WATER

Master Plan Update

Executive Summary

City of Helena

Est. 1881

AE2S

WGM GROUP

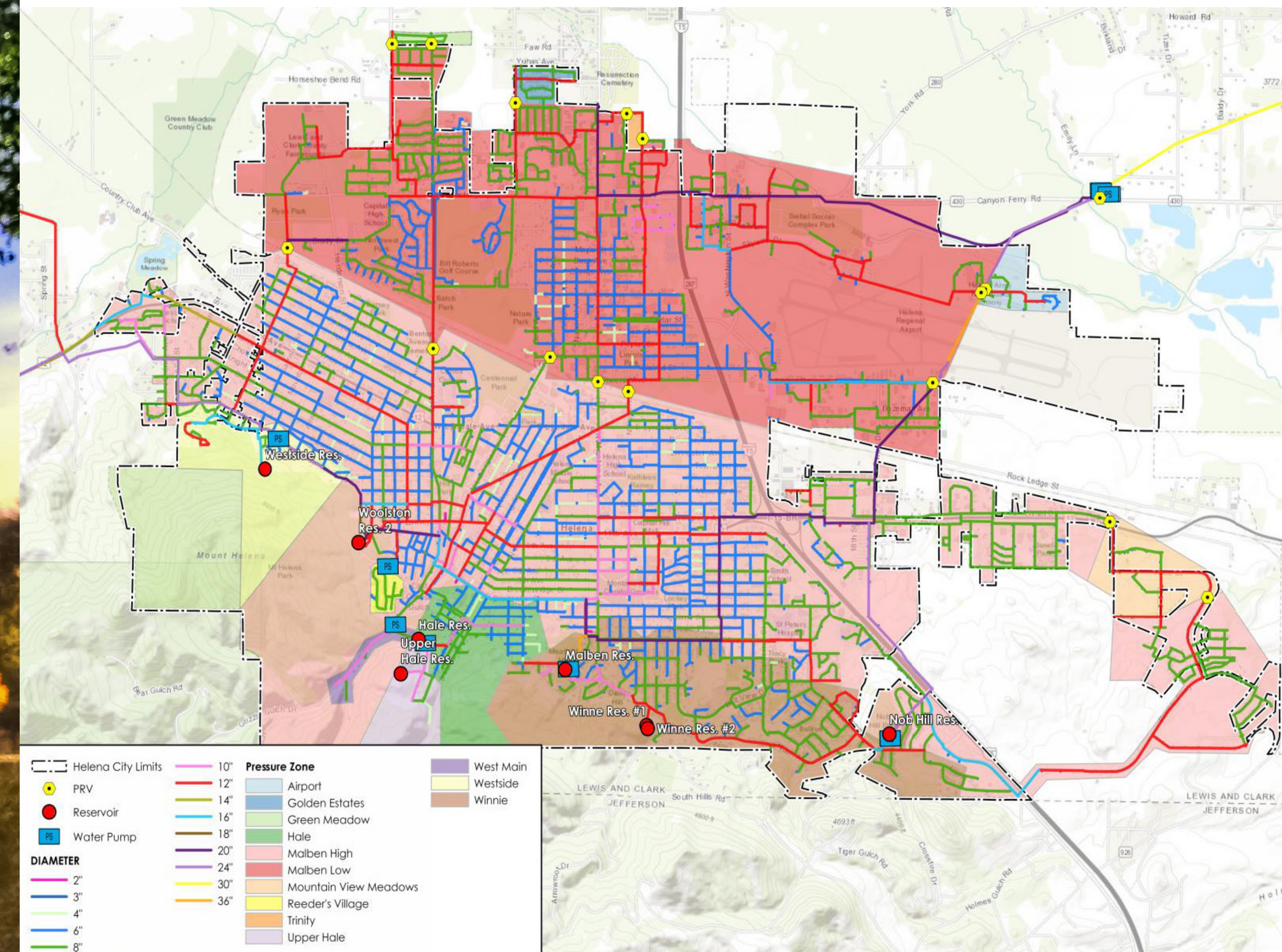
DECEMBER 2020

INTRODUCTION

Proactively addressing system challenges is critical to ensure sustainable system operations. Water system challenges come in many forms including population growth, increasing water demands, aging infrastructure, increased regulatory requirements, emerging technological trends, and effective capital improvements planning. The *2020 Helena Water System Master Plan* provides a guide for capital improvements to the City of Helena's (City) municipal water supply system. The recommended improvements included in the Capital Improvements Plan (CIP) will be the basis for future planning, financing, designing, constructing, and implementing solutions to meet the City 's water system needs. This document serves as an Executive Summary to the 2020 Helena Water System Master Plan.

UNDERSTANDING OF THE EXISTING SYSTEM

The City's current water supply comes predominantly from the Ten Mile Treatment Plant (TMTP) and the Missouri River Treatment Plant (MRTP). The Eureka Well provides a small but important portion of the City's water supply. The water distribution system is divided into 13 pressure zones containing a total of 8 storage reservoirs.



SYSTEM CHALLENGES

UNDERSIZED MAINS

The City currently has about 80 miles of pipe (34% of the system) that is 6-inch diameter or smaller.

ELEVATED PRESSURES

About 60% of the system operates with pressures in excess of 100 psi.

STORAGE TURNOVER

It is difficult to utilize water from Woolston Tank #2, causing increased water age.

AGING INFRASTRUCTURE

Nearly 40% of the pipes are over 50 years old, with 15% being over 75 years old.

PROACTIVE PLANNING

Identifying Areas of Future Growth

The identification of regions where growth is likely to occur is a critical component in the development of the water system master plan. Two specific areas were identified, including the southeast part of Helena in the Mountain View Meadows and Padbury Ranch developments, and the north part of Helena generally between Green Meadow Drive and McHugh Lane.

- **Southeast Helena Growth - New Development**
- **North Helena Growth - Annexation**
- **Long-Term Expansion in the Central and North Valley Areas**

UNDERSTANDING FUTURE GROWTH

A collaborative approach which involved City Planning was used to determine anticipated areas of future growth. The total estimated population increase by 2040 was then divided among identified growth areas with 75% of growth expected to be in the Southeast since new development typically occurs at a faster pace than annexation of existing developments. Future expansion beyond 2040, however, is anticipated to be primarily north of existing City limits.

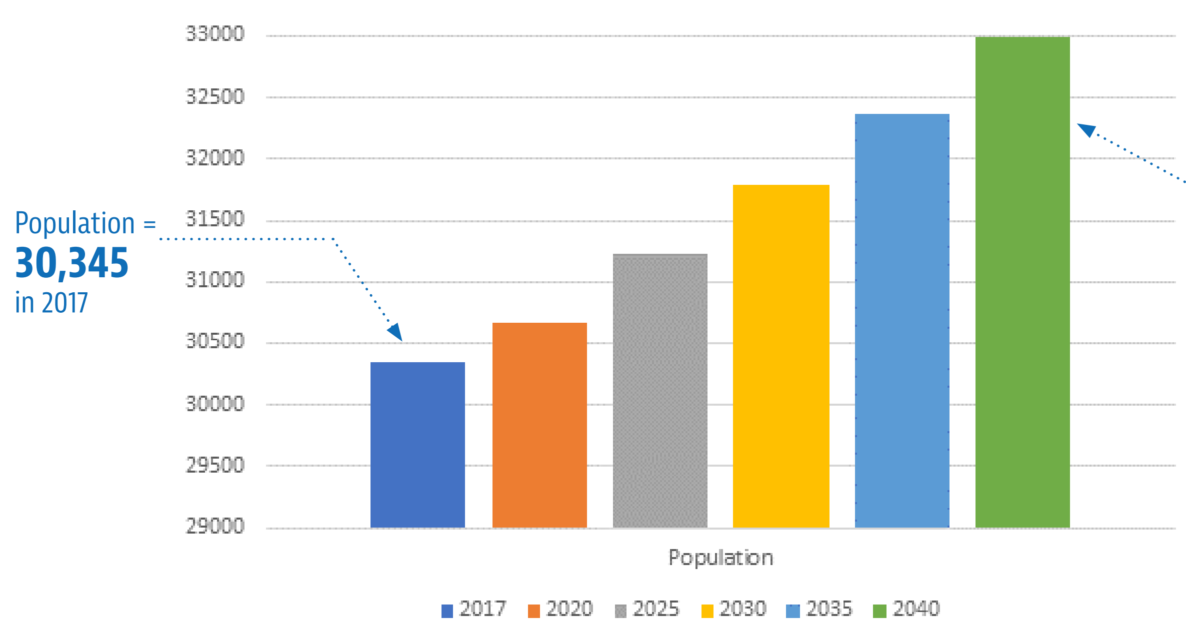
AREAS OF RECENT GROWTH

A review of areas where the water system has expanded in recent years can also be used as a tool to evaluate the areas of Helena that will likely experience growth in the future. As shown in the figure on the following page, there are four major areas where a significant length of new water main has been installed since 2000:

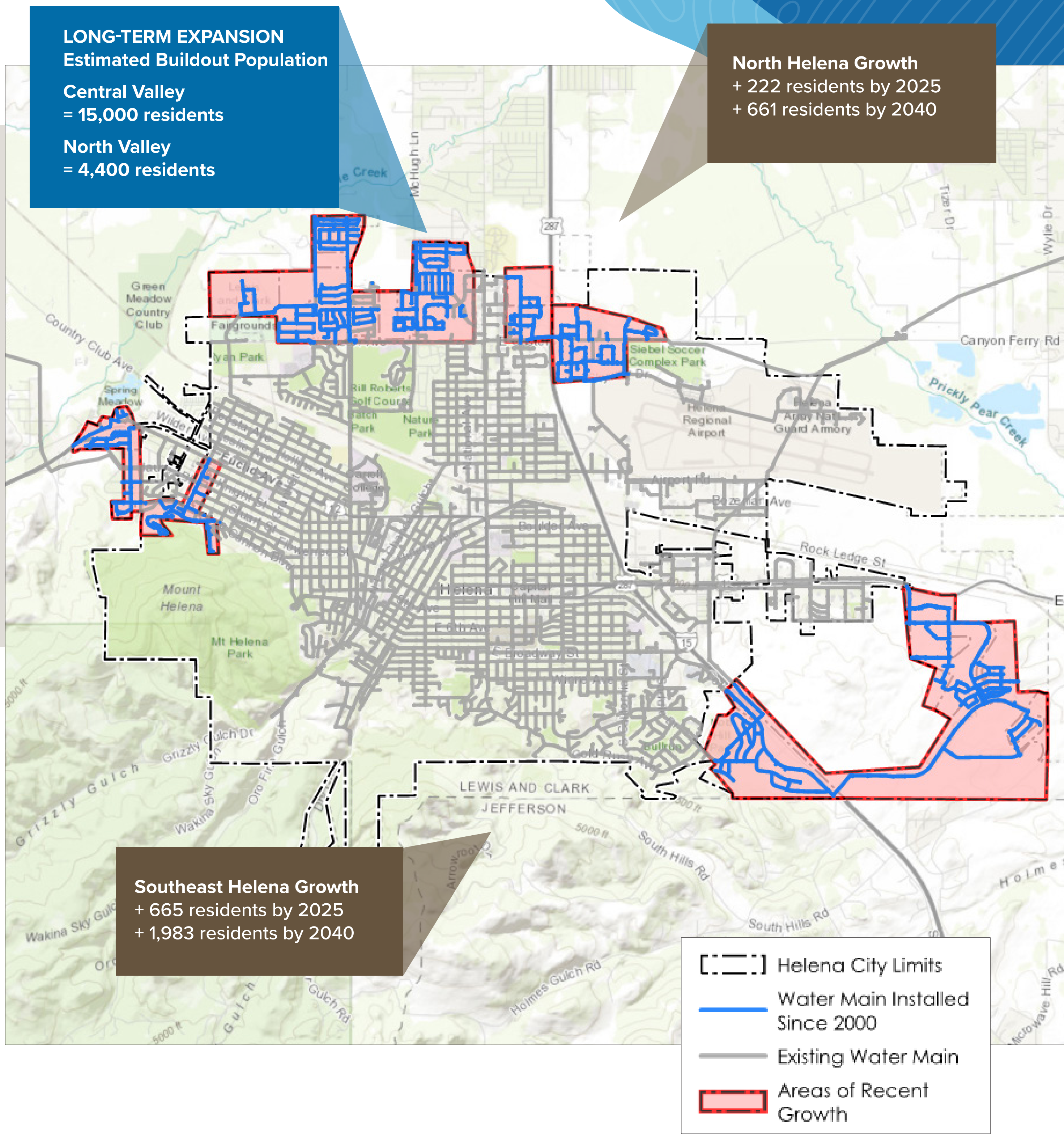
- West Side = 4.0 miles
- North of Custer, West of I-15 = 18.2 miles
- North of Custer, East of I-15 = 4.5 miles
- Nob Hill, Mountain Meadows, Padbury Ranch = 12.7 miles

These areas of recent growth provide a good indication that future growth will continue in the southeast and north parts of the City.

POPULATION PROJECTIONS



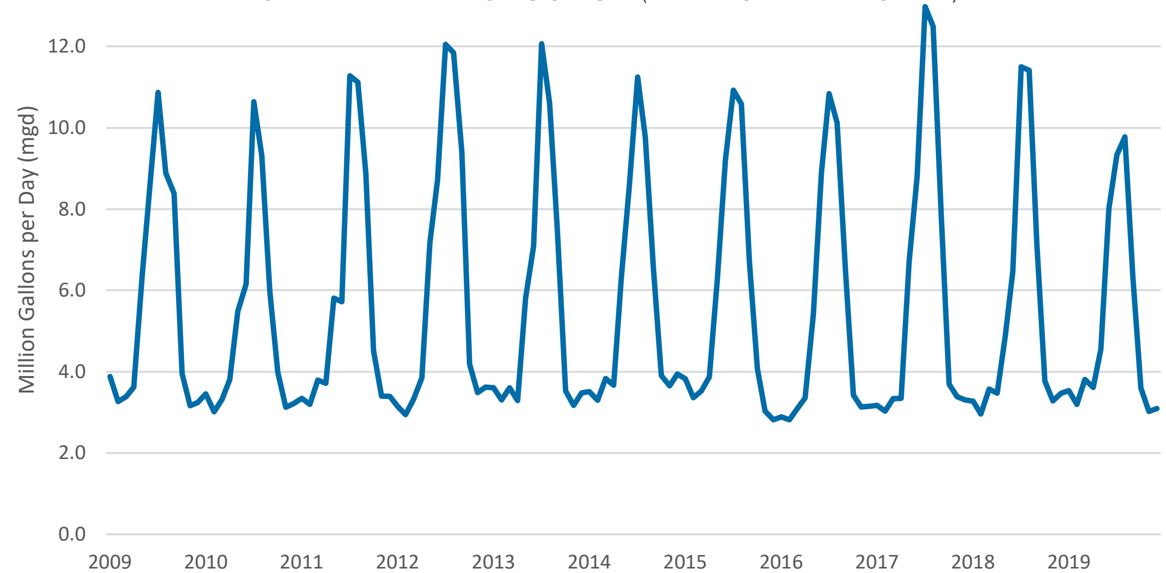
For this planning effort, a 0.36 percent annual growth rate is used to estimate future population projections, which is consistent with the rate currently utilized by the City's Planning Department. Future water use for each planning period was then calculated and used to determine future infrastructure need and anticipated project timing.



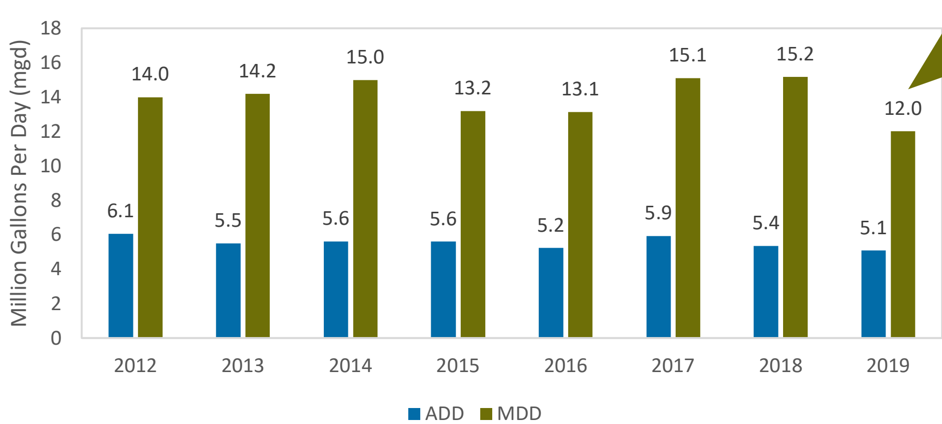
HOW MUCH WATER DO WE USE?

Water use characterization is critical when assessing the performance of the existing and future distribution system. Understanding how water is currently being used can help refine water conservation goals and establish strategies to better position the utility to meet future water needs.

TOTAL WATER PRODUCTION (AVERAGED MY MONTH)

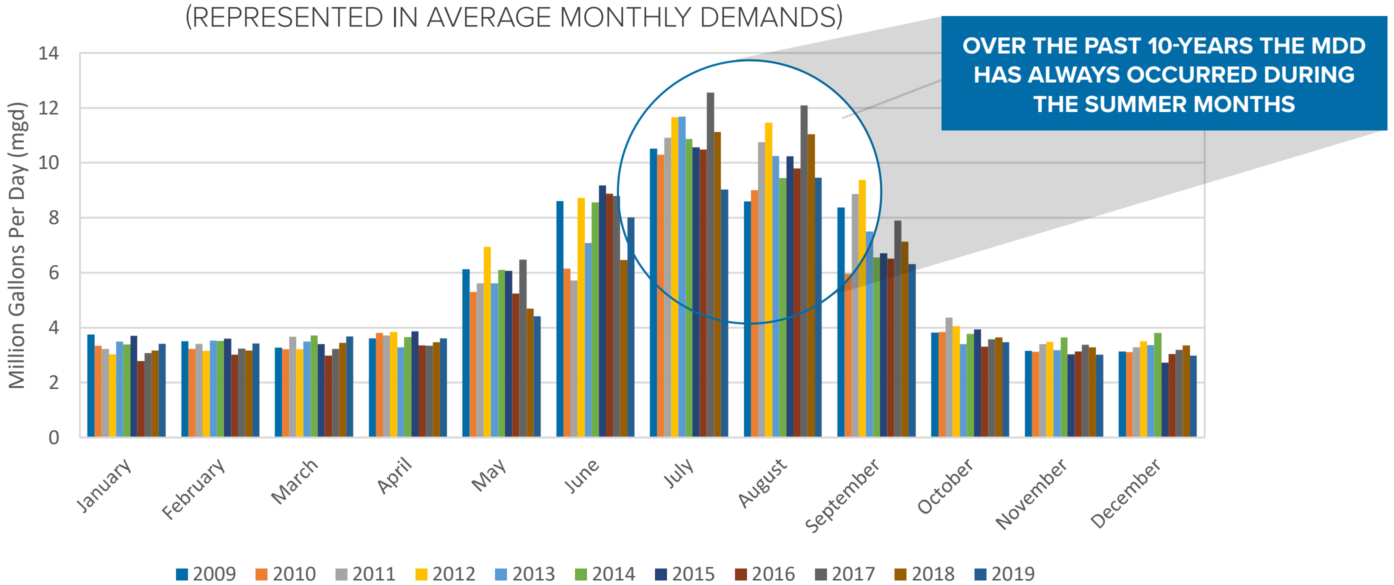


AVERAGE DAY AND MAXIMUM DAY WATER DEMANDS



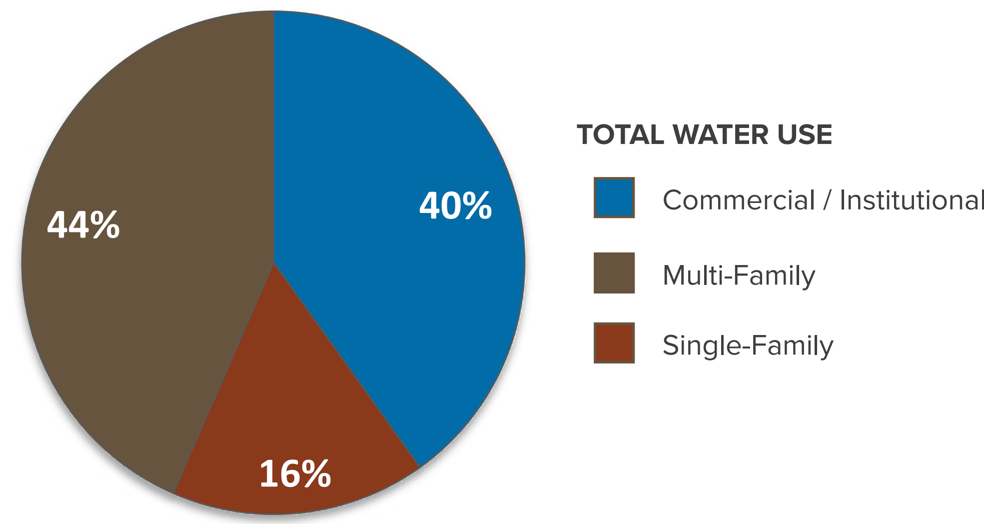
Peaking factors are calculated by dividing Maximum Day Demand (MDD) by the Average Day Demand (ADD). Based on past trends, a peaking factor of 2.8 is recommended for system design.

SEASONAL WATER DEMAND VARIATIONS
(REPRESENTED IN AVERAGE MONTHLY DEMANDS)



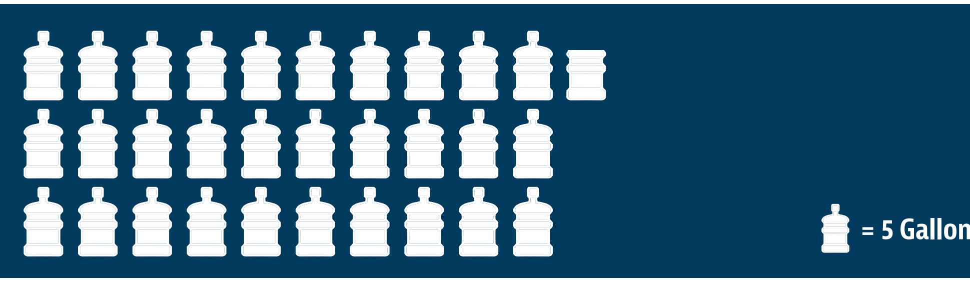
WHO ARE OUR CUSTOMERS & HOW MUCH WATER ARE THEY USING?

Understanding where the City's water is delivered after treatment, and the quantity your customers need is important when estimating future water demands.



In 2019, the average per capita demand =

154 GALLONS PER CAPITA PER DAY



HOW MUCH WATER WILL WE NEED?

Water demand projections are important when sizing future infrastructure and developing capital improvement plans. Future demands were estimated by defining the volume of water needed for an Equivalent Residential Unit (ERU) based on historical water use and projecting that into the future based on the expected growth rate. Additional maximum day demands for each future growth area as well as total future water demands for the City are shown below.

SOUTHEAST HELENA
0.29 MGD BY 2025
0.94 MGD BY 2040

NORTH HELENA
0.10 MGD BY 2025
0.31 MGD BY 2040

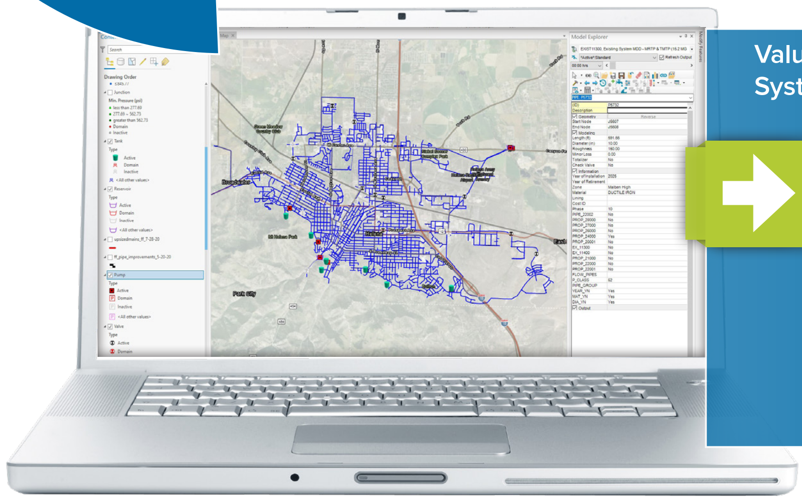
CENTRAL & NORTH VALLEY LONG-TERM EXPANSION AREAS
CENTRAL = 6.5 MGD AT BUILDOUT
NORTH = 1.9 MGD AT BUILDOUT

TOTAL FUTURE WATER DEMANDS

Year	Average Day Demand (ADD) [mgd]	Maximum Day Demand (MDD) [mgd]
2018	5.4	15.2
2025	5.6	15.6
2040	5.9	16.4

MODEL UPDATE & CALIBRATION

The development of an accurately calibrated model provides the City with the ability to analyze countless scenarios and answer the looming "What If" questions as the City grows and expands.



Valuable Tool to Quickly Diagnose System Challenges and Plan for Growth

- System Pressure
- Storage Requirements
- Storage Optimization
- Transmission Capacity
- Fire Flow
- Water Source Management
- Criticality Assessment
- Water Quality

MODEL DEVELOPMENT AND CALIBRATION

Creating a model that accurately simulates a water distribution system is essential to ensure its usefulness of the model. Actual water usage was spatially allocated in the model to accurately simulate the demand on the system. Numerous flow tests were conducted throughout the City to ensure the model was calibrated correctly and accurately simulates existing conditions.

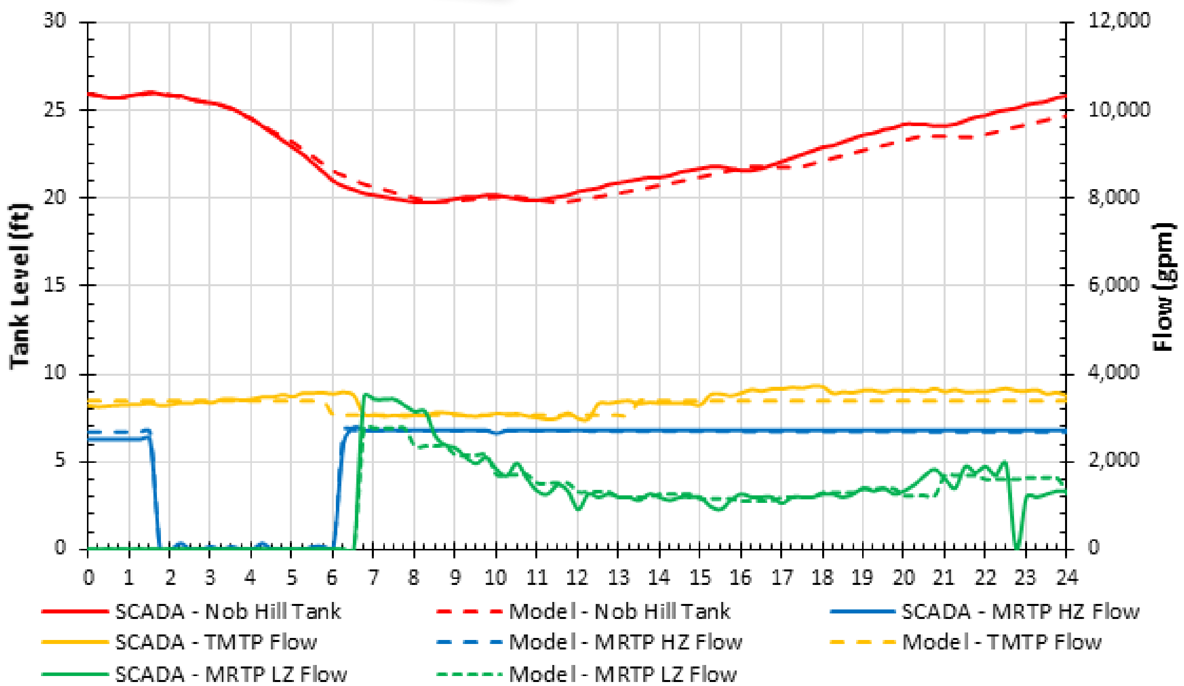
32 HYDRANT FLOW TESTS **+ 13** EXTENDED PERIOD TESTS

DIFFERENT SOURCES BRING DIFFERENT DYNAMICS

Throughout the majority of the year, TMTP provides enough water to meet demands. During summer months when demand is high, TMTP must be supplemented with water from the MRTP. The different dynamics including pressure swings each of these major sources bring to the City were analyzed with separate source scenarios including:

- TMTP Only 5.56 MGD Average Day Demand
- MRTP Only 5.56 MGD Average Day Demand
- TMTP Only 3.25 MGD Winter Day Demand
- MRTP Only 3.25 MGD Winter Day Demand
- TMTP and MRTP 15.2 MGD Maximum Day Demand

Hydraulic Model Water Storage Level Comparison



SYSTEM EVALUATION

The water distribution system was evaluated under existing and future demand conditions using the calibrated hydraulic model. The model was used to better understand the current limitations of the system and identify deficiencies. An understanding of the limitations of the existing water distribution system is critical to the development and expansion of the system for satisfactory system performance, longevity, and to accommodate future growth. The system evaluation included review of the following components:

PRESSURE – Identifies areas of high and low pressure, as well as investigates pressure fluctuations across the system.

STORAGE – Evaluates the adequacy of storage for the existing system and determines future distribution system storage requirements. Also, investigates current operational practices and provides recommendations to City staff to improve system efficiency.

SUPPLY– Evaluates the City's ability to provide water under various conditions. In addition, determines the City's ability to provide water with a single supply source (TMTP or MRTP).

FIRE FLOW – Evaluates the ability of the distribution systems to effectively deliver fire flow during maximum day demand, as well as identify areas that currently do not meet the City's recommended fire flow goals.

RISK ASSESSMENT – Identifies water mains that pose a high risk of failure along with water mains that should be further investigated to determine the most cost-effective mitigation strategy.

PRESSURE

13 Pressure Zones

- Meets minimum pressure criteria.
- The lower edge of the Winne pressure zone experiences operating pressures >140 psi.
- The lower edge of the Malben High pressure zone experiences operating pressures >160 psi.

RECOMMENDATIONS

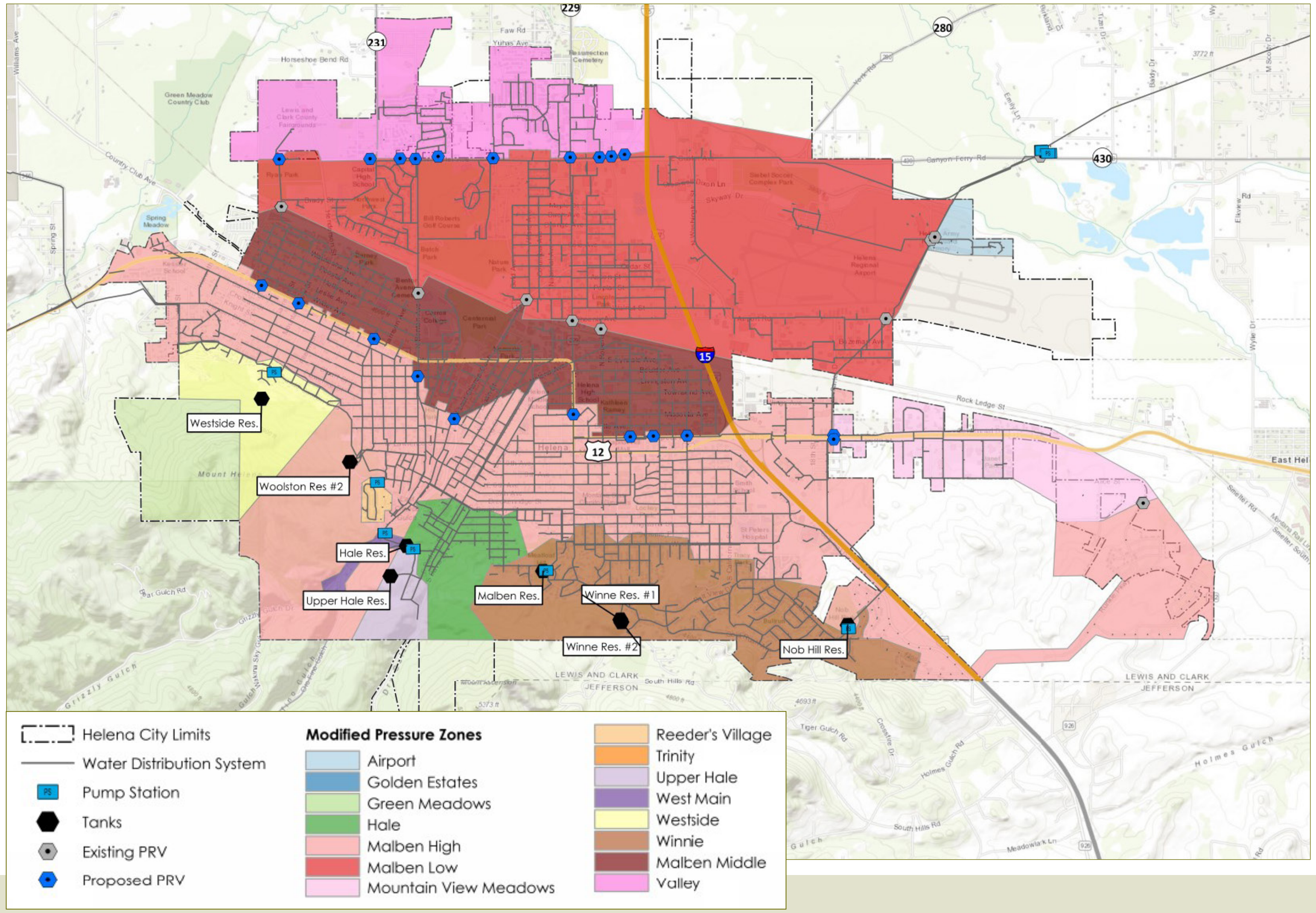
- ✔ Conduct an inventory of fire sprinkler systems throughout the City (and their pressure requirements for operation) to assess the feasibility and cost impacts of adjusting the boundaries of the Malben High and Malben Low pressure zones.
- ✔ Continue to require new fire sprinkler systems to be designed to the reduced operating pressure anticipated with the pressure zone boundary adjustments.

PRESSURE ZONE ANALYSIS

EXISTING PUMPING CAPACITY

13 Existing Pressure Zones

8 Booster Stations



PRESSURE ZONE MODIFICATION RECOMMENDATIONS

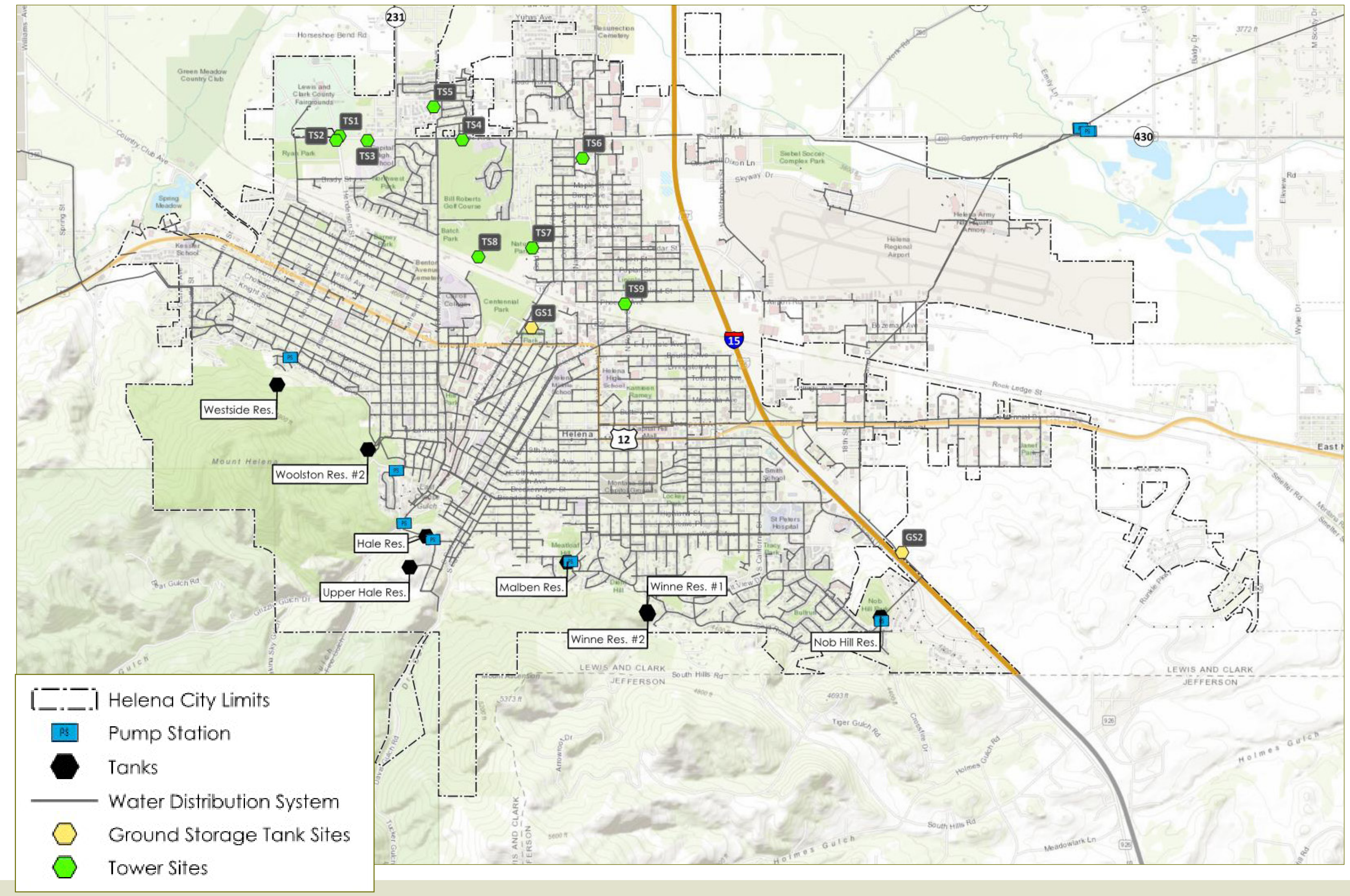
- ✔ The Malben High Zone could reasonably be split into two zones, creating a Malben Middle Zone in the areas with lower elevations. This would reduce the high pressures currently experienced in parts of the Malben High Zone.
- ✔ The split between the Malben Low Zone and the Valley Zone could be modified such that the split essentially occurs at the north side of Custer Avenue. This would reduce the high pressures currently experienced in parts of the Malben Low Zone.

*Before adjusting any pressure zone boundaries, a detailed analysis of the fire suppression systems (sprinklers) that would be negatively affected by a pressure reduction should be completed.

STORAGE

15 MG Total Storage Volume

8 Ground Storage Reservoirs



SHORT-TERM STORAGE RECOMMENDATIONS

- ✔ Install a Pressure Reducing Valve between the Hale Zone and the Malben High Zone that will operate automatically and can be controlled remotely by the system operators.
- ✔ Modify the existing altitude valve at the Woolston Reservoir to allow either hydraulic or electric control of this valve and modify the operating procedures to effectively use the Woolston Reservoir.
- ✔ Install a Pressure Reducing Valve between the Upper Hale Zone and the Reeder's Village Area, to provide fire flows to the Reeder's Village Area.

LONG-TERM STORAGE RECOMMENDATIONS

- ✔ Construct a new tank to provide storage for the Reeder's Village Area. This tank could be adjacent to the Upper Hale Tank or on the Scott Property Site.
- ✔ Construct a new tank to increase the storage in the Malben Low Zone. This tank could be an elevated tank near the railroad tracks to serve the Malben Low Zone, a ground storage tank near the Padbury Ranch Development to serve the Malben Low Zone, a ground storage tank near the railroad tracks to serve an enlarged Valley Zone, or an elevated tank near Custer Avenue to serve an enlarged Valley Zone.

WATER MAIN CAPACITY

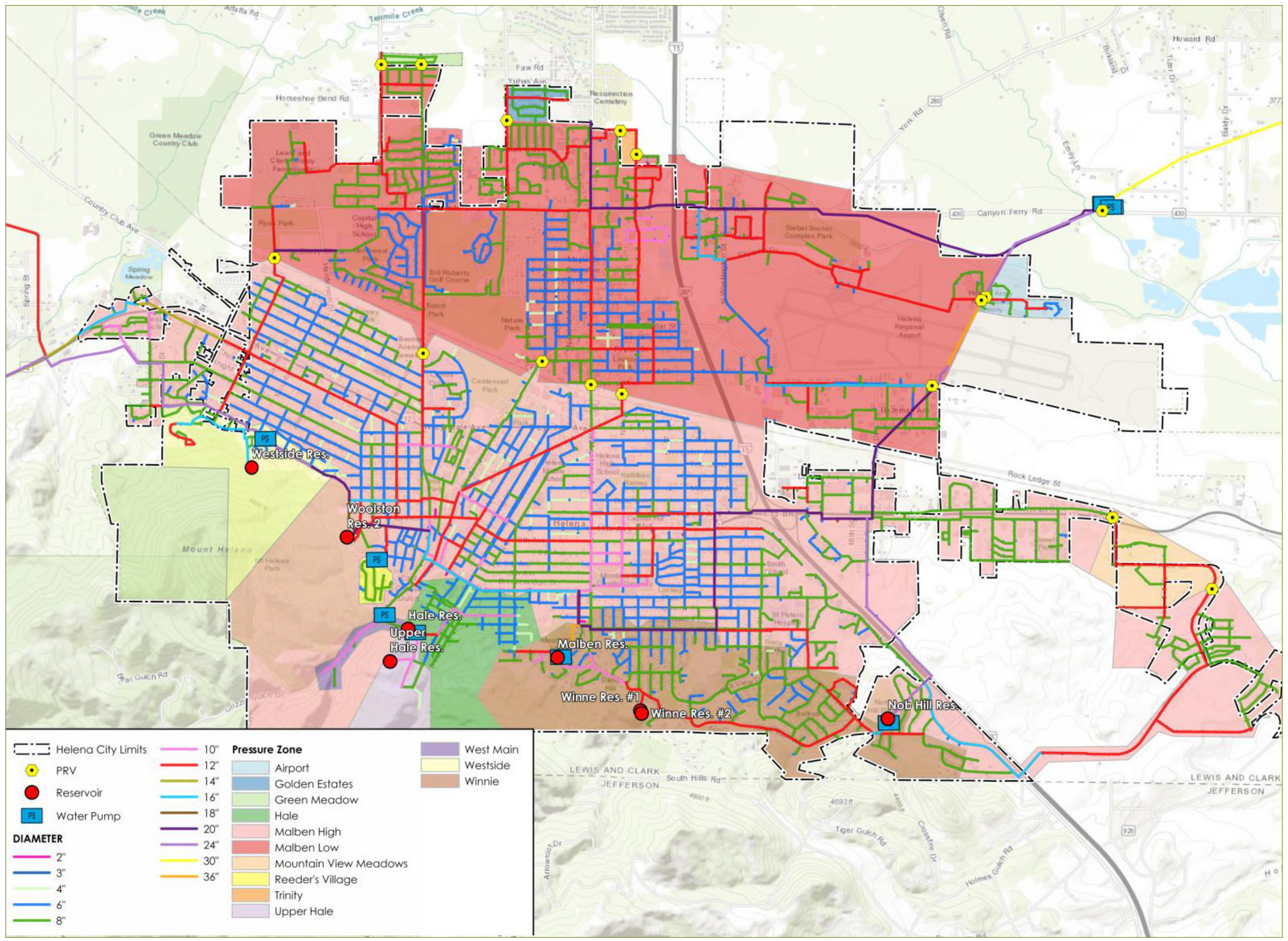
EXISTING WATER MAIN

233
Total Miles of Pipe

108 Miles Ductile Iron
84 Miles Cast Iron
25 Miles PVC
13 Miles Steel
3 Miles Other Materials

7 miles <6"
73 miles 6"
79 miles 8"
7 miles 10"
35 miles 12"
32 miles >12"

Throughout a significant portion of the distribution system, operating pressures are in excess of 100 psi. For the majority of the year, high pressures is provided "for free" from the elevation head of TMTP. Given these factors, evaluating water main capacity by the traditional friction headloss method is not as relevant. System improvements should be prioritized based on the benefit they provide to the City. Fire flow capacity should be the primary driver for upsizing existing pipes in Helena.

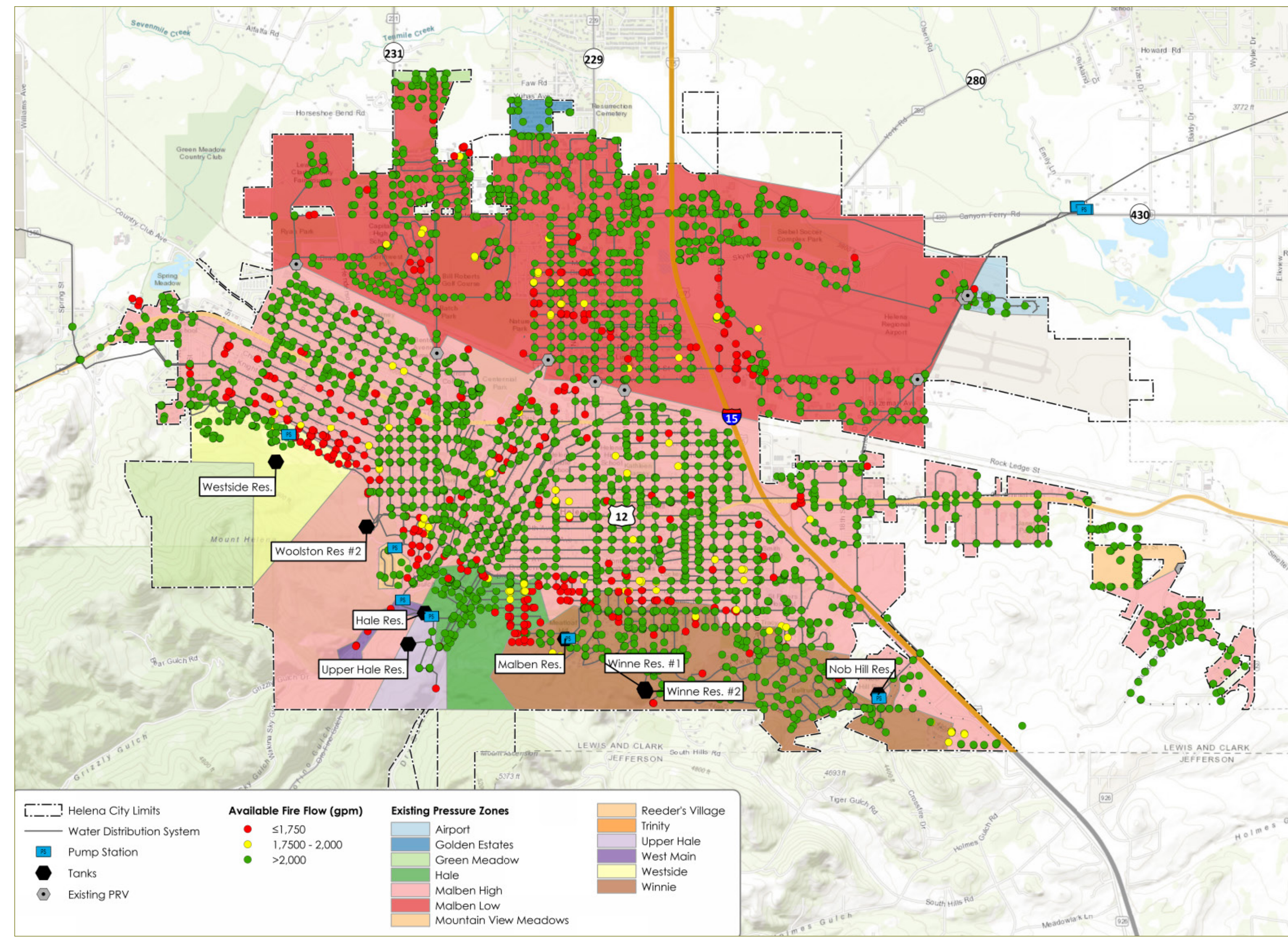


FIRE FLOW

EXISTING HYDRANTS

1,869
Fire Hydrants

Current City design standards require a minimum fire flow capacity of 1,750 gpm. The majority of the system is able to meet this requirement with the high operating pressures compensating for high friction headloss in the smaller diameter pipes. Over time as the City works to adjust pressure zone boundaries and reduce areas of elevated pressures, the smaller diameter pipes should be replaced with at least an 8" diameter pipe. With all of the currently undersized pipe replaced with 8" diameter, essentially the entire system is able to provide >2,000 gpm, even with the reduced operating pressures proposed with the pressure zone adjustment recommendation.



WATERMAIN RECOMMENDATIONS

- ✔ Recommended alteration of pump start up at MRTP to reduce the pressure surge the system currently experiences (80 psi +). Reducing pressure surges will likely reduce the frequency of watermain breaks over time.

- ✔ Re-evaluate future budgets for distribution system improvements. The large amount of old cast iron pipe throughout the system will require a concentrated effort to replace before the aging material creates a maintenance burden for the City. Replacing old cast iron pipe will also improve fire flow capacity.

RISK ASSESSMENT

As the City continues to grow and provide water service to additional customers, it is important to make appropriate investments to keep the water system maintained and operating at a high-level. A risk assessment of the City's water main network was completed to achieve the following:

NOTE: Water main risk should be routinely reevaluated which will help City staff prioritize changes as new information is collected.

Develop a Comprehensive Understanding of Watermain Risk	Develop a Prioritization of Water Main Improvements	Risk Management & Risk Mitigation	Informed & Defensible Decisions	Smart Investments for Appropriate Infrastructure Assessment, Replacement, and Maintenance

WHAT IS RISK?

Likelihood vs. Consequence of Failure

A risk assessment is comprised of assessing the likelihood of failure and consequence of failure. The risk assessment completed for the City consisted of five risk levels, ranging from "Negligible" to "Extreme."

"HOW PROBABLE IS AN ASSET FAILURE?"

Likelihood of Failure (LoF)
CONDITION COMPONENT

+

"HOW CRITICAL IS THE ASSET?"

Consequence of Failure (CoF)
CRITICALITY COMPONENT

= **RISK**

LIKELIHOOD ASSESSMENT

The process of "screening" each individual water main segment through the likelihood of failure components. This process provides a better understanding of how susceptible the water main segment is to failure. Factors identified and used in the Likelihood Assessment include:

- **Reliability** – Evaluation of previous water main breaks and leaks
- **Installation Environment** – Evaluation of susceptibility to corrosion and freezing
- **Age** – Evaluation of water main pipe age and estimated useful life
- **Performance** – Evaluation of capacity and hydraulics

VS

CONSEQUENCE ASSESSMENT

The process of "screening" each water main segment through the various consequence of failure components. This process provides a better understanding of how critical the water main is to the water system, as well as the over-arching consequence that could burden the distribution system in the event of a failure. Factors identified and used in the consequence assessment include:

- **Failure Impact** – Proximity to critical facilites, flow rate, and accessibility
- **Hydraulic Criticality** – Identification of transmission mains and reservoir piping
- **Service Delivery** – Water service lost due to a failure

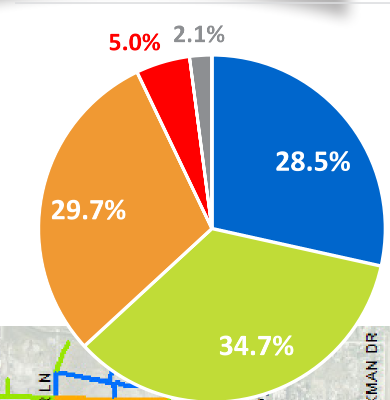
RISK ASSESSMENT RESULTS

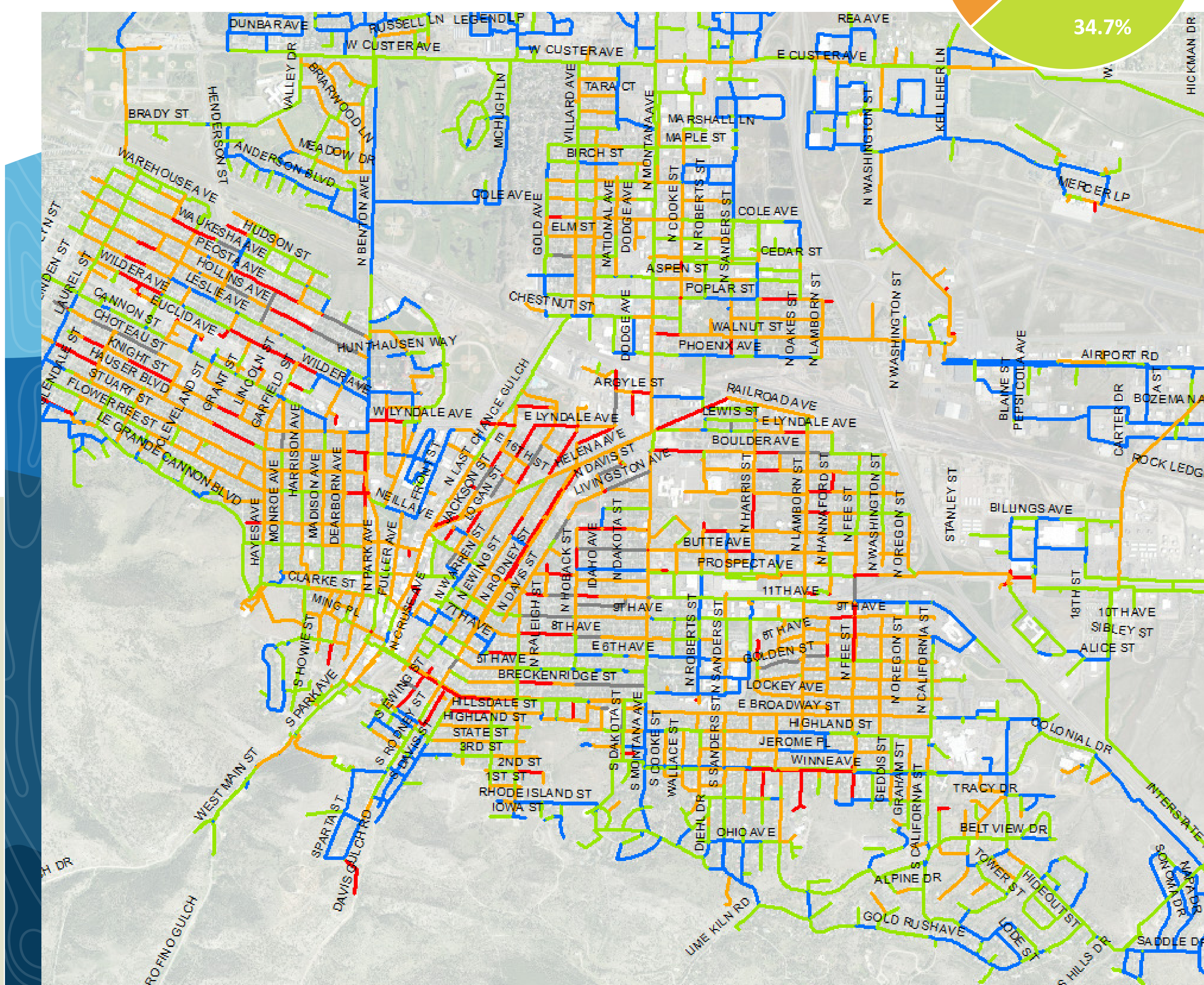
Risk from each pipe segment was determined by combining the scores from the likelihood and consequence of failure assessments. The majority of the City's water system is in the lower risk range, which corresponds to a level one or two risk and thus, does not require any current immediate action. The map below presents a specific area of water mains in the core downtown area and their respective risk levels.

Level 5: *Extreme* (Included in CIP)
Level 4: *High*
Level 3: *Medium*
Level 2: *Low*
Level 1: *Negligible*

Water Main
Risk Breakdown

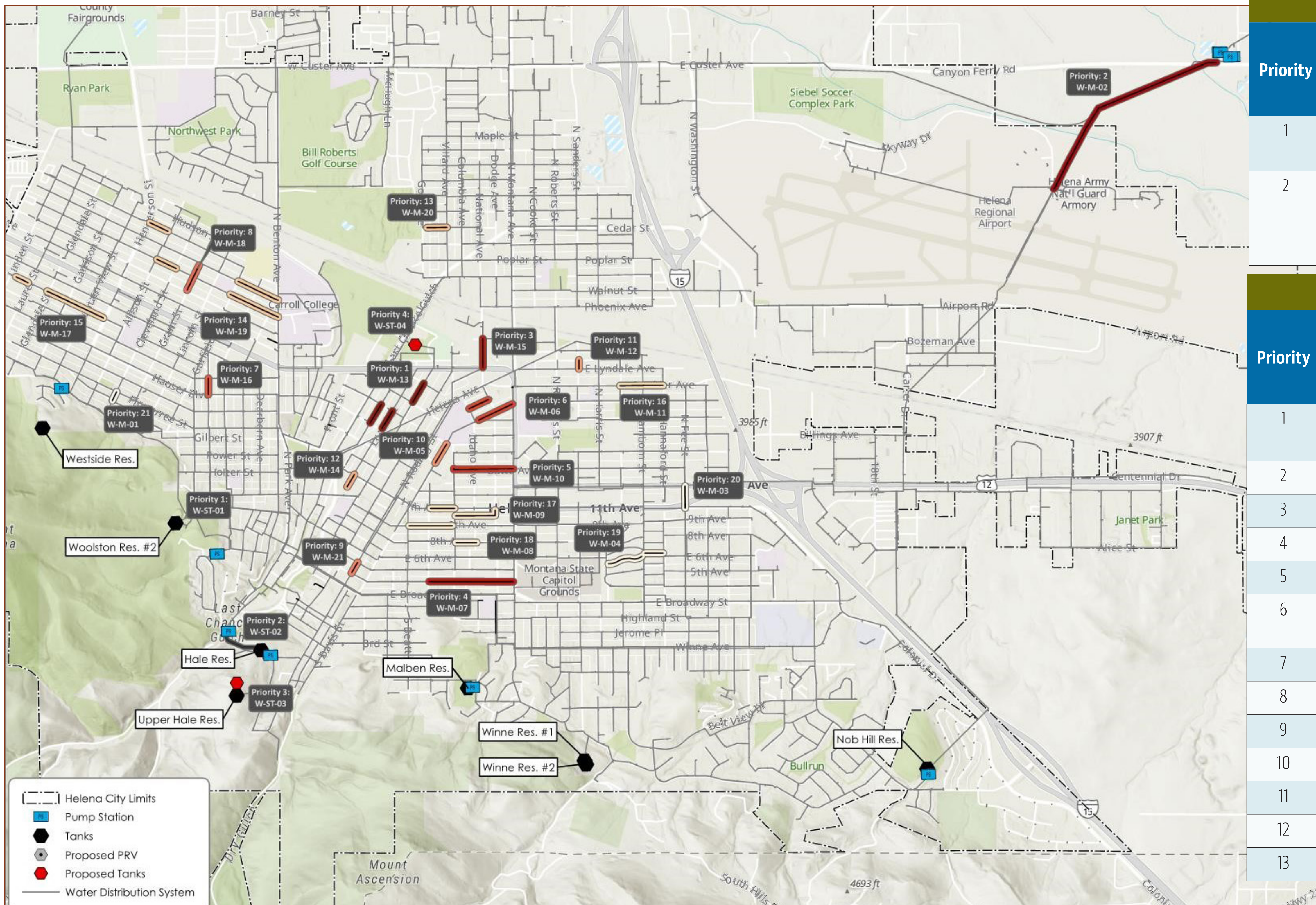
Level 5: 4.6 miles
Level 4: 11.3 miles
Level 3: 66.8 miles
Level 2: 77.9 miles
Level 1 : 64.0 miles





SHORT-TERM CAPITAL IMPROVEMENTS PLANNING

Distribution system improvements are handled by the Utility Maintenance division with an annual budget of $500,000 for improvements. Water Treatment is responsible for storage improvements, with an annual budget of $350,000. Short term (5-year) capital improvement projects were broken out into these two categories and summarized in the accompanying tables.



Short-Term Storage Improvements

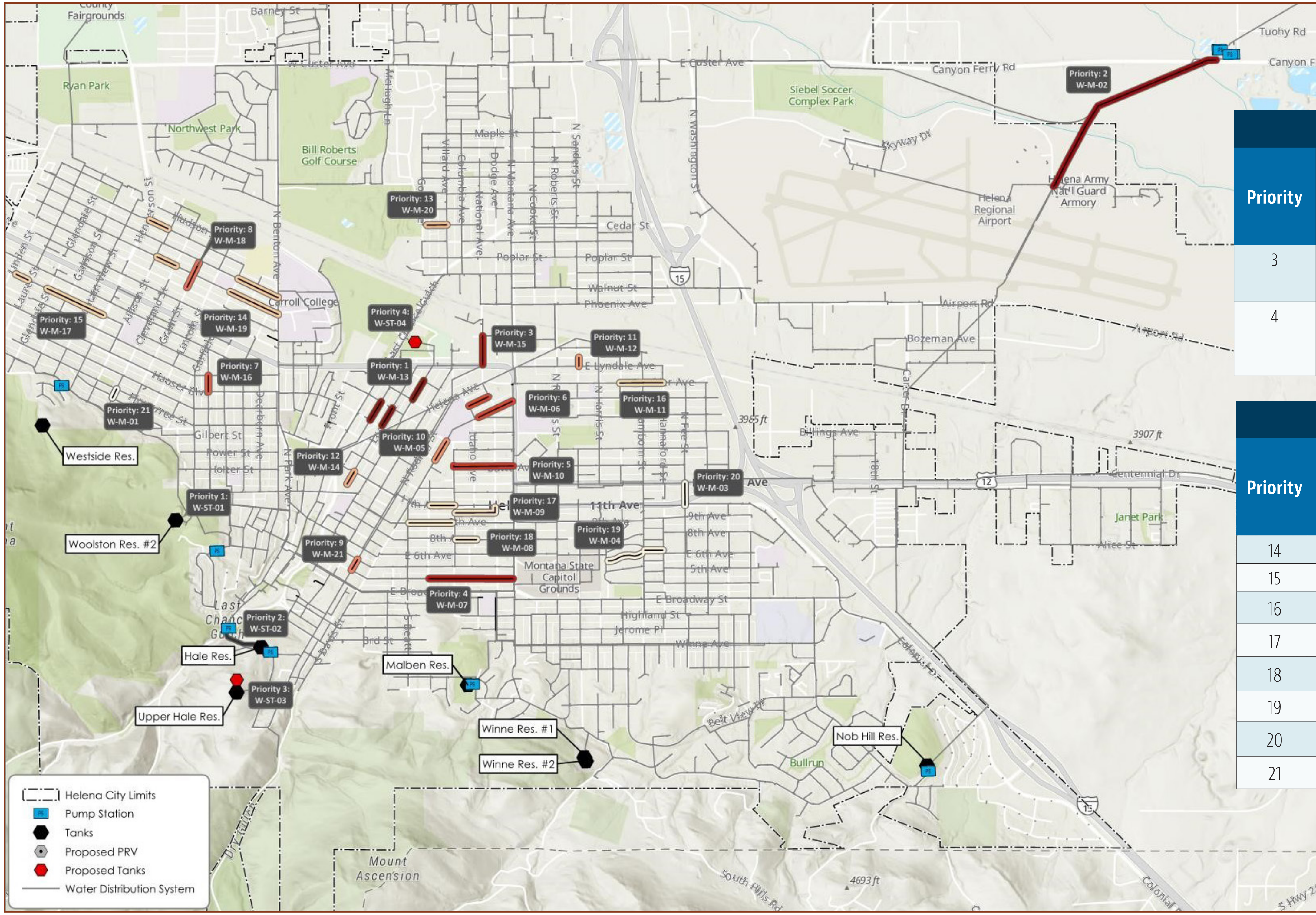
Priority	ID	Description	Opinion of Probable Cost (2020 $)	Opinion of Probable Cost (Construction Year or 2040 $)[1]	Year
1	W-ST-01	Modify altitude valve at Woolston Reservoir	$90,000	$91,000	2021
2	W-ST-02	Water Main connection between Upper Hale Zone and Reeder's Village	$1,191,000	$1,264,000	2023

Short-Term Distribution System Improvements

Priority	ID	Location	Opinion of Probable Cost (2020 $)	Opinion of Probable Cost (Construction Year or 2040 $)[1]	Year
1	W-M-13	Logan St., N Jackson St., Warren St.	$360,000	$367,000	2021
2	W-M-02	MRTP to Airport	$1,952,000	$2,071,000	2023
3	W-M-15	National Ave.	$212,000	$225,000	2023
4	W-M-07	Breckenridge St.	$669,000	$724,000	2024
5	W-M-10	Butte Ave.	$497,000	$538,000	2024
6	W-M-06	Livingston Ave. and North Davis St.	$444,000	$490,000	2025
7	W-M-16	Monroe Ave.	$133,000	$146,000	2025
8	W-M-18	Grant St.	$194,000	$214,000	2025
9	W-M-21	Rodney St.	$85,000	$94,000	2025
10	W-M-05	North Davis St.	$182,000	$201,000	2025
11	W-M-12	North Sanders St.	$69,000	$76,000	2025
12	W-M-14	Logan St.	$97,000	$108,000	2025
13	W-M-20	Cedar St.	$169,000	$186,000	2025

[1]Future costs assume a 2% annual inflation rate

LONG-TERM CAPITAL IMPROVEMENTS PLANNING



Long-Term Storage Improvements					
Priority	**ID**	**Description**	**Opinion of Probable Cost (2020 $)**	**Opinion of Probable Cost (Construction Year or 2040 $)[1]**	**Year**
3	W-ST-03	New 200,000-gallon Ground Storage Tank	$2,926,000	$3,428,000	2028
4	W-ST-04	New 1,000,000-gallon Elevated Tank to serve Malben Low Zone	$5,108,000	$7,590,000	>2040

Long-Term Distribution System Improvements					
Priority	**ID**	**Location**	**Opinion of Probable Cost (2020 $)**	**Opinion of Probable Cost (Construction Year or 2040 $)[1]**	**Year**
14	W-M-19	Hollins Ave., Peosta	$1,076,000	$1,237,000	2027
15	W-M-17	Choteau St.	$596,000	$685,000	2027
16	W-M-11	Boulder Ave.	$232,000	$267,000	2027
17	W-M-09	10th Ave. and 11th	$612,000	$717,000	2028
18	W-M-08	8th Ave. and 9th	$621,000	$743,000	2029
19	W-M-04	Golden St. and E. 6th	$395,000	$472,000	2029
20	W-M-03	Fee St.	$145,000	$174,000	2029
21	W-M-01	Grant St. and	$278,000	$339,000	2030

[1]Future costs assume a 2% annual inflation rate

SUSTAINABLE WATER UTILITY

The **2020 Helena Water System Master Plan** provides a guide for capital improvements that will be the basis for planning, financing, designing, constructing, and implementing solutions to meet the City's foreseeable water system needs for years to come. As the City advances through the planning process, some uncertainties and changes can be expected. However, the risk assessment methodology and investment the City has made in this planning effort provides City staff with a proactive approach for responding to future challenges and maintaining a clear vision and consistent direction for the Water Utility!

Prepared By:

AE2S

ADVANCED ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

405 3rd St. NW Suite 205, Great Falls, MT 59404 | (406) 268-0626

TECHNICAL MEMORANDUM #1

To: Jamie Clark, PE

From: Mark Peterson, PE
Nate Weisenburger, PE

Re: **Planning and Service Area Update**
Water System
City of Helena, MT

Date: December 8, 2020

INTRODUCTION

The purpose of this Technical Memorandum is to provide an update to the planning and service area for the water distribution system.

POPULATION PROJECTIONS

The City is in the process of updating its growth policy document. Chapter 2 of the draft growth policy document addresses population and economics. It states that the population in the City of Helena is expected to increase from 30,345 in 2017 to 32,989 by 2040. This represents a total increase of 8.71% in the 23-year time frame or an average annual increase of 0.36%. Using this annual increase, the projected 2025 population would be 31,230 or an increase of about 2.92%.

AREAS OF PROJECTED GROWTH (20 YEAR OUTLOOK)

Information provided by Lucy Morell-Gengler of Community Development indicated that the primary growth would be in two areas. Figure 1 shows the Area of Future Land Use that is included in the draft 2019 Growth Policy Update. The first area is in the southeast part of Helena, in the Mountain View Meadows and Padbury Ranch developments. These developments are east of Interstate 15 and south of US Highway 12. The second area is in the north part of Helena, generally between Green Meadow Drive and McHugh Lane.

The City does not have any projections regarding the extent that each area will grow. The area in the southeast part of Helena is being developed with City water service, while much of the area north of Helena is already developed without City water service. The area north of Helena will grow primarily due to annexation of existing developments, which typically occurs at a slower pace than new development. For purposes of this study, the projected population increase will be assumed to be 75% in the southeast part of Helena and 25% in the north part of Helena. This would mean that an additional 1983 residents will be in the southeast part of Helena, and an additional 661 residents will be in the north part of Helena by 2040. By 2025, an additional 665 residents will be in the southeast part of Helena and an additional 222 residents in the north part of Helena.

AREAS OF RECENT GROWTH

A review of areas where the water system has expanded in recent years can also be used as a tool to evaluate the areas of Helena that might grow in the future. Due to the relatively slow growth in Helena, the time period included in this review was from 2000 to the present. There are four major areas where a significant length of water main has been installed since 2000. These areas do not include areas where existing water mains were replaced. These four areas are shown in Figure 2 and are summarized in Table 1.

Table 1 Recent Growth Areas

Area	New Pipe Installed (Since 2000)
West Side	4.0 miles
North of Custer, West of I-15	18.2 miles
North of Custer, East of I-15	4.5 miles
Nob Hill, Mountain Meadows, Padbury Ranch	12.7 miles

West Side

This area is generally west of Granite Avenue and mostly south of Euclid Avenue. It also includes the area along Le Grande Cannon Boulevard, generally west of Henderson Street. Most of this area was developed between 2000 and 2010, with only limited additional water mains installed between 2010 and 2020. There appears to be some potential for additional water mains west along Euclid Avenue, but it is limited by topography and by large parcels owned by the City of Helena and the State of Montana. There is very limited potential for additional water mains in the area of Le Grande Cannon Boulevard due to the large, publicly owned parcels.

North of Custer, West of Interstate 15

This area is generally north of Custer Avenue, between Green Meadow Drive and Interstate 15. More new water main has been installed in this area than any other area of Helena. Continued growth in this area seems likely. The primary limitation to development in this area is water and sewer service, which can be provided by the City of Helena. The areas immediately adjacent to the City Limits are the most likely to develop. Ten Mile Creek and the associated floodplain do present some limitations to the extent of development, although there are numerous existing homes within the floodplain boundaries.

North of Custer, East of Interstate 15

This area is generally along both sides of Custer Avenue east of Interstate 15. Continued commercial development in this area is likely. Growth is limited, however, due to the large amount of property owned by the City of Helena and the Helena Regional Airport Authority in the area.

Nob Hill, Mountain Meadows, and Padbury Ranch

This area is in the southeastern part of the City of Helena. The area around Nob Hill, west of Interstate 15, has some potential for additional development along Colonial Drive, but the system is unlikely to be extended farther south due to the county line. The area east of Interstate 15, which includes the Mountain Meadows and Padbury Ranch developments, is likely to continue to grow relatively rapidly (compared to other areas of Helena).

AREAS OF LONG-TERM GROWTH

The primary area for long-term future growth for the City of Helena is the valley north of the City. There are many developments in this area and numerous existing public water systems. From a long-term perspective, many of these developments are likely to be annexed into the City of Helena, so the water distribution system should have adequate capacity to serve this area. Figure 3 shows the general areas in the valley. The areas are divided into the Central Valley and North Valley, with the split between the areas approximately at Norris Road. The estimated maximum day demands for ultimate buildout are 6.5 MGD for the Central Valley and 1.9 MGD for the North Valley. Approximately 2/3 of the Central Valley area is west of Interstate 15, and the large majority of the North Valley area is west of Interstate 15. The projected ultimate buildout demand west of Interstate 15 is 2/3 of 6.5 MGD plus 100% of 1.9 MGD, or about 6.2 MGD.

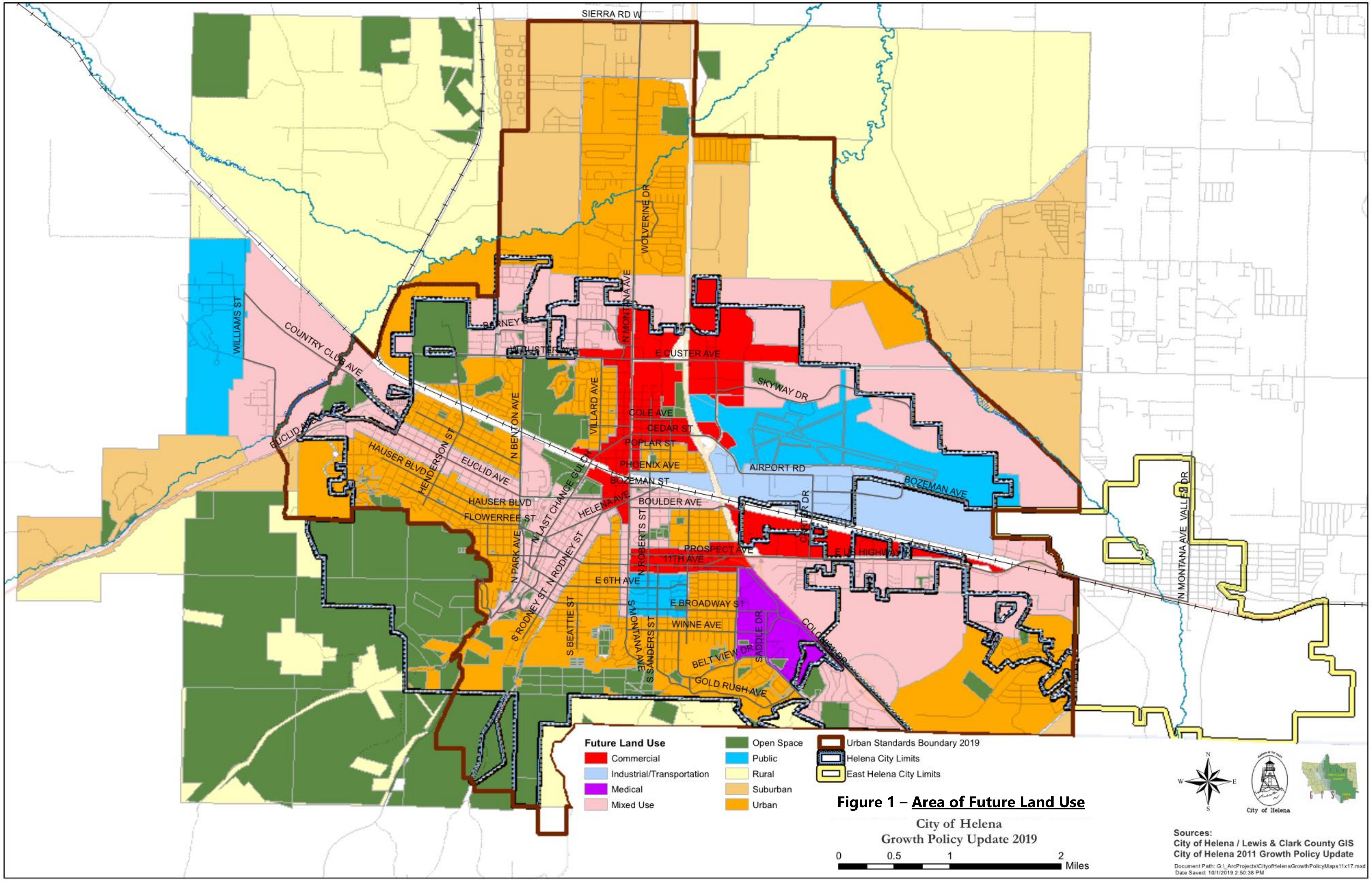
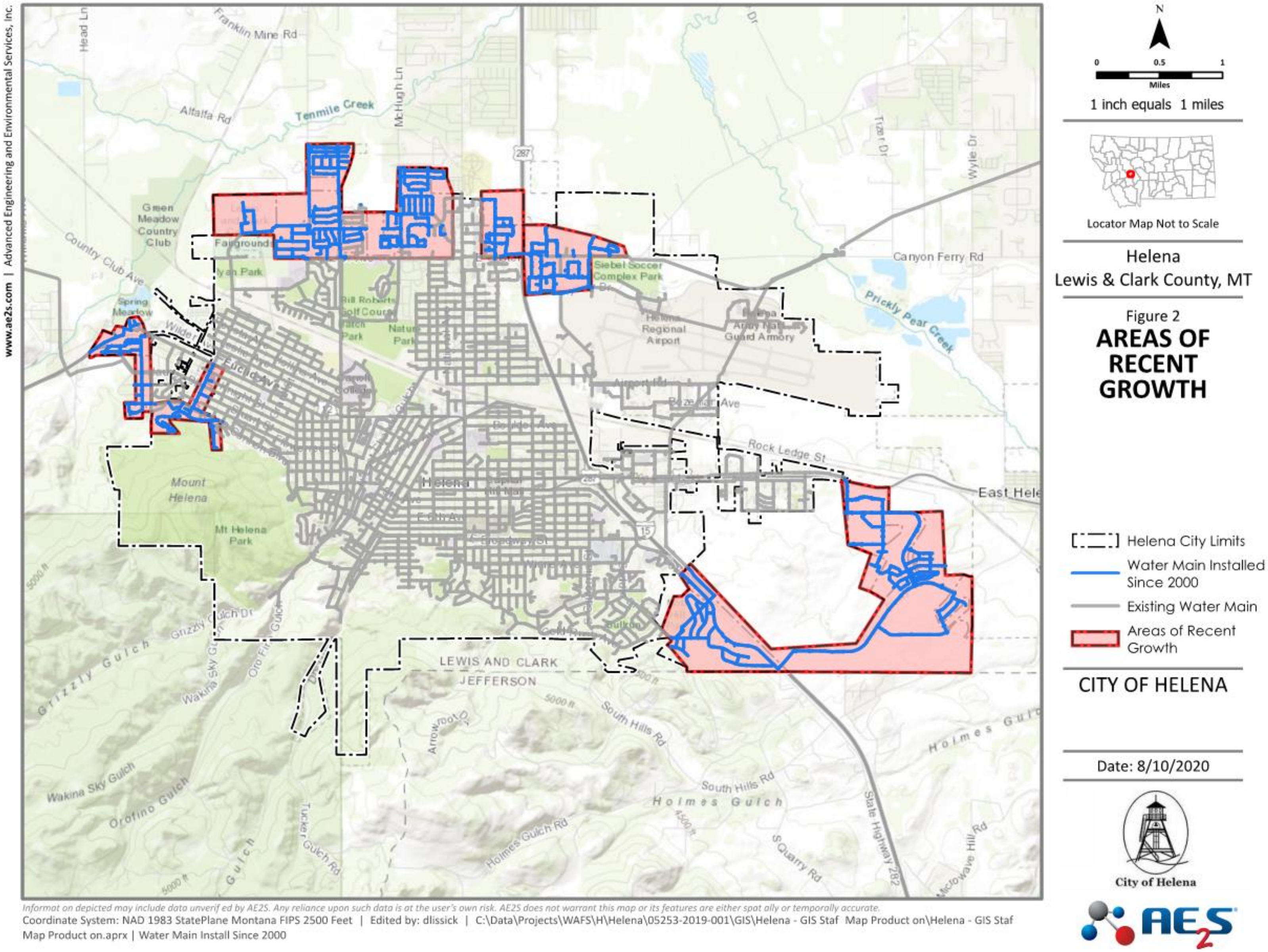
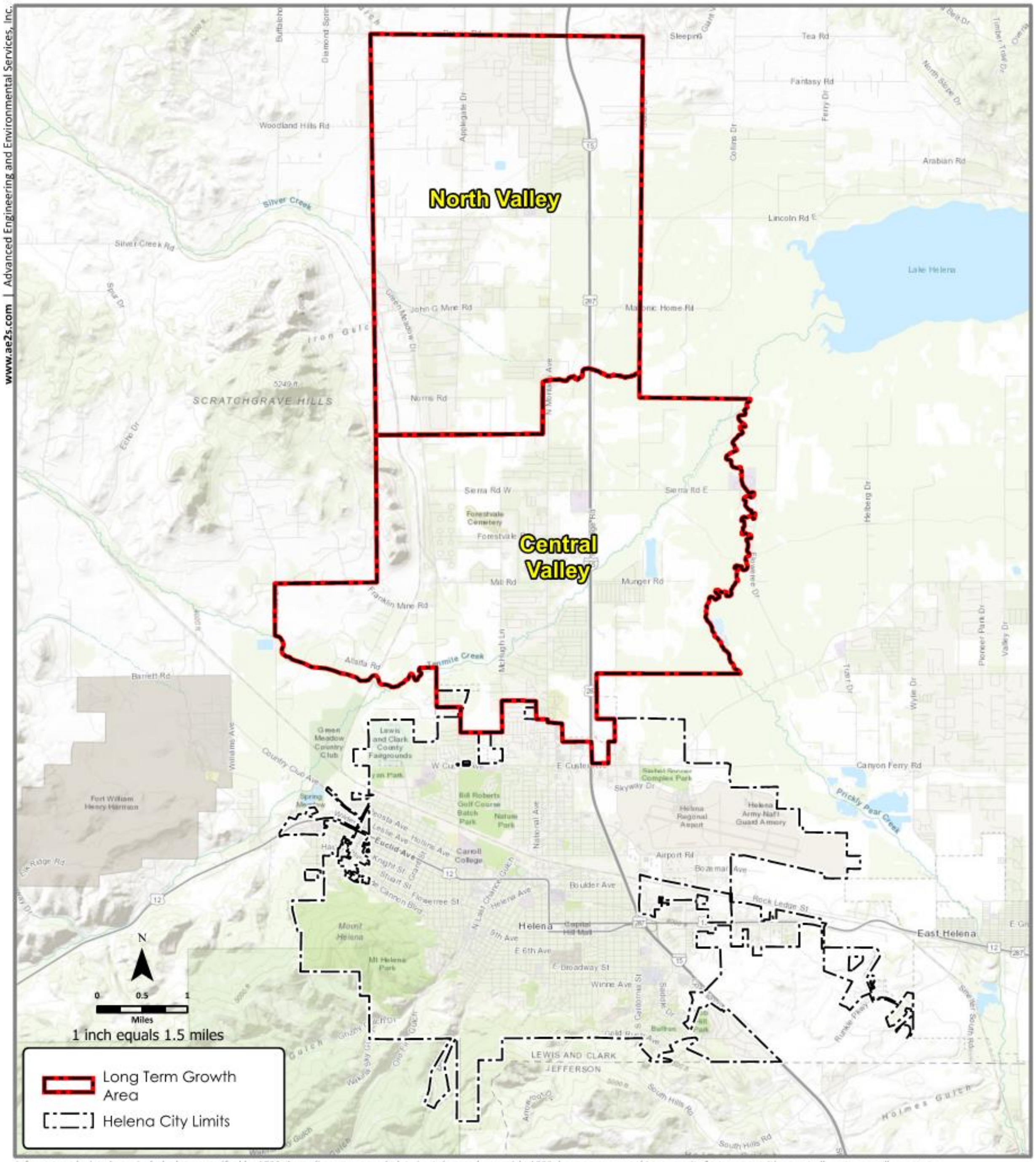


Figure 1 – Area of Future Land Use


www.ae2s.com | Advanced Engineering and Environmental Services, Inc.
1 inch equals 1 miles
Locator Map Not to Scale
Helena
Lewis & Clark County, MT
Figure 2
AREAS OF RECENT GROWTH
Helena City Limits
Water Main Installed Since 2000
Existing Water Main
Areas of Recent Growth
CITY OF HELENA
Date: 8/10/2020
City of Helena
AE2S
Franklin Mine Rd
Tenmile Creek
Alfalfa Rd
McHugh Ln
Green Meadow Country Club
Country Club Ave
Fairgrounds
Siebel Soccer Complex Park
Helena Regional Airport
Canyon Ferry Rd
Prickly Pear Creek
Euclid Ave
Rock Ledge St
East Helena
Mount Helena
Mt Helena Park
LEWIS AND CLARK
JEFFERSON
South Hills Rd
Holmes Gulch
Grizzly Gulch
Wakina Sky Gulch
Orofino Gulch
State Highway 282
Information depicted may include data unverified by AE2S. Any reliance upon such data is at the user's own risk. AE2S does not warrant this map or its features are either spatially or temporally accurate.
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 Feet | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staf Map Product on\Helena - GIS Staf Map Product on.aprx | Water Main Install Since 2000

www.ae2s.com | Advanced Engineering and Environmental Services, Inc.



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Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 Feet | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staf Map Product on\Helena - GIS Staf Map Product on.aprx | Expansion Areas

Locator Map Not to Scale

Figure 3

LONG TERM GROWTH AREA
HELENA VALLEY

City of Helena
Date: 8/10/2020

TECHNICAL MEMORANDUM #2

To: Jamie Clark, PE

From: Mark Peterson, PE
Nate Weisenburger, PE

Re: **Existing Water System Summary**
City of Helena, MT

Date: December 8, 2020

INTRODUCTION

The purpose of this memo is to provide a brief summary of the City's water distribution network. Facility information presented in this memo was gathered from the City's previous water facilities plan, record drawings, or verified with City staff. Field investigations of several tanks and pump stations were completed with this study; however, an independent survey of facility elevations was beyond the scope of this project.

WATER SUPPLY

Most of the water for the Helena Water System comes from two sources – Ten Mile Creek and the Missouri River. The Ten Mile Water Treatment Plant (TMTP) is located southwest of the City and has a design capacity of 10 million gallons per day (MGD). This plant is the primary source of water for the City, and finished water is gravity fed into the distribution system. The Missouri River Water Treatment Plant (MRTP) is located northeast of the City and has an effective capacity of 7 MGD. The MRTP has two pump stations that deliver finished water directly into the Malben High and Malben Low zones. The MRTP is primarily used during summer months to supplement the flows from TMTP.

A smaller percentage of the City's water supply comes from groundwater through the Hale supply system. This system includes the Eureka Well, which has the capacity to produce about 0.55 MGD. This water only requires chlorination, so treatment costs are very low, and it is a desirable source of water. The capacity of this well represents about 25% of the City's wintertime demands, representing a significant source. Upgrades to the pumps in this well and the installation of a new control valve between the Hale Zone and the Malben High Zone will allow this well to produce more water for the system.

EXISTING DISTRIBUTION SYSTEM

The City's water system consists of over 230 miles of transmission and distribution pipe, ranging in size from 2-inches in diameter to 36-inches in diameter. All the distribution system and the transmission system except for the pipeline from the TMTP is shown in Figure 1.

Most of the piping within the City of Helena is cast iron or ductile iron pipe. The City's GIS data indicates there are about 24 miles of PVC pipe and about 13 miles of steel pipe, with the remaining pipe being either cast iron or ductile iron. Figure 2 shows the existing pipe material throughout the system.

The existing distribution system consists of thirteen pressure zones. The three largest zones are the Winne Zone, the Malben High Zone, and the Malben Low Zone. The Malben High Zone and Malben Low Zone are separated by eight pressure reducing valves. The other zones are much smaller and serve areas located around the perimeter of the City. The pressures zones are shown in Figure 1. Table 1 shows the thirteen pressure zones, the approximate maximum hydraulic grade line (HGL) for each zone based on the maximum tank level, and the maximum day demand, based on the 2019 calibrated hydraulic model. The HGL for the Malben Low Zone and the Valley Zone is a function of the settings for the pressure reducing valves in the system. The HGL for the Reeder's Village Zone is a function of the pressure settings at the pump station. Figure 3 provides an existing schematic summary of the HGL for the entire distribution system.

The maximum day demand reported in Table 1 is explained in greater detail in the model calibration memo as well as the water use characterization memo. The maximum day demand for each of the customer meters within the City was spatially allocated using the City's GIS information. Within each pressure zone, the allocated demands were summed to determine the total usage.

Table 1 Existing Pressure Zones

Pressure Zone	HGL (ft)	Model Max Day Demand (gpd)
Malben Low	4,102	3,892,565
Malben High	4,321	9,012,629
Winne	4,502	1,193,645
Hale	4,385	371,491
Upper Hale	4,543	17,294
Reeder's Village	4,464	77,155
Westside (Forrest Estates)	4,479	184,176
Green Meadow (Valley)	3,940	20,131
Airport	3,961	22,075
Golden Estates (Valley)	4,048	378,592
Mountain View Meadows	4,152	4,637
Trinity	Private System	
West Main	4,386	20,362
Total		15,194,750

EXISTING STORAGE

There are eight active storage tanks that provide effective storage for the City's water system. These tanks and the associated total and effective capacity are shown in Table 2. There are also two Woolston Tanks (No. 1 and No. 2). Woolston No. 1 is out of service. Woolston No. 2 is controlled by an altitude valve that opens only when the Malben and Nob Hill Tanks both drop below 19 feet, so it generally provides storage only for high flow events. Since Woolston No. 1 is out of service, it was not included as part of the distribution system analysis.

The capacity of the Malben Tank is partially limited by the Dalhausen Pump Station. The pump station cannot effectively operate when the water level in the Malben Tank drops below 8 feet (about 1/3 full). However, the entire volume of the Malben Tank is available for use in the Malben High Zone.

Table 2 Existing Storage Tanks

Tank	Total Volume (MG)	Effective Volume* MG	Pressure Zone Served
Nob Hill	4.0	4.0	Malben High (gravity) Winne (pump)
Malben	4.0	4.0	Malben High (gravity) Winne (pump)
Hale	2.2	2.2	Hale
Upper Hale	0.2	0.2	Upper Hale
Winne No. 1	0.5	0.5	Winne
Winne No. 2	0.6	0.6	Winne
Westside (Forrest Estates)	0.5	0.5	Westside
Woolston No. 1	3.1	0.0	Malben High
Woolston No. 2	3.0	3.0	Malben High
Ten Mile WTP Clearwell	6.0	6.0	Malben High

**Effective volumes differ from total storage volumes due to various operational issues that prevent the entire volume from being utilized.*

The low water level (LWL) in Winne Tank 2 is 4.5 feet lower than Winne Tank 1. Since there is a difference in LWL between the two tanks, the bottom 4.5 feet of Winne Tank 2 can only be used if Winne Tank 1 is empty.

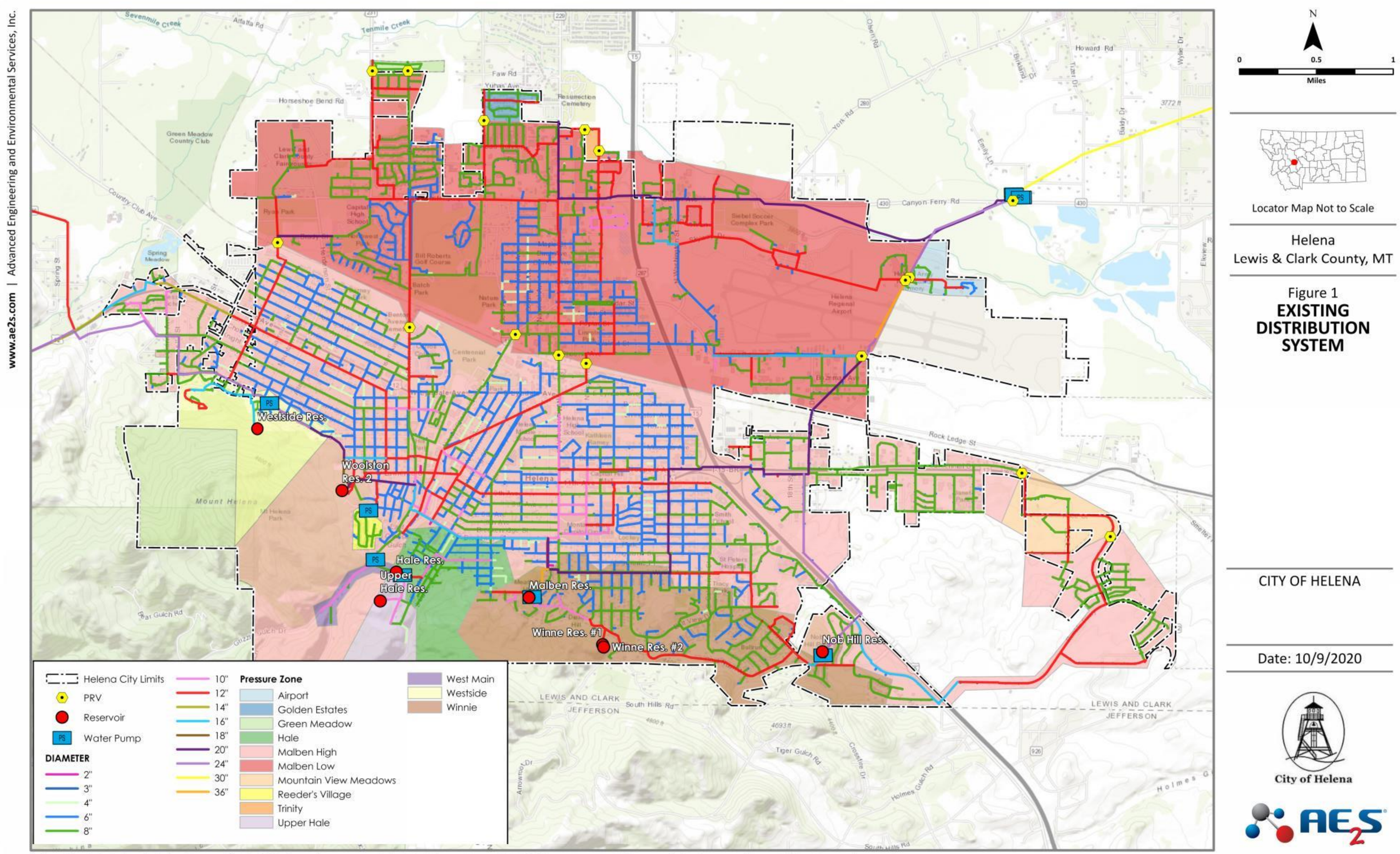
The total effective volume of the existing storage tanks (not including the TMTP clearwell) is 15.0 million gallons.

EXISTING PUMPING STATIONS

There are seven pump stations that serve the City of Helena water distribution system. The pump stations and associated capacities are shown in Table 3. These values were provided by the City of Helena for this report. The firm capacity values do not account for the reduced flows to be expected from each pump when multiple pumps are operating in a single pump station.

Table 3 Existing Pumping Stations

Pump Station	No. Pumps	Pump Capacity (gpm)	Pump Size (HP)	Firm Capacity (gpm)
Malben Low (MRTP)	3	1,000; 2,100; 2,100	125; 300; 300	3,200
Malben High (MRTP)	3	1,750 each	600 each	3,500
Dalhausen	2	1,000 each	70 each	1,000
Eureka	2	300, 450	30; 50	300
Upper Hale	2	80 each	10 each	80
Nob Hill	2	900, 1,800	75; 150	900
Reeder's Village	5	75; (2) 150; (2) 1,750	5; (2) 10; (2) 75	225
Westside (Forrest Estates)	2	500 each	25 each	530



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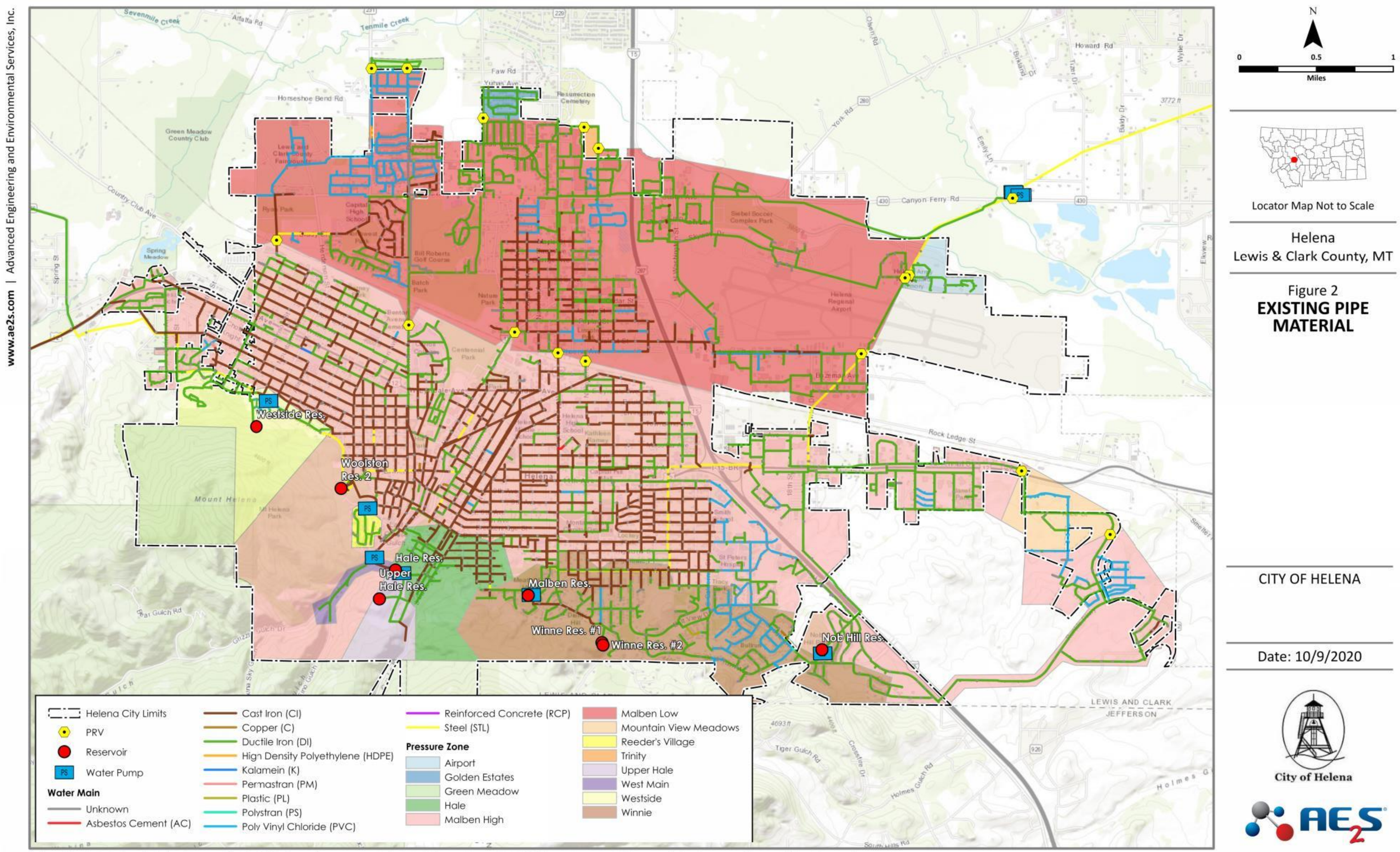

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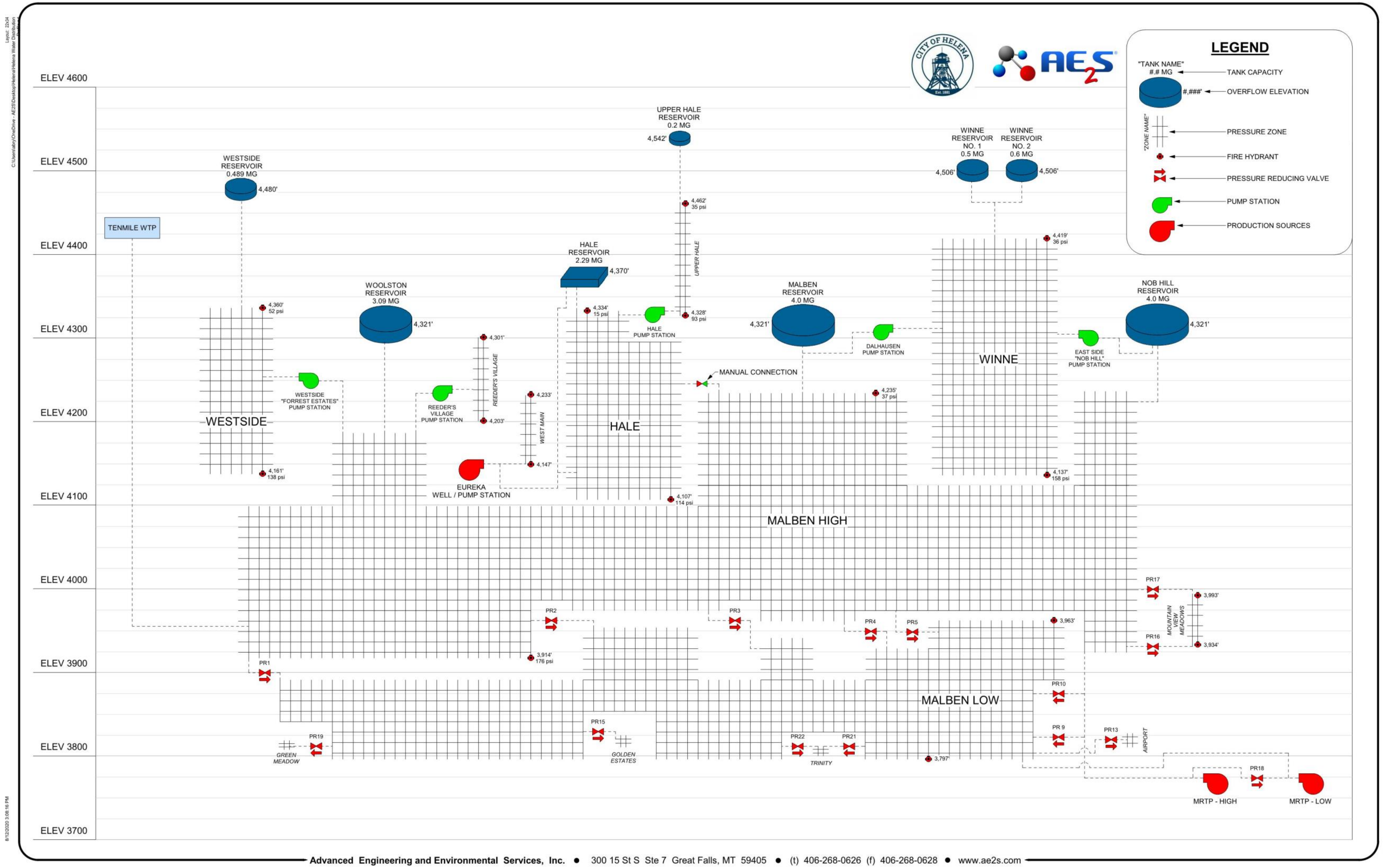


Figure 3 – Existing System HGL Summary

City of Helena

TECHNICAL MEMORANDUM #3

To: Jamie Clark, PE

From: Mark Peterson, PE
Nate Weisenburger, PE

Re: **Water Use Characterization**
City of Helena, MT

Date: December 8, 2020

INTRODUCTION

Water use characterization of the City of Helena's (City) water distribution system involves an analysis of the existing water demands and production data to better understand the system's water use. Water use characterization is necessary to assess the capabilities of the existing facilities to adequately serve current water demands and to ensure the design and operation of proposed water system components can sufficiently accommodate future water demands.

This memorandum presents an overview of the City's recent water production and demand trends. The results of this water use analysis were incorporated into the distribution system hydraulic model to evaluate both existing and future system performance. Results from the modeling analysis will guide future recommended water system capital improvements.

DEFINITION OF TERMS

Water demand is described in the following terms:

- Average Daily Demand (ADD) – The total volume of water delivered to the system over a year divided by 365 days. The average use in a single day is expressed in gallons per day.
- Maximum Month Demand (MMD) – The gallons per day average during the month with the highest demand. The highest monthly usage typically occurs during a summer month.
- Maximum Day Demand (MDD) – The largest volume of water delivered to the system in a single day expressed in gallons per day.
- Peaking Factor (PF) – The ratio of the MDD divided by ADD.

- Equivalent Residential Unit (ERU) – A dwelling, unit, or development that is equal to a single-family residence in terms of the volume of water used on a daily basis.

WATER PRODUCTION AND USAGE DATA

The data provided by the City and reviewed as part of the water use analysis is summarized in Table 1.

Table 1 – Production and Customer Meter Data Sets

Data Set	Time Period	Description
Monthly Water Production Reports	2009 through 2019	This data includes the total volume of water produced at each facility on a monthly basis. These totals represent metered flows which include water used for backwash operations.
Customer Meter Data	January 2016 through July 2019	This data includes the metered volume of water that each customer account in the system was billed for on a monthly basis.
Water Consumption Data	2010 through 2019	This data provides the total volume of water consumed by all customers on a monthly basis, according to billing records.

Water Production

The primary sources of water for the City are Ten Mile Creek and the Missouri River, with an additional groundwater source from the Eureka Well. The Ten Mile Water Treatment Plant (TMTP) operates year-round and supplies most of the City's water. The Missouri River Water Treatment Plant (MRTP) operates primarily during summer months to provide supplemental flows for meeting peak water demands but also serves as the primary source whenever the TMTP is shut down for maintenance. The groundwater supply contributes an average of approximately 6% of the City's water supply and serves a relatively small area within the city. Graphs representing monthly and annual water production from each source are shown in Figures 1 and 2, respectively.

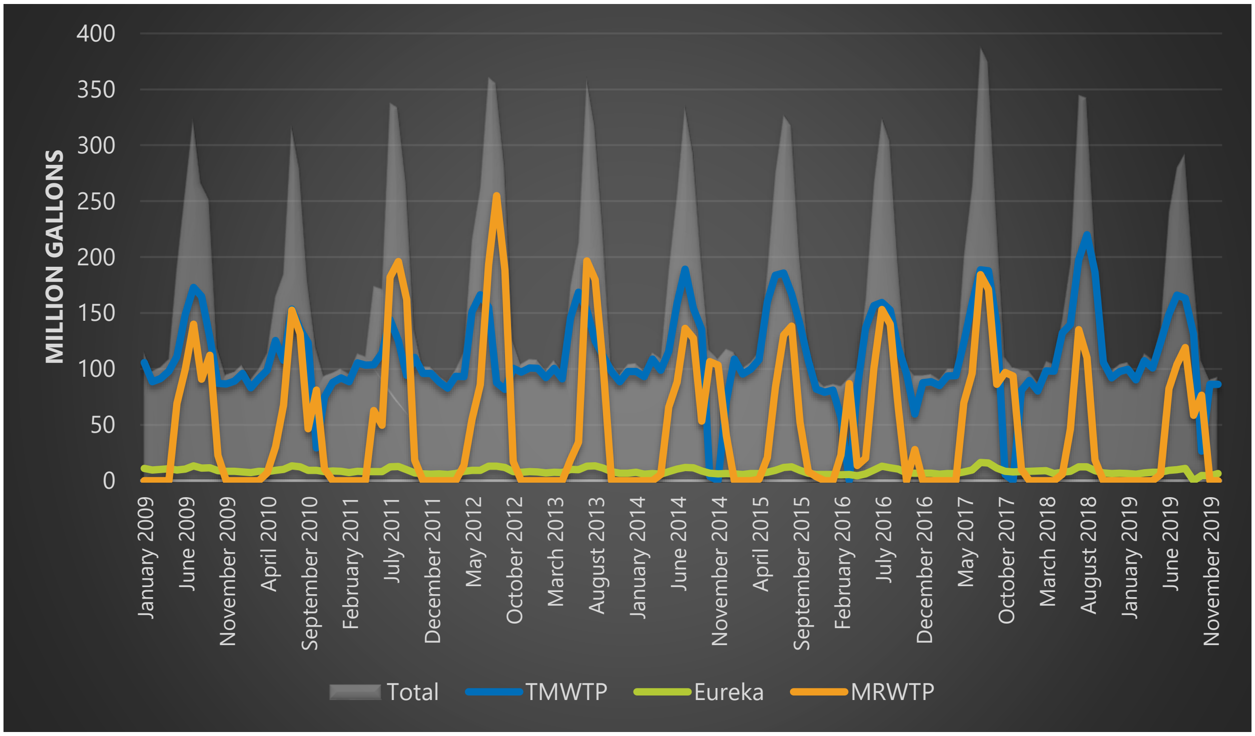


Figure 1 – Monthly Production Totals by Source

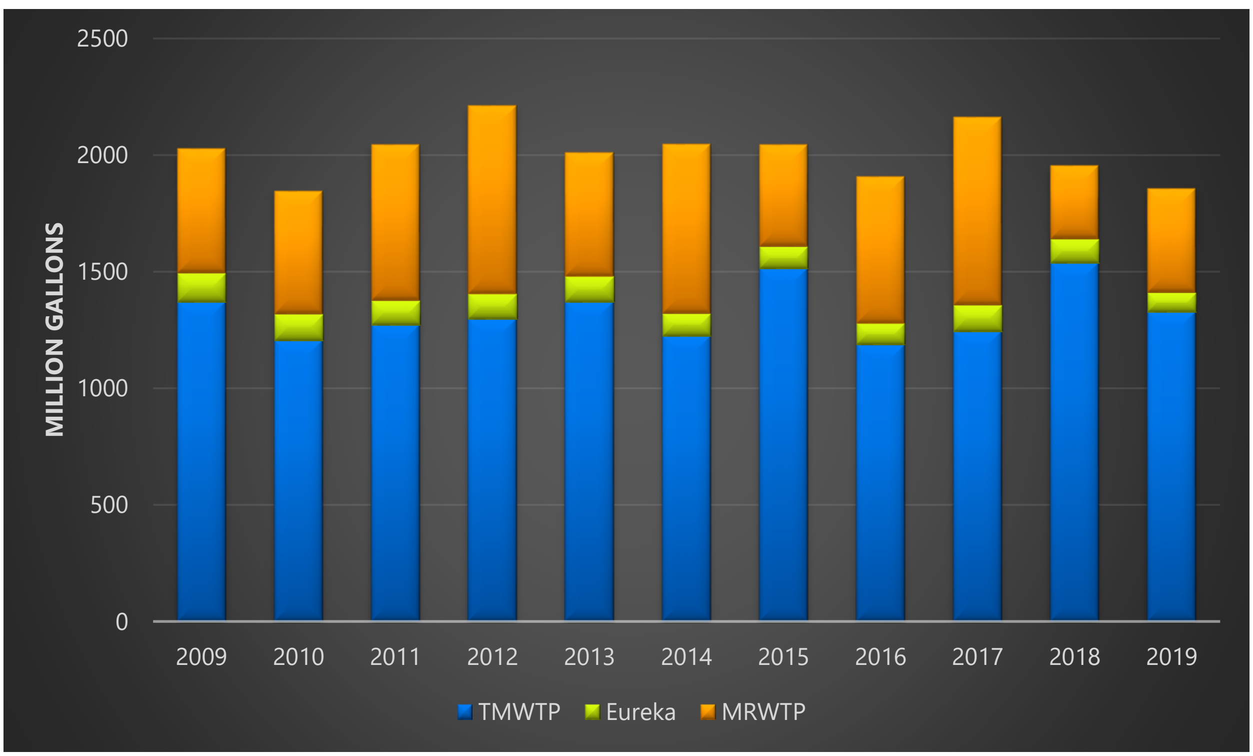


Figure 2 – Annual Production Totals by Source

Average Day Demand (ADD)

Average Day Demand (ADD) is defined as the total volume of water delivered to the system over a year divided by the number of days in that year. ADD is an important metric to understand because it is utilized when analyzing existing water demands as well as estimating future water demands. The ADD for any previous year can be multiplied by the number of days in that respective year, which results in the total volume of water that was needed to provide water to customers in that year. Likewise, future estimated ADD should be utilized when planning for future source water availability and appropriations securement. System-wide ADD for each year is represented in Figure ***3***.

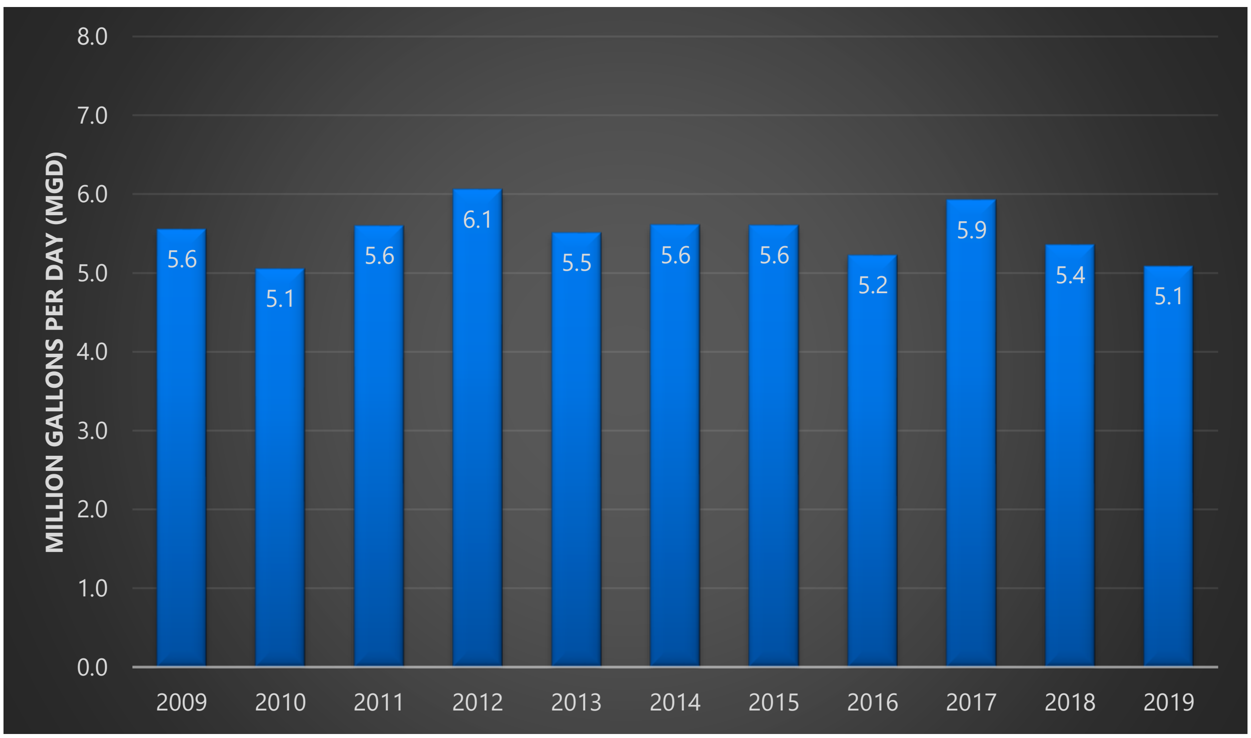


Figure* 3 *– Average Day Demands

Maximum Month Demand (MMD)

Maximum Month Demand (MMD) is defined as the maximum amount of water used on any day in a given month. MMD is commonly used to better understand seasonal variations in water production and typically occurs during a summer month. Table 2 provides MMD values (expressed as the peak day demands of each month) and is conditionally formatted; lighter shading indicates less water produced, and darker shading indicates more water produced.

Table 2 – Maximum Month Demand

Month	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
January	3.8	3.3	3.2	3.0	3.5	3.4	3.7	2.8	3.1	3.2	3.4
February	3.5	3.2	3.4	3.2	3.5	3.5	3.6	3.0	3.2	3.2	3.4
March	3.3	3.2	3.7	3.2	3.5	3.7	3.4	3.0	3.2	3.5	3.7
April	3.6	3.8	3.7	3.8	3.3	3.7	3.9	3.4	3.3	3.5	3.6
May	6.1	5.3	5.6	6.9	5.6	6.1	6.1	5.2	6.5	4.7	4.4
June	8.6	6.2	5.7	8.7	7.1	8.6	9.2	8.9	8.8	6.5	8.0
July	10.5	10.3	10.9	11.7	11.7	10.9	10.6	10.5	12.6	11.1	9.0
August	8.6	9.0	10.8	11.5	10.3	9.4	10.2	9.8	12.1	11.0	9.5
September	8.4	6.0	8.9	9.4	7.5	6.6	6.7	6.5	7.9	7.1	6.3
October	3.8	3.9	4.4	4.1	3.4	3.8	3.9	3.3	3.6	3.6	3.5
November	3.2	3.1	3.4	3.5	3.2	3.6	3.0	3.1	3.4	3.3	3.0
December	3.1	3.1	3.3	3.5	3.4	3.8	2.7	3.0	3.2	3.4	3.0
MMD	**10.5**	**10.3**	**10.9**	**11.7**	**11.7**	**10.9**	**10.6**	**10.5**	**12.6**	**11.1**	**9.5**
Month of Record	*July*	*July*	*July*	*July*	*July*	*July*	*July*	*July*	*July*	*July*	*August*

Maximum Day Demand (MDD)

Maximum Day Demand (MDD) is the largest volume of water delivered to the system in a single day expressed in million gallons per day. MDD is also commonly referred to as peak daily or peak water demand. Figure 4 presents the system-wide MDDs for each year.

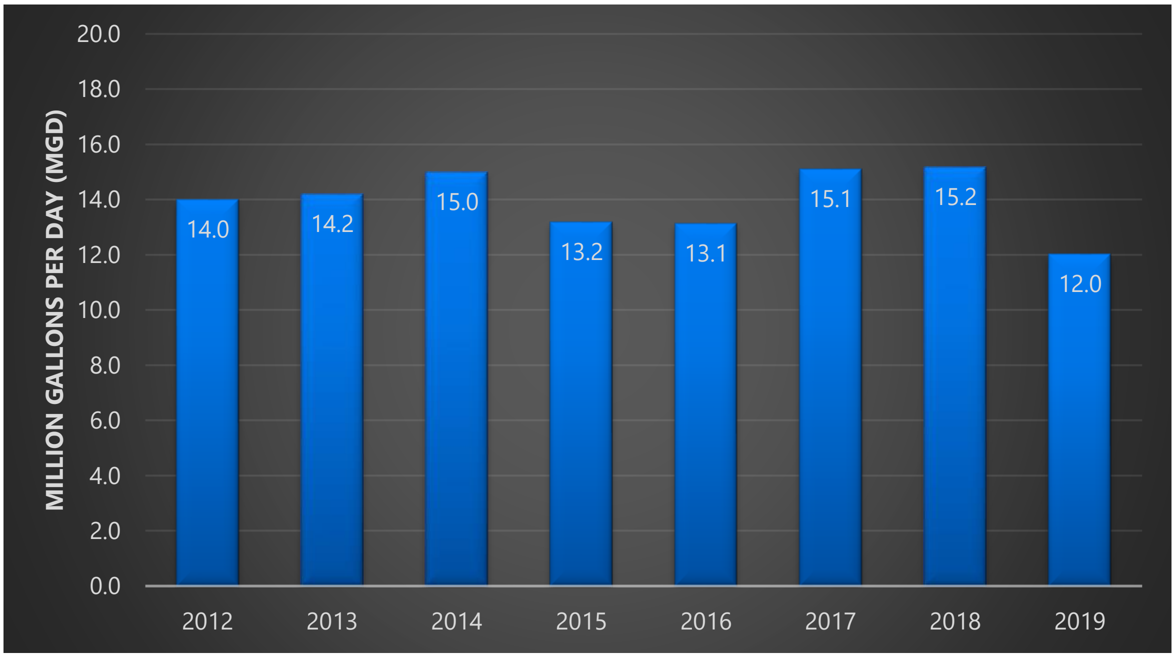


Figure 4 – Maximum Day Demands

Seasonal Variations

Water production and water usage vary greatly depending on the season. The average monthly water usage, expressed in million gallons per day, was evaluated to determine which months had the highest water demand. Figure 5 shows the monthly water production variations from 2009 to 2019.

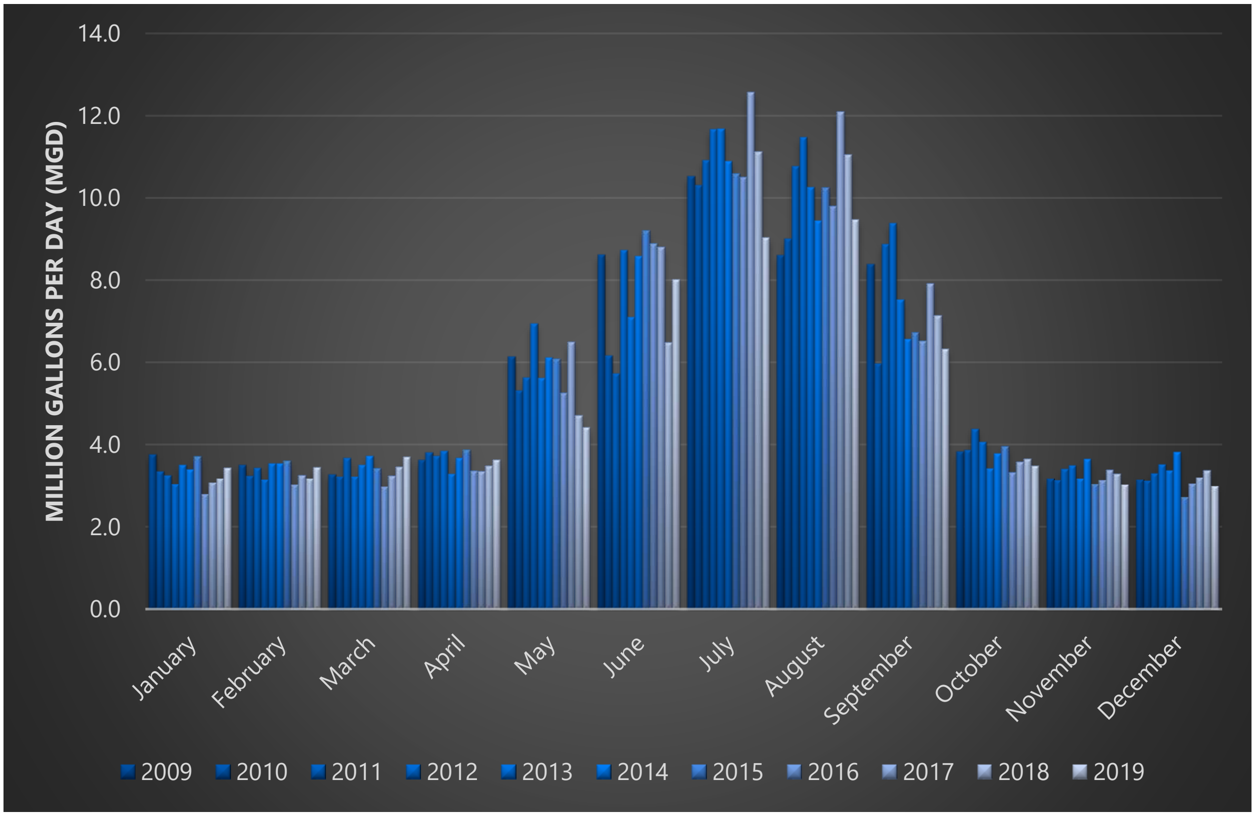


Figure 5 – Seasonal Variations in Water Production

As shown in Figure 5, water production fluctuates greatly depending on the month and season. Water use is much higher in the summer compared to other seasonal periods due to sprinkler and irrigation use.

Peaking Factors

When conducting a water use characterization, it is important to fully understand peaking factors and water demand fluctuations. A maximum day peaking factor is defined as the ratio of MDD to ADD. Peaking factors are used to ensure water system infrastructure is sized appropriately to accommodate peak water needs. Table 3 presents the peaking factors from 2012 to 2019.

Table 3 – Peaking Factors

Year	Peaking Factor
2012	2.3
2013	2.6
2014	2.7
2015	2.4
2016	2.5
2017	2.5
2018	2.8
2019	2.4

Water Production Summary

A summary of the system-wide water production analysis is provided in Figure 6.

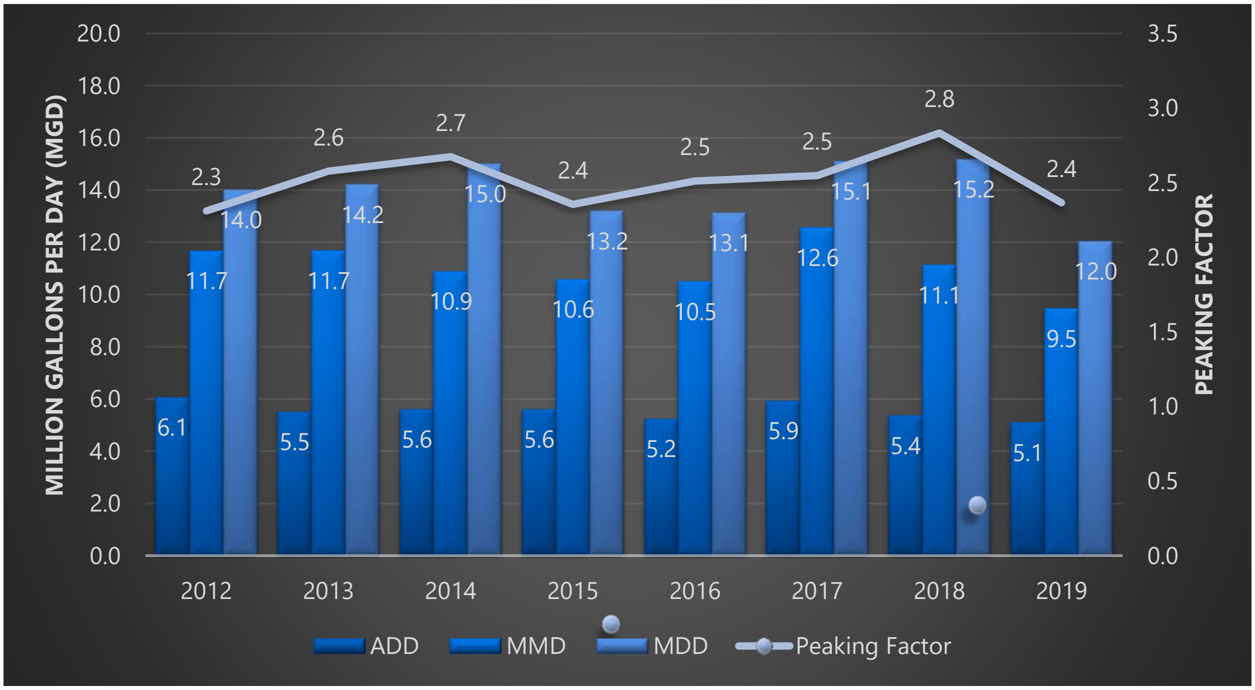


Figure 6 – ADD, MMD, MDD, and Peaking Factor Summary

Metered Water

Analyses of the customer meter records were used to determine overall customer water consumption, develop water use trends, aid in determining future water use values, and estimate non-revenue water present in the system. The customer meter data was provided in monthly occurrences and represented in terms of 100 cubic feet per month (CCF/month). The customer meter data is categorized into three account types: Single-family Residential, Multi-family Residential, and Commercial. Figure 7 shows the system water use separated by account type, as well as the total water recorded on customer meters.

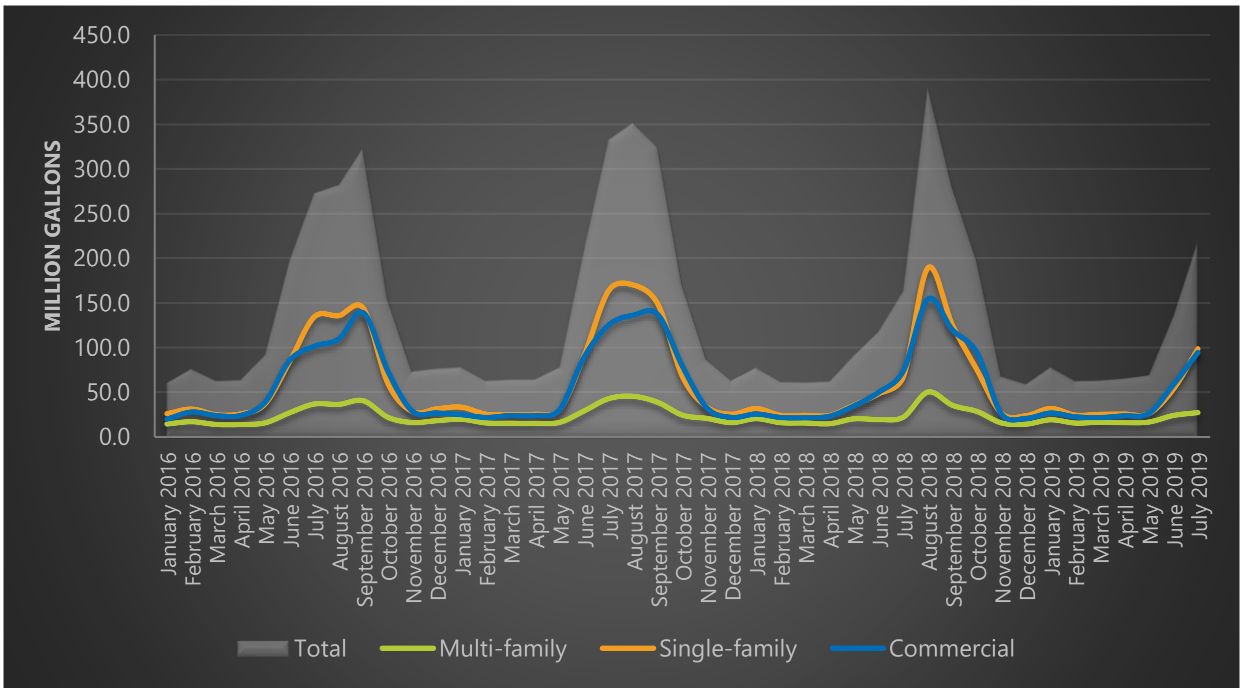
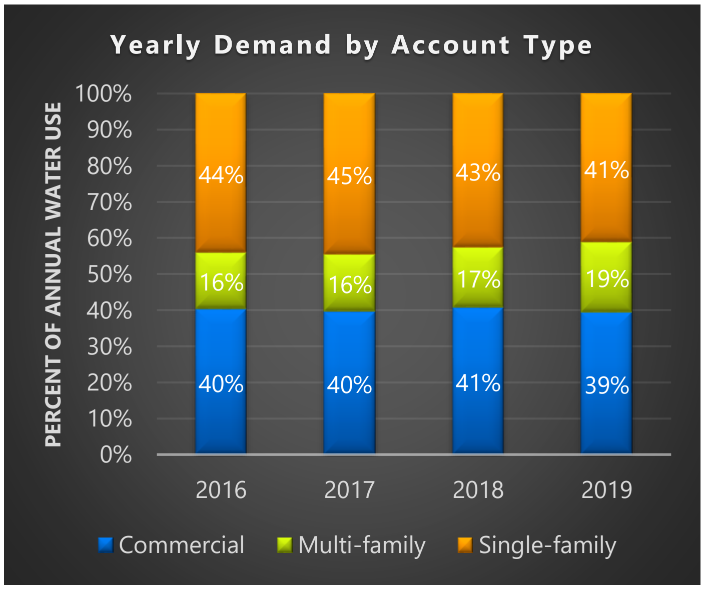


Figure 7 – System Water Use by Account Type

Overall, single-family accounts are contributing the most water demand to the system, but only slightly more than commercial accounts (44% and 40%, respectively). While all three account types exhibit seasonal trends due primarily to increased outdoor uses such as lawn watering, multi-family accounts exhibit a steadier water demand trend. This can likely be attributed to smaller lot sizes and, therefore, smaller overall increases for outdoor use. A breakdown of the demand by account type is shown in Figure 8.



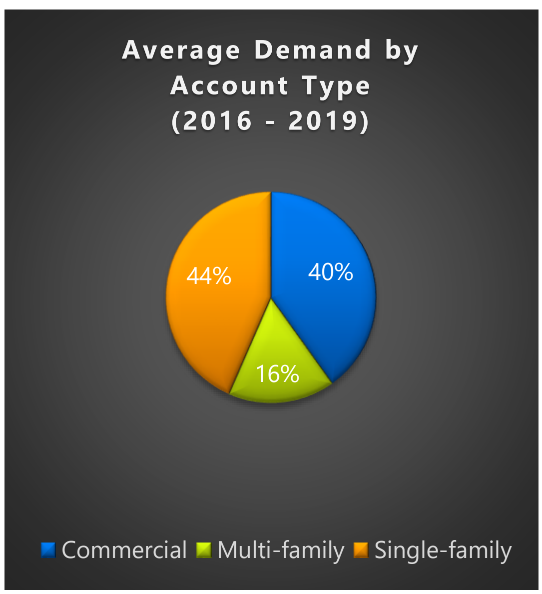


Figure 8 – Water Use by Account Type

Non-Revenue Water (NRW)

Non-revenue water (NRW) is defined as the sum of specific types of water loss and any authorized, unbilled consumption that occurs within the water distribution system. This definition is provided in the IWA/AWWA Water Balance, as shown in Table 4[1]. Water utilities routinely produce more water than the volume of metered water. While the difference can occur in a variety of ways, water loss is generally attributed to water lost through aging infrastructure and meter reading inaccuracies. Other common sources of water loss include firefighting, hydrant use for flushing, and overflow of storage tanks.

Table 4 – IWA/AWWA Water Balance[1]

<table>
<tr><th colspan="7">The IWA/AWWA Water Balance</th></tr>
<tr><td rowspan="9">Volume From Own Sources (corrected for known errors)</td><td rowspan="11">System Input Volume</td><td>Water Exported (corrected for known errors)</td><td colspan="3">Billed Water Exported</td><td>Revenue Water</td></tr>
<tr><td rowspan="10">Water Supplied</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non-revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Unauthorized Consumption</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and Distribution Mains</td></tr>
<tr><td rowspan="2">Water Imported (corrected for known errors)</td><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to the Point of Customer Metering</td></tr>
<tr><td colspan="7">NOTE: All data in volume for the period of reference, typically one year.</td></tr>
</table>

[1]AWWA (American Water Works Association). 2016. Manual M36, *Water Audits and Loss Control Programs.* 4th ed. Denver, CO: AWWA.

Using both the production and total consumption data, an analysis of water loss (or non-revenue water) was performed. Figure 9 shows the water production, metered demand, and calculated water loss percentage. These water loss percentages will be used in later sections to determine future water use projections and for use in the distribution system hydraulic model. Based on this analysis, a NRW percentage of 20% is recommended for water demand planning.

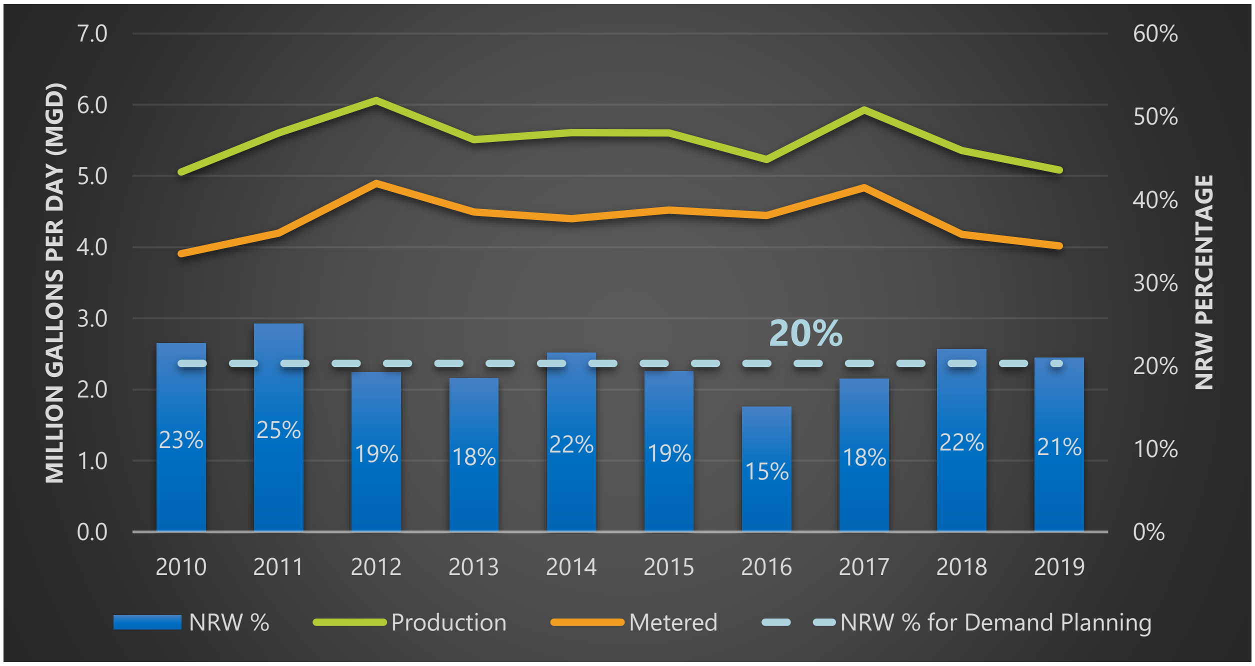


Figure 9 – Annual Non-Revenue Water Percentages

Equivalent Residential Unit (ERU) Evaluation

Defining the volume of water needed for an Equivalent Residential Unit provides a metric for the City to gauge how much additional water supply and storage capacity are available for future growth. This unit is based on the maximum day demand of a single-family residential customer, which is derived from the maximum monthly usage since customer meter data is recorded on a monthly basis. Since an ERU will vary from city to city, an evaluation of the City's water billing records was used to determine the volume of water used per ERU. Figure 10 shows single-family residential water usage trends over the past few years.

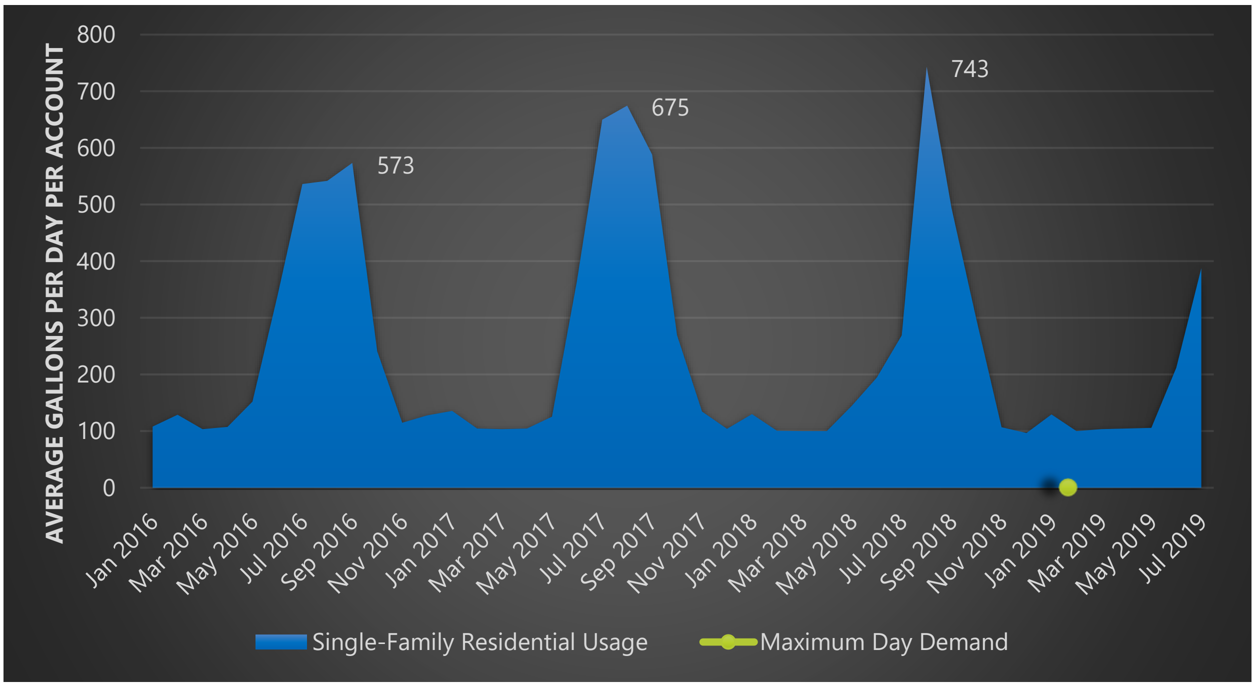


Figure 10 – Single-Family Residential Water Usage

It is important to note that the maximum day demands per single-family residential customer have been increasing each year, based on the data available for the analysis. Typically, a downward trend is expected due to infrastructure improvements, technology, and industry advancements, and conservation efforts. However, peaks in single-family residential water usage that occur during summer months are primarily a representation of outdoor watering, which is highly influenced by the weather. August 2017 and July 2018 are examples of peak water usage occurring when temperatures are high and precipitation is low. Higher than normal temperatures and very little rainfall during the summer months of 2017 and 2018 are the most likely explanation for the increasing peak demands shown in Figure 10.

The volumetric definition of an ERU for the City was determined to be 743 gallons per day (gpd), which represents a maximum day demand. Dividing the corresponding maximum day production value of 15.2 million gallons per day (MGD) by the ERU definition of 743 gpd indicates the City was serving 20,448 ERUs in 2018. This number of ERUs can serve as a baseline for gauging future growth and timing of future capital improvement projects. For example, in the accompanying storage analysis memorandum, the timing of future storage improvements will be tied to an identified number of future ERUs or trigger points.

For the ERU accounting method to be effective, it needs to be monitored and updated at least on a yearly basis. As new connections to the water system are approved, the City should note the location, type of connection (SFR, MFR, COM, etc.), and estimated maximum day water usage.

Unlike single-family residential units, multi-family and commercial units vary significantly in their average water usage. In order to accurately determine the ERU equivalence of multi-family or commercial accounts, they should be evaluated on a case-by-case basis.

WATER DEMAND PROJECTIONS

Water demand projections are important when sizing future infrastructure and developing capital improvement plans. Generally, historical water production and water meter data are utilized to project future water demands. For the purpose of this analysis, water demand projections were determined based on future ERU growth projections.

Future ERU Growth & Water Demand Projections

An average annual population increase of 0.36% was presented in tech memo #1 (Planning and Service Area Update) as the expected growth rate for the City. This rate is based on information found in Chapter 2 of the City's recently updated Growth Policy. It is anticipated that growth will occur primarily in two areas: the southeast part of the City in Mountain View Meadows and Padbury Ranch developments, and the north part of the City, generally between Green Meadow Drive and McHugh Lane. It is assumed that 75% of the growth will be in the southeast, and 25% will be in the north.

Assuming that ERU growth will occur at the same rate as population growth, the City can expect to increase from serving 20,448 ERUs to serving 20,969 ERUs in 2025 and 22,130 ERUs in 2040. Of the additional 521 ERUs by 2025, 391 will be in the southeast part of the City, and 130 will be in the north. Of the additional 1,682 ERUs by 2040, 1,262 will be in the southeast part of the City, and 420 will be in the north.

Using 743 gpd as the volumetric definition of an ERU and multiplying that by the number of ERUs in the City, a future maximum day demand can be projected. Future water demands associated with the anticipated ERU growth are provided in Table 5.

Table 5 – Water Demand Projections

Year	# of ERUs	Maximum Day Demand	Additional Demand to the Southeast	Additional Demand to the North
2018	20,448	15.2 MGD	--	--
2025	20,969	15.6 MGD	291,000 gpd	97,000 gpd
2040	22,130	16.4 MGD	938,000 gpd	312,000 gpd

City of Helena

TECHNICAL MEMORANDUM #4

To: Jamie Clark, PE

From: Mark Peterson, PE
Nate Weisenburger, PE

Re: **Existing Water Rights**
City of Helena, MT

Date: December 8, 2020

INTRODUCTION

In May 2019, the City contracted with AE2S to complete a Water System Storage and Distribution System Capital Improvement Plan. In order to provide a more cost-effective report, the City requested that a series of Technical Memoranda be prepared, rather than a lengthy report. This technical memorandum summarizes the analysis of the existing water rights in conjunction with growth projections and engineering considerations to verify if existing water rights are sufficient for the long-term (20-year) planning period.

TENMILE CREEK WATER RIGHTS

The water rights for Ten Mile Creek date back to 1864 and 1865 and allow for the use of 13.75 cfs or 8.9 million gallons per day (MGD). This water right was confirmed by the Montana Supreme Court in 2017. The period of use for this water right is January 1 through December 31.

Flow records for the Ten Mile Water Treatment Plant indicate that monthly summer production can be as high as 7.1 MGD (August 2018). The design capacity of the Ten Mile Water Treatment Plant is 10 MGD.

MISSOURI RIVER WATER RIGHTS

The City of Helena purchases raw water for treatment at the Missouri River Treatment Plant from the United States Bureau of Reclamation as part of an irrigation project which delivers water from the Missouri River to the Helena Valley. The original contract with the Bureau of Reclamation, dated 1956, was renewed in 2004 and allows the City of Helena to purchase up to an annual maximum of 11,300 acre-feet. This represents about 10.08 MGD. This contract is valid for 40 years and may be renewed at the City's request.

GROUNDWATER RIGHTS

The City of Helena has groundwater rights from two sources – the Oro Fino Well and the Eureka Well. The City's water rights at Oro Fino include 1.2 cfs (0.78 MGD) dated 1866 and 2.5 cfs (1.6 MGD) dated 1867. An additional 1 cfs (0.65 MGD) water right was secured in 1912. However, the Oro Fino source was determined by the Montana Department of Environmental Quality to be Ground Water Under the Influence of Surface Water (GWUISW), so its use was discontinued in about 2006. The City's water right for the Eureka source is 1.1 cfs (0.72 MGD) with a priority date of 1933. The Montana DNRC Water Rights web site indicates that this water right is number 411 89076 00

PROJECTED SYSTEM DEMANDS

Based on the water demand analysis completed to calibrate the existing water system model, the average day demand for the water system in 2017 was about 5.9 MGD, or about 194 gallons per capita per day (gpcd). This is the largest recent value for average day demand. The peak day demand is about 10,537 gpm or about 15.2 MGD. The estimated 2017 population for Helena, obtained from the City Community Development Department, is 30,345. The estimated 2040 population is 32,989. With this 8.7% increase in population, the estimated 2040 average day demand is 6.4 MGD, and the estimated 2040 peak day demand is 16.5 MGD.

ADEQUACY OF EXISTING WATER RIGHTS

As shown in Table 1, the total water rights for the City of Helena are about 22.71 MGD. With a 2040 estimated peak day demand of 16.5 MGD, the existing City water rights are more than adequate to meet the future demands through 2040.

The majority of the system capacity is provided by the Ten Mile Water Treatment Plant and the Missouri River Water Treatment Plant, which have a combined capacity of about 17 MGD and available water rights of about 18.9 MGD.

Table 1 Existing Water Rights

Source	Water Rights, MGD
Ten Mile Creek	8.88
Missouri River	10.08
Eureka Well	0.72
Total	19.68

TECHNICAL MEMORANDUM #5

To: Jamie Clark, PE

From: Mark Peterson, PE
Nate Weisenburger, PE

Re: **Water System Storage Analysis**
City of Helena, MT

Date: December 8, 2020

INTRODUCTION

The purpose of this Technical Memorandum is to summarize the analysis of finished water storage in the water distribution system.

SYSTEM DEMANDS

In the recent update of the City's water model, current water production and billing data were used to allocate demands or water usage throughout the system based on the billing address of each customer. The maximum day demand based on the water production values is 15.2 MGD (August 2018). The average day demand for this same period was found to be 5.7 MGD

The estimated 2017 population for Helena, obtained from the City Community Development Department, is 30,345. The estimated 2040 population is 32,989. With this 8.7% increase in population, the estimated 2040 average day demand is 6.1 MGD, and the estimated 2040 peak day demand is 16.4 MGD.

EXISTING STORAGE

Eight active storage tanks provide effective storage for the City of Helena water system. These tanks and the associated total and effective capacity are shown in Table 1. The total capacity of the tank is the total volume the tank can hold, whereas the effective volume is the total volume that can be used. There are also two Woolston Tanks (No. 1 and No. 2). Woolston No. 1 is out of service. Woolston No. 2 is controlled by an altitude valve that opens only when the Malben and Nob Hill Tanks both drop below 19 feet, so it generally provides storage only for high flow events. Since Woolston No. 1 is out of service, it was not included as part of the distribution system analysis.

The capacity of the Malben Tank is partially limited by the Dalhausen Pump Station. The pump station cannot effectively operate when the water level in the Malben Tank drops below 8 feet (about 1/3 full). However, the entire volume of the Malben Tank is available for use in the Malben High Zone.

The elevations presented in Table 1 are based on record drawings as much as possible. The record drawings reviewed for this analysis did not include references to the vertical datums used. Based on the drawing completion dates, vertical datums were estimated as follows:

- 1929-1990: NGVD 29 (~3.46 feet lower than NAVD 88 in Helena)
- 1991-2020: NAVD 88

It should also be noted that several of the tank elevations appear to have been recorded with local datums, as the conversion factor from 29 to 88 does not provide a hydraulically reasonable elevation.

The total effective volume of the existing storage tanks (not including the Clearwell at the Ten Mile WTP) is 15.0 million gallons.

A hydraulic grade line profile showing the tanks and the corresponding pressure zones is shown in Figure 1.

Table 1 – Existing Storage Tanks

Tank	Total Volume (MG)	Effective Volume MG	Pressure Zone Served	Overflow Elevation (NAVD88)
Nob Hill	4.0	4.0	Malben High (gravity) Winne (pump)	4321.40
Malben	4.0	4.0	Malben High (gravity) Winne (pump)	4321[a]
Hale	2.2	2.2	Hale	4371[b]
Upper Hale	0.2	0.2	Upper Hale	4542
Winne No. 1	0.5	0.5	Winne	4506.46[c]
Winne No. 2	0.6	0.6	Winne	4506.46[c]
West Side (Forrest Estates)	0.5	0.5	Forrest Estates	4479
Woolston No. 1	3.1	0.0	Out of Service	
Woolston No. 2	3.0	3.0	Malben High	4320[d]
Ten Mile WTP Clearwell	6.0	6.0	Malben High	N/A

[a] *1954 record drawings show the overflow at 4306. This is likely in a local vertical datum.* ***Recommend using the elevation of 4321 the City used in the previous model until survey data can be collected.***
[b] *Scanned as-builts do not provide elevation.*
[c] *Converted from NGVD 29 elevation of 4503.*
[d] *1931 record drawings show overflow elevation of 4307. This is likely in a local vertical datum.* ***Recommend using the elevation of 4320 the City used in the previous model until survey data can be collected.***

Nob Hill

The Nob Hill tank is a cylindrical, prestressed concrete tank with a capacity of 4.0 million gallons. The tank was built in 2000 and supplies water to the Malben High Zone by gravity and the Winne Zone through the Nob Hill Pump Station.

Malben

The Malben tank is a cylindrical, welded steel tank with a capacity of 4.0 million gallons. The tank was built in 1954 and supplies water to the Malben High Zone by gravity and the Winne Zone through the Dalhausen Pump Station.

Hale

The Hale tank is a rectangular, masonry tank with a capacity of 2.2 million gallons. The tank was built in the late 1800s. It supplies water to the Hale Zone.

Upper Hale

The Upper Hale tank is a cylindrical, concrete tank with a capacity of 200,000 gallons. The tank was built in 1994 and supplies water to the Upper Hale Zone.

Winne No. 1

The Winne No. 1 tank is a cylindrical, welded steel tank with a capacity of 500,000 gallons. The tank was built in 1972 and supplies water to the Winne Zone.

Winne No. 2

The Winne No. 2 tank is a cylindrical, welded steel tank with a capacity of 600,000 gallons. The tank was built in 1985 and supplies water to the Winne Zone. The low water level (LWL) in Winne Tank 2 is 4.5 feet lower than Winne Tank 1. Since there is a difference in LWL between the two tanks, the bottom 4.5 feet of Winne Tank 2 can only be used if Winne Tank 1 is empty.

West Side (Forrest Estates)

The West Side (Forrest Estates) tank was originally built in 2008 as a cylindrical, riveted steel tank with a capacity of 500,000 gallons. During the summer of 2020, the original tank was replaced with a new 500,000 gallon, on-grade, prestressed concrete tank. The tank supplies water to the West Side (Forrest Estates) Zone.

Woolston No. 1

The Woolston No. 1 tank is a rectangular, masonry tank with a capacity of 3.1 million gallons. The tank was built in the late 1800s and is no longer in service.

Woolston No. 2

The Woolston No. 2 tank is a cylindrical, concrete tank with a capacity of 3.0 million gallons. The tank was built in the early 1930s and supplies water to the Malben High Zone.

Ten Mile WTP Clearwell

The Ten Mile WTP Clearwell is a concrete, below-grade basin with a volume of 6.0 million gallons. The original clearwell was constructed around 1931 and a geomembrane liner was installed in 2015.

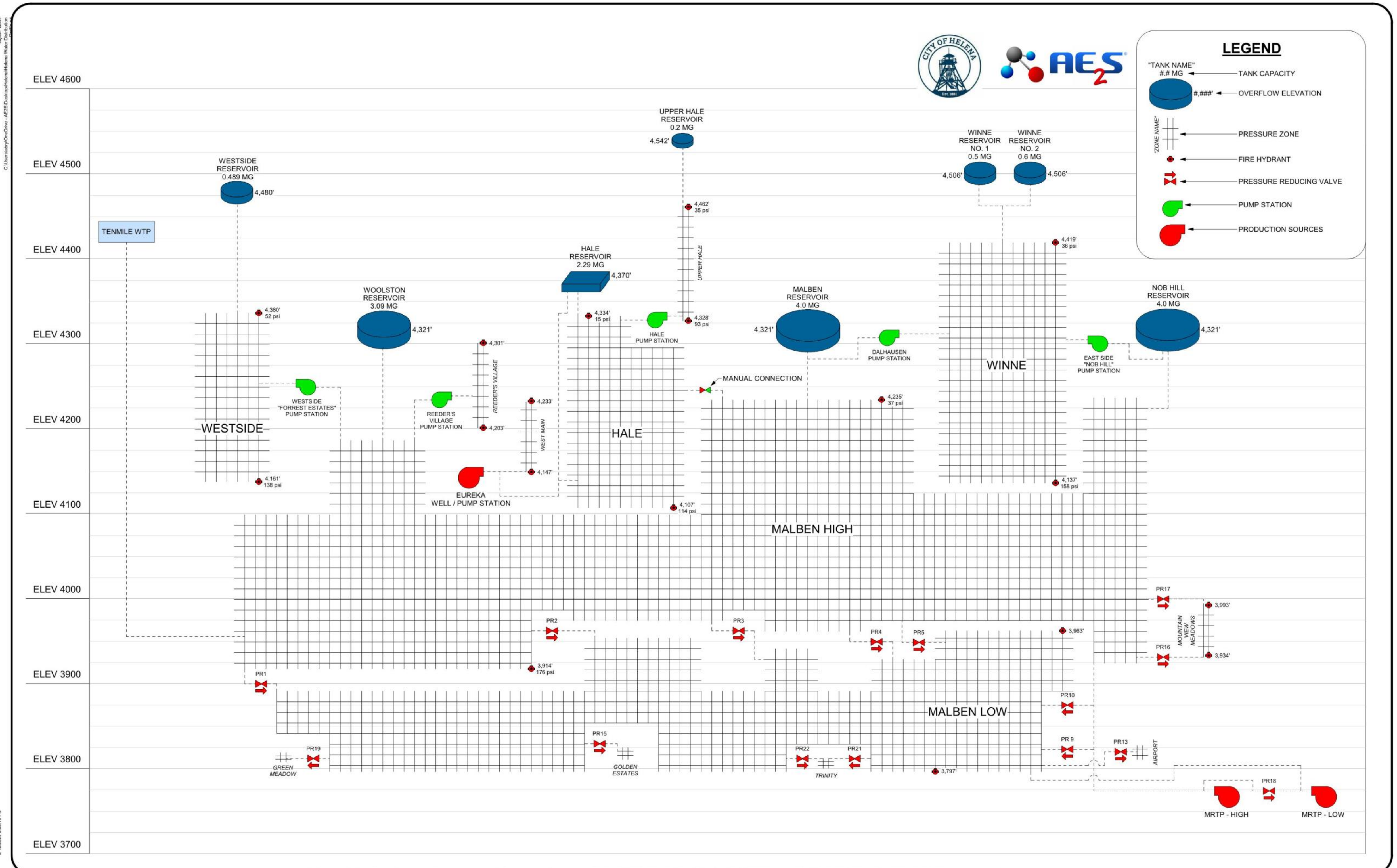


Figure 1 – Existing System Hydraulic Grade Profile

STORAGE NEEDS

There are several approaches to determine the necessary storage for a water system. The first approach is to meet the storage requirements in Circular DEQ-1. Based on Section 7.0.1, the minimum storage is equal to the average day demand plus fire flow demand. From an overall perspective, the average day demand is about 5.6 MGD. The fire flow demands vary from 210,000 gallons (1750 gpm for two hours) to 675,000 gallons (3750 gpm for 3 hours). Total storage of about 6.3 million gallons (5.6 MG + 0.675 MG) would meet the requirements of DEQ-1. The existing storage of 15.0 million gallons substantially exceeds this value.

The same approach can be used to look at each pressure zone. However, the pressure zones are not completely independent, so the analysis needs to look at all the zones and how they interact.

A second approach to determine the necessary storage recommends that the total amount of storage be equal to 65% of the maximum day demand (15% for equalization and 50% for emergency) plus fire flow demands. With a current maximum day demand of 15.2 MGD and maximum fire flow storage of 675,000 gallons, the total storage required to meet these criteria is about 10.6 million gallons (65% of 15.2 MG + 0.675 MG), which is still significantly less than the existing storage. This approach will be referred to as the MDD approach in this Technical Memorandum.

Another approach to determine the necessary storage is a discussion with the system owner. Sometimes the minimum storage requirements of DEQ-1 are met, but the owner has specified operational issues related to storage. The City of Helena has identified three issues related to storage:

- The Woolston Reservoir remains full most of the time due to the operation of the existing altitude valve. This tends to create stale water, which is only used during periods of high demands.
- The Dalhausen Pump Station requires that the Malben Tank maintain at least an 8-foot water depth to reduce cavitation. This limits the ability of the Malben Tank to provide storage for the Winne Zone.
- No storage is currently available to serve the Reeder's Village Zone. Use of the existing Reeder's Village Pump Station provides access to storage in Malben High Zone.

Each of these items will be addressed in more detail in this Technical Memorandum.

Upper Hale Pressure Zone

The Upper Hale Zone is served by the Upper Hale Tank, which has a capacity of 200,000 gallons. The average day demand is about 10,000 gallons per day, and the maximum day demand is about 17,000 gallons per day. The pressure zone is primarily residential, so the fire flow would be in the range of 210,000 gallons (1,750 gpm for 2 hours). The Upper Hale pump station can also provide about 80 gpm during peak flow conditions, which would slightly reduce the total fire flow storage requirements. The required storage based on DEQ-1 requirements would be about 220,000 gallons (10,000 gallons of storage for average day demand and 210,000 gallons of fire storage), and the required storage based on the MDD approach would be about 221,000 gallons (65% of 17,000 gpd maximum day demand plus 210,000 gallons of fire storage). This zone appears to almost meet the storage requirements based on either DEQ-1 or the MDD approach. The Upper Hale Tank has an average water age of about 20 days, based on full capacity and average day demand. This is not uncommon for a system that serves a small population and provides fire flow storage but can create some water quality issues.

Hale Pressure Zone

The Hale Zone is served by the Hale Tank, which has a capacity of 2,200,000 gallons. The average day demand is about 219,000 gallons per day, and the maximum day demand is about 376,000 gallons per day. The pressure zone is primarily residential, but there are some commercial buildings, so the fire flow would likely be in the range of 540,000 gallons (3,000 gpm for 3 hours). The Hale Zone is also served by the Eureka pump station, which can provide about 400 gpm during peak flow conditions, which would reduce the total fire flow storage requirements. The required storage based on DEQ-1 requirements would be about 759,000 gallons (219,000 gallons of storage for average day demand and 540,000 gallons of fire flow storage), and the required storage based on the MDD approach would be about 784,000 gallons (65% of 376,000 gpd maximum day demand plus 540,000 gallons of fire storage). This zone appears to have more than adequate storage to meet the storage requirements based on either DEQ-1 or the MDD approach. The Hale Tank has an average water age of about 10 days, based on full capacity and average day demand, which can create some water quality issues. The Hale Zone can serve the Malben High Zone, but only by operating a manual valve.

West Main Street Pressure Zone

About 2,400 feet of water main along West Main Street, southwest of the Eureka Pump Station, is served directly by the Eureka Pump Station. The estimated average day demand for this small zone is about 10,000 gpd, and the estimated maximum day demand is about 17,000 gpd. No storage is currently available for this zone. The Eureka Pump Station must continually run to maintain pressure to the West Main Street pressure zone.

Reeder's Village Pressure Zone

Reeder's Village Zone is served only by the Reeder's Village Pump Station. This pressure zone has an average day demand of about 37,000 gallons per day, and the maximum day demand is about 77,000 gallons per day. The Reeder's Village Pump Station has a fire pump that has a capacity of 1,750 gpm. This zone is residential, so the fire flow storage is likely 1,750 gpm for two hours or about 210,000 gallons. The required storage based on DEQ-1 requirements would be about 247,000 gallons (37,000 gallons of storage for average day demand and 210,000 gallons of fire flow storage), and the required storage based on the MDD approach would be about 260,000 gallons (65% of 77,000 gpd maximum day demand plus 210,000 gallons of fire storage). The Reeder's Village Pump Station takes water from the Malben High Zone, so the Malben Tank functionally provides storage for the Reeder's Village Zone and provides adequate storage for this zone. The pressure in this zone is maintained by the pump station, and if the pump fails, the zone loses pressure.

West Side (Forrest Estates) Pressure Zone

This zone is served by the West Side Tank, which has a capacity of 500,000 gallons. The average day demand is about 76,000 gallons per day, and the maximum day demand is about 185,000 gallons per day. The pressure zone is entirely residential, so the fire flow would be in the range of 210,000 gallons (1,750 gpm for two hours). The required storage based on DEQ-1 requirements would be about 286,000 gallons (76,000 gallons of storage for average day demand and 210,000 gallons of fire flow storage), and the required storage based on the MDD approach would be about 330,000 gallons (65% of 185,000 gpd maximum day demand plus 210,000 gallons of fire storage). This zone appears to have more than adequate storage to meet the storage requirements based on either DEQ-1 or the MDD approach. The Forrest Estates pump station can also provide about 530 gpm during peak flow conditions, which would reduce the total fire flow storage requirements. The West Side Tank has an average water age of about 7 days, based on full capacity and average day demand.

Winne Pressure Zone

The Winne Zone is served by the Winne Tanks, which have a combined capacity of 1,100,000 gallons. The average day demand is about 462,000 gallons per day, and the maximum day demand is about 1,198,000 gallons per day. The pressure zone is primarily residential but does include the Touchmark Assisted Living Facility. The fire flow storage requirement is 670,000 gallons (3750 gpm for three hours). The required storage based on DEQ-1 requirements would be about 1,132,000 gallons (462,000 gallons for average day demand plus 670,000 gallons for fire storage), and the required storage based on the MDD approach would be about 1,449,000 gallons (65% of 1,198,000 gallons of maximum day demand plus 670,000 gallons of fire storage).

This zone does not appear to have adequate storage to meet the storage requirements based on either DEQ-1 or the MDD approach. However, there are two pump stations (Dalhausen and Nob Hill) that serve this zone, so these pump stations would functionally reduce the required fire flow storage. The Dalhausen pump station has a firm capacity of 1,000 gpm, and the Nob Hill pump station has a firm capacity of 900 gpm. Including the capacity of the two pump stations and corresponding storage facilities, this zone has adequate storage capacity. The Winne Tanks have an average water age of about 2 days, based on full capacity and average day demand.

Malben High and Malben Low Pressure Zones

The Malben High and Low Zones are served by the Nob Hill Tank, which has a capacity of 4,000,000 gallons by the Malben Tank, which has a capacity of 4,000,000 gallons, and by the Woolston No. 2 Tank, which has a capacity of 3,000,000 gallons. The usable capacity of the Malben Tank to serve the Winne Zone is somewhat limited by the ability of the Dalhausen Pump Station to remain in operation. The Nob Hill Pump Station can still serve the Winne Zone when the water level in the Malben Tank is low, and the Malben Tank can indirectly serve the Nob Hill Pump Station via the Nob Hill Tank. The Malben Tank only has a usable capacity of 2,700,000 gallons for the Winne Zone, considering the limitation of the Dalhausen Pump Station. However, this only limits the ability of the Malben Tank to serve the Winne Pressure Zone. It can still serve the Malben High Zone even when the water level drops below the level needed to operate the Dalhausen Pump Station. The average day demand for the Malben High Zone is about 3,446,000 gallons per day and for the Malben Low Zone is about 1,293,000 gallons per day, for a combined demand of about 4,739,000 gallons per day. The maximum day demand for these two zones is about 12,931,000 gallons per day. These zones have a large number of commercial buildings, so the fire flow storage requirement is likely to be 3750 gpm for three hours or 670,000 gallons.

The Malben Low Pressure Zone is separated from the Malben High Pressure Zone at eight locations by pressure reducing valves. The pressure in the Malben Low Zone is determined by the setting on these valves. With the extensive looping in both Malben Zones, the storage in the Malben High Zone also provides storage for the Malben Low Zone.

The required storage based on DEQ-1 requirements would be about 5,409,000 gallons (4,739,000 gallons for average day demand plus 670,000 gallons for fire storage), and the required storage based on the MDD approach would be about 9,075,000 gallons (65% of 12,931,000 gallons of maximum day demand plus 670,000 gallons of fire storage). With the full capacity of the Malben Tank and the Woolston No. 2 Tank, this zone has about 11.0 MG of storage, which meets the DEQ-1 requirements and the requirements based on the MDD approach.

Valley Pressure Zone

The Valley Zone is a small zone on the north edge of the City. Based on the hydraulic model, it currently consists of only an area at the north end of Benton Avenue, just east of Green Meadow Drive. The average day demand for this zone is about 106,000 gallons per day, and the maximum day demand is about 399,000 gallons per day. The pressure zone is currently all residential, so the fire flow storage requirement would likely be about 210,000 gallons. The City has indicated that this zone may expand to include additional areas north of Custer Avenue. This zone is separated from the Malben Low Pressure Zone by a single pressure reducing valve, so storage for this zone is provided by the Malben Tanks. The required storage based on DEQ-1 requirements would be about 316,000 gallons (106,000 gallons for average day demand plus 210,000 gallons for fire storage), and the required storage based on the MDD approach would be about 469,000 gallons (65% of 399,000 gallons of maximum day demand plus 210,000 gallons of fire storage).

Summary of Existing Storage Needs

Table 2 provides a summary of the storage requirements of each pressure zone.

Table 2 – Existing Storage Requirements

Pressure Zone	Required Storage, DEQ-1 (MG)	Required Storage, MDD Approach (MG)	Current Storage MG
Malben (High and Low)	5.409	9.075	11.0
Winne	1.132	1.449	1.1
Hale	0.759	0.784	2.2
Upper Hale	0.220	0.221	0.2
Reeder's Village	0.247	0.260	*
Forrest Estates	0.286	0.330	0.5
Valley	0.316	0.469	*

** Storage included in the Malben Tank*

The total storage requirements for the Malben Zones include Reeder's Village and the Valley Zone, although the requirements for fire flow storage for these zones can be combined with the fire flow storage in the Malben Zones. The total storage requirement for the Malben Zones is therefore 5.552 MG (5.409 + 0.037 + 0.106) based on the DEQ-1 requirements and 9.384 MG (9.075 + 0.050 + 0.259) based on the MDD approach.

New Storage Requirements

Based on the summary in Table 2, the only zone that requires additional storage based on the DEQ-1 requirements could be the Winne Zone, especially if the demands for this zone increase. However, the storage for the Winne Zone is supplemented by storage in the Malben High Zone in conjunction with two pump stations, so additional storage for the Winne Zone is not recommended. Storage to serve the Reeder's Village Zone could reduce or eliminate the need for the Reeder's Village Pump Station. Providing storage for the West Main Street Zone is also recommended.

This analysis indicates that the overall City of Helena Water System has adequate storage capacity if all the existing tanks can be used more effectively. Some additional storage could be considered to provide fire flows for Reeder's Village without the use of the fire pump at the Reeder's Village Pump Station and to provide service to the West Main Street Zone when the Eureka Pump Station is not running.

OPERATIONAL MODIFICATIONS

The potential for changes in the method of operation of the existing tanks could provide more effective use of these tanks. Some of these changes will require the construction of additional components of the system, as identified in the following discussion.

Woolston Reservoirs Operation

There are two Woolston Reservoirs. Woolston No. 1 is a partially buried, rectangular-shaped tank. It was taken out of service due to excessive leakage. Woolston No. 2 is a partially buried, cylindrical reservoir with a reported capacity of 3.1 million gallons. Water from the Ten Mile supply pipeline flows into the Woolston Reservoirs by gravity. An altitude valve at the inlet terminates flow when the reservoir is full.

The head range on Woolston No. 2 is 4,300 feet to 4,320 feet, based on the hydraulic model. The hydraulic model indicates the head in the system at the reservoir varies from about 4,318 feet to 4,321 feet during average day demand conditions. These values match the field observations that the Woolston Reservoir will fill but will not fluctuate noticeably during normal demand conditions. The altitude valve controlling the flow into the Woolston tank does not permit the water in the Woolston tank to be used until the water level in the Malben, and Nob Hill tanks drop below 19 feet. Since the water levels in the Malben and Nob Hill tanks are frequently above 20 ft, the Woolston tank is often poorly engaged.

The overflow of the Woolston No. 2 Reservoir (4,320 feet) is essentially the same as the overflow for the Malben Tank (4,321 feet) and the Nob Hill Tank (4,323 feet). With three tanks having essentially the same overflow elevation, the hydraulics of the supply and demand dictate which tanks fill and empty routinely unless control valves are used to modify the operation. Based on the hydraulic model, the Woolston No. 2 Reservoir does not fluctuate very much during either average winter or peak day demand conditions with the current hydraulic and control configuration. Different operations in the summer and winter can be implemented to allow the Woolston tank to fluctuate better year-round.

Woolston Summer Operation

During the summer months, one modification to the existing system was considered that could allow for more effective use of the Woolston No. 2 Reservoir. This modification would require a change in the control sequence for the Malben High Zone. The altitude valve at the Woolston Reservoir and the hydraulics of the distribution system limit the ability of this tank to effectively float with the hydraulic grade line of the Malben High Zone, so the tank tends to fill and remain mostly full. The addition of more controls for the altitude valve, either hydraulic controls or electric controls, would allow more flexibility in the operation. If the altitude valve is appropriately modified and the control sequence is modified as follows, the Woolston Tank could be used much more effectively:

1. When all three tanks (Woolston, Malben, and Nob Hill) are full, the butterfly valve at Nob Hill is closed, and flow from the treatment facilities is limited as much as possible to meet demands. This allows the Woolston and Malben Tanks to feed the Malben High Zone and the Nob Hill Pump Station to feed the Winne Zone.

2. When water levels in the Woolston Tank drop to a pre-set level (60% to 70% full), flow from the treatment facilities is increased until the Woolston Tank re-fills.

3. If water levels in the Nob Hill Tank drop below a pre-set level (60% to 70% full), the butterfly valve at Nob Hill is opened. This valve remains open until the Nob Hill Tank is re-filled.

This is a very simplified version of the operating sequence but should convey the basic concept, which is to allow the Woolston Reservoir to fluctuate more effectively by closing the Nob Hill tank more often and using the level at the Woolston Reservoir to modulate flow into the Malben High Zone from the treatment facilities.

This option was analyzed using the hydraulic model to determine if it would provide fluctuation of all three tanks. There are many possible iterations of this scenario that could be implemented.

Figure 2 shows the fluctuations in the three tanks based on the existing control scenario modeled during peak day demands. The Nob Hill Tank varies from about 78% full to 88% full, while the Malben Tank varies from about 73% full to 76% full. There is no variation in the Woolston Tank, matching the current conditions. If the lower 8 feet of the Malben Tank is available for regular use based on current operating procedures, then 8 MG of capacity is currently available.

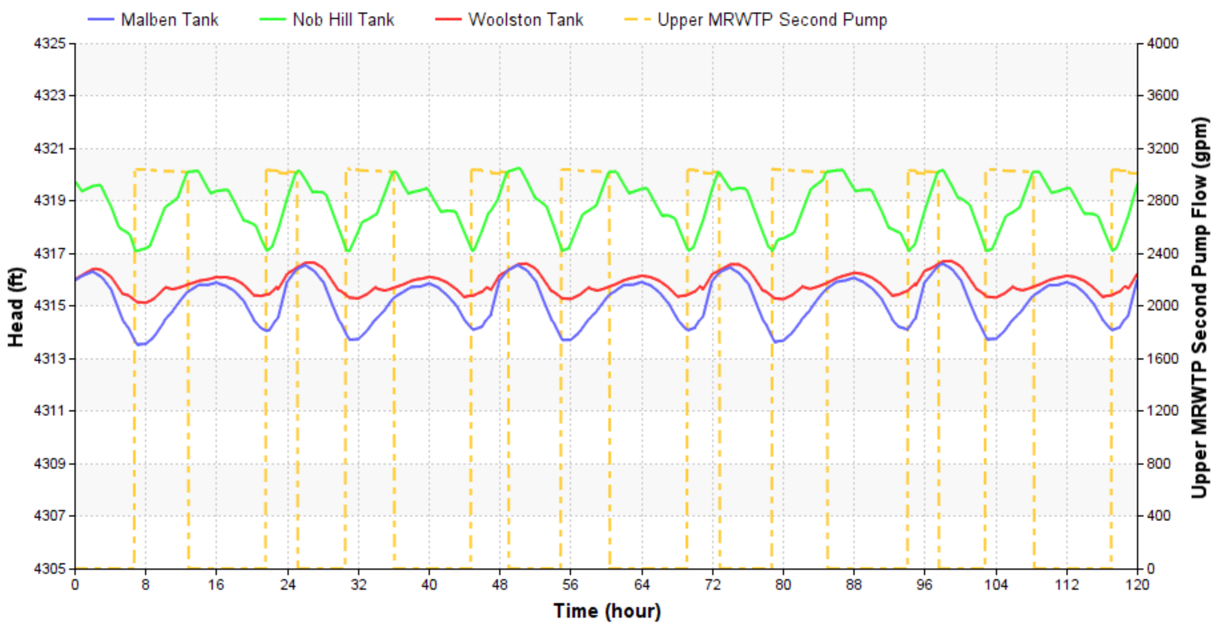


Figure 2 – Storage Tank Fluctuations, Existing Conditions – Summer Demands

A scenario was modeled, which modified the controls to include control valves at each tank and revised the controls for the TMTP and MRTP such that they were based on water levels in the Woolston Reservoir. Figure 3 shows the fluctuations in the three tanks based on this scenario during peak day demand conditions.

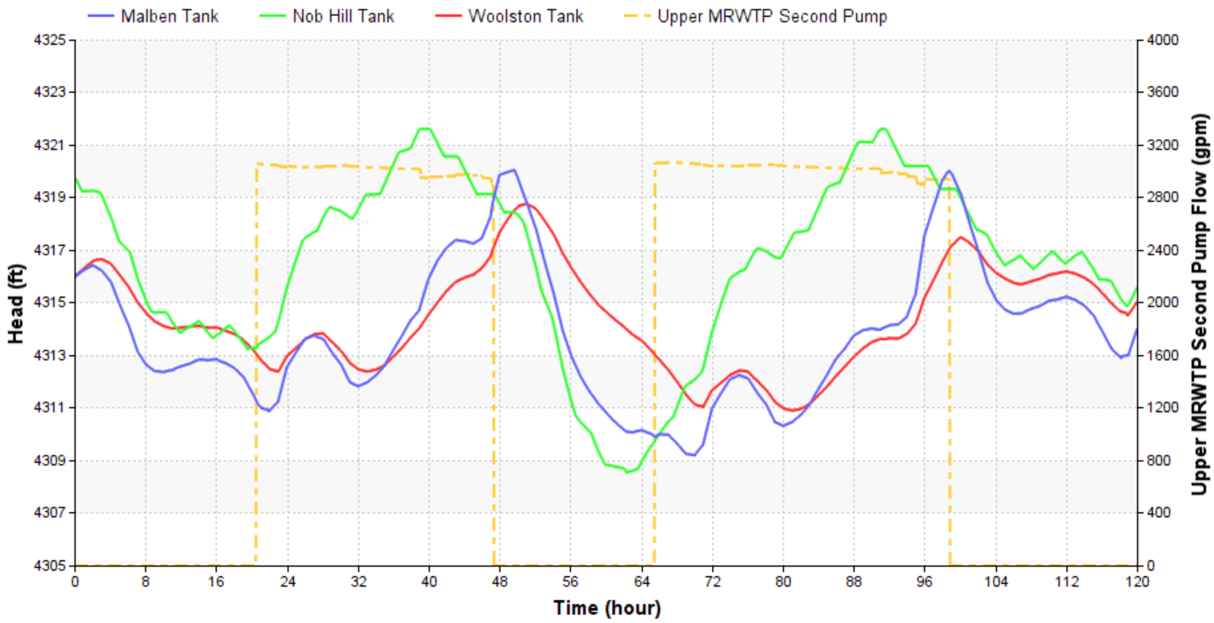


Figure 3 – Storage Tank Fluctuations, Proposed Conditions – Summer Demands

This scenario provides adequate fluctuations in all three tanks, but water levels in the Malben and Nob Hill tanks drop to lower levels than under the existing control scenario. Based on the hydraulic model, the Nob Hill tank drops to about 70% of capacity, the Malben tank to about 60% of capacity, and the Woolston Reservoir to about 65% of capacity. The Woolston Reservoir fluctuates from about 65% full to 90% full, so water age should not be a significant issue with this operational scenario.

This analysis indicates that the Woolston Reservoir could become a more functional part of the water system through revised operating conditions and installation of some additional controls for the altitude valve. The full capacity of all three tanks should generally be available, which would significantly increase the overall storage capacity of the system.

Woolston Winter Operations

During the winter months, the tanks are not likely to fluctuate much when there is a near-constant 24-hour flow from the Ten Mile Water Treatment Plant (TMTP). The lack of fluctuation in the tanks is primarily due to the smaller demands relative to the total volume of storage. Winter demands vary from 2-4 MGD, and the total storage volume for the Malben, Nob Hill, and Woolston tanks is about 12 MG. Figure 4 shows how the tank levels may trend over a period of several days with the output from the TMTP (yellow dashed line) equal to the average winter demand used for the simulation (3.25 MGD). The tanks naturally float closer together in the winter since there is less headloss across the system. However, the Malben and Nob Hill tanks only fluctuate about 2 feet, while the Woolston tank only fluctuates about 1 ft.

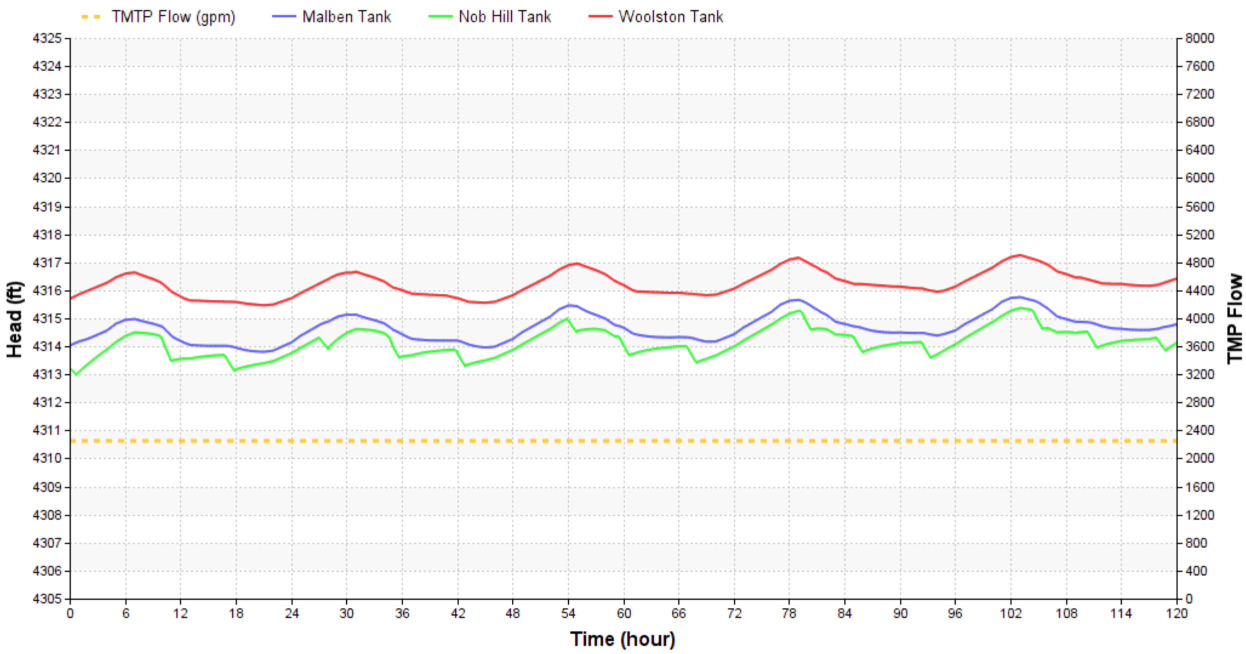


Figure 4 – Storage Tank Fluctuations, Existing Conditions – Winter Conditions

An alternative method for increasing the turnover rate in the Woolston and other tanks in the Malben zone would be to modulate the amount of water that enters and leaves the Woolston, Nob Hill, and Malben Tanks through the use of a remotely-operated solenoid control valve. Figure 5 provides an example of modulating the flow into the Malben tank downstream of where the Dalhausen pump station draws water. Under this scenario, once the Malben tank is mostly full, the solenoid control valve closes and does not allow water to flow into the Malben tank. Water is still able to leave the Malben tank to feed the Dalhausen pump station. After the Dalhausen pump station draws the Malben tank down to about 12 ft, the solenoid control valve opens, and the Malben tank fills. Depending on which treatment plant is producing water, or which Winne Zone pump station is used, a similar control system could be done for the operations of the Eastside pump station and the Nob Hill Tank. Once nearly full, a solenoid control valve would prohibit flow into the Nob Hill Tank, and the Eastside pump station would draw water from the Nob Hill Tank until the level in the Nob Hill tank drops to about 12 feet. At this level, the solenoid control valve would open and allow the Nob Hill tank to fill. For both Winne Zone pumping cases, the solenoid control valve for the pump station not in operation would remain open. A solenoid control valve could also be installed on the Woolston tank to modulate better the flow that enters and leaves this tank as well. However, under the two control scenarios described, the flow control for the Woolston tank would only be used to restrict flow into the Woolston tank if the level exceeded a maximum set point.

A remote solenoid controlled valve is already installed on the line filling the Nob Hill Tank. The use of this valve and the installation of other similar remote controlled solenoid valves on the lines connecting the Malben Zone tanks would allow for better control of water age.

Additionally, the control valve at Baxendale (on the outfall main from TMTP) could be automated as well to allow periodic flow modulations to further fluctuate the Woolston, Malben, and Nob Hill tanks beyond what is shown in Figure 5. Implementing these changes would allow the Malben and Nob Hill tanks to fluctuate 4-5 feet compared to 2 feet and the Woolston tank to fluctuate about 4 feet compared to 1 foot in the average existing winter demand system.

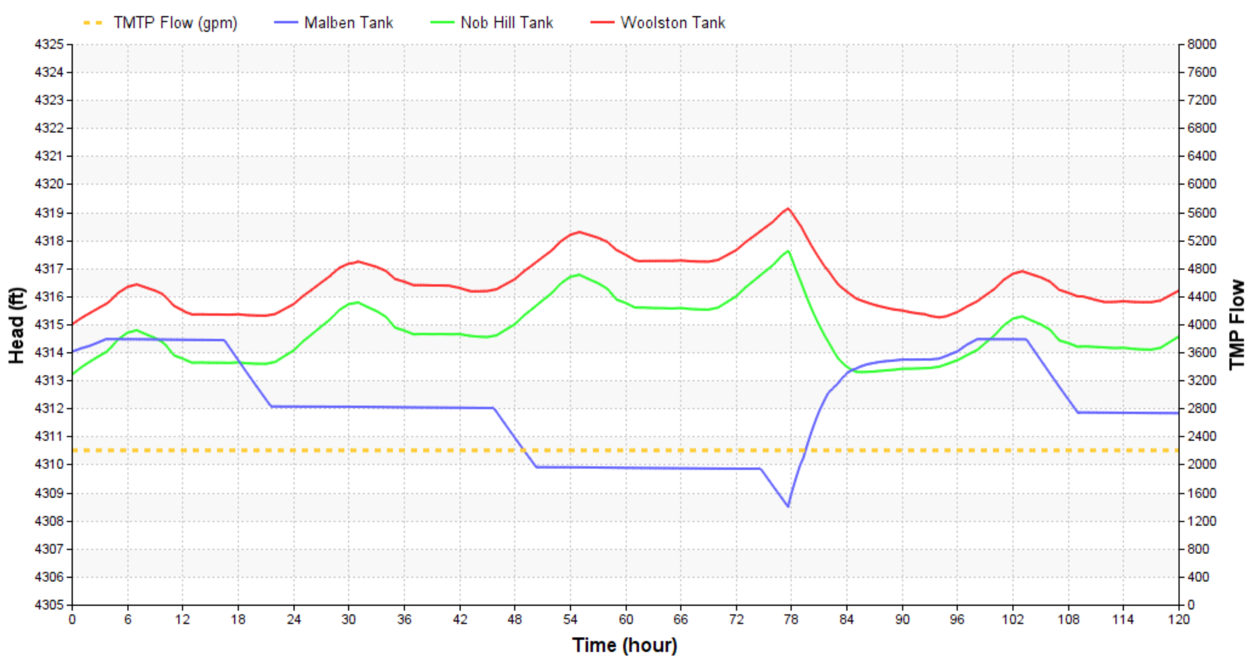


Figure 5 – Storage Tank Fluctuations, Proposed Conditions – Winter Conditions

Hale Tank Operation

The Hale Tank has a storage capacity of 2.2 MG, but the Hale and Upper Hale Pressure Zones only have storage needs of about 0.90 to 1.1 MG. This tank is at an elevation higher than the Malben High Zone, so it can be used to supplement the demands in both Malben Zones.

Based on the information provided by the City of Helena, the distribution system piping configuration includes a small diameter pipe and a closed valve that separate the Hale Zone and the Malben High Zone. The closed valve was originally at the intersection of Miller and Warren, but a valve near the Lewis and Clark Library is now closed, separating these two zones. The valve must be manually opened in order to supplement the Malben High Zone from the Hale Tank.

The City has a project currently under design to be bid soon, which will replace this manual valve with a remote-controlled valve. This will allow the system operators to more effectively use the excess storage and supply in the Hale Pressure Zone.

The supply for the Hale Pressure Zone has a capacity of about 0.85 MGD. The average day demand is only about 30% of that value, so there is additional supply capacity in the Hale Supply System that is not required to serve the Hale and Upper Hale Pressure Zones. About 1.1 MG of the storage capacity of the Hale Tank could be allocated to use in the Malben High Pressure Zone.

Malben Tank/Dalhausen Pump Station Operation

The Malben Tank has a capacity of 4,000,000 gallons. Information from the City indicates if the water level in the Malben Tank drops below 8 feet of depth, the Dalhausen Pump Station, which takes suction from this tank, experiences significant suction head problems and causes the pumps to lose flow and cavitate. Therefore, the current usable capacity of the Malben Tank to provide service to the Winne Zone is only about 2,700,000 gallons. The existing pumps are all split case and include two 70-HP pumps

An evaluation of this pump station is beyond the scope of this project. However, it is possible that modifications to this pump station could lower the minimum head requirements for the pump station. The modifications would likely include replacement of the pumps and pipe size changes where practical. This would make more of the storage capacity of the Malben Tank available for service to the Winne Zone.

The current operation of this pump station is to primarily use the Nob Hill Pump Station when the Missouri River Water Treatment Plant is operating (generally during the summer) and use the Dalhausen Pump Station when only the Ten Mile Water Treatment Plant is operating (generally during the winter). The peak day demand for the Winne Zone is about 760 gpm. Each pump in the Nob Hill Pump Station has a capacity of about 900 gpm, so the peak day demand for the Winne Zone can be met with just the Nob Hill Pump Station. If the Malben Tank was allowed to fluctuate below 8 feet, the entire tank would be available for operational purposes, increasing the available storage for the Malben Zones. Based on conversations with City personnel, this is how the Winne Zone is currently operated, so it would appear reasonable to consider the entire volume of the Malben Tank as available for use during periods of high demands.

POTENTIAL TANK SITES

Scott Water Tank Site

A Site Evaluation Report was completed in 2017 for a potential water tank site located on property owned by Lee and Patti Scott ("Site Evaluation Report, Scott Water Tank Site," November 7, 2017, by DOWL). The site is south of the West Main Street area, above Grizzly Gulch Drive. The 2017 report reviewed a tank with a capacity of 1,250,000 gallons.

The concept presented in the Site Evaluation Report is to install new pumps in the Eureka Pump Station and pump to this new tank. The pressure at the pump station discharge was estimated to be about 226 psi to serve this proposed tank with a static pressure of about 210 psi. This compares to the current pump station discharge pressure of about 100 psi to pump to the Hale Reservoir. The ground elevation at the Eureka Pump Station is about 4,144 feet.

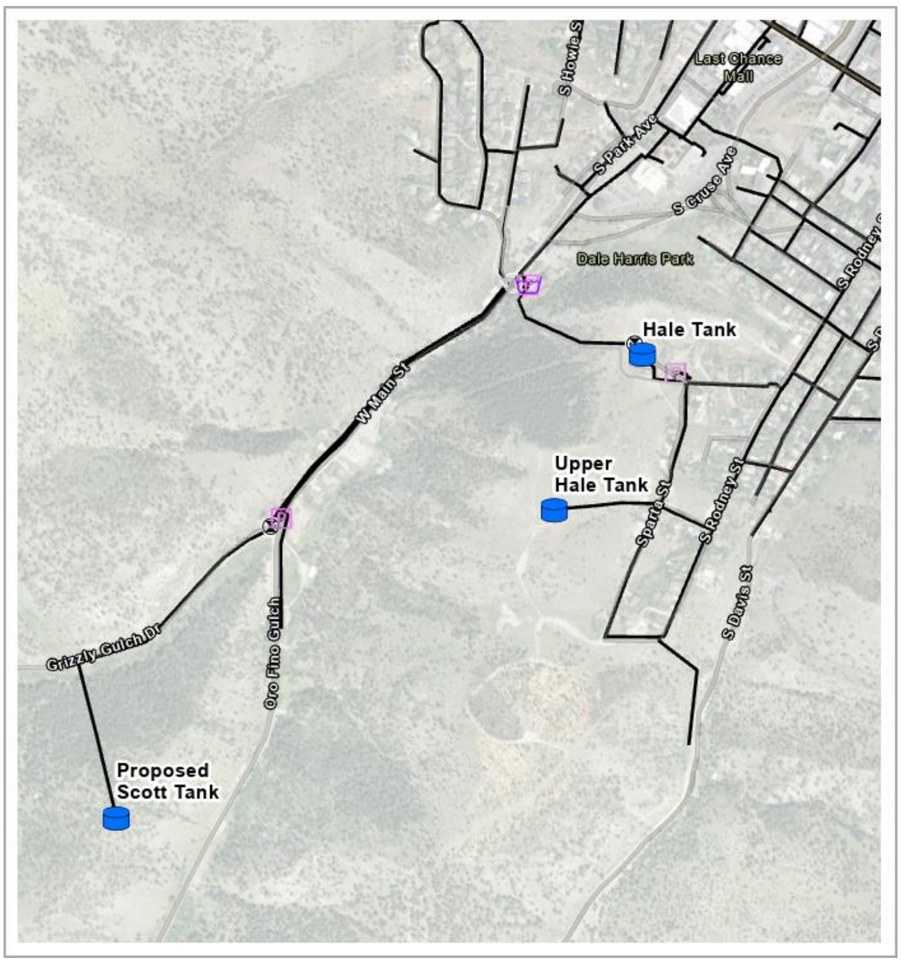


Figure 6 – Scott Tank Site

The concept proposed for the Scott Tank is to connect to the West Main Street area through a pressure reducing valve and potentially connect to the Reeder's Village Pressure Zone and the Hale Pressure Zone using pressure reducing valves. The Upper Hale Reservoir currently provides 200,000 gallons of storage, and the Hale Reservoir provides 2,200,000 gallons of storage. The Hale and the Upper Hale Pressure Zones have adequate storage, so the primary advantage of this site would be to provide storage for the Reeder's Village Area and the West Main Street Zone. The total average day demand for the Reeder's Village Zone is about 37,000 gpd, and the West Main Street Zone is about 5,000 gpd. The maximum fire flow demand in this zone is 315,000 gallons, so the minimum storage requirement would be 357,000 gallons based on DEQ-1 Standards.

The Scott Tank site has an approximate ground elevation of 4,580 feet, so the overflow would be about 4,600 feet. The HGL in the West Main Street area is currently about 4,380, and the existing pressures are in the range of 60 to 100 psi. The HGL for the Hale Pressure Zone is about 4,378 feet. The HGL in the Reeder's Village Pressure Zone is about 4,468 feet, and this results in pressures in the range of 80 psi to 115 psi.

The Scott Tank would be located at an elevation of about 130 to 200 feet higher than the HGL for the Reeder's Village pressure zone. This does not eliminate this location as a possible site, but it will result in more energy required to pump the water to a higher elevation than necessary to provide service to West Main Street and Reeder's Village. A storage tank at this site would improve the fire storage for the Reeder's Village Pressure Zone, which is currently dependent on the fire pumps in the Reeder's Village pump station. The site evaluation indicated that the site was suitable for the construction of a water tank and associated access road and transmission pipeline. The 2017 report by DOWL contains more detailed information.

If a new tank is constructed at the Scott site, a new water transmission main from the Eureka Pump Station to the tank site will also be required. Based on the 2017 report, this transmission line would be about 7,100 feet long. About 2,700 feet of 12-inch diameter pipe was recently installed as part of a reconstruction project on West Main Street. This pipe is not yet in service but was installed to provide additional service to West Main Street and a future storage tank. The 2017 report appears to recommend an 8-inch diameter pipe, which would have a velocity of about 2.6 feet per second, which is a reasonable velocity for a transmission main. Based on the geotechnical information provided, it would appear that the construction of this water main would encounter some bedrock between West Main Street and the Tank Site. A new tank at the Scott site would require new, larger pumps in the Eureka Well because this tank would have an overflow about 200 feet higher than the existing Hale Tank. This extra pressure would need to be reduced for the pipeline going to the Hale Tank, resulting in lost energy and increased pumping costs.

The 2017 report indicated an estimated total project cost of $3,768,000 for a concrete tank. Adding a 2% per year inflation factor to this estimate, the 2020 estimated total project cost of $4,000,000 for a 1.25 MG tank.

A new tank at the Scott site would also allow for a modified operation of the Eureka Pump Station. This pump station currently runs continuously, which is currently necessary to pressurize the West Main Street Pressure Zone. Providing storage for the West Main Street Pressure Zone would eliminate the need for continuous operation. However, eliminating continuous operation would also require some changes to the distribution system adjacent to the Eureka Pump Station. There is a section of existing ductile iron pipe adjacent to the Eureka Pump Station that is above ground (see Figure 7). This pipe does not freeze in the winter because the Eureka Pump Station runs continuously. If a new tank is constructed to serve the West Main Street Zone and allow the pump station to operate intermittently, this pipeline would need to be replaced, and adequate cover would need to be provided to prevent freezing. As an alternative to replacing this pipe, the Eureka Pump Station could be allowed to continue to operate continuously, once the current project to provide a connection is made between the Hale Zone and the Malben High Zone. This connection would allow flow from the Hale Tank into the Malben High Zone during most operating conditions so that the Hale Tank doesn't overflow, and this exposed pipe doesn't freeze. This connection has been designed and will be bid and constructed in 2020.

Figure 7 – Existing Above Ground Ductile Iron Pipe

Upper Hale Tank Site Expansion

Another possible location for a higher elevation tank is adjacent to the existing Upper Hale Tank. The existing overflow for the Upper Hale Tank is about elevation 4,544 feet. The maximum HGL for the Reeder's Village area is elevation 4,505 feet, so the Upper Hale Tank could serve the Reeder's Village area. The existing Upper Hale Tank has a capacity of about 200,000 gallons. The combined average daily flow for the Upper Hale Zone, the Reeder's Village Zone, and the West Main Street Zone is about 52,000 gallons per day, and the maximum day demand is about 135,000 gallons per day. The fire flow storage requirement for the Reeder's Village Zone is 210,000 gallons. Therefore, the combined storage requirement would be about 262,000 gallons based on DEQ-1 requirements (52,000 gallons of average day demand plus 210,000 gallons of fire storage) and about 298,000 gallons based on the MDD approach (65% of 135,000 peak day demand plus 210,000 gallons of fire storage).

If the existing Upper Hale Tank was connected to the Reeder's Village area, it could provide regular service to this area, eliminating the need to operate the Reeder's Village Booster Pump station. The distance from the Upper Hale Zone to the Reeder's Village area is about 2,000 feet along the alignment of the current water mains from the Upper Hale Zone to West Main Street. Construction of a pipeline along this alignment is anticipated to encounter bedrock, although no geotechnical exploration has been completed. An alternate route from the Upper Hale Tank more directly to West Main Street was investigated. Due to the depth of the Upper Hale Tank, a pipeline directly west towards West Main Street or south and then west towards West Main Street would be at least 20 feet deep for a portion of the alignment. There is also no obvious path to follow from the Upper Hale Tank to West Main Street. An alignment that extends northerly from the Upper Hale Tank towards the Hale Tank would not need to be as deep, but this line would need to extend to within about 600 feet of the Hale Tank before it could reasonably turn westerly towards West Main Street. An alignment following the existing pipeline from the Eureka Pump Station to the Hale Tank appears to be the shortest and most effective alignment.

Construction of a new pipeline and a pressure reducing valve would allow the Upper Hale Zone to feed the Reeder's Village Zone. Construction of a new ground storage tank adjacent to the existing tank would increase the storage capacity to meet the requirements of the Upper Hale and Reeder's Village Zones. A second tank with a capacity of at least 200,000 gallons would meet the requirements. The existing Upper Hale Tank is on property owned by the Bureau of Land Management, and the pipeline from the tank to the rest of the distribution system is on a public right-of-way, so it should be possible to obtain the necessary easement for a new tank.

This option is included as projects W-ST-02 and W-ST-03 in the Capital Improvements Plan Technical Memorandum. The opinion of probable cost for these two projects is about $2,488,000. More details on this estimate are provided in the CIP Memorandum.

This option appears to be more desirable than the Scott Property option. This option could use the existing pressures from the Eureka Pump Station (even if new pumps are installed). This option could be constructed in two projects. The first project would be the water line from Eureka Pump Station to the Hale Pump Station and connections to West Main and Reeder's Village. This would allow the use of the Upper Hale Tank to serve the West Main and Reeder's Village zones, eliminating the need for the Reeder's Village Pump Station. The second project would be the construction of the second tank at the Upper Hale Tank site, increasing the available storage. This scenario would reduce the time needed to upgrade the storage for the West Main Street and Reeder's Village zones by reducing the magnitude of the investment required. Connection to the Upper Hale zone, in addition to the West Main and Reeder's Village zones, would also reduce potential problems with water age.

Valley Tank Sites

The Valley Zone is anticipated to see increased demand as the growth in Helena continues to extend north. This pressure zone is currently served by storage in the Malben Zone, which has some capacity issues. The Valley Zone currently has an HGL of about 3,940 feet and is controlled by the PRV setting. At this setting, the operating pressure in this small zone varies from about 53 psi to 57 psi. This zone could be expanded as part of a potential future split in pressure zones. The area north of Custer Avenue and west of Montana Avenue has a current average day demand of about 0.5 MGD. A tank with a capacity of 1 MG would be adequate to meet current and future needs in this area through the planning period of 2040. This would provide some of the storage needed for the Malben Zone by reducing the area currently served by the Malben, Nob Hill, and Woolston Tanks.

Custer Avenue represents a likely dividing point for a future Valley Zone. The highest ground elevations north of Custer Avenue are about 3,870 feet. In order to provide 40 psi at the highest elevations in the expanded Valley Zone, the low operating level in the tank should be about 3,960 feet with an overflow elevation of about 3,980 feet.

The potential for a ground storage tank or an elevated tank for the Valley Zone was reviewed. To achieve a ground elevation of about 3,960 feet for the tank, the site would need to be located south of the railroad tracks that divide the City of Helena. The most likely location for a ground storage tank is in the vicinity of Memorial Park (see GS 1 in Figure 8).

To provide an elevated tank to serve the Valley Zone, a tank near Custer Avenue with a low water elevation of about 3,980 would provide suitable service for the new Valley Zone. An elevated tank with a low water elevation of 3,980 feet would provide 50 psi or more for all areas north of Custer Avenue and west of Montana Avenue. Possible locations and the tank height necessary to provide a minimum HGL of 3,960 feet and a maximum HGL of 3,980 feet are shown in Figure 8 and could include:

- Tower Site 1, Northeast corner of Custer Avenue and Henderson Street, ground elevation about 3,860 feet, 120 feet high (Fairgrounds property owned by Lewis and Clark County)
- Tower Site 2, Southwest corner of Custer Avenue and Henderson Street, ground elevation about 3,860 feet, 120 feet high (property owned by Lewis and Clark County)
- Tower Site 3, South of Custer Avenue, west of Capital High School track, ground elevation about 3,860 feet, 120 feet high (owned by City of Helena)
- Tower Site 4, North edge of Bill Roberts Golf Course, ground elevation about 3,880 feet, 100 feet high (owned by City of Helena)
- Tower Site 5, Northwest or southwest corner of Benton Avenue and Barney Street, in Northgate Meadows, ground elevation about 3,840 feet, 140 feet high (owned by City of Helena)
- Tower Site 6, South of Tara Court between North Montana Avenue and National Avenue, ground elevation about 3,870 feet, 110 feet high (owned by Big Sky Progress LLC)

One of the requirements of the design of an elevated tank is to obtain approval from the FAA. The tank is likely to be somewhere near Custer Avenue, between Green Meadow Drive and Montana Avenue. This area is almost directly in line with the main runways for the Helena Regional Airport. Getting approval for an elevated tank in this area is not impossible but will be challenging, depending on the specific location and the height of the tank.

Malben Low Zone Tank

The Malben Low Zone has an average day demand of about 1.3 MG. Construction of a tank to provide some of this demand would reduce the storage needs for the existing Malben Tank. The HGL just downstream from the pressure reducing valves is about elevation 4,091 feet. A new storage tank should have an operating range of about 4,080 feet to 4,110 feet.

For a ground storage tank, the ground elevation should be about 4,080 feet. To achieve this elevation, the tank would need to be located generally south of Knight Street or south of 9th Avenue. These areas are about 4,000 to 5,000 feet south of the existing Malben Low Zone. There are no apparent large, empty parcels in this area, except at the extreme east and west edges of the City.

The Padbury Ranch proposed development is located east of Interstate 15 and south of the MDT complex (See GS2 in Figure 8). There is an existing 24-inch diameter water main along the west edge of this development that usually conveys water from the MRTP to the Nob Hill Tank. The ground elevations along Interstate 15 near the north edge of this development are about 4,080 feet. A ground storage tank at this location could provide additional storage for the Malben Low Zone and reduce the dependence on the storage tanks that serve the Malben High Zone. To provide adequate service, this tank should be connected to the existing 16-inch diameter water main at the intersection of Carter Drive and Airport Road. This would require about 10,000 feet of new water main along with a crossing of US Highway 12 and the railroad tracks.

Another option would be an elevated tank. To provide an elevated tank to serve the Malben Low Zone, a tank with a low water elevation of about 4,080 feet would approximately match the existing system pressures. If this tank were located near the south edge of the Malben Low Zone, near the railroad tracks, it would have an overflow about 150 feet above the ground surface. A tank with a capacity of about 1 MG would be large enough to supplement the existing Malben Tank to meet the future needs of the Malben Zones. The possible locations for this tank are shown in Figure 8 and are the same as for a ground storage tank serving the Valley Zone:

- Tower Site 7, South edge of Nature Park, west of Gold Avenue near Cedar Street (owned by City of Helena)
- Tower Site 8, South edge of Bill Roberts Golf Course (owned by City of Helena)
- Tower Site 9, Southwest corner of Phoenix Avenue and North Roberts Street (owned by Montana Rail Link)

RECOMMENDATIONS

The planning analysis completed as part of this study indicated that most of the growth in Helena will occur either on the north edge of the city (in the Malben Low Zone) or on the southeast edge of the city (in the Malben High Zone). Assuming that future demand patterns will match existing demand patterns, the 2.92% growth in population by 2025 would correspond to an increase of about 0.17 MG in average day demand. The 8.71% increase in projected population by 2040 would correspond to an increase of about 0.50 MG in average day demand. The storage requirements for the Malben Zone are, therefore, about 5.7 MG by 2025 and 6.0 MG by 2040 based on the DEQ-1 requirements and 9.1 MG by 2025 and 9.4 MG by 2040 based on the MDD approach.

No significant storage deficits were identified in this analysis using the DEQ-1 requirements. The MDD approach indicates a significant deficit in the Malben Zone, however. This is also the zone with the most potential for increased storage with a relatively minor investment. The total required storage for existing demands is about 8.9 MG based on the MDD approach. With the current operation of the Nob Hill Pump Station to provide flows to the Winne Zone during high demand periods, the entire capacity of the Malben Tank is available, so the current available storage in the Malben Zone is about 8.0 MG.

The installation of a remote-controlled valve connecting the Hale Zone to the Malben High Zone will increase the available storage to about 9.1 MG. This project is currently under design by the City of Helena.

The modification of the altitude valve at the Woolston Reservoir and some operational changes would allow for more effective use of this tank. This would increase the available storage in the Malben Zones to about 12.1 MG, which is substantially greater than the projected future storage requirements for existing and future demands.

Based on the results of this analysis, the following projects are proposed to increase the available storage for the City of Helena water distribution system:

1: Install a pressure reducing valve between the Hale Zone and the Malben High Zone that will operate automatically and can be controlled remotely by the system operators. This project is currently under design by the City of Helena.

2: Modify the existing altitude valve at the Woolston Reservoir to allow either hydraulic or electric control of this valve and modify the operating procedures to effectively use the Woolston Reservoir.

3: Install a pressure reducing valve between the Upper Hale Zone and the Reeder's Village Area, to provide fire flows to the Reeder's Village Area.

4: Construct a new tank to provide additional storage for the Reeder's Village Area. This tank could be either the Scott Property Site or adjacent to the existing Upper Hale Tank.

5: Construct a new tank to increase the storage in the Malben Low Zone. This tank could be an elevated tank near the railroad tracks to serve the Malben Low Zone, a ground storage tank near the Padbury Ranch Development to serve the Malben Low Zone, a ground storage tank near the railroad tracks to serve an enlarged Valley Zone, or an elevated tank near Custer Avenue to serve an enlarged Valley Zone.

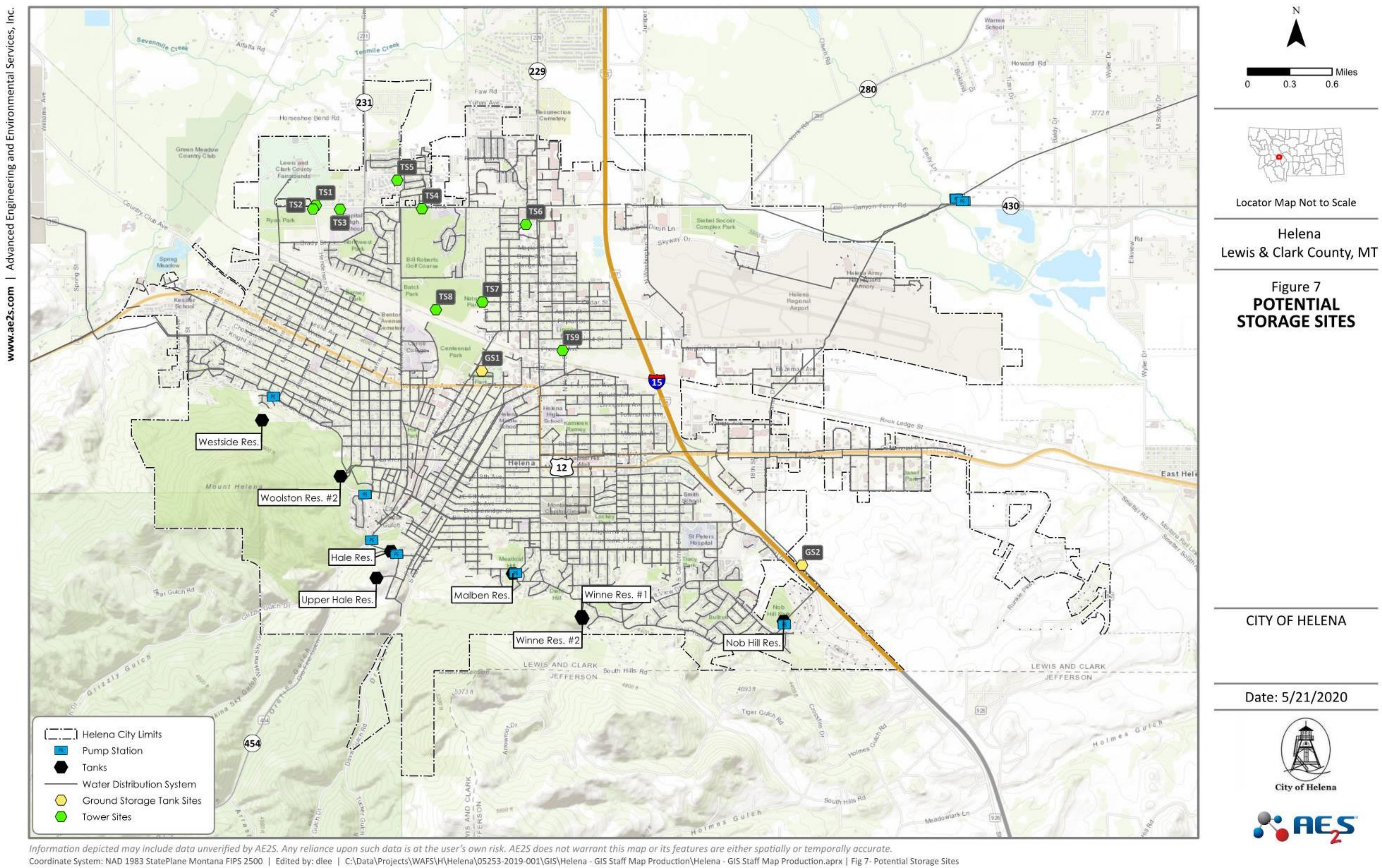


Figure 8 – Potential Storage Sites

TECHNICAL MEMORANDUM #6

To: Jamie Clark, PE

From: Mark Peterson, PE
Nate Weisenburger, PE

Re: **Water System Pressure Zone Analysis**
City of Helena, MT

Date: December 8, 2020

INTRODUCTION

The purpose of this memo is to summarize the pressure zone analysis completed on the water distribution system for the City of Helena. The scope of this analysis is to analyze the Malben existing pressure zones and develop recommendations for splitting the Malben Low and Malben High Zones into three zones. Existing pressure zone boundaries are also reviewed to identify potential modifications to improve the level of service. Expansion of the existing Valley Zone is analyzed, with future zone boundaries presented and potential tank sites with ideal elevations identified.

SYSTEM DEMANDS

In the recent update of the City's water model, current water production and billing data were used to allocate demands or water usage throughout the system based on the billing address of each customer. The maximum day demand based on the water production values is 15.2 MGD (August 2018). The average day demand for this same period was found to be 5.7 MGD. The distribution of these demands by pressure zone is shown in Table 1.

Table 1 - Demands

Pressure Zone	Average Day Demand (gpd)	Maximum Day Demand (gpd)
Airport	10,051	22,075
Hale	217,498	371,491
Malben High	3,434,990	9,012,629
Malben Low	1,291,522	3,892,565
Reeder's Village	37,426	77,155
Upper Hale	10,008	17,294
Westside	76,176	184,176
Winne	461,707	1,193,645
West Main	12,816	20,362
Mountain View Meadows	936	4,637
Golden Estates (Valley)	97,013	378,592
Green Meadows (Valley)	9,418	20,131
Total	**5,659,560**	**15,194,750**

EXISTING ELEVATIONS

There are two sets of elevations that are important in a pressure zone analysis. The first set is the existing ground elevations. The second set is the hydraulic grade line (HGL) elevations. Ground elevations throughout the water system were taken from 2017 LiDAR data, which samples points in a grid spacing of 3.28 feet (1 meter). The vertical accuracy of this elevation data is reported as ¼-inch (0.006 meters). The vertical datum used is NAVD 1988.

The HGL elevations for the Malben High Zone are limited by the overflow elevations of the tanks that serve the zone (Malben, Nob Hill, and Woolston). These elevations were taken from the hydraulic model and verified with record drawings from the City where available. The HGL elevations for the Malben Low Zone and the Valley Zone are a function of the settings on the pressure-reducing valves (PRVs) that separate these zones from the Malben High Zone. The elevations of the PRV's were estimated using the LiDAR data discussed previously. The HGL for the Malben Low Zone and the Valley Zone can be adjusted by altering the settings on the PRV's. A summary of the key elevations in the existing system is shown in Table 2.

Table 2 – Existing Elevations

Pressure Zone	Maximum Ground Elevation	Minimum Static Pressure	Minimum Ground Elevation	Maximum Static Pressure	HGL
Malben High	4,240	36 psi	3,956	159 psi	4,323
Malben Low	3,965	58 psi	3,797	131 psi	4,100
Valley	3,816	54 psi	3,809	57 psi	3,940

DESIRED PRESSURE RANGE

Montana Circular DEQ-1 states that the minimum normal working pressure must be 35 psi, and maximum normal operating pressure should be approximately 60 to 80 psi. The City of Helena meets the requirement for minimum pressures but substantially exceeds the recommended maximum pressures. The following sections discuss system modifications that could help reduce the elevated pressures in portions of the City.

PRESSURE ZONE MODIFICATIONS

The ideal approach to creating new pressure zones is to uniformly split the overall elevation difference into three zones instead of the existing two zones. The difference between the highest ground elevation in the Malben High Zone (4240 feet) and the minimum ground elevation in the Malben Low Zone (3797 feet) is 443 feet. If this elevation difference was uniformly split amongst the three zones, each zone would have an elevation difference of about 148 feet. Table 3 shows the resulting maximum and minimum ground elevations in each zone, and the maximum and minimum pressures in each zone. Some adjustments to the elevation limits would be made to provide more logical breaks.

Table 3 – Equally Divided Elevations

Pressure Zone	Maximum Ground Elevation	Minimum Static Pressure	Minimum Ground Elevation	Maximum Static Pressure	HGL
Malben High	4,240	36 psi	4,092	100 psi	4,323
Malben Middle	4,092	43 psi	3,944	107 psi	4,192
Malben Low	3,944	43 psi	3,797	107 psi	4,044
Valley	3,816	54 psi	3,809	57 psi	3,940

The maximum ground elevation shown in Table 3 for the Malben Low Zone (3,944 feet) is very close to the existing maximum ground elevation in the Malben Low Zone (3,965 feet) shown in Table 2. Moving PRVs and adjusting pressures to account for this small difference in elevations does not appear to be justified. The split between the Malben Low Zone and the upper pressure zones to the south should remain at its current location along the railroad.

The maximum operating pressure at the bottom end of the Malben High Zone could be reduced significantly by splitting the Malben High Zone into two pressure zones. The second zone is termed the Malben Middle Zone for this discussion. The Malben Middle Zone would have an HGL lower than the Malben High Zone but higher than the Malben Low Zone.

The recommended location to divide the Malben High Zone and the Malben Middle Zone generally follows Euclid/Lyndale Avenue, Helena Avenue, and Prospect Avenue, which would limit the maximum pressures in the Malben High Zone to about 125 psi. The proposed split is shown in Figure 1. Figure 2 shows the locations of new PRVs to create the Malben Middle Zone. This figure also shows the locations of isolation valves that would be closed to separate the

Malben High Zone and the Malben Middle Zone. The existing settings on the PRVs between the Malben Low Zone and the Malben High Zone would remain the same, and the existing settings on the PRVs that create the Valley Zone would remain the same. Figure 3 shows the new maximum pressures during the average day demand (ADD) scenario. Figure 4 shows the changes in pressure between the existing conditions and the proposed pressure zone split. Negative values indicate a decrease in pressure with the zone adjustments, while positive values indicate an increase in pressure.

The Malben High Zone is currently served by the High Zone pumps at the Missouri River Water Treatment Plant, and the Malben Low Zone is served by the Low Zone pumps. The Low Zone pump hydraulics were reviewed to determine if they could serve the proposed Malben Middle Zone. To serve the Malben Middle Zone from the Low Zone pumps, a new water main would need to be constructed from the MRTP to the Malben Middle Zone. Based on the analysis, it is more practical to simply continue serving the area of the Malben Middle Zone from the High Zone pumps through PRV's.

The locations of the PRV's and closed isolation valves needed to divide the Malben High Zone from the Malben Middle Zone are shown in Table 4.

Table 4 – Proposed PRV and Isolation Valve Locations

Location	Valve Type	Location	Valve Type	Location	Valve Type
Euclid Ave and Laurel St	PRV	Neill St and Front St	Isolation	Butte Ave and Roberts St	Isolation
Euclid Ave and Mountain View St	PRV	Last Chance Gulch and Helena Ave	PRV	Prospect Ave and Roberts St	PRV
Euclid Ave and Grant St	Isolation	Helena Ave and Logan St	Isolation	Prospect Ave and Sanders St	Isolation
Euclid Ave and Garfield St	PRV	Helena Ave and Warren St	Isolation	Prospect Ave and Harris St	PRV
Euclid Ave and Harrison St	Isolation	Helena Ave and Ewing St	Isolation	Prospect Ave and Oakes St	Isolation
Euclid Ave and Madison St	Isolation	16th St and Rodney St	Isolation	Prospect Ave and Hannaford St	Isolation
Knight St and Benton Ave	Isolation	Livingston Ave and Idaho Ave	Isolation	Prospect Ave and Fee St	PRV
Hauser Blvd and Benton Ave	PRV	Misoula Ave and Idaho Ave	Isolation	Prospect Ave and Oregon St	Isolation
Neill St and Getchell St	Isolation	Missoula Ave and Montana Ave	PRV	Prospect Ave and Carter Dr	PRV (2)

The settings for each of the PRV's will vary depending on the actual location of the installation, but the settings analyzed in the hydraulic model to maintain an HGL of 4,183 at the top of the Malben Middle Zone are shown in Table 5. It is worth noting that the elevations assumed for the pipes and PRV's in the model are based on ground elevations from the 2017 LiDAR data. Actual settings should be verified during the design of the PRV vaults when site-specific survey data is collected.

Table 5 – Proposed PRV and Settings

Location	Elevation (ft)	PRV Setting	HGL Downstream (ft)
Euclid Ave and Laurel St	4,011	75	4,183
Euclid Ave and Mountain View St	4,014	73	4,183
Euclid Ave and Garfield St	4,034	65	4,183
Hauser Blvd and Benton Ave	4,038	63	4,183
Last Chance Gulch and Helena Ave	4,046	59	4,183
Missoula Ave and Montana Ave	4,028	67	4,183
Prospect Ave and Roberts St	4,034	65	4,183
Prospect Ave and Harris St	4,045	60	4,183
Prospect Ave and Fee St	4,038	63	4,183
Prospect Ave and Carter Dr (north side)	3,987	81	4,183
Prospect Ave and Carter Dr (south side)	3,996	81	4,183

The proposed PRV at Prospect Ave and Harris Street has the highest elevation of the PRV's along this boundary. Consequently, this PRV was set to maintain 60 psi downstream pressure, which corresponds to an HGL of 4,183. The remaining PRV's were set to maintain a downstream hydraulic grade line of 4,183 along the zone boundary.

The proposed PRV's at Prospect Ave and Carter Drive will remove a portion of the Malben High zone that currently experiences pressures in excess of 160 psi and place it in the Mountain View Meadows Zone. This boundary adjustment will also require the decommissioning of the existing PRV at the intersection of Crossroads Parkway and Centennial Drive.

VALLEY ZONE EXPANSION

The City is interested in expanding the valley zone to incorporate the bottom portion of the Malben Low Zone. This could be accomplished independently of the split of the Malben High Zone into the two zones discussed previously. For discussion purposes in this Technical Memorandum, it is assumed that the Malben Low Zone will maintain the current HGL.

The ideal split between the Malben Low Zone and the Valley Zone would be approximately Custer Avenue. There are a limited number of water main loops that connect at Custer Avenue, so this will reduce the number of PRVs or closed valves that are required to create this zone. The existing water main in Custer Avenue would need to remain part of the Malben Low Zone to provide service to this zone, with PRVs located north of Custer Avenue. One of the challenges of expanding the Valley Zone is the existing 20-inch diameter water main that extends from the Missouri River Water Treatment Plant along Custer Avenue to Montana Avenue. The areas east of Montana Avenue that could be served by the new Valley Zone will need to have PRVs installed, and these areas do not currently have loops north of Custer Avenue that create a more redundant system. Figures 1 and 2 show the proposed boundaries for the new Malben Low Zone and new Valley Zone and the PRVs that would be required. Figure 3 shows the new maximum pressures during the average day demand (ADD) scenario. Figure 4 shows the changes in pressure between existing conditions and the proposed pressure zone split. Closing an existing gate valve in lieu of a new PRV could be acceptable in some locations.

Table 6 – Valley Zone Expansion Elevations

Pressure Zone	Maximum Ground Elevation	Minimum Static Pressure	Minimum Ground Elevation	Maximum Static Pressure	HGL
Malben Low	3,965	58 psi	3,870	100 psi	4,100
Valley	3,870	56 psi	3,809	83 psi	4,000

Table 6 shows the maximum pressure in the Malben Low Zone is only 100 psi, compared to 131 psi for the existing Malben Low Zone. This lower maximum pressure is generally better for providing water service to buildings.

The locations and settings of the proposed PRV's for the Valley Zone are shown in Table 7.

Table 7 – Proposed Valley Zone PRV's

Location	Elevation	PRV Setting	HGL Downstream
27 W Custer Ave	3,871	63	4,017
118 W Custer Ave	3,870	63	4,017
338 W Custer Ave	3,874	62	4,017
Custer Ave & Benton Ave	3,877	61	4,017
Custer Ave & Bridger Dr	3,879	60	4,017
Custer Ave & McHugh Ln	3,870	64	4,017
Custer Ave & Montana Ave	3,851	72	4,017
1315 E Custer Ave	3,840	77	4,017
Custer Ave & Sanders St	3,435	79	4,017
1465 E Custer Ave	3,831	81	4,017

In addition to the PRV's listed in Table 7, an isolation valve would need to be closed at 700 W Custer Ave to complete the pressure zone boundary.

Finally, the existing valley zone PRV located at 3450 McHugh Lane will need to be decommissioned, and the closed isolation valve at Sand Piper Loop & Snow Goose Street will need to be opened.

OTHER CONSIDERATIONS

With the proposed creation of a Malben Middle Zone and expansion of the Valley Zone, pressures will be reduced in significant portions of the distribution system. The lower pressures are in areas where the existing pressure is in the range of 100 psi or higher.

While reducing these high pressures has benefits for normal water service to buildings, it can have a negative impact on the ability of a sprinkler system to provide adequate fire suppression for a building if the original design of the sprinkler system was based on the existing higher pressure. A reduction in fire suppression for buildings is a negative consequence of lower water distribution system pressures. The City of Helena has required new fire suppression systems to be designed based on lower pressures in recent years (since about 2010), but there are many existing systems that were designed prior to the implementation of this new policy.

Before any pressure zone modifications are undertaken, the fire suppression system for each building within the area of proposed lower pressure should be reviewed to determine the impacts. The creation of the Malben Middle Zone would lower the pressures serving Carroll College, Helena High School, and Helena College, along with many commercial buildings. It is likely that many of the fire suppression systems were designed to operate entirely on the high water pressure currently available. If this pressure is reduced, many of the systems will need to be modified to include a booster pump. The cost of these modifications could vary significantly based on the size of the building.

The cost associated with the design and construction of the proposed PRV's is highly dependent on the size of the valve needed, size and depth of vault, conflicting utilities, traffic impacts, and other factors. For planning purposes, it is reasonable to assume an average cost of $150,000 for the construction of each of the referenced PRV's.

ELEVATED PRESSURE MASKING DEFICIENCIES

Over time as fire protection standards improve, water distribution systems are relied upon to provide much higher flow rates than the standards for which many of them were originally designed. Such is the case with the City of Helena, as many parts of town are served by pipes 6-inch diameter and smaller. The City's current standard for fire flow requirements is 1,750 gpm for two hours. In a single 6-inch cast-iron main, this requires a velocity of over 19 feet per second (fps) and results in a friction headloss of 750 feet per thousand feet of pipe with the roughness factors observed in the City's older cast iron pipes.

Currently, the City's distribution system operates with high pressures throughout a significant portion of the network. With this elevated pressure, many locations are able to provide the required 1,750 gpm despite the large amount of headloss experienced, as illustrated in Figure 5. If the City were to split pressure zones, a slightly increased number of hydrants throughout the system would not be capable of providing 1,750 gpm, as illustrated in Figure 6.

If the City were to replace all undersized mains with a minimum of 8-inch diameter mains (per MDEQ requirements),1,750 gpm could be provided nearly system-wide, as shown in Figure 7.

Recognizing this will take many years to complete, an additional scenario was analyzed to see if connecting several of the large mains in the pressure zone could provide the looping needed to meet fire flow requirements. The pipe improvements modeled are summarized below:

- A 10-inch line was modeled along Peosta Ave from Laurel Street to Benton Ave.
- A 10-inch line was modeled along Boulder Street, extending from Montana Ave to Fee Street, and along Fee Street from Boulder Ave to Prospect Ave.
- An 8-inch main was modeled from Rodney Street to Davis Street along 15th Street.
- An 8-inch main was modeled from Rodney Street to Ewing Street along 16th Street.
- A 10-inch main was modeled from Roberts Street to Fee Street along Butte Ave.

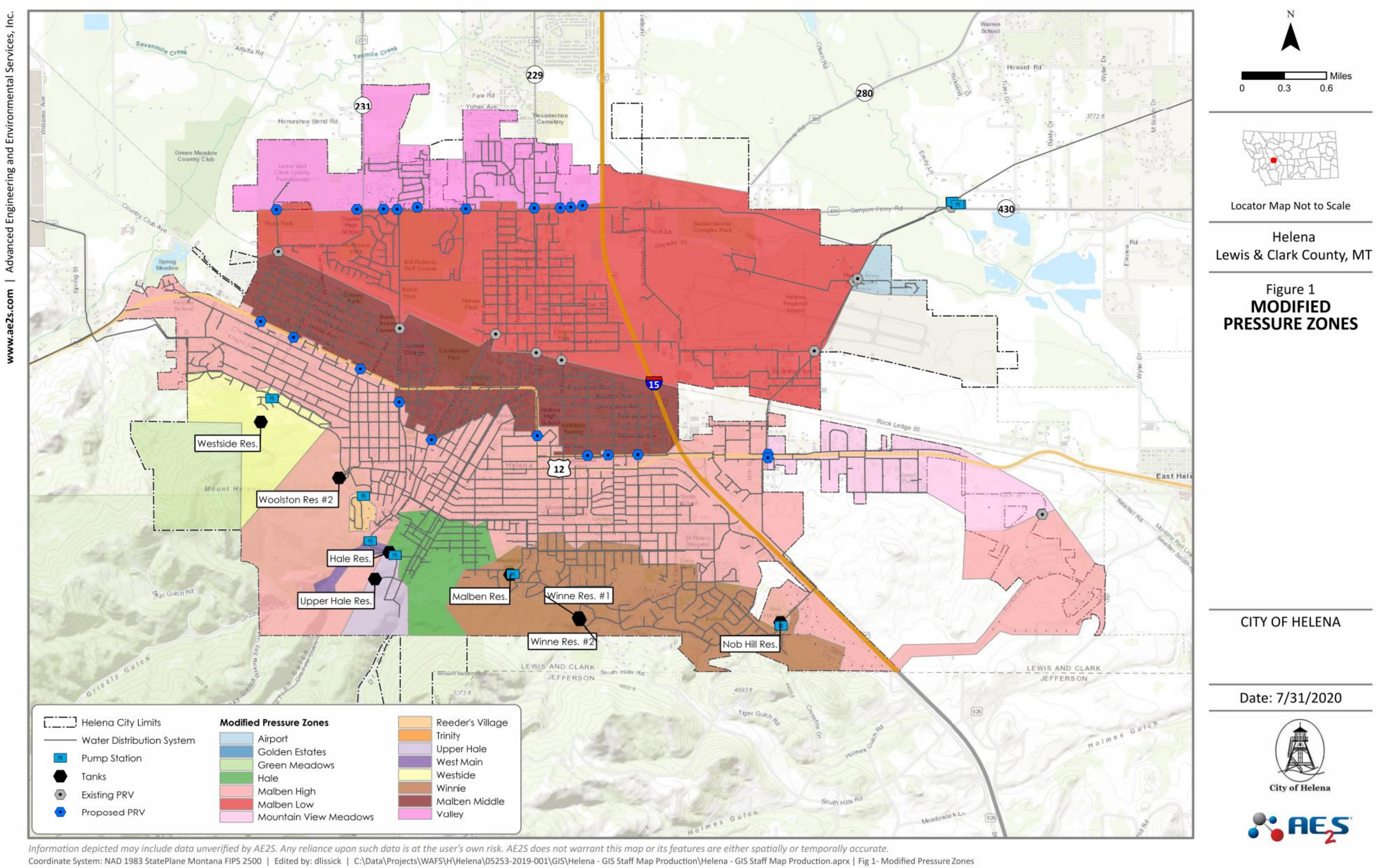
The results of this analysis are shown in Figure 8. While this alternative does not provide the same level of service that replacing all the undersized mains will provide, it does improve the available fire flow significantly with the replacement of fewer than three miles of pipe.

RECOMMENDATIONS

The Malben High Zone could reasonably be split into two zones, creating a Malben Middle Zone in the areas with lower elevations. This would reduce the high pressures currently experienced in parts of the Malben High Zone.

The split between the Malben Low Zone and the Valley Zone could be modified such that the split essentially occurs at the north side of Custer Avenue. This would reduce the high pressures currently experienced in parts of the Malben Low Zone.

The primary reason to split an existing pressure zone is to lower the pressures in areas of lower elevations, where current pressures are in the range of 100 psi or higher. From a hydraulic standpoint, there are reasonable boundaries to create a new Malben Middle Zone and expand the existing Valley Zone into the existing Malben Low Zone. Both of these actions would result in lower system pressures for many buildings with sprinkler systems for fire suppression. Before major effort is expended to complete the engineering design of a project to split these pressure zones, the undersized distribution mains will need to be replaced to provide adequate fire flow. Additionally, a detailed analysis of the number of commercial buildings impacted and the magnitude of impact for each building is recommended.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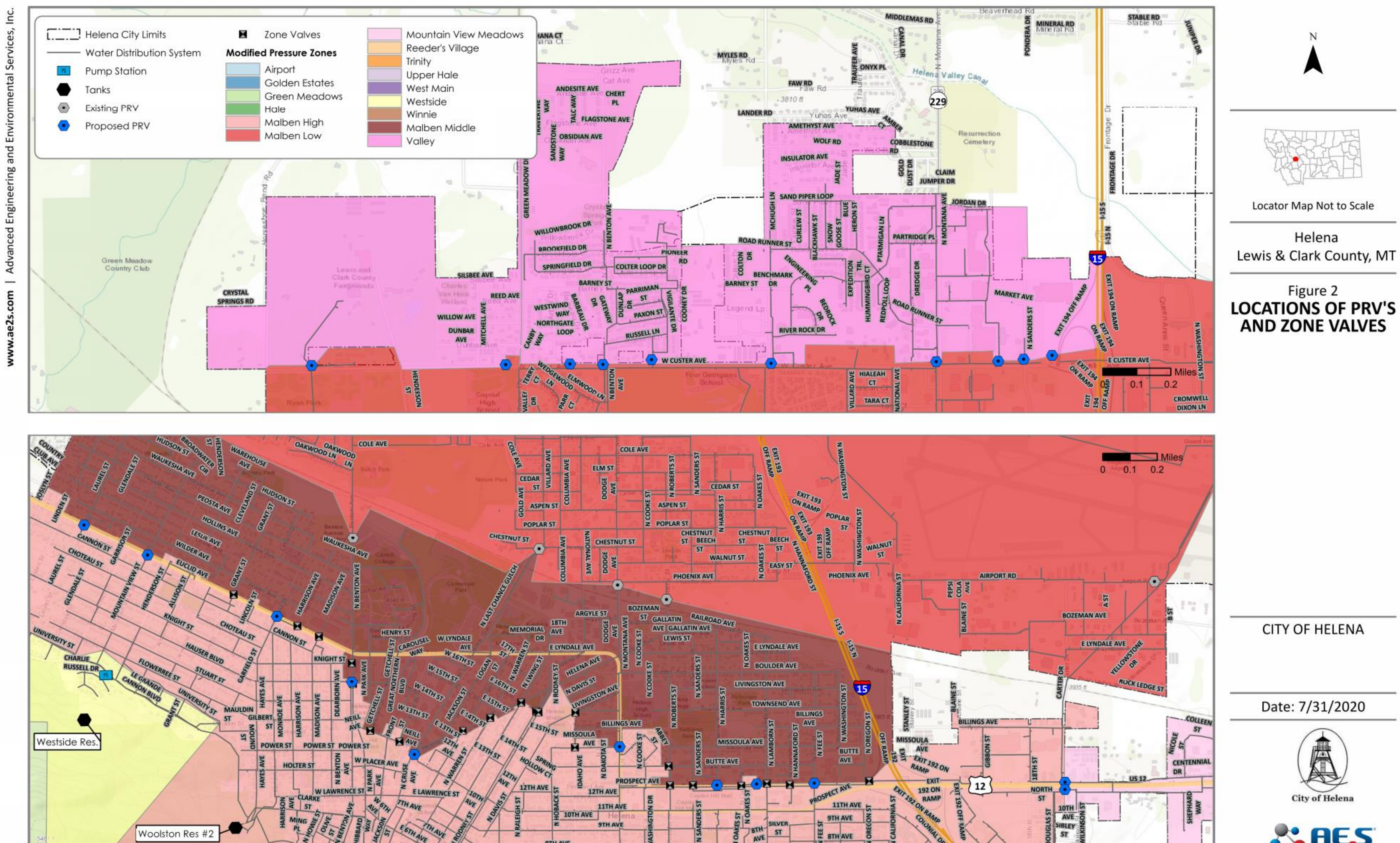
Locator Map Not to Scale
Helena
Lewis & Clark County, MT
Figure 1
MODIFIED PRESSURE ZONES
CITY OF HELENA
Date: 7/31/2020
City of Helena
Westside Res.
Woolston Res #2
Hale Res.
Upper Hale Res.
Malben Res.
Winne Res. #1
Winne Res. #2
Nob Hill Res.
Helena City Limits
Water Distribution System
Pump Station
Tanks
Existing PRV
Proposed PRV
Modified Pressure Zones
Airport
Golden Estates
Green Meadows
Hale
Malben High
Malben Low
Mountain View Meadows
Reeder's Village
Trinity
Upper Hale
West Main
Westside
Winnie
Malben Middle
Valley
Information depicted may include data unverified by AE2S. Any reliance upon such data is at the user's own risk. AE2S does not warrant this map or its features are either spatially or temporally accurate.
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 1- Modified Pressure Zones



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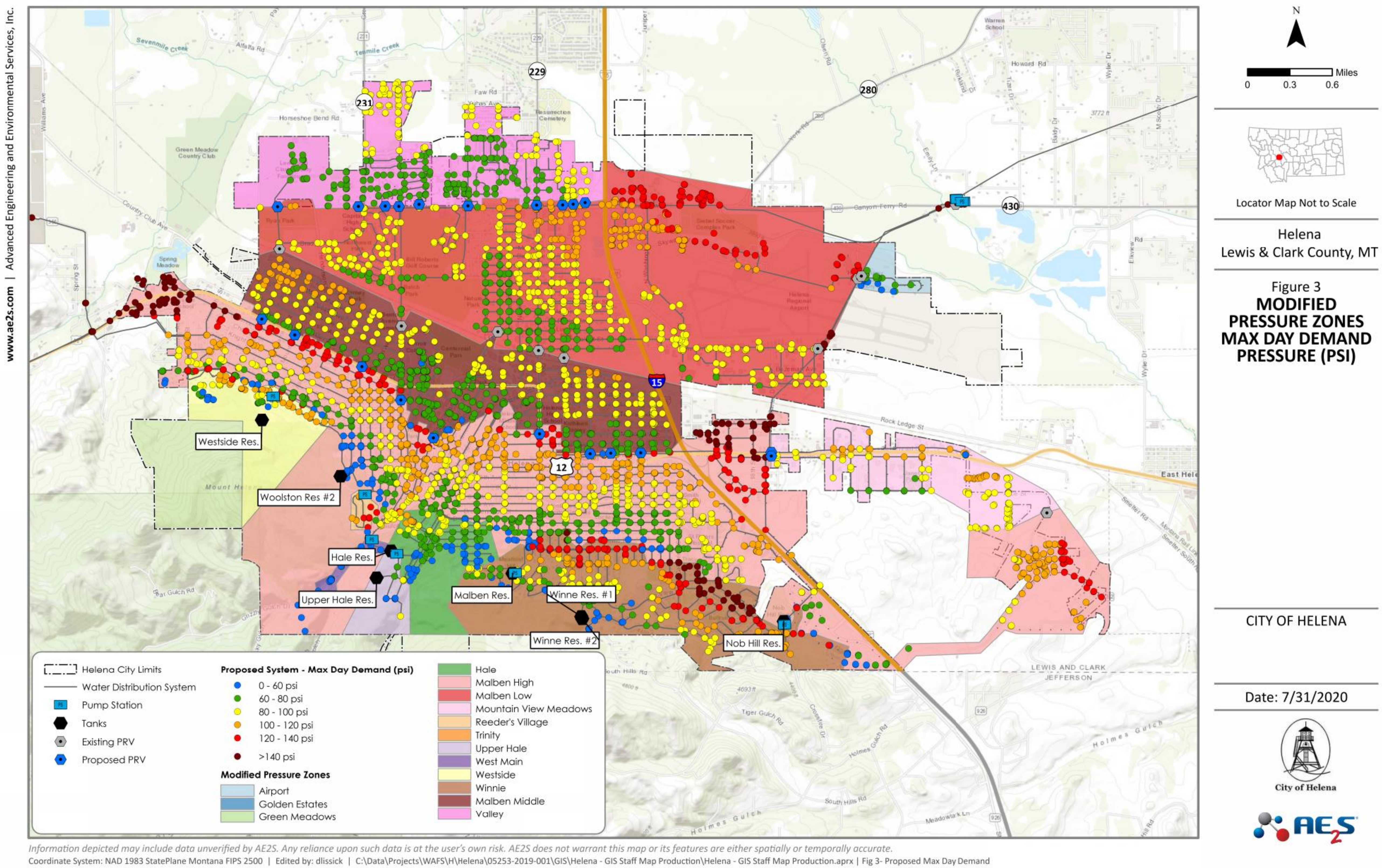
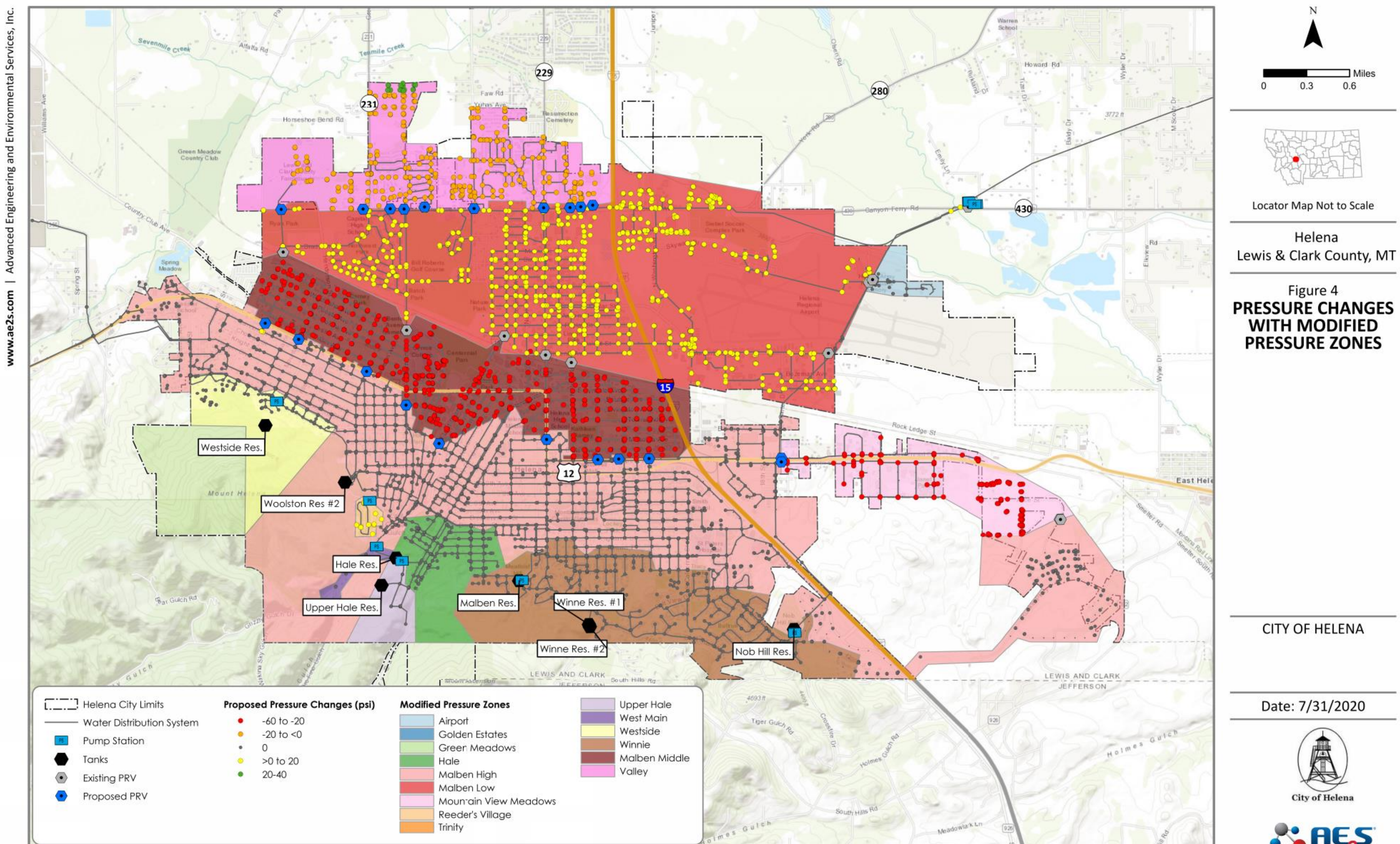
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 2- Locations of PRV's and Zone Valves


www.ae2s.com | Advanced Engineering and Environmental Services, Inc.
N
Miles
0 0.3 0.6
Locator Map Not to Scale
Helena
Lewis & Clark County, MT
Figure 3
MODIFIED PRESSURE ZONES MAX DAY DEMAND PRESSURE (PSI)
CITY OF HELENA
Date: 7/31/2020
City of Helena
Helena City Limits
Water Distribution System
Pump Station
Tanks
Existing PRV
Proposed PRV
Proposed System - Max Day Demand (psi)
0 - 60 psi
60 - 80 psi
80 - 100 psi
100 - 120 psi
120 - 140 psi
>140 psi
Modified Pressure Zones
Airport
Golden Estates
Green Meadows
Hale
Malben High
Malben Low
Mountain View Meadows
Reeder's Village
Trinity
Upper Hale
West Main
Westside
Winnie
Malben Middle
Valley
Westside Res.
Woolston Res #2
Hale Res.
Upper Hale Res.
Malben Res.
Winne Res. #1
Winne Res. #2
Nob Hill Res.
Information depicted may include data unverified by AE2S. Any reliance upon such data is at the user's own risk. AE2S does not warrant this map or its features are either spatially or temporally accurate.
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 3- Proposed Max Day Demand



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Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 4- Pressure Changes with Modified Pressure Zones

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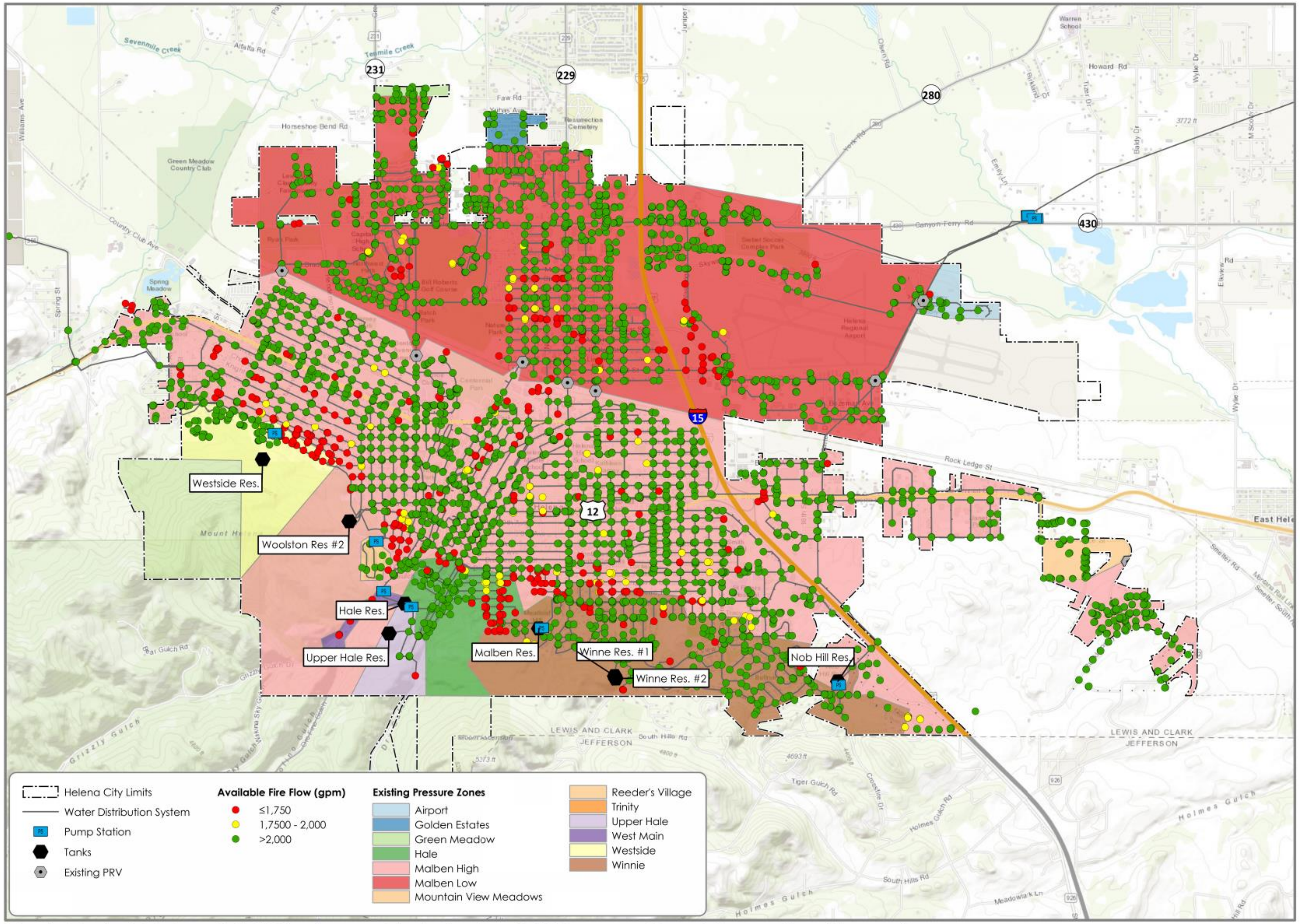

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Miles
0 0.3 0.6

Locator Map Not to Scale

Helena
Lewis & Clark County, MT

Figure 5
AVAILABLE FIRE FLOW CAPACITY WITH EXISTING PRESSURE ZONES

CITY OF HELENA

Date: 7/31/2020

City of Helena

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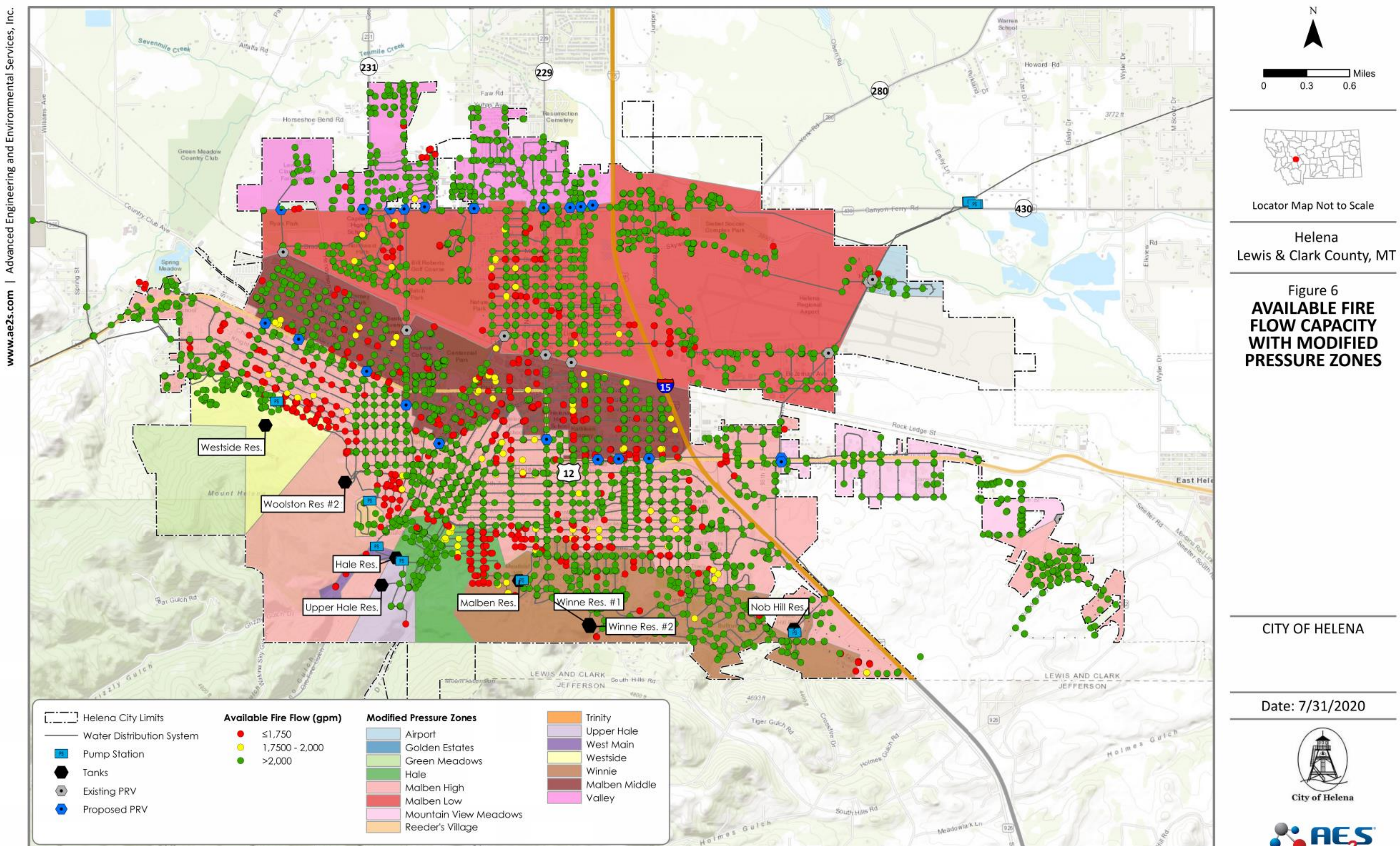
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 5 -Proposed Hydrant Available Fireflow



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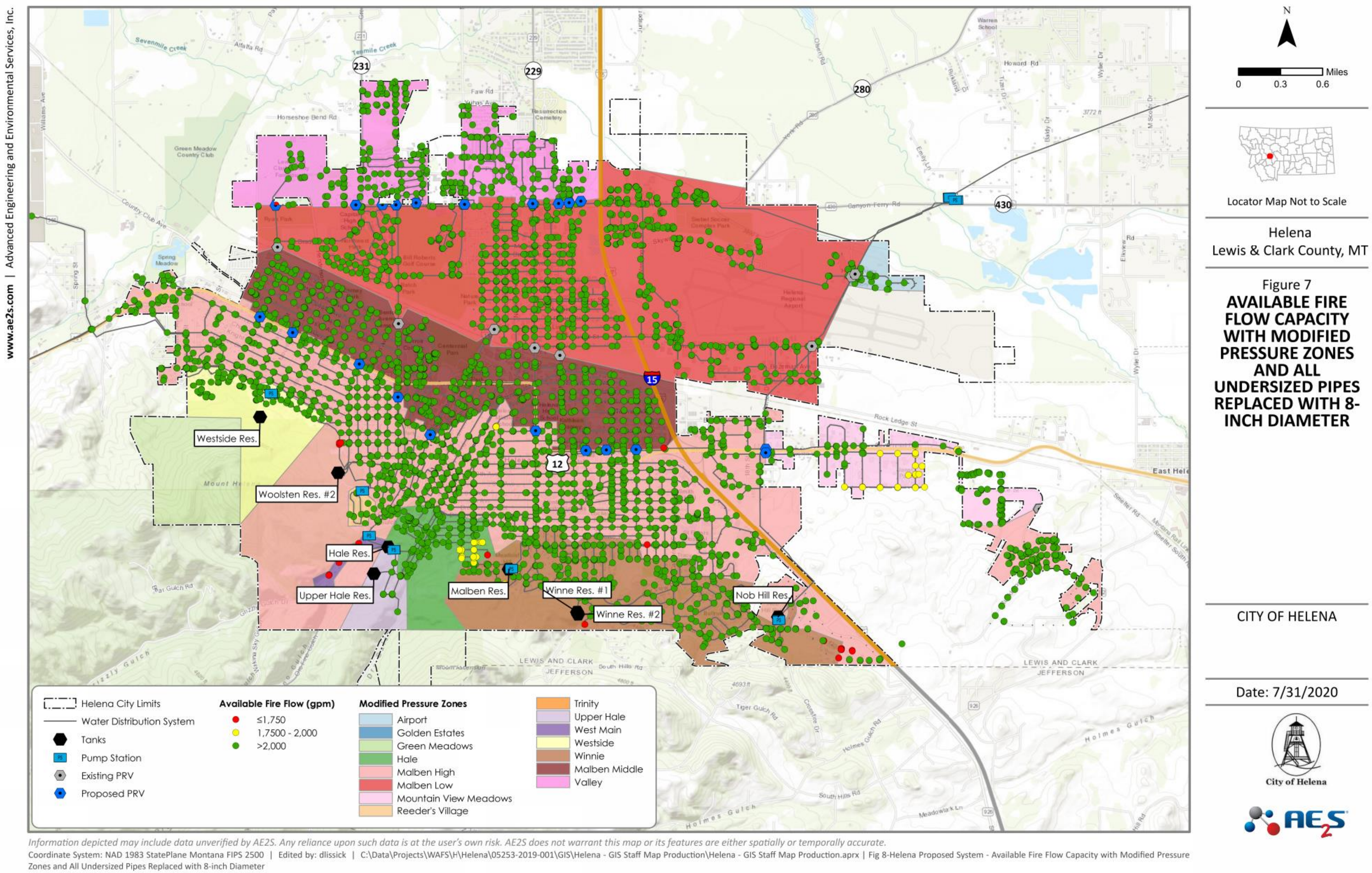
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 6-Helena Proposed System - Available Fire Flow Capacity with Modified Pressure Zones


www.ae2s.com | Advanced Engineering and Environmental Services, Inc.
Westside Res.
Woolsten Res. #2
Hale Res.
Upper Hale Res.
Malben Res.
Winne Res. #1
Winne Res. #2
Nob Hill Res.
Helena City Limits
Water Distribution System
Tanks
Pump Station
Existing PRV
Proposed PRV
Available Fire Flow (gpm)
≤1,750
1,7500 - 2,000
>2,000
Modified Pressure Zones
Airport
Golden Estates
Green Meadows
Hale
Malben High
Malben Low
Mountain View Meadows
Reeder's Village
Trinity
Upper Hale
West Main
Westside
Winnie
Malben Middle
Valley
N
Miles
0 0.3 0.6
Locator Map Not to Scale
Helena
Lewis & Clark County, MT
Figure 7
AVAILABLE FIRE FLOW CAPACITY WITH MODIFIED PRESSURE ZONES AND ALL UNDERSIZED PIPES REPLACED WITH 8-INCH DIAMETER
CITY OF HELENA
Date: 7/31/2020
City of Helena
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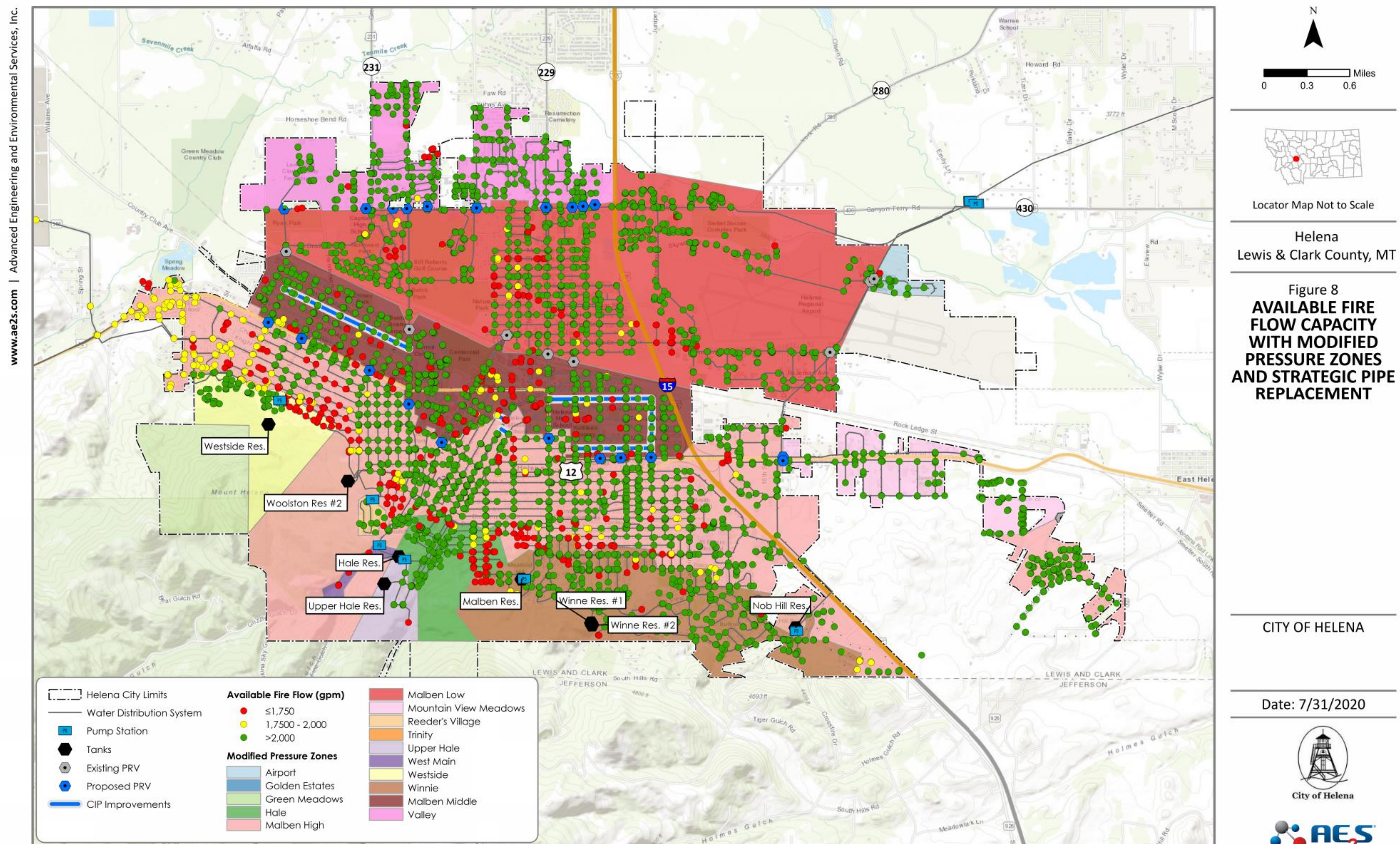
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 8-Helena Proposed System - Available Fire Flow Capacity with Modified Pressure Zones and All Undersized Pipes Replaced with 8-inch Diameter



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Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 8-Helena Proposed System - Available Fire Flow Capacity with Modified Pressure Zones and Strategic Pipe Replacement

TECHNICAL MEMORANDUM #7

To: Jamie Clark, PE

From: Mark Peterson, PE
Nate Weisenburger, PE

Re: **Water Distribution System Analysis**
City of Helena, MT

Date: December 8, 2020

INTRODUCTION

The purpose of this technical memorandum is to summarize the analysis of the existing water distribution system and provide recommendations to improve deficiencies and maintain an adequate level of service throughout the City.

PERFORMANCE CRITERIA

Hydraulic performance standards allow the City to objectively review water infrastructure (both existing and proposed) and identify deficiencies. The design parameters and criteria presented within this document were established to evaluate the performance of the existing distribution system in the City of Helena and to conceptualize improvements necessary to maintain system reliability and accommodate future growth of the system.

Water System Pressure

When evaluating the adequacy of a water distribution system, it is necessary to ensure that adequate pressure is supplied throughout the system. Generally, there are four design parameters that should be defined by each utility:

- Minimum pressure during the maximum day and peak hour demands;
- Minimum pressure on a maximum day demand with a fire flow event;
- Maximum pressure; and
- Pressure fluctuations.

The MDEQ recommends a minimum working pressure of 35 psi, with normal preferred operating pressures of 60 to 80 psi and a maximum working pressure of 100 psi.

Maximum Pressure:

Maximum pressure refers to the highest pressure a customer will experience at the residential or business service connection. High pressures within distribution systems can be problematic, resulting in several issues, including increased wear on system components and more frequent leaks and breaks. Additionally, water main breaks quickly become catastrophic, creating excessive damage to the surrounding area and a safety risk for both the community and City operations staff. The recommended maximum pressure for the Helena water distribution system is 110 psi. However, maximum pressures above 110 psi may be considered acceptable in certain parts of the distribution system where geography or other factors contribute to localized areas of higher pressures.

A significant portion of the City operates under pressures in excess of 110 psi. The pressure zone analysis (summarized in memo #6) provides recommendations to split pressure zones and reduce the maximum operating pressures to 110 psi.

Minimum Pressure:

MDEQ recommends the minimum working pressure in the distribution system should be 35 psi. The Computer Modeling of Water Distribution Systems, AWWA Manual M32, recommends that minimum pressures of 40 to 50 psi be maintained during peak hour demand (PHD) to help ensure there is adequate pressure to the second story fixtures within a property. The AWWA Manual M32 also notes that where residential fire sprinkler systems are required by legislation, the minimum acceptable pressure is 50 psi for the fire sprinklers to operate correctly.

The minimum pressure during fire flows, as recommended by the NFPA, is 20 psi at any point in the distribution system. The value of 20 psi is used to ensure an adequate supply of water to pumper fire trucks while overcoming any friction losses within the pipeline branch, hydrant, and fire hoses.

Based on these guidelines, the minimum pressure performance criteria recommended for the City of Helena during PHD is 50 psi. However, for areas serving customers with certain geography or other factors, a minimum pressure of 35 psi during PHD operations may be acceptable on a case-by-case basis approved by the City. For fire flows, a minimum pressure of 20 psi was used for assessing the performance of the distribution system. For areas of the distribution system not intended to serve customers, the EPA recommends a minimum sanitary pressure of 20 psi be maintained under PHD. These locations may include piping to and from reservoirs or locations in close proximity to pump stations.

In general, the City does not have problems with low pressure. There are a handful of locations on the western edge of the City that drop slightly below 35 psi during maximum day demand due to their high elevations relative to the adjacent tanks. It is not practical to boost pressures for these few locations. The simulated pressures throughout the system under a maximum day demand of 15.2 MGD are shown in Figure 1.

Pressure Fluctuations:

Pressure fluctuation is defined as the difference between the maximum and minimum pressure experienced at any one location in the distribution system over the course of a year. To provide consistent service to customers, it is recommended that pressure fluctuations be limited to a maximum of 20 psi. The hydraulic model was utilized to quantify the pressure fluctuations experienced throughout the year ranging from a maximum day demand of 15.2 MGD during the summer to a winter day demand of 2.73 MGD. The results of this analysis did not identify any areas with pressure swings in excess of 20 psi.

While sustained pressure fluctuations do not appear to be a concern throughout the City, the field data gathered from the hydrant pressure recorders (HPR's) throughout the calibration of the hydraulic model identified severe pressure transients or surges which exceeded 80 psi in some locations. The figures included in Appendix A of this memo provide a detailed summary of the locations and pressure swings recorded with the HPR's.

These observed pressure spikes are likely due to operational conditions (start/stop) of the high service pumps at the MRTP.

Pressure Recommendations:

Table 1 presents the water distribution system pressure criteria recommended for the system analysis.

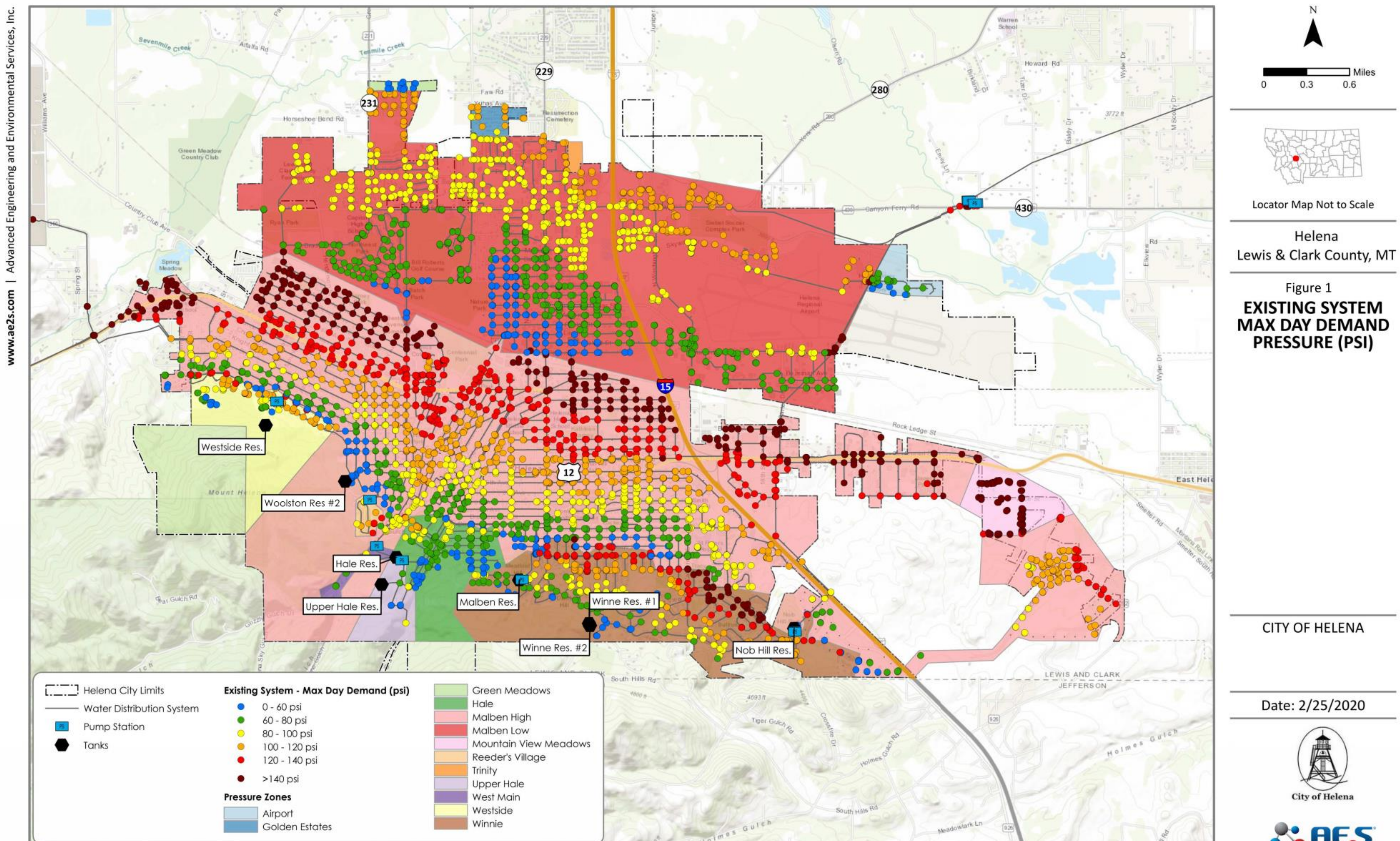
Table 1 - Recommended Pressure Criteria

Distribution System Pressures	Criteria (psi)
Maximum Pressure[1]	110
Minimum Pressure during Peak Hour Demand[2]	50
Minimum Pressure during a Fire Flow/Minimum Sanitary Pressure[3]	20
Maximum Pressure Fluctuation at any one Location	20

1 Maximum pressure above 90 psi may be considered acceptable in certain parts of the distribution system where geography and other factors contribute to localized areas of higher pressures. Home PRVs may be required on a case-by-case basis.

2 For small areas with certain geography or other factors, a minimum pressure of 35 psi during PHD operations may be acceptable with City approval.

3 Areas close to reservoirs/pump stations or areas not intended for customer connections.



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Fire Protection

The decision to provide water for fire protection requires careful consideration of fire flow requirements when sizing pipelines, pumps, and storage reservoirs because it results in higher capital and operation and maintenance (O&M) costs. Provisions for fire flows provide a valuable public service by reducing the potential loss of human life and property and improving fire insurance ratings within the community, which can reduce property insurance policy costs.

International Fire Code

The International Fire Code (IFC) is a model code regulating minimum fire safety requirements for new and existing buildings. As stated in the IFC, the minimum fire flow required for one- and two-family dwellings that do not exceed 3,600 square feet and do not have an automatic sprinkler system is 1,000 gpm. For one- and two-family dwellings exceeding 3,600 square feet, and for all buildings other than one- and two-family dwellings, the minimum fire flow, and flow durations are presented in Table 2. The minimum fire flow for these types of structures ranges from 1,500 gpm to 8,000 gpm over durations from two to four hours.

City of Helena Fire Flow Requirements

In general, the price of fire insurance in a community with a good Public Protection Classification (PPC) is substantially lower than a community with a poor PPC, assuming all other factors are equal. The private and public protection at properties with larger Needed Fire Flow (NFF) is individually evaluated and may vary from the City classification. If a structure is located in the public zoning area and is greater than the planned fire demand for that zone, the structure may be required to have a sprinkler system, or the City may need to review means of providing additional fire flow to the structure through either water main or storage improvements.

For structures, the City uses the International Building Code (IBC) and IFC requirements to determine the various fire safety aspects, such as fire and smoke protection features, interior finishes, fire protection systems. The City's building department provides inspection and approval of these systems. Following these codes, automatic sprinkler systems are required for one or more of the following reasons:

- The proposed occupancy or use in the building or fire area represents a high life-safety risk;
- The occupant load of the building or fire area exceeds code-prescribed limits;
- The building height or area warrants additional fire protection; and
- The amount or hazards of materials stored or used inside the building.

The minimum required fire flow and flow duration for buildings based on the IFC are shown in Table 2.

Table 2 - 2015 IFC Minimum Required Fire Flow and Flow Duration for Buildings

Fire-Flow Calculation Area (ft^2)*					Fire-Flow (gpm)[b]	Flow Duration (hours)
Type IA and IB[a]	Type IIA and IIIA[a]	Type IV and V-A[a]	Type IIB and IIIB[a]	Type V-B[a]		
0-22,700	0-12,700	0-8,200	0-5,900	0-3,600	1,500	2
22,701-30,200	12,701-17,000	8,201-10,900	5,901-7,900	3,601-4,800	1,750	
30,201-38,700	17,001-21,800	10,901-12,900	7,901-9,800	4,801-6,200	2,000	
38,701-48,300	21,801-24,200	12,901-17,400	9,801-12,600	6,201-7,700	2,250	
48,301-59,000	24,201-33,200	17,401-21,300	12,601-15,400	7,701-9,400	2,500	
59,001-70,900	33,201-39,700	21,301-25,500	15,401-18,400	9,401-11,300	2,750	
70,901-83,700	39,701-47,100	25,501-30,100	18,401-21,800	11,301-13,400	3,000	3
83,701-97,700	47,101-54,900	30,101-35,200	21,801-25,900	13,401-15,600	3,250	
97,701-112,700	54,901-63,400	35,201-40,600	25,901-29,300	15,601-18,000	3,500	
112,701-128,700	63,401-72,400	40,601-46,400	29,301-33,500	18,001-20,600	3,750	
128,701-145,900	72,401-82,100	46,401-52,500	33,501-37,900	20,601-23,300	4,000	4
145,901-164,200	82,101-92,400	52,501-59,100	37,901-42,700	23,301-26,300	4,250	
164,201-183,400	92,401-103,100	59,101-66,000	42,701-47,700	26,301-29,300	4,500	
183,401-203,700	103,101-114,600	66,001-73,300	47,701-53,000	29,301-32,600	4,750	
203,701-225,200	114,601-126,700	73,301-81,100	53,001-58,600	32,601-36,000	5,000	
225,201-247,700	126,701-139,400	81,101-89,200	58,601-65,400	36,001-39,600	5,250	
247,701-271-200	139,401-152,600	89,201-97,700	65,401-70,600	39,601-43,400	5,500	
271,201-295,900	152,601-166,500	97,701-106,500	70,601-77,000	43,401-47,400	5,750	
295,901-Greater	166,501-Greater	106,501-115,800	77,001-83,700	47,401-51,500	6,000	
-	-	115,801-125,500	83,701-90,600	51,501-55,700	6,250	
-	-	125,501-135,500	90,601-97,900	55,701-60,200	6,500	
-	-	135,501-145,800	97,901-106,800	60,201-64,800	6,750	
-	-	145,801-156,700	106,801-113,200	64,801-69,600	7,000	
-	-	156,701-167,900	113,201-121,300	69,601-74,600	7,250	
-	-	167,901-179,400	121,301-129,600	74,601-79,800	7,500	
-	-	179,401-191-400	129,601-138,300	79,801-85,100	7,750	
-	-	191,401-Greater	138,301-Greater	85,101-Greater	8,000	

*Reproduced from the 2015 *International Fire Code* (2015 IFC)
a. Types of construction based on the *International Building Code*
b. Measured at 20 psi residual pressure

A reduction of up to 75 percent of NFF is allowed when the building is provided with an approved automatic sprinkler system in accordance with the IBC and IFC requirements.

Between the structural delivery system (ISO) and building (IBC and IFC) requirements, the City works toward achieving the NFF requirement. Each building has different NFF requirements and should be evaluated on a case-by-case basis.

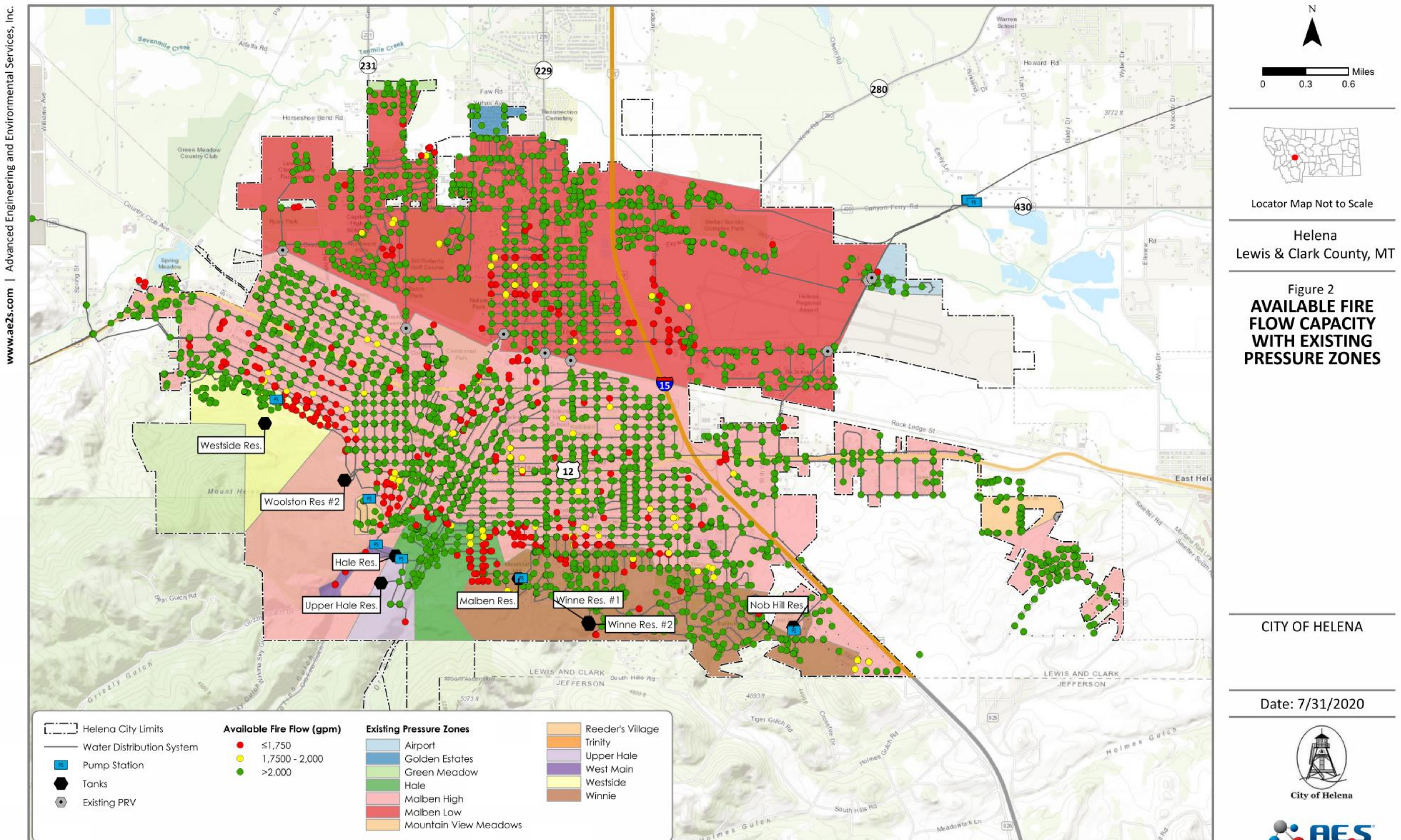
The City of Helena Engineering Standards Section 2.4.1 requires 1,750 gpm at 20 psi residual for a duration of 2 hours. Building specific requirements may vary based on the information presented in Table 2.

FIRE FLOW ANALYSIS

One of the primary ways to identify deficiencies in a water system is an analysis of the available fire flows and a comparison of these values to the required fire flows in each area of the City. The required fire flow based on the City standard is 1,750 gpm. Figure 2 shows the available fire flows throughout the system. Figure 2 shows that there are significant areas where the current available fire flow is below 1,750 gpm. The model was used to determine the impact of replacing all water mains smaller than 8-inch diameter with new 8-inch diameter water mains. The City standard for minimum size for water mains is 8-inch diameter. Figure 3 shows the available fire flows throughout the system, with all the under-sized mains replaced. Almost all the areas of inadequate fire flows are resolved by the replacement of the smaller water mains. The remaining areas of low fire flows are generally along the southern boundary of the system, where elevations are highest.

The existing distribution system includes about 7.2 miles of pipe with a diameter of 4 inches or smaller, and about 72.9 miles of pipe with a diameter of 6 inches. These pipes represent about 34% of the total length of pipe in the system. This large amount of pipe makes it impractical to develop a meaningful plan for replacement. The risk assessment detailed in tech memo #9 provides a more practical approach to determining the priority of pipelines to replace, so it will be the primary approach to establishing projects and priorities.

To identify those areas with the lowest available fire flows, a second limitation is necessary. For purposes of this analysis, the second limitation was set at 1,000 gpm. While this value is less than the City standard, it does meet the IFC requirement for one- and two-family dwellings that do not exceed 3,600 square feet and do not have an automatic sprinkler system. Figure 4 highlights the nodes where the available fire flow is less than 1,000 gpm. Most of the nodes where available fire flow is less than 1,000 gpm are nodes at or near the end of a dead-end line. There are three clusters of nodes that will be reviewed further.



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Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 5 -Proposed Hydrant Available Fireflow

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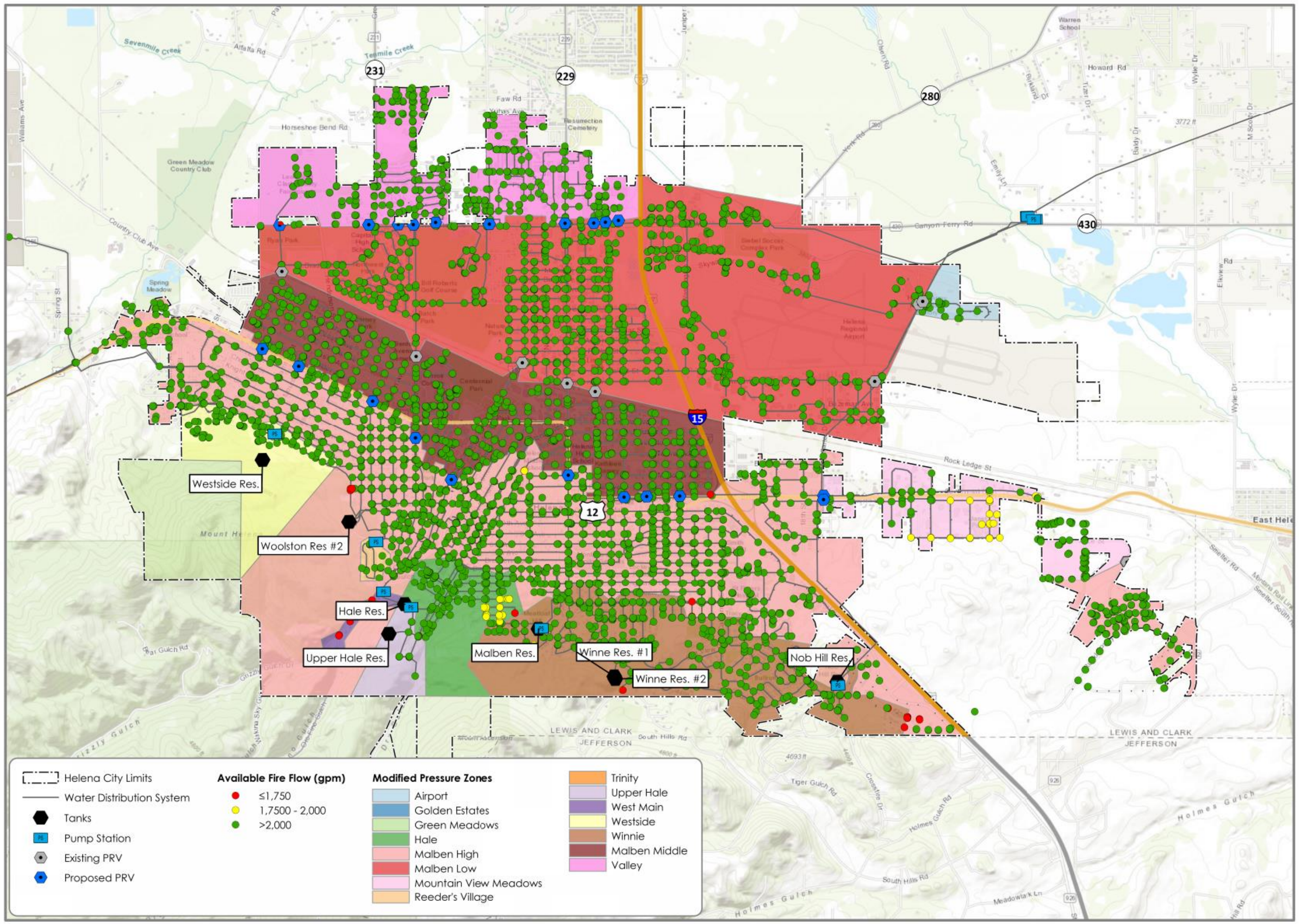

N
0 0.3 0.6 Miles

Locator Map Not to Scale

Helena
Lewis & Clark County, MT

Figure 3
AVAILABLE FIRE FLOW CAPACITY WITH MODIFIED PRESSURE ZONES AND ALL UNDERSIZED PIPES REPLACED WITH 8-INCH DIAMETER

CITY OF HELENA

Date: 7/31/2020

City of Helena

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Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 8-Helena Proposed System - Available Fire Flow Capacity with Modified Pressure Zones and All Undersized Pipes Replaced with 8-inch Diameter

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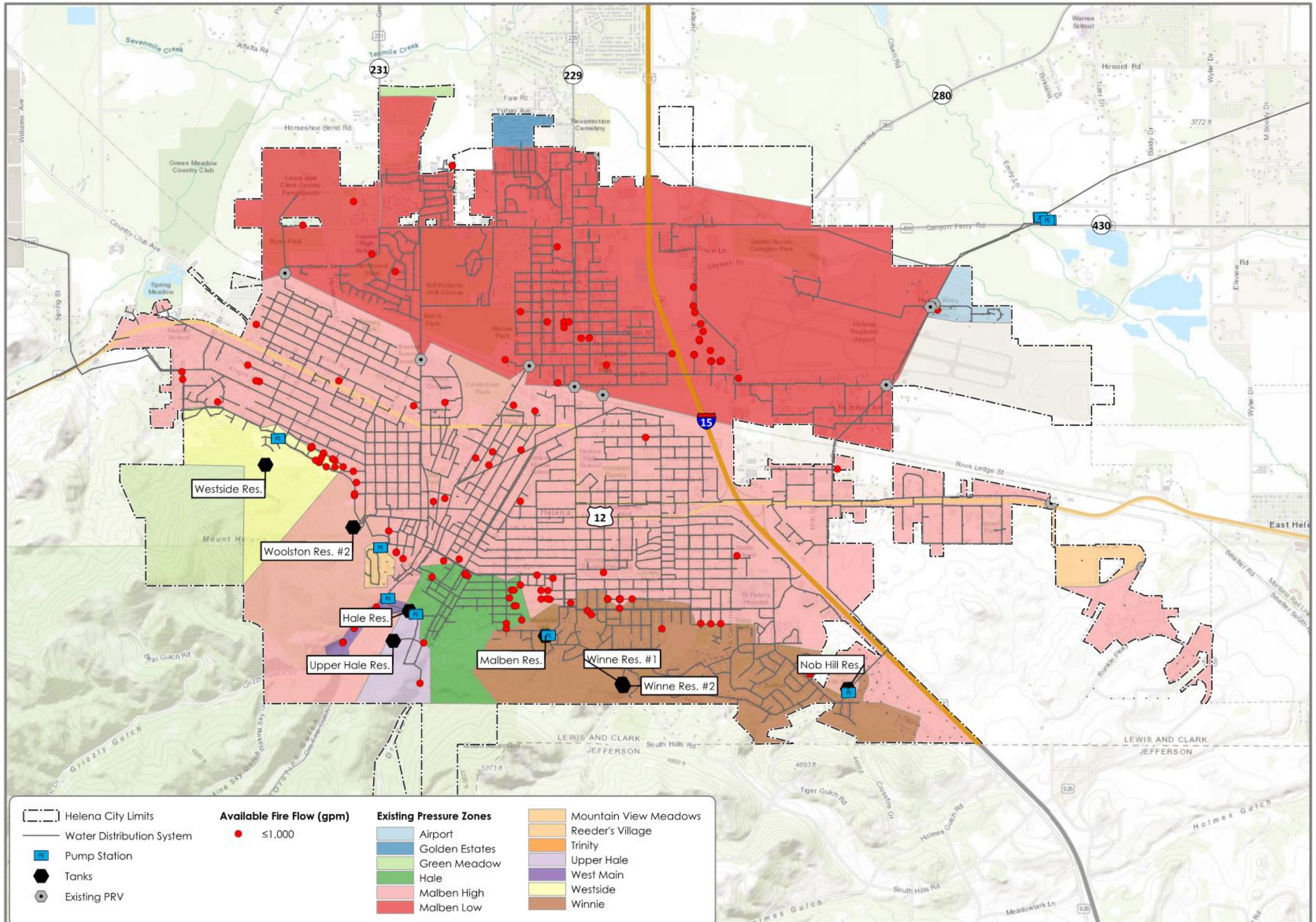

N

Miles
0 0.3 0.6

Locator Map Not to Scale

Helena
Lewis & Clark County, MT

Figure 4
AVAILABLE FIRE FLOW CAPACITY WITH EXISTING PRESSURE ZONES

CITY OF HELENA

Date: 8/12/2020

City of Helena

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FIRE FLOW IMPROVEMENTS

Area 1 – East side of Cedar Street Interchange

There is an existing 16-inch diameter water main on the south side of Airport Road that extends west to South California Street, constructed in 2009. There is also an existing 16-inch diameter water main on the south side of Skyway Drive, west of Washington Street. These two lines are about 4,600 feet apart. A new 16-inch diameter pipeline would improve the redundancy in this part of the Malben Low Zone and increase available fire flows in this area. This area is shown in Figures 5 and 6, along with the proposed new pipeline (checkered line), existing available fire flows (gray labels), and available fire flows with the proposed improvements (green labels).

This proposed pipeline would improve fire flows in the area but would not meet the recommended flows in all areas. Some of this is due to small individual pipelines. This proposed project has some benefits for fire flow, but they are generally not significant compared to the cost of these improvements. This project should be considered for the redundancy that it provides.

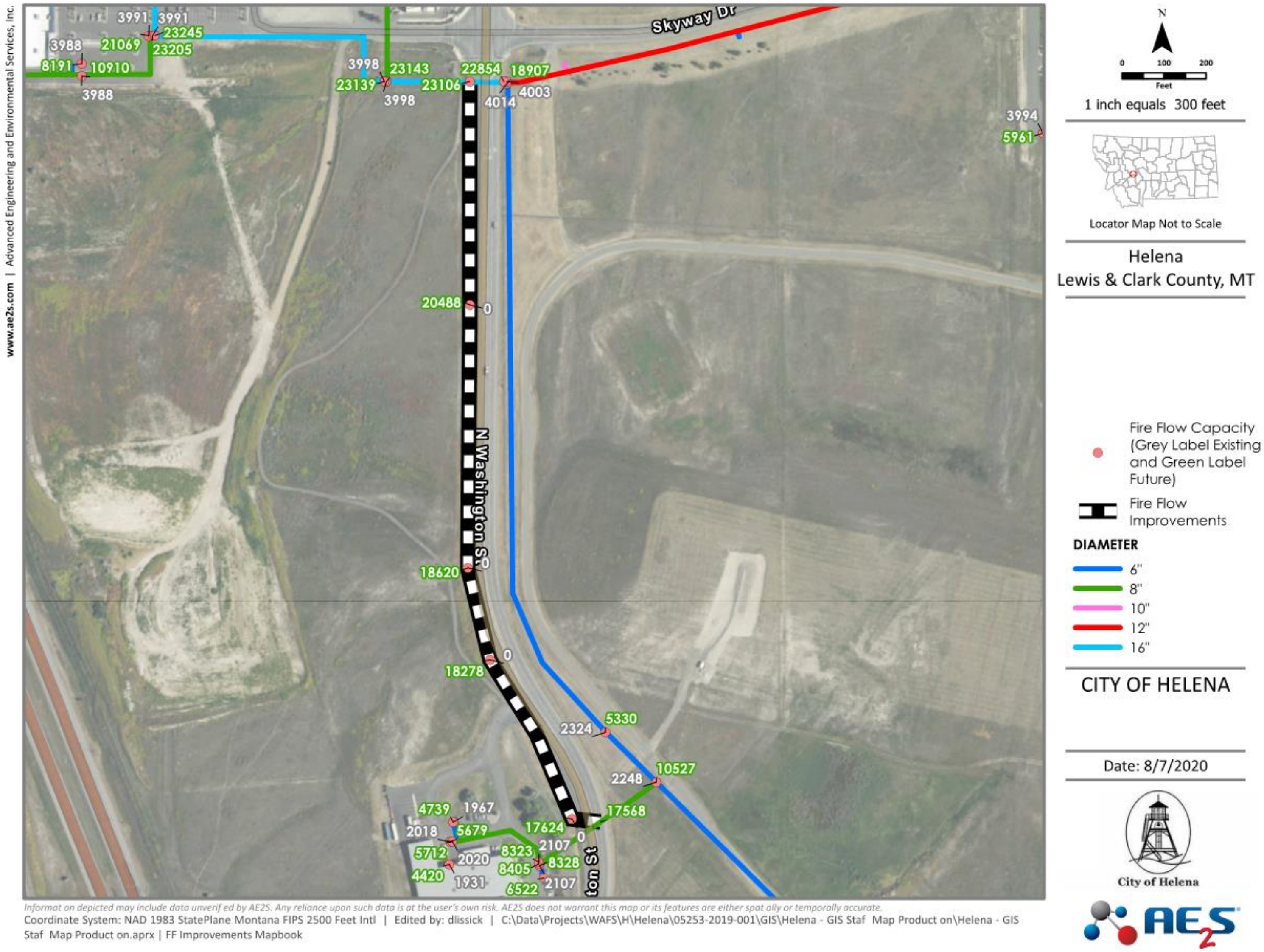
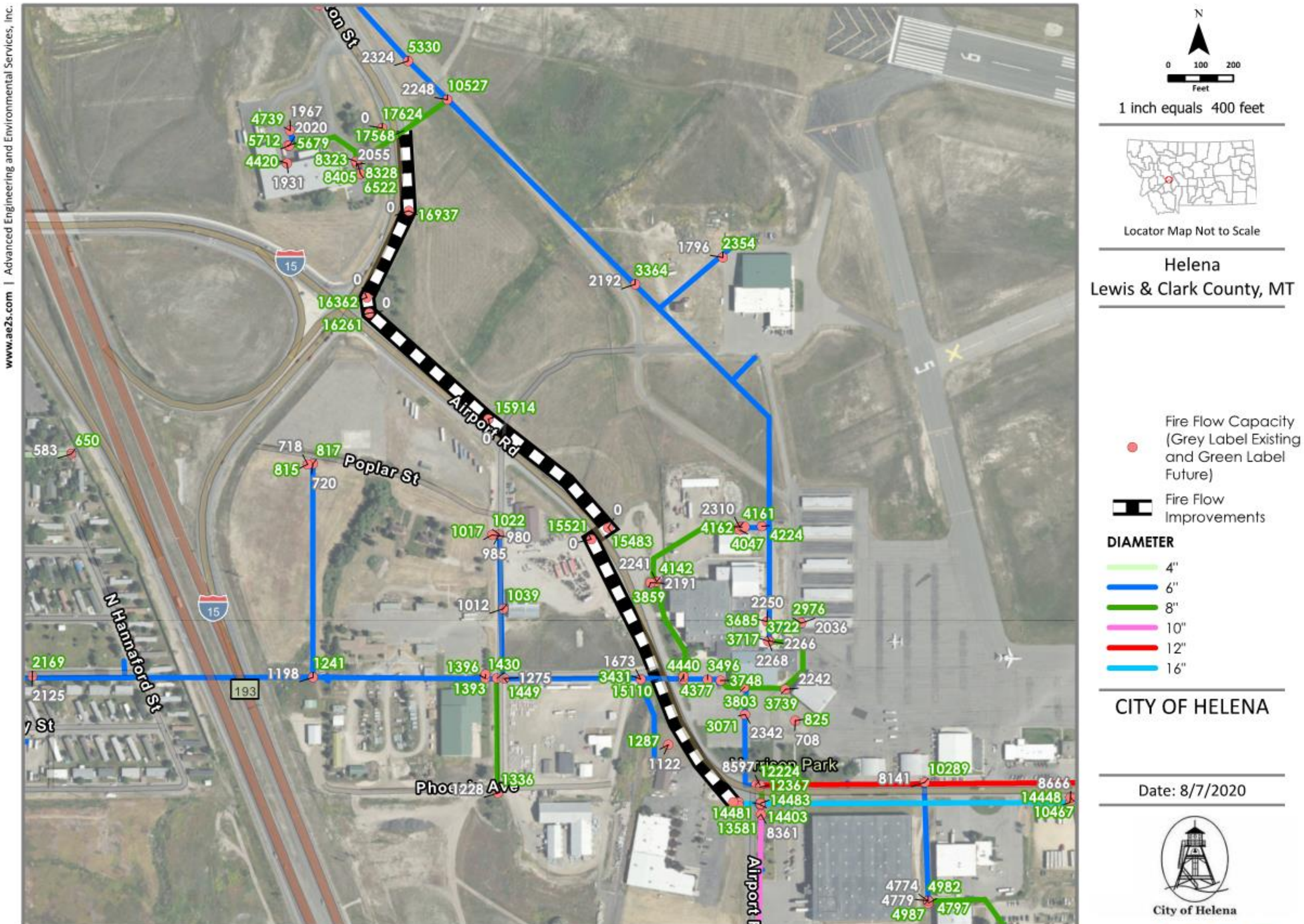


Figure 5 – Area 1 (North)



Information depicted may include data unverified by AE2S. Any reliance upon such data is at the user's own risk. AE2S does not warrant this map or its features are either spatially or temporally accurate.
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 Feet Intl | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Product on\Helena - GIS Staff Map Product on.aprx | FF Improvements Mapbook

Figure 6 – Area 1 (South)

Area 2 – University Street

This area of low fire flows is served primarily by a 6-inch line in University Street. This street is the southern edge of the Malben High Zone, while Le Grande Cannon Boulevard is the northern edge of the Westside Zone. A connection between these two zones, separated by a pressure reducing valve (PRV), would improve the fire flows along University Street. The water mains from the Westside Zone extend down Henderson Street, Allison Street, Cleveland Street, and Grant Street almost to University Street. The lowest available fire flows are near the intersections of Grant Street, so this would be the best location for the PRV, although other locations could also be used. This area is shown in Figure 7 along with the proposed new pipeline/PRV (checkered line), existing available fire flows (gray labels), and available fire flows with the proposed improvements (green labels). A new 4-inch PRV near the intersection of Grant Street and University Street would increase the fire flow at this intersection from 730 gpm to 1,700 gpm, which almost meets the City Standard of 1,750 gpm. A second PRV on an adjacent street would be necessary to meet the City Standard.

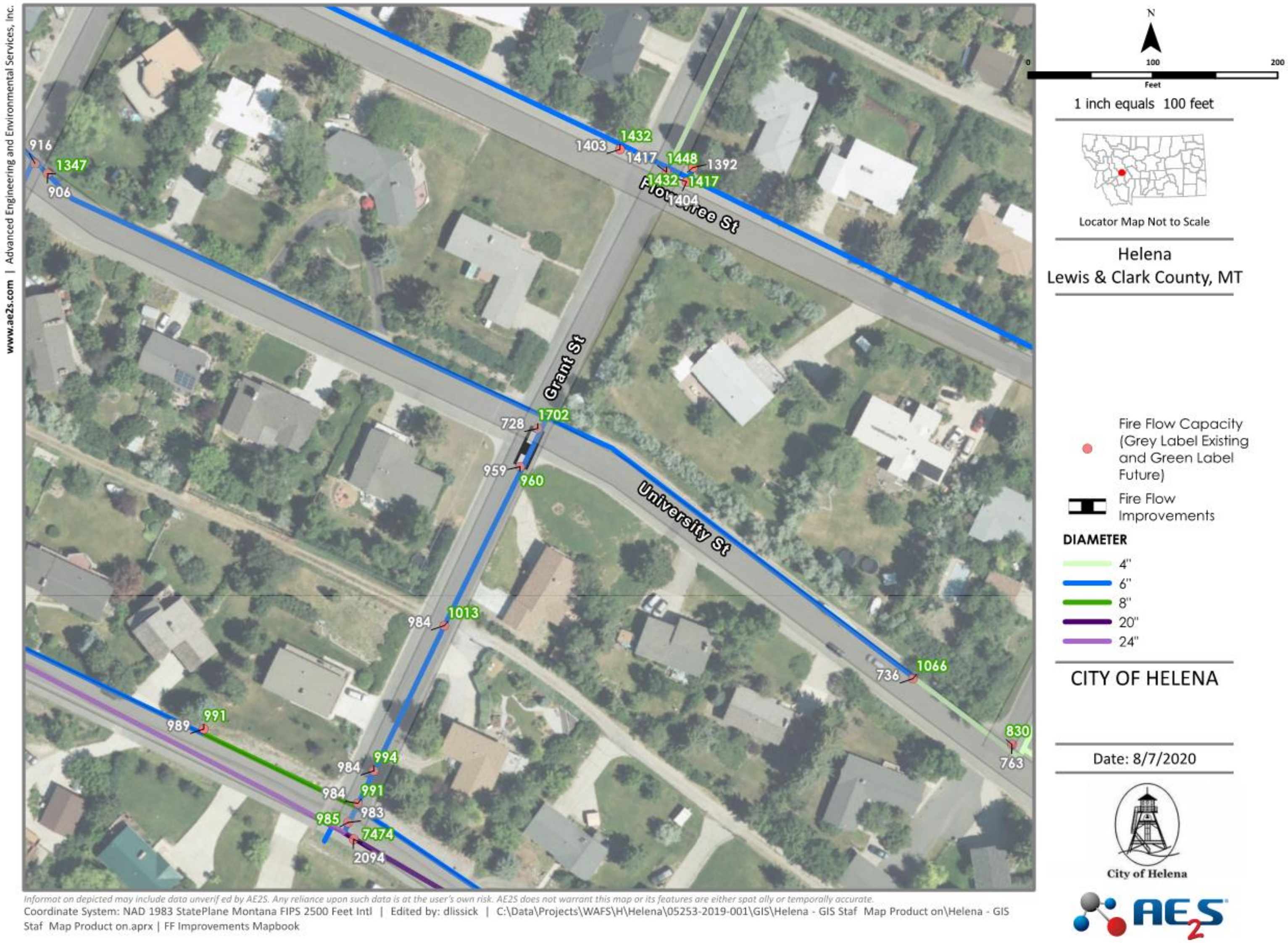


Figure 7 – Area 2

Area 3 – West Main Street

This area of low fire flows is served primarily by a 6-inch line in West Main Street, south and west of the Eureka Pump Station. There are no storage tanks connected to this small pressure zone, so the only available flow is from the Eureka Pump Station. A larger pipeline in West Main Street would not increase the capacity of the pumps at the Eureka Well substantially, so this step alone would not significantly change the fire flows in this area. The first step to improve fire flows in this area is to connect this system to a storage tank. The Technical Memorandum on System Storage describes options to construct a new tank at the Scott Tank site or an additional tank adjacent to the Upper Hale Tank. Either of these new tanks would be connected to the West Main Street pipe system. Connecting the West Main Street Zone to the Upper Hale Tank would increase the fire flow at the south end of West Main Street from 370 gpm to 450 gpm, and near the Eureka Pump Station, the fire flow would increase from 660 gpm to 910 gpm. The recommended fire flow in this area is 1,000 gpm.

The second step to increasing the fire flow along West Main Street would be replacing the existing 6-inch pipe with a larger pipe. As part of a recent roadway project, the City of Helena installed a new 10-inch pipe in most of West Main Street but did not put the line in service. When more system capacity is available, this line can be put into service. Along with connection to the Upper Hale Tank, the fire flow at the south end of West Main Street would increase dramatically. These proposed improvements are shown in Figure 8, along with the proposed new pipelines (checkered lines), existing available fire flows (gray labels), and available fire flows with the proposed improvements (green labels).

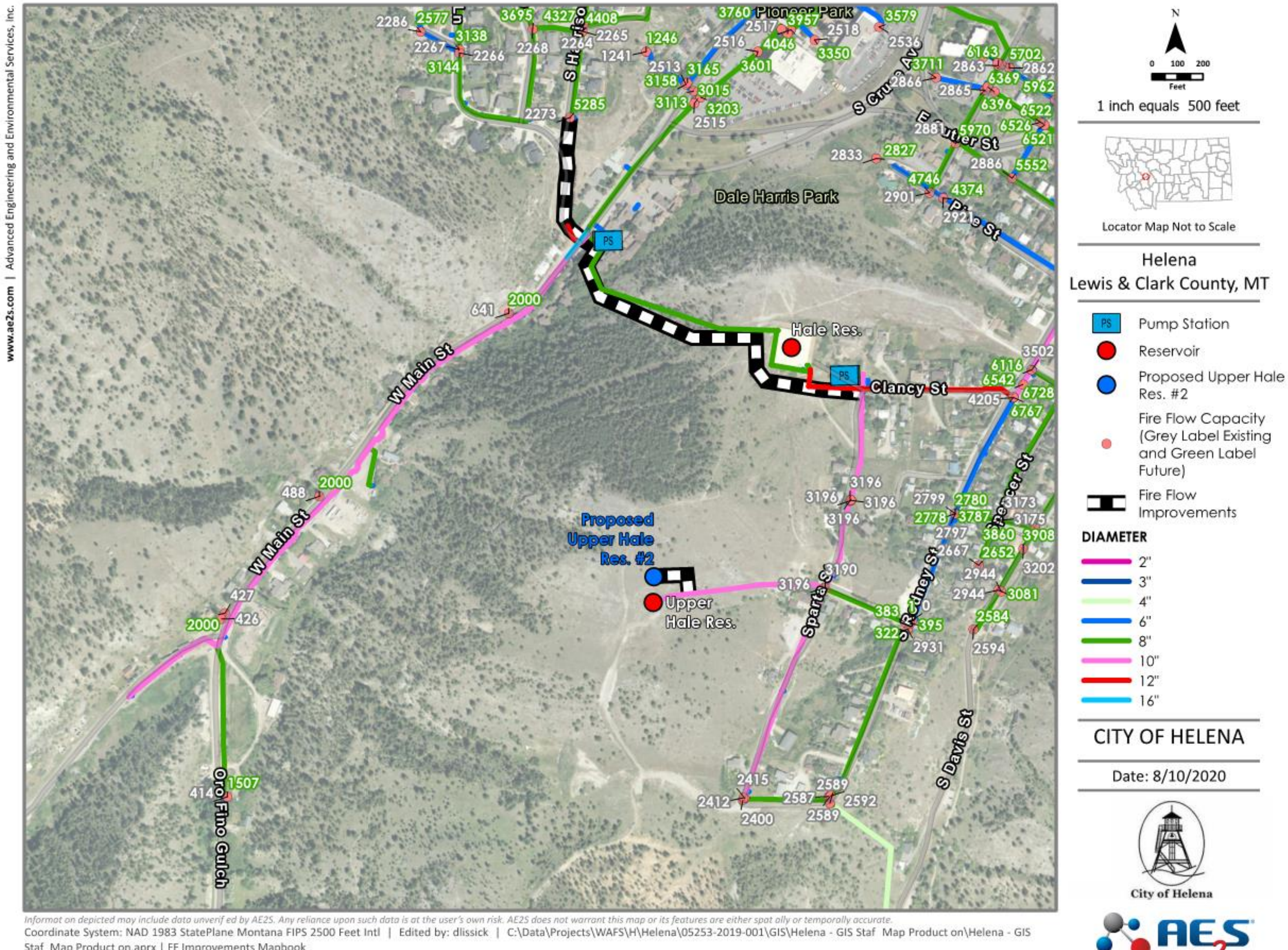


Figure 8 – Area 3

GROWTH IMPROVEMENTS

2040 Growth

The Planning and Service Area Update Technical Memorandum identified two primary areas of growth for the City of Helena: the southeast part of the City in the Mountain View Meadows and Padbury Ranch developments, and the north part of the City, generally between Green Meadow Drive and McHugh Drive. The Water Use Characterization Technical Memorandum presented 2040 water demand projections, indicating that the additional maximum day demand in the southeast part of the City will be approximately 938,000 gallons or about 651 gpm, and the additional demand in the north part of the City will be approximately 312,000 gallons or about 217 gpm. The impacts of the growth in the north part of Helena are addressed separately in the following section.

To evaluate the impact of the potential growth in the southeast part of Helena on the existing water system, a maximum day demand of 651 gpm at the intersection of Runkle Parkway and South Alice Street was added to the existing maximum day demand scenario. While this total demand will not occur at this intersection, the intersection is near the southern and eastern limits of the water system. As this area of Helena continues to develop, more water mains will be constructed, and the additional loops in the system should reduce the impacts. The results of this scenario indicate that the minimum pressure at this intersection is 117 psi with the current demand scenario and 108 psi with the additional demands. At this time, there are no specific improvements being recommended in order to meet the anticipated future demands in that part of the City.

Central and North Valley

The Planning and Service Area Update Technical Memorandum identified long-term future populations north of Helena that could be served by the City of Helena. The areas were divided into the Central Valley and North Valley, with the split between the areas approximately at Norris Road. The Planning and Service Area Update Technical Memorandum identified maximum day demands at the ultimate buildout of 6.5 MGD for the Central Valley and 1.9 MGD for the North Valley. Approximately 2/3 of the Central Valley area is west of Interstate 15, and the large majority of the North Valley area is west of Interstate 15. The projected ultimate buildout demand west of Interstate 15 is 2/3 of 6.5 MGD plus 100% of 1.9 MGD, or about 6.2 MGD.

There are three major north-south corridors west of Interstate 15, including Montana Avenue, McHugh Drive, and Green Meadow Drive. The existing water lines in these streets include a 20-inch diameter main in Montana Avenue to Ptarmigan Lane, a 12-inch diameter main in McHugh

Drive to about Yuhas Avenue, and a 12-inch diameter main in Green Meadow Drive to about Andesite Avenue.

There are a limited number of east-west corridors in the Helena Valley, but cross-connections for these three main lines will be very important to provide some system redundancy. There is an existing 12-inch line in Flagstone Avenue extending east from Green Meadow Drive to a point east of North Benton Avenue. This line should eventually be extended to McHugh Drive. There is an existing 12-inch line in Wolf Road extending east from McHugh Drive to Amber Court. This line should eventually be extended to Montana Avenue. These future east-west connections are shown in Figure 9.

Two different scenarios were analyzed for providing water service to the future development of the Central Valley area. The first scenario considers that there is a larger existing main in Montana Avenue, and there is currently more dense development near Montana Avenue. In this scenario, the flows were split to include 3.1 MGD at the north end of Montana Avenue, 1.6 MGD at the north end of McHugh Drive, and 1.6 MGD at the north end of Green Meadow Drive. This analysis indicated that the main in Montana Avenue could be extended with a 16-inch diameter pipe, reducing from the 20-inch diameter pipe that currently extends from Custer Avenue to Ptarmigan Lane. With these demands, the velocity in the 16-inch line in Montana Avenue is 3.4 feet per second, and the velocity in each of the 12-inch lines is 3.2 feet per second. The water mains in McHugh Drive and Green Meadow Drive should be extended north as 12-inch diameter pipes at least to Mill Road (see Figure 9).

The second scenario considers that the development in the Central Valley could be more uniformly distributed from east to west. In this scenario, the flows were evenly split to include 2.1 MGD at the north end of Montana Avenue, McHugh Drive, and Green Meadow Drive. This analysis indicated that the main in Montana Avenue could be extended with a 16-inch diameter pipe, reducing from the 20-inch diameter pipe that currently extends from Custer Avenue to Ptarmigan Lane. With these demands, the velocity in the 16-inch line in Montana Avenue is 2.3 feet per second, and the velocity in each of the 12-inch lines is 4.1 feet per second. The water mains in McHugh Drive and Green Meadow Drive should be extended north as 12-inch diameter pipes at least to Mill Road (see Figure 9).

The impacts of extending service into the Central Valley area were modeled by imposing the demands shown in Table 3 on the system. Table 3 also shows the normal operating pressures at these points, based on this area remaining a part of the Malben Low Zone. If a larger Valley Zone is created and this area is included in the Valley Zone, pressures would be about 40 psi lower. The pressures shown in Table 3 do not include a 12-inch diameter line on Mill Road, between Montana Avenue and Green Meadow Drive. At least one 12-inch diameter connection between Montana Avenue and Green Meadow Drive is recommended to improve the reliability of the system. With the limited number of current east-west corridors, Mill Road is a logical connection for these three main water lines (see Figure 9). If a future east-west corridor is created near Mill Road, it could also be used.

Table 3 – Central Valley Pressures

Intersection	Max Day Demand, MGD	Normal Pressure, Malben Low Zone
Scenario 1		
North Montana Avenue/Mill Road	3.1	116 psi
McHugh Drive/Mill Road	1.6	84 psi
Green Meadow Drive/ Mill Road	1.6	98 psi
Scenario 2		
North Montana Avenue/Mill Road	2.1	120 psi
McHugh Drive/Mill Road	2.1	79 psi
Green Meadow Drive/ Mill Road	2.1	91 psi

The values in Table 3 indicate if water mains are to be extended along Montana Avenue (16-inch diameter), McHugh Drive (12-inch diameter), and Green Meadow Drive (12-inch diameter), the distribution system should be able to meet the projected future needs (see Figure 10). The water system model did not identify any specific areas of low pressure to provide future service to the Central Valley area.

The possibility of an additional or larger pipeline in Custer Avenue, west of Montana Avenue, should also be considered (see Figure 9). There is a 20-inch diameter water main from the Missouri River Water Treatment Plant to Montana Avenue, but only a 12-inch diameter water main west of Montana Avenue. A larger water main along Custer Avenue could improve the redundancy in the Malben Low Zone and also provide for a simpler split between the Malben Low Zone and a future Valley Zone that starts just north of Custer Avenue.

As the water system expands into the Central Valley, some additional storage will be required to mitigate the impacts of hourly peaks. The analysis completed for this Technical Memorandum only addressed the needs for maximum day demands. The hourly peak demand will be higher and could impact the ability of the overall system to provide the needs of development in the Central Valley.

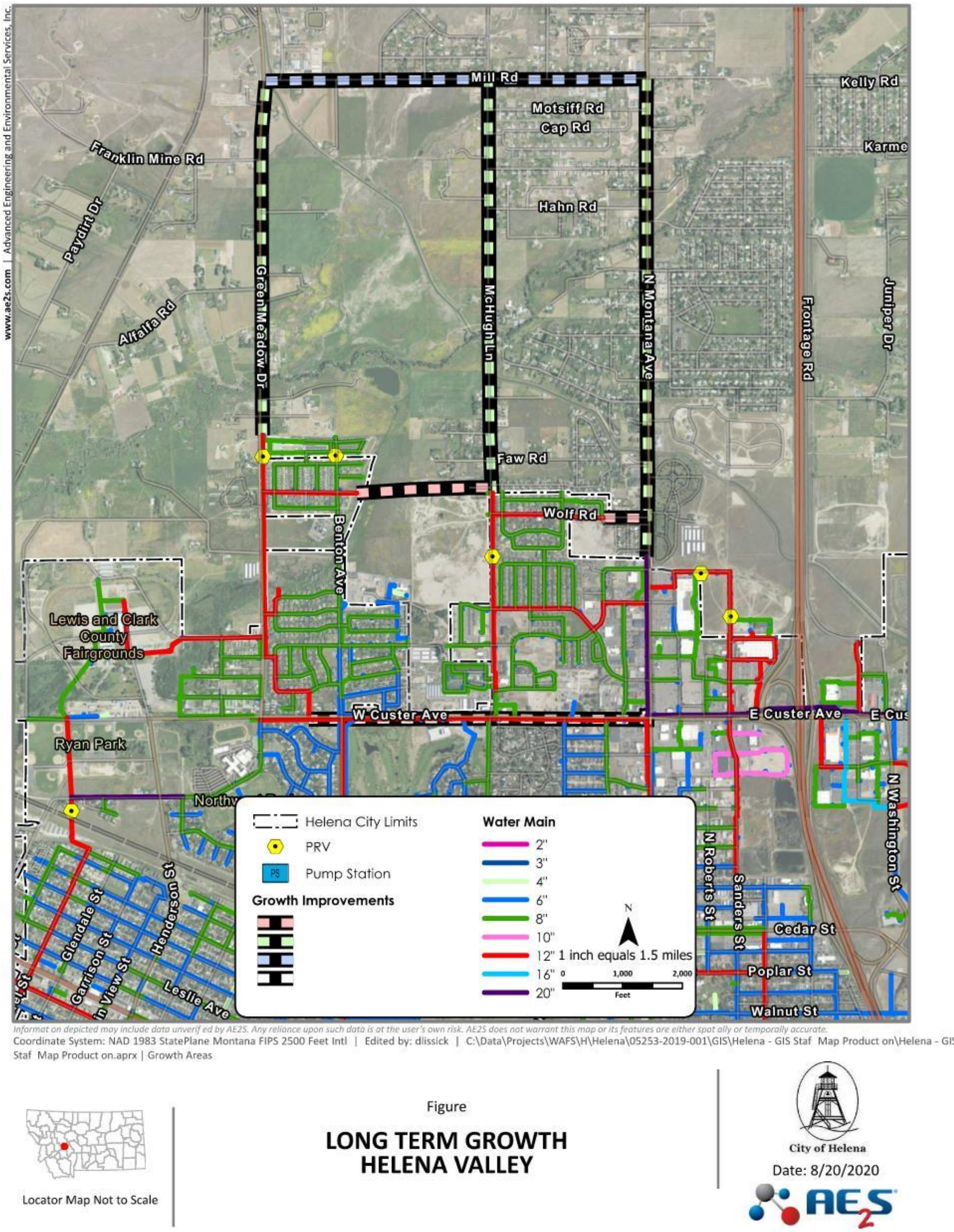


Figure 9 – Future Growth Improvements

RECOMMENDATIONS

Based on the results of this analysis, the following projects are proposed to improve the fire flow capabilities, system operation, redundancy, and future capabilities of the City of Helena water distribution system:

1: New 8-inch line along Grant Street between University Street and Le Grande Cannon Boulevard, with new pressure reducing valve (Area 2, Figure 7).

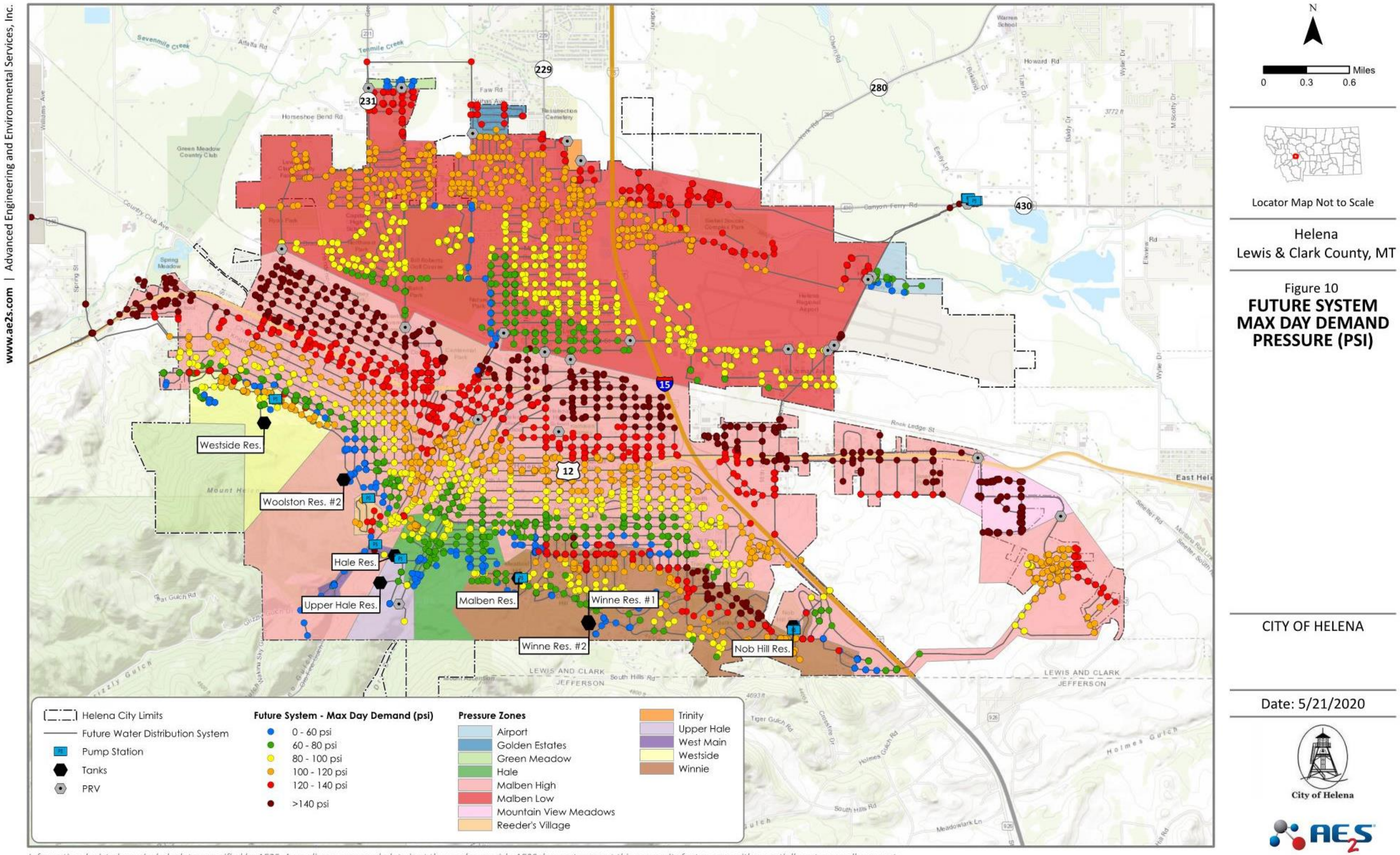
2: Connect recently installed 10-inch line along West Main Street, south and west of the Eureka Pump Station (Area 3, Figure 8) to the existing system. This improvement should only be completed after the West Main Street Zone is connected to a storage tank.

3: Extend existing 12-inch lines east along Flagstone Avenue from North Benton Avenue to McHugh Drive and along Wolf Road from Amber Court to Montana Avenue.

4: Extend existing 12-inch main lines north along Green Meadow Drive and McHugh Drive to Mill Road. Extend the existing main line north along Montana Avenue to Mill Road with a 16-inch line.

5: Add a new 12-inch line along Mill Road from Green Meadow Drive to Montana Avenue.

6: Add new or upsize the 12-inch main line along Custer Avenue west of Montana Avenue.



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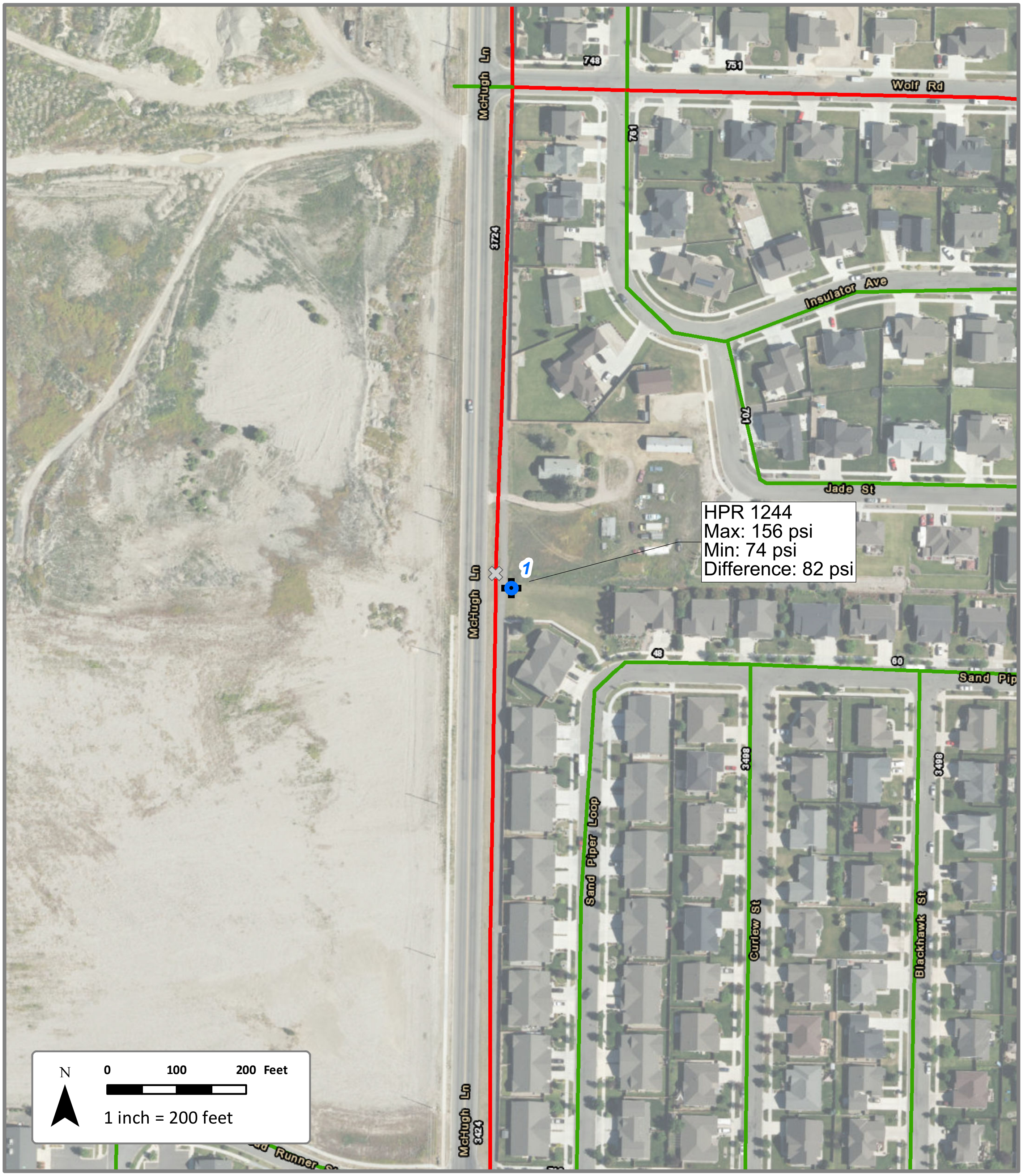
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlee | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 11- Future System Max Day Demand

APPENDIX A – EPS TEST RESULTS



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EPS TEST LOCATIONS

CITY OF HELENA
Helena | Lewis and Clark County, MT

Date: 8/19/2019

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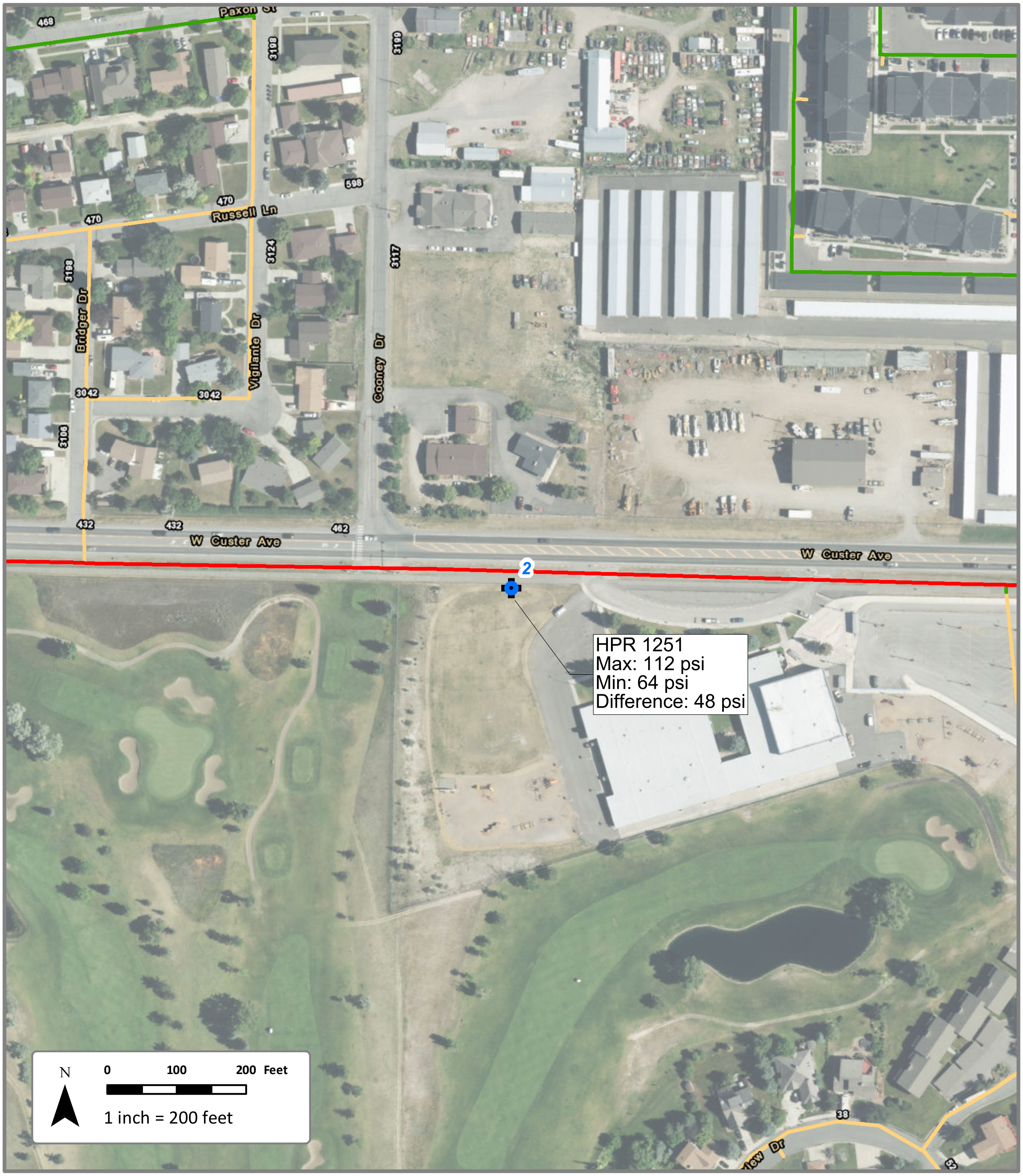

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Helena | Lewis and Clark County, MT

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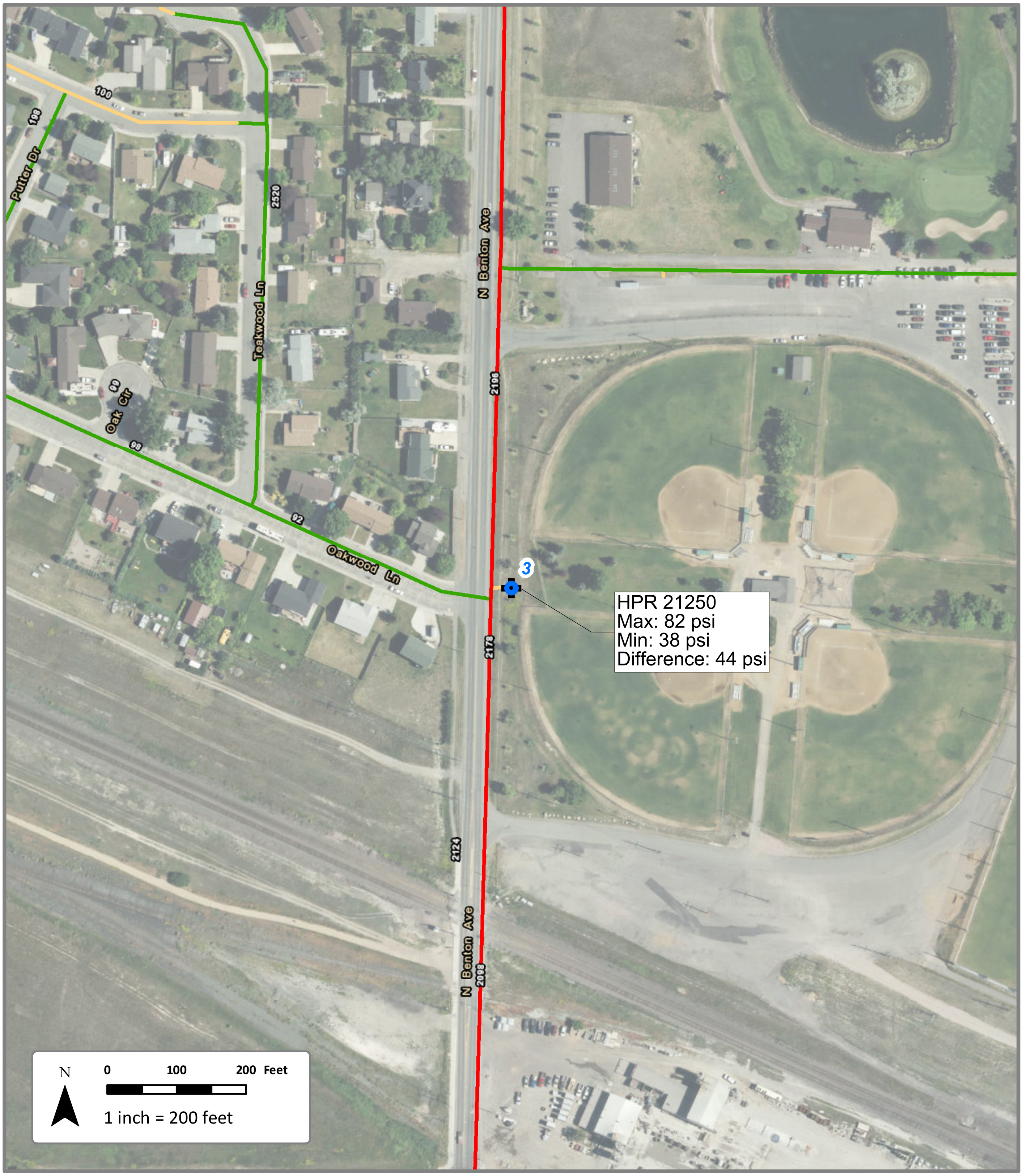

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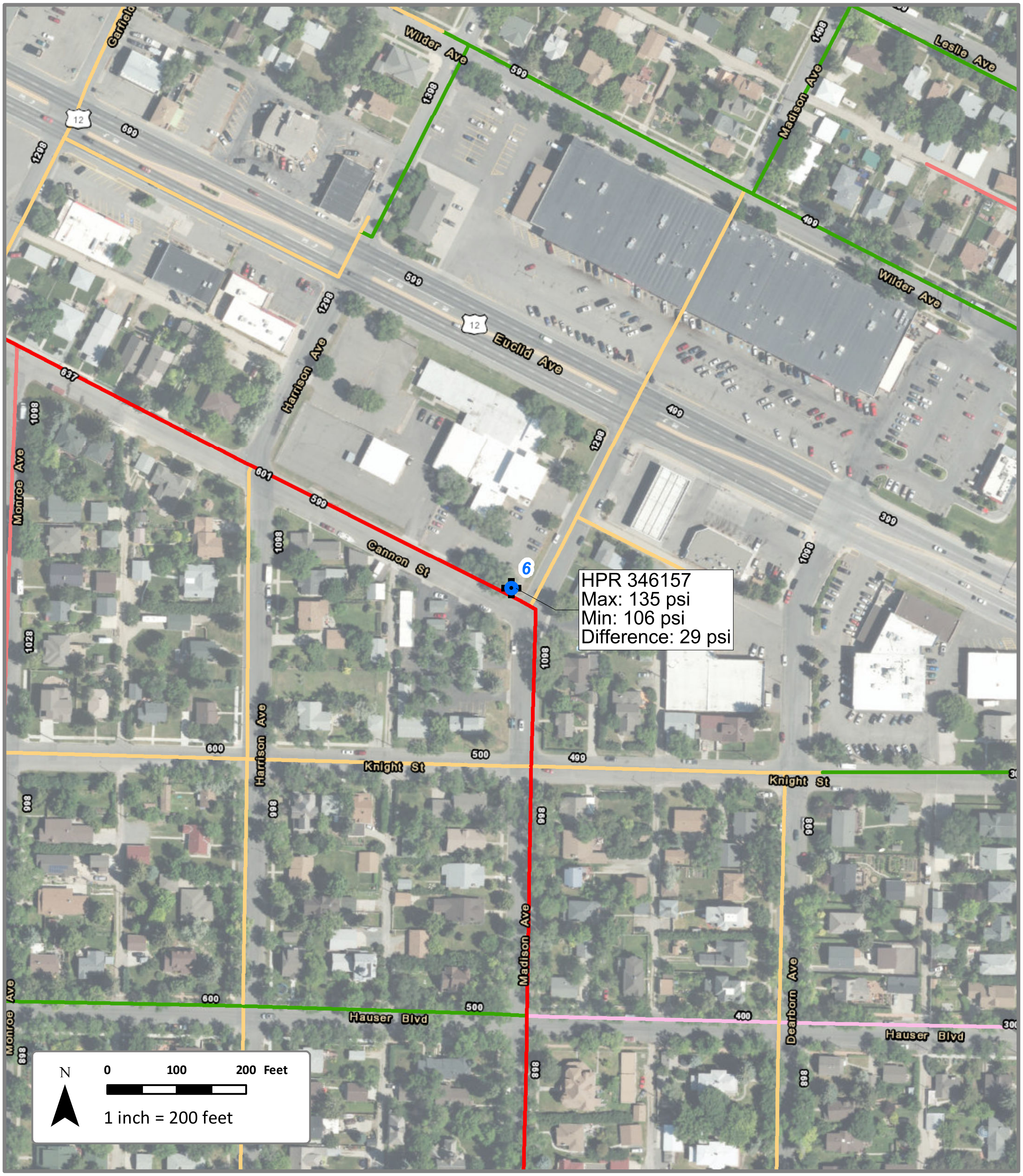

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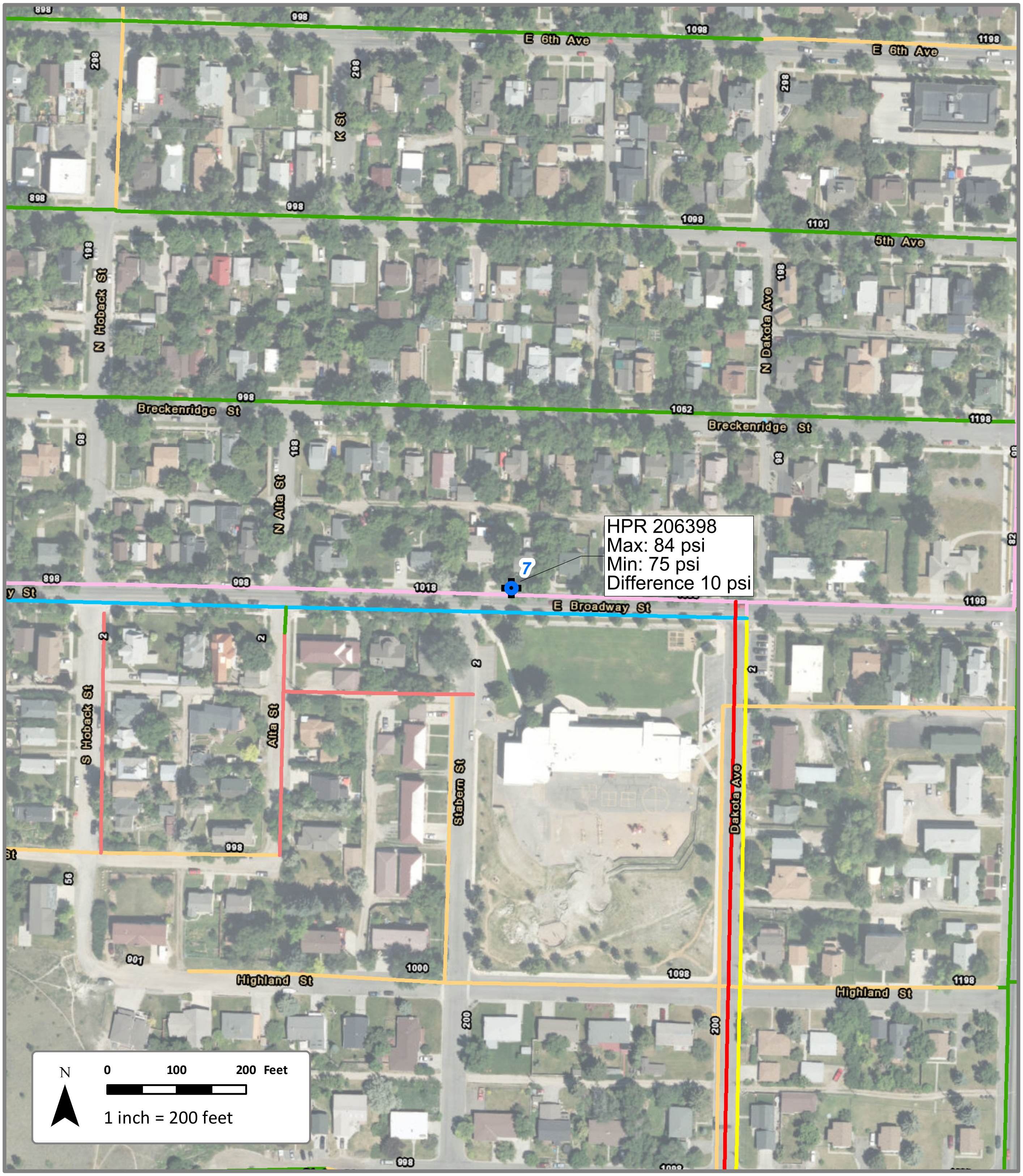

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EPS TEST LOCATIONS

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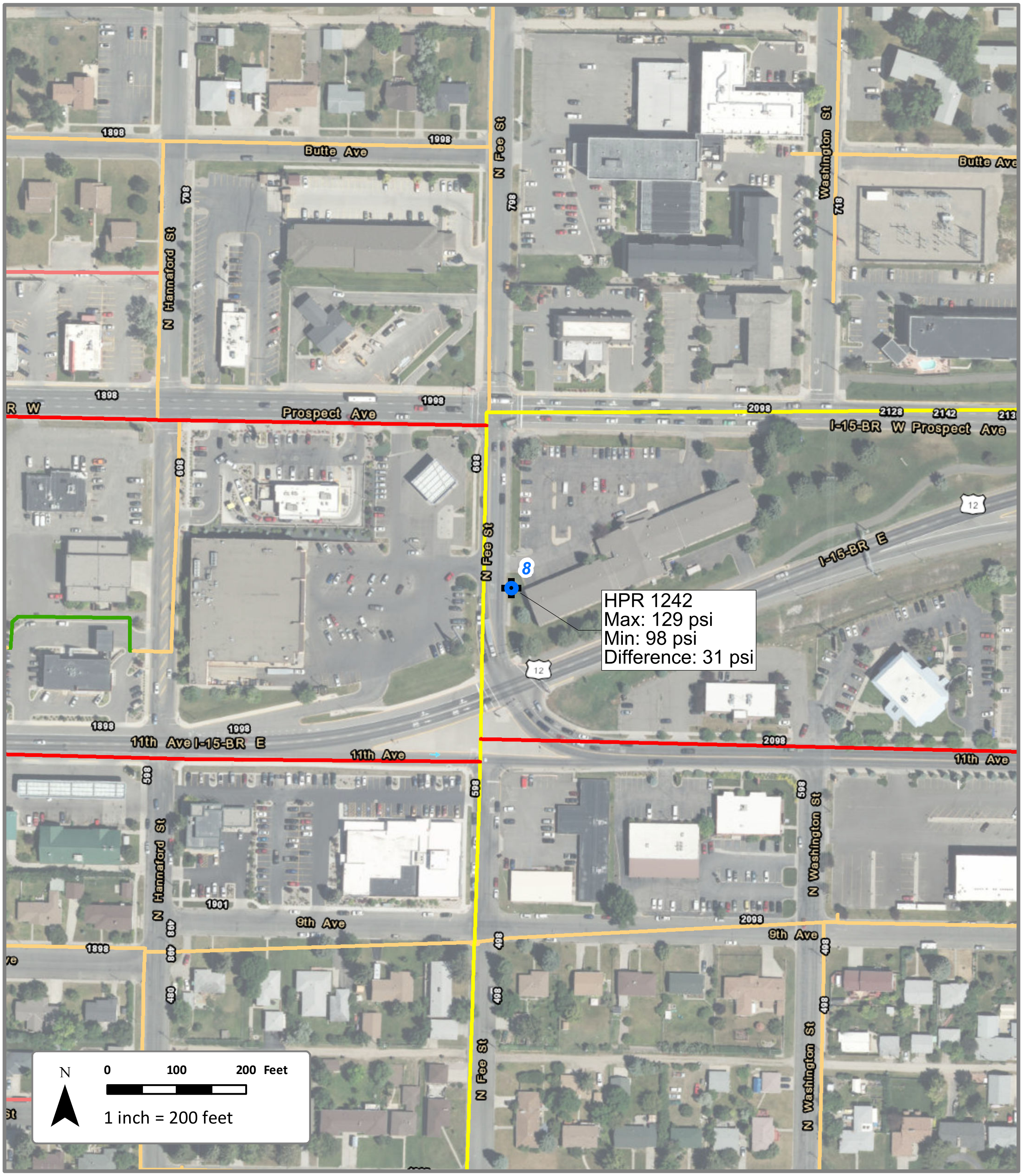

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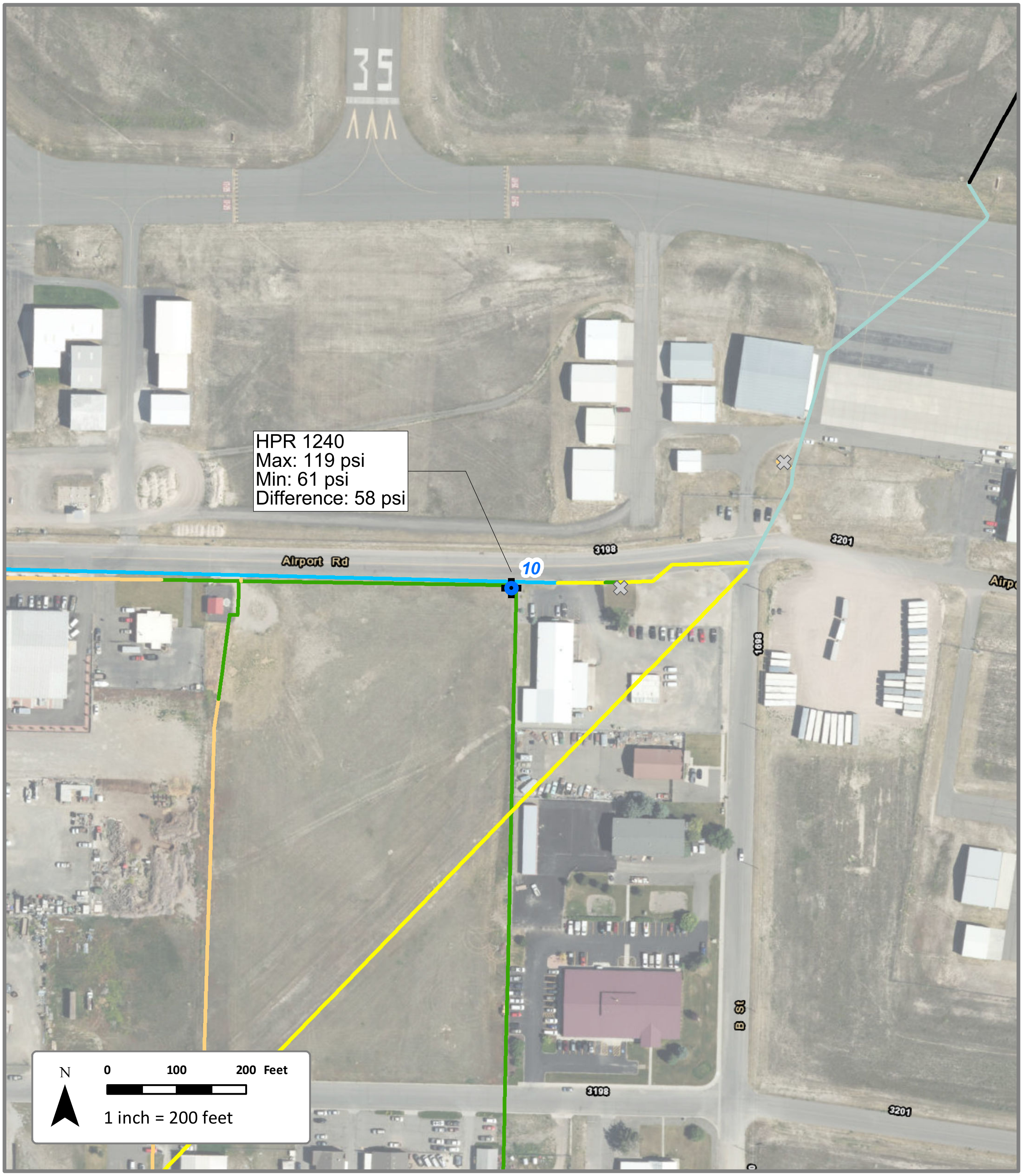

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EPS TEST LOCATIONS

CITY OF HELENA
Helena | Lewis and Clark County, MT

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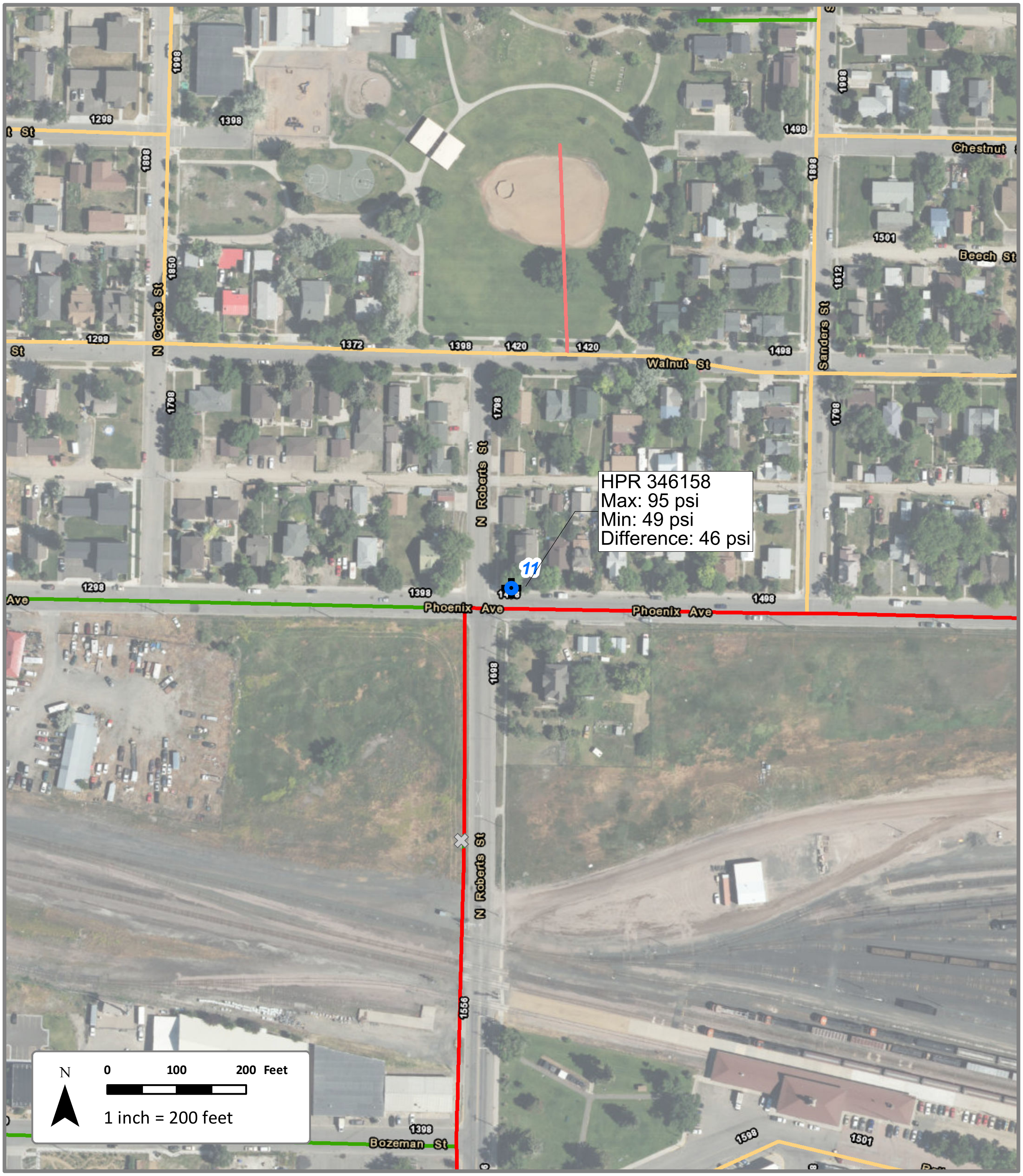

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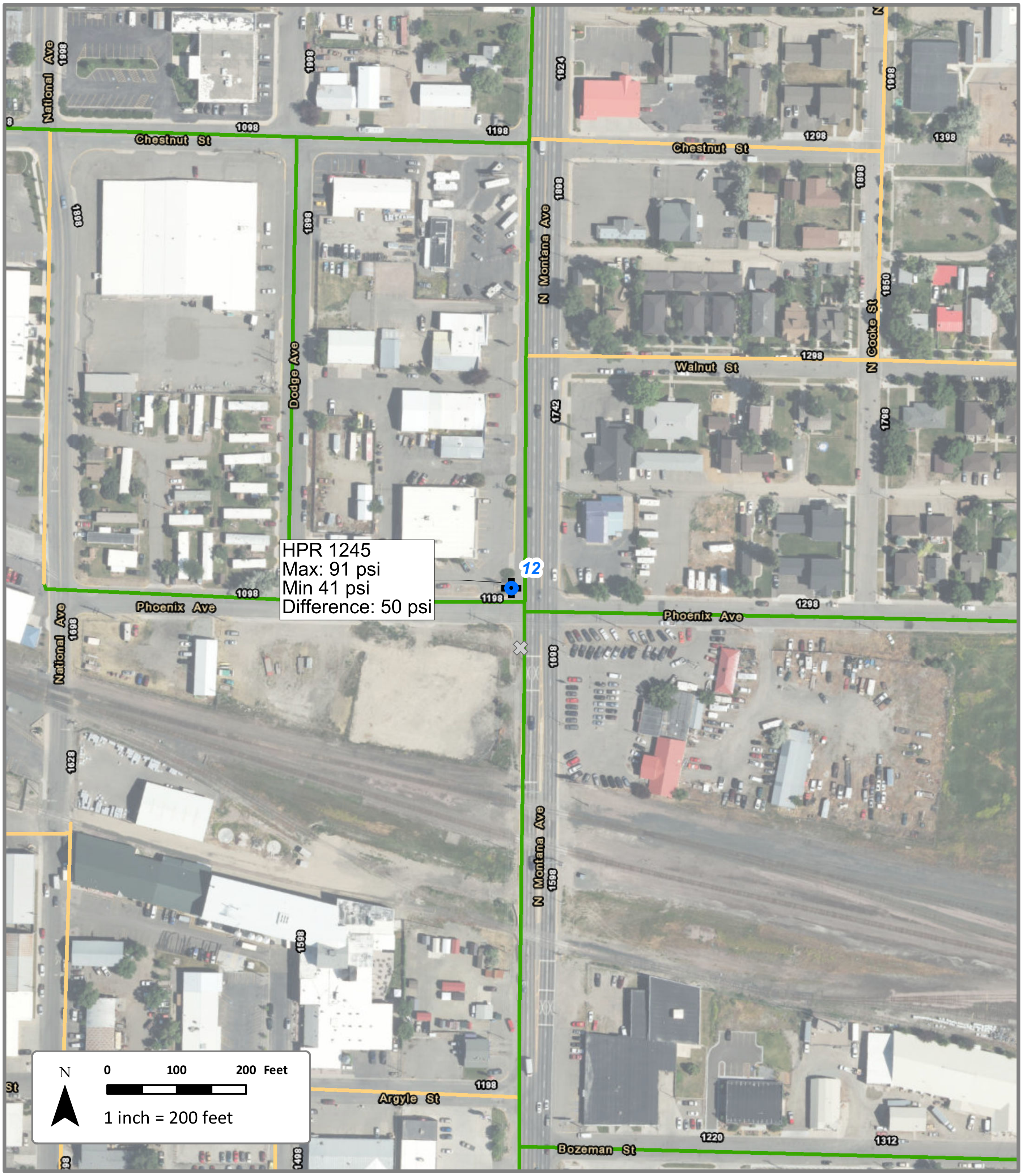

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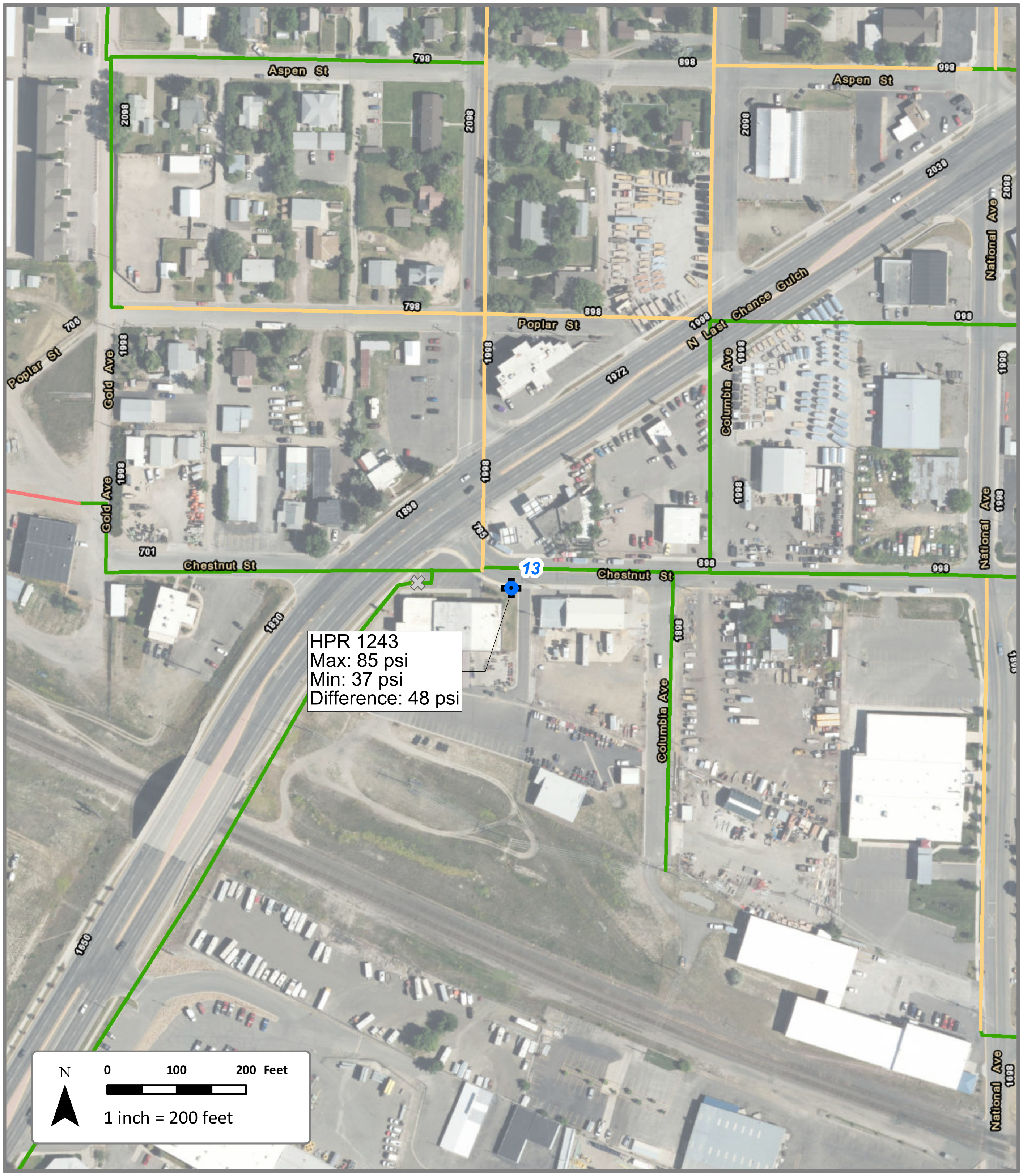

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EPS TEST LOCATIONS

CITY OF HELENA
Helena | Lewis and Clark County, MT

Date: 8/19/2019

TECHNICAL MEMORANDUM #8

To: Jamie Clark, PE

From: Mark Peterson, PE
Nate Weisenburger, PE

Re: **Water Main Risk Assessment**
City of Helena, MT

Date: December 8, 2020

INTRODUCTION

This Technical Memorandum is intended to summarize the process and results of a system-wide risk assessment of the horizontal assets (pipes) within the water distribution system. In accordance with the overall policies set forth in the Water System Risk Program, the assessment provides a system-wide evaluation to categorize risk using a consistent framework based on the consequence of failure (COF) and the likelihood of failure (LOF). In addition, the assessment will assist City staff in appropriately managing risk by planning and prioritizing rehabilitation, replacement, and capital improvements.

PROCESS

The International Standard ISO 55000 (Asset management – Overview, principles, and terminology) outlines several approaches to calculate the risk of an asset. The approach utilized for the City of Helena is the linear addition method. The linear nomenclature implies that risk is evaluated as a composite risk score, as opposed to a bi-directional approach that considers COF and LOF independently, with the highest risk assets being only those that rise to the top of both the COF and LOF categories. The addition nomenclature simply means the weighted COF and LOF scores are summed to calculate the total risk score, as shown in the equation below.

$$\text{Total Risk Score} = (COF_1 * Weight_1 + COF_2 * Weight_2 + COF_3 * Weight_3 + COF_4 * Weight_4 + COF_5 * Weight_5 + COF_6 * Weight_6) + (LOF_1 * Weight_1 + LOF_2 * Weight_2 + LOF_3 * Weight_3 + LOF_4 * Weight_4 + LOF_5 * Weight_5 + LOF_6 * Weight_6 + LOF_7 * Weight_7 + LOF_8 * Weight_8)$$

The risk assessment utilized data from the City's GIS, Cityworks® CMMS, USDA Web Soil Survey, and hydraulic model to score assets based on several COF and LOF criteria, as described in the following sections. The top twenty percent of the assets by risk scores were evaluated to identify potential replacement projects, which are discussed throughout this memo.

CONSEQUENCE OF FAILURE ASSESSMENT

A composite COF score was determined for each water main asset based on the following factors:

- Line primary function - transmission vs. distribution (City's GIS data)
- Proximity to critical facilities - medical, emergency, municipal, airport, school, state (City's GIS data)
- Number of connected service laterals (City's GIS data)
- Accessibility for repairs (City's GIS data)
- Redundancy (risk model)
- Maximum flow rate (hydraulic model output)

The COF scores for each of these criteria, as well as the distribution of assets associated with each score, are summarized in the following tables.

Line Primary Function

To quantify the impact of failure that any transmission main would have on the water distribution system, all transmission and reservoir piping was assigned a COF score of 10, with all other distribution piping receiving a COF score of 0. This is shown in Table 1.

Table 1: Line Primary Function Scoring

Service Type	Score	Asset Distribution
RESERVOIR PIPING	10	1%
TRANSMISSION	10	7%
ALL OTHER PIPING	0	92%

Critical Facilities

The City identified 87 facilities throughout the City considered critical due to the service they provide. These facilities that would be significantly impacted by the interruption of water service were separated into the seven categories shown in Table 2. There are many pipes that contribute to the water service of any single service connection. However, for this COF criteria, the pipes within a 200-foot distance of the critical facility were classified as those directly providing water service to the critical facilities. The COF scores for the seven different types of critical facilities are also shown in Table 2.

Table 2: Critical Facilities Scoring

Facility Type	Score	Asset Distribution
AIRPORT	4	0%
EMERGENCY SERVICES	10	1%
HEALTHCARE	10	0%
MEDICAL	10	3%
MUNICIPAL	6	0%
SCHOOL	6	1%
STATE	6	0%
NON-CRITICAL	0	95%

Connected Service Laterals

When a break on a distribution main occurs, the isolation valves connecting that pipe to the network are closed while the repair is completed. While the isolation valves are closed, any customers connected to the isolated distribution mains will be without water service. The location of the City's isolation valves in GIS were used to delineate segments for this COF analysis. In locations where GIS pipe segments extend through isolation valves, the pipes were not broken in order to preserve data integrity. The number of laterals assigned to each pipe in GIS (for this COF factor) is actually a count of the laterals within the delineated isolation segment. The count is the total number of services that would be affected if any of the pipes in the isolation zone were to fail. The resulting COF scores are shown in Table 3.

Table 3: Connected Service Laterals Scoring

# of Connected Laterals	Score	Asset Distribution
≤ 5	1	72%
6 - 10	2	19%
11 - 15	6	6%
16 - 20	8	2%
> 20	10	1%

Accessibility for Repairs

The level of complexity required for the repair of water mains is quantified in the risk assessment by identifying known challenges such as interstate, railroad, airport, or water crossings. These factors and the resulting COF scores assigned to intersecting water mains are shown in Table 4.

Table 4: Accessibility for Repairs Scoring

Crossing Type	Score	Asset Distribution
AIRPORT	10	2%
INTERSTATE	10	0%
LOCAL ROAD	0	89%
RAILROAD	10	1%
STATE ROUTE	5	8%
WATER	10	0%

Redundancy

Redundancy in a water distribution system is achieved by having extra pumps, pipes, tanks, or other assets in place to maintain uninterrupted service if one of the assets fail. The risk analysis focused on pipelines where redundancy was evaluated as to whether the network was looped or served customers as a single dead-end line. The COF scores assigned for redundancy are shown in Table 5.

Table 5: Redundancy Scoring

Redundancy	Score	Asset Distribution
NO	10	13%
YES	0	87%

Maximum Flow Rate

A higher flow rate in a pipe will typically result in a more severe or urgent repair. Results from the hydraulic model were used to quantify the maximum flow rate each pipe conveys during a current maximum day demand. The COF scores used in the risk assessment are shown in Table 6.

Table 6: Maximum Flow Rate Scoring

Max Flow Rate (gpm)	Score	Asset Distribution
≤ 100	1	68%
$100 < x \leq 500$	2	24%
$500 < x \leq 1000$	4	3%
$1000 < x \leq 1500$	5	2%
$1500 < x \leq 2000$	6	1%
$2000 < x \leq 3000$	7	1%
$3000 < x \leq 4000$	8	1%
$4000 < x \leq 5000$	9	0%
> 5000	10	0%

Weighting Factors

Not all COF criteria are equally as important to the City. This is accounted for in the risk analysis by assigning weighting factors to the COF scores. COF scores are multiplied by the appropriate weighting factor, then added to the weighted LOF scores to calculate the total risk score. Table 7 summarizes the COF weighting factors used in the risk analysis.

Table 7: COF Weighting Factors

COF Factor	Weight
Line Primary Function	3
Proximity to Critical Facilities	3
Number of Connected Service Laterals	5
Accessibility for Repairs	4
Redundancy	2
Maximum Flow Rate	1

LIKELIHOOD OF FAILURE ASSESSMENT

A composite LOF score was determined for each water main asset based on the following factors:

- Pipe Age (City's GIS data)
- Pipe Material (City's GIS data)
- Soil Corrosivity (USDA/NRCS web soil survey)
- Frozen Services History (City's GIS data)
- Pipe Break History (City's GIS data and CityWorks)
- Pipe Maximum Velocity (hydraulic model output)
- Pipe Maximum Pressure (hydraulic model output)
- Undersized Mains (City's GIS data)

The LOF scores for each of these criteria, as well as the distribution of assets associated with each score, are summarized in the following tables.

Pipe Age

As pipes reach the end of their expected useful life, breaks are more likely to occur. The LOF scores based on pipe age (as documented in the City's GIS data) are summarized in Table 8.

Table 8: Pipe Age Scoring

Year Installed	Score	Asset Distribution
≤ 1940	10	12%
1941-1960	8	17%
1961-1980	5	26%
1981-2000	3	18%
2001-2019	1	24%
UNKNOWN	5	3%

Pipe Material

Over the years, the material used to fabricate water mains has changed. Some of the early materials such as asbestos concrete and cast iron are generally more susceptible to breaks than modern materials such as ductile iron and PVC. This is reflected in the LOF scores shown in Table 9.

Table 9: Pipe Material Scoring

Material	Score	Asset Distribution
ASBESTOS CONCRETE	10	0%
CAST IRON	10	36%
COPPER	1	0%
COPPER & GALV	1	0%
DUCTILE IRON	3	48%
GALVANIZED	10	0%
HDPE	1	0%
KALAMEIN	10	0%
PERMASTRAN	6	1%
PLASTIC	3	0%
POLYSTRAN	6	0%
PVC	3	10%
STEEL	6	5%
UNKNOWN	5	0%

Soil Corrosivity

The presence of different chemicals and moisture in soil can cause the corrosion and eventual failure of steel pipes and fittings in a water distribution system. The National Cooperative Soil Survey (produced by the USDA Natural Resources Conservation Service (NRCS)) data was used to delineate the corrosive soils within the City of Helena. Soil corrosivity is categorized as "low," "moderate," or "high" as defined in Table 10 below, which comes from the NRCS National Soil Survey Handbook (NSSH).

Table 10: Guides for Estimating Risk of Corrosion Potential for Uncoated Steel[1]

Property	Limits		
	Low	**Moderate**	**High**
Internal free water occurrence class (or drainage class) and general texture group	•Very deep internal free water occurrence (or excessively drained to well drained) coarse to medium textured soils; *or* •Deep internal free water occurrence (or moderately well drained) coarse textured soils; *or* •Moderately deep internal free water occurrence (or somewhat poorly drained) coarse textured soils	•Very deep internal free water occurrence (or well drained) moderately fine textured soils; *or* •Deep internal free water occurrence (or moderately well drained) moderately coarse and medium textured soils; *or* •Moderately deep internal free water occurrence (or somewhat poorly drained) moderately coarse textured soils; *or* •Very shallow internal free water occurrence (or very poorly drained) soils with a stable high water table	•Very deep internal free water occurrence (or well drained) fine textured or stratified soils; *or* •Deep internal free water occurrence (or moderately well drained) moderately fine and fine textured or stratified soils; *or* •Moderately deep internal free water occurrence (or somewhat poorly drained) medium to fine textured or stratified soils; *or* •Shallow or very shallow internal free water occurrence (or poorly or very poorly drained) soils with a fluctuating water table
Total acidity (cmol(+)/kg^{-1})	<10	10-25	≥25
Conductivity of saturated extract (dS/m^{-1})	<1	1-4 4-10 for saturated soils 6/	>4 >10 for saturated soils 6/
Resistivity at saturation (ohm/cm)	≥5,000	2,000-5,000	<2,000

[1]U.S. Department of Agriculture, Natural Resources Conservation Service. 2019. National Soil Survey Handbook, *Title 430-VI.*

The LOF scores assigned to the different soil corrosivity classifications are shown in Table 11. The Soil corrosivity factors were applied to all pipes regardless of pipe material under the assumption that even on plastic pipe, the ductile iron fittings and valves are still susceptible to corrosion.

Table 11: Soil Corrosivity Scoring

Soil Corrosivity to Steel	Score	Asset Distribution
HIGH	10	11%
MODERATE	6	74%
LOW	2	15%

Frozen Services

The City has recorded the locations of frozen services in GIS over the years. While the frozen service itself does not directly affect how likely the distribution main is to fail, it can identify locations where shallow burial of the distribution main is causing freeze damage in the winter. The LOF scores corresponding to the number of frozen services connected to the main are shown in Table 12.

Table 12: Frozen Services Scoring

# of Frozen Services	Score	Asset Distribution
0	0	96%
1	3	3%
2	5	1%
3	8	0%
≥ 4	10	0%

Pipe Breaks

The City currently utilizes Cityworks® to manage work orders and track asset history throughout the distribution system. Many of the pipe breaks the City has repaired over the years are recorded in Cityworks®. Prior to using Cityworks®, the City recorded pipe breaks in GIS. Both the Cityworks® records and the GIS records were utilized to quantify the number of recorded pipe breaks on each asset. Spatial location and service dates were used to eliminate duplicate records between Cityworks® and GIS. Additionally, any pipe breaks occurring prior to the recorded installation date of the pipe were ignored. The LOF scores corresponding to the number of recorded breaks are shown in Table 13.

Table 13: Pipe Breaks Scoring

# of Breaks	Score	Asset Distribution
0	0	89%
1	2	7%
2-3	4	3%
4-5	6	1%
6-8	8	0%
≥ 9	10	0%

Maximum Velocity

Excessive pipe velocity can be detrimental to a water distribution system. Increased surge or transient pressures as well as the potential for ductile iron pipe linings to be compromised are two of the more common concerns. Output from the hydraulic model was used to quantify the maximum pipe velocity under a current maximum day demand. The LOF scores corresponding to these velocities are shown in Table 14.

Table 14: Maximum Velocity Scoring

Max Velocity (fps)	Score	Asset Distribution
≤ 2	1	93%
2 < x ≤ 4	3	6%
4 < x ≤ 6	4	1%
6 < x ≤ 8	8	0%
> 8	10	0%

Maximum Pressure

Elevated operating pressures in a water distribution system can increase the frequency and severity of pipe leaks and breaks. Output from the hydraulic model was used to quantify the maximum operating pressure under a current maximum day demand. The LOF scores corresponding to these pressures are shown in Table 15.

Table 15: Maximum Pressure Scoring

Max Pressure (psi)	Score	Asset Distribution
≤ 70	1	23%
70 < x ≤ 90	3	21%
90 < x ≤ 110	5	23%
110 < x ≤ 130	7	14%
130 < x ≤ 150	8	12%
> 150	10	7%

Undersized Mains

For fire flow capacity reasons, the minimum pipe diameter that should be installed in the water distribution system is 8-inches. This standard has not always been in place, and there are many locations where smaller mains were installed many years ago. To quantify the risk these undersized mains pose to the system, the LOF scores summarized in Table 16 were used in the risk assessment.

Table 16: Undersized Mains Scoring

Diameter (inches)	Score	Asset Distribution
≤ 4	10	3%
4 < x ≤ 6	5	31%
> 6	0	66%

Weighting Factors

Not all LOF criteria are equally as important to the City. This is accounted for in the risk analysis by assigning weighting factors to the LOF scores. LOF scores are multiplied by the appropriate weighting factor, then added to the weighted COF scores to calculate the total risk score. Table 17 summarizes the LOF weighting factors used in the risk analysis.

Table 17: LOF Weighting Factors

LOF Factor	Weight
Pipe Age	3
Pipe Material	4
Soil Corrosivity	2
Frozen Services	1
Pipe Breaks	5
Pipe Max. Velocity	1
Pipe Max. Pressure	2
Undersized Mains	3

RISK ASSESSMENT RESULTS & PROPOSED PROJECTS

The total risk scores were normalized to a scale of 100, and the top twenty percent were evaluated for potential replacement. The potential projects and the criteria which resulted in the elevated risk determination for each project are identified in the following sections. The numbering system for these projects continues from projects identified in the fire flow analysis.

W-M-02

This project includes replacement of approximately 4,700 feet of 24-inch diameter water main from the **Missouri River Water Treatment Plant (MRTP) to the existing 36-inch diameter water main under the airport runways**. The existing pipe is identified as steel pipe, installed in 1958. This water main serves the Malben Low Zone, the Malben High Zone, and pressure zones above the Malben High Zone from the MRTP. A larger pipe is recommended to serve this area, so this proposed project includes a 30-inch diameter water main. This project includes a direction drill under Canyon Ferry Road. Table 18 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 1 shows the extents of the project with a checkered line.

Table 18: W-M-02 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

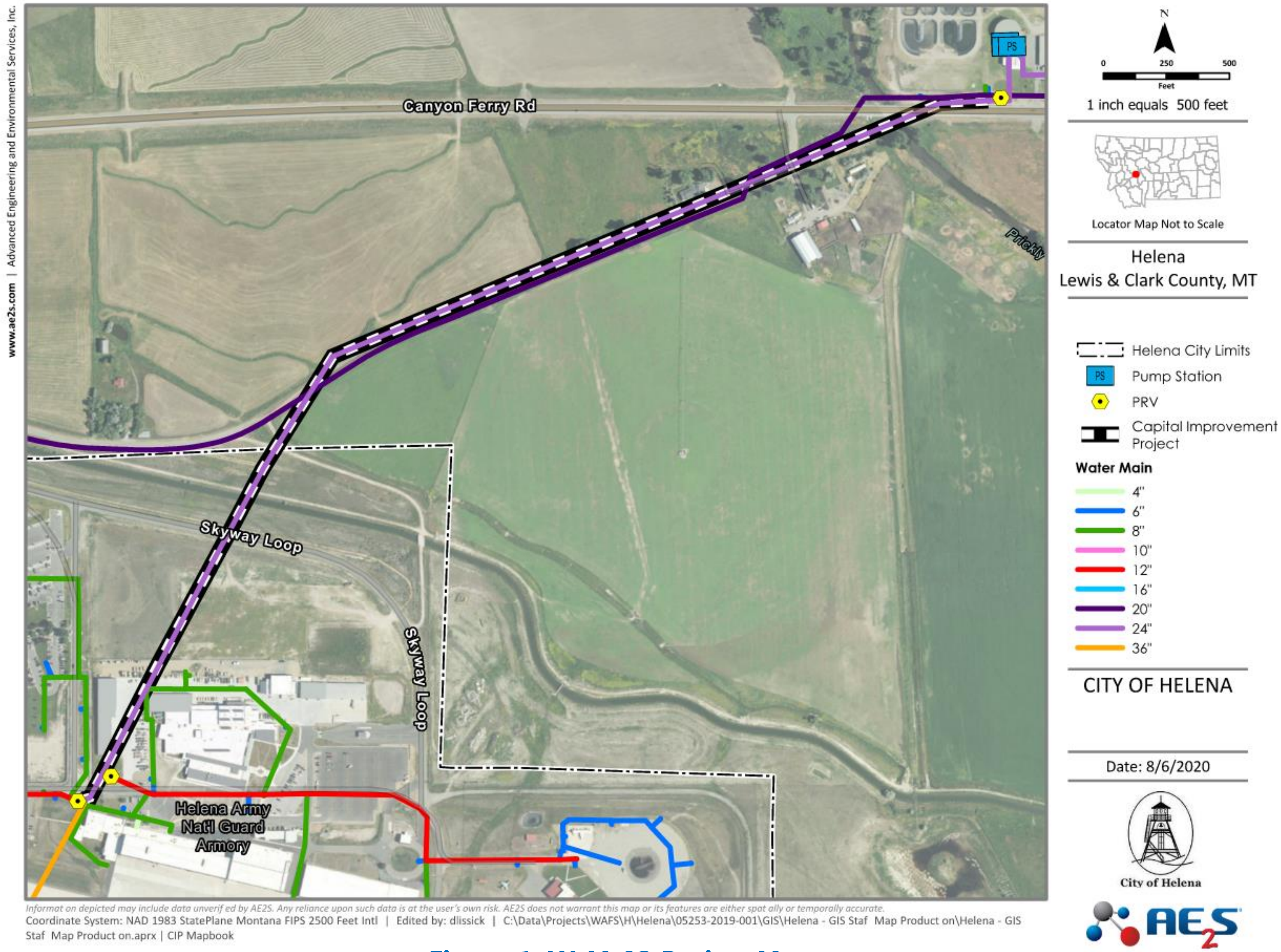

Figure 1: W-M-02 Project Map

W-M-03

This project includes replacement of approximately 450 feet of 20-inch diameter water main along **Fee Street from Prospect Avenue to East 11th Avenue**. The existing pipe is identified as steel pipe installed in 1958. This is a short section of pipe but traffic control has been estimated to be a higher percentage of the project cost due to the high traffic on Fee Street in this area.

Table 19 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 2 shows the extents of the project with a checkered line.

Table 19: W-M-03 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

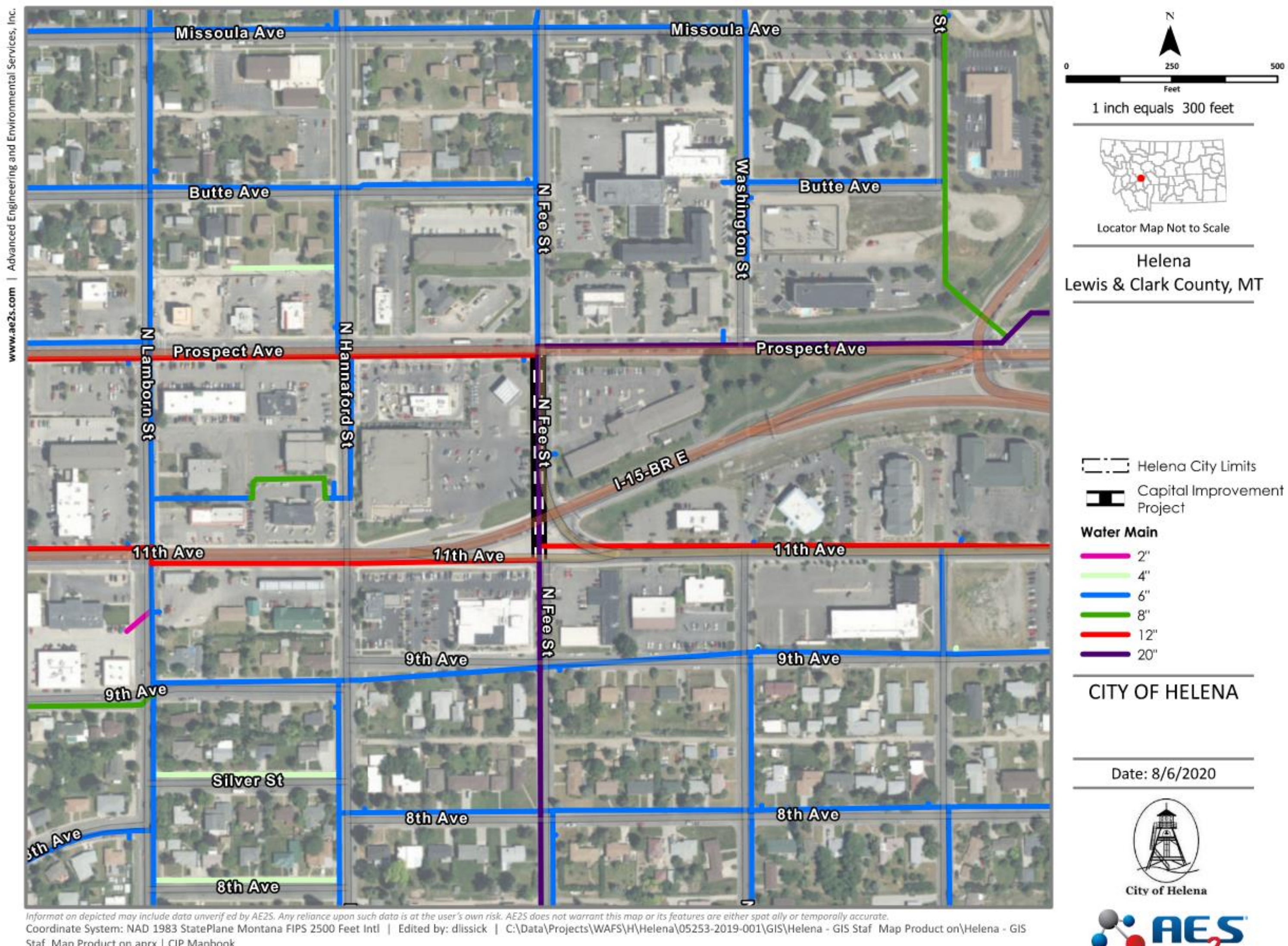

Figure 2: W-M-03 Project Map

W-M-04

This project includes replacement of approximately 800 feet of 6-inch diameter pipe along **Golden Street from North Lamborn Street to North Carson Street** and 400 feet of 4-inch diameter pipe along **East 6th Avenue from North Lamborn Street to North Hannaford Street**. The existing pipe is identified as cast-iron pipe, installed in 1950 (along East 6th Avenue) and 1962 (along Golden Street). New 8-inch diameter pipe is recommended. Table 20 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 3 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 20: W-M-04 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	***Pipe Breaks***
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

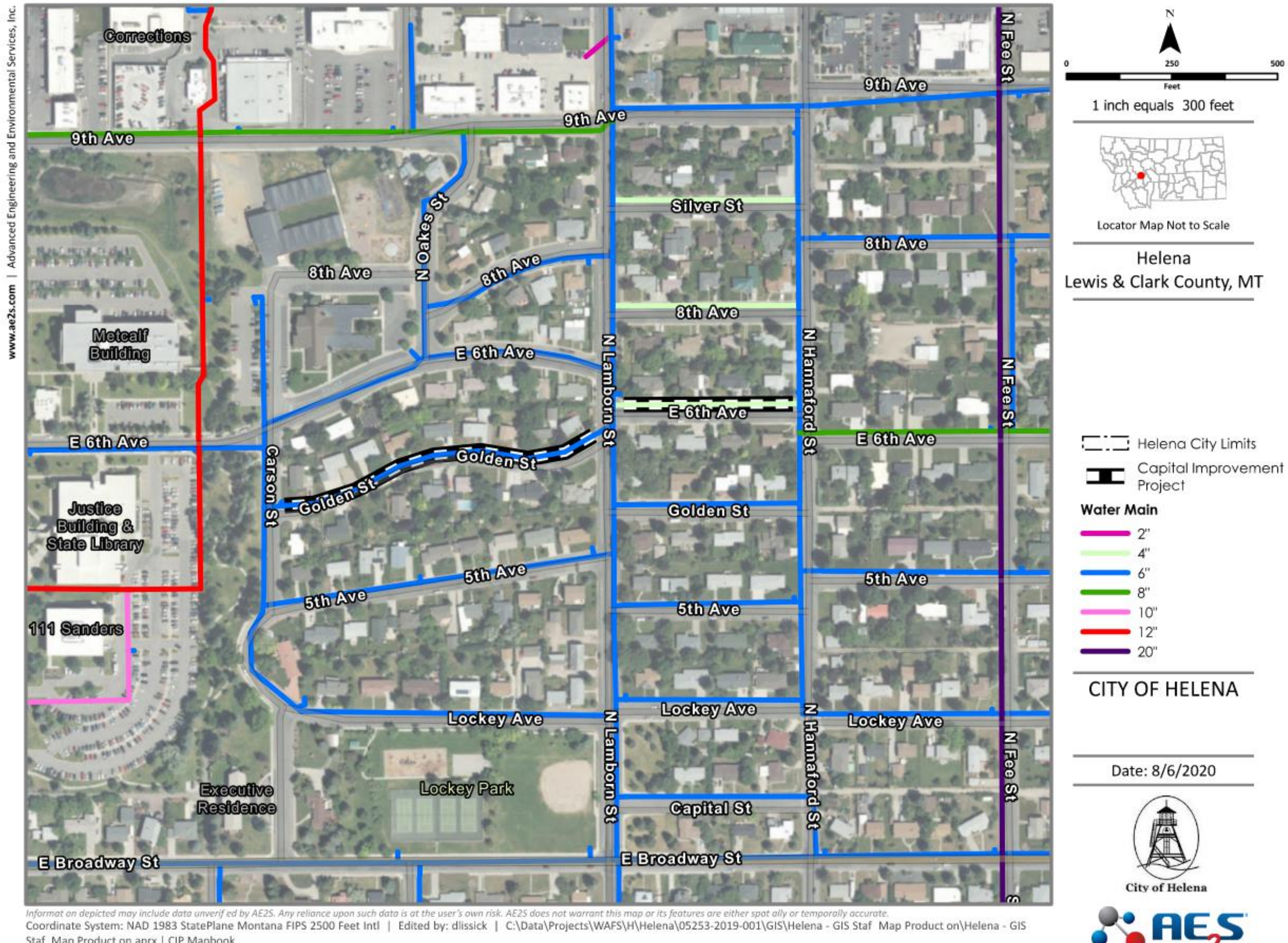

Figure 3: W-M-04 Project Map

W-M-05

This project includes replacement of approximately 500 feet of 8-inch diameter pipe along **North Davis Street from East 15th Street to East 14th Street**. The existing pipe is identified as cast-iron pipe installed in 1934.

Table 21 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 4 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 21: W-M-05 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	***Pipe Breaks***
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

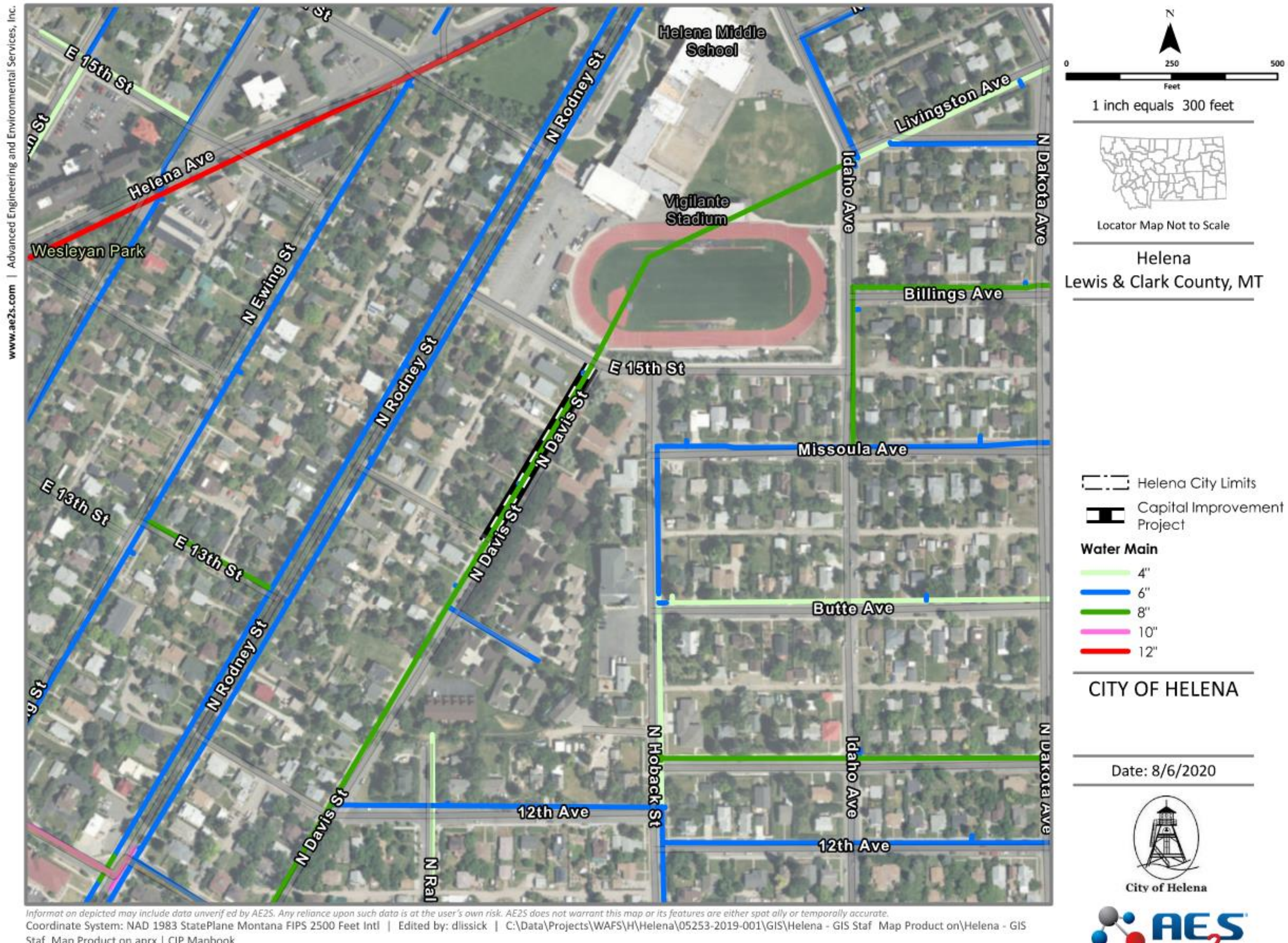

Figure 4: W-M-05 Project Map

W-M-06

This project includes replacement of approximately 850 feet of 4-inch diameter pipe along **Livingston Avenue from North Montana Avenue to Townsend Avenue** and approximately 500 feet of 6-inch diameter pipe along **North Davis Street from North Dakota Street to Idaho Avenue**. The existing pipe in Livingston Avenue is identified as a cast-iron pipe installed in 1917 and the existing pipe in North Davis Street is identified as a cast-iron pipe installed in 1960. A new 8-inch diameter pipe is recommended. Table 22 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 5 shows the extents of the project with a checkered line. This project is in a commercial area so some additional traffic control for businesses will be required. It is close to North Montana Avenue but will not require any excavation into North Montana Avenue so there are no other special considerations.

Table 22: W-M-06 Contributing Factors

COF	LOF
Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

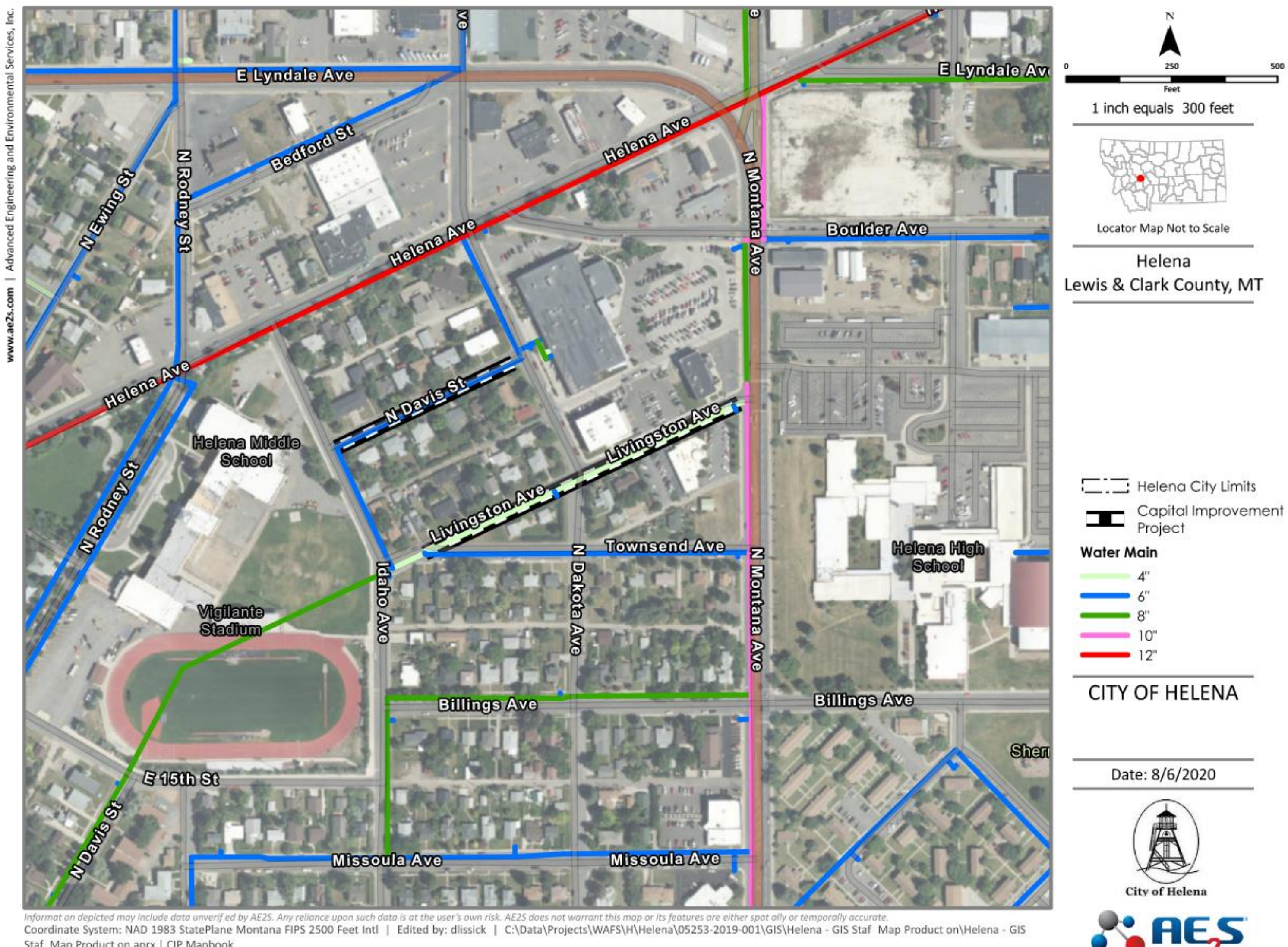

Figure 5: W-M-06 Project Map

W-M-07

This project includes replacement of approximately 1,900 feet of 8-inch diameter pipe along **Breckenridge Street from North Montana Avenue to North Raleigh Street**. The existing pipe is identified as cast-iron pipe and was installed in 1916. The risk assessment classified the pipe on Breckenridge from North Montana Avenue to Hoback Street as Extreme Risk and the section on Breckenridge from Hoback Street to Raleigh Street as Medium Risk. The section from Hoback Street to Raleigh Street is included in this project because it was also installed in 1916. Table 23 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 6 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 23: W-M-07 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

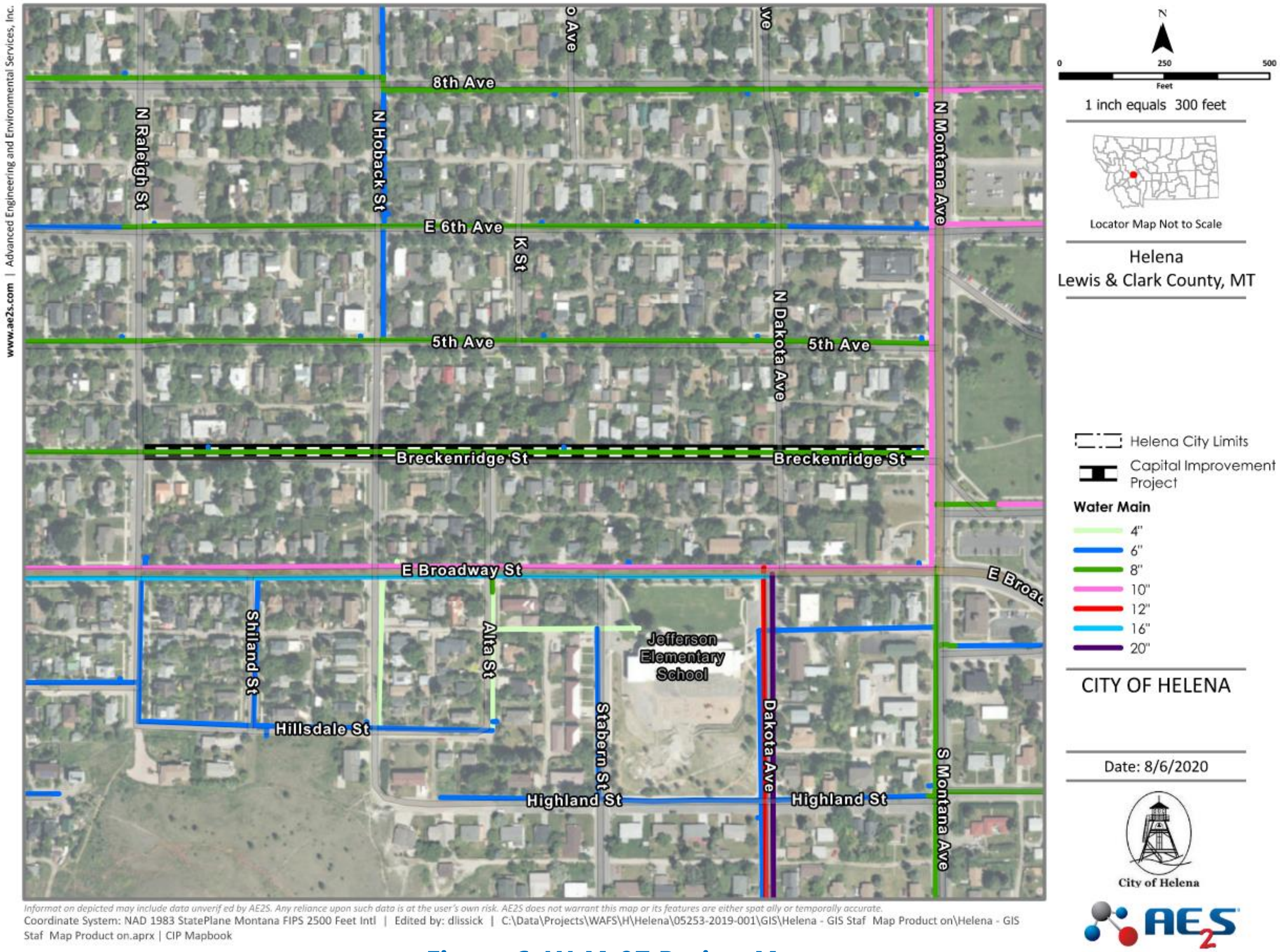

Figure 6: W-M-07 Project Map

W-M-08

This project includes replacement of approximately 500 feet of 8-inch diameter pipe along **8th Avenue from Idaho Avenue to Hoback Street** and approximately 1,000 feet of 12-inch diameter pipe along **9th Avenue from Beattie Street to Hoback Street**. The existing pipe is identified as cast-iron pipe installed in 1950. The 8th Avenue portion of this project was previously identified by the City, and construction is anticipated to occur in 2021. Table 24 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 7 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 24: W-M-08 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	***Pipe Breaks***
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

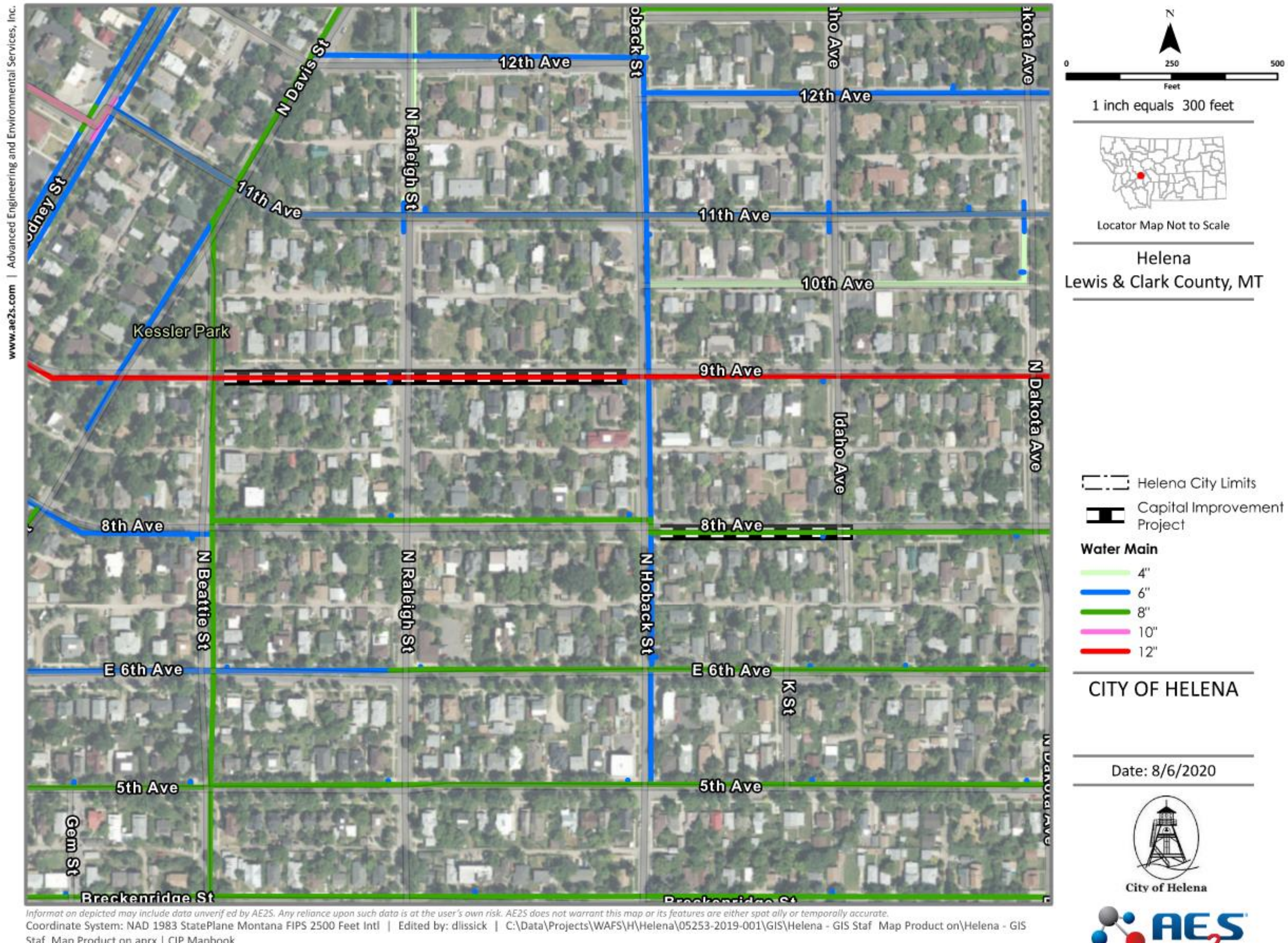

Figure 7: W-M-08 Project Map

W-M-09

This project includes replacement of approximately 1,600 feet of 4-inch and 6-inch diameter pipe along **11th Avenue from Hoback Street to Raleigh Street** and along **10th Avenue from Hoback Street to North Dakota Street**. A portion of 10th Avenue between North Dakota Street and Idaho Avenue is a gravel roadway. The existing pipe is identified as cast-iron pipe installed in 1925 and 1939. A new 8-inch diameter pipe is recommended. Table 25 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 8 shows the extents of the project with a checkered line. This project is in a residential area, but traffic control has been estimated to be a higher percentage of the project cost due to the high traffic on 11th Avenue. There are no other special considerations.

Table 25: W-M-09 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

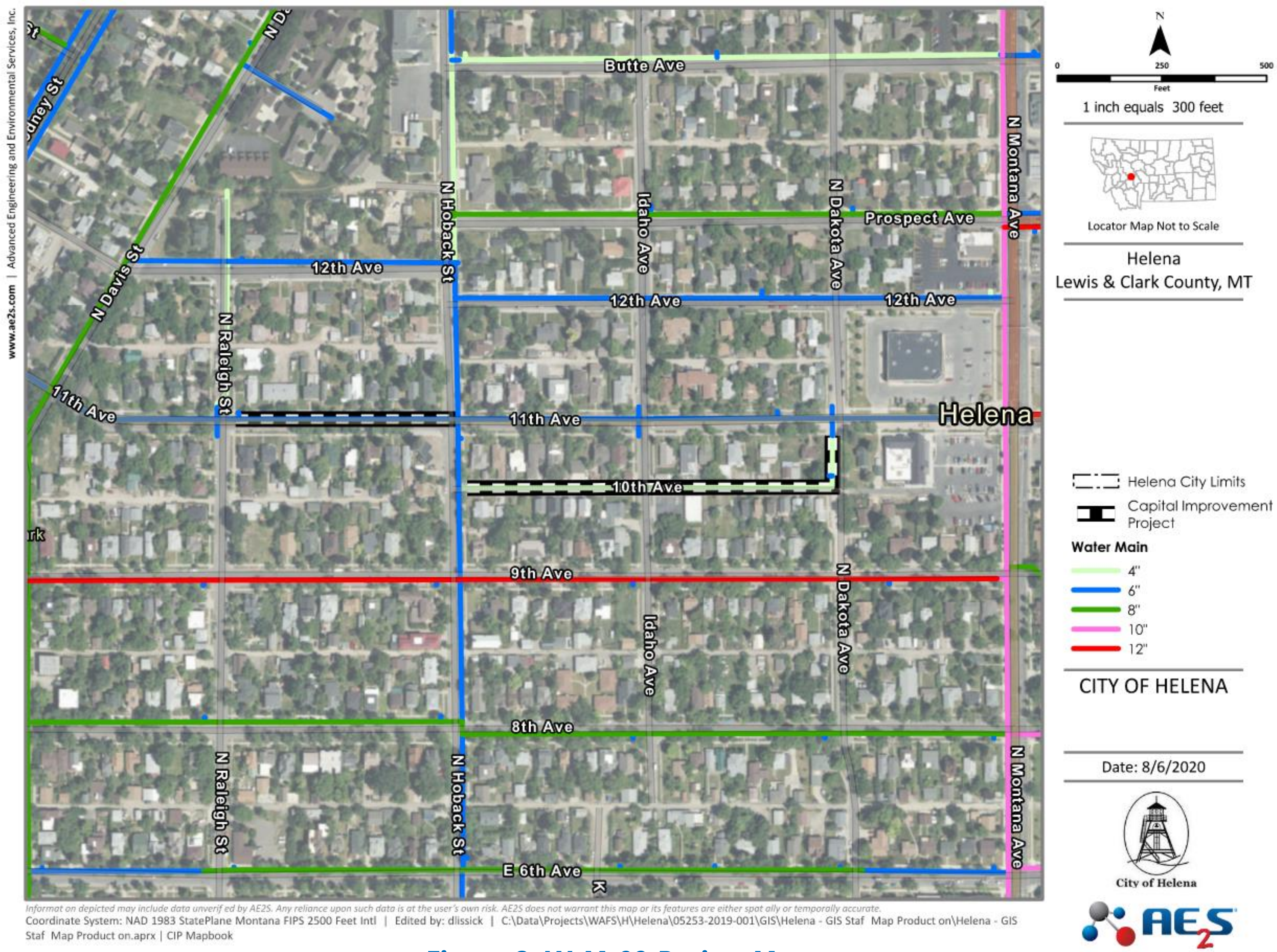

Figure 8: W-M-09 Project Map

W-M-10

This project includes replacement of approximately 1,300 feet of 4-inch diameter pipe along **Butte Avenue from Hoback Street to North Montana Avenue**. This project is in a residential area with no major roadways so there are no special considerations. The project is adjacent to North Montana Avenue, but excavation into North Montana Avenue is not anticipated. The existing pipe is identified as cast-iron pipe installed in 1899. A new 8-inch diameter pipe is recommended. Table 26 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 9 shows the extents of the project with a checkered line.

Table 26: W-M-10 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

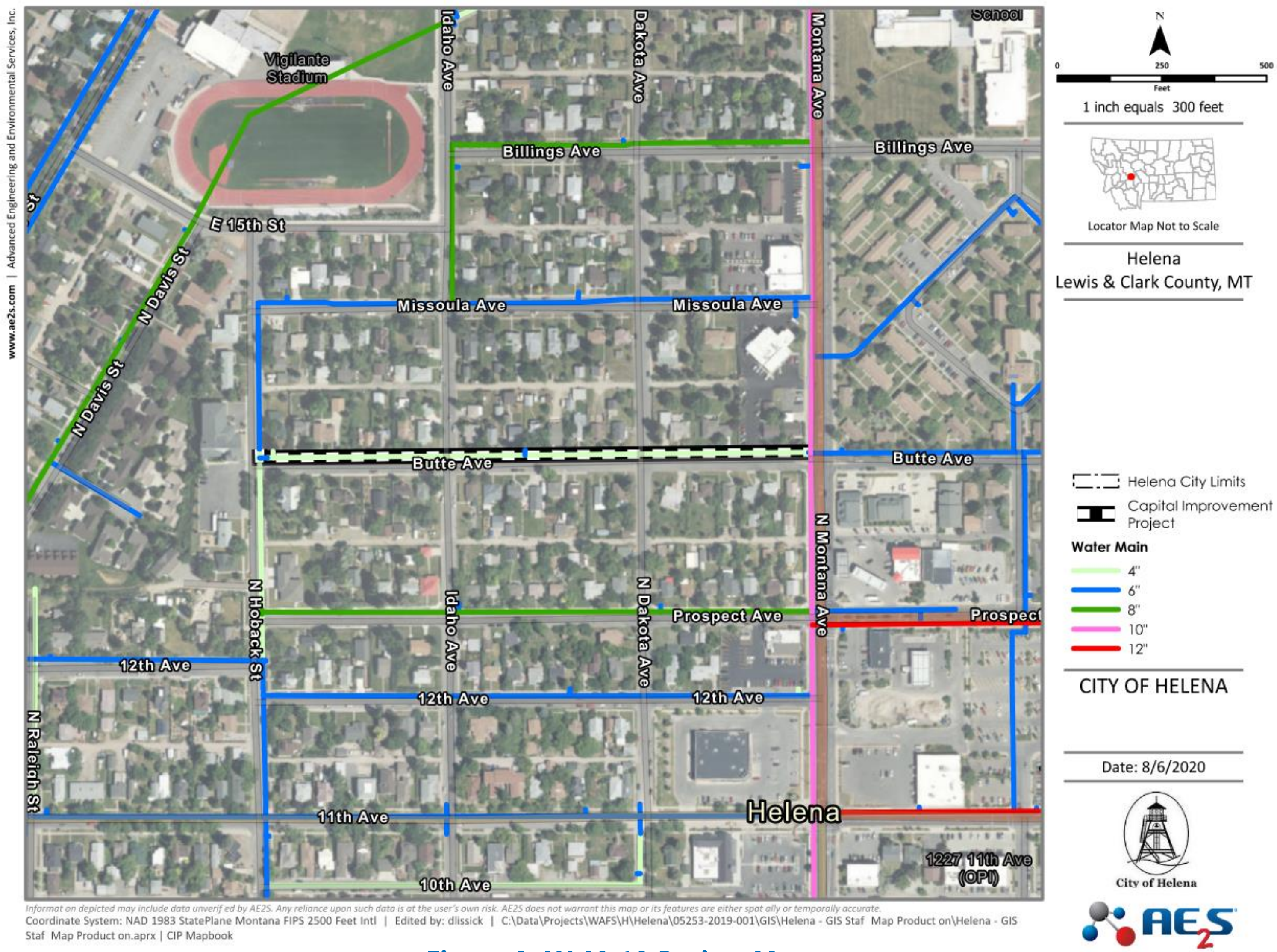

Figure 9: W-M-10 Project Map

W-M-11

This project includes replacement of approximately 900 feet of 4-inch and 6-inch diameter pipe along **Boulder Avenue between North Hannaford Street and North Oakes Street**. The existing pipe is identified as cast-iron pipe installed in 1916 and 1949. A new 8-inch diameter pipe is recommended. Table 27 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 10 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 27: W-M-11 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

Figure 10: W-M-11 Project Map

W-M-12

This project includes replacement of approximately 200 feet of 6-inch diameter pipe along **North Sanders Street from East Lyndale Avenue to Lewis Street**. The existing pipe is identified as cast-iron pipe and was installed in 1936. A new 8-inch diameter pipe is recommended. Table 28 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 11 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 28: W-M-12 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

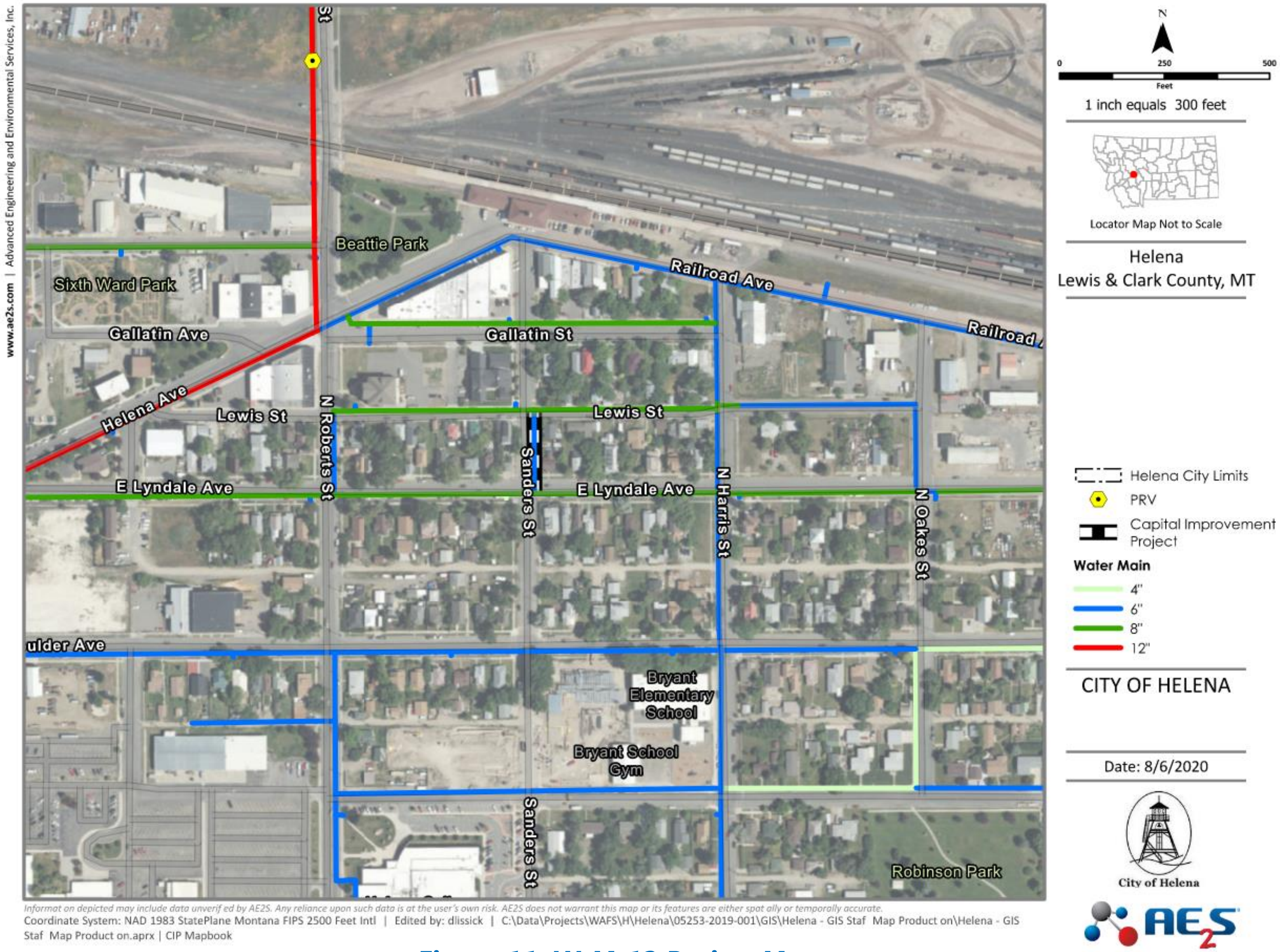

Figure 11: W-M-12 Project Map

W-M-13

This project includes replacement of approximately 1,400 feet of 4-inch and 6-inch diameter pipe on **Logan Street and North Jackson Street between East 14th Street and East 15th Street** and on **North Warren Street between East 16th Street and East 17th Street**. The existing pipe is identified as cast iron, installed in 1916 (Warren), 1941 (Jackson) and 1942 (Logan). A new 8-inch diameter pipe is recommended. Table 29 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 12 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 29: W-M-13 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

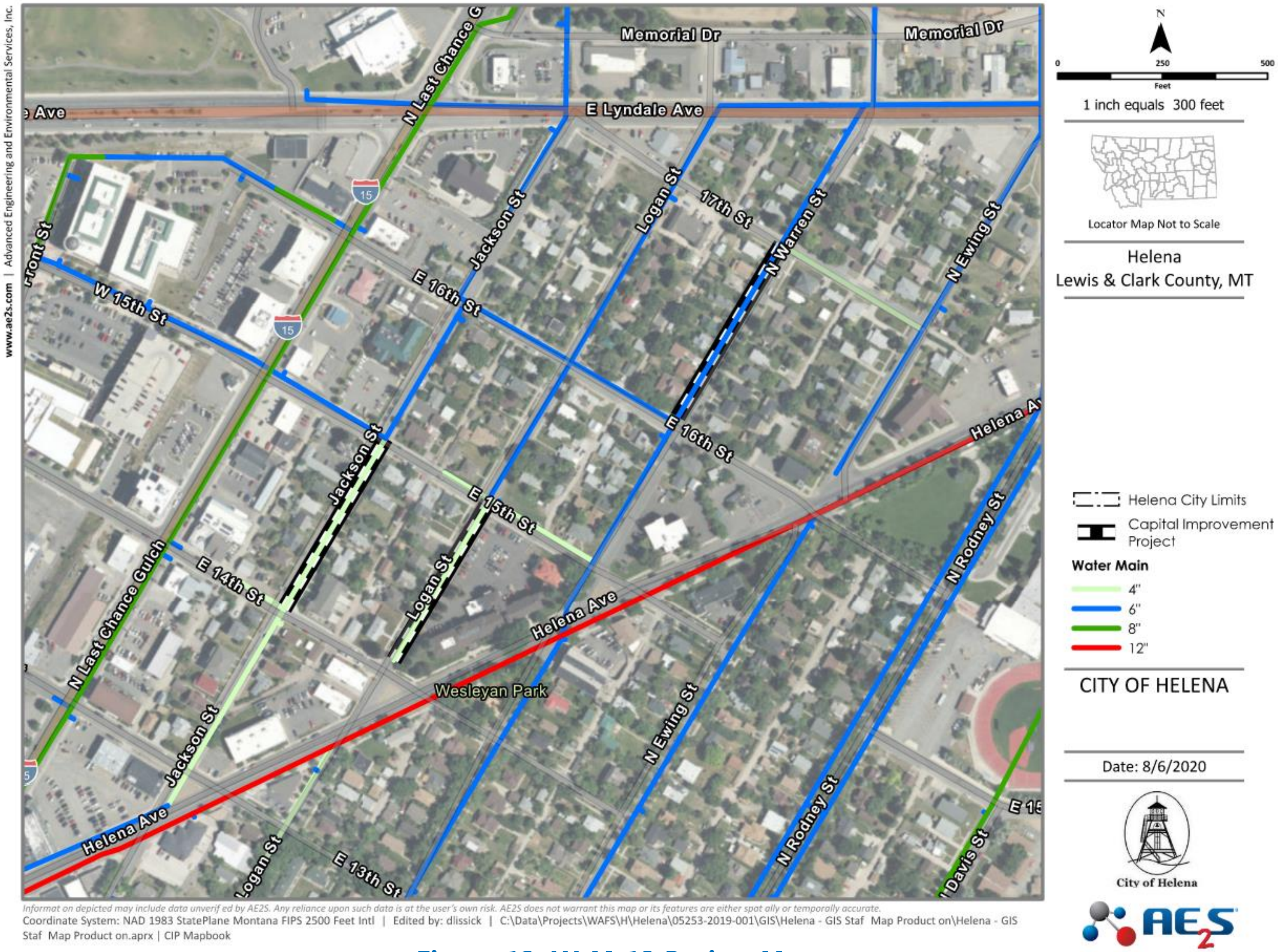

Figure 12: W-M-13 Project Map

W-M-14

This project includes replacement of approximately 300 feet of 4-inch diameter pipe with new 8-inch diameter pipe along **Logan Street from 11th Avenue to the cul-de-sac southwest of 11th Avenue**. The existing pipe is identified as cast-iron pipe installed in 1936. A new 8-inch diameter pipe is recommended. Table 30 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 13 shows the extents of the project with a checkered line. This project is in a commercial area on a cul-de-sac so traffic control has been estimated to be a higher percentage of the project cost.

Table 30: W-M-14 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

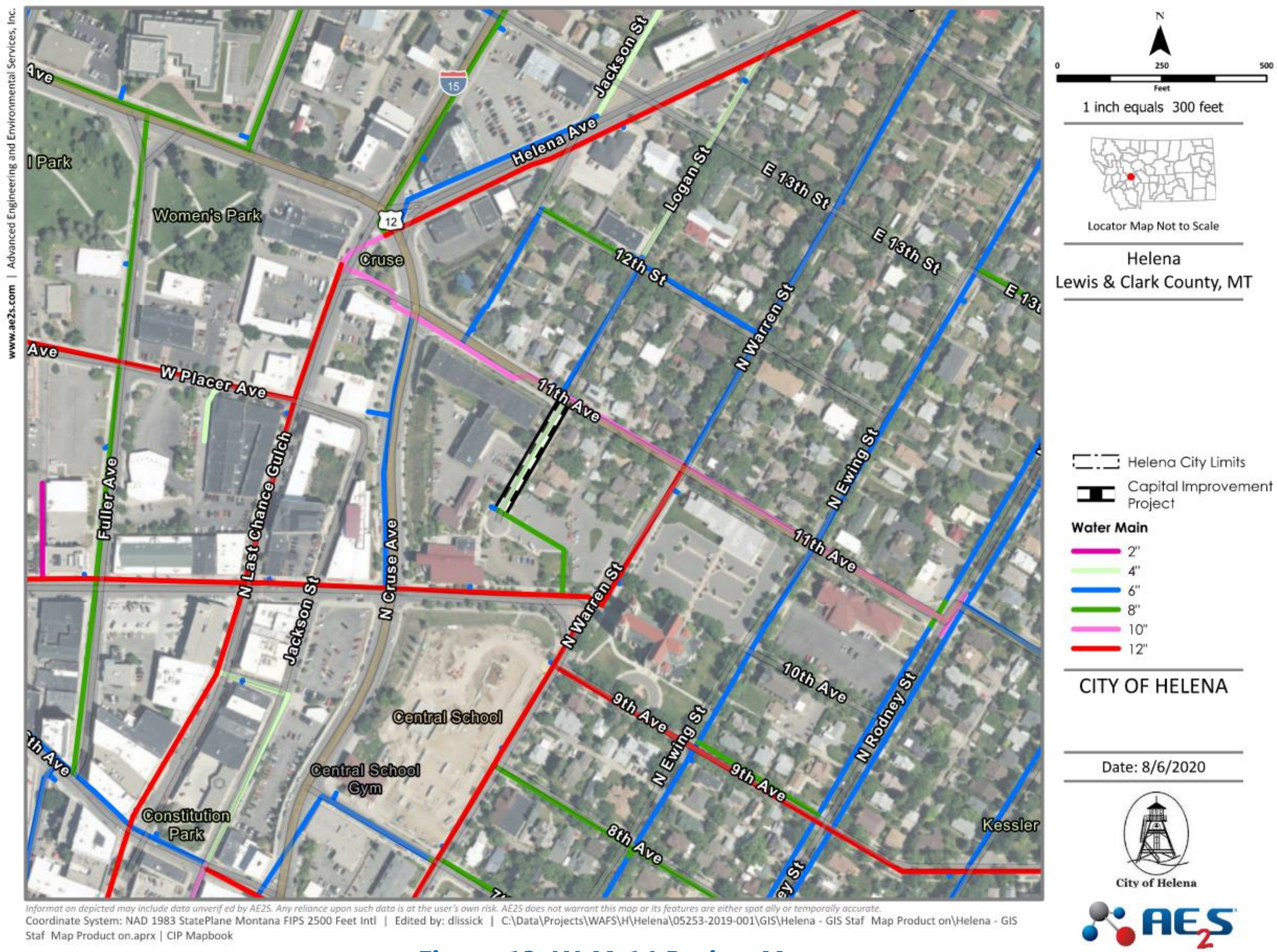

Figure 13: W-M-14 Project Map

W-M-15

This project includes replacement of approximately 650 feet of 6-inch diameter pipe along **National Avenue between East Lyndale Avenue and Argyle Street**. The existing pipe is identified as cast-iron pipe installed in 1899. A new 8-inch diameter pipe is recommended. This project was previously identified by the City, and construction is anticipated to occur in 2021. Table 31 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 14 shows the extents of the project with a checkered line. This project is in a commercial area adjacent to Lyndale Avenue so traffic control has been estimated to be a higher percentage of the project cost.

Table 31: W-M-15 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

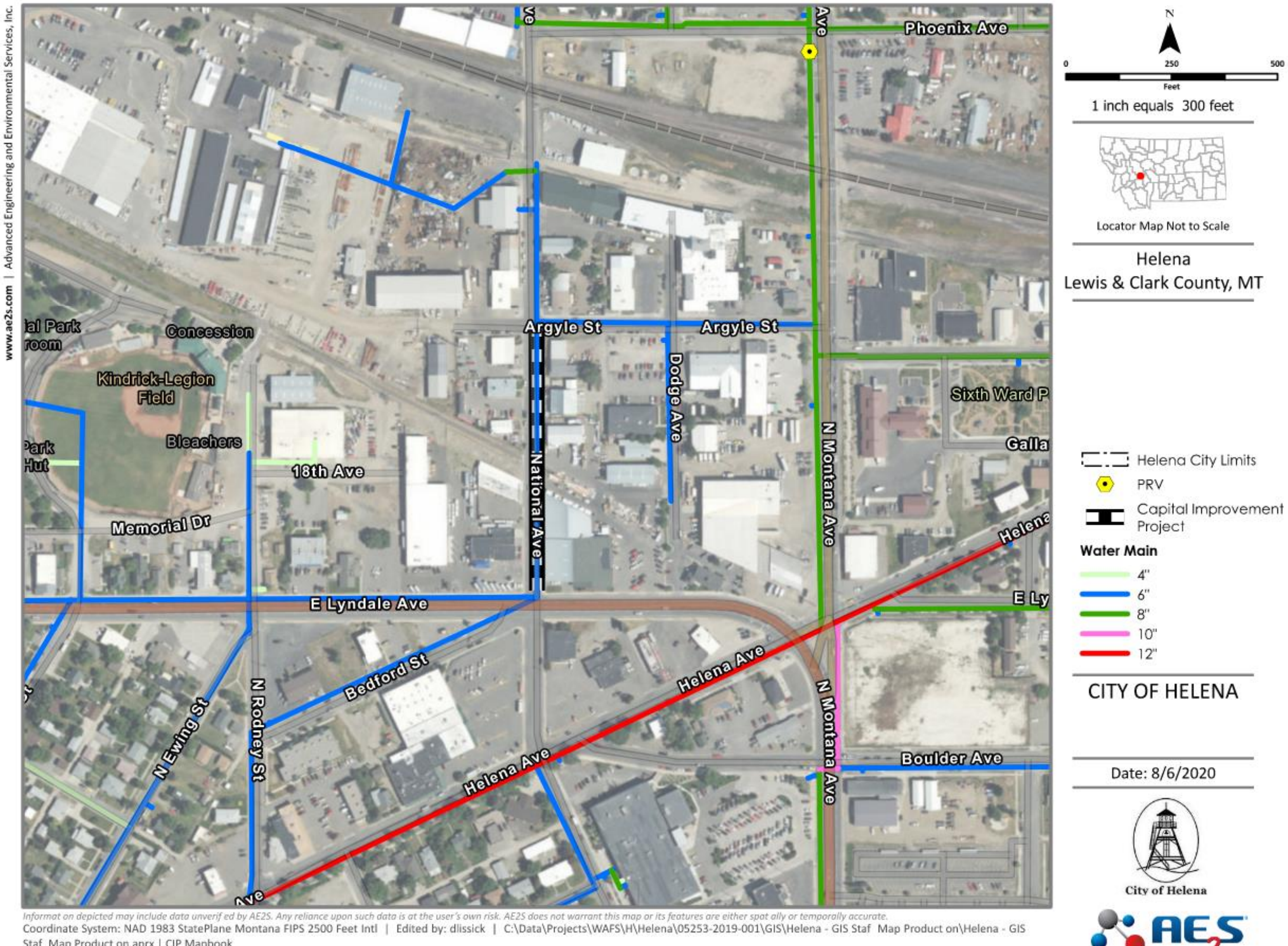

Figure 14: W-M-15 Project Map

W-M-16

This project includes replacement of approximately 350 feet of 4-inch diameter pipe on **Monroe Avenue between Knight Street and Hauser Boulevard**. The existing pipe is identified as cast-iron pipe installed in 1916. A new 8-inch diameter pipe is recommended. Table 32 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 15 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 32: W-M-16 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

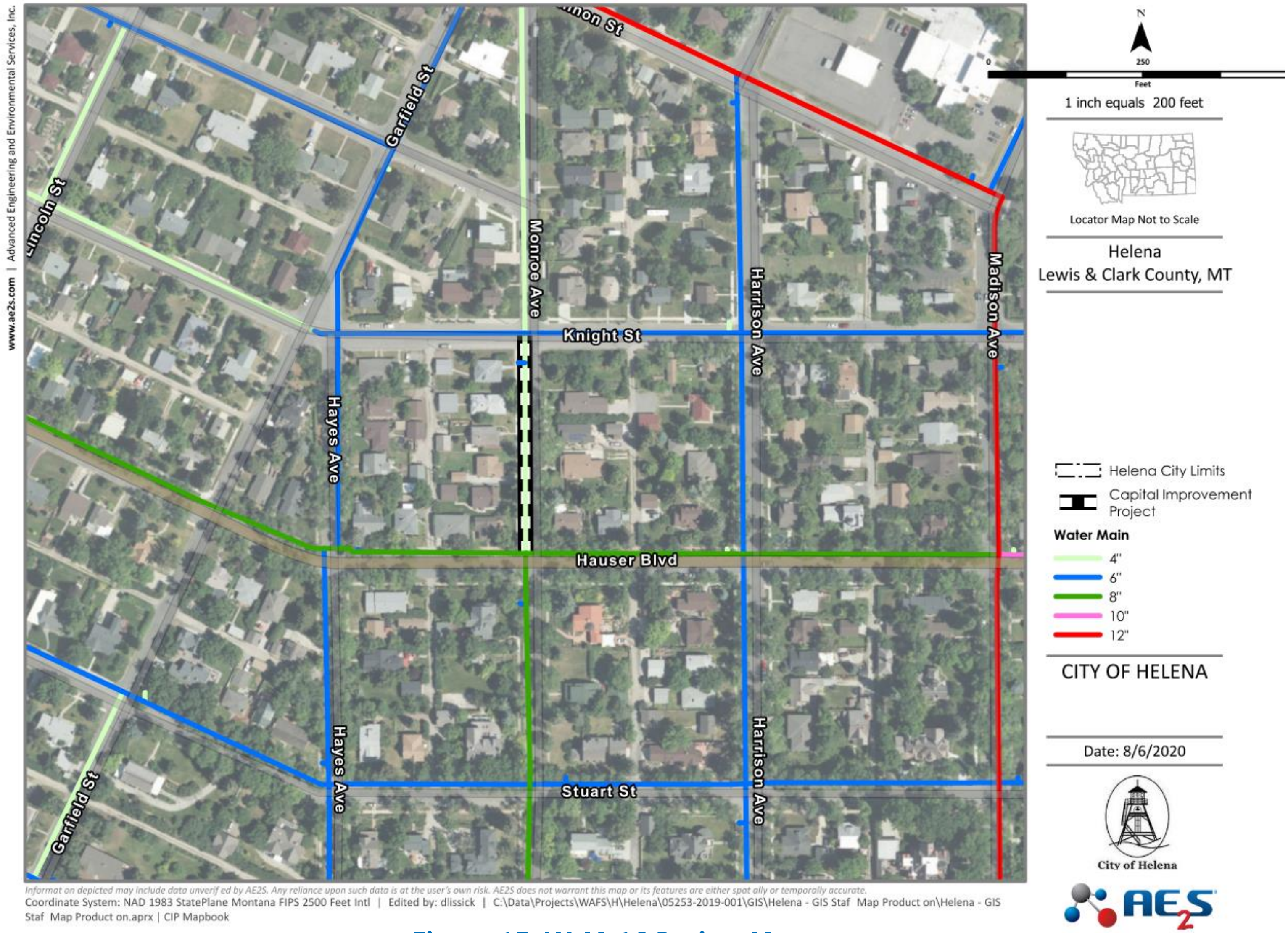

Figure 15: W-M-16 Project Map

W-M-17

This project includes replacement of approximately 1,400 feet of 6-inch diameter pipe along **Choteau Street between Henderson Street and Glendale Street** and 350 feet of 4-inch diameter pipe along **Choteau Street between Laurel Street and Linden Street**. The existing pipe between Henderson Street and Glendale Street is identified as cast-iron pipe installed in 1955. The existing pipe between Laurel Street and Linden Street is identified as cast-iron pipe installed in 1936. A new 8-inch diameter pipe is recommended. Table 33 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 16 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 33: W-M-17 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

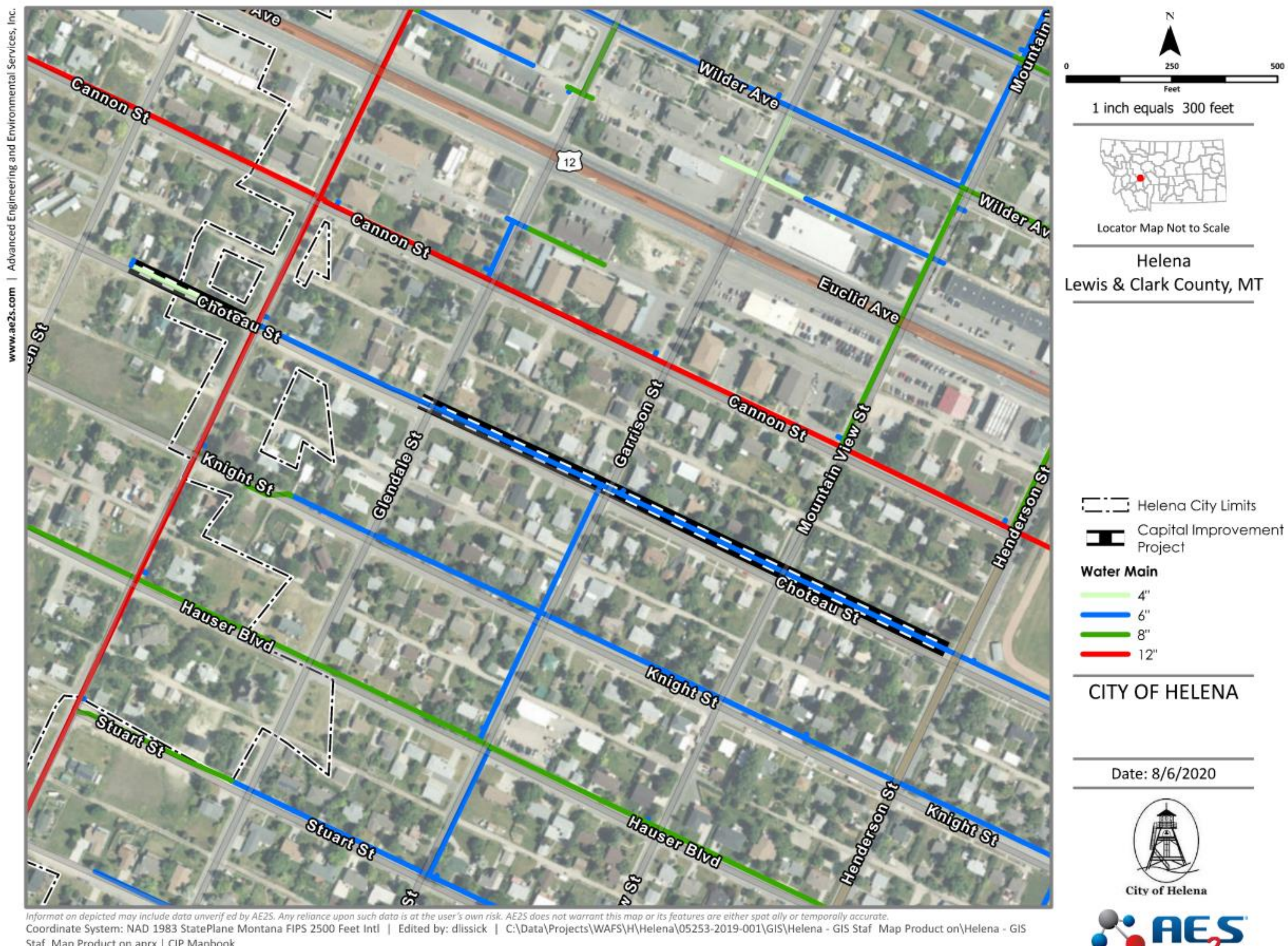

Figure 16: W-M-17 Project Map

W-M-18

This project includes replacement of approximately 600 feet of 4-inch diameter pipe along **Grant Street between Leslie Avenue and Peosta Avenue**. The existing pipe is identified as cast-iron pipe installed in 1916. A new 8-inch diameter pipe is recommended. Table 34 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 17 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 34: W-M-18 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

Figure 17: W-M-18 Project Map

W-M-19

This project includes replacement of approximately 1,600 feet of 6-inch diameter pipe along **Hollins Avenue between North Benton Avenue and Garfield Street and between Cleveland Street and Allison Street**, approximately 1,000 feet of 6-inch diameter pipe along **Peosta Avenue from North Benton Avenue to Garfield Street** and approximately 500 feet of 6-inch diameter pipe along **Waukesha Avenue from Allison Street to Henderson Street**. The existing pipes are all identified as cast-iron pipe. The water main along Hollins Avenue between North Benton Avenue and Garfield Street was installed in 1937, the water main along Hollins Avenue between Cleveland Street and Allison Street was installed in 1948, the water main along Peosta Avenue was installed in 1916, and the water main along Waukesha Avenue was installed in 1957. A new 8-inch diameter pipe is recommended. Table 35 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 18 shows the extents of the project with a checkered line. This project is in a residential area. It is adjacent to Benton Avenue but would not require excavation into Benton Avenue. There are no other special considerations.

Table 35: W-M-19 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

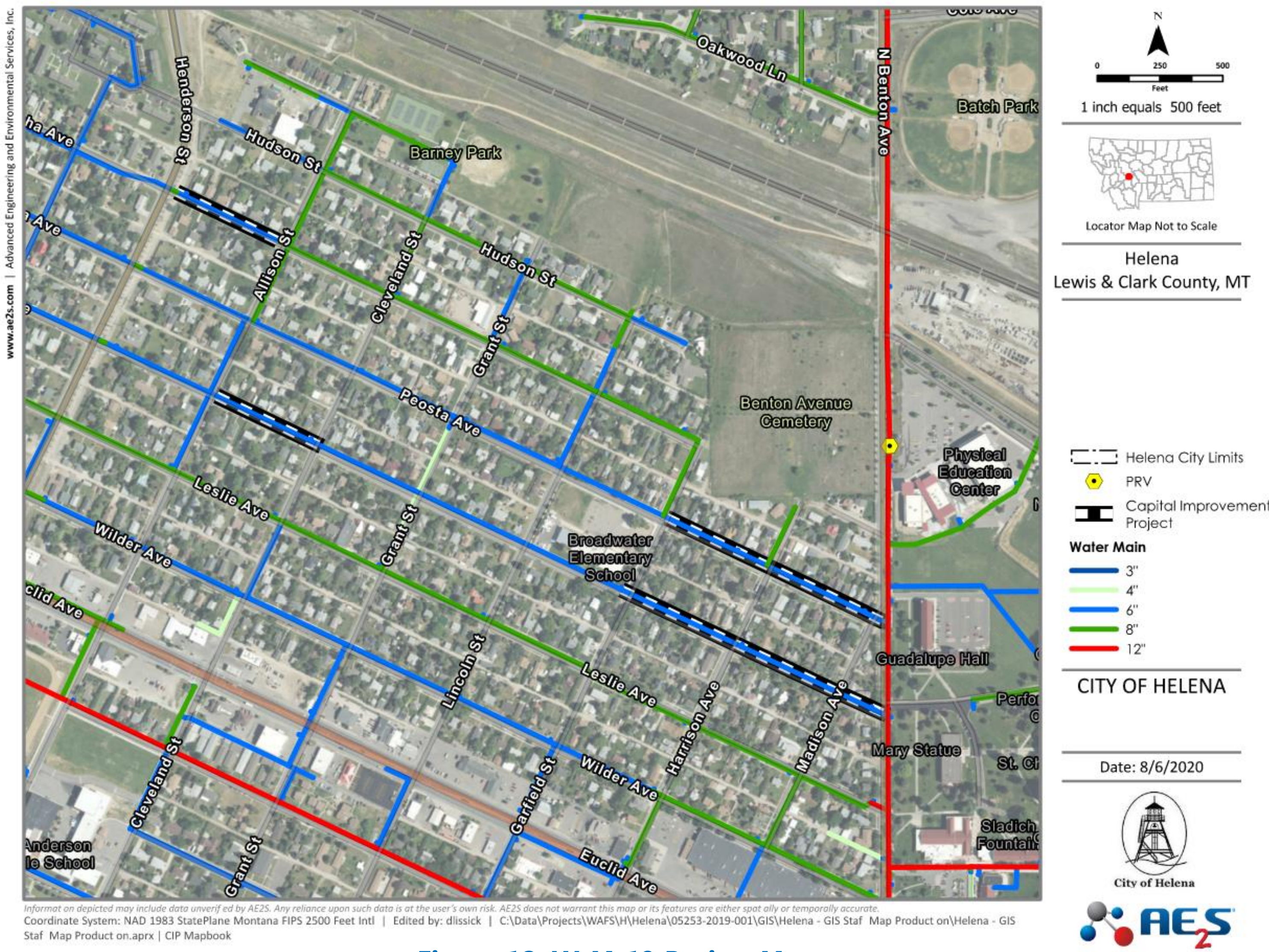

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Figure 18: W-M-19 Project Map

W-M-20

This project includes replacement of approximately 500 feet of 4-inch diameter pipe along **Cedar Street between Villard Avenue and Gold Avenue**. The existing pipe is identified as cast-iron pipe installed in 1936. A new 8-inch diameter pipe is recommended. Table 36 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 19 shows the extents of the project with a checkered line. This project is in a residential area with no major roadways so there are no special considerations.

Table 36: W-M-20 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

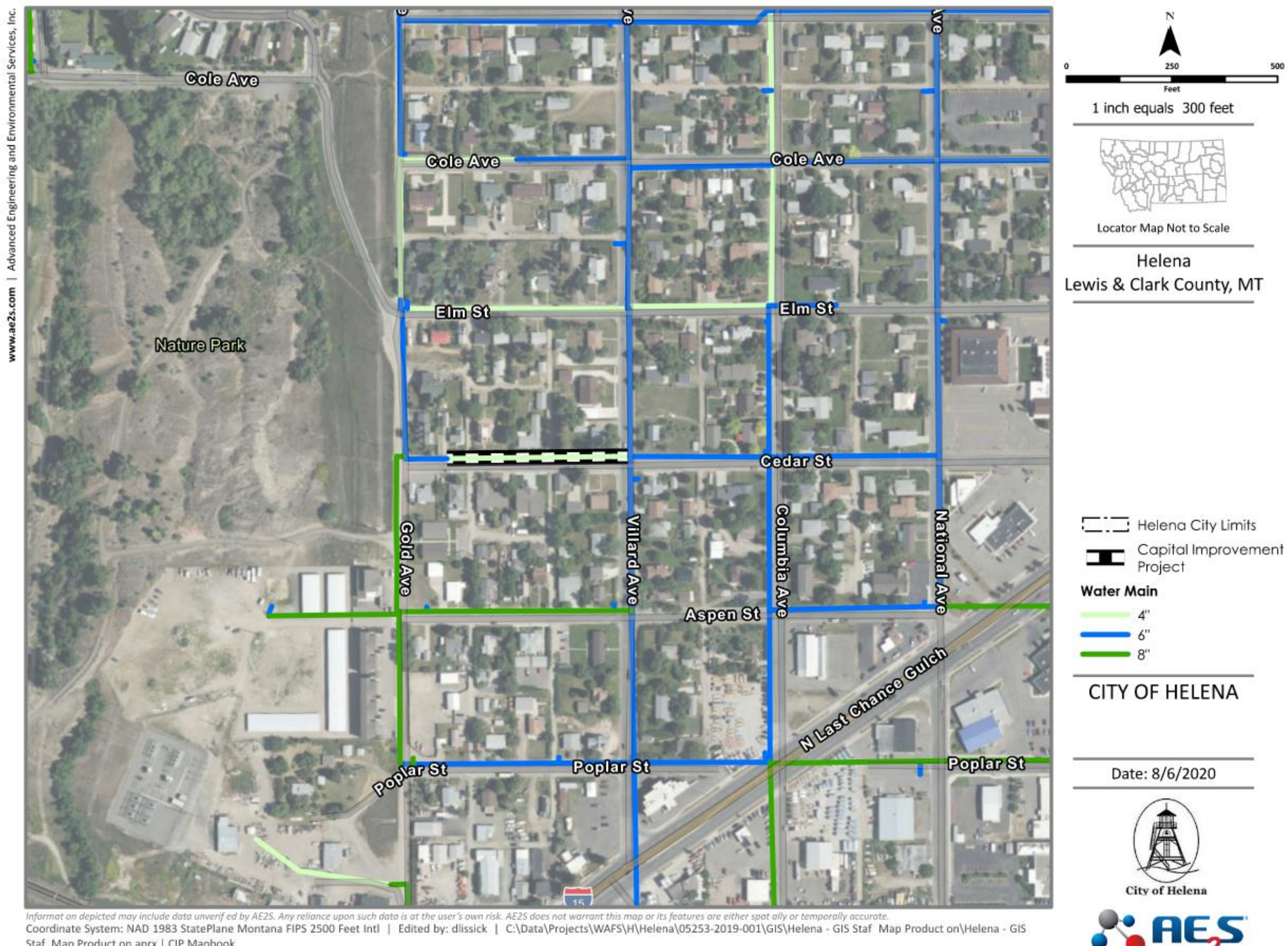

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Figure 19: W-M-20 Project Map

W-M-21

This project includes replacement of approximately 250 feet of 6-inch diameter pipe along **Rodney Street between Breckenridge Street and 5th Avenue**. The existing pipe is identified as cast-iron pipe installed in 1926. A new 8-inch diameter pipe is recommended. This project was previously identified by the City, and construction is anticipated to occur in 2021. Table 37 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 20 shows the extents of the project with a checkered line. This project is in a commercial area so traffic control has been estimated to be a higher percentage of the project cost.

Table 37: W-M-21 Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	***Pipe Breaks***
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

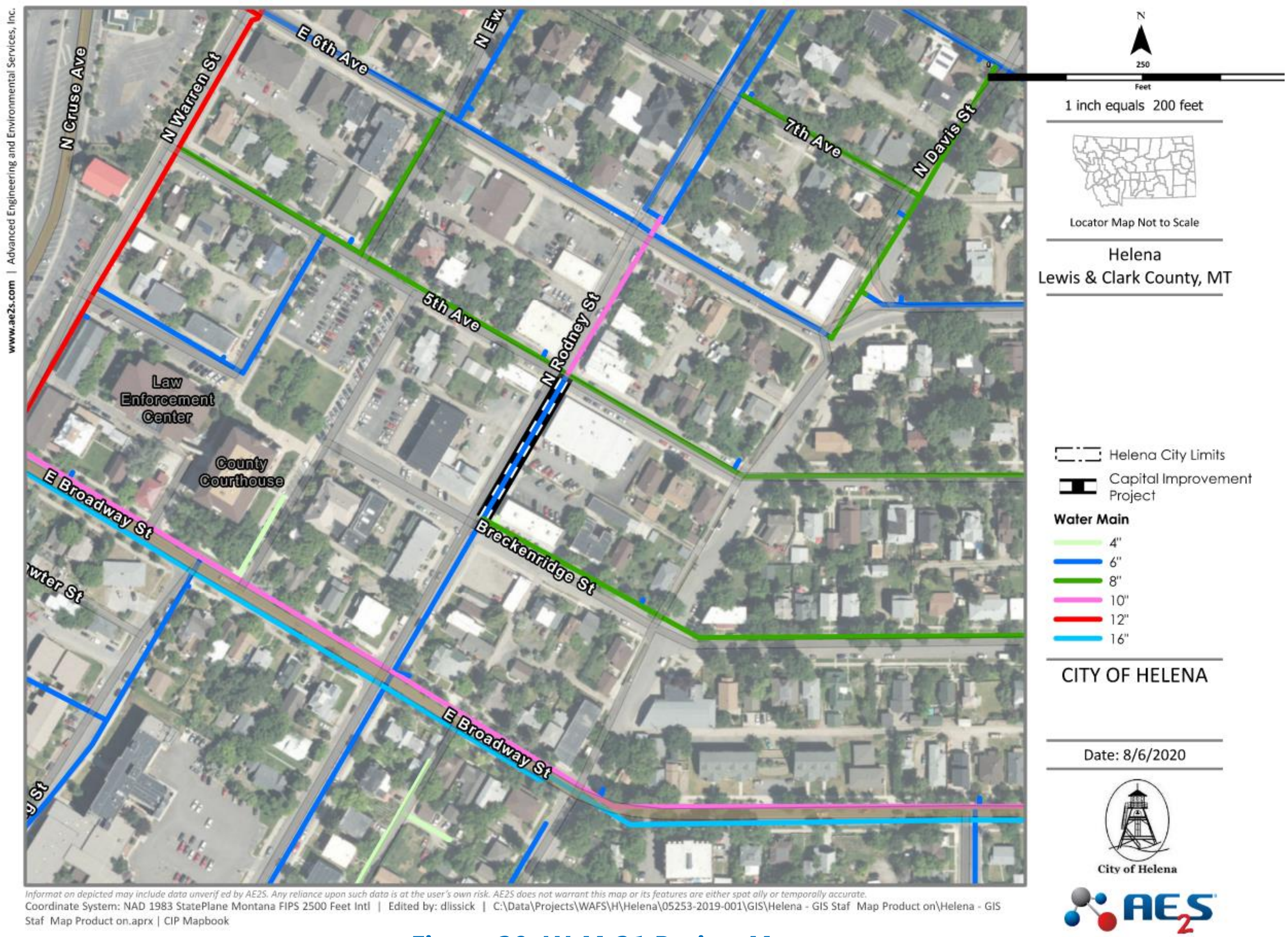


Figure 20: W-M-21 Project Map

OTHER HIGH-RISK AREAS

The Risk Assessment identified a few areas as Extreme Risk or High Risk that have been determined to not justify potential projects. The reasons for the risk determination for each of these areas, and the reasons that projects were not recommended are identified in the following sections.

24-inch Crosstown Connector

The section of 24-inch diameter water main that serves as the crosstown connector, from the intersection of Silverette Street and Woodward Avenue to Laurel Street was identified as Extreme Risk. This steel pipe was installed in 1972. This water main is part of the crosstown connector and feeds the Malben High Zone from the Ten Mile Water Treatment Plant and therefore has a very high consequence of failure. However, this steel pipe is not very old in comparison to many pipes within the City of Helena, so the likelihood of failure is relatively small. Therefore, even though this pipe was identified as Extreme Risk, a replacement project is not recommended. Table 38 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 21 shows the extents of the project with a checkered line.

Table 38: 24" Crosstown Connector Contributing Factors

COF	LOF
Line Primary Function	Pipe Age
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	***Pipe Breaks***
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

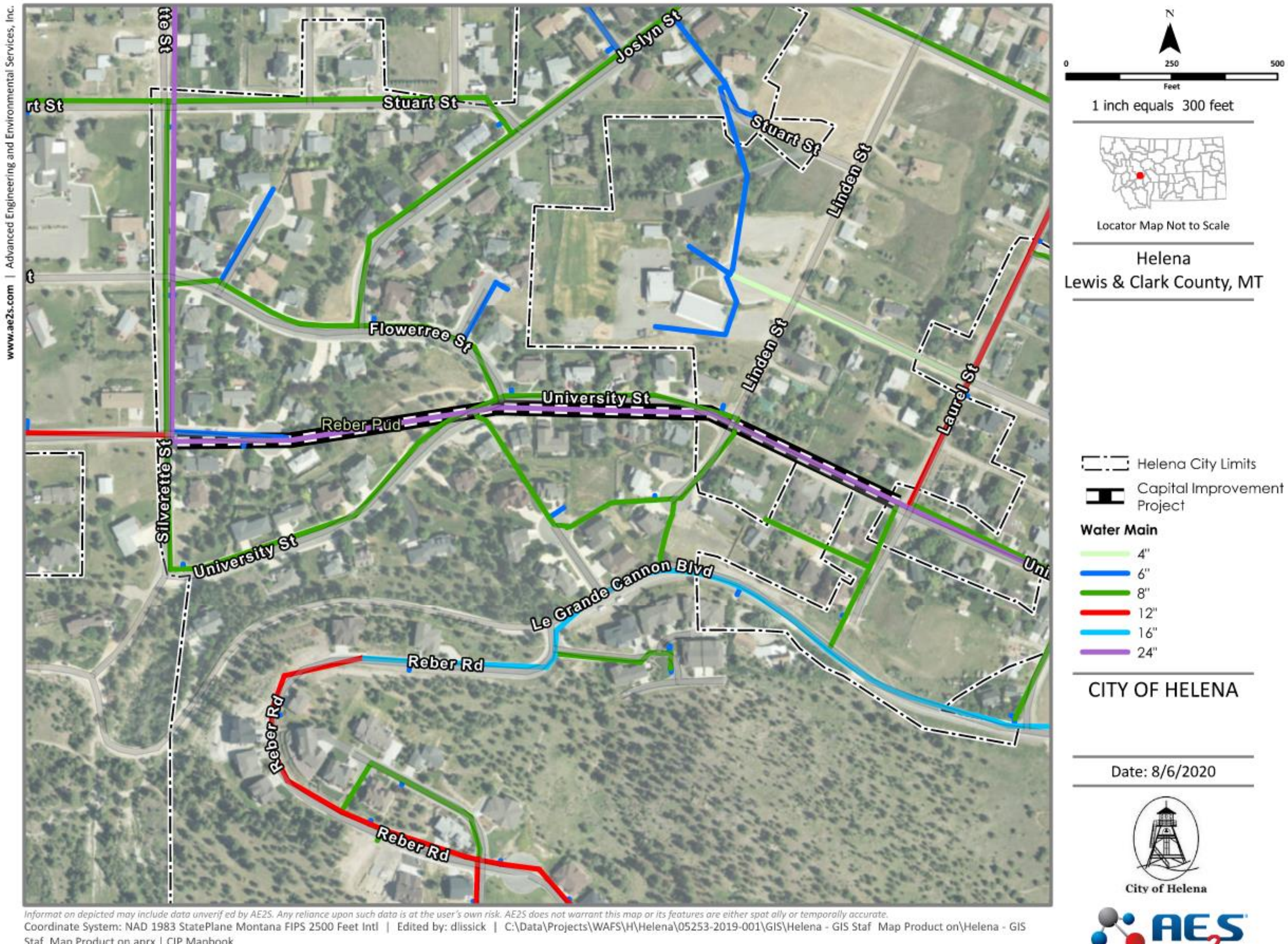


Figure 21: 24" Crosstown Connector Project Map

Tower Hill Apartments

The existing 6-inch diameter water main that serves the Tower Hill Apartments, along South Ewing Street southwest of East Broadway Street was identified as Extreme Risk. This cast-iron water main was installed in 1926. Based on the model it appears this water main is under one of the buildings and serves only these buildings. If a replacement line is constructed, a significantly different alignment would appear to be necessary, so a replacement project is not recommended, although this water main should be monitored. Table 39 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 22 shows the extents of the project with a checkered line.

Table 39: Tower Hill Apartments Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

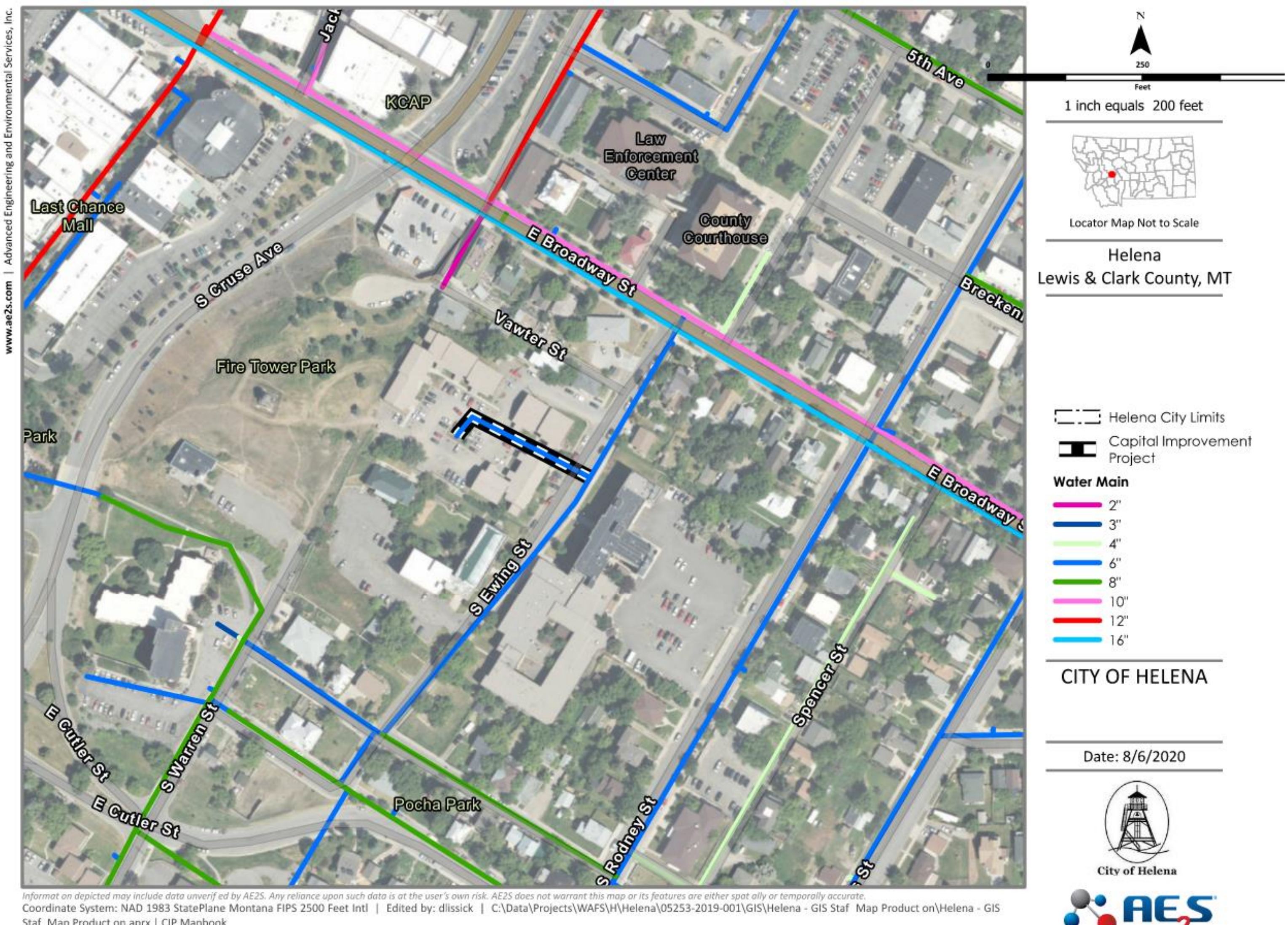


Figure 22: Tower Hill Apartments Project Map

South Dakota Street, East Broadway to State Street

The existing 6-inch diameter water main along South Dakota Street from East Broadway to State Street was identified as extreme risk. This is a cast iron pipe installed in 1951. While this pipe meets the criteria for replacement, there is also a 12-inch diameter pipe in the same street, so if the 6-inch diameter pipe needs to be turned off, the service connections could be moved to the 12-inch diameter pipe with no change in pressures. The portion of the 6-inch diameter pipe between Highland Street and State Street is currently planned for replacement as part of a project that is scheduled for construction in 2021. Table 40 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 23 shows the extents of the project with a checkered line.

Table 40: South Dakota Street Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	Corrosive Soils
Pipe Crossings	Frozen Services
Pipe Redundancy	***Pipe Breaks***
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

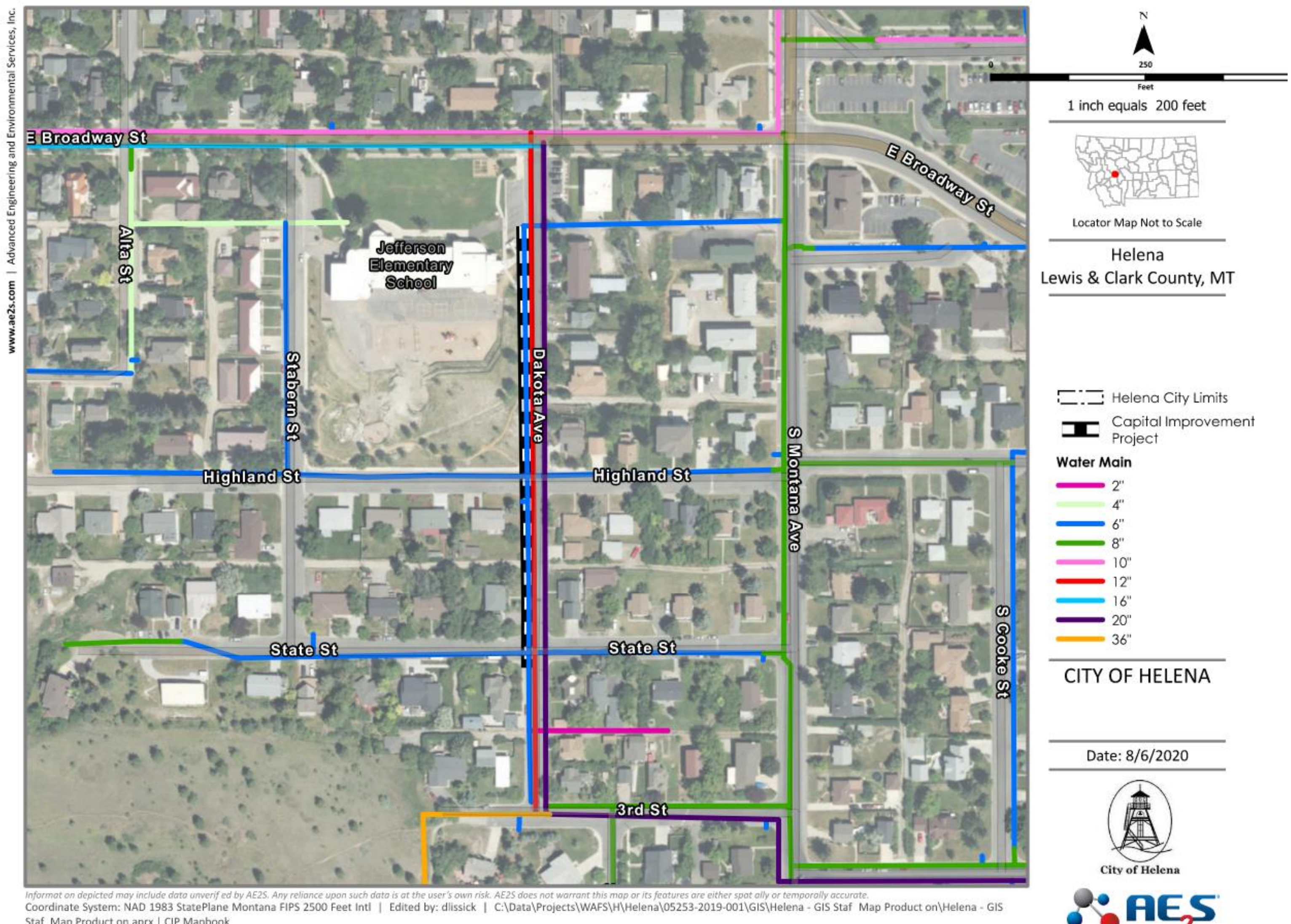


Figure 23: South Dakota Street, East Broadway to State Street Project Map

Jefferson Elementary School Service

The existing 4-inch diameter water main that serves Jefferson Elementary School from Stabern Street was identified as extreme risk. This is a cast iron pipe installed in 1968. While this pipe meets the criteria for replacement, in part due to the size, the pipe only serves the school, so it is essentially a service line and the size of the service line is a function of the building plumbing. Therefore, this pipe is not recommended for replacement. Furthermore, City GIS records indicate some uncertainty as to whether this line continues past the school and connects to Dakota Street. If it does, there is likely some redundancy in the line and the overall risk score may be lower than what is currently shown in the model. Table 41 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 24 shows the extents of the project with a checkered line.

Table 41: Jefferson Elementary School Service Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	Corrosive Soils
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

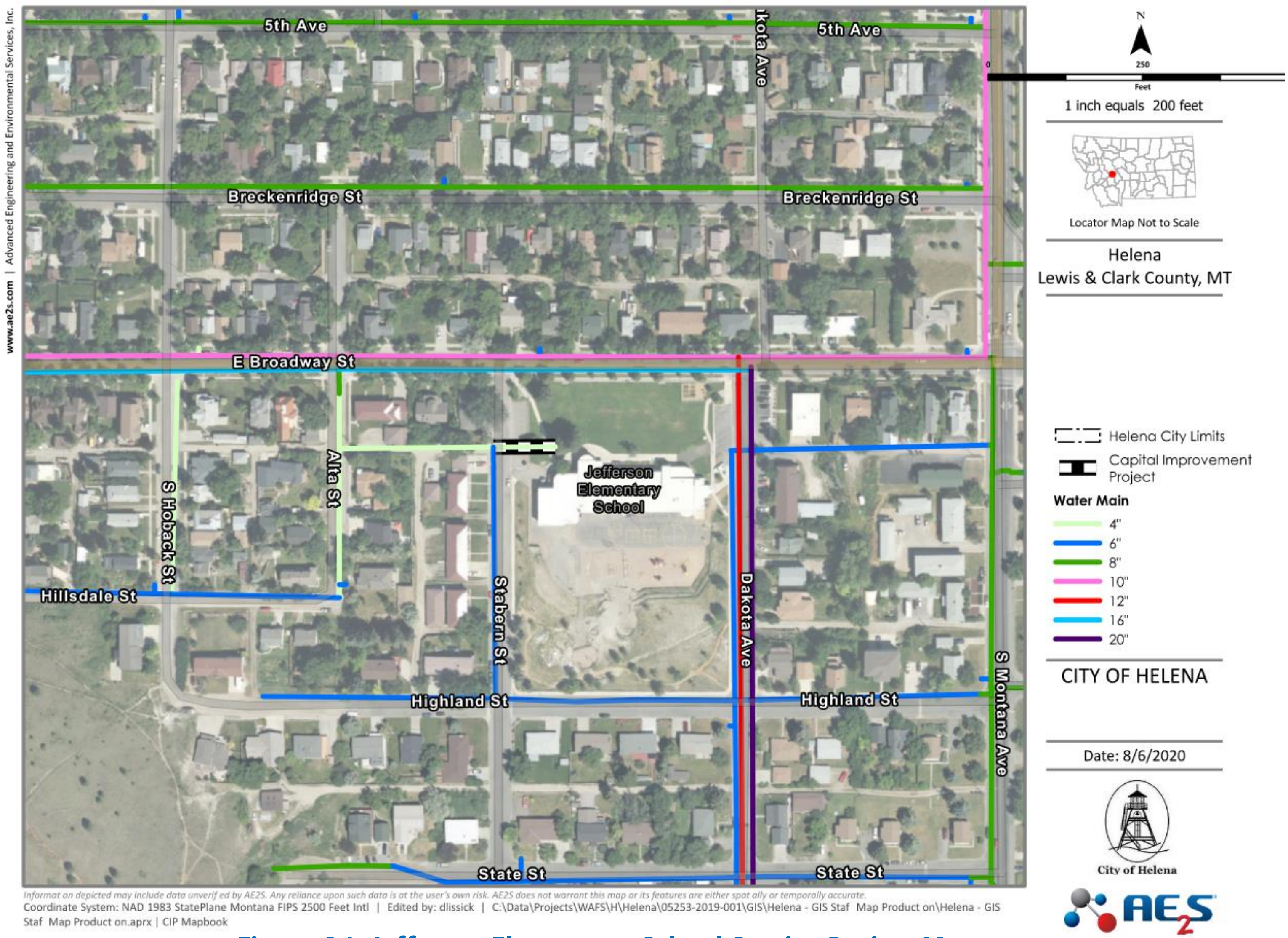


Figure 24: Jefferson Elementary School Service Project Map

Alley between Wilder Avenue and Leslie Avenue

There is an existing 4-inch diameter water main west of North Benton Avenue in the alley between Wilder Avenue and Leslie Avenue. This line is essentially just a long service line that serves several buildings. This is a cast iron pipe installed in 1916. While this pipe meets the criteria for replacement, in part due to the size, the pipe only serves a couple of buildings, so it is essentially a service line. Therefore, this pipe is not recommended for replacement. Table 42 shows the COF and LOF criteria which were the driving factors for the elevated risk score of the asset(s) ***bold and italicized***. Figure 25 shows the extents of the project with a checkered line.

Table 42: Alley Service Line Contributing Factors

COF	LOF
Line Primary Function	***Pipe Age***
Proximity to Critical Facilities	***Pipe Material***
Count of Laterals Connected	***Corrosive Soils***
Pipe Crossings	Frozen Services
Pipe Redundancy	Pipe Breaks
Pipe Max. Flow Rate	Pipe Max. Velocity
	Pipe Max. Pressure
	Undersized Mains

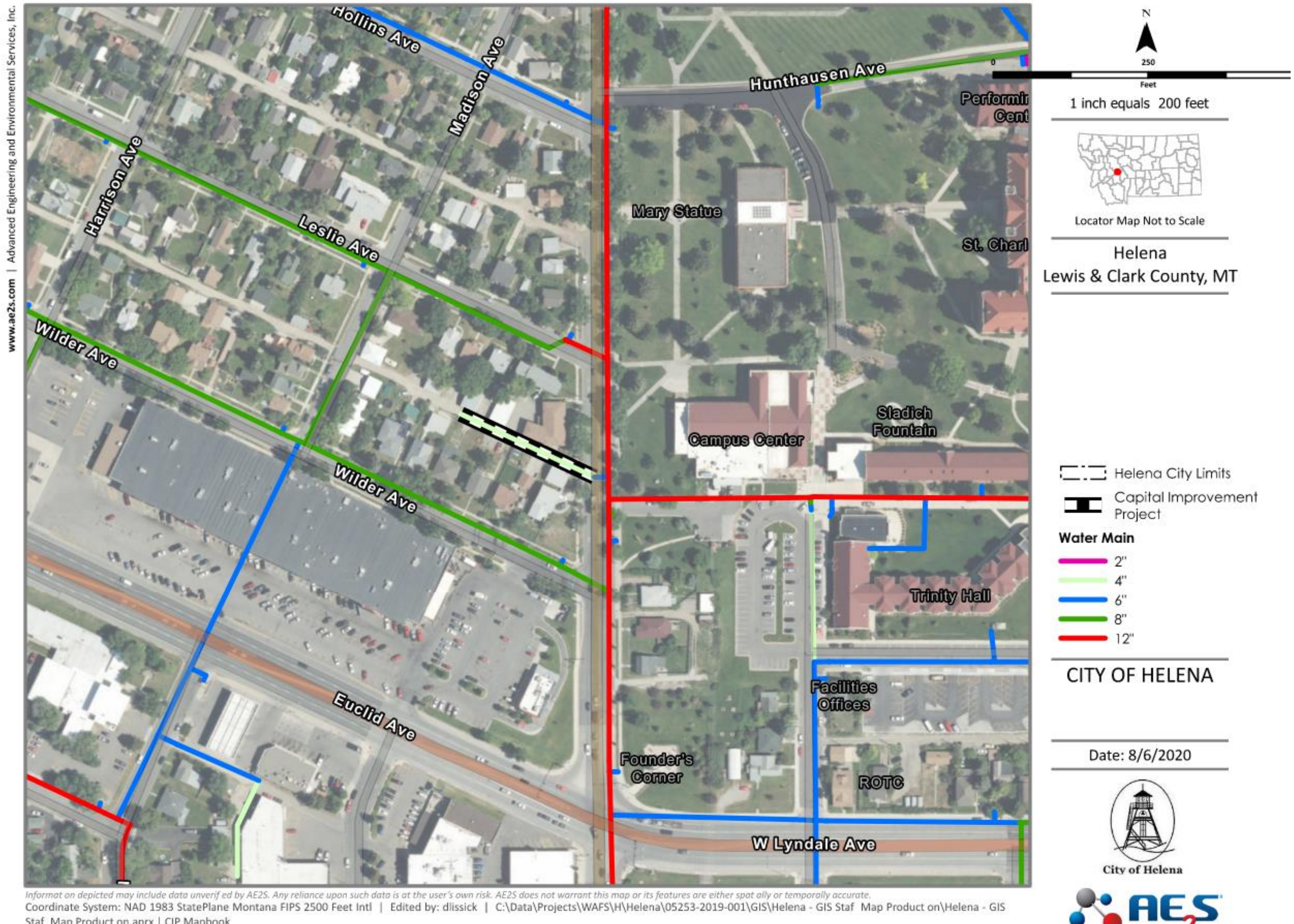


Figure 25: Alley Between Wilder Avenue and Leslie Avenue Project Map

SUMMARY AND RECOMMENDATIONS

As the City completes replacements, repairs, and maintenance on the water distribution system, it is recommended that the risk assessment be updated annually to help guide capital improvement planning and prioritize infrastructure investment.

TECHNICAL MEMORANDUM #9

To: Jamie Clark, PE

From: Mark Peterson, PE
Nate Weisenburger, PE

Re: **Proposed Capital Improvement Projects**
City of Helena, MT

Date: December 8, 2020

INTRODUCTION

This Technical Memorandum is intended to cover the recommended Capital Improvement Projects to improve the water distribution system.

OPINIONS OF PROBABLE COSTS

This Technical Memorandum presents Opinions of Probable Costs. The Opinion of Probable Cost (OPC) values were based on the total capital investment necessary to complete a project from engineering design through construction. All estimates and unit costs are based on engineering experience and judgement, recent bid tabulations for projects of similar scope primarily within the Helena area, and material suppliers.

Total estimated project costs were divided into five main components, as follows:

- Hard Costs: Sometimes referred to as contractor construction costs, represents the actual physical construction of the project. This section was divided into component unit costs and hard cost markups.
    - Component Unit Costs: All estimates are based on engineering experience and judgement, recent bid tabulations for projects of similar scope, cost indexing, and input from contractors and material suppliers. For specific equipment and materials, information was requested from vendors and suppliers, and the costs were increased by applying a multiplication factor to include the related costs and expenses (i.e., labor, connections, and misc. materials) required to complete the installation.

- Unpaved Transmission Main: The pipe material assumed for new unpaved transmission mains located in an easement outside of public right-of-way was DR14 C900 PVC for pipes ranging from 6 inches to 12 inches in diameter and DR18 C900 PVC for pipes ranging from 14 inches to 36 inches in diameter. Table OPC-1 presents the unpaved transmission pipeline construction costs. The cost is based on the following assumptions:
  - Earthwork
    - Trench depth of 6 ft. to 10 ft. to the top of the pipe.
    - Utility bedding for pipe and compaction of bedding in the trench.
  - Fire hydrant every 1,000 ft.
  - Two isolation valves every 1,000 ft.
  - Two fittings every 1,000 ft. (on average).
  - Hydroseeding surface restoration of unpaved areas.

Table OPC-1: Unpaved Transmission Main Cost per Linear Foot

Pipe Diameter (inches)	C900 PVC Pipe ($/Linear Foot)
6	$70
8	$72
10	$92
12	$97
14	$100
16	$105
18	$110
20	$120
24	$150
30	$200
36	$230

- Paved Transmission Mains: The pipe material assumed for paved transmission mains located within paved public right-of-way was DR14 C900 PVC for pipes ranging from 6 inches to 12 inches in diameter and DR18 C900 for 14-inch to 36-inch diameter pipelines. Table OPC-2 presents the paved transmission main construction costs. The cost is based on the following assumptions:
  - Earthwork
    - Trench depth of 6 ft. to 10 ft. to the top of the pipe.

- Utility bedding for pipe and compaction of bedding in the trench.

- Fire hydrant every 1,000 ft.
- Two isolation valves every 1,000 ft.
- Two fittings every 1,000 ft. (on average).
- Asphalt pavement surface restoration of existing paved areas.

Table OPC-2: Paved Transmission Main Cost per Linear Foot

Pipe Diameter (inches)	C900 PVC Pipe ($/Linear Foot)
6	$85
8	$87
10	$102
12	$117
14	$120
16	$125
18	$130
20	$140
24	$200
30	$220
36	$250

- <u>Urban Transmission Mains</u>: The pipe material assumed for the urban transmission mains was DR14 C900 PVC for pipes ranging from 6 inches to 12 inches in diameter and DR18 C900 for 14-inch to 24-inch diameter pipelines. This type of main is typically used in downtown urban areas for replacement projects of existing water mains within the paved right-of-way. Table OPC-3 presents the urban transmission pipeline construction costs for water main replacement. The cost is based on the following assumptions:
  - Earthwork
    - Trench depth of 6 ft. to 10 ft. to the top of the pipe.
    - Utility bedding for pipe and compaction of bedding in the trench.
  - Fire hydrant every 370 ft. (city block).
  - Three isolation valves every 370 ft.
  - One fitting every 250 ft. (on average).

- Fire hydrant removal and valve box removal for existing hydrants in replacement pipe areas every 370 ft.
- Asphalt pavement surface restoration of existing paved areas.

Table OPC-3: Urban Transmission Main Cost per Linear Foot

Pipe Diameter (inches)	C900 PVC Pipe ($/Linear Foot)
6	$137
8	$142
10	$152
12	$177
14	$185
16	$200
18	$210
20	$220
24	$300

- Other Transmission Main Items: Additional items included in the transmission main cost estimates are presented below:
  - 1" Residential Water Service Installations with Curb Stop, Corporation Stop and Meter = $2,000 each.
  - Water Main Connections of proposed transmission main to other mains in the system (Table OPC-4).

Table OPC-4: Water Main Connection Cost per Each

Connecting Pipe Diameter (inches)	Cost Per Connection ($/each)
6 & Smaller	$2,125
8	$2,200
10	$2,250
12	$2,450
14	$2,660
16	$2,960
18	$3,270
20	$3,815
24	$4,360
30	$10,000
36	$10,000

- Soft Costs: To adequately complete the planning, design, and construction of projects listed in this OPC, there are significant soft costs to consider. Soft costs are non-construction labor costs consisting of architecture and engineering fees, permitting and environmental compliance, contract administration, legal fees, etc. Soft costs are applied to the hard costs, including the hard cost markups. A breakdown and summary of the soft costs included in the cost estimates are provided below.

    1) Engineering Design – 0-20 %: Costs include preliminary engineering through final design, which involves the development of final project plans and specifications that will be stamped by a professional consulting engineer. Engineering costs include disciplines such as process, civil, electrical, mechanical, architectural, and structural. Costs also include surveying, testing, investigations, and inspections during the design phase. Examples include surveys of pipeline alignments and facility parcels, security and safety inspections, material and geological testing, and inspection services.

    2) Construction Administration and Management – 0-10 %: Costs include services to provide quality control, quality assurance, and construction management during the construction phase and services associated with the initial operation, including training of operational, maintenance, and supervisory staff.

    3) Legal and Administrative - 0-5 %: Costs associated with the local and state project approval process, and any legal costs, are included in this category. Responsible tasks may include road crossing permits, construction permits, county building permits, Inter-Disciplinary Team Meetings, NEPA compliance, expenses incurred by the City, etc.

    4) Other Soft Costs – Varies: Several specialized projects required unique soft costs that vary from project to project, such as programming and startup for control system updates, hydraulic modeling, and operational evaluations for flow control and booster station upgrades, and filing of provisional water rights for new wells. In some projects, such as water rights change applications, soft costs were the only work involved in the project.

- Contingency: A contingency is an amount added to the base cost to cover both identified and unidentified risk events that occur on the project. Depending on the project type, the contingency value ranged from 10 to 30 percent. The contingency values were added to the overall project base cost (i.e., hard and soft costs) in anticipation of uncertainties inherent to the planning-level analysis completed for the proposed Capital Improvement Projects.

The sum of these components is the total OPC. The OPC values are based on the preliminary concepts and layouts of the water system components developed as a result of the hydraulic modeling of the system and corresponding recommendations. The estimate is to be an indication of fair market value and is not necessarily a reflection of the lowest bid. Fair market value is assumed to be mid-range tender considering three or more competitive bids.

The American Association of Cost Engineers (AACE) provides guidelines for applying the general principals of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The purpose of following a classification process is to align the level of estimating with the use of the information. The Opinions of Probable Cost presented in this Technical Memorandum should be considered Class 5 Estimates based on the AACE Classification System. This class of estimate is used for concept screening and represents a project design that is 0% to 2% complete. The expected accuracy range of Class 5 Estimates is -20% to -50% on the low end and +30% to +100% on the high end. More accurate estimates can be prepared for each project as the design progresses.

For this Opinion of Probable Cost, unless specifically identified, the following items were excluded in the development of the cost estimates:

- Environmental mitigation of hazardous materials and/or disposal.
- Any costs associated with increased thickness of asphalt, base, and subbase plus higher-grade asphalt mix for one square yard of restoration per linear foot of main in projects within MDT paved right-of-way.
- Annual average inflation rate
- Property acquisition costs for projects outside of right-of-way or existing easements
- Operations and maintenance costs for the project components.

Details of the estimates for each proposed project are included in the Appendix.

FIRE FLOW IMPROVEMENTS

A number of areas have been identified as having available fire flows less than the recommended values. The Technical Memorandum on the Distribution System Analysis describes a number of potential improvements but only recommends one area for potential improvements to the existing system. This area is shown in Table 1, along with the Opinion of Probable Cost based on 2020 values. A detailed description of this recommended improvement and its benefits is included in the Technical Memorandum on the Distribution System Analysis.

Table 1 Distribution System Improvements for Fire Flow

Improvement ID	Location of Improvement	Opinion of Probable Cost (2020 $)
W-M-01	Grant St. and University Street	$278,000

STORAGE IMPROVEMENTS

The existing City of Helena water system was also reviewed for potential needs related to system storage. This analysis is covered in the Technical Memorandum on Storage, which recommended and described the benefits of four potential projects related to storage. These projects are summarized in Table 2 and include the following:

W-ST-01: Modify the existing altitude valve at the Woolston Reservoir to allow either hydraulic or electric control of this valve and modify the operating procedures to effectively use the Woolston Reservoir.

W-ST-02: Install an 8-inch diameter connection between the Upper Hale Zone and the Reeder's Village Area and West Main Street, to provide fire flows to the Reeder's Village Area and West Main Street. While this is a distribution main installation, the purpose of this installation is to provide storage capabilities for the Reeder's Village and West Main pressure zones, so it is included as a storage improvement.

W-ST-03: Construct a 200,000-gallon new tank to provide additional storage for the Reeder's Village Area. For estimating purposes, this tank is assumed to be located adjacent to the existing Upper Hale Tank.

W-ST-04: Construct a 1,000,000-gallon new tank to increase the storage in the Malben Low Zone. For estimating purposes, this tank is assumed to be an elevated tank near the railroad tracks to serve the Malben Low Zone.

Table 2 Storage System Improvements

Improvement ID	Improvement	Opinion of Probable Cost (2020 $)
W-ST-01	Modify altitude valve at Woolston Reservoir	$90,000
W-ST-02	Water Main connection between Upper Hale Zone and Reeder's Village	$1,191,000
W-ST-03	New 200,000-gallon Ground Storage Tank adjacent to Upper Hale Tank	$2,926,000
W-ST-04	New 1,000,000-gallon Elevated Tank to serve Malben Low Zone	$5,108,000

RISK-BASED IMPROVEMENTS

In addition to distribution system projects that would improve fire flow, the system was also reviewed to identify areas of high risk. The details of the risk assessment parameters, as well as an explanation of how projects were identified, are described in the Technical Memorandum on Risk Assessment. These projects are summarized in Table 3 and include the following:

W-M-02: Install approximately 4,900 feet of new 30-inch diameter pipe from the High Zone discharge at the Missouri River WTP to the existing 36-inch diameter pipe under the airport runways.

W-M-03: Install approximately 450 feet of new 20-inch diameter pipe along Fee Street from Prospect Avenue to East 11th Avenue.

W-M-04: Install approximately 810 feet of new 8-inch diameter pipe along Golden Street from North Lamborn Street to North Carson Street and approximately 400 feet of new 8-inch diameter pipe along East 6th Avenue from North Lamborn Street to North Hannaford Street.

W-M-05: Install approximately 500 feet of new 8-inch diameter pipe along North Davis Street from East 15th Street to East 14th Street.

W-M-06: Install approximately 850 feet of new 8-inch diameter pipe along Livingston Avenue from North Montana Avenue to Townsend Avenue and approximately 500 feet of new 8-inch diameter pipe along North Davis Street from North Dakota Street to Idaho Avenue.

W-M-07: Install approximately 1,900 feet of new 8-inch diameter pipe along Breckenridge Street from North Raleigh Street to North Montana Avenue.

W-M-08: Install approximately 500 feet of new 8-inch diameter pipe along 8th Avenue from Idaho Avenue to Hoback Street and approximately 1,000 feet of new 12-inch diameter pipe along 9th Avenue from Hoback Street to Beattie Street.

W-M-09: Install approximately 1,650 feet of new 8-inch diameter pipe along 11th Avenue from Hoback Street to Raleigh Street and along 10th Avenue from Hoback Street to North Dakota Street.

W-M-10: Install approximately 1,350 feet of new 8-inch diameter pipe along Butte Avenue from Hoback Street to North Montana Avenue.

W-M-11: Install approximately 900 feet of new 8-inch diameter pipe along Boulder Avenue from North Hannaford Street to North Oakes Street.

W-M-12: Install approximately 200 feet of new 8-inch diameter pipe along North Sanders Street from East Lyndale Avenue to Lewis Street.

W-M-13: Install approximately 1,400 feet of new 8-inch diameter pipes along Logan Street and North Jackson Street from East 14th Street to East 15th Street and along North Warren Street from East 16th Street to East 17th Street.

W-M-14: Install approximately 300 feet of new 8-inch diameter pipe along Logan Street from 11th Avenue to the cul-de-sac southwest of 11th Avenue.

W-M-15: Install approximately 650 feet of new 8-inch diameter pipe along National Avenue from East Lyndale Avenue to Argyle Street.

W-M-16: Install approximately 350 feet of new 8-inch diameter pipe along Monroe Avenue between Knight Street and Hauser Boulevard.

W-M-17: Install approximately 1,400 feet of new 8-inch diameter pipe along Choteau Street from Henderson Street to Glendale Street and approximately 350 feet of new 8-inch diameter pipe along Choteau Street between Laurel Street and Linden Street.

W-M-18: Install approximately 600 feet of new 8-inch diameter pipe along Grant Street between Leslie Avenue and Peosta Avenue.

W-M-19: Install approximately 1,600 feet of new 8-inch diameter pipe along Hollins Avenue from North Benton Avenue to Garfield Street and from Cleveland Street to Allison Street, approximately 1,000 feet of new 8-inch diameter pipe along Peosta Avenue from North Benton Avenue to Garfield Street, and approximately 500 feet of new 8-inch diameter pipe along Waukesha Avenue from Allison Street to Henderson Street.

W-M-20: Install approximately 500 feet of new 8-inch diameter pipe along Cedar Street from Villard Avenue to Gold Avenue.

W-M-21: Install approximately 250 feet of new 8-inch diameter pipe along Rodney Street between Breckenridge Street and 5th Avenue.

Table 3 Distribution System Improvements based on Risk Assessment

Improvement ID	Location of Improvement	Year Installed	Opinion of Probable Cost (2020 $)
W-M-02	MRTP to Airport	1958	$1,952,000
W-M-03	Fee St.	1958	$145,000
W-M-04	Golden St. and E 6th	1950/1962	$395,000
W-M-05	North Davis St.	1934	$182,000
W-M-06	Livingston Avenue	1917/1960	$444,000
W-M-07	Breckenridge St.	1916	$669,000
W-M-08	8th Avenue and 9th	1950	$621,000
W-M-09	10th Avenue and 11th	1925/1939	$612,000
W-M-10	Butte Avenue	1899	$497,000
W-M-11	Boulder Avenue	1916/1949	$232,000
W-M-12	North Sanders St.	1936	$69,000
W-M-13	Logan St., N Jackson	1916/1942	$360,000
W-M-14	Logan St.	1936	$97,000
W-M-15	National Avenue	1899	$212,000
W-M-16	Monroe Avenue	1916	$133,000
W-M-17	Choteau St.	1936/1955	$596,000
W-M-18	Grant St.	1916	$194,000
W-M-19	Hollins Ave, Peosta	1916/1957	$1,076,000
W-M-20	Cedar St.	1936	$169,000
W-M-21	Rodney Street	1926	$85,000

SHORT-TERM CAPITAL IMPROVEMENT PLAN

Based on input from the City of Helena, the short-term (five-year) Capital Improvement plan will include projects that total approximately $1,100,000 per year for distribution system projects and approximately $600,000 per year for storage projects. This value is not adjusted for inflation, but the project costs are adjusted for inflation based on a rate of 2% per year.

The project lists in Tables 4 and 5 are based on the Consultant's recommendations for the priority of projects. This priority will be reviewed with the City of Helena, and appropriate adjustments made in the final recommendations. The total probable cost (in 2020 $) of the improvements shown in Table 4 is $1,281,000, and Table 5 is $5,063,000.

The priorities may also change as a result of future street improvement projects. All of the identified Capital Improvement Projects should be completed if the street is being reconstructed.

Table 4 Short-Term Capital Improvement Plan, Storage

Priority	Improvement ID	Description	Opinion of Probable Cost (2020 $)	Opinion of Probable Cost (Construction Year $)[1]	Year
1	**W-ST-01**	Modify altitude valve at Woolston Reservoir	$90,000	$91,000	2021
2	**W-ST-02**	Water Main connection between Upper Hale Zone and Reeder's Village	$1,191,000	$1,264,000	2023

[1]Future costs assume a 2% annual inflation rate

Table 5 Short-Term Capital Improvement Plan, Distribution System

Priority	Improvement ID	Location	Opinion of Probable Cost (2020 $)	Opinion of Probable Cost (Construction Year $)[1]	Year
1	**W-M-13**	Logan St., N Jackson St., Warren St.	$360,000	$367,000	2021
2	**W-M-02**	MRTP to Airport	$1,952,000	$2,071,000	2023
3	**W-M-15**	National Ave.	$212,000	$225,000	2023
4	**W-M-07**	Breckenridge St.	$669,000	$724,000	2024
5	**W-M-10**	Butte Ave.	$497,000	$538,000	2024
6	**W-M-06**	Livingston Ave. and North Davis St.	$444,000	$490,000	2025
7	**W-M-16**	Monroe Ave.	$133,000	$146,000	2025
8	**W-M-18**	Grant St.	$194,000	$214,000	2025
9	**W-M-21**	Rodney St.	$85,000	$94,000	2025
10	**W-M-05**	North Davis St.	$182,000	$201,000	2025
11	**W-M-12**	North Sanders St.	$69,000	$76,000	2025
12	**W-M-14**	Logan St.	$97,000	$108,000	2025
13	**W-M-20**	Cedar St.	$169,000	$186,000	2025

[1]Future costs assume a 2% annual inflation rate

LONG-TERM CAPITAL IMPROVEMENT PLAN

Based on input from the City of Helena, the long-term (five-to-twenty-year) Capital Improvement plan will include distribution projects that total approximately $1,100,000 per year and storage projects that total approximately $600,000 per year. This value is not adjusted for inflation, but the project costs are adjusted for inflation based on a rate of 2% per year.

The project lists in Tables 6 and 7 are based on the Consultant's recommendations for the priority of projects. This priority will be reviewed with the City of Helena, and appropriate adjustments made in the final recommendations. In general, the projects identified in the risk assessment were prioritized based on the age of the pipe. The total probable cost (in 2020 $) for the distribution system improvements shown in Table 7 is $3,955,000. Given the currently anticipated budgets shown in the paragraph above, all long-term capital improvement projects for both storage and distribution, with the exception of the new 1,000,000-gallon elevated tank to serve Malben Low Zone (W-ST-04), could be completed by 2030.

The priorities may also change as a result of future street improvement projects. All of the identified Capital Improvement Projects should be completed if the street is being reconstructed.

Table 6 Long-Term Capital Improvement Plan, Storage

Priority	Improvement ID	Description	Opinion of Probable Cost (2020 $)	Opinion of Probable Cost (Construction Year or 2040 $)[1]	Year
3	**W-ST-03**	New 200,000-gallon Ground Storage Tank adjacent to Upper Hale Tank	$2,926,000	$3,428,000	2028
4	**W-ST-04**	New 1,000,000-gallon Elevated Tank to serve Malben Low Zone	$5,108,000	$7,590,000	>2040

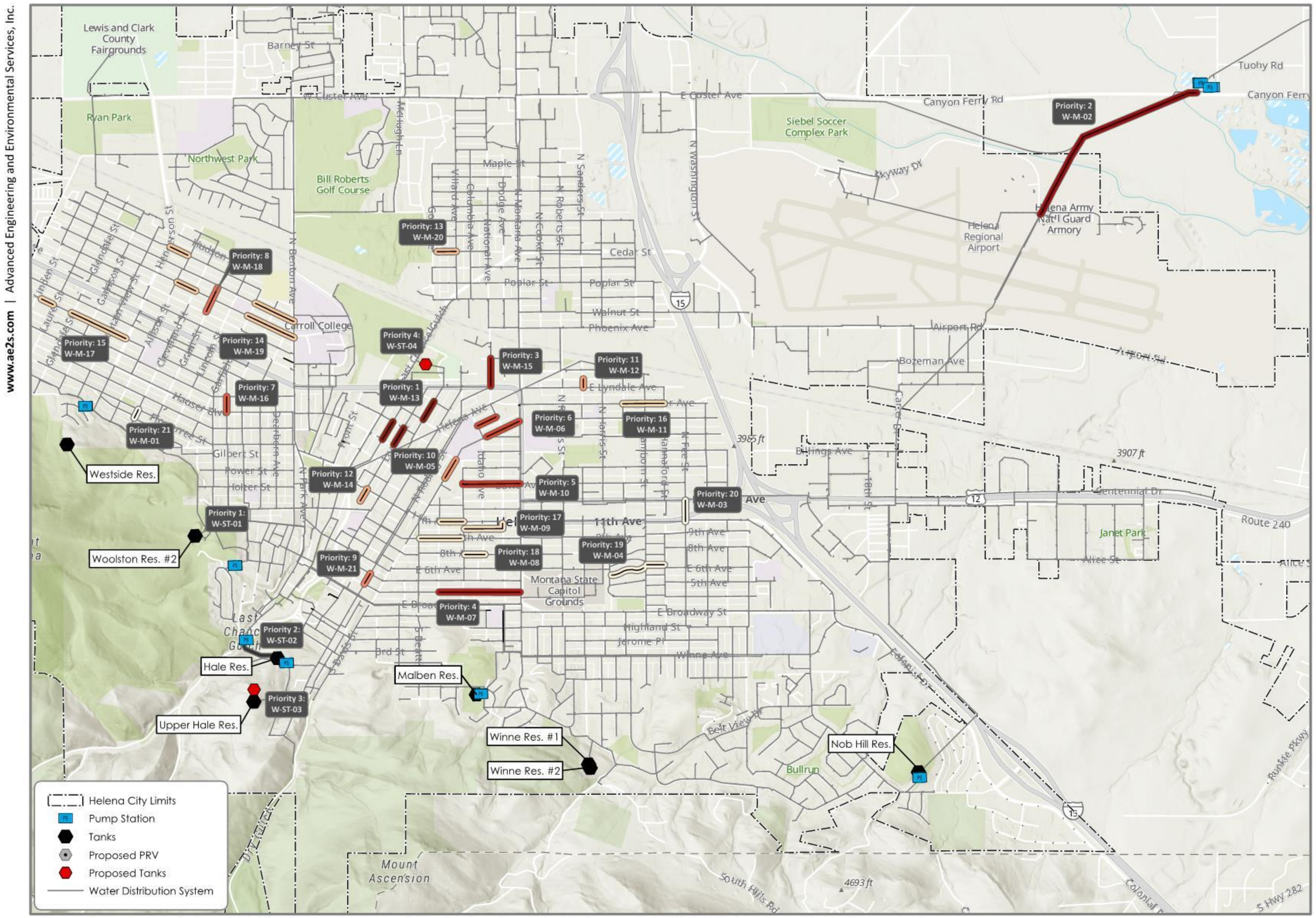
[1]Future costs assume a 2% annual inflation rate

Table 7 Long-Term Capital Improvement Plan, Distribution System

Priority	Improvement ID	Location	Opinion of Probable Cost (2020 $)	Opinion of Probable Cost (Construction Year or 2040 $)[1]	Year
14	**W-M-19**	Hollins Ave., Peosta Ave., Waukesha Ave.	$1,076,000	$1,237,000	2027
15	**W-M-17**	Choteau St.	$596,000	$685,000	2027
16	**W-M-11**	Boulder Ave.	$232,000	$267,000	2027
17	**W-M-09**	10th Ave. and 11th Ave.	$612,000	$717,000	2028
18	**W-M-08**	8th Ave. and 9th Ave.	$621,000	$743,000	2029
19	**W-M-04**	Golden St. and E. 6th Ave.	$395,000	$472,000	2029
20	**W-M-03**	Fee St.	$145,000	$174,000	2029
21	**W-M-01**	Grant St. and University St.	$278,000	$339,000	2030

[1]Future costs assume a 2% annual inflation rate

Figure 1 identifies the locations of the recommended improvement projects. Additional details on the benefits of each of the projects are presented in the Water Distribution System Analysis memo, the Water System Storage Analysis memo, and the Water Main Risk Assessment memo.



Information depicted may include data unverified by AE2S. Any reliance upon such data is at the user's own risk. AE2S does not warrant this map or its features are either spatially or temporally accurate.

Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlee | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Memo Fig 1- Recommended Capital Improvement Projects

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Miles 0 0.2 0.4

Locator Map Not to Scale

Helena
Lewis & Clark County, MT

Figure 1
RECOMMENDED CAPITAL IMPROVEMENT PROJECTS

CITY OF HELENA

Date: 10/7/2020

City of Helena

APPENDIX A – DETAILED COST ESTIMATES

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
May 2020

Project Description: New 200,000 gallon ground storage tank at Upper Hale site.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-ST-01	Modify Woolston Reservoir Controls	2021	$91,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**		**Storage Tank**						
		a.	Storage Tank						
		1.	Controls and Telemetry for Altitude Valve	1	LS	$50,000.00	$50,000		
			Subtotal				$50,000		
Hard Cost - Markups	**2.0**								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$3,000		
		b.	Traffic Control	1	LS	2%	$1,000		
		c.	Erosion Control	1	LS	1%	$500		
		d.	Testing and Construction Surveying	1	LS	3%	$1,500		
			Subtotal				$6,000.00		
								$56,000	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**								
		a.	Engineering Design	1	LS	10%	$5,600		
		b.	Construction Administration and Management	1	LS	8%	$4,480		
		c.	Legal and Administrative	1	LS	5%	$2,800		
			Subtotal				$12,880		
								$12,880	**Estimated Soft Costs**
Property Acquisition	**4.0**								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**								
		a.	Total Project Contingency	1	LS	30%	$20,664		
			Subtotal				$20,664		
								$20,664	**Project Contingency**
Inflation	**6.0**								
		a.	Inflation	1	LS		$1,791		
			Subtotal				$1,791		
								$1,791	**Inflation**
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2021					
			Number of years of inflation	1					
			Additional cost of inflation	$1,791					
								$91,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
April 2020

Project Description: Install an 8-inch diameter connection between the Upper Hale Zone and the Reeder's Village Area and West Main Street, to provide fire flows to the Reeder's Village Area and West Main Street.

CIP ID: W-ST-02

CIP Name: Upper Hale/Reeders Village Connection

Estimated CIP Year: 2023

Estimated CIP Cost: $1,264,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	1.0	Water Transmission System						
	a.	Water Main						
	1.	8" DR14 C900 PVC Water Main (Steep Slope/Rock)	1,550	LF	$263.00	$407,650		
	2.	8" DR14 C900 PVC Water Main (Paved Transmission)	550	LF	$87.00	$47,850		
	3.	6" and Smaller Water Main Connection	4	EA	$2,125.00	$8,500		
	4.	8" Water Main Connection	2	EA	$2,200.00	$4,400		
	5.	4" PRV Station	2	LS	$100,000.00	$200,000		
	6.	1" Residential Service Connection	2	EA	$2,000.00	$4,000		
		Subtotal				$672,400		
Hard Cost - Markups	2.0							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$40,344		
	b.	Traffic Control	1	LS	10%	$67,240		
	c.	Erosion Control	1	LS	1%	$6,724		
	d.	Testing and Construction Surveying	1	LS	3%	$20,172		
		Subtotal				$134,480.00		
							$806,880	Estimated Hard/Construction Costs
Soft Costs	3.0							
	a.	Engineering Design	1	LS	10%	$80,688		
	b.	Construction Administration and Management	1	LS	8%	$64,550		
	c.	Legal and Administrative	1	LS	5%	$40,344		
		Subtotal				$185,582		
							$185,582	Estimated Soft Costs
Property Acquisition	4.0							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	Estimated Property Acquisition Costs
Project Contingency	5.0							
	a.	Total Project Contingency	1	LS	20%	$198,492		
		Subtotal				$198,492		
							$198,492	Project Contingency
Inflation	6.0							
	a.	Inflation	1	LS		$72,896		
		Subtotal				$72,896		
							$72,896	Inflation
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2023					
		Number of years of inflation	3					
		Additional cost of inflation	$72,896					
							$1,264,000	Total Probable Project Cost

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
May 2020

Project Description: New 200,000 gallon ground storage tank at Upper Hale site.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-ST-03	Additional Upper Hale Storage	2028	$3,428,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**	**Storage Tank**						
	a.	Storage Tank						
		1. 200k Ground Storage Tank	1	LS	$650,000.00	$650,000		
		2. Ground Storage Tank Controls	1	LS	$40,000.00	$40,000		
		3. Rock Excavation	3,600	CY	$300.00	$1,080,000		
		Subtotal				$1,770,000		
Hard Cost - Markups	**2.0**							
		a. Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$106,200		
		b. Traffic Control	1	LS	2%	$35,400		
		c. Erosion Control	1	LS	1%	$17,700		
		d. Testing and Construction Surveying	1	LS	3%	$53,100		
		Subtotal				$212,400.00		
							$1,982,400	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**							
		a. Engineering Design	1	LS	10%	$198,240		
		b. Construction Administration and Management	1	LS	8%	$158,592		
		c. Legal and Administrative	1	LS	5%	$99,120		
		Subtotal				$455,952		
							$455,952	**Estimated Soft Costs**
Property Acquisition	**4.0**							
		a. Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**							
		a. Total Project Contingency	1	LS	20%	$487,670		
		Subtotal				$487,670		
							$487,670	**Project Contingency**
Inflation	**6.0**							
		a. Inflation	1	LS		$502,279		
		Subtotal				$502,279		
							$502,279	**Inflation**
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2028					
		Number of years of inflation	8					
		Additional cost of inflation	$502,279					
							$3,428,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
May 2020

Project Description: New 1.000,000 gallon elevated storage tank for Malben Low Zone.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-ST-04	Malben Low Zone Elevated Storage	2040	$7,590,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	1.0	Storage Tank						
	a.	Storage Tank						
	1.	1.0 M Elevated Tank	1	LS	$2,950,000.00	$2,950,000		
	2.	Elevated Tank Controls	1	LS	$140,000.00	$140,000		
	3.	Rock Excavation	0	CY	$300.00	$0		
		Subtotal				$3,090,000		
Hard Cost - Markups	2.0							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$185,400		
	b.	Traffic Control	1	LS	2%	$61,800		
	c.	Erosion Control	1	LS	1%	$30,900		
	d.	Testing and Construction Surveying	1	LS	3%	$92,700		
		Subtotal				$370,800.00		
							$3,460,800	Estimated Hard/Construction Costs
Soft Costs	3.0							
	a.	Engineering Design	1	LS	10%	$346,080		
	b.	Construction Administration and Management	1	LS	8%	$276,864		
	c.	Legal and Administrative	1	LS	5%	$173,040		
		Subtotal				$795,984		
							$795,984	Estimated Soft Costs
Property Acquisition	4.0							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	Estimated Property Acquisition Costs
Project Contingency	5.0							
	a.	Total Project Contingency	1	LS	20%	$851,357		
		Subtotal				$851,357		
							$851,357	Project Contingency
Inflation	6.0							
	a.	Inflation	1	LS		$2,482,288		
		Subtotal				$2,482,288		
							$2,482,288	Inflation
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2040					
		Number of years of inflation	20					
		Additional cost of inflation	$2,482,288					
							$7,590,000	Total Probable Project Cost

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
April 2020

Project Description: Install a new pressure reducing valve (PRV) station tied into a new 8" PVC pipe along Grant Street south from University Street to LeGrand Cannon Street.

CIP ID: W-M-01
CIP Name: Grant Street & PRV
Estimated CIP Year: 2030
Estimated CIP Cost: $339,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	1.0		Water Transmission System						
	a.		Water Main						
		1.	8" DR14 C900 PVC Water Main (Urban Transmission)	360	LF	$142.00	$51,120		
		2.	8" Water Main Connection	1	EA	$2,200.00	$2,200		
		3.	4" PRV Station	1	LS	$100,000.00	$100,000		
		4.	1" Residential Service Connection	6	EA	$2,000.00	$12,000		
			Subtotal				$165,320		
Hard Cost - Markups	2.0								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$9,919		
		b.	Traffic Control	1	LS	4%	$6,613		
		c.	Erosion Control	1	LS	1%	$1,653		
		d.	Testing and Construction Surveying	1	LS	3%	$4,960		
			Subtotal				$23,144.80		
								$188,465	Estimated Hard/Construction Costs
Soft Costs	3.0								
		a.	Engineering Design	1	LS	10%	$18,846		
		b.	Construction Administration and Management	1	LS	8%	$15,077		
		c.	Legal and Administrative	1	LS	5%	$9,423		
			Subtotal				$43,347		
								$43,347	Estimated Soft Costs
Property Acquisition	4.0								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	Estimated Property Acquisition Costs
Project Contingency	5.0								
		a.	Total Project Contingency	1	LS	20%	$46,362		
			Subtotal				$46,362		
								$46,362	Project Contingency
Inflation	6.0								
		a.	Inflation	1	LS		$60,919		
			Subtotal				$60,919		
								$60,919	Inflation
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2030					
			Number of years of inflation	10					
			Additional cost of inflation	$60,919					
								$339,000	Total Probable Project Cost

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 30-inch diameter pipe from the Missouri River WTP to the existing 36-inch diameter pipe under the airport runways.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-02	MRWTP Transmission	2023	$2,071,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**	**Water Transmission System**						
	a.	Water Main						
	1.	30" DR18 C900 PVC Water Main (Unpaved Transmission)	4,900	LF	$200.00	$980,000		
	2.	30" Pipe - Direction Drill	100	LF	$1,500.00	$150,000		
	3.	36" Water Main Connection	2	EA	$10,000.00	$20,000		
		Subtotal				$1,150,000		
Hard Cost - Markups	**2.0**							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$69,000		
	b.	Traffic Control	1	LS	5%	$57,500		
	c.	Erosion Control	1	LS	1%	$11,500		
	d.	Testing and Construction Surveying	1	LS	3%	$34,500		
		Subtotal				$172,500.00		
							$1,322,500	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**							
	a.	Engineering Design	1	LS	10%	$132,250		
	b.	Construction Administration and Management	1	LS	8%	$105,800		
	c.	Legal and Administrative	1	LS	5%	$66,125		
		Subtotal				$304,175		
							$304,175	**Estimated Soft Costs**
Property Acquisition	**4.0**							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**							
	a.	Total Project Contingency	1	LS	20%	$325,335		
		Subtotal				$325,335		
							$325,335	**Project Contingency**
Inflation	**6.0**							
	a.	Inflation	1	LS		$119,479		
		Subtotal				$119,479		
							$119,479	**Inflation**
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2023					
		Number of years of inflation	3					
		Additional cost of inflation	$119,479					
							$2,071,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 20-inch diameter pipe along Fee Street from Prospect Avenue to East 11th Avenue.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-03	Fee Street	2029	$174,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**	**Water Transmission System**						
	a.	Water Main						
	1.	20" DR18 C900 PVC Water Main (Paved Transmission)	450	LF	$140.00	$63,000		
	2.	12" Water Main Connection	3	EA	$2,450.00	$7,350		
	3.	20" Water Main Connection	2	EA	$3,815.00	$7,630		
	4.	1" Residential Service Connection	2	EA	$2,000.00	$4,000		
		Subtotal	2			$81,980		
Hard Cost - Markups	**2.0**							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$4,919		
	b.	Traffic Control	1	LS	10%	$8,198		
	c.	Erosion Control	1	LS	1%	$820		
	d.	Testing and Construction Surveying	1	LS	3%	$2,459		
		Subtotal				$16,396.00		
							$98,376	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**							
	a.	Engineering Design	1	LS	10%	$9,838		
	b.	Construction Administration and Management	1	LS	8%	$7,870		
	c.	Legal and Administrative	1	LS	5%	$4,919		
		Subtotal				$22,626		
							$22,626	**Estimated Soft Costs**
Property Acquisition	**4.0**							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**							
	a.	Total Project Contingency	1	LS	20%	$24,200		
		Subtotal				$24,200		
							$24,200	**Project Contingency**
Inflation	**6.0**							
	a.	Inflation	1	LS		$28,328		
		Subtotal				$28,328		
							$28,328	**Inflation**
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2029					
		Number of years of inflation	9					
		Additional cost of inflation	$28,328					
							$174,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along Golden Street from North Lamborn Street to North Carson Street and along East 6th Avenue from North Lamborn Street to North Hannaford Street.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-04	Golden Street & E. 6th Avenue	2029	$472,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	1.0		Water Transmission System						
	a.		Water Main						
		1.	8" DR14 C900 PVC Water Main (Urban Transmission)	1,210	LF	$142.00	$171,820		
		2.	8" Water Main Connection	4	EA	$2,200.00	$8,800		
		3.	1" Residential Service Connection	26	EA	$2,000.00	$52,000		
			Subtotal				$232,620		
Hard Cost - Markups	2.0								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$13,957		
		b.	Traffic Control	1	LS	5%	$11,631		
		c.	Erosion Control	1	LS	1%	$2,326		
		d.	Testing and Construction Surveying	1	LS	3%	$6,979		
			Subtotal				$34,893.00		
								$267,513	Estimated Hard/Construction Costs
Soft Costs	3.0								
		a.	Engineering Design	1	LS	10%	$26,751		
		b.	Construction Administration and Management	1	LS	8%	$21,401		
		c.	Legal and Administrative	1	LS	5%	$13,376		
			Subtotal				$61,528		
								$61,528	Estimated Soft Costs
Property Acquisition	4.0								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	Estimated Property Acquisition Costs
Project Contingency	5.0								
		a.	Total Project Contingency	1	LS	20%	$65,808		
			Subtotal				$65,808		
								$65,808	Project Contingency
Inflation	6.0								
		a.	Inflation	1	LS		$77,032		
			Subtotal				$77,032		
								$77,032	Inflation
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2029					
			Number of years of inflation	9					
			Additional cost of inflation	$77,032					
								$472,000	Total Probable Project Cost

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along North Davis Street from East 14th Avenue to East 15th Avenue.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-05	North Davis	2025	$201,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	1.0		**Water Transmission System**						
	a.		Water Main						
		1.	8" DR14 C900 PVC Water Main (Urban Transmission)	500	LF	$142.00	$71,000		
		2.	8" Water Main Connection	2	EA	$2,200.00	$4,400		
		3.	1" Residential Service Connection	16	EA	$2,000.00	$32,000		
			Subtotal				$107,400		
Hard Cost - Markups	2.0								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$6,444		
		b.	Traffic Control	1	LS	5%	$5,370		
		c.	Erosion Control	1	LS	1%	$1,074		
		d.	Testing and Construction Surveying	1	LS	3%	$3,222		
			Subtotal				$16,110.00		
								$123,510	**Estimated Hard/Construction Costs**
Soft Costs	3.0								
		a.	Engineering Design	1	LS	10%	$12,351		
		b.	Construction Administration and Management	1	LS	8%	$9,881		
		c.	Legal and Administrative	1	LS	5%	$6,176		
			Subtotal				$28,407		
								$28,407	**Estimated Soft Costs**
Property Acquisition	4.0								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	**Estimated Property Acquisition Costs**
Project Contingency	5.0								
		a.	Total Project Contingency	1	LS	20%	$30,383		
			Subtotal				$30,383		
								$30,383	**Project Contingency**
Inflation	6.0								
		a.	Inflation	1	LS		$18,974		
			Subtotal				$18,974		
								$18,974	**Inflation**
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2025					
			Number of years of inflation	5					
			Additional cost of inflation	$18,974					
								$201,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along Livingston Avenue from North Montana Avenue to Townsend Avenue and North Davis Street from North Dakota Street to Idaho Avenue.

CIP ID: W-M-06
CIP Name: Livingston Avenue & N. Davis St.
Estimated CIP Year: 2025
Estimated CIP Cost: $490,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**	**Water Transmission System**						
	a.	Water Main						
	1.	8" DR14 C900 PVC Water Main (Urban Transmission)	1,350	LF	$142.00	$191,700		
	2.	8" Water Main Connection	4	EA	$2,200.00	$8,800		
	3.	1" Residential Service Connection	25	EA	$2,000.00	$50,000		
		Subtotal				$250,500		
Hard Cost - Markups	**2.0**							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$15,030		
	b.	Traffic Control	1	LS	10%	$25,050		
	c.	Erosion Control	1	LS	1%	$2,505		
	d.	Testing and Construction Surveying	1	LS	3%	$7,515		
		Subtotal				$50,100.00		
							$300,600	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**							
	a.	Engineering Design	1	LS	10%	$30,060		
	b.	Construction Administration and Management	1	LS	8%	$24,048		
	c.	Legal and Administrative	1	LS	5%	$15,030		
		Subtotal				$69,138		
							$69,138	**Estimated Soft Costs**
Property Acquisition	**4.0**							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**							
	a.	Total Project Contingency	1	LS	20%	$73,948		
		Subtotal				$73,948		
							$73,948	**Project Contingency**
Inflation	**6.0**							
	a.	Inflation	1	LS		$46,179		
		Subtotal				$46,179		
							$46,179	**Inflation**
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2025					
		Number of years of inflation	5					
		Additional cost of inflation	$46,179					
							$490,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along Breckenridge Street from North Raleigh Street to North Montana Avenue.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-07	Breckenridge Street	2024	$724,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	1.0	Water Transmission System						
	a.	Water Main						
	1.	8" DR14 C900 PVC Water Main (Urban Transmission)	1,900	LF	$142.00	$269,800		
	2.	8" Water Main Connection	2	EA	$2,200.00	$4,400		
	3.	1" Residential Service Connection	60	EA	$2,000.00	$120,000		
		Subtotal				$394,200		
Hard Cost - Markups	2.0							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$23,652		
	b.	Traffic Control	1	LS	5%	$19,710		
	c.	Erosion Control	1	LS	1%	$3,942		
	d.	Testing and Construction Surveying	1	LS	3%	$11,826		
		Subtotal				$59,130.00		
							$453,330	Estimated Hard/Construction Costs
Soft Costs	3.0							
	a.	Engineering Design	1	LS	10%	$45,333		
	b.	Construction Administration and Management	1	LS	8%	$36,266		
	c.	Legal and Administrative	1	LS	5%	$22,667		
		Subtotal				$104,266		
							$104,266	Estimated Soft Costs
Property Acquisition	4.0							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	Estimated Property Acquisition Costs
Project Contingency	5.0							
	a.	Total Project Contingency	1	LS	20%	$111,519		
		Subtotal				$111,519		
							$111,519	Project Contingency
Inflation	6.0							
	a.	Inflation	1	LS		$55,157		
		Subtotal				$55,157		
							$55,157	Inflation
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2024					
		Number of years of inflation	4					
		Additional cost of inflation	$55,157					
							$724,000	Total Probable Project Cost

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along 8th Avenue from Idaho Avenue to N. Hoback Street and a new 12-inch diameter pipe along 9th Avenue from N. Hoback Street to Beattie Street.

CIP ID: W-M-08
CIP Name: 8th Avenue & 9th Avenue
Estimated CIP Year: 2029
Estimated CIP Cost: $743,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**		**Water Transmission System**						
		a.	Water Main						
		1.	8" DR14 C900 PVC Water Main (Urban Transmission)	500	LF	$142.00	$71,000		
		2	12" DR14 C900 PVC Water Main (Urban Transmission)	1,000	LF	$177.00	$177,000		
		3	8" Water Main Connection	6	EA	$2,200.00	$13,200		
		4	12" Water Main Connection	2	EA	$2,450.00	$4,900		
		5	1" Residential Service Connection	50	EA	$2,000.00	$100,000		
			Subtotal				$366,100		
Hard Cost - Markups	**2.0**								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$21,966		
		b.	Traffic Control	1	LS	5%	$18,305		
		c.	Erosion Control	1	LS	1%	$3,661		
		d.	Testing and Construction Surveying	1	LS	3%	$10,983		
			Subtotal				$54,915.00		
								$421,015	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**								
		a.	Engineering Design	1	LS	10%	$42,102		
		b.	Construction Administration and Management	1	LS	8%	$33,681		
		c.	Legal and Administrative	1	LS	5%	$21,051		
			Subtotal				$96,833		
								$96,833	**Estimated Soft Costs**
Property Acquisition	**4.0**								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**								
		a.	Total Project Contingency	1	LS	20%	$103,570		
			Subtotal				$103,570		
								$103,570	**Project Contingency**
Inflation	**6.0**								
		a.	Inflation	1	LS		$121,234		
			Subtotal				$121,234		
								$121,234	**Inflation**
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2029					
			Number of years of inflation	9					
			Additional cost of inflation	$121,234					
								$743,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 6-inch diameter pipe along 11th Avenue from N. Hoback Street to Raleigh Street and a new 6-inch diameter pipe along 10th Avenue from N. Hoback Street to North Dakota Street.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-09	11th Avenue & 10th Avenue	2028	$717,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**	**Water Transmission System**						
	a.	Water Main						
	1.	8" DR14 C900 PVC Water Main (Urban Transmission)	1,350	LF	$142.00	$191,700		
	2.	8" DR14 C900 PVC Water Main (Unpaved Transmission)	300	LF	$72.00	$21,600		
	3.	8" Water Main Connection	10	EA	$2,200.00	$22,000		
	4.	1" Residential Service Connection	55	EA	$2,000.00	$110,000		
		Subtotal				$345,300		
Hard Cost - Markups	**2.0**							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$20,718		
	b.	Traffic Control	1	LS	10%	$34,530		
	c.	Erosion Control	1	LS	1%	$3,453		
	d.	Testing and Construction Surveying	1	LS	3%	$10,359		
		Subtotal				$69,060.00		
							$414,360	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**							
	a.	Engineering Design	1	LS	10%	$41,436		
	b.	Construction Administration and Management	1	LS	8%	$33,149		
	c.	Legal and Administrative	1	LS	5%	$20,718		
		Subtotal				$95,303		
							$95,303	**Estimated Soft Costs**
Property Acquisition	**4.0**							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**							
	a.	Total Project Contingency	1	LS	20%	$101,933		
		Subtotal				$101,933		
							$101,933	**Project Contingency**
Inflation	**6.0**							
	a.	Inflation	1	LS		$104,986		
		Subtotal				$104,986		
							$104,986	**Inflation**
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2028					
		Number of years of inflation	8					
		Additional cost of inflation	$104,986					
							$717,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along Butte Avenue from N. Hoback Street to North Montana Avenue.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-10	Butte Avenue	2024	$538,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	1.0	Water Transmission System						
	a.	Water Main						
	1.	8" DR14 C900 PVC Water Main (Urban Transmission)	1,350	LF	$142.00	$191,700		
	2.	8" Water Main Connection	6	EA	$2,200.00	$13,200		
	3.	1" Residential Service Connection	44	EA	$2,000.00	$88,000		
		Subtotal				$292,900		
Hard Cost - Markups	2.0							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$17,574		
	b.	Traffic Control	1	LS	5%	$14,645		
	c.	Erosion Control	1	LS	1%	$2,929		
	d.	Testing and Construction Surveying	1	LS	3%	$8,787		
		Subtotal				$43,935.00		
							$336,835	Estimated Hard/Construction Costs
Soft Costs	3.0							
	a.	Engineering Design	1	LS	10%	$33,684		
	b.	Construction Administration and Management	1	LS	8%	$26,947		
	c.	Legal and Administrative	1	LS	5%	$16,842		
		Subtotal				$77,472		
							$77,472	Estimated Soft Costs
Property Acquisition	4.0							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	Estimated Property Acquisition Costs
Project Contingency	5.0							
	a.	Total Project Contingency	1	LS	20%	$82,861		
		Subtotal				$82,861		
							$82,861	Project Contingency
Inflation	6.0							
	a.	Inflation	1	LS		$40,983		
		Subtotal				$40,983		
							$40,983	Inflation
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2024					
		Number of years of inflation	4					
		Additional cost of inflation	$40,983					
							$538,000	Total Probable Project Cost

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along Boulder Avenue from North Hannaford Street to North Oakes Street.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-11	Boulder Avenue	2027	$267,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**	**Water Transmission System**						
	a.	Water Main						
	1.	8" DR14 C900 PVC Water Main (Paved Transmission)	900	LF	$87.00	$78,300		
	2.	8" Water Main Connection	2	EA	$2,200.00	$4,400		
	3.	1" Residential Service Connection	27	EA	$2,000.00	$54,000		
		Subtotal				$136,700		
Hard Cost - Markups	**2.0**							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$8,202		
	b.	Traffic Control	1	LS	5%	$6,835		
	c.	Erosion Control	1	LS	1%	$1,367		
	d.	Testing and Construction Surveying	1	LS	3%	$4,101		
		Subtotal				$20,505.00		
							$157,205	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**							
	a.	Engineering Design	1	LS	10%	$15,721		
	b.	Construction Administration and Management	1	LS	8%	$12,576		
	c.	Legal and Administrative	1	LS	5%	$7,860		
		Subtotal				$36,157		
							$36,157	**Estimated Soft Costs**
Property Acquisition	**4.0**							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**							
	a.	Total Project Contingency	1	LS	20%	$38,672		
		Subtotal				$38,672		
							$38,672	**Project Contingency**
Inflation	**6.0**							
	a.	Inflation	1	LS		$34,500		
		Subtotal				$34,500		
							$34,500	**Inflation**
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2027					
		Number of years of inflation	7					
		Additional cost of inflation	$34,500					
							$267,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along North Sanders Street from East Lyndale Avenue to Lewis Street.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-12	N. Sanders Street	2025	$76,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**		**Water Transmission System**						
	a.		Water Main						
		1.	8" DR14 C900 PVC Water Main (Urban Transmission)	200	LF	$142.00	$28,400		
		2.	8" Water Main Connection	2	EA	$2,200.00	$4,400		
		3.	1" Residential Service Connection	4	EA	$2,000.00	$8,000		
			Subtotal				$40,800		
Hard Cost - Markups	**2.0**								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$2,448		
		b.	Traffic Control	1	LS	5%	$2,040		
		c.	Erosion Control	1	LS	1%	$408		
		d.	Testing and Construction Surveying	1	LS	3%	$1,224		
			Subtotal				$6,120.00		
								$46,920	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**								
		a.	Engineering Design	1	LS	10%	$4,692		
		b.	Construction Administration and Management	1	LS	8%	$3,754		
		c.	Legal and Administrative	1	LS	5%	$2,346		
			Subtotal				$10,792		
								$10,792	**Estimated Soft Costs**
Property Acquisition	**4.0**								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**								
		a.	Total Project Contingency	1	LS	20%	$11,542		
			Subtotal				$11,542		
								$11,542	**Project Contingency**
Inflation	**6.0**								
		a.	Inflation	1	LS		$7,208		
			Subtotal				$7,208		
								$7,208	**Inflation**
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2025					
			Number of years of inflation	5					
			Additional cost of inflation	$7,208					
								$76,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe on Logan Street and North Jackson Street from East 14th Street to East 15th Street and on North Warren Street from East 16th Street to East 17th Street.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-13	Logan, N Jackson and N Warren	2021	$367,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	1.0	Water Transmission System						
	a.	Water Main						
	1.	8" DR14 C900 PVC Water Main (Urban Transmission)	1,400	LF	$142.00	$198,800		
	2.	8" Water Main Connection	6	EA	$2,200.00	$13,200		
	3.	1" Residential Service Connection	42	EA	$2,000.00	$84,000		
		Subtotal				$212,000		
Hard Cost - Markups	2.0							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$12,720		
	b.	Traffic Control	1	LS	5%	$10,600		
	c.	Erosion Control	1	LS	1%	$2,120		
	d.	Testing and Construction Surveying	1	LS	3%	$6,360		
		Subtotal				$31,800.00		
							$243,800	Estimated Hard/Construction Costs
Soft Costs	3.0							
	a.	Engineering Design	1	LS	10%	$24,380		
	b.	Construction Administration and Management	1	LS	8%	$19,504		
	c.	Legal and Administrative	1	LS	5%	$12,190		
		Subtotal				$56,074		
							$56,074	Estimated Soft Costs
Property Acquisition	4.0							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	Estimated Property Acquisition Costs
Project Contingency	5.0							
	a.	Total Project Contingency	1	LS	20%	$59,975		
		Subtotal				$59,975		
							$59,975	Project Contingency
Inflation	6.0							
	a.	Inflation	1	LS		$7,197		
		Subtotal				$7,197		
							$7,197	Inflation
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2021					
		Number of years of inflation	1					
		Additional cost of inflation	$7,197					
							$367,000	Total Probable Project Cost

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along Logan Street from 11th Avenue to the cul-de-sac southwest of 11th Avenue.

CIP ID: W-M-14
CIP Name: Logan Street
Estimated CIP Year: 2025
Estimated CIP Cost: $108,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**		**Water Transmission System**						
		a.	Water Main						
		1.	8" DR14 C900 PVC Water Main (Urban Transmission)	300	LF	$142.00	$42,600		
		2.	8" Water Main Connection	2	EA	$2,200.00	$4,400		
		3.	1" Residential Service Connection	4	EA	$2,000.00	$8,000		
			Subtotal				$55,000		
Hard Cost - Markups	**2.0**								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$3,300		
		b.	Traffic Control	1	LS	10%	$5,500		
		c.	Erosion Control	1	LS	1%	$550		
		d.	Testing and Construction Surveying	1	LS	3%	$1,650		
			Subtotal				$11,000.00		
								$66,000	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**								
		a.	Engineering Design	1	LS	10%	$6,600		
		b.	Construction Administration and Management	1	LS	8%	$5,280		
		c.	Legal and Administrative	1	LS	5%	$3,300		
			Subtotal				$15,180		
								$15,180	**Estimated Soft Costs**
Property Acquisition	**4.0**								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**								
		a.	Total Project Contingency	1	LS	20%	$16,236		
			Subtotal				$16,236		
								$16,236	**Project Contingency**
Inflation	**6.0**								
		a.	Inflation	1	LS		$10,139		
			Subtotal				$10,139		
								$10,139	**Inflation**
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2025					
			Number of years of inflation	5					
			Additional cost of inflation	$10,139					
								$108,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: **Install a new 8-inch diameter pipe along National Avenue from East Lyndale Avenue to Argyle Street.**

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-15	National Avenue	2023	$225,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**		**Water Transmission System**						
		a.	Water Main						
		1.	8" DR14 C900 PVC Water Main (Urban Transmission)	650	LF	$142.00	$92,300		
		2.	8" Water Main Connection	3	EA	$2,200.00	$6,600		
		3.	1" Residential Service Connection	8	EA	$2,000.00	$16,000		
			Subtotal				$114,900		
Hard Cost - Markups	**2.0**								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$6,894		
		b.	Traffic Control	1	LS	15%	$17,235		
		c.	Erosion Control	1	LS	1%	$1,149		
		d.	Testing and Construction Surveying	1	LS	3%	$3,447		
			Subtotal				$28,725.00		
								$143,625	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**								
		a.	Engineering Design	1	LS	10%	$14,363		
		b.	Construction Administration and Management	1	LS	8%	$11,490		
		c.	Legal and Administrative	1	LS	5%	$7,181		
			Subtotal				$33,034		
								$33,034	**Estimated Soft Costs**
Property Acquisition	**4.0**								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**								
		a.	Total Project Contingency	1	LS	20%	$35,332		
			Subtotal				$35,332		
								$35,332	**Project Contingency**
Inflation	**6.0**								
		a.	Inflation	1	LS		$12,976		
			Subtotal				$12,976		
								$12,976	**Inflation**
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2023					
			Number of years of inflation	3					
			Additional cost of inflation	$12,976					
								$225,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along Monroe Avenue between Knight Street and Hauser Boulevard.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-16	Monroe Avenue	2025	$146,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**		**Water Transmission System**						
	a.		Water Main						
		1.	8" DR14 C900 PVC Water Main (Urban Transmission)	350	LF	$142.00	$49,700		
		2.	8" Water Main Connection	2	EA	$2,200.00	$4,400		
		3.	1" Residential Service Connection	12	EA	$2,000.00	$24,000		
			Subtotal				$78,100		
Hard Cost - Markups	**2.0**								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$4,686		
		b.	Traffic Control	1	LS	5%	$3,905		
		c.	Erosion Control	1	LS	1%	$781		
		d.	Testing and Construction Surveying	1	LS	3%	$2,343		
			Subtotal				$11,715.00		
								$89,815	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**								
		a.	Engineering Design	1	LS	10%	$8,982		
		b.	Construction Administration and Management	1	LS	8%	$7,185		
		c.	Legal and Administrative	1	LS	5%	$4,491		
			Subtotal				$20,657		
								$20,657	**Estimated Soft Costs**
Property Acquisition	**4.0**								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**								
		a.	Total Project Contingency	1	LS	20%	$22,094		
			Subtotal				$22,094		
								$22,094	**Project Contingency**
Inflation	**6.0**								
		a.	Inflation	1	LS		$13,798		
			Subtotal				$13,798		
								$13,798	**Inflation**
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2025					
			Number of years of inflation	5					
			Additional cost of inflation	$13,798					
								$146,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: **Install a new 8-inch diameter pipe along Choteau Street from Henderson Street to Glendale Street and from Laurel Street to Linden Street.**

CIP ID: W-M-17
CIP Name: Choteau Street
Estimated CIP Year: 2027
Estimated CIP Cost: $685,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**	**Water Transmission System**						
	a.	Water Main						
	1.	8" DR14 C900 PVC Water Main (Urban Transmission)	1,750	LF	$142.00	$248,500		
	2.	8" Water Main Connection	4	EA	$2,200.00	$8,800		
	3.	1" Residential Service Connection	47	EA	$2,000.00	$94,000		
		Subtotal				$351,300		
Hard Cost - Markups	**2.0**							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$21,078		
	b.	Traffic Control	1	LS	5%	$17,565		
	c.	Erosion Control	1	LS	1%	$3,513		
	d.	Testing and Construction Surveying	1	LS	3%	$10,539		
		Subtotal				$52,695.00		
							$403,995	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**							
	a.	Engineering Design	1	LS	10%	$40,400		
	b.	Construction Administration and Management	1	LS	8%	$32,320		
	c.	Legal and Administrative	1	LS	5%	$20,200		
		Subtotal				$92,919		
							$92,919	**Estimated Soft Costs**
Property Acquisition	**4.0**							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**							
	a.	Total Project Contingency	1	LS	20%	$99,383		
		Subtotal				$99,383		
							$99,383	**Project Contingency**
Inflation	**6.0**							
	a.	Inflation	1	LS		$88,661		
		Subtotal				$88,661		
							$88,661	**Inflation**
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2027					
		Number of years of inflation	7					
		Additional cost of inflation	$88,661					
							$685,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along Grant Street between Leslie Avenue and Peosta Avenue.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-18	Grant Street	2025	$214,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**	**Water Transmission System**						
	a.	Water Main						
	1.	8" DR14 C900 PVC Water Main (Urban Transmission)	600	LF	$142.00	$85,200		
	2.	8" Water Main Connection	6	EA	$2,200.00	$13,200		
	3.	1" Residential Service Connection	8	EA	$2,000.00	$16,000		
		Subtotal				$114,400		
Hard Cost - Markups	**2.0**							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$6,864		
	b.	Traffic Control	1	LS	5%	$5,720		
	c.	Erosion Control	1	LS	1%	$1,144		
	d.	Testing and Construction Surveying	1	LS	3%	$3,432		
		Subtotal				$17,160.00		
							$131,560	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**							
	a.	Engineering Design	1	LS	10%	$13,156		
	b.	Construction Administration and Management	1	LS	8%	$10,525		
	c.	Legal and Administrative	1	LS	5%	$6,578		
		Subtotal				$30,259		
							$30,259	**Estimated Soft Costs**
Property Acquisition	**4.0**							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**							
	a.	Total Project Contingency	1	LS	20%	$32,364		
		Subtotal				$32,364		
							$32,364	**Project Contingency**
Inflation	**6.0**							
	a.	Inflation	1	LS		$20,211		
		Subtotal				$20,211		
							$20,211	**Inflation**
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2025					
		Number of years of inflation	5					
		Additional cost of inflation	$20,211					
							$214,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
April 2020

Project Description: Install a new 8-inch diameter pipe along Hollins Avenue from North Benton Avenue to Garfield Street and between Cleveland Street and Allison Street, a new 8-inch diameter pipe along Peosta Avenue from North Benton Avenue to Garfield Street and a new 8-inch diameter pipe along Waukesha Avenue from Allison Street to Henderson Street.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-19	Hollins Ave., Peosta Ave., & Waukesha Ave.	2027	$1,237,000

COST COMPONENT	ITEM #	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**	**Water Transmission System**						
	a.	Water Main						
	1.	8" DR14 C900 PVC Water Main (Urban Transmission)	3,100	LF	$142.00	$440,200		
	2.	8" Water Main Connection	10	EA	$2,200.00	$22,000		
	3.	1" Residential Service Connection	86	EA	$2,000.00	$172,000		
		Subtotal				$634,200		
Hard Cost - Markups	**2.0**							
	a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$38,052		
	b.	Traffic Control	1	LS	5%	$31,710		
	c.	Erosion Control	1	LS	1%	$6,342		
	d.	Testing and Construction Surveying	1	LS	3%	$19,026		
		Subtotal				$95,130.00		
							$729,330	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**							
	a.	Engineering Design	1	LS	10%	$72,933		
	b.	Construction Administration and Management	1	LS	8%	$58,346		
	c.	Legal and Administrative	1	LS	5%	$36,467		
		Subtotal				$167,746		
							$167,746	**Estimated Soft Costs**
Property Acquisition	**4.0**							
	a.	Right-of-way	0	LF	$19.00	$0		
		Subtotal				$0		
							$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**							
	a.	Total Project Contingency	1	LS	20%	$179,415		
		Subtotal				$179,415		
							$179,415	**Project Contingency**
Inflation	**6.0**							
	a.	Inflation	1	LS		$160,059		
		Subtotal				$160,059		
							$160,059	**Inflation**
		Average annual inflation rate	2%					
		Year of original CIP cost estimate	2020					
		Year of anticipated construction	2027					
		Number of years of inflation	7					
		Additional cost of inflation	$160,059					
							$1,237,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along Cedar Street from Villard Avenue to Gold Avenue.

CIP ID:	CIP Name:	Estimated CIP Year:	Estimated CIP Cost:
W-M-20	Cedar Street	2025	$186,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**		**Water Transmission System**						
		a.	Water Main						
		1.	8" DR14 C900 PVC Water Main (Urban Transmission)	500	LF	$142.00	$71,000		
		2.	8" Water Main Connection	2	EA	$2,200.00	$4,400		
		3.	1" Residential Service Connection	12	EA	$2,000.00	$24,000		
			Subtotal				$99,400		
Hard Cost - Markups	**2.0**								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$5,964		
		b.	Traffic Control	1	LS	5%	$4,970		
		c.	Erosion Control	1	LS	1%	$994		
		d.	Testing and Construction Surveying	1	LS	3%	$2,982		
			Subtotal				$14,910.00		
								$114,310	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**								
		a.	Engineering Design	1	LS	10%	$11,431		
		b.	Construction Administration and Management	1	LS	8%	$9,145		
		c.	Legal and Administrative	1	LS	5%	$5,716		
			Subtotal				$26,291		
								$26,291	**Estimated Soft Costs**
Property Acquisition	**4.0**								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**								
		a.	Total Project Contingency	1	LS	20%	$28,120		
			Subtotal				$28,120		
								$28,120	**Project Contingency**
Inflation	**6.0**								
		a.	Inflation	1	LS		$17,561		
			Subtotal				$17,561		
								$17,561	**Inflation**
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2025					
			Number of years of inflation	5					
			Additional cost of inflation	$17,561					
								$186,000	**Total Probable Project Cost**

Helena Water Facility Plan Update
OPINION OF TOTAL PROBABLE PROJECT COST
June 2020

Project Description: Install a new 8-inch diameter pipe along Rodney Street from Breckenridge Street to 5th Avenue.

CIP ID: W-M-21
CIP Name: Rodney Street
Estimated CIP Year: 2025
Estimated CIP Cost: $94,000

COST COMPONENT	ITEM #		ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST	COMPONENT SUBTOTAL	
Hard Cost	**1.0**		**Water Transmission System**						
		a.	Water Main						
		1.	8" DR14 C900 PVC Water Main (Urban Transmission)	250	LF	$142.00	$35,500		
		2.	8" Water Main Connection	2	EA	$2,200.00	$4,400		
		3.	1" Residential Service Connection	4	EA	$2,000.00	$8,000		
			Subtotal				$47,900		
Hard Cost - Markups	**2.0**								
		a.	Mobilization/Demobilization/Insurance/Permits/Bonds	1	LS	6%	$2,874		
		b.	Traffic Control	1	LS	10%	$4,790		
		c.	Erosion Control	1	LS	1%	$479		
		d.	Testing and Construction Surveying	1	LS	3%	$1,437		
			Subtotal				$9,580.00		
								$57,480	**Estimated Hard/Construction Costs**
Soft Costs	**3.0**								
		a.	Engineering Design	1	LS	10%	$5,748		
		b.	Construction Administration and Management	1	LS	8%	$4,598		
		c.	Legal and Administrative	1	LS	5%	$2,874		
			Subtotal				$13,220		
								$13,220	**Estimated Soft Costs**
Property Acquisition	**4.0**								
		a.	Right-of-way	0	LF	$19.00	$0		
			Subtotal				$0		
								$0	**Estimated Property Acquisition Costs**
Project Contingency	**5.0**								
		a.	Total Project Contingency	1	LS	20%	$14,140		
			Subtotal				$14,140		
								$14,140	**Project Contingency**
Inflation	**6.0**								
		a.	Inflation	1	LS		$8,830		
			Subtotal				$8,830		
								$8,830	**Inflation**
			Average annual inflation rate	2%					
			Year of original CIP cost estimate	2020					
			Year of anticipated construction	2025					
			Number of years of inflation	5					
			Additional cost of inflation	$8,830					
								$94,000	**Total Probable Project Cost**