Water System Hydraulic Model

and

Water Supply Feasibility Report

Village of Shorewood

May 2010

Project Number: 000880-10001-0

Shorewood

Bonestroo

Existing System Description

Water from Milwaukee Water Works (MWW) is fed to Shorewood via two meters, ne at Edgewood and Downer, the other at Edgewood and Oakland. The hydraulic grade line at the Downer Avenue feed is set to approximately 778 feet and the Oakland Avenue feed is set approximately 10 feet lower, at 768. Currently, the domestic water supply is predominantly provided through the Downer Avenue connection, with the Oakland Avenue connection supplementing water for fire flow or other large requirements as needed.

Hydraulic Modeling

A computer hydraulic model was developed of the entire Village of Shorewood water distribution system. The hydraulic model was created in Bentley's WaterCAD software using water main and fire hydrant data from the Village GIS data. The physical data included in the hydraulic model includes all water main geometry (location and diameter), water supply data, ground elevations, and estimated 2009 average day demand. The existing water distribution system is illustrated in the attached Figure 1.

Actual usage data was collected for all large water users for inclusion in the hydraulic model. For the purposes of demand allocation, large users were defined based on water service diameter of three inches or greater. An average day demand was calculated for each large user based on 2009 annual use and assigned to the hydraulic model junction closest to the water user service. 2009 annual water sales to residential, commercial, and public users were distributed evenly to parcels by land use. Each parcel demand was then assigned to the nearest model junction to include water sales to all users. The amount of unaccounted for water (water not sold) in 2009 was approximately nine percent and was assigned evenly across all model junctions.

Pipe roughness coefficients or C values were approximated based on testing completed in similar water mains from surrounding Lake Michigan source water communities. The current hydraulic model C values are conservative and will be reviewed and updated as needed during hydraulic model calibration.

Water supplied from MWW is simulated in the hydraulic model to provide the pressure and flow characteristics present in the field. The model includes pressure reducing valves and hydraulic losses to represent the MWW supply at both Downer Avenue and Oakland Avenue. The hydraulic grade line at Downer Avenue is set to approximately 778 feet and the Oakland Avenue pressure reducing vale set roughly 10 feet lower. Domestic water use in the hydraulic model is met through the Downer Avenue connection and the Oakland Avenue connection supplements water for fire flow or other large requirements.

Hydraulic model scenarios were created to represent different demand conditions typically reviewed during water system analysis. Water use input in the hydraulic model was an average demand of 848 gallons per minute (gpm) or 1.22 million gallons per day (MGD) calculated from 2009 annual data. A maximum day factor of 1.75 and peak hour factor of 1.6 were used to determine maximum day and peak hour demands for the hydraulic model. The Village of Shorewood demands calculated for the hydraulic model are included in Table 1.

Table 1 – Village of Shorewood Hydraulic Model Demands

Hydraulic Model Scenario	Water Demand
Average Day Demand	1.22 MGD (848 gpm)
Maximum Day Demand	2.14 MGD (1,483 gpm)
Peak Hour Demand	2,373 gpm

System Evaluation

The hydraulic model was used to determine water system pressure for average, maximum, and peak demands, as well as available fire flow on a maximum day demand. Fire flow evaluations are conservatively completed during a maximum day, but not during peak hour usage.

The Wisconsin Administrative Code requires a minimum water system pressure of 35 psi during normal operation and 20 psi during emergency operation (i.e. fire flow). Average day demand pressures drop below 35 psi in the northeast portion of the Village water system where the highest ground elevations exist.

During April 2010 field testing, static water system pressures were recorded below 35 psi in this area. Under peak hour demands, when water system pressures are at the lowest, water pressure drops below 35 psi in a large portion of the northeast and along Lake Drive. The increased water demand creates additional pipe hydraulic losses reducing system pressures.

The average day water system pressure results in the Village of Shorewood are illustrated in Figure 2 and range from 31 psi to 63 psi throughout the majority of the Village. Peak hour pressures ranges from 27 psi to 59 psi and are illustrated in Figure 3.

Within the Village of Shorewood, higher fire flow requirements exist in commercial, institutional, and high density residential areas along Capital Drive, Oakland Avenue, and along the western edge of the Village. In general, fire flows of 500 – 1,000 gpm are adequate for low density residential areas and 1,500 gpm –2,500 gpm are required for high density residential and commercial areas. Fire flows up to 3,500 gpm are required for industry and large institutions.

Available fire flow under maximum day demand was calculated using the hydraulic model. The available fire flow is defined as the largest volume available while maintaining pressure of at least 20 psi throughout the water system. The hydraulic model does not include losses due to hydrant services or the hydrant itself, but provides the available flow directly from the water main at ground level. The available fire flow is illustrated in Figure 4.

Our analysis indicates that fire flows less than 500 gpm exist at several dead end water mains with the Village. Fire flows along some portions of Capitol Drive from Oakland Avenue to Downer Avenue range from approximately 2,600 to 3,000 gpm. At the same, 2,500 gpm fire flows are not available to some properties along Capitol Drive and Oakland Avenue.

System Improvement Recommendations

Based on preliminary investigations and engineering, both low system pressure and low fire flows can be resolved by increasing the system hydraulic grade.

- To maintain water system pressures greater than 35 psi during all demand conditions, the supply pressure should be increased by 9 psi, resulting in the system hydraulic grade to increase from 778 to 799 ft. This increase is the minimum amount to achieve regulatory compliance and fire flow needs.
- With this modification, system pressures increase approximately 9 psi with an average day pressure range of 40 – 72 psi, and peak hour system pressure range of 35 – 65 psi. The average day water system pressure results are illustrated in Figure 5 and the peak hour results are illustrated in Figure 6.
- The increase in hydraulic grade improves the available fire flow throughout the Village as shown in Figure 7. Available fire flow along Capitol Drive and Oakland Avenue will provide the minimum desired fire flow of 2,500 gpm at most fire hydrant locations for high density residential and commercial buildings.

- All three supply pressure reducing valves should be serviced and pressure settings set to ensure ideal water supply through both the Downer Avenue and Oakland Avenue connections.
- It is recommended hydraulic grade increases at the pressure reducing valve be conducted very slowly to prevent adverse effects from water hammer due to pressure surges.
- To maintain normal water system pressures greater than 35 psi and increase available fire flow, the water system hydraulic grade was increased to 799 ft.
- Areas of low elevation at Hubbard Park are shown to exceed 80 psi during low demand periods. The building plumbing code requires that water services on mains where the pressure is above 80 psi be equipped with pressure reducing valves. We therefore recommend that such a valve be installed at this location. This is the type of work that is customarily performed by a plumber.
- We recommend that a fire flow evaluation for all parcels be conducted as a separate component of the Village Water System Management Plan. This evaluation should be reviewed and coordinated with fire officials to collaborate on the required fire flows and adequacy of available flow.

Evaluation of Water Supply from North Shore Water Utility

The hydraulic model was used to evaluate the capacity of the water system to receive water from North Shore Water Commission (NSWC) in the north instead of the current southern connections to MWW. The objective of this analysis is to determine the magnitude of improvements needed to maintain current levels of service to Village of Shorewood customers.

We stated earlier that in order to maintain 35 psi pressure throughout the water system, the system hydraulic grade of 799 feet must be maintained. Therefore, the ability of NSWC to provide Shorewood with a hydraulic grade of 799 is a basic premise of our analysis. We note that if the current NSWC system hydraulic grade is lower than 799, additional capital improvements to the NSWC system will be needed to provide adequate water supply to Shorewood.

Shorewood's connection to the NSWC system would occur at two locations at the north end of the Village. The connections are located on Glendale Avenue, at Morris and Oakland. These connections are currently in place, but would need to be evaluated for operability.

We should anticipate that each of the existing meter pits will require reconditioning, rehabilitation, repairs, and upgrades, depending on current condition of these pits. At this time, we would estimate that putting the two connections into service would cost $200,000.

Assuming that NSWC ca supply water at the required hydraulic grade of 799 ft., our hydraulic analysis indicates that,

- A minimum pressure of 35 psi can be maintained in the system.
- Domestic water demands in Shorewood can be met without a decrease in water service when supplied through Morris Boulevard and Oakland Avenue feeds. Figure 5 illustrates peak hour pressure results with a supply hydraulic NSWC supply.
- The available fire flows will be less than the existing MWW supply. The decrease in fire flow is a direct result of the smaller diameter supply pipes on Morris Boulevard and Oakland Avenue.

Figure 8 illustrates the available fire flow with a hydraulic grade of 799 feet supplied from NSWC. Fire flows along Capitol Drive from Oakland Avenue to Downer Avenue area will also be reduced

from greater than 3,500 gpm down to about 2,800 gpm. To address the fire flow reduction while running the system at 799 ft, Shorewood's connection to the NSWC will require one of the three alternatives described below:

- Increasing supply by adding a third connection to NSWC system: NSWC and Shorewood could build a third supply location to Shorewood. Our review of the existing systems suggest the third connection can be achieved by constructing the following watermain extensions:
    - 500 feet of 8 inch main on Wilson Drive at the Whitefish Bay border with an estimated cost of $60,000; or
    - 2,200 feet of 12 inch main on Santa Monica at the Whitefish Bay border with an estimated cost of $385,000, or
    - 2,200 feet of 16 inch main in Estabrook Park at the Glendale border with an estimated cost $630,000.

  The third connection would also require a new meter pit, an estimated $200,000 investment. Clearly, the installation of the 500 feet of 8 inch main at Wilson should be the preferred alternative to meet fire flow demands while running the system at a hydraulic grade line of 799 feet.

- Maintain the existing connections and increase transmission capacity in Shorewood: by increasing the size of water mains in Shorewood to achieve better transmission in order to prevent a reduction in fire flow described above. The goal of this initiative would be to increase capacity from existing connections to the 16 inch main on Capitol Drive by upsizing the north-south mains on Morris Boulevard or Oakland Avenue. Pavement Management Plan coordination suggests that the Morris Boulevard connection to Capitol Drive is best achieved along Ardmore Avenue, due for reconstruction in 2012. The Oakland Avenue connection to Capitol Drive can be programmed for the scheduled reconstruction of Oakland Avenue in 2016. The current line on Morris is a 12 inch main, while Oakland Avenue has an 8 inch main. Water supply goals are achieved by constructing either
    - 3,400 feet of 16 inch main on Ardmore Ave.nue with an estimated cost of $970,000, or
    - 4,000 feet of 8 inch main on Oakland Avenue with a cost of $470,000.

  Neither of these options is competitive with the above referenced option to build a third feed at Wilson Drive, even when the cost of the third meter pit is factored in the equation.

- Maintain the existing connections and increase hydraulic grade line to 820: increasing the hydraulic grade line will achieve the required fire flows. While doing so would not require capital improvements, the net result is to increase average day system pressures may reach a range of 50 to 85 psi. While new water systems are routinely designed to operate under this range of pressures, there maybe a possibility of inducing a higher rate of water main breaks in the system. We note that the Milwaukee water mains on the east side are probably about the same age and condition as Shorewood mains, and Milwaukee operates at much higher pressures seemingly without an unusual rate of watermain breaks. The operational implications of increasing the system pressure needs further consideration by the Utility.

  From an economic standpoint, we estimate that running the system at 820 feet of head will require two booster pumps. The estimated cost of these pumps is $450,000 each, or a total investment of $900,000. Again, we conclude that the high pressure option is not competitive against the construction of a third feed at Wilson.

Conclusion

We find that the connection to NSWC is a feasible alternative to the Village's current water supply from MWW. Not including Shorewood's potential financial participation in NSWC improvements outside Shorewood, the switch needs the following:

- Reconditioning and rehabilitating the existing meters for an estimated sum of $200,000.
- Constructing a third connection to NSWC at Wilson Drive for $60,000.
- Constructing a new meter pit at the new connection for $200,000.

The total estimated construction cost is $460,000. 3 percent survey, 7 percent engineering, 12 percent construction management, and 15 percent contingency would indicate a budget number of $630,000 to achieve the switch.

Recommended Strategy for NSWC Water Supply

At this time, we recommend Shorewood to request a service proposal from NSWC in order to move forward with its evaluation for water supply. Specifically, this request should include consideration of the following needs:

- Shorewood requires its water supply to operate at 799 feet of hydraulic grade. Can NSWC supply this grade, if not, what are the investments needed by NSWC? How about a hydraulic grade elevation of 820? What are the NSWC operation implications and capital investments required to achieve 820 feet?
- In order to provide adequate fire flow, Shorewood requires a third feed location. The preliminary location of the third feed is an 8 inch connection at Wilson Drive. The need for a new meter pit at the new feed is understood. Can NSWC provide sufficient and adequate flow at this location? If not, where can the NSWC system provide this third connection to Shorewood?

The response to the service proposal request will give Shorewood an insight into any other investment needs and provide a complete picture for decision making. At this time, we also note that, based on our current knowledge of the two systems, NSWC will be able to provide a hydraulic grade of 799, and that adding an 8 inch connection and a meter pit at Wilson Drive will fulfill Shorewood's requirements for a minimum pressure of 35 psi, and provide adequate fire flows.

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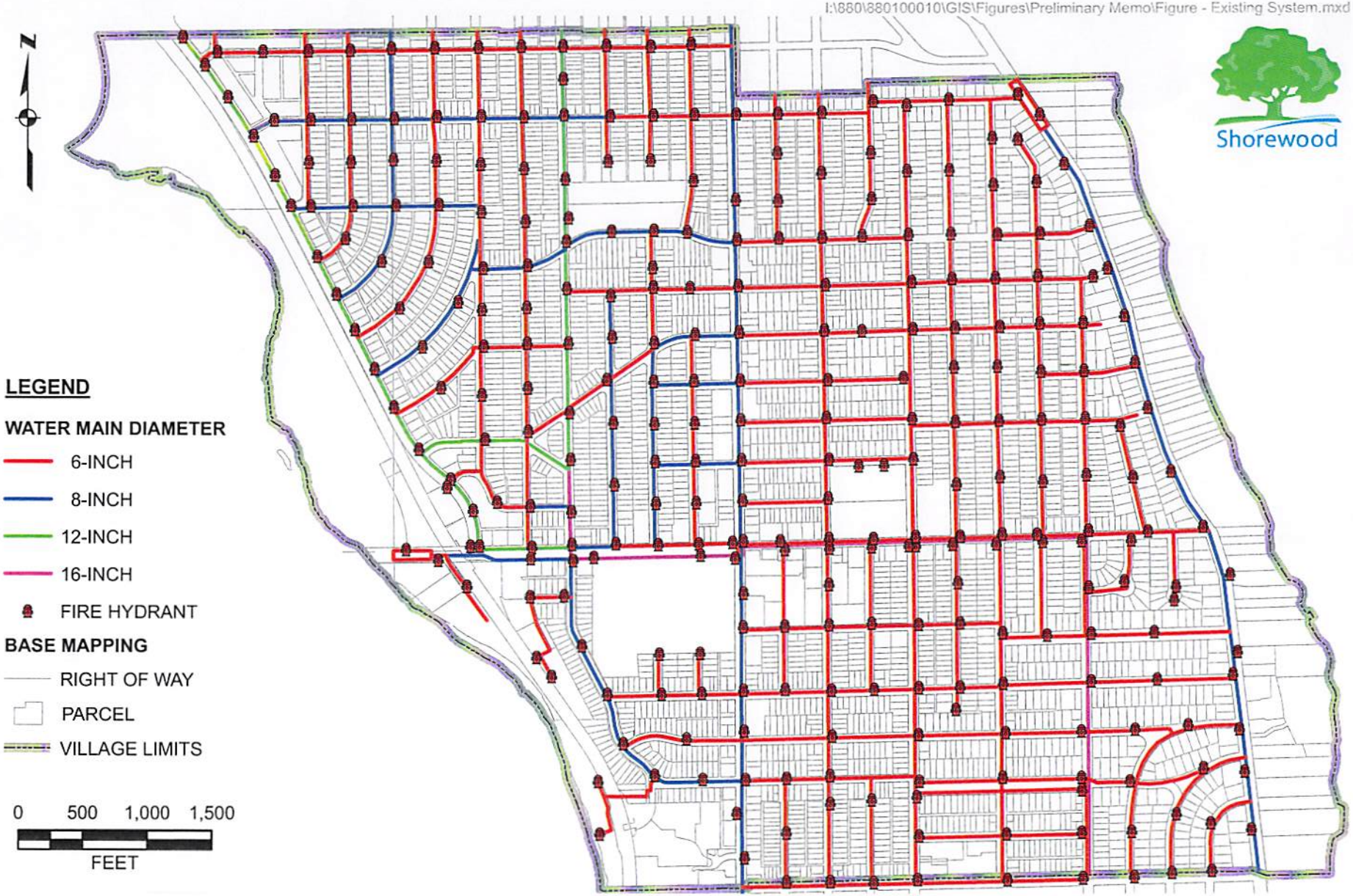

FIGURE 1 - EXISTING WATER DISTRIBUTION SYSTEM

VILLAGE OF SHOREWOOD, WISCONSIN
HYDRAULIC MODEL AND WATER SUPPLY FEASIBILITY STUDY

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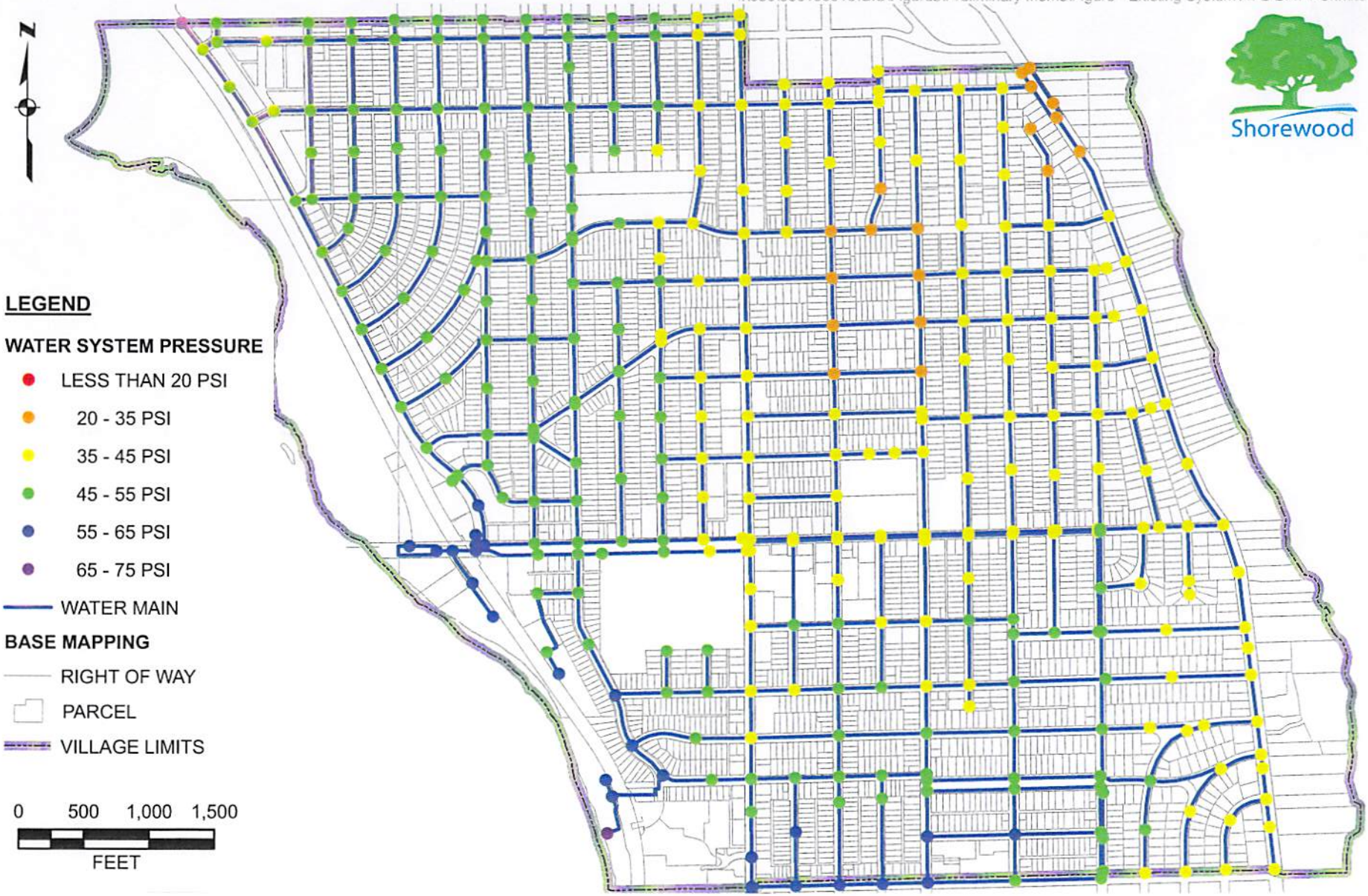

FIGURE 2 - EXISTING WATER SYSTEM PRESSURE - AVERAGE DAY DEMAND

VILLAGE OF SHOREWOOD, WISCONSIN
HYDRAULIC MODEL AND WATER SUPPLY FEASIBILITY STUDY

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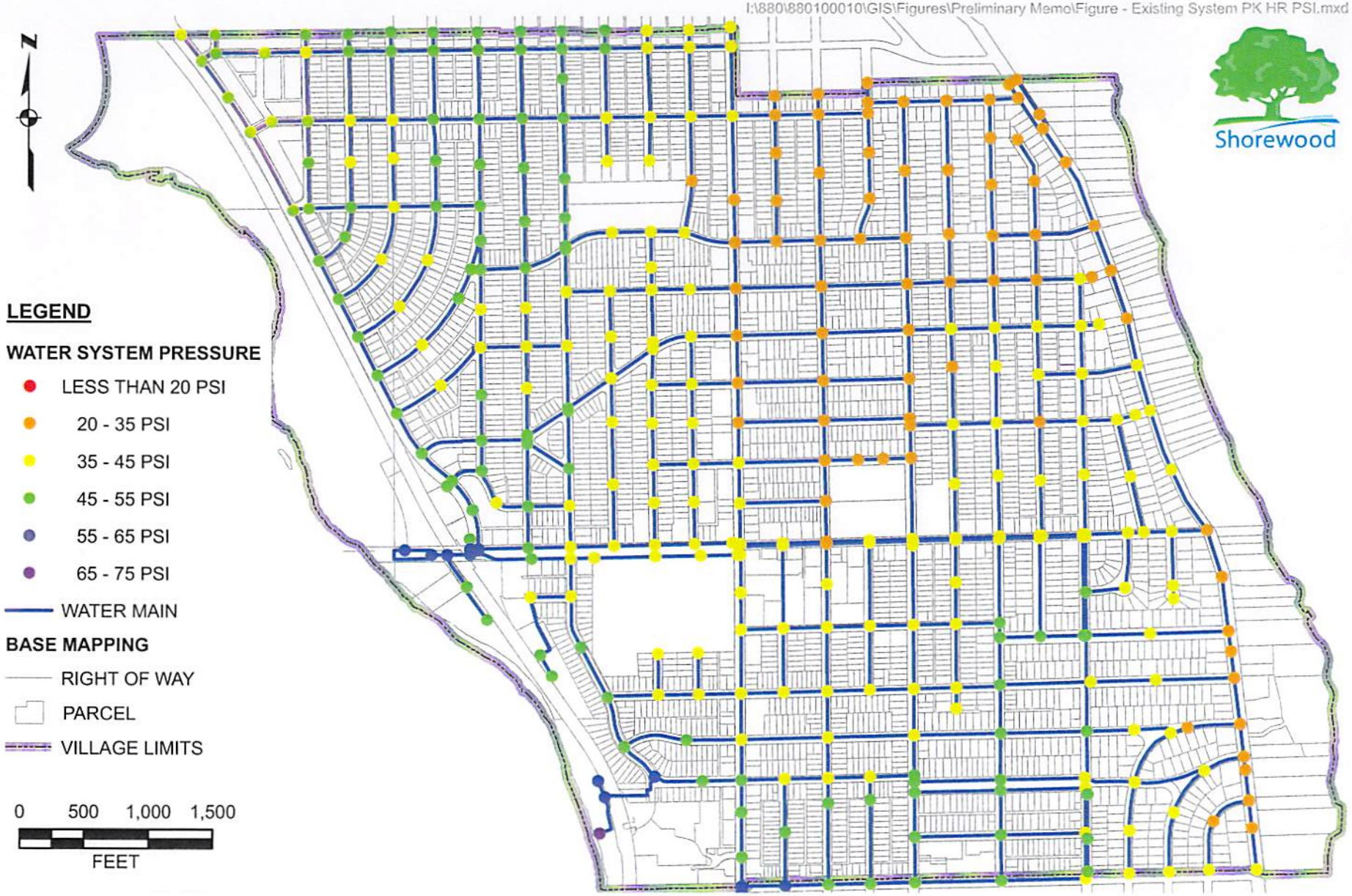

FIGURE 3 - EXISTING WATER SYSTEM PRESSURE - PEAK HOUR DEMAND

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HYDRAULIC MODEL AND WATER SUPPLY FEASIBILITY STUDY

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I:\880\880100010\GIS\Figures\Preliminary Memo\Figure - Existing System Fire Flow.mxd

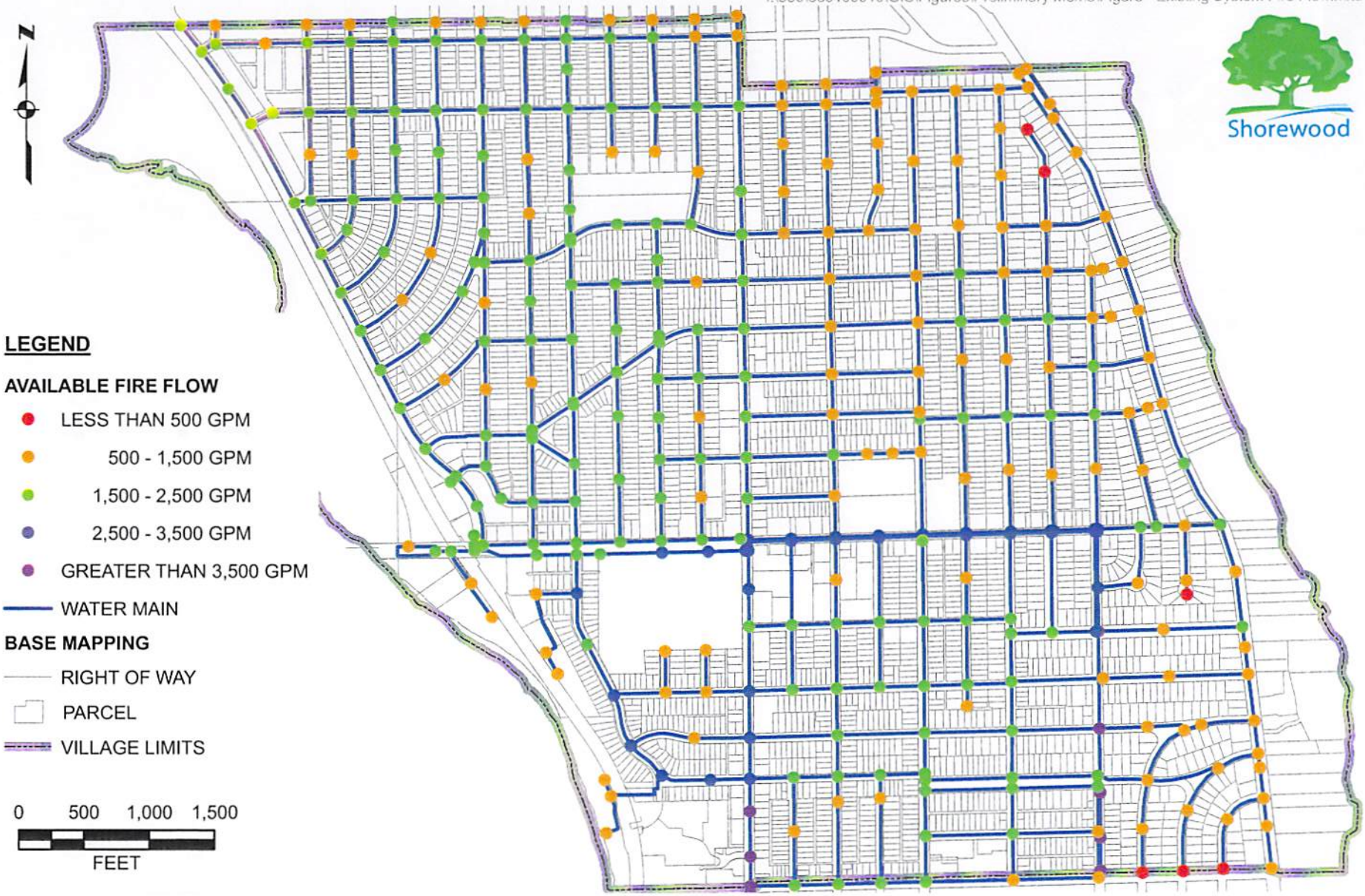

FIGURE 4 - EXISTING WATER SYSTEM AVAILABLE FIRE FLOW - MAXIMUM DAY DEMAND

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HYDRAULIC MODEL AND WATER SUPPLY FEASIBILITY STUDY

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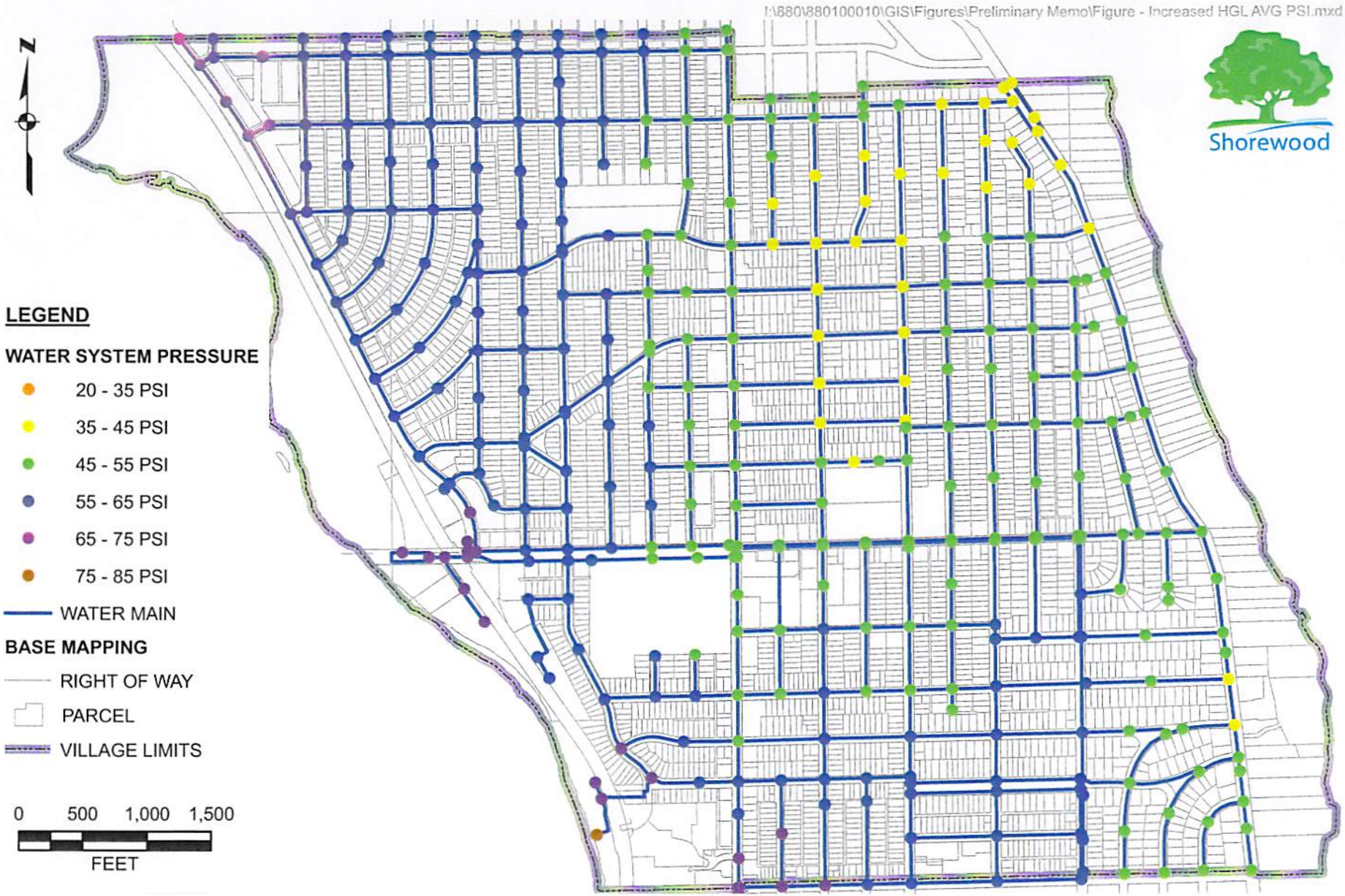

FIGURE 5 - INCREASED HYDRAULIC GRADE WATER SYSTEM PRESSURE - AVERAGE DAY DEMAND

VILLAGE OF SHOREWOOD, WISCONSIN
HYDRAULIC MODEL AND WATER SUPPLY FEASIBILITY STUDY

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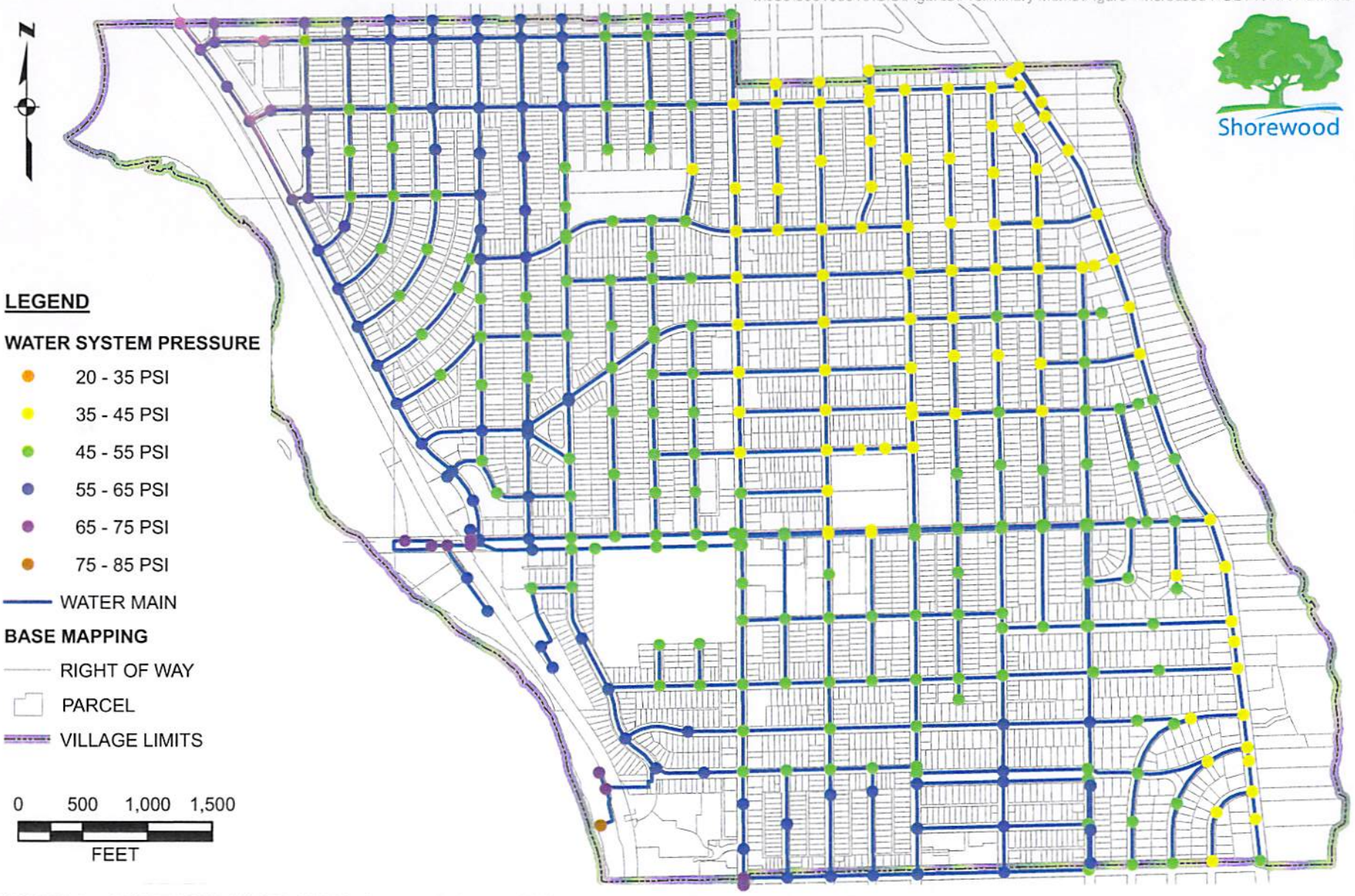

FIGURE 6 - INCREASED HYDRAULIC GRADE WATER SYSTEM PRESSURE - PEAK HOUR DEMAND

VILLAGE OF SHOREWOOD, WISCONSIN
HYDRAULIC MODEL AND WATER SUPPLY FEASIBILITY STUDY

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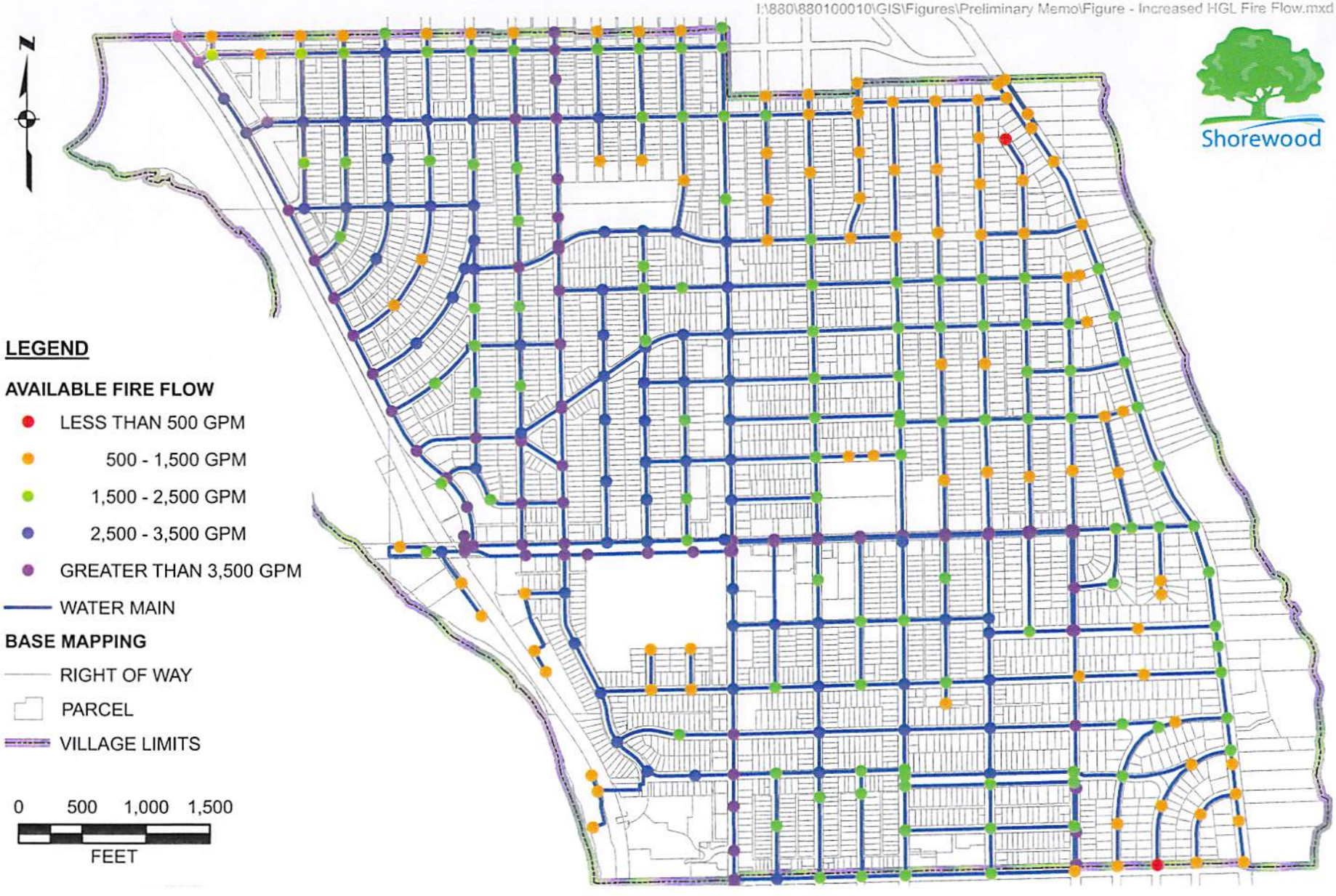

FIGURE 7 - INCREASED HYDRAULIC GRADE WATER SYSTEM AVAILABLE FIRE FLOW - MAX DAY DEMAND

VILLAGE OF SHOREWOOD, WISCONSIN
HYDRAULIC MODEL AND WATER SUPPLY FEASIBILITY STUDY

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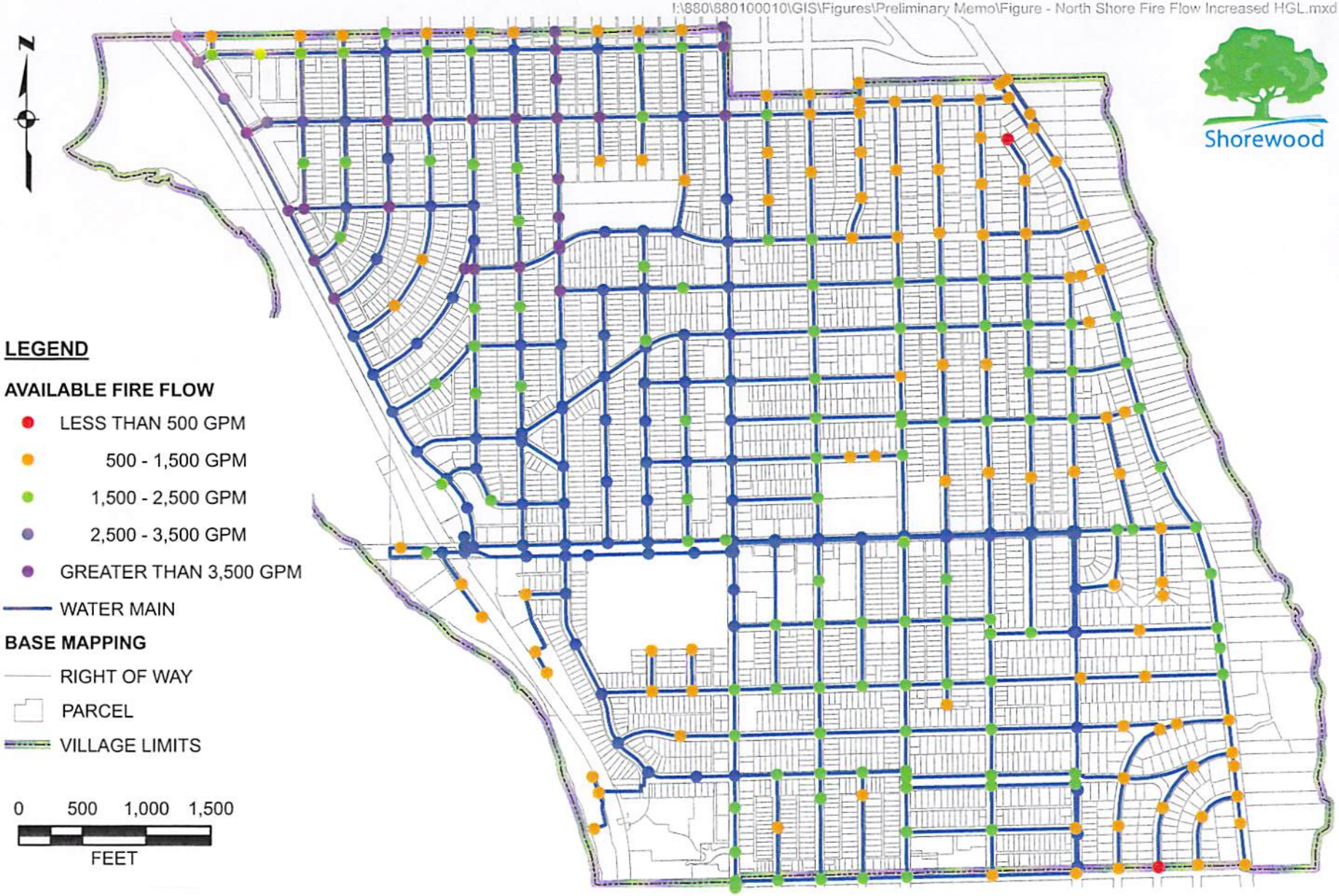

FIGURE 8 - NORTH SHORE WATER COMMISSION SUPPLY AVAILABLE FIRE FLOW - MAX DAY DEMAND

VILLAGE OF SHOREWOOD, WISCONSIN
HYDRAULIC MODEL AND WATER SUPPLY FEASIBILITY STUDY

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