



Comprehensive Water Plan

Joint Water Commission

Serving Crystal, Golden Valley, and New Hope, Minnesota

GOLDV 139168 | June 18, 2018



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June 18, 2018

RE: Joint Water Commission
Comprehensive Water Plan
Serving Crystal, Golden Valley, and New
Hope, Minnesota
SEH No. GOLDV 139168 4.00

Joint Water Commission
7800 Golden Valley Road
Golden Valley, MN 55427

Dear Joint Water Commission:

Enclosed please find the final Comprehensive Water System Plan. This Plan evaluates the adequacy and operation of the existing trunk water supply, storage and distribution system facilities. A primary emphasis of this Plan is to analyze existing facilities, and to anticipate future system needs based on projected redevelopment within the Joint Water Commission communities. As such, this Plan is consistent with each community's 2040 Comprehensive Plan.

Model results are presented in the maps provided in the Appendix of this report.

We are available to discuss the contents of this report in detail with you at your convenience.

Sincerely,

A handwritten signature in black ink that reads "Mark D. Wallis".

Mark Wallis, PE
Project Manager

mh

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Comprehensive Water Plan

Joint Water Commission
Serving Crystal, Golden Valley, and New Hope, Minnesota

SEH No. GOLDV 139168

June 18, 2018

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

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Mark Wallis, PE

Date: June 18, 2018

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Executive Summary

The Joint Water Commission (JWC) directed Short Elliott Hendrickson Inc. (SEH®) to complete an analysis of the water supply, storage and distribution systems for the cities of Crystal, Golden Valley, and New Hope, utilizing a newly constructed water system model. The focus of the report is to analyze existing water utility facilities, and to anticipate future system needs based on projected redevelopment within the JWC member cities. This Water System Comprehensive Plan serves as a guide plan for improvements required to continue to provide reliable water system service to customers.

The JWC water system consists of infrastructure components that perform supply, treatment, storage, and distribution functions. This study evaluates system needs in each category to meet existing and projected water use. The existing facilities include:

1. Five (5) ground storage reservoirs
2. Two (2) water supply pumping stations
3. Three (3) active groundwater wells
4. Three (3) elevated water storage tanks
5. Water system controls
6. A network of transmission and distribution water mains

Water system facilities are designed by industry standard to meet maximum daily demands reliably. Maximum daily water use on the JWC water system has ranged from 8.8 to 18.6 million gallons per day (MGD) since 2005. The amount of water use varies with population and land use patterns, as well as with environmental factors such as precipitation and temperature. Often peak water use is driven by summer irrigation demand.

The JWC communities estimate that the population served by municipal water in 2018 is approximately 64,700 people. Redevelopment is expected to increase the population to approximately 69,800 by 2040. Due to the success of water conservation measures, it is expected that the JWC water system can support this population increase without exceeding historic peak water use levels. This report includes recommendations for infrastructure improvements to reliably serve existing and proposed redevelopment.

Recommended improvements in this report include:

1. Continue Capital Improvement planning for the rehabilitation or replacement of aging JWC PCCP trunk pipes.
2. Continue regular repair and replacement of existing supply, storage, and distribution system facilities.
3. Evaluate the feasibility of installing variable speed drives on the booster station supply pumps, and install flow meters at the booster stations. Continue to monitor water quality from the Minneapolis supply and throughout the distribution system.
4. Install distribution system pipe improvements for potential fire flow improvements and redevelopment needs in conjunction with street reconstruction and redevelopment plans. Utilize the JWC hydraulic water system model to perform final pipe design.
5. Begin planning for the replacement of the existing New Hope water tower.

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Comprehensive Water Plan

Joint Water Commission

Prepared for Village of Golden Valley, Minnesota

1 Introduction

The Village of Golden Valley began purchasing water from Minneapolis in July 1961. The Golden Valley, Crystal, and New Hope Joint Water Commission (JWC) was created in November 1963 by an intergovernmental agreement between the three member cities. The JWC operates and maintains the joint trunk supply, storage, and distribution facilities. Trunk distribution system pipes larger than 12 inches are considered JWC pipes. Pipes 12 inches in diameter and smaller are owned and maintained by the member cities.

The JWC water system consists of five (5) ground storage reservoirs which receive water from Minneapolis, two pumping stations that supply water from the reservoirs to the JWC system, three elevated storage tanks and approximately 14.5 miles of trunk distribution water mains, ranging in size from 16 inches up to 30 inches in diameter. The lateral distribution system water mains owned by each JWC member city consist of an additional 300 miles of piping, ranging from 4 inches to 12 inches. The distribution system is comprised of a single pressure zone with pressure maintained by three elevated storage tanks.

Multiple large and small-scale industrial customers and numerous commercial and residential customers are served by JWC. Each account is metered, and each JWC member community processes its own water bills.

Through proper planning and coordination, the municipal water system facilities are prepared for short-term and long-term community needs. The JWC cities are expecting modest future growth and redevelopment. Proper planning is essential to coordinate water system improvements with proposed street reconstruction efforts and redevelopment planning to meet the short-term and long-term needs of the community.

1.1 Purpose

This report summarizes the results of a comprehensive water system evaluation for the JWC trunk water system, as well as for each of the lateral distribution system piping within the cities of Crystal, Golden Valley, and New Hope. The primary purpose of the study is to evaluate the water needs and system expansion required to serve current customers as well as redevelopment plans. The study also addresses several operational issues experienced by the JWC.

2 Existing Water System Facilities

JWC's municipal water system provides water for domestic and fire protection uses. The water system facilities operated and maintained by JWC include:

- Two (2) water supply pumping stations with five (5) ground storage reservoirs;
- Three (3) active groundwater wells;
- Three (3) elevated water storage tanks;
- Water system controls; and
- Water transmission and distribution system.

The general location and layout of the water system facilities are illustrated on the map in Appendix A. This section presents a summary of the design and operating characteristics of the existing water system components.

2.1 Supply

2.1.1 Minneapolis Supply & Treatment Facilities

Water is currently supplied to the JWC from water purchased from the City of Minneapolis. Since Minneapolis is the supplier of the water, they are charged with delivering water that meets primary drinking water standards. Minneapolis currently owns and operates two water treatment facilities. Nearly all of the water supplied to the JWC water system originates from the Minneapolis Fridley water treatment plant. This facility utilizes lime softening, filtration, fluoridation, chlorination, and, most recently, membrane ultra-filtration.

2.1.2 JWC GSR/Pump Stations

Water from Minneapolis is fed into two (2) ground storage reservoirs (GSRs) owned and maintained by the JWC. The JWC has two separate connections to the Minneapolis system: a 36 inch connection in Crystal (through Robinsdale) and a 48 inch connection in Golden Valley. Water is metered prior to entering the GSRs, where the water is stored prior to being pumped into the JWC system. The GSR tanks are typically filled from Minneapolis between 11:00 pm and 6:00 am. The JWC pump stations then supply water as needed throughout the day.

The total storage capacity of the JWC GSR facilities is 28 million gallons (MG). The JWC pump stations have the capacity to supply water to the JWC system at a rate of 52.9 million gallons per day (MGD) or 36,750 gallons per minute (gpm). The firm capacity is defined as the system capacity minus the capacity of the largest pump. This is the capacity that can be provided consistently, even during maintenance when one well pump might be out of service. The firm capacity with one pump out of service at each booster station is 42.3 MGD (29,400 gpm). Due to operational concerns (pressure surges), the pump stations rarely pump at full capacity.

A summary of the JWC supply facilities is shown in Table 1.

Table 1 – JWC GSR/Booster Station Facilities

| Facility | Concrete Ground Storage | | | Booster Pumps | | | |
|---------------|-------------------------|------|-------------------|--------------------------|-------------------|----------------------|---------------------|
| | Name | Year | Capacity (MG) | Number Pumps, Horsepower | Capacity Per Pump | Total Capacity (gpm) | Firm Capacity (gpm) |
| Crystal | Crystal 1 | 1964 | 4,500,000 | 5 at 300 hp | 4,500 | 22,500 | 18,000 |
| | Crystal 2 | 1964 | 4,500,000 | | | | |
| | Crystal 3 | 1964 | 10,000,000 | | | | |
| | | | 19,000,000 | | | | |
| Golden Valley | Golden Valley 1 | 1962 | 4,500,000 | 5 at 200 hp | 3,900 | 19,500 | 15,600 |
| | Golden Valley 2 | 1965 | 4,500,000 | | | | |
| | | | 9,000,000 | | | | |
| Total | | | 28,000,000 | | | | 33,600 |

2.1.3 Groundwater Resources

The JWC has three (3) municipal groundwater wells that can be utilized in the event of an emergency. The water supply wells vary in depth ranging from 405 to 422 feet, and draw water from deep bedrock sandstone aquifers, namely the Prairie du Chien – Jordan Aquifer (OPCJ). The New Hope Well can pump directly into the distribution system. The Crystal Wells pump directly into the Crystal Reservoir, and must therefore be re-pumped into the distribution system via the Crystal Booster Station. Table 2 summarizes well data for each of the JWC production wells.

Table 2 – Existing JWC Emergency Water Production Wells

| Well Name | Unique Well Number | Depth (ft) | Capacity (gpm) | Capacity (MGD) | Treatment | Aquifer |
|-----------------------|--------------------|------------|----------------|----------------|--------------------|---------|
| New Hope Well | 203542 | 422 | 972 | 1.4 | Chlorine, Fluoride | OPCJ |
| Crystal Well 1 | 806181 | 405 | 1,800 | 2.6 | Chlorine, Fluoride | OPCJ |
| Crystal Well 2 | 806182 | 420 | 1,500 | 2.2 | Chlorine, Fluoride | OPCJ |
| Total Capacity | | | | 6.2 | | |

2.1.4 Emergency Interconnections

The JWC has two (2) separate connection points to Minneapolis and their own emergency back-up wells. There are also two (2) connections to Spring Lake Park: at Douglas Avenue and south of 8905 Wayzata Boulevard.

2.2 Distribution System

The JWC water distribution system provides a means of transporting and distributing water from the supply sources to customers and other points of usage. The distribution system must be capable of supplying adequate quantities of water at reasonable pressures throughout the

service area under a range of operating conditions. Furthermore, the distribution system must be able to provide not only uniform distribution of water during normal and peak demand conditions, but must also be capable of delivering adequate water supplies for fire protection purposes. The current water main size inventory is summarized in Table 3.

Table 3 – Existing Water Distribution System Summary

| Pipe Size | Crystal | | Golden Valley | | New Hope | | Total System | |
|--|----------------|----------------|----------------|----------------|----------------|----------------|---------------|-------------|
| | Length (ft) | Length (Miles) | Length (ft) | Length (Miles) | Length (ft) | Length (Miles) | Total (Miles) | % of Total |
| 6-inch | 318,965 | 60.41 | 395,792 | 74.9 | 235,944 | 44.7 | 180.0 | 66% |
| 8-inch | 113,925 | 21.58 | 175,606 | 33.3 | 111,909 | 21.2 | 76.0 | 24% |
| 10-inch | 51 | 0.01 | 2,755 | 0.5 | | 0.0 | 0.5 | 0% |
| 12-inch | 21,010 | 3.98 | 101,246 | 19.2 | 40,104 | 7.6 | 30.8 | 4% |
| 16-inch | 11,986 | 2.27 | 22,136 | 4.2 | 4,071 | 0.8 | 7.2 | 2% |
| 18-inch | | 0.00 | 10,451 | 2.0 | 4,047 | 0.8 | 2.7 | 0% |
| 24-inch | 8,255 | 1.56 | 13,961 | 2.6 | 4,066 | 0.8 | 5.0 | 2% |
| 30-inch | 10,039 | 1.90 | | 0.0 | | 0.0 | 1.9 | 2% |
| Total | 484,231 | 91.71 | 721,947 | 136.7 | 400,141 | 75.9 | 304.2 | 100% |
| Table Notes: Hydrant leads not included Pipes 16 inches and larger are considered JWC trunk pipes | | | | | | | | |

Source: Water Model

The JWC water system is comprised of about 304 miles of water main ranging in size from 6 inches up to 30 inches in diameter. The existing distribution system is shown in the map in Appendix A at the end of this report

2.3 Storage

The JWC water distribution system is currently served by water supplied from the two booster stations and water fed into the system by gravity from the elevated reservoirs. The City currently has three elevated storage tanks that have a combined storage volume of 3,500,000 gallons (3.5 MG). Water storage facilities are important to water systems, as they help supply water during peak hour demands. During times of peak demand, water is withdrawn from the storage tanks to provide adequate pressures throughout the system and to minimize the pumping capacity required and the size of transmission mains throughout the City. Water stored in elevated tanks also provides system reliability during power outages, fire events, and supply outages.

As discussed above, JWC also has 28 MG of ground level storage available, however this water stored at ground level must be pumped into the system from the booster stations to provide benefit. Due to limitations on the pumping and distribution system components, the ground storage is not factored into the equalization and fire protection water storage calculations.

Table 4 summarizes the water storage facilities within the JWC water system.

Table 4 – Existing Water Storage Facilities

| Facility Name | Year Constructed | Total Volume (gallon) | Overflow Elev. | Style |
|---------------|------------------|-----------------------|----------------|----------|
| Golden Valley | 1962 | 1,500,000 | 1069 | Elevated |
| New Hope | 1959 | 500,000 | 1069 | Elevated |
| Medicine Lake | 1968 | 1,500,000 | 1069 | Elevated |
| Total | | 3,500,000 | | |

3 Population and Community Growth

In order to understand the requirements of the future water system, anticipated water use characteristics must be determined. This involves first understanding how water is currently used and then developing an estimate of how water might be used in the future. This section summarizes the primary assumptions regarding future growth of the City’s water service area. The present and future needs and characteristics of the identified service area will have a direct impact on the need for expansion or reconfiguration of water system facilities. Therefore, the conclusions discussed in this section were used as a primary basis for projecting future water needs, evaluating the adequacy of existing water system facilities, and identifying needs for future water system improvements.

3.1 Population and Relationship to 2040 Comprehensive Plan

In many cases, there is a close relationship between a community's population and total water consumption. As such, future water sales can be expected to reflect future changes in service area population. Similarly, commercial and industrial water consumption will tend to vary proportionately with the growth of the community. However, proportionally increased water use and population growth can vary greatly depending on the specific characteristics of a community.

For the purposes of this study, each JWC City provided population projections and a 2040 Land Use Map consistent with their 2040 Comprehensive Plan. These maps were combined in GIS to prepare a JWC Composite Land Use Map (Appendix A). The projected population served by municipal water for each City and the JWC as a whole is summarized in Table 5.

Table 5 – Projected Population Served Data

| Year | Projected Population Crystal | Projected Population Golden Valley | Projected Population New Hope | Projected Total Population |
|------|------------------------------|------------------------------------|-------------------------------|----------------------------|
| 2018 | 22,640 | 21,070 | 21,063 | 64,773 |
| 2019 | 22,676 | 21,169 | 21,133 | 64,978 |
| 2020 | 22,700 | 21,300 | 21,100 | 65,100 |
| 2021 | 22,748 | 21,368 | 21,273 | 65,388 |
| 2022 | 22,784 | 21,467 | 21,343 | 65,594 |
| 2023 | 22,820 | 21,566 | 21,413 | 65,799 |
| 2024 | 22,856 | 21,666 | 21,483 | 66,004 |
| 2025 | 22,892 | 21,765 | 21,553 | 66,209 |
| 2030 | 23,200 | 22,000 | 22,000 | 67,200 |
| 2040 | 23,800 | 22,900 | 23,100 | 69,800 |

4 Water Requirements

Projections of customer demands serve as the basis for capital improvements planning. Several standard methods were used in this study to project water supply and storage needs based on estimates of population and community land use growth. This section summarizes the methodology used and the results of these projections.

4.1 Variations in Customer's Demand & Pumpage

Water demands are variable and change throughout the day, month, and year. Typically, two water demand days are used for water system planning – average day and maximum day.

- **Average Day (AD) Demand** is defined as the total volume of water pumped throughout the year divided by the number of days in the year. It is typically recommended that a water system's available water storage be equal to or exceed the average daily demand.
- **Maximum Day (MD) Demand** is defined as the maximum volume of water pumped during a single day in a given year.

The maximum day demand conditions typically occur during the summer, when outdoor water use is at its highest level of the year. The maximum day pumpage is of particular importance to water system planning, because water supply facilities are sized to meet this demand.

4.2 Water Consumption History

An analysis of past water consumption characteristics is performed by reviewing historical water use data. The data analyzed includes historical pumping records as well as select historical water billing data.

Average Day (AD) water use was analyzed to develop overall water use trends. Maximum Day (MD) water consumption was analyzed for the previous 10 years to develop an understanding of maximum day peaking factors (refer to October 2017 Water Supply Plan contained in Appendix C). Peaking factors are defined as the ratio of the maximum day water use to the average day water use. Projections of future water requirements are based on the results of this analysis coupled with estimates of population and community growth and future land use.

Based on this analysis, the existing MD demand is determined to be 13.2 MGD (million gallons per day), or 203 gpcd (gallons per person per day), based on a served population of 64,773.

4.3 Hourly Demand Fluctuations

Water demands are variable throughout the day and can vary depending on common use among users. Over the course of a given day, water uses often follow a diurnal demand distribution. Table 6 represents a typical daily demand distribution for residential water use. Commercial and industrial uses are usually more constrained and predictable. The residential demand graph depicts low water demand during the late evening and early morning periods. As the morning progresses, there is an increase in demand as indoor water use increases when people are preparing for the day. During the summer this morning demand is also impacted by automatic lawn sprinkler systems that are typically operated in the morning. During late morning to early afternoon there is a slight recovery prior to a second peak use in the early evening after people arrive home from their daily routine.

Most water systems are designed to meet the maximum daily demand rate with supply facilities such as wells, treatment processes, and pumping facilities. Storage reservoirs are used to supplement the supply of treated water during the peak usage hours within each day. During lower usage periods, the system is able to produce water in excess of the demand. This excess is used to fill the storage reservoirs. When the demand rate exceeds the production rate, the stored water in the reservoirs is used to make up for the deficit.

Table 6 – Typical Diurnal Demand Curve

| Time | Demand Multiplier | Time | Demand Multiplier |
|----------|-------------------|----------|-------------------|
| 12:00 AM | 45% | 12:00 PM | 110% |
| 1:00 AM | 40% | 1:00 PM | 103% |
| 2:00 AM | 45% | 2:00 PM | 103% |
| 3:00 AM | 50% | 3:00 PM | 105% |
| 4:00 AM | 70% | 4:00 PM | 110% |
| 5:00 AM | 115% | 5:00 PM | 120% |
| 6:00 AM | 155% | 6:00 PM | 118% |
| 7:00 AM | 165% | 7:00 PM | 110% |
| 8:00 AM | 160% | 8:00 PM | 100% |
| 9:00 AM | 145% | 9:00 PM | 90% |
| 10:00 AM | 130% | 10:00 PM | 75% |
| 11:00 AM | 115% | 11:00 PM | 63% |

Source: AWWA M32, Computer Modeling of Water Distribution Systems, 2012, American Water Works Association

4.4 Water System Demand Projections

Estimates of future water use are established by assuming future overall per capita water use will be similar to existing trends.

4.4.1 Summary of Projected Water Demands

Table 7 provides a summary of the projected water demand.

Table 7 – Projected Water Demand

| Year | Total JWC Served | Average Day Per Capita Water Pumped (gal) | Average Day Water Pumped (MGD) | Maximum Day Water Pumped (MGD) |
|------|------------------|---|--------------------------------|--------------------------------|
| 2018 | 64,773 | 102 | 6.61 | 13.2 |
| 2020 | 65,100 | | 6.64 | 13.3 |
| 2025 | 66,209 | | 6.75 | 13.5 |
| 2030 | 67,200 | | 6.85 | 13.7 |
| 2040 | 69,800 | | 7.12 | 14.2 |

4.5 Water Needs for Fire Protection

In addition to the water supply requirements for domestic, commercial, and industrial consumption, water system planning for fire protection requirements is an important consideration. In most instances, water main sizes are designed specifically to supply adequate fire flow.

Guidelines for determining fire flow requirements are developed based on recommendations offered by the Insurance Services Office (ISO), which is responsible for evaluating and classifying municipalities for fire insurance rating purposes. When a community evaluation is conducted by ISO, the water system is evaluated for its capacity to provide needed fire flow at a specific location and will depend on land use characteristics and the types of properties to be protected. However, in high value districts, fire flow requirements of up to 3,500 gpm can be expected. Table 8 provides the ISO Typical Fire Flow Requirements. Due to the difficulty of estimating future building construction materials and potential fire sprinklers systems, for the purposes of this study, the JWC TAC and each city's Fire Official provided desired target fire flows based on the 2040 Land Use Map. The resulting target fire flows are shown in Table 9.

Table 8 – Typical ISO Fire Flow Requirements

| Land Use | Building Separation (feet) | Available fire flow @ 20 psi (gpm) |
|---------------------------------------|----------------------------|------------------------------------|
| Single & Two Family Residential | >100 | 500 |
| Single & Two Family Residential | 30-100 | 750 |
| Single & Two Family Residential | 11-30 | 1000 |
| Single & Two Family Residential | <10 | 1500 |
| Multiple Family Residential Complexes | - | 2,000 to 3,000+ |
| Average Density Commercial | - | 1,500 to 2,500+ |
| High Value Commercial | - | 2,500 to 3,500+ |
| Light Industrial | - | 2,000 to 3,500 |
| Heavy Industrial | - | 2,500 to 3,500+ |

Source: Insurance Services Office

Table 9 – Target Fire Flows – By Land Use Type

| Land Use (General) | Target Fire Flow @ 20 psi (gpm) | Duration (Hours) | Crystal | Golden Valley | New Hope |
|---------------------------------------|---------------------------------|------------------|---------------------------------------|--|-------------------|
| Open Space – Transportation | | - | Airport (LDR), Rail, ROW | RR, ROW | RR |
| Open Space | 500 | 1 | Other Undevel (L, Park, PI-PARK) | Active | P/R, P/Semi P |
| Single & Two Family Residential | 1000 | 2 | LDR, NC | Low | LDR |
| Multiple Family Residential Complexes | 3500 | 3 | MDR, HDR, Public-Inst (HDR) | Med, High, MOD | LDR/MDR, MDR, HDR |
| Commercial | 3500 | 3 | GC, Public-Inst (GC), Public-Inst (L) | Civic, Flex, Mixed Use, Office, Passive, Retail/Service, Assembly, Medical | C, CMU, Civic |
| Industrial | 3500 | 3 | I, Other/ Undevel (I) | Light Industrial, Industrial | C, CMU, Civic |

Source: JWC TAC

5 Water System Analysis

Water systems are analyzed, planned, and designed primarily through the application of basic hydraulic principles. Some important factors that must be considered when performing this analysis include:

- Location and capacity of supply facilities;
- Location, sizing, and design of storage facilities;
- Location, magnitude, and variability of customer demands;
- Water system geometry and geographic topography;
- Minimum and maximum pressure requirements; and,
- Land use characteristics and population projections with respect to fire protection and future water demand requirements (Chapter 3 and 4).

For this study, an evaluation of the JWC and member city's water systems were performed to determine the adequacy of the system to supply existing and future water needs and to supply water for fire protection purposes.

The system was evaluated based on the following standard water industry criteria:

- Pressure;
- Flow Capacity;
- Reliability;

- Supply; and,
- Storage.

In general, the existing water system operates well. The JWC has adequate treated water supply capacity, and the existing piping network and storage facilities generally provide adequate flows and pressures.

5.1 Water System Computer Model Construction

The existing JWC water supply, storage, and distribution system was input into a computerized model for hydraulic analysis. Existing pipe lengths, routing, and diameters were input into the model directly from each City's GIS system. Existing water demand was input into the model based on each City's billing and pumping records.

The model was calibrated to field hydrant flow tests conducted in October 2016. Model scenarios were established to mimic the actual field conditions (supply pumping rates, water tower levels, and hydrant flow and pressure readings). The model results compared favorably to the actual field results, indicating that the model is calibrated to an acceptable level for comprehensive water system planning purposes. Refer to Appendix B for details of the calibration and model development.

Precise duplication of the field test results at all locations during the calibration process is not realistic due to the many factors that influence the field test results. The goal of model calibration is to minimize the error between the field test data and the model simulations and create a "best fit" at all locations; therefore, some error between the field tests and model simulations is expected. However, limits to the amount of allowable error must also be made to ensure the calibrated model is a reasonably accurate representation of the actual water distribution system. The desired accuracy for the JWC computer model is the greater of plus or minus 25 percent or 2 psi of the recorded pressure difference to a maximum of 5 psi, and plus or minus 10 percent of the recorded flow. For adequate model calibration, the desired accuracy must be met at a minimum percentage of the field test locations. The goal of this project is to have a minimum of 80 percent of the field test results within the desired calibration accuracy before the model is considered calibrated. Overall, the model calibration results meet the calibration standards, with 36 out of 40 (90 percent) residual hydrants within the calibration criteria.

5.2 Water System Pressures

Existing static water pressures are shown on the map in Appendix A. Pressure between 50 pounds per square inch (psi) and 80 psi are generally considered desirable. Pressures lower than 40 psi may trigger low pressure complaints, and pressures above 80 psi should be fitted with in-building pressure reducing valves to provide adequate pressure. Pressures are lower at the higher ground elevations in western New Hope and Crystal, north of Medicine Lake Road. Northeastern Crystal and eastern Golden Valley have high pressures due to low ground elevations.

5.3 Treated Water Supply and Storage Relationship

Water demands over the course of a Maximum Day event are met from a combination of water supplied from Minneapolis via the Crystal and Golden Valley Pumping Stations, and water drawn from the water towers. Tower levels are drawn down during the day, when the demand is highest, and are refilled at night, when demands are lowest. Providing peak water demands from elevated

water towers allows for more steady state operation of the pump stations. Typically, providing a treated water supply equal to meet 100% of the Maximum Day Demand provides a cost effective and reliable balance of supply and storage.

5.4 Treated Water Supply

5.4.1 Minneapolis Supply, Crystal and Golden Valley GSR/Pump Stations

Treated water from Minneapolis Water has proven to be a reliable and safe supply source. Minneapolis water is tested regularly by Minneapolis to meet the Primary Drinking Water Standards. Water is metered as it flows into the Crystal and Golden Valley GSRs, and this total flow volume is used by Minneapolis for billing purposes. The Crystal and Golden Valley GSR facilities are regularly inspected and maintained, and are generally in adequate condition. The reservoirs are segmented to allow repair and maintenance on one portion of the tank while keeping the remainder in service. The two GSR facilities provide 28.0 MG of storage, or 4 days of emergency storage (at AD demands) in the event of a temporary complete loss of supply from Minneapolis. JWC should continue to test the water entering the Crystal and Golden Valley GSRs and disinfectant residuals in the distribution system to verify water quality. Up to this point, JWC has not had to add additional disinfectant to maintain a residual throughout the JWC system.

The Crystal and Golden Valley Pumping Stations are theoretically able to provide up to 48 MGD, which is much more than the highest Maximum Day Demand projected (14.2 MGD), and more than the highest MD ever recorded (18.6 MGD). In actual operation, the flow from the Crystal and Golden Valley Pump Stations are limited to lessen the potential for hydraulic transients that could potentially damage the existing piping network or create excessive high pressures in the eastern portion of the system. The Crystal Pump Station rarely operates with more than 2 pumps running (9,000 gpm), and the Golden Valley Pump Station rarely operates with more than 3 pumps running (10,000 gpm). The pump stations are typically operated in a “lead-lag” scenario, rather than starting both pump stations at the same time. The total operational supply capacity from these two stations is therefore 19,000 gpm (27.4 MGD), which is still adequate.

In the event of a complete failure of the Golden Valley supply piping or Pump Station, the Crystal Pump Station provides 13.0 MGD of supply to the JWC, or nearly 100% of the MD demand. Similarly, the Golden Valley Pump Station provides 14.4 MGD of supply (100% of the MD) in the event of a complete failure of the Crystal supply pipe or Pump Station.

JWC should continue with plans to install flow meters and variable speed drives on the pump motors at both the Crystal and Golden Valley Pump Stations. The flow meters will help JWC with operations and water auditing purposes. The variable speed drives will provide better pump control and lessen the hydraulic surges caused by pump starts and stops.

5.4.2 Emergency Backup Groundwater Well Supply

The three (3) JWC ground water wells provide 6.2 MGD of water supply in the event of an emergency, or nearly 100% of the average day demand. The water quality from these emergency wells is not treated to remove iron, manganese and hardness like the Minneapolis supply is. Although the water is safe to drink, some customer complaints for taste and odors, and some operational issues may arise with the mixing of Minneapolis water and well water in the distribution system. To lessen the potential for issues, the New Hope well is pumped directly into

the distribution system adjacent to the New Hope water tower, and the Crystal wells are pumped directly into the Crystal GSR, thus allowing mixing of the well water with the Minneapolis water prior to being distributed.

It should be noted that the water from the Crystal wells must be re-pumped into the distribution system by the Crystal Pump Station. Therefore, at least one pump at the Crystal Pump Station must be in service to allow the well to be pumped to the customers.

For additional redundancy, JWC should continue to evaluate the feasibility of installing a new groundwater well near the Golden Valley GSR/Pump Station facility.

5.5 Treated Water Supply and Storage Relationship

Water demands over the course of a Maximum Day event are met from a combination of water supplied from Minneapolis via the Crystal and Golden Valley Pumping Stations and water drawn from the water towers. Tower levels are drawn down during the day, when the demand is highest, and are refilled at night, when demands are lowest. Providing peak water demands from elevated water towers allows for more steady state operation of the pump stations.

The water system computer model was used to model the performance of the water towers over the course of three consecutive MD events. As can be seen from the graph in the model results Appendix, the existing system is reasonably well balanced – all tanks operate similarly, and all tanks refill completely.

5.6 Storage

The purpose of a water distribution system is to deliver water in adequate quantity and at acceptable pressure from the source of supply to the customers. A water system should be capable of meeting all demands during the period of maximum use without reducing pressure below an acceptable limit. This can be achieved through the combination of supply and storage facilities working together to sustain system demands.

In general, elevated water storage tanks serve water systems in multiple ways. The primary purpose is to provide stored water to supply water to the system in the event of a supply shortage. Supply facilities (such as the JWC wells and pump stations) work to fill the water tower and pump directly to satisfy customer water demands. In the event of a well or supply facility failure due to power outage etc. the storage facility holds water in reserve to feed customers with water despite a loss of power.

Furthermore, system storage is used as a "cushion" to equalize fluctuations in customer demands, establish and maintain water system pressures, provide operational flexibility for water supply facilities, and improve water supply reliability. As customer demands exceed supply capacities during peak hour conditions, these excess demands must be met by depleting available storage. The amount of storage depleted is referred to as equalizing storage for peak hour requirements.

Of equal importance is a water storage tanks ability to support water flows for fire protection. A water storage facility does this in two different functions. First, the storage facility holds water in reserve to supply high levels of flows that exceed the capacity of the water supply pumps. Additionally, the placement of a storage facility within the water system supports nearby pressure and flows increasing the available flows to the nearby distribution system.

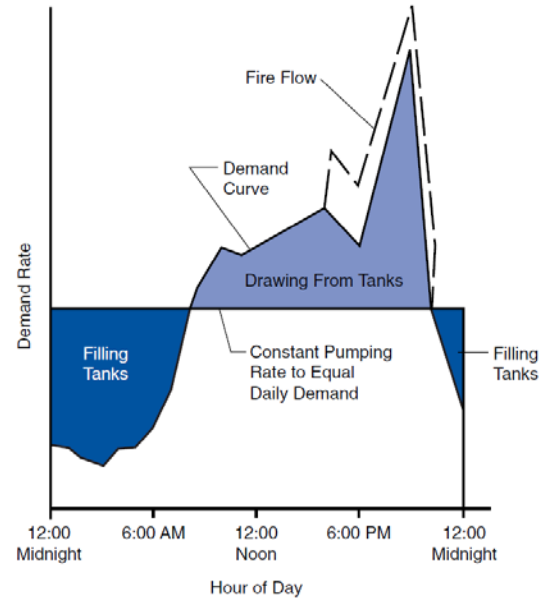
In Summary, the functions of water distribution storage include:

- Equalizing storage (sometimes termed operational storage).
- Fire storage.
- Emergency storage.

Each of these storage components are further defined below:

Equalizing storage

Equalizing storage works to allow the supply & treatment pumping systems to be sized and operate to produce at the rate of average demand over the course of a day. For example, during peak hours of water use, when customers are using large amounts of water, system demand may exceed the production rate of the water supply/treatment. It is during this time when water storage facilities will drain to satisfy the increased system demand. This concept is further illustrated in the figure below.



Fire Storage

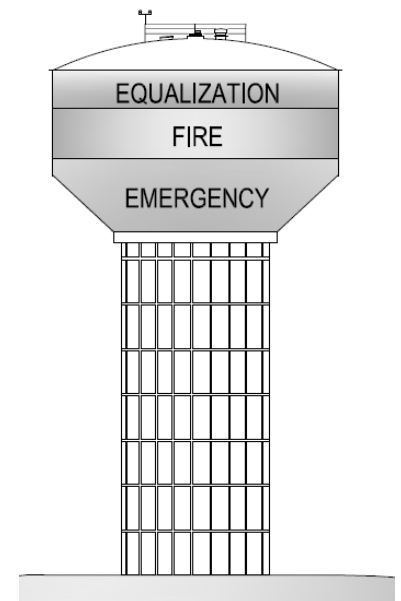
Fire storage includes water held in the tank in the case of an emergency. To assure a reliable supply for fire protection, this reserve storage should not be utilized to meet peak hour requirements and should be available when needed. Guidelines for determining fire flow requirements are developed based on recommendations offered by the Insurance Services Office (ISO), which is responsible for evaluating and classifying municipalities for fire insurance rating purposes. When a community evaluation is conducted by ISO, the water system is evaluated for its capacity to provide needed fire flow at a specific location and will depend on land use characteristics and the types of properties to be protected. Since this plan intends to size water storage for the largest users, high end goal for industrial fire flow is to provide a flow rate of 3,500 gpm for 3 hours. This figure will be used as a basis for estimating the amount of water to be held in the proposed storage tank for fire protection.

Emergency Storage

Emergency storage is required to meet system water demands during an emergency event that limits or disrupts supply. Some examples of emergency events include water main breaks, equipment failure, and power failure or source contamination.

The volume of water storage available to a water system provides for proper system operations. AWWA (American Water Works Association) Manual of Water Supply Practices (M42 Steel Water-Storage Tanks) provides some general guidelines

WATER STORAGE ALLOCATION



in regards to water tank sizing. The selection and sizing of a water-storage tank involves an understanding of numerous factors, including an analysis of water demands, supply rates, and the distribution system. Peak hour and maximum day demand are the primary factors to consider when sizing a water storage tank. Most water supply sources are sized to meet maximum day or peak day demands. Since typical water supply facilities are sized to supply maximum day demands, water storage tanks work to satisfy peak hour demands and maintain pressure in the water system.

In addition to peak demand, fire flow storage is usually the second factor to consider when determining tank capacity. Insurance underwriters have developed recommendations to develop appropriate volume, pressure, and flow duration, which can vary by building and development type. For purposes of this analysis, a fire event duration of 3 hours at 3,500 gpm was considered for sizing of the proposed water storage tank.

The guidance from the AWWA noted above, in addition to industry standards, provides for three potential water tower sizing requirements, commonly used for sizing municipal water storage tanks as defined below and shown in Table 10:

- **Requirement 1:** Average daily consumption should not exceed the available storage (2012 Recommended Standards for Water Works). Based on this calculation, JWC needs an addition 3.6 MG of storage. However, the JWC GSR/Pump Station supply facilities have additional 28.0 MG of storage capacity, with the ability to pump at a rate of 4,100 gpm (6.0 MG) greater than the MD demand.
- **Requirement 2:** Available storage should be large enough to handle the difference between the peak hour and maximum daily consumption for a period of four hours, without depleting one-half the total available storage. As calculated in Table 5-6, JWC has adequate storage to meet this criteria.
- **Requirement 3:** The fire demand should equal the sum of the pumped supply and storage, minus the maximum daily consumption plus fire flow for three hours. The JWC GSR/Pump Stations are able to supply water at this rate, therefore no additional storage is required to meet this criteria.

Table 10 – Complete System Water Storage Requirements

| | Existing System | 2030 Projection | 2040 Projection |
|---|-----------------|-----------------|-----------------|
| Average Day Demand | 6,610,000 | 6,850,000 | 7,120,000 |
| Maximum Day Demand | 13,200,000 | 13,700,000 | 14,200,000 |
| Maximum Day Demand (gpm) | 9,167 | 9,514 | 9,861 |
| Peak Hour Demand (gpm) | 15,583 | 16,174 | 16,764 |
| Existing Storage Volume (gal) | 3,500,000 | 3,500,000 | 3,500,000 |
| Firm Supply Capacity (gpm) | 14,000 | 14,000 | 14,000 |
| Requirement No.1 Storage Volume Recommended (Min. Total Storage) (gal) | 6,610,000 | 6,850,000 | 7,120,000 |
| Requirement No.2 Storage Volume Recommended (Min. Total Storage) (gal) | 3,080,000 | 3,196,667 | 3,313,333 |
| Requirement No.3 Storage Volume Recommended (Min. Elevated Storage) (gal) | (0) | (0) | (0) |

JWC has historically had difficulties balancing the water level in the smaller New Hope tank with the other larger tanks. Based on the computer model results (Appendix C), JWC should consider replacing the New Hope tank with a new 1.5 MG tank rather than continuing to maintain the older 0.5 MG tank.

5.7 Distribution System

5.7.1 JWC Trunk Piping System

The JWC trunk system consists primarily of 14.5 miles of prestressed concrete cylinder pipe (PCCP), ranging in size from 16 inch to 30 inch diameter. The PCCP was constructed between 1955 and 1963, and has suffered two failures. JWC has been repairing/replacing the PCCP as funds are available, and in conjunction with street reconstruction projects. To assist in prioritizing improvements, JWC hired SEH to perform an analysis of the PCCP system (December 20, 2016 Technical Memorandum and Geodatabase). JWC should continue to repair/replace PCCP and update the analysis tool provided in the 2016 report.

The JWC trunk pipe system is adequately sized for providing flows under normal scenarios.

5.7.2 Fire Flow Analysis

Computer modeled fire flows are generally adequate throughout the JWC system. Refer to the existing fire flow map in Appendix A. Modeled fire flows were compared to Land Use based target fire flows from Table 9 in a GIS environment. The Public Works and Fire Officials from each City reviewed the target fire flows on a parcel by parcel basis. The resulting potential fire flow improvement map is shown in Appendix A. Specific recommendations for each member city are provided in the following paragraphs.

Each city should continue to evaluate fire flows with field hydrant flow tests and additional hydraulic modeling performed in conjunction with future street reconstruction and redevelopment plans to determine cost effective pipe replacement strategies.

5.7.3 Crystal Water Distribution System

Much of the Crystal water system operates at a static pressure of over 80 psi. The City should identify these connections in their GIS, and make sure that individual pressure reducing valves are installed in conjunction with redevelopment plans.

The southwest portion of Crystal operates at a static pressure of less than 50 psi. Customers with less than 50 psi. static pressure are likely to complain about low water pressure, especially when water towers levels are lower during peak events. Historically, it has been the practice of some homeowners to install singular water booster pumps to increase water system pressure to individual homes. However it should be noted that 10 State Standards states that "individual booster pumps shall not be allowed for any individual residential service from the public water supply mains" (8.11.2). Therefore alternative water pressure boosting alternatives should be explored if these low pressures are viewed as a problem.

Crystal Public Works and Fire Officials performed a thorough review of the modeled available fire flow map, and determined that modeled fire flows are adequate.

5.7.4 Golden Valley Water Distribution System

Much of the eastern half of Golden Valley operates a static pressure of over 80 psi. The City should identify these connections in their GIS, and make sure that individual pressure reducing valves are installed in conjunction with redevelopment plans.

The northwest portion of Golden Valley operates at a static pressure of less than 50 psi. Customers with less than 50 psi. static pressure are likely to complain about low water pressure, especially when water towers levels are lower during peak events. Historically, it has been the practice of some homeowners to install singular water booster pumps to increase water system pressure to individual homes. However it should be noted that 10 State Standards states that “individual booster pumps shall not be allowed for any individual residential service from the public water supply mains” (8.11.2). Therefore alternative water pressure boosting alternatives should be explored if these low pressures are viewed as a problem.

Golden Valley Public Works and Fire Officials performed a thorough review of the modeled available fire flow map, and determined that all modeled fire flows are generally adequate. Several areas are identified on the potential fire flow improvement map where improvements could be considered in conjunction with future street reconstruction or redevelopment plans. These areas will be modeled in more detail in conjunction with redevelopment plans.

5.7.5 New Hope Water Distribution System

The southwest portion of New Hope operates at a static pressure of less than 50 psi. Some areas have a static pressure of less than 40 psi. Customers with less than 50 psi. static pressure are likely to complain about low water pressure, especially when water towers levels are lower during peak events. Historically, it has been the practice of some homeowners to install singular water booster pumps to increase water system pressure to individual homes. However it should be noted that 10 State Standards states that “individual booster pumps shall not be allowed for any individual residential service from the public water supply mains” (8.11.2). Therefore alternative water pressure boosting alternatives should be explored if these low pressures are viewed as a problem. There are a few homes in New Hope that experience less than 40 psi static pressure. These homes (above elevation 1158) may need to be fitted with in-home booster stations, however their use should be regulated and inspected regularly to be carefully in conformance with the State Plumbing Code.

New Hope Public Works and Fire Officials performed a thorough review of the modeled available fire flow map, and determined that modeled fire flows are adequate. Ensure that a minimum 20 psi residual pressure is maintained in southwestern New Hope during all fire flow events.

5.8 Operational Flexibility

In addition to the normal operational analysis above, JWC TAC desired analysis of several special operational scenarios. The following paragraphs provide model results for these special scenarios. Model output files are presented for each scenario in Appendix C

5.8.1 Existing System Operation

For the purposes of establishing a baseline water system operational understanding, the existing water system configuration was set up in the model utilizing average summer demands. A 72-hour extended period simulation (EPS) was developed with system controls turning water

supply pumps on and off at the Golden Valley and Crystal pump stations station to maintain water tower levels. Additionally, specific locations throughout the water system were selected. Results from this system model operation are presented in Appendix C. (Figures A1.1 and A1.2). The Results show both pump stations turning on and off with tank levels, and in some instances, two pumps turning on during periods of peak demands. Through this operation, water tank levels are sustained. However, as observed in the field, the New Hope water tower tends to fill more quickly than the other tanks when the pumps are in operation and then also drain faster during periods of peak demand. Since this particular tank is approximately 1/3 the capacity of the others, though a similar volume of water may flow in and out of the tank, since it is a smaller tank, the volume of water used from the tank as a percentage is greater than the others and therefore the tank level rises and drops faster.

The only way to keep this tower full is to operate the JWC system with the New Hope tank as the controlling tank, using an altitude valve to prevent overflowing. In practice however, the JWC has experienced significant operation problems when operating in this manner (icing in winter and water quality in summer). Therefore, the JWC continues to control the pump stations based on the Medicine Lake tank, and allows the New Hope tank to float.

Finally, under this operating scenario, multiple hydrant locations throughout the System were identified for model observation (See Appendix C, A1.1). As can be seen in the graphical figure, the pressures at these locations rise and fall with tank levels and pump operation. Of particular note is the LP (low pressure) location noted. During periods of high demand and low tower levels, the model shows this location dropping below 30 psi which would likely be noticeable, and undesirable. Conversely, the high pressure location, near the Golden Valley pump station has the potential for pressures to exceed 120 psi when water towers become full. The results of this analysis will be used moving forward to compare to other alternatives later in this section.

5.8.2 Crystal Pump Station Out of Service

In the event that one of the two primary water supply pumping stations (or the Minneapolis supply pipes) were to be taken out of service, assurances should be made that the system can function reliably with only one pump station online. For purposes of this analysis, the water distribution model was set up to simulate the operation of the JWC water system with the Crystal pumping station taken completely offline. The same 72-hour extended period simulation (EPS) operation was utilized as the previous alternative.

This time, a combination of one, two or three pumps at the Golden Valley pump station were in operation to sustain water tank levels. As might be expected, due to the close proximity of the Golden Valley pump station to the Golden Valley tower, the Golden Valley tower tends to fill quicker than the others and stays full. This is because all water supplied to the distribution system is being delivered to the same location. Overall, the monitored pressures tend to maintain a similar pressure and fire flow level as the normal system operation.

5.8.3 Golden Valley Pump Station Out of Service

For purposes of this analysis, the water distribution model was set up to simulate the operation of the JWC water system with the Golden Valley pumping station (or Minneapolis supply pipe) taken completely offline. The same 72-hour extended period simulation (EPS) operation was utilized as the previous alternative.

This time, a combination of one or two pumps at the Crystal pump station were in operation to sustain water tank levels. Due to the close proximity of the Crystal pump station to the New Hope tower, the New Hope tower tends to fill even quicker than the others and stays full. This lends itself to being an even more prominent trend than when experienced during normal operation. Once again, when the pump station is cycled off, the New Hope tower tends to drop in level much faster than the other towers. Because of this it is recommended that the controls be set so that at least one pump is in constant operation at the pump station to sustain system pressures.

5.8.4 Minneapolis Supply Interruption

The purpose of this scenario is to model the operation of the system in the event of a catastrophic complete loss of supply from Minneapolis. Supply for this scenario is from the three (3) JWC back-up wells (and one pump from the Crystal Pump Station). It is assumed that emergency water restrictions would be in place under this situation to limit the demand to 6.2 MGD to match the total supply available from the back-up wells.

As expected, the New Hope well fills the New Hope water tower, therefore an altitude valve is required on the New Hope tank to prevent overflowing and to allow the New Hope well to continue pumping. Otherwise, the system performs adequately under this scenario (Figure A4.1).

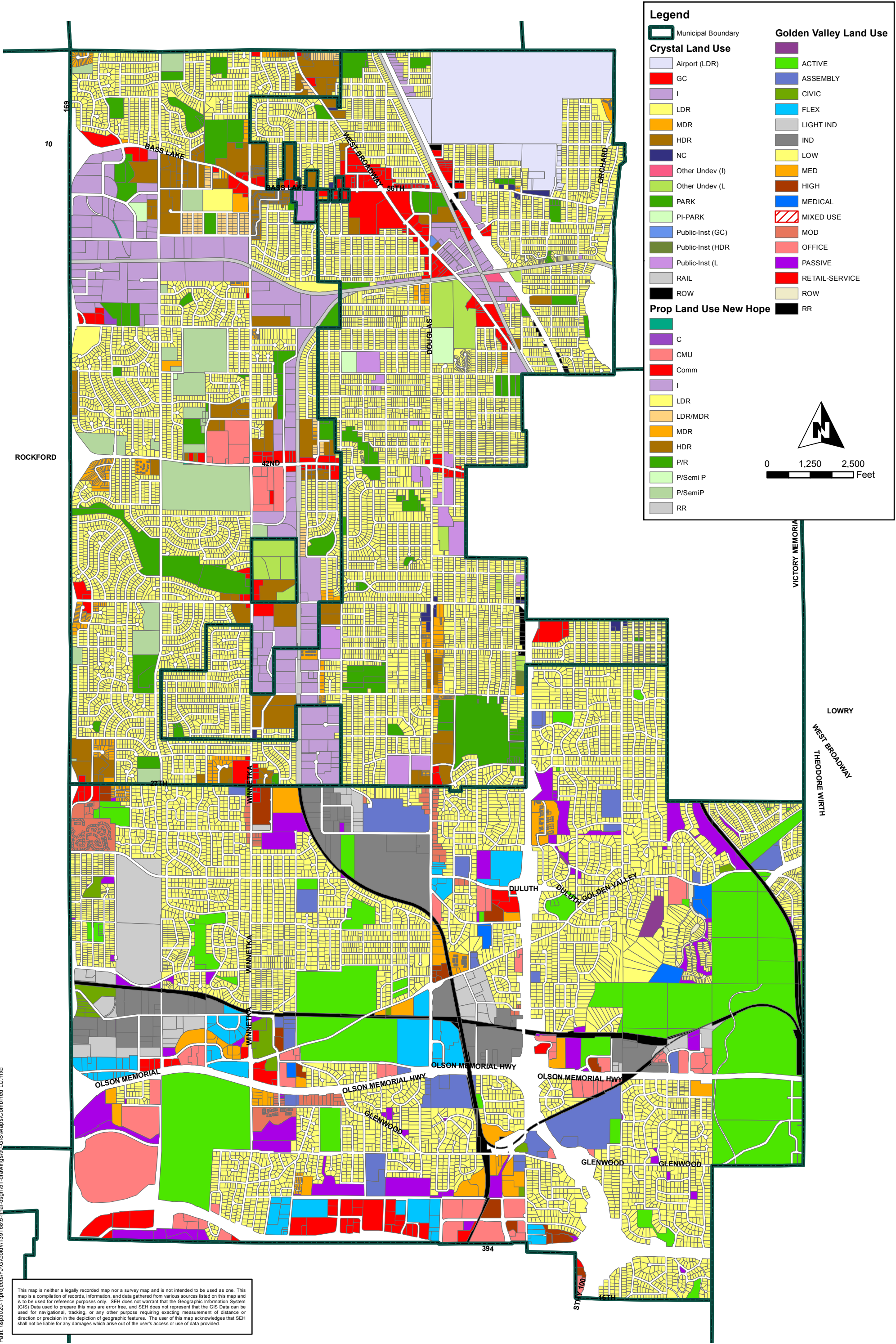
5.9 Summary of Recommendations

Although the existing JWC water system is generally able to handle existing and proposed redevelopment, the following improvements are recommended.

- Continue regular discussions with Minneapolis to discuss water supply and quality advance notification protocols.
- Continue to monitor water from Minneapolis as it enters the Crystal and Golden Valley Reservoirs to provide an early warning detection.
- Continue regular inspections, repair and maintenance of the Crystal and Golden Valley GSR facilities.
- Continue with plans to install flow meters and variable speed drives on the pumps at the Crystal and Golden Valley Pump Stations.
- Consider another back-up well at the Golden Valley GSR.
- Repair/replace PCCP and continue to update the PCCP analysis tool.
- Regularly update the hydraulic model and utilize the model to determine pipe replacement strategies for proposed redevelopment and street reconstruction projects.
- Plan for eventual replacement of the existing 0.5 MG New Hope tank with a 1.5 MG tank.

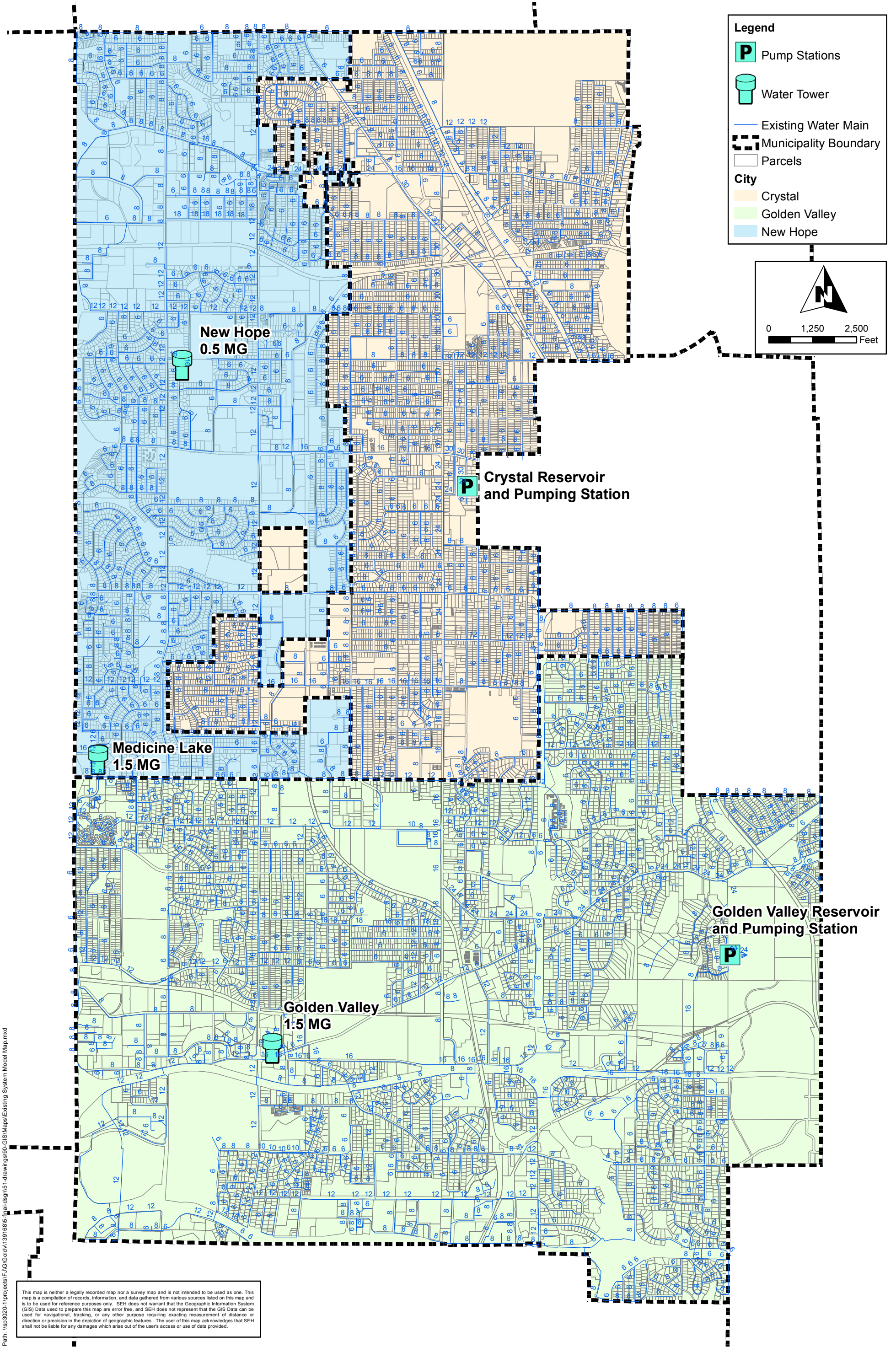
Appendix A

Maps



This map is neither a legally recorded map nor a survey map and is not intended to be used as one. This map is a compilation of records, information, and data gathered from various sources listed on this map and is to be used for reference purposes only. SEH does not warrant that the Geographic Information System (GIS) Data used to prepare this map are error free, and SEH does not represent that the GIS Data can be used for navigational, tracking, or any other purpose requiring exacting measurement of distance or direction or precision in the depiction of geographic features. The user of this map acknowledges that SEH shall not be liable for any damages which arise out of the user's access or use of data provided.

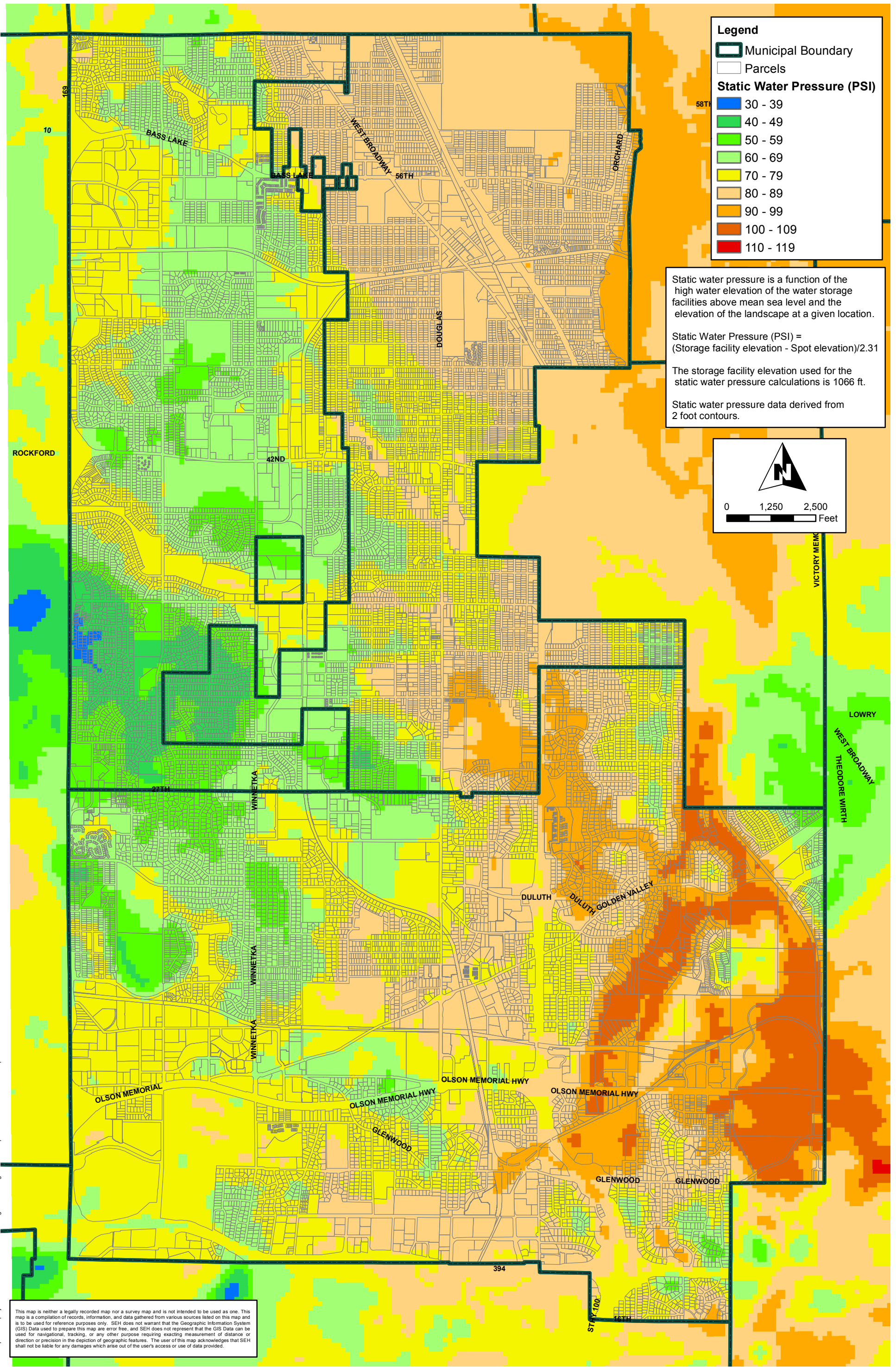
Path: \\sp3020-1\projects\FJ\GOLDV139168\Final-dsgn\51-drawings\GOLDV\GIS\Maps\Combined_LU.mxd



This map is neither a legally recorded map nor a survey map and is not intended to be used as one. This map is a compilation of records, information, and data gathered from various sources listed on this map and is to be used for reference purposes only. SEH does not warrant that the Geographic Information System (GIS) Data used to prepare this map are error free, and SEH does not represent that the GIS Data can be used for navigational, tracking, or any other purpose requiring exacting measurement of distance or direction or precision in the depiction of geographic features. The user of this map acknowledges that SEH shall not be liable for any damages which arise out of the user's access or use of data provided.

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Legend

- Municipal Boundary
- Parcels

Static Water Pressure (PSI)

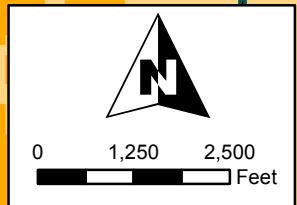
- 30 - 39
- 40 - 49
- 50 - 59
- 60 - 69
- 70 - 79
- 80 - 89
- 90 - 99
- 100 - 109
- 110 - 119

Static water pressure is a function of the high water elevation of the water storage facilities above mean sea level and the elevation of the landscape at a given location.

Static Water Pressure (PSI) =
 $(\text{Storage facility elevation} - \text{Spot elevation}) / 2.31$

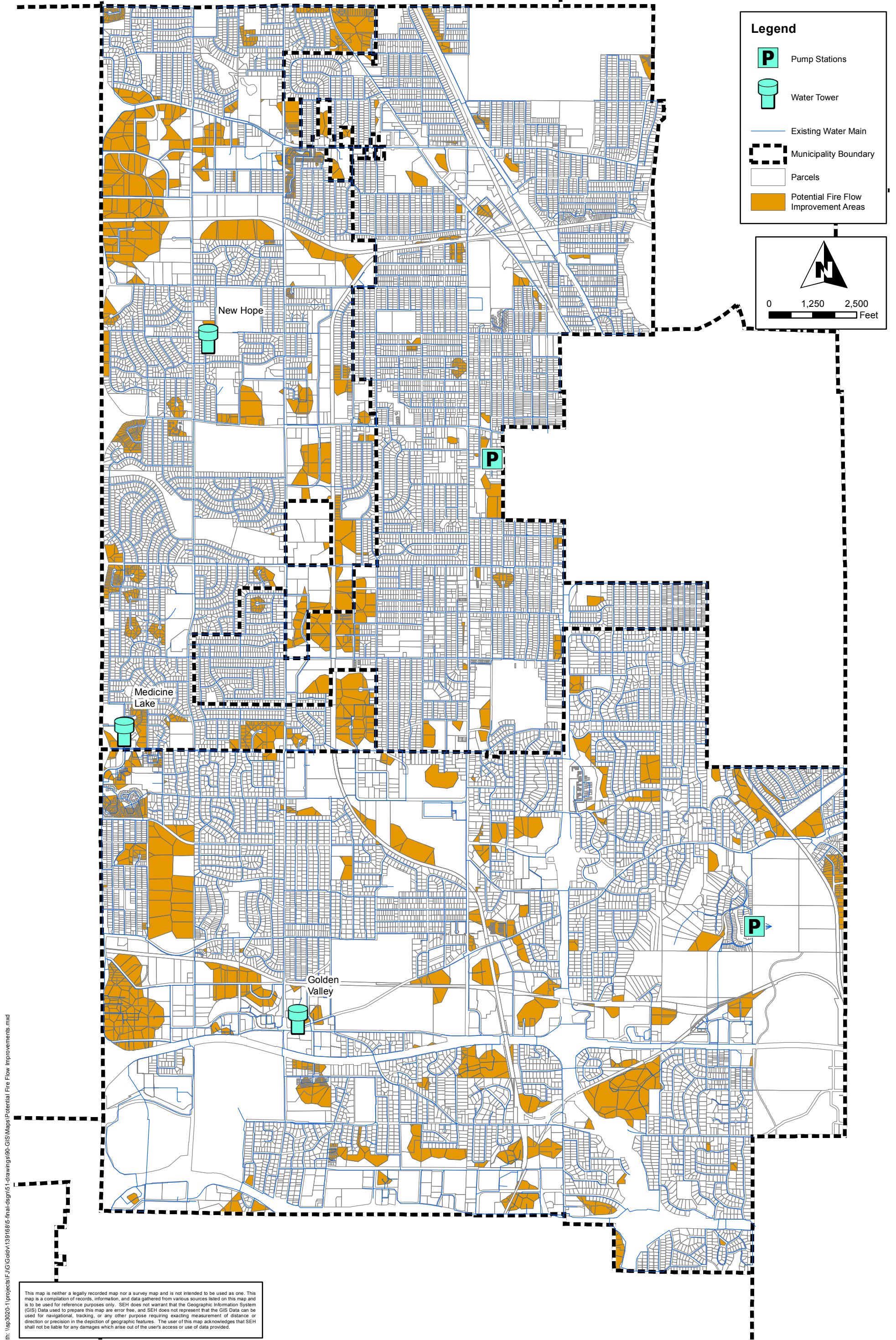
The storage facility elevation used for the static water pressure calculations is 1066 ft.

Static water pressure data derived from 2 foot contours.









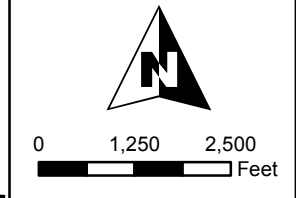
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Legend

-  Pump Stations
-  Water Tower
-  Existing Water Main
-  Municipality Boundary
-  Parcels
-  Potential Fire Flow Improvement Areas



0 1,250 2,500 Feet

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Project Number: GOLDV 139168
 Print Date: 5/30/2018
 Map by: JEM, REH
 Projection: Hennepin County
 Source: WaterCAD

2018 Water System Master Plan Joint Water Commission

Potential Fire Flow Improvements
 By Land Use Model Map

Appendix B

Computer Model Development

PUMP DATA SHEET Turbine 60 Hz

Company:
Name:
Date: 03/10/11

Customer:

Order No:

CRYST 162



Pump:

Size: 24ELC (2 stages)
Type: Lineshaft
Synch speed: 1200 rpm
Curve: E6824EDPC2
Specific Speeds:

Speed: 1185 rpm
Dia: 15.56 in

Ns: 3538

Pump Notes for Standard Sizes:
Curves are certified for water at 60°F only. Consult factory for performance with any other fluid.

Vertical Turbine: Bowl size: 22.25 in
Max lateral: 0.87 in
Thrust K factor: 42 lb/ft

Search Criteria:

Flow: 5000 US gpm

Head: 180 ft

Fluid:

Water
Density: 62.25 lb/ft³
Viscosity: 1.105 cP
NPSHa: — ft

Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

Motor:

Standard: NEMA

Size: 300 hp
Speed: 1200

Sizing criteria: Max Power on Design Curve

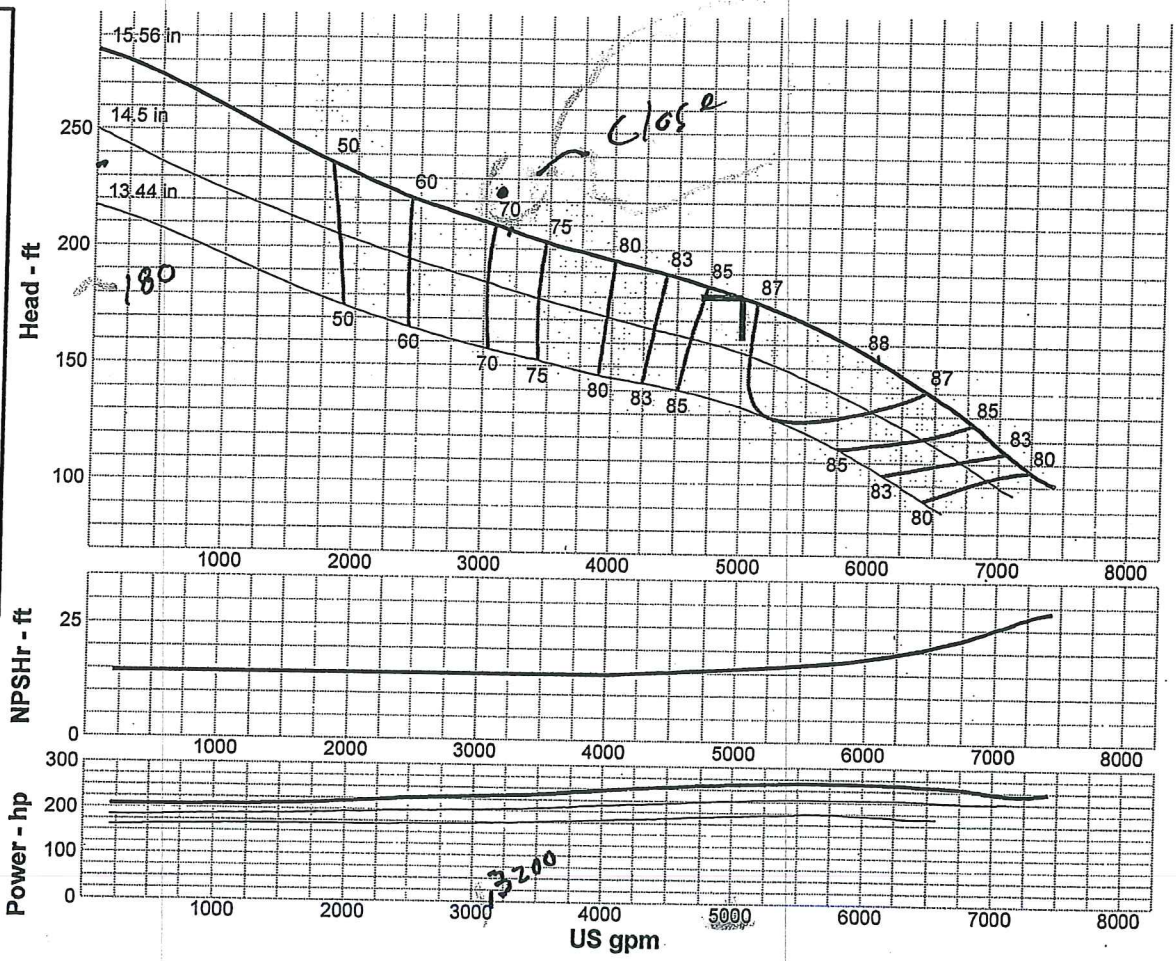
Pump Limits for Standard Construction:

Temperature: 120 °F
Sphere size: 2 in
Pressure: 260 psi g

---- Data Point ----
Flow: 5000 US gpm
Head: 180 ft
Eff: 86.4%
Power: 262 hp
NPSHr: 16 ft

-- Design Curve --
Shutoff Head: 284 ft
Shutoff dP: 123 psi
Min Flow: — US gpm
BEP: 88% eff
@ 6056 US gpm
NOL Pwr: 266 hp
@ 6056 US gpm

-- Max Curve --
Max Pwr: 266 hp
@ 6056 US gpm



Performance Evaluation:

| Flow US gpm | Speed rpm | Head ft | Efficiency % | Power hp | NPSHr ft |
|-------------|-----------|---------|--------------|----------|----------|
| 6000 | 1185 | 155 | 87.9 | 266 | 18.4 |
| 5000 | 1185 | 180 | 86.4 | 262 | 16 |
| 4000 | 1185 | 196 | 79.8 | 247 | 14.6 |
| 3000 | 1185 | 212 | 68.8 | 232 | 14.5 |
| 2000 | 1185 | 232 | 53.1 | 219 | 14.5 |

Company: xylem
 Name:
 Date: 3/16/2015

Customer:
 Order No:



Pump:

Size: 20ELC (3 stage)
 Type: Lineshaft
 Synch speed: 1200 rpm
 Curve: E6620EDPC3
 Specific Speeds:
 Dimensions:
 Vertical Turbine:
 Speed: 1180 rpm
 Dia: 13.0625 in
 Impeller:
 Ns: 3371
 Nss: ---
 Suction: ---
 Discharge: ---
 Bowl size: 18.9 in
 Max lateral: 0.88 in
 Thrust K factor: 31 lb/ft

Search Criteria:

Flow: 3900 US gpm Head: 160 ft

Fluid:

Water
 Density: 62.32 lb/ft³
 Viscosity: 0.9946 cP
 NPSHa: ---
 Temperature: 68 °F
 Vapor pressure: 0.3391 psi a
 Atm pressure: 14.7 psi a

Motor:

Standard: NEMA
 Enclosure: WPI
 Sizing criteria: Max Power on Design Curve
 Size: 200 hp
 Speed: 1200
 Frame: 449

Pump Limits:

Temperature: ---
 Pressure: ---
 Sphere size: 1.75 in
 Power: ---
 Eye area: ---

Design Point

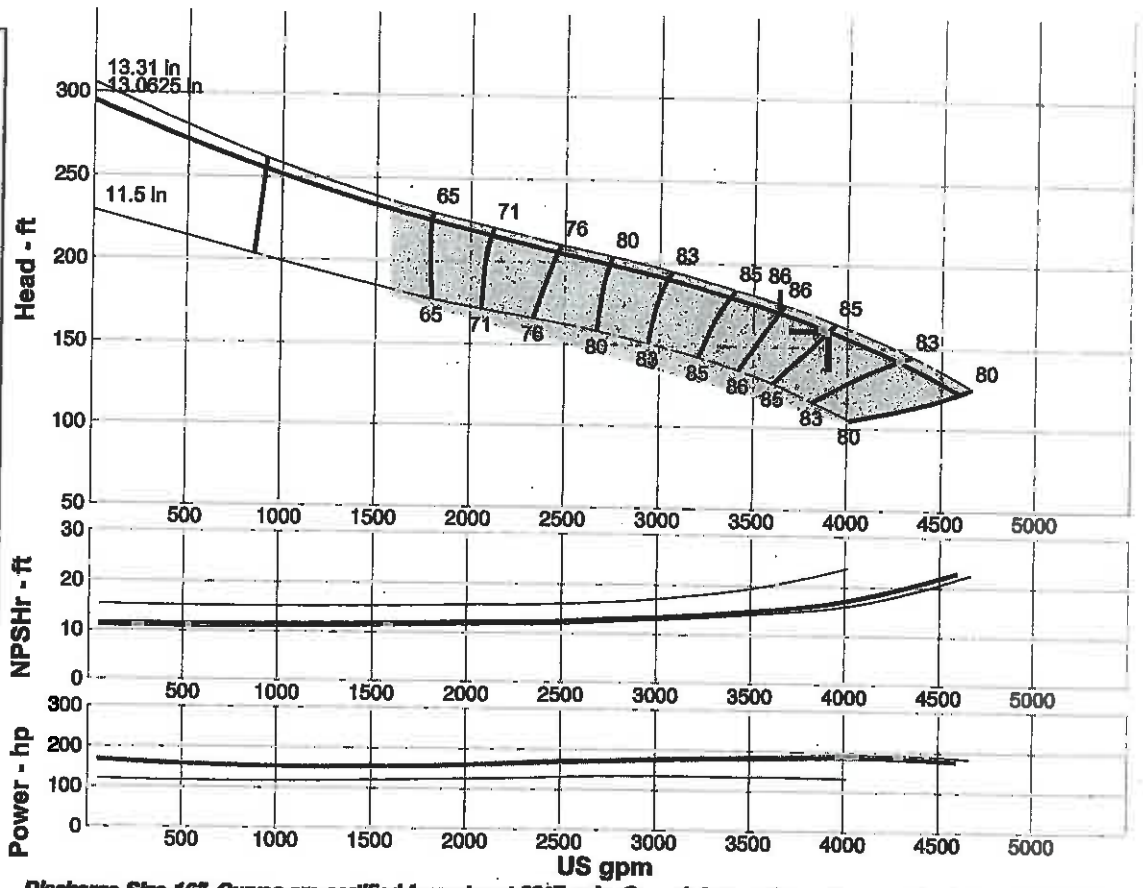
Flow: 3900 US gpm
 Head: 160 ft
 Eff: 85%
 Power: 186 hp
 NPSHr: 16.4 ft

Design Curve

Shutoff head: 295 ft
 Shutoff dP: 128 psi
 Min flow: 910 US gpm
 BEP: 86% @ 3639 US gpm
 NOL power: 186 hp @ 3900 US gpm

Max Curve

Max power: 193 hp @ 3937 US gpm



Discharge Size-16". Curves are certified for water at 60°F only. Consult factory for performance with any other fluid.

Performance Evaluation:

| Flow US gpm | Speed rpm | Head ft | Efficiency % | Power hp | NPSHr ft |
|----------------|--------------|------------|-----------------|-------------|-------------|
| 4680 | 1180 | --- | --- | --- | --- |
| 3900 | 1180 | 160 | 85 | 186 | 16.4 |
| 3120 | 1180 | 188 | 83.5 | 178 | 13.7 |
| 2340 | 1180 | 209 | 74.3 | 166 | 12.4 |
| 1560 | 1180 | 234 | 56.6 | 158 | 11.9 |

Company: xylem
Name:
Date: 3/16/2015

Customer:
Order No:

Pump:

Size: 20ELC (3 stage)
Type: Lineshaft
Synch speed: 1200 rpm
Curve: E6620EDPC3
Specific Speeds:
Dimensions:
Vertical Turbine:

Speed: 1180 rpm
Dia: 13.0625 in
Impeller:
Ns: 3371
Nss: ---
Suction: ---
Discharge: ---
Bowl size: 18.9 in
Max lateral: 0.88 in
Thrust K factor: 31 lb/ft

Search Criteria:

Flow: 3900 US gpm Head: 160 ft

Fluid:

Water
Density: 62.32 lb/ft³
Viscosity: 0.9946 cP
NPSHa: ---
Temperature: 68 °F
Vapor pressure: 0.3391 psi a
Atm pressure: 14.7 psi a

Motor:

Standard: NEMA
Enclosure: WPI
Sizing criteria: Max Power on Design Curve
Size: 200 hp
Speed: 1200
Frame: 449

Pump Limits:

Temperature: ---
Pressure: ---
Sphere size: 1.75 in
Power: ---
Eye area: ---

Data Point

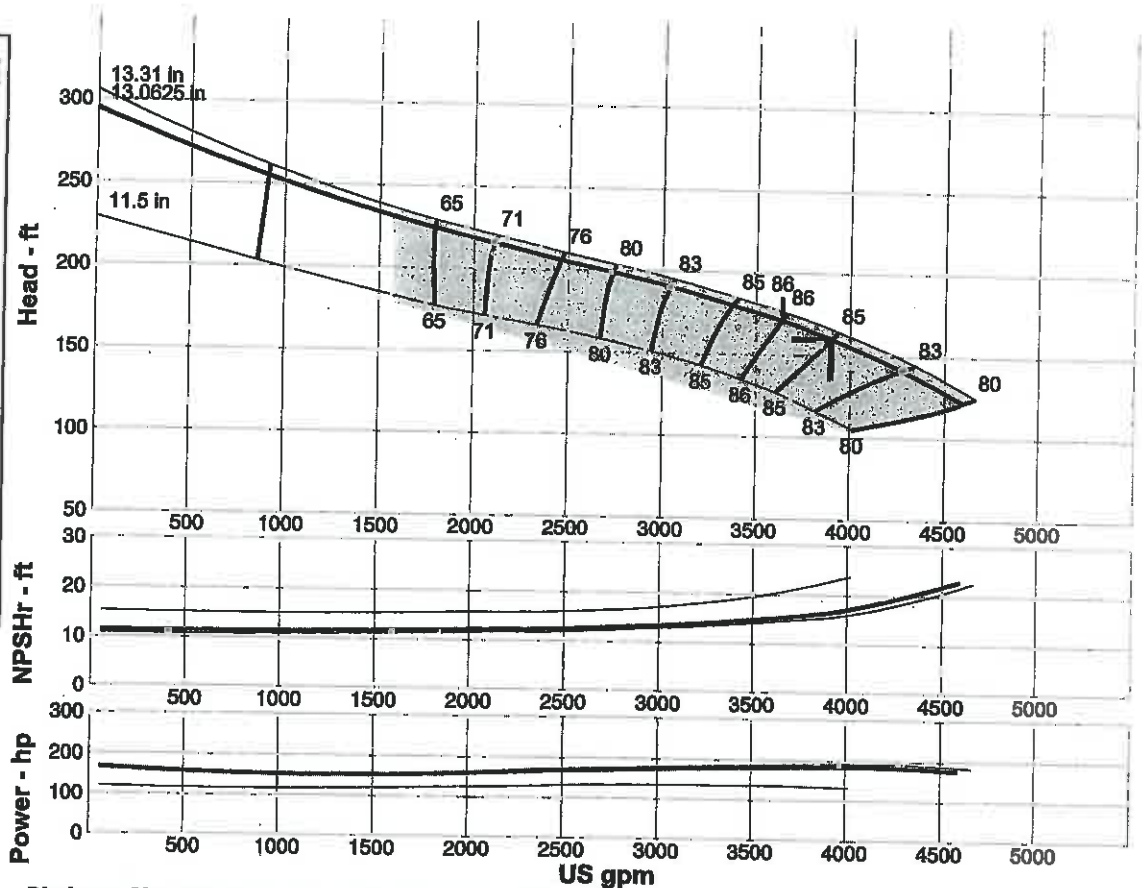
Flow: 2697 US gpm
Head: 200 ft
Eff: 79.5%
Power: 171 hp
NPSHr: 12.9 ft

Design Curve

Shutoff head: 295 ft
Shutoff dP: 128 psi
Min flow: 910 US gpm
BEP: 86% @ 3639 US gpm
NOL power: 186 hp @ 3900 US gpm

Max Curve

Max power: 193 hp @ 3937 US gpm



Discharge Size-18". Curves are certified for water at 60°F only. Consult factory for performance with any other fluid.

Performance Evaluation:

| Flow US gpm | Speed rpm | Head ft | Efficiency % | Power hp | NPSHr ft |
|----------------|--------------|------------|-----------------|-------------|-------------|
| 4680 | 1180 | --- | --- | --- | --- |
| 3900 | 1180 | 160 | 85 | 186 | 16.4 |
| 3120 | 1180 | 188 | 83.5 | 178 | 13.7 |
| 2340 | 1180 | 209 | 74.3 | 166 | 12.4 |
| 1560 | 1180 | 234 | 56.6 | 158 | 11.9 |

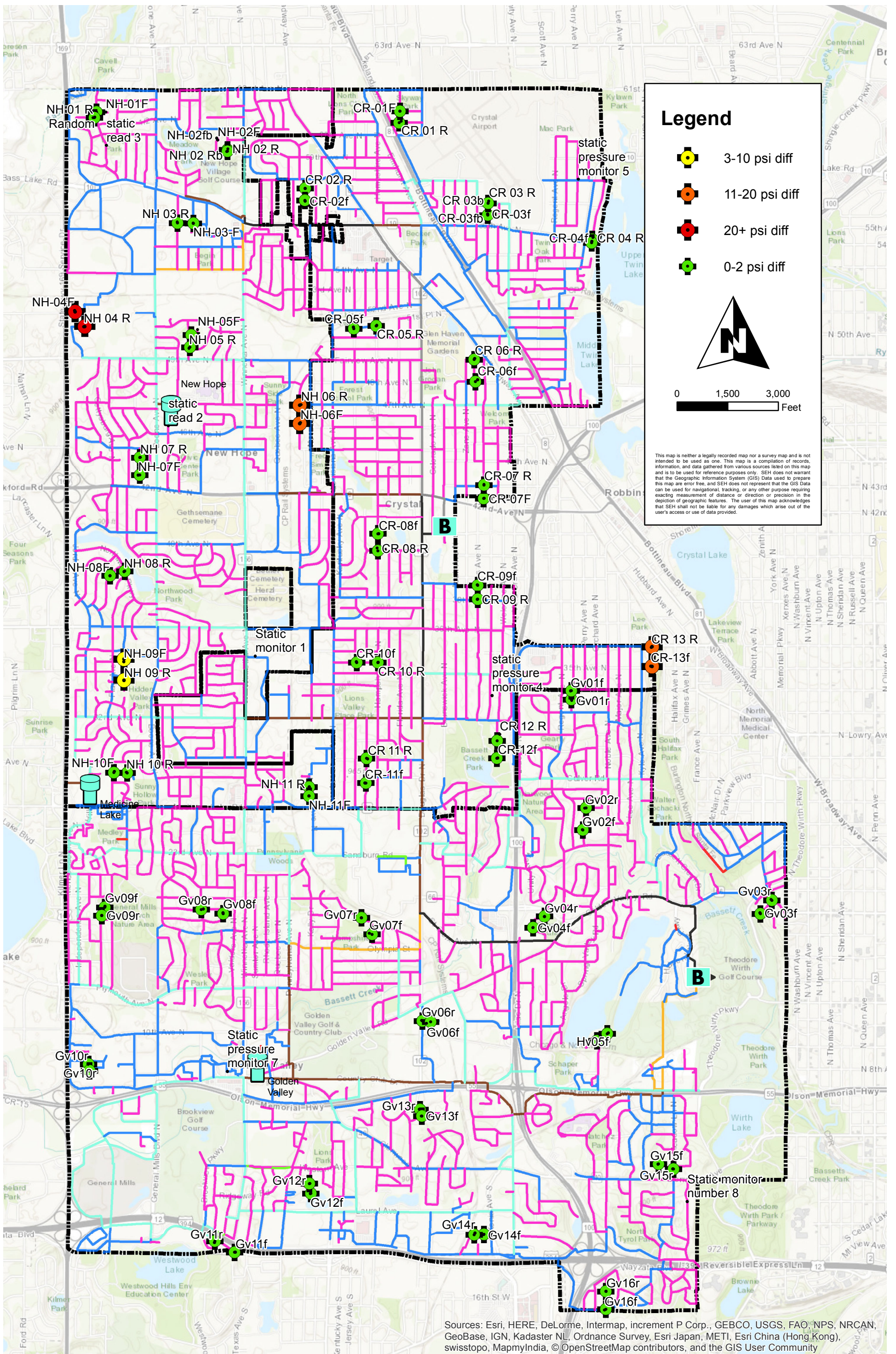


TABLE 1

4.8 0.875

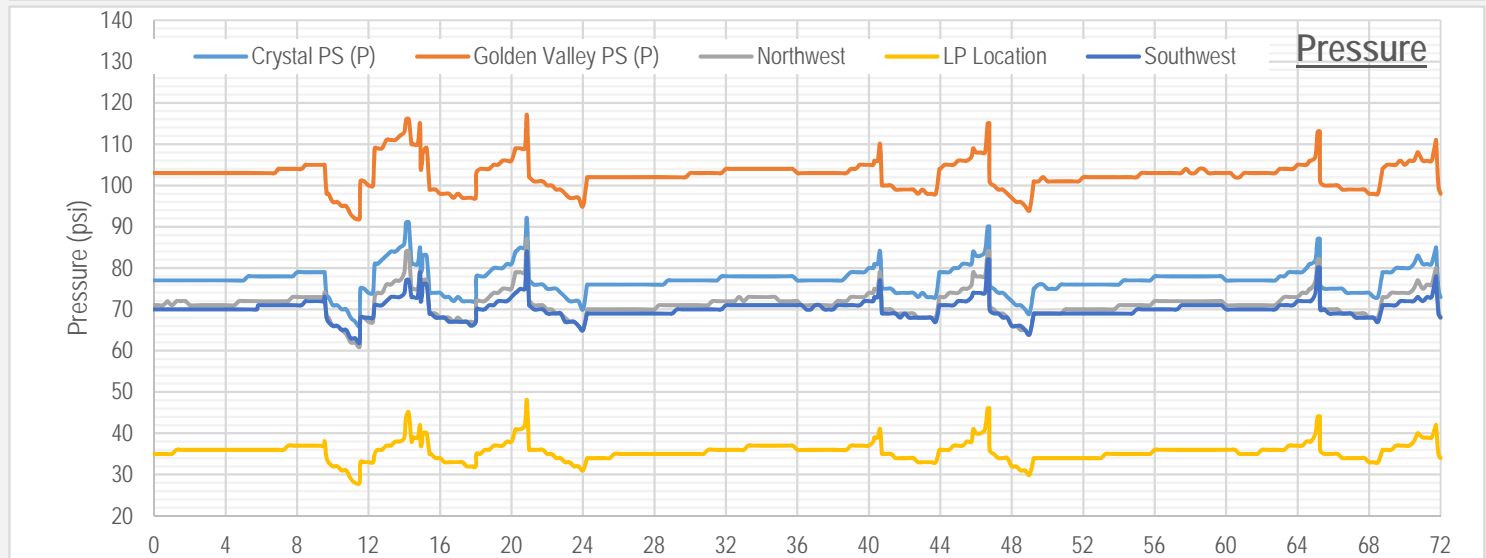
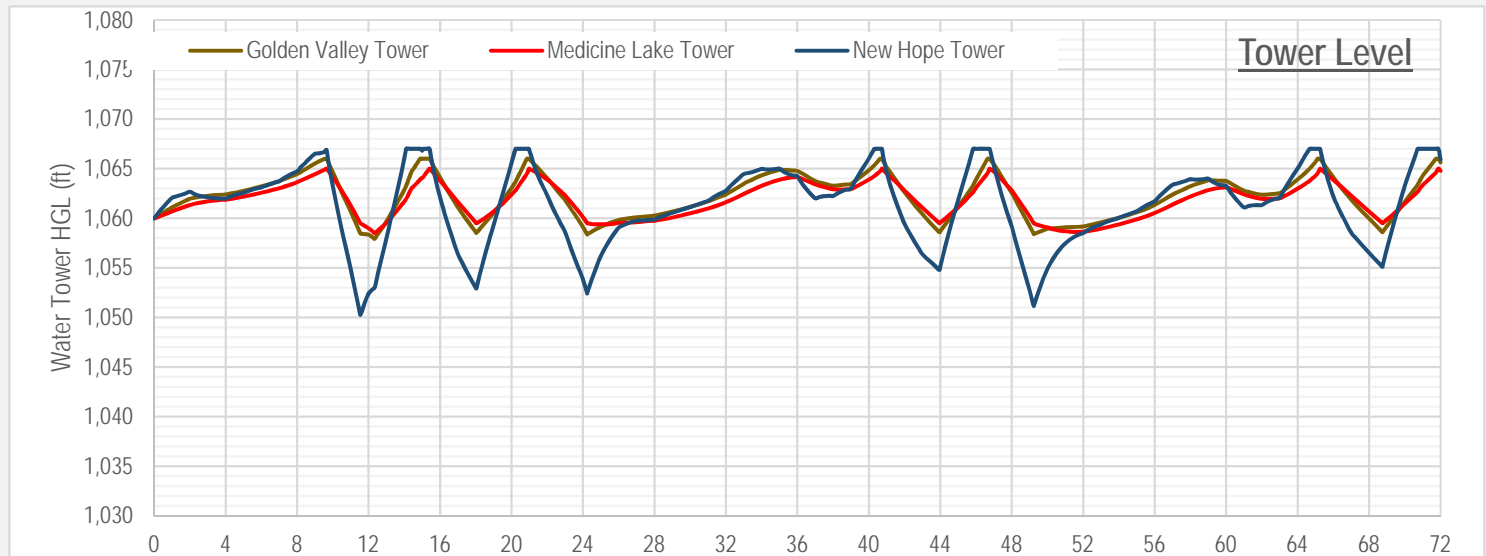
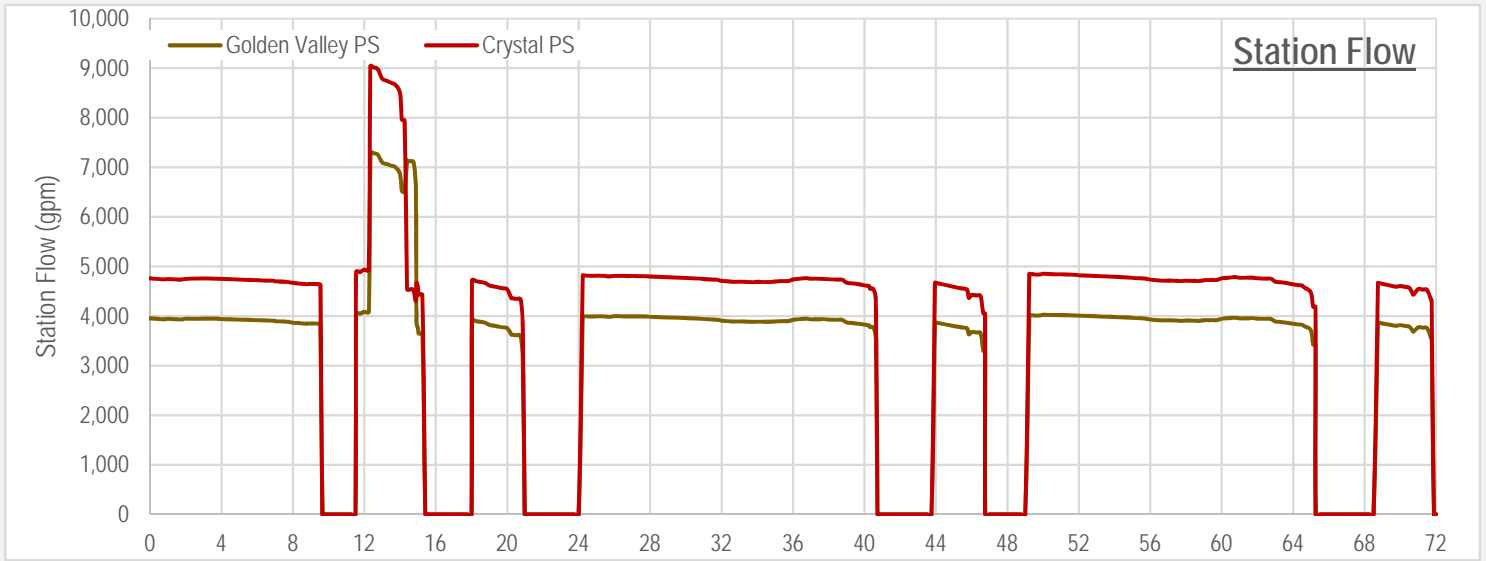
| JWC - FIELD FLOW TESTING RESULTS OCTOBER 2016 | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--------------|------------|-------|----------|-------------------------|---------------------------|---------------------------|------------------------|---------------------------------|------------------|--------------------------|---------------------------|---------------------------|-------------------------|--------------------------|-----------------------|------------------------------|---------------------------|-----------------------|-------------------------|---------------------------|-----------------------|-------------------------|---------------------------------------|
| LOC | EPS Interval | Date | Time | | FIELD TESTING | | | | | | | Boundry Conditions | | | | | | MODEL SIMULATION | | | CALIBRATION RESULTS | | | |
| | | | | | R Static Pressure (psi) | R Residual Pressure (psi) | Pressure Difference (psi) | Flow Meter Size (inch) | Flow Meter pitot pressure (psi) | Field Flow (gpm) | Calc. Fire Flow @ 20 psi | NH NORTH Tower Level (ft) | Med Lake Tower Level (ft) | Gold V Tower Level (ft) | Crystal PS Flow (on/off) | Crystal PS Flow (gpm) | Golv Valley PS Flow (on/off) | Golv Valley PS Flow (gpm) | Static Pressure (psi) | Residual Pressure (psi) | Pressure Difference (psi) | Static Pressure (psi) | Residual Pressure (psi) | Calibration Pressure Difference (psi) |
| NH01 | 1 | 10/11/2016 | 8:50 | 8:50 AM | 81 | 65 | 16 | 3.90 | 12.0 | 1,415 | 2,914 | 1061.6 | 1057.7 | 1057.0 | 1 | 4576 | 1 | 3300 | 75 | 58 | 17 | -6 | -7 | 1 |
| NH02 | 2 | 10/11/2016 | 10:20 | 10:20 AM | 60 | 52 | 8 | 3.90 | 6.0 | 1,000 | 2,385 | 1059.0 | 1057.2 | 1055.9 | 0 | 0 | 0 | 0 | 59 | 51 | 8 | -1 | -1 | 0 |
| NH03 | 3 | 10/11/2016 | 10:51 | 10:51 AM | 61 | 57 | 4 | 3.90 | 15.0 | 1,582 | 5,557 | 1056.8 | 1056.1 | 1054.8 | 0 | 0 | 0 | 0 | 60 | 57 | 3 | -1 | 0 | -1 |
| NH04 | 4 | 10/11/2016 | 11:24 | 11:24 AM | 68 | 40 | 28 | 3.90 | 4.0 | 817 | 1,093 | 1054.7 | 1055.1 | 1053.7 | 0 | 0 | 0 | 0 | 67 | 62 | 5 | -1 | 22 | -23 |
| NH05 | 5 | 10/11/2016 | 12:36 | 12:36 PM | 61 | 55 | 6 | 3.90 | 8.5 | 1,191 | 3,361 | 1051.9 | 1053.0 | 1051.1 | 1 | 4576 | 0 | 0 | 57 | 51 | 6 | -4 | -4 | 0 |
| NH06 | 6 | 10/11/2016 | 12:59 | 12:59 PM | 71 | 41 | 30 | 3.90 | 9.5 | 1,259 | 1,676 | 1054.1 | 1053.3 | 1051.9 | 1 | 4576 | 1 | 3300 | 65 | 24 | 41 | -6 | -17 | 11 |
| NH07 | 7 | 10/11/2016 | 13:30 | 1:30 PM | 61 | 50 | 11 | 3.90 | 4.0 | 817 | 1,662 | 1056.9 | 1054.1 | 1052.9 | 1 | 4576 | 1 | 3300 | 58 | 46 | 12 | -3 | -4 | 1 |
| NH08 | 8 | 10/11/2016 | 13:59 | 1:59 PM | 72 | 60 | 12 | 3.90 | 12.0 | 1,415 | 3,122 | 1059.0 | 1054.9 | 1053.8 | 1 | 4576 | 1 | 3300 | 68 | 58 | 10 | -4 | -2 | -2 |
| NH09 | 9 | 10/11/2016 | 14:27 | 2:27 PM | 43 | 37 | 6 | 3.90 | 3.5 | 764 | 1,635 | 1061.1 | 1055.9 | 1054.9 | 1 | 4576 | 1 | 3300 | 38 | 36 | 2 | -5 | -1 | -4 |
| NH10 | 10 | 10/11/2016 | 14:55 | 2:55 PM | 47 | 32 | 15 | 3.90 | 7.0 | 1,080 | 1,484 | 1061.8 | 1057.1 | 1056.3 | 1 | 4576 | 1 | 3300 | 44 | 29 | 15 | -3 | -3 | 0 |
| NH11 | 11 | 10/11/2016 | 15:26 | 3:26 PM | 61 | 47 | 14 | 3.90 | 23.0 | 1,958 | 3,499 | 1061.8 | 1058.3 | 1057.9 | 1 | 4576 | 1 | 3300 | 56 | 43 | 13 | -5 | -4 | -1 |
| CR01 | 12 | 10/12/2016 | 8:40 | 8:40 AM | 83 | 62 | 21 | 3.90 | 27.0 | 2,122 | 3,840 | 1056.2 | 1054.0 | 1053.6 | 1 | 4576 | 1 | 3300 | 78 | 55 | 23 | -5 | -7 | 2 |
| CR02 | 13 | 10/12/2016 | 9:17 | 9:17 AM | 80 | 48 | 32 | 3.90 | 8.0 | 1,155 | 1,622 | 1058.8 | 1054.9 | 1054.7 | 1 | 4576 | 1 | 3300 | 75 | 42 | 33 | -5 | -6 | 1 |
| CR03 | 14 | 10/12/2016 | 9:57 | 9:57 AM | 88 | 82 | 6 | 3.90 | 20.0 | 1,826 | 6,775 | 1061.5 | 1056.1 | 1056.3 | 1 | 4576 | 1 | 3300 | 83 | 77 | 6 | -5 | -5 | 0 |
| CR04 | 15 | 10/12/2016 | 10:27 | 10:27 AM | 91 | 57 | 34 | 3.90 | 17.0 | 1,684 | 2,506 | 1061.7 | 1057.2 | 1057.6 | 1 | | 1 | 3300 | 84 | 49 | 35 | -7 | -8 | 1 |
| CR05 | 16 | 10/12/2016 | 10:46 | 10:46 AM | 85 | 42 | 43 | 3.90 | 11.0 | 1,354 | 1,693 | 1061.7 | 1058.0 | 1058.5 | 1 | 4576 | 1 | 3300 | 79 | 35 | 44 | -6 | -7 | 1 |
| CR06 | 17 | 10/12/2016 | 11:15 | 11:15 AM | 80 | 72 | 8 | 3.90 | 19.5 | 1,803 | 5,353 | 1061.5 | 1059.0 | 1059.5 | 1 | 4576 | 1 | 3300 | 81 | 72 | 9 | 1 | 0 | 1 |
| CR07 | 18 | 10/12/2016 | 11:40 | 11:40 AM | 76 | 63 | 13 | 3.90 | 11.8 | 1,400 | 3,080 | 1059.7 | 1058.2 | 1058.4 | 0 | 0 | 0 | 0 | 73 | 61 | 12 | -3 | -2 | -1 |
| CR08 | 19 | 10/12/2016 | 12:50 | 12:50 PM | 67 | 60 | 7 | 3.90 | 16.0 | 1,633 | 4,567 | 1056.5 | 1056.0 | 1055.6 | 0 | 0 | 0 | 0 | 66 | 59 | 7 | -1 | -1 | 0 |
| CR09 | 20 | 10/12/2016 | 13:09 | 1:09 PM | 78 | 62 | 16 | 3.90 | 12.0 | 1,415 | 2,836 | 1055.4 | 1055.5 | 1054.9 | 0 | 0 | 0 | 0 | 74 | 60 | 14 | -4 | -2 | -2 |
| CR10 | 21 | 10/12/2016 | 13:26 | 1:26 PM | 63 | 55 | 8 | 3.90 | 13.0 | 1,472 | 3,651 | 1054.5 | 1055.0 | 1054.4 | 0 | 0 | 0 | 0 | 62 | 55 | 7 | -1 | 0 | -1 |
| CR11 | 22 | 10/12/2016 | 13:42 | 1:42 PM | 60 | 43 | 17 | 3.90 | 9.5 | 1,259 | 1,998 | 1053.6 | 1054.5 | 1053.9 | 0 | 0 | 0 | 0 | 58 | 41 | 17 | -2 | -2 | 0 |
| CR12 | 23 | 10/12/2016 | 14:00 | 2:00 PM | 82 | 41 | 41 | 3.90 | 7.8 | 1,137 | 1,421 | 1052.7 | 1054.0 | 1053.3 | 0 | 0 | 0 | 0 | 79 | 37 | 42 | -3 | -4 | 1 |
| CR13 | 24 | 10/12/2016 | 14:17 | 2:17 PM | 69 | 45 | 24 | 3.90 | 8.0 | 1,155 | 1,698 | 1052.0 | 1053.4 | 1052.8 | 0 | 0 | 0 | 0 | 66 | 24 | 42 | -3 | -21 | 18 |
| GV01 | 25 | 10/13/2016 | 8:02 | 8:02 AM | 86 | 70 | 16 | 3.90 | 21.0 | 1,871 | 4,022 | 1061.6 | 1058.7 | 1059.4 | 1 | 4576 | 1 | 3300 | 82 | 66 | 16 | -4 | -4 | 0 |
| GV02 | 26 | 10/13/2016 | 8:24 | 8:24 AM | 87 | 60 | 27 | 3.90 | 21.0 | 1,871 | 3,057 | 1060.3 | 1058.3 | 1058.5 | 1 | 4576 | 0 | 0 | 84 | 55 | 29 | -3 | -5 | 2 |
| GV03 | 27 | 10/13/2016 | 8:42 | 8:42 AM | 64 | 26 | 38 | 3.90 | 7.0 | 1,080 | 1,169 | 1059.3 | 1057.7 | 1057.7 | 0 | 0 | 0 | 0 | 62 | 23 | 39 | -2 | -3 | 1 |
| GV04 | 28 | 10/13/2016 | 8:57 | 8:57 AM | 89 | 77 | 12 | 3.90 | 13.0 | 1,472 | 3,786 | 1058.5 | 1057.3 | 1057.1 | 0 | 0 | 0 | 0 | 87 | 74 | 13 | -2 | -3 | 1 |
| GV05 | 29 | 10/13/2016 | 9:13 | 9:13 AM | 94 | 40 | 54 | 3.90 | 8.5 | 1,191 | 1,411 | 1057.5 | 1056.7 | 1056.4 | 0 | 0 | 0 | 0 | 90 | 38 | 52 | -4 | -2 | -2 |
| GV06 | 30 | 10/13/2016 | 9:30 | 9:30 AM | 79 | 72 | 7 | 2.50 | 48.0 | 1,120 | 3,541 | 1056.6 | 1056.2 | 1055.7 | 0 | 0 | 0 | 0 | 76 | 71 | 5 | -3 | -1 | -2 |
| GV07 | 31 | 10/13/2016 | 9:41 | 9:41 AM | 72 | 63 | 9 | 2.50 | 45.0 | 1,195 | 3,081 | 1056.0 | 1055.7 | 1055.3 | 0 | 0 | 0 | 0 | 70 | 59 | 11 | -2 | -4 | 2 |
| GV08 | 32 | 10/13/2016 | 9:57 | 9:57 AM | 66 | 62 | 4 | 2.50 | 40.0 | 1,152 | 4,308 | 1055.1 | 1055.3 | 1054.7 | 0 | 0 | 0 | 0 | 64 | 60 | 4 | -2 | -2 | 0 |
| GV09 | 33 | 10/13/2016 | 10:09 | 10:09 AM | 54 | 40 | 14 | 2.50 | 19.0 | 810 | 1,308 | 1054.4 | 1054.8 | 1054.3 | 0 | 0 | 0 | 0 | 52 | 36 | 16 | -2 | -4 | 2 |
| GV10 | 34 | 10/13/2016 | 10:22 | 10:22 AM | 69 | 53 | 16 | 2.50 | 37.0 | 1,105 | 2,022 | 1053.6 | 1054.3 | 1053.8 | 0 | 0 | 0 | 0 | 67 | 50 | 17 | -2 | -3 | 1 |
| GV11 | 35 | 10/13/2016 | 10:41 | 10:41 AM | 63 | 60 | 3 | 2.50 | 29.0 | 975 | 4,106 | 1052.5 | 1053.7 | 1053.1 | 0 | 0 | 0 | 0 | 61 | 58 | 3 | -2 | -2 | 0 |
| GV12 | 36 | 10/13/2016 | 10:56 | 10:56 AM | 75 | 59 | 16 | 2.50 | 31.0 | 1,020 | 1,987 | 1051.7 | 1053.1 | 1052.5 | 0 | 0 | 1 | 3300 | 74 | 60 | 14 | -1 | 1 | -2 |
| GV13 | 37 | 10/13/2016 | 11:06 | 11:06 AM | 72 | 56 | 16 | 2.50 | 40.0 | 1,152 | 2,177 | 1051.7 | 1052.8 | 1052.2 | 0 | 0 | 1 | 3300 | 71 | 56 | 15 | -1 | 0 | -1 |
| GV14 | 38 | 10/13/2016 | 11:23 | 11:23 AM | 81 | 76 | 5 | 2.50 | 50.0 | 1,234 | 4,764 | 1053.2 | 1053.2 | 1052.4 | 1 | 4576 | 1 | 3300 | 77 | 70 | 7 | -4 | -6 | 2 |
| GV15 | 39 | 10/13/2016 | 11:35 | 11:35 AM | 88 | 75 | 13 | 2.50 | 39.0 | 1,135 | 2,773 | 1054.4 | 1053.6 | 1052.8 | 1 | 4576 | 1 | 3300 | 85 | 74 | 11 | -3 | -1 | -2 |
| GV16 | 40 | 10/13/2016 | 11:48 | 11:48 AM | 79 | 60 | 19 | 2.50 | 56.0 | 1,290 | 2,379 | 1055.6 | 1053.9 | 1053.3 | 1 | 4576 | 1 | 3300 | 75 | 58 | 17 | -4 | -2 | -2 |

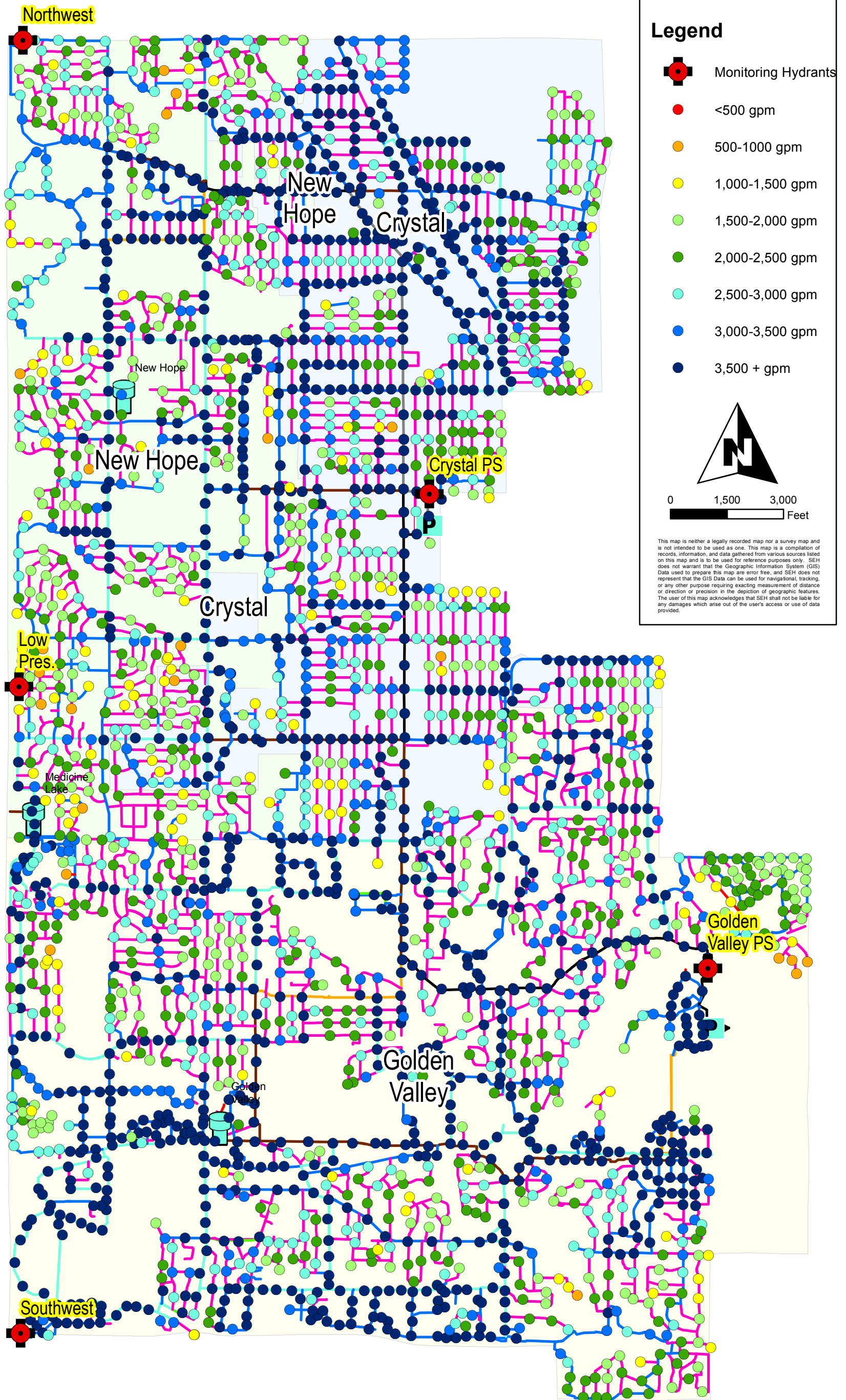
* See flow testing map for locations of flow tests

Appendix C

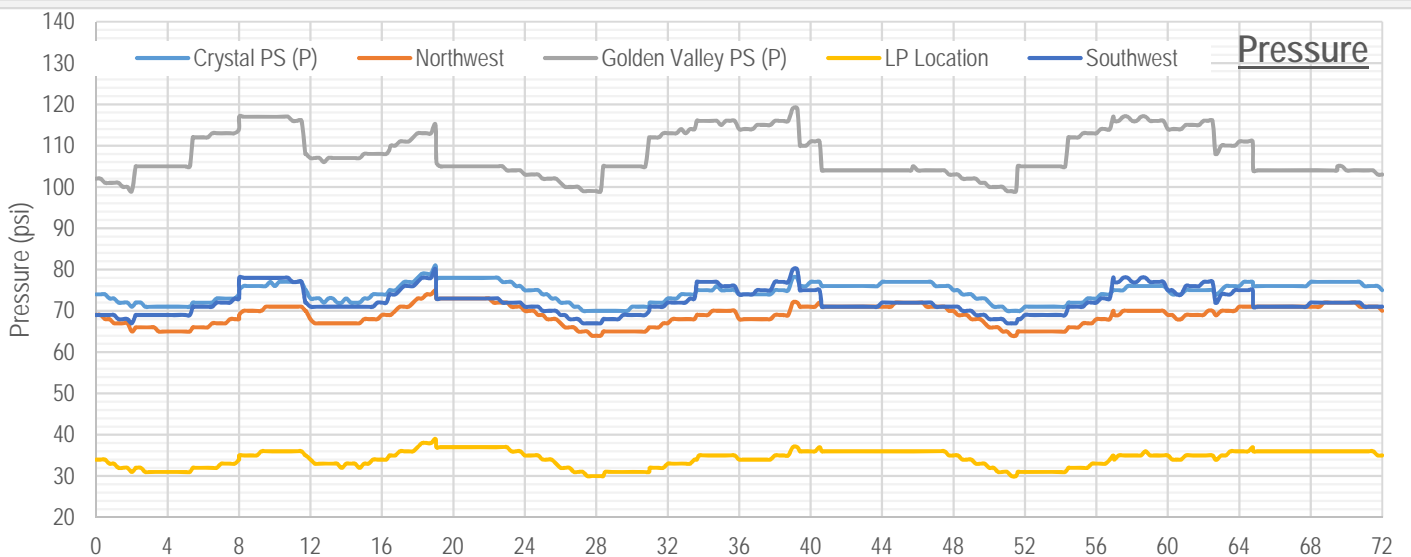
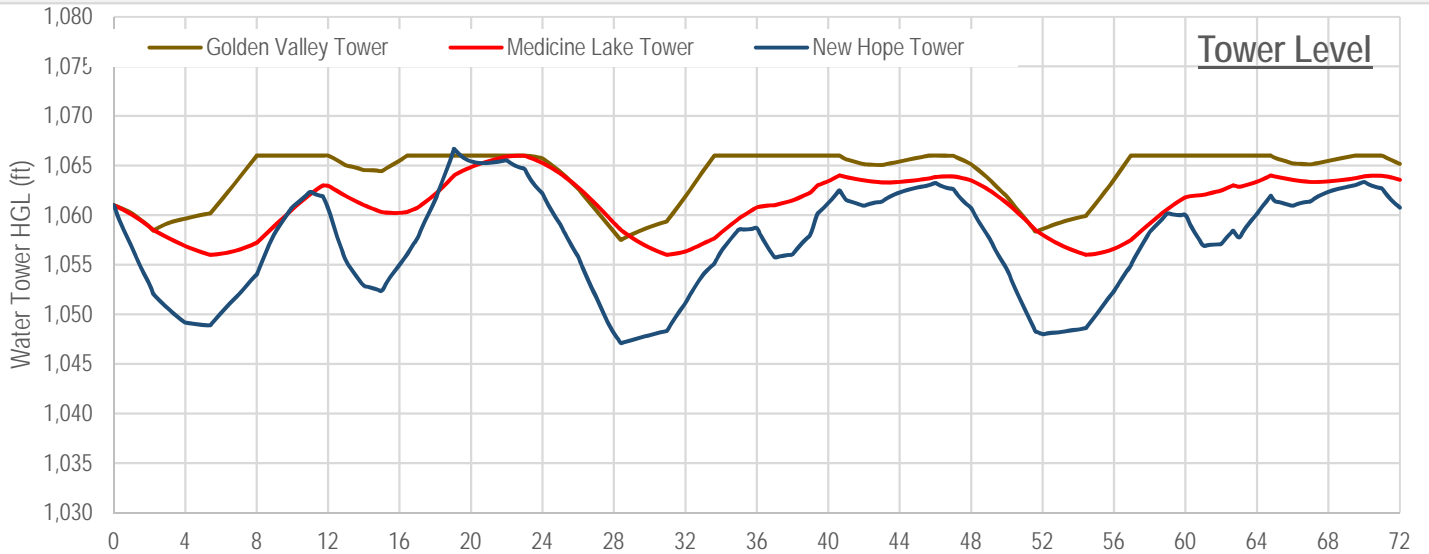
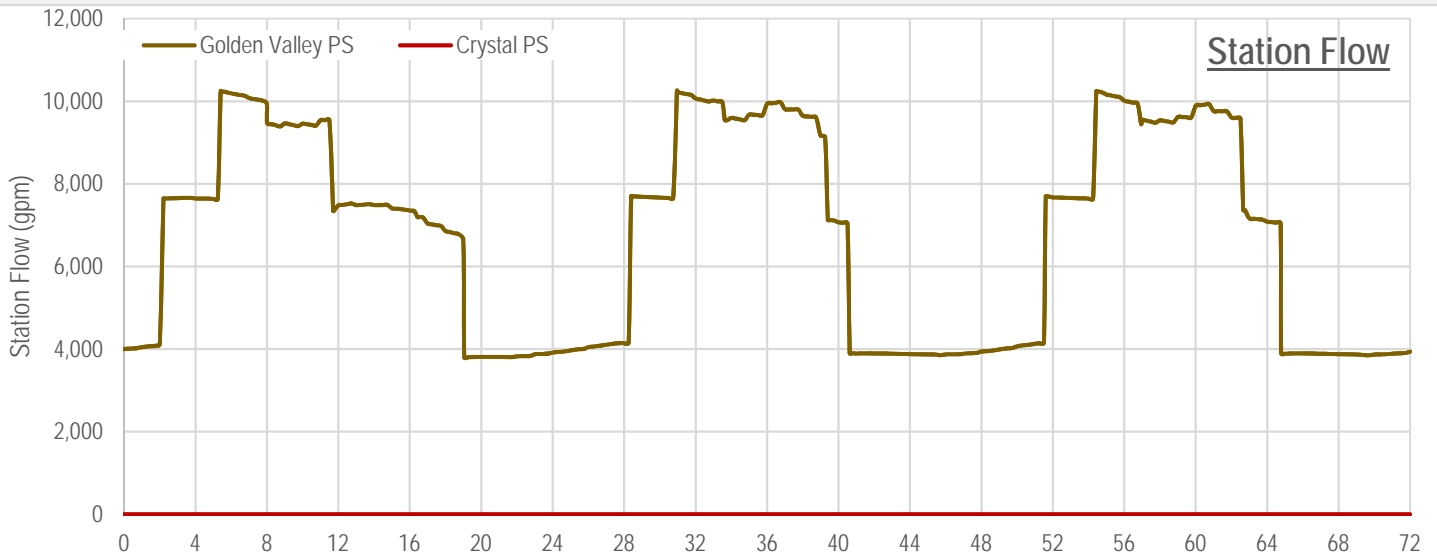
Computer Model Results

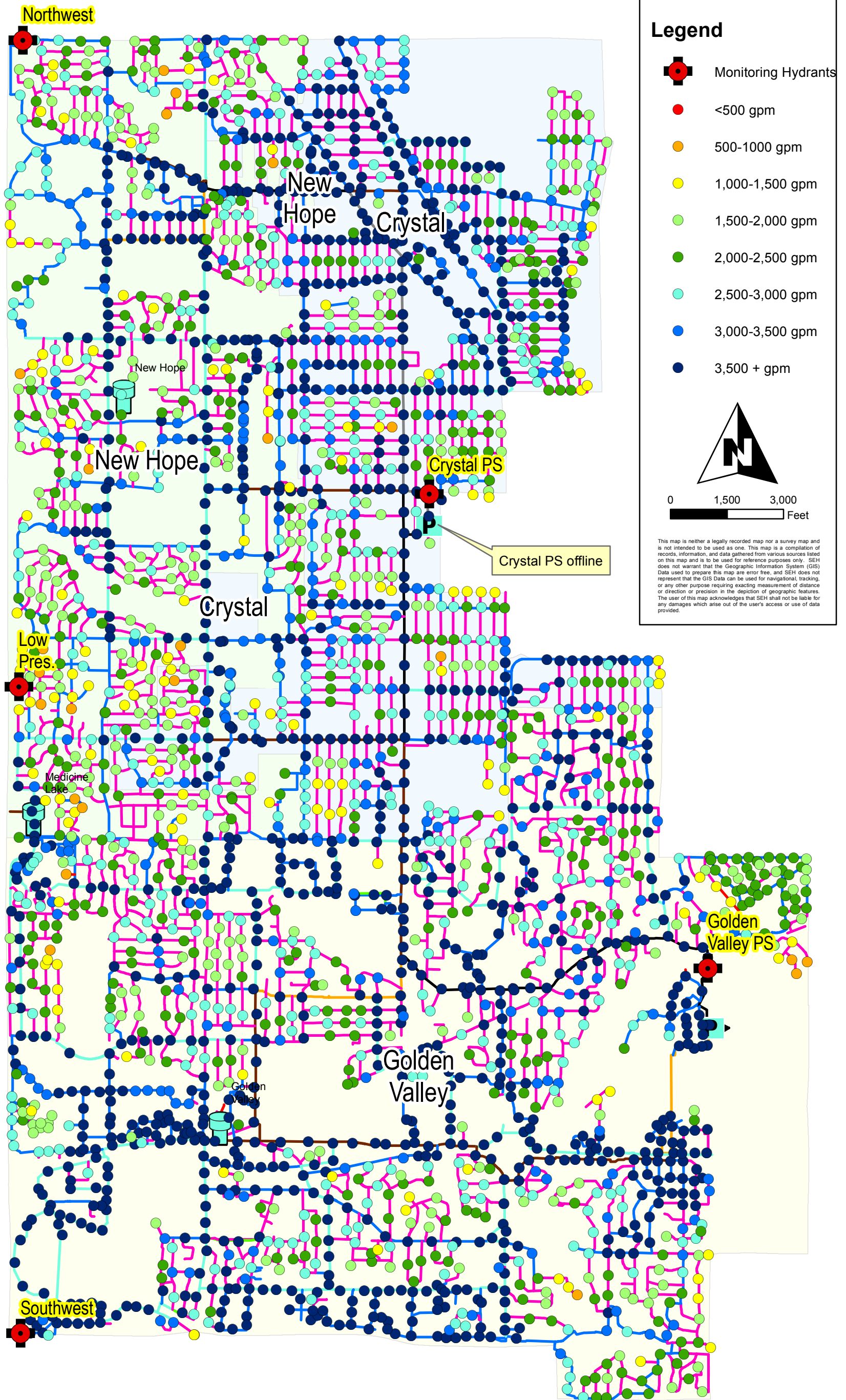
A1.1 - 72 Hour ASD EPS Operation



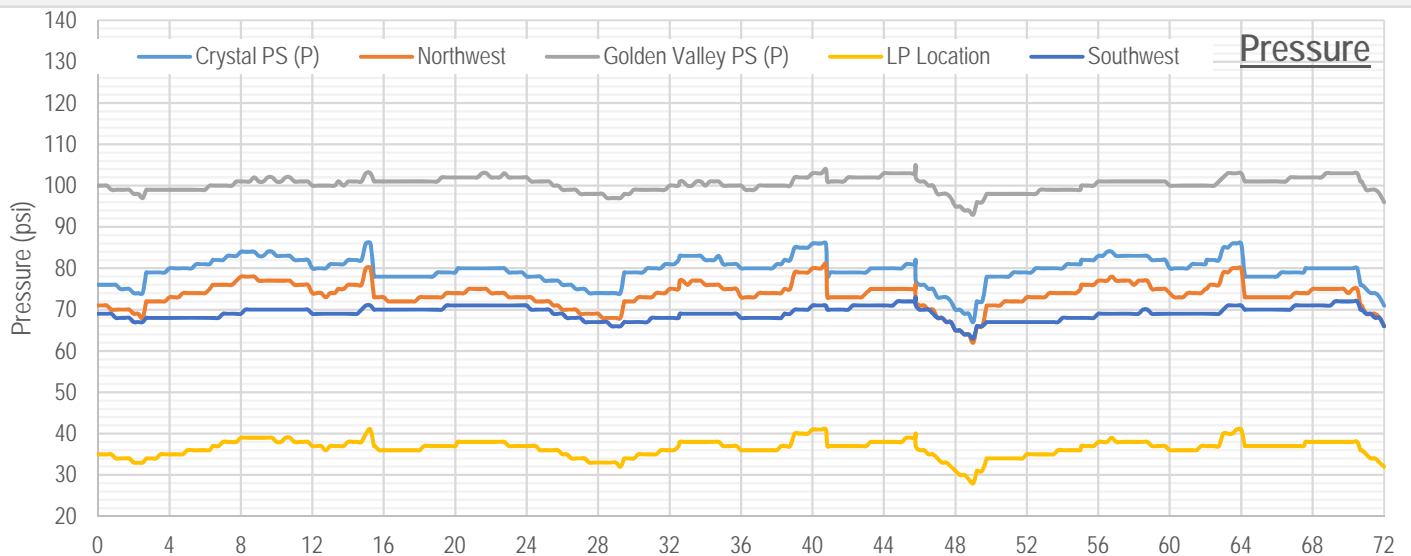
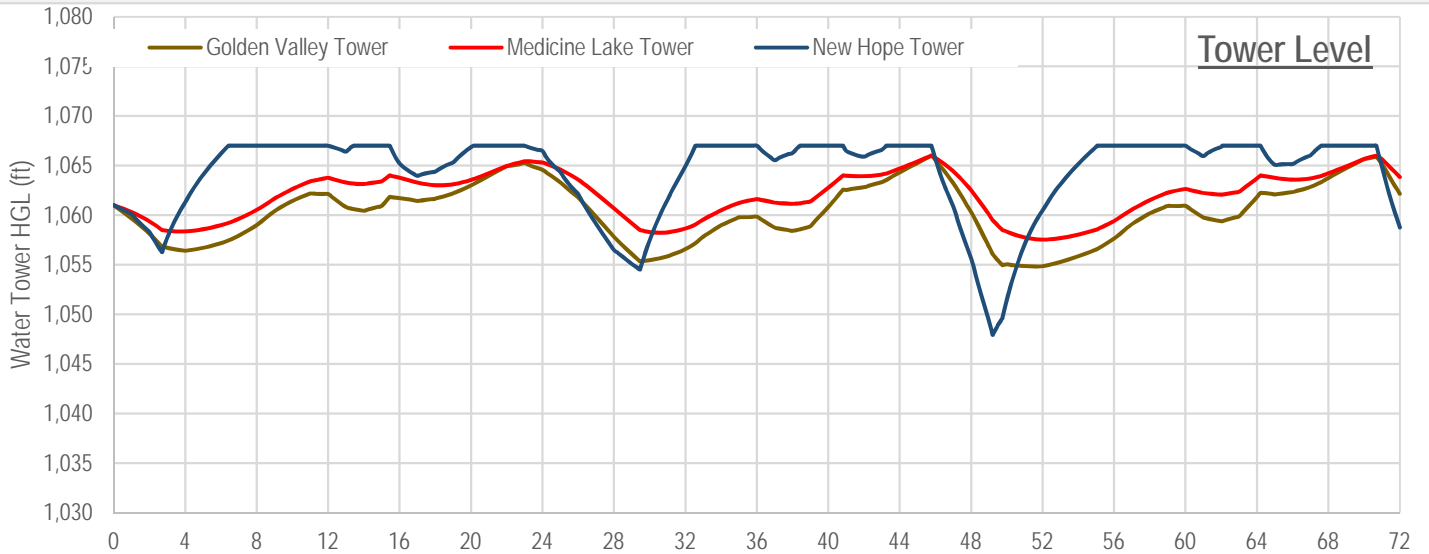
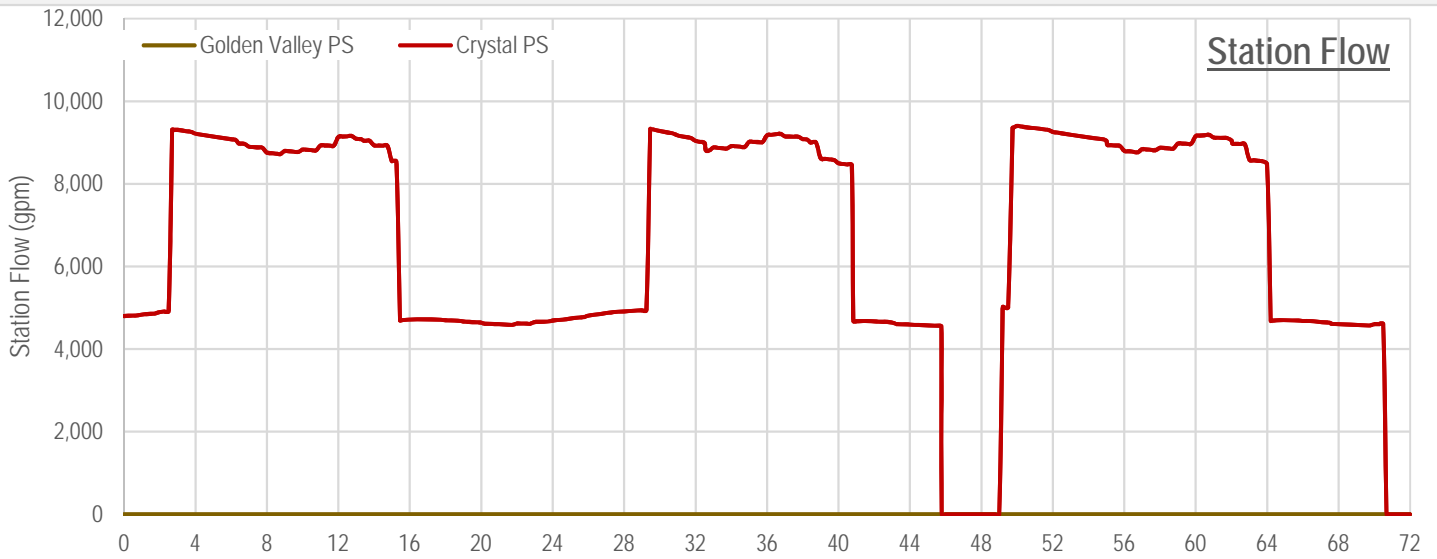


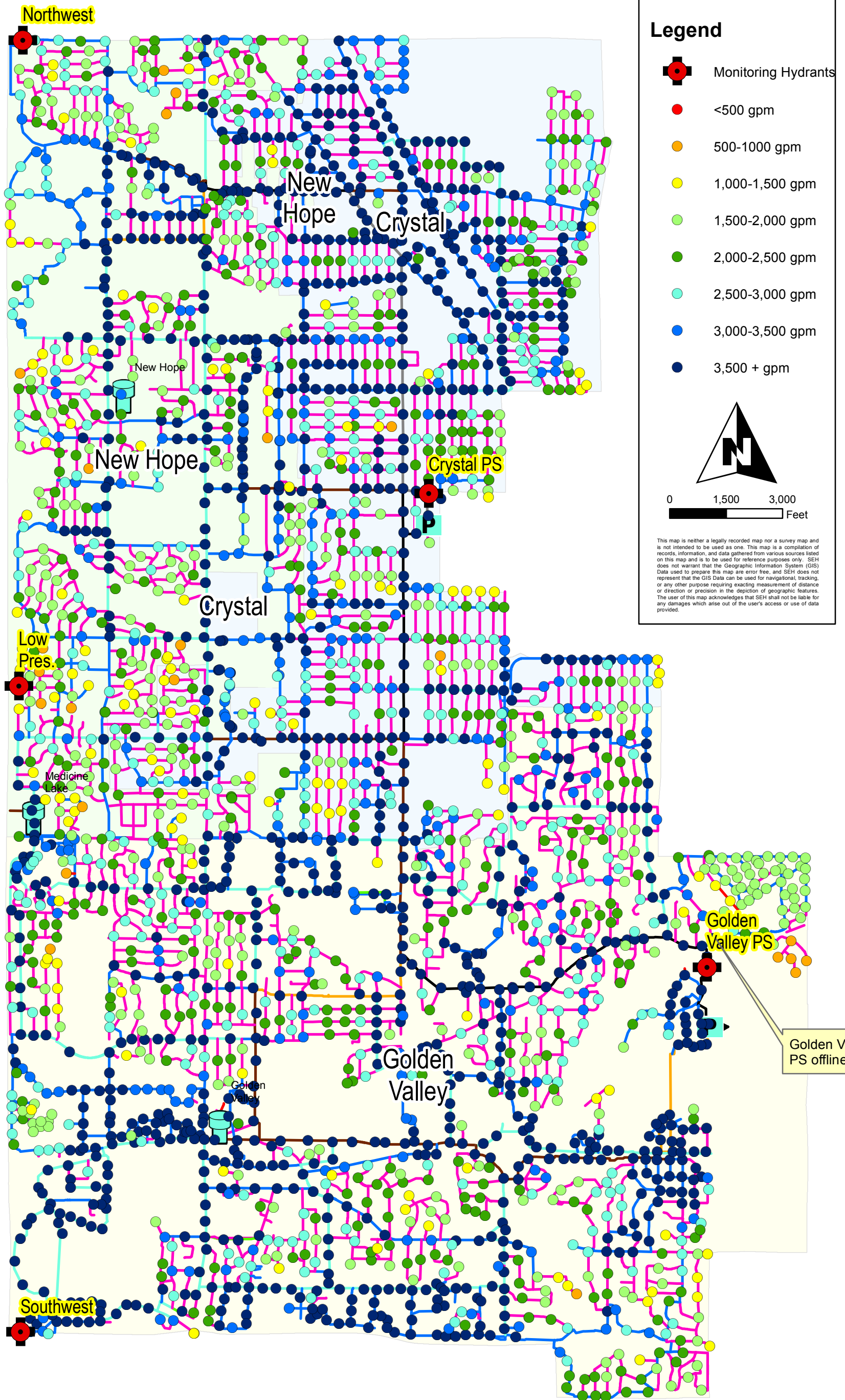
A2.1 - Crystal PS Offline - 72 Hour ASD EPS Operation



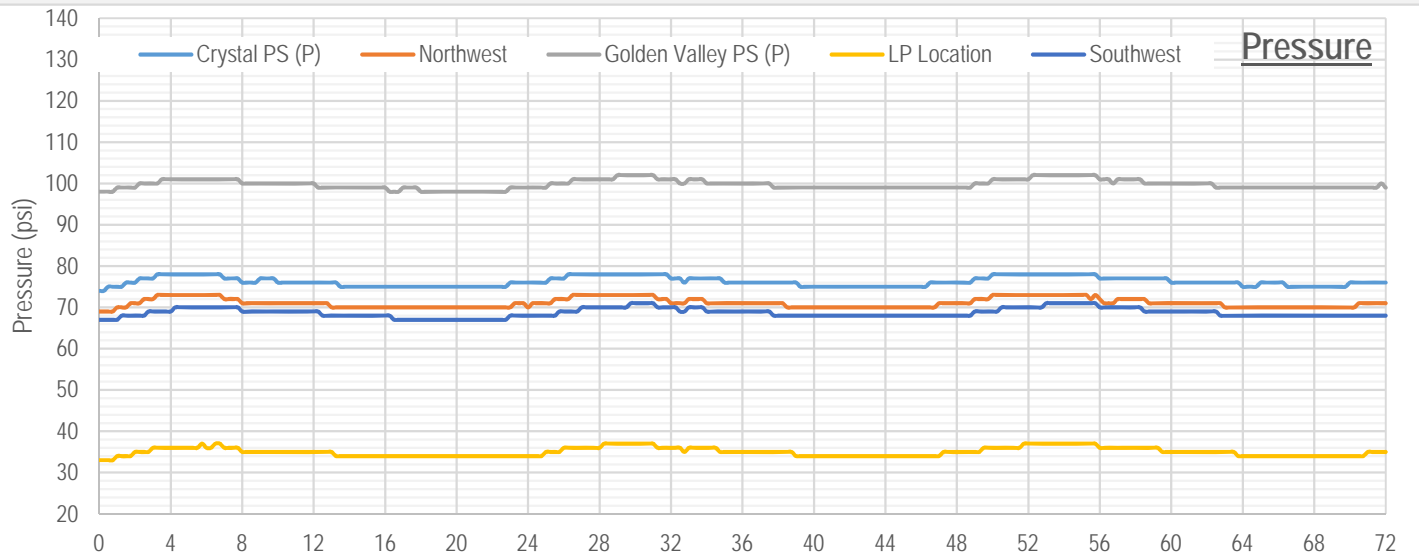
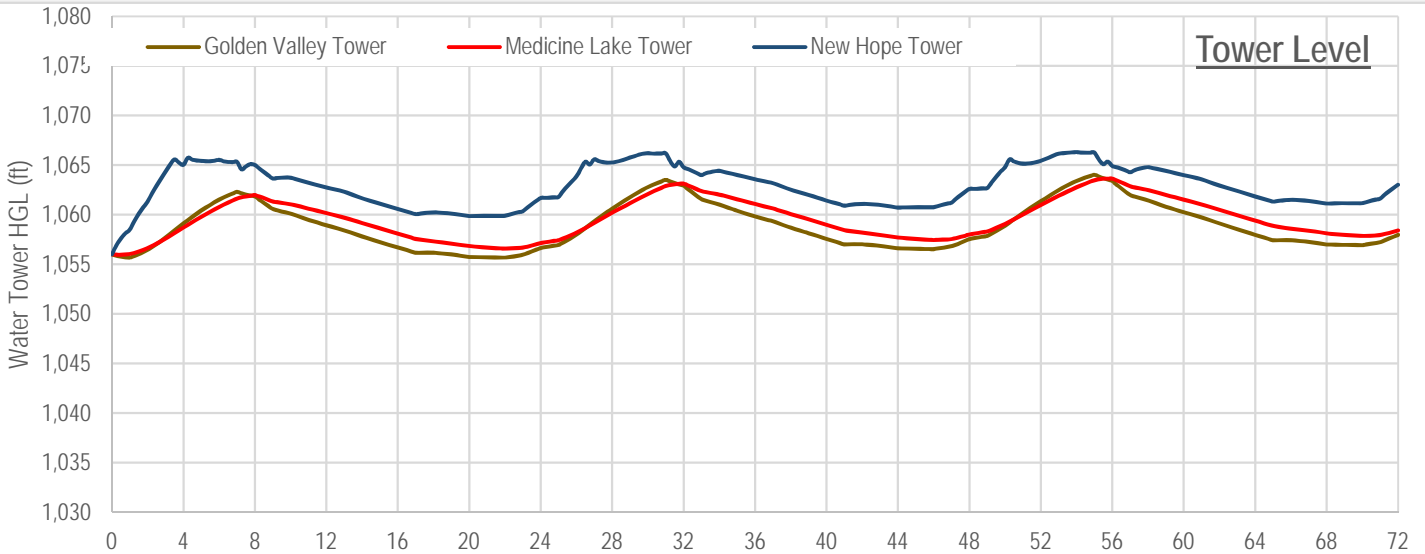
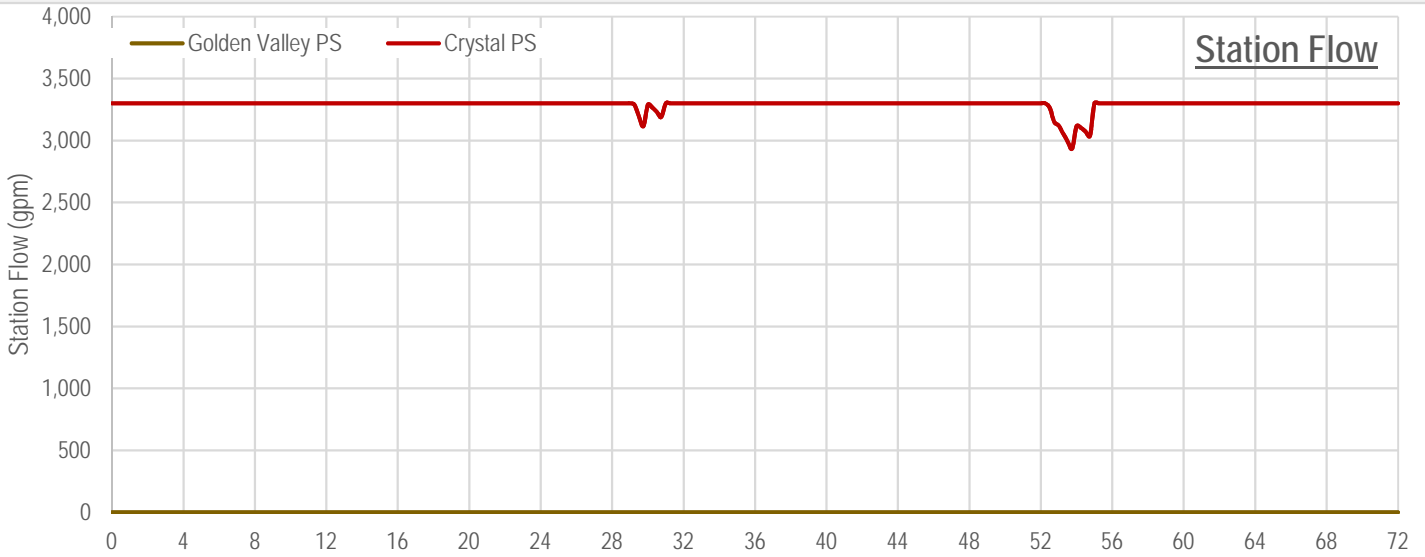


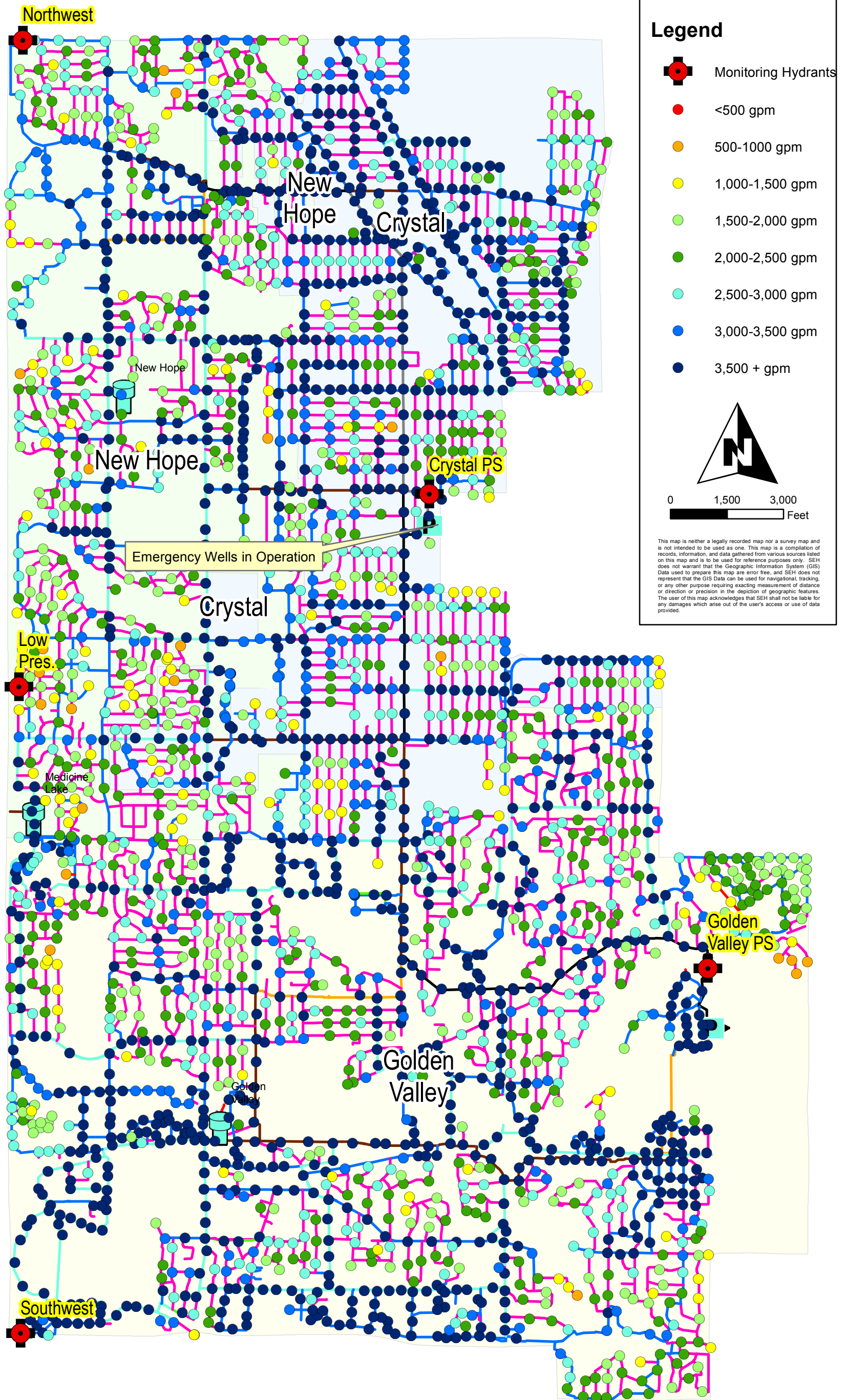
A3.1 - Golden Valley PS Offline -72 Hour ASD EPS Operation



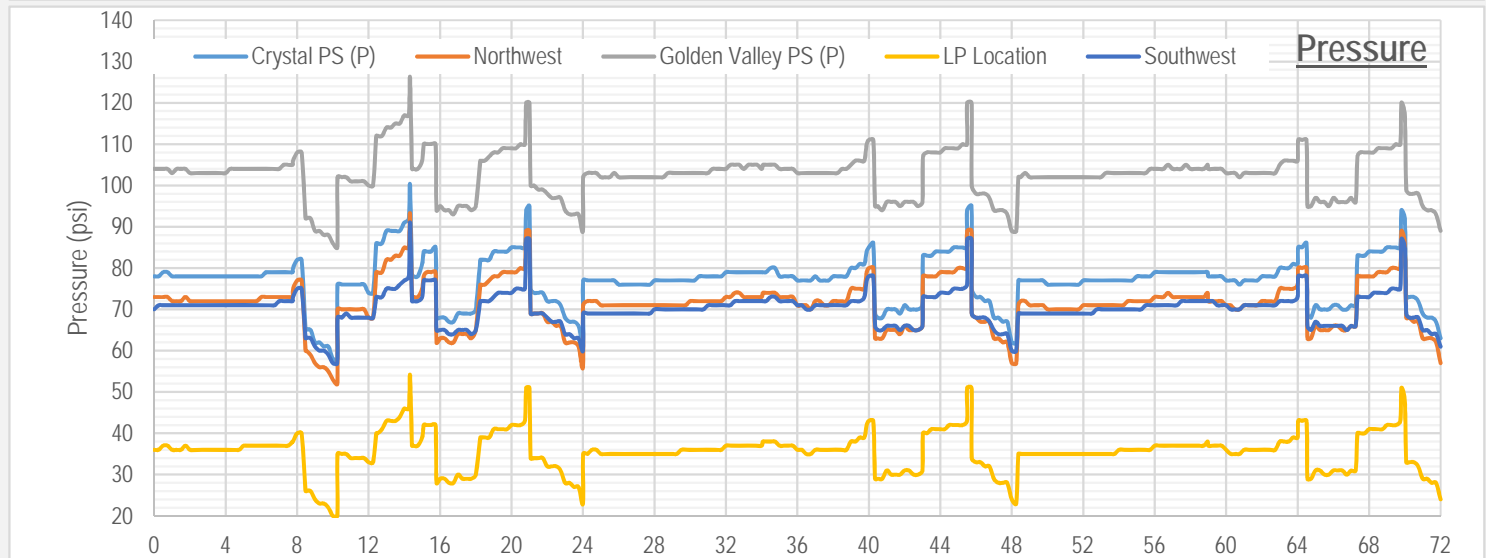
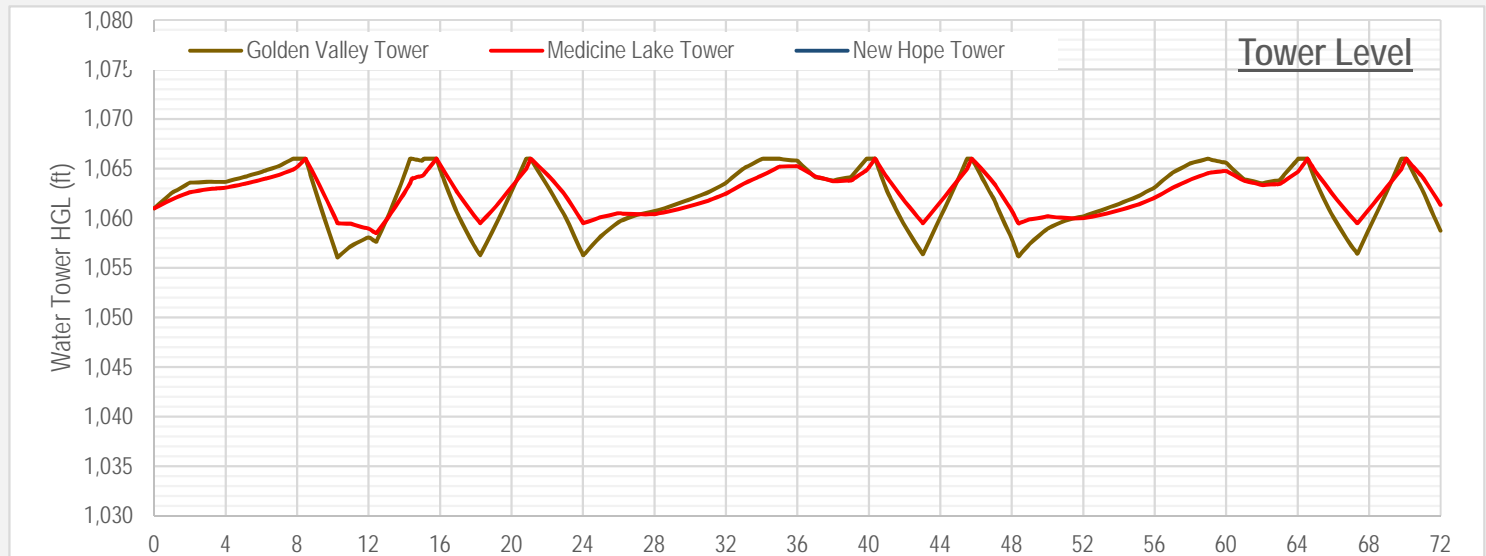
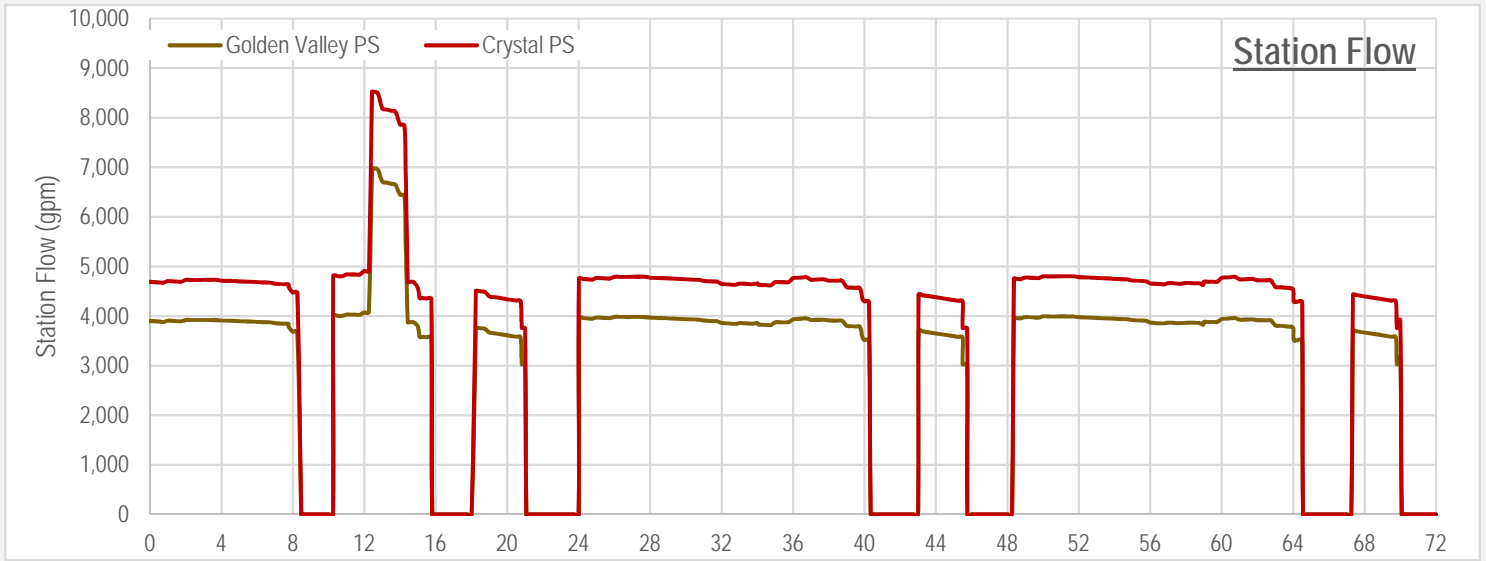


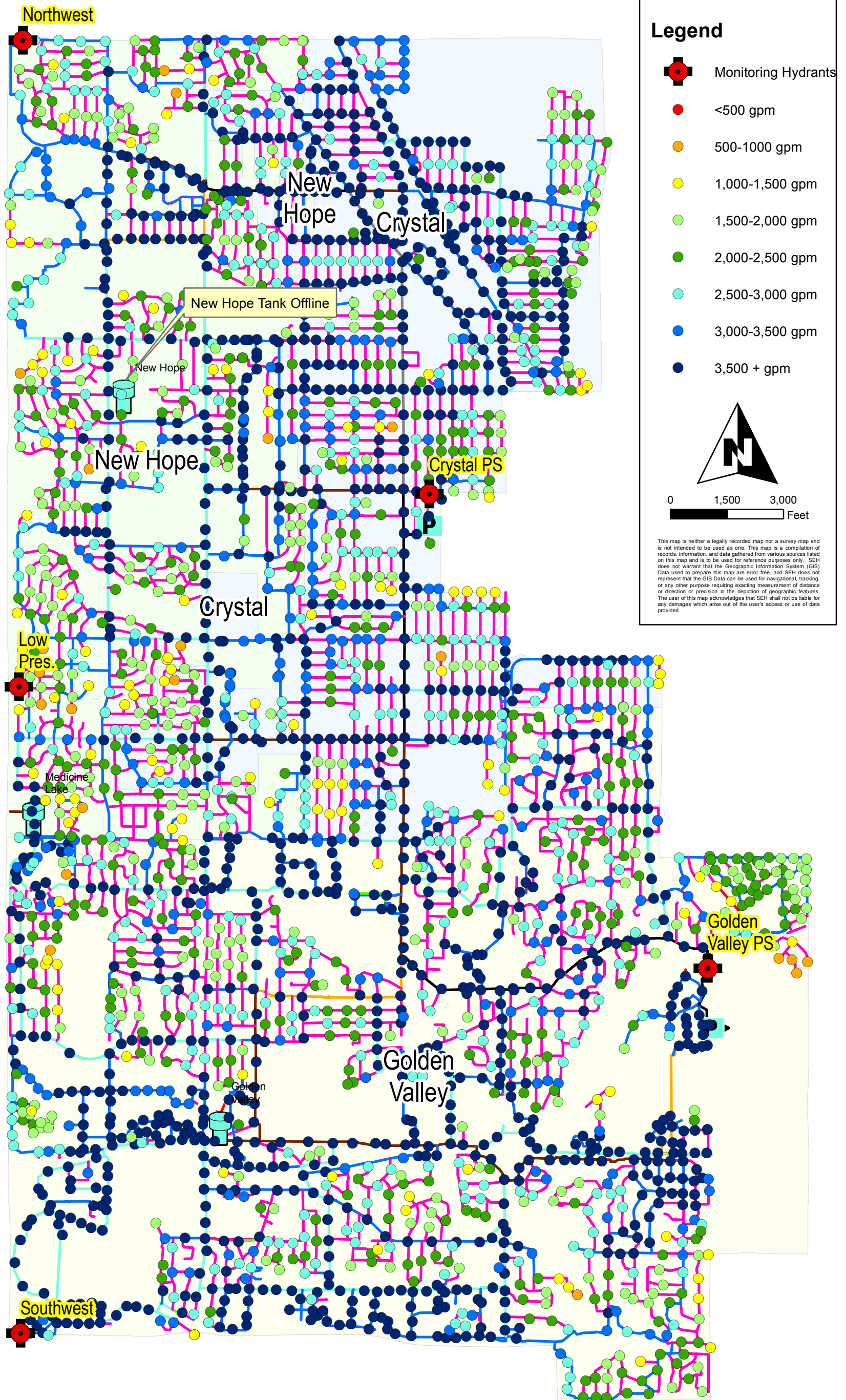
A4.1 - Emergency Wells in Operation - 72 Hour ASD EPS

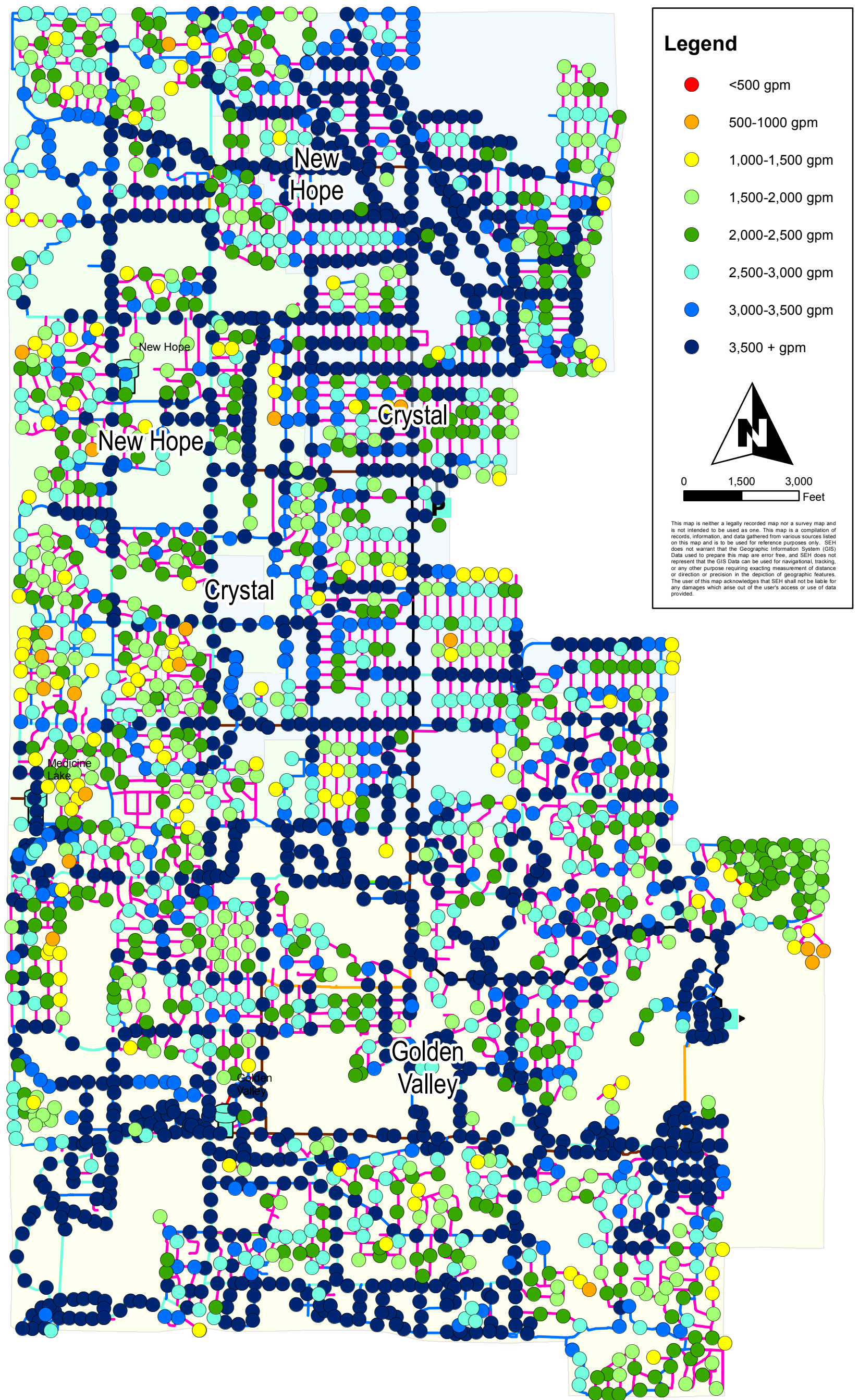




A5.1 - New Hope Tank Offline - 72 Hour ASD EPS Operation









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We're confident in our ability to balance these requirements.

