Water System Reliability Study

Spring Lake Township WSSN #MI006235
City of Ferrysburg WSSN #MI002285
Village of Spring Lake WSSN #MI006230
Crockery Township WSSN #MI001664

Prepared for

Ottawa County Road Commission
Ottawa County, Michigan

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Contents

EXECUTIVE SUMMARY

This report represents the five year update of the NOWS-Northside Water System Reliability Study. Based on the three primary components of the water distribution system (the water treatment plant, the water distribution system (pipe), and the storage requirements), the following conclusions could be made:

- The water supply has met the regulations for microbiological, radioactive, inorganic and volatile organic contaminants.
- The existing supply capacity is adequate for Year 2037 water demands and further into the future. Maximum Day demands represent 74% of the allocated supply capacity for the Northside communities.
- The transmission and distribution system is adequate for the four customer communities. NOWS provides adequate water supply for normal (non-emergency) system conditions and meets emergency supply goals.
- NOWS-Northside communities intend to provide fire protection to all customers. For non-residential customers, a fire flow equivalent to 3,500 gpm for 3 hours is the goal and for residential customers 1,000 gpm for 2 hours is the goal. Spring Lake Township, the City of Ferrysburg, and the Village of Spring Lake provide storage to meet these goals. Crockery Township provides storage up to 2,000 gpm for 2 hours for customers (limited due to funding constraints during construction). Specific distribution and transmission system improvements have been recommended for improved fire protection in some areas of the system.
- Unbilled water for the NOWS Northside communities has been gradually increasing over the past 4 years and is currently about 12 percent of the volume purchased. Communities should track known, unbilled water volumes to better determine whether a significant volume of water is unaccounted for, requiring further investigation.

1 INTRODUCTION

The Northwest Ottawa Water System northside communities (NOWS – Northside) include Spring Lake Township, the City of Ferrysburg, the Village of Spring Lake, and Crockery Township. NOWS also supplies the City of Grand Haven and Grand Haven Charter Township to the south; however, these communities are not included in this analysis.

The NOWS water system is located in Ottawa County on the shore of Lake Michigan and relies on Lake Michigan surface water as the source of its drinking water. The water system as a whole has two submerged intake structures and a direct water treatment facility in the City of Grand Haven. The treatment plant pumps water through two transmission mains to the NOWS-Northside communities of Spring Lake Township, Ferrysburg and the Village of Spring Lake. Crockery Township obtains water from transmission mains on the eastern side of Spring Lake Township and pumps to their own pressure district. This Reliability Study addresses the NOWs-Northside communities only. The service area and existing system layout is shown in Figure 1 and on the General Plan (Figure 5).

The purpose of this report is to provide a reliability study of the NOWS - Northside water system for Ottawa County Road Commission, which in turn is intended to fulfill specific requirements of Part 12 and Part 16 promulgated under Michigan's Safe Drinking Water Act, 1976, P.A. 399, as amended. The Act calls for a 20-year projection of water demands and an evaluation of each of the system components on a 5-year interval.

2 WATER DEMANDS

The Northwest Ottawa Water System northern communities of Spring Lake Township, the City of Ferrysburg, the Village of Spring Lake, and Crockery Township obtain Lake Michigan water from the City of Grand Haven through two master meters. Water is distributed to all residents within the service area through a network of distribution main. Each community maintains their own system with the exception of Crockery Township which is maintained by the Ottawa County Road Commission. Land use within the NOWS Northside service area is primarily residential, with a small commercial area and industrial area. A customer class usage summary is presented in Table 1.

Historic water supply data for the service area is shown in Table 2 in the form of Monthly Meter Supply Volumes for 1997 to 2016. Data includes: average day demand, which is the metered average

daily water use for the year and maximum day demand, which is the metered highest daily use for the year.

Water system demands were projected through Year 2037 based on historic data and the percentage population growth expected in the communities served. Population Projections are provided in Table 3 and Figure 2. Figure 3 graphically shows the historic and projected water system customers. The historical and projected demands are shown graphically in Figure 4.

Demands were projected and probability ranges determined for each demand condition. The average day demand for Year 2017 is estimated to be approximately 2.46 million gallons per day (mgd) based on the recent historic maximum. The breakdown for each community is provided in Table 4.

The maximum day demand is estimated at approximately 2.7 times the average day water use over the past 5 years. The projected maximum day demand is 6.64 mgd, 6.70 mgd and 6.77 mgd for years 2017, 2022 and 2037, respectively.

Actual peak hour water use is not metered and can vary significantly. Peak hour demands were estimated to be 5 times the average day demand based on data from similar communities.

3 WATER SUPPLY SOURCE

Water supplied to the NOWS communities is collected from Lake Michigan through two intake structures that are adjacent to the water treatment facility in the City of Grand Haven. Lake Michigan water is obtained via two infiltration beds each consisting of slotted pipe in a 240 foot by 260 foot gravel bed below the lake bottom. Due to the infiltration beds, Lake Michigan is a high quality water source with low turbidity as it enters the plant.

The treatment facility has a capacity of 23.25 mgd to supply the NOWS-Northside system, the City of Grand Haven, Grand Haven Charter Township and Robinson Township. The intakes have a capacity of 14 mgd each and the low lift pumps have a capacity of 25.9 mgd.

Customers within the NOWS Northside service area are supplied from the filtration plant in the City of Grand Haven through two meter stations located at Pine Street near US-31 and at North Shore Drive at the City Boundary. As summarized in Table 5, the two meters each have a capacity of approximately 5,000 gpm. Water flows through the check valves at the two metering stations into the NOWS Northside distribution system. The distribution system is maintained by each community except Crockery Township, which is maintained by the Ottawa County Road Commission.

3.1 Contract Capacity

The collective capacity allocation of the NOWS Northside Communities is 9.16 mgd, representing 39 percent of the total NOWS Contract Capacity of 23.25 mgd. Spring Lake Township, Ferrysburg, and the Village of Spring Lake have allocations of 6.7 mgd, 1.14 mgd, and 1.33 mgd, respectively. The NOWS contract, however, does not limit use based on financial capacity.

There are three contracts associated with the NOWS Northside Communities. These include the 2000 Interim Financial Agreement, the 2006 Restated Contract, and the 2009 Bond Contract. These are available upon request.

4 WATER SYSTEM INFRASTRUCTURE

4.1 Storage Facilities

The NOWS Northside system contains three elevated storage tanks – one in Crockery Township and two in Spring Lake Township – and the entire NOWS system relies on a ground tank within the City of Grand Haven to provide storage. Spring Lake Township has a one million (1,000,000) gallon tank located at 150th Avenue and Cleveland Street with an overflow elevation of 752 feet. Spring Lake Township has a second elevated storage tank on VanWagoner Road and west Spring Lake Road with a capacity of 500,000 gallons and an overflow elevation of 752 feet. The third elevated tank is located in Crockery Township at 120th Avenue north of Cleveland Street. This tank has a capacity of 200,000 gallons with an overflow elevation of 742 feet. Tank data is summarized in Table 6. Each of the elevated tanks is shown in Figure 6 along with a hydraulic grade line.

4.2 Water Distribution Mains

The NOWS Northside Water System is a complex network of water mains providing transmission and distribution to the NOWS Northside service area customers. The service area covers over 25 square miles and is supplied through a water distribution network consisting of approximately 182 miles of water mains ranging from 4 to 24 inches in diameter. A 20-inch diameter transmission main runs primarily along North Shore Drive and 174th Avenue, and a 16-inch diameter main which feeds the elevated tank off of VanWagoner Road. A second 24-inch transmission main crosses under Spring Lake, from Grand Haven, and continues through the Village of Spring Lake to Fruitport Road. An approximate breakdown of the water mains by size is presented in Table 7.

The distribution system for the Village of Spring Lake was originally constructed on the 1920's. The system consisted of small diameter pipes and was supplied from wells. The water distribution systems for Spring Lake Townships and the City of Ferrysburg were constructed in 1976. In 1989, the Village of Spring Lake began purchasing water from NOWS. The village obtained water through several connections with the 24-inch main that crosses through the village.

The distribution system for Crockery Township was originally constructed in 1984. The system capacity was limited by funding agency requirements and economics, which resulted in a maximum pipe size of 12-inch.

An estimate of water main material for all communities is given in Table 8. A breakdown of water main age is provided in Table 9.

The NOWS-Northside system has made the following water distribution system improvements since 2009:

1. Spring Lake Township - Arcadia Development distributions system off of 148th Street.
2. Crockery Township - Transmission connector and distribution mains for Hathaway Lakes Development.

4.3 Meter Stations

The NOWS Northside currently obtains water through two metering stations ~~from NOWS~~. The meter stations are located at Pine Street near US-31 with a capacity of 5,000 gpm and at North Shore Drive at the City Boundary with a capacity of 5,000 gpm.

Crockery Township obtains water from Spring Lake Township. There are two additional meters located between the Townships with capacities of 2.9 mgd and 1.1 mgd. Meter data is provided in Table 4.

5 WATER SYSTEM ANALYSIS

5.1 Water Storage Analysis

5.1.1 Existing System

Ten State Standards states in Section 7.01: "Storage facilities should have sufficient capacity, as determined from engineering studies, to meet domestic demands and where fire protection is provided, fire flow demands". Presently, there are three storage tanks within the NOWS Northside Water System with a capacity of 1,700,000 gallons.

While no requirements exist for fire protection, the Insurance Services Office typically rates residential customers with a fire flow of 1,000 to 1,500 gpm, and industrial customers with a fire flow of 3,500 gpm, depending on the industry and building, for full insurance credit. No additional storage is necessary at present to meet these recommended protection standards.

The storage analysis reflects a system-wide approach to providing adequate capacity and storage to customers. With the NOWS Northside community's desire to provide fire protection to customers, a common practice is to determine the storage needs based on maximum daily demands, maximum hourly demands and fire demands. An analysis was performed for these demand scenarios with consideration for the capacity of the meter stations. Table 10 shows the results, which indicate that under Year 2017 Demands, the Township can provide up to 3,500 gpm of fire demand for a three-hour duration from an approximate allotted 1.7 million gallons of storage.

A separate analysis was performed for Crockery Township since this system operates as separate pressure district. There is no direct transmission from the NOWS Water Treatment Facility to Crockery Township but instead are two connections to the east side of the Spring Lake Township system. Crockery Township has a lower storage volume of 200,000 gallons. With the supply capacity available through two meters, the available fire flow provided to customers is approximately 2,000 gpm for 2 hours. Results are presented in Table 11.

5.1.2 Future Conditions

The system-wide storage was analyzed for Year 2037 demand projections. The analysis assumes the supply capacity equals the existing firm metered capacity.

Table 10 projects the storage capacity and needs through Year 2037. With an allotted 1.7 million gallons of storage for the entire NOWS Northside, the existing storage tanks provide normal demand (equalization) storage plus 3,500 gpm of fire demand volume for 3 hours through the Year 2037. The results indicate that no additional storage is necessary,

Crockery Township has adequate storage for the residential fire suppression and for non-residential customers up to 2,000 gpm for 2 hour through Year 2037. The township could consider additional elevated storage if requested by customers; however, this could have a negative impact on water quality.

Based on the available supply, no additional storage is recommended for the NOWS - Northside system.

5.2 Distribution System Analysis

The NOWS - Northside Water Supply System network was analyzed using the water distribution software WaterCad v8i. This software combines the ability to perform complex hydraulic computations and the ability to present results in a graphical format through its interface with AutoCad. Model input data consisted of the following: lengths, sizes, and roughness factors (Hazen-Williams coefficients) for pipes, ground elevations and demands for nodes, and storage tank elevations and volumes.

5.2.1 Model Development

A hydraulic model was developed to reflect recent water system improvements. Demands were updated to represent existing demands and future projections.

To calibrate the model, hydrant testing results were used. A hydrant flow test measures the transmission capabilities of a system by measuring and comparing the static pressure at a given location under typical conditions and the residual pressure at that same location for a given hydrant flow. The test data provides information for model calibration; that is, model parameters can be adjusted so that predicted results compare favorably to measured results. In addition, the test data can provide information to determine locations at which a valve might be partially closed, or locations at which an unknown connection could exist.

The individual communities along with Prein&Newhof personnel performed fire hydrant flow tests on March 8-9, 2017 and May 8, 2017. The results of these tests are shown in Table 12. The tests were performed at a variety of locations dispersed throughout the system and provide data to adjust roughness coefficients and demands to simulate results.

Using the hydrant test data, the model was calibrated as follows:

- Simulate system conditions using initial assumptions for parameters
- Adjust water main roughness coefficients and system demand distribution
- Perform a sensitivity analysis on adjusted results
- Fine tune results based on previous steps

Table 13 compares the calibrated model results at the nearest model node to the field test results at the test hydrant sites.

The model reasonably simulates most of the hydrant test results. Static pressures are within 4 pounds per square inch (psi) and 10 percent of the projected fire flow at all hydrant test locations. Residual pressures are within 4 psi at all locations. In general, the calibration results are relatively accurate. Given that hydrant model simulations cannot account for fluctuations in demands, the calibration results are considered reliable.

5.2.2 Existing System

Using the calibrated model of the existing system, simulations were performed for various demand conditions. Resulting pressures were reviewed to determine the adequacy of the system under high demand. Pressures during non-emergency conditions should not fall below 35 psi, nor should pressures in the system exceed approximately 80 psi.

The available fire flow is often the hydraulics standard by which a system is measured since that is typically the highest demand experienced. Typically, the available fire flow represents the flow available at a given location without creating a low pressure problem anywhere in the system. The minimum system pressure which should be maintained at all times is 20 psi.

Table 14 presents simulation output for existing conditions, providing the results for average day and maximum day pressures and the available fire flow. The locations shown represent a cross-section of areas across the service area as well as critical areas and noted areas of concern.

Results indicate that pressures are adequate throughout the system. The model results show that the system transmission capacity is adequate; however, in some areas, the available fire flows are less than suggested due to undersized distribution main. The 6-inch mains, particularly those with dead ends, restrict the available fire flows to some locations in the system.

Pressures are greater than the desired 35 psi in all locations. As stated above, some areas served by older 6-inch diameter and smaller mains cannot achieve the recommended minimum fire flow of 1,000 gpm for residential areas.

Appendix C includes output of the model results.

5.2.3 Future Conditions

Using the model, simulations were performed for Year 2037 conditions to determine where improvements to the existing infrastructure may be needed. All water main Hazen Williams coefficients were reduced by 5 to simulate aging. Resulting pressures and available fire flows were reviewed to determine the adequacy of the existing system under future demands.

Table 15 provides a summary of model results with Year 2037 demands and the existing infrastructure. The results indicate that pressures would again be adequate, but the available fire flows will be further reduced from existing fire flow capabilities because of the additional demands on the system from the projected growth of the service area over the twenty year period. As a result, potential improvements were analyzed to improve the fire protection in the deficient locations.

5.2.4 Distribution System Improvements

Based on the results of the existing system analysis with future demand projections, improvement alternatives were considered. These alternatives were then selected and prioritized based on the most cost-effective recommendations to enhance fire protection and overall service. Areas with less than recommended fire flow are included on Figure 5.

The potential improvement alternatives may also require wetland permits or critical dune permits in some cases. The communities would need to work with the Michigan Department of Environmental Quality (MDEQ), and in some cases, a field investigation may reveal that the proposed project is not feasible.

Each of the following alternatives provides improved reliability flow to the system.

5.2.4.1 Transmission for Improved Reliability

Spring Lake Township, Spring Lake Village and Crockery Township have several transmission main improvements that should be considered for the long-term planning of reliability. These improvements focus on providing improved system hydraulics and redundancy of transmission.

An additional transmission main could be constructed under the Lloyds Bayou which would provide transmission from Spring Lake Township to the Village of Spring Lake. If

the Bayou is crossed, both the Village and Township will be benefit from the improved system hydraulics and additional redundancy. The benefit is even greater when the main is extended to a transmission main - to Pruin Street in the Township or River Street in the Village. In the longer term, the transmission main should be extended through the Village to the existing 24-inch transmission main, perhaps up Lake Avenue.

There is one primary transmission main that serves Crockery Township customers, including those in Nunica. A second transmission main should be included in the long-term for reliability purposes.

A new main was considered connecting the transmission mains for the two meter stations for Crockery Township. While the specific location could be modified based on development, the route recommended is along 136th Avenue and Leonard Road as shown on the Crockery Township Map.

Another long-term another transmission main could be constructed on State Road for reliability of supply into Nunica and the eastern portion of the Township water system. This includes a main from the dead end just east of 130th Avenue to the dead end just west of 112th Avenue.

5.2.4.2 Loop Distribution System Improvements for Improved Fire Flows and Water Quality

There are many distribution mains that are considered undersized according to current standards. These dead ends are where water can become stagnant. Many of these mains were constructed during a time where there were no guidelines or fire flow requirement. If possible, these distribution mains should be looped to remove potential water quality issues, as well as increase fire protection. Many of these areas of deficiency are shown on Figure 5.

5.2.4.3 Replace Small Distribution Mains for Improved Fire Flows

Since many of the distribution mains were constructed before the introduction of guidelines or requirement for fire flow, there are areas that do not provide the suggested fire flow due to small diameters. For various reasons, there are areas that are not easily looped. These mains should be replaced with a larger diameter pipe. This should be

considered when construction is planned on such streets. A listing of some of these locations is provided with the recommendations.

These transmission improvement recommendations are provided in Figure 5. Model simulations were performed with all of these potential improvements included. Simulation results with all the recommended improvements for Year 2037 demands are summarized in Table 16.

Results show that the available fire flows throughout the system meet the general suggestions for fire protection.

6 RELIABILITY ISSUES

6.1 Redundancy

6.1.1 Water Transmission within the System

It is important that this transmission system has adequate redundancy via looping from the north to south side of the water system, and from east to west in case of an emergency such as a water main break. Adequate transmission main exists throughout the served communities.

One concern is the 20-inch lake crossing from Spring Lake Road to Oakwood Drive. Many years ago, this main may not be bedded properly and the NOWS Northside communities have been concerned about the condition and reliability of the main. An evaluation was completed to determine the impact on the system if this transmission main were not in service. Results show that the water system hydraulics change is negligible under normal demand conditions. During emergency conditions such as a fire, the system pressures remain similar depending on the needed fire flow; however, the available fire flows do not drop below 500 gpm anywhere.

A 20-inch crossing could be constructed to the north to maintain system hydraulics under all conditions. Alternatively, another condition assessment with potential repairs could be a more cost effective approach to ensure the reliability of supply to customers east of the crossing.

6.1.2 Storage

The NOWS-Northside currently maintains three (3) elevated storage tanks. There are currently two storage tanks in Spring Lake Township, a million gallon tank is located at 150th Avenue and Cleveland and a 500,000 gallons tank located at VanWagoner Road. The third tank is

located in Crockery Township at 120th Avenue north of Cleveland Street and has a capacity of 200,000 gallons. The existing 1.7 million gallons of storage for the water distribution system is sufficient to provide reliable storage for customers.

6.1.3 Meter Stations

Currently, there are two meter stations supplying water from the City of Grand Haven to the NOWS – Northside water system. The meter located on Pine Street near US-31 in Ferrysburg has a capacity of 5,000 gpm (7.2 mgd). The other meter is located on Norton Shores Avenue and the City Boundary in Ferrysburg. This meter also has a capacity of 5,000 gpm (7.2 mgd).

6.2 Emergency Interconnects

For additional reliability, the water system has five emergency interconnects in addition to the two metering stations. The NOWS-Northside has three emergency interconnects with Norton Shores and two with Fruitport Township. These interconnects are supplied through Spring Lake Township. The emergency interconnect can be utilized to provide additional supply volume and pressure if an emergency should occur. Table 17 provides details on the emergency interconnects.

6.3 Deteriorating Mains

As mains in the NOWS - Northside water distribution system begin to age and deteriorate, they should be replaced. The Village of Spring Lake has many older, small diameter mains. The Village should continue replacing old distribution mains. These mains should be replaced during other street and utility projects.

6.4 Fire Insurance Classification

The Insurance Services Offices (ISO) classifies water systems on a periodic basis. Insurance companies may use this information in calculating property insurance premiums. The ratings are based on fire protection equipment, operations, and availability of water at hydrants. Ratings range from 1 to 10, with 1 being the best and 10 being the worst. A score of 5 (or less) will provide the lowest insurance for residential customers. All the communities in the NOWS-Northside have had independent analyses of their water system. The results follow:

- The last insurance rating for Spring Lake Township was completed in December of 1989. The township received a rating of Class Six (6) and was not close to receiving a Class 5

rating. However, the township may wish to request an evaluation by the ISO due to the amount of time since the last evaluation.

- The City of Ferrysburg most recently received a very good rating of Class Five (5) in the June 2014 report. This reflected an improvement from the Class 6 determination in 1993.
- The Village of Spring Lake received a Class Six (6) rating during their last evaluation. The Village has a volunteer fire department, which reduces their score. Due to the volunteer fire department, significant improvements would be required to the water system hydraulics to improve to Class 5.
- The insurance rating for Crockery Township was completed by the ISO in December 2017. The water system Public Protection Classification was Five (5), which represents the best rating for residential customers.

6.5 General Maintenance

Spring Lake Township, the City of Ferrysburg and the Village of Spring Lake each maintain their water system. The Ottawa County Road Commissions maintains the Crockery Township water distribution system. The metering stations are calibrated by the Ottawa County Road Commission. General maintenance of equipment and facilities enhances overall system reliability.

7 RECOMMENDATIONS FOR IMPROVEMENTS

The following categories of improvements to the NOWS – Northside water system were used to prioritize the recommended system improvements.

Improvements to Address Problems with Existing Infrastructure

- Comply with Federal and State Regulations
- Improve general level of service
- Improve redundancy of transmission

Improvements Required to Expand Service for Projected Growth

- Improvements to existing infrastructure to serve new areas
- Improvements which would enhance the level of service

Recommendations have been separated into projects and general improvements based on the above criteria and demand projections. The existing infrastructure provides an adequate quantity and quality of water to customers. Recommendations developed herein are intended to improve the overall supply but are not urgent. All recommended projects are presented in Figure 5.

7.1 Recommended Projects

7.1.1 Short-Term (0 to 5 Years)

Project 1: Consider providing second Lake Crossing or repairing existing 20-inch Lake Crossing that is kinked and may not be bedded properly.

Project 2: City of Ferrysburg – Install (2) 16-inch valves on Van Wagoner 16-inch water main to allow isolation of the watermain at U.S. 31.

7.1.2 Longer-Term (5 – 20 Years)

Project 3: Crockery Township – Construct 5,000 feet of 12-inch main on Cleveland Street from 144th Avenue to the existing 12-inch main east of 136th Avenue.

Project 4: Crockery Township - Construct 11,500 feet of 12-inch main on State Road, from dead end east of 130th to dead end west of 112th Avenue, and 1,800 feet of 8-inch main on Apple from the dead end to State Road (15-25 years).

Project 5: Crockery Township - Construct 7,200 feet of 12-inch main on 136th, from Cleveland south to Leonard Road and west to dead end (5-15 years).

Project 6: Spring Lake Village and Township – Construct 2,100 feet of 12-inch main on Leonard Rd across Lloyds Bayou, from Pruin Street to Lake Ave (15-25 years).

Project 7: Spring Lake Township – Construct 8-inch water main (loop) to Lake Hills Elementary School (5 – 15 years).

7.2 General Recommendations

7.2.1 Construct Sections of Transmission Main

At present, there are several sections of transmission mains that could be added to complete the transmission system looping. In addition to projects 2, 3 and 4 previously discussed, the following transmission improvements are recommended for construction:

a. Spring Lake Village – Extension of Project #4. Construct 12-inch transmission main from Lake Avenue and Leonard Road to the 10-inch main on River Street (various possible routes; 5-15 years). In the very long term, this main could be extended even further north to the 10-inch main north of Savidge at Railroad Avenue.

7.2.2 Loop Dead End Mains

Whenever possible, dead end mains should be looped. Water tends to become stagnant in dead end mains, often affecting the quality of water provided to nearby customers. Closing dead end mains with loops improves the circulation of water and adds reliability. Additionally, removing dead ends will improve fire protection by providing a second supply route for distribution to the area.

There are a significant number of streets with dead ends mains which should be looped when possible. Some locations with dead end mains include the following:

a. City of Ferrysburg – Spahr Avenue (1,000 feet of 8-inch main to Lavina Street)

b. Spring Lake Township – North Shore Estates Road (3,000 feet of 8-inch main to Cree Court)

c. Spring Lake Township – Tomahawk Court (1,100 feet of 8-inch to Hoffmaster Drive)

d. Spring Lake Township – Highland Drive (700 feet of 6-inch main to Judson Road)

e. Spring Lake Township – Along south shore of Spring Lake (2,500 feet of 8-inch main)

f. Spring Lake Township – Concord Drive (380 feet of 8-inch main to Pruin Street)

g. Spring Lake Township – Leonard Road (520 feet of 8-inch main to Vinecrest Court)

h. Spring Lake Township – Connelly Avenue (340 feet of 8-inch main to Oakwood Drive)

i. Spring Lake Township – Fruitport Road (800 feet of 8-inch main to Pinecrest Lane)

j. Spring Lake Township – Reitsma Lane (230 feet of 8-inch main to State Road)

k. Spring Lake Township – Howard Street (450 feet of 8-inch main to Linn Court)

l. Spring Lake Township – 168th Avenue (1,400 feet of 8-inch main to Wilson Road)

m. Spring Lake Township – Highland Drive (500 feet of 8-inch main to Spring Lake Road)

n. Crockery Township – Cleveland Street (2,200 feet of 8-inch main along Grand Trunk Railroad Row)

o. City of Ferrysburg – Dead end of Peppermill Drive (650 feet of 8-inch main to the dead end of Jordan Lane)

p. City of Ferrysburg – Dead end of Maple Street (350 ft of 8-inch main to 2nd Street)

7.2.3 Replacing Dead End Mains

When looping is not possible, it is suggested to replace the dead end mains with a larger diameter pipe to increase fire flow. Some locations with dead end mains that should be replaced include the following:

a. Spring Lake Township - Construct 8" water main on Tall Pine south of Judson Road

b. Crockery Township - Construct 1300 feet of 8" water main on South Street, east of Main Street

7.2.4 Reliability Study

Update the Water System Reliability Study within five years. Given the uncertainty of growth, demand projections should be reviewed periodically.

7.2.5 Valve Exercising Program

Spring Lake Township currently exercises valve, but there is no specific program or set schedule. All valves are turned either annually or bi-annually. The City of Ferrysburg exercises 112 of the 224 valves annually. The remaining communities do not have a valve exercising program.

Valve exercising enhances the reliability of the system and improves public protection. Each of the communities should develop a valve exercising program that includes turning each valve at least every second or third year. A record of the valves should be tracked. These valve records should include valve number, location, type, normal operating status (open or closed), condition (operable or inoperable), direction of turn, number of turns, and dates of operation.

7.2.6 Water Accountability Plan

The Ottawa County Road Commission calculates unbilled water data annually for the NOWS Northside Communities. Master meters are used to track a combination of the flow provided to the communities. Some unbilled sources of water use include main leakage and breaks, water used during emergencies, flushing, street sweeping, and filling swimming pools. Historical annual water loss data for the past five years is presented in Table 17 and Figure 7. Average unbilled water loss over the past four years is approximately 10.6 percent. Sources of known, unbilled water should be tracked to determine whether the unaccounted-for water is excessive.

- Spring Lake Township: The township has an average water loss of about 10.5% for the past 4 years.
- City of Ferrysburg: Over the past 4 years, the city has an average water loss of 9.8%.
- Village of Spring Lake: The Village of Spring Lake has had an average water loss of 10.9% over the past 4 years.

- Crockery Township: Crockery Township has averaged a water loss of 11.3% over the past 4 years, but in the last two years, it had an average only 2%.

Continuous tracking and development of the program is recommended as results may signal whether a source of lost revenue exists and may ultimately help identify the source. The communities should estimate and account for known, unbilled water use. If unbilled, lost water remains high, the communities should evaluate potential sources and potentially perform leak detection to address high percentages of unknown water usage.

7.2.7 Meter Testing Program

Currently, Ottawa County calibrates the master meters on an annual basis. Calibrating the meters is critical to ensuring the correct flow calculated so customers are not overcharged. Individual communities replace the meters instead of recalibrating them. Each community has a different non-formal program.

- Crockery Township started a meter replacement program 2 years ago. All old meters will be removed and replaced with radio-read meters by approximately 2018.
- Spring Lake Township completed their meter replacement plan. All residential meters are being replaced with Sensus meters.
- The Village of Spring Lake is in the middle of a 10-year meter replacement program.
- The City of Ferrysburg has replaced all meters to radio read style meters.

The NOWS - Northside communities should consider developing a systematic program to help maintain accurate customer billing and to maximize system revenue. The recommended testing/calibration/change-out period for commercial meters is every three years, and ten years for residential meters.

7.2.8 Flushing Program

Hydrants are inspected annually by each community. Flushing of hydrants also occurs annually in the summer or fall. The communities should continue its maintenance and flushing program and make modifications based on the effectiveness.

Hydrant flushing is important for the reliability of the hydrants and for improving the overall quality of the water supplied. The communities in NOWS-Northside should consider creating a program for uni-directional flushing for each hydrant at least once per year in the Fall or Spring.

7.2.9 Cross-Connection Program

The NOWS - Northside communities' water systems each have a formal, documented cross-connection program in place and each submits an annual report. Crockery Township has hired HydroCorp™ to meet program needs. The communities should continue with the program and make improvements as needed to remain in compliance.

7.2.10 Replace Older, Deteriorating Mains

The distribution system for Spring Lake Township, Crockery Township and the City of Ferrysburg is relatively new, being constructed in the 1970's. However, as the mains age and begin to deteriorate, they become a hydraulic restriction within the water system. The communities should replace deteriorating distribution mains when necessary, and when it can be done in conjunction with other street and utility projects.

There are a significant number of streets with deteriorating mains which should be replaced when possible. Some locations with deteriorating mains include the following:

4a. City of Ferrysburg - The water main and service connections on Willow Street needs to be replaced due to corrosion.

4b. Village of Spring Lake - All the 4-inch and 6-inch main that was installed before 1940. Efforts should continue to replace all old distribution mains and deteriorating mains.

8 COST ESTIMATES

An Opinion of Project Costs has been prepared for each element of the project. Costs for projects of similar size and scope that have been constructed in western Michigan were reviewed for relevant information.

The Cost Opinions have been prepared including an allowance of approximately 25% above the estimated construction cost. This allowance is intended to include the cost of construction contingencies (issues which are presently unknown), legal fees, engineering design and construction

services (including preliminary and final design, soil borings, topographic survey, bidding assistance, construction staking, compaction testing, construction inspection and project administration during the entire project) and administrative expenses related to the project.

It has been assumed that land is available for construction of the described improvements. No provision has been made in the cost estimate for cost of land or right-of-way purchase or easements.

Cost Opinions for recommended projects are included in Tables 18A-19D.

Appendix A

Tables

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Table 1 - Customer Class Summary

Spring Lake Township						
Type	Number of Connections	Billed Usage (thousand gallons)				
		2012	2013	2014	2015	2016
Residential	3,684	302,550	278,417	268,237	289,659	321,930
Commercial	92	15,236	14,914	15,488	19,307	19,682
Industrial	72	76,927	68,013	81,991	83,532	96,340
Church & State	18	7,970	6,579	5,682	5,617	6,905
Government	6	374	629	541	461	671
MU/CO		7,763	7,616	7,213	15,813	8,740
MU		31,688	31,273	29,445	41,316	40,026
Total		442,508	407,441	408,597	455,705	494,294
City of Ferrysburg						
Residential	1333					38,592
Commercial	57					5,523
Industrial	23					1,063
Government	17					4,695
Total	1430					49,873
Spring Lake Village (annual average from 2012-2017)						
Residential		16,917				
Commercial		40,741				
Total		57,658				
Crockery Township						
Residential	609					
Non-residential	37					
Total	646					

*Units are in 1,000 gallons.

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Table 2 - Historic Water Supply Data

Year	Spring Lake Township (MGAL)	City of Ferrysburg (MGAL)	Spring Lake Village (MGAL)	Crockery Township (MGAL)	Avg Day Demand (MGD)	Max Day Demand (MGD)
1997	414.59	114.41	139.19	21.8	1.89	5.10
1998	532.41	133.01	149.94	27.74	2.31	6.24
1999	554.89	127.97	131.03	26.39	2.30	6.22
2000	536.5	123.39	123.55	28.66	2.22	5.8
2001	557.58	124.83	118.78	27.7	2.27	5.59
2002	594.65	123.91	118.43	30.57	2.38	6.64
2003	638.55	128.96	126.93	30.4	2.53	6.31
2004	606.88	129.35	136.76	30.28	2.45	5.69
2005	731.9	159.76	157.29	33.24	2.96	6.68
2006	641.46	135.89	126.75	32.94	2.57	6.12
2007	668.96	141.71	132.19	34.4	2.68	6.9
2008	592.03	127.99	111.92	33.03	2.36	6.46
2009	555.68	121.83	99.2	30.96	2.21	4.88
2010	518.93	114.25	93.87	33.426	2.08	4.10
2011*	505.16	108.96	93.39	33.83	1.94	5.23
2012	609.05	128.65	104.70	46.46	2.43	6.53
2013	565.86	119.36	97.28	50.83	2.28	5.51
2014	530.92	112.15	91.27	44.58	2.13	4.78
2015	560.33	120.57	105.77	44.28	2.28	5.24
2016	577.87	124.347	109.078	47.71	2.35	5.12
Average	519.47	121.31	121.39	30.13	2.17	5.69
5yr Avg	568.81	121.05	101.62	46.77	2.29	5.44
10 yr Max.	668.96	141.71	132.19	50.83	2.68	6.90
10 yr Min.	505.16	108.96	91.27	30.96	1.94	4.10

* Meter error occurred in 2011. Values estimated based on available data.

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Table 3 - Historical & Projected Population[1] in Each Community

Year	Spring Lake Township	City of Ferrysburg	Spring Lake Village	Crockery Township	Total
Total Population					
1970	4,979	2,196	3,034	2,861	13,070
1980	6,857	2,440	2,731	3,536	15,564
1990	8,214	2,919	2,537	3,599	17,269
2000	10,626	3,040	2,514	3,782	19,962
2010	14,300	2,892	2,323	3,960	23,475
2020 Projection	15,447	3,107	2,520	4,413	25,487
2030 Projection	16,578	3,335	2,704	4,736	27,353
2040 Projection	17,792	3,579	2,902	5,083	29,356
Population Served by NOWS					
1990	5,136 (39%)	2,919 (100%)	2,537 (100%)	322 (9%)	10,913 (63%)
2000	8,819 (67%)	3,040 (100%)	2,514 (100%)	733 (19%)	15,106 (76%)
2010	12,031 (84%)	2,892 (100%)	2,323 (100%)	708 (18%)	17,955 (76%)
2020 Projection	14,213 (92%)	3,107 (100%)	2,520 (100%)	995 (23%)	20,835 (82%)
2030 Projection	15,344 (92.5%)	3,335 (100%)	2,704 (100%)	1,318 (28%)	22,701 (83%)
2040 Projection	16,558 (93%)	3,579 (100%)	2,902 (100%)	1,665 (33%)	24,704 (84%)

Note:
1. Population data through 2040 is from West Michigan Regional Planning Commission (WMRPC).
2. Population data for 1970 through 2010 is from the U.S. Census Bureau.
3. Service populations based on growth projected all within service area.

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Table 4 - Water Use Projections

Projections (mgd)	2017		2022		2037	
	Avg	Max	Avg	Max	Avg	Max
Spring Lake Township	1.669	4.505	1.671	4.513	1.681	4.538
Ferrysburg City	0.352	0.952	0.355	0.959	0.364	0.984
Spring Lake Village	0.299	0.807	0.302	0.815	0.311	0.839
Crockery Township	0.139	0.376	0.142	0.384	0.151	0.408
Total	2.459	6.640	2.471	6.671	2.507	6.769

Note: Ranges of Projected Water Use based on historical usage, projected growth, and projected changes in system peak factors.

Table 5 - Metering Station Summary

Location	Identifier	Estimated Normal Capacity (gpm)	Estimated Normal Capacity (mgd)
Pine Street near US-31 in Ferrysburg	Meter #1	5,000	7.2
North Shore Avenue and City Boundary in Ferrysburg	Meter #2	5,000	7.2
144th Avenue and State Road, Crockery Township	Meter #3	770	1.1
144th and Leonard Road, Crockery Township	Meter #4	2,000	2.9
Total Source Capacity[1]		10,000	14.4

Notes: 1. Total includes the sum of Meter #1 and Meter #2 only since these supply the entire NOWS Northside service area.
2. Estimate based on High Service Pumping Rate at the NOWS Water Treatment Plant equal to the Maximum Day Demands.
3. Source: 2015 Sanitary survey

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Table 6 - Storage Tank Data

Community	Location	Type	Volume of Storage (mgal)	Usable Elevation Range	Elevation at Base of Tank (feet)
Spring Lake Township	150th Avenue	Elevated	1.0	712'– 752'	600
Spring Lake Twp / Ferrysburg	VanWagoner	Elevated	0.5	715'– 752'	610
Crockery Township	120th Avenue	Elevated	0.2	712'– 742'	600

Note: Usable Elevation Range represents the range from the bottom of the bowl to the overflow.

Table 7 - Water Main Sizes and Lengths

Water Main Diameter (inches)	Approximate Length of Water Main (miles)				
	Spring Lake Twp	City of Ferrysburg	Village of Spring Lake	Crockery Township	Total
2	0	0	0.2	0	0.2
4	0.1	0.1	4.2	0	4.4
6	21.0	10.3	4.8	1.9	38
8	34.1	4.1	5.7	6.5	50.4
10	0	0	3.5	0.01	3.5
12	29.2	4.5	0	17.5	51.2
16	2.9	0.02	0	0	2.9
20	3.3	0.01	0	0	3.3
24	3.8	0	0.01	0	3.8
Total	94.4	18.97	18.5	25.91	157.78

Source: GIS Database for each community

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Table 8 - Water Main Material

Material	Approximate Length of Water Main (feet)	Approximate Length of Water Main (miles)	Percentage of Total
Spring Lake Township			
Ductile Iron	489,860	92.8	98.2%
Plastic	8,750	1.6	1.8%
Cast Iron	0	0	0%
Total	498,610	94.4	100%
City of Ferrysburg			
Ductile Iron	100,180	18.97	100%
Plastic	0	0	0%
Cast Iron	0	0	0%
Total	100,180	18.97	100%
Village of Spring Lake			
Ductile Iron	59,620	11.3	61.2%
Plastic	0	0	0%
Cast Iron	37,870	7.2	38.8%
Total	97,490	18.5	100%
Crockery Township			
Ductile Iron	70,760	13.4	51.7%
Plastic	66,070	12.5	48.3%
Cast Iron	0	0	0%
Total	136,830	25.9	100%
Total Combined			
Ductile Iron	720,420	136.5	86.5%
Plastic	74,820	14.1	9.0%
Cast Iron	37,870	7.2	4.5%
Total	833,110	157.8	100%

Source: GIS Database for each community

Table 9 - Approximate Water Main Age

Year Installed	Approximate Length of Water Main (feet)	Approximate Length of Water Main (miles)	Percentage of Total
Spring Lake Township			
1970 - 1979	268,410	50.8	53.8%
1980 - 1989	87,920	16.7	17.6%
1990 - 1999	93,830	17.8	18.8%
2000 - 2009	39,820	7.5	8.0%
2010 - Present	8,630	1.6	1.7%
Total	498,610	94.4	100%
City of Ferrysburg			
1970 - 1979	70,500	13.4	70.4%
1980 - 1989	11,080	2.1	11.1%
1990 - 1999	8,040	1.5	8.0%
2000 - 2009	9,790	1.8	9.8%
2010 - Present	770	0.1	0.8%
Total	100,180	18.97	100%
Village of Spring Lake			
Pre - 1950	24,430	4.6	25.1%
1950 - 1959	280	0.1	0.3%
1960 - 1969	13,520	2.6	13.9%
1970 - 1979	12,130	2.3	12.4%
1980 - 1989	27,840	5.3	28.6%
1990 - 1999	13,910	2.6	14.3%
2000 - 2009	4,150	0.8	4.3%
2010 - Present	1,230	0.2	1.3%
Total	97,490	18.5	100%
Crockery Township			
1970 - 1979	1,740	0.3	1.3%
1980 - 1989	84,620	16.1	61.8%
1990 - 1999	12,220	2.3	8.9%
2000 - 2009	25,940	4.9	19%
2010 - Present	12,310	2.3	9%
Total	136,830	25.9	100%

Table 9 Cont. - Approximate Water Main Age

Year Installed	Approximate Length of Water Main (feet)	Approximate Length of Water Main (miles)	Percentage of Total
Total			
Pre - 1950	24,430	4.6	2.9%
1950 - 1959	280	0.1	0.03%
1960 - 1969	13,520	2.6	1.5%
1970 - 1979	352,780	66.8	42.3%
1980 - 1989	211,460	40.1	25.4%
1990 - 1999	128,000	24.2	15.4%
2000 - 2009	79,700	15.1	9.6%
2010 - Present	22,940	4.3	2.8%
Total	833,110	157.8	100%

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Table 10 - Water Storage Analysis

Year	Firm Metered Capacity (gpm)	Maximum Day Demand (gpm)	Peak Hour Demand (gpm)	Suggested Fire-Flow[1] (gpm)	Duration[1] (hours)	Water Supplied[2] (gallons)	Typical Customer Demand[3] (gallons)	Fire Demand[4] (gallons)	Recommended Storage Vol. (gallons)	Storage Volume Provided (gallons)	Needed Additional Storage Vol. (gallons)
2017	5000	4350	8060	1000	2	600000	745000	120000	265000	1500000	0
2017	5000	4350	8060	2000	2	600000	745000	240000	385000	1500000	0
2017	5000	4350	8060	3500	3	900000	1006000	630000	736000	1500000	0
2027	5000	4660	8630	1000	2	600000	797000	120000	317000	1500000	0
2027	5000	4660	8630	2000	2	600000	797000	240000	437000	1500000	0
2027	5000	4660	8630	3500	3	900000	1077000	630000	807000	1500000	0
2037	5000	4970	8910	1000	2	600000	833000	120000	353000	1500000	0
2037	5000	4970	8910	2000	2	600000	833000	240000	473000	1500000	0
2037	5000	4970	8910	3500	3	900000	1131000	630000	861000	1500000	0

Notes:
1. Fire demand and duration based on Table 1-1 of AWWA M-31 Manual.
2. Water Supply Volume based on firm meter capacity for the given duration.
3. Customer Demand Volume based on one hour of peak demand and maximum day demands for the remaining duration.
4. Emergency Storage based on Fire Flow Demand over the duration.
5. Example Calculation: Year 2037; 3,500 gpm for 3 hours
   - Firm Meter Capacity = 5,000gpm
   - Maximum Day Demand = 2037 projected max day demand (7.2 mgd) ÷ 24hrs/day ÷ 60min/hr x 1 million = 4,970gpm
   - Peak Hour Demand = 2037 projected peak hour demand (12.8 mgd) ÷ 24 ÷ 60 x 1,000,000 = 8,910 gpm
   - Water Supplied = firm meter capacity x duration = 5,000 gpm x 3 hrs x 60 min/hr = 900,000 gal
   - Typical Customer Demand=1 hr of peak hour demand+2 hr of max day demand=1 hr x 8,910 gpm + 2 hr x 4,970 gpm = 1,131,000gal (rounded)
   - Fire Demand = standard fire flow x duration = 3,500 gpm x 3hr x 60 min/hr = 630,000 gal
   - Recommended Storage Volume = Typical Customer Demand + Fire Demand - Water Supplied = 1,131,000 + 630,000 – 900,000= 861,000 gal
   - Storage Volume Provided = 1,700,000 gallons
   - Recommended Additional Storage Volume = Recommended Storage Volume - Storage Volume Provided = 861,000 – 1,700,000 = 0

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Table 11 - Storage Volume for Crockery Township

Year	Normal Meter Capacity (gpm)	Maximum Day Demand (gpm)	Peak Hour Demand (gpm)	Suggested Fire Flow (gpm)	Duration (hours)	Water Supplied (gallons)	Typical Demand Storage (gallons)	Emergency Storage (gallons)	Recommended Storage Vol. (gallons)	Storage Volume Provided (gallons)	Recommended Additional Stor. Vol. (gallons)
2017	770	262	484	1000	2	92400	45000	120000	73000	200000	0
2017	770	262	484	2000	2	92400	45000	240000	193000	200000	0
2017	770	262	484	3500	3	138600	60000	630000	551000	200000	351000
2027	770	271	502	1000	2	92400	46000	120000	74000	200000	0
2027	770	271	502	2000	2	92400	46000	240000	194000	200000	0
2027	770	271	502	3500	3	138600	63000	630000	554000	200000	354000
2037	770	280	519	1000	2	92400	48000	120000	76000	200000	0
2037	770	280	519	2000	2	92400	48000	240000	196000	200000	0
2037	770	280	519	3500	3	138600	65000	630000	556000	200000	356000

Notes:
1. Fire demand and duration based on Table 1-1 of AWWA M-31 Manual
2. Water Supply Volume based on firm capacity for the given duration
3. Customer Demand Volume based on 1 hour of peak demand and maximum day demands for the remaining duration.
4. Emergency Storage based on Fire Flow Demand over the duration.
5. Normal Meter Capacity is based on the capacity of each booster pump for meter station at State Road and 144th.

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Table 12 - Hydrant Test Results

Hydrant Test No.	Static Hydrant Location	Flow (gpm)	Static Pressure (psi)	Residual Pressure (psi)
	Spring Lake Township			
1ST	Dead end of Judson Rd (S of Judson Rd)	1,387	56	33
2ST	Lovell Rd and Lovell Park Rd	1,957	61	42
3ST	Wilson W of US-31, end hyd	919	59	34
4ST	Dead end of Sioux Dr	979	54	44
5ST	Middle of Shady Ridge Ct	1,823	53	38
6ST	Dead end of Scenic Trail	1,999	63	44
7ST	Dead end of Villa Park Dr	1,895	68	50
8ST	Littlefield Ln and Appletree Ln	822	56	43
	City of Ferrysburg			
1F	Carmen St 2nd from end	1,163	76	64
2F	Dead end of Lavina St	1,233	74	63
3F	End of Lakeview St.	2,272	71	60
4F	Dead end of Cherokee Dr	1,113	63	43
5F	Dead end of Harbor Point Dr	1,088	60	46
6F	17815 Dogwood Dr	2,002	68	54
	Village of Spring Lake			
1SV	Dead end of Savidge St	755	78	67
2SV	Exchange St between School St and Cutler St	945	77	56
3SV	Tolford St and Jackson St	955	73	58
4SV	Prospect St and River St	1,015	63	55
5SV	Dead end Prospect St	1,015	73	63
6SV	Mark St and James St	815	62	49
7SV	DeWitt St and Winter St	1,218	60	51
8SV	E of M-104 and DeWitt Lake	514	61	53
9SV	Buena Vista St E of Alden St	974	71	56
	Crockery Township			
1C	Dead end Longleaf Ln	1,007	60	42
2C	Dead end of Cypress	1,035	75	45
3C	Dead end of Apple Dr	751	44	31
4C	South at E end	1,627	47	29
5C	Dead end of Walnut	935	48	37
1C	Dead end Longleaf Ln	1,007	60	42
2C	Dead end of Cypress	1,035	75	45

Notes: 1. Hydrant Flow tests performed on 3/9/17, 3/27/17 and 5/8/17 by Prein&Newhof and communities.
2. Pressures obtained at Pine St. Meter Station and North Shore Meter Station during tests. High Service Operation and Tank Levels unknown at time of tests.

Table 13 - Comparison of Calibrated Model to Field Test Pressures

Test No.	Model Node No.	Static Hydrant Location	Flow (gpm)	Static Pressure (psi)		Residual Pressure (psi)		Avail. Fire Flow Projection % Difference
				Field Tests	Model Results	Field Tests	Model Results	
1SLT	J-240	Dead end of Tall Pine (S of Judson Rd)	761	56	56	33	28	10%
2SLT	J-1126	Lovell Park Rd and Terrace Rd	1740	61	61	42	39	8%
3SLT	J-222	Wilson W of US-31, end hyd	817	59	63	34	30	10%
4SLT	J-393	Dead end of Sioux Dr	870	54	55	44	43	7%
5SLT	J-1128	Middle of Shady Ridge Ct	1621	53	55	38	37	0%
6SLT	J-609	Dead end of Scenic Trail	1777	63	64	44	46	7%
7SLT	J-275	Dead end of Villa Park Dr	1685	68	71	50	46	0%
8SLT	J-1131	Littlefield Ln and Appletree Ln	731	56	59	43	41	9%
1F	J-1132	Carmen St 2nd from end	1034	76	75	64	65	5%
2F	J-597	Dead end of Lavina St	1096	74	73	63	63	2%
3F	J-575	End of Lakeview St.	2020	71	70	60	60	4%
4F	J-1138	Dead end of Cherokee Dr.	990	63	61	43	45	8%
5F	J-193	Dead end of Harbor Point Dr	967	60	60	46	48	9%
6F	J-1135	17815 Dogwood Dr	1780	68	65	54	54	2%
1SLV	J-503	Dead end of Savidge St	1106	78	77	67	68	2%
2SLV	J-1148	Exchange St btwn School St & Cutler St	2035	77	75	56	55	10%
3SLV	J-491	Tolford St and Jackson St	2110	73	72	58	58	8%
4SLV	J-468	Prospect St and River St	2013	63	64	55	54	2%
5SLV	J-464	Dead end Prospect St	1434	73	73	63	61	8%
6SLV	J-452	Mark St and James St	1938	62	63	49	49	6%
7SLV	J-444	DeWitt St and Winter St	1225	60	61	51	52	4%
8SLV	J-434	E of M-104 and DeWitt Lake	1826	61	64	53	56	4%
9SLV	J-1149	Buena Vista St E of Alden St	1968	71	72	56	58	9%
10SLV	J-509	Jackson St and Mason St	1687	74	72	43	42	9%
11SLV	J-517	Cutler St and Barber St	789	71	71	36	40	4%
1C	J-1141	Dead end Longleaf Ln	895	60	60	42	44	9%
2C	J-415	Dead end of Cypress	920	75	72	45	48	10%
3C	J-561	Dead end of Apple Dr.	667	44	46	31	31	0%
4C	J-411	South at E end	1446	47	47	29	26	10%
5C	J-93	Dead end of Walnut	831	48	48	37	35	9%

Notes:Hydrant Flow tests performed on 3/9/17, 3/27/17 and 5/8/17 by Prein&Newhof and individual communities

Table 14 - Model Results for Existing Conditions

Jct Number	Location	Description	Pressure (psi)		Available Fire Flow (gpm)
			Average Day Demands	Maximum Day Demands	
147/148	17290 Roosevelt Road, Ferrysburg	Ferrysburg Elementary School	71	67	3,360
452	426 River Street, SLV	Holmes Elementary School	67	65	1,290
78	14429 Leonard Road, SLT	Jeffers Elementary School	62	61	5,000
209	18181 Dogwood Drive	Lake Hills Elementary School	58	54	4,970
465	345 Hammond Street, SLV	Spring Lake Junior High School	69	67	4,170
584/586	16140 148th Avenue, SLT	Spring Lake Senior High School	60	59	5,000
434/437	201 DeWitt Lane,	Liberty Woods Senior Housing	68	66	1,280
46	18100 174th Avenue, SLT	Oak Crest Manors	69	67	4,170
127	412 5th Street, S	Providence Housing	73	69	5,000
523	Rex St., north end (also Monarch & Dixie)	Low Available Fire Flow	72	70	580
522	Rex and Liberty	Low Available Fire Flow	72	70	1,250
483	Ann, west of Buchanan Street	Low Available Fire Flow	71	69	3,450
254	Walden Drive & extension	Low Available Fire Flow	65	63	1,870
227	Highland, east end	Low Available Fire Flow	60	57	800
240	Tall Pine, south end	Low Available Fire Flow	60	57	1,040
123	North Shore Estates Road, north end	Low Available Fire Flow	66	62	2,040

Notes:
1. Average and Maximum Day Demand Pressures are based on water treatment plant discharge pressure of 760' with meters stations open.
2. Available Fire Flows are based on maximum day demands water treatment plant discharge of 760' and meters stations open.
3. ISO typically suggests an available fire flow of 2,000 to 5,000 gpm for commercial and industrial areas and 1,000-1,500 gpm for Residential Areas. The recommended available fire flows represents that necessary for full credit toward insurance rating, but is not required.
4. Locations represent the extremities of the system plus other important locations within the Township.

Table 15 - Model Results for Year 2037 Demands with Existing Infrastructure

Jct Number	Location	Description	Pressure (psi)		Available Fire Flow (gpm)
			Average Day Demands	Maximum Day Demands	
147/148	17290 Roosevelt Road, Ferrysburg	Ferrysburg Elementary School	71	69	2,040
452	426 River Street, SLV	Holmes Elementary School	67	66	2,610
78	14429 Leonard Road, SLT	Jeffers Elementary School	61	61	2,620
209	18181 Dogwood Drive	Lake Hills Elementary School	58	56	820
465	345 Hammond Street, SLV	Spring Lake Junior High School	69	67	2,170
584/586	16140 148th Avenue, SLT	Spring Lake Senior High School	60	59	5,000
434/437	201 DeWitt Lane,	Liberty Woods Senior Housing	68	67	4,690
46	18100 174th Avenue, SLT	Oak Crest Manors	69	67	2,170
127	412 5th Street, S	Providence Housing	73	71	3,400
523	Rex St., north end (also Monarch & Dixie)	Low Available Fire Flow	72	71	240
522	Rex and Liberty	Low Available Fire Flow	72	71	550
483	Ann, west of Buchanan Street	Low Available Fire Flow	71	69	440
254	Walden Drive & extension	Low Available Fire Flow	65	63	580
227	Highland, east end	Low Available Fire Flow	60	58	710
240	Tall Pine, south end	Low Available Fire Flow	60	57	590
123	North Shore Estates Road, north end	Low Available Fire Flow	67	66	540

Notes:
1. Average and Maximum Day Demand Pressures are based on water treatment plant discharge pressure of 760' with meters stations open.
2. Available Fire Flows are based on maximum day demands water treatment plant discharge of 760' and meters stations open.
3. ISO typically suggests an available fire flow of 2,000 to 5,000 gpm for commercial and industrial areas and 1,000-1,500 gpm for Residential Areas. The recommended available fire flows represents that necessary for full credit toward insurance rating, but is not required.
4. Locations represent the extremities of the system plus other important locations within the System.

Table 16 - Model Results for Year 2037 Demands with Recommended Improvements

Jct Number	Location	Description	Pressure (psi)		Available Fire Flow (gpm)
			Average Day Demands	Maximum Day Demands	
147/148	17290 Roosevelt Road, Ferrysburg	Ferrysburg Elementary School	71	69	3,120
452	426 River Street, SLV	Holmes Elementary School	68	66	2,280
78	14429 Leonard Road, SLT	Jeffers Elementary School	61	60	5,000
209	18181 Dogwood Drive	Lake Hills Elementary School	58	56	4,870
465	345 Hammond Street, SLV	Spring Lake Junior High School	70	68	3,670
584/586	16140 148th Avenue, SLT	Spring Lake Senior High School	60	59	5,000
434/437	201 DeWitt Lane,	Liberty Woods Senior Housing	69	67	1,290
46	18100 174th Avenue, SLT	Oak Crest Manors	70	68	3,670
127	412 5th Street, S	Providence Housing	73	71	5,000
523	Rex St., north end (also Monarch & Dixie)	Low Available Fire Flow	72	71	5,000
522	Rex and Liberty	Low Available Fire Flow	72	71	2,790
483	Ann, west of Buchanan Street	Low Available Fire Flow	71	70	3,210
254	Walden Drive & extension	Low Available Fire Flow	65	63	1,690
227	Highland, east end	Low Available Fire Flow	60	58	1,890
240	Tall Pine, south end	Low Available Fire Flow	60	58	950
123	North Shore Estates Road, north end	Low Available Fire Flow	61	59	3,330

Notes:
1. Average and Maximum Day Demand Pressures are based on water treatment plant discharge pressure of 760' with meters stations open.
2. Available Fire Flows are based on maximum day demands water treatment plant discharge of 760' and meters stations open.
3. ISO typically suggests an available fire flow of 2,000 to 5,000 gpm for commercial and industrial areas and 1,000-1,500 gpm for Residential Areas. The recommended available fire flows represents that necessary for full credit toward insurance rating, but is not required.
4. Locations represent the extremities of the system plus other important locations within the system.

Table 17 - Water System Emergency Interconnect Data

Location	Main Size	Metered ?	Connection To:	Tank O.F. Elev (ft)	Estimate Flow (gpm)
S. Black Lake Rd & Palm Dr	8 X 8	No	4850–Norton Shores	752	400
Grand Haven Rd & Wilson Rd	12 X 12	No	4850–Norton Shores	752	700
Harvey Rd & Wilson Rd	8 X 8	No	4850–Norton Shores	752	1,000
Judson Rd & Claire Ln	12 X 12	No	3060–Fruitport Ch. Twp	752	600
3rd Ave & Apple Rd	12 X 10	No	3060–Fruitport Ch. Twp	752	1,200

Note: Estimated Flow based on 2037 average day demands, no supply to NOWS-Northside and only one emergency interconnect open.

Table 18 - Water Accountability

Year	Spring Lake Twp	Ferrysburg City	Spring Lake Village	Crockery Twp	Total
Water Purchased (MGAL)					
2013	565.9	119.5	97.3	50.8	833.5
2014	530.9	112.1	91.3	44.6	778.9
2015	560.3	120.6	105.8	44.3	831.0
2016	581.0	125.0	109.7	47.7	863.4
Water Sold (MGAL)					
2013	505.9	111.3	94.0	39.9	751.1
2014	482.2	101.0	82.7	35.7	701.6
2015	499.7	111.7	89.5	43.8	744.7
2016	513.9	106.4	92.8	46.4	759.5
Percent Unbilled (%)					
2013	10.6%	6.9%	3.4%	21.5%	9.9%
2014	9.2%	9.9%	9.4%	20.0%	9.9%
2015	10.8%	7.4%	15.4%	1.1%	10.4%
2016	11.5%	14.9%	15.4%	2.7%	12.0%
Average	10.5%	9.8%	10.9%	11.3%	10.6%
Maximum	11.5%	14.9%	15.4%	21.5%	12.0%

Note: Water volumes do not consider known, unbilled water use.

NOWS - NORTHSIDE
WATER SYSTEM RELIABILITY STUDY

Table 19a - Cost Opinions for Recommended Projects

Improvement Project	Spring Lake Twp	City of Ferrysburg	Spring Lake Village	Crockery Township	Project Cost
P1. Construct New Crossing or Repair 20-inch Lake Crossing	TBD	TBD	TBD	TBD	$ TBD
P2. Install 2 16" valves on Van Wagoner 16" water main between north and south bound U.S. 31		TBD			TBD
P3. Construct 5,000 LF of 12" on Cleveland St, from 144th Ave to existing 12" main east of 136th Ave				$575,000	
P4. Construct 11,500 LF of 12" on State Rd, from dead end east of 130th to dead end west of 112th & 1,800 LF of 8" main on Apple from the dead end to State Rd				$1,840,000	$1,840,000
P5. Construct 7,200 LF of 12" main on 136th, from Cleveland south to Leonard Road & west to dead end.				By Developer	By Developer
P6. Construct 2,100 LF of 12" on Leonard Rd across the Lloyds Bayou, from Pruin St to Lake Ave	$ 295,000		$135,000		$ 430,000
P7. Construct 8" water main (loop) to Lake Hills Elementary School	$ 40,000				$ 40,000
1a. Construct 12" transmission main from Lake Avenue and Leonard Road to the 10-inch main on River (Alternate routes: Grandview/South/Hammond route 3720' is shown)			$485,000		$ 485,000
2a. Construct 1,000 LF of 8" main across Smith Bayou between the dead end on Spahr Ave. and Royal		$290,000			$ 290,000
2b. Construct 3,000 LF of 8" between dead ends on North Shore Estates Road & Cree Court	$ 515,000				$ 515,000
2c. Construct 1,100 LF of 8" between dead ends on Tomahawk Court and Hoffmaster Drive	$ 105,000				$ 105,000
2d. Construct 700 LF of 8" between water main dead end on Highland Dr and Judson Road and 1400 LF of 8" on Highland Dr.	$ 240,000				$ 240,000
2e. Construct 2,500 LF on two, 8" water main segments along the south shore of Spring Lake, north of Fruitport Road	$ 235,000				$ 235,000
Subtotal (see Table 17b for remaining Cost Opinions)	$1,430,000	$290,000	$620,000	$2,415,000	$4,180,000

Notes:
1. Opinion of Cost are Project Costs and include 25 percent allowance for legal and administrative costs, engineering and contingencies.
2. The Opinion of Cost is based on current dollars
3. Does not include water service replacements, extensive restoration or additional costs related to wetland or critical dune activities.
4. Project 1 is listed as To Be Determined (TBD) - it is recommended that a price be solicited from reputable marine contractors.

NOWS - NORTHSIDE
WATER SYSTEM RELIABILITY STUDY

Table 19b - Cost Opinions for Recommended Projects (cont)

Improvement Project	Spring Lake Twp	City of Ferrysburg	Spring Lake Village	Crockery Township	Project Cost
2f. Construct 380 LF of 8" water main from the dead end main on Concord Dr to Pruin St	$ 35,000				$ 35,000
2g. Construct 520 LF of 8" water main from the dead end on Leonard Rd.. to Vinecrest Ct.	$ 50,000				$ 50,000
2h. Construct 340 LF of 8" WM from the dead end main on Connelly to Oakwood Drive.	$ 35,000				$ 35,000
2i. Construct 800 LF of 8" WM from the dead end main on Pinecrest to Fruitport.	$ 75,000				$ 75,000
2j. Construct 230 LF of 8" WM from the dead end main on Reitsma to State Road	$ 25,000				$ 25,000
2k. Construct 450 LF of 8" WM from the dead end mains on Howard Avenue and Linn.	$ 45,000				$ 45,000
2l. Construct 1,400 LF of 8" WM from the dead end mains on Wilson and 168th Avenue.	$ 175,000				$ 175,000
2m. Construct 500 LF of 8" WM from the dead end main on Highland Drive to Spring Lake Road.	$ 45,000				$ 45,000
2n. Construct 8" from the dead end on Cleveland at I-96 north to 12" in Grand Trunk RR ROW				By Developer	
2o. Construct 8" main from the dead end of Peppermill Drive to the dead end of Jordan Lane		$ 65,000			$ 65,000
2p. Construct 675 feet of 8-inch main from the dead end of Maple Street to 2nd street.		$ 35,000			$35,000
3a. Construct 8" WM on Tall Pine south of Judson Road	$ 45,000				$ 45,000
3b. Construct 1300 feet of 8" WM on South St, east of Main St				$ 120,000	$ 120,000
4a. Replace 300 feet water main on Willow Street due to corrosion.		$100,000			$ 100,000
4b. Replace all 4" and 6" main built before 1940 with 8" main			$4,000,000		$4,000,000
Subtotal	$ 530,000	$200,000	$4,000,000	$ 120,000	$4,850,000
Total (including Table 17a)	$1,960,000	$490,000	$4,620,000	$2,180,000	$9,030,000

Notes:
1. Opinion of Cost are Project Costs and include 25 percent allowance for legal and administrative costs, engineering and contingencies.
2. The Opinion of Cost is based on current dollars
3. Does not include water service replacements, extensive restoration, or additional costs related to wetland or critical dune activities

NOWS - NORTHSIDE
WATER SYSTEM RELIABILITY STUDY

Table 20a - Capital Improvements Plan for Spring Lake Township

Improvement Project	Opinion of Probable Project Cost	Estimated Completion Year
P1. Construct New Crossing or Repair 20-inch Lake Crossing	TBD	
P7. Construct 8" water main (loop) to Lake Hills Elementary School	$ 40,000	2020
2d. Construct 700 LF of 8” between water main dead end on Highland Dr and Judson Road and 1400 LF of 8” on Highland Dr.	$ 240,000	2021
3a. Construct 8" WM on Tall Pine south of Judson Road	$ 45,000	2022
2h. Construct 340 LF of 8” WM from the dead end main on Connelly to Oakwood Drive.	$ 35,000	2023
2f. Construct 380 LF of 8” water main from the dead end main on Concord Dr to Pruin St	$ 35,000	2024
2e. Construct 2,500 LF on two, 8” water main segments along the south shore of Spring Lake, north of Fruitport Road	$ 235,000	2025
2g. Construct 520 LF of 8” water main from the dead end on Leonard Rd. to Vinecrest Ct.	$ 50,000	2026
2c. Construct 1,100 LF of 8” between dead ends on Tomahawk Court and Hoffmaster Dr.	$ 105,000	2027
2m. Construct 500 LF of 8” WM from the dead end main on Highland Drive to Spring Lake Road.	$ 45,000	2028
2i. Construct 800 LF of 8” WM from the dead end main on Pinecrest to Fruitport.	$ 75,000	2029
P5. Construct 2,100 LF of 12” on Leonard Rd across the Lloyds Bayou, from Pruin St to Lake Ave	$ 295,000	2030
2l. Construct 1,400 LF of 8” WM from the dead end mains on Wilson and 168th Avenue.	$ 175,000	2033
2j. Construct 230 LF of 8” WM from the dead end main on Reitsma to State Road	$ 25,000	2033
2b. Construct 3,000 LF of 8” between dead ends on North Shore Estates Road & Cree Ct.	$ 515,000	2034
2k. Construct 450 LF of 8” WM from the dead end mains on Howard Street and Linn Court.	$ 45,000	2037
Total	$ 1,960,000	

Notes:
1. Opinion of Cost includes 25-percent allowance for legal and administrative costs, engineering and contingencies.
2. The Opinion of Cost is based on current dollars
3. Does not include water service replacements, extensive restoration, or additional costs related to wetland or critical dune activities.

NOWS - NORTHSIDE
WATER SYSTEM RELIABILITY STUDY

Table 20b - Capital Improvements Plan for Ferrysburg

Improvement Project	Opinion of Probable Project Cost	Estimated Completion Year
P1. Construct New Crossing or Repair 20-inch Lake Crossing	TBD	
P2. Install 2 16" valves on Van Wagoner 16" water main between north and south bound U.S. 31	TBD	
2a. Construct 1,000 LF of 8" main across Smith Bayou between the dead end on Spahr Ave. and Royal	$ 290,000	2025
2o. Construct 650 LF of 8" from the dead end of Peppermill Drive to the dead end of Jordan Lane	$ 65,000	2025
2p. Construct 350 feet of 8-inch main from the dead end of Maple Street to 2nd Street	$ 35,000	2018
4a. Replace the water main and services on Willow Street due to corrosion	$ 100,000	2018
Total	$ 490,000	

Notes:
1. Opinion of Cost includes 25-percent allowance for legal and administrative costs, engineering and contingencies.
2. The Opinion of Cost is based on current dollars
3. Does not include water service replacements, extensive restoration, or additional costs related to wetland or critical dune activities.

Table 20c - Capital Improvements Plan for Village of Spring Lake

Improvement Project	Opinion of Probable Project Cost	Estimated Completion Year
P1. Construct New Crossing or Repair 20-inch Lake Crossing	TBD	
4b. Replace all 4" and 6" main built before 1940 with 8" main	$ 4,000,000	2020
1a. Construct 12" transmission main from Lake Avenue and Leonard Road to the 10-inch main on River (Alternate routes: Grandview/South/Hammond route 3720' is shown)	$ 485,000	2030
P6. Construct 2,100 LF of 12" on Leonard Rd across the Lloyds Bayou, from Pruin St to Lake Ave	$ 130,000	2030
Total	$ 4,620,000	

Notes:
1. Opinion of Cost includes 25-percent allowance for legal and administrative costs, engineering and contingencies.
2. The Opinion of Cost is based on current dollars
3. Does not include water service replacements, extensive restoration, or additional costs related to wetland or critical dune activities.

NOWS - NORTHSIDE
WATER SYSTEM RELIABILITY STUDY

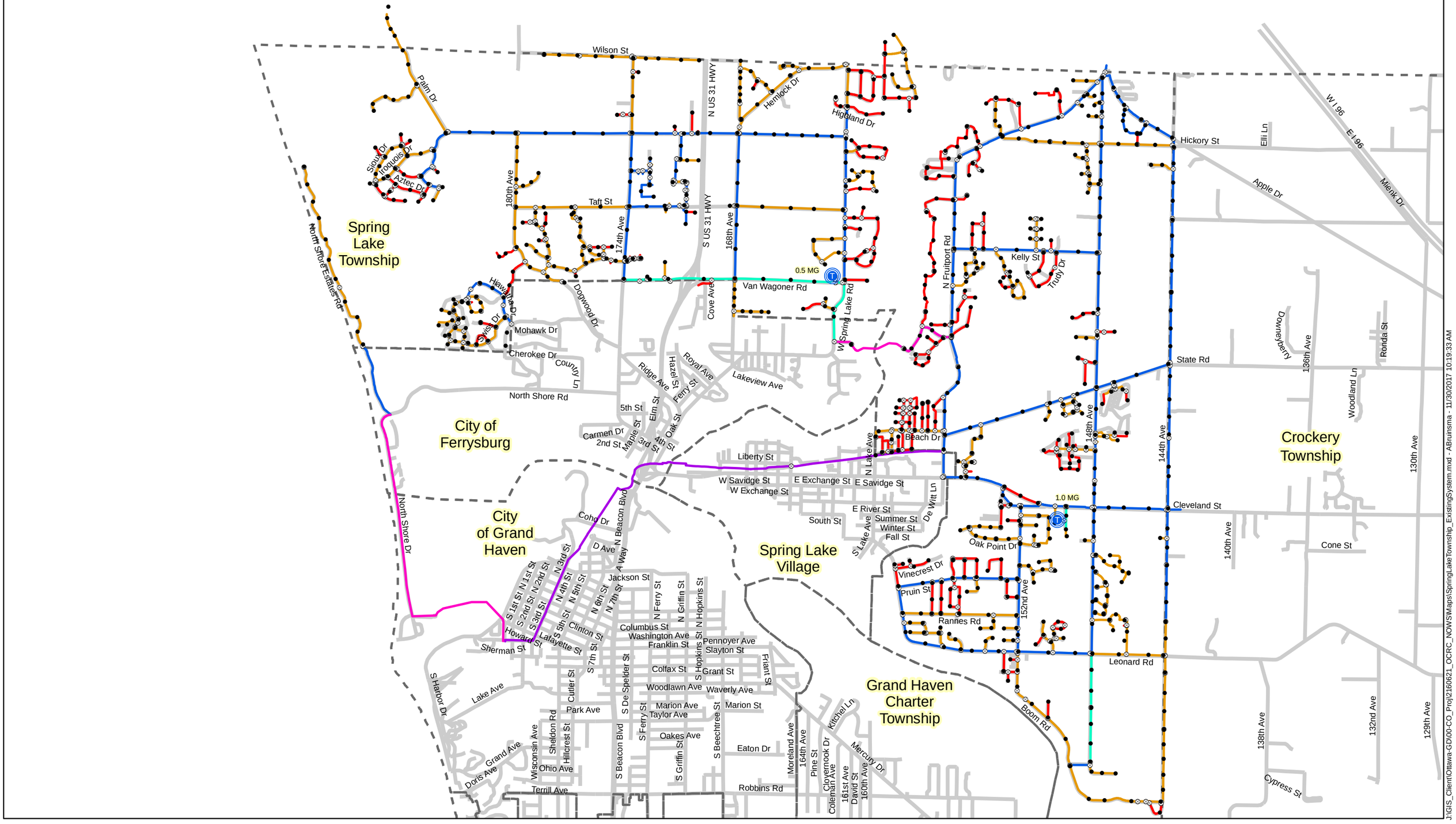
Table 20d - Capital Improvements Plan for Crockery Township

Improvement Project	Opinion of Probable Project Cost	Estimated Completion Year
P1. Construct New Crossing or Repair 20-inch Lake Crossing	TBD	
P3. Construct 5,000 LF of 12" main on Cleveland Street from 144th Ave to existing 12" main east of 136th Ave	$ 575,000	2025
P4. Construct 11,500 LF of 12" on State Rd, from dead end east of 130th to dead end west of 112th & 1,800 LF of 8" main on Apple from the dead end to State Rd	$1,840,000	2030
P5. Construct 7,200 LF of 12" main on 136th, from Cleveland south to Leonard Road & west to dead end.	By Developer	2025
2n. Construct 8" from the dead end on Cleveland at I-96 north to 12" in Grand Trunk RR ROW	By Developer	NA
3b. Construct 1300 feet of 8" WM on South St, east of Main St	$ 120,000	2035
Total	$ 2,535,000	

Notes:
1. Opinion of Cost includes 25-percent allowance for legal and administrative costs, engineering and contingencies.
2. The Opinion of Cost is based on current dollars
3. Does not include water service replacements, extensive restoration, or additional costs related to wetland or critical dune activities.

Appendix B

Figures



N

2,500 1,250 0 2,500 5,000 Feet

LEGEND

- wHydrant
- wSystemValve
- Storage Tanks

6 12 20

8 16 24

SPRING LAKE TOWNSHIP
OTTAWA COUNTY, MICHIGAN

EXISTING SYSTEM

FIGURE 1A

Prein&Newhof

2160621

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Spring Lake Township

City of Ferrysburg

City of Grand Haven

Spring Lake Village

Aztec Dr
Sioux Dr
Taft St
171st Ave
180th Ave
Terrace Rd
Kristina Ct
Lovell Rd
West Willow Dr
Lost Creek Ln
Cobblefield Ln
Waterchase Trl
Wildwood Springs Pkwy
North Shore Estates Rd
Hiawatha Dr
Lake Hills Dr
N Ridge Ct
Woodland Ridge Dr
Oberwald Ln Dr
Swiss Dr
Alpine Ct
Mohawk Dr
Dogwood Dr
Nakaho Dr
Cherokee Dr
Parkwood Dr
Country Ln
North Shore Rd
W North Shore Dr
Piney Point Dr
North Shore Dr
174th Ave
Roosevelt Rd
Lane Ave
Ridge Ave
5th St
Beech St
3rd St
Carmen Dr
2nd St
Maple St
Elm St
Oak St
Pine St
4th St
S US 31 HWY
N US 31 HWY
168th Ave
Van Wagoner Rd
Dawnview Dr
Cove Ave
170th Ave
Spahr St
Bridlepath Dr
Carlson Ave
Virginia Ave
Cecelia Ln
Royal Ave
Hazel St
Ferry St
Lake Rd
Highland Ave
Landing Dr
Bayberry Dr
Dorie Ave
Jordan Ln
Mary Ave
Woodvale Blvd
Lakeview Ave
W Spring Lake Rd
Norfolk Dr
Oakwood Dr
Suffolk Dr
Harbor Point Dr
Barber St
Mason St
Buena Vista Dr
Longview Ave
N Lake Ave
Esther St
Franklin Avenue
Railroad Ave
Parkview Ave
Beach Dr
Cherry St
Ottawa Ave
Coles Park Rd
Villa Park Ave
Rex Ave
Liberty St
N Cutler St
N Park St
N Division St
Grand Trunk Dr
N Buchanan St
Shady Ln
Alden St
E Savidge St
W Savidge St
School St
S Cutler St
S Park St
W Exchange St
E Exchange St
S Buchanan St
Summit St
Meridian St
Prospect St
William St
E River St
Visser St
South St
Hammond St
S Lake Ave
Spring St
Summer St
Fleser Ct
Winter St
Fall St
De Witt Ln
N 3rd St
Coho Dr
Harbor Island Dr
N Beacon Blvd
Grand Isle Dr

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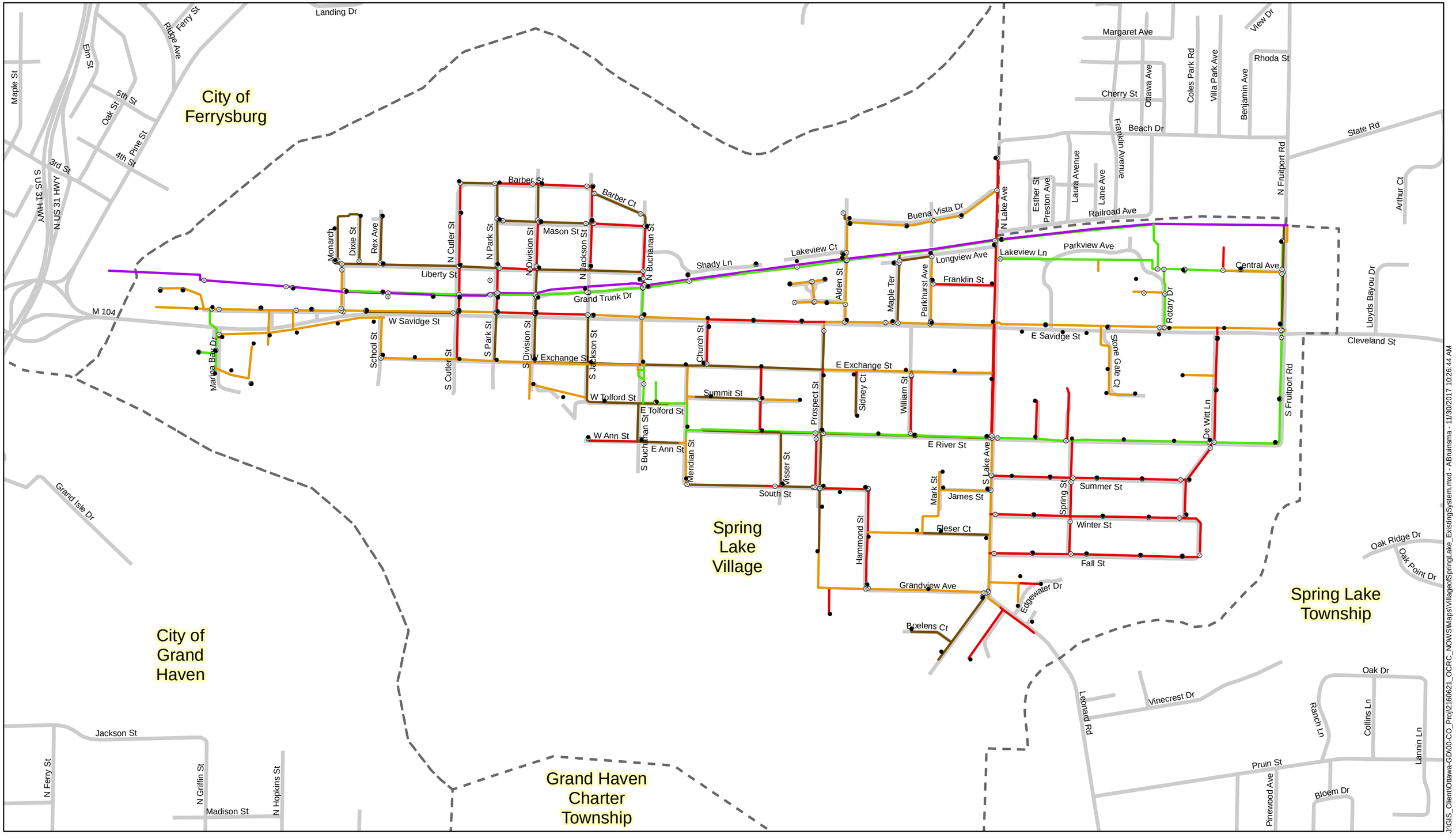
1,000 500 0 1,000 2,000 Feet

LEGEND

Hydrants
Valves
4 6 8 12 16 20 24

CITY OF FERRYSBURG
OTTAWA COUNTY, MICHIGAN
EXISTING SYSTEM
FIGURE 1B
Prein&Newhof
2160621



500 250 0 500 1,000 Feet

LEGEND

- Water Hydrants
- Water System Valves
- Storage Tanks
- 10" 4" 8" 24" 6"

VILLAGE OF SPRING LAKE
OTTAWA COUNTY, MICHIGAN

EXISTING SYSTEM

FIGURE 1C

Prein&Newhof

2160621

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Hickory St
Elli Ln
Mienk Dr
Taft St
Pine Acres Ct
Sheryl Lynn Dr
104th Ave
Apple Dr
120th Ave
112th Ave
Brielle Ln
Arcadia Dr
Walnut Dr
96th Ave
Barbara Blvd
Downeyberry
136th Ave
Ronda St
Jeffrey St
Crockery Township
State Rd
144th Ave
Woodland Ln
130th Ave
Gilbert Ln
W I 96
Charles St
2nd St
1st St
South St
Winter Ave
Birchview Dr
Patchin Dr
Murphy St
Michigan Ave
Main St
Power Dr
0.2 MG
E I 96
116th Ave
140th Ave
Vink Drive
Cone St
Cleveland St
124th Ave
Fitzgerald
Leonard Rd
Meinel St
Long Leaf Ln
SEE INSET

Spring Lake Township
Long Leaf Ln
136th Ave
Leonard Rd
144th Ave
138th Ave
Crockery Township
Cypress St
Boom Rd
Garfield Dr
Robinson Township

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1,750 875 0 1,750 3,500 Feet

LEGEND

- Water Hydrants
- Valve
- Water Storage Facility
- 6"
- 8"
- 10"
- 12"

CROCKERY TOWNSHIP
OTTAWA COUNTY, MICHIGAN
EXISTING SYSTEM
FIGURE 1D
Prein&Newhof
2160621

FIGURE 2

NOWS-Northside Water System Reliability Study
Population and Water Use Data Projections

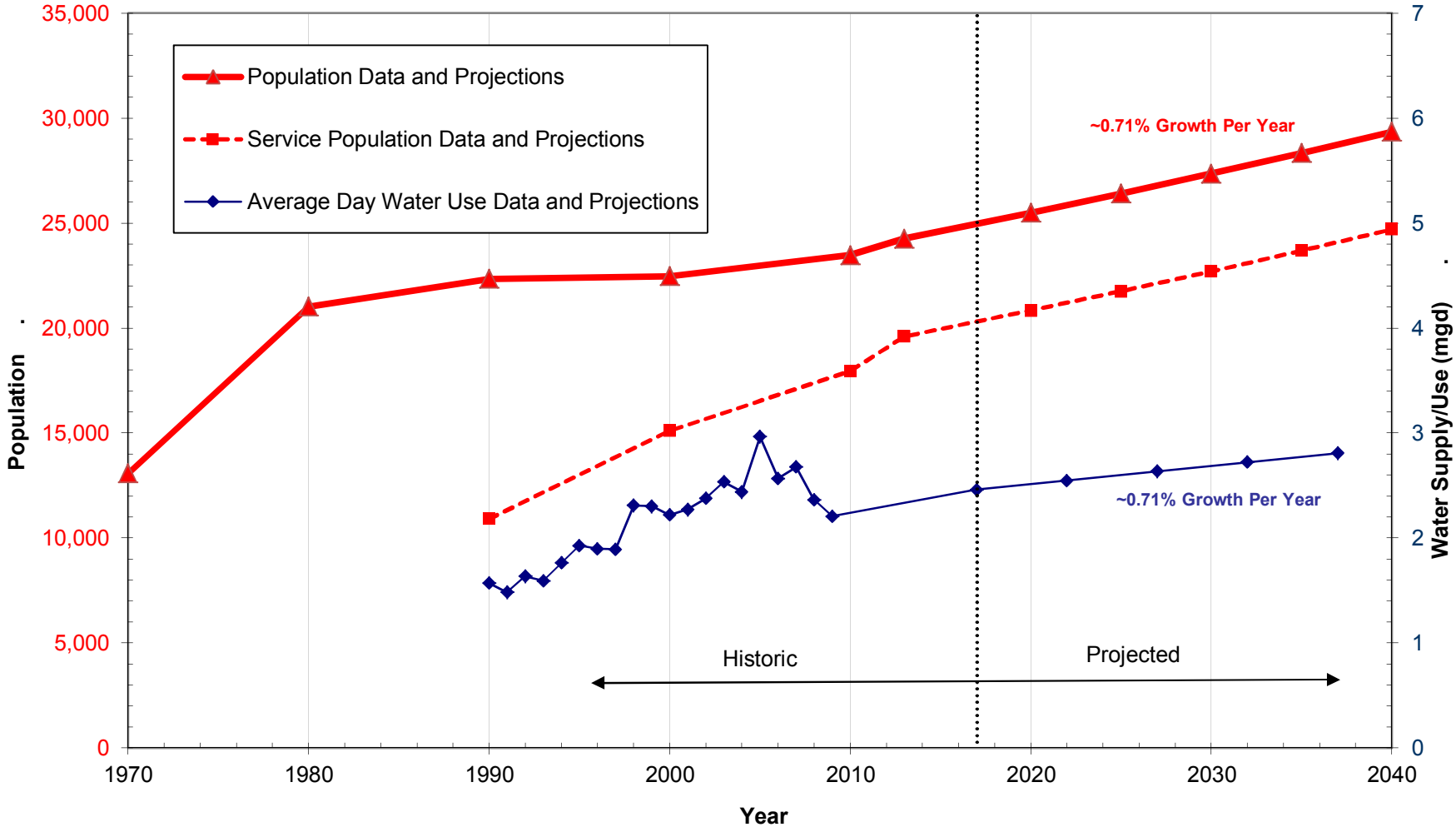


FIGURE 3

NOWS - Northside Water System Reliability Study
Historic And Projected Water System Customers

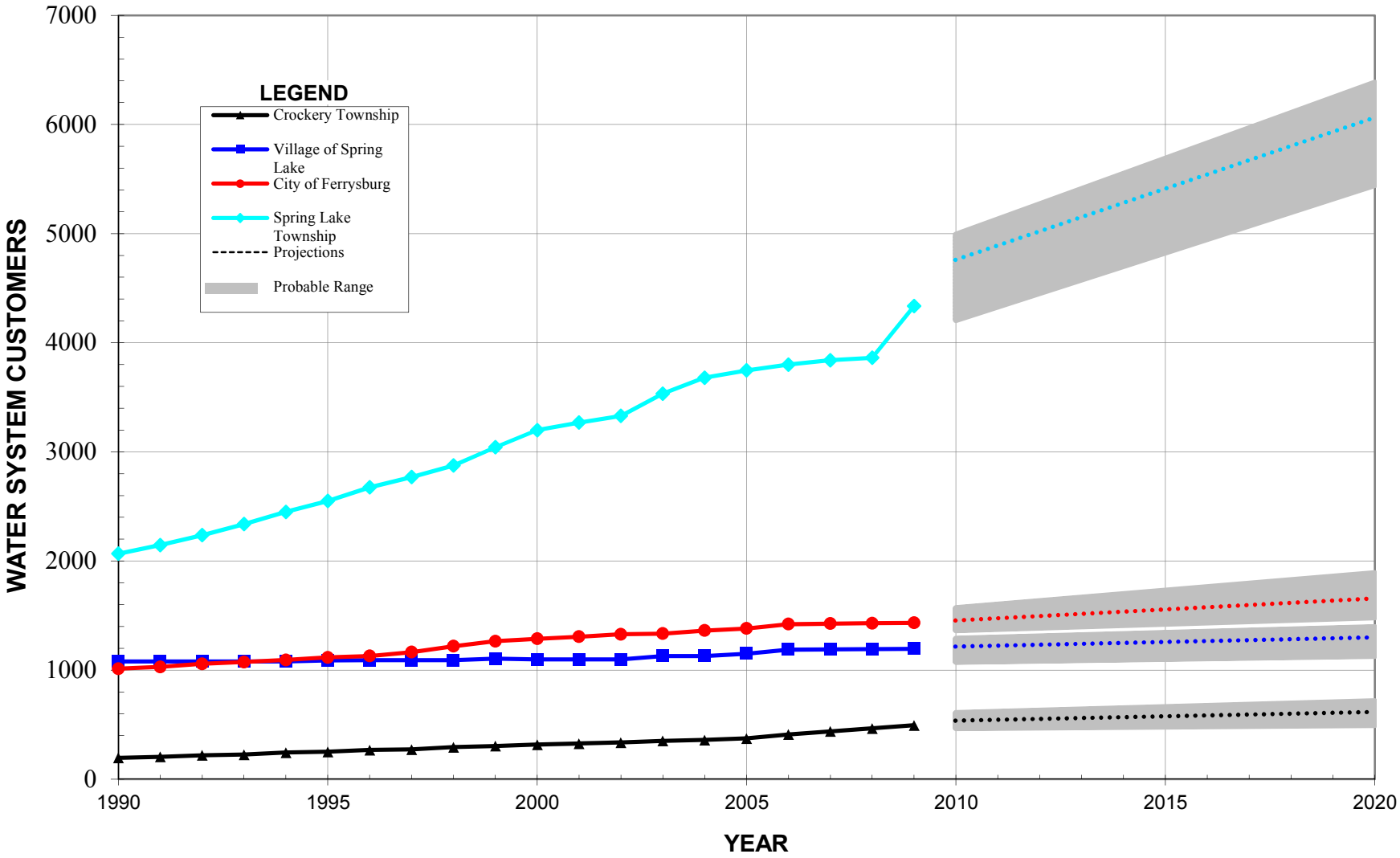
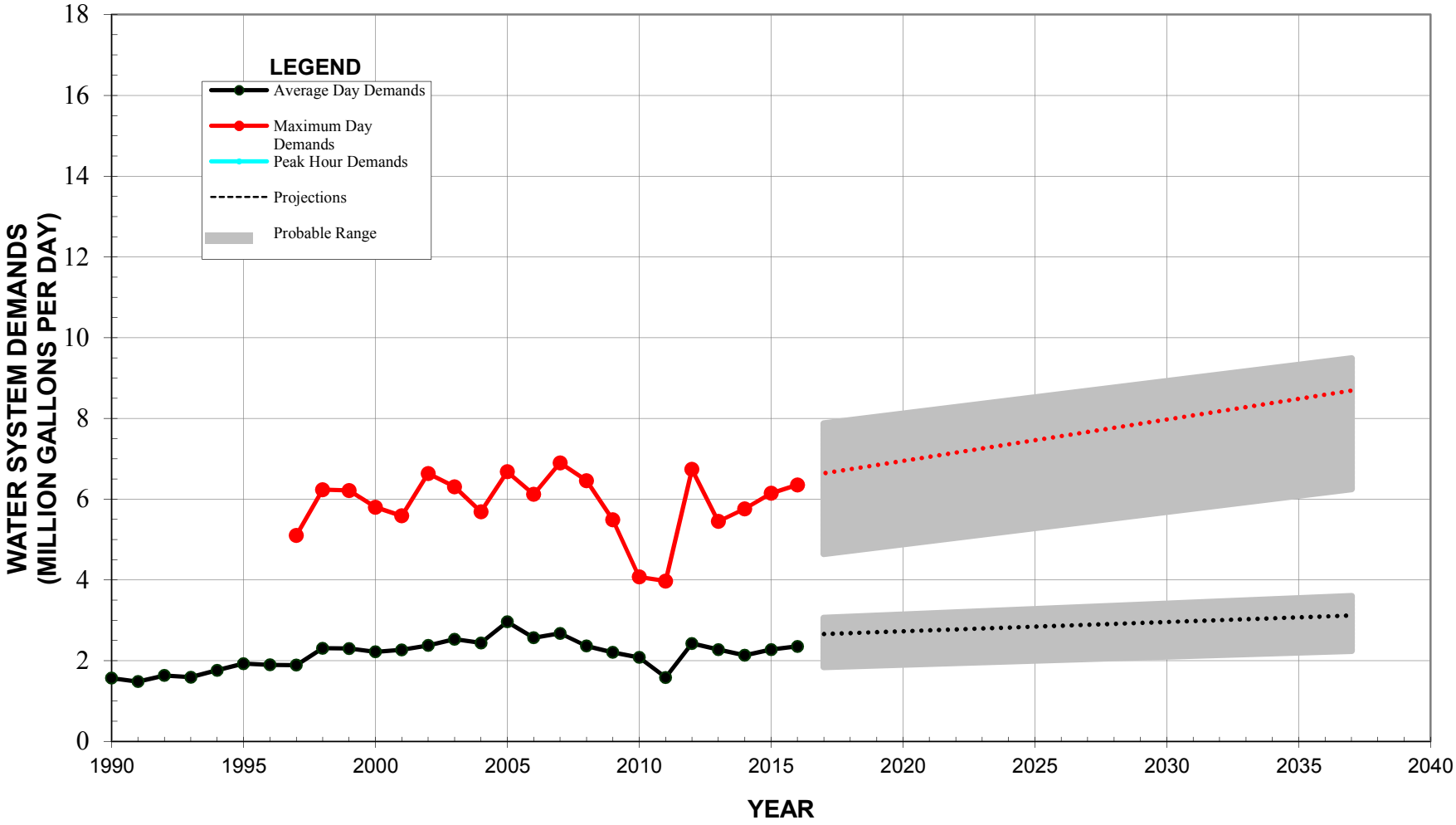


FIGURE 4

NOWS - Northside Water System Reliability Study
Historic And Projected Water System Demands



City of Ferrysburg

City of Grand Haven

Spring Lake Township

Spring Lake Village

Grand Haven Charter Township

Crockery Township

Robinson Township

4b. Replace all 4" and 6" main built before 1940 with 8" main.

0.5 MG

1.0 MG

0.2 MG

LEGEND

- Water Hydrants
- Master Meters
- Emergency Interconnects
- Water Storage Facility
- Low Fire Flow
- WaterMain
- Proposed Projects

0 2,000 4,000 8,000 Feet

NORTHWEST OTTAWA WATER SYSTEM

OTTAWA COUNTY, MI

GENERAL PLAN

FIGURE 5

Prein&Newhof

2160621

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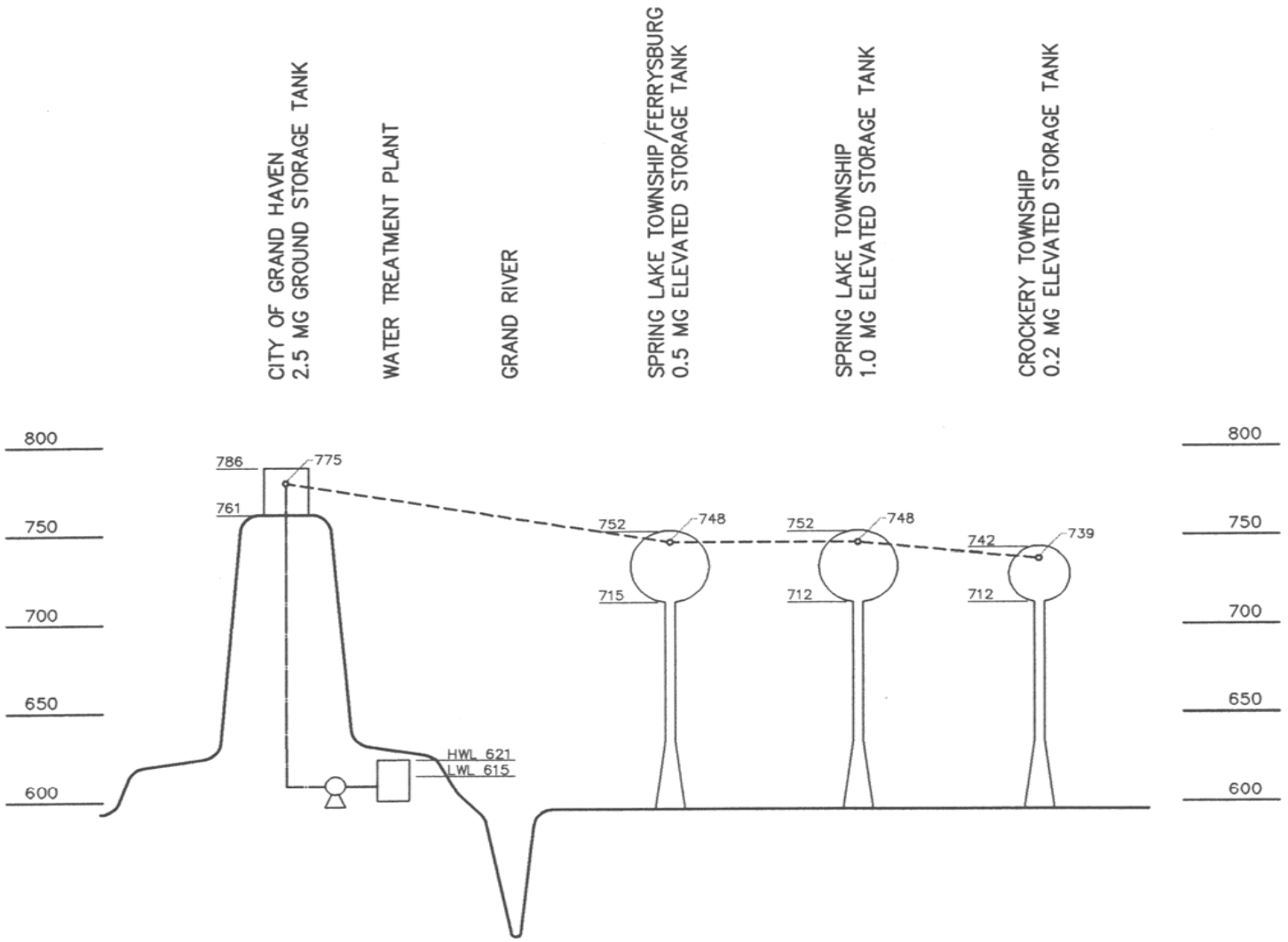
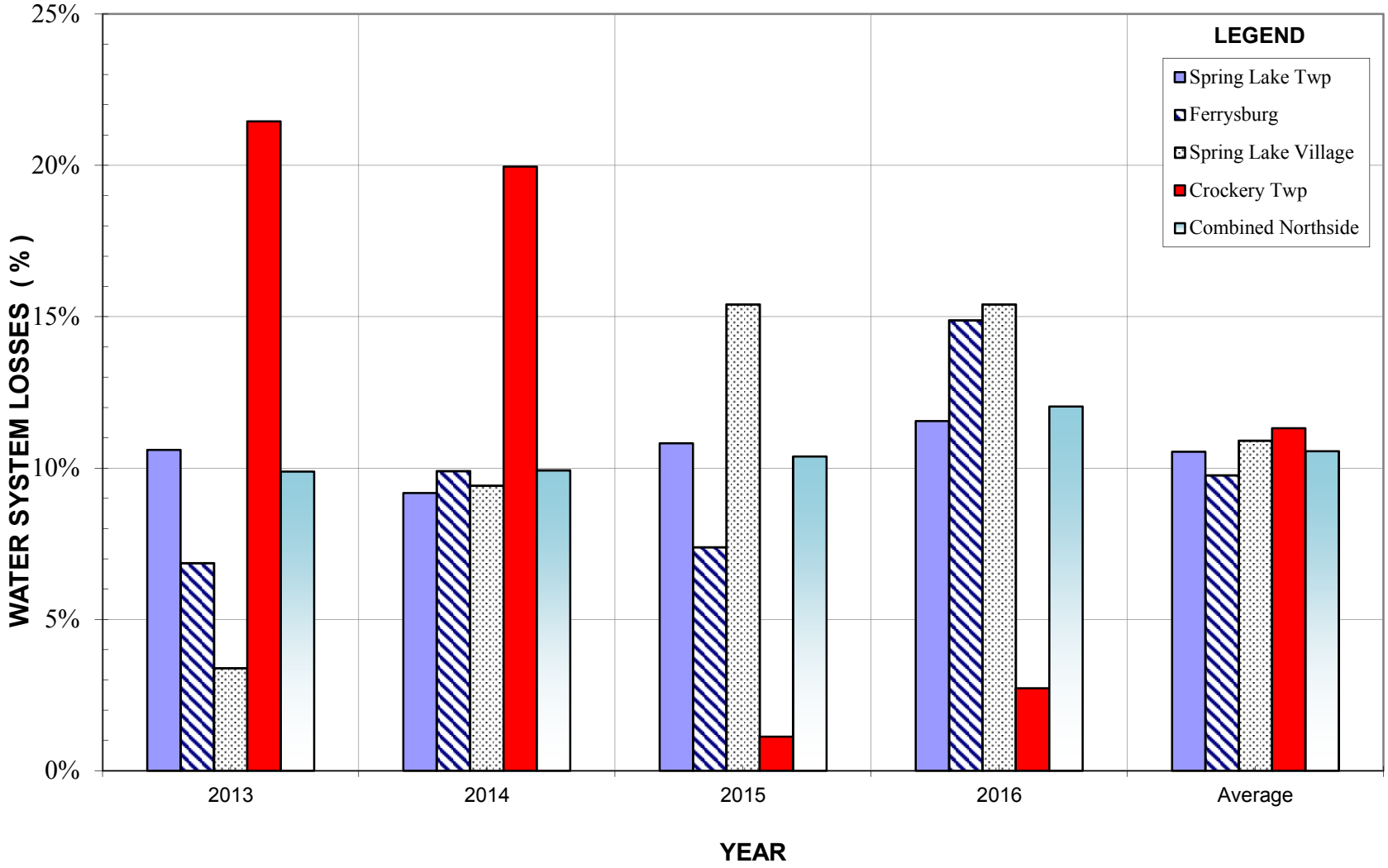


FIGURE 6

NOWS - Northside Water System Reliability Study
NOWS-Northside Water System Profile

FIGURE 7

NOWS - Northside Water System Reliability Study
4-Year History of Unbilled Water



Appendix C

Model Input/Output

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-1	J-1001	J-1002	16	7200	120
P-2	J-1002	T-1	16	15	120
P-3	J-1002	J-1003	16	2599	120
P-4	J-1003	J-1004	12	4500	120
P-5	J-1004	J-1005	12	9600	120
P-6	J-1003	j-1006	16	2702	120
P-7	j-1006	j-1007	16	8100	120
P-8	j-1007	J-1008	12	200	120
P-9	J-1008	J-1009	12	2700	120
P-10	J-1009	J-1010	12	5300	120
P-11	J-1010	J-1011	12	2600	120
P-12	J-1011	J-1004	12	3464	120
P-13	J-1011	j-1006	16	2847	120
P-14	J-1008	J-1010	12	5948	120
P-15	J-1009	J-1012	16	2700	120
P-16	J-1012	J-1013	16	5300	120
P-17	J-1013	J-1014	12	2700	120
P-18	J-1014	J-1015	12	5200	120
P-19	J-1015	J-1016	12	3400	120
P-20	J-1013	J-1017	16	4300	120
P-21	J-1017	J-1016	16	1140	120
P-23	J-1005	J-1018	12	9300	120
P-24	J-1018	J-1019	16	2100	120
P-25	J-1019	J-1016	16	4675	120
P-26	J-1019	J-1020	12	1499	120
P-27	J-1020	J-1021	12	2200	120
P-28	J-1021	J-1022	12	1998	120
P-29	J-1022	J-1023	12	5899	120
P-30	j-1007	J-1024	16	1401	120
P-31	J-1024	J-1025	16	5408	120
P-33	J-1024	J-1026	16	6228	120
P-34	J-1024	J-1026	16	5220	120
P-35	J-1026	J-1027	16	2828	120
P-36	J-1027	J-1028	16	1800	120
P-38	J-1029	J-1030	24	50	120
P-39	J-1030	J-1031	24	50	120
P-40	J-1031	J-1032	24	50	120
P-42	J-1033	J-1034	24	50	120
P-43	J-1034	J-1035	24	50	120
P-44	J-1035	J-1028	12	50	120
P-47	J-1032	PMP-1	24	26	120
P-48	PMP-1	J-1033	24	24	120
P-49	J-1034	PMP-2	16	24	120
P-50	PMP-2	J-1031	16	26	120
P-51	J-1035	PMP-3	16	24	120

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-52	PMP-3	J-1030	16	26	120
P-53	J-1028	PMP-4	16	24	120
P-54	PMP-4	J-1029	16	26	120
P-55	J-1031	R-1	24	69	120
P-56	J-1027	J-1036	12	75	120
P-57	J-1036	J-1037	12	75	120
P-60	J-1036	T-4	12	252	120
P-61	J-1028	J-39	20	18935	120
P-68	J-45	J-44	12	1745	130
P-69	J-45	J-46	20	2433	130
P-70	J-46	J-47	12	2674	135
P-76	J-51	J-52	12	2100	135
P-77	J-52	J-53	12	3926	135
P-79	J-54	J-55	8	3961	115
P-80	J-55	J-52	12	2631	135
P-82	J-55	J-56	12	2633	135
P-88	J-57	J-59	16	2228	135
P-94	J-63	J-64	12	2294	135
P-103	J-66	J-69	12	1739	135
P-109	J-70	J-73	12	2670	135
P-110	J-73	J-65	12	5243	135
P-118	J-78	J-79	8	42	105
P-124	J-81	J-1015	20	8792	120
P-125	J-65	J-82	12	240	130
P-126	J-82	J-83	12	120	130
P-127	J-83	J-84	12	120	130
P-129	J-85	J-86	8	106	115
P-130	J-86	J-87	8	500	110
P-131	J-87	J-82	1	433	110
P-133	J-82	J-88	12	128	130
P-134	J-88	J-87	8	248	110
P-135	J-83	PMP-5	8	209	110
P-136	PMP-5	J-86	8	302	110
P-137	J-84	PMP-6	8	243	110
P-138	PMP-6	J-85	8	270	110
P-139	J-87	J-89	12	324	130
P-140	J-89	J-90	12	192	135
P-142	J-91	T-7	12	214	135
P-145	J-1025	PMP-7	16	1717	120
P-146	PMP-7	J-1026	16	1889	120
P-147	J-39	J-94	16	481	135
P-153	J-1005	J-1040	16	175	120
P-154	J-1040	J-1041	16	5190	120
P-155	J-1041	J-1098	16	5275	120
P-156	J-1098	J-1021	16	2965	120

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-157	J-1040	T-8	16	104	120
P-158	J-1037	J-42	24	13118	120
P-159	J-1027	J-1016	24	18517	120
P-161	J-1038	PMP-9	24	25	120
P-162	PMP-9	J-1039	24	25	120
P-163	J-1039	J-1032	24	10	120
P-160	J-1038	J-1033	24	10	120
P-164	J-1033	J-1037	12	1800	120
P-165	J-48	J-101	12	4162	135
P-169	J-101	J-103	12	2564	135
P-177	J-108	J-109	12	5503	130
P-178	J-109	J-110	12	4540	130
P-179	J-110	J-105	12	1829	130
P-180	J-110	J-107	12	5313	130
P-184	J-113	J-65	12	5258	135
P-186	J-64	J-115	12	1584	135
P-190	J-116	J-108	12	5331	135
P-196	J-116	J-119	12	6780	135
P-197	J-119	J-118	12	5327	135
P-202	J-120	J-111	8	1716	115
P-204	J-121	J-67	12	544	120
P-205	J-39	J-122	20	2856	130
P-206	J-122	J-40	20	5907	130
P-207	J-122	J-123	8	10381	110
P-208	J-40	J-124	20	2903	130
P-210	J-124	J-125	12	733	130
P-211	J-125	J-126	6	575	110
P-212	J-126	J-127	6	323	110
P-213	J-127	J-128	6	545	110
P-214	J-126	J-129	6	541	110
P-215	J-127	J-130	6	703	110
P-216	J-130	J-131	6	950	110
P-217	J-125	J-132	12	391	130
P-219	J-132	J-129	12	438	130
P-220	J-129	J-130	12	294	130
P-221	J-130	J-134	12	673	130
P-222	J-134	J-135	12	323	130
P-223	J-134	J-136	6	318	110
P-224	J-136	J-137	6	467	110
P-225	J-137	J-138	6	336	110
P-226	J-138	J-139	6	579	110
P-227	J-139	J-137	6	853	110
P-228	J-136	J-140	6	318	110
P-229	J-137	J-141	6	309	110
P-230	J-142	J-135	8	594	110

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-231	J-135	J-140	12	319	130
P-232	J-140	J-141	12	467	130
P-233	J-141	J-143	12	425	130
P-234	J-143	J-144	6	413	110
P-235	J-144	J-145	6	309	110
P-236	J-41	J-146	20	682	130
P-237	J-146	J-45	12	319	130
P-238	J-146	J-147	8	922	110
P-239	J-41	J-148	6	660	110
P-240	J-124	J-149	20	376	130
P-241	J-149	J-41	20	331	130
P-243	J-145	J-150	6	1749	110
P-244	J-150	J-151	8	1830	110
P-245	J-143	J-152	12	974.56	130
P-246	J-152	J-153	12	397	130
P-247	J-153	J-151	12	474.98	130
P-248	J-151	J-154	12	828.67	130
P-250	J-155	J-153	6	270.34	110
P-251	J-154	J-156	8	173.13	110
P-252	J-156	J-157	6	720.06	110
P-253	J-157	J-158	6	1,127.60	110
P-254	J-158	J-159	8	291.4	110
P-255	J-159	J-157	6	636.68	110
P-256	J-156	J-159	8	287.51	110
P-257	J-154	J-160	6	281.59	110
P-258	J-160	J-161	6	241.39	110
P-259	J-161	J-162	6	232.47	110
P-260	J-162	J-163	6	240.01	110
P-261	J-163	J-164	6	252.5	110
P-262	J-164	J-165	6	385.4	110
P-263	J-160	J-166	6	350.31	110
P-264	J-161	J-167	6	539.73	110
P-265	J-162	J-168	6	535.37	110
P-266	J-163	J-169	6	548.02	110
P-267	J-164	J-170	6	167.64	110
P-268	J-170	J-171	6	207.26	110
P-269	J-170	J-172	6	430.19	110
P-270	J-165	J-173	6	724.39	110
P-271	J-154	J-166	12	324.3	130
P-272	J-166	J-167	12	299.53	130
P-273	J-167	J-168	12	233.63	130
P-274	J-168	J-169	12	239.34	130
P-275	J-169	J-172	12	247.38	130
P-276	J-172	J-173	12	363.81	130
P-277	J-173	J-174	12	258.34	130

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-281	J-174	J-176	6	1,084.83	110
P-282	J-169	J-177	6	483.26	110
P-283	J-177	J-178	6	352.97	110
P-284	J-178	J-179	6	358.03	110
P-286	J-180	J-167	6	602.98	110
P-289	J-56	J-182	16	797.45	130
P-291	J-182	J-183	6	307.28	110
P-292	J-183	J-184	6	918.55	110
P-293	J-184	J-185	6	285.28	110
P-294	J-185	J-183	6	1,128.92	110
P-295	J-185	J-186	6	1,222.06	110
P-297	J-188	J-189	8	519.79	110
P-298	J-189	J-190	8	367.22	110
P-299	J-190	J-191	8	222.25	110
P-300	J-191	J-192	6	459.84	110
P-301	J-191	J-193	6	735.95	110
P-302	J-188	J-190	6	1,400.53	110
P-303	J-189	J-194	6	1,084.82	110
P-304	J-188	J-195	6	699.92	110
P-305	J-43	J-196	6	1,962.99	120
P-306	J-43	J-197	12	1,714.14	130
P-307	J-197	J-44	12	966.63	130
P-308	J-197	J-196	6	611.89	110
P-310	J-198	J-43	12	912.4	130
P-312	J-199	J-196	6	402.37	110
P-313	J-43	J-200	12	331.25	125
P-314	J-200	J-201	8	551.14	115
P-315	J-201	J-202	8	637.37	115
P-316	J-202	J-203	8	410.75	115
P-317	J-202	J-203	8	776.03	125
P-318	J-201	J-204	8	642.5	115
P-319	J-200	J-205	12	764.97	125
P-322	J-206	J-205	8	1,610.13	115
P-323	J-205	J-207	12	1,079.80	125
P-325	J-208	J-206	8	601.84	115
P-326	J-208	J-209	6	905.56	115
P-327	J-206	J-210	8	836.03	115
P-329	J-210	J-211	8	318.94	115
P-332	J-213	J-214	12	950.19	135
P-333	J-213	J-215	8	770.34	115
P-334	J-215	J-46	12	751.13	135
P-335	J-47	J-216	12	1,291.64	135
P-336	J-216	J-48	12	1,350.48	135
P-337	J-216	J-217	12	699.63	135
P-338	J-217	J-218	12	581.7	135

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-339	J-217	J-219	12	1,470.39	135
P-340	J-48	J-220	8	2,765.70	120
P-341	J-220	J-221	8	2,472.14	120
P-346	J-225	J-226	6	1,044.76	115
P-347	J-225	J-53	12	1,160.24	115
P-348	J-225	J-227	6	1,350.69	115
P-349	J-47	J-228	12	1,371.66	135
P-351	J-228	J-229	8	1,730.68	115
P-352	J-182	J-230	16	1,745.23	130
P-353	J-230	J-46	16	1,481.42	130
P-354	J-230	J-231	6	1,001.47	115
P-362	J-236	J-237	8	1,124.12	115
P-363	J-236	J-238	8	1,004.84	115
P-365	J-239	J-236	6	646.19	115
P-366	J-239	J-240	6	456.4	115
P-367	J-53	J-241	12	521.5	135
P-369	J-241	J-242	6	295.94	115
P-370	J-242	J-243	6	1,114.90	115
P-371	J-243	J-242	6	1,695.10	115
P-372	J-54	J-244	12	228.76	135
P-374	J-244	J-245	6	587.23	115
P-376	J-246	J-247	6	734.59	115
P-379	J-247	J-248	6	436.22	115
P-380	J-247	J-246	6	1,494.34	115
P-381	J-245	J-249	6	437.40	115
P-382	J-57	J-250	16	300.04	135
P-384	J-250	T-5	16	449.89	135
P-385	J-63	J-251	12	222.06	135
P-387	J-251	J-252	8	988.79	115
P-386	J-251	J-253	12	1,765.20	135
P-388	J-253	J-255	12	1,599.11	135
P-390	J-255	J-257	12	743.53	135
P-394	J-258	J-63	12	2,416.52	135
P-396	J-115	J-259	12	248.20	135
P-397	J-259	J-113	12	2,664.09	135
P-398	J-258	J-259	8	2,641.05	115
P-399	J-257	J-260	12	838.37	135
P-401	J-260	J-261	6	2,505.96	115
P-404	J-260	J-263	12	165.54	135
P-405	J-263	J-262	12	1,410.94	135
P-406	J-263	J-264	6	666.64	115
P-407	J-264	J-265	6	661.83	115
P-408	J-264	J-266	6	594.52	115
P-409	J-262	J-267	12	839.72	135
P-410	J-267	J-61	12	1,776.96	135

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-413	J-267	J-268	6	6,470.50	115
P-412	J-268	J-269	20	965.19	135
P-414	J-269	J-60	20	165.85	135
P-415	J-269	J-270	6	833.89	115
P-419	J-60	J-273	12	2,248.94	135
P-421	J-273	J-274	6	1,668.04	100
P-423	J-277	J-278	6	955.77	100
P-424	J-279	J-280	6	768.1	100
P-425	J-280	J-281	6	321.41	100
P-426	J-281	J-282	6	287.92	100
P-427	J-280	J-283	6	241.14	100
P-428	J-283	J-284	6	223.34	100
P-429	J-284	J-285	6	235.63	100
P-430	J-285	J-286	6	154.14	100
P-431	J-286	J-287	6	216.85	100
P-432	J-287	J-280	6	223.77	100
P-433	J-287	J-288	6	325.98	100
P-434	J-288	J-281	6	240.77	100
P-435	J-288	J-289	6	296.17	90
P-436	J-273	J-290	12	1,402.18	120
P-437	J-290	J-121	12	165.20	120
P-438	J-290	J-274	8	390.04	100
P-439	J-274	J-276	8	222.41	100
P-440	J-276	J-278	8	196.8	100
P-441	J-278	J-279	8	277.68	100
P-442	J-279	J-282	8	201.86	100
P-443	J-282	J-289	8	229.33	100
P-444	J-289	J-291	8	447.73	100
P-446	J-291	J-293	6	768.98	90
P-447	J-289	J-294	6	725.18	90
P-448	J-282	J-294	8	1,085.67	100
P-449	J-294	J-295	6	171.16	90
P-450	J-295	J-296	6	451.77	90
P-451	J-295	J-293	6	250.38	90
P-452	J-293	J-292	8	308.46	100
P-497	J-319	J-320	6	777.85	115
P-498	J-320	J-321	6	418.69	115
P-499	J-321	J-322	6	933.63	115
P-500	J-322	J-321	6	1,092.48	115
P-501	J-322	J-323	6	267.63	115
P-502	J-320	J-324	12	376.01	135
P-504	J-324	J-325	6	1,228.98	115
P-503	J-324	J-326	12	350.41	135
P-505	J-326	J-77	12	1,211.35	135
P-507	J-75	J-328	12	1,346.13	135

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-510	J-323	J-325	8	659.02	115
P-515	J-330	J-331	8	1,049.31	115
P-516	J-331	J-332	6	507.20	115
P-517	J-330	J-333	12	1,810.68	135
P-519	J-333	J-334	8	472.59	115
P-520	J-334	J-331	8	503.92	115
P-522	J-335	J-75	12	507.97	135
P-523	J-335	J-336	6	924.28	110
P-524	J-336	J-337	6	333.51	110
P-525	J-81	J-338	8	4,052.64	105
P-526	J-338	J-75	8	721.45	105
P-527	J-336	J-338	6	315.99	110
P-528	J-77	J-339	6	648.21	115
P-529	J-339	J-340	6	884.11	115
P-531	J-342	J-340	6	298.67	115
P-532	J-339	J-343	6	522.8	115
P-539	J-69	J-348	12	362.4	135
P-540	J-348	J-70	12	2,198.00	135
P-545	J-69	J-352	6	1,769.67	115
P-546	J-353	J-354	6	299.14	115
P-547	J-354	J-355	6	978.38	115
P-548	J-354	J-356	6	1,073.58	115
P-550	J-357	J-66	12	911.87	135
P-551	J-357	J-358	6	1,348.66	115
P-555	J-60	J-361	6	1,291.82	115
P-556	J-60	J-362	12	532.64	135
P-559	J-267	J-364	6	750.43	115
P-562	J-365	J-366	6	1,300.12	115
P-563	J-61	J-367	12	694.66	135
P-564	J-367	J-365	12	402.64	135
P-565	J-366	J-367	6	1,701.58	115
P-566	J-365	J-368	12	504.76	135
P-568	J-368	J-369	8	1,619.54	115
P-569	J-369	J-370	8	622.80	115
P-570	J-370	J-369	8	717.06	115
P-571	J-368	J-371	12	1,611.89	135
P-573	J-371	J-372	6	1,129.54	115
P-580	J-371	J-379	12	491.34	135
P-581	J-379	J-62	12	1,561.96	135
P-576	J-372	J-379	6	2,058.61	115
P-575	J-62	J-374	12	1,629.16	135
P-577	J-374	J-357	12	2,389.23	135
P-578	J-374	J-375	6	1,189.20	115
P-579	J-103	J-376	8	2,003.48	115
P-582	J-376	J-104	8	1,956.77	115

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-583	J-376	J-377	8	2,367.18	115
P-584	J-103	J-378	12	775.19	140
P-585	J-378	J-380	8	988.92	120
P-586	J-380	J-381	8	477.27	120
P-587	J-381	J-382	6	678.79	120
P-588	J-381	J-383	6	323.79	120
P-589	J-378	J-384	12	660.37	130
P-590	J-384	J-385	12	567.31	130
P-591	J-385	J-386	8	1,010.40	120
P-592	J-386	J-380	8	569.11	120
P-593	J-386	J-387	8	525.13	120
P-594	J-387	J-388	8	379.23	120
P-595	J-385	J-389	12	498.28	130
P-597	J-381	J-390	8	774.06	120
P-598	J-390	J-391	8	969.35	120
P-599	J-391	J-392	8	664.25	120
P-601	J-392	J-388	8	531.65	120
P-602	J-391	J-387	8	405.1	120
P-603	J-389	J-394	8	981.87	120
P-604	J-390	J-395	6	476.65	120
P-605	J-248	J-396	12	751.81	135
P-606	J-396	J-57	12	143.39	135
P-607	J-396	J-397	6	841.52	115
P-608	J-92	J-398	12	441.43	135
P-609	J-398	J-118	12	3,287.98	135
P-612	J-400	J-120	8	525.46	115
P-613	J-399	J-400	6	621.09	115
P-614	J-120	J-401	12	342.35	135
P-615	J-401	J-92	12	661.35	135
P-616	J-401	J-399	6	431.57	115
P-617	J-399	J-402	6	630.55	115
P-618	J-398	J-403	6	318.36	115
P-619	J-403	J-399	6	346.84	115
P-620	J-402	J-403	6	958.6	115
P-621	J-92	J-404	12	634.09	135
P-622	J-404	J-111	12	616.71	135
P-625	J-405	J-406	6	983.44	115
P-626	J-406	J-111	6	664.8	115
P-627	J-406	J-407	6	450.98	115
P-628	J-111	J-408	12	159.13	135
P-629	J-408	J-112	8	2,441.07	115
P-630	J-407	J-408	12	530.41	115
P-631	J-92	J-409	12	184.27	135
P-632	J-409	J-405	12	449.82	135
P-634	J-398	J-410	6	541.48	115

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-635	J-410	J-411	6	751.07	115
P-637	J-412	J-120	12	873.88	135
P-639	J-413	J-400	8	767.82	115
P-640	J-412	J-413	6	977.14	115
P-641	J-105	J-414	12	4,063.61	130
P-642	J-414	J-416	12	5,801.18	130
P-644	J-416	J-106	8	2,216.24	105
P-645	J-107	J-417	12	1,223.53	135
P-647	J-417	J-418	12	678.01	135
P-648	J-418	J-419	12	540.94	135
P-650	J-418	J-421	8	934.79	135
P-651	J-291	J-422	8	704.23	100
P-652	J-422	J-292	6	867.77	90
P-653	J-422	J-423	6	237.89	90
P-655	J-424	J-425	4	451.75	60
P-656	J-424	J-426	8	606.69	90
P-657	J-426	J-427	8	452.86	90
P-658	J-427	J-428	4	672.74	60
P-659	J-427	J-429	8	287.63	90
P-660	J-429	J-430	4	354.71	60
P-661	J-430	J-431	6	517.13	90
P-663	J-432	J-423	6	359.19	90
P-664	J-430	J-428	4	639.11	60
P-665	J-431	J-433	6	342.53	90
P-670	J-434	J-436	8	614.51	90
P-671	J-436	J-437	10	1,522.21	110
P-672	J-437	J-434	6	965.25	80
P-673	J-437	J-438	10	1,218.79	110
P-674	J-438	J-439	10	287.37	110
P-675	J-439	J-440	6	330.07	90
P-676	J-437	J-441	6	439.32	90
P-677	J-441	J-442	6	977.67	90
P-678	J-442	J-438	6	349.88	90
P-679	J-442	J-443	6	330.07	90
P-680	J-443	J-444	6	980.98	90
P-681	J-444	J-441	6	326.78	90
P-682	J-444	J-445	6	558.23	90
P-683	J-445	J-446	6	984.28	90
P-684	J-446	J-443	6	330.74	90
P-685	J-439	J-447	10	370.69	110
P-686	J-442	J-448	6	650.68	90
P-687	J-443	J-449	6	657.28	90
P-688	J-446	J-450	6	657.28	90
P-690	J-449	J-448	8	330.13	90
P-691	J-448	J-447	8	330.08	90

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-692	J-447	J-433	6	1,006.53	90
P-693	J-447	J-451	6	583.19	90
P-694	J-451	J-433	6	412.35	90
P-695	J-448	J-452	8	574.17	90
P-696	J-450	J-453	8	157.12	90
P-697	J-453	J-449	8	172.96	90
P-698	J-453	J-454	4	548.38	60
P-699	J-454	J-455	8	518.56	90
P-701	J-456	J-457	8	1,067.36	90
P-702	J-457	J-450	8	331.39	90
P-704	J-457	J-459	8	244.16	90
P-705	J-459	J-460	6	453.3	90
P-706	J-457	J-461	6	544.4	90
P-707	J-461	J-458	6	215.14	90
P-708	J-461	J-462	4	387.79	60
P-709	J-455	J-463	6	803.75	90
P-710	J-463	J-464	4	501.7	60
P-711	J-455	J-465	6	272.63	90
P-712	J-465	J-456	6	186.16	90
P-713	J-464	J-465	8	462.67	100
P-714	J-463	J-466	4	471.33	60
P-715	J-466	J-447	10	1,507.83	110
P-716	J-447	J-467	4	730.04	60
P-717	J-467	J-468	4	779.34	60
P-718	J-467	J-469	6	550.82	90
P-719	J-469	J-451	8	694.67	90
P-720	J-469	J-470	8	369.61	90
P-721	J-470	J-471	8	402.96	90
P-722	J-471	J-468	4	547.42	60
P-723	J-470	J-472	4	293.76	60
P-724	J-471	J-473	4	407.77	60
P-725	J-473	J-426	8	193.59	90
P-726	J-466	J-463	6	460.37	90
P-727	J-463	J-474	4	336.9	60
P-728	J-474	J-475	4	464.07	60
P-729	J-475	J-468	4	336.73	60
P-730	J-474	J-476	4	796.2	60
P-731	J-476	J-477	4	445.84	60
P-732	J-477	J-478	10	642.72	110
P-733	J-478	J-466	10	495.65	110
P-734	J-478	J-479	6	277.28	90
P-735	J-479	J-480	6	283.86	90
P-736	J-480	J-471	8	502.25	90
P-737	J-475	J-477	4	819.3	60
P-738	J-479	J-481	4	644.14	60

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-739	J-481	J-477	4	279.01	60
P-740	J-477	J-482	4	489.32	60
P-741	J-482	J-483	6	427.85	90
P-742	J-481	J-484	4	414.64	60
P-743	J-484	J-482	4	349.91	60
P-744	J-480	J-485	8	480.74	100
P-747	J-485	J-487	6	340.07	90
P-748	J-486	J-488	8	406.09	100
P-749	J-485	J-489	8	163.41	100
P-750	J-489	J-486	8	414.64	100
P-751	J-481	J-489	4	283.86	60
P-752	J-473	J-490	6	982.98	90
P-753	J-490	J-488	6	578.06	90
P-754	J-484	J-491	4	449.22	60
P-755	J-491	J-492	4	310.81	60
P-756	J-492	J-486	4	476.99	60
P-757	J-492	J-493	4	370.38	60
P-758	J-493	J-488	6	449.31	90
P-759	J-492	J-494	4	842.89	60
P-760	J-493	J-494	6	466.02	90
P-761	J-494	J-495	6	345.28	90
P-762	J-495	J-496	4	396.25	90
P-763	J-486	J-497	8	930.04	100
P-764	J-497	J-498	8	254.91	100
P-765	J-498	J-491	8	481.69	100
P-766	J-497	J-496	8	330.54	100
P-767	J-496	J-499	8	330.43	100
P-769	J-500	J-501	8	178.13	100
P-770	J-501	J-502	8	486.5	100
P-771	J-502	J-503	8	663.17	100
P-772	J-499	J-504	6	385.88	90
P-773	J-504	J-495	6	326.81	90
P-774	J-504	J-505	8	980.15	100
P-775	J-505	J-501	8	602.1	100
P-776	J-488	J-506	10	359.98	110
P-777	J-506	J-507	6	405.2	60
P-778	J-507	J-508	4	616.12	60
P-779	J-508	J-509	6	307.94	60
P-780	J-509	J-507	6	467.4	60
P-781	J-509	J-510	6	363.59	60
P-782	J-510	J-506	4	499.85	60
P-783	J-508	J-511	6	460.76	60
P-784	J-511	J-512	4	307.94	60
P-785	J-512	J-509	4	460.43	60
P-786	J-512	J-513	6	371.01	60

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-787	J-513	J-510	4	460.38	60
P-788	J-513	J-514	4	330.43	60
P-789	J-514	J-515	4	367.3	60
P-790	J-515	J-512	4	330.45	60
P-791	J-515	J-516	4	315.36	60
P-792	J-516	J-511	6	330.45	60
P-793	J-516	J-517	4	337.86	60
P-794	J-517	J-518	6	682.67	60
P-795	J-518	J-514	4	337.86	60
P-796	J-513	J-519	4	140.99	60
P-797	J-519	J-494	4	262.24	60
P-798	J-514	J-520	6	148.45	60
P-799	J-520	J-495	6	254.52	90
P-800	J-518	J-521	6	163.25	60
P-801	J-521	J-504	6	250.22	90
P-802	J-518	J-522	4	664.57	60
P-803	J-522	J-523	4	389.56	60
P-804	J-522	J-524	4	193.06	60
P-805	J-524	J-525	4	374.72	60
P-806	J-525	J-526	4	620.42	60
P-807	J-526	J-524	4	104.02	60
P-809	J-521	J-520	10	334.47	110
P-810	J-520	J-519	10	334.23	110
P-98	J-66	J-353	6	657.43	115
P-97	J-353	J-65	6	2,168.27	115
P-812	J-175	J-187	12	246.32	130
P-813	J-187	J-59	12	456.93	130
P-296	J-188	J-187	8	380.52	110
P-417	J-270	J-272	6	1,320.33	115
P-418	J-272	J-270	6	407.11	115
P-814	J-367	J-527	8	603.71	125
P-815	J-527	J-528	8	827.69	125
P-816	J-362	J-529	12	1,303.41	135
P-817	J-529	J-61	12	1,365.10	135
P-818	J-528	J-529	8	748.51	125
P-819	J-528	J-527	8	805.86	125
P-820	J-371	J-530	8	1,468.94	115
P-821	J-244	J-531	12	568.40	135
P-823	J-531	J-532	8	2,152.99	115
P-822	J-531	J-533	12	530.23	135
P-824	J-533	J-248	12	353.85	135
P-825	J-532	J-533	8	1,060.31	115
P-826	J-531	J-534	6	813.99	115
P-828	J-535	J-54	12	645.57	135
P-829	J-535	J-536	6	1,028.22	115

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-830	J-62	J-537	12	2,454.92	135
P-831	J-537	J-258	12	1,491.33	135
P-832	J-537	J-538	8	1,344.33	115
P-833	J-257	J-539	8	3,185.01	115
P-834	J-539	J-258	8	487.25	115
P-835	J-538	J-539	8	539.07	115
P-836	J-538	J-540	8	450.98	115
P-837	J-359	J-541	12	505.61	135
P-839	J-541	J-542	8	217.18	115
P-840	J-542	J-543	8	816.27	115
P-841	J-543	J-544	8	254.95	115
P-842	J-543	J-545	8	311.89	115
P-843	J-541	J-546	12	483.85	135
P-844	J-546	J-66	12	956.8	135
P-845	J-545	J-546	8	216.26	115
P-846	J-545	J-542	8	491.24	115
P-847	J-256	J-257	8	1,375.79	115
P-849	J-547	J-47	8	1,925.15	115
P-850	J-547	J-214	8	1,613.55	115
P-851	J-211	J-548	8	1,535.81	115
P-852	J-548	J-213	6	612.38	115
P-853	J-548	J-214	8	754.34	115
P-854	J-214	J-213	8	1,023.70	115
P-855	J-212	J-549	8	604.23	115
P-856	J-212	J-550	6	312.9	115
P-857	J-102	J-551	8	774.53	115
P-858	J-551	J-547	8	1,416.89	115
P-859	J-550	J-551	8	516.46	115
P-860	J-550	J-552	8	465.31	115
P-861	J-211	J-553	8	304.37	115
P-862	J-553	J-212	8	1,091.32	115
P-863	J-553	J-554	8	1,016.70	115
P-864	J-101	J-555	8	2,343.89	115
P-865	J-555	J-102	8	338.88	115
P-866	J-555	J-556	8	1,032.68	115
P-867	J-215	J-557	8	724.34	115
P-869	J-558	J-51	12	1,960.79	135
P-868	J-228	J-559	12	1,577.73	135
P-870	J-559	J-558	8	449.79	115
P-872	J-560	J-133	6	301.06	110
P-873	J-132	J-560	12	2,245.71	130
P-875	J-135	J-42	16	734.82	130
P-874	J-119	J-561	8	2,033.24	115
P-877	J-340	J-341	6	427.02	115
P-878	J-77	J-329	12	968.87	135

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-879	J-329	J-330	12	376.84	135
P-880	J-203	J-563	8	491.18	135
P-882	J-563	J-564	8	992.32	145
P-883	J-564	J-565	8	1,456.69	135
P-541	J-348	J-349	6	815.94	115
P-467	J-299	J-304	12	576.26	135
P-542	J-349	J-350	6	1,039.69	115
P-533	J-72	J-344	12	1,283.81	135
P-462	J-301	J-72	12	893.93	135
P-492	J-315	J-318	6	1,125.56	115
P-554	J-359	J-360	6	611.47	115
P-543	J-350	J-349	6	457.67	115
P-477	J-309	T-9	8	2,043.79	115
P-470	J-304	J-307	8	684.87	125
P-508	J-328	J-314	12	663.59	135
P-460	J-299	J-300	8	2,026.60	125
P-472	J-297	J-305	12	304.35	135
P-108	J-71	T-6	16	932.11	135
P-552	J-346	J-359	12	2,443.48	135
P-486	J-313	J-314	6	457.98	115
P-538	J-346	J-347	8	1,043.17	115
P-489	J-315	J-316	8	760.20	115
P-456	J-298	J-72	6	1,450.24	115
P-476	J-309	J-302	12	715.53	135
P-495	J-317	J-320	12	430.87	135
P-482	J-312	J-310	12	196.65	135
P-461	J-297	J-301	12	283.33	135
P-457	J-297	J-298	12	797.12	135
P-488	J-315	J-317	12	458.16	135
P-471	J-304	J-308	6	585.42	115
P-483	J-312	J-313	6	649.22	115
P-469	J-305	J-306	8	1,509.40	125
P-491	J-317	J-318	6	710.29	115
P-105	J-70	J-71	12	978.27	135
P-480	J-310	J-311	6	1,480.70	115
P-487	J-310	J-315	12	898.66	135
P-536	J-121	J-346	12	1,335.87	135
P-494	J-318	J-319	6	444.21	115
P-455	J-71	J-298	12	1,006.89	135
P-473	J-305	J-304	12	351.62	135
P-485	J-314	J-76	12	649.22	135
P-465	J-302	J-299	12	186.32	135
P-475	J-76	J-309	12	499.47	135
P-481	J-76	J-312	12	455.13	135
P-544	J-350	J-351	6	355.96	115

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-668	J-344	J-436	12	891.05	135
P-838	J-436	J-562	12	516.66	120
P-848	J-562	J-67	12	453.22	120
P-884	J-431	J-566	6	250.33	90
P-885	J-566	J-432	6	199.24	90
P-887	J-506	J-424	6	1,766.55	130
P-888	J-424	J-428	10	469.77	110
P-889	J-428	J-432	10	805.87	110
P-890	J-432	J-292	8	325.45	100
P-891	J-562	J-567	10	1,007.01	110
P-892	J-567	J-566	10	1,626.34	110
P-893	J-432	J-567	10	1,983.37	110
P-894	J-433	J-568	8	1,537.79	90
P-895	J-568	J-434	8	384.94	90
P-896	J-567	J-568	10	499.79	110
P-897	J-506	J-424	10	1,766.55	110
P-898	J-526	J-569	8	128.10	100
P-899	J-569	J-505	8	281.61	100
P-900	J-521	J-569	10	965.11	110
P-901	J-569	J-42	10	2,165.16	110
P-902	J-325	J-570	8	344.59	115
P-903	J-570	J-329	8	1,008.33	115
P-904	J-326	J-570	6	1,166.90	135
P-906	J-571	J-560	6	597.64	110
P-907	J-155	J-572	6	271.27	110
P-909	J-174	J-574	12	667.42	130
P-910	J-574	J-175	12	864.36	130
P-911	J-573	J-574	8	1,111.67	130
P-912	J-573	J-575	8	349.81	130
P-913	J-235	J-237	8	1,619.33	115
P-914	J-237	J-576	8	723.23	115
P-356	J-232	J-233	6	554.74	115
P-344	J-223	J-224	8	827.51	115
P-360	J-233	J-235	6	424.34	115
P-355	J-223	J-232	6	489.22	115
P-358	J-234	J-232	6	926	115
P-359	J-234	J-224	6	502.77	115
P-357	J-233	J-234	6	1,205.74	115
P-345	J-224	J-225	8	454.12	115
P-915	J-52	J-579	8	537.71	115
P-917	J-579	J-578	8	2,133.83	115
P-918	J-74	J-580	12	1,531.30	130
P-919	J-580	J-75	12	1,159.98	130
P-920	J-580	J-581	8	506.35	135
P-921	J-581	J-582	8	789.79	135

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-922	J-581	J-583	8	595.36	135
P-923	J-70	J-584	12	3,173.78	135
P-924	J-584	J-74	12	2,138.54	135
P-925	J-584	J-585	8	588.40	130
P-926	J-585	J-586	8	1,237.52	130
P-928	J-587	J-78	8	1,157.63	105
P-929	J-586	J-587	8	1,792.17	130
P-930	J-118	J-588	12	6,852.62	135
P-931	J-588	J-93	12	1,732.03	135
P-932	J-429	J-433	8	526.38	90
P-934	J-589	J-67	24	1,726.90	130
P-935	J-295	J-589	8	70.17	100
P-936	J-589	J-293	8	219.97	100
P-937	J-253	J-590	6	1,136.48	115
P-938	J-590	J-254	6	1,142.81	115
P-939	J-590	J-252	8	720.92	135
P-940	J-255	J-591	6	770.08	115
P-941	J-591	J-256	6	1,148.62	115
P-942	J-591	J-254	6	1,146.08	135
P-943	J-235	J-592	6	699.81	115
P-944	J-592	J-239	6	938.68	115
P-945	J-227	J-592	8	581.06	135
P-946	J-123	J-395	8	2,772.49	135
P-947	J-377	J-382	8	1,049.01	135
P-948	J-389	J-593	12	443.04	130
P-949	J-593	J-388	8	1,133.23	120
P-951	J-565	J-207	8	888.38	125
P-952	J-79	J-594	8	1,490.68	105
P-953	J-594	J-73	12	3,786.02	135
P-954	J-595	J-578	8	1,428.12	115
P-955	J-579	J-596	8	1,503.06	115
P-956	J-596	J-223	8	3,240.91	115
P-957	J-595	J-596	8	1,017.06	115
P-958	J-150	J-597	8	495.73	110
P-959	J-597	J-186	8	558.21	130
P-960	J-152	J-598	6	297.41	110
P-961	J-598	J-155	6	416.26	110
P-962	J-598	J-144	6	765.81	130
P-964	J-599	J-74	16	806.4	130
P-965	J-74	J-600	8	491.05	105
P-966	J-600	J-587	8	993.01	105
P-967	J-599	J-600	8	1,110.35	110
P-968	J-302	J-601	8	531.15	125
P-969	J-601	J-303	8	554.7	125
P-970	J-601	J-306	8	1,113.20	135

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-971	J-459	J-339	12	1,173.91	130
P-972	J-221	J-578	8	1,406.24	135
P-973	J-262	J-266	8	470.14	135
P-974	J-59	J-602	20	3,053.45	130
P-975	J-602	J-268	20	906.88	135
P-976	J-602	J-272	8	341.27	135
P-978	J-311	J-310	8	757.52	135
P-979	J-342	J-343	6	515.54	135
P-981	J-358	J-66	6	688.27	135
P-982	J-525	J-523	6	193.63	60
P-983	J-361	J-363	6	454.39	135
P-984	J-483	J-498	8	622.52	130
P-985	J-226	J-224	8	691.63	135
P-986	J-344	J-603	6	959.08	115
P-987	J-603	J-345	6	559.39	115
P-988	J-603	J-347	8	313.36	115
P-989	J-241	J-604	12	927.95	135
P-990	J-604	J-535	12	594.9	135
P-991	J-604	J-605	8	621.94	115
P-993	J-394	J-593	8	776.73	140
P-994	J-461	J-460	8	261.47	130
P-995	J-75	J-606	8	930.17	115
P-996	J-328	J-607	8	1,006.49	115
P-998	J-328	J-608	8	937.12	115
P-999	J-608	J-323	8	1,215.73	115
P-1001	J-333	J-610	12	862.59	135
P-1003	J-610	J-611	8	934.23	115
P-1002	J-610	J-612	12	586.82	135
P-1004	J-612	J-335	12	816.86	135
P-1005	J-612	J-613	8	705.19	125
P-1006	J-90	J-614	12	5,127.61	135
P-1007	J-614	J-116	12	3,317.05	135
P-1009	J-112	J-412	8	2,991.52	135
P-1010	J-593	J-207	6	4,793.76	135
P-1012	J-615	J-589	24	796.61	130
P-1013	J-615	J-432	24	47.39	130
P-1015	J-616	J-615	24	1,346.05	130
P-1016	J-616	J-424	24	58.69	130
P-1018	J-617	J-616	24	1,700.61	130
P-1019	J-617	J-506	10	44.89	130
P-1022	J-520	J-618	10	46.41	120
P-1023	J-519	J-619	10	471.43	110
P-1024	J-619	J-506	10	461.65	110
P-1025	J-618	J-620	24	764.29	130
P-1026	J-620	J-617	24	489.86	130

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-1027	J-619	J-620	10	49.58	120
P-1028	J-42	J-621	24	2,189.59	130
P-1029	J-621	J-618	24	1,308.04	130
P-1030	J-569	J-621	6	67.75	60
P-1031	J-118	J-1099	12	2,406.38	135
P-1032	J-1099	J-1100	8	1,411.88	135
P-1033	J-1099	J-1101	12	859.97	135
P-1034	J-108	J-1102	12	6,638.44	135
P-1035	J-1102	J-91	12	925.76	135
P-1037	J-419	J-1104	8	361.54	135
P-1038	J-1104	J-420	8	801.82	135
P-1039	J-1104	J-1105	8	404.51	135
P-1040	J-1105	J-1106	8	169.55	135
P-1041	J-1105	J-1107	8	307.56	135
P-1044	J-1108	J-1109	8	499.88	135
P-1045	J-1109	J-1110	8	379.11	135
P-1046	J-91	J-1111	12	3,039.37	135
P-1047	J-1111	J-412	12	1,116.65	135
P-1048	J-1111	J-1112	6	600.06	115
P-1049	J-250	J-1113	16	1,851.62	135
P-1051	J-1113	J-1114	16	421.70	135
P-1052	J-1114	J-56	16	1,409.92	135
P-1054	J-1114	J-1116	8	637.53	135
P-1055	J-1116	J-1115	8	445.03	135
P-1056	J-1115	J-1117	8	427.55	135
P-1057	J-1117	J-1118	8	247.01	135
P-1058	J-1113	J-1119	8	444.07	135
P-1059	J-1119	J-1115	8	195.61	135
P-1060	J-1118	J-1119	8	424.6	135
P-1061	J-1116	J-1120	8	511.57	135
P-1062	J-1120	J-1121	8	316.68	135
P-1063	J-158	J-1122	8	1,334.11	110
P-1064	J-1122	J-181	8	1,225.45	110
P-1065	J-56	J-1122	8	1,003.00	120
P-1070	J-220	J-1125	8	2,693.09	120
P-1071	J-1125	J-222	8	614.58	120
P-1072	J-245	J-1126	6	577.41	115
P-1073	J-1126	J-246	6	1,009.01	115
P-1074	J-392	J-1127	8	296.41	120
P-1075	J-1127	J-393	8	502.89	120
P-1076	J-563	J-1128	8	435.3	135
P-1077	J-1128	J-564	8	342.46	135
P-1078	J-608	J-1129	8	642.38	115
P-1079	J-1129	J-609	8	359.8	115
P-1080	J-275	J-1130	6	445.1	100

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-1081	J-1130	J-276	6	559.14	100
P-1082	J-261	J-1131	6	347.07	115
P-1084	J-132	J-262	6	2,759.25	115
P-1085	J-1132	J-1132	6	983.80	110
P-1087	J-1133	J-571	6	372.86	110
P-1088	J-210	J-573	8	436.95	130
P-1090	J-1134	J-1134	8	849.94	115
P-1092	J-1135	J-1135	8	393.01	110
P-1093	J-1136	J-1136	8	407.72	110
P-1094	J-1138	J-44	8	736.26	110
P-1095	J-78	J-199	6	340.73	110
P-1096	J-1139	J-1139	12	1,865.29	130
P-1099	J-1139	J-105	12	1,605.59	130
P-1100	J-1142	J-1142	8	991.12	130
P-1101	J-414	J-1141	8	701.79	130
P-1102	J-1143	J-1143	8	834.97	105
P-1103	J-561	J-415	8	514.24	105
P-1104	J-1144	J-1144	8	674.07	115
P-1105	J-409	J-413	8	2,023.31	115
P-1106	J-1145	J-1145	6	502.19	115
P-1109	J-48	J-410	6	687.81	115
P-1110	J-1147	J-1147	12	695.75	135
P-1111	J-218	J-51	12	1,078.78	135
P-1112	J-499	J-1147	12	787.11	135
P-1113	J-1148	J-1148	8	696.79	100
P-1114	J-423	J-500	8	1,245.02	100
P-1115	J-1149	J-1149	8	772.92	90
P-1116	J-466	J-424	8	796.51	90
P-1117	J-454	J-468	4	20.34	60
P-1118	J-1102	J-452	8	475.17	90
P-1119	J-1150	J-1150	12	199.24	125
P-1120	J-614	J-1103	4	397.01	115
P-1121	J-1151	J-1151	12	2,152.62	135
P-1122	J-1151	J-1108	12	2,393.65	135
P-1123	J-1107	J-1152	8	744.53	125
P-1124	J-417	J-107	8	297.44	135
P-1125	J-1153	J-1153	12	867.78	135
P-1126	J-421	J-108	12	1,201.86	135
P-1127	J-1108	J-1153	8	495.63	135
P-1128	J-1154	J-1154	12	252.28	135
P-1129	J-421	J-419	12	453.07	135
P-1130	J-417	J-1154	8	2,238.53	135
P-1131	J-1155	J-1155	8	372.13	135
P-1132	J-1155	J-1156	8	995.19	135
P-1133	J-300	J-1157	8	505.81	135

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-1134	J-1158	J-1158	8	1,123.45	125
P-1135	J-362	J-301	6	1,257.67	115
P-1136	J-1159	J-1159	6	1,159.12	115
P-1137	J-1159	J-363	6	300.48	115
P-1138	J-369	J-1160	8	354.61	125
P-1139	J-128	J-1161	6	412.56	115
P-1140	J-148	J-1162	8	764.15	130
P-1141	J-1163	J-1163	6	251.97	110
P-1142	J-1162	J-149	6	978.25	110
P-1143	J-148	J-1163	6	308.23	130
P-1144	J-136	J-146	8	744.82	110
P-1145	J-138	J-1164	6	243.33	110
P-1146	J-145	J-1165	6	283.9	110
P-1148	J-151	J-1166	6	322.47	110
P-1150	J-1167	J-1167	8	948.66	110
P-1151	J-1168	J-1168	8	773.1	110
P-1152	J-1168	J-152	8	310.36	110
P-1153	J-165	J-1169	6	637.61	110
P-1154	J-1170	J-1170	6	545.44	110
P-1155	J-178	J-1133	8	121.7	130
P-1156	J-178	J-1171	6	273.14	110
P-1158	J-1173	J-1172	6	176.47	130
P-1159	J-1173	J-198	12	400.34	130
P-1160	J-198	J-1174	6	1,942.33	100
P-1161	J-1175	J-1175	6	1,136.89	110
P-1162	J-1175	J-199	6	915.02	110
P-1163	J-40	J-1176	6	305.01	130
P-1164	J-1178	J-1178	12	527.35	130
P-1165	J-1177	J-1173	12	1,423.95	130
P-1166	J-81	J-1178	6	802.57	110
P-1167	J-1179	J-1179	12	756.25	130
P-1168	J-1179	J-599	16	3,175.80	130
P-1169	J-80	J-1180	8	1,212.21	110
P-1170	J-1181	J-1181	6	763.99	105
P-1171	J-78	J-81	8	3,706.90	105
P-1172	J-1182	J-1182	8	5,282.27	105
P-1173	J-1181	J-80	6	388.56	105
P-1176	J-500	J-1182	8	486.41	105
P-1177	J-1184	J-1184	8	463.71	100
P-1178	J-536	J-502	10	268.81	110
P-1179	J-179	J-605	8	1,199.80	115
P-1180	J-102	J-176	6	568.90	130
P-1181	J-1185	J-1185	8	1,132.08	115
P-1182	J-209	J-208	8	274.22	115
P-1183	J-1131	J-1185	6	967.78	130

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL INPUT - EXISTING INFRASTRUCTURE

Label	Start Node	Stop Node	Diameter (in)	Approx Length (ft)	Hazen-Williams C
P-1184	J-1186	J-262	6	1,057.97	115
P-1185	J-536	J-1186	6	1,989.82	130

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-39	607	74	68	5,000
J-40	600	72	68	5,000
J-41	600	71	67	5,340
J-42	590	75	72	5,310
J-43	620	62	57	5,300
J-44	610	66	62	5,000
J-45	600	70	66	5,000
J-46	590	73	70	5,000
J-47	605	66	62	5,460
J-48	612	63	58	4,620
J-51	620	59	55	5,460
J-52	620	58	55	5,000
J-53	610	62	59	5,000
J-54	607	63	61	5,300
J-55	615	60	57	5,000
J-56	590	71	69	5,000
J-57	609	61	60	5,000
J-59	600	65	64	5,000
J-60	588	71	69	5,000
J-61	626	54	52	5,000
J-62	600	65	63	5,660
J-63	613	59	58	4,680
J-64	620	56	54	4,080
J-65	620	55	54	4,290
J-66	610	61	59	5,000
J-67	600	69	66	5,510
J-69	622	55	54	5,000
J-70	610	60	59	5,000
J-73	624	54	53	5,000
J-74	605	62	62	5,000
J-75	595	67	66	5,000
J-77	590	69	68	5,000
J-78	606	62	61	5,000
J-79	606	61	61	5,110
J-80	602	63	63	5,000
J-81	588	69	69	2,990
J-82	625	53	52	2,610
J-83	625	53	52	1,510
J-84	625	53	52	5,000
J-85	625	55	54	4,920
J-86	625	55	54	4,840
J-87	625	53	52	4,780
J-88	625	53	52	4,710
J-89	625	53	52	4,860
J-90	625	53	52	4,960

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-91	625	49	49	4,920
J-92	636	44	43	4,960
J-93	628	47	47	4,950
J-94	607	74	68	5,000
J-101	612	63	59	2,130
J-102	608	65	61	1,160
J-103	606	65	61	5,000
J-104	597	69	65	2,530
J-105	606	62	61	3,660
J-106	597	65	65	1,880
J-107	630	49	48	880
J-108	630	49	48	2,240
J-109	620	(N/A)	(N/A)	980
J-110	608	(N/A)	(N/A)	2,890
J-111	628	47	47	3,540
J-112	627	48	47	#VALUE!
J-113	631	51	50	#VALUE!
J-115	639	48	46	1,940
J-116	621	53	52	910
J-118	629	47	46	3,680
J-119	625	(N/A)	(N/A)	3,700
J-120	630	46	46	3,270
J-121	595	70	68	1,510
J-122	625	64	59	#VALUE!
J-123	620	66	62	2,040
J-124	597	72	68	5,000
J-125	595	73	69	5,000
J-126	595	73	69	570
J-127	595	73	69	5,000
J-128	595	73	69	5,000
J-129	595	73	70	4,060
J-130	595	73	70	3,680
J-131	595	73	70	2,700
J-132	595	73	69	5,000
J-133	585	77	74	5,000
J-134	595	73	70	1,080
J-135	595	73	70	5,000
J-136	595	73	70	1,910
J-137	602	69	66	5,000
J-138	605	68	65	5,000
J-139	605	68	65	4,830
J-140	595	73	70	3,140
J-141	595	72	69	1,950
J-143	595	72	69	5,000
J-144	595	71	69	5,000

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-145	600	69	67	2,980
J-146	600	71	67	5,000
J-147	600	71	67	3,360
J-148	595	73	69	2,100
J-149	597	72	68	5,000
J-150	595	71	68	2,220
J-151	595	71	68	4,970
J-152	600	69	66	5,000
J-153	600	69	66	2,210
J-154	590	72	70	5,000
J-155	610	64	62	5,000
J-156	590	72	70	5,000
J-157	590	72	70	5,000
J-158	595	70	67	2,760
J-159	595	70	68	5,000
J-160	590	72	70	2,980
J-161	590	72	70	4,190
J-162	590	72	70	4,610
J-163	590	71	70	4,820
J-164	590	71	69	4,500
J-165	590	71	69	4,440
J-166	590	72	70	4,330
J-167	595	69	68	4,060
J-168	595	69	67	3,600
J-169	595	69	67	5,000
J-170	590	71	69	5,000
J-171	590	71	69	5,000
J-172	595	69	67	5,000
J-173	595	69	67	3,400
J-174	600	67	65	1,960
J-175	610	62	60	5,000
J-176	602	66	64	5,000
J-177	595	69	67	5,000
J-178	595	69	67	5,000
J-179	595	69	67	940
J-180	595	69	68	1,500
J-181	595	69	67	1,120
J-182	595	69	67	930
J-183	595	69	67	1,340
J-184	595	69	67	1,720
J-185	595	69	67	5,000
J-186	600	67	65	1,880
J-188	610	61	60	1,330
J-189	610	61	60	1,280
J-190	610	61	60	720

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-191	610	61	60	5,000
J-192	610	61	60	3,210
J-193	610	61	60	2,340
J-194	610	61	60	2,110
J-195	610	61	60	1,880
J-196	615	64	60	1,120
J-197	610	66	62	940
J-198	605	68	64	830
J-199	615	64	60	1,070
J-200	620	62	57	2,320
J-201	625	59	55	5,000
J-202	615	64	60	5,000
J-203	610	66	62	1,720
J-204	640	53	49	4,950
J-205	615	64	60	2,670
J-206	615	63	59	2,690
J-207	614	64	60	2,640
J-208	615	63	59	1,650
J-209	625	58	54	4,970
J-210	615	63	59	3,900
J-211	610	65	61	4,190
J-212	605	67	63	2,910
J-213	598	70	66	890
J-214	600	69	65	4,120
J-215	598	70	66	4,020
J-216	610	64	59	2,760
J-217	611	63	59	4,670
J-218	612	63	58	4,560
J-219	608	65	60	5,000
J-220	613	62	58	4,620
J-221	621	59	54	4,500
J-222	607	65	60	3,950
J-225	615	60	57	3,480
J-226	615	60	57	1,110
J-227	615	60	57	800
J-228	610	64	59	810
J-229	610	64	59	2,620
J-230	592	72	68	2,860
J-231	600	68	65	4,160
J-235	620	57	55	900
J-236	622	57	54	790
J-237	625	55	53	5,000
J-238	615	60	57	1,440
J-239	620	57	55	5,000
J-240	615	60	57	1,040

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-241	612	61	59	1,780
J-242	612	61	59	1,320
J-243	612	61	59	1,830
J-244	615	59	57	940
J-245	610	61	59	810
J-246	610	61	59	830
J-247	610	61	59	770
J-248	615	59	57	790
J-249	600	65	64	700
J-250	610	60	60	5,000
J-251	613	59	58	1,740
J-252	604	63	61	1,160
J-253	610	61	59	5,000
J-254	600	65	63	1,870
J-255	610	61	59	1,770
J-256	610	61	59	2,070
J-257	607	62	60	5,000
J-258	630	52	50	1,220
J-259	639	48	46	5,000
J-260	622	55	54	4,720
J-261	610	61	59	1,950
J-262	618	57	56	4,690
J-263	622	55	54	650
J-264	622	55	54	4,770
J-265	610	61	59	2,120
J-266	622	55	54	4,810
J-267	600	65	63	4,570
J-268	610	61	60	3,710
J-269	588	71	69	4,530
J-270	620	57	56	1,080
J-273	600	67	65	4,860
J-274	595	70	68	4,530
J-275	595	70	68	1,070
J-276	595	70	68	820
J-277	595	70	68	780
J-278	595	70	68	5,000
J-279	595	71	68	5,000
J-280	595	71	68	5,000
J-281	595	71	68	1,020
J-282	595	71	68	910
J-283	595	71	68	5,000
J-284	595	71	68	5,000
J-285	595	71	68	920
J-286	595	71	68	4,750
J-287	595	71	68	940

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-288	595	71	68	4,560
J-289	595	71	68	4,740
J-290	595	70	68	2,800
J-291	595	71	69	3,130
J-292	602	68	66	5,000
J-293	602	68	66	2,040
J-294	602	68	65	1,890
J-295	602	68	66	1,920
J-296	600	69	66	2,030
J-319	602	64	63	2,570
J-320	597	66	65	3,040
J-321	597	66	65	4,970
J-322	595	67	66	5,000
J-323	595	67	66	4,640
J-324	597	66	65	5,000
J-325	595	67	66	5,000
J-326	597	66	65	4,130
J-328	597	66	65	5,000
J-330	590	69	68	1,260
J-331	590	69	68	5,000
J-332	590	69	68	5,000
J-333	590	69	68	5,000
J-334	590	69	68	2,430
J-335	595	67	66	5,000
J-336	595	66	66	5,000
J-337	595	66	66	2,600
J-338	595	66	66	5,000
J-339	590	71	70	5,000
J-340	595	69	68	3,650
J-341	600	67	65	2,830
J-342	592	70	69	1,380
J-343	590	71	70	5,000
J-348	622	55	54	5,000
J-352	630	52	51	850
J-353	610	60	59	5,000
J-354	610	60	59	2,770
J-355	600	65	64	5,000
J-356	600	65	64	5,000
J-357	607	62	61	2,420
J-358	612	60	59	5,000
J-359	610	62	60	2,810
J-361	588	71	69	2,280
J-362	588	71	69	5,000
J-363	588	71	69	2,790
J-364	600	65	63	2,880

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-365	595	67	66	4,060
J-366	605	63	61	5,000
J-367	600	65	64	4,370
J-368	595	67	66	5,000
J-369	590	69	68	5,000
J-370	588	70	69	5,000
J-371	602	64	62	5,000
J-372	595	67	65	3,750
J-379	602	64	62	1,440
J-374	595	67	66	5,000
J-375	590	69	68	4,090
J-376	602	67	63	5,000
J-377	650	46	42	2,540
J-378	625	57	53	1,460
J-380	625	57	53	3,810
J-381	625	57	53	3,200
J-382	640	51	46	1,050
J-383	640	51	46	870
J-384	625	57	53	950
J-385	625	57	53	1,400
J-386	625	57	53	5,000
J-387	625	57	53	1,330
J-388	625	57	53	5,000
J-389	625	57	53	3,260
J-390	625	57	53	5,000
J-391	630	55	51	1,080
J-392	630	55	51	970
J-393	630	55	51	830
J-394	625	57	53	630
J-395	640	51	46	1,810
J-396	610	61	60	1,270
J-397	620	56	55	810
J-398	632	45	45	780
J-399	632	45	45	5,000
J-400	625	49	48	810
J-401	632	45	45	5,000
J-402	632	45	45	1,330
J-403	632	45	45	960
J-404	628	47	47	5,000
J-405	628	47	47	890
J-406	628	47	47	1,170
J-407	628	47	47	5,000
J-408	630	46	46	1,550
J-409	628	47	47	5,000
J-410	630	46	46	5,000

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-411	630	46	46	1,690
J-412	622	50	49	1,620
J-413	628	47	47	5,000
J-414	597	65	65	1,610
J-415	593	67	67	5,000
J-416	595	66	66	970
J-417	633	47	46	880
J-418	633	47	46	630
J-419	633	47	46	1,880
J-420	633	47	46	5,000
J-421	633	47	46	1,720
J-422	590	73	71	1,550
J-423	600	69	67	820
J-424	602	69	66	1,040
J-425	602	69	66	1,880
J-426	605	67	65	1,880
J-427	605	67	64	1,780
J-428	602	68	66	1,730
J-429	605	67	64	1,750
J-430	605	67	64	1,870
J-431	605	67	64	1,490
J-432	602	68	66	1,680
J-433	605	67	64	1,690
J-434	600	68	66	1,280
J-436	605	66	64	1,380
J-437	602	67	65	910
J-438	605	66	64	5,000
J-439	605	66	64	1,010
J-440	605	66	64	1,890
J-441	602	67	65	1,710
J-442	605	66	64	1,980
J-443	598	69	67	1,990
J-444	598	69	67	1,190
J-445	597	69	67	1,610
J-446	597	69	67	1,930
J-447	605	66	64	1,920
J-448	602	67	65	1,620
J-449	598	69	67	1,900
J-450	597	69	67	1,930
J-451	605	67	64	1,920
J-452	602	67	65	1,290
J-453	597	69	67	720
J-454	597	69	67	2,240
J-455	597	69	67	1,620
J-456	592	71	69	1,900

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-457	592	71	69	1,280
J-458	592	71	69	1,540
J-459	592	71	69	3,040
J-460	592	71	69	3,030
J-461	592	71	69	3,030
J-462	592	71	69	1,640
J-463	595	70	68	2,770
J-464	597	69	67	4,280
J-465	597	69	67	4,170
J-466	602	68	65	5,000
J-467	605	67	64	290
J-468	602	68	65	4,590
J-469	605	67	64	3,950
J-470	605	67	64	5,000
J-471	605	67	64	3,990
J-472	605	67	64	1,600
J-473	605	67	65	3,310
J-474	590	73	71	5,000
J-475	602	68	65	5,000
J-476	595	71	68	5,000
J-477	595	71	68	5,000
J-478	595	71	68	5,000
J-479	595	71	69	5,000
J-480	599	69	67	5,000
J-481	595	71	69	1,410
J-482	595	71	69	2,680
J-483	595	71	69	3,450
J-484	595	71	69	3,160
J-485	600	69	67	2,310
J-486	598	71	68	1,640
J-487	605	67	65	2,500
J-488	598	71	68	5,000
J-489	600	69	67	4,690
J-490	605	67	65	4,120
J-491	595	72	69	3,950
J-492	593	73	70	3,400
J-493	596	72	69	3,000
J-494	594	73	70	3,960
J-495	590	74	72	2,920
J-496	588	75	72	2,900
J-497	591	74	71	2,560
J-498	595	72	69	3,840
J-499	587	76	73	960
J-500	590	74	72	3,420
J-501	590	74	72	1,220

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-502	590	74	72	1,130
J-503	590	74	72	310
J-504	588	75	72	2,600
J-505	590	75	72	2,010
J-506	595	72	69	2,510
J-507	595	72	69	4,470
J-508	595	72	69	1,430
J-509	595	72	69	2,070
J-510	595	72	69	3,160
J-511	595	72	69	3,120
J-512	595	72	69	3,450
J-513	595	72	69	360
J-514	595	72	69	3,600
J-515	595	72	69	790
J-516	595	72	69	770
J-517	595	72	69	500
J-518	595	72	69	3,480
J-519	595	72	69	4,220
J-520	595	72	69	2,970
J-521	595	72	69	4,080
J-522	595	72	70	1,250
J-523	595	72	70	580
J-524	595	72	70	520
J-525	595	72	70	810
J-526	595	72	70	3,950
J-187	600	66	64	5,000
J-272	620	57	56	1,340
J-527	595	67	66	5,000
J-528	598	66	65	4,310
J-529	621	56	55	1,850
J-530	610	61	59	2,510
J-531	615	59	57	1,200
J-532	615	59	57	2,560
J-533	615	59	57	2,880
J-534	615	59	57	4,680
J-535	605	64	62	4,380
J-536	604	64	62	4,270
J-537	625	54	52	3,240
J-538	623	55	53	4,400
J-539	625	54	52	3,430
J-540	620	56	55	3,540
J-541	610	61	60	2,980
J-542	605	63	62	1,910
J-543	602	65	63	5,000
J-544	600	66	64	5,000

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-545	605	63	62	5,000
J-546	610	61	60	1,700
J-547	601	68	64	1,460
J-548	598	70	66	1,740
J-549	603	68	64	1,300
J-550	605	67	63	1,360
J-551	605	67	63	1,490
J-552	607	66	62	1,710
J-553	610	65	61	2,500
J-554	608	66	62	970
J-555	608	65	61	1,230
J-556	606	66	62	980
J-557	600	69	65	2,310
J-558	615	61	57	5,000
J-559	615	62	57	5,000
J-560	585	77	74	5,000
J-561	628	47	47	660
J-329	590	69	68	290
J-563	625	59	55	1,070
J-564	625	59	55	570
J-565	625	59	55	5,000
J-304	600	65	64	4,530
J-310	597	66	65	4,410
J-311	597	66	65	5,000
J-316	597	66	65	1,670
J-317	597	66	65	5,000
J-349	610	60	59	3,000
J-347	590	71	70	5,000
J-345	590	71	70	1,140
J-309	597	66	65	5,000
J-346	600	67	65	2,340
J-318	602	64	63	4,730
J-315	597	66	65	2,960
J-72	600	65	64	3,540
J-300	600	65	64	2,050
J-312	597	66	65	5,000
J-307	600	65	64	5,000
J-351	610	60	59	4,260
J-314	597	66	65	3,070
J-305	600	65	64	5,000
J-301	600	65	64	5,000
J-360	600	66	64	4,010
J-298	600	64	64	3,890
J-303	600	64	64	1,950
J-350	610	60	59	3,010

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-299	600	64	64	3,740
J-313	597	66	65	2,140
J-306	600	65	64	3,320
J-297	600	65	64	1,750
J-344	600	67	65	3,190
J-71	600	64	64	1,720
J-302	600	64	64	2,500
J-308	600	65	64	4,640
J-76	590	69	68	4,450
J-562	602	68	65	5,000
J-566	604	67	65	820
J-567	598	70	67	5,000
J-568	598	70	67	2,400
J-569	593	73	70	2,390
J-570	595	67	66	2,650
J-571	584	78	74	5,000
J-572	625	58	56	5,000
J-573	593	69	68	5,000
J-574	605	64	63	5,000
J-575	600	66	65	4,490
J-576	625	55	53	2,260
J-233	618	58	56	1,460
J-224	615	60	57	3,240
J-223	610	62	59	5,000
J-234	615	60	57	2,560
J-232	610	62	59	770
J-578	621	58	55	1,850
J-579	622	57	54	3,030
J-580	600	64	64	5,000
J-581	601	64	63	3,140
J-582	601	64	63	2,110
J-583	605	62	62	2,230
J-584	610	60	59	5,000
J-585	612	59	59	3,590
J-586	612	59	59	2,830
J-587	607	61	61	3,540
J-588	630	46	46	1,200
J-589	602	68	66	5,000
J-590	604	63	62	910
J-591	610	61	59	1,740
J-592	620	57	55	820
J-593	625	57	53	1,860
J-594	612	59	58	3,700
J-595	618	59	56	1,990
J-596	618	59	56	2,450

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-597	595	71	68	1,780
J-598	605	67	64	3,790
J-599	605	62	62	5,000
J-600	607	61	61	3,670
J-601	600	64	64	4,420
J-602	620	57	55	5,000
J-603	590	71	70	3,040
J-604	608	62	60	5,000
J-605	605	64	62	3,110
J-606	596	66	66	2,990
J-607	596	66	66	2,870
J-608	596	66	66	3,610
J-609	596	66	66	1,880
J-610	596	66	66	5,000
J-611	596	66	66	2,180
J-612	596	66	66	5,000
J-613	596	66	66	2,670
J-614	620	54	53	3,680
J-615	602	68	66	5,000
J-616	602	69	66	5,000
J-617	595	72	69	5,000
J-618	595	72	69	5,000
J-619	595	72	69	5,000
J-620	595	72	69	5,000
J-621	593	73	70	5,000
J-1099	635	44	44	1,340
J-1100	636	44	43	970
J-1101	636	44	43	1,290
J-1102	625	49	49	5,000
J-1103	625	49	49	470
J-1104	630	49	48	2,580
J-1105	630	49	48	2,520
J-1106	630	49	48	2,230
J-1107	630	49	48	2,560
J-1108	630	49	48	3,100
J-1109	630	49	48	2,080
J-1110	630	49	48	1,740
J-1111	624	49	49	2,700
J-1112	624	49	49	1,000
J-1113	597	67	65	5,000
J-1114	596	68	66	5,000
J-1115	595	(N/A)	(N/A)	#VALUE!
J-1116	595	(N/A)	(N/A)	#VALUE!
J-1117	595	(N/A)	(N/A)	#VALUE!
J-1118	595	(N/A)	(N/A)	#VALUE!

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

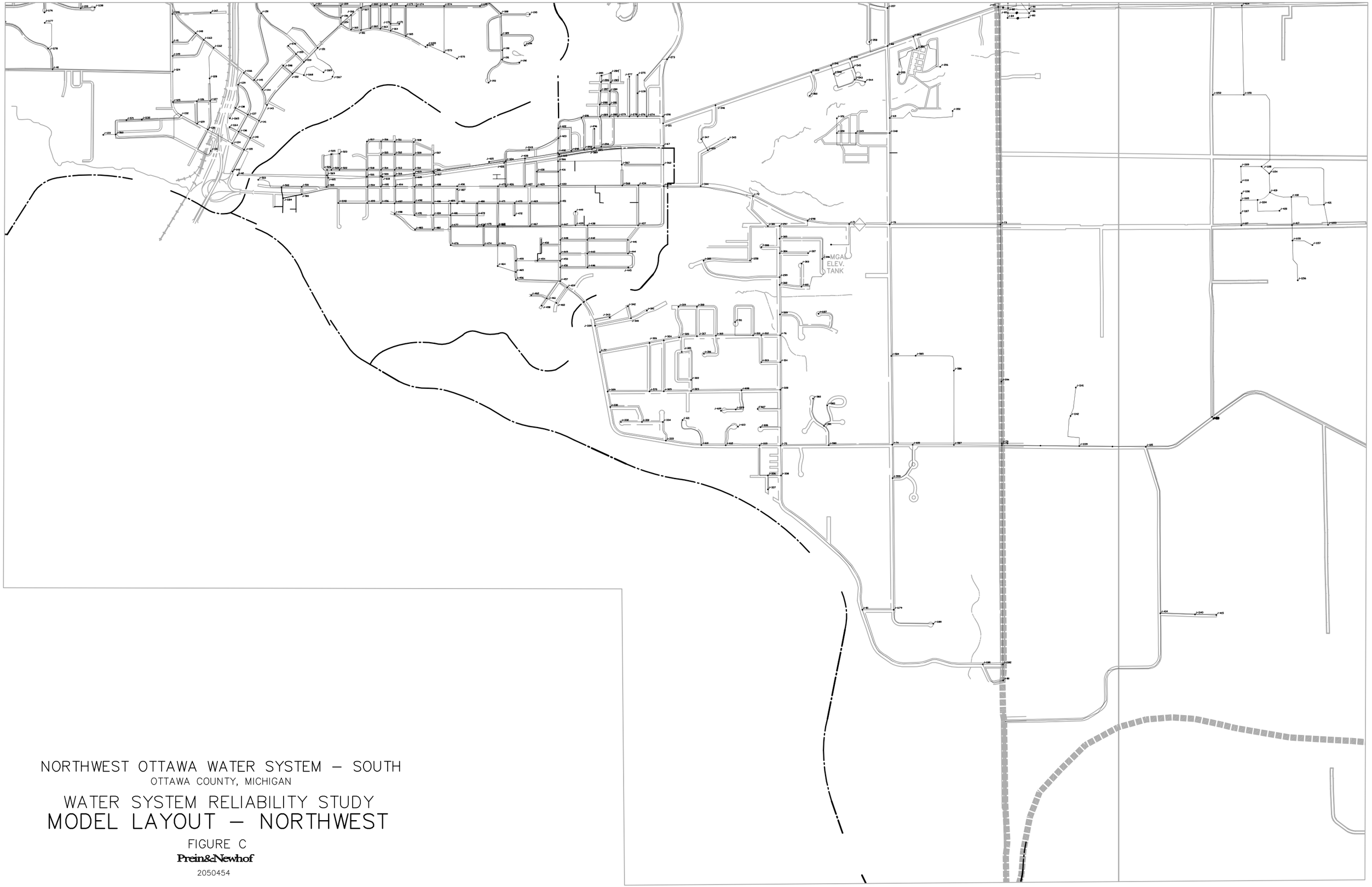
MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-1119	596	(N/A)	(N/A)	#VALUE!
J-1120	595	(N/A)	(N/A)	#VALUE!
J-1121	596	(N/A)	(N/A)	#VALUE!
J-1122	595	69	67	3,860
J-1125	608	64	60	850
J-1126	610	61	59	1,600
J-1127	630	55	51	1,500
J-1128	625	59	55	2,290
J-1129	596	66	66	2,200
J-1130	595	70	68	1,230
J-1131	611	60	59	1,070
J-1132	584	78	74	2,140
J-1133	592	70	68	3,110
J-1134	613	64	60	3,190
J-1135	612	64	60	3,200
J-1136	612	65	61	3,440
J-1138	615	64	60	1,160
J-1139	606	62	61	2,510
J-1141	606	62	61	1,440
J-1142	606	62	61	1,700
J-1143	595	66	66	1,430
J-1144	628	47	47	910
J-1145	629	47	46	1,310
J-1147	615	61	57	4,460
J-1148	588	75	72	3,260
J-1149	590	74	71	3,730
J-1150	625	49	49	5,000
J-1151	630	49	48	3,160
J-1152	630	49	48	1,760
J-1153	632	48	47	3,190
J-1154	630	49	48	3,090
J-1155	630	49	48	2,250
J-1156	630	49	48	1,470
J-1157	630	49	48	1,740
J-1158	600	65	64	2,190
J-1159	588	71	69	980
J-1160	594	68	67	950
J-1161	586	71	70	1,210
J-1162	600	71	67	2,790
J-1163	595	73	69	3,770
J-1164	595	73	70	2,000
J-1165	600	70	67	1,380
J-1166	605	67	64	1,340
J-1167	595	71	68	3,900
J-1168	599	69	67	4,710

NOWS-NORTHSIDE
2017 WATER SYSTEM RELIABILITY STUDY

MODEL OUTPUT - 2017 DEMANDS WITH EXISTING INFRASTRUCTURE

Label	Elevation (ft)	Pressure (psi)		Available Fire Flow (gpm)
		Avg Day	Max Day	
J-1169	597	70	68	1,250
J-1170	591	70	69	3,060
J-1171	595	69	67	970
J-1172	595	69	67	1,040
J-1173	604	69	65	5,000
J-1174	600	71	67	640
J-1175	611	66	62	1,580
J-1176	610	66	62	1,240
J-1177	605	69	65	1,110
J-1178	601	71	67	5,000
J-1179	591	68	68	5,000
J-1180	592	68	67	1,860



NORTHWEST OTTAWA WATER SYSTEM – SOUTH

OTTAWA COUNTY, MICHIGAN

WATER SYSTEM RELIABILITY STUDY

MODEL LAYOUT – NORTHWEST

FIGURE C

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NORTHWEST OTTAWA WATER SYSTEM – NORTHSIDE

OTTAWA COUNTY, MICHIGAN

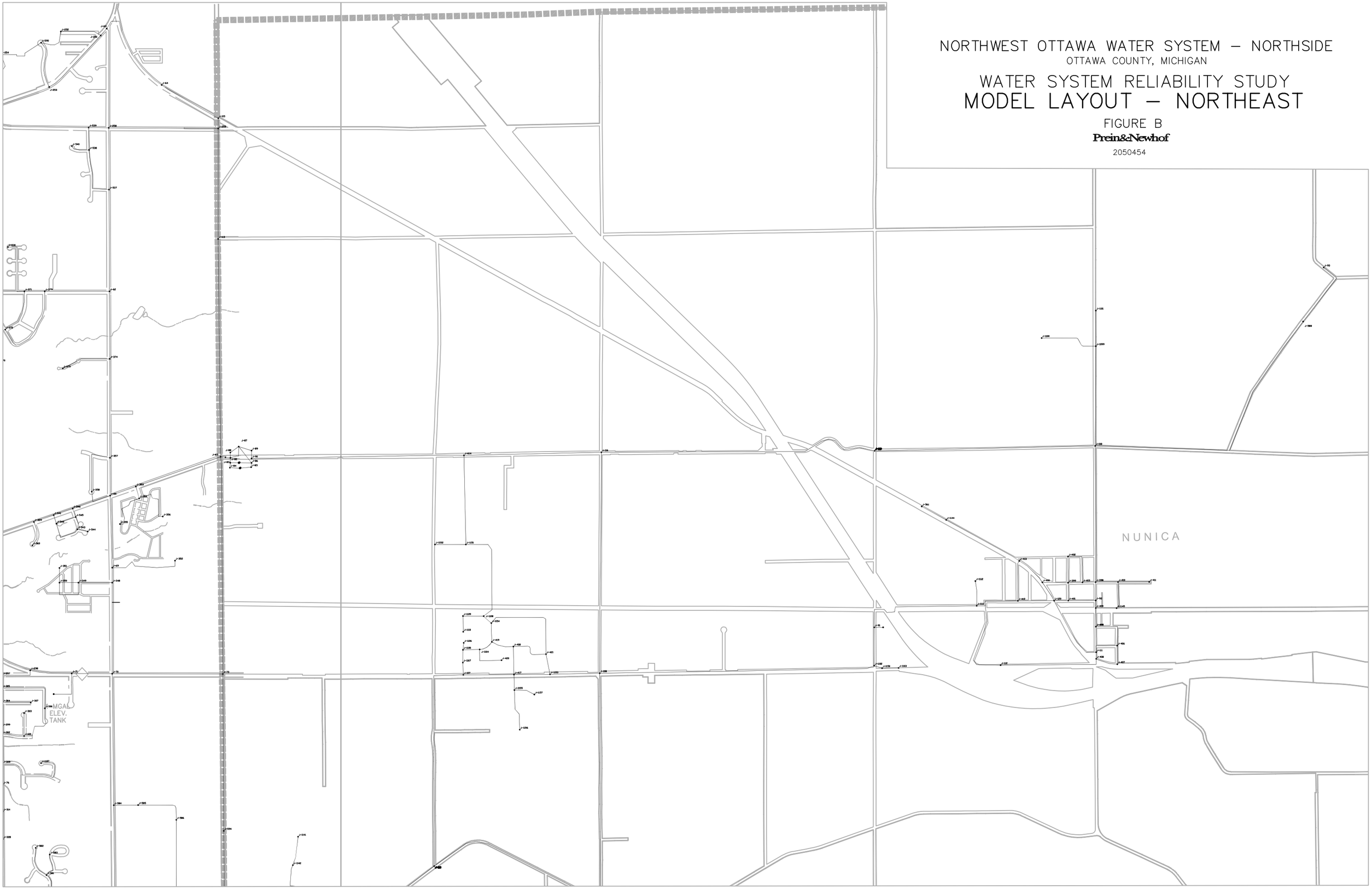
WATER SYSTEM RELIABILITY STUDY

MODEL LAYOUT – NORTHEAST

FIGURE B

Prein&Newhof

2050454



RYCENGA PARK

WATER TOWER PARK

500,000 GAL ELEVATED TANK

MGAL ELEV. TANK

NORTHWEST OTTAWA WATER SYSTEM – NORTHSIDE

OTTAWA COUNTY, MICHIGAN

WATER SYSTEM RELIABILITY STUDY

MODEL LAYOUT – NORTHWEST

FIGURE A

Prein&Newhof

2050454

Appendix D

Annual Pumpage Data (2008 – 2016)

Appendix E

Water Shortage Response Plan

102 W. SAVIDGE ST. * SPRING LAKE, MI 49456
PHONE 616-842-1393 * FAX 616-847-1393
www.springlakevillage.org

VILLAGE OF SPRING LAKE

WATER SHORTAGE RESPONSE PLAN

I. PURPOSE

The procedures herein are written to reduce potable water demand and supplement existing drinking water supplies whenever they are in danger of being inadequate to meet customer needs.

II. WATER SYSTEM SUMMARY

The Village of Spring Lake operates and maintains a purchase water system. All the drinking water is supplied by the Northwest Ottawa Water Treatment Plant. The Northwest Ottawa Water Treatment Plant is operated and managed by the City of Grand Haven under the Department of Public Works and is contracted by the Townships of Grand Haven, Crockery, and Spring Lake, City of Ferrysburg, and the Village of Spring Lake.

III. AUTHORITY

When a water shortage is detected at the Northwest Ottawa Treatment Plant the plant director will notify authorities that a water shortage exists and, the Village Manager may implement temporary emergency procedures. Should other emergency situations occur such as line breaks, contamination, mechanical failures, or similar emergencies, the Village Manager may also consider implementing temporary emergency procedures.

The Village Manager is authorized to enact water shortage response provisions whenever the trigger conditions outlined are met. In his or her absence, the Village President will assume this role.

Chris Burns
Village Manager
Phone: 616-788-8945
E-mail: christine@springlakevillage.org

Mark Powers
Village President
Phone: 616-842-1393
E-mail: mark.powers.jd@gmail.com

IV. RESTRICTIONS

Adopted Water Use Restriction Guidelines - NOWS
(2007 – Revised 2015)

In accordance with the Northwest Ottawa Water Production Facilities Contract, the following water use restriction guidelines are in place for the Northwest Ottawa Water System (NOWS).

During periods of severe drought many communities in the Ottawa – Muskegon – Kent Counties service areas found it necessary to impose mandatory water use restrictions. While the water supply systems serving the area continue to grow and develop, this made water use restriction planning necessary.

Experience very clearly demonstrates the need for a coordinated and consistent water use restriction plan. It was obvious a substantial number of residents, as well as members of the media, were unaware which system supplied their drinking water. There also was a surprising amount of confusion concerning simple geography.

In an effort to reduce this confusion factor, the following guidelines have been adopted by NOWS and the Ottawa County Road Commission, Public Utilities Department.

All jurisdictions within the NOWS service area will comply with the four tiered, increasingly severe water use restriction guidelines as outlined below.

1. Odd-Even Lawn Sprinkling.

   Addresses ending in an odd number will be allowed to sprinkle any time on odd numbered dates; even numbered addresses may sprinkle any time on even numbered dates. (Non-addressed Municipal parks and parkways will sprinkle on odd days).

2. Odd-Even Sprinkling – Midnight to Noon.

   Same as above, except all permitted sprinkling activity must occur between the hours of mid-night and noon. All sprinkling, regardless of address, is prohibited from noon to midnight.

3. Total Ban on Sprinkling.

4. Total Ban on Sprinkling and Non-essential use of water such as:

   A. Non-commercial car washes.
   B. Hosing off drives and walks.

   The above guidelines will be implemented as recommended by the Water Plant Operators and Manager and as authorized by the City of Grand Haven Manager as the Administrator, starting at approximately 90% (20.9 MGD) of rated plant capacity demands and for other circumstances as necessary.

V. ENFORCEMENT

Sec. 78-43. - Water emergency orders.

The village manager or the village president, when the village manager is unavailable or unable to act, may, by written order, subject to review and modification or reversal by the village council, regulate, limit or prohibit the use of water. Such order may restrict less essential water uses to the extent deemed necessary to assure an adequate supply for essential domestic and commercial water needs and for fire protection. Notice of the promulgation of any such order shall be published in a newspaper of general circulation in the village as soon as reasonably possible after promulgation. Violation of such an order shall constitute a violation of this article and shall be subject to the penalties and other remedies prescribed in this article.

(Code 1982, § 19-28)

Sec. 78-47. - Violations.

Any person violating any of the provisions of this article shall be deemed guilty of a misdemeanor and upon conviction shall be punished as provided in section 1-8. In addition to the penalties set forth in that section, the village may maintain equitable or legal action available to it for the abatement of any violation of this article.

(Code 1982, § 19-32)

Sec. 1-8. - General penalties and sanctions for violations of Code and village ordinances; continuing violations; injunctive relief.

(a) Unless a violation of this Code or any ordinance of the village is specifically designated in the Code or ordinance as a municipal civil infraction, the violation shall be deemed to be a misdemeanor.

(b) The penalty of a misdemeanor violation shall be a fine not exceeding $500.00 (plus costs of prosecution), or imprisonment not exceeding 90 days, or both, unless a specific penalty is otherwise provided for the violation by this Code or any ordinance.

(c) The sanction for a violation which is a municipal civil infraction shall be a civil fine in the amount as provided by this Code or any ordinance, plus any costs, damages, expenses and other sanctions, as authorized under chapter 87 of Public Act No. 236 of 1961 (MCL 600.8701 et seq., MSA 27A.8701 et seq.), and other applicable laws. Municipal civil infractions shall be subject to the enforcement procedures as set forth in article VI of chapter 2

(1) Unless otherwise specifically provided for a particular municipal civil infraction violation by this Code or any ordinance, the civil fine for a violation shall be $50.00, plus costs and other sanctions, for each infraction.

(2) Increased civil fines may be imposed for repeated violations by a person of any requirement or provision of this Code or any ordinance. As used in this section, the term "repeat offense" means a second (or any subsequent) municipal civil infraction violation of the same requirement or provisions committed by a person within any 12-month period (unless some other period is specifically provided by this Code or any ordinance) and for which the person admits responsibility or is determined to be responsible. Unless otherwise specifically provided by this Code or any ordinance for a particular municipal civil infraction violation, the increased fine for a repeat offense shall be as follows:

a. The fine for any offense which is a first repeat offense shall be $250.00, plus costs.

b. The fine for any offense which is a second repeat offense or any subsequent repeat offense shall be $500.00, plus costs.

c. A violation includes any act which is prohibited or made or declared to be unlawful or an offense by this Code or any ordinance, and any omission or failure to act where the act is required by this Code or any ordinance.

d. Each day on which any violation of this Code or any ordinance continues constitutes a separate offense and shall be subject to penalties or sanctions as a separate offense.

e. In addition to any remedies available at law, the village may bring an action for an injunction or other process against a person to restrain, prevent or abate any violation of this Code or any village ordinance.

(Code 1982, § 1-8; Ord. No. 232, § 7, 5-15-1995; Ord. No. 233, § 2, 5-15-1995)

State law reference— Limitation on penalties, MCL 78.24(b), MSA 5.1534, (b).

VI. INTERCONNECTION CONTRACT

WATER INTERCONNECTION CONTRACT

THIS CONTRACT, dated for reference purposes as of May 1 , 2003, is by and among the CITY OF MUSKEGON HEIGHTS, a Michigan municipal corporation, whose address is 2724 Peck Street, Muskegon Heights, Michigan, 49444, referred to as "Muskegon Heights," the CITY OF NORTON SHORES, a Michigan municipal corporation, whose address is 4814 Henry Street, Muskegon, Michigan, 49441 , referred to as "Norton Shores," the CHARTER TOWNSHIP OF FRUITPORT, a Michigan charter township, whose address is 6543 Airline Road, Fruitport, Michigan, 49415, referred to as "Fruitport," the COUNTY OF OTTAWA, a body corporate created under the provisions of the Michigan Constitution, acting by and through its Board of County Road Commissioners, whose address is P.O. Box 739, Grand Haven, Michigan, 49417, referred to as "Ottawa County," the TOWNSHIP OF SPRING LAKE, a Michigan general law township, whose address is 106 S. Buchanan Street, Spring Lake, Michigan, 49456, referred to as "Spring Lake Township," the VILLAGE OF SPRING LAKE, Michigan municipal corporation, whose address is 102 West Savidge Street, Spring Lake, Michigan, 49456, referred to as "Spring Lake Village," the CHARTER TOWNSHIP OF GRAND HAVEN, a Michigan charter township, whose address is 13300 168th Avenue, Grand Haven, Michigan, 49417, referred to as "Grand Haven Township," the CITY OF FERRYSBURG, a Michigan municipal corporation, whose address is 408 Fifth Street, Ferrysburg, Michigan, 49409, referred to as "Ferrysburg," and the CITY OF GRAND HAVEN, a Michigan municipal corporation, whose address is 519 Washington Street, Grand Haven, Michigan, 49417, referred to as "Grand Haven." This Contract is made with reference to the following facts and circumstances:

Muskegon Heights, Norton Shores, and Fruitport (collectively referred to as the "Muskegon Parties") all own and/or operate water systems in Muskegon County, Michigan.

Ottawa County, Grand Haven, Spring Lake Township, Spring Lake Village, Ferrysburg and Grand Haven Township (collectively referred to as the "Northwest Ottawa Parties") all own and/or operate water systems in Ottawa County, Michigan.

These water systems are adjacent to each other at various points along the common border between Muskegon County and Ottawa County.

The parties have previously interconnected the Muskegon County water systems and the Ottawa County water systems at four locations on the Ottawa County, Muskegon County boundary line. These locations are designated as Interconnections A, B, C, and D, respectively, are described on attached Exhibit A, and are referred to collectively as the "interconnections."

NOW, THEREFORE, for and in consideration of the mutual covenants and agreements herein contained, it is agreed by the parties hereto as follows:

Section 1. General Agreement. The parties agree that the Interconnections shall be governed by the terms and provisions of this Contract.

Section 2. Maintenance of Interconnection. Spring Lake Township shall be responsible for maintaining the valve for the Interconnection A. Spring Lake Township and Fruitport shall each be responsible for maintaining the water mains which lead to the Interconnection A valve. Spring Lake Township shall provide routine maintenance for the valve (opening it, closing it and inspecting it)

without charge. Should the valve require a replacement of parts, seals, etc., or other maintenance beyond routine matters, then all costs and expenses of such maintenance shall be divided equally between the Muskegon Parties and Ottawa County. The Muskegon Parties shall share their portion of the cost as they mutually agree. Ottawa County shall allocate its portion of the cost among the Northwest Ottawa Parties as they mutually agree.

For Interconnection B, Spring Lake Township shall be responsible for maintaining the southerly valve, and Fruitport shall be responsible for maintaining the northerly valve. Spring Lake Township and Fruitport shall each be responsible for maintaining the water mains which lead to these valves. Spring Lake Township and Fruitport shall provide routine maintenance for the southerly vaive and northerly valve, respectively (opening it, closing it, and inspecting it) without charge. Should the southerly valve require a replacement of parts, seals, etc., or other maintenance beyond routine matters, then all costs and expenses of such maintenance shall be paid by Ottawa County and allocated among the Northwest Ottawa Parties as they mutually agree. Should the northerly valve require a replacement of parts, seals, etc., or other maintenance beyond routine matters, then all costs and expenses of such maintenance shall be shared by the Muskegon Parties as they mutually agree. Should the pipeline between the southerly and northerly valves require repair or replacement, as determined by Spring Lake Township, then all costs and expenses of such work shall be divided equally by the Muskegon Patties and Ottawa County. The Muskegon Parties shall share their portion of the cost as they mutually agree. Ottawa County shall allocate its share of the cost among the Northwest Ottawa Parties as they mutually agree.

For Interconnections C and D, Spring Lake Township shall be responsible, in each case, for maintaining the southerly valve, and Norton Shores shall be responsible, in each case, for maintaining the northerly valve. Spring Lake Township and Norton Shores shall each be responsible for maintaining the water mains which lead to these valves. Spring Lake Township and Norton Shores shall provide routine maintenance for the southerly valves and northerly valves, respectively (opening them, closing them, and inspecting them) without charge. Should a southerly valve require a replacement of parts, seals, etc., or other maintenance beyond routine matters, then all costs and expenses of such maintenance shall be paid by Ottawa County and allocated among the Northwest Ottawa Parties as they mutually agree. Should a northerly valve require a replacement of parts, seals, etc., or other maintenance beyond routine matters, then all costs and expenses of such maintenance shall be shared by the Muskegon parties as they mutually agree. Should a pipeline between the southerly and northerly valves require repair or replacement, as determined by Spring Lake Township, then all costs and expenses of such work shall be divided equally by the Muskegon Parties and Ottawa County. The Muskegon Patties shall share their portion of the cost as they mutually agree. Ottawa County shall allocate its share of the cost among the Northwest Ottawa Parties as they mutually agree.

Written notification shall be given by personal delivery, by facsimile transmission, by e-mail, or by ordinary or certified mail properly addressed with sufficient postage in advance of undertaking any maintenance, repair, and/or replacement. For maintenance, repair, and/or replacement to be performed by Spring Lake Township, Spring Lake Township shall give notice to Muskegon Heights in all cases and for Interconnection B, Fruitport and for Interconnections C and D, Norton Shores. For maintenance, repair, and/or replacement to be performed by Fruitport for Interconnection B, Fruitport shall give notice to Ottawa County and Spring Lake Township. For maintenance, repair, and/or replacement to be performed by Norton Shores for Interconnections C and D, Norton Shores shall give notice to Ottawa County and Spring Lake Township. Notice shall be given at least 3 days in advance of the commencement date of the maintenance, repair, and/or replacement.

Section 3. <u>Use of Inter-connections</u>. The Interconnections may be utilized only in an emergency situation that results in the loss of water supply or threatens the loss of water pressure, quantity or

quality of water service to any or all of the Muskegon Parties or any or all of the Northwest Ottawa Parties.

If any or all of the Northwest Ottawa Parties desire to utilize one or more of the Interconnections, a request shall be made orally with written confirmation of the request by personal delivery, by facsimile transmission, by e-mail, or by ordinary or certified mail properly addressed with sufficient postage to the Muskegon Heights Director of Utilities. This request shall be made by the Ottawa County Director of Utilities or his/her designee. The request shall include the reason for the request, the time during which the Interconnection(s) is to be opened, the estimated flow rate through the Interconnection(s), the estimated duration that the Interconnection(s) will be open and the person who will be in charge of the Interconnection(s) opening and his/her phone number. Upon completion of the use of an Interconnection, the person in charge of the Interconnection opening will complete a "Valve Operation Report" and serve and transmit a copy, in the manner provided in Section 8, to both Ottawa County and Muskegon Heights. A sample of the report is included as Exhibit F. Muskegon Heights shall then promptly notify the remaining Muskegon Parties of the request to open the Interconnection(s) before responding, by facsimile transmission or e-mail, to grant the request and specify the time that the Interconnection(s) shall be open and the rate of flow or to deny the request.

If any or all of the Muskegon Parties desire to use the Interconnection(s), a request shall be made orally with written confirmation of the request by personal delivery, by facsimile transmission, by e-mail, or by ordinary or certified mail properly addressed with sufficient postage to the Ottawa County Director of Utilities or his/her designee. This request may be made by any or all of the Muskegon Parties. The request shall include the reason for the request, the time during which the Interconnection(s) is to be opened, the estimated flow rate through the Interconnection(s), the estimated duration that the Interconnection(s) will be open and the person who will be in charge of the Interconnection(s) opening and his/her phone number. Upon completion of the use of an Interconnection, the person in charge of the Interconnection opening will complete a "Valve Operation Report" and serve and transmit a copy, in the manner provided in Section 8, to both Ottawa County and Muskegon Heights. A sample of the report is included as Exhibit F. Ottawa County shall then promptly respond by facsimile transmission or e-mail to the request to open the Interconnection(s) and, in responding, shall have the discretion to grant the request and specify the time that the Interconnection(s) shall be open and the rate of flow or to deny the request.

The Interconnections are for use only in the event of a water emergency situation as described above. Opening of an Interconnection for any other reason, including lack of water quantity due to high water demand and/or lack of adequate system infrastructure, is prohibited.

Section 4. Water Usage. If an Interconnection valve is opened, water usage shall be estimated by the water supplier, i.e. Grand Haven in the case of Ottawa County, and Muskegon Heights in the case of Muskegon County. In those instances where Muskegon Heights is the water supplier, it shall credit the water use through the Interconnection against the metered water use of the Muskegon County Party whose system delivered the water. The water supplier shall have the option to bill its counterpart water supplier for this water usage if it so elects. If the water supplier elects to render a billing, the billing shall be at the normal rate it provides water to its bulk water customers. The water system supplier who is charged for and receives such billing shall have the option, in its discretion, to rebill the unit(s) it supplies water to in such proportion and on such basis as they shall mutually agree upon and shall determine is equitable. All billings rendered pursuant to this paragraph shall be paid within thirty (30) days of their date.

Section 5. Indemnification. The Muskegon Parties assume all risk and liability for injury or damage to persons or property in performing their maintenance, repair, and other responsibilities pursuant to this Contract. The Muskegon Parties agree to indemnify the Northwest Ottawa Parties and their respective board members, officers, employees and agents from any and all losses,

damages, claims and expenses, including reasonable attorney fees incurred for defense, resulting from injury or damage to persons or property for which the Muskegon Parties have assumed all risk and liability pursuant to the immediately preceding sentence to the extent that any insurance maintained by the Muskegon Parties therefor is insufficient.

The Northwest Ottawa Parties assume all risk and liability for injury or damage to persons or property in performing their maintenance, repair, and other responsibilities pursuant to this Contract. The Northwest Ottawa Parties agree to indemnify the Muskegon Parties and their respective board members, officers, employees and agents from any and all losses, damages, claims and expenses, including reasonable attorney fees incurred for defense, resulting from injury or damage to persons or property for which the Northwest Ottawa Parties have assumed all risk and liability pursuant to the immediately preceding sentence to the extent that any insurance maintained by the Northwest Ottawa Parties therefor is insufficient.

Section 6. Risk of Loss and Insurance. The Muskegon Parties and the Northwest Ottawa Parties shall have equal responsibility for risk of loss for the valve for Interconnection A and the other Interconnection A facilities exclusive of the water mains leading to Interconnection A The Muskegon Parties shall have sole responsibility for risk of loss to the northerly Interconnection valves for Interconnections B, C, and D, respectively. The Northwest Ottawa Parties shall have full responsibility for risk of loss to the southerly Interconnection valves for Interconnections B, C, and D, respectively. The parties may insure the respective Interconnection valves and facilities for which they have responsibility at their own expense.

The Muskegon Parties and the Northwest Ottawa Parties, respectively, shall have full responsibility for risk of loss to the water mains that each is required to maintain as is provided in Section 2 except that with respect to the water pipelines between the southerly and northerly valves for Interconnections B and C, respectively, the Muskegon Parties and the Northwest Ottawa Parties shall have equal responsibility for risk of loss.

Section 7. Term. This Contract shall be effective as of May 1, 2003, and shall continue until December 31, 2023. The term of this Contract may, however, be extended on the same terms and provisions or other mutually agreeable terms and provisions by one or more renewals. The Interconnection Contract between the parties dated December 1, 1981, is revoked as of the effective date of this Contract as are all other contracts and agreements which pertain to the Interconnection, except for the provisions of those Contracts which contemplate performance after termination including, but without limitation, the indemnifications provisions.

Section 8. Miscellaneous. Neither this Contract nor any rights under it may be assigned nor may any duty be delegated (except as is provided in this Contract) without the prior written consent of all of the non-assigning or non-delegating parties. Any attempt to assign or delegate rights or duties without prior written consent shall be void. This Contract shall inure to the benefit of and be binding upon the parties hereto and their respective successors and permitted assigns.

All notices and other documents to be served and transmitted hereunder shall be in writing and addressed to the designated contact persons for the respective parties hereto at the addresses stated on page 1 of this Contract or such other address or addresses as shall be specified by the parties hereto from time to time and may be served or transmitted by personal delivery, by facsimile transmission, by e-mail, or by ordinary or certified mail properly addressed with sufficient postage. This is an integrated Contract. It contains the full understanding of the parties and supersedes all other understandings, agreements or conditions, written or oral, regarding the subject matter of this Contract. This Contract has been executed in the State of Michigan and shall be governed by Michigan law. The waiver by any party hereto of a breach or violation of any provision of this Contract shall not be a waiver of any subsequent breach of the same or any other provision of this Contract. If any section or provision of this Contract is unenforceable for any reason, the

unenforceability thereof shall not impair the remainder of this Contract, which shall remain in full force and effect. It is contemplated that this Contract will be executed in multiple counterparts, all of which together shall be deemed to be one Contract. The captions in this Contract are for convenience only and shall not be considered as part of this Contract or in any way to amplify or modify the terms and provisions hereof. This Contract shall be enforceable only by the parties hereto and their successors in interest by virtue of an assignment which is not prohibited under the terms of this Contract and no other person shall have the right to enforce any of the provisions contained herein. All exhibits attached hereto are incorporated herein by reference as though fully stated herein, No amendment. modification or waiver shall be effective unless in writing and signed by all parties. All rights and remedies set forth in this Contract are cumulative and are in addition to any other legal or equitable rights and remedies.

IN WITNESS WHEREOF, the parties have executed this Contract.

Witnessed as to both signatures by:

CITY OF MUSKEGON HEIGHTS

By: Bellastine R. Wilkins

Its: Mayor

By:

Its: Clerk

Dated: April 21, 2003

C
I

By: Nancy Crandall

OF NORTON SHORES

Marilynn R. Westjohn

Marilynn R. Westjohn

Nancy Cra dall

Marshelle D. Stibitz

Marshelle D. Stibitz

By: Lynne Fuller

Lynne Fuller

Its: Mayor

Its: City Clerk

Dated: May 7, 2003

305/03

CHARTER TOWNSHIP OF
FRUITPORT

Patricia M. Nichols

By: Constance L. Smith
Its: Supervisor

Sharon K. Tardani

By: Carol Hulka
Its: Clerk

Dated: April 16, 2003

COUNTY OF OTTAWA, by its Board of
County Road Commissioners

By: _____

Its: CHAIRMAN

By: _____

Its: SECRETARY

Dated: JUNE 10, 2003

TOWNSHIP OF SPRING LAKE

Beth Ann Boyink

Beth Ann Boy ink

By:

James A. Jeske Il

Its: Supervisor

Barbara E. Beaune

By:

Donald E. Miller Its: Clerk

Dated: July 14 2003

Kristie Mills

C. A. Masterson

VILLAGE OF SPRING LAKE

By: Maribeth Lawrence

Its: CLERK/TREASURER

By:

Its: PRESIDENT

Dated: August 4, 2003

CHARTER TOWNSHIP OF
GRAND HAVEN

Peter J Bommarito

By: Sue Buitenhuis

Its: Clerk

Kristi Kulash

By: _____

Its: _____

Dated: 1/24/03, 2003

Witnessed as to both signatures by:

CITY OF FERRYSBURG

By: _____
Ray Tejchma
Its: Mayor

By: _____
Debbie Wierenga
Its: Interim Clerk

AUG 4 2003

Dated:2003

Witnessed as to both signatures by:

Diane Cjarmac-Kirk

Mary A. Swedeker

CITY OF GRAND HAVEN

By: _____

Its: Mayor

By: Linda L. Nieto

Its: Deputy City Clerk

Dated: August 4, 2003

m02\021.4

Interconnection A

On the North line of Section 1, Town 8 North, Range 16 West of Spring Lake Township, which is the South line of Section 36, Town 9 North, Range 16 West of Fruitport Township (the Village of Fruitport), at a point in the Fruitport Road right-of-way 420 feet south of the intersection of the centerline of Fruitport Road and Apple Drive as shown on Exhibit B.

Interconnection B

430 feet north of North line of Section 2, Town 8 North, Range 16 West of Spring Lake Township, which is the South line of Section 35, Town 9 North, Range 16 West of Fruitport Township, at points in the Judson Road right-of-way a valve 30 feet North and a valve 35 feet North of the centerline of Claire Lane as shown on Exhibit C.

Interconnection C.

On the North line of Section 4, Town 8 North, Range 16 West of Spring Lake Township, which is the South line of the City of Norton Shores, at points in the 174th Avenue (Grand Haven Road) right-of-way a valve 5 feet South and a valve 36.5 feet North of the centerline of Wilson Road as shown on Exhibit D.

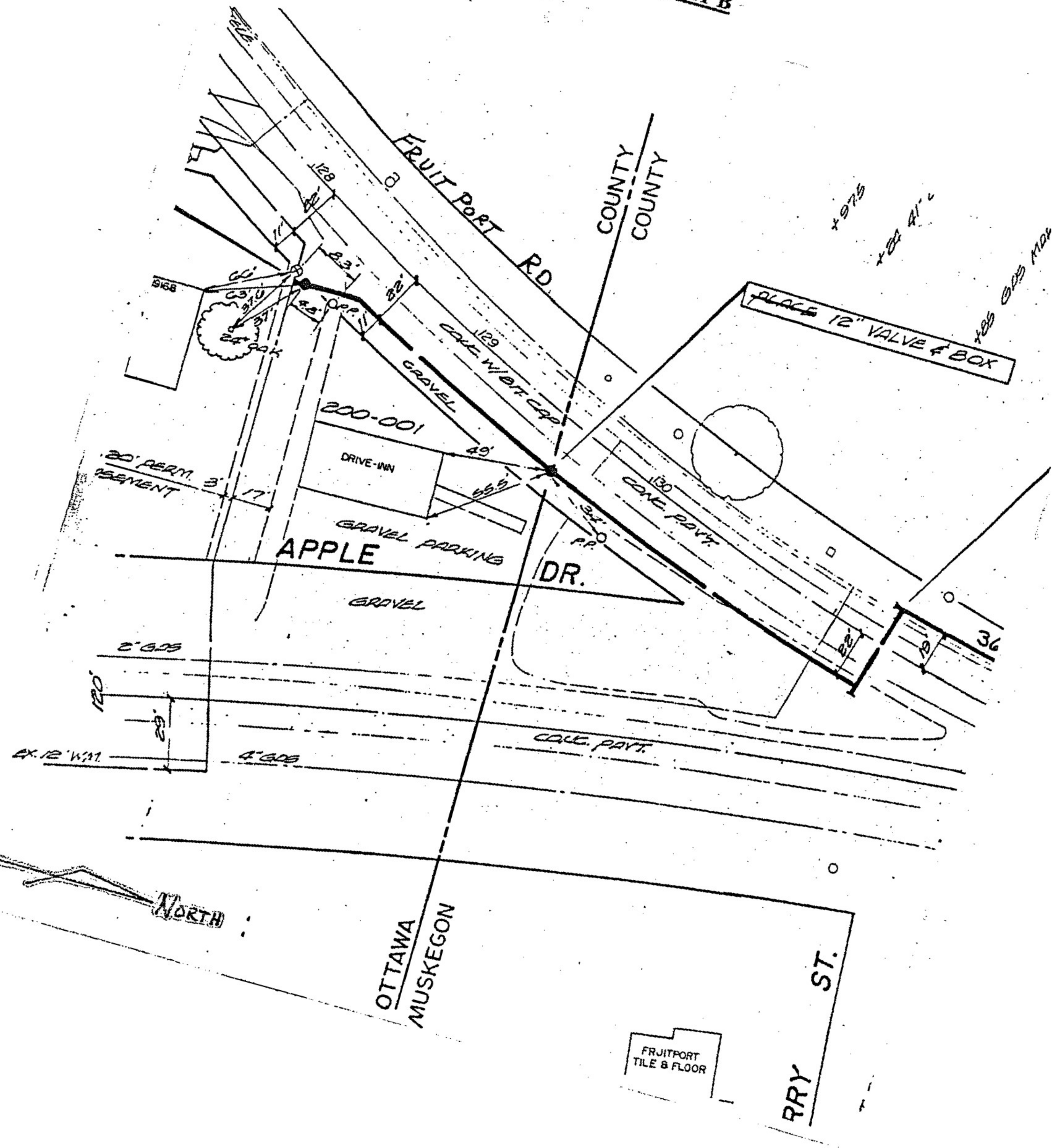
Interconnection D.

On the North line of Section 6, Town 8 North, Range 16 West of Spring Lake Township, which is the South line of the City of Norton Shores, at points in the Palm Drive (Black Lake Road) right-of-way a valve 18 feet South and a valve 12 feet North of the Ottawa County-Muskegon County line as shown on Exhibit E.

Interconnection E

L tea at + Township, which Section 3, Township, at points i south line of Fruitport Street (168th Avenue) right of way a valve Ottawa Coun... c- Muskegon County line as shown in Exhibit F

EXHIBIT B



FRUIT PORT RD.
COUNTY
COUNTY
PLACE 12" VALVE & BOX
200-001
DRIVE-INN
GRAVEL
GRAVEL PARKING
APPLE DR.
GRAVEL
CONC. PAVT.
CONC. PAVT.
COLC. PAVT.
20' PERM. EASEMENT
2" GDS
4" GDS
EX. 12" W.M.
24" OAK
NORTH
OTTAWA
MUSKEGON
ST.
FRUITPORT TILE & FLOOR

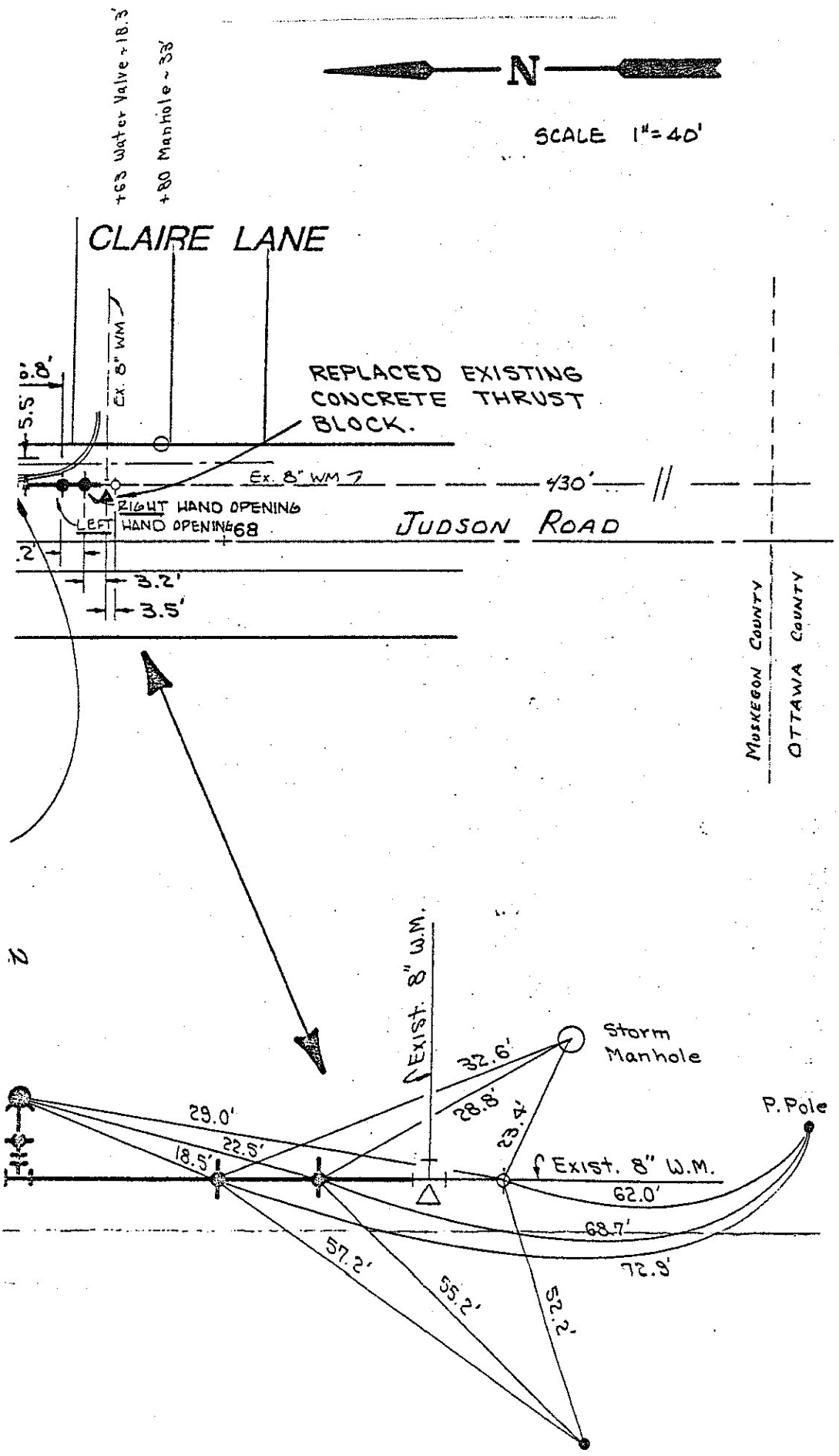
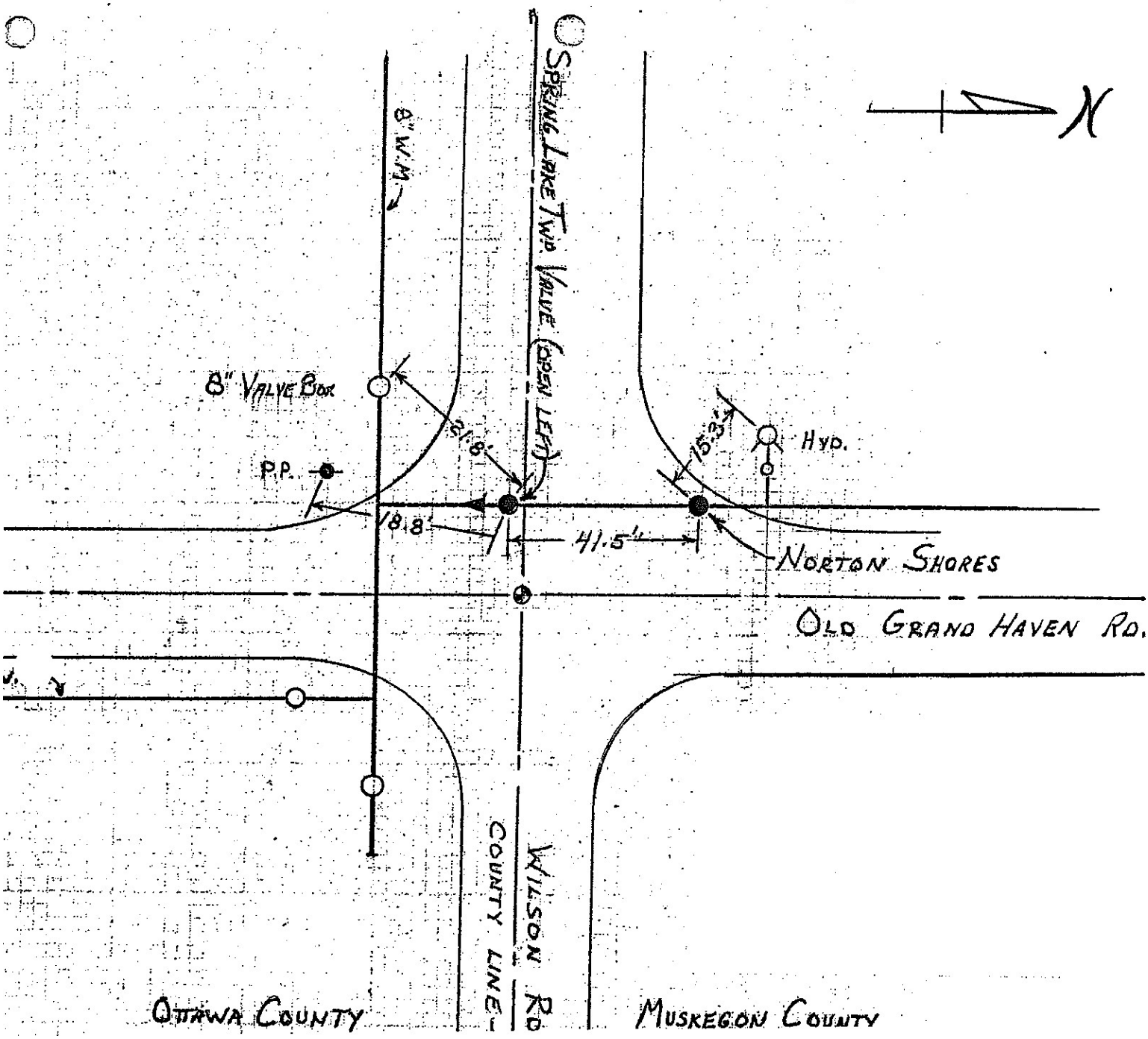
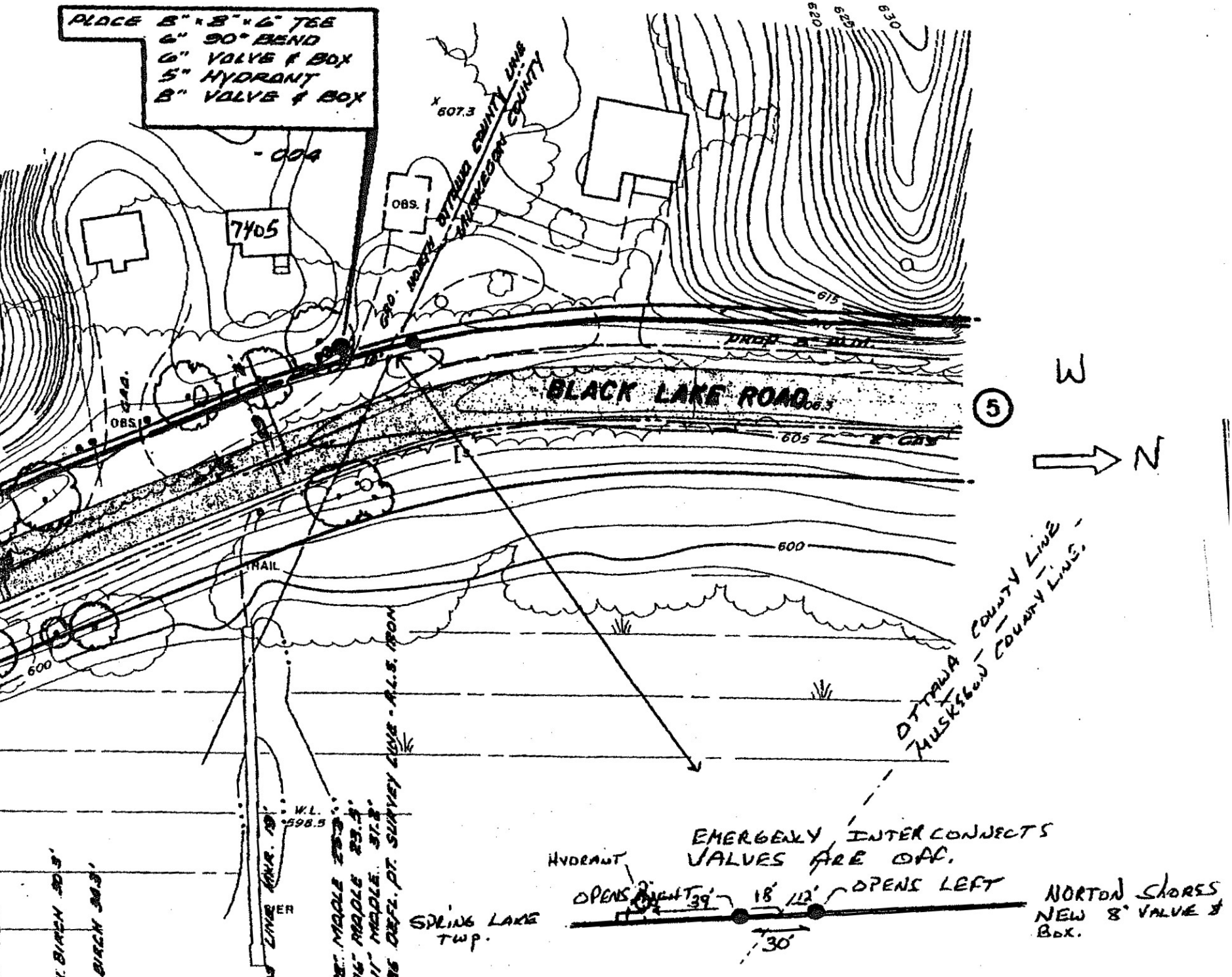

+63 Water Valve ~ 18.3'
+80 Manhole ~ 33'
N
SCALE 1"=40'
CLAIRE LANE
Ex. 8" WM
REPLACED EXISTING CONCRETE THRUST BLOCK.
Ex. 8" WM
430'
RIGHT HAND OPENING
LEFT HAND OPENING
68
JUDSON ROAD
MUSKEGON COUNTY
OTTAWA COUNTY
3.2'
3.5'
Exist. 8" W.M.
Storm Manhole
P. Pole
32.6'
28.8'
23.4'
29.0'
22.5'
18.5'
Exist. 8" W.M.
62.0'
68.7'
72.9'
57.2'
55.2'
52.2'

EXHIBIT D


8" W.M.
SPRING LAKE TWP. VALVE (OPEN LEFT)
8" VALVE BOX
P.P.
21.8'
18.8'
41.5'
15.3'
HYD.
NORTON SHORES
OLD GRAND HAVEN RD.
COUNTY LINE
WILSON RD.
OTTAWA COUNTY
MUSKEGON COUNTY
N


PLACE 8" x 8" x 6" TEE
6" 90° BEND
6" VALVE & BOX
5" HYDRANT
8" VALVE & BOX
7405
OBS.
607.3
GEO. NORTH OTTAWA COUNTY LINE MUSKEGON COUNTY
620
625
630
615
605
BLACK LAKE ROAD
5
W
N
600
TRAIL
OTTAWA COUNTY LINE
MUSKEGON COUNTY LINE.
W.L. 598.5
EMERGENCY INTERCONNECTS
VALVES ARE OPEN.
HYDRANT
OPENS RIGHT
39'
18'
12'
OPENS LEFT
30'
SPRING LAKE TWP.
NORTON SHORES
NEW 8" VALVE & BOX.

Muskegon County - Ottawa County Emergency .Water Supply Interconnection

Valve Operation B.±P-Q.C!.

1 - Reason for opening: Emergency Ma intenance & _____ Operation
Explanation:

_____

_____

_____

_____

2 - Date and time opened: _____

3 - Opened by: _____ Title _____

Name

Unit of Government _____

Opening authorized by: (if opened by other than designated operator)

Name _____ Title_____.

Unit of Gov't. _____.

4 - Date and time closed: _____.

5 - Closed by: Name _____ Title _____.

Unit of Gov't. _____.

6 - Remarks: _____

_____

_____

_____

_____

_____

_____

_____

_____

VII. RETURN TO NORMAL CONDITIONS

Should significant rainfall be received to safely provide sufficient water to meet demand and stated trigger points are exceeded, the Village Manager shall issue a public notice pursuant declaring the water shortage resolved and the termination of water restrictions.

VIII. EFFECTIVENESS

The effectiveness of the Village of Spring Lake Water Shortage Response Plan will be determined by comparing the stated water conservation goals with observed water use reduction data. Other factors to be considered include frequency of plan activation, any problem periods without activation, total number of violation citations, desired reductions attained and evaluation of demand reductions compared to the previous year's seasonal data.

IX. REVISION

The Water Shortage Management Plan will be reviewed and revised as needed to adapt to new circumstances affecting water supply and demand, following implementation of emergency restrictions, and at a minimum of every five years, as required. The Village of

Spring Lake Director of Public Works is responsible for initiating all subsequent revisions. The procedures herein are written to reduce potable water demand and supplement existing drinking water supplies whenever they are in danger of being inadequate to meet customer needs. Following is a list of available staff and their contact information.

Emergency Contact List

John Stuparits, Director	616-638-8902
Ben VanHoeven, Foreman	616-638-6472
Ty Inso, Operator	616-638-6479
Will Dirkse, Operator	616-638-6475
Josh VanOpynen, Operator	616-638-6470

After hours contact number 616-843-7460

spring lake township

"WHERE NATURE SMILES FOR SEVEN MILES"
101 South Buchanan, Spring Lake, Michigan 49456
Phone: (616) 842-1340
Fax: (616) 842-1546

SPRING LAKE TOWNSHIP

WATER SHORTAGE RESPONSE PLAN

I.

PURPOSE

The procedures herein are written to reduce potable water demand and supplement existing drinking water supplies whenever they are in danger of being inadequate to meet customer needs.

II.

WATER SYSTEM SUMMARY

Spring Lake Township operates and maintains a purchase water system. All the drinking water is supplied by the Northwest Ottawa Water Treatment Plant. The Northwest Ottawa Water Treatment Plant is operated and managed by the City of Grand Haven under the Department of Public Works and is contracted by the Townships of Grand Haven and Spring Lake, City of Ferrysburg, and the Village of Spring Lake.

III.

AUTHORITY

When a water shortage is detected at the Northwest Ottawa Treatment Plant the plant director will notify authorities that a water shortage exists and, the Township Manager may implement temporary emergency procedures. Should other emergency situations occur such as line breaks, contamination, mechanical failures, or similar emergencies, the Township Manager may also consider implementing temporary emergency procedures.

The Spring Lake Township Manager is authorized to enact water shortage response provisions whenever the trigger conditions outlined are met. In his or her absence, the Director of Public Works will assume this role.

Mr. Gordon Gallagher

Township Manager

Phone: 616-842-1546

E-mail: ggallagher@springlaketwp.org

Mr. John Stuparits

Public Works Director

Phone: 616-846-2422

E-mail: jstuparits@springlaketwp.org

Adopted Water Use Restriction Guidelines

2007 – Revised 2015

In accordance with the Northwest Ottawa Water Production Facilities Contract, the following water use restriction guidelines are in place for the Northwest Ottawa Water System (NOWS).

During periods of severe drought many communities in the Ottawa – Muskegon – Kent Counties service areas found it necessary to impose mandatory water use restrictions. While the water supply systems serving the area continue to grow and develop, this made water use restriction planning necessary.

Experience very clearly demonstrates the need for a coordinated and consistent water use restriction plan. It was obvious a substantial number of residents, as well as members of the media, were unaware which system supplied their drinking water. There also was a surprising amount of confusion concerning simple geography.

In an effort to reduce this confusion factor, the following guidelines have been adopted by NOWS and the Ottawa County Road Commission, Public Utilities Department.

All jurisdictions within the NOWS service area will comply with the four tiered, increasingly severe water use restriction guidelines as outlined below.

1. Odd-Even Lawn Sprinkling.

   Addresses ending in an odd number will be allowed to sprinkle any time on odd numbered dates; even numbered addresses may sprinkle any time on even numbered dates. (Non-addressed Municipal parks and parkways will sprinkle on odd days).

2. Odd-Even Sprinkling – Midnight to Noon.

Same as above, except all permitted sprinkling activity must occur between the hours of mid-night and noon. All sprinkling, regardless of address, is prohibited from noon to midnight.

3. Total Ban on Sprinkling.

4. Total Ban on Sprinkling and Non-essential use of water such as

    A. Non-commercial car washes.
    B. Hosing off drives and walks.

The above guidelines will be implemented as recommended by the Water Plant Operators and Manager and as authorized by the City of Grand Haven Manager as the Administrator, starting at approximately 90% (20.9 MGD) of rated plant capacity demands and for other circumstances as necessary.

IV. ENFORCEMENT

Sec. 38-65. - Emergency conservation rules.

(a)
Rules. When weather or other extraordinary conditions place unusual water use demand upon the system or when the system water supply or capacity is reduced due to mechanical failure, catastrophe or other physical limitations, and low pressure or reduced volumes threaten the public health, safety or welfare, the township supervisor or the township supervisor's designee is empowered to make all rules necessary to conserve and protect the public health, safety and welfare and the integrity of the system. Such rules may restrict or prohibit less essential water uses (such as a full or partial sprinkling ban) to the extent deemed necessary by the township supervisor or the township supervisor's designee to ensure an adequate water supply for essential domestic and commercial needs and for firefighting.

(b)
Effective date of rules. Rules promulgated under this section shall become effective immediately and shall remain in effect until modified or rescinded by further order of the township supervisor or the township supervisor's designee or by resolution of the township board.

(c)
Notice. Notification of rules promulgated under this section shall be by any reasonable means and may include, without limitation, public announcement by broadcast from a radio or television station with a normal operation range in the township, announcement by loudspeaker in the township, placement on the township internet website, publication in a newspaper of general circulation in the township and/or posting in public places within the township.

(d)
Exceptions. The township supervisor or the township supervisor's designee may grant exceptions to these rules in cases where outdoor irrigation is necessary to preserve nursery stock or newly established landscaping, if proof of new purchase is provided to the township, or where necessary to prevent imminent financial loss to the water customer.

(e)
Penalty. Any person who violates any rule made pursuant to this section shall be punished for a violation of this division.

(f)
Termination of service. The township supervisor or the township supervisor's designee shall have the power and authority to shut off and discontinue the water service provided to any water customer who violates any rule made pursuant to this section. Water service shall only be restored at such time as the township supervisor or the township supervisor's designee is reasonably satisfied that future violations of rules promulgated pursuant to this section will not occur and when the water customer has paid a turn-on charge to the township in the amount specified in the rate schedule.

(g)
Injunction. The enforcement of any rules promulgated under this section may be by injunctive action. The imposition of the civil penalties prescribed in this division shall not preclude the township from instituting an appropriate action to prevent violation of any rules promulgated under this section.

(Ord. No. 199, § 27, 9-11-2006)

Spring Lake Township

Water Shortage Management

V. RETURN TO NORMAL CONDITIONS

Should significant rainfall be received to safely provide sufficient water to meet demand and stated trigger points are exceeded, the Township Manager shall issue a public notice pursuant declaring the water shortage resolved and the termination of water restrictions.

VI.EFFECTIVENESS

The effectiveness of the Spring Lake Township Water Shortage Response Plan will be determined by comparing the stated water conservation goals with observed water use reduction data. Other factors to be considered include frequency of plan activation, any problem periods without activation, total number of violation citations, desired reductions attained and evaluation of demand reductions compared to the previous year's seasonal data.

VII. REVISION

The Water Shortage Management Plan will be reviewed and revised as needed to adapt to new circumstances affecting water supply and demand, following implementation of emergency restrictions, and at a minimum of every five years, as

required. The Spring Lake Township Director of Public Services is responsible for initiating all subsequent revisions. The procedures herein are written to reduce potable water demand and supplement existing drinking water supplies whenever they are in danger of being inadequate to meet customer needs.

spring
lake
township

"WHERE NATURE SMILES FOR SEVEN MILES"
101 South Buchanan, Spring Lake, Michigan 49456
Phone: (616) 842-1340
Fax: (616) 842-1546

Water &Sewer Department
Emergency Contact Numbers

John Stuparits, Public Works Director	616-638-8902
Kyle Botbyl, Public Works Supervisor	**616-502-2162**
Pete Eliopulos, Parks and Grounds Crew Leader	616-402-5153
Tim VanderSchaaf Service Technician	616-502-2161
Erik Erhorn Service Technician	616-502-2167
Scott Rochon Service Technician	616-843-8963
Water Department Billing Office	616-842-0080
Public Works Building	616-846-2422
After Hours Pager	**616-844-2104**

Contact after hours' pager after normal business hours Monday thru Friday 8:00am to 5:00pm. Contact the Public Works Supervisor second after ten minutes without a call back. Thank you.

CROCKERY TOWNSHIP
WATER SHORTAGE RESPONSE PLAN

The Crockery Township Water System has been designed to minimize the potential for occurrence of a water shortage. This plan has been prepared to provide basic information on how the Township would approach a water shortage, should one occur.

1. Authorization (to declare & rescind a water shortage) Contact Information

Primary	Backup
Pat Staskiewicz, P.E.	Joe Hebert
Public Utilities Director	Public Utilities Supervisor
Ottawa County Road Commission	Ottawa County Road Commission
PO Box 739	PO Box 739
Grand Haven, MI 49417	Grand Haven, MI 49417
616-850-7208	616-850-7219

2. Notification (how are staff and customers notified about the water shortage, stage, and any actions required)

   Notification through local media; Grand Haven Tribune (newspaper) and WGHN (radio)

3. Enforcement (how are required actions, use restrictions, etc. enforced)

   The Township has an ordinance that allows the Township to stop service in the case of an emergency.

4. Critical Customer Needs (list of hospitals, dialysis, industrial equipment requirements to prevent overheating/explosion/meltdown)

   Jean will provide input.

5. Water Use Restrictions (this may include several stages, each more restrictive, voluntary, rationing)

   See attached Adopted Water Use Restrictions Guidelines.

6. Interconnection Use/Procedures

   Two water supplies are available for emergency water through interconnections. Muskegon interconnections and Grand Rapids interconnections are both governed by interconnection agreements. The Water Plant Superintendent initiates the procedure for requesting emergency water.

7. Mutual Aid Agreements

   There are no written mutual aid agreements to address water shortages.

8. Water Hauler & Bottler Information and location of pickup

   Joe to provide input.

CITY OF FERRYSBURG
WATER SHORTAGE RESPONSE PLAN

The City of Ferrysburg Water System has been designed to minimize the potential for occurrence of a water shortage. This plan has been prepared to provide basic information on how the City of Ferrysburg would approach a water shortage, should one occur.

1. Authorization (to declare & rescind a water shortage) Contact Information

Primary	Backup
Joe VanderStel	Craig Bessinger
Northwest Ottawa Treatment Plant	City of Ferrysburg
30 Sherman Avenue	17290 Roosevelt Rd. PO Box 38
Grand Haven, MI 49417	Ferrysburg, MI 49409

2. Notification (how are staff and customers notified about the water shortage, stage, and any actions required) Newspaper: Grand Haven Tribune, Website: www.ferrysburg.org, Radio: WGHN, Signs

3. Enforcement (how are required actions, use restrictions, ect. enforced)
   Ferrysburg Public Works Staff, Citations, Ottawa County Sheriff Department

4. Critical Customer Needs (list of hospitals, dialysis, industrial equipment requirements to prevent overheating/explosion/meltdown)
   Citgo Petroleum — Fire Suppression System
   524 Third Street
   Ferrysburg, MI 49409

5. Water Use Restrictions (this may include several stages, each more restrictive, voluntary – rationing) See Attached

6. Interconnection Use/Procedures
   See Attached

7. Mutual Aid Agreements
   DPW verbal agreements with Spring Lake Village, Spring Lake Township, and City of Grand Haven. Fire Department written agreements with Spring Lake Township Fire Department, Crockery Fire Department and City of Grand Haven.]

8. Water Hauler & Bottle Information and location of pickup
   Kent County — Mr. Craig Hoppen
   J & H Oil Company
   PO Box 9464
   Grand Rapids, MI 49509-0464
   Phone: 616-534-2181/1-800-203-9931