# APPENDIX B

## WSSC Design Criteria for Water Distribution Systems

### a. System Requirements

1) Pressure Requirements

a) The water distribution system shall have adequate capacity to supply "domestic" demand to all customers -- residential, public, commercial, and industrial -- while maintaining the following minimum pressures.

- 40 psi at the maximum-day demand flow rate
- 20 psi at the sum of the maximum-day demand flow rate and the appropriate fire flow rate or, if greater, at the peak hour demand flow rate.

b) Maximum-day demand conditions are represented by the low hydraulic grade for an area. Exceptions to the maximum-day flow rate pressure are permitted in small areas where it is not feasible to provide service from a higher pressure zone or not reasonable to create a new zone.

c) Where the pressure at a connection during the maximum-day demand flow rate is between 25 and 40 psi, either a booster pump can be installed by the building owner or the house connection and plumbing design can be enlarged to meet pressures required in Plumbing Code. Where the pressure at the connection during the maximum-day demand flow rate is between 20 and 25 psi, the installation of booster pumps by the building owner will be required.

d) The high hydraulic grade represents system conditions with minimal demand. Connections with more than 80 psi during high hydraulic grade conditions will be required to be fitted with an individual pressure reducing valve as described in Plumbing Code.

e) The water distribution system should be designed to provide domestic pressures generally no higher than 115 psi and not to exceed 130 psi based on the high hydraulic grade.

2) Domestic Demand Requirements: Unless more specific information is available, the following criteria will be used in estimating water demand.

a) Average Demand Flow Rate

(1) The average demand flow rate can be estimated by using the following current water production factors:

| | |
|---|---|
| Single-family Dwelling Unit (SFDU) | 231 gpd/unit |
| Multi-family Dwelling Unit (MFDU) | 121 gpd/unit |
| Employment | 51 gpd/employee |

(2) Other demand factors can be estimated from the base sanitary flow numbers (see Appendix C of the Sewer Design Guidelines).

b) Maximum-Day Demand Flow Rate

(1) The maximum-day demand flow rate can be estimated by multiplying the average

demand flow rate by the maximum-day factor. The current maximum-day factor for determining the size of service mains is 2.0. Other maximum-day factors can be used for determining the size of distribution mains as determined by WSSC. For example, in some instances, a zone-specific maximum-day factor provided by the WSSC may be used.

c) Peak Hour Demand Flow Rate

(1) The peak hour demand rate is not normally used for design unless directed by WSSC. Use either one (1) of the following:

(a) Peak hour flow is to be two (2) times the maximum-day flow.

(b) Peak hour factor will be provided by WSSC.

3) Fire-Flow Rate Requirements

a) A minimum fire-flow rate of 1,000 gallons per minute should be available with a residual pressure of at least 20 psi at all WSSC system fire hydrants during maximum-day demand conditions.

b) Hydrants in areas with attached housing should have 1,000 gpm available at the last, most hydraulically remote hydrant with an additional 500 gpd fire flow available simultaneously at an adjacent hydrant during maximum-day demand conditions.

c) The minimum fire-flow rate for non-residential land uses is 1,500 gpm during maximum-day demand conditions between two adjacent hydrants, as described above for attached housing. Fire protection in excess of 1,500 gpm shall be provided as called for by the Prince George's County and the Montgomery County Fire Marshals, and may require on site storage and pumping.

## b. Hydraulic Design Criteria

1) Demand used in hydraulic modeling to determine water main sizing shall be the greater of maximum-day demand flow rate plus the appropriate fire-flow rate or the peak hour demand.

Example: (Determining Demands)

Proposed development consists of 512 apartments and 27,500 square feet of office space. Since the number of employees is unknown, the base sanitary sewage flow factor for office use can be used to estimate the average water demand. The base sanitary flow factor for offices is currently 0.093 gpd per square foot of office space. (See Appendix C, WSSC Design Criteria for Sewer Systems)

| Proposed Development | Average Demand (gpd) | Maximum-Day Demand (mgd) | Peak-Hour Demand (mgd) |
|---|---|---|---|
| 512 apartments | 61,952 | 0.12 | 0.24 |
| 27,500 sf office | 2,558 | 0.01 | 0.01 |
| Total | 64,100 | 0.13 | 0.25 |

The fire flow demand requirement of 1,500 gpm (or 2.16 mgd) would apply for this development. The maximum-day demand plus fire flow would be 2.29 mgd. This rate is greater than the peak-hour demand of 0.25 mgd. Therefore, maximum-day demand plus fire flow should be used when modeling for this subdivision.

2) In addition to the domestic demand, pressure and fire-flow demand requirements, the hydraulic design should take into account pipe sizes, length, and roughness. The ability of a pipe network, instead of a single feed, to convey water should be considered in many cases to avoid over-sizing mains. The proposed system should also take into account the ability to accommodate future planned development. Finally, when large-diameter mains or long extensions to serve a relatively small demand are proposed, the travel time between a point with acceptable chlorine-residual levels to the most remote connection point will be evaluated.

3) Water mains should be sized to limit the friction headloss in the distribution system. The calculations should show that the highest and most hydraulically remote fire hydrant(s) will maintain the required design conditions. The Hazen-Williams formula should be used for calculating head loss in pipes during fire flow conditions.

$$Head\ Loss = \frac{1{,}905{,}872 * L * Q^{1.85}}{C^{1.85} * D^{4.87}}$$

In the version shown above, the head loss and the pipe length (L) are feet, the demand (Q) is in million gallons per day and the pipe diameter (D) is in inches. The Hazen-Williams "C" value (C) is unitless.

4) Estimating Maximum-Day Demand

a) Where specific land uses are known, maximum-day demand will be estimated using the method described herein.

Where specific land uses are not known, the maximum-day demand rate in existing mains, and future areas of fewer than 100 acres, can be estimated by a flow that would be equivalent to the flow that would cause a head loss of 1 foot through a 1000-foot long pipe with design "C" values. The following table shows the flow causing headloss of 1'/1000' for common pipe diameters.

**TABLE "8"**

Guidelines for Estimating Maximum-Day Demand in Existing Mains

| Pipe Diameter (inches) | Flow which would cause 1′ of head loss through a 1000′ length of pipe (mgd) |
|---|---|
| 6 | 0.11 |
| 8 | 0.23 |
| 10 | 0.46 |
| 12 | 0.74 |
| 14 | 1.20 |
| 16 | 1.71 |
| 20 | 3.25 |
| 24 | 5.23 |

5) Roughness

a) While new pipes tend to have relatively high "C" values, hydraulic design should take into consideration the future conditions of proposed pipelines. Use the Hazen-Williams "C" values shown below for factory-lined pipes built during or after the years shown in Table "9a".

b) Mains that were installed before the years shown in Table "9a" were not factory lined. Many of these mains originally installed without a lining have been cleaned and lined. It can be assumed that these mains have the "C" values shown in Table "9a" unless it is known that they have been lined, or that a smaller C value is warranted.

**TABLE "9a"**

Hazen-Williams "C" Coefficients for Lined Pipes

| Pipe Diameter (inches) | Built Since | Hazen-Williams "C" Coefficient |
|---|---|---|
| 4 - 8 | 1965 | 100 |
| 10 | 1952 | 110 |
| 12 | 1946 | 110 |
| 16 - 20 | 1946 | 120 |
| 24 and greater | 1946 | 130 |

c) Unlined pipes are often tuberculated. Not only is the effective diameter of the pipe reduced, the roughness of the inside surface of the pipe is increased. The net effect is much greater head loss than would be expected in lined pipe. When possible, field tests should be run to either verify the condition of the unlined mains or the ability of the existing system to convey flows. When field tests are unavailable, "C" values of the unlined pipe can be approximated (see Table "9b" at the end of this Appendix).

d) Example of modeling with reduced "C" values.

Beginning fire hydraulic grade = 348 feet
Calculate head losses in pipes between the fire hydraulic grade and the study point:

| Length (feet) | Diameter (inches) | "C" value | Fire Flow (mgd) | Domestic (mgd) | Total Flow (mgd) | Head Losses (feet) |
|---|---|---|---|---|---|---|
| 1400 | 12 | 110 | 1.44 | 0.74 | 2.18 | 10 |
| 500 | 8 | 46 | 1.44 | 0.01 | 1.45 | 64 |
| 500 | 8 | 100 | 1.44 | 0.01 | 1.45 | 15 |
| Total Head Losses | | | | | | 89 |

Beginning Fire Hydraulic Grade 348 feet
Head Losses - 89
Fire Grade at study point 259 feet

Residual pressure at the study point needs to be 20 psi or greater

Fire Grade at study point 259 feet
Elevation at study point -187
Pressure at the study point 72 feet

Convert feet to psi: 72 feet / 2.31 feet/psi = 31 psi

6) Pipe Diameter

a) The minimum size for a WSSC main is 4 inches in diameter. (4-inch mains in the pipe network should be excluded.)

b) Fire hydrant should not be located on 6-inch and smaller water mains.

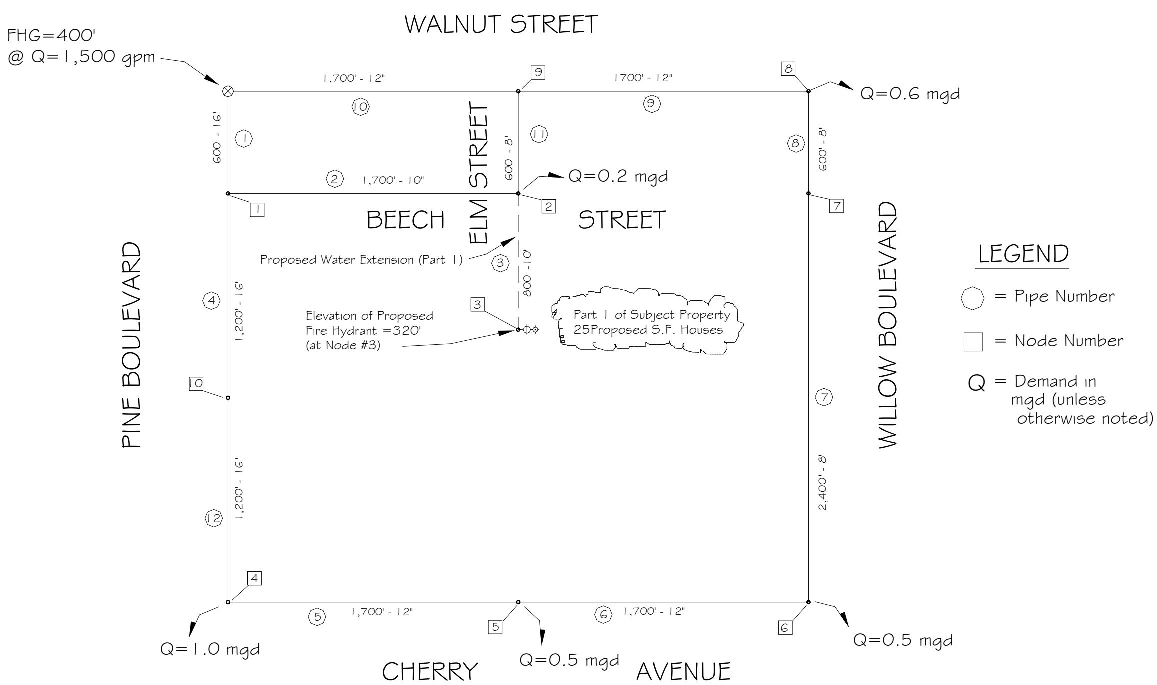
7) Starting Point

a) Modeling calculations will begin at one or more nodes and use the fire hydraulic grade at that point. The fire hydraulic grades represent the hydraulic grade with maximum-day demand and a fire flow rate at that particular point in the system. These fire hydraulic grades are prepared by the Planning Group.

8) Effect of the Pipe Network

a) Designs that use more than one feed into an area usually result in fewer head losses and, therefore, would result in smallest pipe diameters needed for the proposed project.

Example & Modeling of a simple pipe network.




EXAMPLE "1"

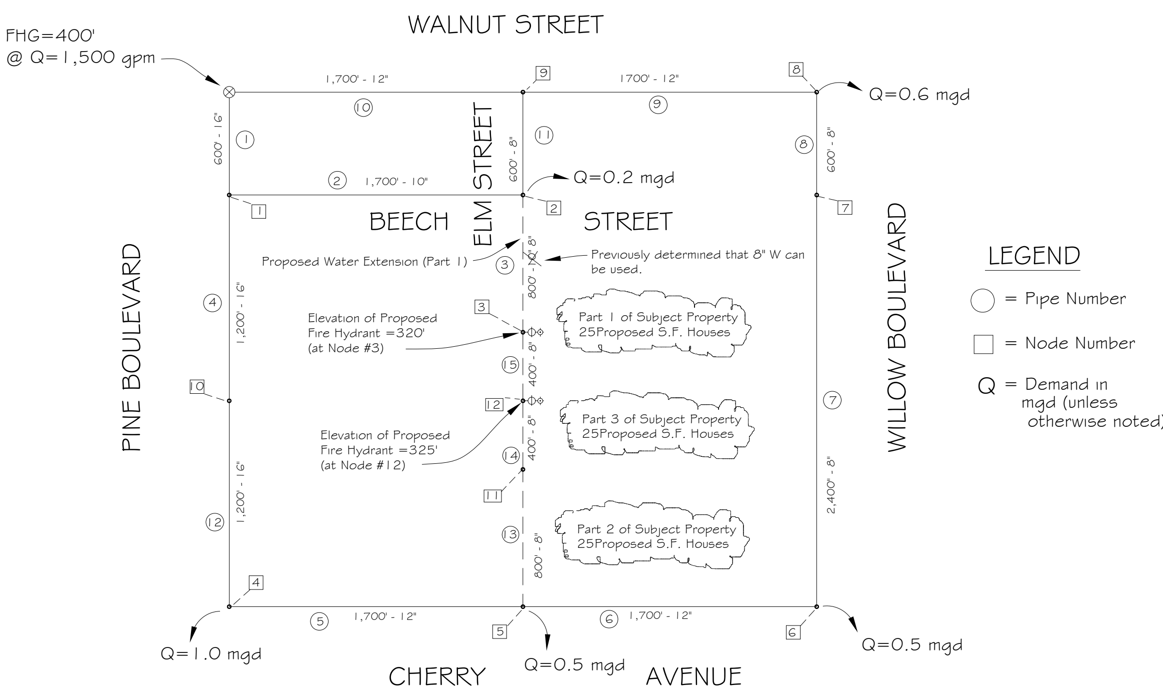
In the example shown, the proposed water extension is initially sized as a 10" W line. The proposed fire hydrant at node #3 is initially served by a "single feed" through pipes #1, #2, and #3. For a demand of 1.46 mgd (1.44 mgd fire flow and 0.02 mgd maximum day domestic demand) at node #3, the proposed water extension (pipe #3) is sized as 10" W, and the resulting pressure at the fire hydrant at node #3 is 22.78 psi.

However, in Change Situation #1, a "networking" effect is achieved by including pipe #11 in the water network so that a "2nd Feed" to the proposed water extension is provided. With pipe #11 included in the network, the proposed water extension (pipe #3) can be down-sized to 8"W. The resulting pressure with 1.46 mgd of water flow to the proposed fire hydrant at node #3 is 20.32 psi, which is adequate water pressure, as well.

9) Dependencies

a) When a subdivision is built in more than one phase, it must be demonstrated that the system requirements will be met throughout build out of the subdivision. Should one phase of the subdivision be dependent on other(s) in order to meet the system requirements, the dependency should be noted in the hydraulic calculations.

Example of a part dependency.




EXAMPLE "2"

In the example shown (see sketch), there is a small proposed 3-part subdivision. Pipe #3 passes through and will be built under Part #1. Pipe #13 passes through and will built under Part #2. Pipes #14 and #15 pass through and will be built under Part #3, and will provide flow to the proposed fire hydrant at node #12 (which will provide fire protection to Part #3).

Because of the way this proposed subdivision is set up, the question must be answered as to whether Part 3 can be dependent on Part 1 only, Part 2 only, or if Part 3 is dependent on BOTH Part 1 and Part 2, together.

First, check if Part 3 can be solely dependent on pipe #3 in Part 1. If pipe #13 in Part 2 is closed, and 1.46 mgd is pulled from node #12 (i.e. a proposed fire hydrant serving Part 3), the resulting pressure at node #12 is 12.88 psi, resulting in sub-standard fire flow pressure.

Similarly, check if Part 3 can be solely dependent on pipe #13 in Part 2. If pipe #3 in Part 1 is closed, and 1.46 mgd is pull from node #12, the resulting pressure at node #12 is 9.88 psi, again resulting in sub-standard fire flow pressure.

Last, determine if Part 3 can be obtain adequate fire flows & pressures with dependencies on both Part 1 and Part 2. If pipe #3 and pipe #13 are both opened, and 1.46 mgd of flow is pulled from proposed fire hydrant at node #12, the resulting pressure at node #12 is 25.05 psi, which is adequate pressure by WSSC standards.

10) Service Zone Concerns

a) Subdivisions located near a pressure zone boundary may be served by more than one zone. To determine which zone would better serve a particular main, the range of domestic pressures that would be provided from each zone should be compared. The high domestic pressure should not exceed 115 psi and is limited to 130 psi. The low domestic pressure should not be less than 40 psi. While the lower zone's domestic pressures may appear to be more than acceptable, sometimes the fire flow requirements cannot be met. If either zone appears appropriate, a determination should be made regarding the best way to serve the surrounding area. Specialty valves (i.e., pressure reducing valves, pressure relief valves) may be required in these areas.

11) Minor Losses

a) To minimize minor losses in distribution mains, the layout should be adjusted whenever possible to avoid bends greater than 40° in mains 12 inches in diameter and larger.

12) Travel Times

a) When a relatively large volume of water is available to serve a small demand, long travel times can result. Excessive travel times can be expected in Capital Improvement Program (CIP) sized mains during the early phases of a subdivision build out, but can also be found in long extensions of smaller mains serving only a few dwellings. Water that sits too long tends to lose its chlorine residual and has the potential to experience bacterial regrowth. Since chlorine dissipation time varies based on a number of uncontrollable variables (e.g., temperature, age of the pipe), there are currently no hard rules as to how long water can sit before it becomes unpotable.

b) Travel times should be estimated and, where calculations show the travel times to be 14 days or more, a mitigating solution to the excessive travel times should be required.

c) Delaying the construction of distribution mains might be a solution for some long travel-time situations. The WSSC will determine whether a service main -- rather than a distribution main -- could be economically constructed based on Maryland National Capital Park and Planning Commission (MNCP&PC) population projections. A present worth analysis might be initiated to see if it is worthwhile to have a service main built for the current service request knowing that it will be replaced later with a distribution main when the demand increases.

13) Considerations for Future Service

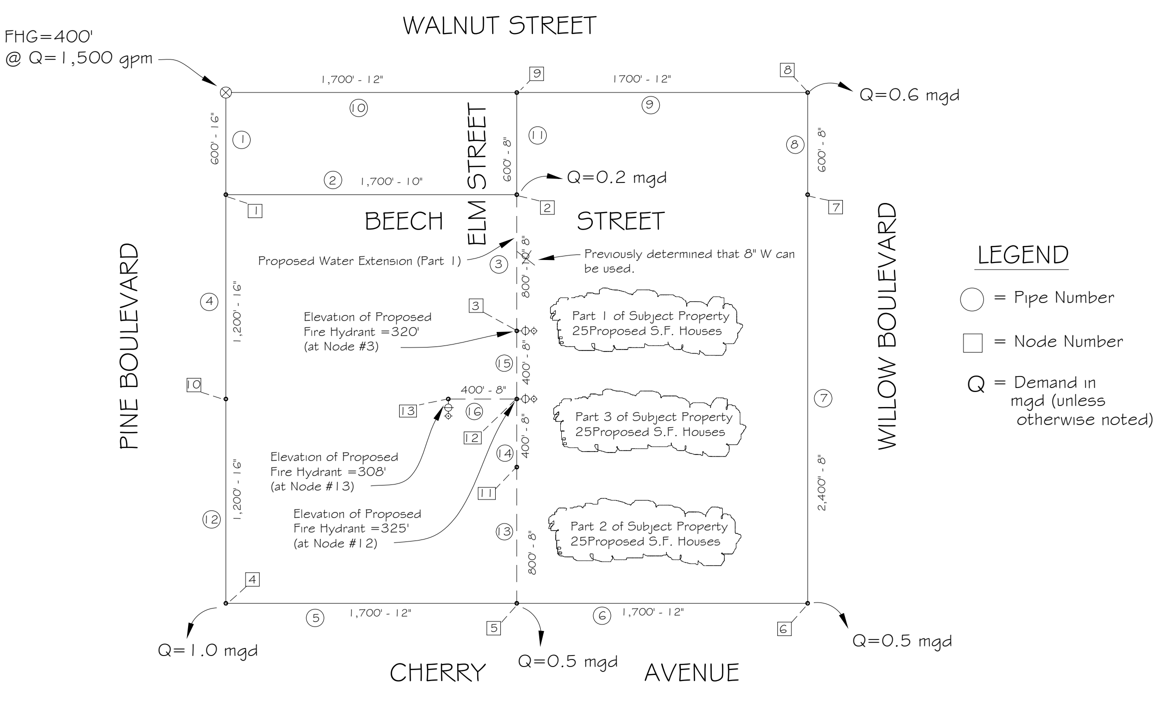
a) Hydraulic calculations should assume that in areas zoned for apartments and non-residential land uses there will be private site utility system (on-site) served off the proposed extensions. The proposed mains might also have to serve additional future development and this possibility should also be taken into consideration.

b) Future Private Site Utility System (on-site)

(1) Other Future Subdivisions: Every extension needs to be adequately sized to handle future development. The following can be consulted for information about future development: facility plans, zoning maps, land use maps, and service area category maps. Other references that are useful for this effort are topographic maps and non-tidal wetland maps.

(2) It should be realized that multi-family and non-residential development tying into the current extension are likely to have an on-site systems with fire hydrants. These private site utility system (on-site) hydrants will also be required to meet the fire flow requirements shown in section above. Allowances for losses within the private site utility system (on-site) must be made. It may be necessary to assume alignments for those private site utility systems (on-site) if they have not yet been designed.

Example of planning for future development.




EXAMPLE "3"

Water lines must be sized to adequately serve NOT ONLY the current subject property, but also other adjacent properties that may be developed and served in the future. In the previous examples, it was determined that single-family houses in Part #1, Part #2, and Part #3 can adequately be served using 8-inch for proposed water lines. However, consideration must be given as to whether a future, adjacent subdivision composed of 60 proposed townhouses can adequately be served using 8-inch water in Parts #1, #2, and #3.

If all 8-inch water is used in Parts #1, #2, and #3, and 8-inch water is also used to serve the future townhouses, and 2.18 mgd of flow is pulled from the proposed fire hydrant at node #13 that serves the townhouses, the resulting pressure at node #13 is 15.14 psi, which is sub-standard pressure.

However, if 2 water lines (pipe #13 in Part 2 and pipe #14 in Part 3) are UP-SIZED to 12-inch, and 2.18 mgd is again pulled from node #13, the resulting pressure at the proposed future fire hydrant serving the future townhouses is 20.54 psi, which is adequate pressure by WSSC standards.

In order to satisfy BOTH conditions of providing adequate service to the current proposed property composed of 3 parts, as well as the anticipated future development composed of 60 townhouses, we must size pipes #3 and #15 as 8-inch water, and size pipes #13 and #14 as 12-inch water. The future water extension (pipe #16) will be sized as 8-inch water when the future development is submitted to WSSC for review.

### c. Non-Hydraulic Alignment Considerations

1) Often there are factors other than adequate hydraulics that will affect the layout and sizes of a portion of the water distribution system.

   a) Future Service

      (1) Rights-of-way and construction strips necessary for future extensions should be granted to the WSSC. For extensions, size should be determined to allow for adequate rights of way and when necessary, adequately sized stubs.

   b) Large-diameter Mains

      (1) Intersecting large-diameter mains: So that relocating distribution and transmission mains is not necessary, the layout should avoid crossing these mains whenever possible.

2) Acquisition of Additional Rights-of-Way

   a) Water mains 16-inch and larger diameter exist on a parcel to be developed, acquisition of additional rights-of-way for operation and maintenance of the main may be necessary. Many existing transmission mains do not have adequate rights-of-way to repair the main, see Part Three (Common), Section 2 (Rights of Way and Construction Strips).

3) Looping and Valve Policy

   a) Looping, as well as conscientious placement of valves, improves the reliability of the entire water distribution system. The policy was created for two reasons: 1) to minimize outages during periods when mains are out of service and 2) to discourage poor water quality by minimizing dead-end mains. After determining the mains which are required for service, the layout should be evaluated against the Looping and Valve Policy outlined below.

b) Outage-Protection Loops.

(1) An outage-protection loop is a loop that is not required in order to provide adequate pressures for required flows under normal circumstances. An outage-protection loop is intended to provide an additional feed during a break in the principal feed to an area.

(2) Outage-protection loops should be sized large enough so that during a main break normal domestic pressures can be achieved with either 1) the maximum-day demand flow rate when the loop is 12 inches in diameter or smaller or 2) the average-day demand flow rate when the loop is 16 inches in diameter and larger.

c) System-Improvement Loops

(1) A system-improvement loop is not required to serve the current area at hand, but to improve the existing system, to either bring it up to design standards or otherwise improve pressures in an area in order to meet design standards in the future.

d) System Improvements

(1) On occasion, a portion of main being designed to serve a subdivision will have to be larger than that needed to serve the new subdivision alone. These system improvements are usually necessary to be able to serve future development in the area or to complete a portion of a future distribution main. Sometimes system improvements are needed to correct or avoid substandard conditions.

**TABLE "9b"**

Estimating "C" Coefficients in Unlined Mains

| Years Old | Diameter (inches) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 20 | 24 | 30 | 36 |
| 100 | 0 | 5 | 13 | 21 | 28 | 34 | 38 | 45 | 50 | 55 | 59 |
| 99 | 0 | 5 | 14 | 22 | 28 | 34 | 38 | 45 | 50 | 56 | 59 |
| 98 | 0 | 5 | 14 | 22 | 29 | 34 | 39 | 46 | 51 | 56 | 60 |
| 97 | 0 | 5 | 14 | 22 | 29 | 35 | 39 | 46 | 51 | 56 | 60 |
| 96 | 0 | 6 | 15 | 23 | 30 | 35 | 39 | 46 | 51 | 56 | 60 |
| 95 | 0 | 6 | 15 | 23 | 30 | 35 | 40 | 47 | 51 | 57 | 60 |
| 94 | 0 | 6 | 15 | 23 | 30 | 36 | 40 | 47 | 52 | 57 | 61 |
| 93 | 0 | 7 | 16 | 24 | 31 | 36 | 41 | 47 | 52 | 57 | 61 |
| 92 | 0 | 7 | 16 | 24 | 31 | 37 | 41 | 48 | 52 | 57 | 61 |
| 91 | 0 | 7 | 17 | 25 | 32 | 37 | 41 | 48 | 53 | 58 | 61 |
| 90 | 0 | 7 | 17 | 25 | 32 | 37 | 42 | 48 | 53 | 58 | 61 |
| 89 | 0 | 8 | 17 | 25 | 32 | 38 | 42 | 49 | 53 | 58 | 62 |
| 88 | 0 | 8 | 18 | 26 | 33 | 38 | 42 | 49 | 54 | 58 | 62 |
| 87 | 0 | 8 | 18 | 26 | 33 | 38 | 43 | 49 | 54 | 59 | 62 |
| 86 | 1 | 9 | 19 | 27 | 34 | 39 | 43 | 50 | 54 | 59 | 62 |
| 85 | 1 | 9 | 19 | 27 | 34 | 39 | 44 | 50 | 54 | 59 | 63 |
| 84 | 1 | 10 | 19 | 28 | 34 | 40 | 44 | 50 | 55 | 59 | 63 |
| 83 | 1 | 10 | 20 | 28 | 35 | 40 | 44 | 51 | 55 | 60 | 63 |
| 82 | 1 | 10 | 20 | 28 | 35 | 41 | 45 | 51 | 55 | 60 | 63 |
| 81 | 1 | 11 | 21 | 29 | 36 | 41 | 45 | 51 | 56 | 60 | 64 |
| 80 | 1 | 11 | 21 | 29 | 36 | 41 | 45 | 52 | 56 | 61 | 64 |
| 79 | 1 | 11 | 22 | 30 | 37 | 42 | 46 | 52 | 56 | 61 | 64 |
| 78 | 2 | 12 | 22 | 30 | 37 | 42 | 46 | 52 | 57 | 61 | 64 |
| 77 | 2 | 12 | 23 | 31 | 38 | 43 | 47 | 53 | 57 | 61 | 65 |

| Years Old | Diameter (inches) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 20 | 24 | 30 | 36 |
| 76 | 2 | 13 | 23 | 31 | 38 | 43 | 47 | 53 | 57 | 62 | 65 |
| 75 | 2 | 13 | 24 | 32 | 39 | 44 | 48 | 53 | 58 | 62 | 65 |
| 74 | 2 | 14 | 24 | 32 | 39 | 44 | 48 | 54 | 58 | 62 | 65 |
| 73 | 3 | 14 | 25 | 33 | 40 | 44 | 48 | 54 | 58 | 63 | 66 |
| 72 | 3 | 15 | 25 | 33 | 40 | 45 | 49 | 55 | 59 | 63 | 66 |
| 71 | 3 | 15 | 26 | 34 | 41 | 45 | 49 | 55 | 59 | 63 | 66 |
| 70 | 4 | 16 | 26 | 34 | 41 | 46 | 50 | 55 | 59 | 64 | 66 |
| 69 | 4 | 16 | 27 | 35 | 42 | 46 | 50 | 56 | 60 | 64 | 67 |
| 68 | 4 | 17 | 27 | 35 | 42 | 47 | 51 | 56 | 60 | 64 | 67 |
| 67 | 5 | 17 | 28 | 36 | 43 | 47 | 51 | 57 | 60 | 65 | 67 |
| 66 | 5 | 18 | 28 | 36 | 43 | 48 | 52 | 57 | 61 | 65 | 68 |
| 65 | 5 | 18 | 29 | 37 | 44 | 48 | 52 | 57 | 61 | 65 | 68 |
| 64 | 6 | 19 | 30 | 37 | 44 | 49 | 52 | 58 | 62 | 66 | 68 |
| 63 | 6 | 20 | 30 | 38 | 45 | 49 | 53 | 58 | 62 | 66 | 69 |
| 62 | 7 | 20 | 31 | 38 | 45 | 50 | 53 | 59 | 62 | 66 | 69 |
| 61 | 7 | 21 | 31 | 39 | 46 | 50 | 54 | 59 | 63 | 67 | 69 |
| 60 | 7 | 21 | 32 | 40 | 47 | 51 | 54 | 60 | 63 | 67 | 70 |
| 59 | 8 | 22 | 33 | 40 | 47 | 52 | 55 | 60 | 64 | 67 | 70 |
| 58 | 8 | 23 | 33 | 41 | 48 | 52 | 56 | 61 | 64 | 68 | 70 |
| 57 | 9 | 23 | 34 | 41 | 48 | 53 | 56 | 61 | 65 | 68 | 71 |
| 56 | 10 | 24 | 34 | 42 | 49 | 53 | 57 | 62 | 65 | 68 | 71 |
| 55 | 10 | 25 | 35 | 42 | 50 | 54 | 57 | 62 | 65 | 69 | 71 |
| 54 | 11 | 25 | 36 | 43 | 50 | 54 | 58 | 63 | 66 | 69 | 72 |
| 53 | 11 | 26 | 36 | 44 | 51 | 55 | 58 | 63 | 66 | 70 | 72 |
| 52 | 12 | 27 | 37 | 44 | | | | | | | |
| 51 | 13 | 28 | 38 | 45 | | | | | | | |
| 50 | 13 | 28 | 39 | 46 | | | | | | | |
| 49 | 14 | 29 | 39 | 46 | | | | | | | |
| 48 | 15 | 30 | 40 | 47 | | | | | | | |
| 47 | 16 | 31 | 41 | 48 | | | | | | | |
| 46 | 17 | 32 | 42 | | | | | | | | |
| 45 | 17 | 32 | 42 | | | | | | | | |
| 44 | 18 | 33 | 43 | | | | | | | | |
| 43 | 19 | 34 | 44 | | | | | | | | |
| 42 | 20 | 35 | 45 | | | | | | | | |
| 41 | 21 | 36 | 46 | | | | | | | | |
| 40 | 22 | 37 | 46 | | | | | | | | |

Notes:

1. The above estimates are to some extent based on WSSC field tests and a review of literature. It is important to note that C values may vary considerably for pipes of the same age and material.

2. The above "C" values were calculated as follows, for 12" and larger mains built before 1946 where a year represents the age of the pipe:

$$C = \left[ \left\{ 50(0.9319^{years}) + 80 \right\}^{1.85} \left\{ \frac{Diameter - 0.039774 * years}{Diameter} \right\}^{4.87} \right]^{1/1.85}$$

3. For 10" mains built before 1952 and 4"-8" mains before 1965, where a year represents the age of the pipe:

$$C = \left[ \left\{ 50(0.9552^{years}) + 80 \right\}^{1.85} \left\{ \frac{Diameter - 0.039774 * years}{Diameter} \right\}^{4.87} \right]^{1/1.85}$$