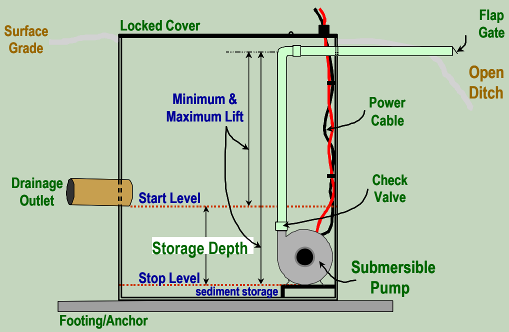
TILE DRAINAGE PUMPED OUTLETS

Graham Copithorn, P. Eng.

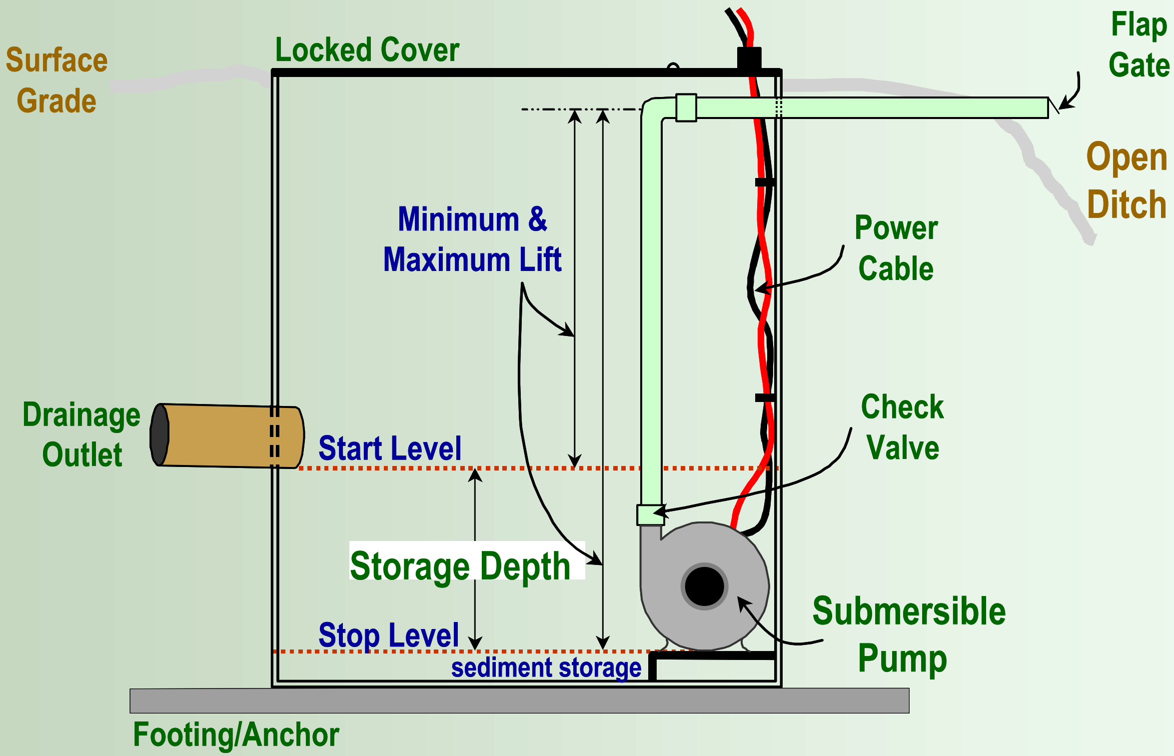
Senior Design Engineer
Irrigation and Drainage Unit
Agriculture and Agri-Food Canada - PFRA
408 - FCC Tower, 1800 Hamilton Street
Regina, Sask. S4P 4L2
Telephone: 306-780-6654
Facsimile: 306-780-5018
copithorng@agr.gc.ca

Pumped Outlets



- Consider when no natural outlet exists
- OR If recycling is an option
- Controlled Drainage could easily be implemented
- O&M costs enter economics
- Design guidelines should be followed

Components of Station



Design Guidelines

- Sump should be larger in area, not tall and narrow
- Water level has less than 2.5 ft of bounce (On to Off level)
- Pump sized to match maximum flow when running continuously (cycles on and off at reduced inflows, with maximum cycles at inflow of half design flow)

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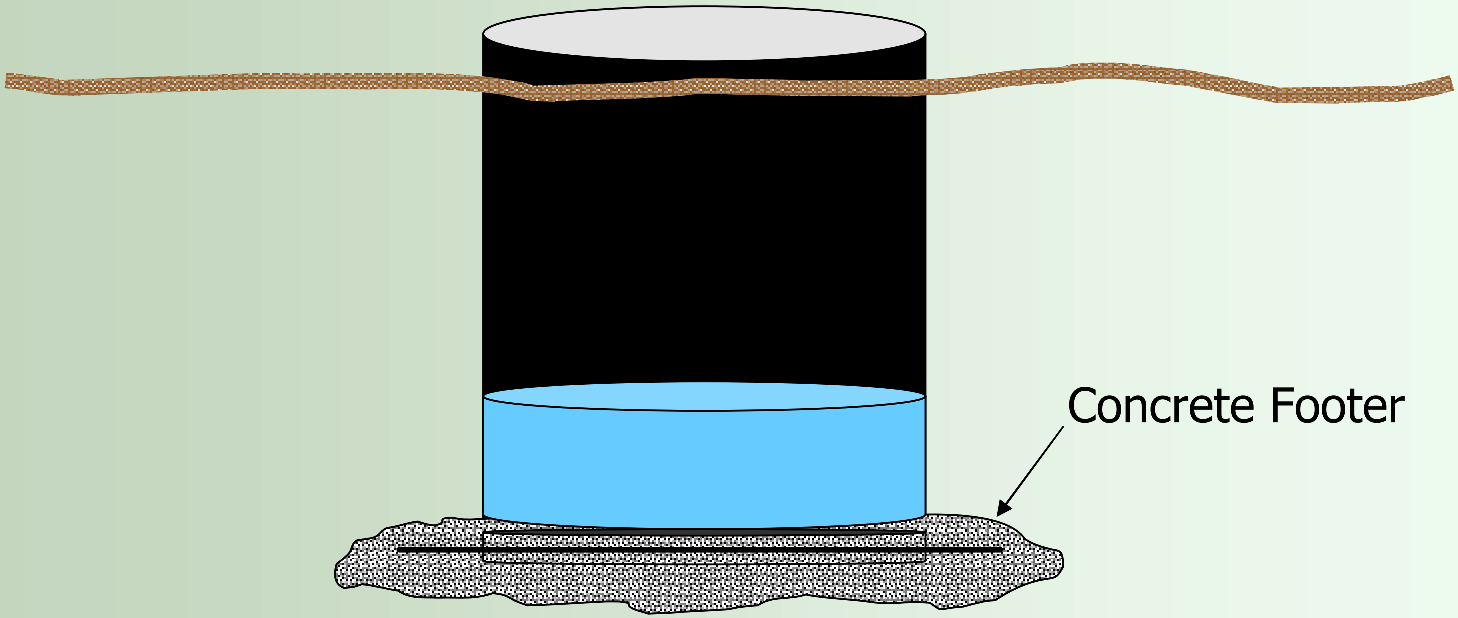
Design Guidelines

- Watch out for “floating” of sump
- Handling buoyancy forces



Design Guidelines

- Pump and sump size/shape are determined together, for efficient operation
- Mismatching means less efficient, more costly, and shorter life

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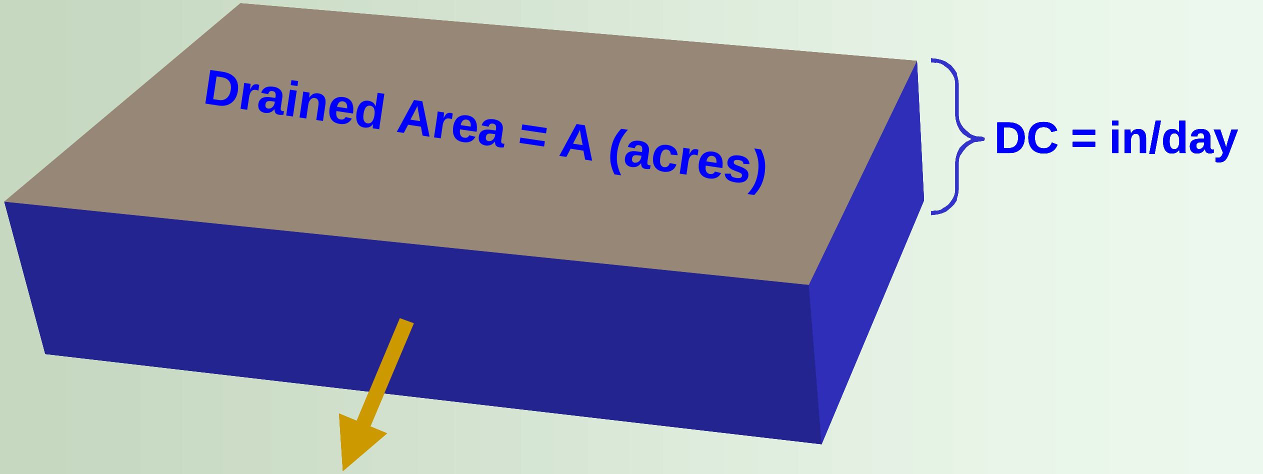
Calculating Flowrate

Drainage Coefficient



Flowrate (Q)=DC x A

(ac-in/day or gpm)

Q (usgpm) = 18.9 x DC x A

Resulting Flow rates

Flowrate (gpm)

Area (ac)	Drainage Coefficient (in/day)			
	1/4	3/8	1/2	3/4
100	475	713	950	1,425
200	950	1,425	1,900	2,850
300	1,425	2,138	2,850	4,275
400	1,900	2,850	3,800	5,700
500	2,375	3,563	4,750	7,125
600	2,850	4,275	5,700	8,550

Pump Sizing

- Capacity >= Design Inflow Rate

- Total Dynamic Head (TDH)

  The TDH is the head the pump must produce to overcome the lift to the outlet and the losses created by water flowing through the piping system

Pump Sizing

Total Dynamic Head (TDH)

$TDH = H_{stat} + H_{fric} + H_{vel} + H_{misc}$

Where:

H_{stat} = Static lift (Sump Water Level to Outlet)

H_{fric} = Friction loss due to flow through piping

H_{vel} = Velocity head loss at pipe outlet ($V^2/64.4$)

H_{misc} = Misc valving & pipe fitting losses

Losses due to water flow are proportional to the square of the flow velocity in the pipe

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Pump Sizing

Pump Power Requirement

$$\text{Power} = \frac{Q \times TDH}{3960 \times \mathbf{h}}$$

Where:

Power is in units of horsepower (x 0.746 for kW)

Q = Pump flow in usgpm

TDH = Pump head in feet

h = Pump efficiency expressed as decimal

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Pump Sizing

Pump Power Requirement Example

$$\text{Power} = \frac{Q \times TDH}{3960 \times \mathbf{h}}$$

Q = 2000 usgpm
H = 14 ft
h = 0.75, 0.5

Power @ **h** = 0.75
P = (2000 x 14) / (3960 x 0.75) = 9.5 hp

Power @ **h** = 0.5
P = (2000 x 14) / (3960 x 0.5) = 14.2 hp

Lower efficiency means bigger motor and electrical controls, higher operating costs

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Discharge Pipe Sizing

- Choose pipe type and diameter (to minimize head losses)
  - Short discharge lines – limit velocity to 6 ft/s
  - Longer discharge lines – limit friction losses to 2 ft per 100 ft of pipe length

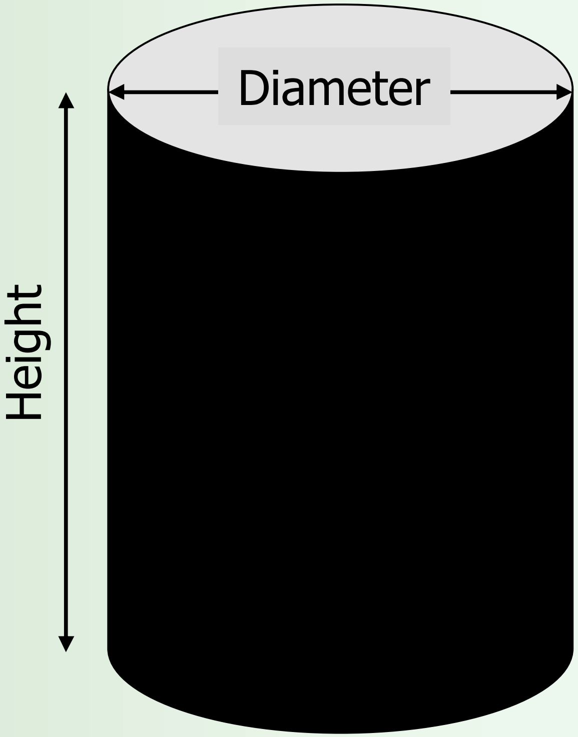
Sump Sizing Equation

$$\text{Storage Volume (ft}^3\text{)} = \frac{2 \times Q \text{ (usgpm)}}{n \text{ (cycles/hr)}}$$

- 1 Cycle includes on/off time
- 8-20 cycles/hr (3 to 8 min./cycle) is typical range
- Use pump specs from manufacturer
- More cycles→ smaller sump volume, but can decrease efficiency

Sump Dimensions

- Higher bounce means taller sump and smaller diameter
- The trade off is operating efficiency
- Higher bounce stretches range of operation for pump
- Inadequately sizing sump for desired flow increases "n"



Example Problem

- Given:

  DC = 0.25" per day

  Area drained = 27 acres

  Lift (from tile outlet in sump to discharge pipe outlet) = 6 ft

  Length of discharge pipe = 25 ft

  Pump cycles per hour = 5 and 20

Example Problem

Design Flowrate

$Q = 18.9 \times DC \times A$

$Q = 18.9 \times 0.25 \times 27 = 127.6$ usgpm

Say use $Q = 130$ usgpm

Sump Volume Calculation (5 cycles/hr)

$Vol = 2 \times Q / n$

$Vol = 2 \times 130 / 5 = 52\ ft^3$

Example Problem

Min Required Volume = 52 ft^3

-Try 4 ft diameter well

Area = **p** x 4^2 / 4 = 12.6 ft^2

Storage Depth = 52 /12.6 = 4.1 ft

-Try 6 ft diameter well

Area = **p** x 6^2 / 4 = 28.3 ft^2

Storage Depth = 52 /28.3 = 1.8 ft

Example Problem

Min Required Volume at 20 cycles/hr

- Vol = 2 x Q / n

  Vol = 2 x 130 / 20 = 13 ft^3

-Try 3 ft diameter well

  Area = p x 3^2 / 4 = 7.1 ft^2

  Storage Depth = 13 / 7.1 = 1.8 ft

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Example Problem

Discharge Pipe Sizing

Pipe Diameter (in)	2	3	4
Velocity (ft/s)	13.3	5.9	3.3
H_{fric} (ft)	6.9	1.0	0.2
H_{vel} (ft)	2.7	0.5	0.2
H_{misc} (ft)	2.7	0.5	0.2

Choose 3”

Example Problem

Pump TDH

-TDH at Max Sump Level

$TDH = H_{stat} + H_{fric} + H_{vel} + H_{misc}$

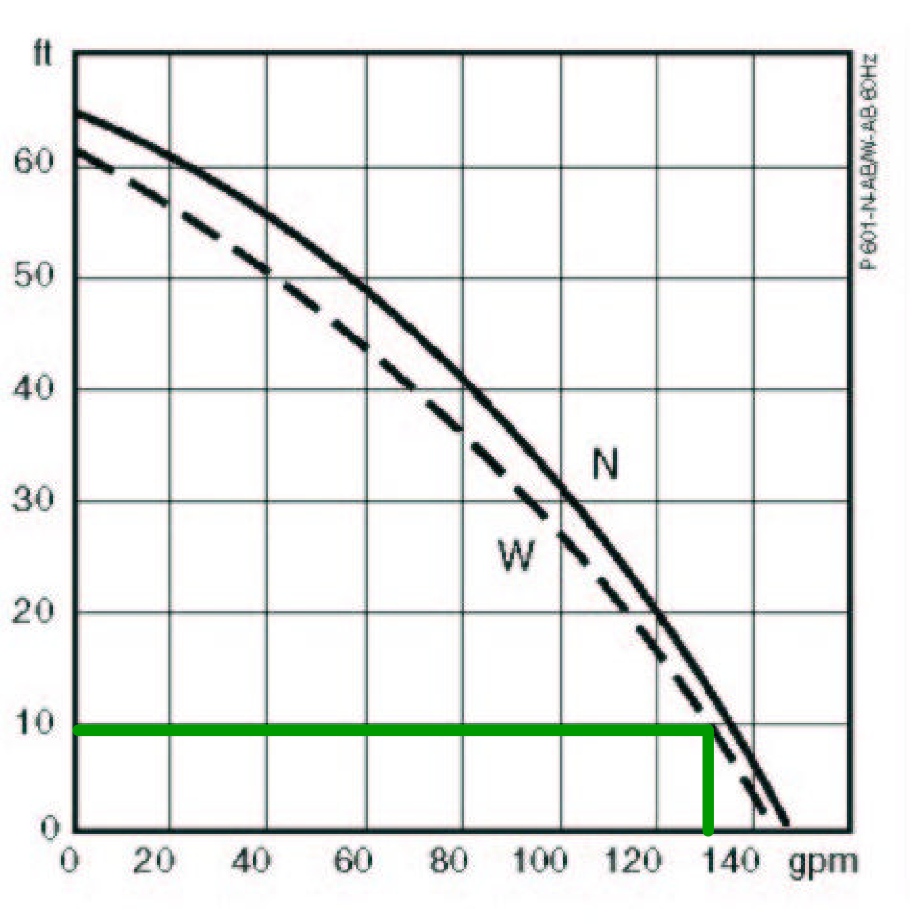
$TDH = 6.0 + 1.0 + 0.5 + 0.5 = 8.0$ ft

-TDH at Min Sump Level

$TDH = H_{stat} + H_{fric} + H_{vel} + H_{misc}$

$TDH = 7.8 + 1.0 + 0.5 + 0.5 = 9.8$ ft

Example Problem

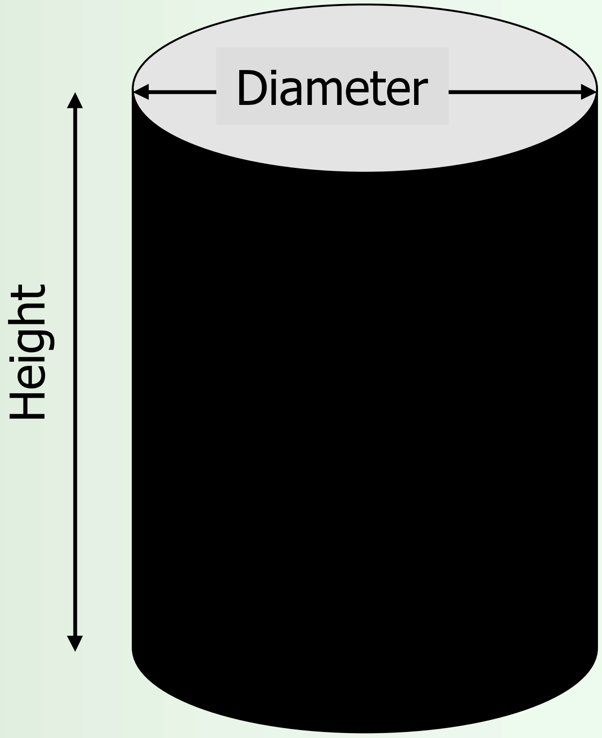


Single Phase Submersible Pump

Motor Size = 1.5 hp

Minimizing Sump Volume

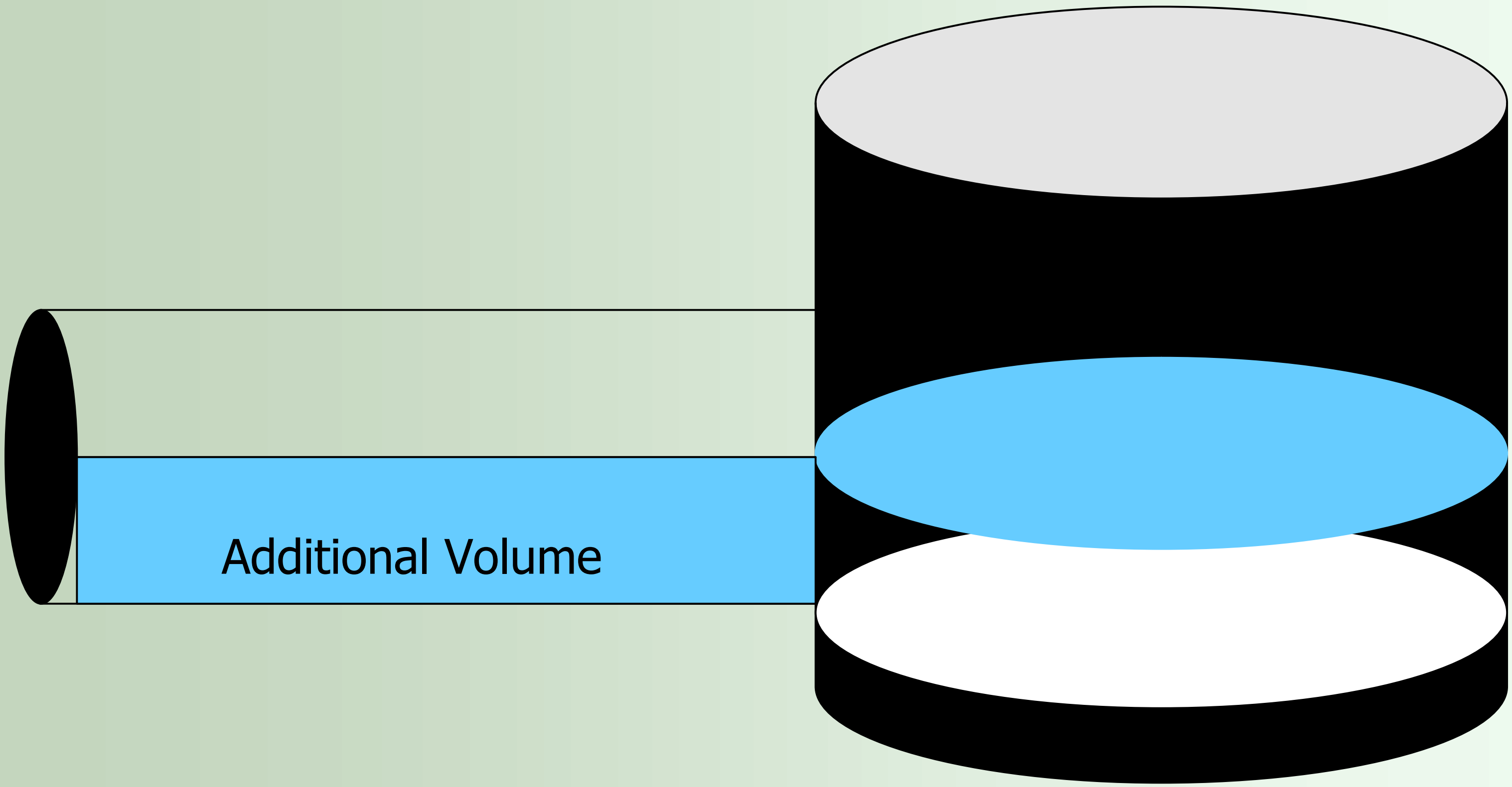
- Volume of collector pipe
- Variable Frequency Drives
- Twinned Pumps



Volume of Collector Pipe Example

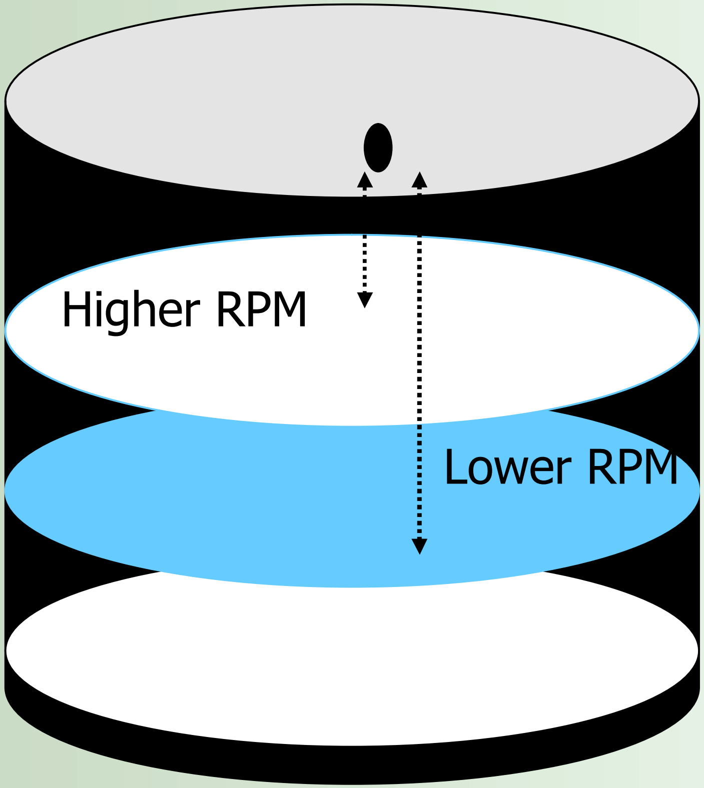
- Pump sized for max design flow
- Sump volume can be reduced by additional volume in collector pipe

For Qpump = 650 gpm a 1ft dia pipe 82 ft long can provide ½ of required (n=10)



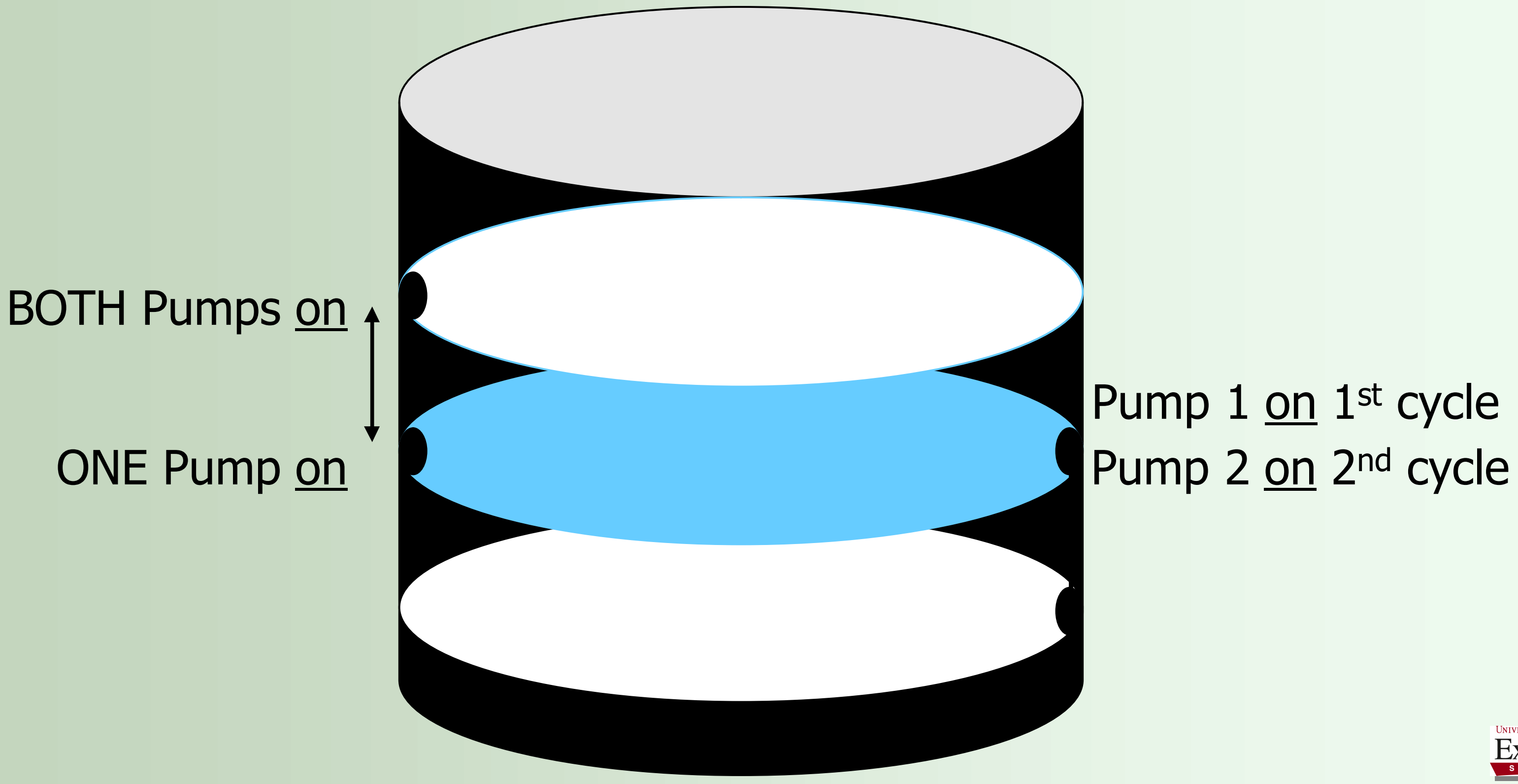
Variable Frequency Drive Example

- Pump capacity @ max RPM >= design flow; depending on risk
- Minimum volume required; only to provide for pump installation and pump or sump maintenance
- Drive can be sized for use as phase converter, if required



Twinned Pump Example

- Pump capacity = max design flow (or > 50% of max with reduced benefit)
- Operation alternates (or run together if inflow > max design flow)
- Pump cycles are increased by up to 2X for sump volume calculation, reducing the required volume by up to 50% of that for single pump
- Station will handle > max design flow (if design flow underestimated)



Examples of Pumped Outlets

Surface Drainage

Non-Submersible

Electric, Submersible

Concrete Culvert

Inside the Sump

Splitting Flow between Reservoir and Creek