CHAPTER 4

HYDRAULIC ANALYSIS

This chapter presents information on the computer hydraulic model of the City's water system and the results of hydraulic analyses. The purpose of the hydraulic analysis is to evaluate the existing and future capabilities of the water system.

The operation of a municipal water system involves dynamic interactions between various water system components including source, storage, transmission, and distribution system facilities. These interactions and their effect on the level of service provided to the City's customers are dependent on the distribution and magnitude of water demands within the system and the performance characteristics of the water system facilities. In addition, infrequent high water demand events, such as fire fighting and other emergencies, can significantly alter the normal flow patterns and pressures in the municipal water system and its components. These factors must be considered in analyzing the ability of a water system to provide for future demands, while maintaining an adequate level of water service to customers.

The development of a computer hydraulic model, which can accurately and realistically simulate the response of a water system under a variety of conditions and scenarios, has become an increasingly important element in the planning, design, and analysis of municipal water systems. The Washington State Department of Health's WAC 246-290 requires hydraulic modeling as a component of water system comprehensive plans.

HYDRAULIC MODELING PROGRAM

The City's system is analyzed using MWHSoft's H_2ONet hydraulic modeling software, which operates in an AutoCAD computer-aided design and drafting environment. The H_2ONet model is configured with a graphical user interface. Each model element, including pipes, valves, pumps, and reservoirs, is assigned a unique graphical representation within the program. Each element is also assigned a number of attributes specific to its function. Element attributes include spatial coordinates, elevation, water demand, pipe length, diameter, and pipe status (open/closed), as well as pump, valve and reservoir characteristics. Model input is accomplished through the creation and manipulation of these objects and their attributes. The H_2ONet software produces the model output in the form of flows and pressures throughout the simulated water system.

MODEL LAYOUT AND CONSTRUCTION

The City's hydraulic model was created from a review of existing system basemaps, construction drawings, planning documents, and topographic maps. Meetings with City

staff regarding the operation of system components has also been a crucial element in developing an accurate model.

SOURCE

The six wells are included in the hydraulic model. Each well consists of a fixed-head reservoir simulating the aquifer and a pump. Well pumps are called on and off based on reservoir levels in the pressure zones to which they pump, as described in Chapter 1.

STORAGE

In H_2ONet reservoirs are modeled as "tanks" with finite size, using actual reservoir dimensions and elevations. The model includes the City's three storage tanks. Dimensions and critical elevations of the storage facilities are provided in Table 1-4.

Per WAC 246-290-230 (6), fire flows must be provided when equalizing storage (ES) and fire suppression storage (FSS) have been depleted from the reservoirs and while maintaining a system wide minimum pressure of 20 psi. Similarly, peak hour demands must be met while maintaining a system wide minimum pressure of 30 psi with equalizing storage depleted. Table 4-1 summarizes reservoir levels used in the model and storage volumes depleted.

TABLE 4-1

Modeled Reservoir Depleted Volumes and Drawdown Levels

Reservoir	FSS (gal, ft)	2009 ES (gal, ft)	2015 ES (gal, ft)	2029 ES (gal, ft)
15th Avenue Reservoir	135,000/15.12'	10,222/1.14'	22,229/2.49'	49,317/5.52'
1 MG Reservoir	263,250/20.29'	13,629/1.05'	29,638/2.28'	65,757/5.07'
2 MG Reservoir	276,750/21.33'	27,259/2.10'	59,276/4.57'	131,513/10.14'
Total Volume Depleted	**675,000**	**51,110**	**111,143**	**246,587**

Volumes depleted are based on reservoir volumes and demands within the zone in which the reservoir is located. The 15th Avenue Reservoir serves the 330 Zone, which accounts for almost 30 percent of system demand. However, the reservoir volume accounts for only 10 percent of system storage. Considering both demand and volume, 20 percent of fire suppression storage and equalizing storage is depleted from the 15th Avenue Reservoir. The 1 MG and 2 MG Reservoirs fire suppression and equalizing storage are split between the two such that the resulting hydraulic grade at each is the same.

PRESSURE REDUCING VALVES

All distribution system pressure reducing valves (PRVs) are included in the model. All known settings are applied. Table 1-9 summarizes the PRV settings.

MODEL DEMANDS

Existing system demands were determined for the City's service area from existing production data. System production demands were evenly distributed to the nodes throughout the system.

The production demands for the year 2029 are based on 2008 production demands and the anticipated population growth projections determined in Chapter 2.

Table 4-2 presents the projected population and demands for the water system.

TABLE 4-2

Population and Demand Forecasts

Year	Projected Service Area Population	Projected Average Day Production/ Demand (gpd)	Projected Peak Day Production/ Demand (gpd)	Projected Peak Hour Production/ Demand (gpm)	Projected ERUs[(1)]
2009	7,947	926,917	2,041,431	2,341	3,776
2015	9,305	1,085,400	2,390,473	2,741	4,421
Build-out/2029[(2)]	12,371	1,442,967	3,177,973	3,644	5,878

(1) ERU = 233 gallons per day per single family residence.
(2) Build out is projected to occur in 2025.

Scenarios

The H_2ONet modeling software allows the user to input a variety of demands. For the purpose of this plan, the following sets of demands were developed in the hydraulic model:

- 2008 Average Day Demand: These demands were used for model calibration and verification of existing demands.

- 2008 Maximum Day Demand: These demands were used to evaluate the system's ability to meet the required fire flows for the Department of Health requirement of a system wide minimum pressure of 20 psi and a maximum pipe velocity of 10 feet per second.

- 2008 Peak Hour Demand: These demands were used to verify the system is capable of meeting the Department of Health Standards to supply domestic water at a minimum system wide pressure of 30 psi.

- 2029/Buildout Maximum Day Demand: These demands were used to evaluate the system's ability to meet the required fire flows for the Department of Health requirement of a system wide minimum pressure of 20 psi and a maximum pipe velocity of 10 feet per second with the 20-year growth projections.

- 2029/Buildout Peak Hour Demand: These demands were used to verify the system is capable of meeting the Department of Health Standards to supply domestic water at a minimum system wide pressure of 30 psi with the 20-year growth projections.

These scenarios were used to determine the improvements required to meet the current and projected expansion of the City's water system.

MODEL CALIBRATION

For the purposes of model calibration, fire hydrant flow tests were conducted in October and December of 2008 at various locations throughout the City's water system. These field results were used to calibrate the hydraulic model through adjustment of system elevations and verification of pipe sizes. Table 4-3 describes the locations of the nodes used for the fire hydrant flow tests and model calibration.

TABLE 4-3

Calibration Node Numbers and Locations

Node Number	Hydrant Locations
J132	8-inch main along Hylebos Avenue at Douglas Court
J188	8-main main along Meridian East approx. 400 feet north of Emerald Drive
J216	12-inch main along 5th Avenue approx. 600 feet south of South 376th Street
J-8623	8-inch main at Vine Street and 11th Avenue

The conditions of the hydrant tests were simulated as closely as possible in the model, including reservoir levels, well production, and booster station performance. The calibration was conducted under 2008 average daily demand conditions. Table 4-4 presents actual field fire flow test data along with the corresponding results from the calibrated model.

TABLE 4-4

Hydraulic Model Calibration Results

Location	Node	Static (psi)		Residual (psi)		Flow (gpm)
		Field	Model	Field	Model	
Hylebos Avenue at Douglas Court	J132	92	92	65	67	1,087
5th Avenue ~600 feet south of South 376th Street	J216	60	57	45	44	934
Vine Street and 11th Avenue	J-8623	83	85	73	74	1,186
300 Meridian East	J188	70	73	60	57	1,210

Calibration of the system produced results between 0 to 5 percent of actual field test data for both static pressures and residual pressures. It can be assumed that the model is an accurate representation of the system.

EXISTING SYSTEM ANALYSIS AND RESULTS

Results for the hydraulic modeling can be found in Appendix K.

Peak Hour Demand

According to Department of Health Waterworks Standards and WAC 246-290-230, a water system must maintain a minimum pressure of 30 psi and a maximum pipe velocity of 8 ft/s in the distribution system under peak hour demand conditions. The City's existing distribution system was modeled under 2008 and 2029 peak hour demand conditions. In both cases, all pressures throughout the system exceeded the minimum system pressure of 30 psi.

Available Fire Flows

Department of Health Guidelines state a water system should be designed to provide adequate fire flow under maximum day demand conditions, while maintaining a minimum system pressure of 20 psi and a maximum pipe velocity of 10 ft/s. Table 4-4 provides the general fire flow requirements for various buildings. The requirements were obtained from the 2003 International Fire Code, which has been adopted as part of the City's Municipal Code, and conversations with the City Fire Marshal. The Fire Marshall calculated required flows for a selection of the City's commercial, industrial, and institutional facilities. These flows are shown in Table 4-5.

TABLE 4-5

General Fire Flow Requirements

Building/Business	Address	Required Flow, gpm	Flow Duration, hrs
Residential (one- and two-family dwellings <3,600 sq. ft)	Many	1,000	1
Multi-family, Commercial, and other Non-residential buildings	Many	Varies	Varies
Minimum required flow	Many	2,500	2
Discovery Primary School	1205 19th Avenue	3,500(1)	3
Millridge Village Apartments	607 28th Avenue	3,750(1)	3
Albertsons Grocery Store	2800 Milton Way	2,750(1)	2
Harland Manufacturing	300 Meridian Avenue East	3,500(1)	3
Safeway Grocery Store	900 Meridian Avenue East	3,375(1)	3
Tacoma Hydraulic	405 Porter Way	2,750(1)	2

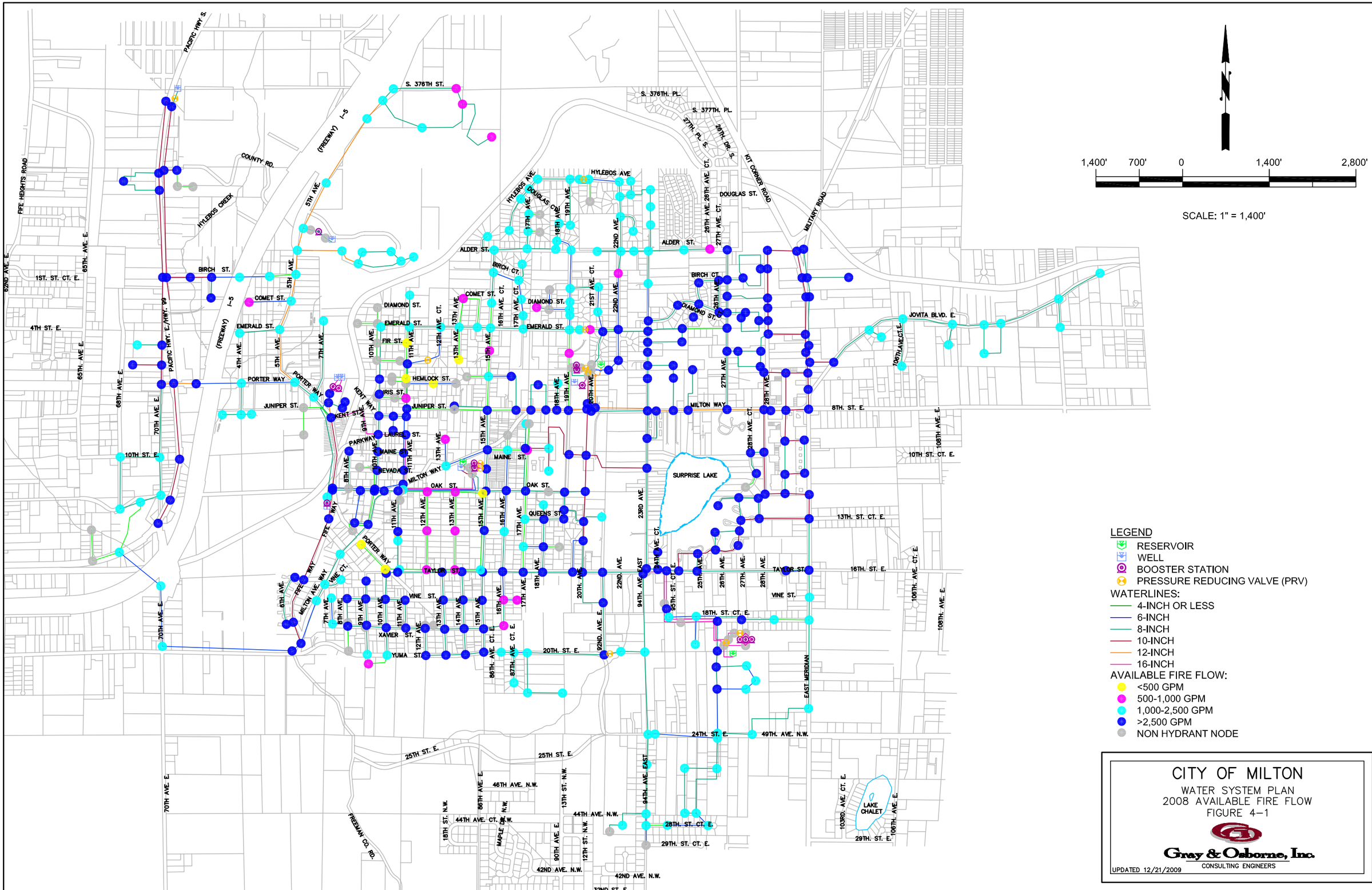
(1) As calculated by the Fire Marshal per IFC 2003.

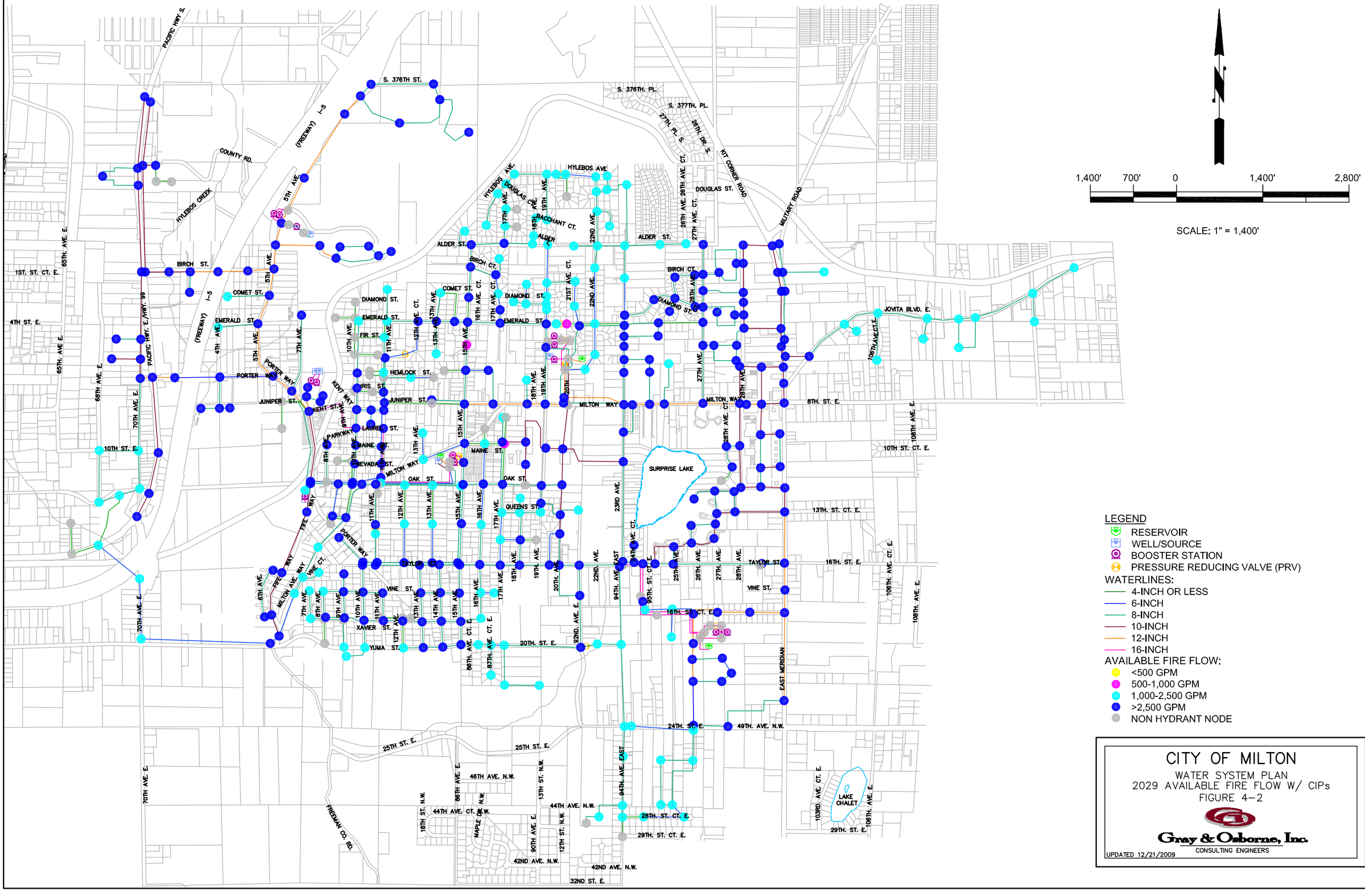
The minimum required flow for multi-family, commercial, and other non-residential buildings, and the one- and two-family residential dwellings are minimum flows only for water main extensions required for development. Actual fire flow requirements for Certificate of Water Availability and building permit acquisition with the City shall be in accordance with the 2003 IFC.

The completed hydraulic model was used to simulate the fire flows available throughout the system.

Deficiencies

The majority of the City's distribution system is able to meet the required fire flows for the 2008 and 2029 maximum day demand. However, portions of the City cannot currently meet the minimum fire flow requirements. Figure 4-1 shows the available fire flows under 2008 maximum day demand conditions. Table 4-6 shows numerical results for areas in the system where fire flows are not currently met. The majority of the fire flow deficiencies are due to undersized pipes, however there are several areas that are limited by pressure requirements. As a result, most of the improvements discussed in Chapter 8 are pipe replacements projects, which will upgrade small pipes to 8-inch or larger. Table 4-6 and Figure 4-2 also show the improved available flow with improvements made as designated in Chapter 8, Capital Improvement Plan. Figures 4-1 and 4-2 represent available flow based as limited by design pressure and does not show velocity limited results.


PACIFIC HWY. S.
S. 376TH ST.
S. 376TH. PL.
S. 377TH. PL.
27TH. PL. S.
26TH. DR. S.
KIT CORNER ROAD
MILITARY ROAD
COUNTY RD.
HYLEBOS CREEK
FIFE HEIGHTS ROAD
62ND AVE. E.
65TH. AVE. E.
1ST. ST. CT. E.
4TH ST. E.
68TH AVE. E.
70TH AVE. E.
10TH ST. E.
(FREEWAY) I-5
5TH AVE.
PACIFIC HWY. E./HWY. 99
4TH AVE.
7TH AVE.
BIRCH ST.
COMET ST.
EMERALD ST.
PORTER WAY
JUNIPER ST.
KENT ST.
KENT WAY
FIFE WAY
PARKWAY
LAUREL ST.
MAINE ST.
NEVADA ST.
MILTON WAY
OAK ST.
QUEENS ST.
TAYLOR ST.
VINE ST.
VINE CT.
MILTON AVE. WAY
XAVIER ST.
YUMA ST.
HYLEBOS AVE
HYLEBOS AVE.
DOUGLAS CIR.
DOUGLAS ST.
ALDER ST.
DIAMOND ST.
FIR ST.
HEMLOCK ST.
IRIS ST.
20TH. ST. E.
86TH. AVE. CT. E.
87TH. AVE. CT. E.
92ND. AVE. E.
SURPRISE LAKE
23RD AVE.
94TH. AVE. EAST
95TH. ST. CT. E.
EAST MERIDIAN
24TH. ST. E.
49TH. AVE. N.W.
25TH ST. E.
46TH AVE. N.W.
44TH AVE. N.W.
44TH AVE. CT. N.W.
42ND AVE. N.W.
32ND ST. E.
FREEMAN CO. RD.
MAPLE LN. N.W.
18TH ST. N.W.
13TH ST. N.W.
12TH ST. N.W.
90TH AVE. E.
28TH. ST. CT. E.
29TH. ST. CT. E.
LAKE CHALET
103RD. AVE. CT. E.
106TH. AVE. CT. E.
108TH. AVE. E.
JOVITA BLVD. E.
8TH. ST. E.
MILTON WAY
13TH. ST. CT. E.
16TH. ST. E.
18TH. ST. CT. E.
1,400' 700' 0 1,400' 2,800'
SCALE: 1" = 1,400'
LEGEND
RESERVOIR
WELL
BOOSTER STATION
PRESSURE REDUCING VALVE (PRV)
WATERLINES:
4-INCH OR LESS
6-INCH
8-INCH
10-INCH
12-INCH
16-INCH
AVAILABLE FIRE FLOW:
<500 GPM
500-1,000 GPM
1,000-2,500 GPM
>2,500 GPM
NON HYDRANT NODE
CITY OF MILTON
WATER SYSTEM PLAN
2008 AVAILABLE FIRE FLOW
FIGURE 4-1
Gray & Osborne, Inc.
CONSULTING ENGINEERS
UPDATED 12/21/2009



CITY OF MILTON

WATER SYSTEM PLAN
2029 AVAILABLE FIRE FLOW W/ CIPs
FIGURE 4-2

Gray & Osborne, Inc.
CONSULTING ENGINEERS

UPDATED 12/21/2009

TABLE 4-6

Available Fire Flows

Model Node	Location	Required Fire Flow (gpm)[(1)]	2008 Available Flow (gpm)[(2)]	Limiting Factor	2029 Available Flow w/CIP (gpm)
J16, J-8291	7th Avenue north of Xavier Street	1,000	881	Velocity	2,709
J176, J178	Millridge Village Apartments	3,750	2,307	Velocity	4,423
J184	Diamond Loop at 28th Avenue	2,500	2,432	Velocity	4,958
J190	Dead end near Meridian Road and East Meridian	2,500	1,567	Velocity	4,118
J246	19th Avenue between Milton Way and Emerald Street	1,000	587	Pressure	2,672
J248	9th Avenue and Yuma Street	1,000	392	Both	2,591
J72	Hemlock Street and 11th Avenue	1,000	350	Both	1,590
J-8106	Porter Way – Tacoma Hydraulic	2,750	1,405	Both	4,862
J-8111	Porter Way from 5th Avenue to Pacific Highway East	2,500	2,421	Pressure	4,289
J-8121	Comet Street and I-5	1,000	881	Velocity	3,096
J-8137	Milton Way and 11th Street	2,500	2,030	Velocity	2,845
J-8149	Hemlock Street east of 11th Avenue	1,000	332	Pressure	1,307
J-8151	Fir Street and 11th Avenue	1,000	272	Pressure	1,514
J-8162	Pacific Highway near 67th Avenue East	1,000	943	Velocity	2,856
J-8225	13th Avenue south of Emerald Street	1,000	392	Both	1,843
J-8228	13th Avenue and Comet Street	1,000	706	Both	1,955
J-8235	18th Avenue north of Diamond Street	1,000	784	Both	1,302
J-8236	13th dead end off Milton Way	1,000	881	Both	2,025
J-8264, J-8263	Vine Street near 16th Avenue	1,000	760	Pressure	1,533
J-8309	22nd Avenue cul-de-sac	1,000	881	Velocity	1,975
J-8348	Driveway north of Queens Way	2,500	1,567	Velocity	4,719
J-8369	24th Street East and Meridian Avenue East	2,500	2,390	Both	4,757
J-8634	Porter Way and Milton Avenue West	1,000	341	Pressure	2,436

TABLE 4-6 – (continued)

Available Fire Flows

Model Node	Location	Required Fire Flow (gpm)(1)	2008 Available Flow (gpm)(2)	Limiting Factor	2029 Available Flow w/CIP (gpm)
J-8665	16th Avenue and Xavier Street	1,000	782	Pressure	1,922
J-9510, -9511	21st Avenue Court	1,000	877	Velocity	2,760
J-9514	Dead end off Birch Street west of I-5	2,500	1,567	Velocity	4,067
J-9519	Discovery Primary School	3,500	2,127	Both	4,202
Many	Area encompassed by Oak Street, Taylor Street, 11th Avenue and 15th Avenue	1,000	425-583	Both	2,206-4,268
J-8317, J148	Area of Hylebos Avenue and Alder Street in the 520 Zone	1,000	939-968	Velocity	1,417-1,962
Many	Llyod's Development at 5th Avenue and South 376th Street	>2,500	760-1,006	Both	>2,500
Many	Corridor Wells and Apartments on 1st Street SE	2,500	1,062-1,141	Both	>2,500
Several	Northwood Elementary School	2,500	1,523-2,070	Both	2,141-5,714
Several	Kent Street and Laurel Street from 10th Avenue to 11th Avenue	2,500	1,929-2,346	Velocity	3,744-4,740
Several	Apartments on 6th Avenue	2,500	2,242-2,394	Velocity	4,016-5,005
Several	Pacific Hwy near 70th Avenue East	2,500	2,421	Both	3,600-3,875

(1) Based on City zoning and calculations by the Fire Marshal.
(2) Limited by either a minimum system wide pressure of 20 psi or maximum pipe velocity of 10 ft/s.
(3) Required flows for the development have not yet been finalized.