

V. **DESIGN OF WATER MAINS**

A. **Fire Flow And Residual Pressure Requirements**

When fire protection is to be provided, system design should be such that fire flows and facilities are in accordance with the requirements of the State Insurance Services Office. The minimum fire flow shall be 1000 GPM with a minimum residual pressure of 20 PSI. Minimum residential service flow shall be 10 GPM at 20 PSI residual pressure (as measured at the meter). Where these requirements cannot be met, contact CMUD Public Service Engineer for guidance.

B. **Hydraulic Design**

Water distribution systems shall be designed to provide adequate flow and pressure for both domestic supply and fire protection.

Transmission mains 12-inches in diameter and larger shall be designed to deliver maximum daily design flow with a head loss not to exceed 5' per 1000'. Lower head loss criteria may be established based on length of main and available system head. Distribution mains 8-inches in diameter and smaller shall meet the same criteria for maximum daily domestic demand, but head losses up to 10' per 100' are acceptable for fire flow design provided volume and residual pressure requirements are met. Design shall be based on a Hazen-William "C" value of 150 for PVC pipe and 130 for ductile iron or concrete cylinder pipe.

When requested, the Engineer shall submit the calculations of fire flow requirements and domestic water demands for the project. Information concerning the available water pressures and capacity will be furnished through the Systems and Records Section upon request.

The water distribution systems and any extensions shall be designed to supply the demands of all customers while maintaining the following minimum pressures and velocity.

- 1) 40 PSI for maximum daily flow
- 2) 30 PSI for peak hourly flow
- 3) 20 PSI for instantaneous flow plus fire flow. If this requirement cannot be met due to system limitations, the minimum pipe diameter shall be 8-inches.
- 4) 4 FPS for flushing

Average daily flow may be estimated at 1500 gallons per day per acre. This estimate should be modified as necessary based on specific zoning and land use data. Maximum daily flow and peak hourly flow shall be determined as follows:

$$\begin{aligned} \text{Maximum daily flow} &= \text{Average daily flow times } 1.5 \\ \text{Peak hourly flow} &= \text{Average daily flow times } 2.1 \end{aligned}$$

Instantaneous demand for residential areas shall be based on the number of 3/4-inch service connections according to Figure 1. Instantaneous demand for business and industrial development shall be based on detailed analysis of water volume and usage patterns for the particular type of development.

Transmission mains larger than 12-inches shall be designed on the basis of the most recent system wide demand data and hydraulic modeling.

Services and meters shall be sized and locations designed in accordance with Standard Details. Minimum service size shall be 3/4" pipe with a 5/8" meter. A maximum of 20 services shall be allowed on dead end 2-inch mains and a maximum of 40 services shall be allowed on a looped 2-inch main. No 2-inch main shall exceed 1,000 feet in length.

Pressure reducing valves shall be installed on the customer side of the meter whenever the maximum system pressure at the service connection is greater than 80 PSI.

### **C. Survey Requirements**

All new water mains greater than 12-inches in diameter shall be field surveyed under the supervision of a surveyor or registered in North Carolina.

1. All existing underground utilities (water, sewer, gas, storm drains, telephone, electric power, cable TV, etc.) along the route shall be located horizontally. Where potential for significant elevation conflicts with the proposed water main exist, the existing utilities shall be exposed and elevations determined. Contact the individual utilities to determine dig up policies and procedures.
2. Vertical control shall be tied to NGS, NCGS or established CMUD vertical control points. Temporary bench marks shall be established at intervals of approximately 1000 feet and tied back to the established vertical control with a maximum error of  $0.03\bar{7} M$  where M is the number of miles in the level loop.
3. Horizontal alignment shall be chosen in coordination with the design engineer and referenced to the edge of pavement, right-of-way line, or other identifiable feature. Center line profile shots shall be taken at 50 foot intervals with closer shots at break points such as culverts, creeks, etc. In cut sections, edge of pavement profile is required also.
4. Any requirements for private rights-of-way shall be determined in consultation with the design engineer. A separate right-of-way map shall be prepared for each individual property crossed. Refer to IV. D.3 for specific requirements for right-of-way maps.
5. Water mains 12-inches or less in diameter do not require profile views on the construction plans except, when in the opinion of the design engineer, a profile view is needed to convey a specific vertical alignment. High points and low points are to be identified for location of air releases and blow offs.

### **D. Location And Depth**

As a general rule, water mains are located only within the limits of street or highway rights-of-way. Where this is not possible because of construction conditions, underground conflicts, or requirements of the controlling agency, location in private easements may be approved by CMUD. Insofar as possible, water mains should be located out of existing paved areas and a fixed distance from the edge of pavement or back of curb. Alignment should be chosen so as to minimize conflicts with utilities and underground structures.

Depth of water lines shall be set to minimize high and low points and at sufficient depth to prevent freezing. A minimum cover of 36-inches is required except where short sections at shallower depth are required to avoid major utility conflicts. Whenever depth of cover is less than 24-inches, the pipe must be encased in concrete. Encased water mains shall have at least one foot of cover over the casing. Where centerline grade is higher than the edge of pavement, the top of the water main shall be at least 3' below edge of pavement.

**E. Pipe Materials And Thickness Design**

Complete specifications for CMUD approved water main materials are contained in the MS Section of current CMUD Water Main Specifications. The following pipe materials are approved for various applications.

<b>SIZE</b>	<b>THICKNESS</b>	<b>MATERIAL</b>	<b>SPECIFICATIONS</b>
<b>SUBDIVISION STREETS (New Streets)</b>			
2-inch ***	SDR 13.5	PVC	ASTM D2241
6-inch, 8-inch, & 12-inch	SDR 14	PVC	AWWA C-900
	Pressure Class 350	DIP	AWWA C-151
<b>DISTRIBUTION MAINS (Existing Roadways)</b>			
2-inch ***	SDR 13.5	PVC	ASTM D2241
6-inch, 8-inch, & 12-inch	SDR 14	PVC	AWWA C-900
	Pressure Class 350	DIP	AWWA C-151
<b>TRANSMISSION MAINS</b>			
16-inch - 20-inch	Pressure Class 250 (Minimum) **	DIP	AWWA C-151
24-inch & Above	*	PCCP/ECP	AWWA C-301
	Pressure Class 250 (Minimum) **	DIP	AWWA C-151

\* Thickness design per Appendix C, AWWA C301

\*\* Thickness design per AWWA C150

\*\*\* NCDHS requires 2-inch galvanized under certain conditions. See current CMUD Standard Specifications for Water Main Construction, DS Section

**F. Thrust Restraint**

Thrust restraint for water mains shall be provided by concrete thrust blocks bearing on undisturbed soil or by approved restrained joints. The bearing area for thrust blocks shall be based on the required test pressure of 200 PSI and a field determination of the load bearing capacity of the soil. Conservative estimates of soil load bearing capacities by experienced and qualified inspectors are normally allowed. However, analysis may be required by the Engineer.

Restrained joints shall be as specified in current Material Specifications (MS Section) or as recommended by the pipe manufacturer and approved by the Engineer. Restrained lengths shall be calculated by the design engineer for each application. Calculations shall be based on a test pressure of 200 PSI and skin friction coefficients supplied by the pipe manufacturer with a safety factor of 1.5.

**G. Valving Requirements**

Main line valves shall be located at all pipeline intersections and at changes in pipe diameter. Maximum valve spacing shall be 1500 feet in the distribution system and 3000 feet for transmission mains 16-inches in diameter and larger.

Two valves shall be provided at tees and three valves at crosses, with valves located either at road intersection radius points or as close to the fittings as possible. Where valves must be located away from intersections, they should be located at hydrant installations. If the line is a one way feed, the valve should be on the dead end side of the hydrant branch. Each fire hydrant shall have a hydrant guard valve between the hydrant and the main line located according to current standard details for hydrant installation.

**H. Fire Hydrant Spacing**

Current NC DHS regulations specify that a hydrant must be located within a radial distance of 1000' from each residence and 500' from each business. CMUD practice is to limit the maximum distance to 750' from the building set back line for single family and duplex residences and 500' from the building set back line for multi-family residences and businesses. These distances are measured along streets as the fire truck would travel.

**I. Provision For Testing And Disinfection**

New water mains may be tied to the existing system at one point only prior to pressure testing and disinfection. When the connection is such that the new main will be pressure tested against an existing valve, the valve will be pressure tested, prior to the connection, at the same differential pressure that will be applied during testing of the new main. If the valve does not hold constant pressure for a ten minute test period, then the connection will not be permitted until the new main is tested and disinfected. Instead a jumper connection will be provided to furnish the water for testing, disinfection and flushing. Following testing against an active valve, the valve will be opened and the line thoroughly flushed through the valve. Access to flush points for contractors and CMUD staff will be provided.

Where new mains are connected to the existing system by tapping sleeves and valves, the valves will be hydrostatically tested after the sleeve and valve have been bolted on but before the tap is made.

Temporary taps and air releases may be made to accommodate testing and disinfection with the approval of the Engineer. Wherever possible, blow offs will be located close to sanitary sewer manholes for convenient disposal of chlorinated water following disinfection.

**J. Air Releases, Air Relief And Vacuum Valves and Blowoffs**

Manual air releases shall be provided at high points on all 12-inch and larger water mains. Also, air releases shall be provided at high points on 6-inch and 8-inch water mains where air cannot be adequately released from the main through service connections. Manual air releases shall be according to current standard details.

On pumped lines or in any other application where the potential for water column separation exists, the design engineer shall evaluate the need for automatic air relief and vacuum valves and shall recommend specific valve configurations for approval by the CMUD Chief Engineer or his representative.

All transmission mains 16-inches in diameter and larger must be designed such that they can be de-watered completely within four hours through blowoffs and fire hydrants. Dead end lines shall be terminated with a 2-inch blow off according to current CMUD standard details.

**K. Minimum Pipe Size And Limitations On Use Of Small Diameter Mains**

The minimum pipeline diameter for distribution system mains providing fire flow shall be 6-inches. Two-inch diameter lines may be used within residential subdivisions only for a maximum length of 1000 feet where fire flow requirements and minimum hydrant spacing is provided by 6-inch and larger mains. No more than 20 residential customers may be served from a dead end 2-inch main and no more than 40 customers may be served from a looped 2-inch main.

**L. Conflicts With Existing And Proposed Utilities**

1. Sewer mains -
  - a. 18-inch vertical clearance for water line installed above sewer line
  - b. 10-feet horizontal separation for water line parallel to sewer line
  - c. Ductile iron pipe required for water and sewer when these clearances are not maintained.
2. Storm Drains, Gas Mains and Telephone Duct Banks - when crossing storm drains, gas main or telephone duct banks, a vertical clearance of 12-inches shall be maintained. When crossing storm drains with minimum cover, this clearance may be reduced provided specific approval of the North Carolina Department of Transportation or Charlotte DOT is obtained and provided the minimum cover requirements for water mains are maintained. Wherever the 12-inch clearance is not met, Ductile Iron Pipe must be used.
3. Underground Cables - Individual telephone, electric power and cable TV cables may be crossed with a minimum of 12-inches of clearance.

**M. Bores And Tunnels**

Water main crossings of railroads, major City streets and numbered State highways must be encased in a steel pipe installed by boring and jacking or in a dug tunnel lined with prefabricated steel tunnel liner plates. Minor City streets and secondary roads maintained by NCDOT may be open cut with specific permission of the controlling agency and if specifically shown as open cuts on the construction plans. Material and construction specifications for carrier pipe and for steel casing pipe and tunnel liners shall be in accordance with current CMUD standard specifications.

The minimum size and thickness standards for casing pipe and tunnel liners for various water main sizes are as follows:

Carrier Pipe	DOT Size	DOT Thickness	Railroad Size	Railroad Thickness	Tunnel Size*
6-inch DIP	12.75"	.250"	16"	.281"	48"
8-inch DIP	16"	.250"	18"	.312"	48"
10-inch DIP	18"	.250"	20"	.344"	48"
12-inch DIP	20"	.250"	24"	.406"	48"
16-inch DIP	24"	.250"	30"	.469"	48"
18-inch DIP	30"	.312"	30"	.469"	48"
20-inch DIP	36"	.375"	36"	.562"	48"
24-inch DIP	36"	.375"	36"	.562"	48"
27-inch PCCP	42"	.500"	42"	.625"	54"
30-inch DIP	42"	.500"	48"	.750"	54"
30-inch PCCP	48"	.500"	48"	.750"	54"
36-inch DIP					60"
36-inch PCCP					60"
42-inch DIP					72"
42-inch PCCP					72"
48-inch DIP					78"
48-inch PCCP					78"
54-inch DIP					78"
54-inch PCCP					78"
60-inch DIP					84"
60-inch PCCP					84"

\*Liner plate gauge to be determined by controlling agency and/or by depth of installation.



**N. Stream Crossings**

Water mains crossing streams shall be of ductile iron pipe or concrete pressure pipe only and shall meet current CMUD standard material specifications. The pipe shall be buried at sufficient depth to provide four feet of cover between the top of the pipe and the stream bed. The pipe and joints shall be protected against stream bed erosion, unstable subsoil conditions and any other anticipated horizontal or vertical loading. Protective measures may include rip rap, concrete encasement, driven or drilled piers at each pipe joint or use of ball and socket pipe. For large stream crossings, the Engineer may require specific designs based on subsurface soil investigations.

**O. Design of Soil Erosion And Sediment Control Measures**

All water main construction plans, regardless of project size shall include measures and/or devices to prevent soil erosion and to prevent sedimentation of streams and drainage ways. This requirement is waived for water mains in subdivision projects where the project erosion control plans includes water main construction and where enforcement of erosion control requirements is not under CMUD control. Design of Erosion and Sediment Control devices shall be in accordance with CMUD specifications and standard details for erosion control and with the State of North Carolina Erosion and Sediment Control Planning and Design Manual.