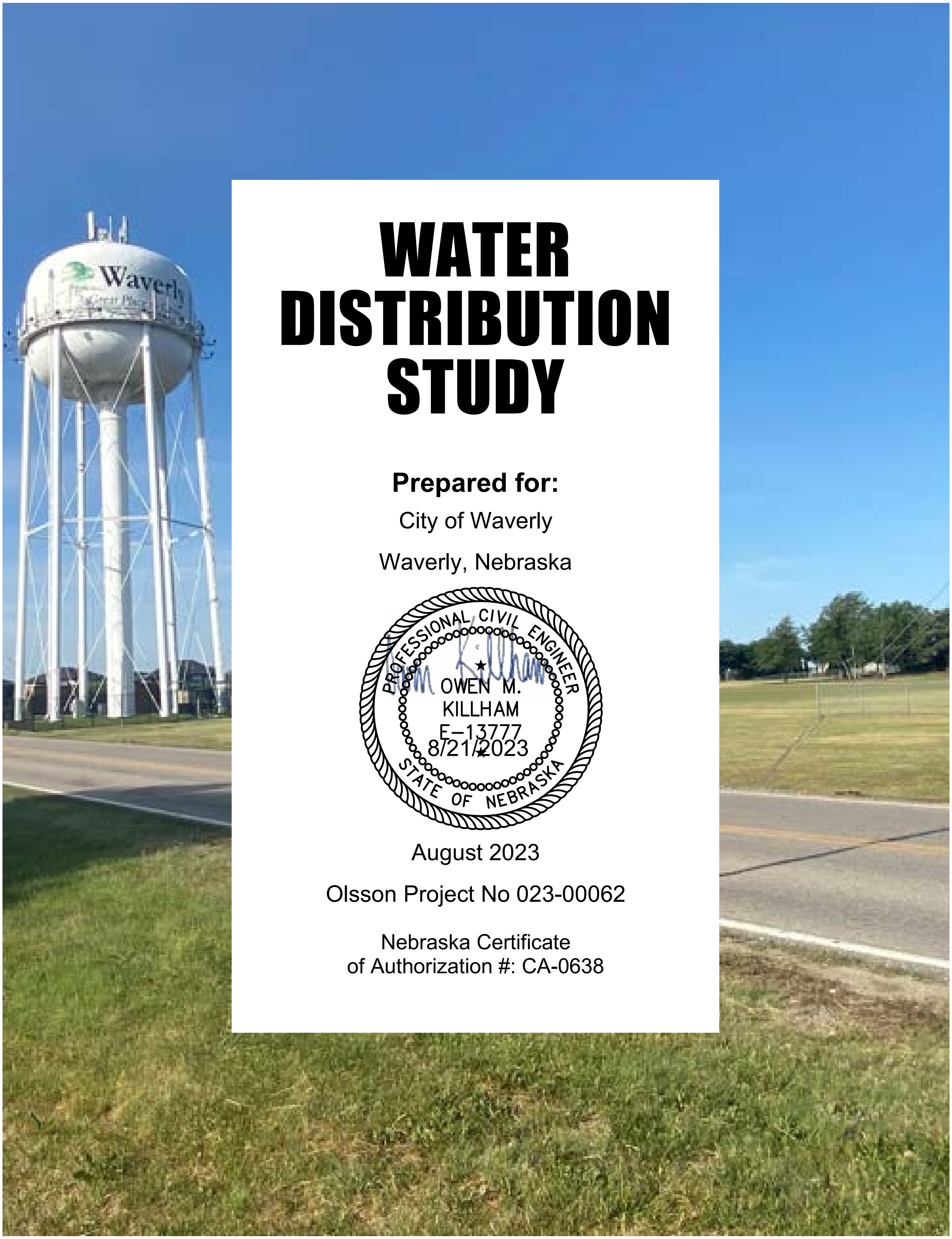

WATER DISTRIBUTION STUDY

Prepared for:

City of Waverly

Waverly, Nebraska

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8/21/2023
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August 2023

Olsson Project No 023-00062

Nebraska Certificate
of Authorization #: CA-0638

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ABBREVIATIONS

µg/L .... micrograms per liter
AWWA .... American Water Works Association
$CACO_3$ .... calcium carbonate
CDBG .... Community Development Block Grant
cfu .... colony forming unit
CIP .... cast iron pipe
DBCP 1,2-Dibromo-3-chloropropane
DIP .... ductile iron pipe
DWSRF .... Drinking Water State Revolving Fund
EA .... each
EDA .... Economic Development Administration
EPA .... Environmental Protection Agency
FEMA .... Federal Emergency Management Agency
fps .... feet per second
gal .... gallons
GIS .... geograpical information system
gpcd .... gallons per capita per day
gpd .... gallons per day
gpm .... gallons per minute
HFPO-DA .... Hexafluoropropylene oxide-dimer acid
ISO .... Insurance Services Office
IUP .... Intended Use Plan
JEO .... Johnson Erickson O'Brien
kW .... kilowatt
LF .... linear feet
LWS .... Lincoln Water System
MCL .... Maximum Contaminant Level
MCLG .... Maximum Contaminant Level Goal
MFL .... million fibres per liter
MGD .... million gallons per day
mg/L .... milligrams per liter
MHI .... Median Household Income
NDEE .... Nebraska Department of Energy and Environment

NDEQ .... Nebraska Department of Environmental Quality
NDNR .... Nebraska Department of Natural Resources
NE .... Nebraska
NeDED .... Nebraska Department of Economic Development
O&M .... Operation & Maintenance
LF .... linear feet
pCi/L .... picocuries per liter
ppt .... parts per trillion
psi .... pounds per square inch
PFAS .... polyfluoroalkyl substances
PFBS .... perfluorobutane sulfonate
PFNA .... perfluorononanoic acid
PFAS .... perfluorooctanoic acid
PFHxS .... perfluorohexane sulfonate
PFOS .... perfluorooctane sulfonate
PVC .... polyvinyl chloride
RDD .... Rural Development Division
RL .... reporting limit
ROW .... right-of-way
RWD .... Rural Water District
SRF .... State Revolving Fund
TBD .... to be determined
TC .... total coliform
TCDD 2,3,7,8-Tetrachlorodibenzo-p-dioxin
TDS .... total dissolved solids
THM .... Trihalomethane
US .... United States
USDA .... United States Department of Agriculture
USGS .... United States Geological Survey
WTP .... Water Treatment Plant
WWAC .... Water Wastewater Advisory Committee

SUMMARY

FINDINGS:

1. The current population of Waverly is 4,532 people and is expected to be 6,734 by 2043 based on the high growth rate from Waverly's 2023 Comprehensive Plan.
2. The average quantity of water distributed by the City of Waverly is approximately 591,265 gpd based on historical pump records. This equates to an average daily use of 411 gpm and 138 gpcd.
3. Waverly's wells have a firm pumping capacity of 2,342 gpm. There are generators with the ability to provide backup power to three wells, which results in a backed up firm pumping capacity of 725 gpm.
4. There are currently no water quality problems with Waverly's water supply. However, nitrate levels in approximately half the wells are over 5 mg/L, trending upwards, and warrant the need to begin searching for a well site and planning a new well to ensure adequate supply is available during peak water usage.
5. During a drought condition, when the aquifers are not recharged via precipitation, the wells are known to operate close to the top of their screen.
6. The existing storage tanks and supply wells with backup power are capable of providing sufficient capacity for one day's worth of water consumption under peak demands. It is also able to provide average water consumption during a 2-hour residential or 3-hour commercial fire flow event. This is true for the present and projected 2043 water system demands.
7. The distribution system has pressures ranging from 60 to 76 psi within City Limits, which is within the Ten States Standards recommended pressures of 60 to 80 psi. Future demands are not expected to create issues with maintaining adequate pressures. Some portions of the transmission main operate at 40 psi +/-, but this has not been a cause for concern since there are no water services or fire protection provided in these locations.
8. Waverly's residential fire flow demand is 1,500 gpm while retaining a residual pressure of 20 psi. The distribution system able to meet these requirements in the majority of the system. Some areas, such as 4-inch mains and cul-de-sacs around the outskirts of town are slightly deficient in their ability to provide this fire flow capacity.

RECOMMENDATIONS:

1. The City should improve water system components to serve the existing and projected population to satisfy pressure and fire flow requirements. This can be done by upsizing crucial mains from 4 inches to 6 inches or larger, constructing loops to better facilitate flow, and proactively replacing mains with a higher tendency of failure due to material and age.
2. The City should adopt a new schedule for operating their wells to more evenly spread out the impact on the underlying aquifer. This is especially significant in periods of drought, as the City experienced in Spring/Summer of 2023.
3. It is recommended that the City proceed with the suggested improvements #1-2, #4-9, and #11 within the next five years as funding allows. These improvements include upsizing water mains and constructing loops to meet fire flow requirements, adding additional hydrants to provide hydrant coverage to lacking areas, replacing old CIP mains with a history of main breaks, and a well siting study as a first step to replacing a well that may need to be taken out of service.
4. Additional recommendations were provided to be ideally completed within the next ten to twenty years or as needed to support growth. These include large water main loops east of town where future development is planned, replacing all old metal mains, and constructing a new well as needed.

1. INTRODUCTION

The City of Waverly is a community experiencing major growth. There has been a considerable increase in population from the 1960s through the present. The expansion of industry and proximity to the City of Lincoln is expected to increase the population in Waverly significantly over the next several years. To plan for future residential and industrial development within the community, the water distribution system must also be improved to handle increased stress on the system with the increased water demand associated with the population growth. Maintaining adequate water pressure and quality and managing an aging distribution system are key factors in providing an ample supply of quality water to residents of Waverly.

1.1 Purpose

The purpose of this report is to review and identify potential system deficiencies and water quality issues for the City of Waverly's water supply and distribution systems. This report summarizes the present water system and forecasts future growth and its anticipated impact on the water system. By evaluating these conditions, the existing distribution system can be evaluated to determine how it performs under present and future conditions. The evaluation allows suggestions for recommended improvements and related financial planning.

1.2 Scope

The scope of this study is to evaluate the City's water system based on an agreement dated January 11, 2023. The key objectives of that agreement are as follows:

1. Review available documents from the City regarding existing infrastructure maps, water use records, maintenance records, previous studies, and annual operating budget.
2. Review historical population trends and develop population projection for the next 20 years, based on the current Comprehensive Plan.
3. Project future water use, including average and peak daily demands.
4. Review of existing water infrastructure for physical condition, capacity, and quality – including supply, distribution, and storage components.
5. Recommend improvements based on the evaluation of existing system and projected needs.
6. Prioritize the recommended improvements and determine a potential timeline for implementation of recommended alternatives.
7. Develop preliminary design criteria and opinions of probable total cost for recommended improvements.
8. Prepare pre-application requirements for the WWAC including preliminary review of direct and indirect environmental impacts of selected design alternative.

9. Provide a cost-effective analysis and rank the recommended improvement alternatives based on project costs, 20-year present worth, and anticipated environmental impacts.
10. Evaluate the financial requirements of the alternatives, including the financial history of operation from the previous three years.
11. Review of amortization schedule on existing indebtedness.
12. Develop a projected fee schedule based on the opinions of cost.
13. Review funding options and financial alternatives.

To assist in the system evaluation, a hydraulic model will be created of the water system in InfoWater. The model will include supply, distribution, and storage components of the existing water system. The model will be used to evaluate the system robustness including pressures and fire flow capabilities for the present and future demand scenarios.

2. BACKGROUND

The existing water distribution system consists of a variety of pipes differing in age, size, and material. A majority of the system is PVC installed after 1990, though there is a notable amount of CIP water mains installed prior to 1990. Pipe sizes range from 2-inch to 16-inch. Water storage consists of two 500,000-gallon reservoirs, described in further detail later in this report.

The system's supply currently consists of seven active wells, as outlined in Table 1. Well #7 was taken out of service in 2021 due to a damaged well casing. The well and well house were damaged beyond repair in February 2023, and is anticipated to be replaced with a new submersible well with valve vault in 2023/early 2024.

Table 1. Waverly Wells and Status

Well	Year Constructed	Status
#1	-	Inactive since 1982
#2	-	Inactive since 2003
#3	-	Inactive since 1982
#4	1982	In service
#5	1985	In service
#6	1986	In service
#7	1986	Inactive since 2021
#8	2001	In service
#9	2006	In service
#10	2014	In service
#11	2014	In service

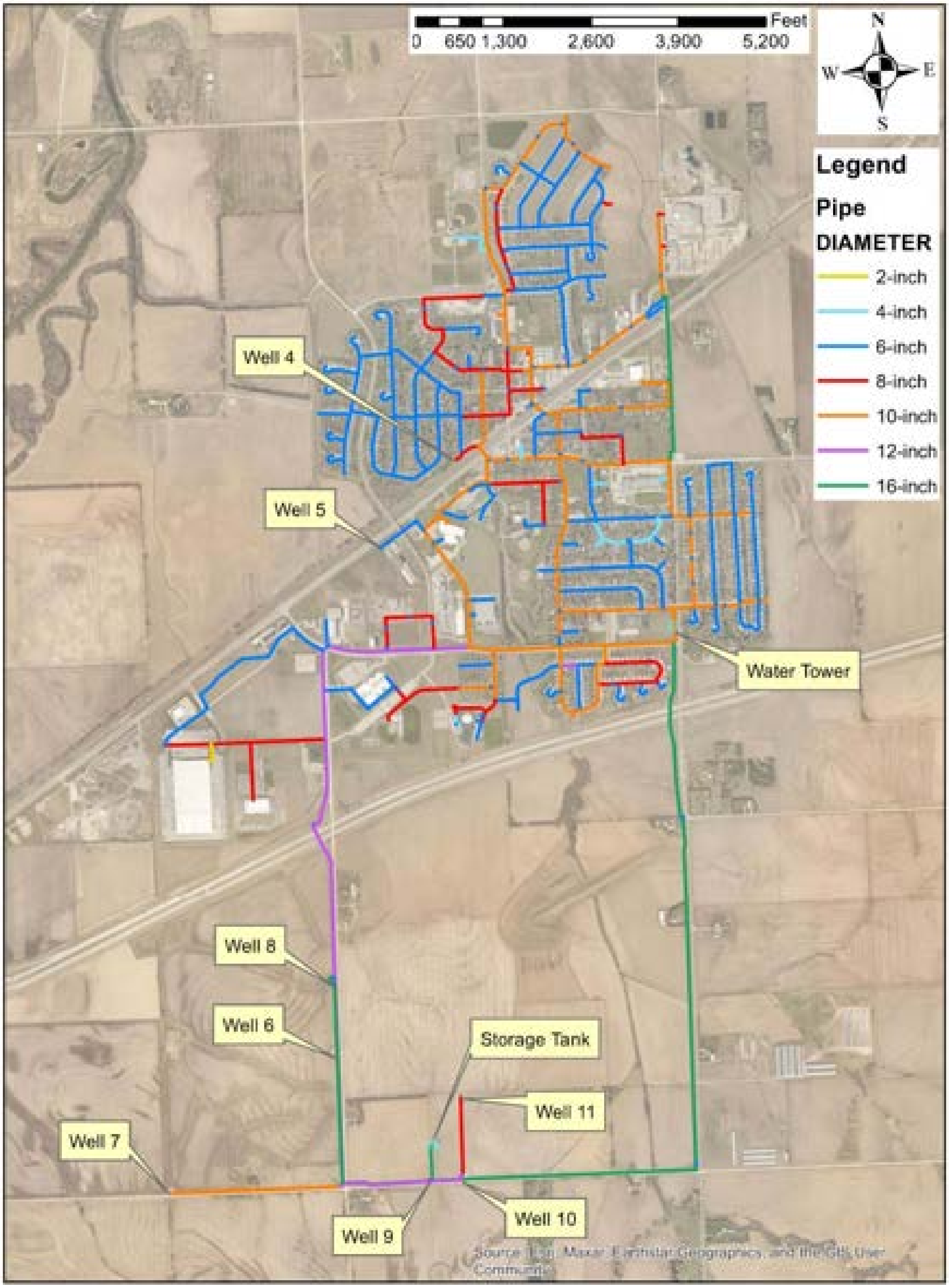

Figure 1. Map of Water System

3. POPULATION PROJECTIONS

Table 2 shows the historic population trends for the City of Waverly. The population numbers are based on US Census data and information obtained from the Nebraska Department of Economic Development.

Historic records can be used to determine existing system needs and improvements, but future system demands must also be considered to prepare the system for future growth in Waverly. Population growth was relatively flat in Waverly in the 1980s but has increased significantly since 1990. With the proximity to Lincoln and development of industry, continued population growth is expected. The 2023 Comprehensive Plan, currently under development by Hanna Keelan Associates, projected growth using a low (1.8%), medium (2.2%), and high (2.5%) annual growth rate. The projected population growth data is summarized in Table 2, and shown graphically in Figure 2.

Table 2. Historical Population

Year	Population	Percent Change Over Previous Year (%)	Annual Percent Change (%)
1940	306	--	--
1950	310	+1.3	+0.13
1960	511	+64.8	+6.48
1970	1,152	+125.4	+12.54
1980	1,726	+49.8	+4.98
1990	1,869	+8.3	+0.83
2000	2,448	+31.0	+3.10
2010	3,277	+33.9	+3.39
2020	4,279	+30.6	+3.06
2023*	4,532	+5.9	+1.97
2033 Low*	5,371	+18	+1.8
2033 Medium*	5,520	+22	+2.2
2033 High*	5,667	+25	+2.5
2043 Low*	6,211	+18	+1.8
2043 Medium*	6,478	+22	+2.2
2043 High*	6,734	+25	+2.5

* Estimated from previous data and various methods of estimated growth

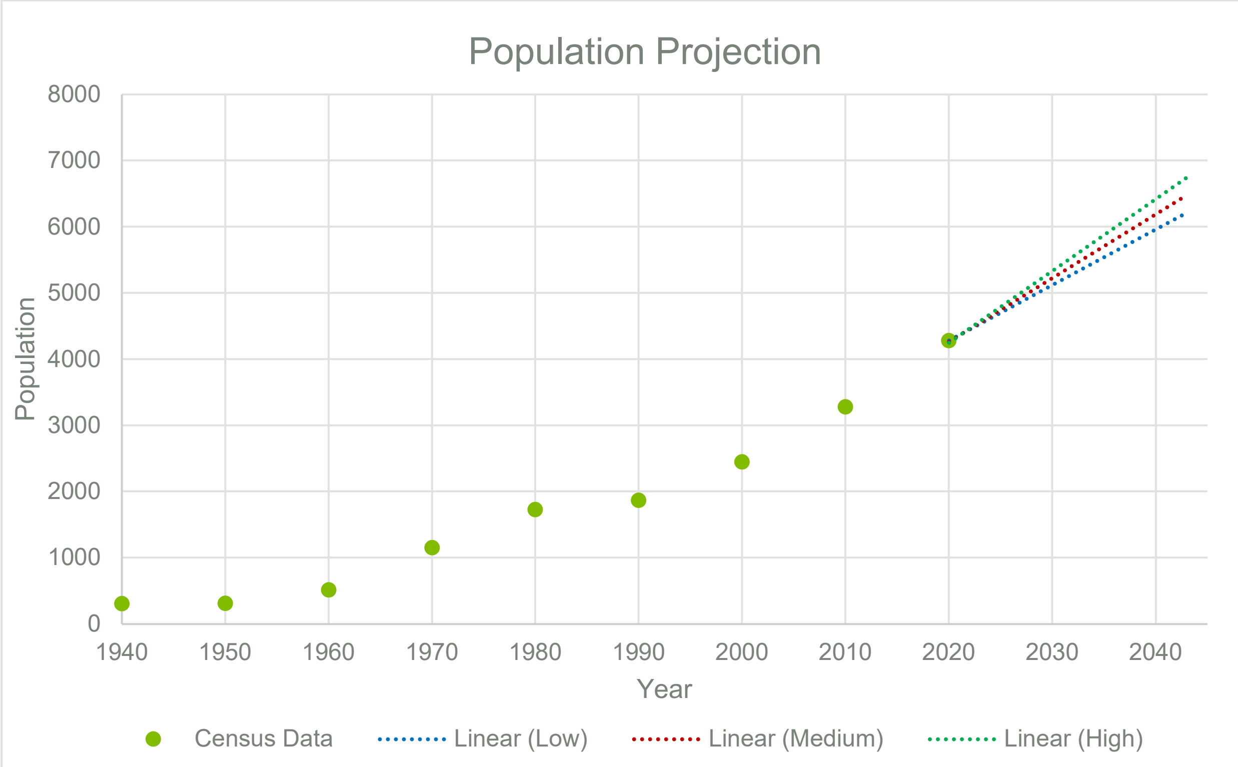

Figure 2. Population Projections for Waverly, NE

The high growth rate results in a projected 2043 population of 6,734 people. This population estimate provides the most conservative number and will be used as the 2043 population for the purposes of this report to analyze and recommend future distribution system improvements.

4. WATER REQUIREMENTS

4.1 Average Daily Demands

Water usage data was provided by the City in the form of well pumping records. Water usage data was analyzed from 2018 to 2022 to calculate the average per capita water usage, as shown in Table 3. The population for each year was determined using interpolation between 2010 and 2020 Census data points. The per capita water use was determined by dividing the water demand (in gpd) by the population. Based on these calculations, the per capita water demand in Waverly is 138 gpcd, and the average day demand is 591,265 gpd. For comparison, the per capita water demand in the 2005 Olsson water study was 141 gpcd.

Table 3. Water Use Summary, 2018-2022

Year	Population	Water Pumped (gal)	Average Water Demand (gpd)	Per Capita Use (gpcd)
2018	4,079	194,504,331	532,889	131
2019	4,179	208,022,655	569,925	136
2020*	4,279	208,961,017	570,932	133
2021	4,363	227,928,394	624,461	143
2022	4,448	240,212,814	658,117	148
		Average	**591,265**	**138**

**Calculation based on a leap year with 366 days.*

As indicated in Table 3, water use significantly increased in 2021 and 2022 due to the population growth experienced over the past twenty years. This is in line with the projections provided in the 2005 report, which predicted an average day demand of approximately 648,000 gpd in 2025.

Figure 3 shows the water pumped from wells per month graphically, based on Waverly's pump records from 2018 to 2022. The water use has been generally increasing each year, in conjunction with the growing population. One changing trend is the duration of the peak flow season. Typically, peak season is assumed to be May through August due to lawn irrigation. However, recently the peak has begun to gradually rise earlier in the year and extend further into the fall, increasing the per capita water usage in 2021 and 2022. A likely explanation for this is the increased irrigation associated with new homes where lawns need to be established.

Periods of drought, as experienced in 2022 and 2023, cause significant strain on the water system and the underlying aquifer. Increased pumping from the groundwater wells has dropped the aquifer levels that supply Waverly with water to dangerously low levels. Due to the lack of precipitation, the groundwater has not been able to recharge sufficiently to keep up with demand.

On June 27, 2023, the City declared a water emergency to help reduce water use, after voluntary water restrictions to curb demand were not observed. The water emergency required that the community irrigate every other day, with no irrigation on Mondays.

The City of Waverly website (citywaverly.com) indicates that between June 2023 and July 2023, average water usage dropped from just over 1.1 MGD to approximately 0.6 MGD, a decrease of 44%. Water usage was back up to pre-emergency conditions in late July when average demands exceeded 1 MGD on a few days in the last week of the month. In response to the spike in water usage, the City instituted more water restrictions on August 5, 2023, limiting irrigation to one day a week, with half of the residents being allowed to water on Saturdays and half on Sundays. Watering was prohibited completely from 10:00 AM to 4:00 PM.

Water demands decreased throughout early August, dropping to levels experienced earlier in the summer. The City observed that when water usage dropped to the 700,000 gpd range, adequate pumping levels were able to be maintained at the wells. The City is currently reevaluating their ordinance to determine the best triggers for water watches and warnings to encourage residents to conserve water.

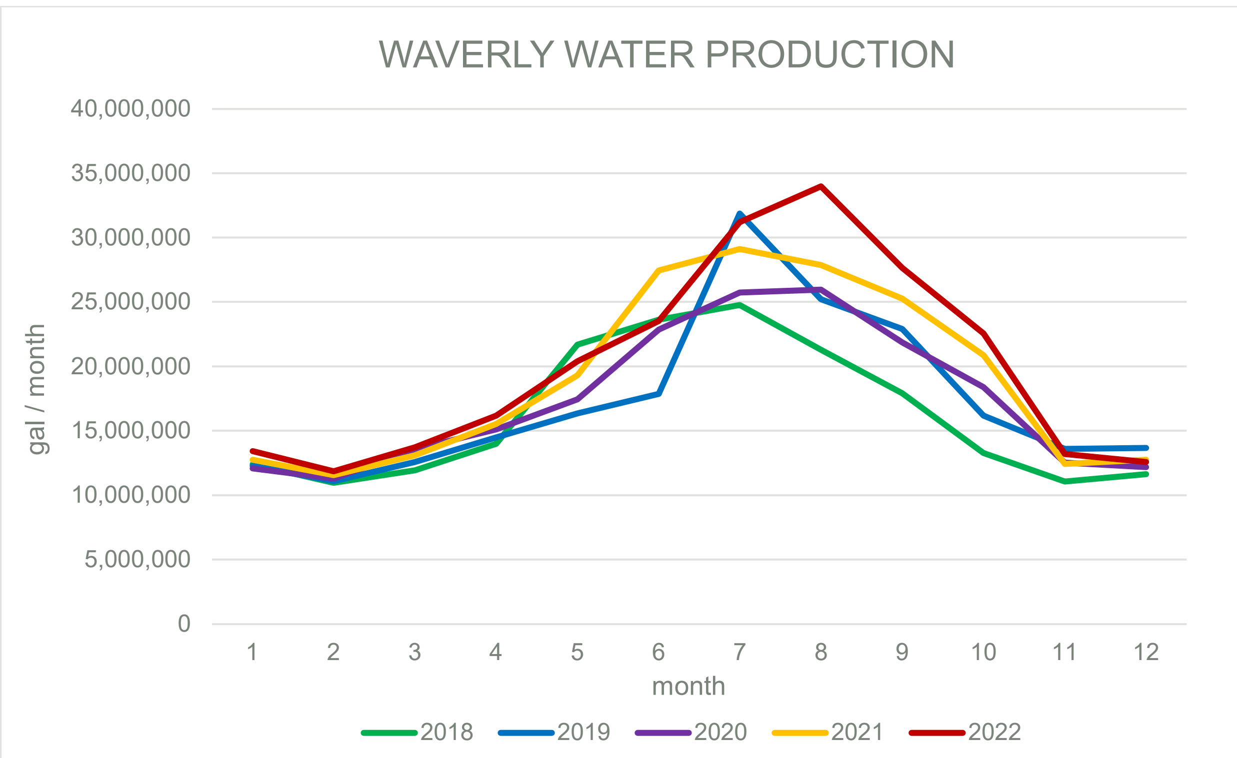

Figure 3. Monthly Well Production Trends

Water usage data was also provided for the top 5 water users in the system, as shown in Table 4. All these users have multiple water connections linked to their accounts. The water use rate is based on an assumed constant use over 24 hours.

Table 4. Water Consumption for Top 5 Users

	Yearly Average Use (gal)	Daily Average Use (gpd)*	Water Use (gpm)
User 1	31,762,927	86,962	60.4
User 2	21,958,241	60,118	41.7
User 3	1,956,200	5,356	3.7
User 4	1,877,200	5,139	3.6
User 5	1,559,400	4,269	3.0
TOTAL	**59,113,968**	**161,845**	**112.4**

**Daily average based on a 365.25-day year since water consumption was provided for four years.*

In addition to average daily demands, peak day, fire flow, and future demands must also be considered to determine necessary water storage and wellfield capacity.

4.2 Peak Daily Demands

Peak daily demands occur during the summer months (June-September) and are primarily due to lawn irrigation. From well pumping records analyzed from 2018 to 2022, the peak water consumption for Waverly was 1,096,119 gpd, or 761 gpm, which occurred in August 2022. The ratio of peak day to average day demand factor was determined to be 1.85.

By comparison, the peak to average day ratio in the 2002 study was 1.70. This increase in peak day factor is likely linked to the higher water use during the peak season associated with the establishment of more new lawns in conjunction with the construction of new homes.

4.3 Peak Hourly Demands

Peak demands on a water supply system occur for short periods of time, normally one to four hours in duration. This condition generally occurs before and after working hours when people start watering lawns and gardens during the summer and use more water within the house when cooking, showering, or washing dishes. These short periods of high demand, referred to as peak hourly demands, impose critical demands on various elements of the water system. The combination of well pumping and flow from storage must supply these high demand rates. The distribution mains must be adequate to deliver the water throughout the entire system without excessive loss in pressure.

Various publications (Clark, 1971) indicate peak hour demands based on population, housing density, and a variety of other factors. In general, small communities are affected more by peak demands than larger communities, and thus have larger factors. The following equation can be used to determine the peak hourly demand. The 2020 Census indicated 1,487 total housing units in Waverly.

$$Q_{peak\ hour} = (3.34 * \#\ of\ Dwelling\ Units) + (2.02 * Q_{peak\ day})$$

$$Q_{peak\ hour} = (3.34 * 1{,}487) + (2.02 * 1{,}096{,}119\ gpd) = 2{,}219{,}127\ gpd$$

Based on the calculations above, the ratio of peak hour to peak daily demands is 2.02. This is the same as the peak hour factor of 2.02 calculated in the 2005 study.

4.4 Fire Flow

The standards for grading a municipality's fire defense and physical conditions are based on criteria outlined by the ISO of Nebraska. Per Ten States Standards a water system must be "designed to maintain a minimum pressure of 20 psi at ground level at all points in the distribution under all conditions of flow" (2012). The recommended fire flow capacity depends on the size, construction type, occupancy, and exposure of buildings within an area. A fire flow of 1,000 to 1,500 gpm is generally recommended for residential areas, depending on the spacing of structures. For instance, for 1- and 2-family dwellings not exceeding two stories in height, spaced up to ten feet apart, ISO recommends 1,500 gpm fire flow.

The ISO determines fire-stream requirements throughout the distribution system's service area. Waverly's most recent ISO report was done in 2018. However, the hydrant flow data summary that lists needed and available fire flows at various locations could not be located for this report. Instead, fire flow assumptions were carried over from the hydrant flow data summary from 2000 and Waverly's 2005 water study. A copy of this ISO hydrant flow table can be found in Appendix A. The hydrant flow data summary from 2000 listed a maximum of 1,500 gpm at a residential hydrant and 3,500 gpm for a commercial area. These fire flows were used to evaluate the storage and fire flow supply requirements for residential and commercial areas in Waverly.

The assumed duration of a fire flow event increases as fire flow demands increase. The AWWA Manual of Water Supply Practices M32 sets varying required durations to sustain fire flows depending on the needed fire flow, as outlined in Table 5. For the purposes of this report, a 2-hour duration was used for residential fire flows (1,500 gpm) and 3 hours for the commercial fire flow (3,500 gpm).

Table 5. Required Duration of Fire Flow (AWWA M32)

Fire Flow (gpm)	Required Duration of Flow (hours)
< 2,500	2
3,000 – 3,500	3
4,000 – 12,000	4

4.5 Future Demands

As determined previously, the average daily demand was approximately 591,265 gpd with a peak to average demand ratio of 1.85. Assuming the high population projections discussed in Section 3, Table 6 summarizes estimated present and future demands placed on the system including fire demands. These demand rates serve as the basis for recommending improvements to the major components of the system which will serve the City's water demands until the year 2043.

Table 6. Future Water Demands and Residential & Commercial Fire Flow

	2023	**2033**	**2043**
Population	4,532	5,667	6,734
Per Capita Demand (gpd)	138	138	138
Avg. Daily Demand (gpd)	591,265	784,802	932,537
Avg. Daily Demand (gpm)	411	545	648
Peak Day/Avg. Day Ratio	1.85	1.85	1.85
Peak Hour/Peak Day Ratio	2.02	2.02	2.02
Peak Day Demand (gpm)	761	1,010	1,201
Peak Hour Demand (gpm)	1,538	2,041	2,425
Residential Fire Flow			
Residential Fire Demand (gpm)	1,500	1,500	1,500
Fire Flow + Average Day Demand (gpm)	1,911	2,045	2,148
Commercial Fire Flow			
Commercial Fire Demands (gpm)	3,500	3,500	3,500
Fire Flow + Average Day Demand (gpm)	3,911	4,045	4,148

5. WATER QUALITY

Demands for water cannot be satisfied by quantity alone; the quality must also be satisfactory for its intended use. The prime consideration for supplying good quality water is to protect public health. Pollution of public water supply and the consequent danger to health has been traced to many sources. These include leakages from human activities, agricultural chemicals, leaking fuel tanks, breaking transmission mains, floods of contaminated water, and the relaxation of vigilance in the purification of a public water supply system.

Waverly presently does not have a full water treatment facility, but they do inject drinking water with chlorine and fluoride, as well as polyphosphate for corrosion control. Water from the wells south of I-80 are routed to Well #10 for this treatment to be applied. It is individually added at Wells #4 and #5.

5.1 Regulatory Requirements

The Safe Drinking Water Act requires the EPA to enforce regulations for a number of drinking water contaminants. These contaminants fall within six broad contaminant groups:

- Microorganisms
- Disinfectants
- Disinfection byproducts
- Inorganic chemicals
- Organic chemicals
- Radionuclides

Table 7 outlines the EPA limits of regulated contaminants. The presence of substances in excess of the limits for human health constitutes grounds for rejection of the water supply. Water supplies containing substances in excess of aesthetic limitations may be suitable from a health standpoint, but unacceptable due to odors, discoloration, or taste; rendered economically or aesthetically inferior; or are toxic to fish or plants.

Table 7. Drinking Water Standard Contaminant Limits

Contaminant	EPA Approved Limit Level (mg/L, unless otherwise noted)
Microorganisms	
TC (including fecal coliforms and E. coli)	Maximum 5% of samples may be TC-positive
Disinfection Byproducts	
Bromate	0.01
Chlorite	1.0
Haloacetic acids	0.06
Total Trihalomethanes	0.08
Disinfectants (Maximum Residual Disinfectant Levels)	
Chloramines (as Cl2)	4.0
Chlorine (as Cl2)	4.0
Chlorine dioxide (as ClO2)	0.8
Inorganic Chemicals	
Antimony	0.006
Arsenic	0.01
Asbestos	7 MFL
Barium	2
Beryllium	0.004
Cadmium	0.005
Chromium	0.1
Copper	1.3
Cyanide	0.2
Fluoride	4.0
Lead	0.015
Mercury	0.002
Nitrate	10
Nitrite	1
Selenium	0.05
Thallium	0.002

Organic Chemicals	
Alachlor	0.002
Atrazine	0.003
Benzene	0.005
Benzo(a)pyrene (PAHs)	0.0002
Carbofuran	0.04
Carbon tetrachloride	0.005
Chlordane	0.002
Chlorobenzene	0.1
2,4-D (2,4-Dichlorophenoxyacetic acid)	0.07
Dalapon	0.2
1,2-Dibromo-3-chloropropane (DBCP)	0.0002
o-Dichlorobenzene	0.6
p-Dichlorobenzene	0.075
1,2-Dichloroethane	0.005
1,1-Dichloroethylene	0.007
cis-1,2-Dichloroethylene	0.07
trans-1,2-Dichloroethylene	0.1
Dichloromethane	0.005
1,2-Dichloropropane	0.005
Di(2-ethylhexyl) adipate	0.4
Di(2-ethylhexyl) phthalate	0.006
Dinoseb	0.007
Dioxin (2,3,7,8-TCDD)	0.00000003
Diquat	0.02
Endothall	0.1
Endrin	0.002
Ethylbenzene	0.7
Ethylene dibromide	0.00005
Glyphosate	0.7
Heptachlor	0.0004
Heptachlor epoxide	0.0002
Hexachlorobenzene	0.001
Hexachlorocyclopentadiene	0.05
Lindane	0.0002
Methoxychlor	0.04
Oxamyl (Vydate)	0.2
Pentachlorophenol	0.001
Picloram	0.5
Simazine	0.004
Styrene	0.1
Tetrachloroethylene	0.005

Organic Chemicals, continued	
Toluene	1
Toxaphene	0.003
2,4,5-TP (Silvex)	0.05
1,2,4-Trichlorobenzene	0.07
1,1,1-Trichloroethane	0.2
1,1,2-Trichloroethane	0.005
Trichloroethylene	0.005
Vinyl chloride	0.002
Xylenes (total)	10
Radionuclides	
Alpha particles	15 pCi/L
Beta particles and photon emitters	4 millirems/year
Radium 226 and Radium 228	5 pCi/L
Uranium	30 µg/L

5.2 Nitrates

The City provided nitrate levels, recorded annually, at each well since 1994. Figure 4 shows these levels graphically. The EPA MCL for nitrates is 10 mg/L. As depicted in this graph, all the wells remain under the MCL, with the exception of Well #11, which spiked above 10 mg/L three times between 2015 and 2018, and once in 2021. Continued monitoring is recommended, especially for Wells #5, #8, #10, and #11 if they continue to trend close to 10 mg/L.

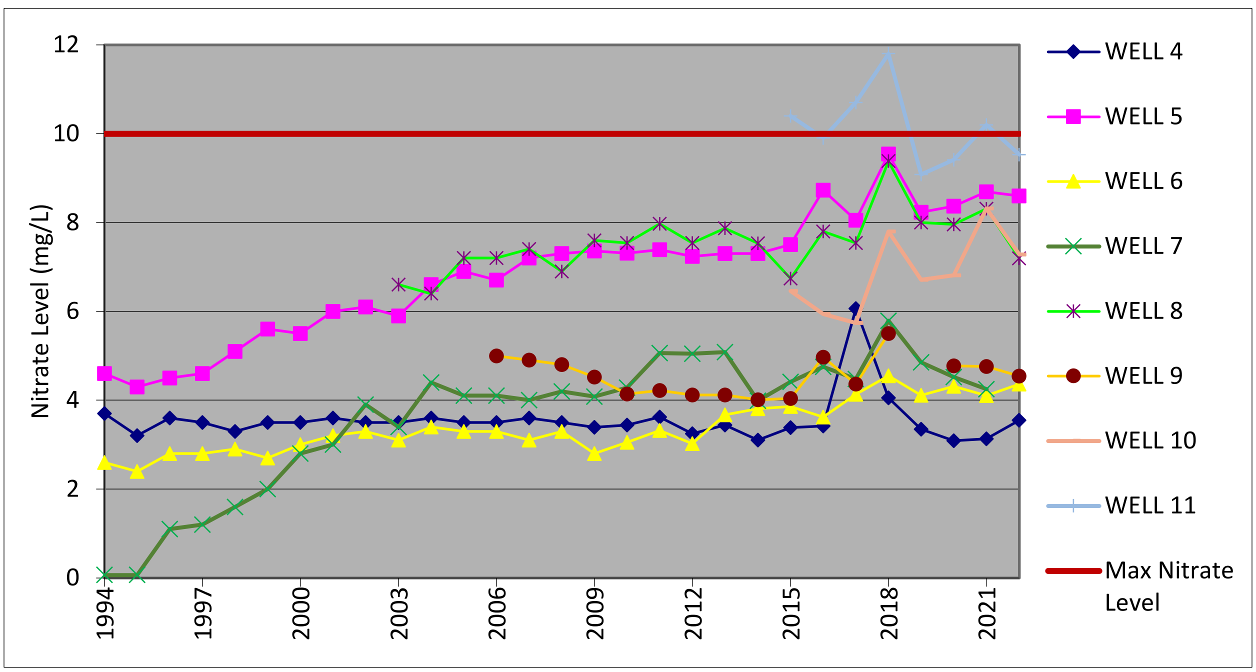

Figure 4. Well Nitrate Levels

Figure 5 shows a map of Waverly's supply wells with the labels color-coded to indicate the location of the higher nitrate wells. The southwestern-most cluster of Wells #6, #7, and #9 show the lowest nitrate concentrations in the system, indicating that this area would potentially be a candidate for an additional municipal well. Additionally, this area is outside the FEMA flood zone, so it is anticipated to have minimal environmental risk from flooding.

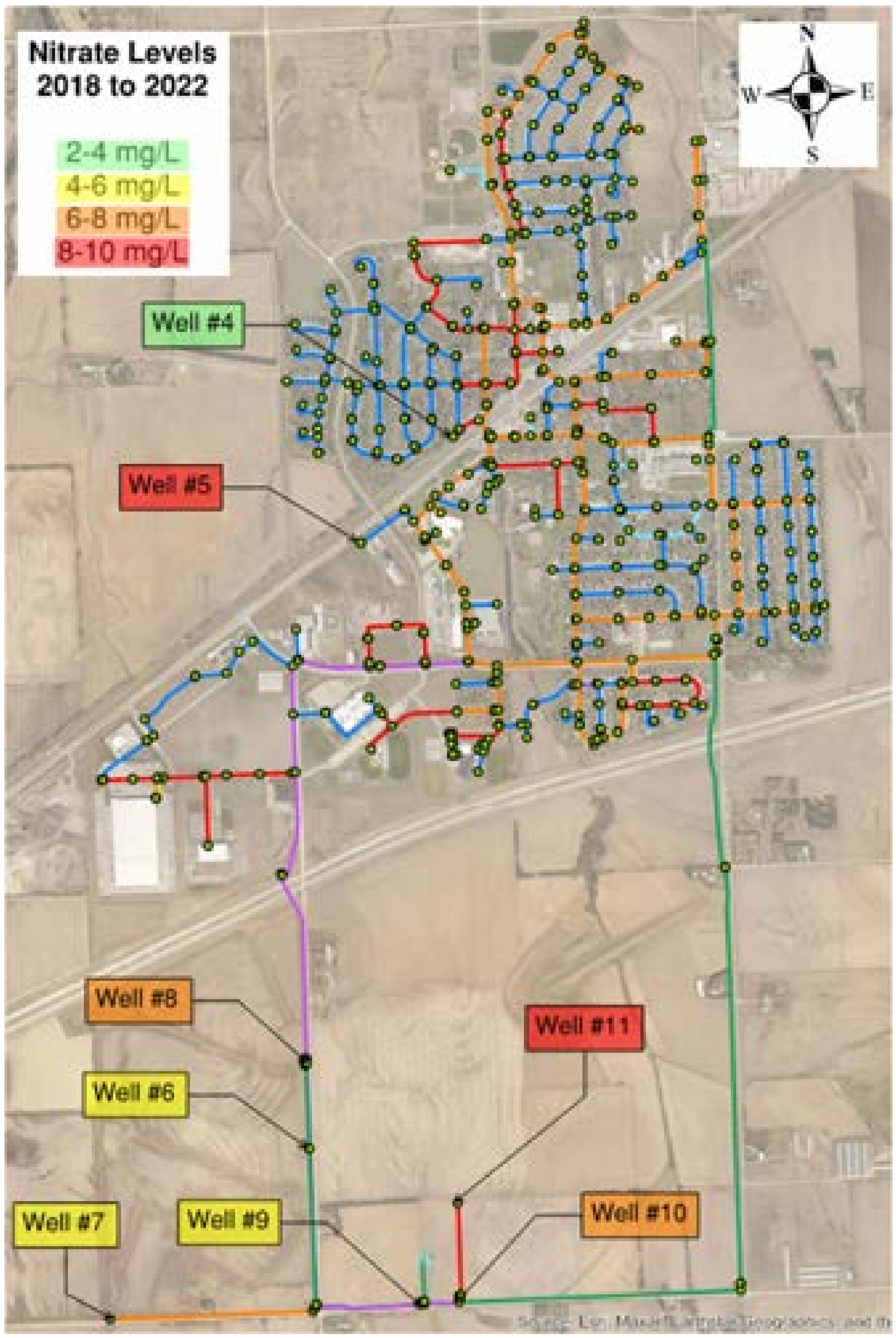

Figure 5. Map of Wells with Symbolized Nitrate Levels

5.2.1 Possible Solutions to Address High Nitrates

Although half of Waverly's wells are seeing nitrate levels below half the nitrate MCL (3 to 5 mg/L), the other half of wells range from 7 to 9 mg/L and could potentially spike above the 10-mg/L limit. With the nitrate levels trending upwards, especially the ones that are already above 7 mg/L, it is recommended that the City start looking into solutions now, such as another water source and/or blending.

There are several different solutions that could be considered to lower the nitrate levels in the water system or provide additional water in the case that some wells needed to be shut off due to nitrates. Preliminary discussions for several options are provided below, but detailed analysis and cost estimating for these options is outside the scope of this study.

Waverly should also refer to the recommendations in their 2022 Drinking Water Protection Management Plan prepared by JEO to minimize further nitrate contamination in the groundwater, especially in critical source areas.

Blending

The first potential solution to addressing the nitrates issue is to blend water from two or more water sources and convey the blended water into the water system. If the right combination of wells was blended, one or more of the City's wells could potentially remain in service even if they surpass the 10 mg/L nitrate limit.

The primary constraint is that two or more wells must be running simultaneously into a blending vault to implement this option, and these well nitrate levels will be combined with a weighted average. Due to their location within town, it may not be feasible to blend Wells #4 and #5 at the same blending vault as the other wells.

The effects of blending may be estimated by using the following equation:

$$C_{blend} = \frac{Q_1 C_1 + Q_2 C_2}{Q_1 + Q_2}$$

Where:

C_{blend}: Contaminant concentration in blended water
Q_1: Flow rate of first source
Q_2: Flow rate of second source
C_1: Contaminant concentration of first source
C_2: Contaminant concentration of second source

Overall, the blended average of nitrate levels in the wells is 6.2 mg/L. This shows that although some wells are getting close to the 10 mg/L limit, there is still some room for lower nitrate wells to bring the average down. Depending on the rotational schedule of wells, the blended nitrate level is expected to be anywhere between 5 and 7 mg/L. The following calculation shows the blended nitrate level of Wells #6 and #11, which respectively have one of the lowest and one of the highest nitrate levels.

$$C_{blend} = \frac{(449 * 4.36) + (345 * 9.53)}{449 + 345} = 6.61\ mg/L\ nitrates$$

Should this option be selected, more detailed analysis and testing would be performed to validate the effects of blending the two water sources.

Construction of a New Well

The first step would be a well siting hydrogeological study to identify locations with adequate quality and quantity to be utilized for a municipal well site. After potential sites were identified, a well driller would be hired to dig a test hole at the site to verify the aquifer capacity. If a suitable water bearing formation was found, a test well would be constructed to determine the optimum pumping rate and verify water quality is suitable for a municipal water well. After the completion of a successful test hole/well at the site, the City could proceed with the design and construction of a new well.

As previously depicted in Figure 5, the land near Wells #6, #7, and #9 are shown to have the lowest nitrates in the vicinity of the water system, so some preliminary water quality sampling and investigation of well capacity in the vicinity could be done prior to constructing a full test hole/well.

Purchase Water from LWS

A third option for securing a reliable water source is to connect to and purchase water from LWS. The City has held an early feasibility discussion with LWS, but more investigation is needed to determine feasibility and logistics. Connection would include the construction of a new transmission main, and backflow preventers would be required to prevent water from Waverly from entering Lincoln’s system.

A benefit to connecting to Lincoln’s water system is that some of all of Waverly's water would be guaranteed from Lincoln and the City would not be responsible for O&M on more wells. However, Waverly would still need to maintain their existing water infrastructure. This connection would drop O&M costs on the City’s water infrastructure by reducing the need for well pump operation since LWS would be responsible for any maintenance on their supply and source. A downside is that Waverly would lose control of water rates and would be dependent any changes to LWS water rates in the future. To pursue this option, a feasibility study would be needed to compare costs and determine water chemistry blending.

Treatment Facility

The final option for improving water quality in the system is a WTP for nitrates. This would likely be the most expensive option to construct and maintain, so would only be recommended if all well nitrate levels begin to spike above 7 mg/L. 7 mg/L is the baseline nitrate level that NDEE begins to require elevated testing frequency and indicate that the current wells may soon spike and no longer be viable water sources.

Several different treatment technologies exist such as reverse osmosis and ion exchange. If this route is taken, a nitrate removal study would be recommended to evaluate the best system and costs for Waverly.

5.3 Quality Sampling

A 13 Parameter quality test was conducted on Wells #4 through #9 in January 2008. Table 8 presents the results of the water quality sampling data. It can be seen that no chemical constituents exceeded the maximum levels set by the EPA. TDS is approaching the 500 mg/L limit and primarily contributes to taste problems with the water. Testing has not been conducted since 2008, and thus no 13 Parameter sample data is available for Well #10 or #11, which were constructed after 2008.

Table 8. 13 Parameter Water Quality Sampling Results

Chemical Constituent	Maximum Level Limit	Well #4	Well #5	Well #6	Well #7	Well #8	Well #9
pH	6.5–- 8.5	7.03	7.03	7	7.15	7	6.94
Sulfate (mg/L)	250	86	53	40	100	39	46
Chloride (mg/L)	250	19.8	8.34	5.97	8.31	6.17	5.57
Iron (µg/L)	300	<RL	<RL	79.8	<RL	<RL	<RL
Total Hardness (as CaCO3) (mg/L)		330	230	240	310	230	240
Total Dissolved Solids (mg/L)	500	490	402	369	492	376	421
Total Alkalinity (as CaCO3) (mg/L)		308	248	276	304	274	268
Calcium (mg/L)		98.9	67.7	69.5	88.7	64.7	68.7
Sodium (mg/L)		47.9	46.9	44.4	51.3	50.8	44.8
Total Coliform (cfu/10)	< 5% positive	0	0	0	0	0	0
E. Coli (cfu/10)		0	0	0	0	0	0
Nitrate + Nitrite (as N) (mg/L)	10	3.6	7.1	3.1	3.9	7	4.5
Fluoride (mg/L)	2.0	0.47	0.38	0.36	0.37	0.33	0.37
Manganese (µg/L)	50	49.3	17.4	<RL	<RL	<RL	<RL

Based on these 13 Parameter test results, all the constituents were below stated maximum level limits, however not all constituents have set limits. Although there is no regulatory limit for water hardness in Nebraska, the US Department of Interior and Water Quality Association state that any water with hardness of 180 mg/L as $CaCO_3$ is "very hard." The measured hardness in Waverly's wells ranges from 230 to 330 mg/L as $CaCO_3$. Hard water has not been shown to have any adverse health impacts, but it can cause mineral buildup on plumbing fixtures and interfere with cleaning tasks by causing soap and detergent to be less effective. The City operators noted that they are not seeing any problems from the hard water, and most residents have their own water softeners.

There is also no regulated limit for alkalinity, and there are no known detrimental health effects. However, it is notable that values above 150 mg/L may contribute to scaling, which is when there is a high level of minerals, and a substance begins to build up in pipes. Alkalinity and hardness are related due to both forming from calcium carbonate.

Sampling results for various other contaminants has been provided for wells in the Waverly water system between 2017 and 2023. Overall, the sample results were lower than EPA maximum contaminant levels. A test from April 2022 on Wells #10 and #11 recorded levels of 0.720 µg/L each for both bromodichloromethane and bromoform. Another test in August 2022 recorded a THM level of 1.10 µg/L and a bromoform level of 1.77 µg/L. These contaminants are both part of the Total Trihalomethane contaminant group which is regulated to have an MCL of 80 µg/L. However, both THM and bromoform have goal MCLs of 0.

Over time, Well #4 has been tested for selenium, which has a MCL of 50 µg/L. In 2017, the result was 86 µg/L. However, since then the selenium concentration has lowered to the mid-30s, with the most recent test in 2022 reading 27 µg/L. It is recommended to continue monitoring this well for selenium to ensure the level remains below 50 µg/L.

5.4 Anticipated EPA Emerging Contaminant Changes

In March 2023, the EPA issued a plan for proposed action for six PFAS contaminants. Currently, they are just proposing health-based, non-enforceable MCLGs, though enforceable MCLs may be expected eventually. The proposed rule would require public water systems to monitor these PFAS levels and notify public and reduce levels if necessary. The earliest this rule could be in place is 2026.

The proposed limits for PFAS contaminants are shown in Table 9. The Hazard Index limit is based on the evaluation of potential health risks from chemical mixtures and can be found through a calculation using health-based water concentrations for each of those four compounds.

Table 9. EPA's Proposed Action for PFAS Drinking Water Regulations

Compound	Proposed MCLG	Proposed MCL (enforceable level)
PFOA	0 ppt	4.0 ppt
PFOS	0 ppt	4.0 ppt
PFNA	1.0 (unitless) Hazard Index	1.0 (unitless) Hazard Index
PFHxS		
PFBS		
HFPO-DA (GenX)		

Another expected change is with regard to manganese. Currently, manganese is a secondary drinking water regulation, meaning that the Secondary MCL is a non-enforceable recommendation. However, it is anticipated that this will be changed to an MCL of 50 µg/L. Based on a 2020 study by DHHS, it is also possible that there will be a warning level of 30 µg/L at which communities may be asked to notify residents. With the manganese levels in Well #4 at 49 µg/L, it is recommended to get updated tests and consider a blending solution to reduce overall manganese in the water system as needed.

6. EXISTING WATER SYSTEM FACILITIES

The City of Waverly has a GIS map of the water system created by JEO. This map is available online, and the files making up the water system components were also provided for this study.

6.1 Wells and Pumps

Waverly's water distribution consists of seven active wells and one inactive well (Well #7). A project to replace Well #7 is in progress. The well locations were previously shown in Figure 1. The wells are currently run every other day to reduce wear on the pumps, with odd-numbered wells one day and even-numbered the next.

While no WTP is in place, chlorine, fluoride, and polyphosphate are added to treat the water from the wells. Polyphosphate is added for corrosion control. The wellhouse at Well #10 has chemical feed rooms, and all the water from wells south of I-80 (Wells #6 through #11) are routed there for treatment. Treatment is individually applied at Wells #4 and #5.

All of Waverly's wells pump directly into the system and fill a 500,000-gallon storage tank and 500,000-gallon water tower. The water pressure in the system is a result of the water level in the elevated water tower and storage tank.

The wells and pumps are inspected and serviced as necessary each year. Sargent Well Inspections from 2022 and 2023 were provided and are included in Appendix B of this report. At this time, no repairs or replacements were recommended for any active wells. The motors are serviced as needed during well inspections. Well #6 was relined in 2000 due to holes forming in the casing. In 2020, the pumps were replaced for Wells #6 through #8. Wells #4, #5, and #6 were all installed in the 1980s, thus having a higher potential for failure in the future. A cost estimate will be provided so the City can plan for replacing one if needed. The City plans to soon pull Wells #4, #5, and #9 for routine maintenance, cleaning, and inspection.

6.1.1 Pump Capacity

Table 10 outlines the well capacities found in state well registrations. Apparent present capacities and average pump efficiencies, as determined from the 2022 Sargent Well inspections, are also summarized in Table 10. Based on these numbers, the wells are pumping 96% of the registered capacity. The apparent capacities and efficiencies are lower than designed due to pump repair and replacement or wear over time. Sargent noted that no modifications were recommended at this time to the pumps. The apparent total capacity of the active wells is 2,832 gpm. The firm pumping capacity, defined as the available capacity if the highest producing well (Well #8) is out of service, is 2,342 gpm.

It is noted that these numbers will change, and the pumping capacity will increase once Well #7 is replaced.

Table 10. Active Well Capacities

Well #	Backup Power Connection Available (Y/N)	Registered Capacity (gpm)	Apparent Capacity (gpm)	Average Pump Efficiency (%)
4	N	400	383	76
5	N	300	303	62
6	Y	500	449	81
8	Y	500	490	82
9	Y	500	482	76
10	Y	400	380	73
11	Y	350	345	68

6.1.2 Backup Capability and Redundancy

The City has a 150 kW diesel generator from 2014 near Wells #10 and #11 which is able to power both wells at the same time, if needed. There is also a diesel generator from 1986 on a trailer that can power one well (either Well #6, #8, or #9). Wells #4 and #5 do not have transfer switches installed, therefore backup power is not available at those sites. In the case of total power loss, this means that three wells could continue to run. Assuming the generators would power the highest capacity well (Well #8) and can power both Wells #10 and #11, this results in an available pumping capacity of 1,215 gpm for wells with backup power.

Five of the seven active wells are located south of the City Limits, and provide 2,146 gpm, or 76% of the current total pumping capacity. A looped transmission main ranging from 12 to 16 inches transfers the water from the wells and one storage tank to the other storage tank and the remainder of the distribution system. This loop was installed per the recommendation in the previous 2005 water study to add redundancy. If there were a rupture or line break anywhere along this main, water could still flow through the other side of the main loop and minimize disruption of service.

6.1.3 Aquifer Levels

Wells #4 and #5 within town are located in the shallow alluvial unconsolidated Lower Salt Creek aquifer. The remaining wells south of I-80 are in the Dakota bedrock aquifer. All wells pump at approximately the same elevation above sea level, but Wells #4 and #5 are shallower below grade.

The City monitors the static water level at each well when it is not pumping. The water level below grade while pumping is also recorded. These levels are shown in Table 11. Each well also has a maximum pumping level, which acts as a trigger to shut the wells off to avoid excessive drawdown of the aquifer or issues with the pump.

Annual trends show that the aquifer level typically lowers throughout the high demand summer season when peak water demand in Waverly coincides with peak irrigation. Aquifer levels recover in the spring due to snowmelt and rain and lower water use over the previous winter. Since 2019, all the wells have had a downward trend in seasonal aquifer levels. Most significantly, Wells #4 and #5 have not seen the typical springtime recovery as of May 2023. It should be noted that 2023 was an exceptionally dry spring/summer with one of the worst drought conditions in recent history.

As shown in Table 11, Wells #4, #5, #9, and #11 are all within 5 feet of the minimum pumping level, which is concerning, especially Well #5 which is 1 foot above the level. As the water level approaches the minimum pumping level, it is not harmful to the pump but should be a warning level that the well is in danger of getting shut off if water levels continue to decline. The minimum pumping level is based on information from the well vendors on when the well would need to be shut off. The well may be in danger of malfunctioning if the water level is not above this point.

Table 11. Aquifer Levels During Well Pumping (May 2023)

	Static Level (ft)	Pumping Water Level (ft)	Min Pumping Level (ft)	Water Level Over Shutoff (ft)
Well #4	22	44	48	4
Well #5	20	46	47	1
Well #6	79	129	155	26
Well #8	72	128	138	10
Well #9	105	147	150	3
Well #10	86	120	142	22
Well #11	98	135	140	5

Since Well #7 has been inactive, there has been increased strain on the odd-numbered wells, which have a pump capacity of approximately 600 gpm less than the even-numbered wells. This is backed up by the most critical aquifer levels being seen in these three odd-numbered wells. A proposed pumping schedule to more evenly spread out well pumping across the aquifer is outlined in Section 10.1.2.

If the pumping water levels continue to drop to unsafe levels, it may be necessary to use VFDs (where available) to lower the pump speed. This could result in longer pump run times but would overall reduce the strain on the aquifer and prevent the well from having to be turned off completely.

Another potential solution to low aquifer levels during pumping is imposing water restrictions on Waverly, as outlined in the City ordinances. Currently, a pumping water level of 5 ft or less over the shutoff is allowable grounds for a water emergency which would impose enforceable restrictions. Some level of water restrictions is recommended if the new pump schedule does not help or if the drought continues to allow the aquifer to lower throughout the summer.

In June of 2023, a Water Emergency was declared, imposing mandatory watering restrictions for all residents. After this was put in place, water use decreased, and aquifer levels slightly rose. However, it is unknown whether this trend can be fully attributed to the Water Emergency since there was a significant amount of rainfall around this time as well, around 7 inches. Olsson is assisting the City in updating the trigger criteria for the different levels of water restrictions. This effort will be in a memo separate from this study but will aim to protect and regulate several aspects of the system such as daily demand, aquifer water levels, and pumping ability.

Low aquifer levels could potentially cause the wells to shut off and be unable to serve the City demands. However, this can also have environmental effects. Consequences of depleted aquifer levels include lower lake or stream levels, which can negatively impact riparian plants and animals in the area (EPA, 2023). In areas of heavy withdrawal, it is possible for land subsidence or sinkhole formation to occur. It is important to conserve water or have additional/alternate water sources to maintain adequate water supply to the City and minimize potential environmental impacts to excessive aquifer drawdown.

6.2 Distribution System

According to the GIS database, Waverly has approximately 161,809 linear feet of water main, or 30.6 miles. Table 12 summarizes the length and percent of pipe in the system for each material. The known installation dates of water main range from 1964 to present, although approximately half of the installation dates are unknown. A majority of the pipe installed prior to 1990 is CIP, but almost exclusively PVC pipe has been installed after that point. The City has expressed a desire to eventually phase out all old CIP water mains, replacing them with PVC.

Table 12. Pipe Material Summary

Pipe Material	Length of Pipe (ft)	Length of Pipe (mi)	Percent of Total Length (%)
PVC	103,803	19.7	64
CIP	2,815	0.5	27
DIP	43,357	8.2	2
Unknown	11,834	2.2	7
Totals	161,809	30.6	100

City water operators did not report any pressure deficiencies in the water system. In general, deficiencies in available capacity may result from older water mains or undersized piping. The condition of the piping and suggested improvements is discussed later in further detail.

The current distribution system ranges in pipes sizes 2 to 16 inches. Ten States Standards indicate that where fire protection is provided, water mains should be a minimum of 6 inches in diameter. The approximate pipe totals in the system are shown in Table 13. The majority of the water main is between 6 to 10 inches. Only 2.39% of the system is 4 inches or smaller.

Table 13. Pipe Length Totals

Pipe Size (in)	Length of Pipe (ft)	Length of Pipe (mi)	Percent of Total Length (%)
2	367	0.07	0.23
3	414	0.08	0.26
4	3,068	0.58	1.90
6	62,994	11.93	38.93
8	21,438	4.06	13.25
10	41,035	7.77	25.36
12	12,211	2.31	7.55
16	19,552	3.70	12.08
Unknown	728	0.14	0.45
Totals	161,809	30.65	100.00

6.3 Hydrant Coverage

The Waverly GIS system indicates that there are over 250 hydrants providing fire protection throughout the distribution system. The City indicated that some of the hydrants south of town along N 134th St and N 148th St are painted black to indicate that they are not in service, and the corresponding valves are closed.

Hydrant coverage is an important factor in the ability to provide fire protection. Generally, Ten States Standards recommends fire hydrant spacing to range from 350 to 600 feet, depending on the area being served. To verify existing hydrant coverage in Waverly, 300-foot radius buffer circles were drawn around each hydrant in the system map, as shown in Figure 6. Some areas that are lacking coverage are classified as parks and open space per Waverly’s land use map, and thus would not require the same hydrant coverage. Industrial areas are also assumed to have their own interior fire protection systems.

Based on these assumptions, a majority of the residential areas are adequately covered. However, the following areas were noted as lacking hydrant coverage, listed in below:

1. Along N 140th St between Jamestown St and Kenilworth St

2. Along Jamestown St between N 144th St and N 148th St
3. Along Heywood St between N 146th St and N 148th St
4. Along Folkestone St between Oak Lanes
5. Along N 143rd St at Carlson Ct
6. Along Amberly Rd at N 145th St
7. Along Amberly Rd between N 145th St and N 148th St
8. At the east end of Bradford Ct
9. Along road just east of Amberly Rd and N 148th St
    a. This area is outside City limits, and there is not an existing water main providing service to these houses. Therefore, no improvement is recommended for this area currently.

Adding hydrants should ideally be done in conjunction with water main replacement projects to minimize disruption to the water system.

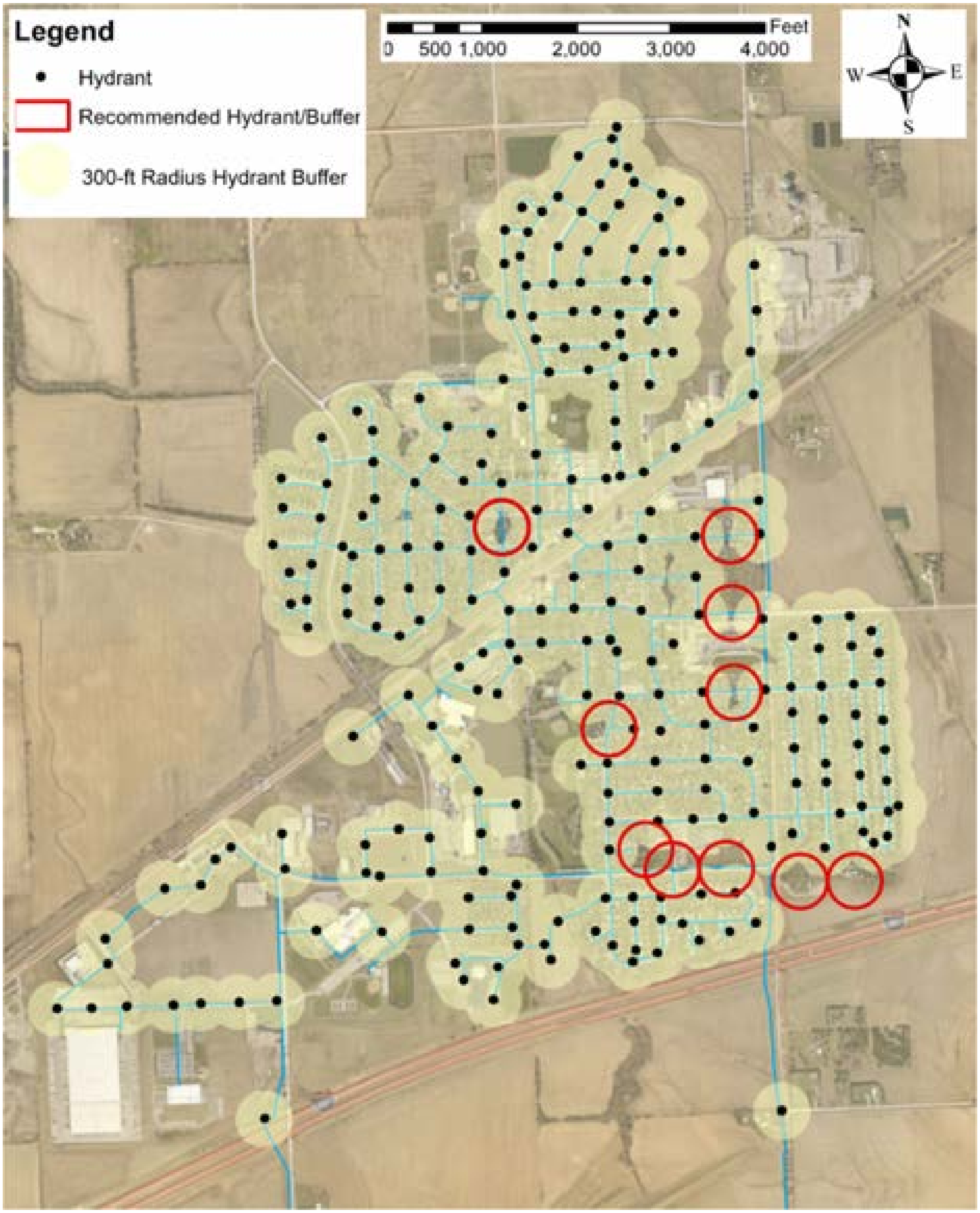

Figure 6. Hydrant Coverage Map

6.4 Water Storage Facilities

Water storage provides increased reliability for equalizing peak demands and for fire protection and emergencies during power outages. The required storage is a function of system demands, supply, and fire protection. The distribution system pressure is regulated by the water level in the two storage tanks. The wells are programmed to turn on and off based upon the level in the tanks. System pressures at the base of the storage tanks fluctuate depending on the system demands. Normal operating pressures throughout the distribution system range from 45 to 73 psi.

A 500,000-gallon elevated water storage tower, installed in 1975, is located on the northwest corner of Amberly Rd and N 148th Street. The high-water level is 140 feet above grade, with an operating range of 40 feet. This tower is shown in Figure 7.

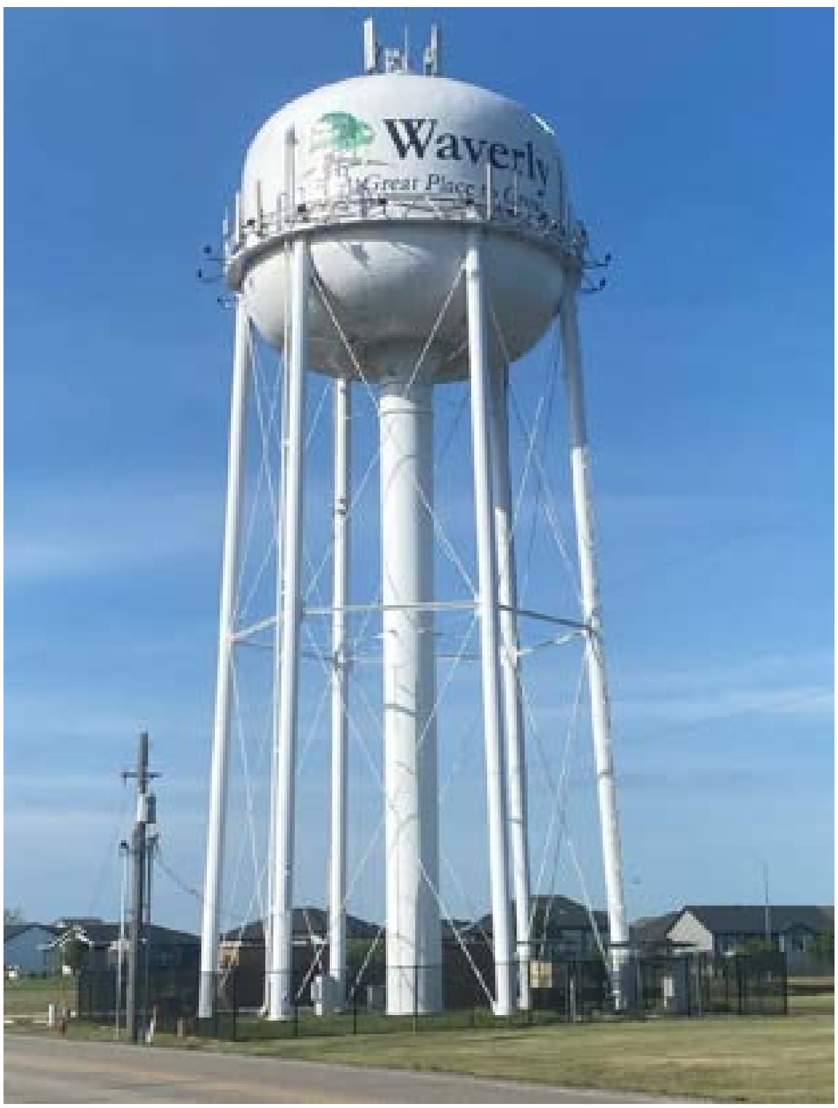

Figure 7. 500,000-Gallon Elevated Water Tower

The second storage facility is a 500,000-gallon prestressed concrete water tank, which was installed in 2014. It is located northeast of Alvo Rd and N 134th St, just north of Well #9. The high-water level is 40 feet above the base elevation. This storage tank is shown in Figure 8.

Figure 8. 500,000-Gallon Alvo Rd Water Tank

General maintenance has been performed periodically on the tanks. The elevated water tower was last drained and repainted (interior and exterior) five years ago and is due for an inspection in 2023. The Alvo Rd ground storage tank was last inspected in 2020. Overall, this inspection found the water storage tank to be in very good condition with a small amount of sediment accumulating on the tank floor. The continued periodic inspection of both the interior and exterior of the storage facilities is recommended.

6.5 General Information

AWWA has suggested minimum design standards for distribution piping that the City should continue to follow when expanding the system and making improvements.

Standards for distribution pipe sizing include:

- Smallest pipe size: 6-inch
- Smallest pipe size on dead end: 8-inch
- Smallest pipes in high-value district: 8-inch
- Smallest pipes on principal streets in central district: 12-inch

Standards for valve placement include:

- Largest spacing on long branches: 800 feet
- Largest spacing in high-value district: 500 feet

Standards for hydrants include:

- All hydrants should be provided with auxiliary valve
- Minimum pipe size for hydrant branch: 6-inch
- Spacing in congested areas: 300 feet
- Spacing in light residential areas: 600 feet
- Suggested locations for hydrants include:
    - All intersections
    - The middle of long blocks
    - At end of dead-end streets

7. SYSTEM DEFICIENCIES

The analysis of the existing system and the establishment of estimated demands permit a determination of the present deficiencies and the development of a plan for potential improvements. An adequate supply of quality water must be backed up with adequate storage and distribution systems to provide good service to all areas of the City for the present and future years.

7.1 Storage

Ten States Standards recommends that a water system have adequate storage to provide the following conditions:

- A full day at peak demand.
- Average daily demand plus the capacity required for a fire flow event.

Waverly has two 500,000-gallon storage facilities; therefore, both combined should store enough water to handle the two demand conditions outlined above for the entire City.

The required storage capacity may be decreased if there is a source with backup power to supplement peak demands of the system. Table 14 summarizes the pumping capacity for wells with backup power connections and which ones would be powered in the case of power loss. In a situation where one well out of Wells #6 through #9 can be connected to the City's portable generator, Well #8 would be prioritized due to having the highest capacity. Wells #10 and #11 are wired such that the portable generator can power both of them simultaneously in the event of a power outage. In a power outage, the total capacity of wells on backup power is 1,215 gpm. The firm capacity of wells on backup power, calculated by removing the largest capacity well (Well #8) from the calculations, is 725 gpm.

Table 14. Summary of Wells With Backup Power

Wells With Generator Connections	Pumping Capacity (gpm)
Well #6	449
Well #8	**490**
Well #9	482
Well #10	**380**
Well #11	**345**
Pumping Capacity for Wells on Backup Power	
Apparent Pumping Capacity (gpm)*	1,215
Firm Pumping Capacity (gpm)	725

** Apparent pumping capacity is the sum of Wells #8, #10 and #11 that could be powered with generators in case of emergency*

7.1.1 Peak Day Storage Analysis

The first way to determine needed storage is ensuring that a full day's worth of peak demands could be provided by the wells with backup power and available storage. Table 15 outlines the water balance for a full day of peak demands at both the present 2023 condition and estimated 2043 future demands. The calculations show a surplus of available storage for both the present and future conditions. If the population and demand increase as forecasted in this study, the current water storage capacity of 1,000,000 gallons will be adequate for the projected 2043 population.

Table 15. Peak Day Storage Analysis

2023 Storage Analysis	
Peak Daily Demand	761 gpm
Firm Pumping Capacity for Wells with Backup Power	725 gpm
Water Balance	-36 gpm
Remaining Quantity Required for One Day	51,840 gal
Available Storage	1,000,000 gal
Net Water Balance after One Day	+948,160 gal
2043 Storage Analysis	
Peak Daily Demand	1,201 gpm
Firm Pumping Capacity for Wells with Backup Power	725 gpm
Water Balance	-476 gpm
Remaining Quantity Required for One Day	685,440 gal
Available Storage	1,000,000 gal
Net Water Balance after One Day	+314,560 gal

7.1.2 Fire Flow Plus Average Day Storage Analysis

The second storage analysis performed is calculating water consumption during fire flow conditions. Table 16 indicates the surplus and deficiency in supply and storage resulting from residential fire demand plus average day demands under firm pumping capacity of wells with backup power. In this report, a 2-hour residential fire flow duration was assumed per AWWA standards. As indicated in this table, there is a surplus of 857,680 gallons after a 2-hour residential fire flow event at average day conditions. Combining the flows provided by the existing water storage and firm pumping capacity conditions, the existing system can provide for average day demand plus 1,500-gpm fire demand in residential areas through 2043.

Table 16. Average Demands Plus Residential Fire Demands

2-Hour Fire Event	2023	2033	2043
Residential Fire Demand (gpm)	1,500	1,500	1,500
Average Day Demand (gpm)	411	545	648
Total Demand (gpm)	1,911	2,045	2,148
Firm Pumping Capacity for Wells with Backup Power (gpm)	725	725	725
Water Balance (gpm)	- 1,186	- 1,320	- 1,423
Water Balance After 2 Hours (gal)	- 142,320	- 158,400	- 170,760
Available Storage (gal)	1,000,000	1,000,000	1,000,000
Net 2-Hour Balance (gal)	+857,680	+841,600	+829,240

*Positive indicates a surplus, Negative (-) indicates a deficiency

Large commercial buildings have higher fire flow requirements. Table 17 outlines the surplus and deficiency in supply and storage resulting from commercial fire flow demand of 3,500 gpm plus average day demands under firm pumping capacity of wells with backup power. Per AWWA standards, a 3-hour fire flow duration was assumed for this condition. In the event of a fire in a commercial area, the distribution system would have a surplus of 426,520 gallons after the 3-hour fire flow event at average day conditions. This table shows that Waverly will continue to meet this 3,500-gpm fire flow capacity using their existing storage tanks and backed up wells firm pumping capacity through 2043.

Table 17. Average Demands Plus Commercial Fire Demands

3-Hour Fire Event	2023	2033	2043
Commercial Fire Demand (gpm)	3,500	3,500	3,500
Average Day Demand (gpm)	411	545	648
Total Demand (gpm)	3,911	4,045	4,148
Firm Pumping Capacity for Wells with Backup Power (gpm)	725	725	725
Water Balance (gpm)	- 3,186	- 3,320	- 3,423
Water Balance After 3 Hours (gal)	- 573,480	- 597,600	- 616,140

Available Storage (gal)	1,000,000	1,000,000	1,000,000
Net 3-Hour Balance (gal)	+426,520	+402,400	+383,860

*Positive indicates a surplus, Negative (-) indicates a deficiency

7.1.3 Water Turnover

The EPA recommends a 3-to-5-day complete water turnover in storage facilities as a starting point for maintaining water quality. This prevents excessive water age, which can lead to poor water quality entering the system. Using the 1,000,000-gallon storage capacity and the average daily demand for both present and 2043 conditions results in a storage turnover of 1.1 to 1.7 days. Thus, the anticipated turnover rate is considerably lower than the general recommendation.

7.2 Wells

It was noted previously that the City has two diesel generators that can provide backup power to three wells. Out of the seven active wells, five have the capability to be hooked onto backup power. Based on the calculations in the previous section, there is enough capacity using the existing generators to power wells and available storage to meet peak flow and average demand plus fire flow. Thus, an additional generator is not needed at this time to provide backup power to wells. However, if Waverly began to near exceeding storage requirements, a generator would be a cheaper alternative to provide additional water versus constructing a new storage facility or additional wells.

Ideally, Waverly’s wells should be run no more than 12 hours a day to prevent excessive wear on the pumps. Since Waverly runs half their wells each day, the total pump capacity can be divided in half, equaling approximately 1,400 gpm. This assumes that both days have roughly equivalent pump capacities. Currently, the wells are programmed to run with the even numbered wells running one day and odd numbered wells the next. It is recommended that Waverly develop a well schedule that will run wells of an approximately equal capacity each day to minimize excessive wear on pumps that run on a lower-capacity day.

Table 18 outlines the present and future water use as compared to the pump capacity assuming that only half of the wells run each day. As shown in the table, there is a surplus water supply in the present and future condition. This shows that Waverly has sufficient well capacity to alternate wells every other day and run them for a maximum of 12 hours on an average day. Assuming the current pump capacity remains constant, a new well will be needed when Waverly’s average daily demand reaches 700 gpm. Based on the population projections from this report, this will not happen until after 2043. These calculations do only account for average demand, but the peak day water use has been accounted for through the storage calculations showing that there is enough water stored to provide a peak day’s worth of water.

Table 18. Water Use at 12-Hour Pump Schedule

	2023	2043
Average Water Use (gpm)	411	648
Water Use X 2 (gpm)	822	1,296
Half of Pump Capacity (gpm)	1,400	1,400
Water Balance (gpm)	+578	+104

7.3 Fire Flow

Olsson conducted fire flow testing with the City on February 6, 2023 throughout the distribution system. The purpose for such testing is to determine areas of the system which are unable to supply adequate water to handle fire demand and identify areas which lack sufficient pressures for normal water consumption.

The results were also used to calibrate the InfoWater model to ensure the model acted in a similar manner as the existing distribution system. The locations and results of the fire flows conducted are listed in Section 8.3 in Figure 10 and Table 19.

Even if water storage and supply can provide for demands in the event of a fire, distribution system deficiencies limit the ability to deliver the necessary flow to fight a fire in some areas of town. Per Ten States Standards, a desired range of system pressures is between 60 psi and 80 psi throughout fluctuating system demands, with a minimum working pressure of 40 psi. Under fire flow demand conditions, as the system must provide a minimum of 20 psi. During the flow tests performed by Olsson and the City, the lowest pressure recording was 42 psi, which is above the required minimum. Refer to Section 9.5 for additional discussion of the system fire flow capabilities.

7.4 Distribution System

Ten States Standards recommend that where fire protection is provided, water mains should be a minimum of 6 inches in diameter. Currently, approximately 3,850 LF, or 2.4%, of the system is comprised of mains less than 6-inches in diameter. The existing 4-inch pipe should be replaced with 6-inch pipe in areas where fire protection is provided to meet AWWA standards.

Water system maintenance records have been reviewed based on the main breaks recorded from 1998 to present in the GIS database. A history of breaks in a concentrated area can warrant replacement in areas of the water distribution system. Areas of high concentration of historical main break locations are shown in Figure 9. These three locations are outlined in red and are located along water mains on:

1. N 137th St from Newgate St to Jamestown St
2. Lancashire St from N 137th St to N 141st St

3. Eastbourne St/N 147th St
4. Danvers St

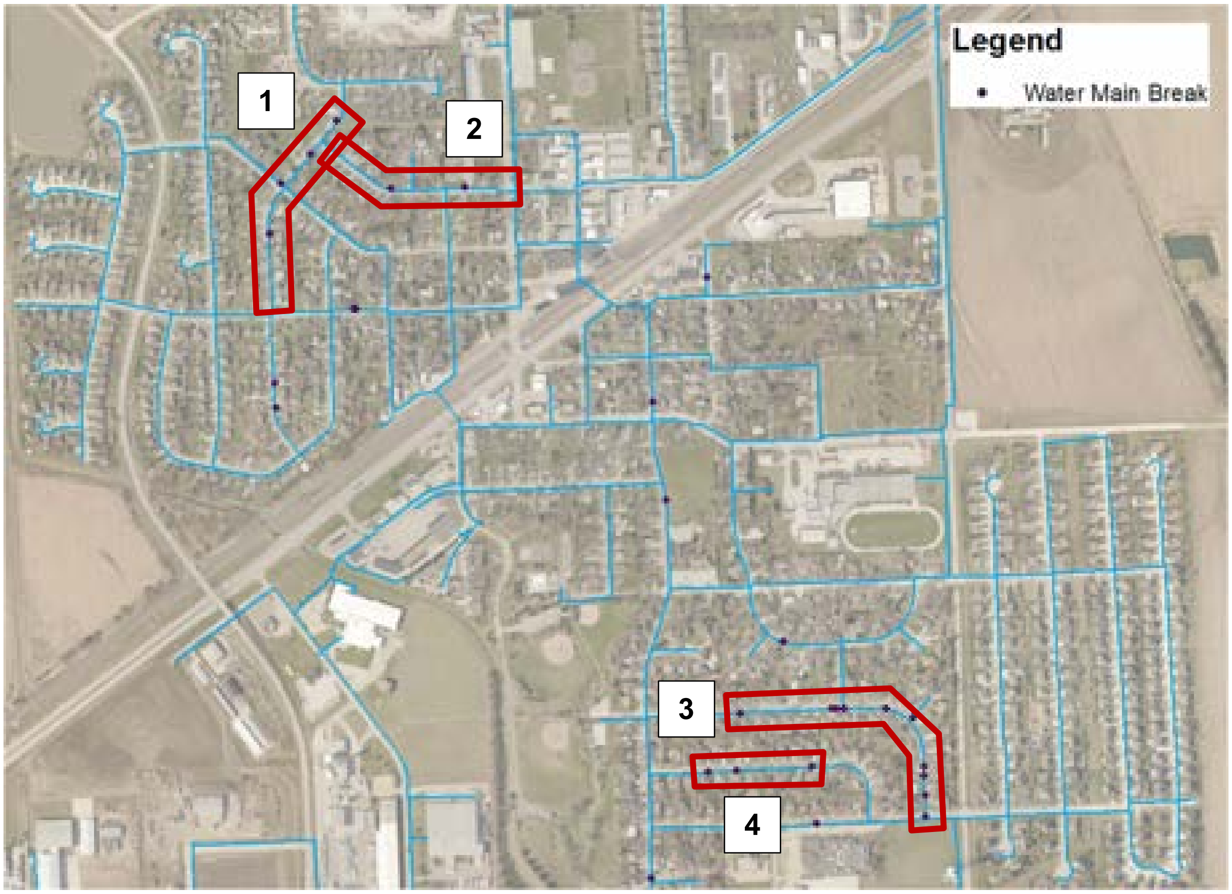

Figure 9. Main Break Locations

The project along Eastbourne St (#3) has been designed and is planned to be constructed in the 2023/2024 budget year. The project along Lancashire St (#2) has been designed, but the construction has not yet been scheduled.

The main breaks along N 137th St (#1) and Danvers St (#4) have occurred sporadically over the past 20 years. These are both CIP material and were built in the 1960s. There does not seem to be a worsening problem in this area, but the City has expressed interest in eventually phasing out all the old metal mains and replacing with PVC. Due to the history of main breaks, these two areas would be good places to start, especially if additional main breaks occur here in the future.

8. WATER MODEL HYDRAULIC ANALYSIS

A hydraulic model of the Waverly's water distribution system was created to evaluate the existing water mains to ensure appropriate capacity, pressures, velocities, and fire flow capabilities throughout the City. The InfoWater model creates a computerized representation of the water distribution system, which enables a hydraulic modeler to analyze the system and determine the water system's ability to provide adequate pressures and fire protection. Where potential deficiencies are identified, the hydraulic model may be used to recommend improvements.

System deficiencies are generally indicated by inadequate system pressures. The desired range of system pressures is between 60 psi and 80 psi, with a minimum working pressure of 40 psi. During fire flow conditions, the water system must provide a minimum system pressure of 20 psi.

For distribution facilities, pipe segments are generally considered potentially deficient, or the most-limiting segments, if they are predicted to have velocities greater than 5 fps or head loss greater than 10 ft/1000 ft. Velocities in pipe segments are acceptable up to 10 fps. However, as velocities increase, pipe head losses increase exponentially and problems with the water system performance under emergency conditions increase. The important objectives are to identify potentially vulnerable portions of the system, investigate the results of the system performance under emergency scenarios, and identify alternatives to improve reliability.

8.1 Model Development

Waverly's water system was input into InfoWater, a hydraulic modeling software by Autodesk. Existing hydrant and water main location and water main sizes were determined using the Waverly GIS system as a reference. Elevations within the water model nodes were derived from USGS Raster Data. The water tower and storage tower elevations were obtained from City record drawings.

No minor head losses anticipated from fittings, water meters, backflow preventers, or other items were introduced into the water model.

A Hazen-Williams coefficient of friction (C-factor) of 100 was assumed for the existing water mains, as recommended by Nebraska Title 123. This value was confirmed through model calibration efforts and adjusted as necessary to match most closely what was observed in flow testing. The extent to which pipes and valves are corroded in Waverly's distribution system is unknown, but generally a lower C-factor is associated with a greater degree of internal corrosion. Different areas of the water system likely represent different degrees of corrosion due to age and material of the pipes.

8.2 Water Demands

The 2023 average water use was found to be 411 gpm, as outlined in Section 4. The water use from the top 5 users is 112 gpm. The top 5 water user demands are applied at nodes representing their location in the water system, while the remaining 298 gpm was distributed evenly throughout the water model. There are 672 nodes throughout the system. Dividing the 298 gpm over those nodes results in a demand of 0.44 gpm at each node.

The model was also run with scenarios for peak daily demand and peak hourly demand. Peak daily demand is 761 gpm, as previously determined. The peak hour demand is 1,538 gpm. For both of these scenarios, 112 gpm was subtracted to account for specific demands applied near the top users (assumed constant over 24 hours), and the remaining demand was divided between the 672 nodes in the model.

8.3 Model Calibration

After the initial development of the hydraulic model, it must be calibrated to field conditions. This is achieved by conducting field hydrant flow testing and making adjustments within the hydraulic model until it most closely matches the conditions observed during flow testing. Flow testing field data was collected by Olsson with City water employees on February 6, 2023.

Hydrant flow testing consists of the following steps:

- Pairs of hydrants were identified throughout the water system for flow testing.
- Approximately 10% of the system's hydrants were tested.
- At each test location, one hydrant is identified as the "flow" hydrant, and one as the "residual" hydrant. It was attempted to sample two hydrants on the same water main line.
- A pressure gauge is installed on the fully opened residual hydrant. The pressure at that hydrant is recorded.
- The flow hydrant is opened fully, and the pressure of the water leaving the hydrant is recorded using a pitot gauge.
- The pressure drop at the residual hydrant is recorded.

After the flow testing is complete, results are entered into a spreadsheet to document the results for use in calibrating the model. The pressure recorded from the flow hydrant (in psi) is converted to a flow rate (in gpm) using the following equation:

$$Q = 29.83 * CD^2\sqrt{P}$$

Where:
Q = Hydrant Flow (gpm)
C = Opening Coefficient (unitless), ranges from 0.7 to 0.9 depending on the shape of opening
D = Hydrant Opening Diameter (inches)

P = Pitot Tube Pressure (psi)

After computing the flows from the hydrants at each flow test, the static and residual pressures from each test are compared against those in the model. Where the model static pressures differ from what was recorded in the field, node elevations are adjusted until the static pressures most closely replicate what was observed in the field to within 2 psi.

To calibrate to flow conditions, the calculated flow from each flow hydrant is input into its corresponding node in the model, and the residual pressure in the model is observed. To calibrate the model to field conditions, the roughness values in the nearby water mains are adjusted up and down until the model results most closely match the field results within 7 psi. The full calibration table is included in Table 19, and the flow test locations are shown in Figure 10.

As indicated in Table 19, the model was able to be calibrated to field conditions in nearly all locations. Test 18 was calibrated well to static conditions, but the residual pressure in the model was slightly higher than the allowable range. This is not a major concern and is likely due to the distance between the flow and residual hydrants for this test.

Table 19. Model Calibration Results

Test No.	Location of Flow Hydrant	Location of Residual Hydrant	Field Static Pressure (psi)	Model Static Pressure (psi)	Δ (psi)	Calculated Flow (gpm)	Field Residual Pressure (psi)	Model Residual Pressure (psi)	Δ (psi)
1	Alvo Rd & N 134th St, F-221	Alvo Road, F-222	45	45	0	538	42	44	2
2	Dovers St, F-213	Dovers St, F-214	65	67	2	1,007	55	56	1
3	Dovers St & Bailie Ct, F-255	Bailie Ct, F-161	63	64	1	993	58	58	0
4	Amberly Rd & Canongate Rd, F-199	Amberly Road, F-200	70	70	0	1,061	65	68	3
5	Deer Park Rd, F-189	Deer Park Rd & Amberly Rd, F-188	66	68	2	715	62	66	4
6	Bailie St, F-166	Bailie St & N 145th St, F-165	54	55	1	839	50	52	2
7	Castlewood & N 152nd St, F-155	N 152nd St, F-154	61	62	1	650	54	59	5
8	Eastbourne St & 143rd St, F-116	Eastbourne St, F-117	58	59	1	505	53	57	4
9	Guildford Rd, F-98	Guildford Rd & N 140th St, F-97	70	71	1	1,061	64	68	4
10	Heywood St & N 141st St, F-90	Heywood St & N 142nd St, F-89	68	70	2	1,061	66	70	3
11	N 150th St, F-136	N 150th St & Bluff Rd, F-135	63	65	2	993	55	54	1
12	Jamestown St, F-79	Jamestown St & N 148th St, F-78	67	69	2	875	62	66	4
13	Jamestown St & N 141st St, F-45	Jamestown St & N 139th St, F-42	69	69	0	949	65	66	1
14	N 135th Street, F-20	N 135th Street, F-19	70	72	2	787	52	58	6
15	Northloch St & Lucia Ct, F-4	Northloch St & Montrose Ct, F-2	69	69	0	750	49	56	7
16	Oldfield St, F-55	Oldfield St & N 142nd St, F-56	66	68	2	839	60	63	3
17	Quentin St, F-231	Quentin St & N 146th St, F-232	68	70	2	839	58	58	0

Test No.	Location of Flow Hydrant	Location of Residual Hydrant	Field Static Pressure (psi)	Model Static Pressure (psi)	Δ (psi)	Calculated Flow (gpm)	Field Residual Pressure (psi)	Model Residual Pressure (psi)	Δ (psi)
18	N 148th St, F-76	N 148th St, F-74	71	73	2	888	60	69	9
19	N 142nd St & Red Gauntlet, F-225	N 143rd St & Red Gauntlet, F-226	69	69	0	888	59	62	3
20	N 143rd St & N 142nd St, F-252	N 142nd St, F-251	69	71	2	993	55	61	6
21	Lancashire St, F-40	Lancashire St & N 137th St, F-31	70	72	2	825	65	68	3
22	Lancashire St & N 143rd St, F-50	Lancashire St & N 142nd St, F-49	68	70	2	1,186	65	64	1

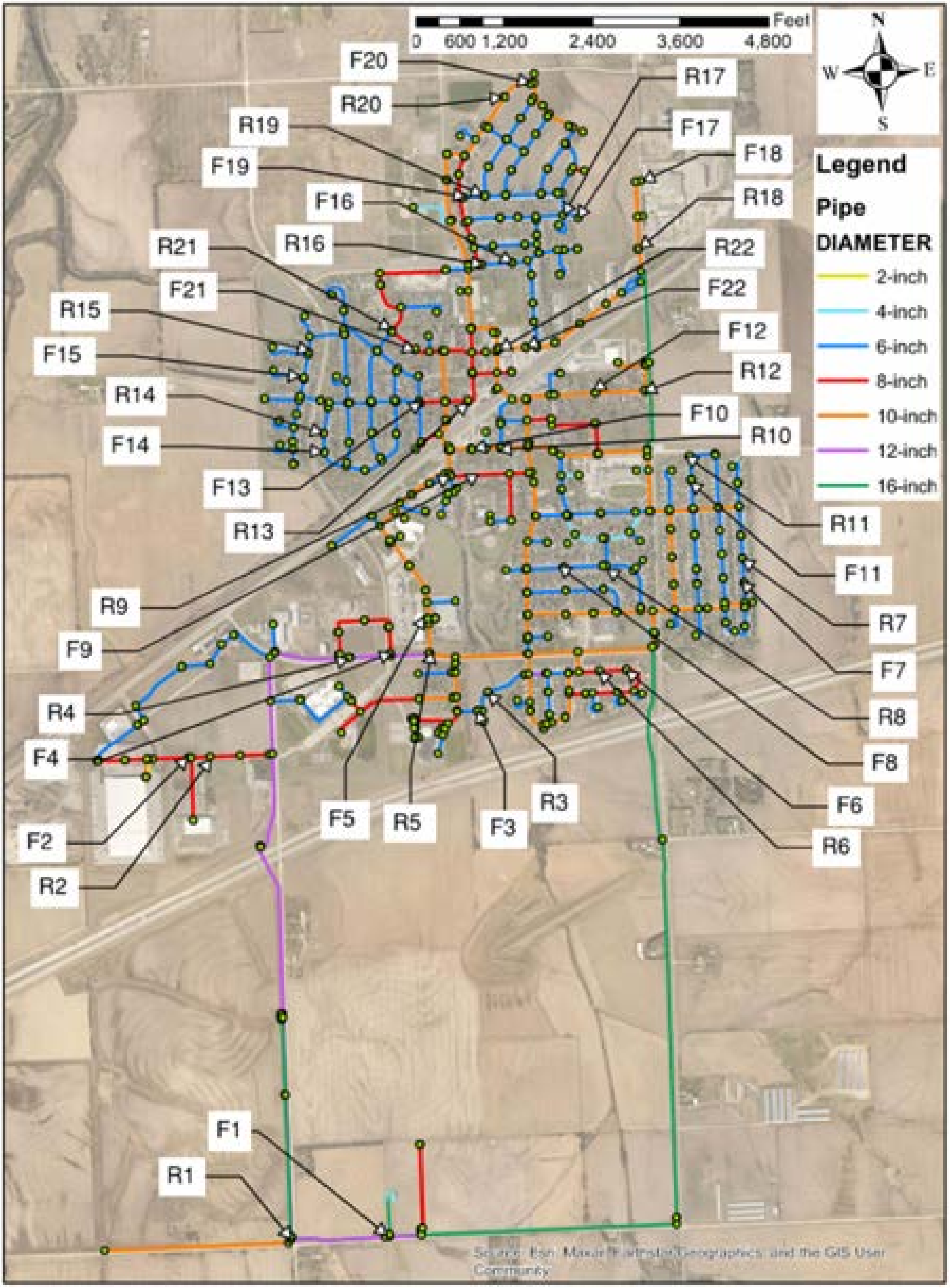

Figure 10. Flow Testing Map

8.4 System Pressures and Velocities

The calibrated hydraulic model was used to simulate operation of the water system and identify potential deficiencies in its ability to provide adequate pressures. Ten States Standards indicate that a water system should provide working pressures ideally between 60 and 80 psi, with a minimum pressure of 40 psi. The model indicated system pressures throughout the City limits ranging from 60 to 76 psi at average demand conditions. South of the City, on the transmission main from the wellfield, the pressure drops to as low as 35 psi in the very southeast, which can be attributed to the increase in elevation moving south. Since this portion of the water main is primarily for transmission and not distribution, and the transmission main is not being used to provide fire protection, this portion of the system operating at pressures nearing the 35-psi minimum is not cause for concern.

The model was used to generate a contour map of the system pressures, in psi, throughout the water system, as shown in Figure 11. The hydraulic model shows that pressures drop by about 1 to 4 psi from present average day conditions to peak hour conditions, depending on the location within the water system.

Future water demands were also modeled in the hydraulic model. The projected 2043 average daily demand is slightly lower than the 2023 peak daily demand, which the system is able to handle with minimal pressure drops (1 to 4 psi). The scenario that would put the most stress on the system is the 2043 peak hour demand of 2,313 gpm. Subtracting the top user water usage that is applied on specific nodes, this results in 3.44 gpm at the remaining nodes. When the model was run at these conditions, the pressures within the water system ranged from 60 to 70 psi. Although this is a drop from pressures at the average demand, it is still within the recommended 60 to 80 psi and these conditions will only occur at the peak hours. Note that there is the potential for new industrial development in the water system, which is not accounted for in these calculations. These calculations should be revisited once an estimated water usage is known for potential future industrial users in the water system.

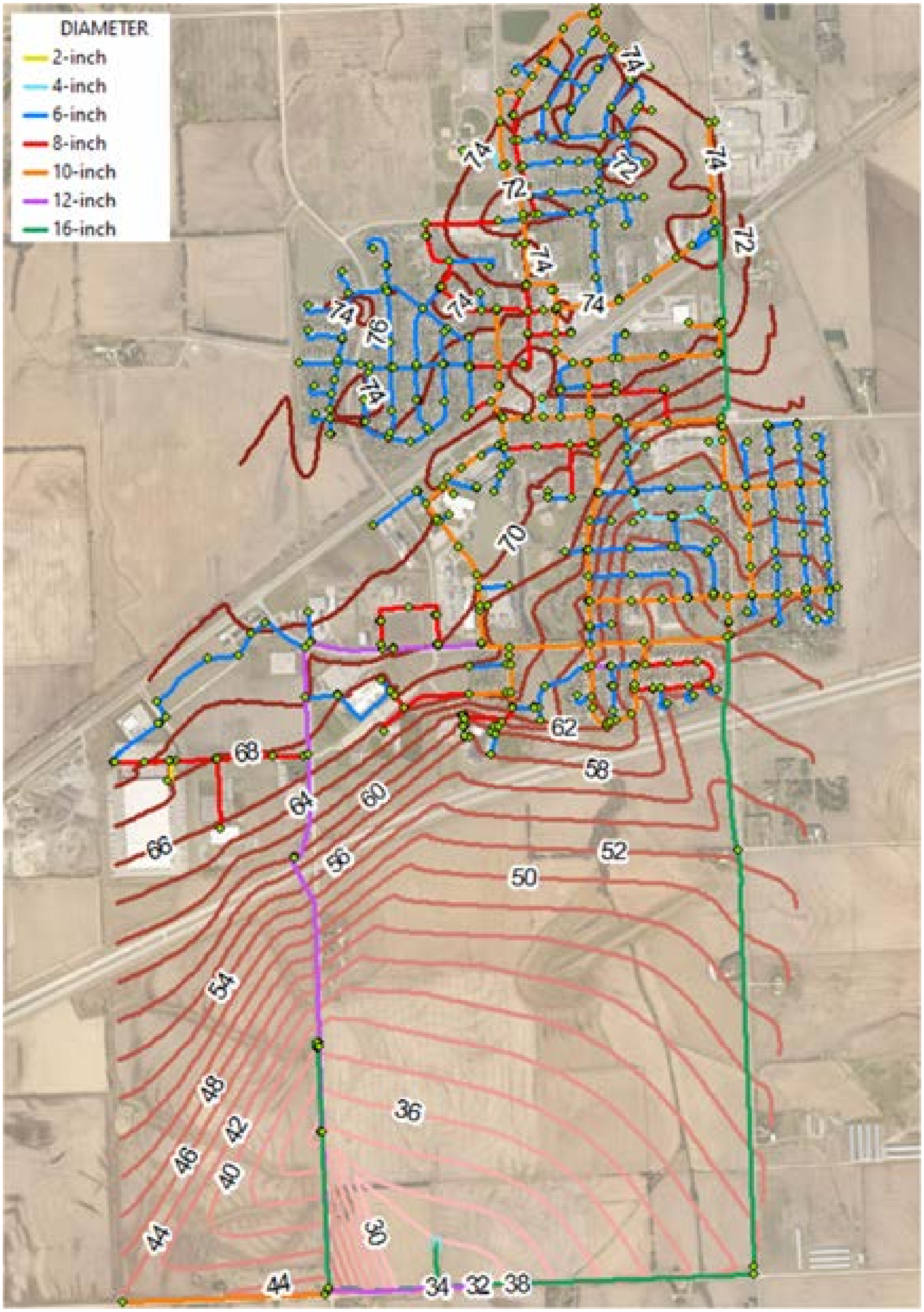

Figure 11. System Pressures at Average Day Demand

For all three demand scenarios, the velocity in pipes did not exceed 5 fps, and thus was determined to be acceptable. Figure 12 shows the velocity of water in pipes under the 2023 peak hour demand. As can be seen in the figure, the highest velocities are near the water tower. Velocities are lower moving to the north and to the outskirts of the water system.

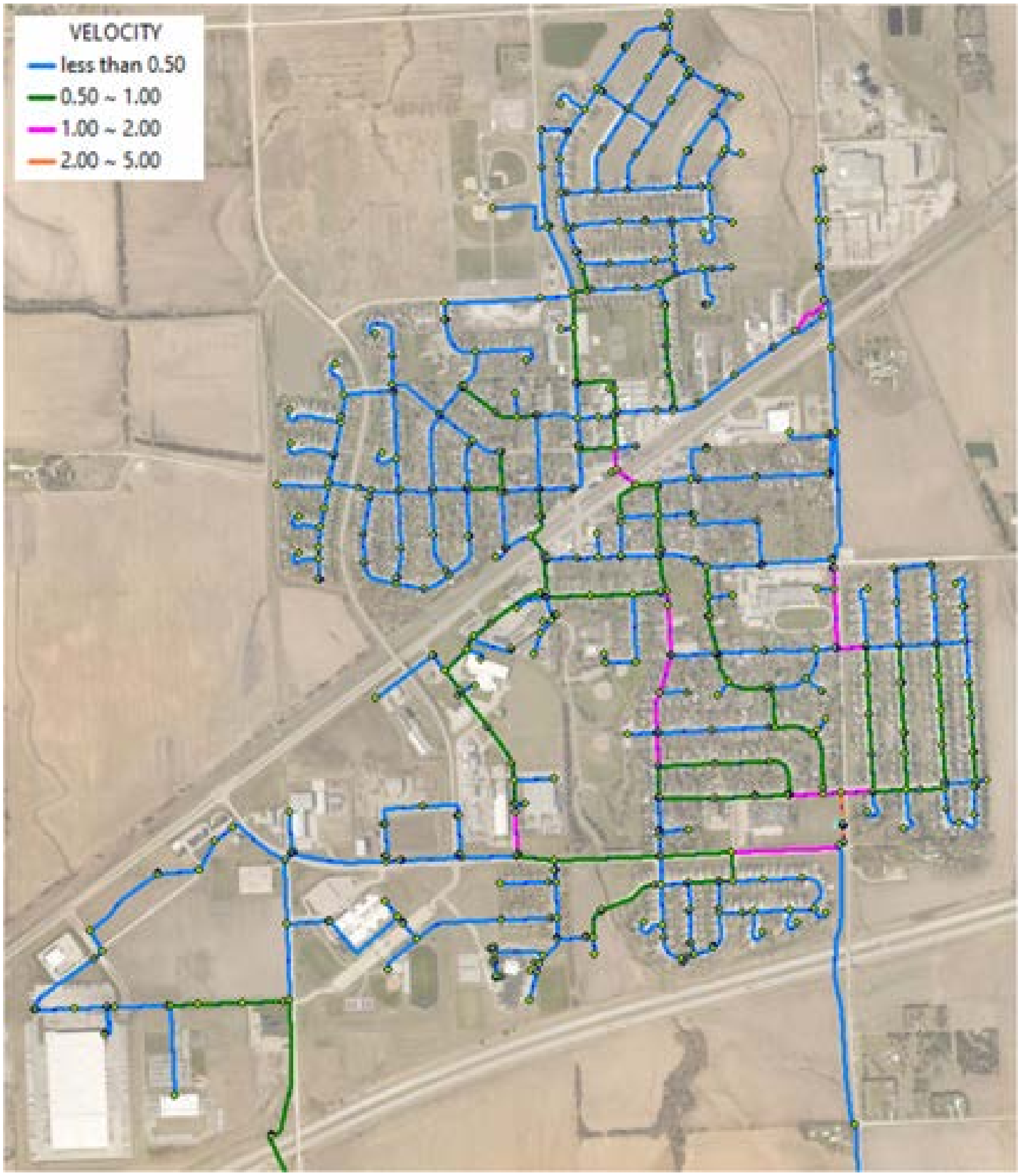

Figure 12. Pipe Velocity (in fps) at Peak Hour Demand

8.5 Fire Flow Simulation

The hydraulic model was next used to identify deficiencies in the system's fire protection capabilities. A distribution system should be capable of providing the needed fire flow (previously determined to be 1,500 gpm in residential locations and 3,500 gpm in commercial areas) while maintaining a residual pressure of 20 psi.

A fire flow analysis was performed within the hydraulic model to identify potential deficiencies in the water distribution system using the Fire Flow Scenario in InfoWater. The fire flow analysis utilizes the hydraulic model to gradually increase demands on the water system until the pressure drops to 20 psi. The demand that corresponds to a residual pressure of 20 psi is indicated to be the available fire flow at that location, in gpm. Where the available fire flow is lower than the needed fire flow identified earlier in this report, it is indicative of a potential deficiency in the water system.

To address potential system deficiencies, the model is used to simulate water improvements and their effect on addressing those deficiencies. Potential improvements can be projects such as upsizing water mains, looping water mains to eliminate dead ends in the system, or other projects listed in this section. Waverly's water distribution system generally meets Ten States Standards for minimum 6-inch diameter water mains where fire protection is provided. There is only one area where there is a 4-inch loop, along Oak Lane, which results in fire flow capabilities less than 1,500 gpm in this area. The remaining areas of pipe with smaller than 6-inch diameter are all dead ends or services to buildings and are not significantly hindering the transport of water for fire flow.

After simulating fire flows throughout the water system in the model, locations where potential deficiencies are located were identified. A contour map of the available fire flow, in gpm, is provided in Figure 13. This map shows that most of the system can provide the residential demand of at least 1,500 gpm while maintaining a residual pressure of 20 psi. The commercial areas of Waverly, primarily along Highway 6 as outlined on their land use map, were cross referenced with the fire flow map. It was found that these commercial areas are able to supply a minimum of 3,500 gpm for fire flow. The future land use map can be found in Appendix C.

Where the contours show that available fire flow is less than required, improvements are identified to address them. The hydraulic model shows that fire flow capabilities are lowest on the northwest outskirts of town and at various other dead ends such as cul-de-sacs or lines running to building services. These areas of lower fire flows along dead-end service lines are to be expected, and no recommendations are provided for these cases. Available fire flow is also lacking though the 4-inch main along Oak Ln, Recommended improvements to increase fire flow capability are outlined in Section 10.2.

In areas that are lacking the 1,500-gpm fire flow capability, it is recommended that the firefighters take caution. If they use pumps on the trucks to pull more water than is readily available, they should monitor the system pressures, and lower the output flow if it is nearing 20 psi.

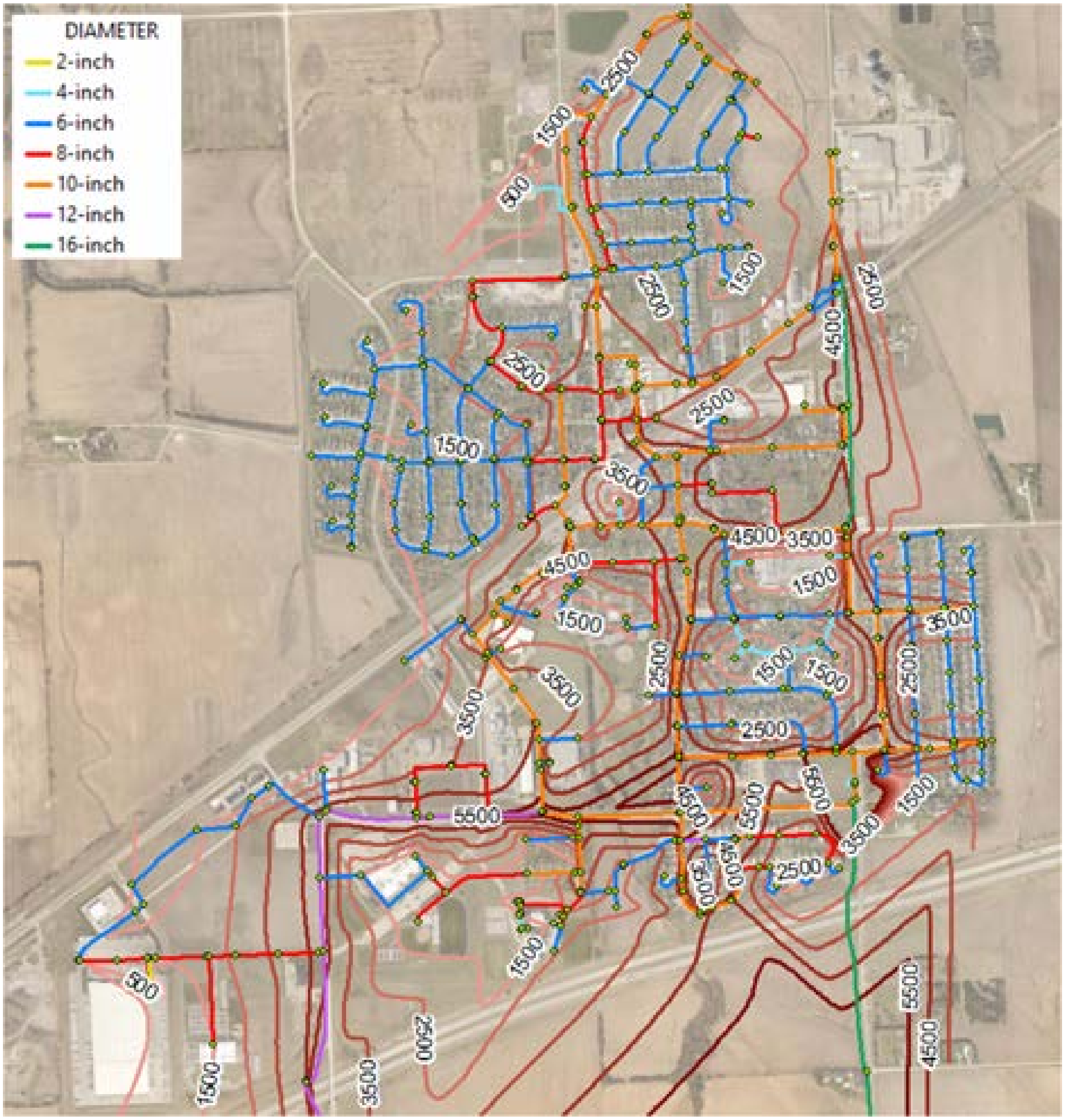

Figure 13. Fire Flow Capabilities

9. FUTURE GROWTH

Although future population growth has already been explored in Section 3 through projections provided in Waverly's Comprehensive Plan, it is also necessary to identify growth areas as the land outside of the water system to ensure that they will be able to be served with water when constructed. The Comprehensive Plan, prepared by Hanna Keelan Associates, determined what areas of town may be developed in the future and what type of land use is expected. This future land use map can be found in Appendix C.

9.1 Development East of Waverly

The City is presently in the process of completing a new Comprehensive Plan and has provided the current land use map that determines what areas of town may be developed in the future and what type of land use might be expected. This map is shown in Figure 14. The future land use map shows planned areas of Urban Density Residential, Multi-Family Residential, and Commercial east of N 148th St and west of N 162nd St. The City confirmed that these areas are still being planned for development, likely starting with residential south of Highway 6 and North of I-80 within the next 15 to 20 years.

Figure 14 also shows a proposed water main loop consisting of approximately 41,500 linear feet to serve these areas of new development. The loop was assumed to be near the roadways within right-of-way to prevent the need for property acquisition or easements for their construction. Benefits of the looped layout include providing redundancy, preventing dead ends, and maintaining pressure. Depending on the timeline for developing this area, different portions of the loop would likely be constructed in phases. In order to match the 16-inch transmission main and maximize capacity, these future water main loops are proposed to be 16 inches, installed in open right-of-way.

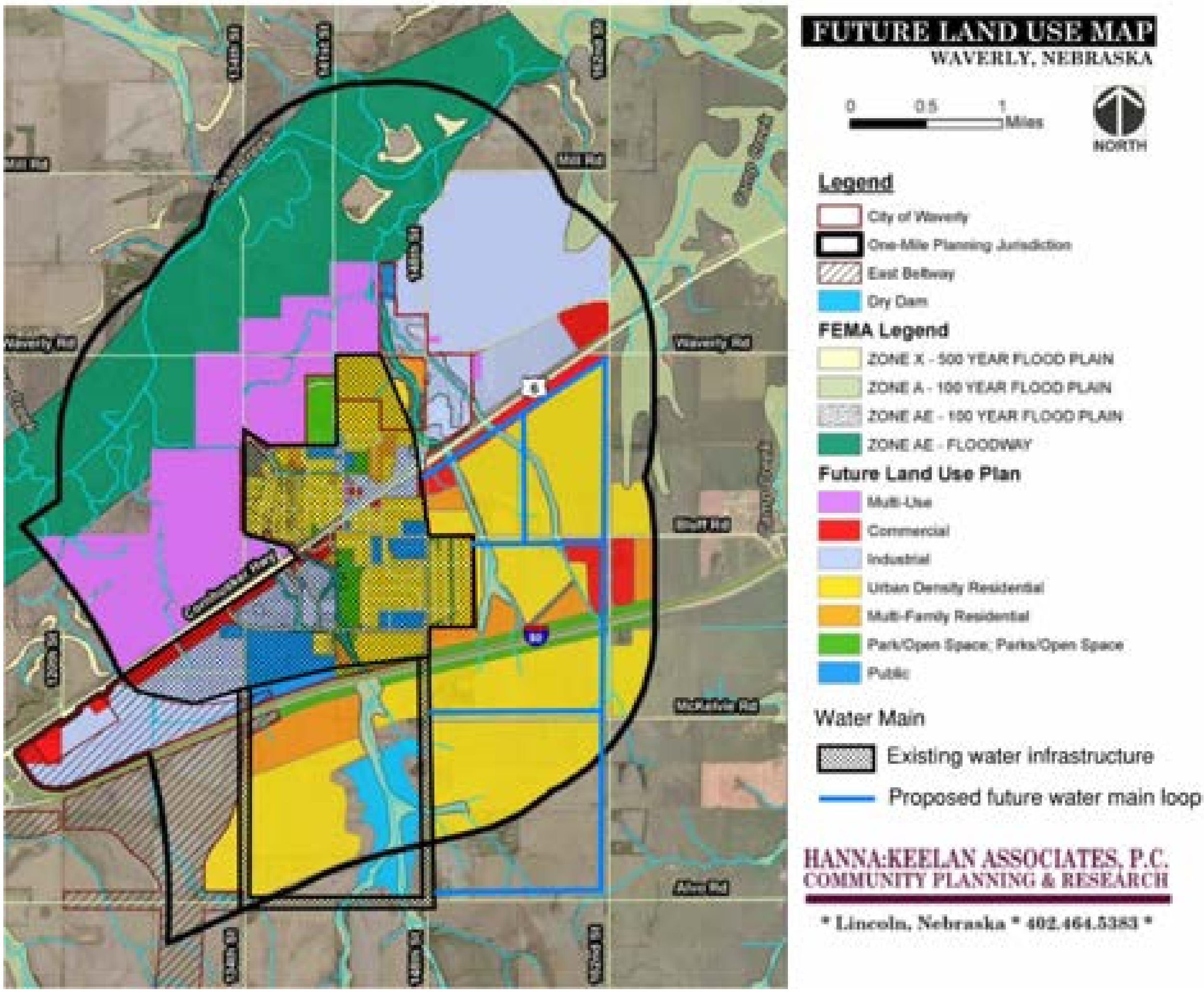

Figure 14. Future Land Use Map with Proposed Water Main Loops

9.1.1 Future Loop Demand

Population density is used to estimate population growth in the future growth areas. The proposed future loops cover approximately 1,500 acres of potential development. Several methods of population density for residential areas were considered, as outlined in Table 20.

Table 20. Residential Population Density by Different Estimation Methods

	Residential Density (people/acre)
2005 Water Study	8.28
2013 Comprehensive Plan	11.27
National Planning Standard	10

The National Planning Standard density was used for this report, resulting in an expected 15,000-person population increase from this new development area, which is primarily residential. It is noted that this population increase is considerably higher than the growth rates defined in Section 3. This method of estimation is used as a preliminary conservative assumption. The future population will likely be much lower due to parks and other types of developments besides only residential houses in this area. Additionally, this development will likely take longer than 20 years to be fully complete and populated.

If the calculated 138 gpcd was applied over this future water loop, this would result in an additional average demand of 2,070,000 gpd, or 1,438 gpm. The current pumping capacity would be able to provide this additional average demand, but a new well or additional storage may be necessary to meet peak demands. However, no specific recommendations will be made at this time due to the exact developments and timeline not being planned yet.

9.1.2 Future Loop Pressure and Fire Flow

With expected demands applied, pressures in this proposed loop are similar to the pressures around the present distribution main within town, as shown in Figure 15. Pressures north of I-80 range from 50 to 75 psi. Pressures south of I-80 range from 36 to 55 psi. Further study and modeling are recommended prior to planning the portion of this loop south of I-80 to ensure the development has adequate pressure. It is likely that a booster pump station will be needed in this southern area in order to provide pressures within 60 to 80 psi.

Due to the large-diameter main, fire flow in this loop is more than sufficient, ranging from 3,000 to 5,500 gpm in the model, as shown in Figure 16. While the hydraulic model is shown to provide fire protection for the loop in this area, it is recommended that the pressures and fire protection capabilities be further modeled when exact water mains are designed for the site.

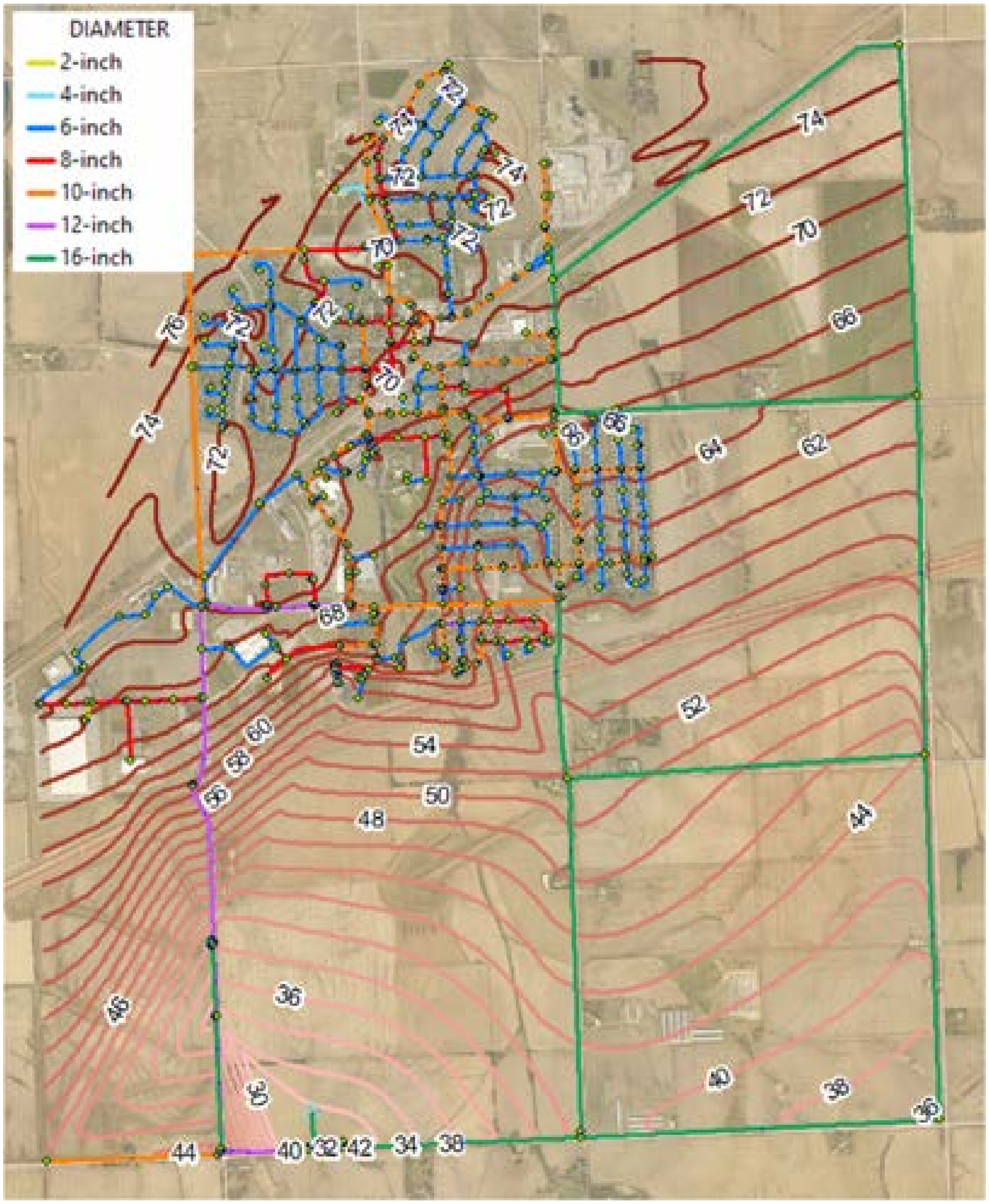

Figure 15. Pressures Around Proposed 16-inch Loop

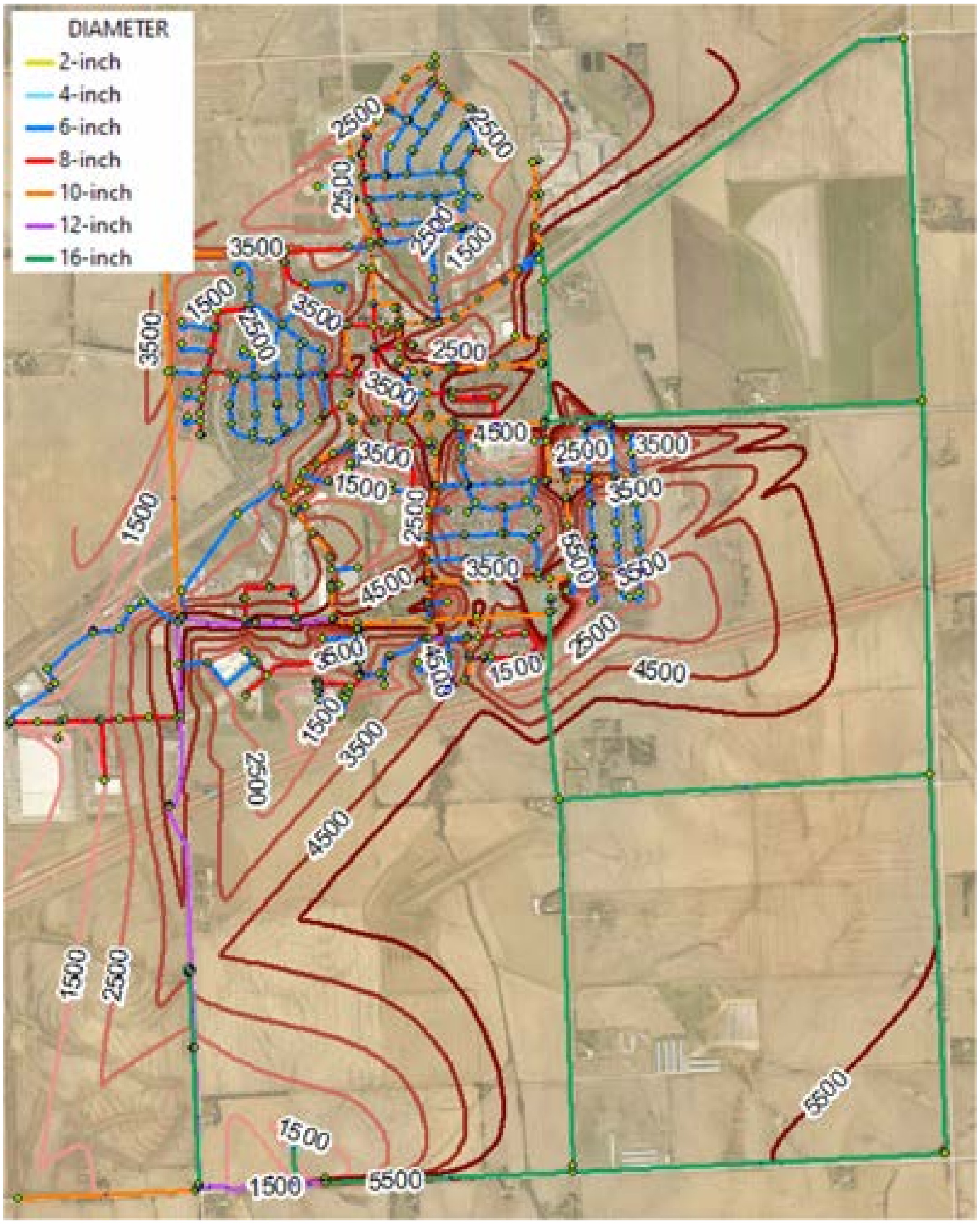

Figure 16. Available Fire Flow Around Proposed 16-inch Loop

9.1.3 Future Loop Phasing

This water main loop is very large and will likely be constructed in phases as land development is planned and constructed. This proposed phasing, as shown in Figure 17, will be used to break down the cost, to be further detailed in Section 11. Recently, the land in the northwestern portion of this loop (Phase A) has been purchased, and residential development is expected within the next 10 years.

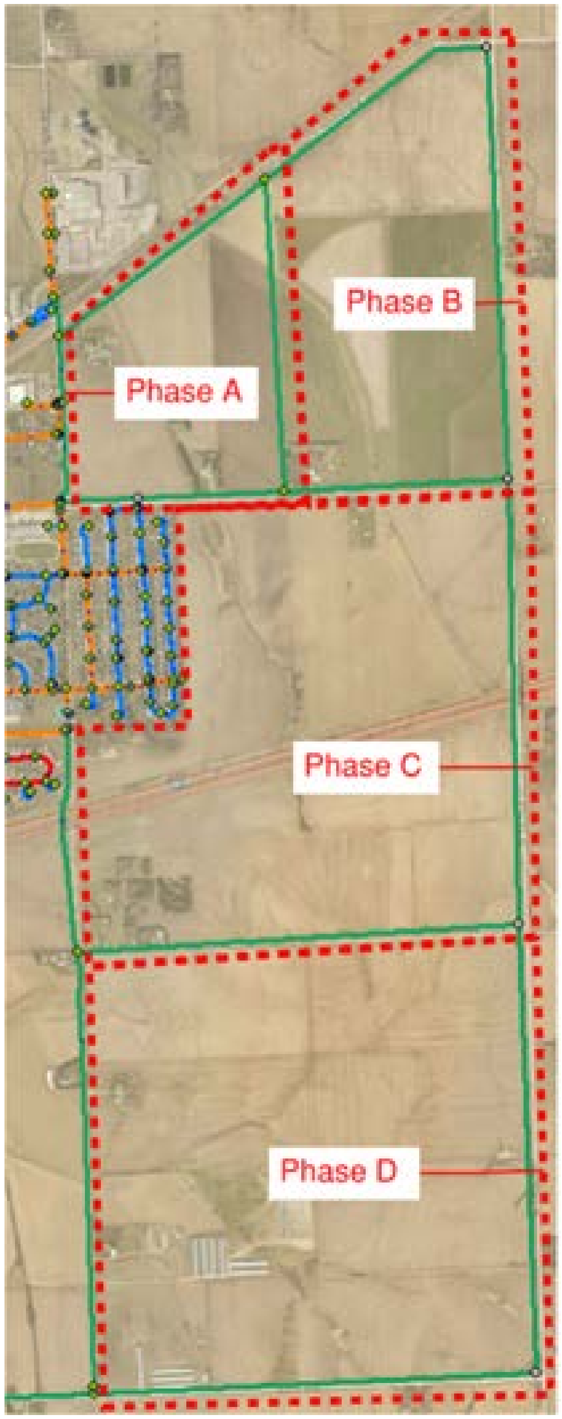

Figure 17. Future Loop Phasing

9.2 Potential Water Main Extensions and Cost

The City mentioned a couple areas on the outskirts of City limits that have expressed interest in a water main extension and connecting onto Waverly's system. These landowners are currently getting water from private wells.

The first potential extension is approximately 7,500 LF of water main north along 148th St to Mill Rd and the buildings north of the wastewater treatment plant. The City said there are about 8 buildings that could be connected to water. The model finds a pressure of approximately 75 psi on the line, which is good. For a 6-inch water main, fire flow at the furthest north point is only 350 gpm. Due to the spacing between buildings being more than 30 feet apart, there would be a 500-gpm fire flow requirement in this area. If this extension is upsized to 8 inches, then it can provide 700 gpm at the most remote point, which is adequate. The estimated cost for this 7,500-LF extension of 8-inch water main is approximately $930,000.

The second potential extension is southwest along Highway 6 to 120th St, which is approximately 3,500 LF of water main. The pressure at the end of this extension is about 70 psi, which is good. For an 8-inch main, the fire flow at the end is approximately 850 gpm. Upsizing this to 10 inches results in a fire flow of 1,200 gpm. The closet buildings in this area are about 30 feet apart, which will result in an ISO fire flow requirement of 750 gpm. Therefore, an 8-inch main would likely be adequate, unless additional fire protection is desired. The estimated cost for an 8-inch water main extension is approximately $434,000.

It is noted that these water mains were approximately drawn in the model based on preliminary discussions with the City. Additional modeling may be required once the water main and expected demands are configured to confirm adequate pressures and fire flows.

10. RECOMMENDED IMPROVEMENTS

10.1 General Improvements

Much of the existing water main in Waverly is adequately sized at 6 inches or larger. Water mains 4 inches or smaller compose only 2.4% of the system. Most of these are dead ends serving only one property and should not be a priority to upsize.

Looping dead ends or branched runs would be beneficial in increasing flow and pressures to deficient areas of the City. However, the majority of dead ends currently occur in cul-de-sacs or in providing service to one property, which would make looping an infeasible solution. As the City continues to grow, a main that encompasses the City boundaries is recommended for to accommodate future water users.

When specific new developments or water main extensions are planned, it is recommended to model the system to ensure that adequate pressures and fire flow can be provided to the new areas. A Master Services Agreement can be created upon request for Olsson to provide these on-call services for modeling updates for specific future projects utilizing the model of Waverly's water system.

Analysis of the water system shows that the current wells provide a sufficient quantity of water to regularly meet present and future demands. Thus, a new well is not recommended at this time to supplement water quantity. If a new well was to be planned for, it would be recommended to look around the southwest area of the existing wellfield near Wells #6 and #7 due to the lowest nitrate concentrations in that area. A separate well study would be recommended at that point to explore and further refine a site for a test hole.

10.1.1 Old Metal Water Mains

It was requested by the City to evaluate the cost to eventually replace all old metal water mains, which comprise approximately 29% of the system (plus 7% unknown material). Table 21 shows a summary of the length of pipe that is a different size of DIP, CIP, or unknown pipe material. The unknown pipe material is included due to the likelihood that it is unknown because the plans are older and thus more likely to be a metal material. Standard costs are assumed for the design, construction, and associated fees for the various sizes of pipe. All costs are rounded to the nearest $1,000. To replace all water mains assumed to be metal would result in an estimated cost of $24.7 million. Replacing all non-PVC water mains at once is not feasible, and it is more practical to replace the mains in areas known to be deficient and then in a scheduled replacement plan to slowly make progress over time.

Table 21. Summary of DIP, CIP, and Unknown Material Water Mains

Pipe Diameter (in)	Length (LF)	Cost per LF	Cost to Replace
Unknown*	88,192	$ 133	$ 11,730,000
2	367	$ 44	$ 16,000
3	414	$ 67	$ 28,000
4	2,364	$ 89	$ 210,000
6	27,082	$ 133	$ 3,602,000
8	6,323	$ 178	$ 1,125,000
10	23,516	$ 222	$ 5,221,000
12	10,356	$ 266	$ 2,755,000
TOTAL	**158,615**	**-**	**$ 24,687,000**

**When the pipe size was unknown, it was assumed to be the construction cost of 6-inch pipe due to that being the most common occurrence in the system.*

One method of planning for the replacement of all older, metallic mains is to budget for their replacement over a 20-year period. Based upon the total in the previous table, this will result in a cost of $1,234,350 per year for the next 20 years.

10.1.2 Recommended Pump Schedule

The current wells are scheduled to run even-numbered wells one day, odds the next. The pump capacity of even-numbered wells is approximately 600 gpm higher than odd-numbered wells. Consequently, this is likely adding increased strain on the aquifer level near the odd-numbered wells. This is reflected in Wells #5, #9, and #11 all having critical pumping water levels within 5 feet of the intake in May 2023.

A new recommended setup of pumps to alternate daily is shown in the table below. This arrangement was chosen to better equalize the production capacity across all wells. This also geographically spreads out the wells in a different way which could potentially help aquifer levels. Pumping and static water levels are recommended to be monitored after this shift to confirm if there is a positive impact on the aquifer levels. This exercise should be revisited once Well #7 is constructed and the optimum pumping rate for that site is verified.

Table 22. Recommended Pump Schedule

	Day 1	Day 2
	Well #5	Well #4
	Well #6	Well #8
	Well #10	Well #9
	Well #11	--
Total Capacity	1,477 gpm	1,355 gpm

10.2 System Improvements

The following improvements to the distribution system will help facilitate better flow throughout the system, improve pressures and fire flow capability, meet minimum sizing recommendations, and plan for future growth and development around Waverly. Figure 18 shows a map of the locations for all improvements.

Improvement 1

Upsize approximately 1,525 LF of 4-inch water main to 6 inches along Oak Lane and W Oak Lane Circle. Based on the modeled fire flow, this segment is currently not able to meet the 1,500-gpm residential requirements. Upsizing this line to 6 inches improves the fire flow to meet 1,500 gpm as well as satisfying Ten States Standards recommendations for mains providing fire protection. Additionally, this area of water main has had two main breaks within the past year, and replacing it would reduce the risk of this happening again and affecting the customers served off this line.

It is noted that the City does not have the original drawings for this segment of water main that was constructed in the 1960s. It is believed that it is part 4-inch and part 6-inch. The 4-inch segments that restrict the flow and the age would both contribute to reasons that this main should be replaced.

Improvement 2

Currently, almost all of Northloch Street and the cul-de-sacs to the west are under the 1,500-gpm residential fire flow requirements. Adding another connection point to the water system and looping this development to the water system would improve fire flow along Northloch St and the cul-de-sacs to the west. This would include installing approximately 1,300 LF of 10-inch pipe from the existing 6-inch main along Northloch St going south to Energy Way and Well #5. Approximately 450 LF of that pipe would be bored with casing under US Highway 6 and the railroad. In addition, approximately 860 LF of 6-inch water main along Energy Way and Deer Park Rd would need to be upsized to 10 inches.

After this improvement, all of Northloch St will meet the 1,500-gpm fire flow capability. The western ends of the cul-de-sacs can only provide roughly 1,100 to 1,400 gpm, but they are within 500 feet of another hydrant that could provide additional flow if needed.

Improvement 3

As part of planning for future growth, a 16-inch main is recommended to loop around the proposed development area east of town. This would be the first step to provide adequate facilities for the new development areas. As part of the proposed water main along Bluff Rd for this loop, a 100-LF connection south into the 6-inch main along N 151st St is recommended in order to improve flow in that area. This water main loop is recommended to be installed in four phases as development is planned. This improvement is further expanded on in Section 9.1.

Improvement 4

It is recommended that the 6-inch main from Well #5 along Energy Way is looped to connect to the 6-inch main at N 134th St. The City mentioned that this connection is being planned but is dependent on some future development layouts in this area. The two connection points are approximately 1,400 LF apart, and 2,000 LF of 6-inch pipe will be assumed for the length of water main to allow for installing around future developments.

This improvement will help towards the general goal of looping water mains to improve pressures and flow throughout the system. This location by a well is also beneficial to provide a redundant connection, so that the well could continue supplying water if there was an issue with the one water main along Energy Way which presently connects the well to the distribution system.

Improvement 5

Although the water main replacement project along Eastbourne St and N 147th St has already been designed, it has not been constructed and therefore will be included in the cost estimate in this water study. This project consists of approximately 2,335 LF of 6-inch pipe. There has been a history of many main breaks in this area, which necessitates this project.

Improvement 6

The water main replacement along Lancashire St from N 141st St to N 137th St has been designed. A cost estimate for construction is included in this study. This replacement includes approximately 1,185 LF of 8-inch water main and 230 LF of 6-inch pipe.

Improvement 7

As outlined in Section 7.4, the water main along N 137th St has had a history of main breaks and is recommended to be replaced. It is 8-inch CIP between Newgate St and Lancashire St and 6-inch CIP between Lancashire St and Jamestown St. Both were installed in the late 1960s. It is recommended to replace this 370 LF of 8-inch pipe and 1,050 LF of 6-inch main.

Improvement 8

As outlined in Section 7.4, the 6-inch water main along Danvers St has a history of water main breaks and is recommended to be replaced. The installation date is unknown and likely around the 1960s. The material is cast iron, which the City would prefer to replace. It is recommended that the entire 1,480 LF of water main along Danvers St from N 143rd St to Castlewood St is replaced in order to upgrade this area all at once.

Improvement 9

As discussed in Section 6.3, several areas throughout Waverly are lacking sufficient hydrant coverage. In order to improve the coverage, eight hydrants are recommended in the locations previously described. When possible, it is recommended that these projects be completed in conjunction with main replacements or other projects rather than installing them individually on existing water mains. This would minimize disruption to the overall water system and likely bring cost savings.

Improvement 10

Approximately 29% of Waverly's water system is comprised of old metal CIP and DIP mains. The City has expressed interest in replacing these over time. Improvement 10 consists of a 20-year plan to do so.

Improvement 11

Due to the trending upwards nitrate levels, it is recommended to take the first steps towards looking for a new well or other water source. A nitrate/well study is recommended to start planning for new well(s) to replace high nitrate wells.

This study could also investigate the logistics and preliminary costs of purchasing water from Lincoln if the City is interested in that as an alternate to a new well as an additional water source. This would include a review of water chemistry to confirm blending is possible.

Improvement 12

Instead of or in conjunction with an additional water source, it is recommended that Waverly look into a blending solution to lower the overall system nitrate levels. This would involve calculations to set up a well schedule configuration that combines water from high- and low-nitrate wells.

This would also include the construction of a blending vault near the treatment application points. The blending vault would be a small structure that includes a static mixer, pipes and valves, and a downstream sampling station.

Improvement 13

Due to the aging Wells #4, #5, and #6, the City has expressed interest in the associated costs for replacing these wells rather than rehabilitating them. In the case of Wells #4 and #6, due low nitrates in this area, the best option may be drilling a new well adjacent to the existing well.

High nitrates in the vicinity of Well #5 may necessitate a nitrate/well study (Improvement 11) to ensure a reliable water supply. Improvement 13 includes the associated costs for design and construction of a new well and pump.

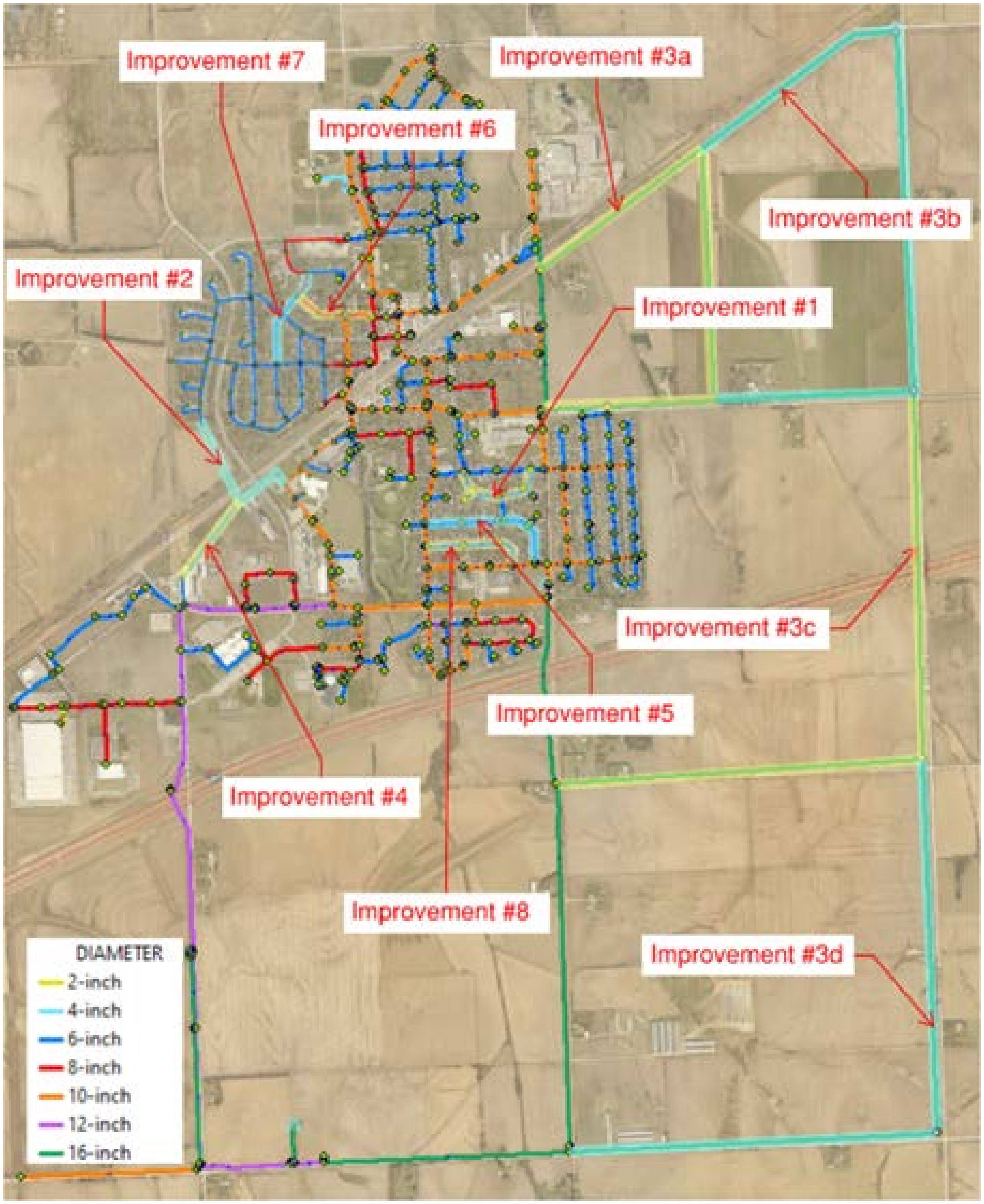

Figure 18. Distribution System Improvements Map

10.3 System Improvement Priority Ranking and Timeline

The proposed projects are prioritized to aid the City in budgeting and planning for their construction. Table 23 outlines the recommended improvements and provides a timeline for each project. It is noted that several improvements are indicated as needed to support growth, and the timeline for those is dependent on planned development in Waverly.

Table 23. Recommended Improvements Priority and Timeframes

Improvement No.	Description	Prioritization Timeframe
1	Oak Ln Water Main Upsize (4” to 6”)	0-3 Years
2	Looped Connection to Northloch St	0-5 Years
3a	Future 16" Loop around East Development Area - Northwest	0-10 Years
3b	Future 16" Loop around East Development Area - Northeast	As needed to support growth
3c	Future 16" Loop around East Development Area - Central	As needed to support growth
3d	Future 16" Loop around East Development Area - South	As needed to support growth
4	Construct Water Main between N 134th St and Well #5/Energy Way	0-5 Years
5	Eastbourne St Main Replacement (6” Pipe)	0-2 Years
6	Lancashire St Main Replacement (8” and 6” Pipe)	0-2 Years
7	N 137th St Main Replacement (8” and 6” Pipe)	0-5 Years
8	Danvers St Main Replacement (6” Pipe)	0-5 Years
9	Install 8 New Hydrants to Improve Coverage	0-3 Years
10	Replace Old Metal Water Mains (Done Over 20 Years)	0-20 Years
11	Nitrate/Well Siting Study/LWS Feasibility	0-3 Years
12	Blending Vault	5-10 Years
13	New Well	0-10 Years

11. OPINION OF COST

An opinion of project cost for each of the proposed improvements is presented in Table 25. The opinions of cost assume that all work is competitively bid and performed by registered contractors with complete plans and specifications. All costs are estimated using 2023 pricing. The rate of inflation in construction costs is difficult to forecast, so opinions of cost for improvements that are not completed in the near future will require updating at that time. A more detailed analysis of cost will also likely be performed when a project is designed.

Estimates of cost were compiled using data from RS Means Estimating Guide, tabulations from recently bid projects, and pricing from vendors. The budget cost estimates assume that the projects are designed by a Professional Engineer, and that the work is performed by a licensed contractor with complete plans and specifications, approved by NDEE.

For proposed water distribution system improvement projects, a budget cost per inch-diameter of water main was used to estimate the potential cost for each project, which will include hydrants, valves, disinfection and testing, pavement removal and replacement, service line installation, and other miscellaneous items associated with the construction of new water mains. Budget cost per inch-diameter of water mains were derived from the LWS Master Plan. These unit costs were used as a basis and compared to RS Means Estimating Guide, recently bid projects, and information provided by vendors and suppliers. It was determined that the unit prices for the water mains in open ROW were accurate to recent costs. However, a 40% contingency was added to the LWS unit prices for water mains in congested areas in order to account for the project and market variability in alignment with recently bid projects in similar communities.

In preparing the opinion of cost for piping improvement projects, it has been assumed that new water mains will be located in open right-of-way since they are primarily planned to run along existing roads, and they will not require the removal/replacement of any pavement or sidewalks. This includes Improvements #2, #3, and #4. The water mains that are being upsized are assumed to be constructed in a congested area. This includes Improvements #1, #5, #6, #7, #8 and #10.

Standard budget costs for each of these are outlined in Table 24. These unit costs include material and construction cost as well as assuming a 20% contingency to account for engineering, legal, and administrative costs.

Table 24. Budget Costs for Water Main Projects

Water Main in Open ROW	
Main Size (in)	Construction Cost per LF
6	$93
8	$124
10	$155
12	$186
16	$248
Water Main in Congested Areas	
Main Size (in)	Construction Cost per LF
6	$186
8	$249
10	$311
12	$372
16	$497

Budget cost estimates for the recommended projects are included in Table 25. Costs are rounded to the nearest thousand dollars. A total of 13 recommended projects are provided, ranging from new water main loops, to main replacements, to new wells. The costs for each assume that the projects are completed individually as their own project, though it is likely that cost savings would be experienced if two or more projects are combined into a single larger project.

The estimate for a new well as Improvement 13 includes design of a well, test hole and soil analysis, drilling of a well, casing, screen, gravel pack, well development and testing, wellhouse, and electrical and pipe connection to the new well. If it was decided to re-drill Well #4 or #6 adjacent to the existing well, this cost would likely be slightly lower, although there would still be some cost associated with abandoning the existing well.

Table 25. Opinion of Cost for Recommended Improvements

No.	Description	Quantity	Estimated Cost	Timeframe	Annual Cost, 20-yr Loan @ 7%
1	Oak Ln Water Main Upsize	1,525 LF 6" Main	$ 203,000	0-3 Years	$ 26,808
2	Looped Connection to Northloch St	2,160 LF 10" Main	$ 715,000	0-5 Years	$ 67,491
3a	Future 16" Loop around East Development Area - Northwest	9,500 LF 16" Main	$ 2,356,000	0-10 Years	$ 222,390
3b	Future 16" Loop around East Development Area - Northeast	10,900 LF 16" Main	$ 2,704,000	As needed to support growth	$ 255,238
3c	Future 16" Loop around East Development Area - Central	10,500 LF 16" Main	$ 2,604,000	As needed to support growth	$ 245,799
3d	Future 16" Loop around East Development Area - South	10,500 LF 16" Main	$ 2,604,000	As needed to support growth	$ 245,799
4	Construct Water Main between N 134th St and Well #5	2,000 LF 6" Main	$ 186,000	0-5 Years	$ 17,557
5	Eastbourne St Main Replacement	2,335 LF 6" Main	$ 311,000	0-2 Years	$ 41,061
6	Lancashire St Main Replacement	1,185 LF 8" and 230 LF 6" Main	$ 242,000	0-2 Years	$ 31,999
7	N 137th St Main Replacement	370 LF 8" and 1,050 LF 6" Main	$ 206,000	0-5 Years	$ 27,185
8	Danvers St Main Replacement	1,480 LF 6" Main	$ 197,000	0-5 Years	$ 26,052
9	Install New Hydrants to Improve Coverage	8 Hydrants	$ 56,000	0-3 Years	$ 5,286
10	Replace Old Metal Water Mains (Over 20 Years)	158,615 LF, various sizes	$ 24,687,000	0-20 Years	$ 1,729,750*
11	Nitrate/Well Study/LWS Feasibility	Engineering Study	$ 11,000	0-3 Years	$ 1,038
12	Blending Vault	Vault Design & Construction	$ 17,000	5-10 Years	$ 1,605
13	New Well	1 Well (Design & Construction)	$ 700,000	0-10 Years	$66,075
TOTAL COST OF RECOMMENDED IMPROVEMENTS			$48,169,991		$ 3,011,134

**This is not a 20-year loan cost. It is the total estimated cost of this improvement divided over 20 years, since the City is considering budgeting 4% of these replacements each year.*

12. OPERATING BUDGET & WATER RATES

The current water rates for Waverly are provided in Table 26. There is a base service charge for each different size of meter, and a volume fee is charged for the amount of water used. There are presently 1,648 water service connections to the system. Table 27 summarizes the total number of each size of meter/service in Waverly. It is estimated that there are around 70 to 90 non-residential meters in the system.

Table 26. Current Water Rates

Metered Connections Service Charge	
5/8-inch Meter	$16.75/month
3/4-inch Meter	$16.87/month
1-inch Meter	$17.19/month
Volume Fees (per 1,000 gallons)	
First 10,000	$1.88
Next 10,000	$2.41
Above 20,000	$2.99

Table 27. Water Service Summary

Meter Size	Number of Services
5/8”	656
1”	933
1.5”	18
2”	32
4”	9
TOTAL	**1,648**

In 2022, Waverly sold approximately 220,961,831 gallons of water. This can be compared to the total amount of water pumped in 2022, which was 240,212,814 gallons. This equates to a water loss of 8%. Water loss can be due to leaks in the system or unbilled water such as water used for City buildings. Overall, this amount of water loss is not a cause for concern in this system.

Financial information on the City’s water fund was provided for the 2021-22 and 2022-23 fiscal years. A summary of expenses and revenue for each of these fiscal years is provided in Table 28.

Table 28. City Financial Summary

Category	2021-22 Budget	2022-23 Budget
Employee Pay & Benefits	$141,600	$189,500
Worker's Comp Ins	$500	$1,000
Clothing	$250	$500
Contracted or Secured Services	$2,000	$3,000
Professional & Technical Services	$1,000	$40,000
Electricity	$37,000	$37,000
Fuel & Oil	$3,000	$3,000
Rentals & Leases	$1,000	$1,000
Postage	$3,500	$3,500
Telephone	$1,800	$2,000
Advertising & Printing	$1,000	$1,000
Supplies	$40,000	$50,000
Furniture & Equipment	$80,000	$170,000
School, Dues, Seminars	$3,000	$3,000
Sales Tax for Water	$50,000	$15,000
Property Insurance	$8,300	$9,000
Travel & Mileage	$1,000	$1,000
Repair & Maintenance-Buildings	$0	$0
Repair & Maintenance-Water System	$35,000	$35,000
Repair & Maintenance-Equipment	$7,000	$15,000
Vehicle Maintenance	$1,000	$1,000
Capital Improvement	$520,000	$1,550,000
NDEQ Loan Payments / 2021 Water Bond	$142,673	$137,093
Meter & Readout Purchase	$110,000	$180,000
Laboratory Services	$5,000	$5,000
TOTAL COSTS	**$1,195,623**	**$2,452,593**
Revenue from Water Rates	$852,868	TBD
NET COSTS INCURRED	**$342,755**	**TBD**

Work and improvements recommended in this report would fall under the following categories: Professional & Technical Services, Repair & Maintenance, Capital Improvement, and Loan/Bond Payments. The total amount budgeted in these categories was $705,673 and $1,777,093 in the respective 2021-22 and 2022-23 budget years.

13. FUNDING OPTIONS

Several potential options are available to the City to fund this project, including: bonds, assistance from funding agencies/programs, and loans. The following is an overview of some of the various options available to the City.

- Revenue Bonds
  - These are tax-exempt bonds in which the debt service is paid by a dedicated revenue source, such as revenue from the sale of water to consumers, property, or sales tax.

- General Obligation Bonds
  - General obligation bonds are backed by the full faith and credit of the taxing authority. Utility revenues can be used to pay the annual debt service, and/or a tax can be levied on properties within the City. These are considered to be more secure than revenue bonds. As with revenue bonds, voter approval is often required prior to issuance.

- WWAC
  - To assist communities seeking funding for water projects, Nebraska established the WWAC in 1997. WWAC is an advisory panel for municipalities, counties, and RWDs that are seeking public financing from DWSRF or USDA.
  - Communities seeking funds must go through the WWAC, which consists of representatives from NDEE and USDA. The process for submitting to the WWAC includes a pre-application and a completed facility plan or preliminary engineering report. The pre-application and other associated guidance can be found at http://deq.ne.gov.
  - The WWAC reviews submittals monthly to determine actions taken. If the project is selected for funding, and the community meets the eligibility requirements, the WWAC will recommend one or a combination of funding sources. It should be noted that receiving funds is highly competitive, and the City may not qualify for funding from all agencies.
  - The various funding sources under WWAC are described further, below:
    - SRF Loan Program: SRF loans are administered by the NDEE through the DWSRF. The City’s eligibility to qualify for a State or Federal SRF loan is dependent upon the SRF IUP. This process, which repeats each year, consists of individual communities submitting their project needs to the State, which then ranks the projects based upon several criteria.

Should the City choose to move forward with one of these options, they should get onto the IUP for funding consideration.

- It is noted that Waverly's MHI is on the high end of what NDEE considers to be possibly eligible for loan forgiveness, so SRF with loan forgiveness may be challenging to obtain. Until at least 2026, a lot of NDEE's money that could typically be given out as an SRF cash loan is otherwise tied up in assisting with FEMA projects.
- It is noted that any funding from DWSRF prioritizes projects that are necessary to maintain public health, such as to prevent high levels of nitrates or copper.
- DWSRF would be unable to fund any project that has a primary purpose to support future growth or fire protection. A project could be funded if it is deemed necessary to maintain the current customer base such as replacing a well or installing a new well to lower the system blended nitrate level.

▪ USDA Rural Development Program: The Water and Waste Disposal program of USDA's RDD provides funding through direct loans or grants and guaranteed loans to develop and/or upgrade rural water distribution and wastewater facilities.
  - USDA typically funds projects for communities less than 500 people, so Waverly would likely not be eligible for this funding.

- Community Development Block Grant
  - CDBG is a highly competitive program administered by NeDED. To be eligible for a CDBG grant, a community must have a maximum population of less than 50,000 and a minimum of 51% of low to moderate income families.
  - Applications are accepted throughout any given year. CDGB provides matching grants for water or wastewater to a maximum of $350,000. The City's match would range from 25 to 75%, with the amount ultimately determined by the program.

- NDNR Water Sustainability Fund
  - The Nebraska Water Sustainability Fund provides financial assistance to programs, projects, or activities that increase aquifer recharge, mitigate threats to drinking water or provide increased water productivity and enhance quality.
  - Projects related to a study and new well may be especially qualified for this funding.

  - Applications are filed between March 16th and 31st each year. More information can be found on their website: https://nrc.nebraska.gov/water-sustainability-fund-0

- US EDA Funding
  - The EDA is a bureau of the Department of Commerce that helps financially support infrastructure projects through its public works program. There are many different funding opportunities that can be found on their website: https://www.eda.gov/funding/funding-opportunities
  - Funding is prioritized for projects that create jobs, especially high-skill and high-wage jobs. EDA does not participate in projects related to infrastructure for new residential developments.
  - EDA determines eligibility for funding based on the county in which the community is located. Currently, Lancaster County is not eligible for funding due to low unemployment rate and high MHI.

- Direct Loans and Grants
  - Public entities such as municipalities, counties, special purpose districts, Indian Tribes, and corporations operated on a not-for-profit basis may apply for loans or grants to develop drinking water and waste disposal systems, including solid waste disposal and storm drainage. To apply, communities must have a population of 10,000 or less, be unable to obtain sufficient credit from commercial sources at reasonable rates and terms, and have a MHI below the non-metropolitan MHI for the State of Nebraska.
  - Loans may be made at one of three interest rates: the poverty rate, intermediate rate, and market rate. The rate of the loan depends upon the need to meet applicable health or sanitary standards, and the MHI of the community. Once the loan rate is established, it remains fixed for the life of the loan maximum term, of which is up to 40 years. Normal term for treatment projects is 20 years. Funding preference is given to low-income communities, communities with fewer than 5,500 residents, restoring deteriorating water supplies, improving, enlarging, or modifying a water facility or an inadequate waste facility or merging small water facilities.
  - The RDD considers reasonable user rates to be $40 to $45 per month per household for 5,000 gallons used. Currently, for 5,000 gallons used, residential users in Waverly pay $26.59 per month. Loan amounts are based upon the reasonable rate amount multiplied by the number of user households. If repayment of loans increase monthly residential rates beyond this reasonable

amount, RDD grant monies will be sought to maintain reasonable rates. If monthly rates are below what is considered a reasonable rate, they will need to be increased as necessary for a loan to be secured.

- Grants are made in combination with direct loans or with funding from other sources. Grants may be up to 75% of eligible project costs, but are limited to the amount necessary to enable the residents to be charged reasonable user rates. The MHI of the service area must be below that of the non-metropolitan MHI for the State as well as generally below the national poverty rate, or 80% of the State poverty rate figure. Grants can only be made for projects which address health or safety issues.

- Guaranteed Loans
    - This method is most often used when communities with populations of 10,000 or less identify a private lender interested in financing a project, but will only do so if risk can be reduced. Loan guarantees are 90% of the total loan amount. Interest rates are negotiated between the lender and borrower, and may either be fixed or variable, but must be in-line with rates customarily charged to borrowers in similar circumstances.

- Public-Private Partnerships
    - In addition to traditional funding methods, there are several forms of public-private partnerships that can be used to fund water projects.

- Lease-Purchase Agreement
    - This is a contract in which a private entity funds the project, and the City makes scheduled lease payments until the lease is paid in full.

- Leverage Fund Loans through NDEE
    - The possibility of leverage funds through NDEE has been discussed. NDEE has the opportunity to use bond proceeds to offer a community a lower interest rate than a private loan. NDEE would also likely be able to offer a longer loan term (up to 30 years) than a private loan.
    - Since this funding is from the state, it would have the same requirements as SRF loans such as Davis-Bacon, American Iron and Steel Acts, and Minority-Owned Business Enterprises. These requirements can typically cause a contractor to have higher bids due to the extra work associated with these requirements.
        - If this route is considered for funding, it is recommended to have a bid alternate: one with SRF requirements, and the other with no restrictions

and the City obtaining a private loan. Then, the cost savings between the bid prices and the loan interest rates can be compared.

- Leverage funds would also have the same restrictions as DWSRF such as not being allowed to fund projects that primarily support future growth or fire protection.
- This funding option would be dependent on if NDEE can gather interest from more communities than just Waverly. Discussions are currently paused until information on federal earmark funds is released September 2023, as that may affect some other communities' interest.

14. CONCLUSIONS AND RECOMMENDATIONS

It is recommended that Waverly improve their water supply and distribution system by constructing projects that ensure there is sufficient quantity of quality water. With unpredictable and increasing nitrate levels in some wells, it is recommended that Waverly proceed with a nitrate and well siting study and planning to construct a new well.

Additionally, system modifications should be made to ensure adequate pressures and fire flow capabilities throughout the distribution system. This is recommended to be done by upsizing pipes, creating new loops, or replacing old metal water mains in the locations noted in this report.

Additional recommendations were provided with longer timelines to support continued growth and proactively replace old metal mains with a higher likelihood of breaks and other maintenance issues. The mains installed to support future growth should be constructed in anticipation of new residential/commercial developments.

15. REFERENCES

AWWA. (n.d.) Manual of Water Supply Practices, M32.

City of Lincoln Transportation and Utilities. (2020). *2020 Lincoln Water System Facilities Master Plan Update*. https://www.lincoln.ne.gov/City/Departments/LTU/Utilities/LWS/Documents-and-Reports/Facilities-Master-Plan

City of Waverly. (n.d.). Waverly Nebraska GIS App. https://www.citywaverly.com/vnews/display.v/SEC/Public%20Works%7CGIS

Dvorak, Bruce, University of Nebraska Extension. (2021) *Drinking Water: Iron and Manganese*. https://extensionpublications.unl.edu/assets/pdf/g1714.pdf

FEMA. (2023). *Flood Maps*. https://www.fema.gov/flood-maps

Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers (Illinois Indiana Iowa Michigan Minnesota Missouri New York Ohio Ontario Pennsylvania Wisconsin). (2012). *Recommended Standards for Water Works.* www.health.state.mn.us/communities/environment/water/docs/tenstates/waterrev2012.pdf

Hanna-Keelan Associates, P.C. (2013). *Comprehensive Plan 2013-2033 Prepared for City of Waverly, Nebraska.*

Insurance Services Office. (2014). *Guide for Determination of Needed Fire Flow.* https://www.isomitigation.com/ppc/technical/needed-fire-flow/

Skipton, Sharon & Dvorak, Bruce. (2016). Drinking Water: Hard Water. https://extensionpublications.unl.edu/assets/html/g1274/build/g1274.htm

US Census Bureau. (2022, August 18). Decennial Census of Population and Housing. https://www.census.gov/programs-surveys/decennial-census.html

US EPA. (2002). *Finished Water Storage Facilities*. https://www.epa.gov/sites/default/files/2015-09/documents/2007_05_18_disinfection_tcr_whitepaper_tcr_storage.pdf

US EPA. (2023). *Ground Water.* https://www.epa.gov/report-environment/ground-water#:~:text=Some%20consequences%20of%20aquifer%20depletion,in%20areas%20of%20heavy%20withdrawal.

US EPA. (2023). National Primary Drinking Water Regulations.

US EPA. (2023). *Proposed PFAS National Primary Drinking Water Regulation*.

APPENDIX A
ISO HYDRANT FLOW TABLE - 2000

07-98

INSURANCE SERVICES OFFICE, INC.

HYDRANT FLOW DATA SUMMARY

City WAVERLY STATE NE 68462 Witnessed by Insurance Services Office, Inc.

Date July 24, 2000

TEST NO.	TYPE DIST.*	TEST LOCATION	SERVICE	FLOW - GPM INDIVIDUAL HYDRANTS			FLOW - GPM TOTAL	PRESSURE PSI STATIC	PRESSURE PSI RESID.	FLOW AT 20 PSI NEEDED **	FLOW AT 20 PSI AVAIL.	REMARKS
1	Comm	WOODSTOCK & 142 ST	Main	2120			2120	72	60	3000	4700	
2	Res	JAMESTOWN & 138 ST	"	1120			1120	70	14	1000	1100	
3	Comm	WOODSTOCK & E. OF 144 ST	"	670	670		1340	71	42	2500	1800	
4	Comm	HEYWOOD AND 148 ST	"	2430			2430	68	46	3500	3700	
5	Res	FOLKSTONE & OAK LANE	"	670	670		1340	60	48	1500	2600	
6	Comm	CASTLEWOOD & DANVERS	"	2120			2120	54	48	2000	5400	
7	Comm	GUILDFORD & 142 ST	"	1970			1970	67	42	2250	2800	
8	Comm	DEER PARK RD 3 S. OF ENERGYWAY	"	2260			2260	70	56	1750	4500	
9	Comm	AMBERLY ROAD @ SCHOOL (EAST)	"	1800			1800	72	36	-	2200	

THE ABOVE LISTED NEEDED FIRE FLOWS ARE FOR PROPERTY INSURANCE PREMIUM CALCULATIONS ONLY AND ARE *NOT* INTENDED TO PREDICT THE MAXIMUM AMOUNT OF WATER REQUIRED FOR A LARGE SCALE FIRE CONDITION. THE AVAILABLE FLOWS ONLY INDICATE THE CONDITIONS THAT EXISTED AT THE TIME AND AT THE LOCATION WHERE TESTS WERE WITNESSED.

*Comm = Commercial; Res = Residential

**Needed is the rate of flow for a specific duration for a full credit condition. Needed Fire Flows greater than 3,500 gpm are not considered in determining the classification of the city when using the Fire Suppression Rating Schedule.

APPENDIX B
SARGENT WELL INSPECTIONS – 2022 & 2023

2022 Well Inspections

PO Box 367
846 S 13th St.
Geneva, NE 68361

SARGENT Drilling

Toll Free: 888-496-3902
Phone: 402-759-3902
Fax: 402-759-4960

June 10, 2022

City of Waverly
P.O. Box 427
Waverly, NE 68462

RE: 2022 Well and pump results

Attention: Honorable Board Members

On May 25, 2022 Sargent Drilling performed well and pump tests in your community and this letter is a summary of the results:

Well #4: The average pump efficiency is 76%, this is excellent. The well is producing 17 gallons of water per foot of drawdown. This is the same as the last test. The flow meter registers 10% high. The electric motor was serviced and the packing was greased.

Well #5: The average pump efficiency is 62%, this is excellent. The well is producing 13 gallons of water per foot of drawdown. This is slightly down from last test. The flow meter registers 2% low.

Well #6: The average pump efficiency is 81%, this is excellent. The well is producing 10 gallons of water per foot of drawdown. This is down slightly from last test. The flow meter registers 3% high. The electric motor was serviced and the packing was greased.

Well #8: The average pump efficiency is 82%, this is excellent. The well is producing 10 gallons of water per foot of drawdown. This is the same as last test. The flow meter registers 3% low. The electric motor was serviced and the packing was greased.

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846 S 13th St.
Geneva, NE 68361

SARGENT Drilling

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Phone: 402-759-3902
Fax: 402-759-4960

Well #9: The average pump efficiency is 76%, this is excellent. The well is producing 11 gallons of water per foot of drawdown. This is the same as last test. The flow meter registers 7% high. The electric motor was serviced and the packing was greased.

Well #10: The average pump efficiency is 73%, this is excellent. The well is producing 13 gallons of water per foot of drawdown. This is up slightly from last test. The flow meter registers 1% high. The electric motor was serviced and the packing was greased.

Well #11: The average pump efficiency is 68%, this is excellent. The well is producing 10 gallons of water per foot of drawdown. This is the same as last test. The flow meter registers 3% high.

Sargent Drilling appreciates the opportunity to be of service to the City of Waverly.

If you have any questions feel free to contact the office at (402) 759-3902.

Thank You,

Ivan Mumm,
Technician

Sargent Drilling

INDUSTRIAL ENGINEERING

COMPLETE MUNICIPAL AND INDUSTRIAL WELL AND PUMP SERVICE

Box 367
846 S 13th St

Geneva, NE.
68361

Phone 402-759-3902
Fax 402-759-4960

SARGENT PUMP TEST

DATE: 5-25-2022 OWNER: City of Waverly OPERATOR: Andrew

CITY: Waverly STATE: NE WELL #: 4 WELL ID#:

GPS N-LATITUDE: 40 - 54 - 53.8 W-LONGITUDE: 96 - 31 - 57

MOTOR MFG: U S Motors HP: 40 FRAME: MOTOR EFFICIENCY: 89.5 %

PUMP MFG: Goulds SETTING: 50 Ft. 6 X 1 1/2 BOWL: 5 Stage 10WAHC

STATIC W. L.(Ft.): 14.3 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI): 121

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	1789	1789	1788
Pumping Pressure (PSI)	95	85	75
Pump Loss (Ft.)	2.89	3.51	4.08
Pumping Level (Ft.)	34.9	37.3	39.9
TDH (Ft.)	257.24	237.16	217.23
GPM: Meter	384	428	457
GPM: Test Equipment	345	383	415
Water HP	22.41	22.94	22.77
SP Capacity (GPM/Ft.)	16.7	16.7	16.2
KW	23.86	24.91	25.64
Input HP	31.98	33.39	34.37
Pump HP	28.63	29.89	30.76
Wire To Water (%)	70.1	68.7	66.2
Bowl Efficiency (%)	80.2	78.5	75.7
Pump Efficiency (%)	78.3	76.7	74

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68361

Phone 402-759-3902
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SARGENT PUMP TEST

DATE: 5-25-2022 OWNER: City of Waverly OPERATOR: Andrew

CITY: Waverly STATE: NE WELL #: 5 WELL ID#:

GPS N-LATITUDE: 40 - 54 - 40.6 W-LONGITUDE: 96 - 32 - 12.9

MOTOR MFG: Franklin HP: 25 FRAME: MOTOR EFFICIENCY: 83 %

PUMP MFG: Grundfos SETTING: 52 Ft. 4 X Sub BOWL: 7 Stage 300S250

STATIC W. L.(Ft.): 15.9 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI):

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	3450	3450	3450
Pumping Pressure (PSI)	80	70	60
Pump Loss (Ft.)	7.7	8.53	9.35
Pumping Level (Ft.)	37.3	39.3	41
TDH (Ft.)	229.8	209.53	188.95
GPM: Meter	279	296	312
GPM: Test Equipment	287	303	318
Water HP	16.65	16.03	15.17
SP Capacity (GPM/Ft.)	13.4	12.9	12.7
KW	22.89	22.76	22.69
Input HP	30.68	30.51	30.42
Pump HP	25.47	25.32	25.24
Wire To Water (%)	54.3	52.5	49.9
Pump Efficiency (%)	65.4	63.3	60.1

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Fax 402-759-4960

SARGENT PUMP TEST

DATE: 5-25-2022 OWNER: City of Waverly OPERATOR: Andrew

CITY: Waverly STATE: NE WELL #: 6 WELL ID#:

GPS N-LATITUDE: 40 - 53 - 27.1 W-LONGITUDE: 96 - 32 - 24.8

MOTOR MFG: U S Motors HP: 50 FRAME: MOTOR EFFICIENCY: 89.5 %

PUMP MFG: Sargent Pipe Co. SETTING: 130 Ft. 6 X 1 1/2 BOWL: 6 Stage 10SC

STATIC W. L.(Ft.): 75 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI): 115

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	1787	1788	1788
Pumping Pressure (PSI)	90	80	70
Pump Loss (Ft.)	8.61	11.72	13.78
Pumping Level (Ft.)	110.9	118	122.6
TDH (Ft.)	327.41	314.52	298.08
GPM: Meter	360	460	500
GPM: Test Equipment	380	449	490
Water HP	31.42	35.66	36.88
SP Capacity (GPM/Ft.)	10.6	10.4	10.3
KW	33.68	35.82	37.18
Input HP	45.15	48.02	49.84
Pump HP	40.41	42.97	44.61
Wire To Water (%)	69.6	74.3	74
Bowl Efficiency (%)	81.2	86.4	86
Pump Efficiency (%)	77.8	83	82.7

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Fax 402-759-4960

SARGENT PUMP TEST

DATE: 5-25-2022 OWNER: City of Waverly OPERATOR: Andrew

CITY: Waverly STATE: NE WELL #: 8 WELL ID#:

GPS N-LATITUDE: 40 - 53 - 37.5 W-LONGITUDE: 96 - 30 - 25.02

MOTOR MFG: U S Motors HP: 50 FRAME: MOTOR EFFICIENCY: 89.5 %

PUMP MFG: Sargent Pipe Co. SETTING: 140 Ft. 6 X 1 1/2 BOWL: 6 Stage 10SC

STATIC W. L.(Ft.): 68.3 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI): 131

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	1789	1789	1788
Pumping Pressure (PSI)	90	80	70
Pump Loss (Ft.)	12.49	14.81	17.79
Pumping Level (Ft.)	112.9	118	122.3
TDH (Ft.)	333.29	317.61	301.79
GPM: Meter	430	480	520
GPM: Test Equipment	447	490	541
Water HP	37.62	39.3	41.23
SP Capacity (GPM/Ft.)	10	9.9	10
KW	38.51	39.78	40.7
Input HP	51.62	53.32	54.56
Pump HP	46.2	47.73	48.83
Wire To Water (%)	72.9	73.7	75.6
Bowl Efficiency (%)	84.8	85.6	87.7
Pump Efficiency (%)	81.4	82.3	84.4

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SARGENT PUMP TEST

DATE: 5-26-2022 OWNER: City of Waverly OPERATOR: Andrew

CITY: Waverly STATE: NE WELL #: 9 WELL ID#:

GPS N-LATITUDE: 40 - 53 - 7.6 W-LONGITUDE: 96 - 32 - 7.0

MOTOR MFG: U S Motors HP: 60 FRAME: MOTOR EFFICIENCY: 90 %

PUMP MFG: Sargent Pipe Co. SETTING: 150 Ft. 8 X 1 1/2 BOWL: 6 Stage 10SC

STATIC W. L.(Ft.): 97 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI): 111

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	1784	1786	1785
Pumping Pressure (PSI)	80	70	60
Pump Loss (Ft.)	2.26	2.78	3.29
Pumping Level (Ft.)	134.3	139.6	143.9
TDH (Ft.)	321.36	304.08	285.79
GPM: Meter	470	520	565
GPM: Test Equipment	431	482	528
Water HP	34.98	37.01	38.11
SP Capacity (GPM/Ft.)	11.6	11.3	11.3
KW	38.48	40.13	41.07
Input HP	51.58	53.79	55.05
Pump HP	46.42	48.41	49.55
Wire To Water (%)	67.8	68.8	69.2
Bowl Efficiency (%)	78.7	79.7	80.1
Pump Efficiency (%)	75.4	76.5	76.9

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SARGENT PUMP TEST

DATE: 5-25-2022 OWNER: City of Waveryly OPERATOR: Andrew

CITY: Waverly STATE: NE WELL #: 10 WELL ID#:

GPS N-LATITUDE: 40 - 53 - 7.8 W-LONGITUDE: 96 - 32 - 1.3

MOTOR MFG: U S Motors HP: 30 FRAME: MOTOR EFFICIENCY: 88.5 %

PUMP MFG: Goulds SETTING: 140 Ft. 8 X 1 1/2 BOWL: 5 Stage 9RCLC

STATIC W. L.(Ft.): 80.3 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI): 90

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	1778	1775	1774
Pumping Pressure (PSI)	50	40	30
Pump Loss (Ft.)	1.42	1.67	2.06
Pumping Level (Ft.)	107	111.3	115
TDH (Ft.)	223.92	205.37	186.36
GPM: Meter	350	385	431
GPM: Test Equipment	348	380	425
Water HP	19.68	19.71	20
SP Capacity (GPM/Ft.)	13	12.3	12.2
KW	21.53	22.28	22.68
Input HP	28.86	29.87	30.4
Pump HP	25.54	26.43	26.91
Wire To Water (%)	68.2	66	65.8
Bowl Efficiency (%)	82.9	80	79.7
Pump Efficiency (%)	77.1	74.6	74.3

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Fax 402-759-4960

SARGENT PUMP TEST

DATE: 5-25-2022 OWNER: City of Waverly OPERATOR: Andrew

CITY: Waverly STATE: NE WELL #: 11 WELL ID#:

GPS N-LATITUDE: 40 - 53 - 19.5 W-LONGITUDE: 96 - 32 - 1.4

MOTOR MFG: Franklin HP: 25 FRAME: N/A MOTOR EFFICIENCY: 83 %

PUMP MFG: Grundfos SETTING: 137 Ft. 4 X Sub BOWL: 4 Stage 385S250-4

STATIC W. L.(Ft.): 94.2 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI):

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	3450	3450	3450
Pumping Pressure (PSI)	45	35	25
Pump Loss (Ft.)	16.86	23.18	28.45
Pumping Level (Ft.)	123.6	128.6	133
TDH (Ft.)	244.41	232.63	219.2
GPM: Meter	317	350	384
GPM: Test Equipment	291	345	385
Water HP	17.96	20.27	21.31
SP Capacity (GPM/Ft.)	9.9	10	9.9
KW	25.48	26.16	26.48
Input HP	34.16	35.07	35.5
Pump HP	28.35	29.11	29.46
Wire To Water (%)	52.6	57.8	60
Pump Efficiency (%)	63.4	69.6	72.3

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June 13, 2023

City of Waverly
P.O. Box 427
Waverly, NE 68462

RE: 2023 Well and pump results

Attention: Honorable Board Members

On May 30, 2023 Sargent Drilling performed well and pump tests in your community and this letter is a summary of the results:

Well #4: The average pump efficiency is 75%, this is excellent. The well is producing 16 gallons of water per foot of drawdown. This is slightly up from the last test. The flow meter registers 13% high. The electric motor was serviced and the packing was greased.

Well #5: The average pump efficiency is 64%, this is excellent. The well is producing 13 gallons of water per foot of drawdown. This is the same as the last test. The flow meter registers 3% low.

Well #6: The average pump efficiency is 75%, this is excellent. The well is producing 10 gallons of water per foot of drawdown. This is the same as the last test. The flow meter registers 4% high. The electric motor was serviced and the packing was greased.

Well #8: The average pump efficiency is 82%, this is excellent. The well is producing 10 gallons of water per foot of drawdown. This is the same as last test. The flow meter registers 6% low. The electric motor was serviced and the packing was greased.

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SARGENT Drilling

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Phone: 402-759-3902
Fax: 402-759-4960

Well #9: The average pump efficiency is 68%, this is excellent. The well is producing 10 gallons of water per foot of drawdown. This is lightly down from the last test. The flow meter registers 20% high. The electric motor was serviced and the packing was greased.

Well #10: The average pump efficiency is 75%, this is excellent. The well is producing 12 gallons of water per foot of drawdown. This is down slightly from the last test. The flow meter registers 2% high. The electric motor was serviced and the packing was greased.

Well #11: The average pump efficiency is 80%, this is excellent. The well is producing 10 gallons of water per foot of drawdown. This is the same as the last test. The flow meter registers 1% high.

Sargent Drilling appreciates the opportunity to be of service to the City of Waverly.

If you have any questions feel free to contact the office at (402) 759-3902.

Thank You,

Ivan Mumm,
Technician

IM/jk

Enclosures

Sargent Drilling

INDUSTRIAL ENGINEERING

COMPLETE MUNICIPAL AND INDUSTRIAL WELL AND PUMP SERVICE

Box 627
West Hwy 2

Geneva, NE.
68822

Phone (308)872-5125
Fax (308)872-6912

SARGENT PUMP TEST

DATE: 5-30-2023 OWNER: City of Waverly OPERATER: Andrew

CITY: Waverly STATE: NE WELL #: 4 WELL ID#:

GPS N-LATITUDE: 40 - 54 - 53.8 W-LONGITUDE: 96 - 31 - 57

MOTOR MFG: U S Motors HP: 40 FRAME: MOTOR EFFICIENCY: 89.5 %

PUMP MFG: Goulds SETTING: 50 Ft. 6 X 1 1/2 BOWL: 5 Stage 10WAHC

STATIC W. L.(Ft.): 20.3 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI): 118.6

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	1786	1787	1787
Pumping Pressure (PSI)	95	85	75
Pump Loss (Ft.)	2.5	3.18	3.74
Pumping Level (Ft.)	40	43	45.9
TDH (Ft.)	261.95	242.53	222.89
GPM: Meter	380	414	452
GPM: Test Equipment	319	363	396
Water HP	21.1	22.23	22.29
SP Capacity (GPM/Ft.)	16.2	16	15.5
KW	22.97	24.38	25.31
Input HP	30.79	32.68	33.93
Pump HP	27.56	29.25	30.37
Wire To Water (%)	68.5	68	65.7
Bowl Efficiency (%)	78.5	77.8	75.1
Pump Efficiency (%)	76.6	76	73.4

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SARGENT PUMP TEST

DATE: 5-30-2023 OWNER: City of Waverly OPERATER: Andrew

CITY: Waverly STATE: NE WELL #: 5 WELL ID#:

GPS N-LATITUDE: 40 - 54 - 40.6 W-LONGITUDE: 96 - 32 - 12.9

MOTOR MFG: Franklin HP: 25 FRAME: N/A MOTOR EFFICIENCY: 83 %

PUMP MFG: Grundfos SETTING: 52 Ft. 4 X Sub BOWL: 7 Stage 300-S-250

STATIC W. L.(Ft.): 20.9 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI):

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	3450	3450	3450
Pumping Pressure (PSI)	80	70	60
Pump Loss (Ft.)	7.6	8.43	9.29
Pumping Level (Ft.)	43	45	46.6
TDH (Ft.)	235.4	215.13	194.49
GPM: Meter	277	294	309
GPM: Test Equipment	285	301	317
Water HP	16.94	16.35	15.57
SP Capacity (GPM/Ft.)	12.9	12.5	12.3
KW	22.76	22.71	22.63
Input HP	30.51	30.44	30.34
Pump HP	25.32	25.27	25.18
Wire To Water (%)	55.5	53.7	51.3
Pump Efficiency (%)	66.9	64.7	61.8

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SARGENT PUMP TEST

DATE: 5-30-2023 OWNER: City of Waverly OPERATER: Andrew

CITY: Waverly STATE: NE WELL #: 6 WELL ID#:

GPS N-LATITUDE: 40 - 53 - 27.1 W-LONGITUDE: 96 - 32 - 24.8

MOTOR MFG: U S Motors HP: 50 FRAME: MOTOR EFFICIENCY: 89.5 %

PUMP MFG: Sargent Pipe Co. SETTING: 130 Ft. 6 X 1 1/2 BOWL: 6 Stage 10SC

STATIC W. L.(Ft.): 80 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI): 114

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	1785	1785	1785
Pumping Pressure (PSI)	90	80	70
Pump Loss (Ft.)	6.48	10.45	12.66
Pumping Level (Ft.)	113.6	122.3	127.3
TDH (Ft.)	327.98	317.55	301.66
GPM: Meter	350	425	480
GPM: Test Equipment	326	422	468
Water HP	27	33.84	35.65
SP Capacity (GPM/Ft.)	9.7	10	9.9
KW	33.81	35.72	37.11
Input HP	45.32	47.88	49.75
Pump HP	40.56	42.85	44.52
Wire To Water (%)	59.6	70.7	71.7
Bowl Efficiency (%)	69.5	82.2	83.3
Pump Efficiency (%)	66.6	79	80.1

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SARGENT PUMP TEST

DATE: 5-30-2023 OWNER: City of Waverly OPERATER: Andrew

CITY: Waverly STATE: NE WELL #: 8 WELL ID#:

GPS N-LATITUDE: 40 - 53 - 37.5 W-LONGITUDE: 96 - 30 - 25.02

MOTOR MFG: U S Motors HP: 50 FRAME: MOTOR EFFICIENCY: 89.5 %

PUMP MFG: Sargent Pipe Co. SETTING: 140 Ft. 6 X 1 1/2 BOWL: 6 Stage 10SC

STATIC W. L.(Ft.): 72.3 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI): 129.20

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	1787	1786	1787
Pumping Pressure (PSI)	90	80	70
Pump Loss (Ft.)	12.08	14.92	16.83
Pumping Level (Ft.)	115	121.3	126
TDH (Ft.)	334.98	321.02	304.53
GPM: Meter	410	460	510
GPM: Test Equipment	439	492	525
Water HP	37.14	39.88	40.37
SP Capacity (GPM/Ft.)	10.3	10	9.8
KW	37.95	39.61	40.62
Input HP	50.87	53.1	54.45
Pump HP	45.53	47.52	48.73
Wire To Water (%)	73	75.1	74.1
Bowl Efficiency (%)	85	87.3	86.1
Pump Efficiency (%)	81.6	83.9	82.8

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Fax (308)872-6912

SARGENT PUMP TEST

DATE: 5-31-2023 OWNER: City of Waverly OPERATER: Andrew

CITY: Waverly STATE: NE WELL #: 9 WELL ID#:

GPS N-LATITUDE: 40 - 53 - 7.6 W-LONGITUDE: 96 - 32 - 7

MOTOR MFG: U S Motors HP: 60 FRAME: MOTOR EFFICIENCY: 90 %

PUMP MFG: Sargent Pipe Co. SETTING: 150 Ft. 8 X 1 1/2 BOWL: 6 Stage 10SC

STATIC W. L.(Ft.): 103.3 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI): 109

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	1784	1786	1785
Pumping Pressure (PSI)	80	70	60
Pump Loss (Ft.)	1.46	1.99	3.04
Pumping Level (Ft.)	139.9	145	149
TDH (Ft.)	326.16	308.69	290.64
GPM: Meter	460	520	570
GPM: Test Equipment	341	403	506
Water HP	28.09	31.41	37.14
SP Capacity (GPM/Ft.)	9.3	9.7	11.1
KW	37.11	39.65	40.74
Input HP	49.75	53.15	54.61
Pump HP	44.77	47.84	49.15
Wire To Water (%)	56.5	59.1	68
Bowl Efficiency (%)	65.6	68.5	78.7
Pump Efficiency (%)	62.7	65.7	75.6

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SARGENT PUMP TEST

DATE: 5-31-2023 OWNER: City of Waverly OPERATER: Andrew

CITY: Waverly STATE: NE WELL #: 10 WELL ID#:

GPS N-LATITUDE: 40 - 53 - 7.8 W-LONGITUDE: 96 - 32 - 1.3

MOTOR MFG: U S Motors HP: 30 FRAME: MOTOR EFFICIENCY: 88.5 %

PUMP MFG: Goulds SETTING: 140 Ft. 8 X 1 1/2 BOWL: 5 Stage 9RCLC

STATIC W. L.(Ft.): 86 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI): 87

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	1777	1775	1775
Pumping Pressure (PSI)	50	40	30
Pump Loss (Ft.)	1.21	1.56	2.03
Pumping Level (Ft.)	111.9	116.3	120.6
TDH (Ft.)	228.61	210.26	191.93
GPM: Meter	326	377	427
GPM: Test Equipment	319	366	422
Water HP	18.42	19.43	20.45
SP Capacity (GPM/Ft.)	12.3	12.1	12.2
KW	20.92	22.04	22.82
Input HP	28.04	29.54	30.59
Pump HP	24.82	26.15	27.07
Wire To Water (%)	65.7	65.8	66.9
Bowl Efficiency (%)	80	79.8	80.9
Pump Efficiency (%)	74.2	74.3	75.5

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COMPLETE MUNICIPAL AND INDUSTRIAL WELL AND PUMP SERVICE

Box 627
West Hwy 2

Geneva, NE.
68822

Phone (308)872-5125
Fax (308)872-6912

SARGENT PUMP TEST

DATE: 5-31-2023 OWNER: City of Waverly OPERATER: Andrew

CITY: Waverly STATE: NE WELL #: 11 WELL ID#:

GPS N-LATITUDE: 40 - 53 - 19.5 W-LONGITUDE: 96 - 32 - 1.4

MOTOR MFG: Franklin HP: 25 FRAME: N/A MOTOR EFFICIENCY: 83 %

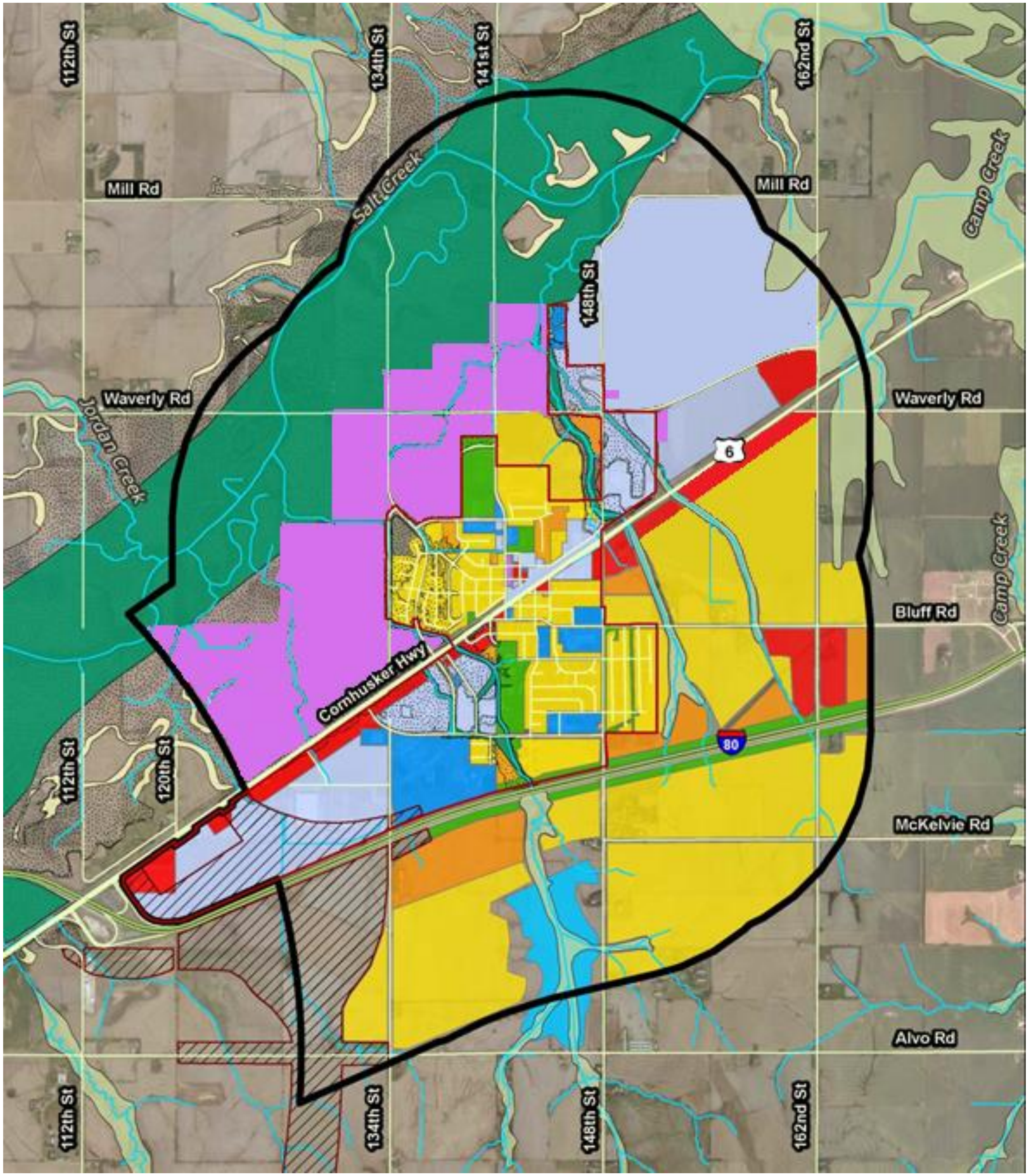
PUMP MFG: Grundfos SETTING: 134 Ft. 4 X Sub BOWL: 4 Stage 385-S-250-4

STATIC W. L.(Ft.): 99.3 DESIGN SP (GPM/Ft. DD): 0 SHUT OFF (PSI):

CONDITION	TEST #1	TEST #2	TEST #3
Pump RPM	3450	3450	3450
Pumping Pressure (PSI)	45	35	40
Pump Loss (Ft.)	18.17	22.37	19.3
Pumping Level (Ft.)	127.9	134	131.9
TDH (Ft.)	250.02	237.22	243.6
GPM: Meter	307	345	313
GPM: Test Equipment	306	342	316
Water HP	19.32	20.49	19.44
SP Capacity (GPM/Ft.)	10.7	9.9	9.7
KW	21.61	22.54	21.74
Input HP	28.97	30.21	29.14
Pump HP	24.04	25.08	24.19
Wire To Water (%)	66.7	67.8	66.7
Pump Efficiency (%)	80.4	81.7	80.4

APPENDIX C
FUTURE LAND USE MAP - 2023

FUTURE LAND USE MAP
WAVERLY, NEBRASKA



NORTH

Legend

- City of Waverly
- One-Mile Planning Jurisdiction
- East Beltway
- Dry Dam

FEMA Legend

- ZONE X - 500 YEAR FLOOD PLAIN
- ZONE A - 100 YEAR FLOOD PLAIN
- ZONE AE - 100 YEAR FLOOD PLAIN
- ZONE AE - FLOODWAY

Future Land Use Plan

- Multi-Use
- Commercial
- Industrial
- Urban Density Residential
- Multi-Family Residential
- Park/Open Space; Parks/Open Space
- Public

HANNA:KEELAN ASSOCIATES, P.C.
COMMUNITY PLANNING & RESEARCH

* Lincoln, Nebraska * 402.464.5383 *

WAVERLY WATER DISTRIBUTION STUDY

City of Waverly, Nebraska

August 2023

Olsson Project No. 023-00062