CHAPTER 6
Water System Performance and Operational Criteria

The purpose of this Chapter is to define the recommended performance and operational criteria for the City's potable water system. These criteria include recommendations for the required fire flow and duration, definition of "emergency events", system pumping capacity, system storage capacity (including operational, fire flow, and emergency components), minimum and maximum system pressures, and maximum pipeline velocity and head loss.

The City currently uses the City of Modesto Standard Specifications[1] and the recommendations from the 2004 *Revised Design/System Performance Criteria* Technical Memorandum, prepared by West Yost Associates for the City's *2005 Water System Hydraulic Model Update Project* for the performance and operation of its water system. Key water system performance criteria and operational standards from these documents are incorporated into this Chapter. However, additional explanation and discussion have been added to further describe the various system recommendations Table 6-1 summarizes the recommendations and the following sections of this Chapter present the recommended performance and operational criteria for the City's potable water system:

- Water System Reliability and Water Quality
- Fire Flow Requirements
- Water System Capacity During High Demand Periods
- Pumping Facility Capacity (Wells and Storage Tank Booster Pumps)
- Storage Facility Capacity
- Water Transmission and Distribution Pipeline Sizing

6.1 WATER SYSTEM RELIABILITY AND WATER QUALITY

6.1.1 Water System Reliability

Enhancing the reliability of the system under all conditions is an important part of maintaining high quality water service. Water system reliability is achieved through a number of system features, including: (1) appropriately sized storage facilities; (2) redundant or "firm" pumping, transmission/distribution, and wellhead treatment facilities where required; and (3) alternate (back-up) power supplies. Reliability and water quality are also improved by designing looped water distribution pipelines and avoiding dead-end distribution mains whenever possible. Looping pipeline configurations reduces the potential for stagnant water and the associated problems of poor taste and low chlorine residuals. In addition, proper valve placement is also necessary to maintain reliable and flexible system operation and maintenance.

[1] Accessed at http://www.modestogov.com/ced/about/engineering/ on 8/17/2015.

Table 6-1. Summary of Recommended Potable Water System Performance and Operational Criteria

Component	Criteria	Remarks / Issues
Fire Flow Requirements (flow [gpm] @ duration [hours])		
Single Family Residential	1,500 gpm @ 2 hrs	
Multi Family Residential	2,500 gpm @ 2 hrs	
Commercial	4,000 gpm @ 2 hrs (with approved automatic sprinkler system)	
Institutional (schools, hospitals, etc.)	4,000 gpm @ 4 hrs (with approved automatic sprinkler system)	
Industrial / Business Park	4,000 gpm @ 4 hrs (with approved automatic sprinkler system)	
Water Supply Capacity		
Supply / Pumping Capacity	Provide firm supply capacity equal to maximum day demand	Firm groundwater supply capacity is defined as 60% of the active operational groundwater production capacity for one day. An active well is defined as any well that is currently operational. Wells that are abandoned, or temporarily out of service due to mechanical breakdowns, routine maintenance, water quality or other operational issues, or wells that pump directly into tanks are not considered active.
Water Distribution System Capacity		
Maximum Day Demand plus Fire Flow	Provide firm capacity equal to maximum day demand plus fire flow	Assumes two simultaneous fire flow events (one Multi-Family Residential fire flow and one Commercial fire flow).
Peak Hour Demand	Provide firm capacity equal to peak hour demand	
Pumping Facility Capacity		
Pumping Capacity	Provide the greater of maximum day concurrent with fire flow or peak hour demand	Assume firm pumping capacity. Firm pumping capacity is defined as the total booster pump station capacity with the largest pump out of service or 60% of the active operational groundwater production capacity from all wells for one day.
Backup Power	Equal to the firm capacity of the pumping facility	On-site generator for critical stations.[(a)] Plug in portable generator for less critical stations.
Water Storage and System Peaking Capacity		
Operational	25 percent of maximum day demand	Equivalent to about 1/2 average day demand
Fire	<u>Contiguous Service Area</u> 1.26 MG (Two simultaneous fire events, multi-family residential (non-sprinklered) and industrial fire events; see Remarks for required fire flow volumes) <u>Outlying Service Areas</u> Varies; see requirements listed in Remarks column	Varies depending on land use, sprinklered vs. non-sprinklered and associated required fire flow duration. Highest fire flow demand in any particular area controls size of required storage. 1,500 gpm @ 2 hours = 0.18 MG 2,500 gpm @ 2 hours = 0.30 MG 4,000 gpm @ 2 hours = 0.48 MG 4,000 gpm @ 4 hours = 0.96 MG
Emergency	1 x average day demand (minimum)	
Emergency Groundwater Storage Credit (EGWSC)	Equal to 85% of the active well production capacity for one day equipped with back-up power	The minimum emergency groundwater storage credit is equal to zero. The maximum emergency groundwater storage credit is equal to the recommended emergency storage capacity or 85% of the City's active well production capacity for one day equipped with back up power supply, whichever is lower.
Total Water Storage and System Peaking Capacity	Operational + Fire + Emergency - EGWSC	
Water Transmission Line Sizing		
Diameter	16-inches in diameter or larger	Locate new transmission pipelines within designated utility corridors wherever possible.
Average Day Demand Condition		
Minimum Pressure [psi]	50 psi	
Maximum Pressure [psi]	80 psi	
Maximum Head loss [ft/1000 ft]	2 ft/kft	
Maximum Velocity [ft/sec]	5 fps	
Maximum Day Demand Condition		
Minimum Pressure [psi]	40 psi	
Maximum Head loss [ft/1000 ft]	7 ft/kft	
Maximum Velocity [ft/sec]	7 fps	
Maximum Day w/ Fire Flow Demand Condition		
Minimum Pressure [psi]	20 psi	
Maximum Head loss [ft/1000 ft]	10 ft/kft	
Maximum Velocity [ft/sec]	10 fps	
Peak Hour Demand Condition		
Minimum Pressure [psi]	40 psi	
Maximum Head loss [ft/1000 ft]	7 ft/kft	
Maximum Velocity [ft/sec]	7 fps	
Hazen Williams "C" Factor	120	For consistency in hydraulic modeling.
Pipeline Material	Ductile Iron or equivalent	For consistency in hydraulic modeling.
Water Distribution Line Sizing		
Diameter	Less than 16-inches in diameter	Must verify pipeline size with maximum day plus fire flow analysis. Locate new distribution pipelines within designated utility corridors wherever possible.
Average Day Demand Condition		Criteria based on requirements for new development, existing distribution mains will be evaluated on case-by-case basis. Evaluation will include age, material type, velocity, head loss, and pressure.
Minimum Pressure [psi]	50 psi	
Maximum Pressure [psi]	80 psi	
Maximum Head loss [ft/1000 ft]	3 ft/kft	
Maximum Velocity [ft/sec]	5 fps	
Maximum Day Demand Condition		
Minimum Residual System Pressure [psi] (at fire node)	40 psi	
Maximum Head loss [ft/1000 ft]	7 ft/kft	
Maximum Velocity [ft/sec]	7 fps	
Maximum Day w/ Fire Flow Demand Conditions		
Minimum Residual System Pressure [psi] (at fire node)	20 psi	
Maximum Head loss [ft/1000 ft]	10 ft/kft	
Maximum Velocity [ft/sec]	12 fps	
Peak Hour Demand Condition		
Minimum Pressure [psi]	40 psi	
Maximum Head loss [ft/1000 ft]	7 ft/kft	
Maximum Velocity [ft/sec]	7 fps	
Minimum Pipe Diameter		
Distribution to cul-de-sac / dead end street	8-inch	
Distribution to fire hydrants	6-inch	
Hazen Williams "C" Factor	120 (Ductile Iron, Steel); 130 (PVC)	For consistency in hydraulic modeling.
Pipeline Material	PVC, Ductile Iron, or Steel	For consistency in hydraulic modeling.
Other Criteria		
Maximum Number of residential lots that can be served by a non-looped water pipeline	25 lots	If a non-looped water line goes out-of-service, all associated residences lose water service.

[(a)] A pumping facility is defined as critical if it provides service to local service area(s) without sufficient emergency storage and that meet the following criteria:

- A pumping facility that provides water from a supply turnout from an MID transmission main;
- A facility that provides water from key groundwater supply wells (depends on capacity, quality, location, and/or local pressure cluster); or
- All storage tank booster pump stations.

6.1.2 Water Quality Standards

Water quality standards largely pertain to protecting public health and consistently delivering a satisfactory supply to the customer. The U.S. Environmental Protection Agency (EPA) and the California State Water Resources Control Board (SWRCB) DDW are the agencies responsible for establishing water quality standards. EPA and DDW prescribe regulations that limit the amount of certain contaminants in the water provided by a public water system. The City, as a water purveyor, is responsible for ensuring that all applicable water quality standards and regulations are met at all times.

6.2 FIRE FLOW REQUIREMENTS

The City's Water Utilities Department operates and maintains the water system within the City and the 'outlying' systems within the City's service areas. The City's Fire Department is concerned with the availability of a sufficient water supply for firefighting purposes. Consequently, the Fire Department establishes minimum water flows and residual system pressures during a firefighting event that the City is responsible for providing.

The City Fire Department is currently using the 2013 California Fire Code (CFC) Table B105.1 *Minimum Required Fire Flow and Flow Duration for Buildings* to assist them in establishing minimum fire flow guidelines and durations for individual structures. It should be noted that in this Water Master Plan, these minimum sprinklered fire flows are used for system wide hydraulic performance and operational evaluations to ensure that the City's water system can provide required flows and pressures to new buildings. The recommended fire flow requirements for the City are based on the requirements established in the 2013 CFC and are generalized for the City based on general land use designations. These recommendations are presented in Table 6-2. These fire flow requirements will be used for the evaluation of the existing and future water system.

From a performance and operational perspective, the minimum fire flows identified in Table 6-2 are to be met concurrently during an assumed Maximum Day Demand condition, while maintaining a minimum residual system pressure of 20 psi throughout the water system. Additionally, it is recommended that the City's contiguous water system have the capability to meet two simultaneous fire flow events (appropriate for a larger municipality like Modesto, which is configured with specific service areas, such as North and South Modesto.) while maintaining a minimum residual system pressure of 20 psi. It is assumed that these two fire events will consist of one Multi-family Residential fire flow combined with another larger Commercial fire flow. This conservative assumption of two simultaneous fire flow demands will help stress the City's contiguous water system and determine if the water system can provide reliable service during high demand conditions. For the outlying service areas, a single fire flow event based on the land use requiring the highest water demand will be assumed.

Additionally, as discussed in subsequent sections of this Chapter, minimum fire flows presented in Table 6-2 and their expected duration will also be used to establish the City's water storage capacity requirements.

Table 6-2. Recommended Fire Flow Requirements[a,b,c]

Land Use Designation	Non-Sprinklered			Sprinklered[d]		
	Fire Flow, gpm	Duration, hours	Recommended Storage, MG	Fire Flow, gpm	Duration, hours	Recommended Storage, MG
Single-Family Residential[e]	1,500	2	0.18	1,500	2	0.18
Multi-Family Residential[f]	2,500	2	0.30	2,500	2	0.30
Commercial/Office[g]	8,000	2	0.96	4,000	2	0.48
Industrial[h]	8,000	4	1.92	4,000	4	0.96
Institutional (schools, hospitals, etc.)	8,000	4	1.92	4,000	4	0.96

(a) Construction type and fire flow calculation area are not generally known during the development of a Water Master Plan; consequently, fire flow requirements set forth in this table are based on previous estimates for these land use types and similar communities.

(b) Unique projects or projects with alternate materials may require higher fire flows and should be reviewed by the Fire Marshal on a case-by-case basis (e.g., proposed commercial/industrial areas, hospitals, schools, etc.).

(c) Specific fire flows were determined from Table B105.1 of the 2013 CFC, and depend on construction type and fire flow calculation area. See Section 3-1.208 of the City of Modesto Municipal Code for automatic sprinkler system requirements and exceptions.

(d) As outlined in the 2014 City of Modesto Standard Specifications, the Fire Marshal normally allows up to a 50 percent reduction in CFC fire flow requirements if a building is provided with an automatic sprinkler system. However, the CFC requires that no fire flow be less than 1,000 gpm for single family residential or 1,500 gpm for all other building types. For master planning purposes and to achieve more conservative fire flow estimates, Single Family and Multiple Family Residential buildings were considered non-sprinklered and no reduction was applied. Commercial/Office, Industrial, and Institutional buildings were assumed to be sprinklered for the purposes of this Water Master Plan. It should be noted, that while these assumptions were used for the Water Master Plan, it is up to the City Fire Marshal's discretion as to what the fire flow requirements are for new buildings.

(e) Includes Residential and Village Residential land uses.

(f) This category should be used in cases where the housing density is greater than Single-Family Residential.

(g) Includes Mixed Use, Commercial, Regional Commercial, Business Park, Redevelopment Planning District, and Salida Community Plan land uses.

(h) Includes the Industrial land use.

6.3 WATER SYSTEM CAPACITY DURING HIGH DEMAND PERIODS

Maximum Day Demand, Maximum Day Demand plus Fire Flow, and Peak Hour Demand conditions will be used to assess the adequacy of the City's potable water supply and transmission/distribution system during high demand periods. Adopted peaking factors for Maximum Day and Peak Hour Demands are discussed in Chapter 3. The following subsections discuss the assumptions and recommended criteria for each demand condition.

6.3.1 Water Supply Capacity

The City must be able to provide a firm supply capacity equal to the Maximum Day Demand, which can be met by a combination of treated surface water supplied from MID (via the Terminal Reservoir tanks and booster pump station) and City groundwater wells. Even though the contiguous service area has eight storage tanks and associated booster pump stations, this storage is limited to meeting diurnal system peaking demands and only holds one Average Day of emergency storage and fire flows, and therefore this storage cannot be counted on as a reliable source to meet the Maximum Day Demand requirements.

6.3.1.1 Firm Groundwater Supply Capacity

Firm groundwater supply capacity assumes that 60 percent of the City's active well capacity is available. An active well is defined as any well that is currently operational. Wells that are abandoned, or temporarily out of service due to mechanical breakdowns, routine maintenance, water quality or other operational issues, or wells that pump directly into tanks are not considered active[2]. This conservative planning-level assumption is consistent with the City's 2010 Engineer's Report and ensures the reliability and flexibility of the system to provide sufficient supply capacity to meet the Maximum Day Demand, especially considering increasing regulation, tightening of groundwater pumping, and aging infrastructure.

6.3.2 Maximum Day Demand plus Fire Flow

In accordance with typical industry standards, the City's water supply system should have the capability to meet a system demand condition equal to the occurrence of a Maximum Day Demand concurrent with either one or two fire flow events (depending on the service area) while meeting the recommended system performance criteria (e.g., minimum and maximum system pressures) discussed under *Section 6.6 Water Transmission and Distribution Pipeline Sizing* of this Chapter.

Maximum Day Demand plus Fire Flow will be met by a combination of the City's wells, storage tanks/booster pump stations and treated surface water from MID. The analysis of specific fire flow evaluations will be conducted assuming the largest booster pump at each pump station is off-line (i.e., the definition of the firm capacity of a booster pump station). The City's groundwater wells will be assumed to pump at their firm capacity (i.e., firm groundwater pumping capacity).

[2] Well status is based on data provided by the City in October 21, 2014

6.3.3 Peak Hour Demand

Peak Hour Demand should be met from a combination of supply sources (i.e., groundwater from wells, treated surface water, and water from storage tanks). Assumptions regarding firm pumping capacity will also apply during a Peak Hour Demand condition. During a Peak Hour Demand condition, the City's water system should be able to meet the recommended system performance criteria (e.g., minimum and maximum system pressures) discussed under *Section 6.6 Water Transmission and Distribution Pipeline Sizing* of this Chapter.

6.4 PUMPING FACILITY CAPACITY (WELLS AND STORAGE TANK BOOSTER PUMPS)

6.4.1 Required Pumping Capacity

Sufficient water system pumping capacity should be provided to meet the greater of the following two demand conditions within the system:

1. A Maximum Day Demand plus Fire Flow event [based on the highest fire flow requirement for the different land use types within the particular service area (i.e., the City's contiguous area would be different from the Del Rio area)] with booster pumps and wells assumed to operate at their firm pumping capacity; or
2. A Peak Hour Demand event (with booster pumps and wells assumed to operate at their firm pumping capacity).

The highest demand between these two conditions sets the water system pumping capacity requirements of the wells and the storage tank's booster pumps. Sufficient pumping capacity should also be provided so that the Maximum Day Demand within the system can be supplied using firm well pumping capacity with no assistance from storage tanks, as noted in Section 6.3.1 above.

6.4.2 Critical Supply Facilities

All critical supply facilities should be equipped with an on-site, back-up power generator. A pumping facility is defined as critical if it provides service to local service area(s) without sufficient emergency storage and that it meets one of the following criteria:

- A pumping facility that provides water from a supply turnout (i.e., Terminal Reservoir Pumps);
- A pumping facility that provides water from key groundwater wells based on capacity, quality, location, and/or local pressure cluster; and
- All storage tank booster pump stations.

Each of the critical supply facilities listed above should be equipped with generators for back-up power, if it does not already have an auxiliary power source, in order to provide sufficient reliable pumping capacity.

6.5 STORAGE FACILITY CAPACITY

The total treated water storage capacity required will be based on the following three components:

- Operational Storage,
- Fire Flow Storage, and
- Emergency Storage.

A discussion of these three storage components follows, along with a discussion of "credits" for groundwater storage and pumping capacity are discussed in more detail below.

6.5.1 Operational Storage

Over any 24-hour period, water demands will vary. Typically, higher water demands will occur during the early morning hours when people are irrigating landscape and getting ready to go to work or school. Water demands will then decline to some nominal baseline level (depending on the proximity to water use patterns of adjacent commercial/industrial areas), and will then begin to increase again depending on outside water needs (and corresponding temperature) until it reaches a higher water demand in the evening hours as people return home from work or school. Throughout the year, the peaks of this cycle will vary according to customer needs, creating Maximum Day and Peak Hour Demands.

Usually, water treatment plants and/or some specific wells within a water system are operated at a fairly constant rate over a continuous period of time (baseline). This supply is then typically augmented, as needed, by additional flows from storage tanks and/or additional wells during high demand periods. Storage tanks are normally refilled when demands drop below the baseline water production flow rate. The storage volume used to meet these higher than baseline demand periods is called operational storage.

Ideally, the operational storage requirement should be calculated based on the diurnal demand pattern within the service area. If sufficient data is not available to develop a diurnal demand pattern, then the recommended volume of water to be stored as operational storage should be at least equal to 25 percent of the total volume of water needed to meet the service area's Maximum Day Demand.

6.5.2 Fire Flow Storage

As discussed above, current fire flow requirements for the City are identified in the 2013 CFC. These requirements are based on the building use type (i.e., residential, commercial, etc.), building size (in square feet), whether or not automatic sprinklers are installed, and type of construction (wood frame, metal, masonry, etc.). After a fire flow requirement is established, it is multiplied by the required fire flow duration to produce an estimate of the total volume of fire flow storage required.

Table 6-2 presents the recommended fire flow criteria and associated required fire flow storage by land use types. Based on the fire flows listed in Table 6-2, sufficient fire flow storage should be available in the contiguous service area for two simultaneous fire flow events: a Multi-family Residential and a Commercial (assuming sprinklered conditions for both events), for a total fire storage volume of 1.26 MG. Sufficient fire flow storage should be available in the outlying service areas based on the land use requiring the highest water demand as outlined in Table 6-2. In all service areas, the pump(s) and motor(s) combination at each tank booster pump station must be equipped with a backup power source of sufficient capacity to reliably access the fire flow storage and meet the required fire flow and minimum residual system pressure requirements.

6.5.3 Emergency Storage

A reserve of stored water is also required to meet demands during an emergency. An emergency is defined as an unforeseen or unplanned event that may degrade the quality or disrupt the quantity of potable water supplies available to serve customers. Some examples of emergency events that a water utility may prepare for include[3]:

- Minor emergency. A fairly routine, normal, or localized event that affects a few customers, such as a distribution or service pipeline break, malfunctioning valve, hydrant break, or a brief power loss. Utilities plan for minor emergencies and typically have staff and materials on-hand and available to mitigate these minor emergencies relatively quickly (typically within hours).
- Major emergency. A disaster that affects an entire, and/or large portion of a water system, lowers the quantity and quality of the water, or places the health and safety of the community at risk. Examples include water treatment plant failures, raw water contamination, or major power grid outages. Water utilities seldom experience major emergencies but typically plan to have alternative sources of supply and/or storage sufficient to provide a minimum of one to two days or more of supply in local storage facilities.
- Natural disaster. A disaster caused by natural forces or events that create a major water utility emergency. Examples include earthquakes, forest or brush fires, hurricanes, tornados or high winds, floods, and other severe weather conditions such as freezing or drought that damage or cause water system facilities to be unable to operate.

Determination of the required volume of emergency storage is a policy decision based on the assessment of the risk of failures and the readily available desired degree of system reliability. The amount of required emergency storage is a function of several factors, including the diversity of the supply sources, redundancy and reliability of the production facilities, and the anticipated length of the emergency outage.

[3] *M-19 Emergency Planning for Water Utilities*, AWWA 2001.

The American Water Works Association states that no formula exists for determining the amount of emergency storage required, and that the decision will be made by the individual utility based on a judgment about the perceived vulnerability of the system. For this Water Master Plan, for planning purposes, the emergency storage requirement will be based on minor emergencies and *specific* major emergency criteria. Based on this planning criterion, it is recommended that the City have a minimum quantity of emergency storage volume equivalent to one times the Average Day Demand.

6.5.4 Emergency Groundwater Storage Credit

Because of the City's available wells, the groundwater basin can account for a portion of the recommended water storage and system peaking capacity in the form of an emergency groundwater storage credit.

The emergency groundwater storage credit is defined as 85 percent of the production capacity of the City's active wells that have generators to provide back-up power (wells that pump directly into storage tanks are not included) over the duration of the emergency (assumed to be 24 hours). These facilities would include the firm capacity of the wells that are equipped with auxiliary power operated over a 24-hour period. On a system-wide basis, the minimum credit is equal to zero, and the maximum credit is equal to the recommended emergency storage capacity (up to one day's worth of the Average Day Demand).

6.5.5 Total Storage Capacity Recommended

The City's recommended potable water storage capacity should be the sum of the following components:

- Operational: Volume of water necessary to meet diurnal peaks observed throughout the day, assumed to be equivalent to at least 25 percent of the Maximum Day Demand; plus
- Fire Flow: Volume of water necessary to supply a defined fire flow event(s), where the fire flow event(s) is/are contingent upon the service area; plus
- Emergency: Volume of water necessary to provide one times the Average Daily Demand; minus
- Emergency Groundwater Storage Credit: Equal to 85 percent of the firm groundwater supply that can be reliably accessed to meet emergency storage needs, up to a maximum of the emergency storage requirement.

The amount of total system storage and system peaking capacity required to meet these criteria will change over time as the City continues to grow and potable water demands increase.

6.6 WATER TRANSMISSION AND DISTRIBUTION PIPELINE SIZING

The following criteria will be used as guidelines for sizing new transmission and distribution pipelines. Pressure, velocity, and head loss criteria are all described in the different demand scenarios included below.

Pressure criteria provided in this section range from a minimum of 40 psi to a maximum of 80 psi to allow for variations in elevation and different operating conditions. 80 psi is the maximum allowable system operating pressure without requiring pressure regulation of individual customer services.

New transmission and distribution pipelines to serve the City's future planning areas should be located within designated utility corridors wherever possible. These designated utility corridors should be within public rights-of-way to minimize or eliminate the need for utility easements within private property.

The City's existing system will be evaluated on a case-by-case basis using pressure as the primary criterion. Secondary criteria, such as velocity, head loss, age, and pipeline material type, will be used as indicators to locate and help prioritize where water system improvements may be needed. For example, if an existing pipeline experiences head loss in excess of the criteria described below during a Maximum Day plus Fire Flow event, this condition by itself does not necessarily indicate a problem as long as the minimum system pressure criterion is satisfied.

6.6.1 Water Transmission System

Transmission pipelines are generally defined as being 16 inches in diameter or larger and should be designed based on the criteria described below for Average Day, Maximum Day, Maximum Day plus Fire Flow, and Peak Hour demand conditions. The criteria reflect West Yost's experience working with the City's existing water system.

6.6.1.1 Average Day Demand

- Service pressures should be maintained between a maximum of 80 psi and a minimum of 50 psi.
- The maximum velocity within transmission pipelines should be 5 feet per second (fps).
- Head losses within the transmission system pipelines should be limited to 2 feet per thousand feet (ft/kft) of pipeline.

6.6.1.2 Maximum Day Demand

- Service pressures should be maintained between a maximum of 80 psi and a minimum of 40 psi.
- The maximum velocity within transmission pipelines should be 7 fps.
- Head losses within the transmission system pipelines should be limited to 7 ft/kft of pipeline.

6.6.1.3 Maximum Day plus Fire Flow Demand

- The minimum allowable residual pressure should be 20 psi at the flowing fire hydrant.
- The maximum velocity within transmission pipelines should be 10 fps.
- Head losses within the transmission system pipelines should be limited to 10 ft/kft of pipeline.

6.6.1.4 Peak Hour Demand

- Service pressures should be maintained between a maximum of 80 psi and a minimum of 40 psi.
- The maximum velocity within transmission pipelines should be 7 fps.
- Head losses within the transmission system pipelines should be limited to 7 ft/kft of pipeline.

6.6.2 Water Distribution System

Distribution pipelines are generally less than 16-inches in diameter and should be sized based on the criteria described below for Average Day, Maximum Day, Maximum Day plus Fire Flow, and Peak Hour demand conditions. The criteria reflect West Yost's experience working with the City's existing water system.

6.6.2.1 Average Day Demand

- Service pressures should be maintained between a maximum of 80 psi and a minimum of 50 psi.
- The maximum velocity within distribution system pipelines should be 5 fps.
- Head losses within the distribution system pipelines should be limited to 3 ft/kft of pipeline.

6.6.2.2 Maximum Day Demand

- Service pressures should be maintained between a maximum of 80 psi and a minimum of 40 psi.
- The maximum velocity within distribution system pipelines should be 7 fps.
- Head losses within the distribution system pipelines should be limited to 7 ft/kft of pipeline.

6.6.2.3 Maximum Day plus Fire Flow Demand

- The minimum allowable residual pressure should be 20 psi at the flowing fire hydrant.
- The maximum velocity within distribution system pipelines should be 12 fps, or the head losses within the distribution system pipelines should be limited to 10 ft/kft of pipeline, whichever criteria is more conservative given the specific hydraulic/system condition.

6.6.2.4 Peak Hour Demand

- Service pressures should be maintained between a maximum of 80 psi and a minimum of 40 psi.
- The maximum velocity within distribution system pipelines should be 7 fps.
- Head losses within the distribution system pipelines should be limited to 7 ft/kft of pipeline.