Water for the World

Designing Community Distribution Systems
Technical Note No. RWS. 4.D.4

A community water distribution system technically begins where the transmission main ends as described in "Designing a Transmission Main," RWS.4.D.3. Basically, this is the point at which water begins to be used either at individual services or public standposts. Designing a distribution system requires the assistance of an experienced engineer. This technical note only explains the basic steps involved in design.

As is true of all aspects of water system design, a map of the area to be served and a profile along the proposed line are necessary. These are illustrated in Figure 1 and 2. Homes to be served and their elevations should be accurately located on the map. This is important in locating public watering points.

Rural water distribution systems generally consist of one or more main lines which do not interconnect at the end. This is because the lines are generally far apart. In larger communities, the ends of the lines are "looped", or connected to one another, to keep the water in the end of the lines from becoming stagnant and to allow it to flow from more than one direction. Looping the lines provides more flexibility in operation and maintenance.

Looping should always be considered if the layout of the community is such that it is feasible.

The design of a community water system serving public standposts should follow certain standards. These include a minimum of one tap for each 50 users. Up to 300 people can be served by each standpost if sufficient taps are added. Figure 3 shows a single tap standpost and Figure 4 shows a standpost with multiple taps. Public watering points should be located within 200m of each household or up to 500m in sparsely populated areas. Each faucet should be designed to provide from 0.23-0.03 liters/second. Static

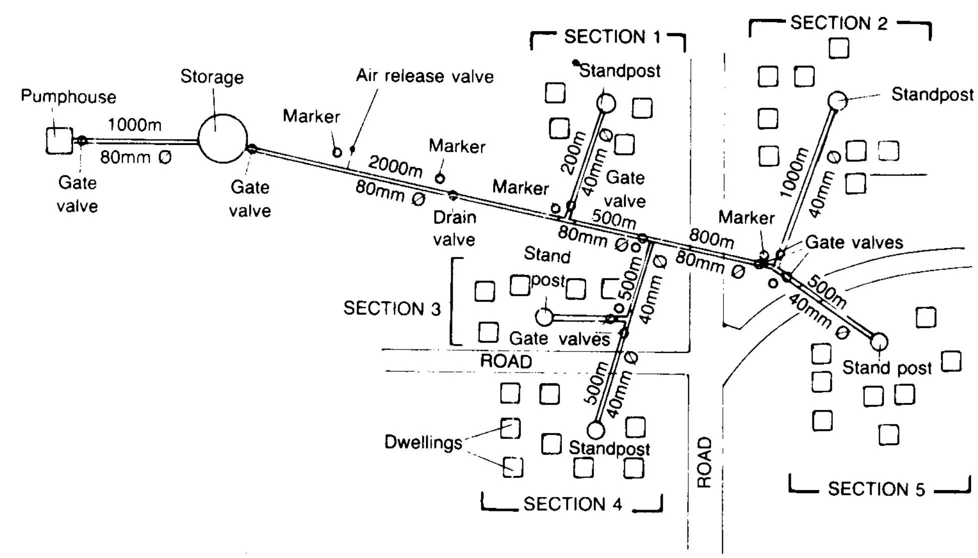

Figure 1. Design Map of Transmission Main and Distribution System

water pressure should be a minimum of 7m. Maximum water pressure should be less than 15-20m due to increased problems of leakage and wastage under higher pressures. Community standposts should be designed so that rain and wastewater drains away from the area and are not allowed to stand. Spigots or faucets are often leaky and easily broken. They should be designed for easy repair and replacement.

Design Example

Assume that a community distribution system using Figure 1 as the layout is being designed. While the population is relatively scattered, there are groupings of homes which can be served with public watering points. As shown on the map, there are five sections of 5, 9, 7, 15 and 12 dwellings. The estimated population is seven people per house. No other services are planned.

Since the map and profile have already been prepared, the next step is to plan the number of faucets for each watering point and calculate the expected peak flow using the information given. This is shown in Table 1.

Table 1. Peak Flows for Public Watering Points

Section	Number of homes	People	Number of Faucets	Peak Flow Per Faucet liters/second	Total liters/second
1	5	35	1	0.23	0.23
2	9	63	2	0.23	0.46
3	7	49	1	0.23	0.23
4	15	105	3	0.23	0.69
5	12	84	2	0.23	0.46
					2.07

The pipelines can now be sized according to flow. Table 2 shows pipe sizes based on limiting the velocity of water in the pipeline to 0.75m per second or 1.5m per second. Each line should be sized individually and the head loss determined. This can be done tabular form as shown for this village in Table 3. Worksheet A shows step-by-step how to design a water transmission line from storage to distribution, including how to arrive at the information presented in Table 3.

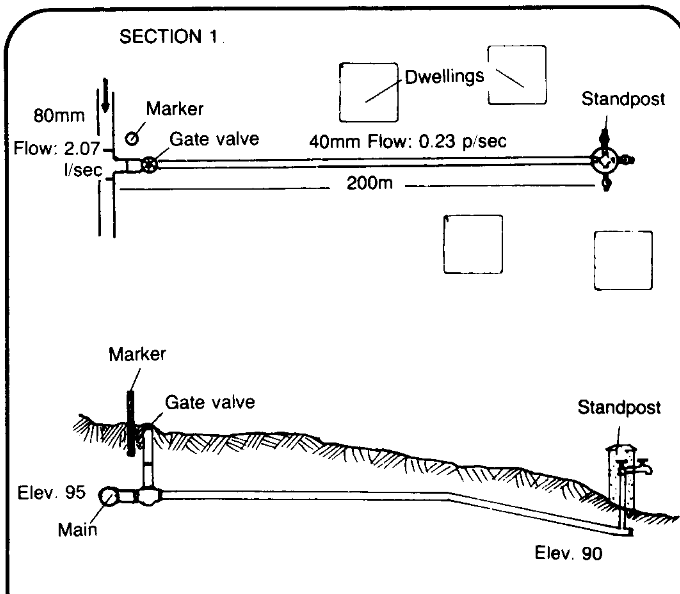

Figure 2. Plan and Profile of Typical Map Section

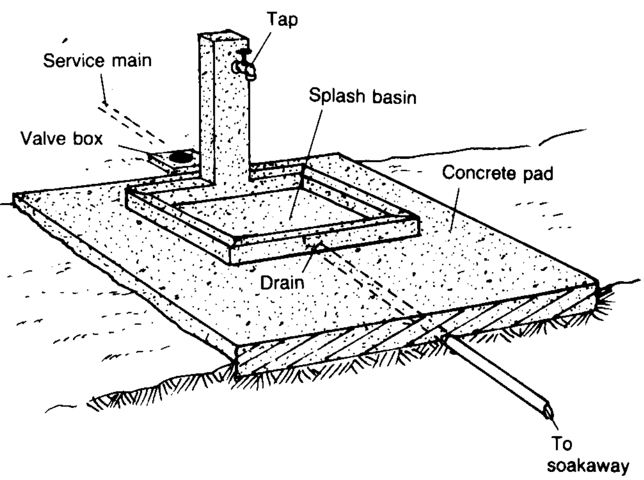

Figure 3. Standpost Design

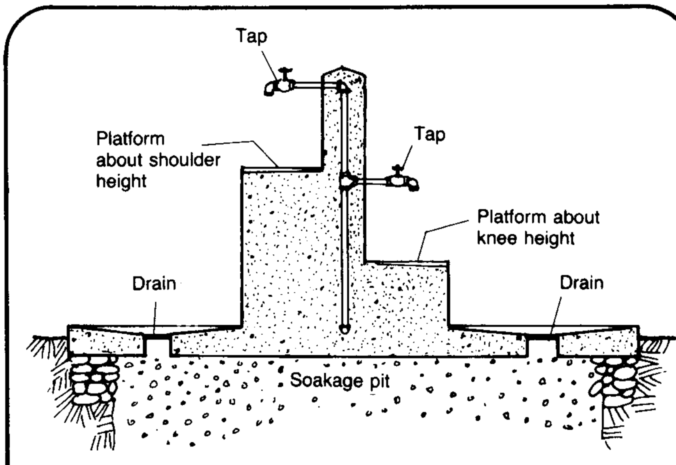

Figure 4. Standpost with Multiple Taps

Table 2. Pipe Sizes Based on Limiting Velocities in the Pipe to 0.75 and 1.5 meters/second

Range of Flow (1/sec)	Pipe Sized Based a Velocity of 0.75 m/sec*	Range of Flow (1/sec)	Pipe Size Based on Velocity of 1.5 m/sec*
0.1-0.6	30mm	0.1-1.3	30mm
0.7-1.0	40mm	1.4-2.2	40mm
1.0-1.5	50mm	2.3-3.5	50mm
1.6-3.9	80mm	3.6-8.9	80mm
4.0-6.0	100mm	9.0-13.8	100mm
6.1-14.0	150mm	13.9-31.0	150mm

*Formula for determining pipe size:

Flow of 0.75 m/sec. Diameter = 1.3/Q
Flow of 1.5 m/sec. Diameter = 0.85/Q

Table 3. Head Loss for Design Example

Section	Line	Flow	Size mm (1)	Head Loss (2)	Length (1000m)	Head Loss	Difference in Elevation	Additional Head Required Head Loss ± Elevation
1	AB BG	2.07 0.23	80mm 30mm	4m 4m	2 0.2	8m 0.8 8.8m	-10m	-1.2
2	AB DC CD DF	2.07 1.8 0.69 0.46	80mm 80mm 40mm 40	4m 3.2 16.0 7.3	2 0.5 0.2 1.0	8.0 1.6 3.2 7.3 20.1	-10	10.1
3	AB BC CD DE	2.07 1.8 0.69 0.23	80mm 80 40 30	4m 3.2 16.0 4	2 0.5 0.2 0.5	8.0 1.6 8.0 2.0 19.6	-15	4.6
4	AB BC CI IH	2.07 1.8 1.15 0.69	80mm 80 50 40	4m 3.2 10 15	2 0.5 0.5 0.5	8.0 1.6 5.0 7.5 22.1	-10	12.1
5	AB BC CI IJ	2.07 1.8 1.15 0.46	80mm 80 50 30	4m 3.2 10 18	2 0.5 0.5 0.5	8.0 1.6 5.0 9.0 23.6	-15	8.6

From Table 3, it can be determined that the bottom of the storage tank will have to be at least 12.1m above ground level in order to provide the design flows to the most critical spot, Section 4. Section 2 would have been critical, but the pipes line from D to F was increased in size to reduce head loss. In addition to the 12.1m elevation to allow flow, an additional 5m should be added to the tank height to maintain a positive head during times of peak flow.

If the bottom of the storage tank had to be located at elevation 100, then friction losses would have to be reduced by increasing pipe sizes, limiting flow with flow controlling devices, or both. A flow controlling device can be a partially closed valve or an orifice design to limit flow to a preset level.

It should be noted that Section 1 shows a negative head (-) needed. This indicates that the head losses are less than the available head.

Worksheet A. Designing Water Transmission Line from Storage to Distribution

1. Design Flow - Present
   Line _____ to _____

   Peak demand from homes with individual services

   No. of homes served _____

Range	Actual	x Demand in liters/second	Total
First	1	x 0.23	_____
2 to 10	_____	x 0.08	_____
11 to 20	_____	x 0.06	_____
21 to 30	_____	x 0.06	_____
31 to 50	_____	x 0.05	_____

Total _____

Peak demand from public watering fountains

Number of faucets			Demand per faucet in liters/second	Total
1 to 6	_____	x	0.23	_____
7 to 9	_____	x	0.19	_____
10 to 12	_____	x	0.17	_____

Total _____

Peak demand from other points of use

Facility	Number of fixtures		Demand in liters/second	Total
Schools	_____	x	0.23	_____
Religious	_____	x	0.23	_____
Commerical	_____	x	0.23	_____
Industrial*	_____	x	varies	_____
Fire*	_____	x	varies	_____
Animal*	_____	x	varies	_____

Total _____

*Normally not included in rural system.

Total instantaneous demand _____ l/sec.

2. Estimated water use--Future
   Use a 20 year design life. If no better information is available, use a population growth of 2 times the present population and an increase in animals of 1.25 times the present number.

   Population — Present use _____ x 2 = _____ l/sec.

   Institutions & public fountains — Present use _____ x 2 = _____ l/sec.

   Animals — Present use _____ x 1.25 = _____ l/sec.

   Total future water use = _____ l/sec.

3. Determine transmission line diameter for each section of pipe being considered and tabulate in step 5. Table 3 solves this formula for a range of flows.

   Line _____ to _____

   Pipe diameter d = 1.3/Q m^3 per second
   = 1.3/.00___ l/sec. = _____ m

   Convert meters to mm 1000 x _____ m = _____ mm

   Round mm calculated to available pipe size d = _____ mm

(Note: This method of pipe sizing is based on limiting the velocity of water the pipe to 0.75m/sec)

Worksheet A. Designing Water Transmission Line from Storage to Distribution (continued)

4. Head requirements:
To calculate the head required, first find the total dynamic head (TDH). Use Table 2 to determine friction losses. Do this for each section of pipe being considered.

TDH = static head + friction losses

Friction Losses,

a. Determine head require to overcome friction.
Equivalent length of pipe due to fittings* (Table 2)

Fitting	No.	x	Equivalent length	=	
Gate valve	_____	x	_____	=	_____m
Elbow, 90°	_____	x	_____	=	_____m
Elbow, 45°	_____	x	_____	=	_____m
Tee (straight through)	_____	x	_____	=	_____m
Tee (through side)	_____	x	_____	=	_____m
Swing check valve	_____	x	_____	=	_____m

Total equivalent length _____m

b. Length of pipe from _____ to _____ = _____m

c. Total pipe length = a + b = _____m

Friction loss = $\frac{\_\_\_\_\_ m}{1000}$ x _____ head loss per 1000/m = _____m

*Note: When pipelines exceed 500m, these losses are relatively small and can usually be ignored.

5. Tabulate results of first 4 steps for each length and branch.

Line	1 & 2 Flow l/sec	3 Pipe Size	4c Length m (x 1000)	4d Head loss 1000m (HL)	Elevation difference (EL)	Total required (HL-EL)
Branch _____						
_____ to _____	_____	_____	_____	_____	_____	
_____ to _____	_____	_____	_____	_____	_____	
_____ to _____	_____	_____	_____	_____	_____	
_____ to _____	_____	_____	_____	_____	_____	
_____ to _____	_____	_____	_____	_____	_____	
		Branch Total ---		_____	_____	_____
Branch _____						
_____ to _____	_____	_____	_____	_____	_____	_____
_____ to _____	_____	_____	_____	_____	_____	_____
_____ to _____	_____	_____	_____	_____	_____	_____
_____ to _____	_____	_____	_____	_____	_____	_____
_____ to _____	_____	_____	_____	_____	_____	_____
		Branch Total ---		_____	_____	_____

Worksheet A. Designing Water Transmission Line from Storage to Distribution (continued)

Branch ____							
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
				Branch Total	____	____	____
Branch ____							
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
				Banch Total	____	____	____
Branch ____							
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
____	to ____	____	____	____	____	____	
				Branch Total	____	____	____