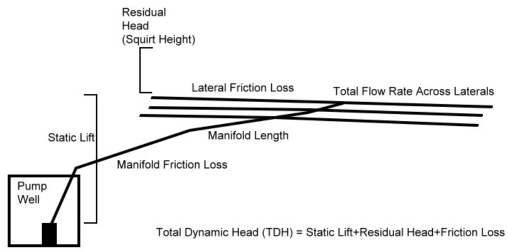
Pressure Dosing Systems

Pressure Dosing Manifolds

- Mounds *must* be pressure dosed to operate effectively
- Consideration and calculation of hydraulics important. Particularly for larger mounds
- A number of configurations available depending on the type of application

Generic Layout



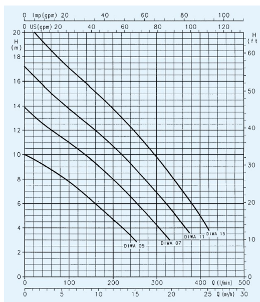
Dosing Methods

- Timed dosing is the preferred option for mounds
- Ensures that the media is provided with an even (and quantifiable) dose of effluent and limits shock loads
- Demand dosing (using a float switch) does not limit shock loads

Effluent Pumps

- Pump - usually submersible centrifugal / vortex pump:
  - Appropriate for wastewater
  - Adequate pump duty
    - Pump total head
    - Pump flow rate
- Pipelines and fittings - design for:
  - Pressure rating
  - Flushing velocity
  - Airlocks
  - Pressure loss

Pumps



Dosing

- Dosing volume - consider:
  - System capacity at start-up
  - Need to pressurise the laterals and maintain pressurised flow for at least 75% of the dosing period.
  - AS/NZS 1547:2012 recommends minimum of 200 litres
- Dosing volume determines pump-sump capacity

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Delivery Lines and Manifolds

- Typically 25-40 mm polyethylene or (less often PVC) pipe
- Need to consider length and friction loss when sizing the pump
- Use of smaller diameter pipe will result in higher friction losses
- Larger diameter pipe increases the volume of effluent required to pressurise the system

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Lateral Configurations

- Laterals are usually set up in a split configuration (i.e. dosed in the middle of the manifold)
- Smaller effluent volumes mean that dosing manifolds may be more effective if separated into zones in larger mounds and filters
- Can use indexing valves to automatically split effluent between zones (only with pressurised systems)

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Lateral Configurations

- Pipe diameter can range between 20-40mm depending on system size
- 25mm is typically suitable for domestic systems
- 3-5mm holes drilled and deburred. Lines need to be cleaned of debris prior to final commissioning
- Holes typically at 300-500 mm centres depending on desired coverage and available volume of water

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Lateral Configurations

- Holes can be drilled in the top or the bottom of the laterals
- Holes in the bottom allow laterals to drain after operation, but require larger volumes to pressurise (~70-100L)
- Holes in the top require higher residual heads (~1.6-1.8m) and may need more sophisticated flushing mechanisms
- Holes in top allow system to remain primed ensuring more even distribution and smaller dosing volumes

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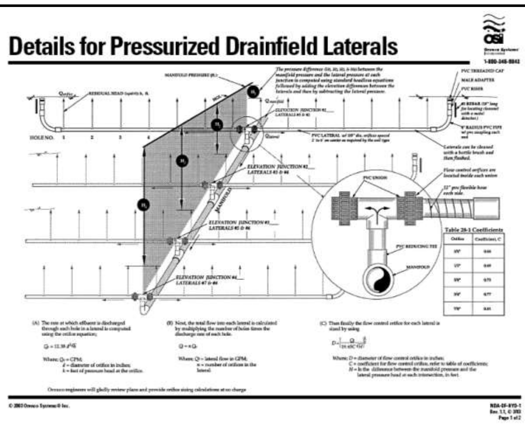

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Flushing Systems

- Need to provide air space around holes to enable organisms to break down biofilms (e.g. using ag-line or slotted pipe sheathing)
- Flushing capabilities essential in any pressure manifold. Screw cap fittings on the ends of laterals a minimum
- Can use automatic field flushing valves developed for subsurface irrigation
- Can install forward/reverse flushing lines
- Some installers use pressure compensating subsurface irrigation line as dosing pipework in mounds dosed with secondary effluent. Must have good filter

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Basic Hydraulics

- Flow rate at an orifice can be calculated by:

$$Q = 0.132(h^{1/2})(d^2)$$

Where Q = flow rate (L/min)
h = head at the orifice in m
d = orifice diameter (mm)

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Basic Hydraulics

- Friction loss in a pipe can be calculated by the Hazen-Williams equation:

$$H/L = 587(Q)^{1.85}(D)^{-4.87}$$

Where H/L = Head (friction) Loss in m
Q = flow rate (L/min)
D = pipe diameter (mm)

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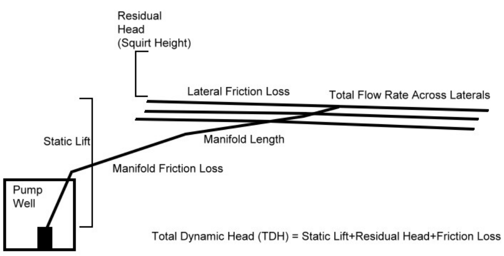
Generic Layout



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Design Considerations

- Need to design for even distribution by accounting for pressure loss down a lateral.
- No more than 15% variation in squirt height across the manifold.
- Minimum squirt heights;
  - 1.5m for upward facing holes;
  - 0.5m for downward facing holes

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Hydraulic Design of a Distribution System

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Diminishing flow

Applies to flows in:

- Manifolds in mound systems
- Manifolds in sand filters
- Irrigation lines

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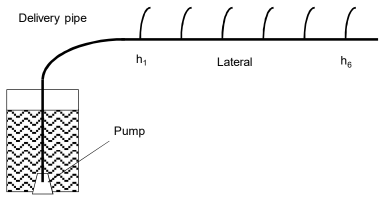
Flows in effluent distribution systems

- Consider flow in a pump or siphon driven distribution system



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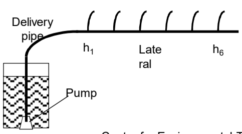
Flows in effluent distribution systems

- Pressure head h_1 depends on:
  - Pump characteristics
  - Total flow from orifices
  - Friction loss in delivery pipe



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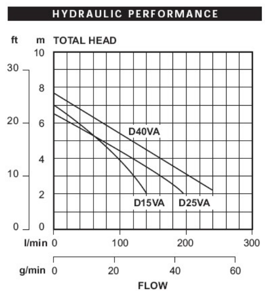
Pump characteristics

- Davey D15VA pump



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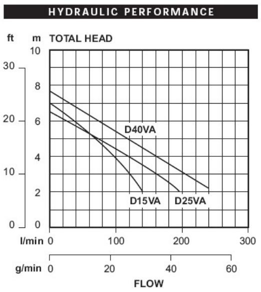
Pump performance curve

- Davey D15VA pump
- As flow increases the total head decreases from 7m at very low flow, to about 2m at maximum flow of 120 L/minute



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Flow from orifices

Flow rate depends on:

- Number of orifices
- Diameter of orifices
- Pressure head at each orifice

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Flow from orifices

Relationship described by continuity equation:

$Q = V \times A$, or

$Q = C \times (2gh)^{1/2} \times (\pi d^2/4)$ **Equation (1)**

Where:

Q = flow rate in m^3/second

d = orifice diameter in millimetres

h = static head in metres

C = orifice discharge coefficient = 0.63 for plastic pipes, and

g = gravitational acceleration = 9.81 m/second^2

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Flow from orifices

$Q = C \times (2gh)^{1/2} \times (\pi d^2/4)$

$Q = 0.63 \times (2 \times 9.81 \times h)^{1/2} \times (3.14 \times d^2/4)$

$Q = 0.63 \times (19.62 \times h)^{1/2} \times (0.79 \times d^2)$

$Q = 0.63 \times 4.43 \times (h^{1/2}) \times 0.79 \times (d^2)$

$Q = 2.20 \times (h^{1/2}) \times (d^2)$ m^3/sec

Converting to L/min

$Q = (2.20 \times 60)/1000(h^{1/2})(d^2)$ L/min

$Q = 0.132(h^{1/2})(d^2)$ L/min **Equation (2)**

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Flow from orifices

The flow from twelve 3 mm orifices has been tabulated for various pressure heads in the following table

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Flow from orifices (Table 1)

nQ flow from n orifices, d mm in diameter, subject to head of h metres				
h (m)	d (mm)	Q (L/min)	n	NQ (L/min)
1	3	1.19	12	14.28
2	3	1.68	12	20.16
3	3	2.06	12	24.72
4	3	2.38	12	28.56
5	3	2.63	12	31.56
6	3	2.91	12	34.92
7	3	3.15	12	37.80

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Friction loss in delivery pipe

The friction loss in the delivery pipe can be determined using the Hazen-Williams formula

$H/L = 587(Q)^{1.85}(D)^{-4.87}$ **Equation (3)**

where:

H/L = head loss (H) in metres of head per metre of pipe (length L)

Q = flow rate in L/min

D = internal diameter of pipe in mm

Friction loss in delivery pipe

The head loss in 5 metres of 25 mm poly pipe is tabulated against various flows in the following table

Head loss in 5 m of 25 mm pipe vs flow rate (Table 2)

Q (L/min)	D (mm)	H/L (m/m)	Length, L (m)	Head loss (m)
10	25	0.006	5	0.03
20	25	0.023	5	0.12
30	25	0.049	5	0.25
40	25	0.084	5	0.42
50	25	0.127	5	0.63
60	25	0.178	5	0.89
70	25	0.237	5	1.18
80	25	0.303	5	1.51
90	25	0.377	5	1.88
100	25	0.458	5	2.29

Thought experiment

Read and follow through the thought experiment:

Here we will envisage firstly one lateral….

Then two laterals on the same distribution line…

And note that the flow rate depends on the number of orifices…

And the head at the distribution pipe dependent on the total flow

Thought experiment

To estimate the flow we can assume a value for h_1 (less than the maximum head the pump can deliver, h_{1a}) and work out the resulting flow rate…

Having worked out the flow rate we can determine the head delivered by the pump at that flow and subtract the frictional loss in the delivery pipe and any elevational difference…

If this value is the same as our initial guess we have solved the problem… If not…

Thought experiment

If not…

We recalculate the flow rate using a new estimate of h_1, h_{1b},

Our new estimate should be between h_{1a} and h_{1b} ….

It should be closer to the earlier estimate h_{1a} than the latter h_{1b} ….

This is called an iterative process, which we continue until we have two identical values for total flow

Ensuring even distribution in the lateral

Ensuring even distribution depends on maintaining constant pressure head in the lateral

The pressure drop along the lateral can be calculated by the Hazen-Williams formula

The longer the pipe (L), the smaller the diameter (D) and the higher the flow rate (Q), then the greater will be the drop in pressure and the more uneven the flow from the first and last orifices

Ensuring even distribution in the lateral

In a pipe with n orifices the nth orifice should carry at least 95% of the flow of the first orifice

$q_n/q_1 > 0.95$ **Equation (4)**

From Equation (2) we see that for a given orifice diameter, the flow rate is proportional to the square root of the pressure head, h, so we can say

$(h_n/h_1)^{1/2} > 0.95$

or $h_n/h_1 > 0.95^2 = 0.9$ **Equation (5)**

Ensuring even distribution in the lateral

So we now ask…

"What diameter pipe is required to ensure that the last orifice operates at at least 90% of the pressure head of the first orifice?"

So we can now work through an example based on a mound with a 15 metre delivery line and four three metre laterals, each with six 3 mm diameter orifices. The system is driven by a Davey D15VA pump located 2 metres downhill of the mound.

Something similar?

Something similar?

Something similar?

Distribution system

- Short video showing squirt height
- https://www.arris.com.au/water/products/wisconsin-mounds/

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