WaterForce
wise with water

Understanding Pressure Loss in Pipelines

Young Vit Education Days

Central Otago

26th June 2022

Terminology

Pressure

"Force that makes the flow of water strong or weak" – How much energy the water has

We need water pressure to get the water where it needs to go and ensure that it is coming out of the sprinkler/emitter correctly

kPa (kilopascals)	Bar	mH (meters head)	PSI
100	1	10	14.5
400	4	40	59

Flow

"The amount of water flowing per unit of time" - How much water is being used

Flow is determined by how much water is coming out of the sprinkler/emitter and how many of these we have running at a time **OR** by how much the pump can produce.

l/s (litres per second)	lpm (litres per minute)	m3/H (cubes an hour)
1	60	3.6 (3600 litres)
5	300	18 (18,000 litres)

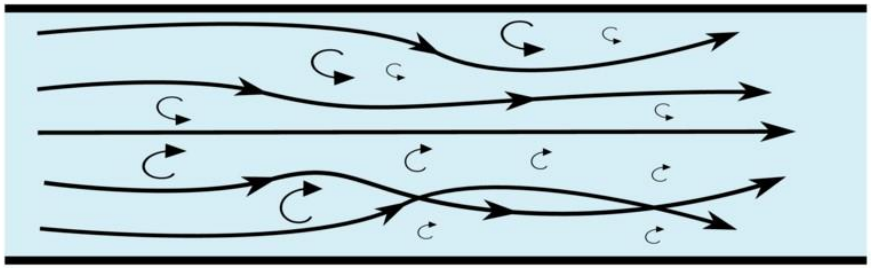
Pipe Friction

As water moves through a pipe, friction occurs between molecules as it travels along the pipe.

Friction occurs between

- the fluid molecules and the pipe wall
- the fluid molecules tumbling past each other

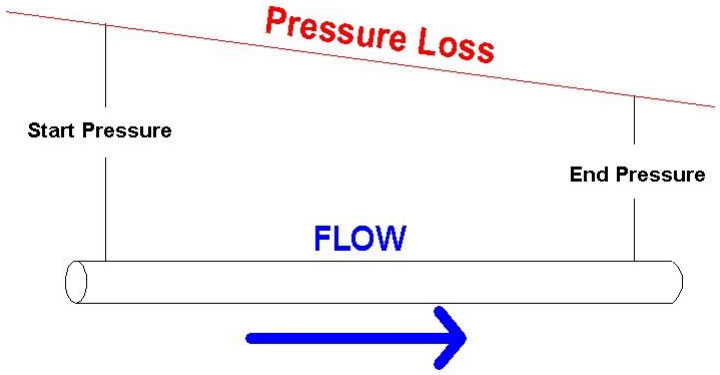
turbulent flow



The faster the fluid is moving, the more turbulent it will be, the more friction will occur

Pressure Loss

As friction occurs, you loose energy which causes the pressure to drop between the start and end of the pipe when water is flowing



<u>Factors affecting the amount of pressure loss through pipe</u>

- **the flow through the pipe**
- **the size/type of the pipe**

These factors affect how fast the water moves through the pipe
- Faster water = more turbulent
- More turbulent = more pressure loss

- **the length of the pipe**

As pipeline gets longer, friction continues along the whole length so more pressure loss will occur over a longer pipe

Pressure Loss Calculations

There are some complicated equations which are used to figure out how much friction loss we will have through a length of pipe....

Head Loss Darcy Weisbach Equation

$$\Delta h = f_D \frac{L}{D} \frac{V^2}{2g}$$

$\Delta h - pressure\ loss\ in\ m$
$f_D - darcy\ friction\ factor$
$L - pipe\ length\ in\ m$
$D - hydraulic\ diameter\ in\ m$
$V - fluid\ flow\ avg\ velocity\ in\ m/s$
$g - standard\ gravity = 9.81\ m/s^2$

858 × 309

Hazen-Williams formula

$$h_f = \frac{10.44 \cdot L \cdot Q^{1.85}}{C^{1.85} \cdot d^{4.8655}}$$

Where:
- h_f = head loss due to friction (ft)
- L = length of pipe (ft)
- Q = flow rate of water (gpm)
- C = Hazen-Williams constant
- d = diameter of the pipe (in.)

....luckily we have handy calculators and spreadsheets to prevent us having to do these equations every day!!!

Flowrate	Units
6	l/s

Length (m)	Flow Type
100	FULL

PN Rating	Pipe Material
6.3 Bar	PE80B

Optional

Pipe id (mm)	Headloss(m)	Velocity(m/s)
52.9	12.9	2.7

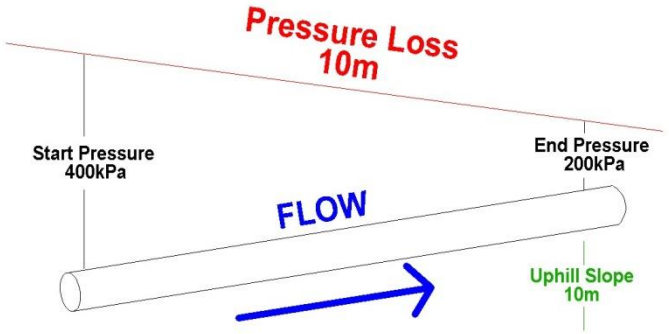
6.3 Bar **PE80B**

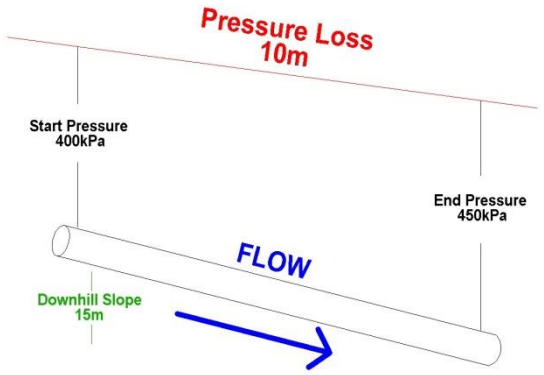
HL from Lamonts EQN

	Pipe id	Headloss		Velocity	PN Rating	Velocity Flag
	mm	m	EQN	m/s	Bar	
15mm	-	-	-	-	-	-
20mm	-	-	-	-	-	-
25mm	-	-	-	-	-	-
32mm	28.9	233.2	S3	9.2	6.3 Bar	Too High !!
40mm	36.1	80.0	S3	5.9	6.3 Bar	Too High !!
45mm	-	-	S3	-	-	-
50mm	45.1	27.8	S3	3.8	6.3 Bar	Way Up!
63mm	56.9	9.1	S3	2.4	6.3 Bar	Velocity Up
75mm	67.7	4.0	S3	1.7	6.3 Bar	-
90mm	81.3	1.7	S3	1.2	6.3 Bar	-
110mm	99.2	0.6	S3	0.8	6.3 Bar	-
125mm	112.9	0.3	S3	0.6	6.3 Bar	-
140mm	126.5	0.2	S3	0.5	6.3 Bar	-
160mm	144.5	0.1	S3	0.4	6.3 Bar	-
180mm	162.7	0.1	S3	0.3	6.3 Bar	-
200mm	180.8	0.0	S3	0.2	6.3 Bar	-

Slope

We also have to take slope into consideration as this will add or reduce pressure in our pipes





Scenario

Existing sprinkler
- 15m of 20mm LDPE Pipe

Extend sprinkler to another location
- 100m extra pipe needed

What do we think will happen?

...the sprinkler looks terrible!!

- Not going the distance

- Flow stream looks weak

- The sprinkler isn't turning around properly

So what happened?

Water source = 350kPa

Flowrate	Units
0.5	l/s
Length (m)	**Flow Type**
15	FULL
PN Rating	**Pipe Material**
6.3 Bar	LDPE

LD PE — HL from Lamonts EQN

	Pipe id	Headloss		Velocity	PN Rating	Velocity Flag
	mm	m	EQN	m/s	Bar	
15mm	12.8	20.7	S3	3.9	9.70	Way Up!
20mm	19.0	3.1	S3	1.8	8.00	-
25mm	25.3	0.8	S3	1.0	6.00	-
32mm	31.1	0.3	S3	0.7	5.00	-
40mm	37.5	0.1	S3	0.5	0.00	-
45mm	-	-	S3	-	-	-
50mm	50.0	0.0	S3	0.3	0.00	-
63mm	-	-	S3	-	-	-
75mm	-	-	S3	-	-	-

15m of pipe loses 3.1m pressure

– Sprinkler has 319kPa and works well

Flowrate	Units
0.5	l/s
Length (m)	**Flow Type**
100	FULL
PN Rating	**Pipe Material**
6.3 Bar	LDPE

LD PE — HL from Lamonts EQN

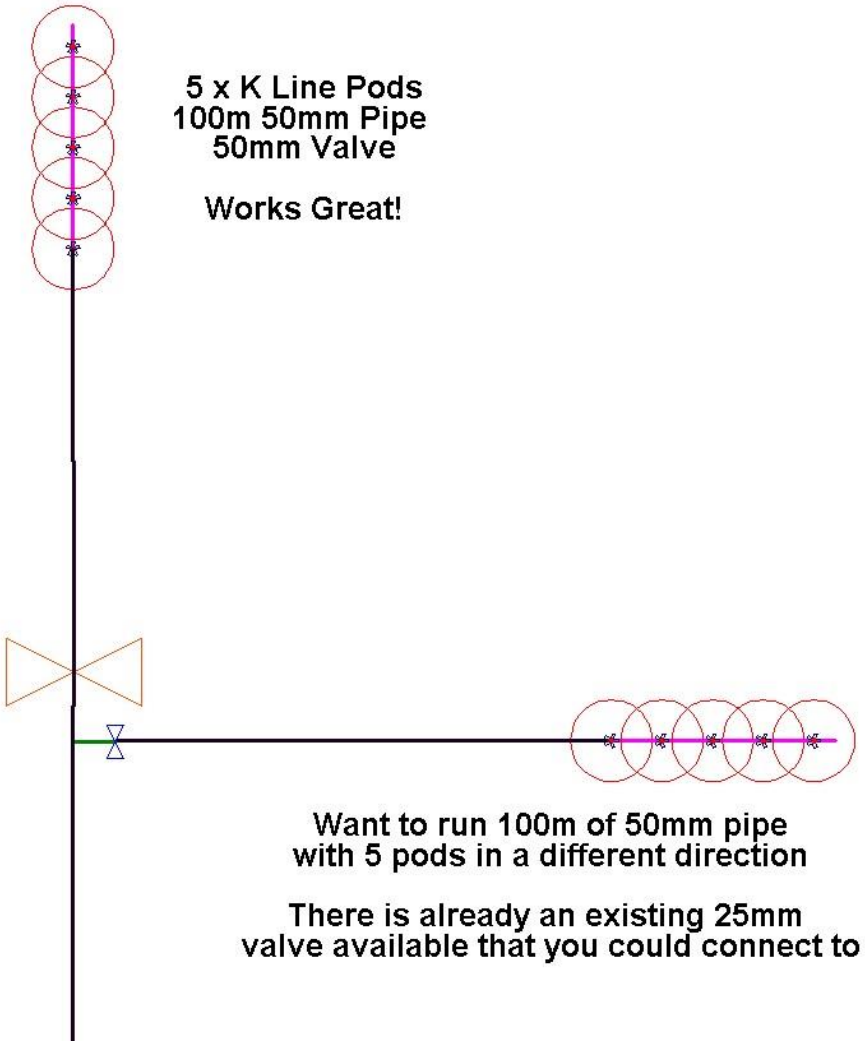
	Pipe id	Headloss		Velocity	PN Rating	Velocity Flag
	mm	m	EQN	m/s	Bar	
15mm	12.8	137.9	S3	3.9	9.70	Way Up!
20mm	19.0	20.9	S3	1.8	8.00	-
25mm	25.3	5.3	S3	1.0	6.00	-
32mm	31.1	2.0	S3	0.7	5.00	-
40mm	37.5	0.8	S3	0.5	0.00	-
45mm	-	-	S3	-	-	-
50mm	50.0	0.2	S3	0.3	0.00	-
63mm	-	-	S3	-	-	-
75mm	-	-	S3	-	-	-

Addding another 100m of pipe gives another 20.9m pressure loss

-Sprinkler now only has 110kPa which isn't enough to work properly

If we had gone up to 25mm pipe instead we would have 266kPa at the sprinkler which would have been OK

Scenario 2



Can we connect to the 25mm valve and still have enough flow and pressure at the other end??

1" (25 MM) PGV VALVE

Flow m^3/hr	Pressure Loss bar
0.3	0.08
1.0	0.11
2.5	0.13
3.5	0.16
4.5	0.23
5.5	0.43
6.5	0.62
8.0	1.10
9.0	1.48

.23bar loss
through valve

Flowrate	Units
4.5	m3/hr
Length (m)	Flow Type
2	FULL
PN Rating	Pipe Material
6.3 Bar	LDPE

LD PE

HL from Lamonts EQN

	Pipe id	Headloss		Velocity	PN Rating	Velocity Flag
	mm	m	EQN	m/s	Bar	
15mm	12.8	14.0	S3	9.7	9.70	Too High !!
20mm	19.0	2.1	S3	4.4	8.00	Way Up!
25mm	25.3	0.5	S3	2.5	6.00	Velocity Up
32mm	31.1	0.2	S3	1.6	5.00	-
40mm	37.5	0.1	S3	1.1	0.00	-
45mm	-	-	S3	-	-	-
50mm	50.0	0.0	S3	0.6	0.00	-
63mm	-	-	S3	-	-	-
75mm	-	-	S3	-	-	-

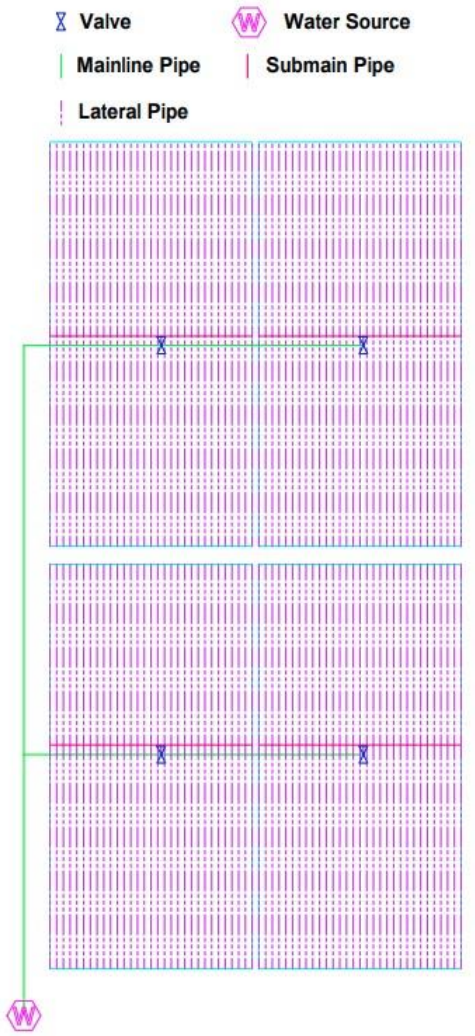
0.5m loss through
2m of 25mm pipe

0.28bar plus 0.5m
= 33kPa pressure loss

If we had 350kPa at the other sprinkler line and lost 33kPa going to this line, the sprinklers will have 317kPa here which will still be in operating range

So it should be all good!

Vineyard System



<u>Aim of an irrigation design</u>

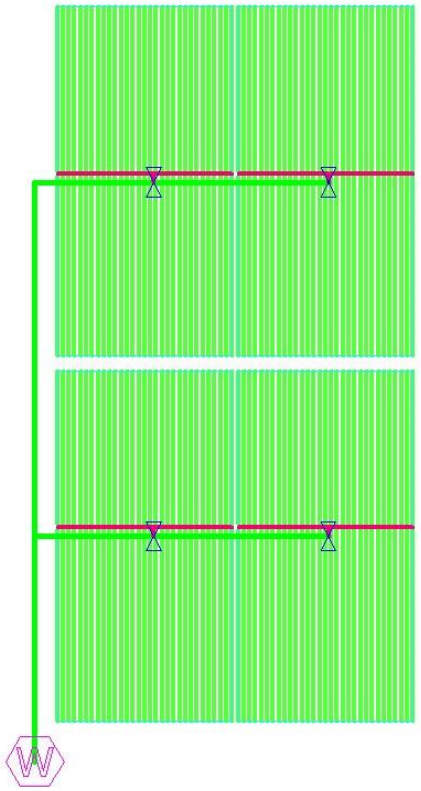
- Water dispersed **evenly** across the block
- Water dispersed **efficiently** across the block

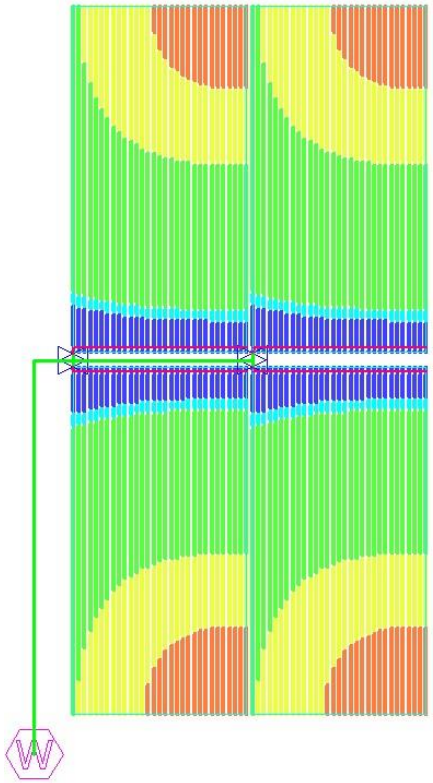
<u>Other Considerations</u>

- Split into a manageable amount of zones
- Split into different soil types/varieties
- Flow rate available from consent/existing pump

Design Differences

- There are many ways a designer can split up a block
- Cheapest design not necessarily going to be the cheapest long term
  - Smaller Mainline will have a lower capital cost, but there is likely to be more pressure loss so the pump will have to pump at a higher pressure which will take more power to do so
  - Pressure differences across the block can cause the drippers to wear out quicker, or some vines not to get as much water causing loss of yield or poor quality wine, etc





Summary

- There is never a “one size fits all” solution in irrigation

- We are always available to give advice & find the best solution for you

  Details that might be required

  - Flow rate or type of sprinkler/emitters
  - Pressure you have available
  - Distance you want to go

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