Water Distribution System

Objectives

- **To deliver water of sufficient quantity and at reasonable pressure to the consumers.**
- **To ensure the quality of the treated water is maintained throughout the distribution system.**
- **To minimize interruption of supply in the event of pipe burst (limit affected areas)**
- **Capable of supplying emergency requirements such as fire.**
- **To provide pipe network that is durable and economic.**
- **To ensure minimal disturbance to traffic while repairing or in any upgrading work.**

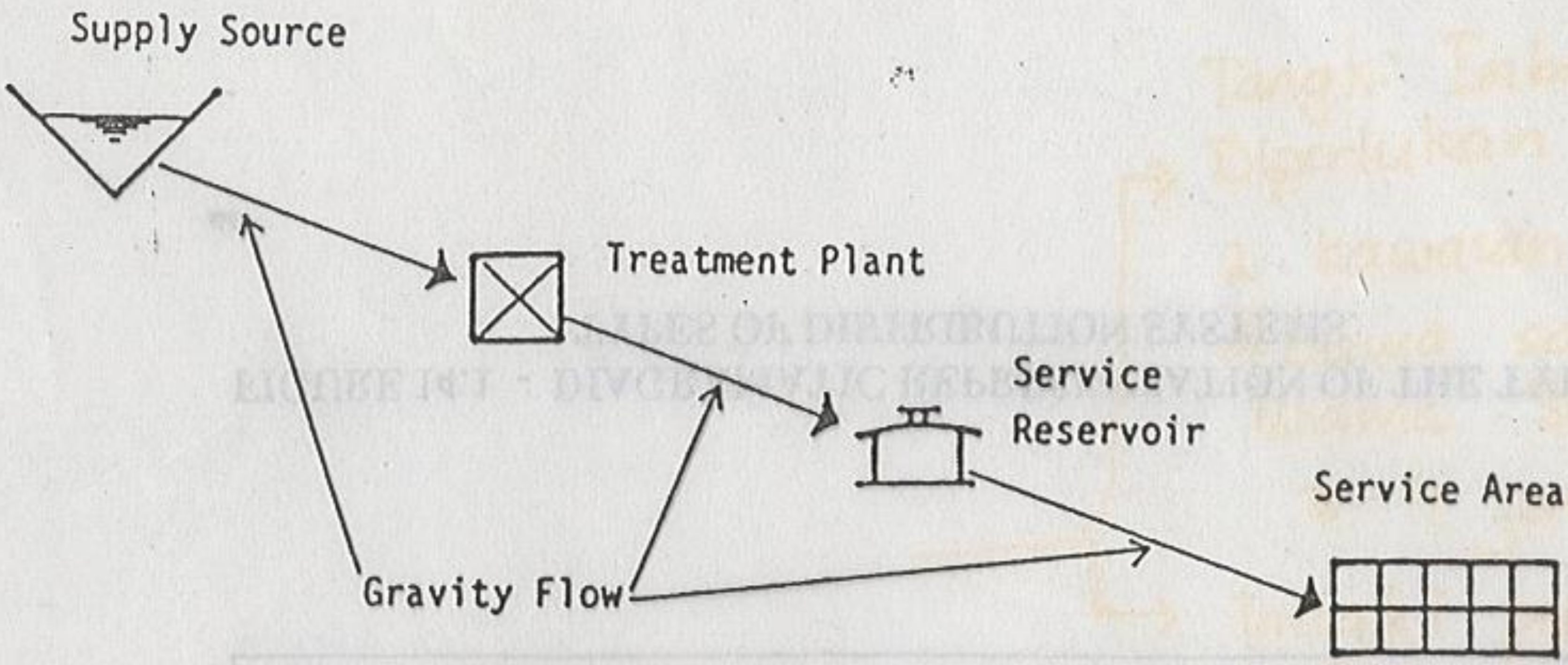
Water Distribution System

Component of Water Distribution System

- Tanks (suction and/or storage)
- Open channels
- Main delivery pipe (gravity / pumped)
- Consumer (reticulation) pipe network
- Pumping Station

Types of Distribution System

- Gravity
- Direct Pumping
- Combination of Pumped and Gravity



a. GRAVITY SYSTEM

Water Distribution System

Gravity System

Source of water at higher elevation relative to demand zones.

No pumping required

Typical examples :

Klang Gate / Bukit Nenas WS

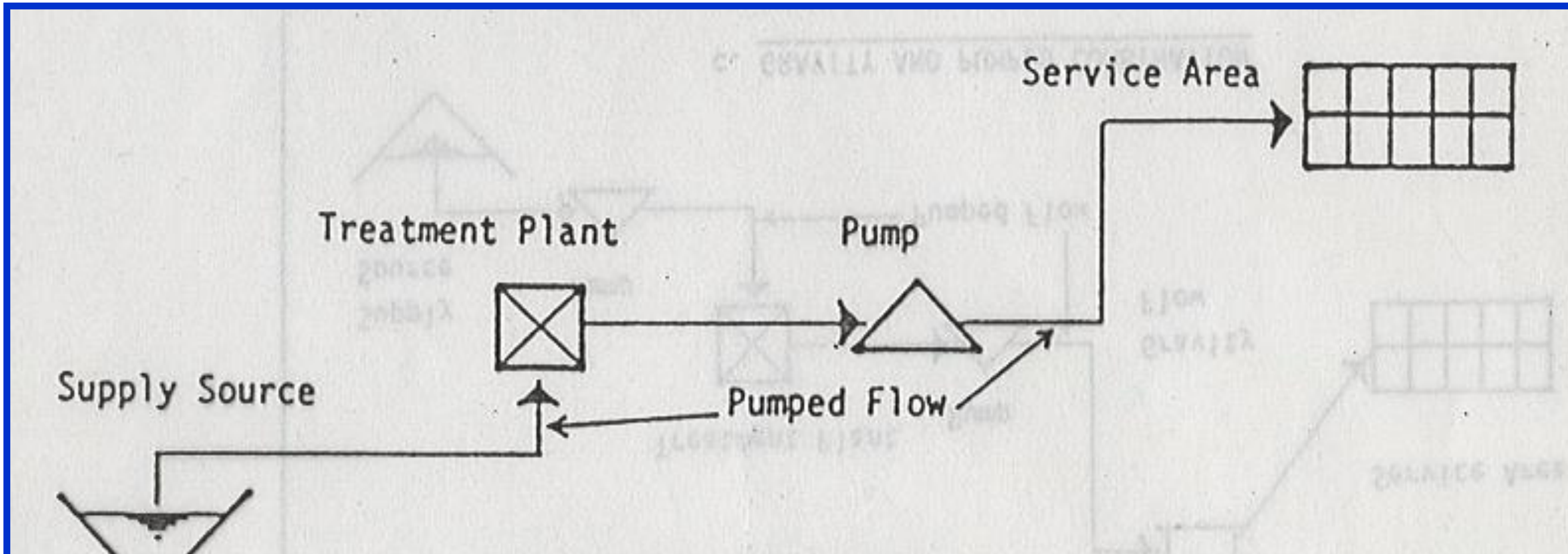
Gunung Ledang WS

Advantages

- **Consistent pressure and supply.**
- **Minimal maintenance required**
- **Low operation cost**

Disadvantages

- **Need to open up sensitive areas (upland)**
- **Need to built dams and long pipeline (high capital cost)**
- **Limited or relatively low reliable yield.**



b. DIRECT PUMPED SYSTEM

Water Distribution System

Direct Pumping System

Treated water is pumped direct to the distribution system and consumers.

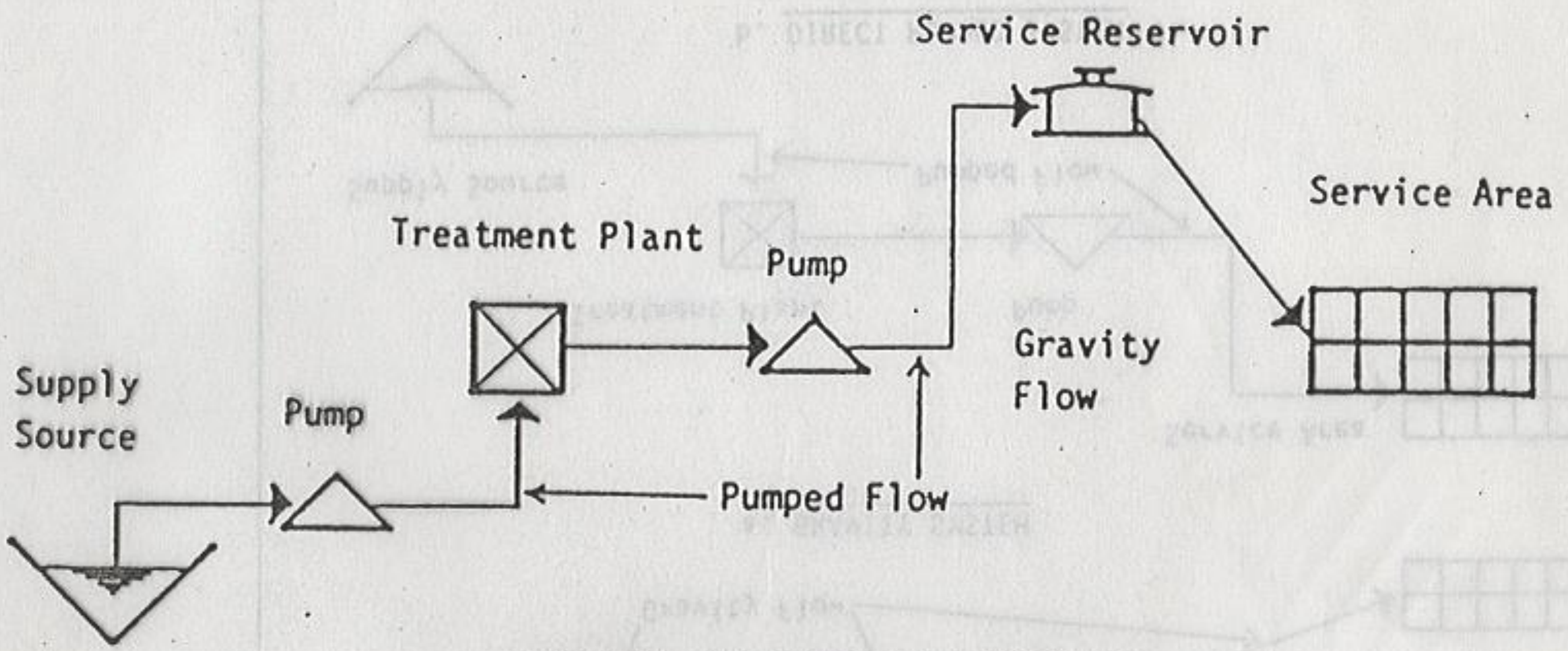
Normally for small or temporary supply

Advantages

- Do not require many storage tank
- Pipeline is relative short
- Low capital cost

Disadvantages

- Low supply reliability – immediate interruption if pump fail.
- Requires close monitoring of system
- Duplicate or triplicate set of pumps required.
- Maintenance of pumps need to be done regularly
- Requires special pumps (variable speed/pressure) to take care of variable demand and pressure.



c. GRAVITY AND PUMPED COMBINATION

Water Distribution System

Pumped and Gravity System

Treated water from plant pumped to balancing tank and/or service tank.

Water is then gravitated to consumers from the service tanks

Most popular distribution system in Malaysia

Advantages

- **Supply to consumers via tank (with minimum 1-day storage) – buffer from pump breakdown.**
- **Consistent pressure and more reliable supply**
- **Do not require variable speed pumping**

Disadvantages

- **High capital cost; pumps and tanks.**
- **Pumps require maintenance.**

Water Distribution System

Component of Distribution System

- Main delivery pipes (pump and gravity)
- Pump Station
- Tanks – balancing and service
- Consumer pipe networks (reticulation system)

Types of Main Delivery Pipe

- Mild steel
- Asbestos cement
- Cast iron / ductile iron
- Plastic based : uPVC, HDPE, ABS, etc

Water Distribution System

Hydraulic Design of Main Pipe

(a) Hazen – Williams (pipe of dia. > 50 mm and flow < 3m/s)

$$V = 0.355\ C.D^{0.63}.S^{0.54}$$

$$Q = 0.279\ C.D^{2.63}.S^{0.54}$$

$$D^{2.63} = \frac{Q}{0.279.C.S^{0.54}}$$

V is flow velocity (m/s)

Q is flow rate (m^3/s)

C is roughness coefficient

D is pipe dia (m)

S is hydraulic gradient = h/L

h is head loss (m)

L is length of pipe.

Water Distribution System

Hydraulic Design of Main Pipe

(a) Colebrook – White (suitable for all pipe sizes and flow rate)

$$\mathbf{V = 2}\sqrt{2gDS}\ \mathbf{Log}\left(\frac{Ks}{3.7D}+\frac{2.51\nu}{D\sqrt{2gDS}}\right)$$

V is flow velocity (m/s)

S is hydraulic gradient (h/L)

D is pipe diameter (m)

g is gravitational acceleration (m/s2)

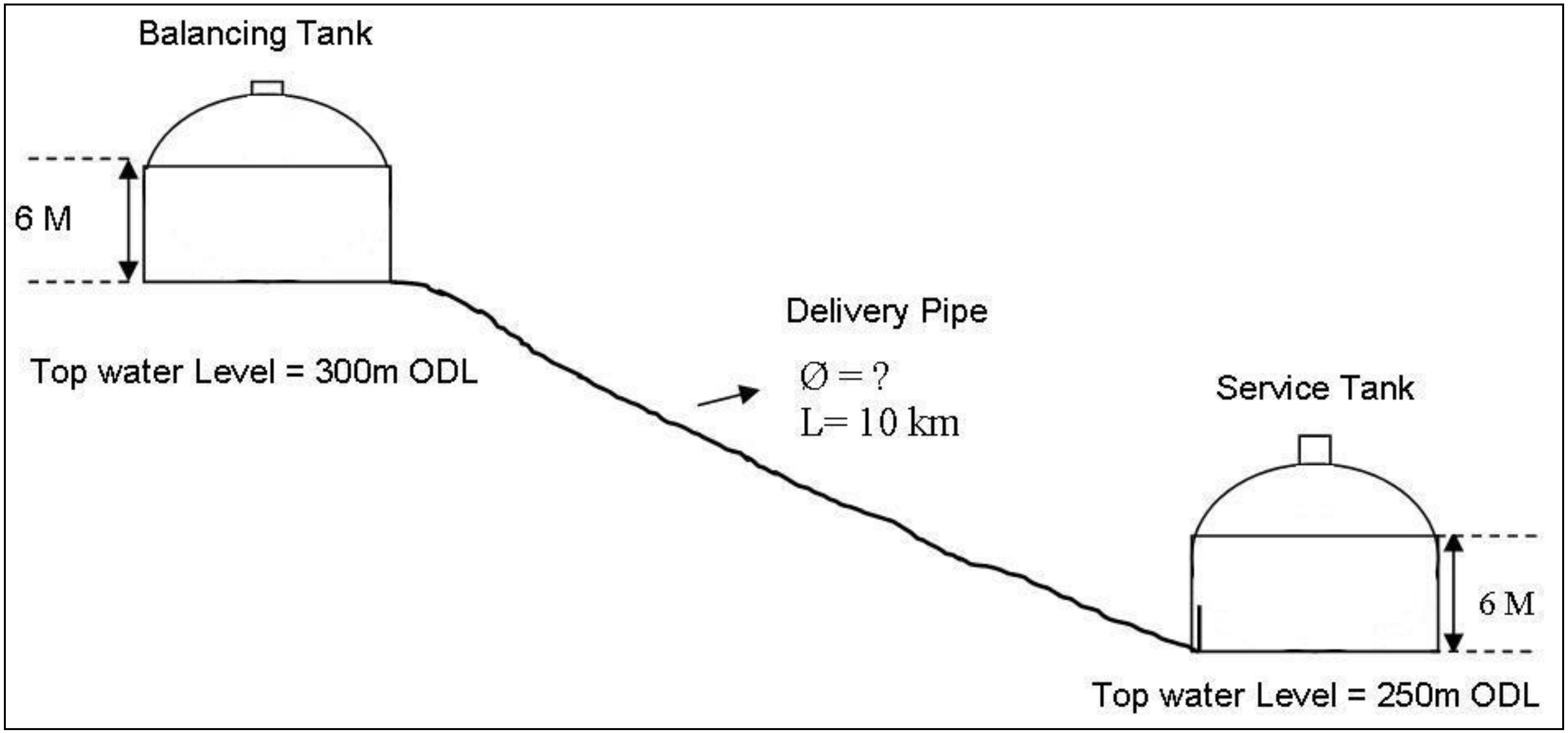
ν is kinematics viscosity (1.011 x 10^{-6} m/s at 20^{0}C)

Ks is C-W roughness value (taken as 0.15 mm for most pipe)

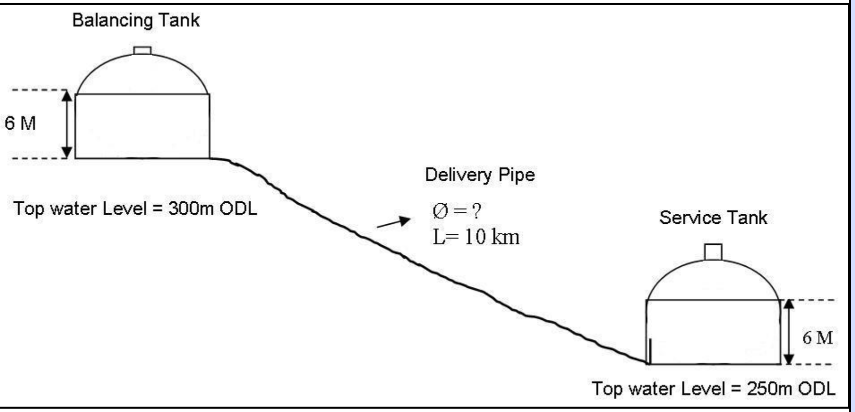
h is head loss (m)

L is length of pipe

Determine Diameter of Delivery Pipe between Balancing and Service Tanks



Determine Diameter of Delivery Pipe between Balancing and Service Tanks



Main Delivery Pipe

Example of Design Calculation

Determine the appropriate size of MS pipe required to deliver 4000 m3/day from a balancing tank to a service tank. The distance between the two tank is 10 km. Other detail of the two tanks is shown in the sketch below.

Solution

Bottom elevation of balancing tank	= 294 m
Top elevation of service tank	= 250 m
Static elevation different bet 2 tanks	= 44 m
Residual head of pipe at service tank (normal)	= 2 m
Available head to cause flow	= 42 m

Assume head loss along pipe (bends, valves, etc) as 2% of pipe length – hence effective pipe length = 10,200 m

$$\text{Therefore hydraulic gradient, } S = \frac{42}{10200} = 0.00412$$

$$Q = \frac{4000}{24.60.60} = 0.0463 \text{ m}^3/\text{s}$$

Peak factor (for delivery pipe) taken as 1.2

Hence design Q = 0.0463x1.2 = 0.056 m^3/s

C (hazen – Williams) assume as 100.

$$\text{Hence } D^{2.63} = \frac{0.056}{0.279x100x0.00412^{0.54}} = 0.0387$$

D = 0.290 m but adopt D of 300 mm.

Table 4-1. Approximate Minor Head Losses in Fittings and Valves

Fitting or Valve	Loss Coefficient k	Equivalent Length (Diameters of Pipe)
Tee (run)	0.60	20
Tee (branch)	1.80	60
90° bend-	—	—
Short radius	0.90	32
Medium radius	0.75	27
Long radius	0.60	20
45° bend	0.42	15
Gate valve (open)	0.48	17
Swing check valve (open)	3.7	135
Butterfly valve (open)	1.2	40

Table 4-2. Values of Coefficient C for the Hazen Williams Formula, Equations 4-7, 4-8, and 4-9

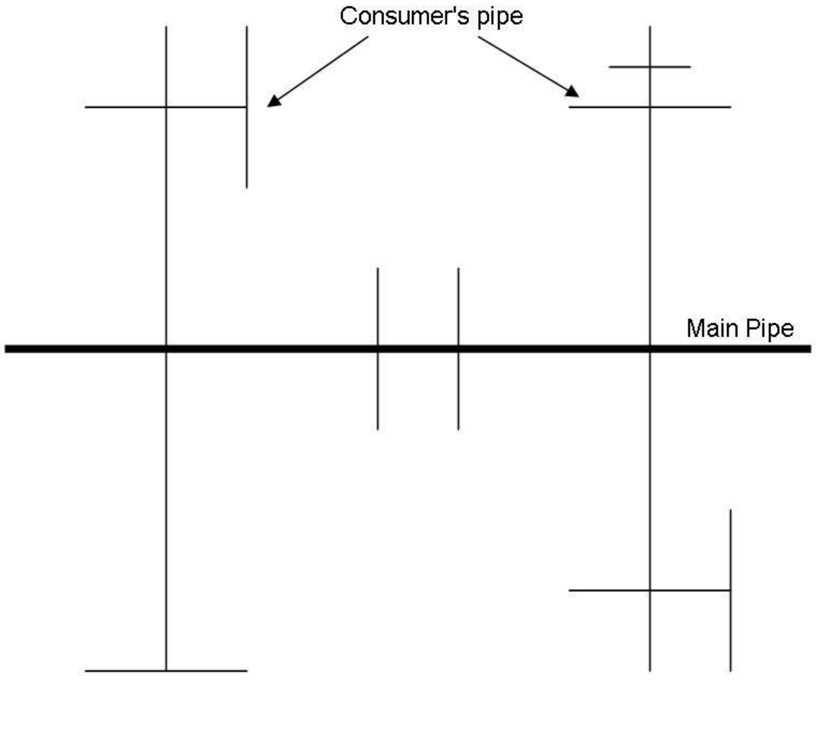
Pipe Material	C
Asbetos cement	140
Ductile iron	
Cement lined	130 to 150
New, unlined	130
5-year-old, unlined	120
20-year-old, unlined	100
Concrete	130
Copper	130 to 140
Plastic	140 to 150
New welded steel	120
New riveted steel	110

Consumer Pipe Network

Types of Consumer’s Pipe Network

- Branch / Grid
- Loop
- Ring or circular
- Radial

Distribution System



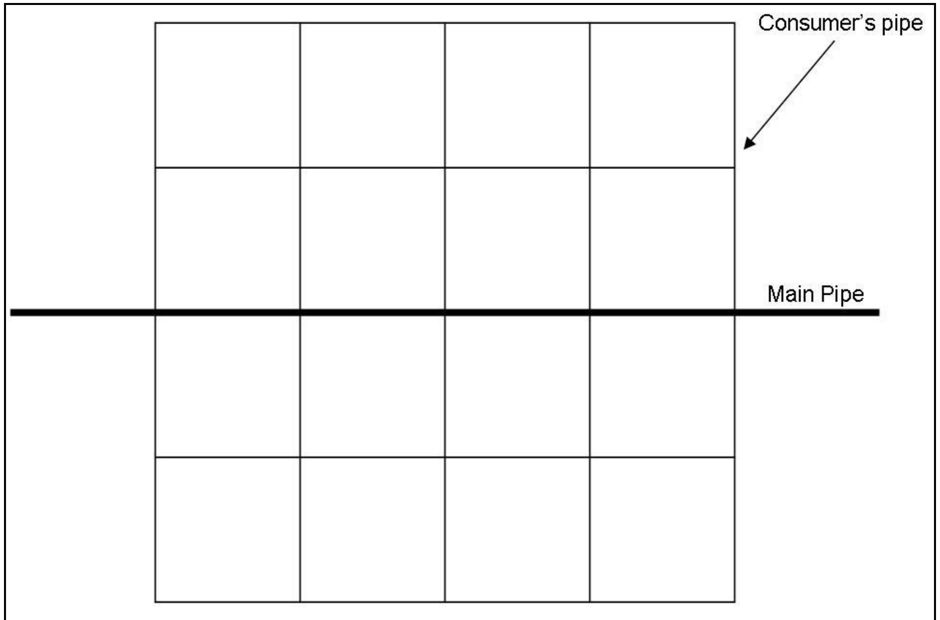
Branch System

Consumer Pipe Network

Branch / Grid Pipe Network

- Consist of main pipe and sub main or branch pipe
- Normally found in rural area and not properly planned settlements
- Difficult to isolate in case of emergency or pipe burst.
- Many dead end locations that cause stagnant water resulting in poor water quality.
- Water for fire fighting is limited by single source.

Distribution System



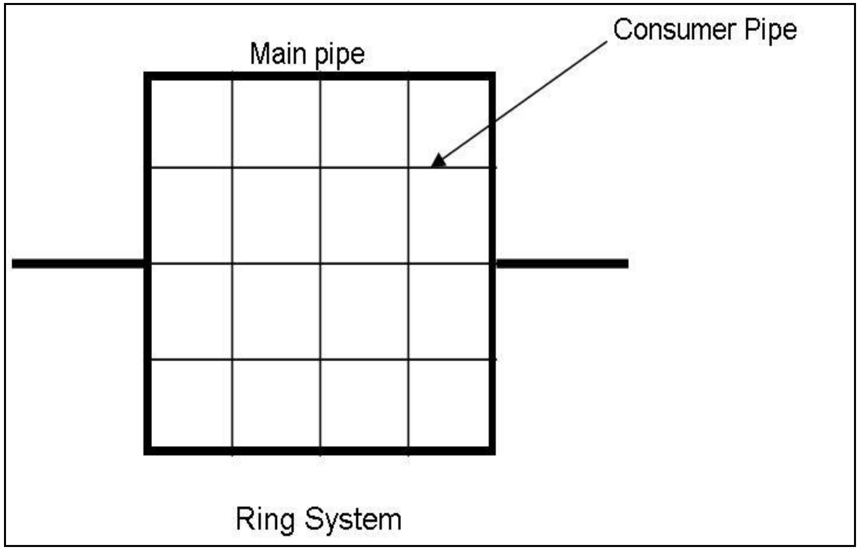
Loop System

Consumer Pipe Network

Loop Pipe Network

- Normally referred to reticulation pipe network.
- An upgrade to branch network with closed loop
- Featured in well planned housing area and township
- Areas effected by interruptions can be minimized
- In case of emergency (fire) flow regulation is much easier to manage
- Head loss is relatively low within the network.
- No or few locations with stagnant water
- More pipes and valves required – more expensive.
- Hydraulic (head loss) analysis is more complex.

Distribution System



Consumer Pipe Network

Circular Pipe Network

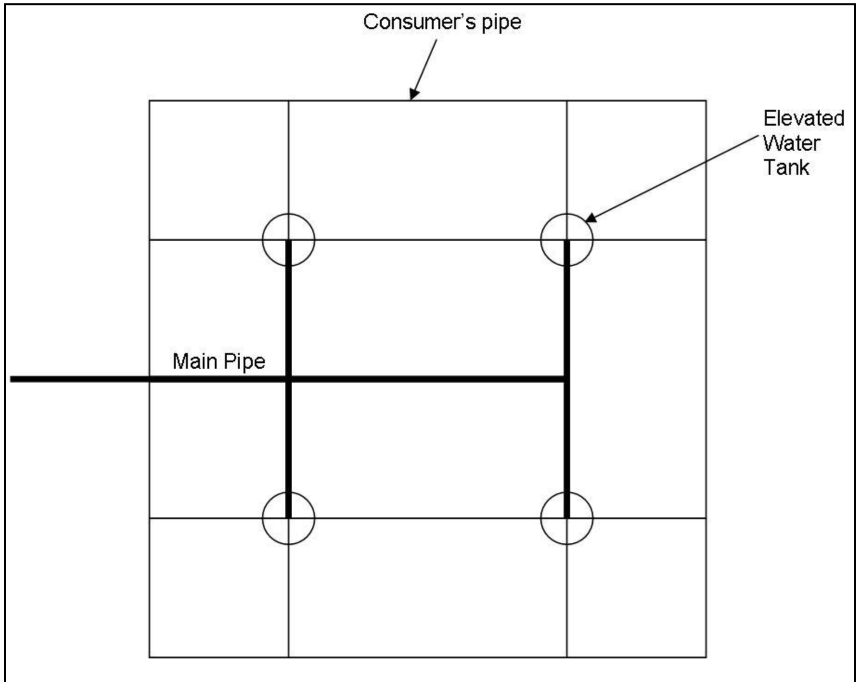
An improvement to the Loop pipe network

Main pipe along periphery of supply zone

All locations will enjoy equitable water pressure.

More expensive to installed (more big size pipes)

Distribution System



Radial System

Consumer Pipe Network

Radial Pipe Network

An improvement to the Loop pipe network

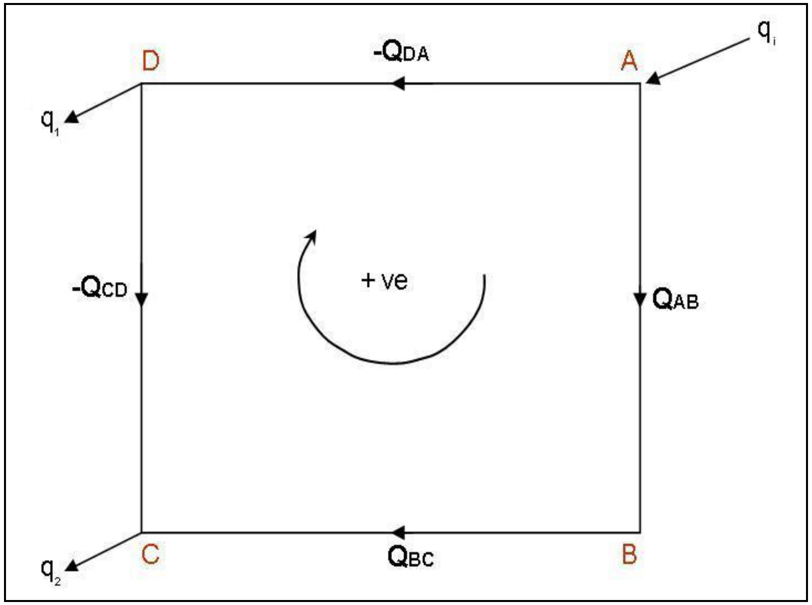
Main pipes feed water into centrally placed service tank

Consumer pipe network radiate from service tanks.

All locations will enjoy equitable water pressure.

Normally installed in very flat ground.

More expensive to installed (tanks)



Reticulation Pipe Network

Reticulation Pipe Design

Complex network design requires "trial and error" analysis method.

Normal method used developed by Hardy – Cross (analysis of flow in networks of conduit, 1946)

Complex pipe network seen as combination of circuits where;

Continuity of flow is assured at each junction or node.

Algebraic Sum of head loss through each circuit is nil (zero)

Head loss (ignore minor losses and kinetic energy) is as follows;

$$h = kQ^n \qquad (1)$$

h is head loss

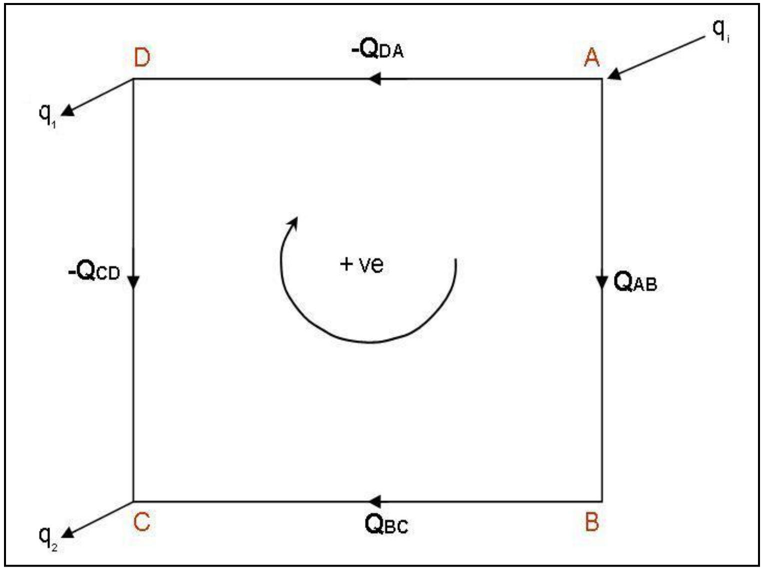
Q is flow rate m^3/s

k & n are coefficients that depend on formula used.

Example for Hazen – Williams formula;

$$k = \frac{h}{\left(0.279.C.D^{2.63}\right)^{1.85}}$$

$$n = 1.85$$



Reticulation Pipe Network

If initials flow rate in pipe is assumed as Q1 and the 1st correction factor as ΔQ_1,

Then the 2nd set of flow;

$$Q_2 = Q_1 + \Delta Q_1 \qquad (2)$$

Sum of head loss around the circuit based on (1) is;

$$h_1 = \Sigma Q_1^n$$

After the 1st correction, sum of head loss is

$$h_2 = \Sigma k(Q_1 + \Delta Q_1)^n$$

$$h_2 = \Sigma k(Q_1^n + nQ_1^{n-1}\Delta Q_1 + n^2 Q_1^{n-2}\Delta Q_1^2 + \ldots\ldots\ldots.)$$

maintaining the 1st two terms,

$$h_2 = \Sigma k(Q_1^n + nQ_1^{n-1}\Delta Q_1)$$

sum of head loss in circuit = 0

therefore $Q_1^n + nQ_1^{n-1}\Delta Q_1 = 0$

$$\Delta Q_1 = \frac{-\Sigma k Q_1^n}{\Sigma\left[knQ_1^{n-1}\right]} = \frac{-\Sigma h_1}{\Sigma\left\{n\frac{kQ_1^n}{Q_1}\right\}} = \frac{-\Sigma h_1}{n\left\{\Sigma\frac{h_1}{Q_1}\right\}}$$

Reticulation Pipe Network

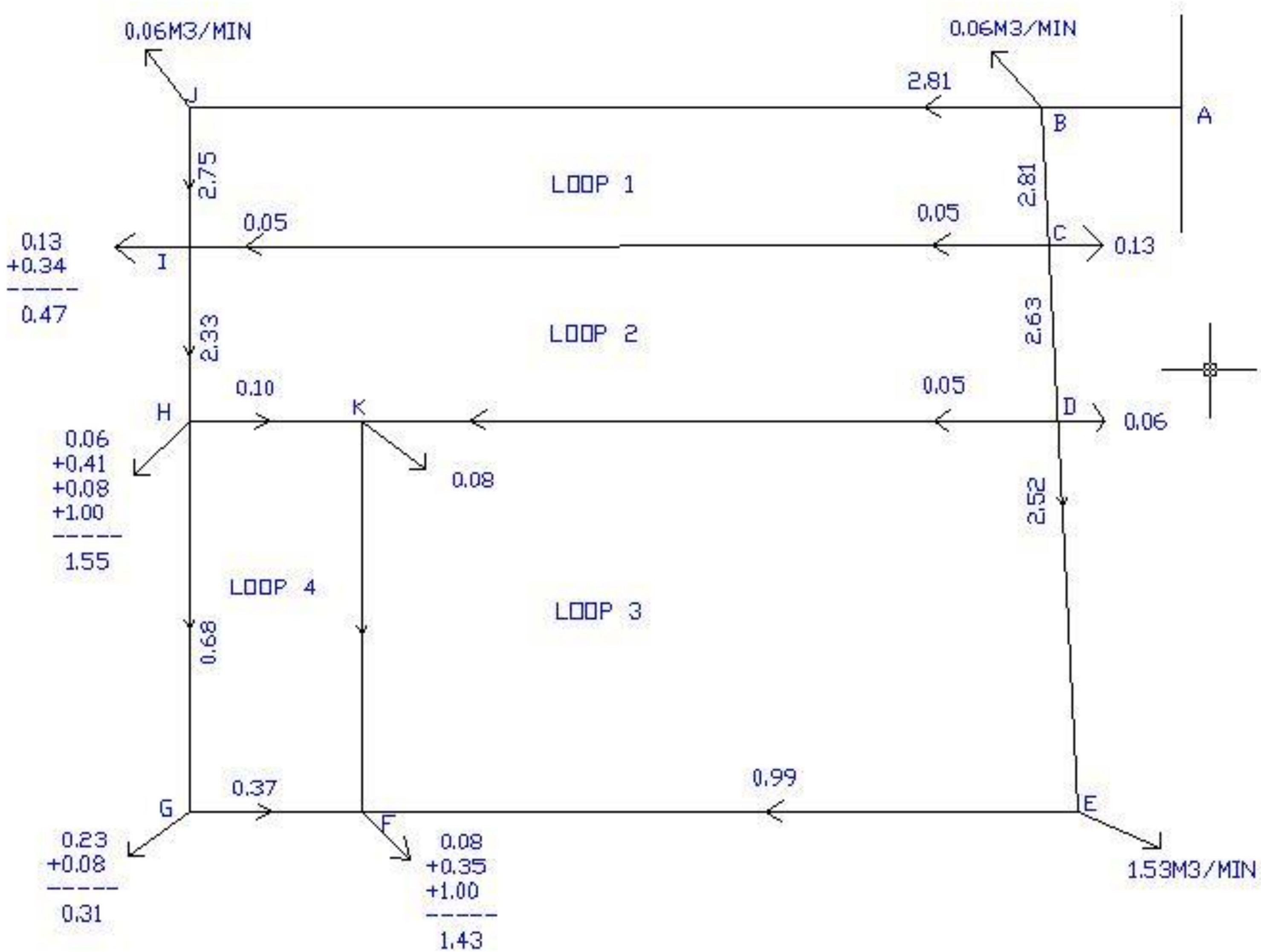
Design Procedure

1. Sketch out geometric of pipe network and determine water demand at nodes.
2 Decide on formula to use
3 Estimate the flow rate along all pipes base of flow continuity at all nodes / junctions.
4 For each loop;
   (i) Calculate head loss for each pipe
   (ii) Determine sum of algebraic head loss (Σh) taking account conventional signage (+ve for clockwise)
   (iii) Determine correction factor, ΔQ.
5. Repeat step 4 for corrected flow rate with each ΔQ for all pipes. Step 4 is repeated several times to arrive at the most accurate value.

Working Example of Reticulation Design

Working Example of Reticulation Design

Working Example of Reticulation Design



Reticulation Pipe Network

eg of Nodal Demand & Pipe Flow

@ B & J

No of terrace house = 45
Daily water demand = 45 x 1600 l/day
= 72 m^3/day
= 0.05 m^3/min
Take peak factor = 2.5
Peak water demand = .0.05x2.5
= 0.125 m^3/min
Therefore at each node, q = 0.0625 m^3/min.

@ E (Industry II)
Daily water demand = 2,200 m^3/day
= 1.53 m^3/min (no peak)

@ F (industry I)
No pf industry = 100
Water Demand = 5m^3/industry
Industry demand = 500m^3/day or 0.35 m^3/min.

Fire demand = 1.0 m^3/min
Shop house = 0.08 m^3/min
Total @ F = 1.43 m^3/min

Total overall demand (A to B) = 0.06 + 0.13 + 0.06 + 1.53 + 1.43+ 0.31 + 1.55 + 0.47 + 0.06 + 0.08= 5.68

Flow along B-C, Q_{BC} = (5.68 – 0.06)/2 = 2.81 m^3/min

Reticulation Design - Kg. Pasir

First Run

Loop I

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	$\Delta 1 = -\Sigma h/(1.85\Sigma(h/Q))$	v (m/s)
BC	2.81	0.046833	0.2	50	0.115676	0.018492586	0.924629	0.329049582		1.490084
CI	0.05	0.000833	0.1	350	0.012741	0.000312354	0.109324	2.186477229		0.106056
IJ	-2.75	-0.045833	0.2	50	0.113206	0.017768733	-0.888437	0.323067864		-1.458267
JB	-2.81	-0.046833	0.2	350	0.115676	0.018492586	-6.472405	2.303347072		-1.490084
						Σ	-6.326889	5.141941747	0.6651	

Loop II

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	$\Delta 1 = -\Sigma h/(1.85\Sigma(h/Q))$	v (m/s)
CD	2.63	0.043833	0.15	50	0.230717	0.066328248	3.316412	1.260993304		2.479349
DK	0.05	0.000833	0.1	300	0.012741	0.000312354	0.093706	1.874123339		0.106056
KH	-0.1	-0.001667	0.1	60	0.025483	0.001126036	-0.067562	0.675621811		-0.212112
HI	-2.33	-0.038833	0.15	50	0.2044	0.053013789	-2.650689	1.137634953		-2.196533
IC	-0.05	-0.000833	0.1	350	0.012741	0.000312354	-0.109324	2.186477229		-0.106056
						Σ	0.582543	7.134850636	-0.0441	

Loop III

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	$\Delta 1 = -\Sigma h/(1.85\Sigma(h/Q))$	v (m/s)
DE	2.52	0.042	0.15	140	0.221068	0.061287427	8.58024	3.404857066		2.37565
EF	0.99	0.0165	0.1	300	0.252278	0.07824877	23.47463	23.71174855		2.099905
FK	-0.07	-0.001167	0.1	140	0.017838	0.000582081	-0.081491	1.164162968		-0.148478
KD	-0.05	-0.000833	0.1	300	0.012741	0.000312354	-0.093706	1.874123339		-0.106056
						Σ	31.87967	30.15489192	-0.5715	

Loop IV

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	$\Delta 1 = -\Sigma h/(1.85\Sigma(h/Q))$	v (m/s)
KF	0.07	0.001167	0.1	140	0.017838	0.000582081	0.081491	1.164162968		0.148478
FG	-0.37	-0.006167	0.1	70	0.094286	0.012668512	-0.886796	2.396745476		-0.784813
GH	-0.68	-0.011333	0.1	140	0.173282	0.039056552	-5.467917	8.041054807		-1.442359
HK	0.1	0.001667	0.1	60	0.025483	0.001126036	0.067562	0.675621811		0.212112
						Σ	-6.20566	12.27758506	0.2732	

Hazen – Williams

$$Q = 0.279\ C\ D^{2.63}\ S^{0.54}$$

$$s^{0.54} = \frac{Q}{0.279 x 100 x dia^{2.63}}$$

Pipe dia (assume)

First Run

Loop I

Q/60

H =S x L

Q/A

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	$\Delta 1 = -\Sigma h/(1.85\Sigma(h/Q))$	v (m/s)
BC	2.81	0.046833	0.2	50	0.115676	0.018492586	0.924629	0.329049582		1.490084
CI	0.05	0.000833	0.1	350	0.012741	0.000312354	0.109324	2.186477229		0.106056
IJ	-2.75	-0.045833	0.2	50	0.113206	0.017768733	-0.888437	0.323067864		-1.458267
JB	-2.81	-0.046833	0.2	350	0.115676	0.018492586	-6.472405	2.303347072		-1.490084
						Σ	-6.326889	5.141941747	0.6651	

$$= -\left[\frac{6.32689}{1.85 x 5.1419417}\right]$$

Second Run

Loop I	Δ1
	0.6651

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	$\Delta 2 = -\Sigma h/(1.85\Sigma(h/Q))$	velo (m/s)
BC	3.475107	0.057918	0.2	50	0.143055	0.027395677	1.369784	0.394170295		1.842776
CI	0.75924	0.012654	0.1	350	0.193475	0.047891037	16.76186	22.0771453		1.610437
IJ	-2.084893	-0.034748	0.2	50	0.085826	0.010646235	-0.532312	0.255318469		-1.105575
JB	-2.144893	-0.035748	0.2	350	0.088296	0.011219965	-3.926988	1.830854585		-1.137392
						Σ	13.67235	24.55748865	-0.3009	

Loop II	Δ1
	-0.0441

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	$\Delta 2 = -\Sigma h/(1.85\Sigma(h/Q))$	velo (m/s)
CD	2.585866	0.043098	0.15	50	0.226846	0.064283805	3.21419	1.24298399		2.437743
DK	0.577324	0.009622	0.1	300	0.147118	0.028852206	8.655662	14.99272209		1.224572
KH	-0.417348	-0.006956	0.1	60	0.106351	0.015829761	-0.949786	2.275764162		-0.885243
HI	-2.374134	-0.039569	0.15	50	0.208271	0.054886432	-2.744322	1.155925403		-2.238139
IC	-0.75924	-0.012654	0.1	350	0.193475	0.047891037	-16.76186	22.0771453		-1.610437
						Σ	-8.586118	41.74454094	0.1112	

Loop III	Δ1
	-0.5715

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	$\Delta 2 = -\Sigma h/(1.85\Sigma(h/Q))$	velo (m/s)
DE	1.948542	0.032476	0.15	140	0.170936	0.038084078	5.331771	2.736287465		1.836926
EF	0.418542	0.006976	0.1	300	0.106656	0.01591364	4.774092	11.4064843		0.887776
FK	-0.914672	-0.015245	0.1	140	0.233083	0.067591735	-9.462843	10.34561052		-1.940126
KD	-0.577324	-0.009622	0.1	300	0.147118	0.028852206	-8.655662	14.99272209		-1.224572
						Σ	-8.012642	39.48110436	0.1097	

Loop IV	Δ1
	0.2732

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	$\Delta 2 = -\Sigma h/(1.85\Sigma(h/Q))$	velo (m/s)
KF	0.914672	0.015245	0.1	140	0.233083	0.067591735	9.462843	10.34561052		1.940126
FG	-0.096786	-0.001613	0.1	70	0.024664	0.001059995	-0.0742	0.766638031		-0.205294
GH	-0.406786	-0.00678	0.1	140	0.10366	0.015096599	-2.113524	5.195667684		-0.86284
HK	0.417348	0.006956	0.1	60	0.106351	0.015829761	0.949786	2.275764162		0.885243
						Σ	8.224905	18.58368039	-0.2392	

$$Q_{BC} = 2.81 + 0.6651$$

Second Run

$$Q_{CI} = 0.05 + [0.6651 - (-0.0441)]$$

Loop I	Δ1
	0.6651

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	Δ2= – Σh/(1.85Σ(h/Q))	velo (m/s)
BC	3.475107	0.057918	0.2	50	0.143055	0.027395677	1.369784	0.394170295		1.842776
CI	0.75924	0.012654	0.1	350	0.193475	0.047891037	16.76186	22.0771453		1.610437
IJ	-2.084893	-0.034748	0.2	50	0.085826	0.010646235	-0.532312	0.255318469		-1.105575
JB	-2.144893	-0.035748	0.2	350	0.088296	0.011219965	-3.926988	1.830854585		-1.137392
						Σ	13.67235	24.55748865	-0.3009	

Loop II	Δ1
	-0.0441

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	Δ2= – Σh/(1.85Σ(h/Q))	velo (m/s)
CD	2.585866	0.043098	0.15	50	0.226846	0.064283805	3.21419	1.24298399		2.437743
DK	0.577324	0.009622	0.1	300	0.147118	0.028852206	8.655662	14.99272209		1.224572
KH	-0.417348	-0.006956	0.1	60	0.106351	0.015829761	-0.949786	2.275764162		-0.885243
HI	-2.374134	-0.039569	0.15	50	0.208271	0.054886432	-2.744322	1.155925403		-2.238139
IC	-0.75924	-0.012654	0.1	350	0.193475	0.047891037	-16.76186	22.0771453		-1.610437
						Σ	-8.586118	41.74454094	0.1112	

Third Run

Loop I	Δ1	Δ2
	0.6651	-0.3009

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	Δ3= – Σh/(1.85Σ(h/Q))	velo (m/s)
BC	3.174162	0.052903	0.2	50	0.130667	0.023168859	1.158443	0.364960311		1.683191
CI	0.347116	0.005785	0.1	350	0.088454	0.011257181	3.940013	11.35072245		0.736272
IJ	-2.385838	-0.039764	0.2	50	0.098215	0.013662397	-0.68312	0.28632275		-1.26516
JB	-2.445838	-0.040764	0.2	350	0.100685	0.014304819	-5.006686	2.047022521		-1.296977
						Σ	-0.59135	14.04902803	0.0228	

Loop II	Δ1	Δ2
	-0.0441	0.1112

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	Δ3= – Σh/(1.85Σ(h/Q))	velo (m/s)
CD	2.697046	0.044951	0.15	50	0.236599	0.069490239	3.474512	1.288265799		2.542554
DK	0.578802	0.009647	0.1	300	0.147494	0.028988971	8.696691	15.02533319		1.227706
KH	-0.066932	-0.001116	0.1	60	0.017056	0.000535763	-0.032146	0.480276633		-0.14197
HI	-2.262954	-0.037716	0.15	50	0.198518	0.050226224	-2.511311	1.109749051		-2.133328
IC	-0.347116	-0.005785	0.1	350	0.088454	0.011257181	-3.940013	11.35072245		-0.736272
						Σ	5.687733	29.25434712	-0.1051	

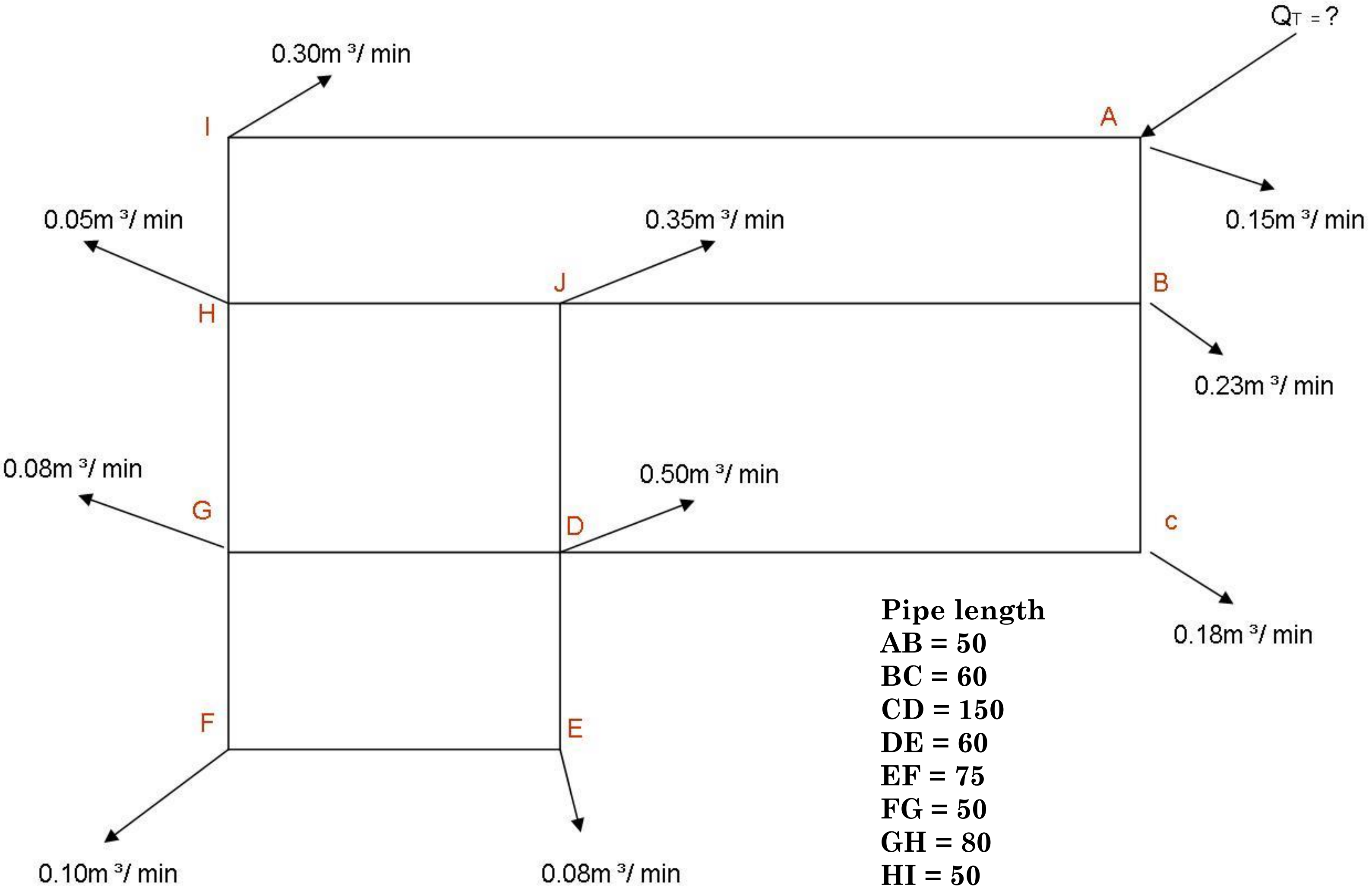
Loop III	Δ1	Δ2
	-0.5715	0.1097

Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	Δ3= – Σh/(1.85Σ(h/Q))	velo (m/s)
DE	2.058244	0.034304	0.15	140	0.18056	0.042145341	5.900348	2.866690139		1.940344
EF	0.528244	0.008804	0.1	300	0.134611	0.024479151	7.343745	13.90218435		1.120467
FK	-0.565734	-0.009429	0.1	140	0.144164	0.027789755	-3.890566	6.877026507		-1.199987
KD	-0.578802	-0.009647	0.1	300	0.147494	0.028988971	-8.696691	15.02533319		-1.227706
						Σ	0.656836	38.67123418	-0.0092	

Loop IV	Δ1	Δ2
	0.2732	-0.2392

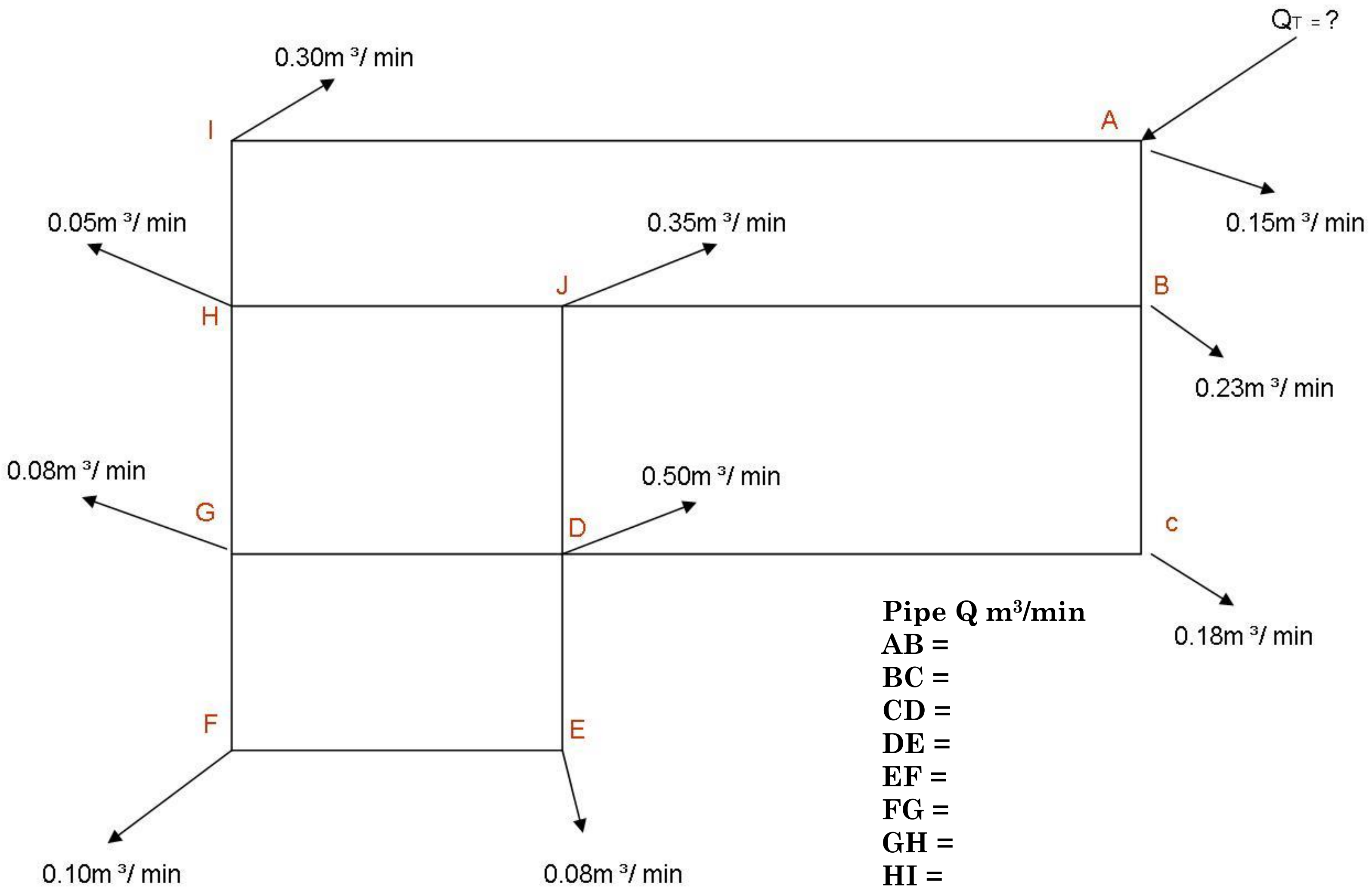
Line	Q (m^3/min)	Q(m^3/s)	Dia. (m)	Lenghth (m)	$s^{0.54}$	s (m/m)	h (m)	h/Q (m/m^3/min)	Δ3= – Σh/(1.85Σ(h/Q))	velo (m/s)
KF	0.565734	0.009429	0.1	140	0.144164	0.027789755	3.890566	6.877026507		1.199987
FG	-0.336022	-0.0056	0.1	70	0.085627	0.010600672	-0.742047	2.208326756		-0.712742
GH	-0.646022	-0.010767	0.1	140	0.164624	0.035523054	-4.973228	7.698229051		-1.370288
HK	0.066932	0.001116	0.1	60	0.017056	0.000535763	0.032146	0.480276633		0.14197
						Σ	-1.792563	17.26385895	0.0561	

Tugasan



Pipe length
AB = 50
BC = 60
CD = 150
DE = 60
EF = 75
FG = 50
GH = 80
HI = 50
IA = 280
BJ = 200
CD = 220
DG = 75
HJ = 75
JD = 100

Tugasan



Pipe Q m³/min
AB =
BC =
CD =
DE =
EF =
FG =
GH =
HI =
IA =
BJ =
DG =
HJ =
JD =

END