Water System Master Plan

Prepared for:

Verona Public Works/ Sewer & Water
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Verona WI 53593

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September 2006

Earth Tech Project No. 91960

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EXECUTIVE SUMMARY

The City of Verona is a growing community of approximately 9,000 persons located in Dane County near Madison. The City of Verona Water Utility was established in the 1930s and provides water service to residences and businesses within the City limits.

The Verona water system consists of four groundwater supply wells, two elevated water storage tanks, two booster pump stations, three pressure zones, and approximately 52 miles of transmission and distribution water mains ranging in size up to 12 inches in diameter.

POPULATION

According to the Wisconsin Department of Administration (WI DOA), the 2005 population for the City of Verona was 9,103 persons. As shown in Figure ES-1, it was assumed that the total population served by the Verona Water Utility (City and Town of Verona) will increase to a population of approximately 28,000 persons by 2030.

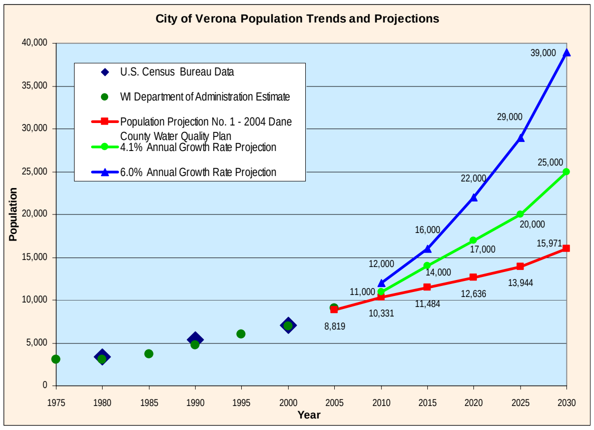


FIGURE ES-1: POPULATION PROJECTIONS

WATER REQUIREMENTS

Based on an analysis of land development and population growth, the projected 2030 average day water requirement is estimated to be approximately 3.73 million gallons per day (MGD), as illustrated in Figure ES-2. This represents an increase in water requirements of nearly 250 percent from the current average day water requirement of approximately 1.07 MGD.

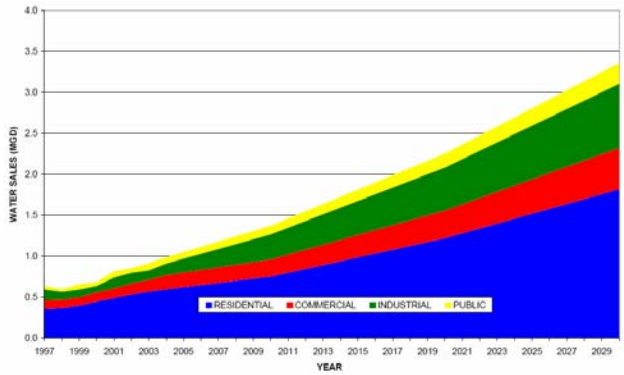


FIGURE ES-2: WATER DEMAND PROJECTIONS

WATER SYSTEM EVALUATION

The major findings from the existing water system evaluation include the following:

1. Under all normal operation conditions, the system provides pressures that meet the minimum recommended pressure of 35 pounds per square inch (psi) to all portions of the City. Water system pressures range from approximately 46 to 96 psi under peak hour demand conditions.

2. Available fire flows range from approximately 900 gpm to 3,500+ gpm throughout the water system. The required fire flows are available throughout the majority of the water system; however, some deficient areas were identified.

3. Based on hydraulic model simulations, only the water main serving the Central Tower and the 8-inch discharge water mains at Wells 3 and 4 experience velocities in excess of 5 feet per second (fps) and headlosses of 10 feet per 1,000 feet during peak hour simulations.

4. Under simulated average day water demands, water age was estimated to exceed five days at the extremities of the system and at dead end locations. General industry guidelines indicate water age should not exceed five to seven days in the system to maintain good water quality, according to an American Water Works Association Research Foundation (AwwaRF) report. The majority of the Central Pressure Zone was estimated to have water age less than two days.

5. Verona has adequate reliable supply to meet current optimum supply requirements; however, additional supply capacity (approximately 4.6 MGD) is needed to meet projected 2030 reliable supply requirements.

6. The system currently has adequate reliable booster pumping capacity to meet existing water demands in the North Pressure Zone; however, it is projected that by 2030, there will be a deficiency in reliable booster pumping capacity in the North Pressure Zone of approximately 0.35 MGD.

7. The system currently has adequate reliable booster pumping capacity to meet existing water demands in the Southeast Pressure Zone; however, it is projected that by 2030, there will be a deficiency in reliable booster pumping capacity in the Southeast Pressure Zone of approximately 0.49 MGD.

8. As development occurs, it is projected that the future East Pressure Zone will require a reliable booster pumping capacity of approximately 0.26 MGD.

9. The Verona Water Utility can maintain water supply provided with auxiliary sources of power to meet a minimum of an average day water demand throughout the planning period for all existing pressure zones.

10. The system currently does not have adequate storage in the Central, Southeast, and North Pressure Zones to meet existing and projected 2030 storage requirements.

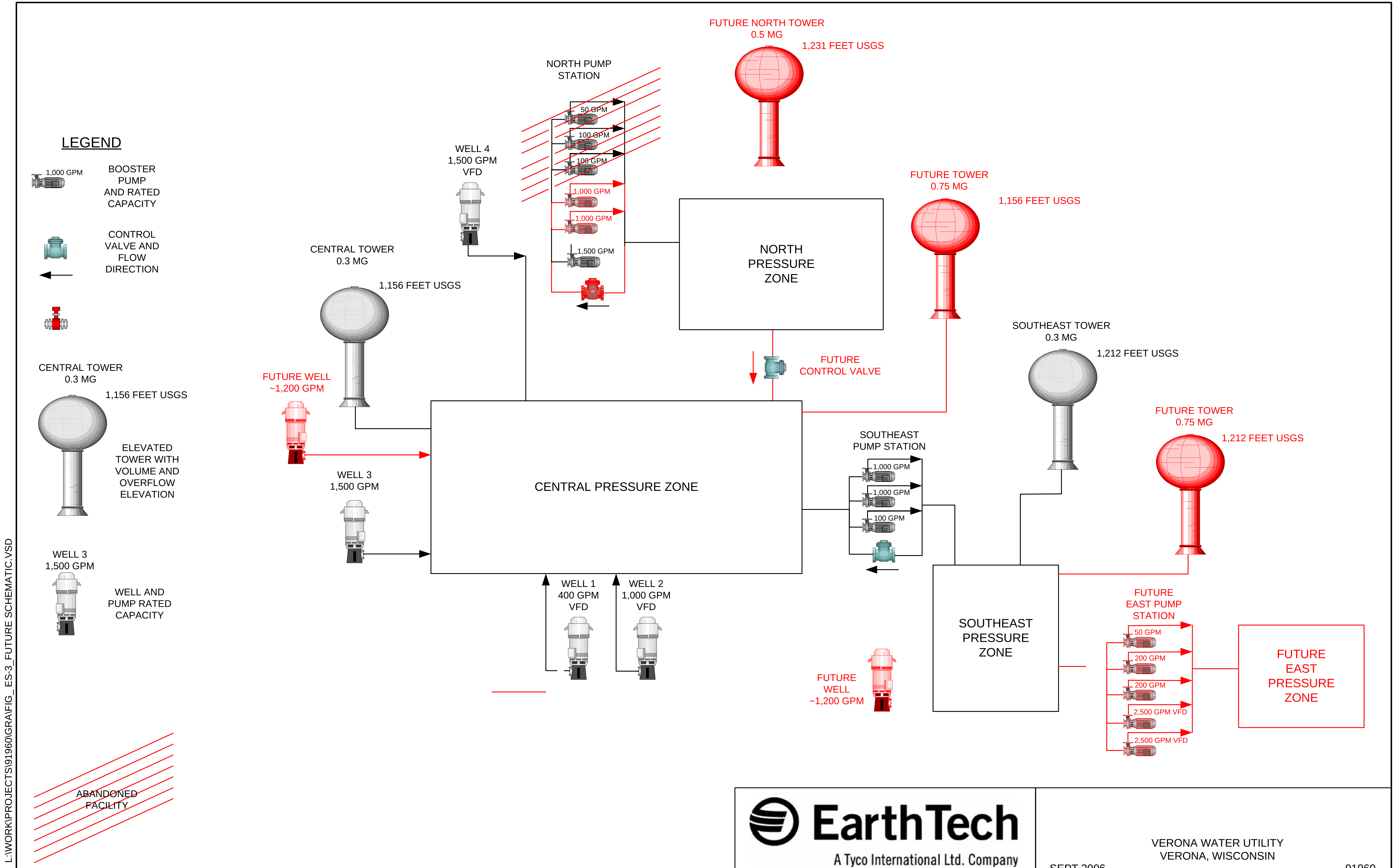
CAPITAL IMPROVEMENTS PLAN

The schematic of the recommended future water distribution system is illustrated in Figure ES-3. Table ES-1 summarizes the proposed Verona Water Utility Capital Improvements Plan which is illustrated in Figure ES-4.

TABLE ES-1
CAPITAL IMPROVEMENTS PLAN

Short-Term Improvements	Estimated Cost[3]
New 0.5 MG Tower in North Pressure Zone	$850,000
New Pumps and Flow Control Valve at North Pump Station	$300,000
Water Distribution System Improvements to Address Existing Deficiencies (approximately 6,800 feet)	$890,000
Transmission Mains for Development (assumed approximately 25,000 feet)	$2,500,000
Subtotal	$4,540,000
Engineering and Contingencies[1]	$1,816,000
Total	$6,356,000
Mid-Term Improvements	**Estimated Cost**
New 0.75 MG Tower in Central Pressure Zone	$1,000,000
New Supply Well in the Central Pressure Zone	$750,000
New Flow Control Valve from North Pressure Zone to Serve Central Pressure Zone	$75,000
New Flow Control Valve from Southeast Pressure Zone to Serve Central Pressure Zone	$75,000
Transmission Mains for Development (assumed approximately 50,000 feet)	$5,000,000
Subtotal	$6,900,000
Engineering and Contingencies[1]	$2,760,000
Total	$9,660,000
Long-Term Improvements	**Estimated Cost**
New 0.75 MG Tower in Southeast Pressure Zone	$1,100,000
New Altitude Valve on the Existing Southeast Tower	$150,000
New Supply Well in the Southeast Pressure Zone	$750,000
New Supply Well in the Central Pressure Zone	$750,000
East Pressure Zone and 0.2 MG Ground Reservoir and Booster Station with Standby Power	$850,000
New Flow Control Valve from Southeast Pressure Zone to Serve Central Pressure Zone	$75,000
Transmission Mains for Development (assumed approximately 90,000 feet)	$9,000,000
Subtotal	$12,675,000
Engineering and Contingencies[1]	$5,070,000
Total	$17,745,000
Grand Total	$33,761,000

Footnotes:
[1] Assumed 15 percent for engineering and 25 percent for contingencies.
[2] Water main cost estimates were based on $85 per foot for future expansion water main and $130 per foot for water main constructed in previously developed areas.
[3] Estimates do not include land purchase if necessary.



LEGEND
1,000 GPM
BOOSTER PUMP AND RATED CAPACITY
CONTROL VALVE AND FLOW DIRECTION
CENTRAL TOWER 0.3 MG
1,156 FEET USGS
ELEVATED TOWER WITH VOLUME AND OVERFLOW ELEVATION
WELL 3 1,500 GPM
WELL AND PUMP RATED CAPACITY
ABANDONED FACILITY
NORTH PUMP STATION
50 GPM
100 GPM
100 GPM
1,000 GPM
1,000 GPM
1,500 GPM
FUTURE NORTH TOWER 0.5 MG
1,231 FEET USGS
WELL 4 1,500 GPM VFD
CENTRAL TOWER 0.3 MG
1,156 FEET USGS
NORTH PRESSURE ZONE
FUTURE TOWER 0.75 MG
1,156 FEET USGS
FUTURE CONTROL VALVE
FUTURE WELL ~1,200 GPM
SOUTHEAST TOWER 0.3 MG
1,212 FEET USGS
FUTURE TOWER 0.75 MG
1,212 FEET USGS
WELL 3 1,500 GPM
CENTRAL PRESSURE ZONE
SOUTHEAST PUMP STATION
1,000 GPM
1,000 GPM
100 GPM
WELL 1 400 GPM VFD
WELL 2 1,000 GPM VFD
SOUTHEAST PRESSURE ZONE
FUTURE EAST PUMP STATION
50 GPM
200 GPM
200 GPM
2,500 GPM VFD
2,500 GPM VFD
FUTURE EAST PRESSURE ZONE
FUTURE WELL ~1,200 GPM
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VERONA, WISCONSIN
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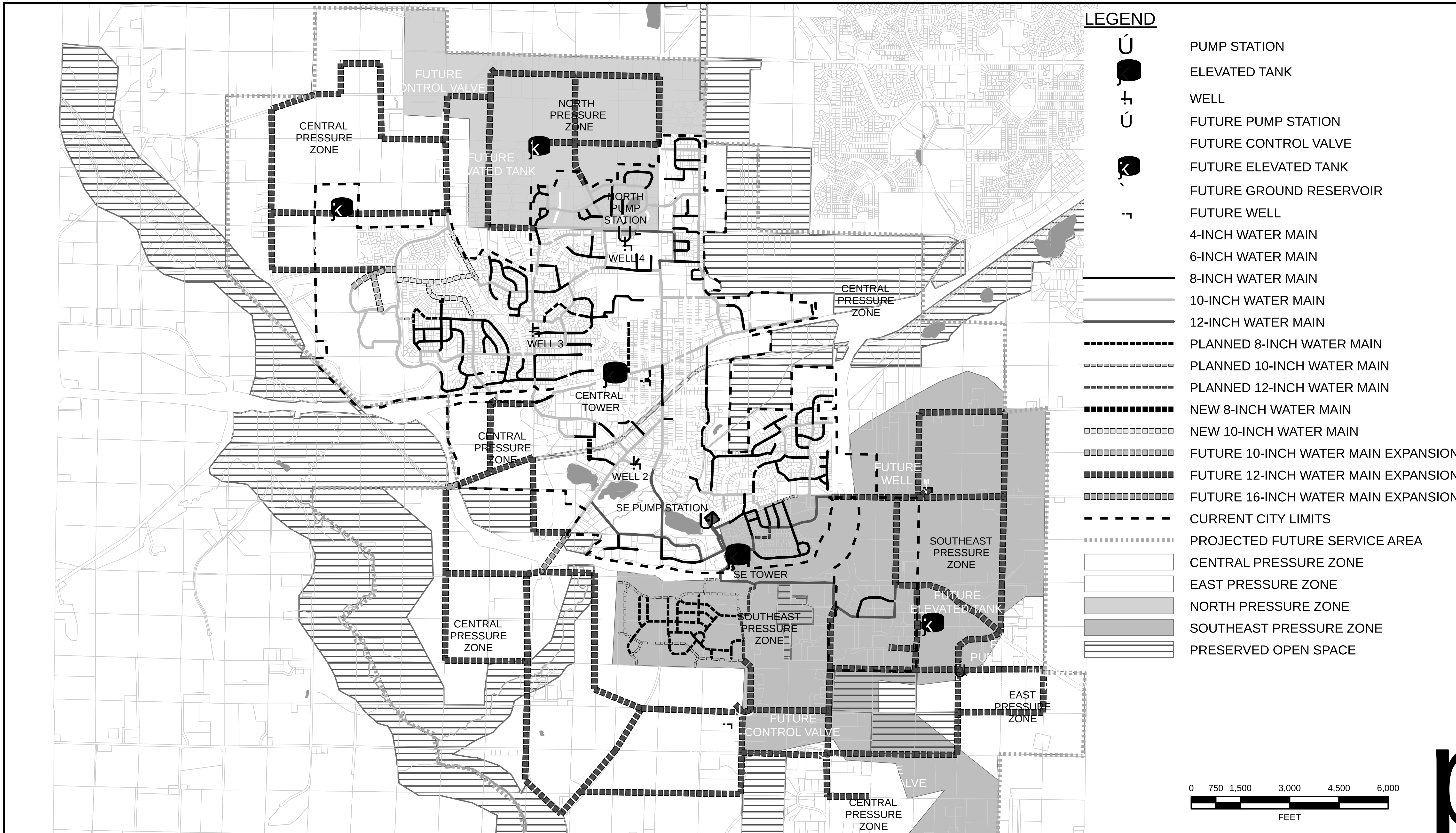

PLANNED WATER MAINS INCLUDED BASED ON WATER MAINS CONSTRUCTED IN 2006 AND PLANS FOR SCENIC RIDGE AND CATHEDRAL POINT DEVELOPMENT.
NEW WATER MAINS INCLUDE WATER MAINS RECOMMENDED TO ADDRESS EXISTING DEFICIENCIES.
FUTURE WATER MAINS ARE RECOMMENDED TRANSMISSION MAINS TO SUPPLY FUTURE GROWTH.

FIGURE ES-4
RECOMMENDED WATER SYSTEM
MASTER PLAN
VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006

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1.0 INTRODUCTION

The City of Verona is a growing community of approximately 9,000 persons located in Dane County. The City of Verona Water Utility was established in the 1930s and provides water service to residences and businesses within the City limits.

The Verona water system consists of four groundwater supply wells, two elevated water storage tanks, two booster pump stations, three pressure zones, and nearly 52 miles of transmission and distribution water mains ranging in size up to 12 inches in diameter.

The customers of the Verona Water Utility include industrial water users, commercial users, public users, and residential users. The Water Utility primarily serves residential customers; approximately 61 percent of the total water consumption was attributed to residential users in 2005. Approximately 14 percent of water sales are generated by industrial users, and 17 percent of sales are to commercial users.

As indicated by recent growth, the City of Verona's location with respect to nearby major urban centers and principal transportation corridors offers significant potential for future growth and development; therefore, proper planning is essential to coordinate the expansion of municipal water system facilities with short-term as well as long-term needs of the community.

1.1 PURPOSE

This report summarizes the results of a water system planning study for the Water Utility. The primary purpose of the study was to evaluate the water needs and system expansion required to serve current and future Utility customers. The present and future water needs of the City of Verona have been evaluated, and recommendations have been made concerning improvements necessary to maintain an adequate level of water service. This report will serve as a comprehensive plan to guide future expansion of the water system.

1.2 SCOPE

Population, community growth, and water consumption projections serve as the foundation for evaluating and identifying recommended improvements to the system. Current and future water needs were evaluated over a planning period extending to the year 2030. Chapter 2 discusses existing and expected future land uses and community growth. The assumptions and conclusions presented in Chapter 2 were used to develop projections of water requirements that are presented in Chapter 3. A review of existing facilities is summarized in Chapter 4. Chapter 5 summarizes the evaluation of the water system. A summary of recommended water system improvements is presented in Chapter 6. Chapter 7 includes a proposed Utility Capital Improvements Plan.

Because needs change with time, comprehensive planning is a continuous function; therefore, the longer-term projections and improvements discussed in this report should be periodically reviewed, reevaluated, and modified, as necessary, to assure the adequacy of future planning efforts. Proper future planning will help assure that system expansion is coordinated and constructed in the most effective manner.

2.0 POPULATION AND COMMUNITY GROWTH

This chapter summarizes the planning assumptions made regarding future service area characteristics for the City of Verona Water Utility. To maintain consistency between individual planning efforts, the results of previous planning efforts were reviewed.

2.1 POPULATION

There is generally a close relationship between a community's population and total water consumption volumes. Future water sales can be expected to generally reflect future changes in service area population.

The City of Verona experienced a 47 percent increase in population between 1990 and 2000 according to WI DOA estimates. The U.S. Census Bureau and WI DOA estimates of population for the City of Verona were both approximately 7,000 people in 2000. The City's population also grew an average of 6 percent per year between 2000 and 2005 based on population estimates from the WI DOA. Table 2-1 summarizes past population trends, and Table 2-2 summarizes the possible projected future population of the City of Verona. Three population projections were calculated for the City of Verona to ensure the population estimates used for this study were reasonable. The three population projections are summarized in the following sections.

2.1.1 Population Projection No. 1 - 2004 Dane County Water Quality Plan

Current estimates from the 2004 Dane County Water Quality Plan indicate that the City's population is projected to increase to 12,636 by the year 2020 and 15,251 by the year 2030. The 2004 Dane County Water Quality Plan was completed by Dane County Regional Planning Commission and adopted in September 2004. The Dane County Water Quality Plan states "the purpose of the plan is to provide a policy framework and guidance for federal, state, and local water quality protection programs in Dane County… The trends and forecasts that have been presented and provide the basis for current plans were developed from the 2000 Census and statewide forecasts." The forecasted growth from 2000 to 2005 in the Water Quality Plan was approximately 1,500 people; however, the WI DOA annually estimated growth over the same period was approximately 2,150 people. Therefore, the City of Verona Water Utility expressed concern that this population projection may be too conservative due to recent rapid growth.

2.1.2 Population Projection No. 2 - 1975 to 2005 Growth Rate

The City of Verona and other portions of Dane County are currently growing at the fastest rate within the entire State of Wisconsin. Since 2000, growth within the City of Verona occurred at an annual rate of 6.0 percent. If this growth rate continues, the projected population of the City of Verona will be approximately 22,000 by the year 2020 and approximately 39,000 by the year 2030. At 6 percent growth, the population in 2030 will be twice the population from the from the 2004 Dane County Water Quality Plan. Based upon more historical population trends, it may be unlikely that this high growth rate will continue throughout the planning period and, therefore, will likely overestimate the population of the City of Verona by 2030.

TABLE 2-1

CITY OF VERONA POPULATION TRENDS
VERONA WATER UTILITY
VERONA, WISCONSIN

Year	WI DOA Estimate	Population Percent Change	Year	WI DOA Estimate	Population Percent Change
1973	2,641	-	1990	4,735	3.2%
1974	2,760	4.5%	1991	5,466	15.4%
1975	3,002	8.8%	1992	5,595	2.4%
1976	3,166	5.5%	1993	5,732	2.4%
1977	3,323	5.0%	1994	5,939	3.6%
1978	3,541	6.6%	1995	5,992	0.9%
1979	3,802	7.4%	1996	6,017	0.4%
1980	3,022	-20.5%	1997	6,044	0.4%
1981	3,361	11.2%	1998	6,189	2.4%
1982	3,391	0.9%	1999	6,437	4.0%
1983	3,442	1.5%	2000	6,954	8.0%
1984	3,529	2.5%	2001	7,502	7.9%
1985	3,633	2.9%	2002	8,050	7.3%
1986	3,823	5.2%	2003	8,726	8.4%
1987	3,994	4.5%	2004	8,888	1.9%
1988	4,220	5.7%	2005	9,103	2.4%
1989	4,587	8.7%			

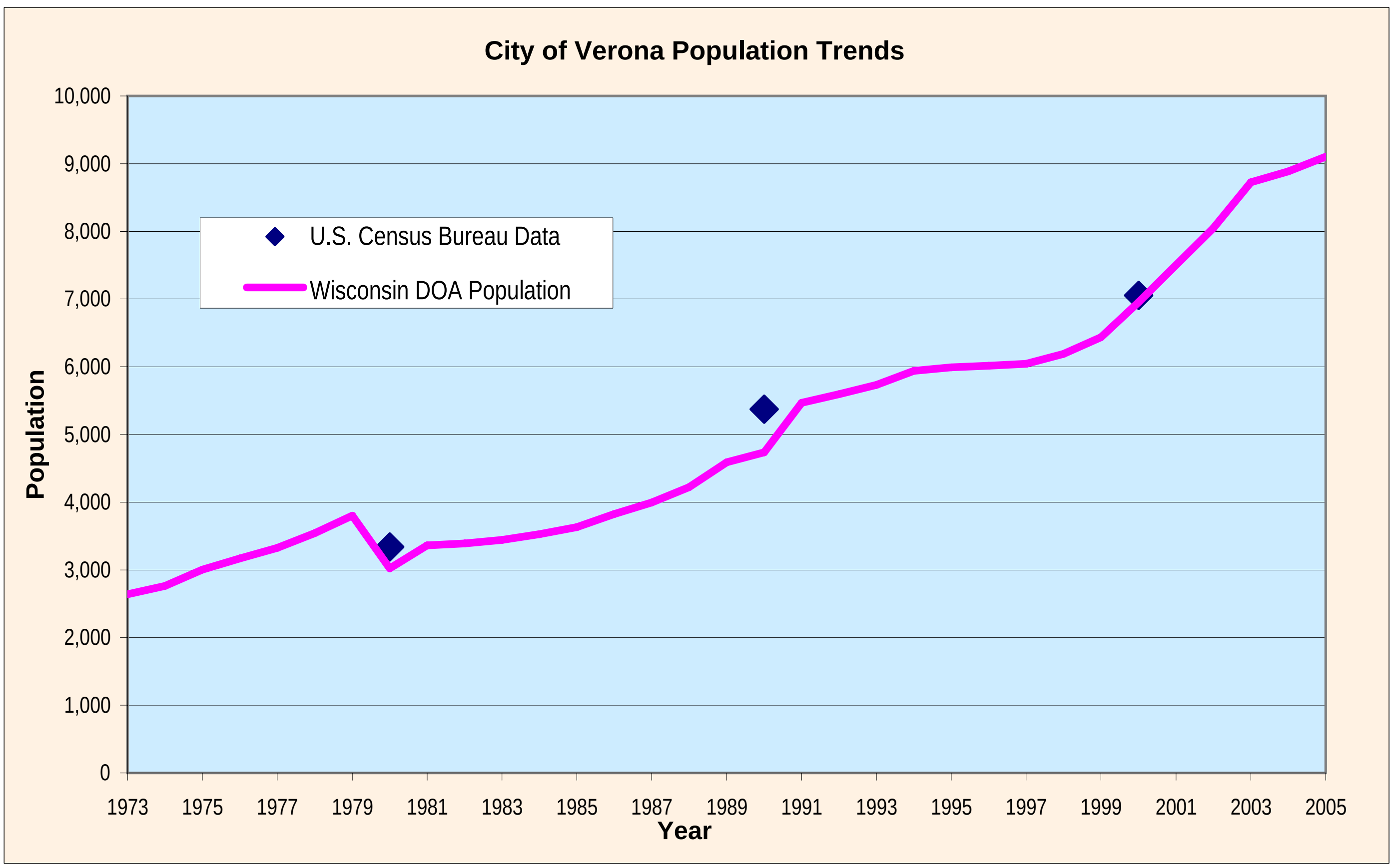

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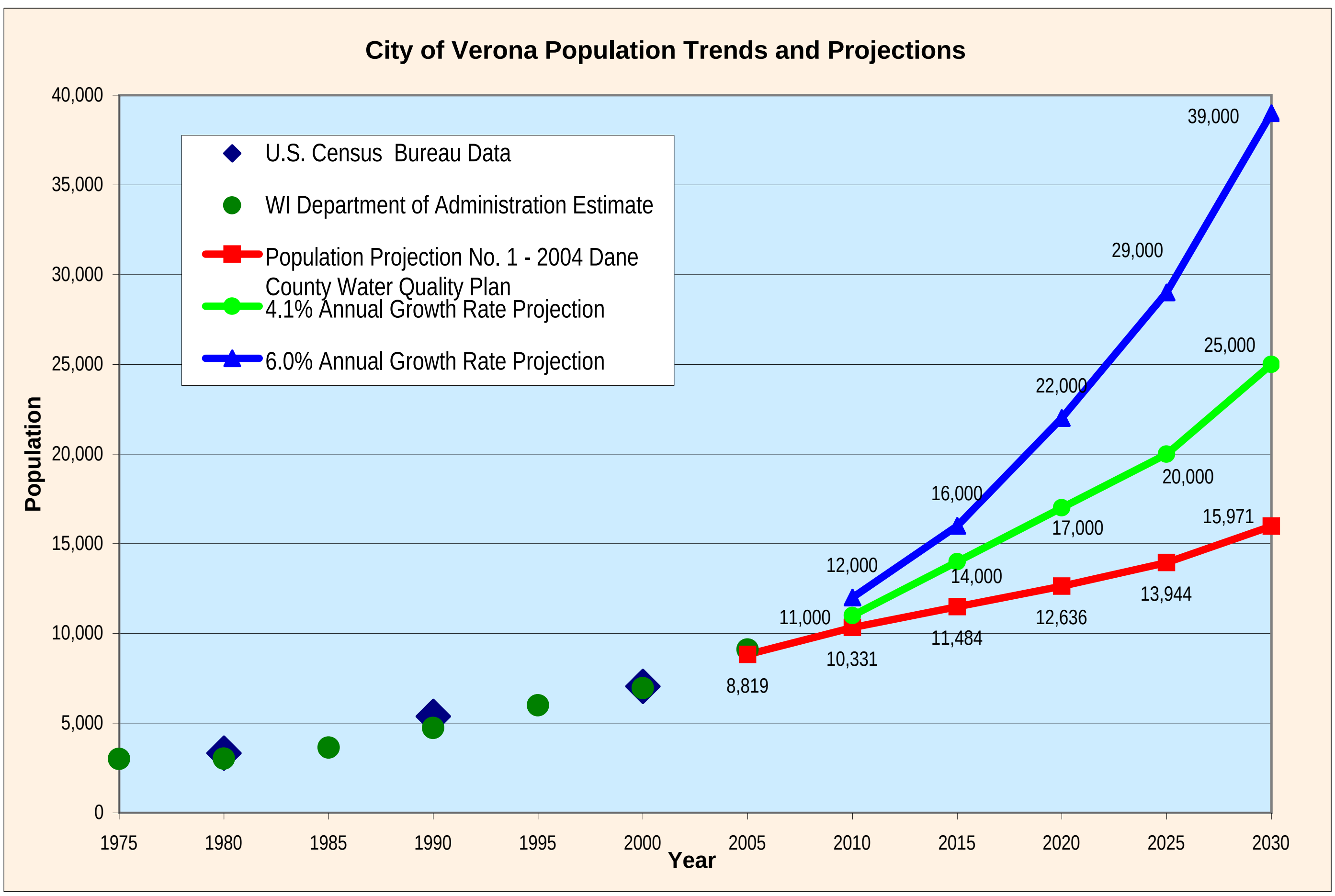
TABLE 2-2

CITY OF VERONA POPULATION TRENDS AND PROJECTIONS
VERONA WATER UTILITY
VERONA, WISCONSIN

Year	U.S. Census Bureau Data	WI DOA Estimate	Population Projection No. 1 - 2004 Dane County Water Quality Plan	Population Projection No. 2 - 1975 - 2005 Growth Rate 4.1% Annual Growth	Population Projection No. 3 - 2000 - 2005 Growth Rate 6.0% Annual Growth
1975		3,002			
1980	3,336	3,022			
1985		3,633			
1990	5,374	4,735			
1995		5,992			
2000	7,052	6,954			
2005		9,103	8,819		
2010			10,331	11,000	12,000
2015			11,484	14,000	16,000
2020			12,636	17,000	22,000
2025			13,944	20,000	29,000
2030			15,971	25,000	39,000



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2.1.3 Population Projection No. 3 - 2000 to 2005 Growth Rate

As growth trends tend to change over time, a population projection growth rate based on long-term historical population estimates may more accurately predict future population throughout the planning period, accounting for changes in growth trends. Since 1975, growth within the City of Verona occurred at an annual rate of 4.1 percent. With growth at the same 4.1 percent, projected population from 2005 (9,103 population) will be approximately 17,000 by the year 2020 and approximately 25,000 by the year 2030. The population projection to be used for this study is based on this moderate growth estimate of 4.1 percent growth based on the City of Verona historical population trend.

2.1.4 Town of Verona Population

The City of Verona and the Town of Verona are currently working to merge governments into a single City of Verona government. Consolidating the City and Town will increase the City's population, although not every resident will initially be provided with water service. As the existing water system expands, current Town of Verona residents will be added to the water system in addition to the population projected in the previous section. As provided by the City of Verona, an estimated population of 3,000 people will gradually be added to the served population as projected below in Table 2-3.

TABLE 2-3
PROJECTED POPULATION

Year	Projected City of Verona Population	Town of Verona Population Added to City Water System	Total Projected Population for Water System Master Plan Study
2010	11,000	600	11,600
2015	14,600	600	15,200
2020	18,200	600	18,800
2025	21,800	600	22,400
2030	27,400	600	28,000

2.2 EXISTING LAND USE

For this study, a current City of Verona land use map was also reviewed. The current City land use map represents the nature and extent of development within the City. The City of Verona consists largely of single-family residential uses with commercial properties located along Highway 18. Manufacturing concerns are mainly located in the south-central part of the City of Verona. Figures 2-1 and 2-2 identify existing and future land uses for the City of Verona, respectively. As seen in Figure 2-2, a considerable portion of the future service area is comprised of preserved open space. The future of these lands for development is uncertain, as land uses can and do change over time. For the purposes of this study, it is assumed the preserved open space land will not be developed.

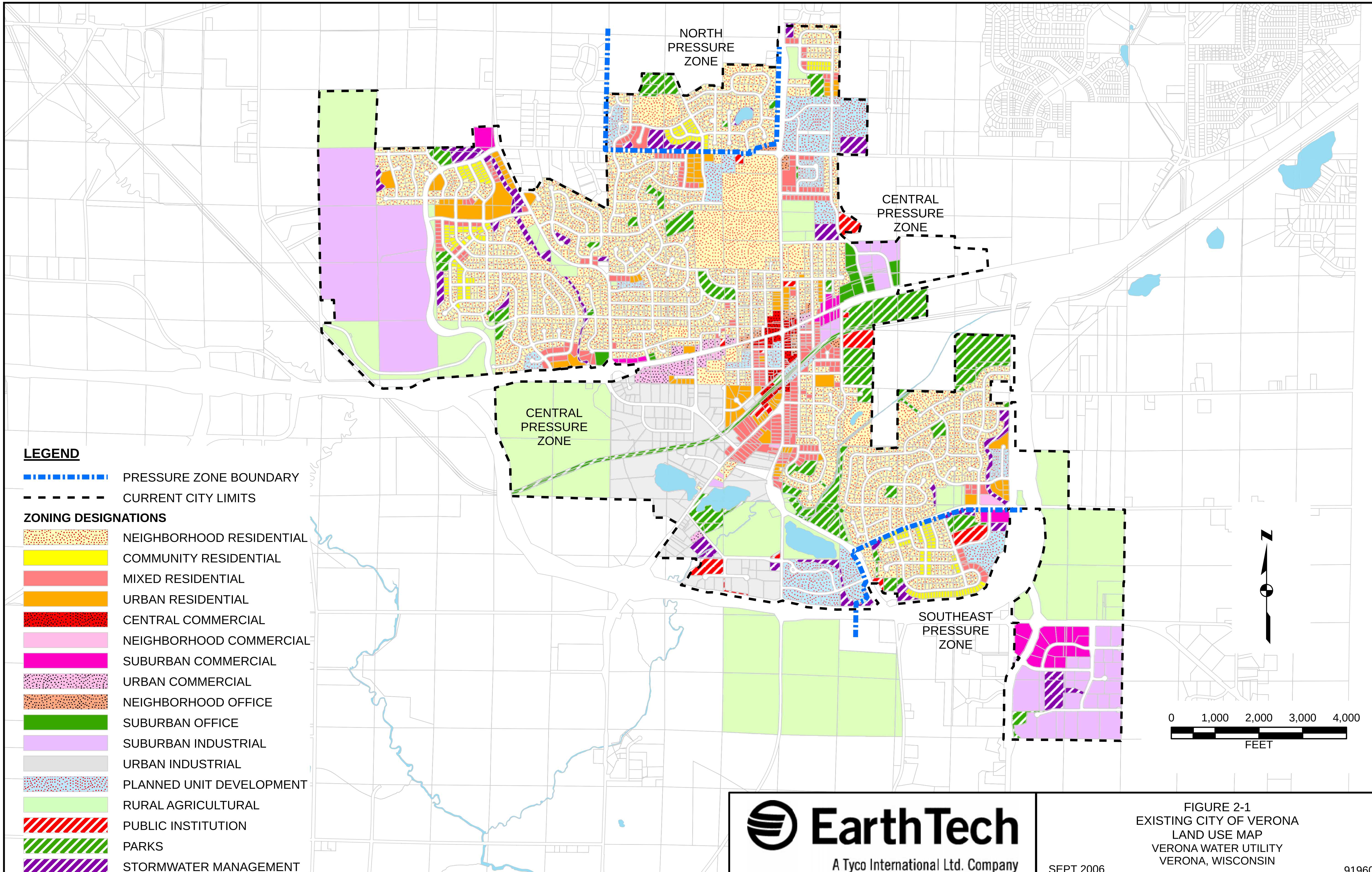

FIGURE 2-1
EXISTING CITY OF VERONA
LAND USE MAP
VERONA WATER UTILITY
VERONA, WISCONSIN

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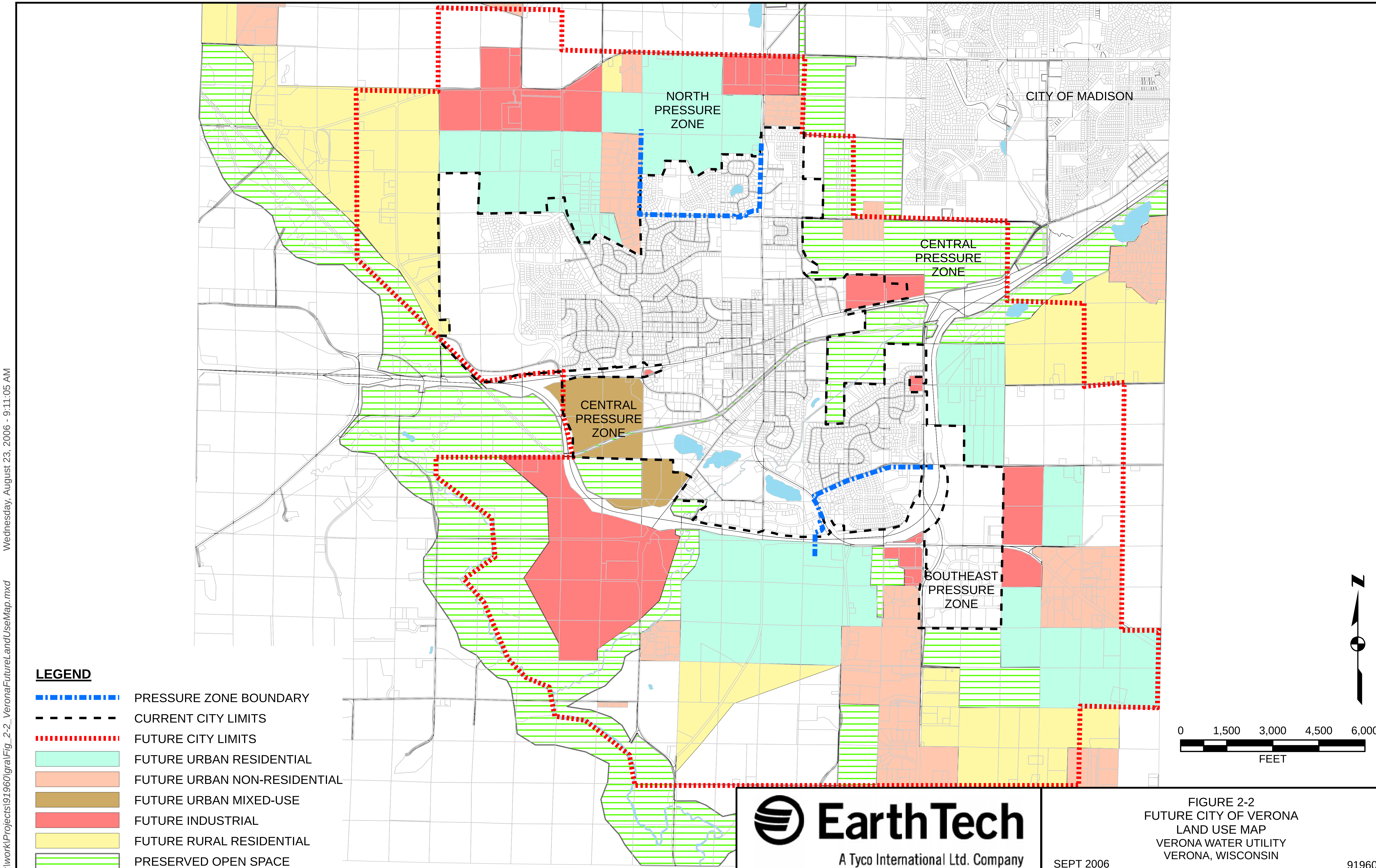

NORTH PRESSURE ZONE
CITY OF MADISON
CENTRAL PRESSURE ZONE
CENTRAL PRESSURE ZONE
SOUTHEAST PRESSURE ZONE
N
0 1,500 3,000 4,500 6,000
FEET
LEGEND
PRESSURE ZONE BOUNDARY
CURRENT CITY LIMITS
FUTURE CITY LIMITS
FUTURE URBAN RESIDENTIAL
FUTURE URBAN NON-RESIDENTIAL
FUTURE URBAN MIXED-USE
FUTURE INDUSTRIAL
FUTURE RURAL RESIDENTIAL
PRESERVED OPEN SPACE
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FIGURE 2-2
FUTURE CITY OF VERONA
LAND USE MAP
VERONA WATER UTILITY
VERONA, WISCONSIN
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2.3 FUTURE COMMUNITY GROWTH

The expected increase in residential development is directly related to projections of population growth. Commercial and public land use are also expected to increase with increases in population. Future changes in industrial activity are more difficult to estimate due to the many uncertainties associated with factors which may affect industrial development. Future growth in industrial development in the City of Verona will not only be a function of changes in population (employment base) but also other often uncontrollable factors.

Potential future growth in industrial land use was projected based upon previous planning efforts and existing land use mapping. Industrial water use was projected for the proposed industrial growth as described in Chapter 3.

2.4 FUTURE UTILITY SERVICE AREAS

Figure 2-3 identifies the existing service area and the boundaries of the future urban service area for the Water Utility. The assumed urban service area has been defined as the area in which City of Verona urban services are expected to grow, but may not be fully developed by 2030. Future service additions are projected to occur throughout the City and Town of Verona within the defined urban service area (except in the preserved open space areas as illustrated in Figure 2-3). Future growth limits used previously by Earth Tech for future planning were expanded based on recent discussions with the City of Verona. The outer boundary of the future urban service area illustrated in Figure 2-3 was used for this study to identify the area which is expected to develop over the next 25 years and require City of Verona municipal water utility services.

2.5 SUMMARY

The current City of Verona population of approximately 9,000 is projected to increase to nearly 19,000 by the year 2020 and approximately 28,000 by the year 2030 through population growth and inclusion of the Town of Verona within the Water Utility service area.

These population changes represent the primary assumption regarding future growth of the City of Verona urban service area and will have a direct impact on the present and future needs for expansion of the water system facilities. Water requirements estimated in Chapter 3 are based upon the population projections outlined in this chapter, which in turn will be used as the primary basis for evaluating the adequacy of the existing water system facilities and identifying needs for future water system expansion as discussed in Chapters 5 and 6.

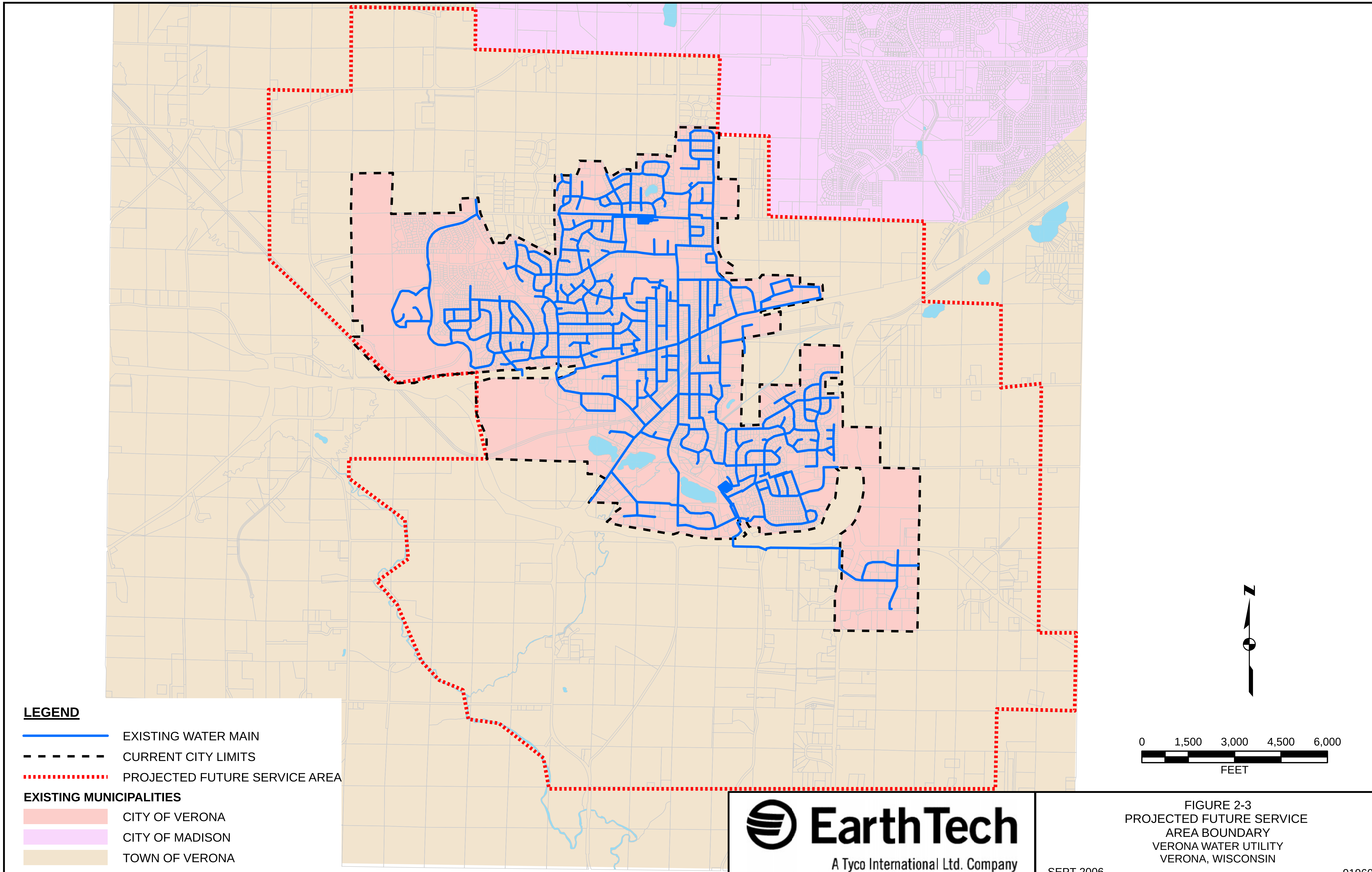

FIGURE 2-3
PROJECTED FUTURE SERVICE
AREA BOUNDARY
VERONA WATER UTILITY
VERONA, WISCONSIN

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3.0 WATER REQUIREMENTS

Projections of customer demands serve as the basis for capital improvements planning. This chapter summarizes the methodology used and the results of these water needs projections.

3.1 WATER CONSUMPTION HISTORY

An analysis was made of past water consumption characteristics by reviewing annual pumpage and water sales records for the period of 1995 to 2005. Projections of future water requirements are based on the results of this analysis coupled with estimates of population and community growth discussed in Chapter 2. A summary of historical water sales is provided in Table 3-1. Total annual water sales reached a peak of nearly 361 million gallons per year (MGY) in 2005, largely due to residential sales of over 218 MG.

Water sales have increased during the 1995 to 2005 period. Water sales in 1995 were 195 MGY; sales in 2005 were 361 MGY. Figure 3-1 illustrates the trends in water sales by customer sector. Since its creation in the 1930s, the Water Utility has seen fairly steady growth in service connections to this day. A historical summary of Water Utility customers served is provided in Table 3-2 and Figure 3-2. Figure 3-3 shows the relationship between total pumpage and water sales from 1995 to 2005.

The largest customer classification as determined from metered sales volume is residential, which presently accounts for approximately 61 percent of total metered sales. With approximately 17 percent of total sales in 2005, commercial water users rank as the second largest customer class. The remaining two customer classes, industrial and public, account for approximately 14 and 8 percent of total sales, respectively. The City has seen nearly steady growth in the number of residential, industrial, commercial, and public customers since 1995.

3.2 PER CAPITA WATER USAGE

Residential, commercial, and public water usage can often be related to a community's population. Water consumption to these customer classes tends to rise and fall with corresponding increases and decreases in population. An analysis of per capita water consumption for the City of Verona for each of these customer classifications was made from historical sales records and is summarized in Table 3-3. As indicated in this table and Figure 3-4, per capita sales to residential, commercial, and public customers have remained nearly constant over the previous decade. Residential per capita consumption in the City of Verona is slightly higher than other Wisconsin water utilities as indicated in Table 3-4.

The average residential per capita use has averaged 62 gallons per capita per day (gpcd) since 1995 and 64 gpcd since 2000. The residential per capita water usage had grown annually until 2004, when usage was at a 10-year low of 56 gpcd. To project future water needs, average daily water usage for residential customers was projected at approximately 65 gpcd throughout the planning period. Commercial consumption was projected to average approximately 18 gpcd, and water sales to public customers was projected at approximately 9 gpcd over the planning period.

TABLE 3-1

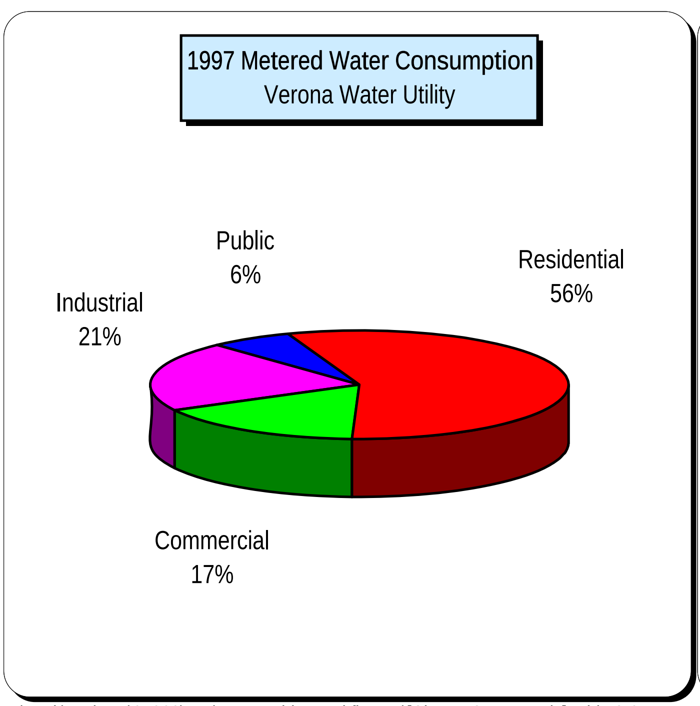
WATER SALES AND PUMPAGE HISTORY
VERONA WATER UTILITY
VERONA, WISCONSIN

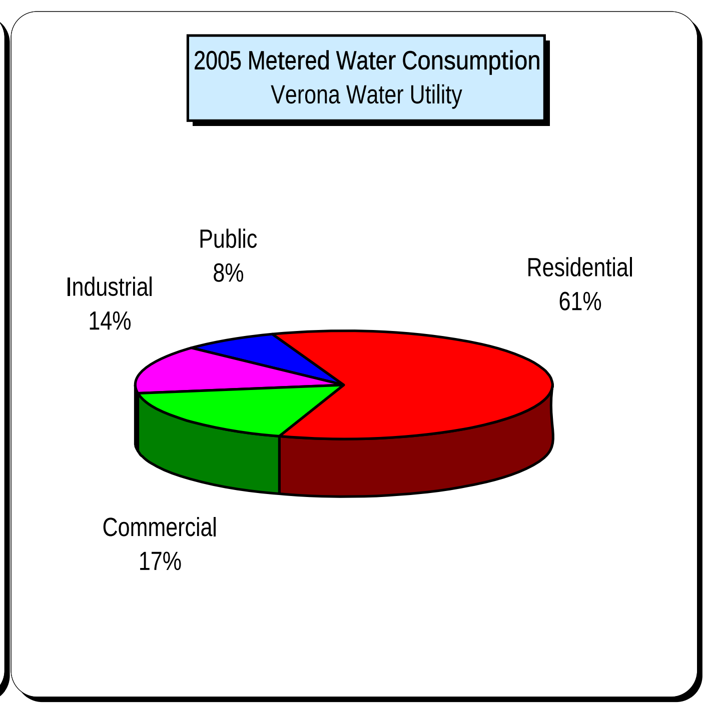
Year	Annual Water Sales (MGY)				Total Sales (MGY)	Accounted For But Not Sold (MGY)	Total Pumpage (MGY)	Percent Accounted For
	Residential	Commercial[1]	Industrial	Public				
1995	128.78	37.91	16.16	11.70	194.55	4.51	283.82	70.1%
1996	126.08	36.04	40.11	8.67	210.90	8.30	291.76	75.1%
1997	131.20	38.74	48.69	14.62	233.24	3.72	327.97	72.3%
1998	135.41	35.75	36.34	11.72	219.23	4.14	347.49	64.3%
1999	145.98	35.91	35.91	22.33	240.14	5.97	307.77	80.0%
2000	164.05	40.68	28.77	15.87	249.36	5.29	299.18	85.1%
2001	178.70	43.60	48.41	28.40	299.09	11.00	334.66	92.7%
2002	195.04	49.57	47.45	19.91	311.97	12.00	347.11	93.3%
2003	208.85	51.15	42.81	32.21	335.02	6.00	362.68	94.0%
2004	181.64	50.10	45.60	11.42	288.76	14.00	341.53	88.6%
2005	218.57	62.93	52.05	27.19	360.74	9.00	389.38	95.0%

Maximum value in each category is highlighted blue =

Note:

1 The 2004 and 2005 Commercial values include unmetered sales to customers





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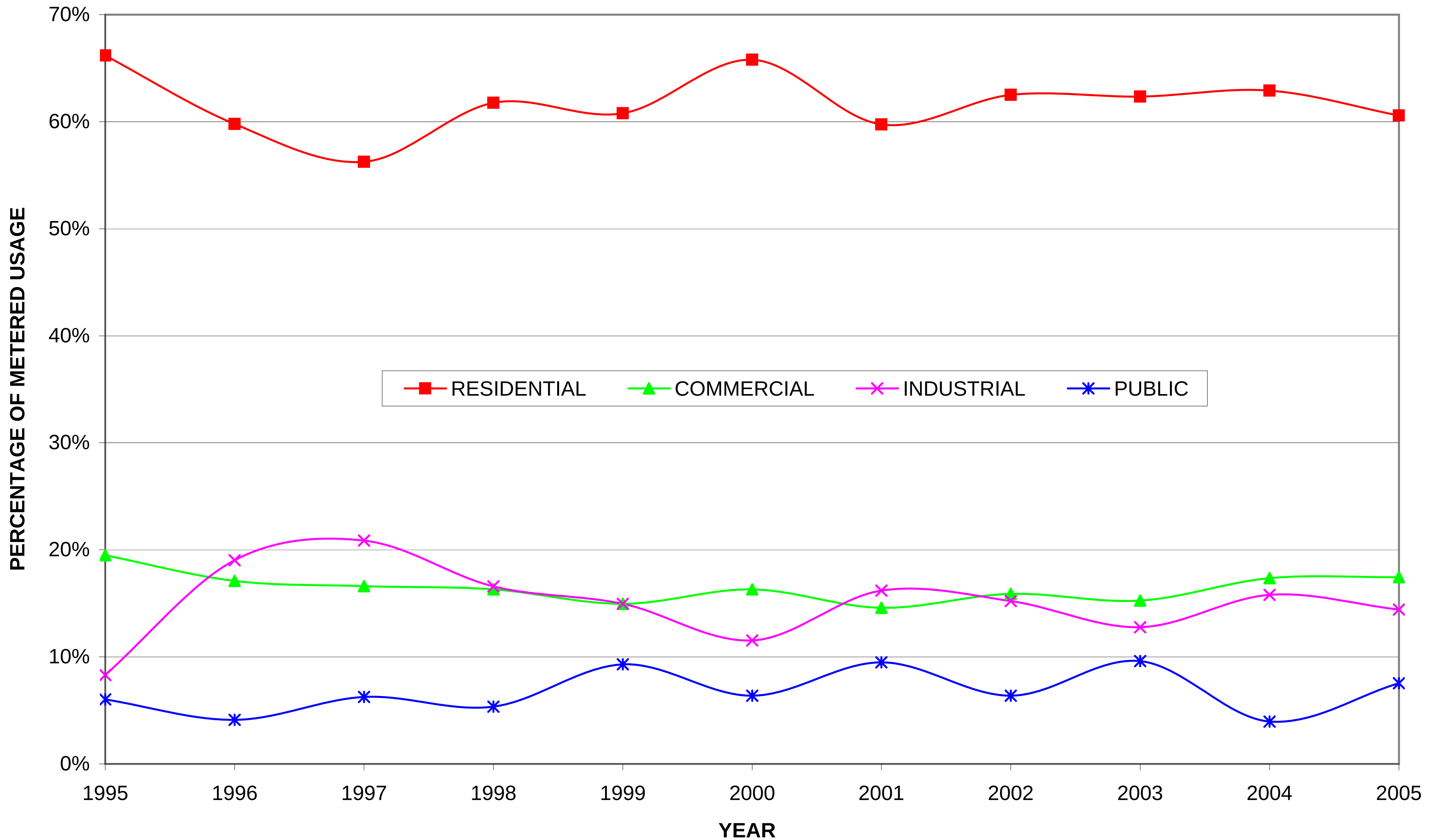

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FIGURE 3-1
HISTORICAL WATER USAGE
BY CUSTOMER SECTOR
VERONA WATER UTILITY
VERONA, WISCONSIN

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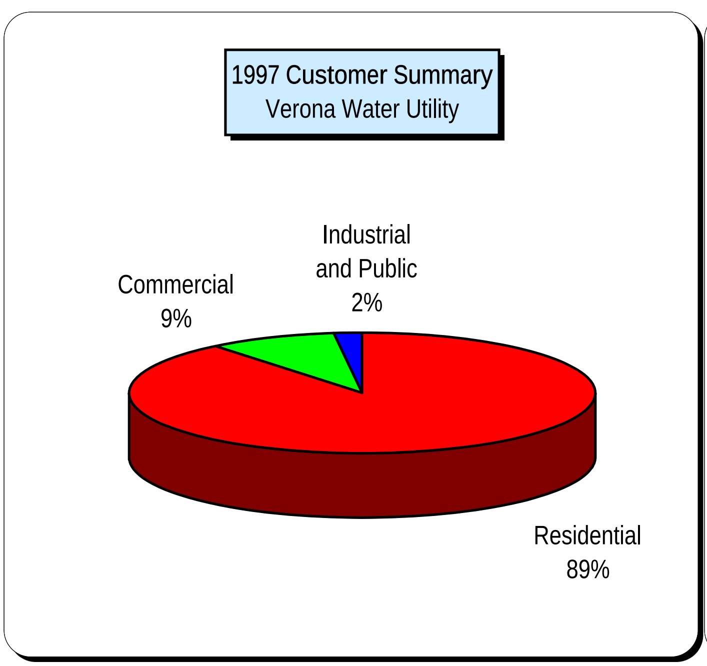
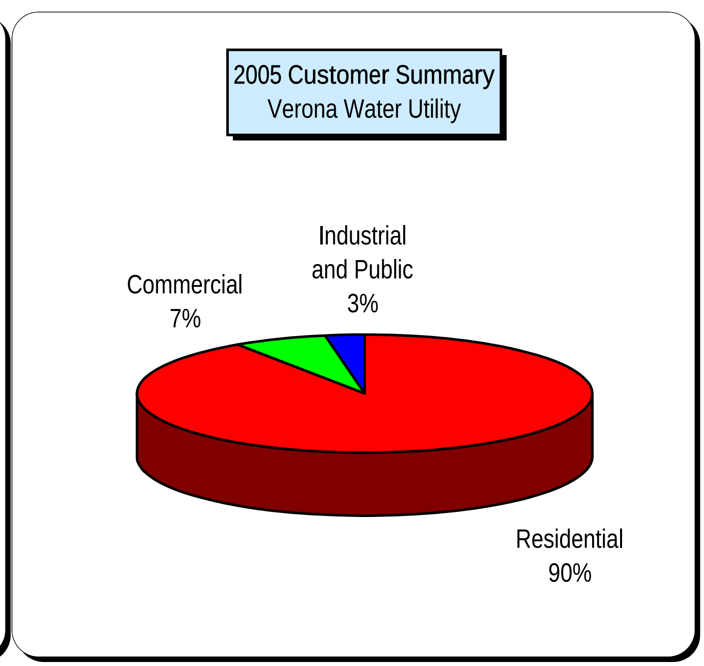
TABLE 3-2

HISTORICAL NUMBER OF CUSTOMERS SERVED
VERONA WATER UTILITY
VERONA, WISCONSIN

Year	Number of Customers				
	Residential	Commercial	Industrial	Public	Total
1995	1,829	177	19	21	2,046
1996	1,807	180	21	20	2,028
1997	1,894	184	24	20	2,122
1998	2,051	193	35	21	2,300
1999	2,089	187	35	11	2,322
2000	2,181	195	37	12	2,425
2001	2,670	229	44	24	2,967
2002	2,817	229	46	29	3,121
2003	2,993	238	46	30	3,307
2004	3,096	238	55	31	3,420
2005	3,258	245	65	31	3,599

Maximum value in each category is highlighted blue =





L:\work\Projects\91960\eng\report tables and figures\[Chapter3Verona.xls]Table 3-02

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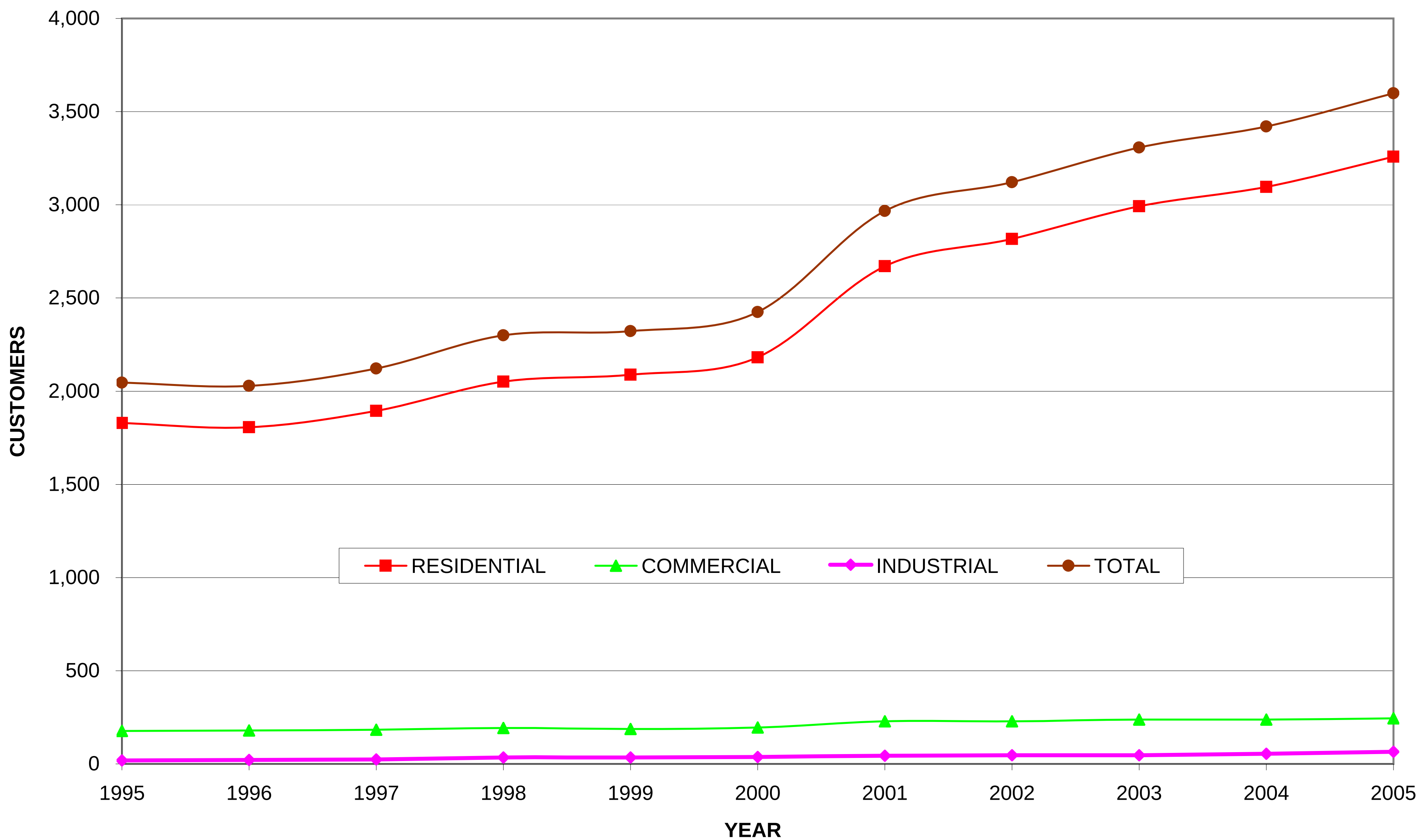

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FIGURE 3-2
HISTORICAL NUMBER OF CUSTOMERS SERVED
VERONA WATER UTILITY
VERONA, WISCONSIN

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L:\work\Projects\91960\eng\report tables and figures\[Chapter3Verona.xls]Figure 3-03

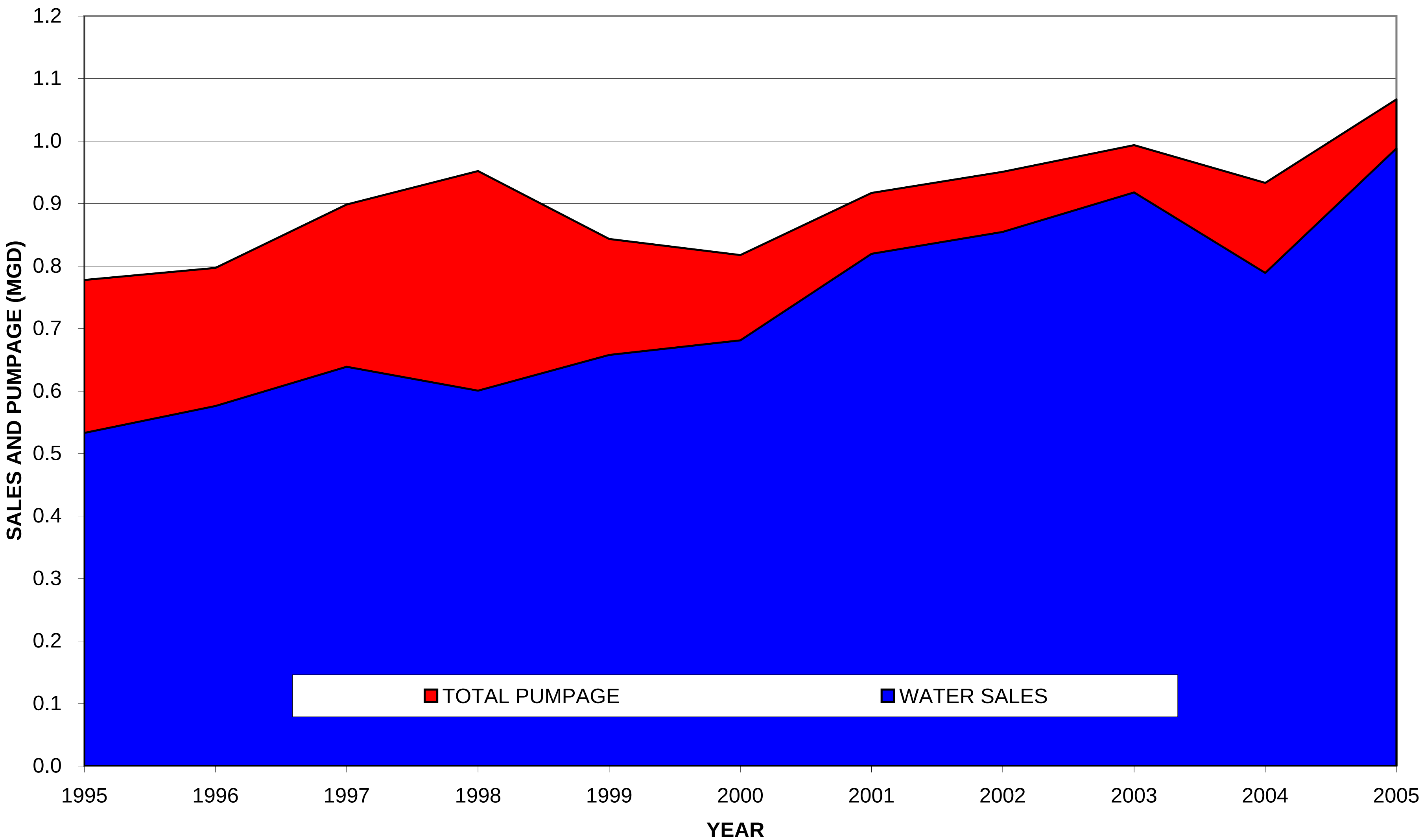

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FIGURE 3-3
WATER SALES AND
TOTAL PUMPAGE HISTORY
VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006 91960

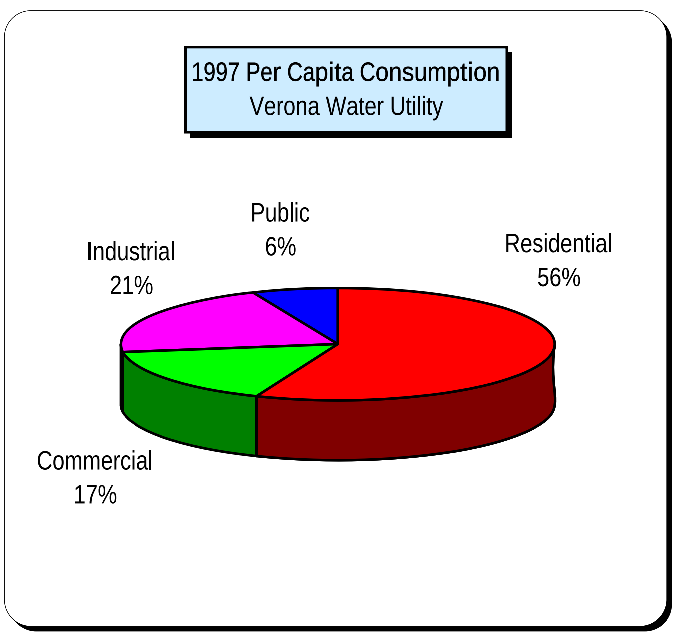
TABLE 3-3

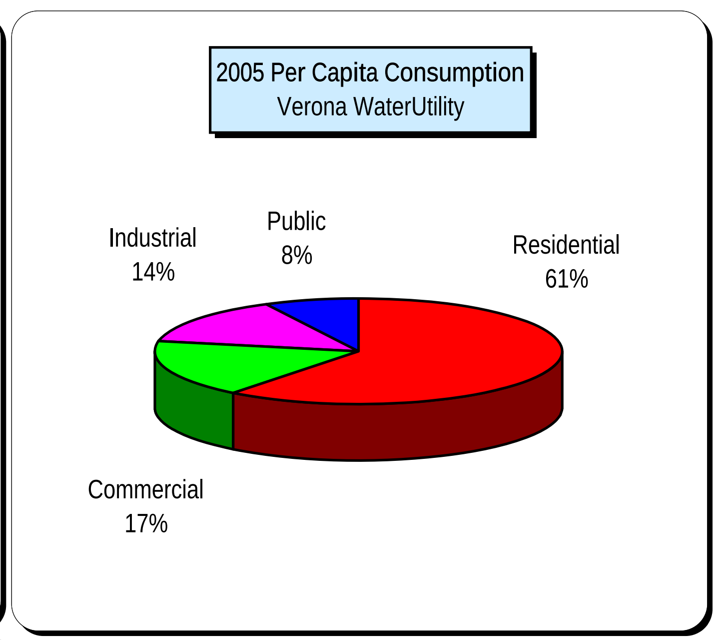
HISTORICAL PER CAPITA CONSUMPTION
VERONA WATER UTILITY
VERONA, WISCONSIN

Year	Estimated Population[1]	Gallons per Capita per Day: Residential	Commercial	Industrial	Public	Total
1995	5,992	58.9	17.3	7.4	5.4	89
1996	6,017	57.4	16.4	18.3	3.9	96
1997	6,044	59.5	17.6	22.1	6.6	106
1998	6,189	59.9	15.8	16.1	5.2	97
1999	6,437	62.1	15.3	15.3	9.5	102
2000	6,954	64.6	16.0	11.3	6.3	98
2001	7,502	65.3	15.9	17.7	10.4	109
2002	8,050	66.4	16.9	16.1	6.8	106
2003	8,726	65.6	16.1	13.4	10.1	105
2004	8,888	56.0	15.4	14.1	3.5	89
2005	9,103	65.8	18.9	15.7	8.2	109

Maximum Value =

[1] Estimated population data from WI DOA.





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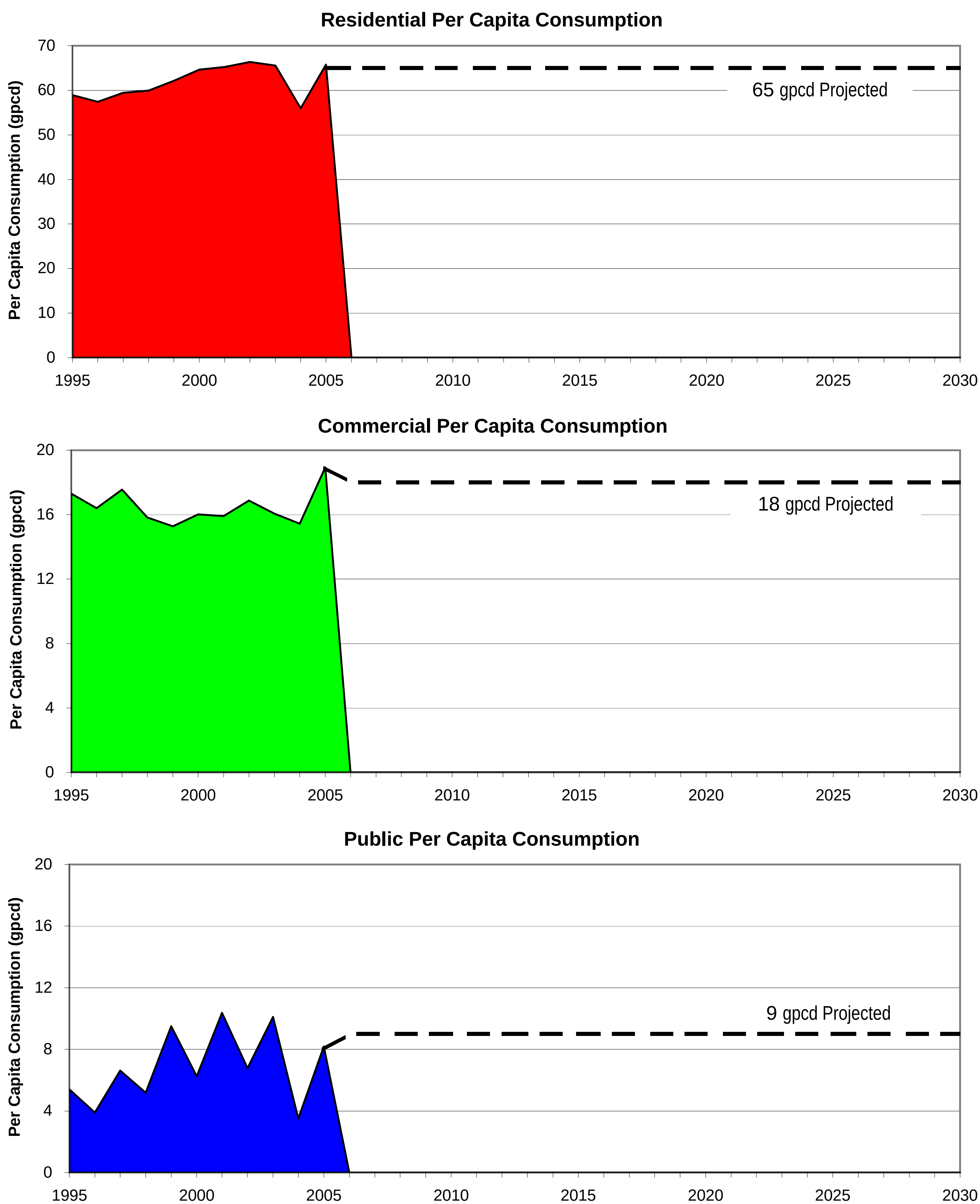

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FIGURE 3-4
HISTORICAL AND PROJECTED PER CAPITA CONSUMPTION
VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006 91960

L:\work\Projects\91960\eng\report tables and figures\[Chapter3Verona.xls]Figure 3-04

TABLE 3-4

UTILITY RESIDENTIAL PER CAPITA CONSUMPTION COMPARISONS

VERONA WATER UTILITY

VERONA, WISCONSIN

Wisconsin Water Utility	***2005 DATA***				
	Residential Sales (MGY)	Total Sales (MGY)	Residential to Total Sales Percentage	2005 Population Estimate	Per Capita Residential Sales (gpcd)
Hudson	324	598	54.2%	11,353	78.2
Janesville	1,547	3,723	41.6%	62,130	68.2
Greenville	127	160	79.4%	~ 5,200	66.9
Verona	**219**	**361**	**60.7%**	**9,103**	**65.9**
Grafton	252	383	65.8%	11,310	61.0
Cedarburg	245	449	54.6%	11,386	59.0
Oregon	167	227	73.6%	8,279	55.3
Fort Atkinson	238	626	38.0%	12,046	54.1
Brown Deer	232	505	45.9%	11,831	53.7
Stevens Point	477	2,376	20.1%	25,125	52.0
Hartford	235	514	45.7%	12,732	50.6
Wisconsin Rapids	339	772	43.9%	18,522	50.1
Weston	238	626	38.0%	13,195	49.4
Rice Lake	153	409	37.4%	8,603	48.7
Watertown	396	735	53.9%	22,973	47.2
Appleton	1,217	2,959	41.1%	72,085	46.3
Fond du Lac	699	1,512	46.2%	43,101	44.4
Medford	69	161	42.9%	4,279	44.2
New London	114	737	15.5%	7,212	43.3
Portage	157	445	35.3%	9,981	43.1
Plover	192	333	40.4%	11,351	46.3
Marshfield	296	695	42.6%	19,258	42.1
Chippewa Falls	206	1,250	16.5%	13,493	41.8
Grand Chute	283	682	41.5%	20,019	38.7

Notes

Water use data From Wisconsin Public Service Commision.
Population estimates From Wisconsin Department of Administration.

L:\work\Projects\91960\eng\report tables and figures\[Chapter3Verona.xls]Table 3-04

3.3 INDUSTRIAL WATER USAGE

Industrial water usage often can amount to a significant portion of the Utility's overall water supply needs. As such, any high volume users can have a large impact on total water requirements. A review of recent City of Verona water sales records indicates that industrial consumption is not a significant component of the Utility's total water sales. The four largest industrial consumers in the City of Verona are Carnes Company, Engineering Industry, Epic Systems Corporation, and the Dane County Home. These four large customers account for nearly 100 percent of the total industrial water use in the City of Verona.

3.4 UNACCOUNTED-FOR WATER

There is generally a close relationship between the total gallons of water pumped and the gallons of water metered and sold to Utility customers. The total metered water sales are generally less than the volume of pumped water due to several factors including:

1. Unmetered water usage for firefighting.
2. Inaccuracies in water metering devices.
3. Unaccounted-for public water usage.
4. Leakage within the distribution system.
5. Unmetered water usage for maintenance purposes such as hydrant flushing and water main repairs.

The difference between total pumpage and total water sales is termed non-revenue water and is usually expressed as a percentage. That portion of "non-revenue water" attributed to leakage, meter inaccuracies, and other unknown losses is often termed "unaccounted-for water" and can be an indicator of the condition of the water system. When the distribution system is very old or poorly maintained, the amount of unaccounted-for water often increases dramatically. Unaccounted-for water is also often expressed as a percentage. As a general rule, the percentage of unaccounted-for water should be less than 10 percent.

Since 1995, the percent of accounted-for water has been reported to be as low as 64 percent and as high as 95 percent, as shown in Table 3-1. Over the previous 11 years, unaccounted-for water has varied considerably; however, unaccounted-for water has been more constant in the last five years. The latter five years have averaged approximately 7 percent unaccounted-for water. For this study, it was assumed that the percentage of unaccounted-for water in the future will be consistent with the previous five years, and water accountability in future projections will be 90 percent.

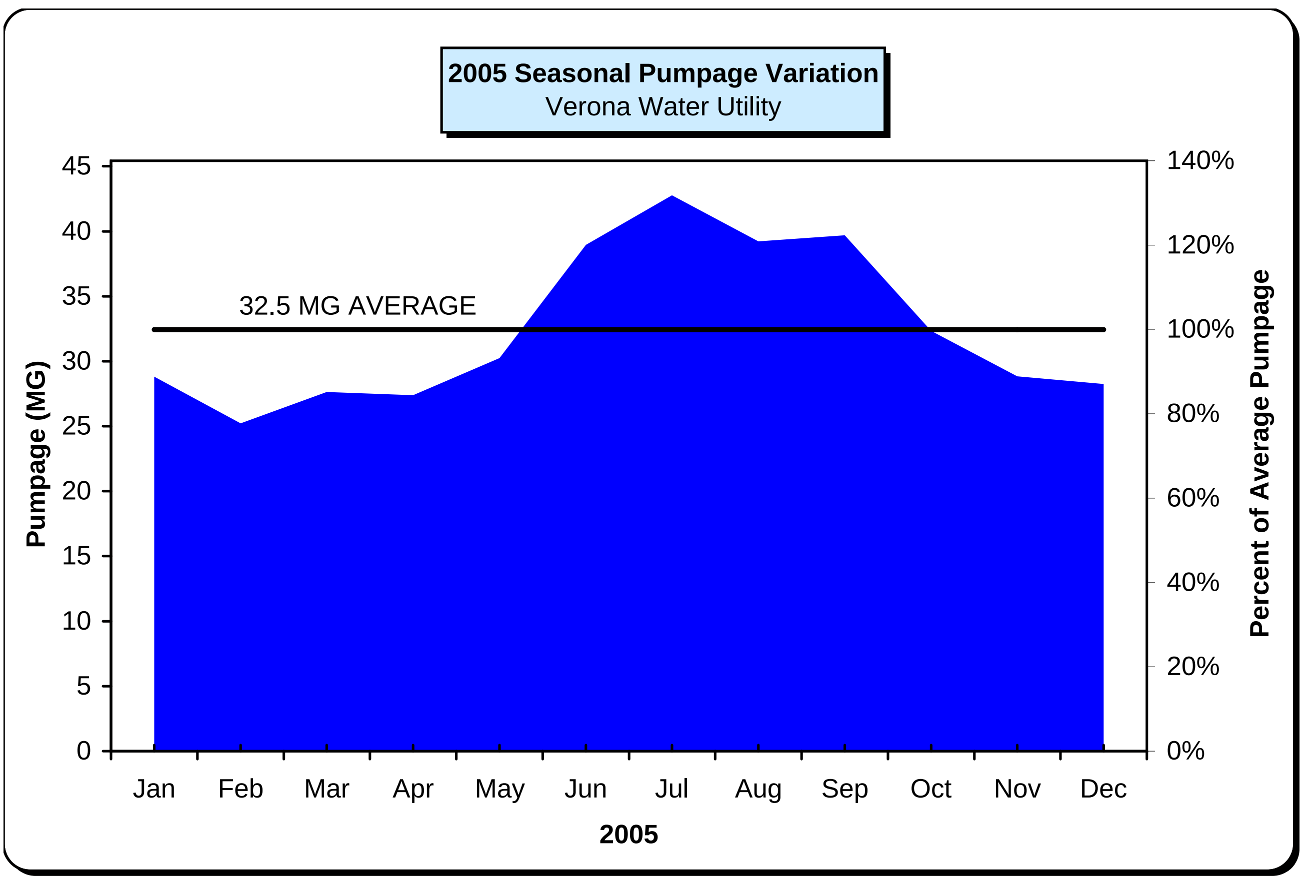
3.5 VARIATIONS IN CUSTOMER DEMANDS AND PUMPAGE

Seasonal fluctuations in water usage are important factors in the design and sizing of water supply and storage facilities. The seasonal nature of water consumption in the City of Verona can be demonstrated by an analysis of monthly and daily variations in pumpage. The most recent data indicates the month of highest demand is normally July. The Utility's average monthly pumpage in 2005 was approximately 32 MG. Table 3-5 summarizes the monthly pumpage breakdowns for the Utility in 2005.

TABLE 3-5

SEASONAL PUMPAGE VARIATIONS
VERONA WATER UTILITY
VERONA, WISCONSIN

Month	2005 Monthly Pumpage (MG)	Percentage of Total Pumpage	Percentage of Average Pumpage
January	28.816	7.4%	88.8%
February	25.227	6.5%	77.7%
March	27.634	7.1%	85.2%
April	27.395	7.0%	84.4%
May	30.245	7.8%	93.2%
June	38.948	10.0%	120.0%
SEPT	42.763	11.0%	131.8%
August	39.227	10.1%	120.9%
September	39.687	10.2%	122.3%
October	32.330	8.3%	99.6%
November	28.848	7.4%	88.9%
December	28.256	7.3%	87.1%
Total	**389.376**	**100.0%**	



L:\work\Projects\91960\eng\report tables and figures\[Chapter3Verona.xls]Table 3-05

Table 3-6 presents the average and maximum day pumpage for each year from 1975 to 2005, excluding 1977 and 1984, as data was unavailable. The largest recorded maximum day pumpage not due to a system leak in the last 31 years for the City of Verona occurred in 2003 at 2.27 MGD. This maximum day pumpage represented over a 2 to 1 ratio of maximum to average day pumpage for the Utility in 2003.

A normal distribution statistical analysis was performed of historical maximum day pumpage ratios. Two periods of analysis were examined; the entire period of 1975 to 2005, and the latest 16-year period from 1990 to 2005. The 2001 data was excluded due to the high maximum day factor caused by a water system leak. Table 3-7 summarizes the results of this analysis. Table 3-7 also includes an analysis of calculated maximum day pumpage ratios for various statistical confidence levels. For example, based on the analysis of the data from 1990 to 2005, there is statistically an 80 percent chance in any given year that the actual maximum day pumpage ratio will be less than or equal to 201 percent. Conversely, there is statistically a 20 percent chance the actual ratio will exceed 201 percent. To evaluate future water supply and storage needs, a maximum day pumpage ratio of 235 percent is recommended. This ratio provides a statistical confidence level of over 98 percent based on maximum day pumpage ratios over the last 16 years.

3.6 HOURLY DEMAND FLUCTUATIONS

The hour-to-hour variation of customer demands is also an important characteristic used to evaluate water supply and storage requirements. As with maximum day demands, peak hour demand is often expressed as a ratio of average day demand for the year. The peak hour demand is simply the hour of maximum demand which occurs on the maximum day.

For an accurate determination of daily demand variations, Earth Tech analyzed hourly supervisory control and data acquisition (SCADA) data (pumpage and tanks levels) for each of the pressure zones. Figure 3-5 illustrates composite time of day demand curves for the data reviewed for the Central Pressure Zone and the North Pressure Zone. Due to limitations in the accuracy of the Southeast Pressure Zone data and the small water demands in the pressure zone, an accurate time of day demand curve could not be estimated; however, due to the small demands in the water Southeast Pressure Zone currently, it is believed that the peak factor may be relatively high.

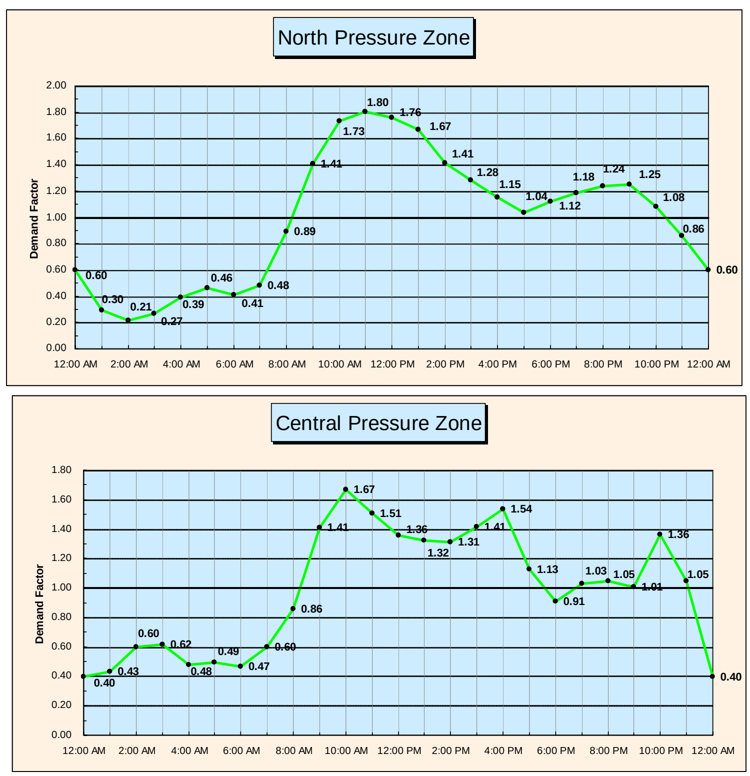
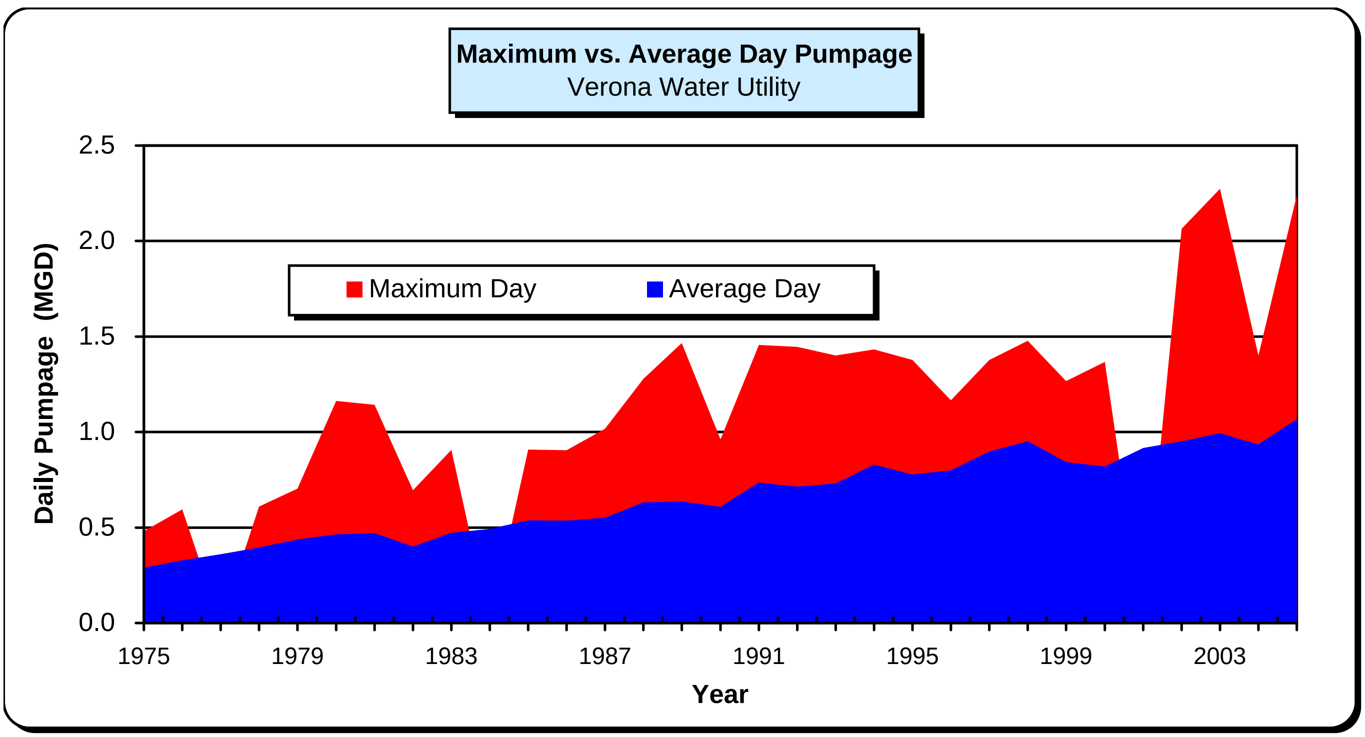


FIGURE 3-5: TIME OF DAY DEMAND CURVES

TABLE 3-6

DAILY PUMPAGE VARIATIONS
VERONA WATER UTILITY
VERONA, WISCONSIN

Year	Avg. Day Pumpage (MGD)	Max. Day Pumpage (MGD)	Ratio of Maximum to Average Day	Year	Avg. Day Pumpage (MGD)	Max. Day Pumpage (MGD)	Date of Maximum Day	Ratio of Maximum to Average Day
1975	0.29	0.48	1.66	1990	0.61	0.96		1.58
1976	0.33	0.60	1.81	1991	0.74	1.46		1.98
1977	0.36	- [1]	-	1992	0.71	1.45		2.03
1978	0.40	0.61	1.54	1993	0.73	1.40		1.92
1979	0.44	0.70	1.61	1994	0.83	1.43		1.73
1980	0.46	1.16	2.51	1995	0.77	1.38	06/20	1.79
1981	0.47	1.14	2.43	1996	0.78	1.17	10/02	1.50
1982	0.40	0.70	1.73	1997	0.90	1.38	12/04	1.53
1983	0.47	0.91	1.92	1998	0.95	1.48	08/01	1.55
1984	0.49	- [1]	-	1999	0.84	1.27	07/15	1.50
1985	0.54	0.91	1.69	2000	0.82	1.37	07/27	1.67
1986	0.54	0.90	1.69	2001	0.92	3.99	02/23 [2]	4.36
1987	0.55	1.02	1.84	2002	0.95	2.07	07/16	2.17
1988	0.63	1.28	2.02	2003	0.99	2.27	08/19	2.29
1989	0.64	1.47	2.30	2004	0.93	1.40	09/14	1.50
				2005	1.07	2.24	05/19	2.09



Notes

1. 1977 and 1984 maximum day pumpage data unavailable.
2. 2001 maximum day pumpage on February 23rd due to a hydrant leak and not shown on graph.

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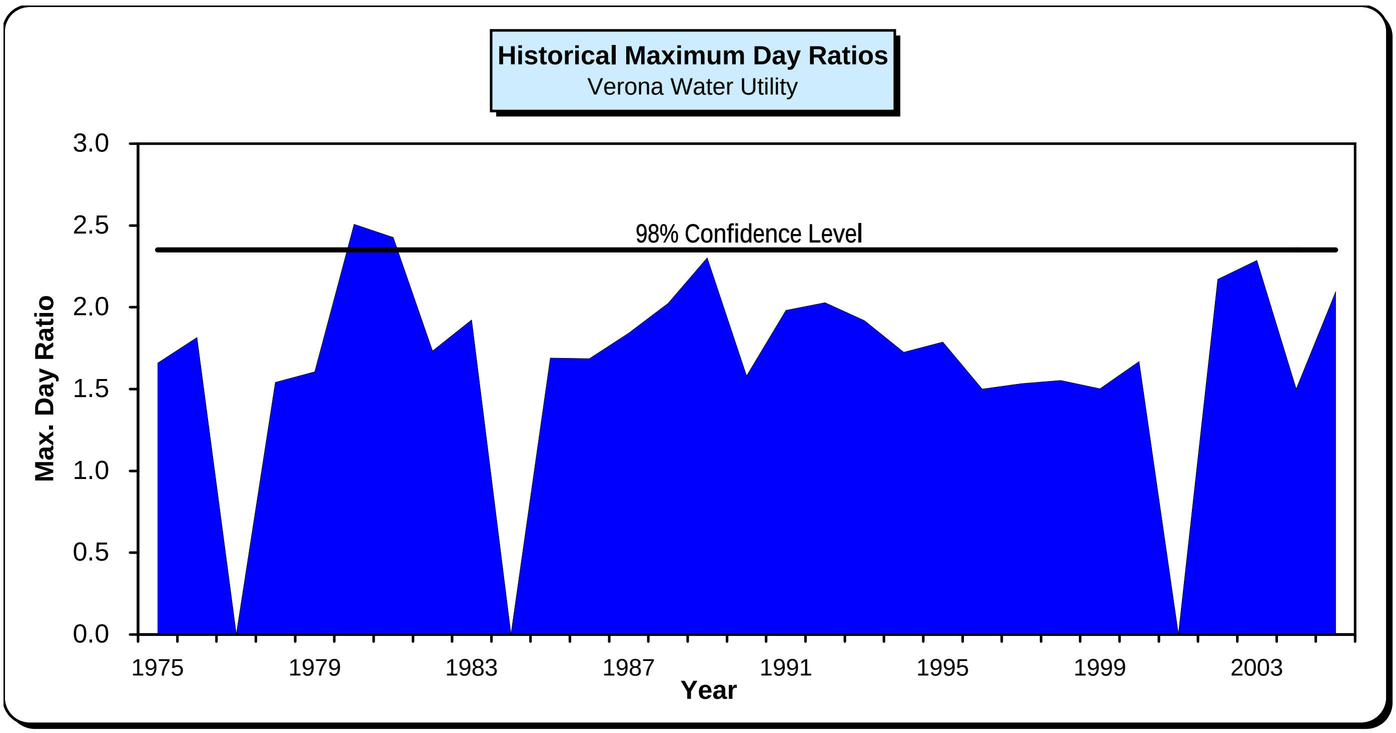
TABLE 3-7

STATISTICAL ANALYSIS:
RATIO OF MAXIMUM TO AVERAGE DAY DEMAND
VERONA WATER UTILITY
VERONA, WISCONSIN

	1975 to 2005	1990 to 2005
Number of years of Data	28	15
Maximum Ratio - Max. to Avg. Day Pumpage	250.6%	228.7%
Minimum Ratio - Max. to Avg. Day Pumpage	150.1%	150.1%
Average Ratio Max. to Avg. Day Pumpage	184.2%	178.9%
Standard Deviation	29.0%	26.2%

Confidence Level (%)	Ratio of Max. to Avg. Day Pumpage	Ratio of Max. to Avg. Day Pumpage
80%	209%	201%
85%	214%	206%
90%	221%	212%
95%	232%	222%
98%	244%	233%
99%	252%	240%

Note
The "Confidence Level" represents the probability (%) that in any given year, the actual ratio of maximum to average day pumpage will be less than or equal to the ratio indicated in the table. The ratios in the table were determined based on a statistical analysis of historical ratios over each period of analysis, assuming a normal distribution. Maximum day demand data for 1977, 1984 and 2001 was unavailable.



L:\work\Projects\91960\eng\report tables and figures\[Chapter3Verona.xls]Table 3-07

Based upon this analysis, the design peak hour demand ratio for the Central and Southeast Pressure Zones was assumed to be 1.67 times maximum day, or 3.92 times average day, and the design peak hour demand ratio for the North Pressure Zone was assumed to be 1.80 times maximum day, or 4.23 times average day.

3.7 WATER CONSUMPTION AND PUMPAGE PROJECTIONS

Future sales and pumpage projections are based on assumptions of water demand, coupled with estimates of future population and community growth. A detailed summary of the individual components of projected water sales and pumpage requirements is provided in Table 3-8. Projected water sales by customer sector are illustrated graphically in Figure 3-6.

3.7.1 Industrial Sales

Sales to existing and future industrial customers were projected based on a historical per capita demand basis except for Epic Systems. It is difficult to project future industrial demands due to the many factors which influence the water use of industrial customers. The water usage of each industrial customer varies depending on the nature of the industry, size of the complex, number of shifts, and various other factors. Without significantly large water users, it is possible that a relationship between population and industrial demands can be estimated. The actual 2005 per capita industrial sales were nearly 16 gpcd, which is slightly less than the 23 gpcd used for industrial demand projections in the 1995 Water System Study. For the purposes of this study, future industrial sales were estimated based on 20 gpcd.

As there are currently no water usage records available for Epic Systems, water requirements were estimated based upon the number of employees. Epic Systems personnel indicated that there are currently an estimated 2,200 employees at the Verona campus. As additional office facilities are constructed, the number of employees is expected to increase to over 5,000. For this study, it is assumed the number of employees will reach approximately 5,000 by the year 2020 and will increase up to 7,500 by 2030. In addition to water consumption by employees, Epic also utilizes water for irrigation. A per capita consumption of 30 gpd per employee was used to estimate the water requirements for Epic Systems. This per capita consumption is slightly higher than the estimate for the sewer study currently being prepared for the City and accounts for water used for irrigation.

Utilizing the 30 gpd per employee per capita demand, the existing demand at Epic Systems is approximately 0.07 MGD, and future demands are estimated to be approximately 0.15 MGD by 2020 and 0.23 MGD by 2030. It is recommended that as meter records become available, the water demands for Epic Systems be reviewed and updated as necessary.

Based on the per capita demands presented above, future annual industrial water sales are projected to increase from approximately 0.14 MGD in 2005 to approximately 0.79 MGD by the year 2030. Because future changes in industrial activity are difficult to estimate due to many of the uncertainties associated with industrial development, it may be necessary to review and revise the water needs projections during future planning efforts if new industrial development occurs.

TABLE 3-8

WATER SALES AND PUMPAGE PROJECTIONS

VERONA WATER UTILITY
VERONA, WISCONSIN

Customer Classification	**Actual 2005**	**Projected 2010**	**Projected 2020**	**Projected 2030**
Population Served [1]	9,103	11,600	18,800	28,000
Residential Sales				
Per Capita Sales (gpcd)	65.8	65.0	65.0	65.0
Average Sales (MGD)	0.60	0.75	1.22	1.82
Commercial Sales				
Per Capita Sales (gpcd)	18.9	18.0	18.0	18.0
Average Sales (MGD)	0.17	0.21	0.34	0.50
Public Sales				
Per Capita Sales (gpcd)	8.2	9.0	9.0	9.0
Average Sales (MGD)	0.07	0.10	0.17	0.25
Industrial Sales				
Sales:				
Per Capita Sales (gpcd) [2]	15.7	20.0	20.0	20.0
Average Sales (MGD)	0.14	0.23	0.38	0.56
Additional Sales to Epic Systems [3]	-	0.08	0.15	0.23
TOTAL METERED SALES (MGD)	***0.99***	***1.37***	***2.26***	***3.36***
Unaccounted-For Water (MGD) [4]	0.08	0.15	0.25	0.37
TOTAL PUMPAGE (MGD)	***1.07***	***1.53***	***2.51***	***3.73***

Notes

1. Refer to Table 2-3 for population data. Future population determined in Chapter 2.
2. Per Capita Industrial Sales was projected to be approximately 20.0 gpcd throughout the planning period.
3. Average water use per employee of 22 gpcd plus an additional 8 gpcd for irrigation was used for projecting water use attributed to Epic Systems. Number of employess of Epic System estimated at 5,000 by 2020.
4. Unaccounted-for water was projected at 10% of total pumpage for future years.

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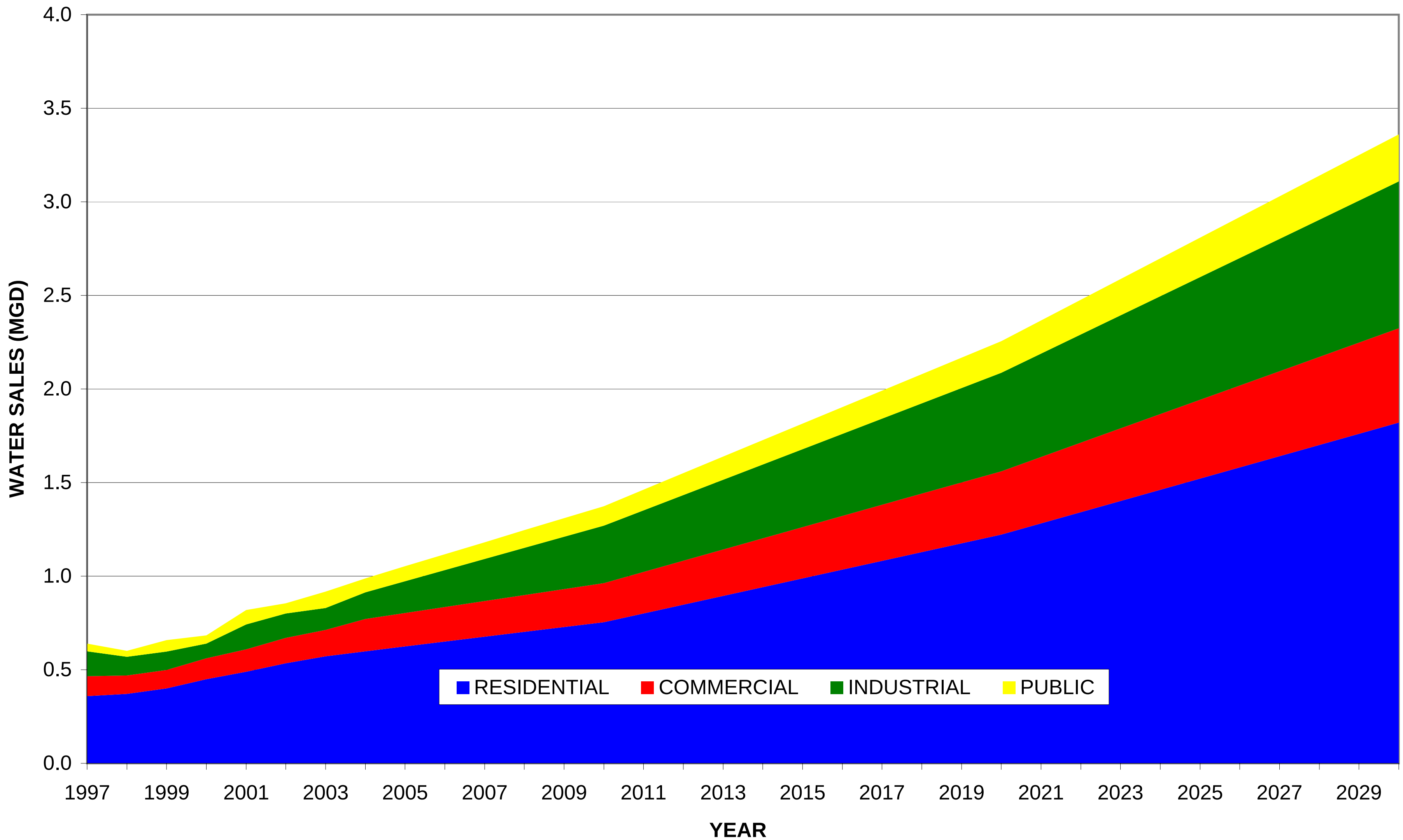

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FIGURE 3-6
ANNUAL WATER SALES PROJECTIONS
BY CUSTOMER SECTOR
VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006 91960

3.7.2 Summary of Demand and Pumpage Requirements

Table 3-9 summarizes projections of future water needs. Future annual sales are projected to increase from approximately 361 MGY (0.99 MGD) in 2005 to 1,227 MGY (3.36 MGD) by the year 2030. Total annual pumpage is projected to increase to approximately 1,363 MGY (3.73 MGD) by the year 2030. Estimates of daily demand fluctuations have also been made based on projections of future annual sales. The demand factors used in this study are 2.35 for maximum day demand, 1.67 for peak hour demand in the Central and Southeast Pressure Zones, and 1.80 for peak hour in the North Pressure Zone. By the year 2030, average day pumpage is projected to increase to 3.73 MGD, and maximum day pumpage is projected to increase to 8.78 MGD. Peak hour demand is projected to increase to a rate of 10,180 gpm by the year 2030.

3.7.3 Pumpage Requirements by Pressure Zone

Because the Verona water distribution system is segmented into pressure zones to alleviate pressures variations caused by elevation changes, the overall pumpage requirements determined above need to be assigned to the corresponding pressure zone. The assignment of pumpage requirements is necessary to ensure that adequate facilities are available to serve each zone.

Pumpage projections by pressure zone were estimated based on the amount of developing acreage of each customer classification in each pressure zone according to the future urban service and land use discussed in Chapter 2. Table 3-10 summarizes the projections of future water needs by pressure zone that are used for this study.

3.8 WATER NEEDS FOR FIRE PROTECTION

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

Guidelines for determining fire flow requirements are provided by the Insurance Services Office (ISO). ISO is the insurance service organization responsible for evaluating and classifying municipalities for fire insurance rating purposes. When a community evaluation is conducted by ISO, the water system is evaluated for its capacity to provide needed fire flow at a location. Determination of the needed fire flow is dependent on land use characteristics and the types of properties to be protected; however, in high value districts, fire flow requirements of up to 3,500 gpm can be expected.

TABLE 3-9

FUTURE PUMPAGE PROJECTION
VERONA WATER UTILITY
VERONA, WISCONSIN

		Design 2005	Projected 2010	Projected 2020	Projected 2030
Total Annual Sales	(MGY)	361	502	823	1,227
	(MGD)	0.99	1.37	2.26	3.36
Total Annual Pumpage	(MGY)	389	557	915	1,363
	(MGD)	1.07	1.53	2.51	3.73
Average Day Pumpage	(MGD)	1.07	1.53	2.51	3.73
	(gpm)	740	1,060	1,740	2,590
Design Maximum Day Demand	(MGD)	2.51	3.59	5.89	8.78
	(gpm)	1,740	2,490	4,090	6,090
Design Peak Hour Demand	(gpm)	2,900	4,200	6,800	10,200

Notes

1. Design maximum day demand projections were estimated using a ratio of maximum day to average day demand of 235 percent.
2. Design peak hour demand projections were estimated using a ratio of peak hour to maximum day of 167 percent.

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TABLE 3-10

FUTURE PUMPAGE PROJECTIONS
VERONA WATER UTILITY
VERONA, WISCONSIN

	Design 2005			Projected 2010			Projected 2020			Projected 2030		
	AVG (MGD)	MAX (MGD)	PEAK (gpm)	AVG (MGD)	MAX (MGD)	PEAK (gpm)	AVG (MGD)	MAX (MGD)	PEAK (gpm)	AVG (MGD)	MAX (MGD)	PEAK (gpm)
Existing Service Areas:												
Central Pressure Zone	0.95	2.24	2,600	1.24	2.91	3,400	1.88	4.42	5,100	2.55	5.99	7,000
Southeast Pressure Zone	0.07	0.17	200	0.22	0.51	600	0.43	1.00	1,200	0.77	1.81	2,000
North Pressure Zone	0.05	0.11	100	0.08	0.19	200	0.20	0.47	500	0.30	0.71	900
Subtotal	**1.07**	**2.52**	**2,900**	**1.53**	**3.60**	**4,200**	**2.51**	**5.90**	**6,800**	**3.62**	**8.51**	**9,900**
Future Service Areas:												
Future East Pressure Zone	-	-	-	-	-	-	-	-	-	0.11	0.26	300
Subtotal	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.11**	**0.26**	**300**
TOTAL	**1.07**	**2.52**	**2,900**	**1.53**	**3.60**	**4,200**	**2.51**	**5.90**	**6,800**	**3.73**	**8.77**	**10,200**

Notes

1. Design maximum day demand projections were estimated using a ratio of maximum day to average day demand of 235 percent.
2. Design peak hour demand projections were estimated using a ratio of peak hour to maximum day of 167 percent for all pressure zones except 180 percent was used for the North Pressure Zone.

L:\work\Projects\91960\eng\report tables and figures\[Chapter3Verona.xls]Table 3-10

4.0 EXISTING WATER SYSTEM

4.1 GENERAL DESCRIPTION OF WATER SYSTEM

This chapter presents a summary of the existing City of Verona water system components. The general location and layout of the water system is illustrated in Figure 4-1. The water system is schematically illustrated in Figure 4-2. To prevent unacceptable water system pressures resulting from elevation changes, the distribution system is separated into three pressure zones: Central, North, and Southeast.

The City of Verona water system consists of the following:

1. Four groundwater wells
2. Two elevated water storage tanks
3. Two booster pump stations
4. Approximately 52 miles of transmission and distribution water mains

Verona Water Utility controls and monitors the water system using a SCADA system. The SCADA system allows monitoring of remote facilities and control of well and booster pumping equipment from the Utility office.

4.2 WATER DISTRIBUTION SYSTEM

Verona's water distribution system provides a means of transporting and distributing water from the supply sources to the location of water usage. The distribution system must be capable of supplying adequate quantities of water at adequate pressures throughout the City under a range of operating conditions. Furthermore, the distribution system must be able to provide not only distribution of water during normal and peak demand conditions, but must also be capable of delivering adequate water supplies for fire protection purposes.

The water distribution system (as it existed in April 2006) consists of approximately 52 miles of water main ranging in size from less than 4 inches to 12 inches in diameter. Additional 2006 water main construction projects are illustrated in Chapter 6. Figure 4-1 illustrates the existing water distribution system from the hydraulic model created from the City of Verona geographic information system (GIS) data. The water main size inventory is summarized in Table 4-1. Of the approximately 52 miles of water main, approximately 40 percent are 10 inches in diameter or larger. These large diameter (10-inch and larger) water mains represent the potable water system's primary transmission mains and are illustrated in Figure 4-3. The Verona distribution system includes transmission mains (10-inch and larger) throughout the system; however, in several areas, older and smaller diameter water mains exist which restrict flow capacity in the transmission network.

The water main materials in the potable water system are summarized in Table 4-1 and illustrated in Figure 4-4. The water system is comprised of cast iron, ductile iron, and asbestos cement water mains, with approximately 86 percent of the water main being ductile iron. The water main inventory based on pipe installation date is summarized in Table 4-1 and illustrated in Figure 4-5. Approximately 57 percent of the existing water mains were installed since 1990, while 15 percent of the water mains were installed prior to 1970.

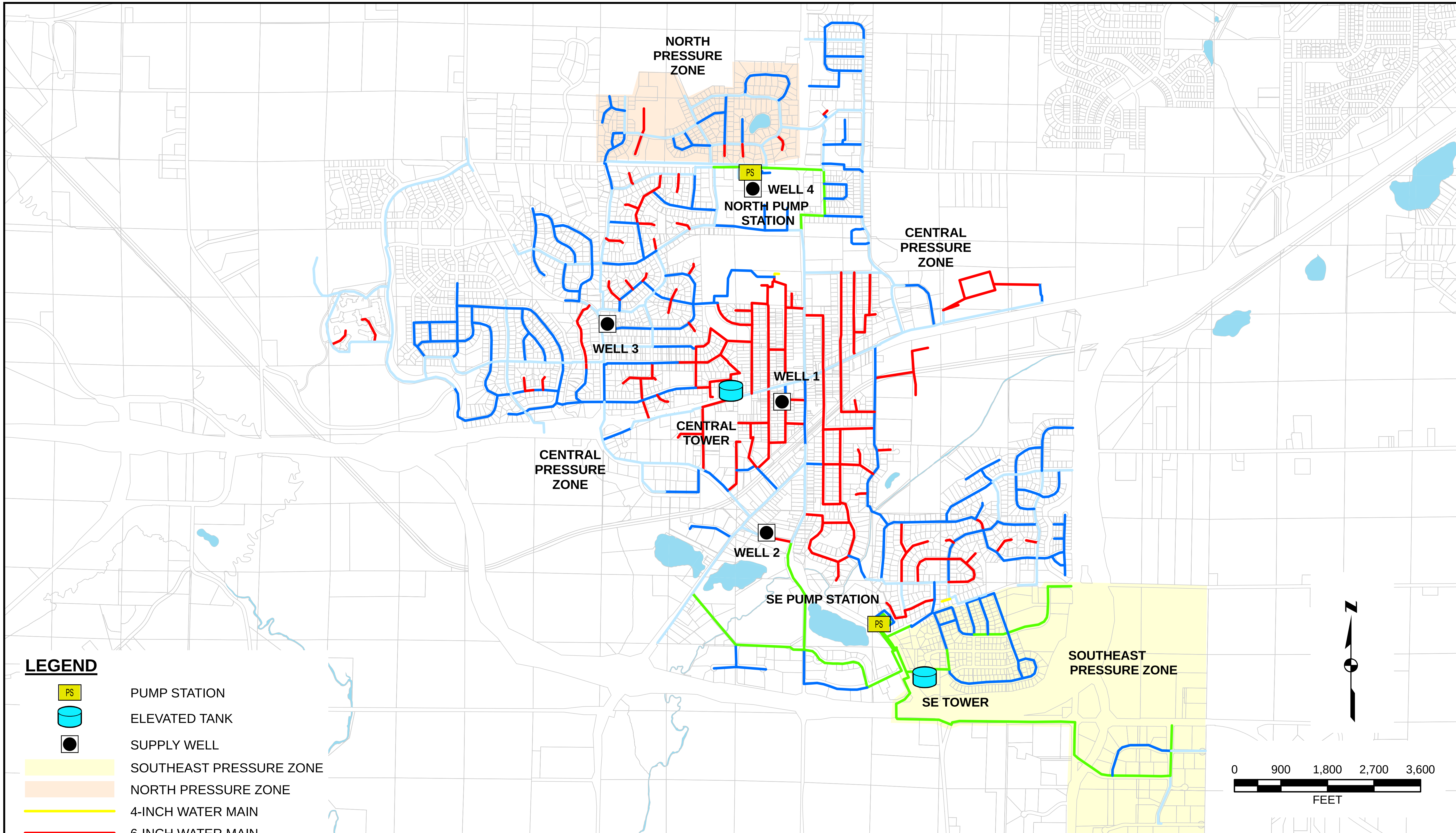

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FIGURE 4-1
EXISTING WATER
DISTRIBUTION SYSTEM
VERONA WATER UTILITY
VERONA, WISCONSIN

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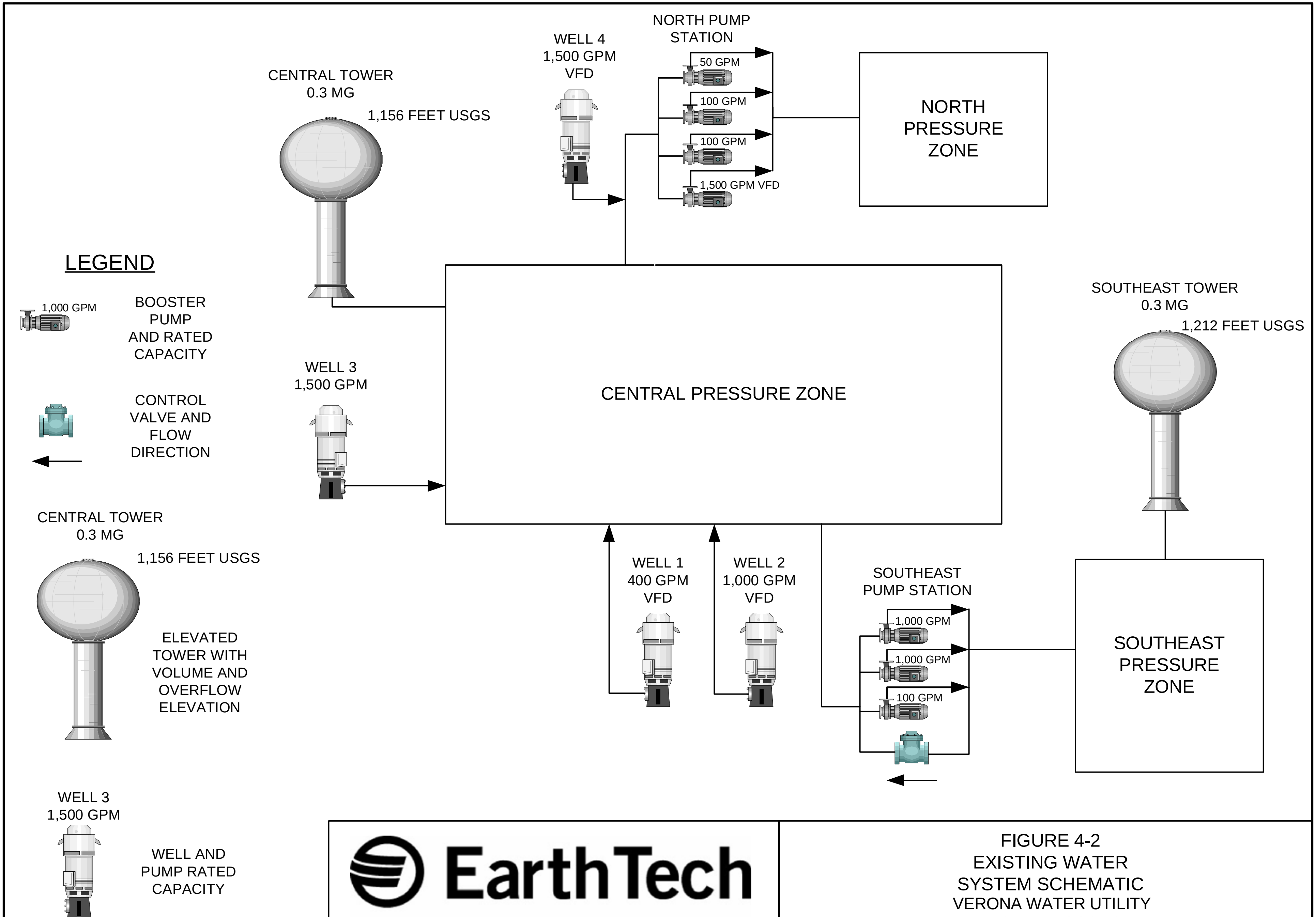

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FIGURE 4-2
EXISTING WATER
SYSTEM SCHEMATIC
VERONA WATER UTILITY
VERONA, WISCONSIN

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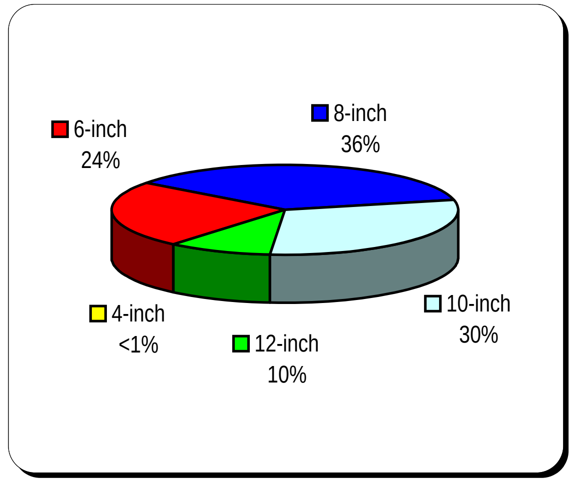
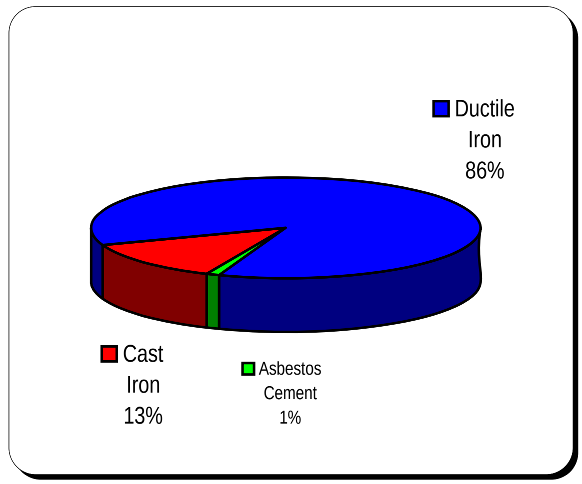
TABLE 4-1

WATER MAIN SIZE, MATERIAL, AND INSTALLATION DATE DISTRIBUTION
VERONA WATER UTILITY
VERONA, WISCONSIN

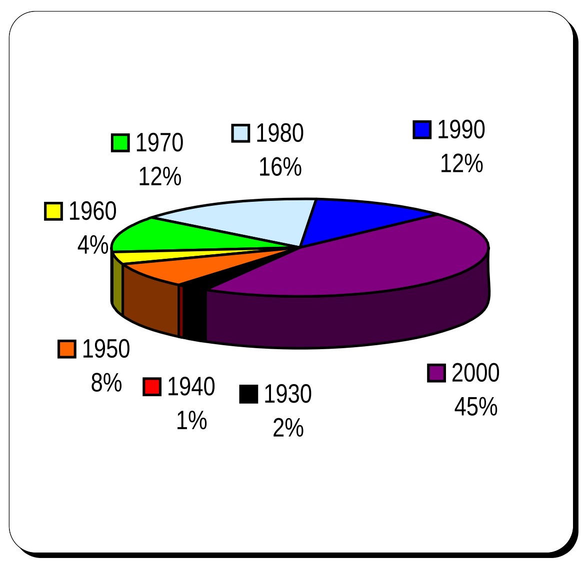
Diameter	Approximate Total Length	Percentage of Total
4-inch	310 feet	<1%
6-inch	66,200 feet	24%
8-inch	99,240 feet	36%
10-inch	81,710 feet	30%
12-inch	26,840 feet	10%
Total	**274,300 feet**	**100%**



Material	Approximate Total Length	Percentage of Total
Asbestos Cement	3,170 feet	1%
Cast Iron	35,150 feet	13%
Ductile Iron	235,980 feet	86%
Total	**274,300 feet**	**100%**



Installation Decade	Approximate Total Length	Percentage of Total
1930	6,240 feet	2%
1940	1,730 feet	1%
1950	22,640 feet	8%
1960	11,080 feet	4%
1970	33,160 feet	12%
1980	43,120 feet	16%
1990	32,050 feet	12%
2000	124,280 feet	45%
Total	**274,300 feet**	**100%**



Note: Water main size, material, and installation date distribution based on GIS data.

L:\work\Projects\91960\eng\report tables and figures\TableCh4\[Chapter 4 table.xls]Table 4-1

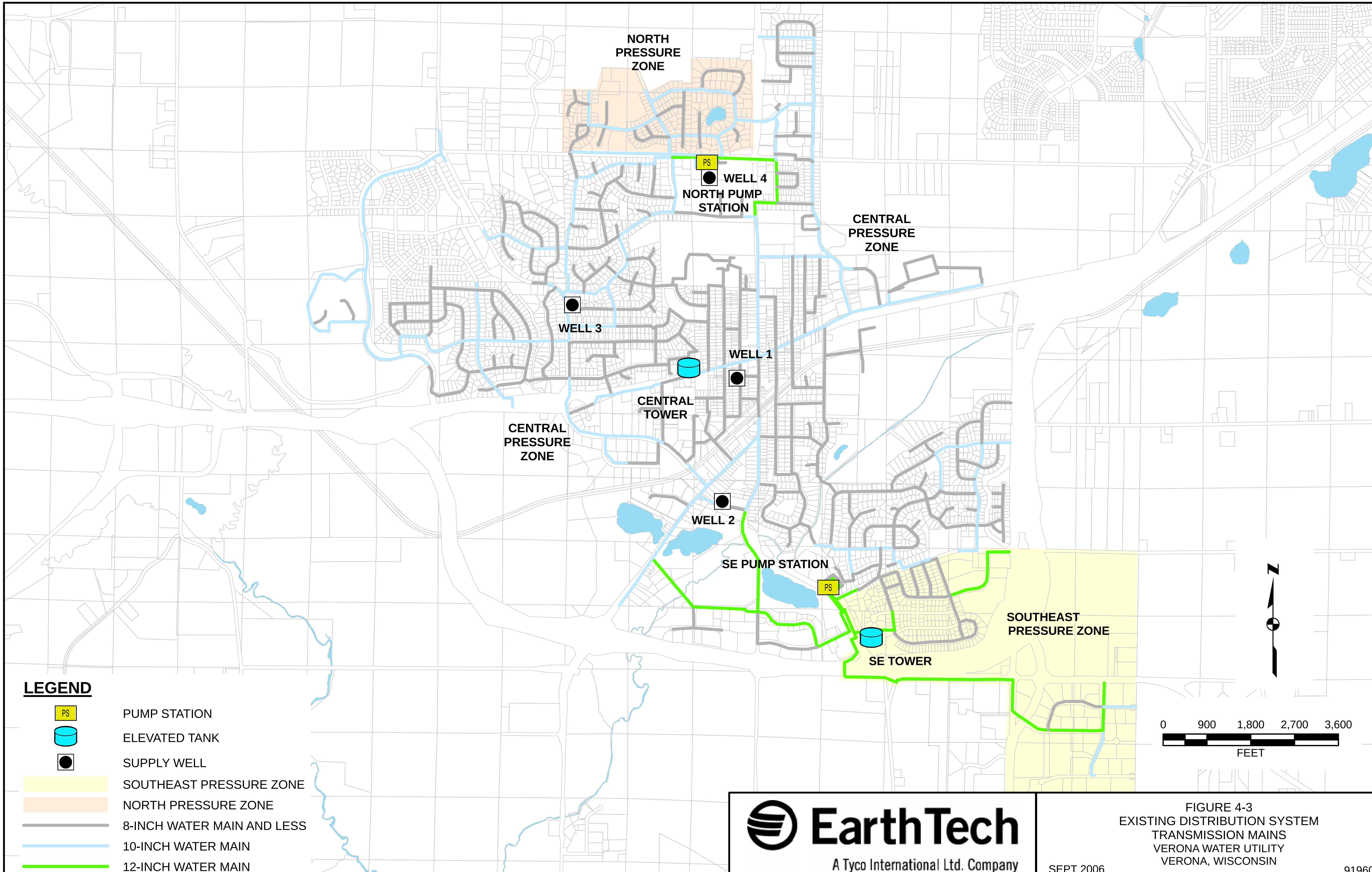


FIGURE 4-3
EXISTING DISTRIBUTION SYSTEM
TRANSMISSION MAINS
VERONA WATER UTILITY
VERONA, WISCONSIN

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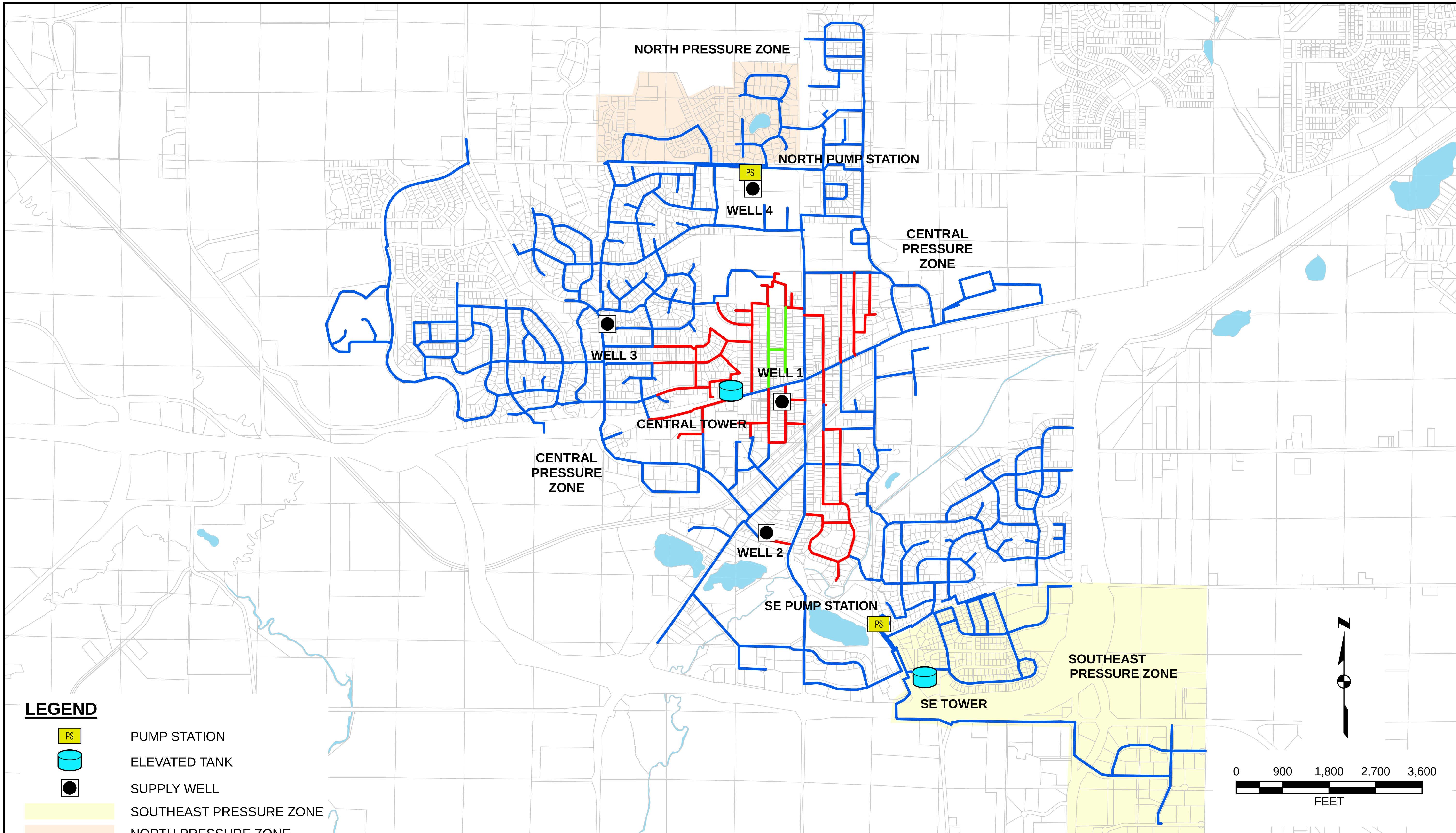

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FIGURE 4-4
EXISTING WATER MAIN
MATERIAL INVENTORY
VERONA WATER UTILITY
VERONA, WISCONSIN

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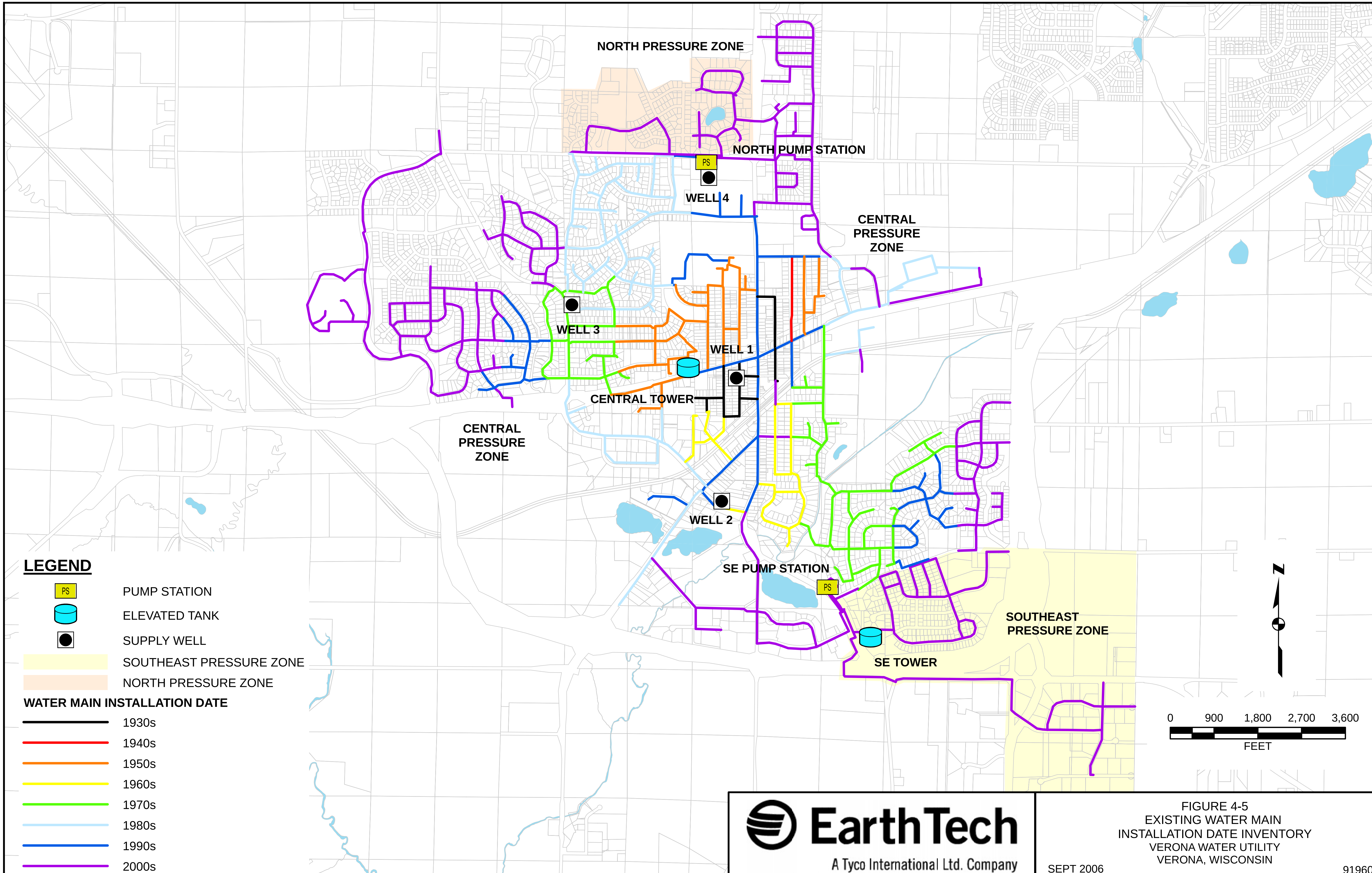

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4.3 WATER SYSTEM OPERATION

The Verona water system is fully automated using a SCADA system. According to Utility personnel, the four wells are operated based on the level of water in the Central Tower located in the Central Pressure Zone. During typical operation, the Central Tower (available operating head range of 32.5 feet) operates with a water level between 10 and 30 feet. When the water level in the Central Tower falls to 10 feet, the SCADA system turns on Wells 1, 3, and 4 until the Central Tower water level reaches 30 feet. Well 2 operates between the hours of 3:15 a.m. and 6:30 a.m. if the Central Tower falls below 25 feet during that time. Well 2 operates until the Central Tower water level reaches 30 feet. Operation of Wells 2 and 3 has been alternated at times.

The water level at the Southeast Tower (located in the Southeast Pressure Zone) is allowed to fluctuate between 5 and 30 feet. When the water level reaches the low level of 5 feet, the SCADA calls one of two 1,000 gpm pumps located at the Southeast Pump Station to run. The booster pumps which pump water from the Central Pressure Zone to the Southeast Pressure Zone alternate starts and once called, continue to operate until the water level at the Southeast Tower reaches 30 feet. Under normal operation, the existing 100 gpm pump at the Southeast Pump Station is not called to run.

A flow control valve, also located at the Southeast Pump Station, is utilized to transfer water from the Southeast Pressure Zone back to the Central Pressure Zone. The flow control valve is currently utilized to create an artificial demand in the Southeast Pressure Zone to reduce potential water quality problems that may otherwise result due to existing low water demands within the Southeast Pressure Zone. The current valve setting allows approximately 500 gpm to flow between the zones, and the valve is called to open as long as the following conditions are met:

- The Southeast Tower water level is greater than 5 feet.
- No pumps are operating at the Southeast Pump Station.
- The water level in the Central Tower is less than 25 feet.

The North Pressure Zone has no storage and utilizes four booster pumps at the North Pump Station to meet water demands in the zone. The SCADA system determines which pumps to run based on the water demands in the zone. The four booster pumps consisting of a 50 gpm jockey pump, two 100 gpm pumps, and a 1,500 gpm fire pump operate as summarized in Table 4-2.

TABLE 4-2
SUMMARY OF NORTH PUMP STATION OPERATION

North Pressure Zone Water Demand	Pump 1 (50 gpm)	Pump 2 (100 gpm)	Pump 3 (100 gpm)	Pump 5 (1,500 gpm)
Greater than 0 gpm	Operating	Off	Off	Off
Greater than 40 gpm	Operating	Operating	Off	Off
Greater than 90 gpm	Off	Operating	Operating	Off
Greater than 200 gpm	Off	Off	Off	Operating

4.4 WATER SYSTEM FACILITIES

Detailed information on the water system facilities is provided in the following sections, organized by pressure zone:

4.4.1 Central Pressure Zone
4.4.2 North Pressure Zone
4.4.3 Southeast Pressure Zone

4.4.1 Central Pressure Zone

The Central Pressure Zone contains all four of the existing supply wells in the City of Verona water system. The Central Pressure Zone also contains an elevated tank for water storage and supplies water to the North and Southeast Pressure Zones.

The following facilities located in the Central Pressure Zone are presented in detail in the tables that follow:

1. Central Tower - Table 4-3
2. Well 1 (S. Shuman Street) - Table 4-4
3. Well 2 (Factory Street) - Table 4-5
4. Well 3 (N. Nine Mound Road) - Table 4-6
5. Well 4 (Cross Country Road) - Table 4-7

TABLE 4-3
CENTRAL TOWER

Central Tower	
Pressure zone	Central
Capacity	0.3 MG
Year constructed	1974
Constructed by	CB&I
Type	Elevated Spheroid Tank
Construction material	Steel
Overflow elevation	1,156 feet USGS
Diameter	46.4 feet
Head range	32.5 feet
Date last inspected	2005
Date last repaired	1998
Repair details	1998 repainted 2005 cleaned out sand

Central Tower

Comments
The expansion joints were scheduled to be replaced in spring 2006. Ground level at the tank is 1,007.5 feet USGS.
Note: USGS = United States Geological Survey

TABLE 4-4
WELL 1

Well 1 (S. Shuman Street)			
Key Components		Well	
• Well pump		Year constructed	1932
• Aquastream sand filter		Depth	771 feet
• Chlorine and fluoride addition		Casing size	10-inch
Operation:		Date of last rehabilitation	2004
Pumps into Central Pressure Zone		Static water level	50 feet below ground surface
Well Pump		Specific capacity	17.0 gpm/feet
Type	Vertical turbine line shaft with variable speed drive		
Manufacturer	Layne		
Year installed			
Pump	1982		
Motor	-		
Horsepower	40 hp		
Standby power	None		
Related conditions			
Flow	400 gpm		
TDH	244 feet		

Well 1

Well 1 Pump

Well 1 Chlorine and Fluoride Equipment

Comments
The pump was rebuilt in 2004.

TABLE 4-5
WELL 2

Well 2 (S. Shuman Street)			
Key Components		**Well**	
• Well pump		Year constructed	1959
• Aquastream sand filter		Depth	1,153 feet
• Chlorine and fluoride addition		Well casing size	16-inch
Operation:		Static water level	70 feet below ground surface
Pumps into Central Pressure Zone		Specific capacity	12.8 gpm/feet

Well Pump	
Type	Vertical turbine line shaft with variable speed drive
Manufacturer	Layne Northwest
Year installed	
Pump	1987
Motor	2005
Horsepower	150 hp
Standby power	Engine
Rated conditions	
Flow	1,000 gpm
TDH	415 feet

Well 2

Well 2 Pump

Well 2 Chlorine and Fluoride Equipment

Comments
Well modifications and maintenance include adding an Aquastream sand filter, and the well pump was pulled, the well was air bursted, chemical injected, and cleaned. The pump was rebuilt in 2005.

TABLE 4-6
WELL 3

Well 3 (N. Nine Mound Road)

Well	
Year constructed	1975
Depth	1,033 feet
Date of last rehabilitation	~2000
Well casing size	20-inch
Static water level	80 feet below ground surface
Specific capacity	16.2 gpm/feet

Well 3

Key Components
• Well pump
• Aquastream sand filter
• Chlorine and fluoride addition
Operation:
Pumps into Central Pressure Zone

Well Pump	
Type	Vertical turbine line shaft
Manufacturer	Layne
Year installed	
Pump	2002
Motor	2002
Horsepower	200 hp
Standby power	None
Rated conditions	
Flow	1,500 gpm
TDH	344 feet

Well 3 Pump

Comments
The well capacity was increased to 1,500 gpm in 2002.

TABLE 4-7
WELL 4

Well 4 (Cross Country Road)			
Key Components		Well	
• Well pump		Year constructed	1992
• Chlorine and fluoride addition		Depth	1,148 feet
• Location of North Pump Station		Date of last rehabilitation	1994
Operation		Well casing size	18-inch
Pumps into Central Pressure Zone		Static water level	90 feet below ground surface
Well Pump		Specific capacity	69.6 gpm/feet
Type	Vertical turbine line shaft with variable speed drive	 Well 4	
Manufacturer	Layne		
Year installed			
Pump	1993		
Motor	2005		
Horsepower	150 hp		
Standby power	Cummins Generator		
Rated conditions			
Flow	1,500 gpm		
TDH	300 feet		
 Well 4 Pump		 Generator	
Comments			
Well 4 is housed in the same building as North Pump Station.			

4.4.2 North Pressure Zone

The North Pressure Zone contains one booster station that pumps water from the Central Pressure Zone. The North Pump Station, located in the same building as Well 4, is presented in detail in Table 4-8.

TABLE 4-8
NORTH PUMP STATION

North Pump Station		
Key Components		
• Four booster pumps on a prefabricated skid		
Operation		
• Pumps from Central Pressure Zone to North Pressure Zone		
Booster Pumps		
Number of pumps	Four	
	Pump 1	Pump 2
Type	End Suction	End Suction
Manufacturer	Aurora	Aurora
Rated conditions		
Flow	50 gpm	100 gpm
TDH	75 feet	75 feet
Year installed		
Pump	1999	1999
Motor	1999	1999
Horsepower	2 hp	5 hp
	Pump 3	Pump 4
Type	End Suction	End Suction
Manufacturer	Aurora	Cornell
Rated conditions		
Flow	100 gpm	1,500 gpm
TDH	75 feet	105 feet
Year installed		
Pump	1999	1999
Motor	1999	2005
Horsepower	5 hp	50 hp VFD
Standby power	Generator	

North Pump Station

North Pumps

Comments

Pump 4 has a VFD and is currently operated in summer to meet increased demands in the North Pressure Zone.

Note: VFD = variable frequency drive

4.4.3 Southeast Pressure Zone

The Southeast Pressure Zone contains an elevated tank and one booster station which pumps from the Central Pressure Zone.

The following facilities located in the Southeast Pressure Zone are presented in detail in the tables that follow:

1. Southeast Tower - Table 4-9
2. Southeast Pump Station - Table 4-10

TABLE 4-9
SOUTHEAST TOWER

Southeast Tower	
Pressure zone	Southeast
Capacity	0.30 MG
Year constructed	2000
Constructed by	McGuire Iron, Inc.
Type	Single pedestal spheroid
Construction material	Steel
Overflow elevation	1,212 feet USGS
Diameter	46.4 feet
Head range	31 feet
Date last inspected	-
Date last repaired	No work since construction
Repair details	None
Comments	
The Southeast Tower is equipped with cathodic protection.	

Southeast Tower

TABLE 4-10
SOUTHEAST PUMP STATION

Southeast Pump Station			
Key Components			
• Booster Pumps and Control Valve			
Operation			
• Pumps from Central Pressure Zone to Southeast Pressure Zone			
Booster Pumps			
Number of pumps	Three		
	Pump 1	Pump 2	Pump 3
Type	End Suction	End Suction	End Suction
Manufacturer	Aurora	Aurora	Aurora
Rated conditions			
Flow	1,000 gpm	1,000 gpm	100 gpm
TDH	81 feet	81 feet	56 feet
Year installed			
Pump	2000	2000	2000
Motor	2000	2000	2000
Horsepower	30 hp	30 hp	5 hp
Standby power	Portable generator		
Comments			
The control valve allows water to flow back from the Southeast Pressure Zone into the Central Pressure Zone. The control valve is typically operated at approximately 500 gpm to ensure turnover in the Southeast Tower.			

Southeast Pump Station


Southeast Pumps


Southeast Pumps


Southeast Control Valve

5.0 WATER SYSTEM EVALUATION

This chapter summarizes the findings from the water system evaluation and deficiency analysis of the existing City of Verona water system. Recommendations to address the findings of the water system evaluation and deficiency analysis can be found in Chapter 6.

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

1. Location, capacity, and water quality of supply facilities
2. Location, sizing, and elevation of storage facilities
3. Location, magnitude, and variability of customer demands
4. Water system geometry and geographic topography
5. Minimum and maximum pressure requirements
6. Land use characteristics with respect to fire protection needs
7. Operation criteria which define the manner in which the system can be operated most efficiently

For this study, an evaluation of the City of Verona water system was performed to determine the adequacy of the system to supply existing water needs and to supply water for fire protection purposes. The system was evaluated based on the following criteria:

1. Pressure
2. Fire flow capacity
3. Reliability
4. High headlosses and velocities
5. Water age
6. Supply capacity
7. Pumping capacity
8. Storage capacity

The water system evaluation was based on compliance with state code requirements and standard water industry engineering practice.

5.1 WATER SYSTEM HYDRAULIC MODEL

For this study, a hydraulic computer model was developed of the City's water distribution system. The City of Verona water system was modeled using WaterCAD, a pipe network program developed by Bentley Systems, Inc. The hydraulic model was developed using the City GIS data for the water system. Required data for the creation of the computer model includes water main diameter and length, customer demands, ground elevations, and general operating characteristics of water system facilities (pump curves, water storage tank gauging tables). In addition to the above inputs, the model also requires pipe roughness coefficients, or C-values, which represent the relative internal condition of the water main. The C-values are utilized in the hydraulic calculation to determine pressure losses within the modeled system. Water main roughness coefficients were estimated based upon available data of diameter, material, and age.

Prior to utilizing a hydraulic model to evaluate a water system, the model must be calibrated. Model calibration is the term given to the adjustment of the model input data so that the hydraulic model accurately simulates measured field conditions and data. The calibration of the Verona water system model was performed under both steady-state simulations (micro calibration) and extended period simulations (EPS) (macro calibration). The steady-state model calibration simulations were performed to replicate results from actual field test data collected April 12 through April 13, 2006. The EPS model calibration simulations were performed to replicate the results from the extended period pressure monitoring and SCADA data collected for the period April 11 through 17, 2006. The following summarizes the field tests performed and the model calibration.

5.1.1 Micro Calibration

The micro calibration of the Verona water system model used the results of flow and pressure tests performed in April 2006. Flow and pressure test results were used to verify the model accurately simulates actual field conditions by comparing flows and pressures measured in the field with those simulated by the hydraulic model. During the model calibration process, well and pump status, customer demands, and tower water levels were set to the field conditions, and pipe roughness coefficients were adjusted until the calibrated system model adequately simulated field test data. Appendix C contains the flow testing results. Initial roughness coefficients were estimated based upon results of C-value tests performed on April 11, 2006, and were assigned to water mains based upon diameter, material, and age as stated above. A summary of the model calibration results is included in Appendix D.

Precise duplication of the field test results at all locations within the water distribution system during micro calibration of the computer model is not realistic due to the many factors that influence the field test results. The goal of micro calibration is to minimize the error between the field test data and the model simulations and create a “best fit” at all locations; therefore, some error between the field tests and model simulations is expected. However, limits to the amount of allowable error must also be made to ensure the calibrated model is a reasonably accurate representation of the actual water distribution system. The desired accuracy for the Verona water system model is ± 3 psi of the recorded pressure drop, ± 1 psi if the pressure drop is less than 10 psi, and ± 10 percent of the measured flow at the flowing hydrant. A minimum of 80 percent of the field test locations must meet the desired accuracy of ± 3 psi, 100 percent of the locations must meet the flow accuracy, and if applicable, the ± 1 psi accuracy. The City of Verona water system model has been calibrated to the desired accuracy and is believed to provide a reasonably accurate representation of the actual system. Three locations within the water system where calibration could be improved include: near Gatsby Glen Drive and Marlow Bay Drive, near the abandoned County Home on Verona Avenue, and near Prairie Oaks Drive and Enterprise Drive. It is possible that discrepancies in these areas are due to closed valves or inaccurate system geometry.

5.1.2 Macro Calibration

The purpose of macro calibration is to ensure that the results of the hydraulic model simulations reliably reflect actual water system conditions during normal demand periods. The macro calibration of the Verona water system model used the results of the continuous pressure monitoring performed in April 2006 along with SCADA data collected for the same time period. The pressure and SCADA data were used to verify the model accurately reflects the water system operation with respect to pump status, control valve status, fluctuations in storage tank volume, and changes in water system pressures for a 24-hour period. Appendix D provides overall details on the field measurements and EPS model calibrations that were performed. Based upon the information presented in Appendix D, the Verona EPS model is believed to present a reasonable representation of actual water system operation.

5.2 WATER SYSTEM PRESSURES

The Verona water system computer hydraulic model was used to evaluate existing water distribution system characteristics and identify deficiencies with respect to water system pressures. Water system pressure varies around the City of Verona based on differences in topographic elevations and pressure zones, as well as supply rates and user demands. In general, as water demand increases, water system pressure decreases. Areas higher in topographic elevation will also tend to exhibit lower water system pressures.

A water distribution system must be designed to provide pressure within a range of minimum and maximum allowable conditions. When system pressures are too low, water users may complain of inadequate water supply, and fire protection will be limited. Pressures that are too high can cause problems with system operation and maintenance (O&M) and will tend to cause higher consumption rates by water users. High water system pressures can also increase the amount of water loss, as leakage rates will increase with increases in water system pressure. During the site investigation, water system pressures were observed as varying from approximately 45 psi to 95 psi during normal system operation.

The Wisconsin Administrative Code (WAC), Chapter NR 811, requires that municipal water systems be designed with a minimum pressure of 35 psi and a maximum pressure of 100 psi at all locations in the service area under normal operating conditions. In addition, water systems are required to be operated so that even under emergency conditions (fire flow), the residual pressure in the system will not fall below 20 psi at any location. Furthermore, WAC Chapter Comm 82 requires that pressure reducing valves (PRVs) be installed on individual services if the supply pressure exceeds 80 psi. While not the responsibility of the Utility, knowledge of the Comm 82 requirement can assist the Utility with decision making during the water system planning process.

Figure 5-1 illustrates water system pressures throughout the City of Verona under peak hour demand conditions. The water system pressures simulated by the hydraulic model indicate that under peak hour demand conditions, water system pressures meet the minimum required pressure of 35 psi and range between approximately 46 psi and 96 psi.

Pressures between 50 and 100 psi are typical and occur throughout the water system. The highest water system pressures, greater than 90 psi, typically occur in the low topographic elevation areas in the south and southeast portions of the Central Pressure Zone and in the Southeast Pressure Zone near the discharge of the Southeast Booster Station. The lowest pressure, between 40 and 50 psi, occurs in the northeastern portion of the Central Pressure Zone due to high ground elevation.

5.3 FIRE FLOW CAPACITIES

Water system planning for fire protection is an important consideration. In most instances, water main sizes are designed specifically to supply desired fire flows.

Fire protection needs vary with the physical characteristics of each building to be protected. For example, needed fire flows for a specific building can vary from 500 gpm to as high as 12,000 gpm, depending on habitual classifications, separation distances between buildings, height, materials of construction, size of the building, and the presence or absence of building sprinklers. Municipal fire insurance ratings are partially based on the City's ability to provide needed fire flows up to 3,500 gpm. If a specific building has a needed fire flow greater than this amount, the community's fire insurance rating will only be based on the water system's ability to provide 3,500 gpm.

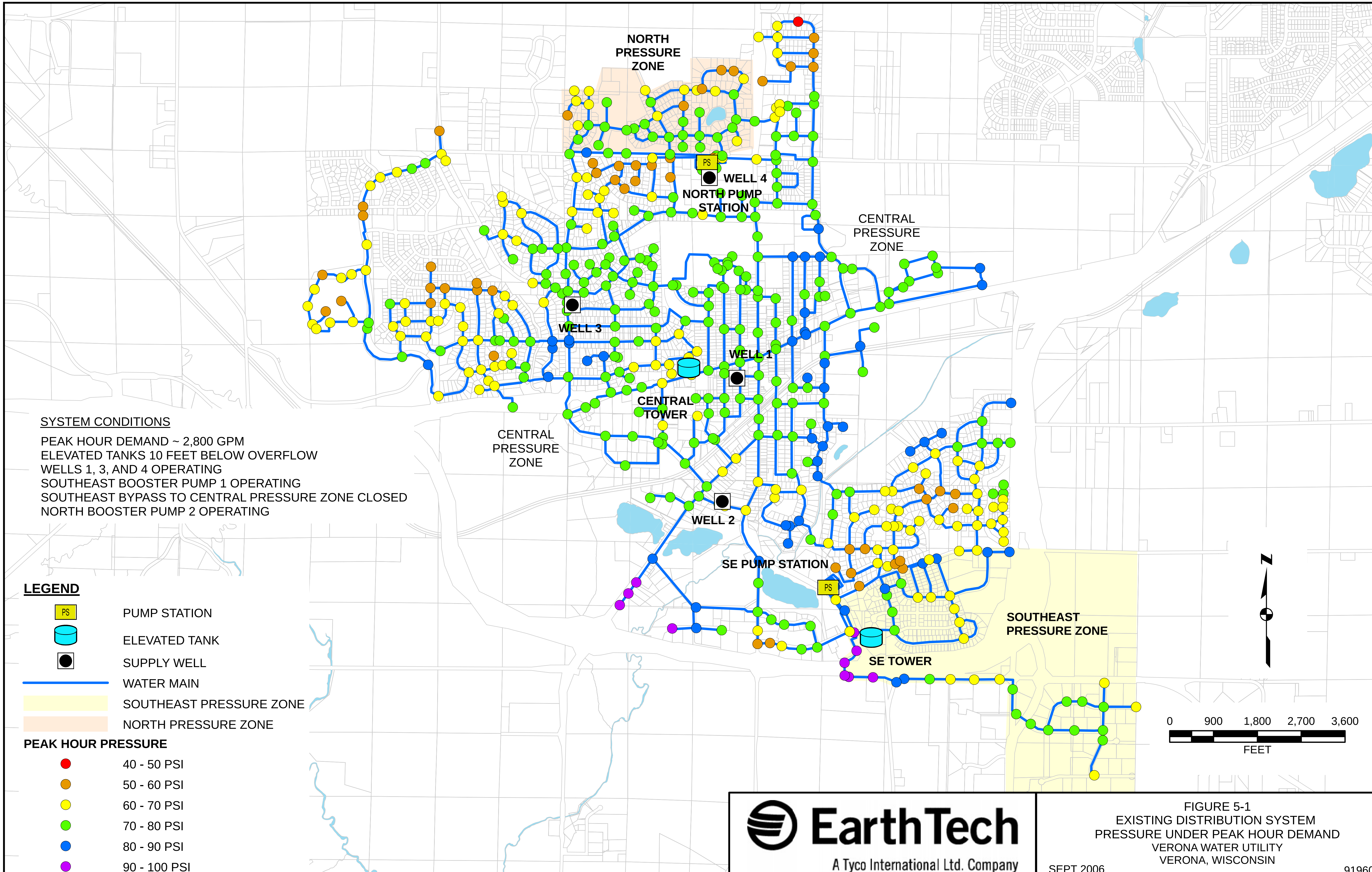

FIGURE 5-1
EXISTING DISTRIBUTION SYSTEM
PRESSURE UNDER PEAK HOUR DEMAND
VERONA WATER UTILITY
VERONA, WISCONSIN

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For the City of Verona, typical industry standard fire flow requirements were assigned by property type (land use classification) served as follows:

- 1,000 gpm for single-family housing
- 2,000 gpm for multi-family housing
- 2,500 gpm for commercial
- 3,500 gpm for industrial

For areas with multiple property types, the highest fire flow need was assigned to that area. The estimated fire flow requirements throughout the water system determined by land use classification are illustrated in Figure 5-2. The requirements illustrated in the figure were used as the basis for evaluating the Verona water system. As stated above, actual fire flow need for specific buildings can be highly variable; however, the requirements illustrated are useful as guidelines for evaluating purposes. As seen in Figure 5-2, the largest fire flow requirements were determined for industrial areas including the Verona Technology Park, Verona; Venture Court and Bruce Street Industrial Parks; Epic Systems Corporation; and along Horizon Drive.

To evaluate the capacity of the water system to provide fire protection, the available flow throughout the water system was estimated using the hydraulic model. Figure 5-3 illustrates the available fire flow superimposed on a maximum day demand at each pipe intersection, while maintaining a residual system pressure of 20 psi throughout the water system. Available fire flows ranged from approximately 900 gpm to 3,500+ gpm under maximum day water demand conditions. Based upon the fire flow requirements determined above (Figure 5-2), Figure 5-4 illustrates the locations which are anticipated to meet the needed fire flow requirement and those that are not anticipated to meet the required fire flow requirement. Based upon this evaluation, it should be noted that the required fire flows are available throughout the majority of the existing water system. Several deficient areas were identified, however, including:

1. Dead end water mains and small diameter water mains.

2. Industrial areas including the Verona Technology Park, Venture Court Industrial Park, along Investment Court, and at Epic Systems Corporation.

3. Extremities of the water system.

5.4 HEADLOSS AND VELOCITY

One important element of any hydraulic system analysis is to evaluate the distribution system network for water mains that are at or near capacity. High velocities or high headlosses are indicators of potential capacity problems. Velocities in excess of 5 fps and headlosses of 10 feet per 1,000 feet or more during peak hour simulations may contribute to low water system pressures, inadequate fire flows, and increased energy costs to operate the system. Based on hydraulic model simulations, only the water main serving the Central Tower and the 8-inch discharge water mains at Wells 3 and 4 experience velocities in excess of 5 fps and headlosses of 10 feet per 1,000 feet during peak hour simulations.

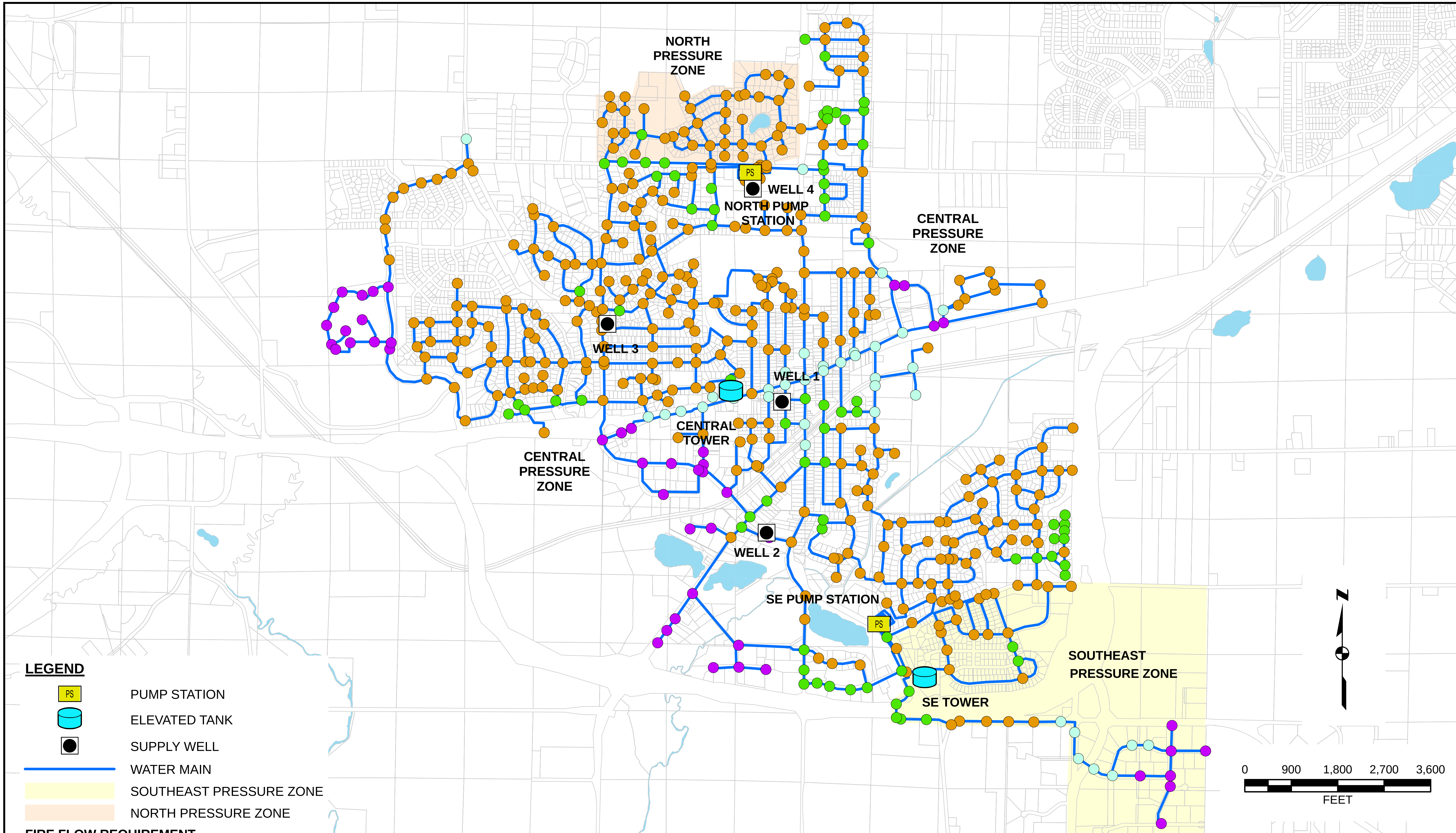

FIGURE 5-2
SUMMARY OF FIRE FLOW
REQUIREMENTS BASED ON LAND USE
VERONA WATER UTILITY
VERONA, WISCONSIN

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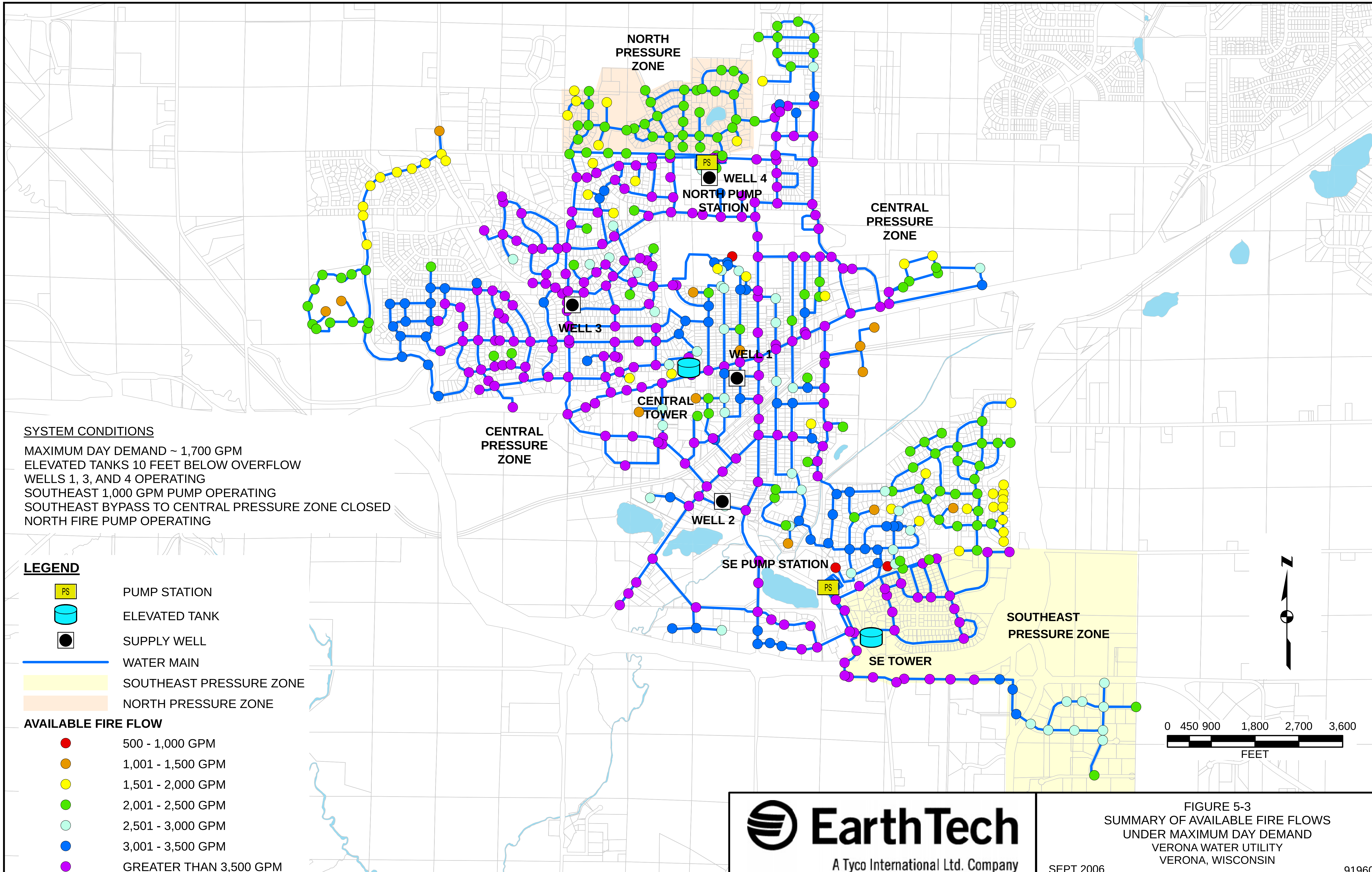

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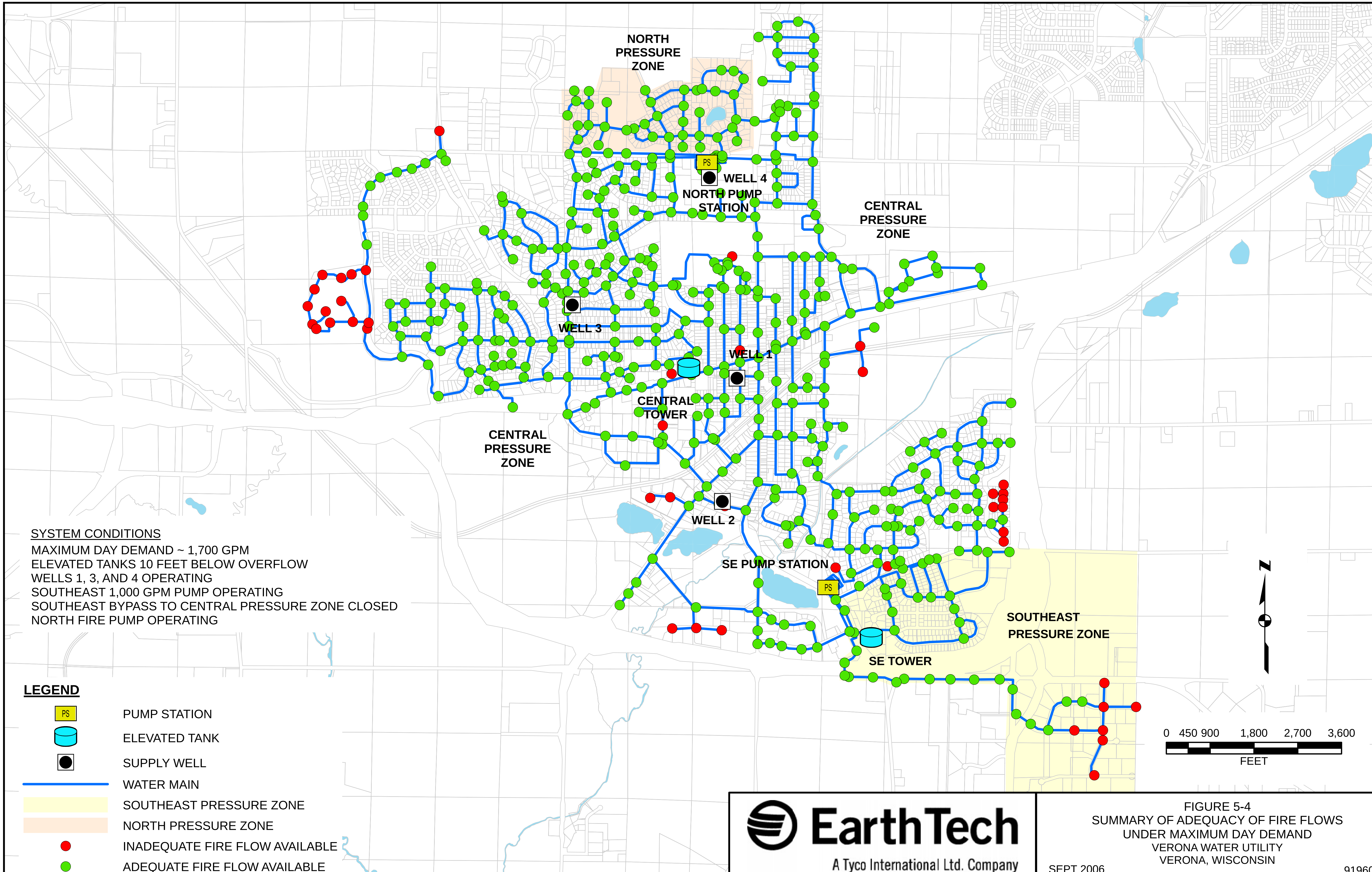
NORTH PRESSURE ZONE
PS
WELL 4
NORTH PUMP STATION
CENTRAL PRESSURE ZONE
WELL 3
WELL 1
CENTRAL TOWER
CENTRAL PRESSURE ZONE
WELL 2
SE PUMP STATION
PS
SE TOWER
SOUTHEAST PRESSURE ZONE
N
0 450 900 1,800 2,700 3,600
FEET
SYSTEM CONDITIONS
MAXIMUM DAY DEMAND ~ 1,700 GPM
ELEVATED TANKS 10 FEET BELOW OVERFLOW
WELLS 1, 3, AND 4 OPERATING
SOUTHEAST 1,000 GPM PUMP OPERATING
SOUTHEAST BYPASS TO CENTRAL PRESSURE ZONE CLOSED
NORTH FIRE PUMP OPERATING
LEGEND
PS PUMP STATION
ELEVATED TANK
SUPPLY WELL
WATER MAIN
SOUTHEAST PRESSURE ZONE
NORTH PRESSURE ZONE
INADEQUATE FIRE FLOW AVAILABLE
ADEQUATE FIRE FLOW AVAILABLE
EarthTech
A Tyco International Ltd. Company
FIGURE 5-4
SUMMARY OF ADEQUACY OF FIRE FLOWS
UNDER MAXIMUM DAY DEMAND
VERONA WATER UTILITY
VERONA, WISCONSIN
SEPT 2006
91960

5.5 WATER AGE

Levels of chemical water treatments or water contaminant (such as chlorine and disinfection byproducts (DBPs), respectively) are generally not constant within a water distribution system. Constituent levels will vary over time as either decay or growth in the water distribution system. As a result of these and other time dependent reactions in the distribution system, water age can be used as the basis for evaluating water quality. In general, water quality deteriorates with time, thus older water can be an indicator of potential water quality concerns.

General industry guidelines indicate water age should be minimized in the distribution system to maintain good water quality. According to the AwwaRF *Guidance Manual for Maintaining Distribution System Water Quality* report, distribution system water age should not exceed five to seven days.

Water age in the City of Verona varies depending upon water demands and distance from the supply wells. As water demands increase, water age decreases, and water age will be lower nearer the source of supply than locations farther away. To determine water age, the water system model was run for a period of 240 hours (10 days). Under average day demand conditions, water age was estimated to exceed five days at dead ends and at the extremities of the system, as illustrated on Figure 5-5. As seen in Figure 5-5, the majority of the Central Pressure Zone was estimated to have water age less than two days. Actual water age, however, will vary depending upon actual demand conditions.

One of the important limitations in water quality modeling is the type of mixing that is assumed at the water towers. In reality, there are many variables at a tank that affect circulation, such as inlet/outlet piping configurations, inlet velocity, tank geometry, and thermal stratification. Therefore, there may be isolated pockets of water in some tanks that are significantly older than the average water age predicted by the model.

Low water age within the Verona water system can be attributed to the current system operations. Based on current operation, the volume of water towers are allowed to reach near empty before being refilled, resulting in reduced water age. Consequently, very little water is stored for fire emergencies when the water towers are at the lowest water levels.

5.6 WATER SUPPLY AND STORAGE ANALYSIS

A critical step in the water system evaluation for the City of Verona is an assessment of water supply and storage requirements. Water supply and storage needs are closely related. The primary criteria used in determining required supply rates and storage volumes include maximum day and peak hour demands, operational characteristics, and fire protection needs.

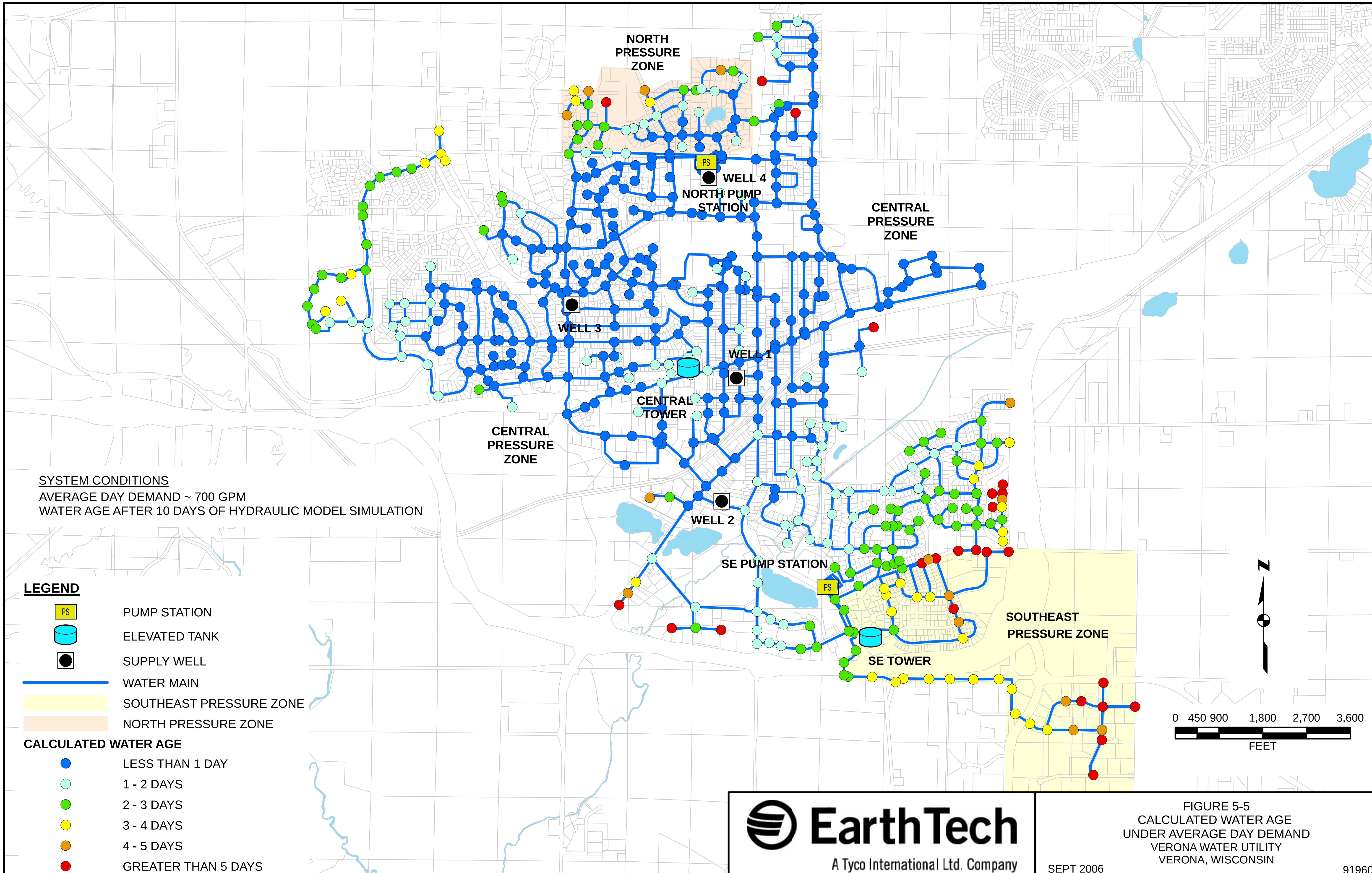

FIGURE 5-5
CALCULATED WATER AGE
UNDER AVERAGE DAY DEMAND
VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006

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5.6.1 Reliable System Capacity

It is frequently necessary to take a well and/or booster pump out of service for periods of several days to several weeks for maintenance; therefore, the reliable system capacity is the total available delivery rate with the largest pumping unit out of service. For evaluating a municipal water system, reliable system capacity should at least equal maximum day pumpage requirements, assuming adequate storage is available. If this criterion is met, supply facilities will have adequate capacity to replenish storage during off-peak hours, while depletion of available storage occurs during peak demand hours.

For the Verona Water Utility, reliable system capacity needs to be evaluated for the following two specific requirements:

1. Water supply capacity
2. Booster pumping capacity

Reliable water supply capacity is the capacity of the existing supply system to reliably supply maximum day demands. Reliable booster pumping capacity is the capacity of the booster pumps to deliver water to the appropriate pressure zones as required. Table 5-1 summarizes the well and booster pump capacities used for the reliable water supply and booster pumping capacity evaluations. The following two sections discuss reliable water supply capacity and reliable booster pumping capacity in further detail for the existing water system.

5.6.1.1 Reliable Water Supply Capacity

Based on the reliable water supply capacities of the existing wells (summarized in Table 5-1), reliable supply capacity evaluations were performed on the existing water system for the following two demand conditions:

1. Current design maximum day
2. 2030 projected maximum day

Since all the current water supply capacity is in the Central Pressure Zone, the reliable water supply capacity evaluation is for the entire system. The following section discusses the reliable booster pumping capacity for evaluating the ability to deliver water to the pressure zones as required.

The reliable supply capacity evaluation for the current design maximum day and 2030 projected maximum day is summarized in Table 5-2. The table summarizes the maximum day demand requirement and the available reliable water supply capacity.

As shown in Table 5-2, the reliable supply capacity from the wells is 4.18 MGD (2,900 gpm). As summarized in the table, there is currently adequate reliable water supply capacity (an excess of approximately 1.67 MGD (1,160 gpm); however, by 2030, there will be a deficiency of approximately 4.6 MGD (3,190 gpm).

TABLE 5-1
EXISTING RELIABLE SUPPLY CAPACITY
VERONA WATER UTILITY
VERONA, WISCONSIN

	Current Average Operating Capacities					
	Central Pressure Zone		North Pressure Zone		Southeast Pressure Zone	
SUPPLY SOURCE	**(gpm)**	**(MGD)**	**(gpm)**	**(MGD)**	**(gpm)**	**(MGD)**
Groundwater Wells						
Well 1	400	0.58				
Well 2	1,000	1.44				
Well 3	1,500	2.16				
Well 4	1,500	2.16				
Booser Pumps						
North Booster Pump 1			50	0.07		
North Booster Pump 2			100	0.14		
North Booster Pump 3			100	0.14		
North Booster Pump 4			1,500	2.16		
Southeast Booster Pump 1					1,000	1.44
Southeast Booster Pump 2					1,000	1.44
Southeast Booster Pump 3					100	0.14
Total Supply Capacity	4,400	6.34	1,750	2.52	2,100	3.02
Less: Largest Supply Unit	1,500	2.16	1,500	2.16	1,000	1.44
RELIABLE SUPPLY CAPACITY	**2,900**	**4.18**	**250**	**0.36**	**1,100**	**1.58**

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TABLE 5-2
SUMMARY OF RELIABLE WATER SUPPLY CAPACITY

Description	Design 2005		Projected 2030	
Design Maximum Day Demand	2.51 MGD	1,740 gpm	8.78 MGD	6,090 gpm
Existing Reliable Water Supply (from Table 5-1)	4.18 MGD	2,900 gpm	4.18 MGD	2,900 gpm
Additional Reliable Supply Capacity Required	--	--	4.60 MGD	3,190 gpm
Excess Reliable Supply Capacity	1.67 MGD	1,160 gpm	--	--

5.6.1.2 Reliable Booster Pumping Capacity

Based on the reliable booster pumping capacities of the existing booster pumps (summarized in Table 5-1), reliable booster pumping capacity evaluations were performed by pressure zone based on the existing water system for the following two demand conditions:

1. Current design maximum day
2. 2030 projected maximum day

The reliable booster pumping capacity evaluation for the current design maximum day and the 2030 projected maximum day are summarized in Table 5-3. For each pressure zone, the table summarizes the maximum day demand requirement and the required reliable booster pumping capacity for each pressure zone. The table also illustrates the current available reliable booster pumping capacity and identifies the deficiency in reliable booster pumping capacity if one exists.

As summarized in the table, there is currently adequate reliable booster pumping capacity in the North Pressure Zone to meet current requirements; however, by 2030, it is projected there will be a deficiency of approximately 0.35 MGD (240 gpm).

There is currently adequate reliable booster pumping capacity in the Southeast Pressure Zone; however, by 2030, it is projected there will be a deficiency of approximately 0.49 MGD (340 gpm).

As development occurs in the future, the future East Pressure Zone will be created to provide the customers in this area adequate pressures and flows. By 2030, it is estimated the future East Pressure Zone will require a reliable booster pumping capacity of approximately 0.26 MGD (180 gpm).

TABLE 5-3
SUMMARY OF RELIABLE BOOSTER PUMPING CAPACITY

Description	Design 2005		Projected 2030	
North Pressure Zone				
Design Maximum Day Demand	0.11 MGD	80 gpm	0.71 MGD	490 gpm
Existing Reliable Booster Pumping Capacity (from Table 5-1)	0.36 MGD	250 gpm	0.36 MGD	250 gpm
Additional Reliable Booster Pumping Capacity Required	--	--	0.35 MGD	240 gpm
Excess Reliable Booster Pumping Capacity	0.25 MGD	170 gpm	--	--
Southeast Pressure Zone				
Design Maximum Day Demand[1]	0.17 MGD	120 gpm	1.81 MGD	1,260 gpm
Required Reliable Booster Pumping Capacity	0.17 MGD	120 gpm	2.07 MGD	1,440 gpm
Existing Reliable Booster Pumping Capacity (from Table 5-1)	1.58 MGD	1,100 gpm	1.58 MGD	1,100 gpm
Additional Reliable Booster Pumping Capacity Required	--	--	0.49 MGD	340 gpm
Excess Reliable Booster Pumping Capacity	1.41 MGD	980 gpm	--	--
Future East Pressure Zone				
Design Maximum Day Demand	--	--	0.26 MGD	180 gpm
Existing Reliable Booster Pumping Capacity (from Table 5-1)	--	--	--	--
Additional Reliable Booster Pumping Capacity Required	--	--	0.26 MGD	180 gpm
Excess Reliable Booster Pumping Capacity	--	--	--	--

Footnote:
[1] The design maximum day demand for the Southeast Pressure Zone includes the maximum day for the future East Pressure Zone, as this is the required reliable booster pumping capacity for the Southeast Pressure Zone.

5.6.2 Supply Reliability

For any water utility to serve its customers and protect the public welfare, water system facilities, equipment, and distribution systems must be reliable under all operating conditions. Reliability of utility service comprises a large part of the investment in plant and equipment.

WAC, Section NR 811.30, requires all pumping stations to be served by a power supply from at least two independent electrical substations or from a standby, auxiliary power source dedicated to water supply use. As a general rule, the City of Verona should be able to reliably supply average day customer demands and maintain adequate fire protection using auxiliary power sources.

The City of Verona has standby power available at Well 2 and Well 4 . The system can supply approximately 2,500 gpm (3.60 MGD) using standby power sources in the event of an emergency or other power interruption; therefore, the system has sufficient auxiliary power to meet current needs and projected year 2030 average day pumpage requirements. The Verona Water Utility can maintain water supply provided with auxiliary sources of power to meet a minimum of an average day water demand throughout the planning period.

The standby generator at Well 4 also supplies power to the North Pump Station, ensuring adequate power to meet current and future average day demands within the North Pressure Zone. A transfer switch exists at the Southeast Pump Station to allow for connection of a portable generator to power the booster station in the event of power interruption.

5.6.3 Water Storage Needs

In addition to providing water for fire protection, system storage is used as a “cushion” to equalize fluctuations in customer demands, establish and maintain water system pressures, provide operational flexibility for water supply facilities, and improve water supply reliability. The primary criteria used in this study for evaluating storage volume needs include average and peak demands, water supply capacities, and fire protection needs.

In general, storage facilities should be adequately sized to provide sufficient quantities of water for fire protection on days of maximum customer demands. Although storage requirements for fire protection are not anticipated to change over the planning period of this study, peak hour demands and reliable supply capacities will change as the community grows and improvements are implemented.

Figure 5-6 illustrates general categories of system storage. As customer demands exceed supply capacities during peak hour conditions, the excess demands must be met by depleting available storage. The amount of storage depleted is referred to as equalizing storage for peak hour requirements. Storage should also be available for fire protection purposes. To assure a reliable supply for fire protection, this reserve storage should not be utilized to meet peak hour requirements.

In some instances, it may be desirable to provide additional reserve storage for other purposes. Reserve storage may be needed as a safety factor in emergencies or where customer demands are unpredictable and fluctuate widely. Additional storage may also be desired to take advantage of off-peak electrical rates for pumping. Additional reserve storage of approximately 10 to 15 percent is usually provided to allow an operating range for pump station operation.

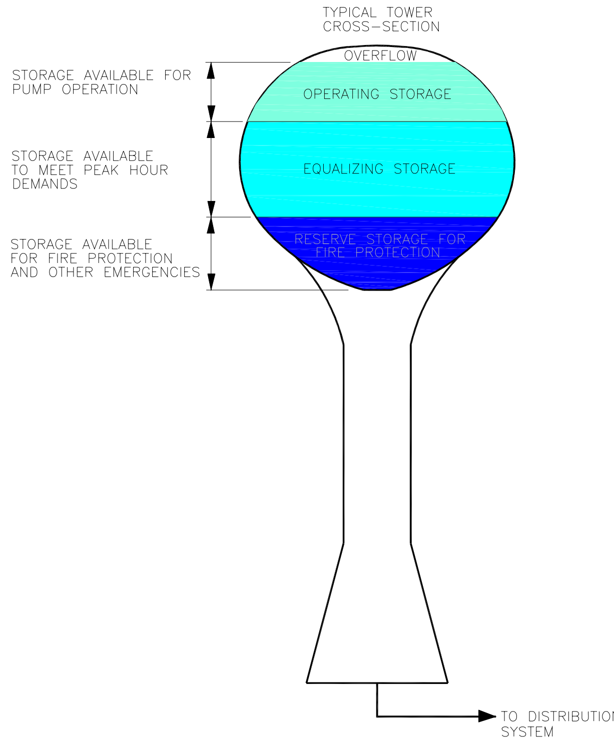

FIGURE 5-6: DISTRIBUTION SYSTEM STORAGE REQUIREMENTS

The primary criteria used to develop a relationship between supply capacities and optimum storage volumes were:

1. Reliable supply capacity should at least equal projected maximum day supply requirements.

2. Total available storage should be capable of meeting fire protection needs, assuming reliable supply capacity is adequate to meet maximum day requirements.

3. Where reliable system capacity exceeds maximum day demands, the excess reliable system capacity may offset total storage requirements in the following ways:

   a. Peak Hour Equalization Storage: If reliable system capacity is greater than maximum day demand requirements.

   b. Fire Protection Storage: Equal to the excess reliable system capacity which exceeds the peak hour demand requirements for the duration of the maximum fire flow requirement for the pressure zone.

4. If an automatic control valve(s) allows water to be provided from a high level pressure zone to a lower pressure zone, available storage in the high pressure zone less the sum of the peak hour equalization storage and the reserve storage may offset the fire protection storage requirement in the lower pressure zone.

Based on the criteria discussed in Section 5.3, the maximum fire flow requirement assumed for each pressure zone is summarized in Table 5-4.

TABLE 5-4
SUMMARY OF MAXIMUM FIRE FLOW REQUIREMENTS BY PRESSURE ZONE

Pressure Zone	Fire Flow Requirement		Duration	Recommended Fire Protection Storage Requirement	
	Current	Future		Current	Future
Central Pressure Zone	3,500 gpm	3,500 gpm	3 hours	630,000 gallons	630,000 gallons
North Pressure Zone	2,500 gpm	3,500 gpm		450,000 gallons	630,000 gallons
Southeast Pressure Zone	3,500 gpm	3,500 gpm		630,000 gallons	630,000 gallons
Future East Pressure Zone	---	2,500 gpm		---	450,000 gallons

5.6.4 Available Storage Capacity

A global review of available storage capacity for the entire Verona water system does not provide a completely adequate evaluation of available storage capacity, since the system is currently divided into three pressure zones. The following sections evaluate the storage requirements for each pressure zone. Tables 5-5 and 5-6 summarize the existing and projected storage needs for each pressure zone.

5.6.4.1 Central Pressure Zone

The total available storage for the Central Pressure Zone is 0.3 MG. The estimated existing and projected optimum water storage requirements for the Central Pressure Zone, assuming a fire flow requirement of 3,500 gpm for three hours, are approximately 1.2 MG and 1.6 MG, respectively; therefore, there is currently a shortfall of storage in the Central Pressure Zone.

5.6.4.2 Southeast Pressure Zone

The total available storage for the Southeast Pressure Zone is 0.3 MG. The estimated existing and projected optimum water storage requirements for the Southeast Pressure Zone, assuming a fire flow requirement of 3,500 gpm for three hours, are approximately 0.8 MG and 1.0 MG, respectively; therefore, there is currently a shortfall of storage in the Southeast Pressure Zone (largely due to the fire flow requirement).

TABLE 5-5
EXISTING STORAGE REQUIREMENTS
VERONA WATER UTILITY
VERONA, WISCONSIN

SUPPLY REQUIREMENTS	Central Pressure Zone	North Pressure Zone	Southeast Pressure Zone
Design Average Day Demand (gpm)	660	50	30
Design Maximum Day Demand (gpm)	1,550	110	80
Design Peak Hour Demand (gpm)	2,590	200	130
Present Reliable Supply Capacity (gpm)	2,900	250	1,100
Reliable Supply Capacity in Excess of Maximum Day Demand (gpm)	1,350	140	1,020
Reliable Supply Capacity in Excess of Peak Hour Demand (gpm)	310	50	970

STORAGE REQUIREMENTS	Central Pressure Zone	North Pressure Zone	Southeast Pressure Zone
Peak Hour Equalizing Requirements (gallons) [1]	405,000	35,000	15,000
Optimum Fire Protection Needs (gallons) [2]	630,000	450,000	630,000
Reserve Storage (gallons; 15% of Total) [3]	183,000	86,000	114,000
Total Optimum Storage Requirements (gallons)	1,218,000	571,000	759,000
Available Effective Storage Capacity (gallons):			
Central Tower	300,000		
Southeast Tower			300,000
Total Effective Storage Capacity	300,000	None	300,000
Subtotal Capacity Required (gallons)	918,000	571,000	459,000
Less Excess Available Reliable System Supply Capacity			
Supply Capacity in Excess of Peak Hour for Fire Protection	56,000	9,000	175,000
Peak Hour Supply Capacity for Peak Hour Equalization [4]	405,000	35,000	15,000
Less Fire Protection from High Level Pressure Zone			
Capacity in Excess of Peak Hour Equalizing and Reserve	171,000	None	None
Total Additional Capacity Required (gallons)	286,000	527,000	269,000

Notes

1. Peak hour storage is storage required to meet demands which exceed the maximum day demand rate assuming the reliable supply capacity is equal to the maximum day demand rate.
2. Optimum fire protection based on requirement for industrial of 3,500 gpm for 180 minutes and commercial of 2,500 gpm for 180 mins.
3. Reserve storage is storage required to provide a start/stop range for pump operation and an emergency reserve storage supply.
4. Peak Hr Supply Capacity cannot exceed Peak Hr Equalization and calculated utilizing time of day demand curve and supply capacity.

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TABLE 5-6
FUTURE STORAGE REQUIREMENTS
VERONA WATER UTILITY
VERONA, WISCONSIN

SUPPLY REQUIREMENTS	Central Pressure Zone	North Pressure Zone	Southeast Pressure Zone	Future East Pressure Zone
Design Average Day Demand (gpm)	1,770	210	530	80
Design Maximum Day Demand (gpm)	4,160	490	1,260	180
Design Peak Hour Demand (gpm)	6,950	880	2,100	300
Present Reliable Supply Capacity (gpm)	2,900	250	1,100	0
Maximum Day Demand in Excess of Reliable Supply Capacity (gpm)	None	None	None	None
Peak Hour Demand in Excess of Reliable Supply Capacity (gpm)	None	None	None	None

STORAGE REQUIREMENTS	Central Pressure Zone	North Pressure Zone	Southeast Pressure Zone	Future East Pressure Zone
Peak Hour Equalizing Requirements (gallons) [1]	762,000	90,000	230,000	33,000
Optimum Fire Protection Needs (gallons) [2]	630,000	630,000	630,000	450,000
Reserve Storage (gallons; 15% of Total) [3]	246,000	128,000	152,000	86,000
Total Optimum Storage Requirements (gallons)	1,638,000	848,000	1,012,000	569,000
Available Effective Storage Capacity (gallons):				
Central Tower	300,000			
Southeast Tower			300,000	
Total Effective Storage Capacity	300,000	None	300,000	None
Subtotal Capacity Required (gallons)	1,338,000	848,000	712,000	569,000
Less Excess Available Reliable System Capacity				
Capacity in Excess of Peak Hour for Fire Protection	None	None	None	None
Peak Hour Capacity for Peak Hour Equalization	None	None	None	None
Less Fire Protection from Other Pressure Zone				
Capacity in Excess of Peak Hour Equalizing and Reserve	None	None	None	None
Total Additional Capacity Required (gallons)	1,338,000	848,000	712,000	569,000

Notes

1. Peak hour storage is storage required to meet demands which exceed the maximum day demand rate assuming the reliable supply capacity is equal to the maximum day demand rate.
2. Optimum fire protection based on requirement for industrial of 3,500 gpm for 180 minutes and commercial of 2,500 gpm for 180 minutes.
3. Reserve storage is storage required to provide a start/stop range for booster pump operation and an emergency reserve storage supply.

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5.6.4.3 North Pressure Zone

There is currently no storage in the North Pressure Zone. Assuming a current fire flow requirement of 2,500 gpm for three hours, the existing water storage requirement for the North Pressure Zone is approximately 0.6 MG; therefore, there is currently a shortfall. With the future potential increase in fire flow requirements and additional growth within the pressure zone, the existing storage shortfall will increase to approximately 0.85 MG.

5.6.4.4 Future East Pressure Zone

Table 5-6 summarizes the projected storage needs for the future East Pressure Zone. The estimated 2030 optimum water storage requirement for the future East Pressure Zone, assuming a fire flow requirement of 2,000 gpm for three hours, is approximately 0.5 MG.

5.7 SUMMARY

This section summarizes the findings from the evaluation of the Verona water system. Major findings from this evaluation include the following:

1. Under all normal operation conditions, the system provides pressures that meet the minimum recommended pressure of 35 psi to all portions of the City. Water system pressures range from approximately 46 to 96 psi under peak hour demand conditions.

2. Estimated available fire flows range from approximately 900 gpm to 3,500+ gpm throughout the water system. The available fire flows meet the assumed need throughout the majority of the water system; however, some deficient areas were identified including:

    a. Dead end water mains and small diameter water mains

    b. Industrial areas including the Verona Technology Park, Venture Court Industrial Park, along Investment Court, and at Epic Systems Corporation (improvement in available fire flows in area with additional 2006 water main projects).

    c. Multi-family area on Golden Rod Circle (improvement in available fire flows in area with additional 2006 water main projects).

    d. Extremities of the water system.

3. Based on hydraulic model simulations, only the water main serving the Central Tower and the 8-inch discharge water mains at Wells 3 and 4 experience velocities in excess of 5 fps and headlosses of 10 feet per 1,000 feet during peak hour simulations.

4. Under simulated average day water demands, water age was estimated to exceed five days at the extremities of the system and at dead end locations. General industry guidelines indicate water age should not exceed five to seven days in the system to maintain good water quality, according to an AwwaRF report. The majority of the Central Pressure Zone was estimated to have water age less than two days.

5. Verona has adequate reliable supply to meet current optimum supply requirements; however, additional supply capacity (approximately 4.6 MGD) is needed to meet projected 2030 reliable supply requirements.

6. The system currently has adequate reliable booster pumping capacity to meet existing water demands in the North Pressure Zone; however, it is projected that by 2030, there will be a deficiency in reliable booster pumping capacity in the North Pressure Zone of approximately 0.35 MGD.

7. The system currently has adequate reliable booster pumping capacity to meet existing water demands in the Southeast Pressure Zone; however, it is projected that by 2030, there will be a deficiency in reliable booster pumping capacity in the Southeast Pressure Zone of approximately 0.49 MGD.

8. As development occurs, it is projected that the future East Pressure Zone will require a reliable booster pumping capacity of approximately 0.26 MGD.

9. The Verona Water Utility can maintain water supply provided with auxiliary sources of power to meet a minimum of an average day water demand throughout the planning period for all existing pressure zones.

10. The system currently does not have adequate storage in the Central, Southeast, and North Pressure Zones to meet existing and projected 2030 storage requirements.

6.0 ANALYSIS OF WATER SYSTEM IMPROVEMENTS

This chapter presents an evaluation of water system improvements to address the existing water system deficiencies and improve overall water system operation. Based on deficiencies discussed in Chapter 5, the water system will require improvements to address existing water system deficiencies and improve overall water system operation. In addition, the water system will require improvements to serve future developments. The chapter concludes with recommended water system improvements that will meet the needs and requirements of the Verona Water Utility over the planning period.

This chapter details the evaluation of the following improvements:

- Water supply to the 2030 service area
- Water supply improvements
- Water storage improvements
- Supply to pressure zones and booster pumping improvements
- Distribution system improvements and expansion

The recommended improvements have been developed as a tool to guide the Utility in the siting and sizing of future system improvements. While the plan may represent the current planned expansion of the Verona water system, future changes in land use, water demands, or customer characteristics could substantially alter implementation of the plan. For this reason, it is recommended that the plan be periodically reviewed and updated using City planning information to reflect the most current projections of area growth and development.

The improvement plan is a guidance document that details existing conditions and recommendations for the future. The plan is based on future conditions as perceived in 2006. As time progresses and the entire water system master plan is completed, additional information will become available and events will shape the development of the Verona water system service area The plan must be dynamic in response; it should be studied and used but also adjusted to conform to the changes and knowledge that will come with time.

6.1 WATER SUPPLY TO 2030 URBAN SERVICE AREA

A critical step in long range planning for the Verona Water Utility was identifying the future needs of the service area coupled with an assessment of water supply and storage requirements. Figure 2-2 in Chapter 2 illustrates the anticipated City of Verona year 2030 urban service boundary within which municipal water service is expected to serve. The topography of the Verona area makes providing water service to some areas difficult. Therefore, as development occurs, the Utility will need to review the preferred method to provide service to each area.

Figure 6-1 illustrates the areas in the 2030 urban service area that can be served by the existing hydraulic grade lines (HGLs) in the existing pressure zones. As illustrated in the figure, there are areas which can be adequately served from more than one existing pressure zone. There are also areas which cannot or may marginally be able to be served from the existing pressure zones which are included on Figure 6-1 as Areas A through H. As the City develops in these areas, the Utility has the following three options to consider:

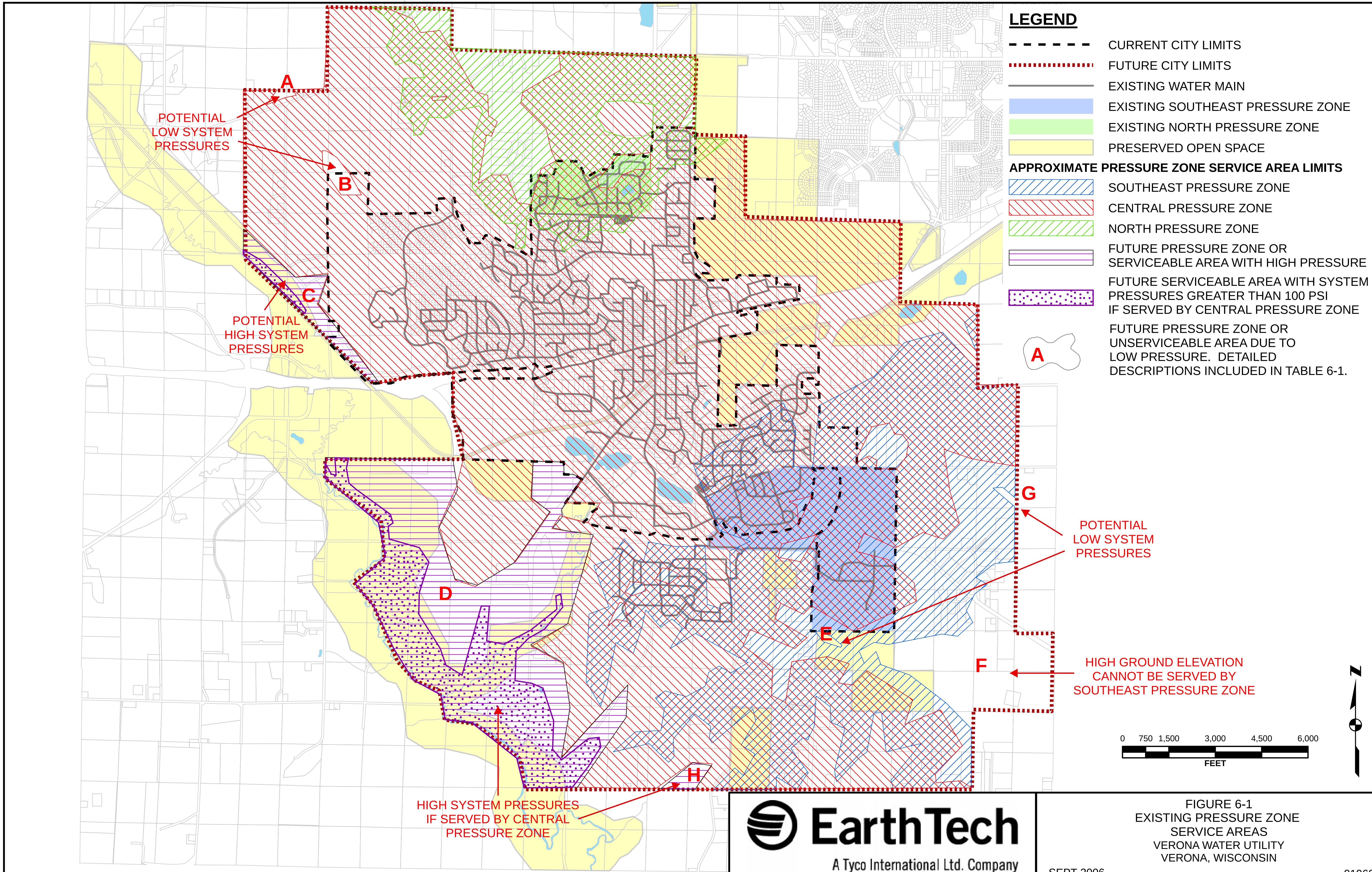

FIGURE 6-1
EXISTING PRESSURE ZONE
SERVICE AREAS
VERONA WATER UTILITY
VERONA, WISCONSIN

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1. Prohibit growth in the area.

2. In areas of lower elevation, accept areas of pressure in excess of 100 psi and install PRVs on individual services.

3. Create an additional pressure zone(s) as necessary to adequately serve the areas of higher or lower elevation as development occurs.

Table 6-1 summarizes the concern areas and the recommendations.

TABLE 6-1
SUMMARY OF AREAS OF CONCERN

Area	Concern	Recommendation Option
A	Area of high elevation (approximately 1,052 to 1,058 feet USGS) which will experience pressures below 38 psi. Due to low pressures and size of area, limit growth in this area.	1
B	Area of high elevation (approximately 1,052 to 1,060 feet USGS) which will experience pressures below 37 psi. Due to low pressures and size of area, limit growth in this area.	1
C	Area of low elevation (approximately 924 to 940 feet USGS) which will experience pressure above 90 psi when served by the Central Pressure Zone.	2
D	Area of low elevation (approximately 920 to 940 feet USGS) which will experience pressure above 90 psi when served by the Central Pressure Zone, may consider additional pressure zone.	2
E	Area of high elevation (approximately 1,108 to 1,128 feet USGS) which will experience pressures below 35 psi. Due to low pressures and size of area, limit growth in this area.	1
F	Area of high elevation (up to approximately 1,208 feet USGS) which will experience pressure below 35 psi. New high level pressure zone recommended.	3
G	Area of high elevation (approximately 1,108 to 1,116 feet USGS) which will experience pressures below 37 psi. Due to low pressures and size of area, limit growth in this area.	1
H	Area of low elevation (approximately 932 to 940 feet USGS) which will experience pressure above 90 psi when served by the Central Pressure Zone.	2

The two areas that warrant further discussion are Areas F and D. Area F cannot be adequately served from an existing pressure zone. For the short term, development may be able to be discouraged in this area of higher elevation. However, it will be difficult to prohibit development in this area over the long-term future. Therefore, it is recommended that a new East Pressure Zone with an HGL of approximately 1,324 feet USGS be established as development occurs in Area F.

Area D may be served from the Central Pressure Zone; however, water system pressures above 100 psi may be experienced at times. As previously stated, WAC Chapter Comm 82 requires that PRVs be installed on individual services if the supply pressure exceeds 80 psi. While not the responsibility of the Utility, knowledge of the Comm 82 requirement may assist the Utility with decision making during the planning process. One option is to create an additional pressure zone which may be served from the Central Pressure Zone by PRVs. Due to the large area of preserved open space in Area D (and the higher elevations on the west side of the Sugar River), it is recommended that the Utility begin to serve Area D from the existing Central Pressure Zone and evaluate the need for an additional pressure zone as development occurs.

Figure 6-2 illustrates the proposed pressure zones for the 2030 urban service area. The major modifications to the pressure zones are summarized in Table 6-2.

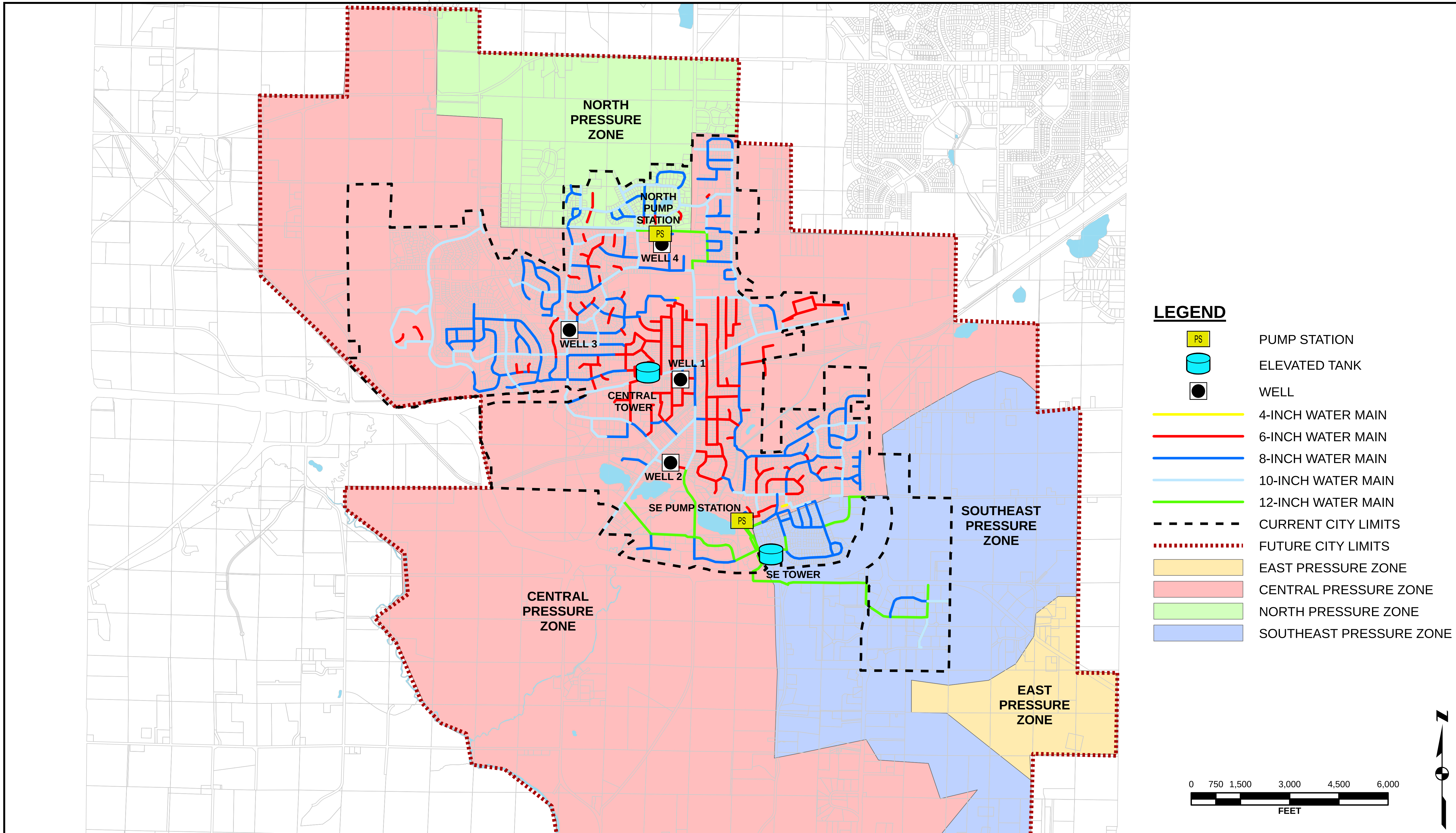

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FIGURE 6-2
FUTURE WATER SYSTEM
PRESSURE ZONES
VERONA WATER UTILITY
VERONA, WISCONSIN

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TABLE 6-2
SUMMARY OF PRESSURE ZONES

Pressure Zone	Description
Central Pressure Zone	Expanding primarily to the south and west, some potential areas of high water system pressure as illustrated in Figure 6-1.
North Pressure Zone	Expanding to the north and west.
Southeast Pressure Zone	Expanding primarily to the south and east.
Future East Pressure Zone	New pressure zone due to the high elevations which cannot be adequately served by the Southeast Pressure Zone.

Table 6-3 summarizes the existing range of elevations served in each pressure zone and the proposed future elevations to be served.

TABLE 6-3
SUMMARY OF ELEVATIONS SERVED BY PRESSURE ZONE

Pressure Zone	Existing			Future[3]		
	HGL (feet USGS)	Elevations (feet USGS)	Pressures[1] (psi)	HGL (feet USGS)	Elevations (feet USGS)	Pressures[1] (psi)
Central Pressure Zone	1,156	940 - 1,050	46 - 94	1,156	920 - 1,060	42 - 102
North Pressure Zone	1,231	1,008 - 1,072	69 - 97	1,231	992 - 1,128	45 - 103
Southeast Pressure Zone	1,212	1,008 - 1,084	55 - 88	1,212	972 - 1,128	36 - 104
Future East Pressure Zone	--	--	--	1,324[2]	1,068 - 1,208	50 - 111

Footnotes:
1 Pressures will vary depending on system conditions (demands, facilities operating, etc.)
2 Based on providing a static pressure of approximately 50 psi at the highest elevation in the service area.
3 With proposed pressure zone boundary modifications and future growth within planning area.

As previously stated, the Utility will have to determine how to serve specific growth areas as future development occurs. During planning for future development, the information provided in this section should be reviewed with additional information available at the time to determine the best possible strategy to provide water service. One such preliminary evaluation was completed as part of this project. As outlined in Figure 6-3, a future development is planned south of the existing Verona Technology Park. This development is shown in three separate future pressure zones on Figure 6-2; however, only the Southeast Pressure Zone currently provides service near this development. The majority of this future development can be served by the Southeast Pressure Zone with some areas of high pressure. As shown on Figure 6-3, the extreme northeast corner cannot be served due to high ground elevations, and the area in the west of the development where low ground elevations exist will experience high water pressures.

It is recommended that initially, the development be served by the Southeast Pressure Zone, and if the Utility is concerned with the high system pressure, PRVs can be installed. Individual PRVs may be installed on each service according to WAC, Chapter Comm 82, or system PRVs may be installed to keep water system pressure in the water mains below a desired pressure. It is recommended that as the Central Pressure Zone develops near this development, the development should be spilt into the pressure zones illustrated in Figure 6-2 to remove the need for the PRVs. The layout of water mains in this development should be planned to allow for this conversion in the future.

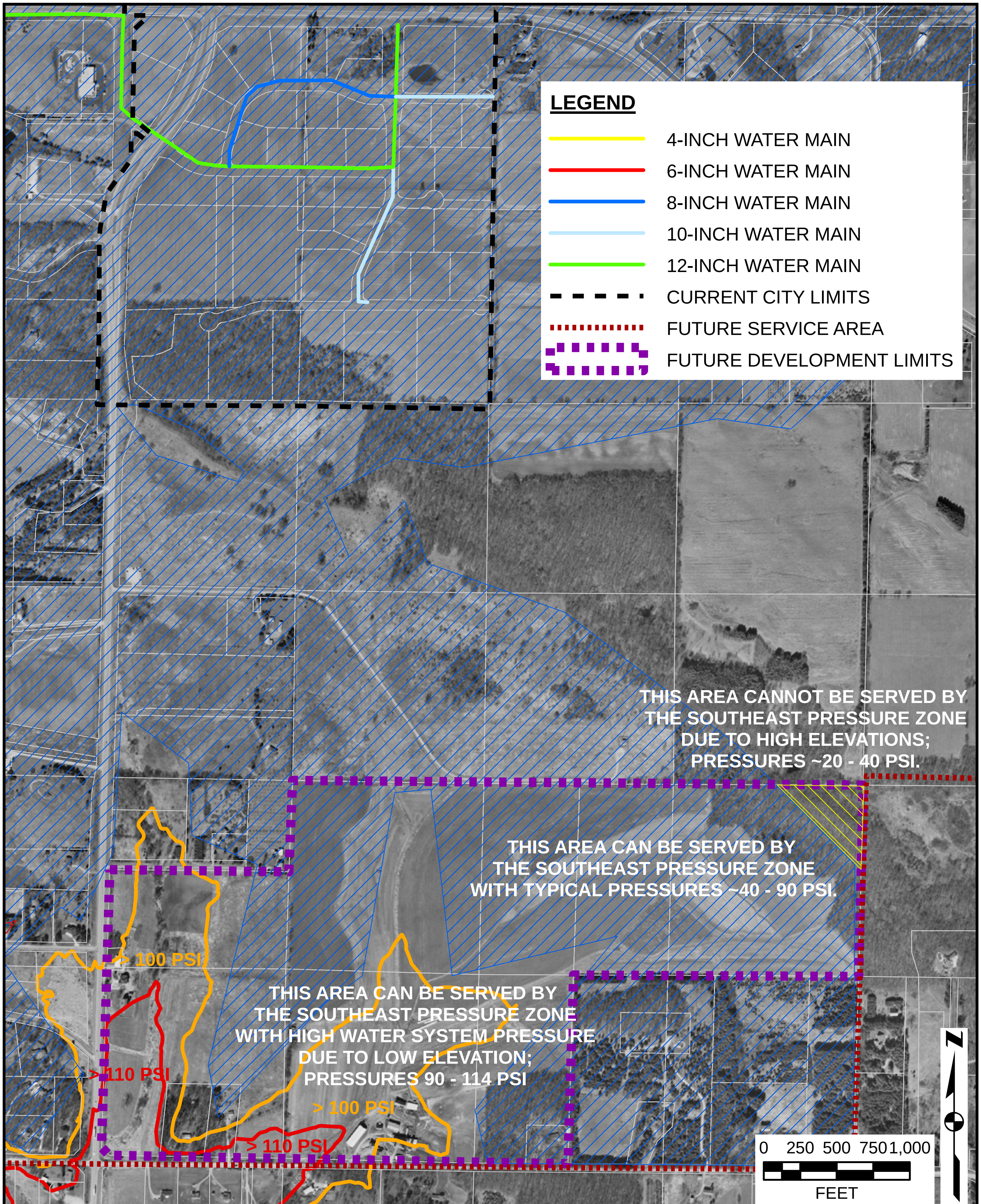

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FIGURE 6-3
FUTURE DEVELOPMENT EVALUATION
SOUTHEASTERN VERONA
VERONA WATER UTILITY
VERONA, WISCONSIN

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6.2 WATER SUPPLY IMPROVEMENTS

The projected 2030 maximum day water demand is approximately 8.78 MGD (6,090 gpm), which is approximately 4.6 MGD (3,190 gpm) greater than the existing reliable water supply capacity of the system. Therefore, additional water supply is required to meet the projected future water system demands. Based on the projected water system demands, it is recommended that a minimum of three additional wells with a minimum capacity of 1,200 gpm be constructed during the planning period. It is believed the potential well capacity in the area is 1,000 to 1,500 gpm; therefore, it is assumed 1,200 gpm is achievable.

The exact year that the supply wells will be required is based on the population growth discussed in Chapter 2 and the water needs described in Chapter 3. If a large water user is added or populations do not meet expectations, the timeframe may change.

The Utility is interested in constructing a future well at the site of existing Well 1. The existing 400 gpm capacity Well 1, which was constructed in 1932, would be abandoned to construct a new higher capacity well. If Well 1 is replaced with a new 1,200 gpm or larger capacity well, only two additional wells will need to be constructed during the planning period. The Wisconsin Department of Natural Resources (DNR) will treat a new well at the Well 1 site as a completely new well and require all the elements listed in WAC, Chapter NR 811, for new well sites.

It is recommended that a study be completed for the siting of the future supply wells. The locations of a proposed well sites needs to be evaluated based on at least the following considerations:

1. Estimated yield potential.
2. Estimated water quality characteristics.
3. Proximity to existing and planned municipal wells, existing private wells, wetlands, and surface waters.
4. Apparent proximity to fracture traces or lineaments.
5. Location of known potential and existing contamination sources.
6. Minimum recommended separation distances to potential contamination sources.
7. Apparent land availability.
8. Transmission main requirements.
9. Probable wellhead protection requirements and the impacts on surrounding land uses.
10. Other possible limitations that may affect the feasibility of a well site area or well site.

The locations of the recommended new supply wells will impact the recommendations to provide adequate supply to the existing and future pressure zones. For the purposes of this study, it is assumed that two supply wells will be developed in the Central Pressure Zone, with one well at the existing Well 1 site, and one will be developed in the Southeast Pressure Zone. The locations of the new supply wells shown on the figures in this chapter are for illustrative purposes only.

6.3 CENTRAL PRESSURE ZONE

There is currently inadequate storage in the Central Pressure Zone, and as previously discussed, there is inadequate supply to meet the future projected system maximum day demand of 8.78 MGD (6,090 gpm). Therefore, it is recommended that a new 0.75 MG elevated tank and two new supply wells, with one well at the existing Well 1 site, be constructed in the Central Pressure Zone.

6.4 NORTH PRESSURE ZONE

It is anticipated that the existing North Pressure Zone will expand and development will occur during the planning period. Currently, the North Pressure Zone does not have storage; therefore, it is deficient in water storage. Assuming a supply well is not constructed in the North Pressure Zone in the future, the North Booster Station does not provide adequate booster pumping capacity to meet the projected future maximum day demand of 0.71 MGD (490 gpm). It is recommended that a 0.5 MG elevated tank be constructed in the North Pressure Zone with an overflow elevation of approximately 1,231 feet USGS. The location of the future elevated tank is planned in the vicinity of High Point Park, which will reduce initial water mains cost and the available open space will reduce future maintenance/painting costs. In addition, it is recommended that the three small booster pumps be replaced with two new 1,000 gpm booster pumps and a flow control valve which allows water to be supplied from the North Pressure Zone to the Central Pressure Zone if necessary. It is also recommended that an additional control valve be installed between the North and Central Pressure Zones.

6.5 SOUTHEAST PRESSURE ZONE

Currently, there is a deficiency in storage in the Southeast Pressure Zone (due to the large fire flow requirement, although current water system demands are small). As development occurs, it is recommended that a new supply well be constructed in the Southeast Pressure Zone (to eliminate the need to pump all the water from the Central Pressure Zone) and an additional 0.75 MG elevated tank with an overflow elevation of 1,212 feet USGS (to match the existing Southeast Tower) be constructed. It is also recommended that an altitude valve be installed at the existing Southeast Tower at the time the proposed new tower is constructed and two additional control valves be installed between the Central and Southeast Pressure Zones to improve available fire flows in the southern Central Pressure Zone. In the future, this pressure zone will also supply water to the future East Pressure Zone.

6.5.1 Storage Options

Although the permitting process with the Federal Aeronautics Administration (FAA) to build the proposed future elevated tank is time consuming due the proximity of the Verona Airpark, the Utility should plan an appropriate timeframe for approval to construct the recommended elevated tank when water demands warrant. Additional water storage options were considered due the proximity of the proposed elevated tank to the Verona Airpark. The Utility could consider constructing a ground reservoir and booster pump station to supply fire flow demands for the Southeast Pressure Zone. Construction of the ground reservoir for fire protection could be done in conjunction with the future East Pressure Zone Booster Station, allowing storage to also provide constant suction pressure to the high pressure zone while minimizing capital costs. Some of the disadvantages of ground storage with a booster station are:

- Available water storage dependent on mechanical equipment.
- Pressure variations may occur when booster pumps are operated.
- Higher operating costs associated with need to pump stored water into system to maintain water quality and inefficiencies in dual pumping systems.
- Additional operational complexity.

- More difficult to operate system when existing Southeast Tower is out of service for maintenance.

As stated previously, it is recommended that an additional 0.75 MG elevated tank with an overflow elevation of 1,212 feet USGS (to match the existing Southeast Tower) be constructed to meet future water storage capacity needs.

6.6 FUTURE EAST PRESSURE ZONE

It is recommended that the future East Pressure Zone be supplied by a booster pumping station and 0.2 MG ground reservoir located near the pressure zone boundary with the Southeast Pressure Zone. The booster pumping station should be equipped with variable speed booster pumps to establish the East Pressure Zone's pressure plane. The ground level storage tank will provide reliability in the event of a transmission main break serving the booster pump station. In addition, the ground storage can be utilized to reduce the dependency upon the Southeast Pressure Zone storage and transmission capacity by providing peak hour equalization. While no elevated storage is recommended at this time, if the future pressure zone demand warrants, an elevated tank should be constructed in the new high level pressure zone.

6.7 SUMMARY OF RECOMMENDED FACILITY IMPROVEMENTS

Table 6-4 summarizes the recommended water system facility improvements.

TABLE 6-4
SUMMARY OF IMPROVEMENTS

<table>
<tr><th>Short-Term Improvements</th><th>Comments</th></tr>
<tr><td>New 0.5 MG Tower in North Pressure Zone</td><td rowspan="2">• Optimum storage requirement is projected to be larger; additional storage volume may impact water quality.
• Recommended additional reliable booster pumping capacity to offset recommended reduced storage volume.
• Future storage requirement based on a fire flow requirement of 3,500 gpm for 3 hours (industrial areas). If no industrial areas develop in the North Pressure Zone, smaller tank and/or smaller booster pumps may be adequate.
• Flow control valve recommended to allow storage in North Pressure Zone to be available to the Central Pressure Zone in an emergency.</td></tr>
<tr><td>New Pumps and Flow Control Valve at North Pump Station</td></tr>
<tr><th>Mid-Term Improvements</th><th>Comments</th></tr>
<tr><td>New 0.75 MG Tower in Central Pressure Zone</td><td>• The location of the tank was selected due to higher elevation and anticipated larger fire flow requirements in area. Due to close proximity, Epic Systems concerns may need to be included during planning period.</td></tr>
<tr><td>New Supply Well in the Central Pressure Zone at Well 1 Site</td><td>• Additional supply source recommended in the Central Pressure Zone to support future development.
• Locating the new supply well at the Well 1 site allows the Utility to replace the existing low capacity well. The DNR will treat a new well at the Well 1 site as a completely new well and require the same permitting process as other new supply wells.</td></tr>
<tr><td>New Control Valves - North and Southeast Pressure Zones</td><td>• Allows storage in North and Southeast Pressure Zones to be available to Central Pressure Zone in an emergency.</td></tr>
<tr><td>New 0.75 MG Tower in Southeast Pressure Zone</td><td rowspan="2">• Additional storage in Southeast Pressure Zone will be needed.</td></tr>
<tr><td>Altitude Valve on existing Southeast Tower</td></tr>
</table>

TABLE 6-4 (cont.)

Long-Term Improvements	Comments
New Supply Well in the Southeast Pressure Zone	• Recommended supply source in Southeast Pressure Zone to reduce the need to re-pump water from the Central Pressure Zone and improve supply reliability in Southeast Pressure Zone. • Additional pump station and/or additional pumping capacity at Southeast Pump Station will be required if the new well not located in Southeast Pressure Zone.
New Supply Well in the Central Pressure Zone	• Additional supply source recommended in southern section of Central Pressure Zone to support future development and improve available fire flows in the southern portion of the Central Pressure Zone. • Location of well in the south may increase localized high system pressures in vicinity even higher.
New East Pressure Zone and Booster Station with Standby Power	• Variable speed booster pumps should be installed to establish the East Pressure Zone's pressure plane. • Fire protection must be supplied by booster pumps; therefore, two large capacity pumps recommended for reliability. • 0.2 MG ground reservoir recommended to provide some supply reliability in the event of a water main break on a major transmission main to the pump station, ground storage would be available. • No elevated storage is recommended in the pressure zone. If development and demands warrant, the Utility may want to consider constructing elevated storage.
New Control Valve - Southeast Pressure Zone	• Allows storage in Southeast Pressure Zone to be available to Central Pressure Zone in an emergency.

6.7.1 Supply and Storage Analysis with Recommended Facilities

An evaluation of water supply and storage requirements was performed with the recommended improvements summarized in Table 6-4 for the projected 2030 water demands. Based on the reliable water supply capacities of the existing and future wells (summarized in Table 6-5), a reliable supply capacity evaluation was performed and is summarized in Table 6-6.

TABLE 6-5

FUTURE RELIABLE SUPPLY CAPACITY

VERONA WATER UTILITY

VERONA, WISCONSIN

	Current Average Operating Capacities							
	Central Pressure Zone		North Pressure Zone		Southeast Pressure Zone		East Pressure Zone	
SUPPLY SOURCE	**(gpm)**	**(MGD)**	**(gpm)**	**(MGD)**	**(gpm)**	**(MGD)**		
Groundwater Wells								
Future Well 1	1,200	1.73						
Well 2	1,000	1.44						
Well 3	1,500	2.16						
Well 4	1,500	2.16						
Future Well 5					1,200	1.73		
Future Well 6	1,200	1.73						
Booster Pumps								
Future North Booster Pump 1			1,000	1.44				
Future North Booster Pump 2			1,000	1.44				
North Booster Pump 4			1,500	2.16				
Southeast Booster Pump 1					1,000	1.44		
Southeast Booster Pump 2					1,000	1.44		
Southeast Booster Pump 3					100	0.14		
Future East Booster Pump 1							50	0.07
Future East Booster Pump 2							200	0.29
Future East Booster Pump 3							200	0.29
Future East Booster Pump 4							2,500	3.60
Future East Booster Pump 5							2,500	3.60
Total Supply Capacity	6,400	9.22	3,500	5.04	3,300	4.75	5,450	7.85
Less: Largest Supply Unit	1,500	2.16	1,500	2.16	1,200	1.73	2,500	3.60
RELIABLE SUPPLY CAPACITY	**4,900**	**7.06**	**2,000**	**2.88**	**2,100**	**3.02**	**2,950**	**4.25**

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TABLE 6-6
SUMMARY OF RELIABLE WATER SUPPLY CAPACITY

Description	Projected 2030	
Design Maximum Day Demand	8.78 MGD	6,090 gpm
Future Reliable Water Supply (from Table 6-5)	8.79 MGD	6,100 gpm
Additional Reliable Supply Capacity Required	--	--
Excess Reliable Supply Capacity	0.01 MGD	10 gpm

Table 6-7 summarizes the evaluation of reliable booster pumping capacities for each of the pressure zones.

TABLE 6-7
SUMMARY OF RELIABLE BOOSTER PUMPING CAPACITY

Description	Projected 2030	
North Pressure Zone		
Design Maximum Day Demand	0.71 MGD	490 gpm
Existing Reliable Booster Pumping Capacity (from Table 6-5)	2.88 MGD	2,000 gpm
Additional Reliable Booster Pumping Capacity Required	--	--
Excess Reliable Booster Pumping Capacity[3]	2.17 MGD	1,510 gpm
Southeast Pressure Zone		
Design Maximum Day Demand[1]	2.07 MGD	1,440 gpm
Required Reliable Booster Pumping Capacity[2]	0.34 MGD	2,402 gpm
Existing Reliable Booster Pumping Capacity (from Table 6-5)	1.58 MGD	1,100 gpm
Additional Reliable Booster Pumping Capacity Required	--	--
Excess Reliable Booster Pumping Capacity[3]	1.24 MGD	860 gpm
Future East Pressure Zone		
Design Maximum Day Demand	0.26 MGD	180 gpm
Existing Reliable Booster Pumping Capacity (from Table 6-5)	4.25 MGD	2,950 gpm
Additional Reliable Booster Pumping Capacity Required	--	--
Excess Reliable Booster Pumping Capacity[3]	3.99 MGD	2,770 gpm

Footnote:
[1] The design maximum day demand for the Southeast Pressure Zone includes the maximum day for the future East Pressure Zone, as this is the required reliable booster pumping capacity for the Southeast Pressure Zone.
[2] Required reliable booster pumping capacity is the projected design maximum day demand less the anticipated well supply of 1,200 gpm.
[3] Excess reliable pumping capacity may be used to offset storage requirements.

Table 6-8 summarizes the storage evaluation. There is a slight shortfall in storage in the North Pressure Zone with the new 0.5 MG elevated tank. However, the shortfall does not warrant a larger tank. Although there is no storage in the future East Pressure Zone, two 2,500 gpm pumps are recommended to provide adequate reliable booster pumping capacity to meet maximum day plus fire flow requirements. In the future, if water demands warrant, the Utility may consider storage in the East Pressure Zone.

TABLE 6-8
FUTURE STORAGE REQUIREMENTS WITH IMPROVEMENTS
VERONA WATER UTILITY
VERONA, WISCONSIN

SUPPLY REQUIREMENTS	Central Pressure Zone	North Pressure Zone	Southeast Pressure Zone	Future East Pressure Zone
Design Average Day Demand (gpm)	1,770	210	530	80
Design Maximum Day Demand (gpm)	4,160	490	1,260	180
Design Peak Hour Demand (gpm)	6,950	880	2,100	288
Future Reliable Supply Capacity (gpm)	4,900	2,000	2,100	2,950
Reliable Supply Capacity in Excess of Maximum Day Demand (gpm)	740	1,510	840	2,770
Reliable Supply Capacity in Excess of Peak Hour Demand (gpm)	None	1,120	None	2,662

STORAGE REQUIREMENTS	Central Pressure Zone	North Pressure Zone	Southeast Pressure Zone	Future East Pressure Zone
Peak Hour Equalizing Requirements (gallons) [1]	762,000	90,000	230,000	33,000
Optimum Fire Protection Needs (gallons) [2]	630,000	630,000	630,000	450,000
Reserve Storage (gallons; 15% of Total) [3]	246,000	128,000	152,000	86,000
Total Optimum Storage Requirements (gallons)	1,638,000	848,000	1,012,000	569,000
Available Effective Storage Capacity (gallons):				
Central Tower	300,000			
Southeast Tower			300,000	
Future North Tower		500,000		
Future Central Pressure Zone Tower	750,000			
Future Southeast Pressure Zone Tower			750,000	
Total Effective Storage Capacity	1,050,000	500,000	1,050,000	None
Subtotal Capacity Required (gallons)	588,000	348,000	None	569,000
Less Excess Available Reliable System Supply Capacity				
Supply Capacity in Excess of Peak Hour for Fire Protection	None	202,000	None	479,000
Peak Hour Supply Capacity for Peak Hour Equalization [4]	311,000	90,000	None	33,000
Less Fire Protection from High Level Pressure Zone				
Capacity in Excess of Peak Hour Equalizing and Reserve	630,000	None	None	None
Total Additional Capacity Required (gallons)	None	56,000	None	57,000

Notes

1. Peak hour storage is storage required to meet demands which exceed the maximum day demand rate assuming the reliable supply capacity is equal to the maximum day demand rate.
2. Optimum fire protection based on requirement for industrial of 3,500 gpm for 180 minutes and commercial of 2,500 gpm for 180 minutes.
3. Reserve storage is storage required to provide a start/stop range for booster pump operation and an emergency reserve storage supply.
4. Peak Hour Supply Capacity cannot exceed Peak Hour Equalization and calculated utilizing time of day demand curve and supply capacity.

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6.8 DISTRIBUTION SYSTEM IMPROVEMENTS

6.8.1 Existing System Deficiencies

Distribution system improvements have been recommended to strengthen the existing system and improve flow capacity and fire protection to various parts of the City based on the deficiency analysis. The recommended distribution system improvements are summarized in Table 6-9 and illustrated in Figure 6-4.

TABLE 6-9
SUMMARY OF WATER DISTRIBUTION SYSTEM IMPROVEMENTS TO ADDRESS EXISTING DEFICIENCIES

Segment	Diameter	Approximate Length	Pressure Zone	Description
A	10-inch	3,200 feet	Central	To improve fire flow, new water main on North Nine Mound Road from Meister Drive to Cross Country Road. Also, new water main from North Nine Mound Road and Meister Drive to Meister Drive and Westridge Parkway.
B	10-inch	2,950 feet	Central	To improve fire flow, new water main from Westridge Parkway and Jenna Drive along Westridge Parkway to Meister Drive and west to Cross Country Road.
C	8-inch	655 feet	Central	To improve fire flow, new water main from Venture Court Industrial Park to Commerce Parkway in the Verona Industrial Park.

The recommended improvements do not resolve all fire flow deficiencies. Available fire flow must be balanced with cost and complexity of correction. It is recommended the Utility evaluate the required fire flows in these areas on an individual basis.

6.8.2 Water Main Replacement

The Utility should consider developing a water main replacement program in the future. As some of the water main begins to reach the end of its useful life, it should be replaced. A replacement plan will allow the Utility to proactively budget and plan for the water main replacement instead of all the water main reaching the end of its useful life at the same time, requiring large amounts of funds to be allocated for replacement (the situation many communities established in the early 1900s are in).

6.9 DISTRIBUTION SYSTEM EXPANSION

Figure 6-5 illustrates recommended water main improvements to serve the future urban service area. All major transmission mains identified in Figure 6-5 have been sized to meet projected future water system demands and support system supply sources and storage facilities to serve outlying area land uses. As supply and storage facilities are constructed, the transmission main plans may need to be adjusted to account for changes in location, size, etc. Water mains were sized to provide at least 3,500 gpm of flow capacity.

Recommended water main highway crossings are needed to properly supply water customers south of Highway 18/151. Recommended water mains include two highway crossings for both the Central and Southeast Pressure Zones. To reliably meet fire flow requirements in the southern portion of the Central Pressure Zone, the two highway crossings and proposed control valves to allow water from the Southeast Pressure Zone are required. Without the proposed controls valves and available storage in the Southeast Pressure Zone, an additional Central Pressure Zone highway crossing will be required. Large fire flows in the southern portion of the Central Pressure Zone will rely on the elevated storage in the Southeast Pressure Zone, and locating the future supply well in this portion of the pressure zone will supplement transmission requirements crossing Highway 18/151.

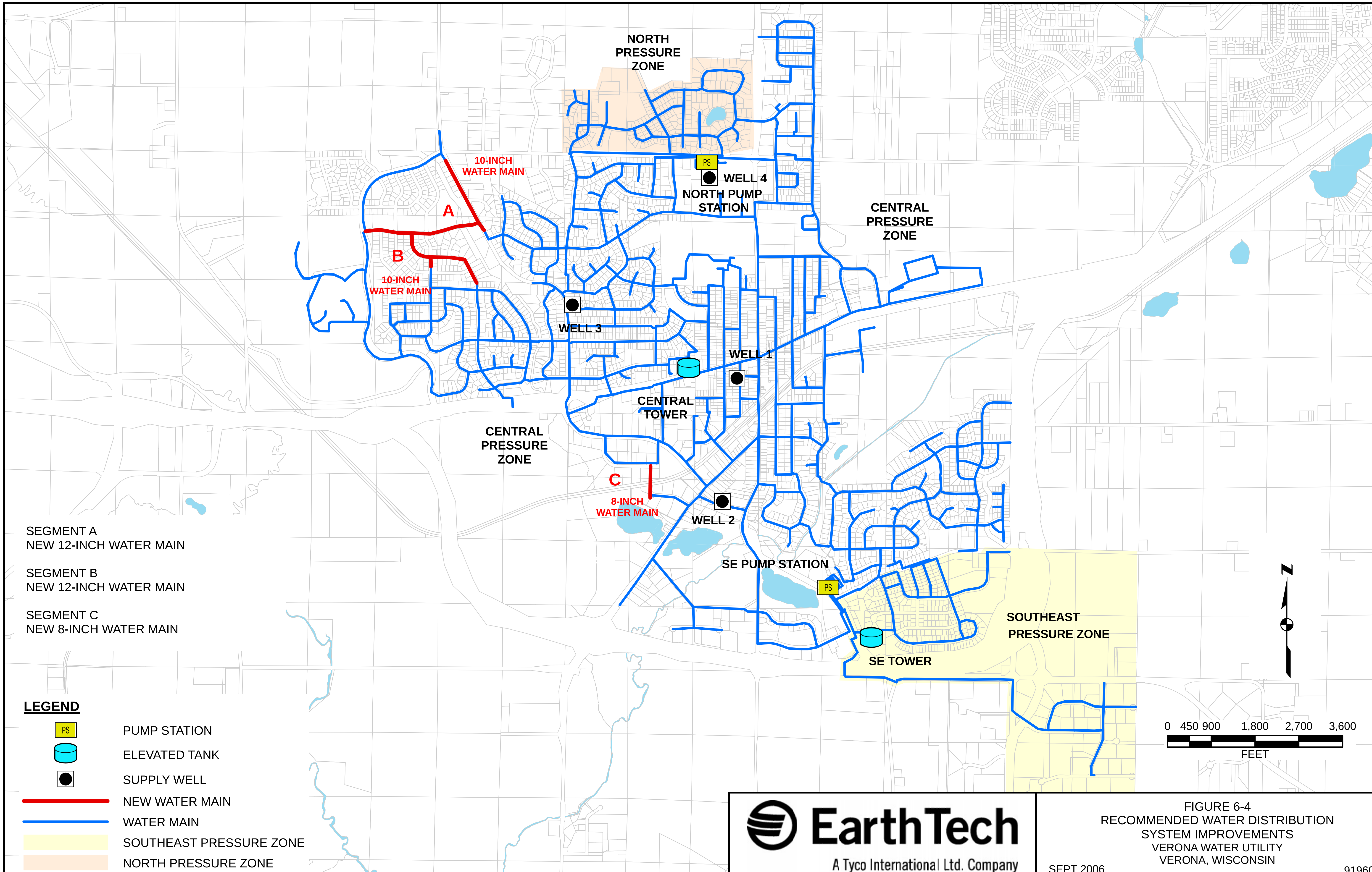

FIGURE 6-4
RECOMMENDED WATER DISTRIBUTION
SYSTEM IMPROVEMENTS
VERONA WATER UTILITY
VERONA, WISCONSIN

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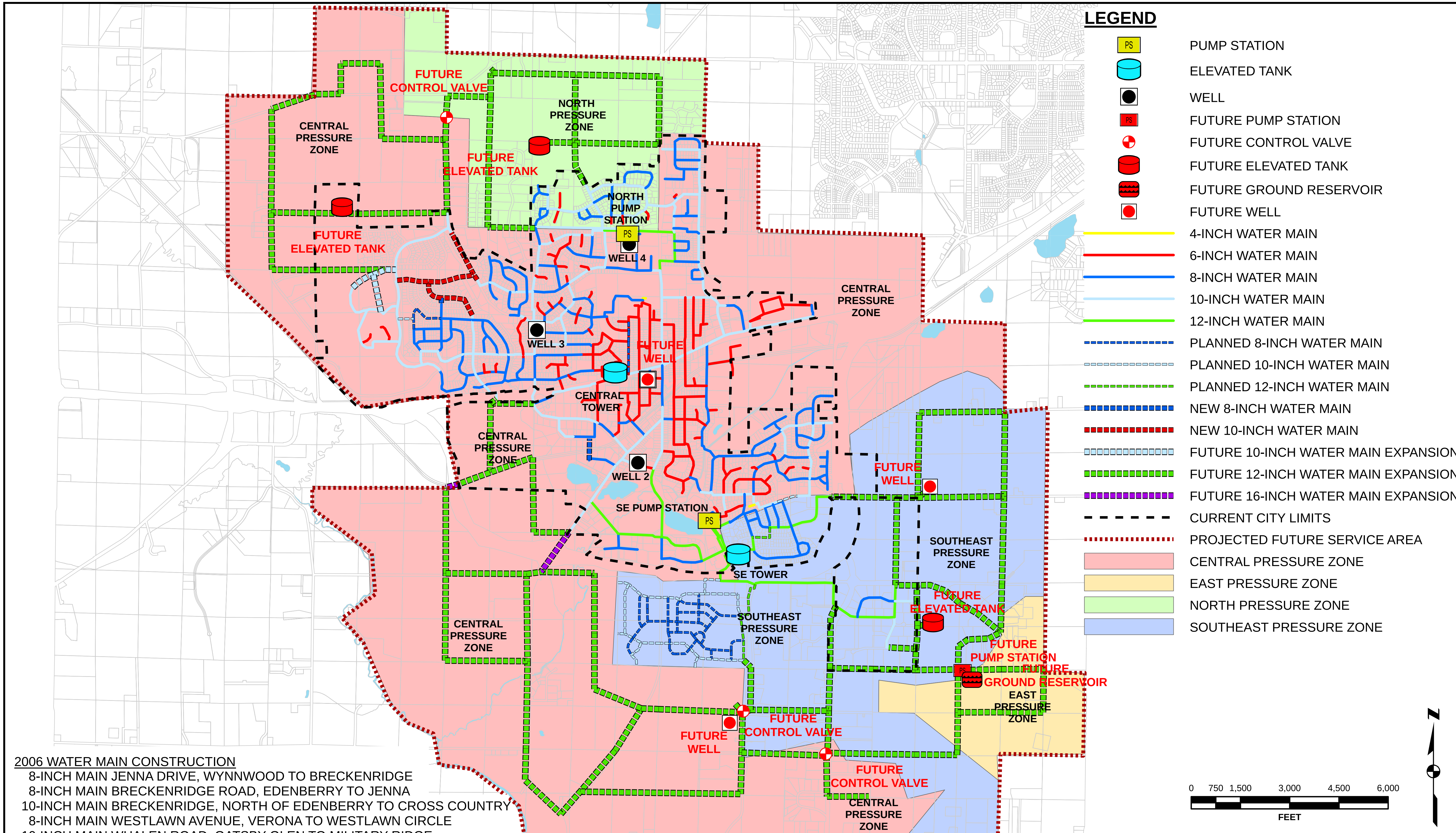

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2006 WATER MAIN CONSTRUCTION

8-INCH MAIN JENNA DRIVE, WYNNWOOD TO BRECKENRIDGE
8-INCH MAIN BRECKENRIDGE ROAD, EDENBERRY TO JENNA
10-INCH MAIN BRECKENRIDGE, NORTH OF EDENBERRY TO CROSS COUNTRY
8-INCH MAIN WESTLAWN AVENUE, VERONA TO WESTLAWN CIRCLE
10-INCH MAIN WHALEN ROAD, GATSBY GLEN TO MILITARY RIDGE
12-INCH MAIN MARLOW BAY DRIVE AND FAIRVIEW TER. TO ETHAN TER. AND POTTER PASS

PLANNED WATER MAINS INCLUDED BASED ON WATER MAINS CONSTRUCTED IN 2006 AND PLANS FOR SCENIC RIDGE AND CATHEDRAL POINT DEVELOPMENT.
NEW WATER MAINS INCLUDE WATER MAINS RECOMMENDED TO ADDRESS EXISTING DEFICIENCIES.
FUTURE WATER MAINS ARE RECOMMENDED TRANSMISSION MAINS TO SUPPLY FUTURE GROWTH.

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FIGURE 6-5
RECOMMENDED FUTURE DISTRIBUTION SYSTEM IMPROVEMENTS
VERONA WATER UTILITY
VERONA, WISCONSIN

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The mains shown in Figure 6-5 are only the recommended transmission mains. Smaller local service mains have not been shown. It is recommended that water mains to serve developing residential land should be sized at a minimum of 8 inches in diameter. The proposed transmission mains shown follow known or presumed locations for major streets or roads in the future urban service area. Adjustments in the actual locations of those mains can be expected at the time the mains are required or as local needs dictate.

The evaluation of the Verona water system was repeated with the distribution system recommendation for both existing deficiencies and future water system expansion and the additional facilities for a typical maximum day water demand. Figure 6-6 illustrates the average day water system pressures, and Figure 6-7 illustrates the estimated available fire flow throughout the system while maintaining a residual pressure of 20 psi throughout the system. Figure 6-8 illustrates areas where the available fire flow is less than the estimated fire flow requirement based on land use. As illustrated in the figures, the water system improvements and new facilities solve fire flow issues throughout the water system, and in general, the water system expansion water mains provide adequate fire flow for future needs.

The remaining deficient areas include dead end water mains, small diameter water mains in residential areas, and the extremities of the water system. The deficient areas are isolated areas of the system where it is believed it is not cost effective to address the deficiencies. It is recommended the Utility evaluate the required fire flows in these areas on an individual basis.

6.10 WATER SYSTEM OPERATION AND STORAGE

Current water system operation, as described in Chapter 4, allows for the Central Tower and Southeast Tower water levels to fall to 10 and 5 feet, respectively. While this operational strategy provides large quantities of water turnover, greatly reducing water age in the distribution system, the amount of stored water for fire protection is greatly reduced. As shown in Table 6-10, when the storage tanks are nearly empty, very little volume of water is available.

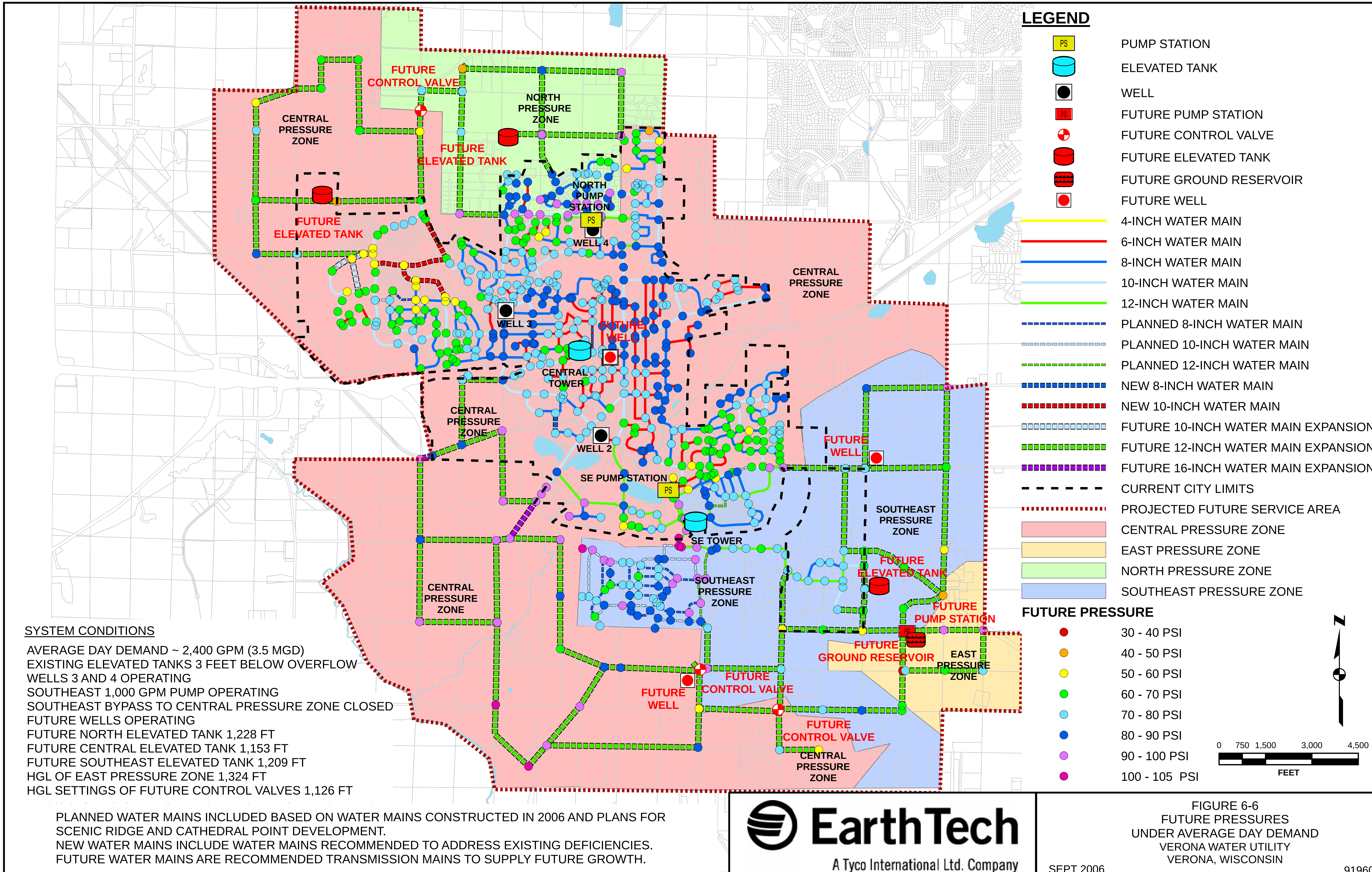
TABLE 6-10
SUMMARY OF AVAILABLE STORAGE

Water Storage Tank	Volume of Stored Water at Specific Water Levels (gallons)			
	30 feet	20 feet	10 feet	5 feet
Central Tower	287,000	180,000	61,000	21,000
Southeast Tower	293,000	183,000	64,000	23,000

Notes:
1. Central Tower volumes from Chicago Bridge and Iron 0.3 MG Water Spheroid Gauging Table (32.5 feet nominal head).
2. Southeast Tower volumes from Maguire Iron 0.3 MG Spheroid Volume Calculation Data Sheet (31 feet nominal head).

With both water towers nearly full with water levels at 30 feet, the total volume available for fire protection is 0.58 MG. When the water towers are at the lowest water level, the Central Tower water level is at 10 feet and the Southeast Tower water level is at 5 feet, the total volume available is 0.04 MG. Based on the current water system operation, twice on a normal day, only 40,000 gallons of water from elevated storage is available to fight a fire. With the water towers at 20 feet, 0.36 MG of water is stored. In addition, there currently is not adequate storage in the pressure zones; therefore, allowing water levels in the towers to drop so low makes this situation worse.

It is recommended the Utility consider altering the current operating strategy to operate over the top 10 feet of the towers.



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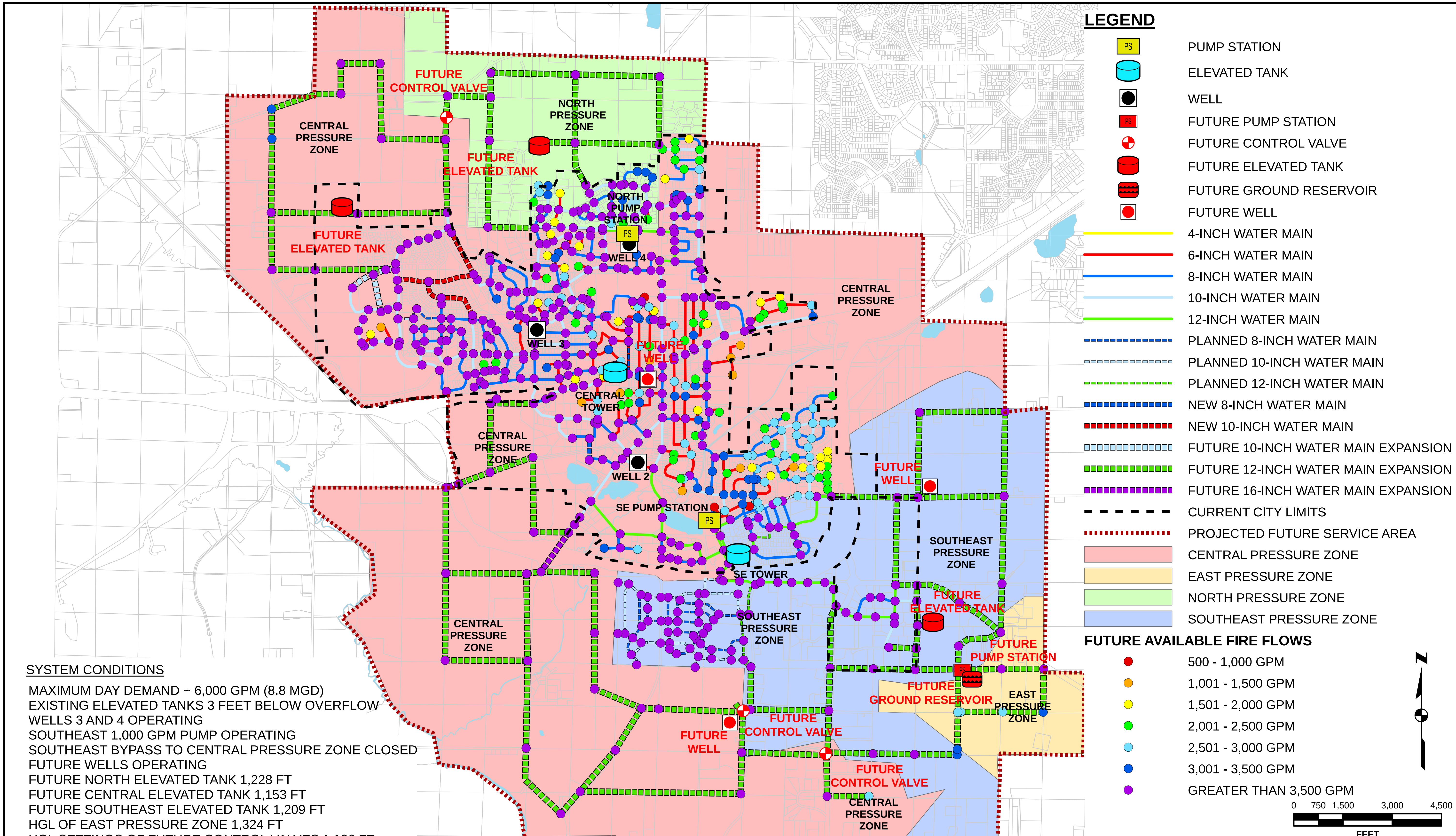

SYSTEM CONDITIONS

MAXIMUM DAY DEMAND ~ 6,000 GPM (8.8 MGD)
EXISTING ELEVATED TANKS 3 FEET BELOW OVERFLOW
WELLS 3 AND 4 OPERATING
SOUTHEAST 1,000 GPM PUMP OPERATING
SOUTHEAST BYPASS TO CENTRAL PRESSURE ZONE CLOSED
FUTURE WELLS OPERATING
FUTURE NORTH ELEVATED TANK 1,228 FT
FUTURE CENTRAL ELEVATED TANK 1,153 FT
FUTURE SOUTHEAST ELEVATED TANK 1,209 FT
HGL OF EAST PRESSURE ZONE 1,324 FT
HGL SETTINGS OF FUTURE CONTROL VALVES 1,126 FT

PLANNED WATER MAINS INCLUDED BASED ON WATER MAINS CONSTRUCTED IN 2006 AND PLANS FOR SCENIC RIDGE AND CATHEDRAL POINT DEVELOPMENT.
NEW WATER MAINS INCLUDE WATER MAINS RECOMMENDED TO ADDRESS EXISTING DEFICIENCIES.
FUTURE WATER MAINS ARE RECOMMENDED TRANSMISSION MAINS TO SUPPLY FUTURE GROWTH.

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FIGURE 6-7
FUTURE AVAILABLE FIRE FLOWS
UNDER MAXIMUM DAY DEMAND
VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006 91960

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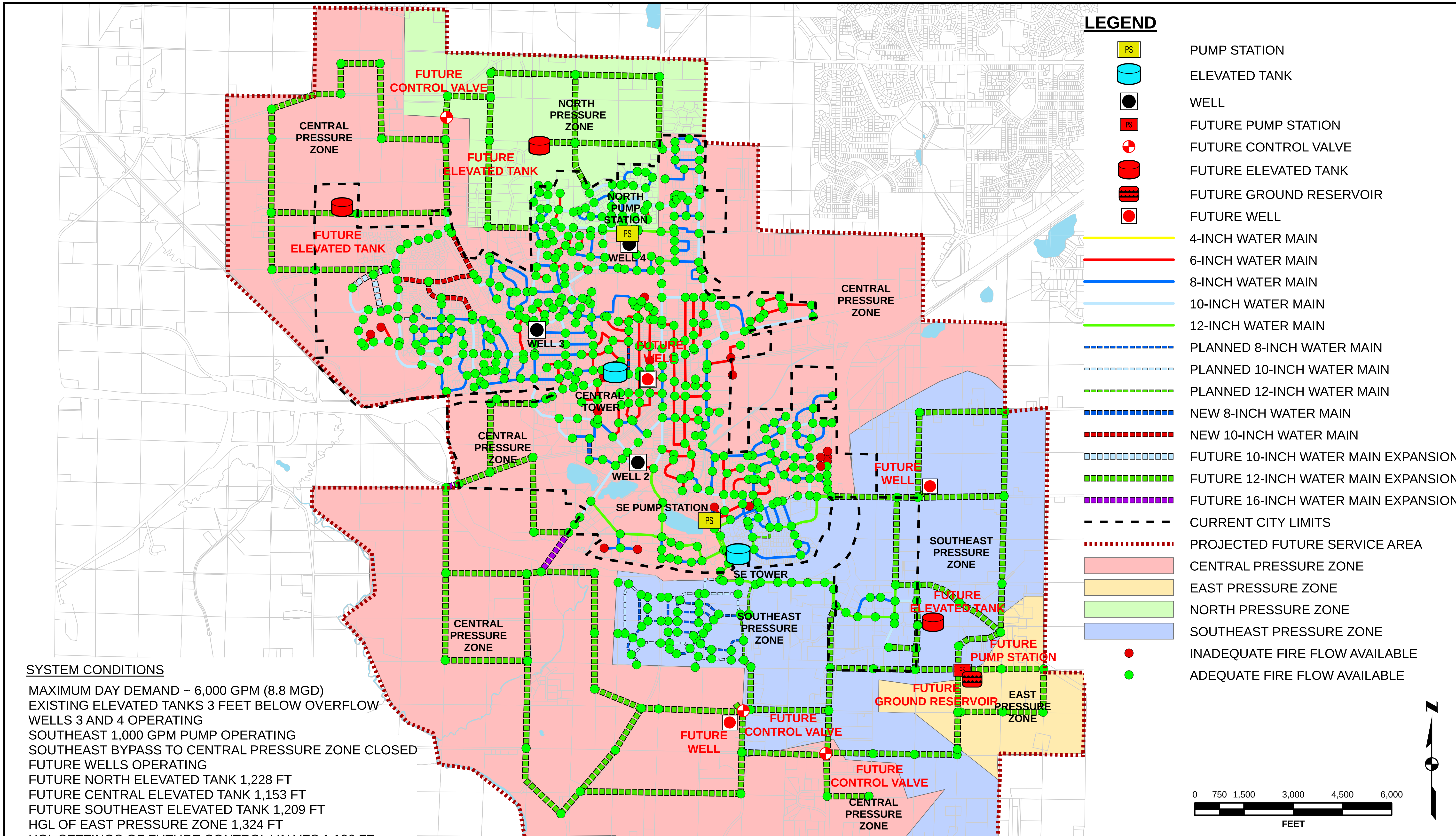

SYSTEM CONDITIONS

MAXIMUM DAY DEMAND ~ 6,000 GPM (8.8 MGD)
EXISTING ELEVATED TANKS 3 FEET BELOW OVERFLOW
WELLS 3 AND 4 OPERATING
SOUTHEAST 1,000 GPM PUMP OPERATING
SOUTHEAST BYPASS TO CENTRAL PRESSURE ZONE CLOSED
FUTURE WELLS OPERATING
FUTURE NORTH ELEVATED TANK 1,228 FT
FUTURE CENTRAL ELEVATED TANK 1,153 FT
FUTURE SOUTHEAST ELEVATED TANK 1,209 FT
HGL OF EAST PRESSURE ZONE 1,324 FT
HGL SETTINGS OF FUTURE CONTROL VALVES 1,126 FT

PLANNED WATER MAINS INCLUDED BASED ON WATER MAINS CONSTRUCTED IN 2006 AND PLANS FOR SCENIC RIDGE AND CATHEDRAL POINT DEVELOPMENT.
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FUTURE WATER MAINS ARE RECOMMENDED TRANSMISSION MAINS TO SUPPLY FUTURE GROWTH.

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FIGURE 6-8
FUTURE ADEQUACY OF FIRE FLOWS
UNDER MAXIMUM DAY DEMAND
VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006 91960

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7.0 CAPITAL IMPROVEMENTS PLAN

This chapter summarizes the recommended water system improvements and presents a proposed capital improvements program. The recommended capital improvements plan prioritizes system improvements and provides a schedule for the timing of construction. Budget cost estimates for each improvement are also summarized.

7.1 RECOMMENDED IMPROVEMENTS

The schematic of the recommended future water distribution system is illustrated in Figure 7-1. Figure 7-2 illustrates the recommended water system master plan. The following sections summarize the improvements.

7.1.1 Supply

The Verona Water Utility should plan to construct three additional supply wells with a minimum capacity of 1,200 gpm, one well by 2015 and the other in two wells by the end of the planning period. The exact location of each well should be evaluated and may effect the other facility recommendations along with the transmission main recommendations. For the purpose of this study, it is recommended that two wells be constructed in the Central Pressure Zone, with one well at the existing Well 1 site and one well to be constructed in the Southeast Pressure Zone, as they are the two pressure zones with the largest projected water demands. Well siting studies should be performed and land acquired.

7.1.2 Storage

The Utility currently has inadequate water storage capacity available to meet present storage needs in the pressure zones. It is recommended that a 0.75 MG elevated tank be constructed in the Central Pressure Zone, a 0.75 MG elevated tank be constructed in the Southeast Pressure Zone, and a 0.5 MG elevated tank be constructed in the North Pressure Zone.

7.1.3 Booster Pumping Capacity

With the construction of the new 0.5 MG elevated tank in the North Pressure Zone, it is recommended that the three small pumps be replaced with two 1,000 gpm pumps and a flow control valve that allows water to flow from the North Pressure Zone to the Central Pressure Zone.

7.1.4 Valves

With the addition of the new elevated tank in the Southeast Pressure Zone, it is recommended that an altitude valve be installed at the existing Southeast Tower. To provide available storage from the North and Southeast Pressure Zones to the Central Pressure Zone, it is recommended that one additional automatic control valve be installed between the North and Central Pressure Zones and two additional automatic control valves be installed between the Southeast and Central Pressure Zones.

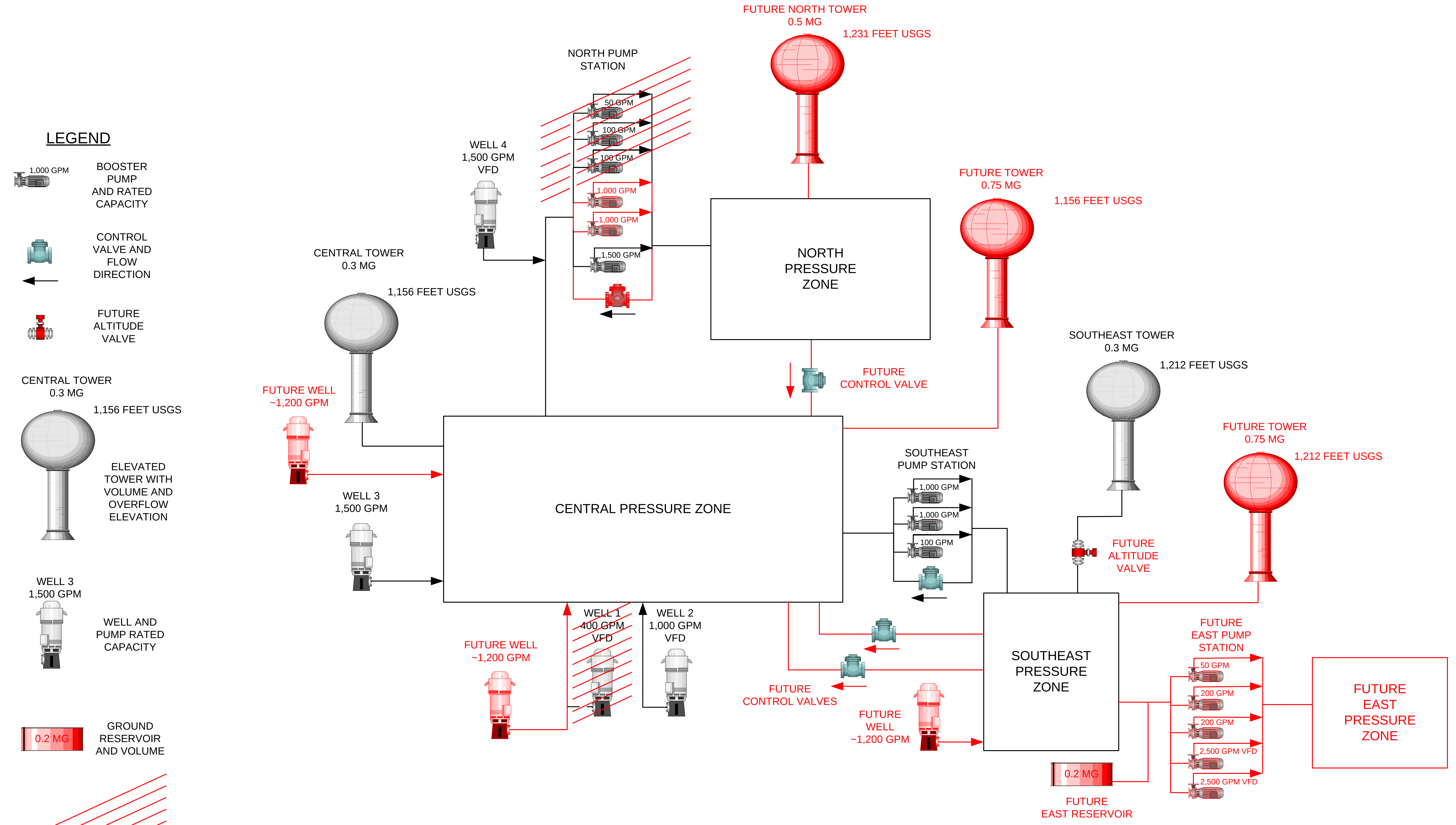

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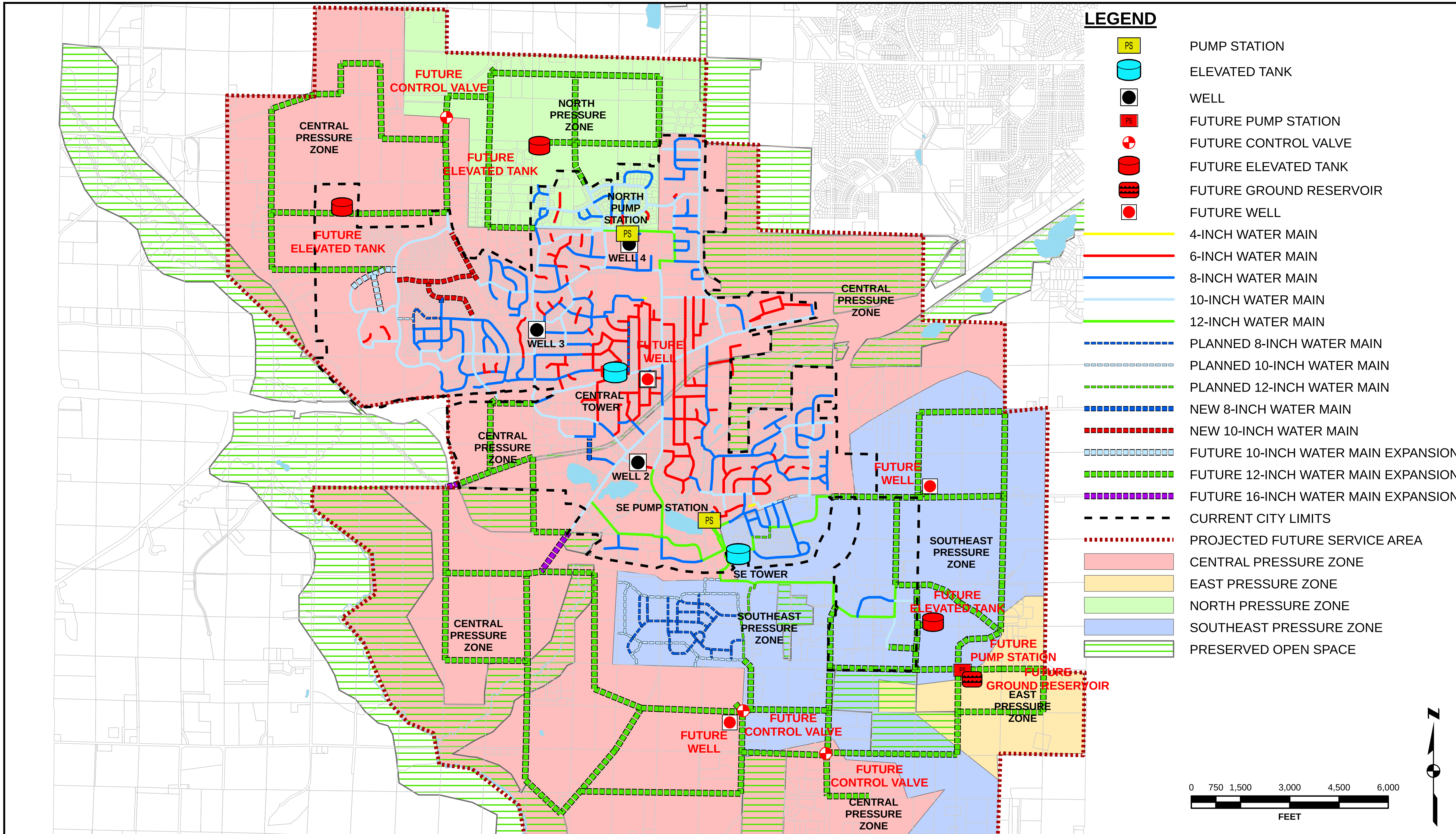
FIGURE 7-1
RECOMMENDED FUTURE WATER SYSTEM SCHEMATIC
VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006 91960



PLANNED WATER MAINS INCLUDED BASED ON WATER MAINS CONSTRUCTED IN 2006 AND PLANS FOR SCENIC RIDGE AND CATHEDRAL POINT DEVELOPMENT.
NEW WATER MAINS INCLUDE WATER MAINS RECOMMENDED TO ADDRESS EXISTING DEFICIENCIES.
FUTURE WATER MAINS ARE RECOMMENDED TRANSMISSION MAINS TO SUPPLY FUTURE GROWTH.

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FIGURE 7-2
RECOMMENDED WATER SYSTEM
MASTER PLAN
VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006

91960

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7.1.5 Distribution System

Distribution system improvements have been recommended to strengthen the existing water system, enhance system reliability, loop major transmission mains, and improve flow and fire projection capacity. Figure 6-4 illustrates the recommended distribution system improvements. Approximately 6,800 feet of water main are recommended to improve the existing water system. Approximately 165,000 feet (31 miles) of future transmission mains are recommended to supply development during the planning period.

7.1.6 Future Pressure Zones

It is recommended that the Utility serve much of the future development of the urban service area from the existing pressure zones. The implementation of the new East Pressure Zone will be necessary when the Utility is required to serve areas above an elevation of approximately 1,115 feet USGS in the Southeast Pressure Zone. The future East Pressure Zone will need to be supplied by a pump station located near the pressure zone boundary. To increase system reliability (in the event of a Southeast Pressure Zone water main break), it is recommended that a 0.2 MG ground storage tank be constructed at the pump station. It is recommended that the zone’s pressure plane be established by continuous operation of variable speed booster pumps. The pump station should also include a standby generator. If the pressure zone demand warrants, it is recommended that an elevated tank be constructed in the new high level pressure zone.

7.2 RECOMMENDED IMPROVEMENTS PLAN

Table 7-1 presents the recommended capital improvements that should be implemented in the foreseeable future and provides a proposed schedule and summary of budget cost estimates.

The proposed capital improvements plan has been formulated based on all the information presented in this study. All the improvements listed have been developed and prioritized based on deficiencies identified in the existing water system and the needs of the Utility's future service area. Improvements have been broken down into three categories:

1. Short-term improvements (2006 through 2008)
2. Intermediate-term improvements (2009 through 2015)
3. Long-term improvements (2015 through 2030)

The actual construction costs for recommended improvements may vary from the costs outlined in this report, depending on the year facilities are constructed, the rate of increase in future construction costs, and unforeseen conditions which could be encountered during the design of the improvements. In establishing priorities for these improvements, it will be necessary to take into consideration the availability of City financial resources and local needs to assure that the recommended improvements are implemented in an orderly, coordinated, and economical fashion.

TABLE 7-1
CAPITAL IMPROVEMENTS PLAN

Short-Term Improvements	Estimated Cost[3]
New 0.5 MG Tower in North Pressure Zone	$850,000
New Pumps and Flow Control Valve at North Pump Station	$300,000
Water Distribution System Improvements to Address Existing Deficiencies (approximately 6,800 feet)	$890,000
Transmission Mains for Development (assumed approximately 25,000 feet)	$2,500,000
Subtotal	$4,540,000
Engineering and Contingencies[1]	$1,816,000
Total	$6,356,000
Mid-Term Improvements	**Estimated Cost**
New 0.75 MG Tower in Central Pressure Zone	$1,000,000
New Supply Well in the Central Pressure Zone	$750,000
New Flow Control Valve from North Pressure Zone to Serve Central Pressure Zone	$75,000
New Flow Control Valve from Southeast Pressure Zone to Serve Central Pressure Zone	$75,000
Transmission Mains for Development (assumed approximately 50,000 feet)	$5,000,000
Subtotal	$6,900,000
Engineering and Contingencies[1]	$2,760,000
Total	$9,660,000
Long-Term Improvements	**Estimated Cost**
New 0.75 MG Tower in Southeast Pressure Zone	$1,100,000
New Altitude Valve on the Existing Southeast Tower	$150,000
New Supply Well in the Southeast Pressure Zone	$750,000
New Supply Well in the Central Pressure Zone	$750,000
East Pressure Zone and 0.2 MG Ground Reservoir and Booster Station with Standby Power	$850,000
New Flow Control Valve from Southeast Pressure Zone to Serve Central Pressure Zone	$75,000
Transmission Mains for Development (assumed approximately 90,000 feet)	$9,000,000
Subtotal	$12,675,000
Engineering and Contingencies[1]	$5,070,000
Total	$17,745,000
Grand Total	$33,761,000

Footnotes:
1 Assumed 15 percent for engineering and 25 percent for contingencies.
2 Water main cost estimates were based on $85 per foot for future expansion water main and $130 per foot for water main constructed in previously developed areas.
3 Estimates do not include land purchase if necessary.

APPENDIX A

GLOSSARY OF TERMS

APPENDIX A
GLOSSARY OF TERMS

Average Day Demand:	The average quantity of daily water usage in a municipal water system.
Elevated Storage:	A facility for storing water supplies above ground level at a specific elevation.
Flow Capacity:	The maximum flow rate that can be supplied by a water distribution system at a specified location and residual pressure (usually expressed as gpm).
Hydraulic Gradient:	The unconfined change in water surface elevation with respect to horizontal distance for a sloping water surface.
Maximum Day Demand:	The highest quantity of daily water usage in a municipal water system.
Maximum Day Ratio:	The ratio of maximum day to average day demand (usually expressed as a percentage).
Peak Hour Demand:	The daily rate of water usage during the hour of greatest water demand on a maximum usage day.
Peak Hour Demand Ratio:	The ratio of peak hour pumpage (expressed as a daily rate) to average day pumpage (usually expressed as a percentage).
Pipe Roughness Coefficient:	A coefficient (generally assumed to be constant) which describes the energy loss due to friction that will occur as water flows through a section of piping.
Reliable Supply Capacity:	The pumping capacity of a water supply facility with the largest pumping unit out of service.
Residual Pressure:	Pressure at a specified location in the water distribution system when water is being removed or flowed.
Static Pressure:	Normal pressure at a specified location in the water distribution system when no water is being removed or flowed.
Static Water Level:	The water level in a well when no water is being taken from the aquifer either by pumping or free flow (usually measured from ground surface or top of well casing).
Time-of-day Demand Curve:	A curve which describes changes in the quantities of water used by customers at different times of the day.

Total Dynamic Head:	The total energy that a pump must overcome to deliver a given flow rate including suction lift, discharge, and friction losses (usually expressed in feet of water).
Unaccounted-For Water:	The difference between the total volume of water pumped and the volume of water sold (expressed as gallons or as a percentage of total pumpage).
Water Balance:	A water balance displays how quantities of water flow into and out of the distribution system and to the customer. All data in the water balance is expressed as a volume per year.
Water Demand:	The amount of water required by a water user or users at a specific point or area within a water distribution system.
Water Distribution Main:	A water main which primarily extends water services and fire protection to an area.
Water Distribution System:	A facility usually consisting of a network of piping which is designed to distribute water from a given water supply to specific water users.
Water Supply System:	Facilities designed to collect and furnish a controlled supply of water for consumption or other water needs.
Water Transmission Main:	A large water main (generally 10-inch or larger) which is used to convey water between a water system's supply/storage facilities and service area.

APPENDIX B

LIST OF ABBREVIATIONS

APPENDIX B
LIST OF ABBREVIATIONS

fps	feet per second
gpcd	gallons per capita per day
gpm	gallons per minute
psi	pounds per square inch
AWWA	American Water Works Association
AwwaRF	American Water Works Association Research Foundation
DBPs	Disinfection Byproducts
DNR	Wisconsin Department of Natural Resources
EPS	Extended Period Simulation
FAA	Federal Aeronautics Administration
GIS	Geographic Information System
ISO	Insurance Services Office
MG	Million Gallons
MGD	Million Gallons per Day
MGY	Million Gallons per Year
O&M	Operation and Maintenance
PRV	Pressure Reducing Valve
SCADA	Supervisory Control and Data Acquisition
SE	Southeast
TDH	Total Dynamic Head
USGS	United States Geological Survey
VFD	Variable Frequency Drive
WAC	Wisconsin Administrative Code
WI DOA	Wisconsin Department of Administration

APPENDIX C

FIELD TEST FORMS

FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-1 **Date & Time:** 4/12/06 9:17 **Area:** Southeast

FLOWING HYDRANT(S)

Location(s):			
	F1	4TH HYDRANT EAST OF PB + AMERICAN WAY	Model Node: J-2424

RESIDUAL HYDRANT(S)

Location(s):			
	R1	3RD HYDRANT EAST OF PB + AMERICAN WAY	Model Node: J-2676
	R2	1ST HYDRANT EAST OF PB + AMERICAN WAY	Model Node: J-2290
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	Initial	Final		DIF	4.5	21	2,190
F1 - Nozzle 2							
Residual 1	70	68	43				
Residual 2	70	68	46				
Residual 3	81	78	79				
Residual 4	79	75	76				
Residual 5	61	61	61				
Residual 6	69	69	69				
Residual 7	64	64	64				
Residual 8	70	70	69				
Residual 9	66	66	65				
Residual 10	86	85	86				
Residual 11	66	66	67				
Residual 12	73	73	73				
Residual 13	68	68	68				
Residual 14	56	56	56				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)
Central	18.5
SE	17.1

BS	Suction (psi)
North	44.8

BS	Flow of water to HPSI (gpm)
SE	0
North	37

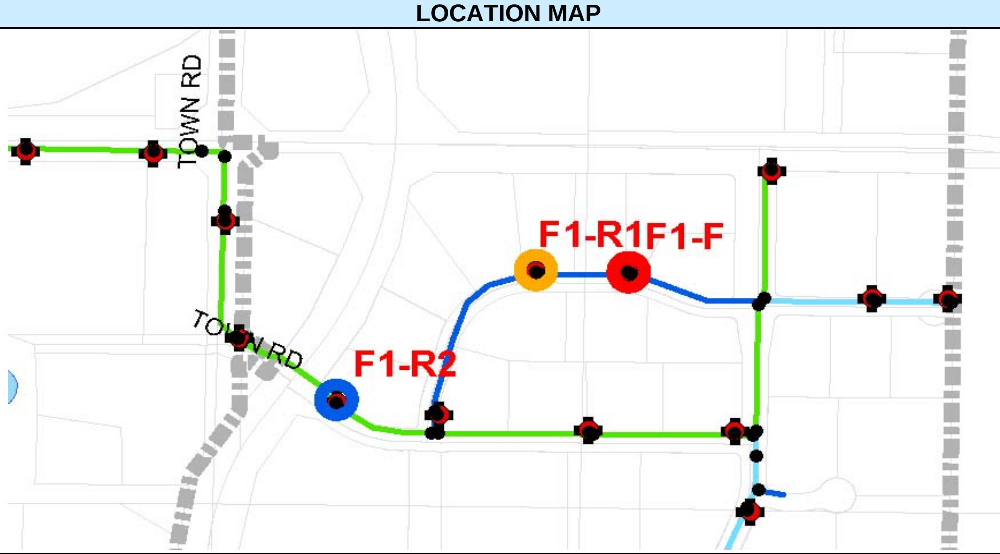
BS	Flow of water from HPSI (gpm)
SE	1

Well	(GPM)	Press
1	0	
2	0	
3	0	
4	0	

BS	Discharge of water (psi)
SE	87.8
North	72.6

LOCATION MAP

NTS



REMARKS:

FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-2 **Date & Time:** 4/12/06 9:39 **Area:** Southeast

FLOWING HYDRANT(S)

Location(s):	F1	1ST HYDRANT SOUTH OF WHALEN RD + GATSBY GLEN DR	Model Node: J-2446

RESIDUAL HYDRANT(S)

Location(s):	R1	1ST HYDRANT SOUTH OF WHALEN RD + THORNTON	Model Node: J-2448
	R2	1ST HYDRANT WEST OF HARVEST LN + ARIEL LN	Model Node: J-2458
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

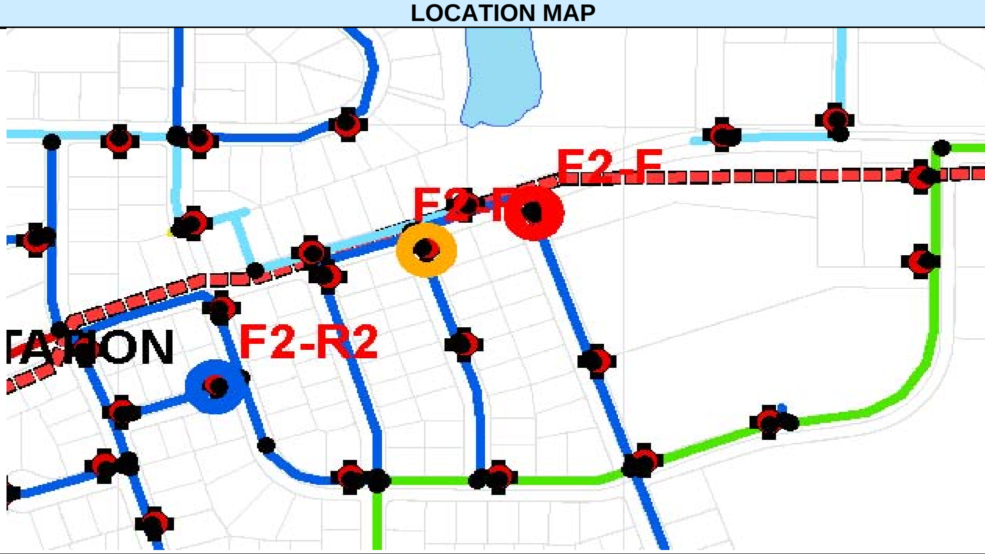
Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	**Initial**	**Final**		DIF	4.5	21	2,190
F1 - Nozzle 2							
Residual 1	81	79	41				
Residual 2	70	70	48				
Residual 3	82	82	82				
Residual 4	80	79	79				
Residual 5	60	60	60				
Residual 6	68	68	68				
Residual 7	64	63	63				
Residual 8	70	69	68				
Residual 9	66	66	63				
Residual 10	85	85	85				
Residual 11	66	66	66				
Residual 12	72	72	71				
Residual 13	68	67	67				
Residual 14	56	55	56				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)	Well	(GPM)	Press
Central	17.3	1	0	
SE	16.5	2	0	
		3	0	
BS	Suction (psi)	4	0	
North	44.7			
		BS	Discharge of water (psi)	
BS	Flow of water to HPSI (gpm)			
SE	0	SE	91	
North	35	North	78.1	
BS	Flow of water from HPSI (gpm)			
SE	1			

LOCATION MAP

NTS



REMARKS:

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FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-3 **Date & Time:** 4/13/06 9:58 **Area:** North

FLOWING HYDRANT(S)

Location(s):	F1	TAMARACK WAY + KETTLE WOODS DR	Model Node: J-2570

RESIDUAL HYDRANT(S)

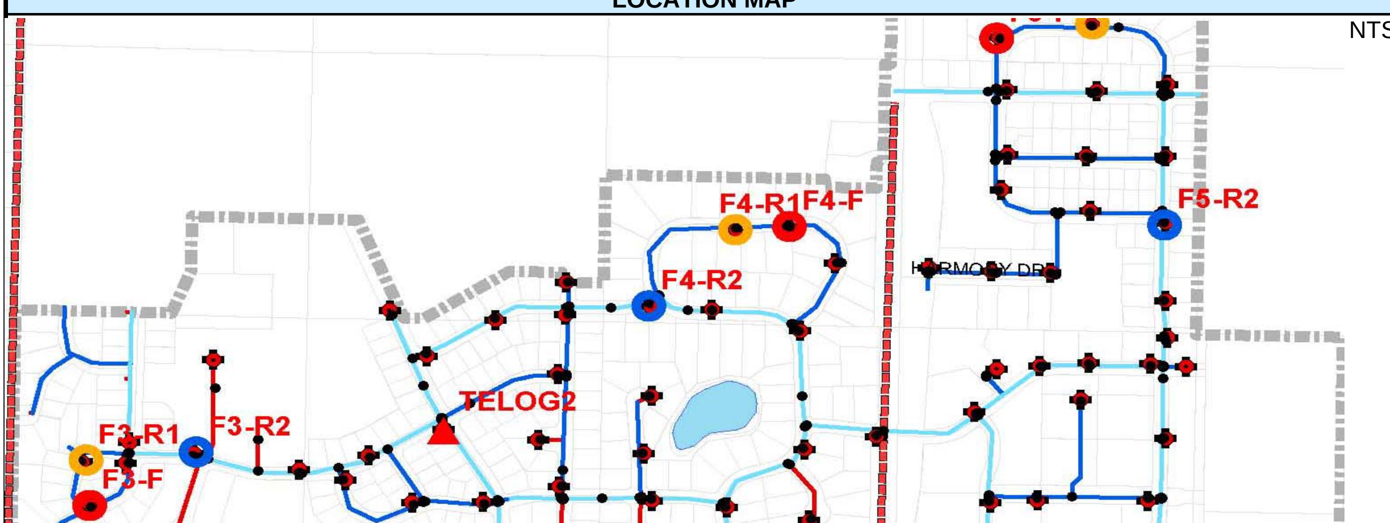
Location(s):	R1	1ST NORTH OF TAMARACH WAY + KETTLE WOODS DR	Model Node: J-2572
	R2	LONE PINE WAY + KETTLE CT	Model Node: J-2252
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	**Initial**	**Final**		DIF	4.5	17	2,010
F1 - Nozzle 2							
Residual 1	80	80	31				
Residual 2	85	85	40				
Residual 3	84	84	49				
Residual 4	81	81	43				
Residual 5	61	61	59				
Residual 6	70	70	66				
Residual 7	65	65	61				
Residual 8	69	69	69				
Residual 9	66	65	65				
Residual 10	87	86	83				
Residual 11	68	68	64				
Residual 12	74	73	68				
Residual 13	69	69	64				
Residual 14	57	56	52				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)	Well	(GPM)	Press
Central	19.4	1	0	
SE	15	2	0	61.1
		3	0	
BS	Suction (psi)	4	0	
North	33.7			
		BS	Discharge of water (psi)	
BS	Flow of water to HPSI (gpm)			
SE	0	SE	88.3	
North	1919	North	46.3	
BS	Flow of water from HPSI (gpm)			
SE	1054			

LOCATION MAP



REMARKS:

FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-4 **Date & Time:** 4/13/06 9:41 **Area:** NORTH

FLOWING HYDRANT(S)

Location(s):			
	F1	2ND HYDRANT NORTH OF GATEWAY PASS + MONTE CRISTO CIR	Model Node: J-2108

RESIDUAL HYDRANT(S)

Location(s):			
	R1	1ST HYDRANT WEST OF FLOWING HYDRANT	Model Node: J-2588
	R2	1ST HYDRANT EAST OF DUNHILL DR + ZINGG DR	Model Node: J-2030
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
	Initial	Final					
F1 - Nozzle 1				DIF	4.5	13	1,800
F1 - Nozzle 2							
Residual 1	64	65	33				
Residual 2	70	68-70	40				
Residual 3	84	84	58				
Residual 4	82	81	53				
Residual 5	62	61	59				
Residual 6	70	70	67				
Residual 7	65	65	62				
Residual 8	69	69	69				
Residual 9	66	66	65				
Residual 10	87	87	84				
Residual 11	68	68	64				
Residual 12	74	74	69				
Residual 13	69	69	65				
Residual 14	57	57	53				

BOUNDARY CONDITIONS

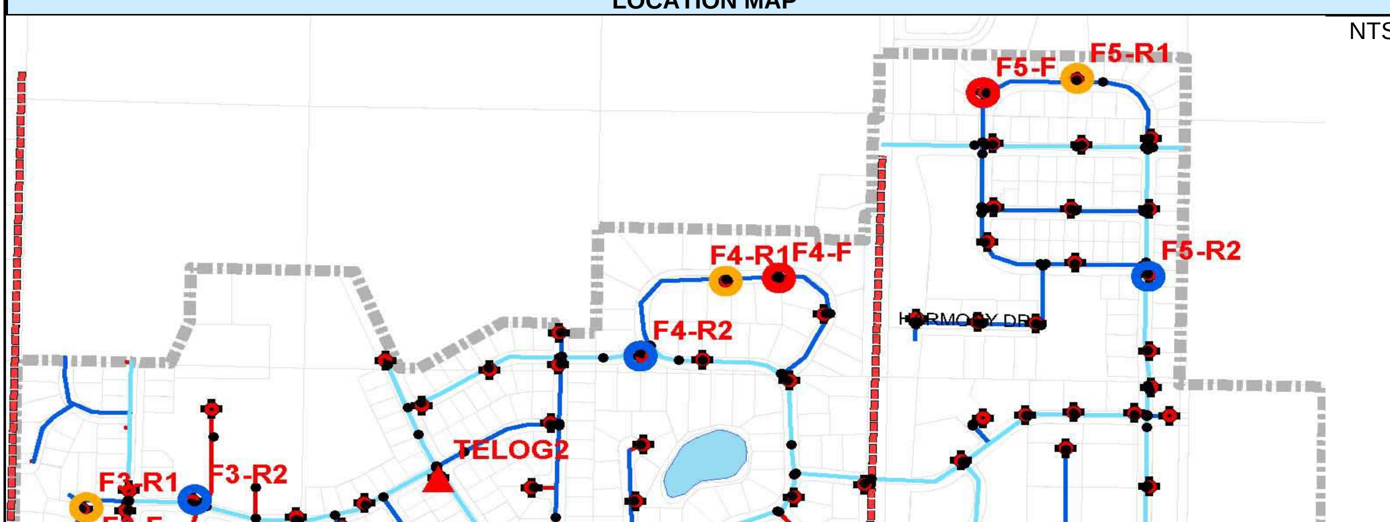
Towers	Height of water in tower (ft)	Well	(GPM)	Press
Central	20	1	0	
SE	16	2	0	61.8
		3	0	
BS	Suction (psi)	4	0	
North	35.3			

BS	Discharge of water (psi)
SE	88.6
North	55.2

BS	Flow of water to HPSI (gpm)
SE	0
North	1772

BS	Flow of water from HPSI (gpm)
SE	979

LOCATION MAP



REMARKS:

FLOW AND PRESSURE TESTS

VERONA WATER UTILITY

VERONA, WISCONSIN

Test Number: F-5 **Date & Time:** 4/12/06 13:43 **Area:** Central

FLOWING HYDRANT(S)

Location(s):	F1	1ST HYDRANT NORTH OF INEICHEN DR + MATTERHORN DR	Model Node: J-2596

RESIDUAL HYDRANT(S)

Location(s):	R1	1ST HYDRANT EAST OF FLOWING HYDRANT	Model Node: J-2598
	R2	ENTERPRISE DR NORTH OF PRAIRIE OAKS DR	Model Node: J-2686
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	**Initial**	**Final**		DIF	4.5	8	1,460
F1 - Nozzle 2							
Residual 1	45	46	9				
Residual 2	71	71	53				
Residual 3	88	87	77				
Residual 4	86	83	74				
Residual 5	67	67	58				
Residual 6	76	77	67				
Residual 7	71	73	64				
Residual 8	67	67	67				
Residual 9	64	64	64				
Residual 10	92	94	84				
Residual 11	74	75	65				
Residual 12	80	80	69				
Residual 13	75	76	65				
Residual 14	63	64	53				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)
Central	25
SE	9.3

Well	(GPM)	Press
1	520	65
2	2000	
3	0	
4	0	

BS	Suction (psi)
North	41.9

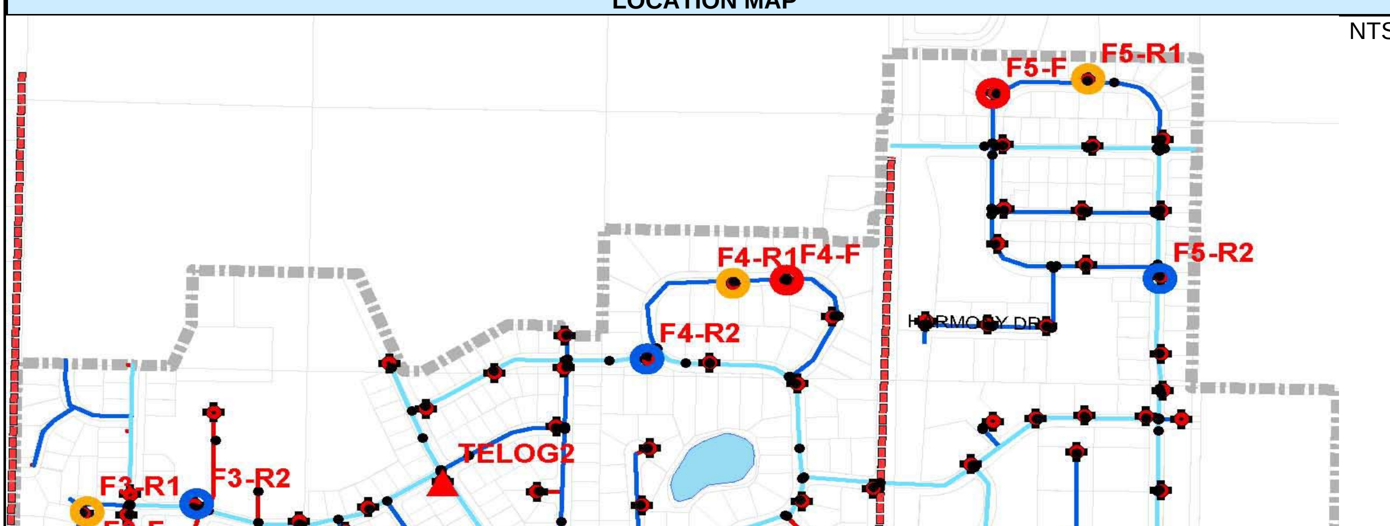
BS	Flow of water to HPSI (gpm)
SE	1
North	17

BS	Flow of water from HPSI (gpm)
SE	0

BS	Discharge of water (psi)
SE	88.5
North	73

LOCATION MAP

NTS



REMARKS:

L:\work\Projects\91960\eng\Calibration\[Verona Calib and flow test forms.xls]f-5

FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-6 **Date & Time:** 4/12/06 14:05 **Area:** Dane County Home

FLOWING HYDRANT(S)

Location(s):	F1	1ST HYDRANT NORTHEAST OF F6 R2	Model Node: J-2056

RESIDUAL HYDRANT(S)

Location(s):	R1	1ST HYDRANT EAST OF FLOWING HYDRANT	Model Node: J-2058
	R2	1ST HYDRANT EAST OF E VERONA AV + HORIZON DR	Model Node: J-541
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	**Initial**	**Final**		DIF	2.5	31	710
F1 - Nozzle 2							
Residual 1	76	64	46				
Residual 2	78	69	75				
Residual 3	90	86	89				
Residual 4	87	83	86				
Residual 5	68	67	67				
Residual 6	78	75	75				
Residual 7	72	69	70				
Residual 8	67	67	67				
Residual 9	64	64	64				
Residual 10	94	91	91				
Residual 11	76	73	73				
Residual 12	82	79	78				
Residual 13	76	74	74				
Residual 14	64	63	62				

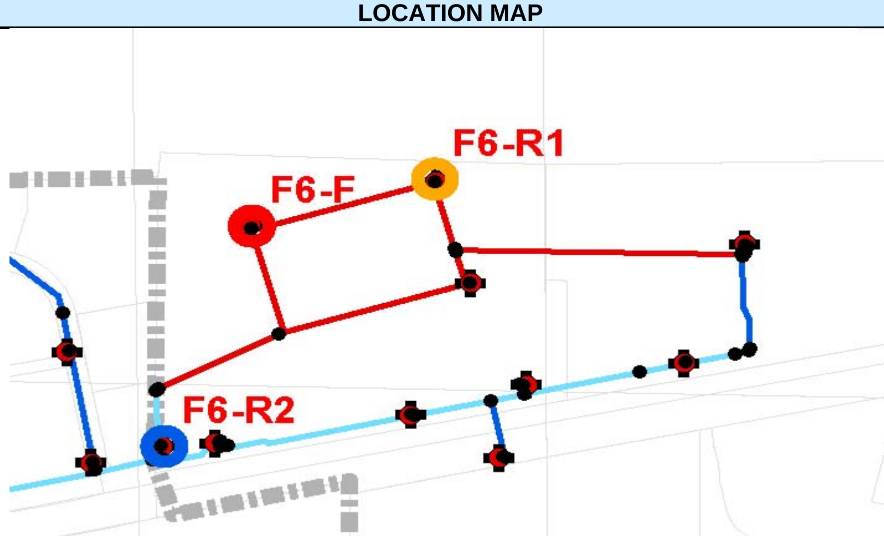
BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)	Well	(GPM)	Press
Central	27	1	464	
SE	9.4	2	861	72
		3	0	
BS	Suction (psi)	4	0	
North	55.2			

BS	Flow of water to HPSI (gpm)	BS	Discharge of water (psi)
SE	1	SE	88.6
North	35	North	83.6
BS	Flow of water from HPSI (gpm)		
SE	0		

LOCATION MAP

NTS



REMARKS:

FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-7 **Date & Time:** 4/12/06 13:25 **Area:** Central

FLOWING HYDRANT(S)

Location(s):			
	F1	2ND HYDRANT EAST OF BASSWOOD AV + HEMLOCK DR	Model Node: J-2602

RESIDUAL HYDRANT(S)

Location(s):			
	R1	3RD HYDRANT EAST OF BASSWOOD AV + HEMLOCK DR	Model Node: J-979
	R2	N MAIN ST + BASSWOOD AV	Model Node: J-2106
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
	Initial	Final					
F1 - Nozzle 1				DIF	4.5	19	2,110
F1 - Nozzle 2							
Residual 1	65	63	50				
Residual 2	71	70	61				
Residual 3	81	80	71				
Residual 4	78	77	68				
Residual 5	59	58	54				
Residual 6	68	67	60				
Residual 7	62	61	54				
Residual 8	67	67	67				
Residual 9	64	64	64				
Residual 10	84	83	75				
Residual 11	66	64	56				
Residual 12	72	70	62				
Residual 13	67	65	58				
Residual 14	55	53	47				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)
Central	12
SE	9.2

BS	Suction (psi)
North	45.8

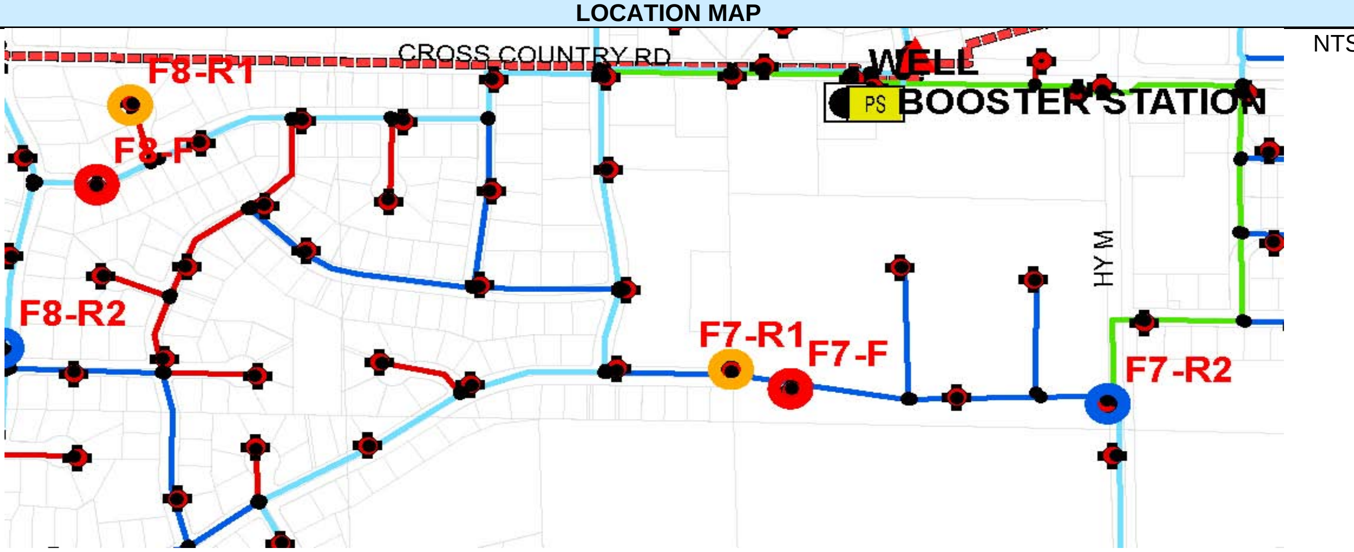
BS	Flow of water to HPSI (gpm)
SE	1
North	16

BS	Flow of water from HPSI (gpm)
SE	0

Well	(GPM)	Press
1	520	63
2	0	
3	0	
4	0	

BS	Discharge of water (psi)
SE	88.4
North	77

LOCATION MAP



REMARKS:

FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-8 **Date & Time:** 4/12/06 13:09 **Area:** Central

FLOWING HYDRANT(S)

Location(s):	F1	1ST HYDRANT EAST OF TAMARACK WAY + POPLAR WAY	Model Node: J-2600

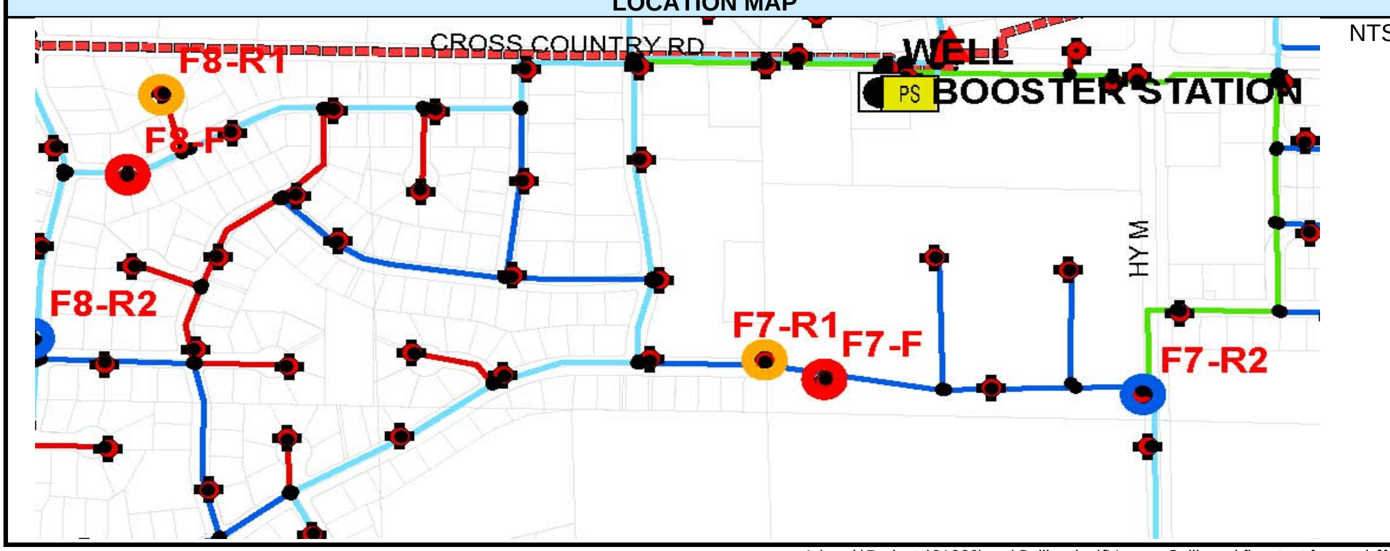
RESIDUAL HYDRANT(S)

Location(s):	R1	NORTH CORNER OF PINE CT	Model Node: J-977
	R2	1ST HYDRANT NORTH OF TAMARACK WAY + SPRUCE	Model Node: J-947
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	Initial	Final		DIF	4.5	19	2,110
F1 - Nozzle 2							

Hydrant	Initial	Final	Residual					
				BOUNDARY CONDITIONS				
Residual 1	47	48	34					
Residual 2	59	58	47	Towers	Height of water in tower (ft)	Well	(GPM)	Press
Residual 3	75	75	66	Central	13	1	525	
Residual 4	73	72	63	SE	8.8	2	0	59
Residual 5	57	57	52			3	0	
Residual 6	65	66	58	BS	Suction (psi)	4	0	
Residual 7	58	59	51	North	41			
Residual 8	67	67	67			BS	Discharge of water (psi)	
Residual 9	64	64	64	BS	Flow of water to HPSI (gpm)			
Residual 10	79	80	72	SE	905	SE	90	
Residual 11	61	62	54	North	11	North	72.6	
Residual 12	69	70	60					
Residual 13	64	65	54	BS	Flow of water from HPSI (gpm)			
Residual 14	52	53	43	SE	0			

LOCATION MAP



REMARKS:

FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-9 **Date & Time:** 4/12/06 12:55 **Area:** EPIC

FLOWING HYDRANT(S)

Location(s):	F1	N NINE MOUND RD + CROSS COUNTRY RD	Model Node: J-2516

RESIDUAL HYDRANT(S)

Location(s):	R1	1ST HYDRANT NORTH OF N NINE MOUND RD + CROSS COUNTRY RD	Model Node: J-2514
	R2	3RD HYDRANT SOUTHWEST OF N NINE MOUND RD + CROSS COUNTRY RD	Model Node: J-2632
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

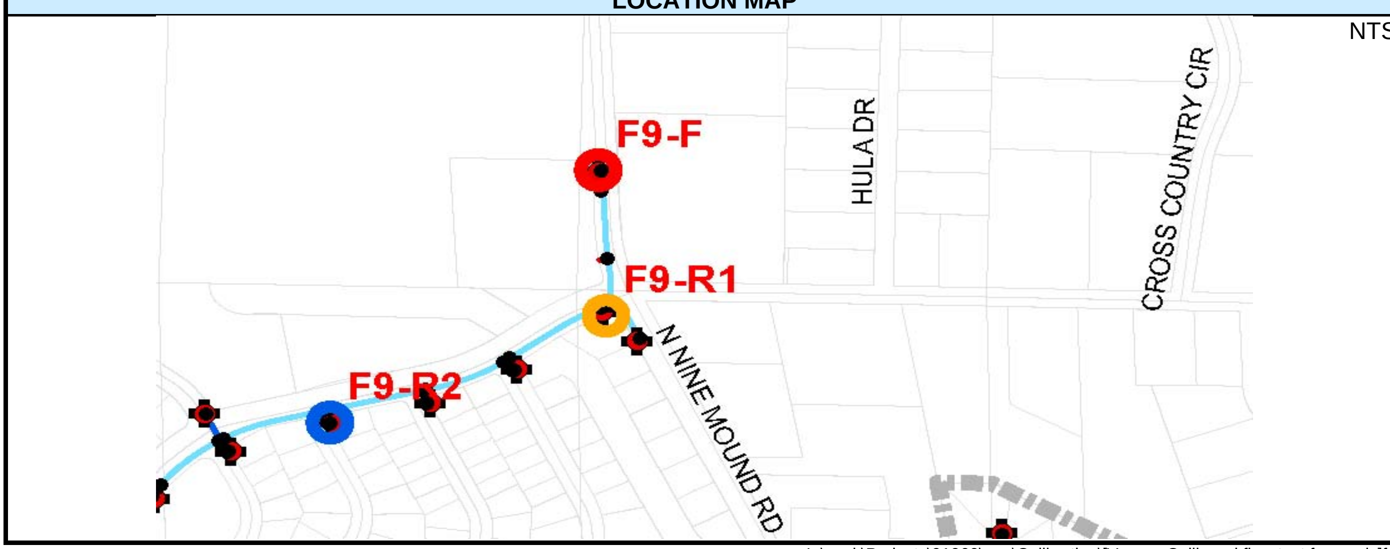
Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
	Initial	**Final**					
F1 - Nozzle 1				DIF	4.5	9	1,540
F1 - Nozzle 2							
Residual 1	63	63	21				
Residual 2	70	70	34				
Residual 3	85	87	85				
Residual 4	82	84	82				
Residual 5	67	67	63				
Residual 6	75	75	71				
Residual 7	68	69	63				
Residual 8	67	67	67				
Residual 9	63	64	63				
Residual 10	89	89	85				
Residual 11	71	71	65				
Residual 12	79	80	73				
Residual 13	77	77	69				
Residual 14	64	64	51				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)	Well	(GPM)	Press
Central	24	1	493	
SE	7.1	2	0	69
		3	1819	
BS	Suction (psi)	4	0	
North	52.5			
		BS	Discharge of water (psi)	
BS	Flow of water to HPSI (gpm)			
SE	1188	SE	90.2	
North	37	North	83.6	
BS	Flow of water from HPSI (gpm)			
SE	0			

LOCATION MAP

NTS



REMARKS:

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FLOW AND PRESSURE TESTS

VERONA WATER UTILITY

VERONA, WISCONSIN

Test Number: F-10 **Date & Time:** 4/12/06 12:38 **Area:** EPIC

FLOWING HYDRANT(S)

Location(s):			
	F1	1ST HYDRANT WEST OF F10 R1	Model Node: J-2612

RESIDUAL HYDRANT(S)

Location(s):			
	R1	2ND HYDRANT WEST OF F10 R2	Model Node: J-2610
	R2	4TH HYDRANT SOUTH OF CROSS COUNTRY RD + MEISTER DR	Model Node: J-2608
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	Initial	Final		DIF	4.5	12	1,740
F1 - Nozzle 2							
Residual 1	57	57	29				
Residual 2	68	68	42				
Residual 3	78	79	69				
Residual 4	76	76	66				
Residual 5	59	58	53				
Residual 6	68	67	59				
Residual 7	63	61	53				
Residual 8	66	66	66				
Residual 9	62	63	62				
Residual 10	84	83	74				
Residual 11	66	65	58				
Residual 12	71	70	63				
Residual 13	67	66	56				
Residual 14	54	54	40				

BOUNDARY CONDITIONS

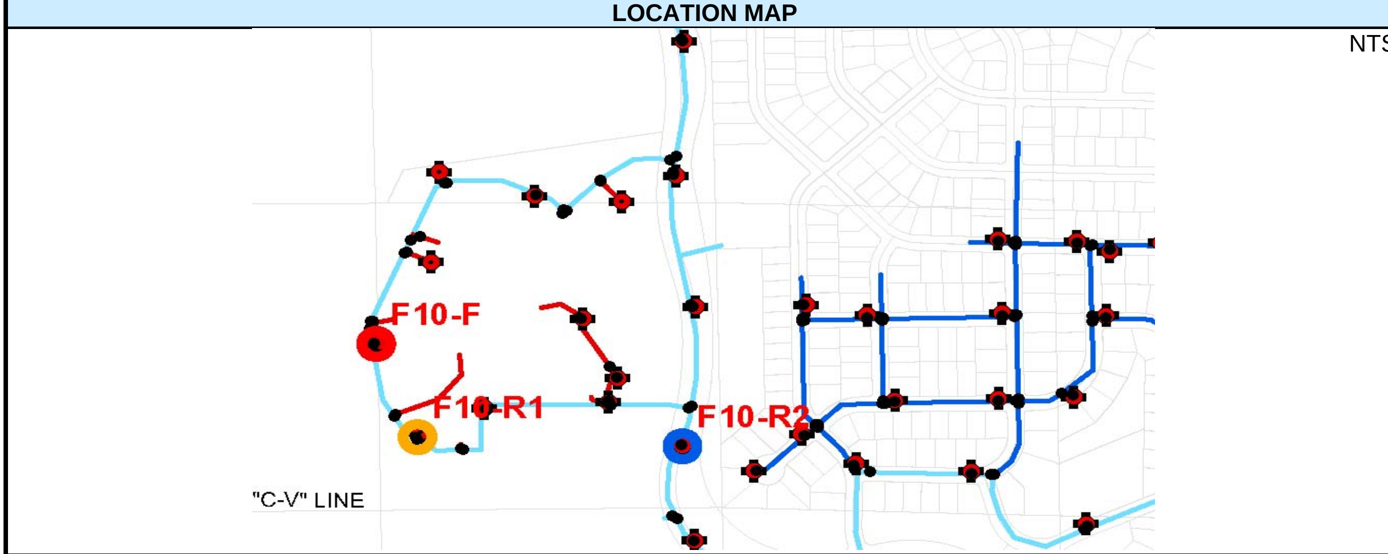
Towers	Height of water in tower (ft)
Central	14.1
SE	5.3
BS	**Suction (psi)**
North	44
BS	**Flow of water to HPSI (gpm)**
SE	0
North	32
BS	**Flow of water from HPSI (gpm)**
SE	1

Well	(GPM)	Press
1	0	
2	2000	63
3	0	
4	0	

BS	Discharge of water (psi)
SE	87.3
North	73.5

LOCATION MAP

NTS



REMARKS:

FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-11 **Date & Time:** 4/12/06 11:21 **Area:** Central

FLOWING HYDRANT(S)

Location(s):			
Location(s):	F1	EDWARD ST + BIRCHWOOD LN	Model Node: J-2606

RESIDUAL HYDRANT(S)

Location(s):	R1	2ND HYDRANT NORTH OF EDWARD ST + RIDGEVIEW TR	Model Node: J-2604
	R2	EDWARD ST + BIRCHWOOD LN	Model Node: J-2140
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	**Initial**	**Final**		DIF	4.5	19	2,110
F1 - Nozzle 2							
Residual 1	58	58	44				
Residual 2	63	63	51				
Residual 3	79	78	73				
Residual 4	77	75	71				
Residual 5	59	59	56				
Residual 6	68	68	64				
Residual 7	63	63	59				
Residual 8	67	67	67				
Residual 9	64	64	64				
Residual 10	85	84	81				
Residual 11	66	66	62				
Residual 12	72	71	66				
Residual 13	67	66	60				
Residual 14	55	54	43				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)	Well	(GPM)	Press
Central	14.7	1	0	
SE	10.4	2	0	57
		3	0	
BS	Suction (psi)	4	0	
North	45			

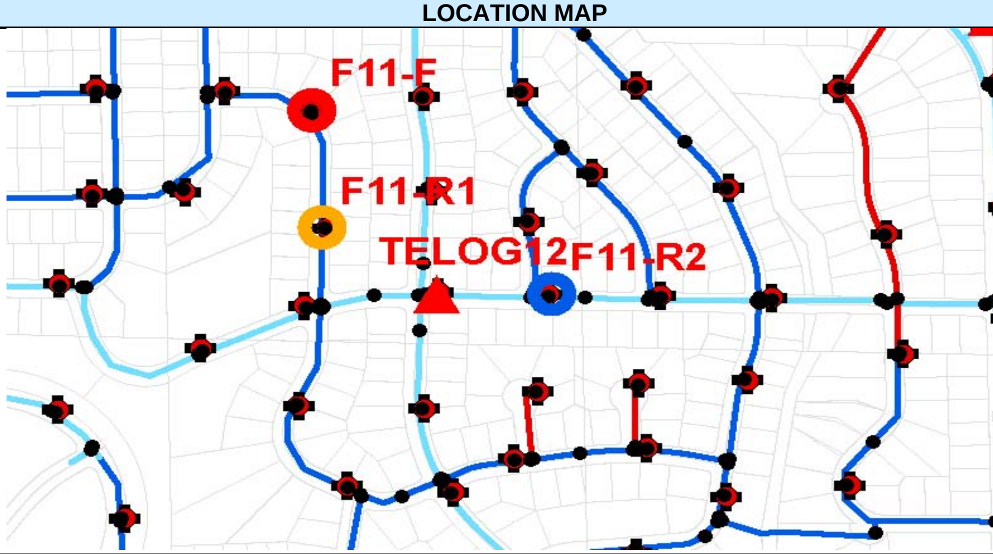
BS	Flow of water to HPSI (gpm)
SE	0
North	24

BS	Discharge of water (psi)
SE	87.7
North	73

BS	Flow of water from HPSI (gpm)
SE	922

LOCATION MAP

NTS



REMARKS:

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FLOW AND PRESSURE TESTS

VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-12 **Date & Time:** 4/12/06 11:06 **Area:** CENTRAL

FLOWING HYDRANT(S)

Location(s):	F1	2ND HYDRANT EAST OF MARK DR + TODD ST	Model Node: J-874

RESIDUAL HYDRANT(S)

Location(s):	R1	BARBRA & MARK	Model Node: J-873
	R2	1ST HYDRANT EAST OF W VERONA AV + TODD ST	Model Node: J-2642
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	**Initial**	**Final**		DIF	4.5	21	2,190
F1 - Nozzle 2							
Residual 1	60	60	50				
Residual 2	66	66	60				
Residual 3	82	82	77				
Residual 4	80	79	74				
Residual 5	59	59	56				
Residual 6	68	68	64				
Residual 7	63	63	59				
Residual 8	68	68	68				
Residual 9	64	64	64				
Residual 10	85	85	81				
Residual 11	66	66	61				
Residual 12	72	72	67				
Residual 13	67	67	61				
Residual 14	55	55	48				

BOUNDARY CONDITIONS

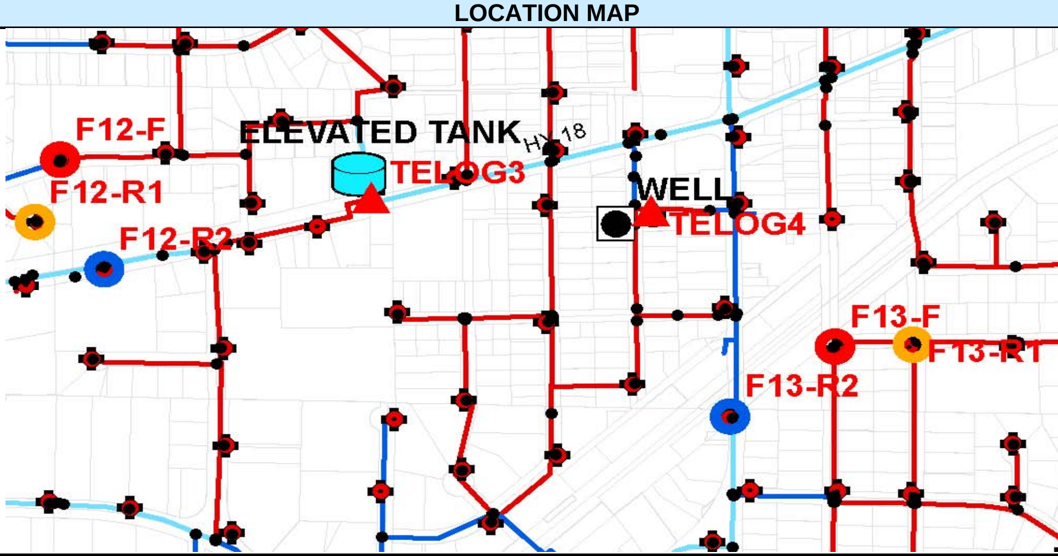
Towers	Height of water in tower (ft)
Central	15.1
SE	11.3
BS	Suction (psi)
North	44
BS	Flow of water to HPSI (gpm)
SE	0
North	52
BS	Flow of water from HPSI (gpm)
SE	1032

Well	(GPM)	Press
1	0	
2	0	59
3	0	
4	0	

BS	Discharge of water (psi)
SE	87
North	76

LOCATION MAP

NTS



REMARKS:

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FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-13 **Date & Time:** 4/12/06 10:51 **Area:** CENTRAL

FLOWING HYDRANT(S)

Location(s):	F1	S FRANKLIN ST + SCHWEITZER ST	Model Node: J-251

RESIDUAL HYDRANT(S)

Location(s):	R1	S JEFFERSON ST + SCHWEITZER ST	Model Node: J-264
	R2	1ST NORTH OF N MAIN ST + VALLEY VIEW ST	Model Node: J-173
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	**Initial**	**Final**		DIF	4.5	23	2,270
F1 - Nozzle 2							
Residual 1	69	68	59				
Residual 2	66	66	61				
Residual 3	80	80	69				
Residual 4	79	77	70				
Residual 5	59	59	57				
Residual 6	68	68	64				
Residual 7	63	63	59				
Residual 8	68	68	68				
Residual 9	65	65	64				
Residual 10	85	85	81				
Residual 11	66	65	60				
Residual 12	72	72	67				
Residual 13	67	67	63				
Residual 14	54	55	52				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)
Central	15.5
SE	12.3

Well	(GPM)	Press
1	0	
2	0	
3	0	
4	0	

BS	Suction (psi)
North	44

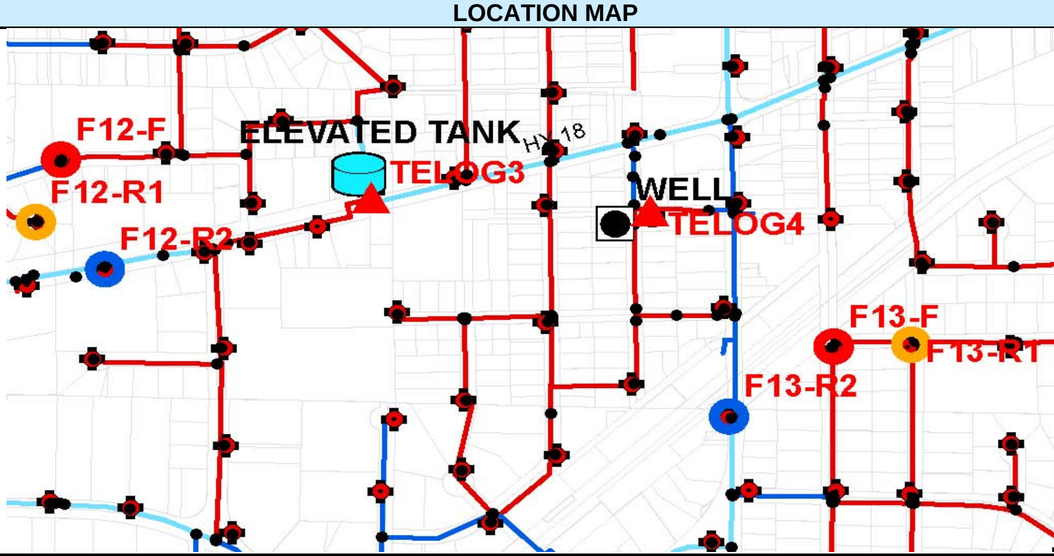
BS	Flow of water to HPSI (gpm)
SE	0
North	76

BS	Discharge of water (psi)
SE	87
North	78

BS	Flow of water from HPSI (gpm)
SE	1370

LOCATION MAP

NTS



REMARKS:

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FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-14 **Date & Time:** 4/12/06 10:39 **Area:** CENTRAL

FLOWING HYDRANT(S)

Location(s):	F1	WEST CORNER OF VENTURE CT	Model Node: J-13

RESIDUAL HYDRANT(S)

Location(s):	R1	1ST HYDRANT EAST OF FLOWING HYDRANT	Model Node: J-2646
	R2	1ST HYDRANT NORTHEAST OF PAOLI ST + VERTURE CT	Model Node: J-17
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	**Initial**	**Final**		DIF	4.5	24	2,300
F1 - Nozzle 2							
Residual 1	68	68	48				
Residual 2	67	67	61				
Residual 3	81	81	77				
Residual 4	79	78	75				
Residual 5	60	60	57				
Residual 6	68	68	65				
Residual 7	63	63	57				
Residual 8	68	68	68				
Residual 9	65	65	64				
Residual 10	85	85	80				
Residual 11	66	67	62				
Residual 12	72	72	68				
Residual 13	67	67	64				
Residual 14	55	55	52				

BOUNDARY CONDITIONS

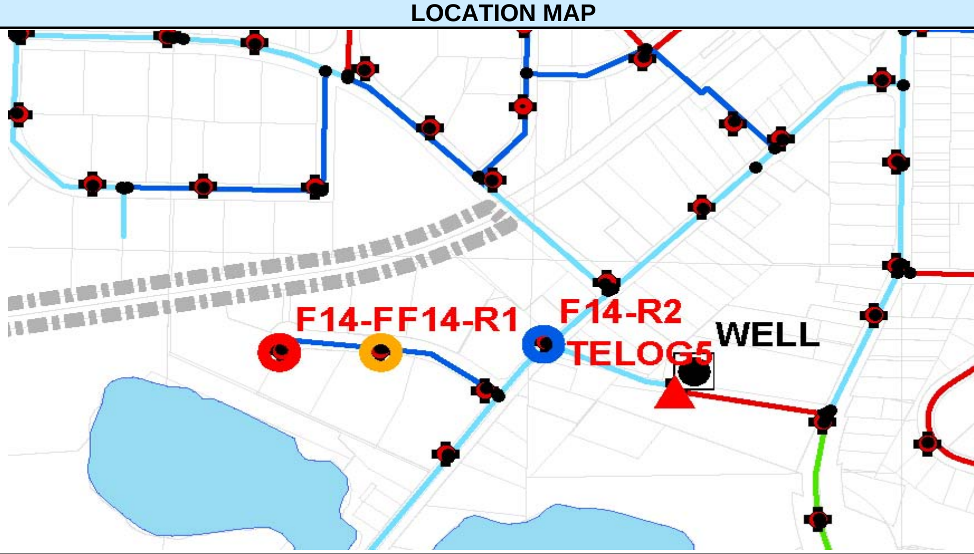
Towers	Height of water in tower (ft)
Central	15.7
SE	13.3
BS	**Suction (psi)**
North	40.9
BS	**Flow of water to HPSI (gpm)**
SE	0
North	18
BS	**Flow of water from HPSI (gpm)**
SE	1327

Well	(GPM)	Press
1	0	
2	0	
3	0	
4	0	

BS	Discharge of water (psi)
SE	86.5
North	76.8

LOCATION MAP

NTS



REMARKS:

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FLOW AND PRESSURE TESTS

VERONA WATER UTILITY

VERONA, WISCONSIN

Test Number: F-15 **Date & Time:** 4/12/06 10:25 **Area:** CENTRAL

FLOWING HYDRANT(S)

Location(s):	F1	2ND HYDRANT EAST OF LOCUST DR + PRAIRIE HEIGHTS DR	Model Node: J-2660

RESIDUAL HYDRANT(S)

Location(s):	R1	1ST HYDRANT EAST OF LOCUST DR + PRAIRIE HEIGHTS DR	Model Node: J-2262
	R2	1ST HYDRANT NORTH OF LOCUST DR + MEADOWSIDE DR	Model Node: J-2652
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

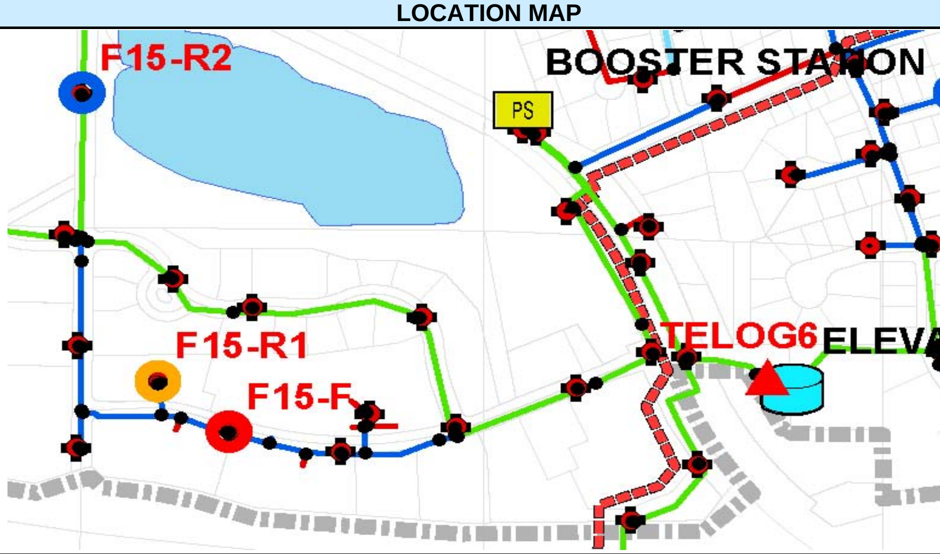
Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
	Initial	Final					
F1 - Nozzle 1				DIF	4.5	22	2,230
F1 - Nozzle 2							
Residual 1	53	53	43				
Residual 2	73	72	68				
Residual 3	81	80	77				
Residual 4	78	77	74				
Residual 5	60	60	58				
Residual 6	69	69	65				
Residual 7	64	64	59				
Residual 8	69	69	68				
Residual 9	65	65	65				
Residual 10	85	85	80				
Residual 11	67	66	63				
Residual 12	72	72	69				
Residual 13	68	67	64				
Residual 14	56	55	52				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)	Well	(GPM)	Press
Central	16.3	1	0	
SE	14	2	0	
		3	0	
BS	Suction (psi)	4	0	
North	40.9			
		BS	Discharge of water (psi)	
BS	Flow of water to HPSI (gpm)			
SE	0	SE	86.7	
North	34	North	76.5	
BS	Flow of water from HPSI (gpm)			
SE	1434			

LOCATION MAP

NTS



REMARKS:

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FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-16 **Date & Time:** 4/13/06 8:48 **Area:** Central

FLOWING HYDRANT(S)

Location(s):	F1	1ST HYDRANT WEST OF E HILLCREST DR + FOREST VIEW DR	Model Node: J-364

RESIDUAL HYDRANT(S)

Location(s):	R1	E HILLCREST DR + FOREST VIEW DR	Model Node: J-366
	R2	1ST HYDRANT WEST OF E HILLCREST DR + ELM ST	Model Node: J-339
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	**Initial**	**Final**		DIF	4.5	19	2,110
F1 - Nozzle 2							
Residual 1	60	58-60	39				
Residual 2	73	72	60				
Residual 3	82	82	76				
Residual 4	80	80	72				
Residual 5	62	62	60				
Residual 6	70	70	67				
Residual 7	65	65	62				
Residual 8	71	70	70				
Residual 9	67	67	66				
Residual 10	87	86	84				
Residual 11	69	68	49				
Residual 12	74	73	71				
Residual 13	69	69	67				
Residual 14	57	57	55				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)
Central	21
SE	19.6

Well	(GPM)	Press
1	0	
2	0	62.1
3	0	
4	0	

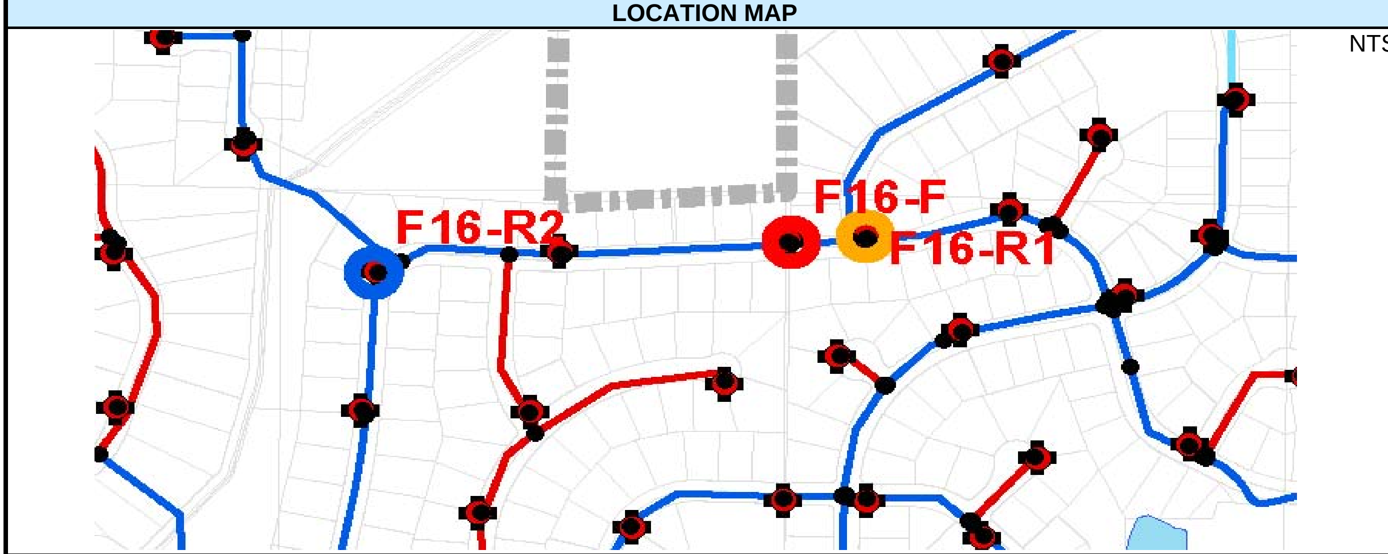
BS	Suction (psi)
North	43.8

BS	Flow of water to HPSI (gpm)
SE	0
North	57

BS	Discharge of water (psi)
SE	88.8
North	75.5

BS	Flow of water from HPSI (gpm)
SE	1359

LOCATION MAP



REMARKS:

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FLOW AND PRESSURE TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: F-17 **Date & Time:** 4/13/06 8:32 **Area:** Central

FLOWING HYDRANT(S)

Location(s):	F1	1ST HYDRANT NORTH OF HARPER DR + GOLDENROD CIR	Model Node: J-2668

RESIDUAL HYDRANT(S)

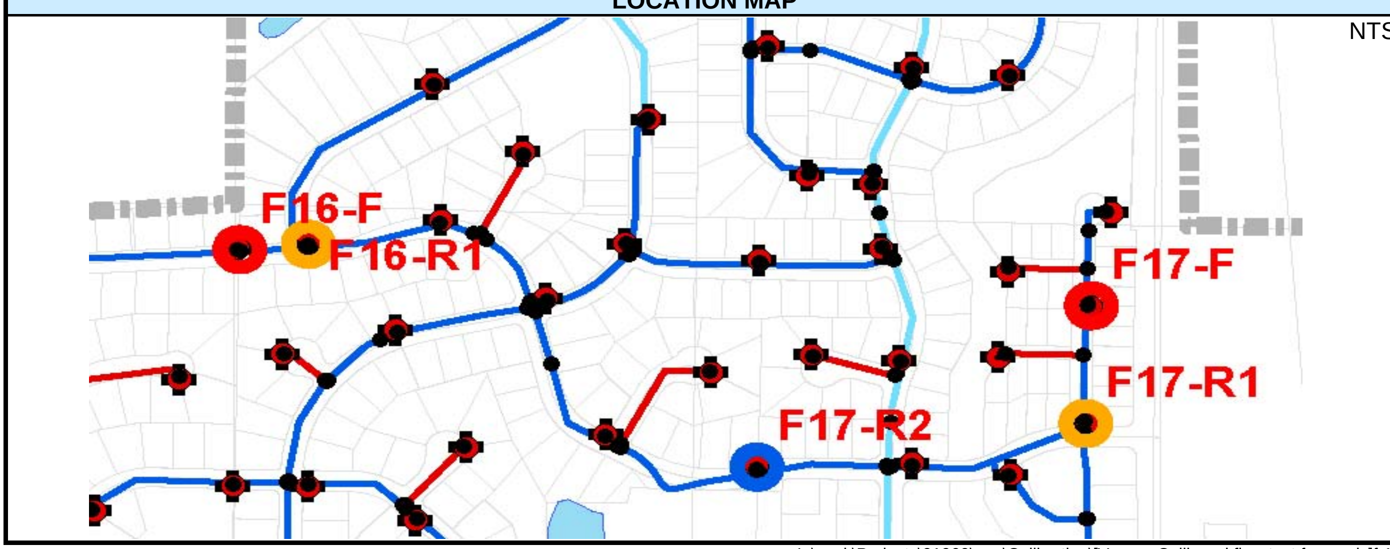
Location(s):	R1	HARPER DR + GOLDENROD CIR	Model Node: J-2220
	R2	1ST HYDRANT WEST OF HARPER DR + MILITRAY	Model Node: J-423
	R3	1739 - SOUTH OF CROSS COUNTRY RD + GATEWAY PASS WELL 4	Model Node: J-2112
	R4	1738 - LONE PINE WAY + HEMLOCK DR	Model Node: J-2548
	R5	202486 - W VERONA AV + WESTLAWN AV TOWER 1	Model Node: J-159
	R6	202485 - S SHUMAN ST + PARK LN WELL 1	Model Node: J-165
	R7	1656 - WEST CORNER OF FACTORY ST WELL 2	Model Node: J-53
	R8	1509 - S MAIN ST; SOUTHWEST OF HAMLET CIR TOWER 2	Model Node: J-2398
	R9	1508 - FAIRVIEW TER + GATSBY GLEN DR	Model Node: J-2438
	R10	1652 - BRUCE ST + INVESTMENT CT	Model Node: J-2158
	R11	2218 - FOREST VIEW DR + HARVEST LN	Model Node: J-372
	R12	2217 - 1ST HYDRANT SOUTH OF ENTERPRISE DR + LLANOS ST	Model Node: J-2488
	R13	202488 - N NINE MOUND RD + ASPEN AV WELL 3	Model Node: J-785
	R14	202487 - EDWARD ST + WESTRIDGE PKWY	Model Node: J-2142

Hydrant	Static Pressure (psi)		Residual Pressure (psi)	Flow Device	Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)
F1 - Nozzle 1	**Initial**	**Final**		DIF	4.5	11	1,680
F1 - Nozzle 2							
Residual 1	63	62	31				
Residual 2	60	58-60	38				
Residual 3	83	81	77				
Residual 4	81	78	73				
Residual 5	62	62	60				
Residual 6	71	70	68				
Residual 7	66	65	62				
Residual 8	71	71	70				
Residual 9	67	67	67				
Residual 10	88	87	84				
Residual 11	69	68	50				
Residual 12	75	74	71				
Residual 13	70	69	67				
Residual 14	58	57	55				

BOUNDARY CONDITIONS

Towers	Height of water in tower (ft)	Well	(GPM)	Press
Central	21.8	1	0	
SE	21	2	0	62.4
		3	0	
BS	Suction (psi)	4	0	
North	44.3			
		BS	Discharge of water (psi)	
BS	Flow of water to HPSI (gpm)			
SE	0	SE	89.5	
North	49	North	78	
BS	Flow of water from HPSI (gpm)			
SE	1182			

LOCATION MAP



REMARKS:

ROUGHNESS COEFFICIENT TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: C-1 **Date & Time:** 4/11/06 9:12 **Pressure Zone:** Central

FLOWING HYDRANT

Location: F1 1st Hydrant North of E Verona Ave + N Franklin St

RESIDUAL HYDRANTS

Locations:
R1 2nd Hydrant North of E Verona Ave + N Franklin St
R2 1st Hydrant East of N Main St + E Harriet St

CLOSED VALVES

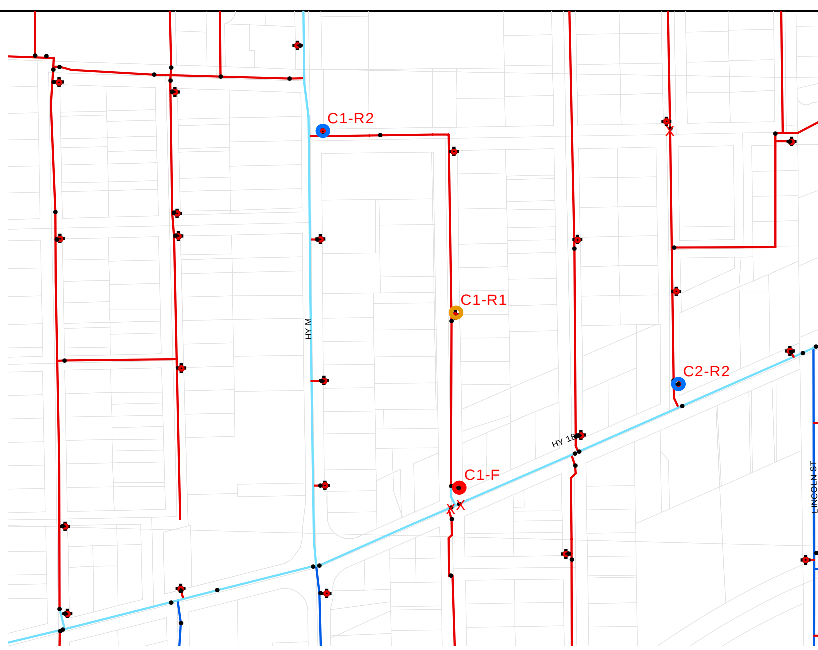
See Map Three normally closed valves on line to be tested, so test was not conducted.

Hydrant	Flow Device	Flow Test Kit Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)	Static Pressure (psi)		Residual Pressure (psi)	Pressure Differential (ft)	
					Initial	Final		Initial	Final
F1 - Nozzle 1	DIF	2.50	30	700					
F1 - Nozzle 2				0					
Residual R1					74	74	45	67	67
Residual R2					75	75	71	9	9

Pipe Diameter 6 inches
Pipe Material Cast Iron
Year Installed 1930
Pipe Age 76
Distance Between Residual Hydrants 853 feet

Calculated C-Value 96

Location Map NTS



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REMARKS:

ROUGHNESS COEFFICIENT TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: C-2 **Date & Time:** 4/11/06 9:47 **Pressure Zone:** Central

FLOWING HYDRANT

Location: F1 1st Hydrant South of Silent St + Noel Way

RESIDUAL HYDRANTS

Locations:
R1 2nd Hydrant South of Silent St + Noel Way
R2 1st Hydrant North of E Verona Ave + Gilman Way

CLOSED VALVES

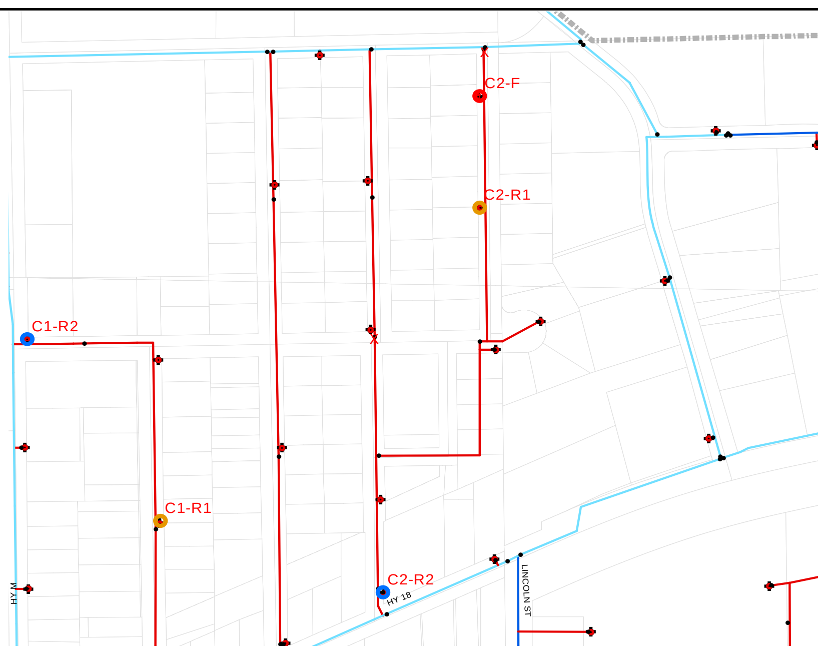
See Map Three normally closed valves on line to be tested, so test was not conducted.

Hydrant	Flow Device	Flow Test Kit Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)	Static Pressure (psi)		Residual Pressure (psi)	Pressure Differential (ft)	
					Initial	Final		Initial	Final
F1 - Nozzle 1	DIF	2.50	25	660					
F1 - Nozzle 2				0					
Residual R1					73	73	34	90	90
Residual R2					75	75	72	7	7

Pipe Diameter 6 inches
Pipe Material Cast Iron
Year Installed 1945
Pipe Age 61
Distance Between Residual Hydrants 1,360 feet

Calculated C-Value 95

Location Map NTS



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REMARKS:

ROUGHNESS COEFFICIENT TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: C-3 **Date & Time:** 4/11/06 10:13 **Pressure Zone:** Central

FLOWING HYDRANT

Location: F1 1st Hydrant South of Park View Lane + E Melody Lane

RESIDUAL HYDRANTS

Locations:
R1 2nd Hydrant South of Park View Lane + E Melody Lane
R2 1st Hydrant South of Park View Lane + W Melody Lane

CLOSED VALVES

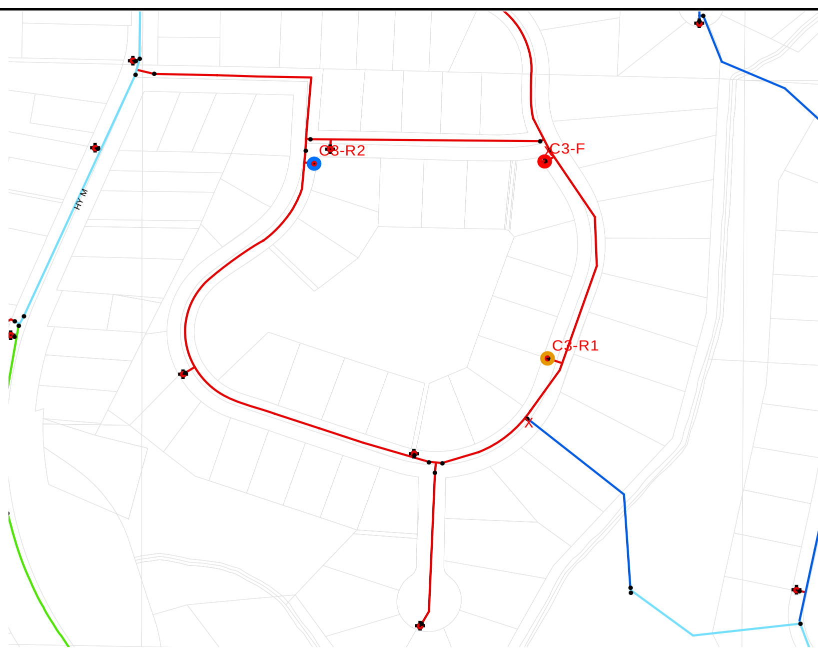
See Map Three normally closed valves on line to be tested, so test was not conducted.

Hydrant	Flow Device	Flow Test Kit Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)	Static Pressure (psi)		Residual Pressure (psi)	Pressure Differential (ft)	
					Initial	Final		Initial	Final
F1 - Nozzle 1	DIF	2.50	20	610					
F1 - Nozzle 2				0					
Residual R1					69	69	36	76	76
Residual R2					60	60	53	16	16

Pipe Diameter 6 inches
Pipe Material Cast Iron
Year Installed 1960
Pipe Age 46
Distance Between Residual Hydrants 1,520 feet

Calculated C-Value 111

Location Map NTS



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REMARKS:

ROUGHNESS COEFFICIENT TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: C-4 **Date & Time:** 4/11/06 13:48 **Pressure Zone:** Central

FLOWING HYDRANT

Location: F1 Oak Ct Cul De Sac

RESIDUAL HYDRANTS

Locations:
R1 Lincoln St Cul De Sac
R2 1st Hydrant West of Hillcrest Dr + Forest View Dr

CLOSED VALVES

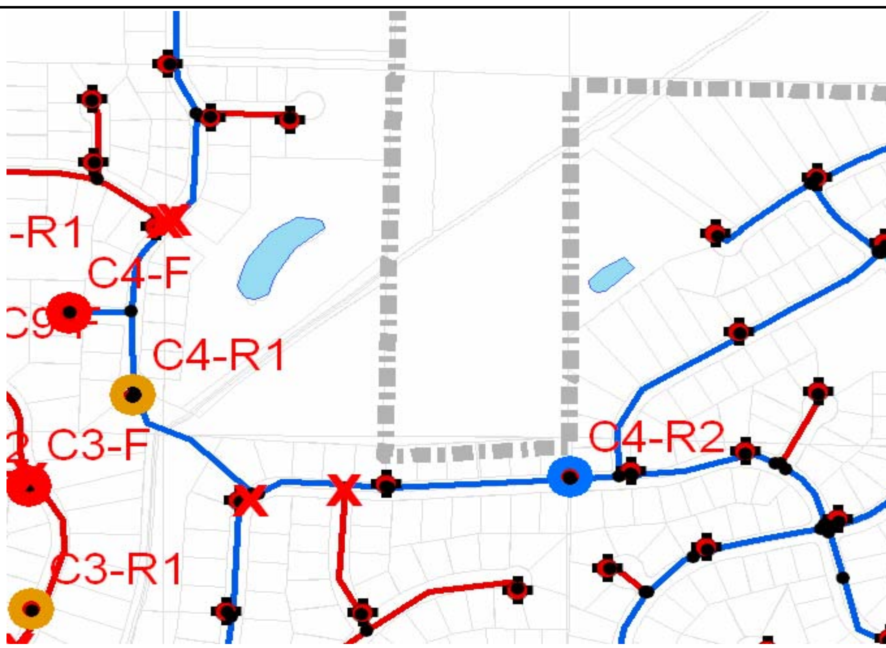
See Map Three normally closed valves on line to be tested, so test was not conducted.

Hydrant	Flow Device	Flow Test Kit Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)	Static Pressure (psi)		Residual Pressure (psi)	Pressure Differential (ft)	
					Initial	Final		Initial	Final
F1 - Nozzle 1	DIF	2.50	31	710					
F1 - Nozzle 2				0					
Residual R1					78	77	54	55	53
Residual R2					59	58	41	42	39

Pipe Diameter 8 inches
Pipe Material Ductile Iron
Year Installed 1972
Pipe Age 34
Distance Between Residual Hydrants 1,620 feet

Calculated C-Value 139

Location Map NTS



REMARKS:

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ROUGHNESS COEFFICIENT TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: C-5 **Date & Time:** 4/11/06 11:06 **Pressure Zone:** Central

FLOWING HYDRANT

Location: F1 1st Hydrant Northeast of Paoli St + S Nine Mound Rd

RESIDUAL HYDRANTS

Locations:
R1 1st Hydrant Southwest of Paoli St + S Nine Mound Rd
R2 1st Hydrant Northeast of Paoli St + Bruce St

CLOSED VALVES

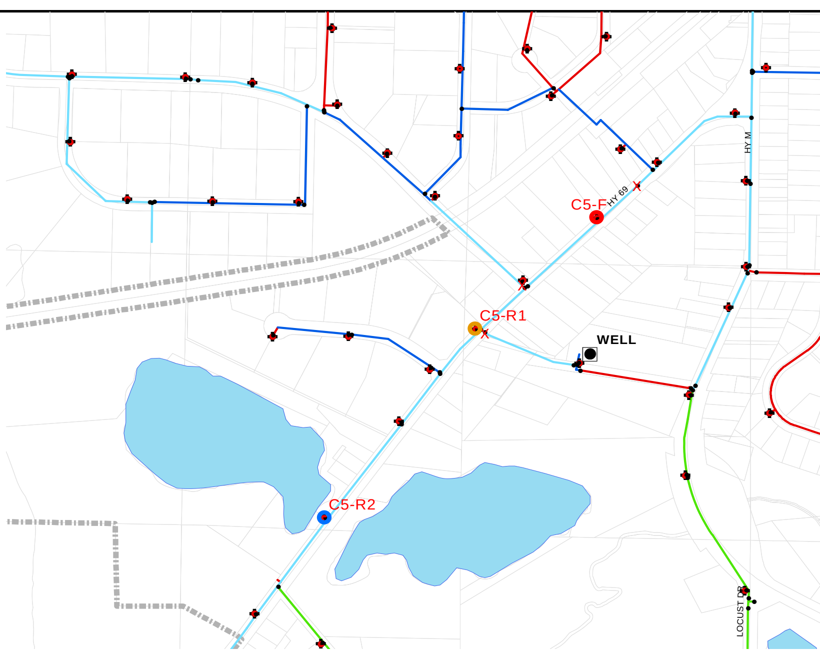
See Map Three normally closed valves on line to be tested, so test was not conducted.

Hydrant	Flow Device	Flow Test Kit Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)	Static Pressure (psi) Initial	Static Pressure (psi) Final	Residual Pressure (psi)	Pressure Differential (ft) Initial	Pressure Differential (ft) Final
F1 - Nozzle 1	DIF	4.50	12	1,740					
F1 - Nozzle 2				0					
Residual R1					60	61	32	65	67
Residual R2					70	70.5	48	51	52

Pipe Diameter 10 inches
Pipe Material Ductile Iron
Year Installed 1988
Pipe Age 18
Distance Between Residual Hydrants 1,160 feet

Calculated C-Value 158

Location Map NTS



REMARKS:

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ROUGHNESS COEFFICIENT TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: C-6 **Date & Time:** 4/11/06 12:12 **Pressure Zone:** Central

FLOWING HYDRANT

Location: F1 1st Hydrant Northwest of Amanda Way + Birchwood Ln

RESIDUAL HYDRANTS

Locations:
R1 1st Hydrant Eastt of Jenna Dr + Amanda Way
R2 1st Hydrant North of Edward St + Jenna Dr

CLOSED VALVES

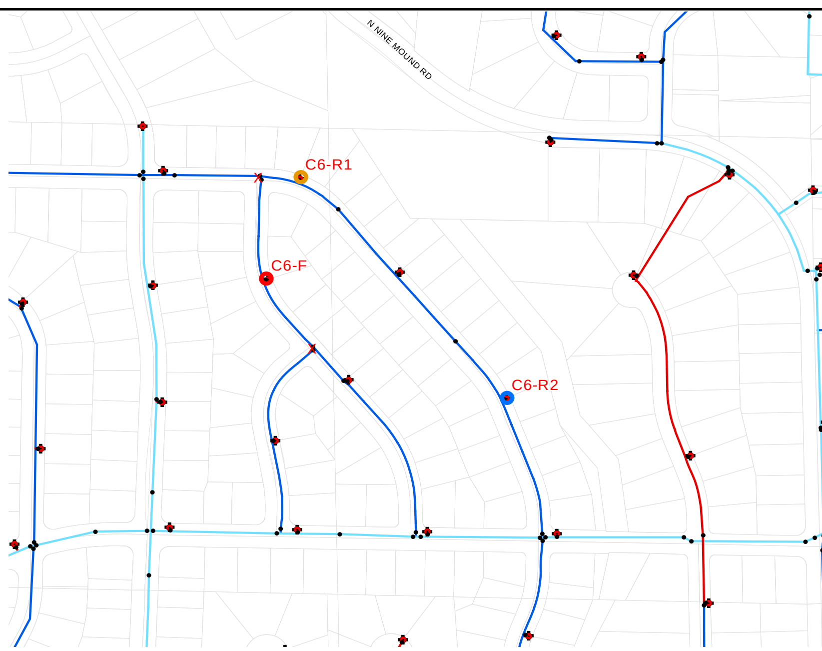
See Map Three normally closed valves on line to be tested, so test was not conducted.

Hydrant	Flow Device	Flow Test Kit Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)	Static Pressure (psi)		Residual Pressure (psi)	Pressure Differential (ft)	
					Initial	Final		Initial	Final
F1 - Nozzle 1	DIF	2.50	45	780					
F1 - Nozzle 2				0					
Residual R1					67	67	53	32	32
Residual R2					84	84	75	21	21

Pipe Diameter 8 inches
Pipe Material Ductile Iron
Year Installed 1992
Pipe Age 14
Distance Between Residual Hydrants 830 feet

Calculated C-Value 117

Location Map NTS



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REMARKS:

ROUGHNESS COEFFICIENT TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: C-7 **Date & Time:** 4/11/06 12:50 **Area of System:** **Central**

FLOWING HYDRANT

Location: F1 2nd Hydrant N of West Mark Dr + Barbara St

RESIDUAL HYDRANTS

Locations:
R1 1st Hydrant N of West Mark Dr + Barbara St
R2 1st Hydrant N of East Lucille + Barbara St

CLOSED VALVES

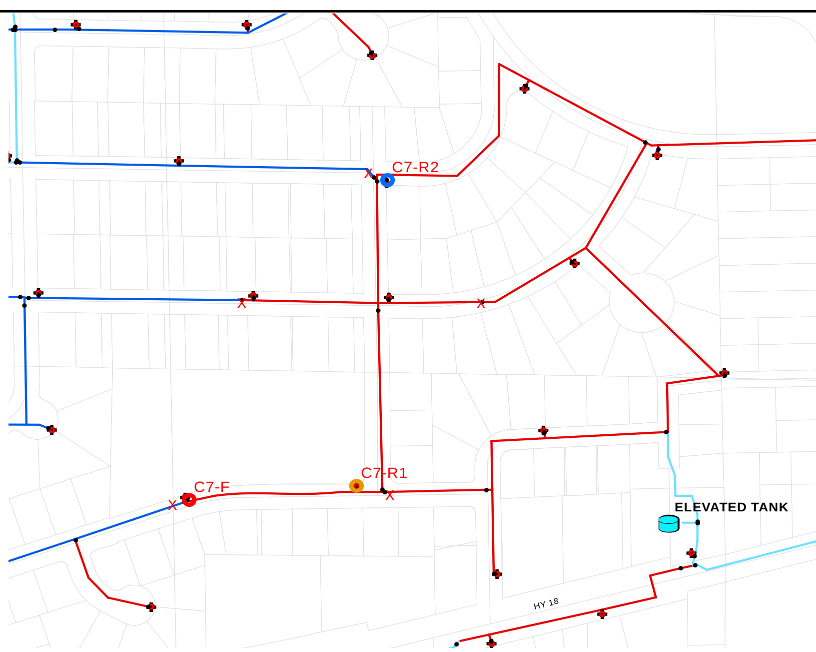
See Map Three normally closed valves on line to be tested, so test was not conducted.

Hydrant	Flow Device	Flow Test Kit Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)	Static Pressure (psi)		Residual Pressure (psi)	Pressure Differential (ft)	
					Initial	Final		Initial	Final
F1 - Nozzle 1	DIF	2.50	21	620					
F1 - Nozzle 2				0					
Residual R1					71	71	38	76	76
Residual R2					74	74	57	39	39

Pipe Diameter 6 inches
Pipe Material Ductile Iron
Year Installed 1955
Pipe Age 51
Distance Between Residual Hydrants 870 feet

Calculated C-Value 109

Location Map NTS



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REMARKS:

ROUGHNESS COEFFICIENT TESTS
VERONA WATER UTILITY
VERONA, WISCONSIN

Test Number: C-9 **Date & Time:** 4/11/06 10:40 **Area of System:** **Central**

FLOWING HYDRANT

Location: F1 1st Hydrant North of S Jefferson St + Melody Ln

RESIDUAL HYDRANTS

Locations:
R1 2nd Hydrant North of S Jefferson St + Melody Ln
R2 Jefferson St + Schweitzer

CLOSED VALVES

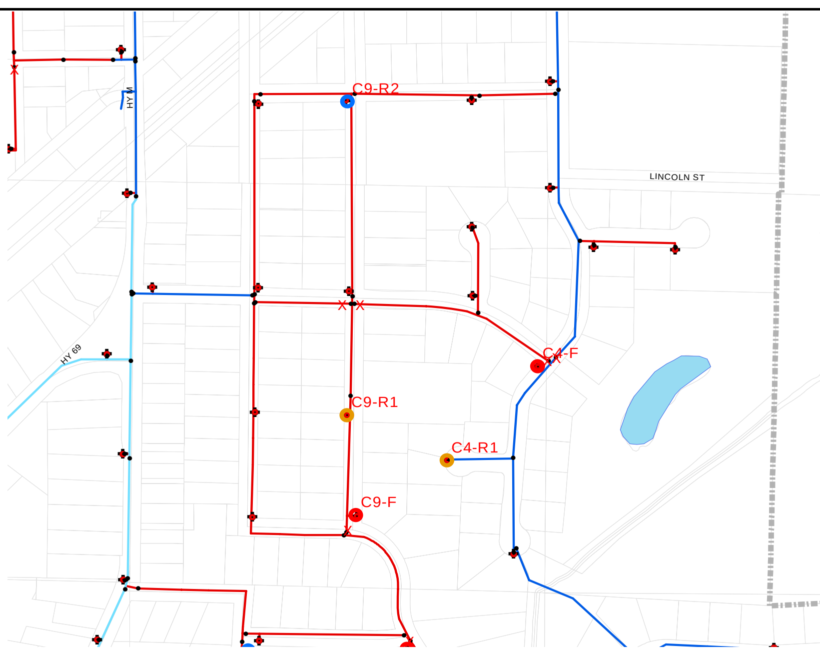
See Map Three normally closed valves on line to be tested, so test was not conducted.

Hydrant	Flow Device	Flow Test Kit Nozzle Size (inches)	Velocity Pressure (psi)	Flow (gpm)	Static Pressure (psi) Initial	Static Pressure (psi) Final	Residual Pressure (psi)	Pressure Differential (ft) Initial	Pressure Differential (ft) Final
F1 - Nozzle 1	DIF	2.50	20	610					
F1 - Nozzle 2				0					
Residual R1					66	66	29	85	85
Residual R2					70	70.5	64	14	15

Pipe Diameter 6 inches
Pipe Material Ductile Iron
Year Installed 1960
Pipe Age 46
Distance Between Residual Hydrants 1,040 feet

Calculated C-Value 83

Location Map NTS



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REMARKS:

APPENDIX D

CALIBRATION OF MODEL

HYDRAULIC MODEL CALIBRATION TABLE
VERONA WATER UTILITY
VERONA, WISCONSIN

FIELD TESTING/MODEL SIMULATIONS (Part 1: Residual 1, Residual 2, Telog 1, Telog 2)

Flow Test Number	Test Hydrant Flow (gpm) / Test Location	F= Field Test Data M= Model Data	Residual 1 Static Pressure (psi)	Residual 1 Residual Pressure (psi)	Residual 1 Pressure Differential (psi)	Residual 1 ∆ Pressure Differential (psi)	Residual 2 Static Pressure (psi)	Residual 2 Residual Pressure (psi)	Residual 2 Pressure Differential (psi)	Residual 2 ∆ Pressure Differential (psi)	Telog 1 Static Pressure (psi)	Telog 1 Residual Pressure (psi)	Telog 1 Pressure Differential (psi)	Telog 1 ∆ Pressure Differential (psi)	Telog 2 Static Pressure (psi)	Telog 2 Residual Pressure (psi)	Telog 2 Pressure Differential (psi)	Telog 2 ∆ Pressure Differential (psi)
F-1	2,190 gpm	F	70	43	27		70	46	24		81	79	2		79	76	3	
F-1	Southeast	M	72	44	28	1	72	47	25	1	82	81	1	-1	81	80	1	-2
F-2	2,190 gpm	F	81	41	40		70	48	22		82	82	0		80	79	0	
F-2	Southeast	M	79	35	44	4	68	44	24	2	82	81	1	1	81	80	1	1
F-3	2,010 gpm	F	80	31	49		85	40	45		84	49	35		81	43	38	
F-3	North	M	82	38	44	-5	87	45	42	-3	83	48	35	0	82	44	39	1
F-4	1,800 gpm	F	64	33	31		70	40	30		84	58	26		82	53	28	
F-4	NORTH	M	65	34	32	1	72	45	27	-3	83	61	22	-4	82	58	25	-4
F-5	1,460 gpm	F	45	9	36		71	53	18		88	77	10		86	74	12	
F-5	Central	M	46	34	12	-24	75	68	7	-11	89	85	4	-7	88	84	4	-8
F-6	710 gpm	F	76	46	30		78	75	3		90	89	0		87	86	0	
F-6	Dane County Home	M	75	68	28	-2	80	77	3	0	89	87	1	1	88	87	1	1
F-7	2,110 gpm	F	65	50	15		71	61	10		81	71	11		78	68	11	
F-7	Central	M	65	50	15	0	71	61	10	0	80	69	10	0	79	69	10	0
F-8	2,110 gpm	F	47	34	13		59	47	12		75	66	10		73	63	10	
F-8	Central	M	47	32	15	2	58	44	13	1	77	65	12	2	76	64	12	2
F-9	1,540 gpm	F	63	21	42		70	34	36		85	85	0		82	82	0	
F-9	EPIC	M	62	23	39	-3	71	37	34	-2	88	84	4	3	87	83	4	4
F-10	1,740 gpm	F	57	29	28		68	42	26		78	69	8		76	66	10	
F-10	EPIC	M	59	31	28	0	69	44	25	-1	80	72	8	0	79	71	8	-2
F-11	2,110 gpm	F	58	44	14		63	51	12		79	73	6		77	71	6	
F-11	Central	M	60	44	16	2	63	51	12	0	81	75	6	0	80	74	6	0
F-12	2,190 gpm	F	60	50	10		66	60	6		82	77	5		80	74	6	
F-12	CENTRAL	M	62	49	13	3	67	62	5	-1	82	77	5	0	81	76	5	-1
F-13	2,270 gpm	F	69	59	10		66	61	5		80	69	12		79	70	9	
F-13	CENTRAL	M	71	58	13	3	67	63	4	-1	81	73	9	-3	80	72	9	0
F-14	2,300 gpm	F	68	48	20		67	61	6		81	77	4		79	75	4	
F-14	CENTRAL	M	69	47	22	2	67	60	7	1	81	78	4	-1	81	77	4	0
F-15	2,230 gpm	F	53	43	10		73	68	5		81	77	4		78	74	4	
F-15	CENTRAL	M	56	44	12	2	75	69	6	1	82	78	3	-1	81	78	3	-1
F-16	2,110 gpm	F	60	39	21		73	60	13		82	76	6		80	72	8	
F-16	Central	M	61	39	22	1	75	63	12	-1	84	76	8	2	83	75	8	0
F-17	1,680 gpm	F	63	31	32		60	38	22		83	77	6		81	73	8	
F-17	Central	M	65	37	28	-4	61	43	18	-4	84	77	7	1	83	76	7	-1

FIELD TESTING/MODEL SIMULATIONS (Part 2: Telog 3 – Telog 6)

Flow Test Number	Test Hydrant Flow (gpm) / Test Location	F= Field Test Data M= Model Data	Telog 3 Static Pressure (psi)	Telog 3 Residual Pressure (psi)	Telog 3 Pressure Differential (psi)	Telog 3 ∆ Pressure Differential (psi)	Telog 4 Static Pressure (psi)	Telog 4 Residual Pressure (psi)	Telog 4 Pressure Differential (psi)	Telog 4 ∆ Pressure Differential (psi)	Telog 5 Static Pressure (psi)	Telog 5 Residual Pressure (psi)	Telog 5 Pressure Differential (psi)	Telog 5 ∆ Pressure Differential (psi)	Telog 6 Static Pressure (psi)	Telog 6 Residual Pressure (psi)	Telog 6 Pressure Differential (psi)	Telog 6 ∆ Pressure Differential (psi)
F-1	2,190 gpm	F	61	61	0		69	69	0		64	64	0		70	69	1	
F-1	Southeast	M	61	61	0	0	70	70	0	0	64	64	0	0	69	69	0	-1
F-2	2,190 gpm	F	60	60	0		68	68	0		64	63	0		70	68	2	
F-2	Southeast	M	61	61	0	0	70	70	0	0	65	65	0	0	69	69	0	-1
F-3	2,010 gpm	F	61	59	3		70	66	4		65	61	4		69	69	0	
F-3	North	M	62	61	1	-2	71	67	4	0	66	62	3	0	68	68	0	0
F-4	1,800 gpm	F	62	59	2		70	67	4		65	62	3		69	69	0	
F-4	NORTH	M	62	62	1	-2	71	68	3	-1	66	63	3	-1	69	69	0	0
F-5	1,460 gpm	F	67	58	9		76	67	9		71	64	8		67	67	0	
F-5	Central	M	67	66	0	-9	77	75	2	-8	73	72	2	-6	66	66	0	0
F-6	710 gpm	F	68	67	1		78	75	3		72	70	3		67	67	0	
F-6	Dane County Home	M	67	67	0	-1	77	76	1	-1	73	72	1	-1	66	66	0	0
F-7	2,110 gpm	F	59	54	5		68	60	8		62	54	9		67	67	0	
F-7	Central	M	59	57	1	-4	68	61	7	-1	62	54	8	-1	66	66	0	0
F-8	2,110 gpm	F	57	52	5		65	58	8		58	51	7		67	67	0	
F-8	Central	M	58	56	2	-3	65	57	8	1	58	49	9	2	66	66	0	0
F-9	1,540 gpm	F	67	63	4		75	71	5		68	63	5		67	67	0	
F-9	EPIC	M	67	66	1	-3	75	72	3	-2	67	64	3	-2	66	65	0	0
F-10	1,740 gpm	F	59	53	6		68	59	9		63	53	10		66	66	0	
F-10	EPIC	M	60	58	1	-4	68	61	7	-2	62	55	7	-3	64	64	0	0
F-11	2,110 gpm	F	59	56	3		68	64	4		63	59	4		67	67	0	
F-11	Central	M	60	59	1	-2	69	65	4	0	64	60	4	0	66	66	0	0
F-12	2,190 gpm	F	59	56	3		68	64	4		63	59	4		68	68	0	
F-12	CENTRAL	M	60	59	1	-2	69	66	3	-1	64	61	3	-1	67	67	0	0
F-13	2,270 gpm	F	59	57	3		68	64	4		63	59	4		68	68	0	
F-13	CENTRAL	M	60	60	1	-2	69	65	4	-1	64	60	4	-1	67	67	0	0
F-14	2,300 gpm	F	60	57	2		68	65	4		63	57	6		68	68	0	
F-14	CENTRAL	M	60	60	1	-1	69	65	4	0	64	58	6	0	68	68	0	0
F-15	2,230 gpm	F	60	58	2		69	65	3		64	59	5		69	68	1	
F-15	CENTRAL	M	61	60	1	-1	69	66	3	0	64	59	5	0	68	68	0	-1
F-16	2,110 gpm	F	62	60	2		70	67	3		65	62	3		71	70	0	
F-16	Central	M	63	62	1	-1	71	68	3	0	66	63	4	1	70	70	0	0
F-17	1,680 gpm	F	62	60	2		71	68	3		66	62	4		71	70	0	
F-17	Central	M	63	63	0	-1	72	69	2	-1	67	64	3	-1	71	71	0	0

FIELD TESTING/MODEL SIMULATIONS (Part 3: Telog 7 – Telog 10)

Flow Test Number	Test Hydrant Flow (gpm) / Test Location	F= Field Test Data M= Model Data	Telog 7 Static Pressure (psi)	Telog 7 Residual Pressure (psi)	Telog 7 Pressure Differential (psi)	Telog 7 ∆ Pressure Differential (psi)	Telog 8 Static Pressure (psi)	Telog 8 Residual Pressure (psi)	Telog 8 Pressure Differential (psi)	Telog 8 ∆ Pressure Differential (psi)	Telog 9 Static Pressure (psi)	Telog 9 Residual Pressure (psi)	Telog 9 Pressure Differential (psi)	Telog 9 ∆ Pressure Differential (psi)	Telog 10 Static Pressure (psi)	Telog 10 Residual Pressure (psi)	Telog 10 Pressure Differential (psi)	Telog 10 ∆ Pressure Differential (psi)
F-1	2,190 gpm	F	66	65	1		86	86	0		66	67	0		73	73	0	
F-1	Southeast	M	65	65	0	-1	85	85	0	0	66	66	0	0	73	73	0	0
F-2	2,190 gpm	F	66	63	4		85	85	0		66	66	0		72	71	1	
F-2	Southeast	M	65	61	3	-1	86	86	0	0	66	66	0	0	73	73	0	-1
F-3	2,010 gpm	F	66	65	0		87	83	3		68	64	4		74	68	6	
F-3	North	M	64	64	0	0	87	84	3	0	67	64	3	-1	74	68	6	0
F-4	1,800 gpm	F	66	65	0		87	84	3		68	64	4		74	69	5	
F-4	NORTH	M	65	65	0	0	87	84	2	0	68	65	3	-2	74	69	5	0
F-5	1,460 gpm	F	64	64	0		92	84	9		74	65	9		80	69	11	
F-5	Central	M	62	62	0	0	93	91	2	-7	74	72	2	-7	80	76	4	-8
F-6	710 gpm	F	64	64	0		94	91	3		76	73	2		82	78	3	
F-6	Dane County Home	M	62	62	0	0	93	92	1	-1	74	73	1	-1	80	78	2	-2
F-7	2,110 gpm	F	64	64	0		84	75	9		66	56	10		72	62	10	
F-7	Central	M	62	62	0	0	83	75	8	-1	64	56	8	-2	71	61	10	0
F-8	2,110 gpm	F	64	64	0		79	72	7		61	54	6		69	60	9	
F-8	Central	M	62	62	0	0	78	69	8	1	58	50	8	2	68	57	11	2
F-9	1,540 gpm	F	63	63	0		89	85	4		71	65	6		79	73	6	
F-9	EPIC	M	61	61	0	0	87	84	3	-1	68	65	3	-2	79	75	3	-3
F-10	1,740 gpm	F	62	62	0		84	74	10		66	58	8		71	63	9	
F-10	EPIC	M	60	60	0	0	83	76	7	-2	64	57	7	0	71	63	8	-1
F-11	2,110 gpm	F	64	64	0		85	81	4		66	62	4		72	66	5	
F-11	Central	M	62	62	0	0	85	81	4	0	65	62	4	0	72	67	5	0
F-12	2,190 gpm	F	64	64	0		85	81	4		66	61	5		72	67	5	
F-12	CENTRAL	M	63	62	0	0	85	82	3	-1	66	63	3	-2	72	68	4	-1
F-13	2,270 gpm	F	65	64	0		85	81	4		66	60	6		72	67	4	
F-13	CENTRAL	M	63	63	0	0	85	82	3	-1	65	61	4	-2	72	68	4	0
F-14	2,300 gpm	F	65	64	0		85	80	6		66	62	4		72	68	4	
F-14	CENTRAL	M	63	63	0	0	85	79	6	0	66	62	4	0	72	69	4	0
F-15	2,230 gpm	F	65	65	1		85	80	5		67	63	4		72	69	3	
F-15	CENTRAL	M	64	64	0	-1	85	79	6	1	66	62	4	0	73	69	3	0
F-16	2,110 gpm	F	67	66	0		87	84	3		69	49	19		74	71	3	
F-16	Central	M	66	66	0	0	87	84	4	1	68	48	20	1	75	71	3	0
F-17	1,680 gpm	F	67	67	0		88	84	3		69	50	19		75	71	3	
F-17	Central	M	67	67	0	0	88	85	3	-1	68	52	17	-3	75	73	2	-1

FIELD TESTING/MODEL SIMULATIONS (Part 4: Telog 11 – Telog 12)

Flow Test Number	Test Hydrant Flow (gpm) / Test Location	F= Field Test Data M= Model Data	Telog 11 Static Pressure (psi)	Telog 11 Residual Pressure (psi)	Telog 11 Pressure Differential (psi)	Telog 11 ∆ Pressure Differential (psi)	Telog 12 Static Pressure (psi)	Telog 12 Residual Pressure (psi)	Telog 12 Pressure Differential (psi)	Telog 12 ∆ Pressure Differential (psi)
F-1	2,190 gpm	F	68	68	0		56	56	0	
F-1	Southeast	M	68	68	0	0	56	56	0	0
F-2	2,190 gpm	F	68	67	0		56	56	0	
F-2	Southeast	M	68	68	0	0	57	57	0	0
F-3	2,010 gpm	F	69	64	5		57	52	5	
F-3	North	M	69	63	5	0	58	53	5	-1
F-4	1,800 gpm	F	69	65	4		57	53	4	
F-4	NORTH	M	69	65	5	0	58	54	4	0
F-5	1,460 gpm	F	75	65	10		63	53	10	
F-5	Central	M	75	72	3	-7	63	61	2	-8
F-6	710 gpm	F	76	74	2		64	62	2	
F-6	Dane County Home	M	75	73	1	-1	63	62	1	-1
F-7	2,110 gpm	F	67	58	9		55	47	8	
F-7	Central	M	65	56	9	0	54	46	8	0
F-8	2,110 gpm	F	64	54	10		52	43	9	
F-8	Central	M	63	51	12	2	51	41	11	1
F-9	1,540 gpm	F	77	69	8		64	51	13	
F-9	EPIC	M	75	71	4	-4	63	55	8	-4
F-10	1,740 gpm	F	67	56	10		54	40	14	
F-10	EPIC	M	66	57	9	-2	55	42	13	-1
F-11	2,110 gpm	F	67	60	7		55	43	12	
F-11	Central	M	67	60	7	0	56	43	13	1
F-12	2,190 gpm	F	67	61	6		55	48	6	
F-12	CENTRAL	M	67	62	5	-1	56	50	6	-1
F-13	2,270 gpm	F	67	63	3		54	52	3	
F-13	CENTRAL	M	67	63	4	0	56	52	3	1
F-14	2,300 gpm	F	67	64	4		55	52	3	
F-14	CENTRAL	M	67	64	4	0	56	52	4	0
F-15	2,230 gpm	F	68	64	4		56	52	4	
F-15	CENTRAL	M	67	64	3	0	56	53	3	-1
F-16	2,110 gpm	F	69	67	3		57	55	3	
F-16	Central	M	70	66	3	0	58	55	3	0
F-17	1,680 gpm	F	70	67	3		58	55	3	
F-17	Central	M	70	68	2	-1	59	56	2	-1

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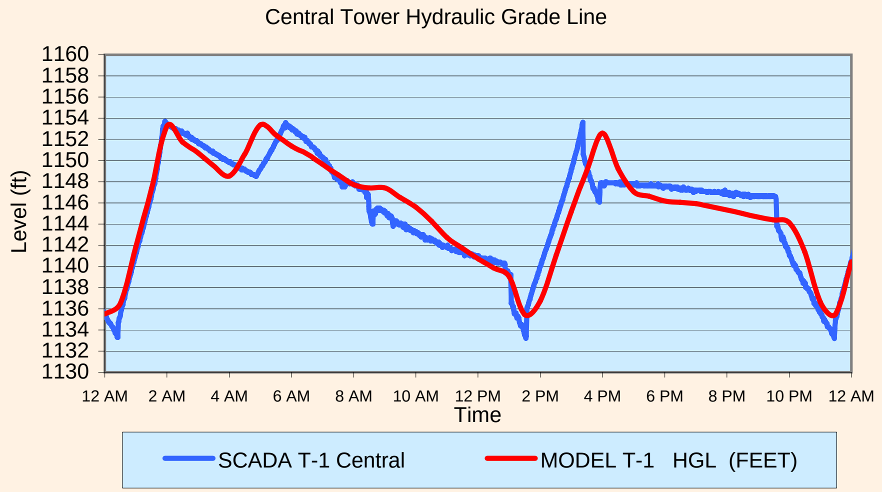

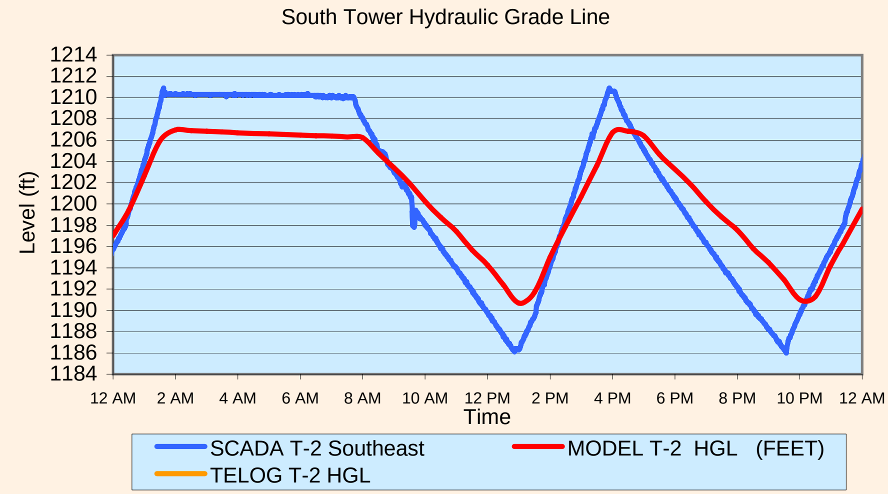

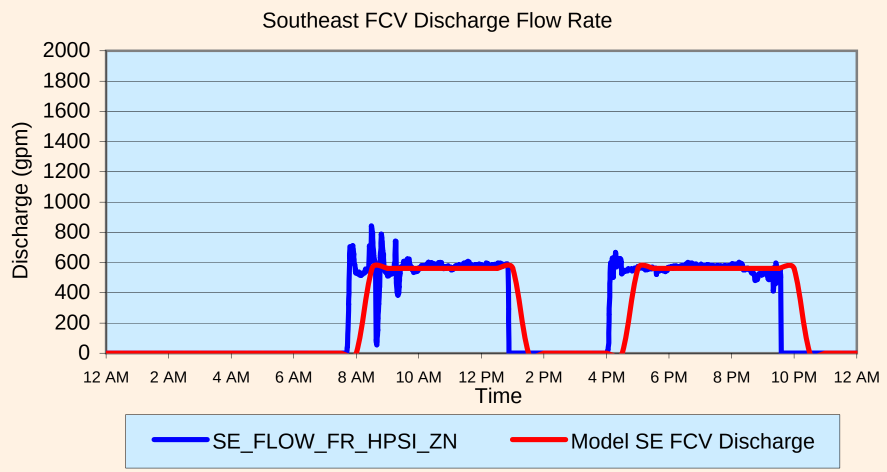

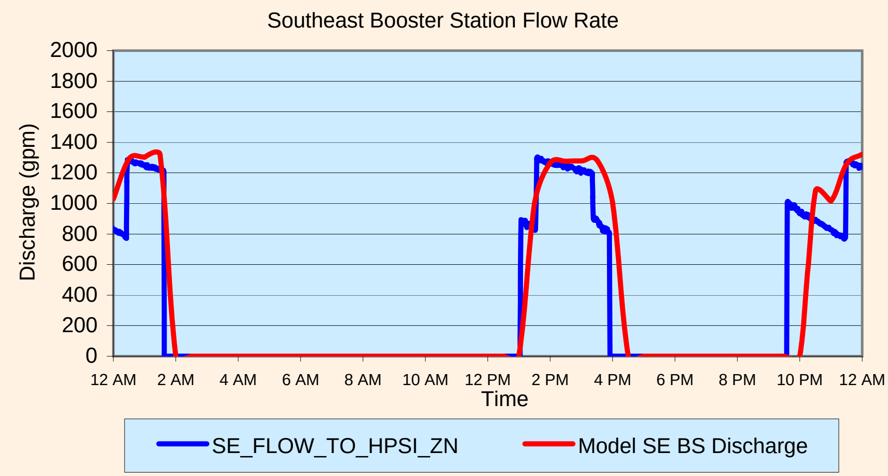

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FIGURE 1
AVERAGE DAY DEMAND

VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006

91960

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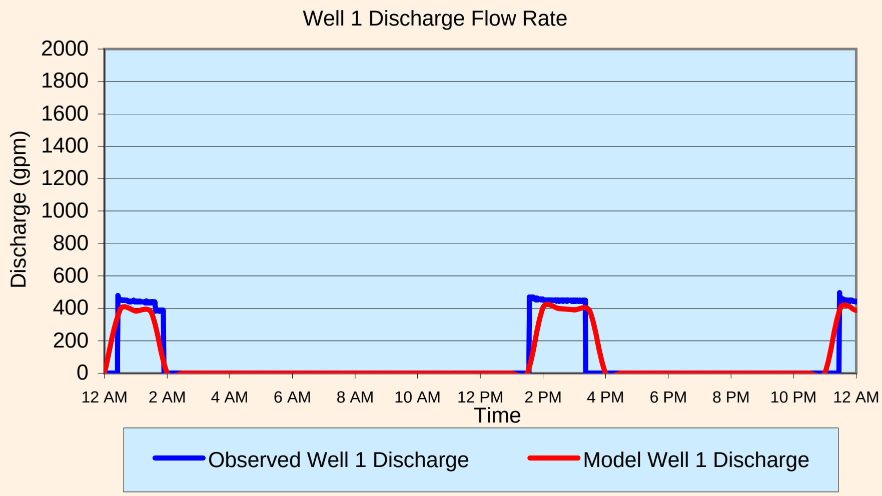

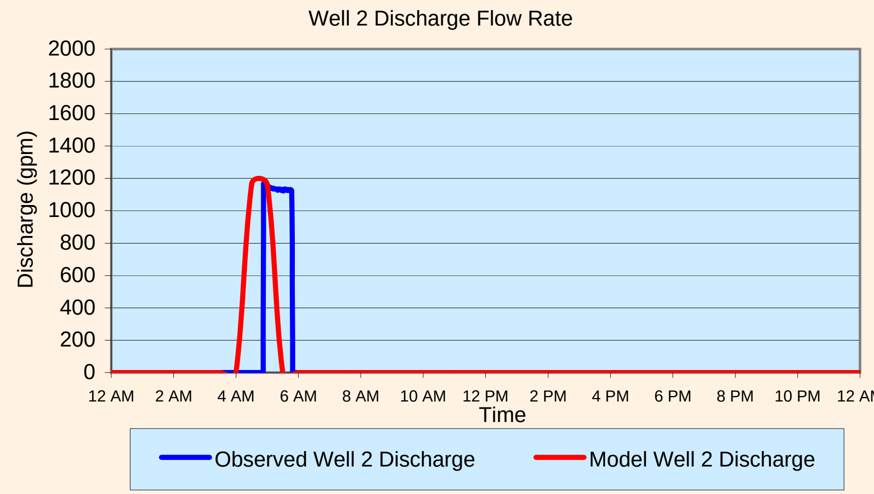

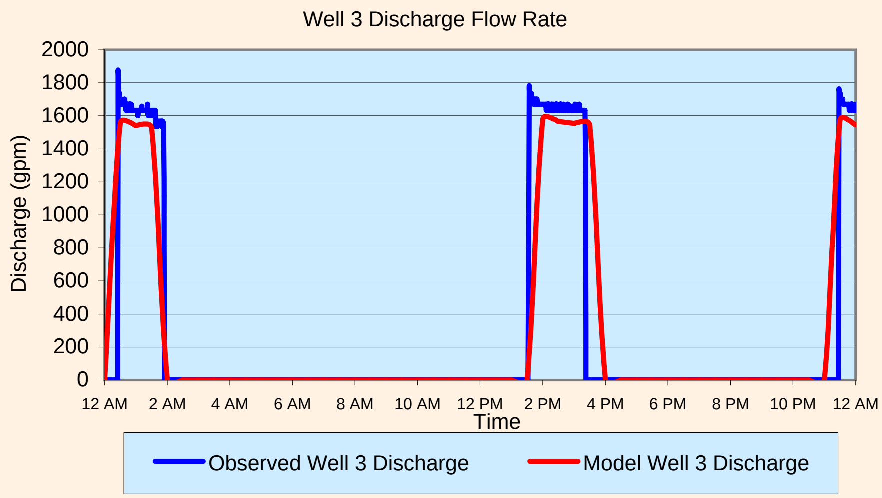

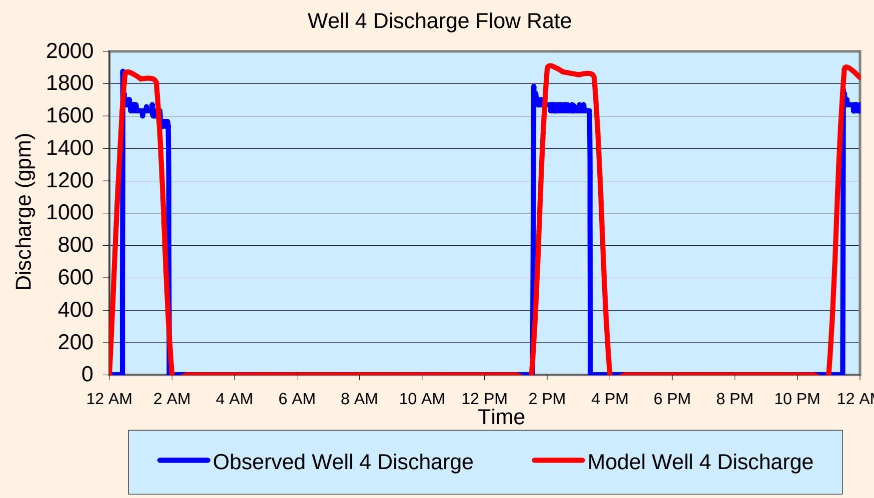

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FIGURE 2
AVERAGE DAY DEMAND

VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006 91960

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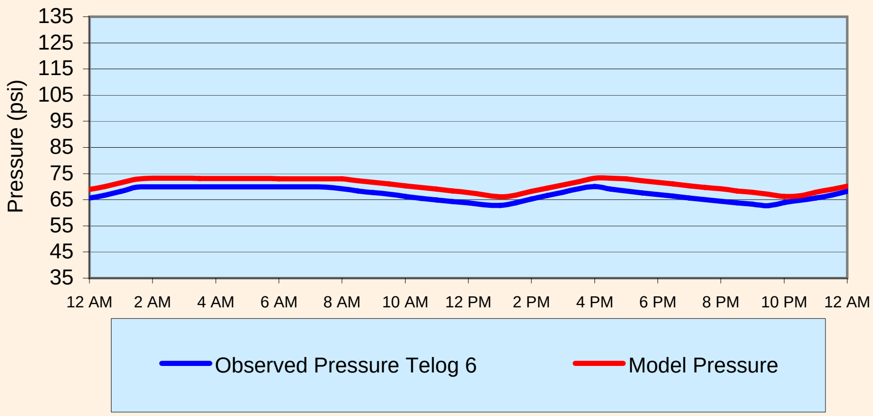
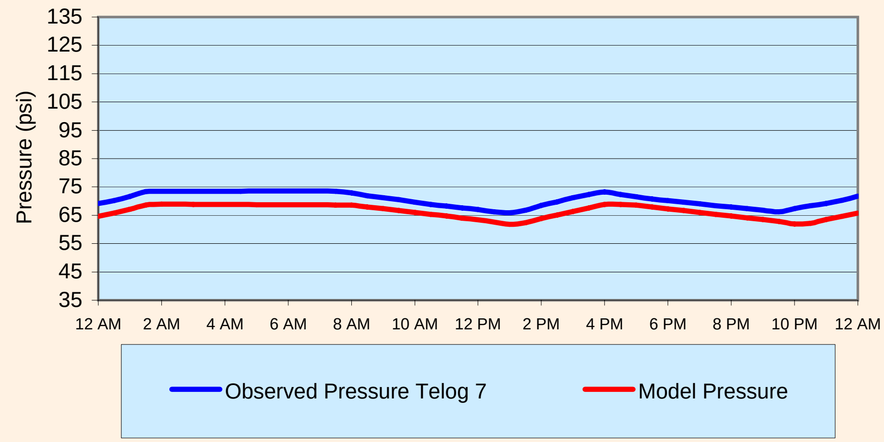
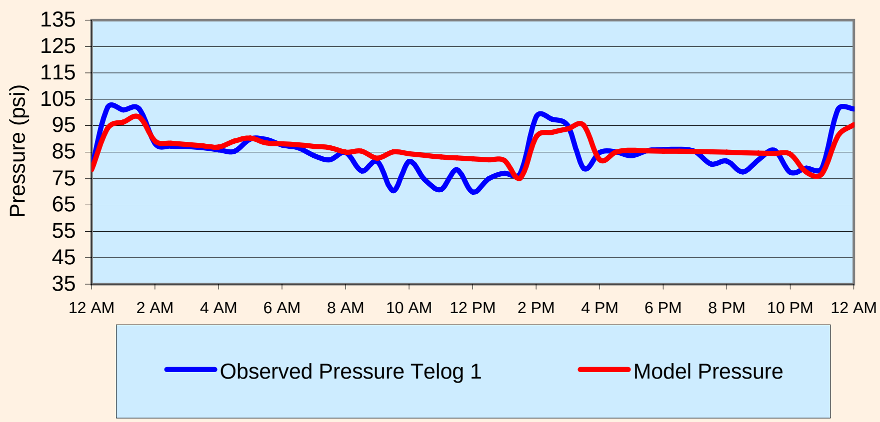
Southeast Zone - Southeast Tower



Southeast Zone - Fairview Terrace and Gatsby Glen Dr



North Zone - Well 4 North Pump Station



North Zone - Lone Pine Way and Hemlock Dr

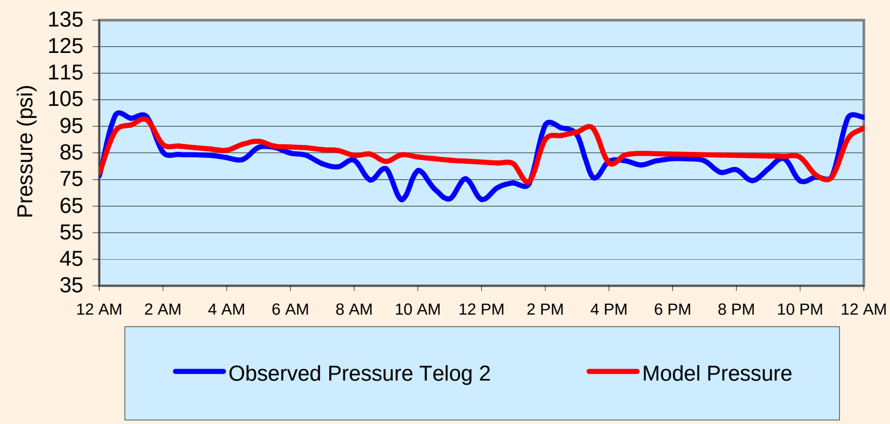


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FIGURE 3
AVERAGE DAY DEMAND

VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006

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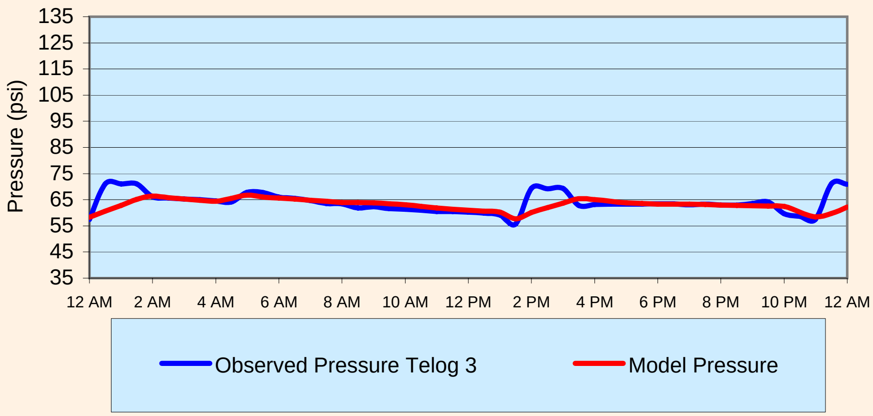
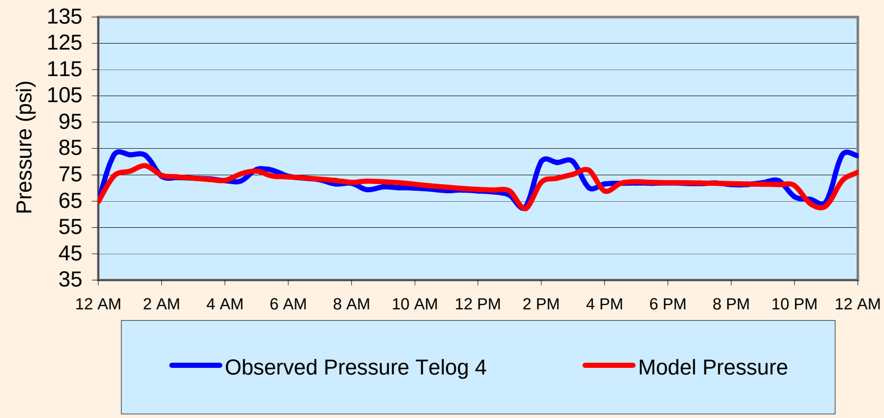
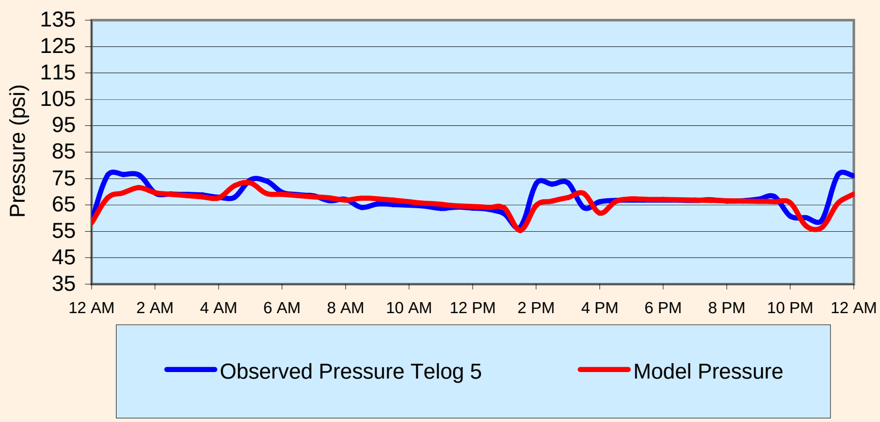
Central Tower Bottom Pressure



Well 1 Dicharge Pressure



Well 2 Discharge Pressure



Bruce St and Investment Ct

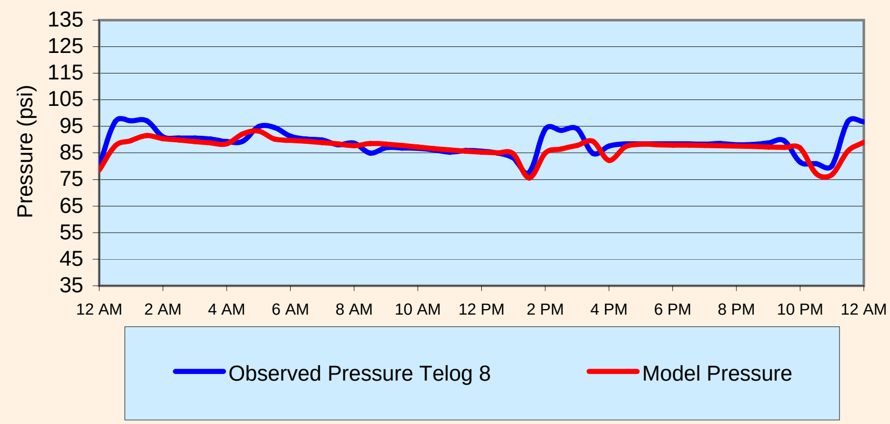


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FIGURE 4
AVERAGE DAY DEMAND

VERONA WATER UTILITY
VERONA, WISCONSIN

SEPT 2006

91960

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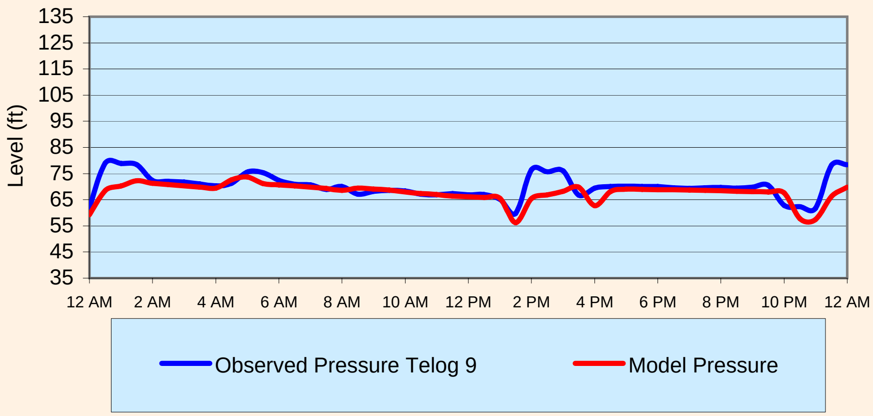
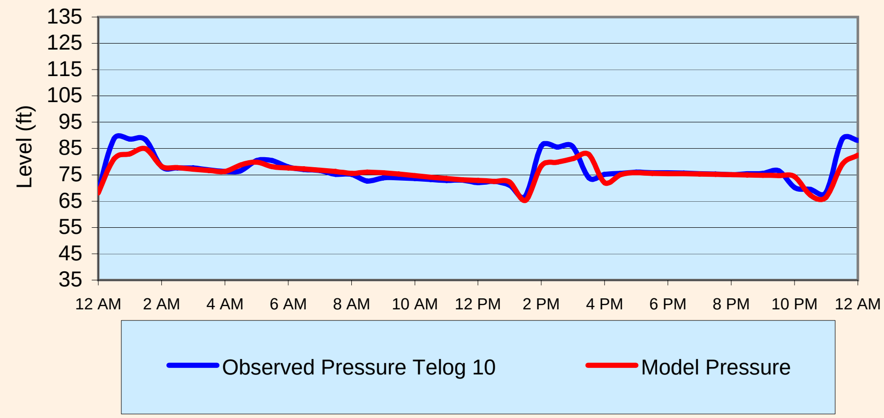
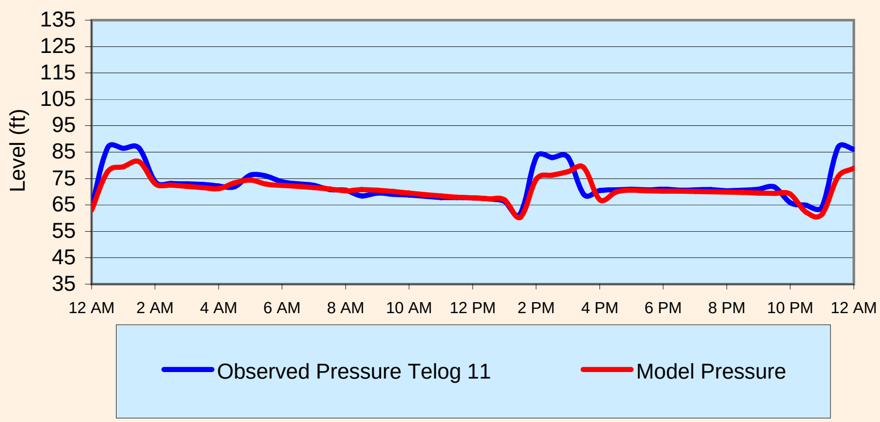
Forest View Dr and Harvest Ln



1st Hydrant South of Enterprise Dr and Llanos St



Well 3 Discharge Pressure



Edwards St and Westridge Pkwy

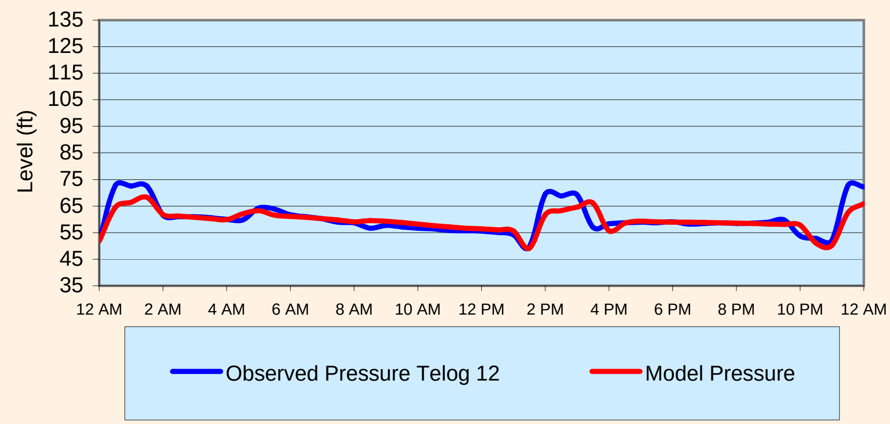


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FIGURE 5
AVERAGE DAY DEMAND

VERONA WATER UTILITY
VERONA, WISCONSIN

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