Environmental Finance Center
Syracuse University

Great Lakes Environmental Infrastructure Center
Environmental Finance Center for EPA Region 5

Wastewater Lift Station Operation & Maintenance

Thursday, June 27, 2024

This program is made possible under a cooperative agreement with US EPA.

Logistics

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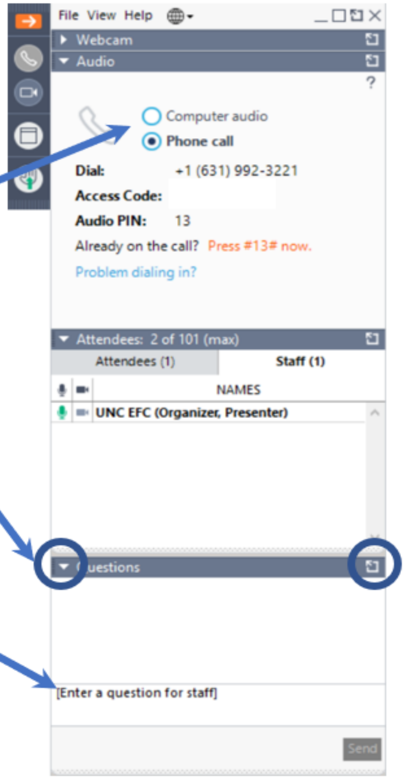

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Certificate of Completion

This session has **NOT** been submitted for pre-approval of Continuing Education Credits, but eligible attendees will receive a certificate of attendance for their personal record.

To receive a certificate:

- You must attend the entire session
- You must register and attend using your real name and unique email address - group viewing credit will not be acceptable
- You must participate in polls
- Certificates will be sent via email within 30 days

If you have questions or need assistance, please contact smallsystems@syr.edu.

EFCN
environmental finance center network

About Us

The **Environmental Finance Center Network (EFCN)** is a university- and non-profit-based organization creating innovative solutions to the difficult how-to-pay issues of environmental protection and water infrastructure.

The EFCN works collectively and as individual centers to address these issues across the entire U.S, including the 5 territories and the Navajo Nation. The EFCN aims to assist public and private sectors through training, direct professional assistance, production of durable resources, and innovative policy ideas.

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Great Lakes Environmental Infrastructure Center

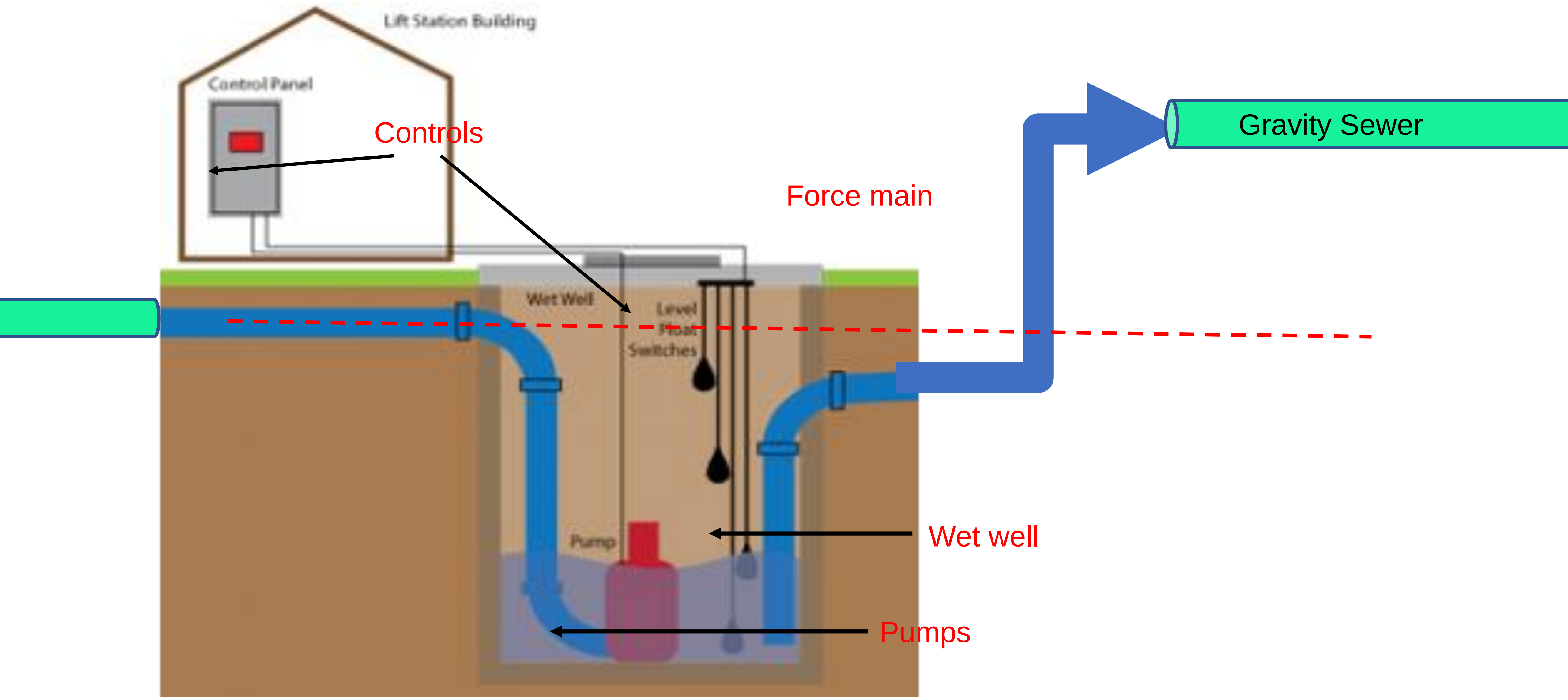
Environmental Finance Center for EPA Region 5

Serves small communities (population of less than 10,000) throughout EPA Region 5: Indiana, Illinois, Michigan, Minnesota, Ohio, Wisconsin, and 35 federally recognized American Indian governments.

Training, Research, and Technical Assistance to increase technical, managerial, and financial capacity (TMF) of utilities. Focus areas: Asset management, infrastructure funding, & financial management.

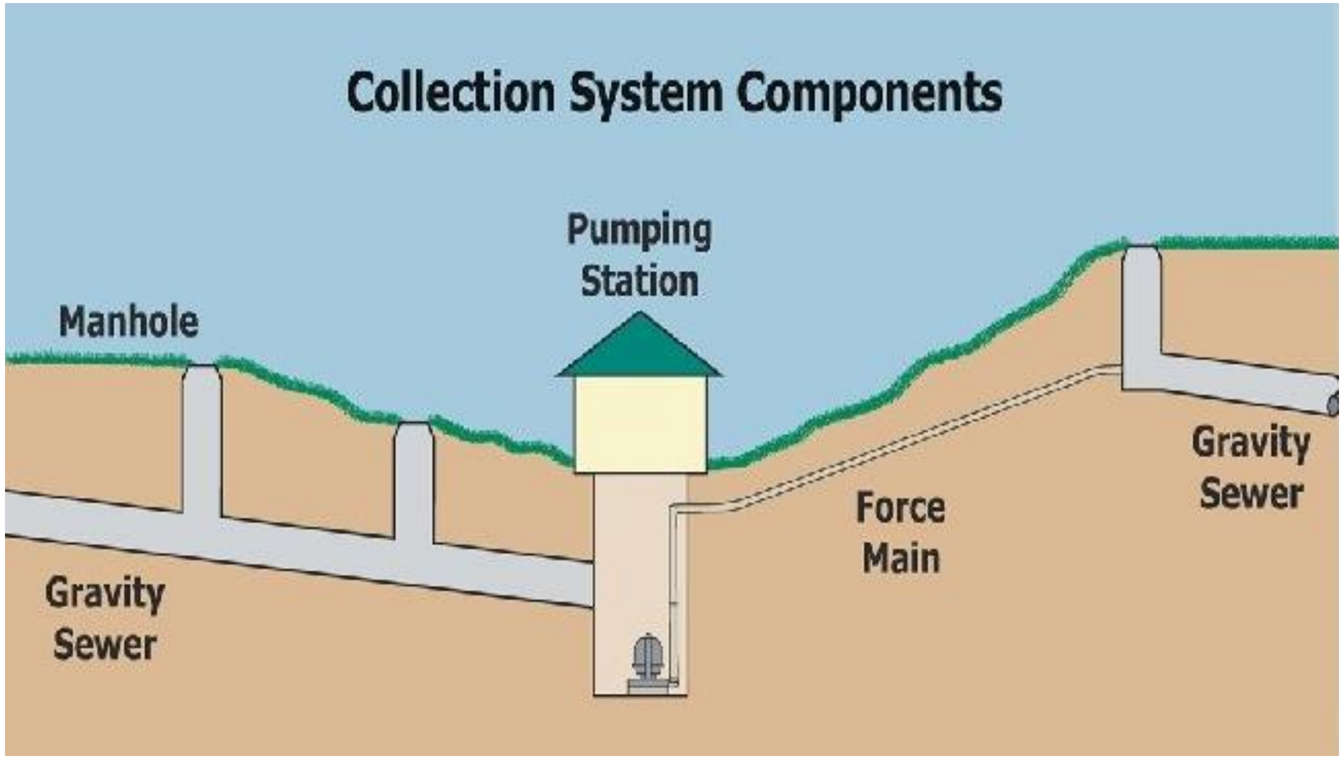
Greg Pearson, MBA Water & Wastewater Systems Trainer

Wastewater lift stations are facilities designed to move wastewater from lower to higher elevation through pipes.



Other reasons to install lift stations

- Installation costs too high for gravity flow with a velocity (2.5 fps)
- Soil stability is unsuitable for gravity sewer construction.
- Groundwater table is too high for installing deep sewer pipe.
- Wastewater flows are not sufficient to justify extension of large truck sewers



Advantages

1. Avoids costly excavation and construction
2. Can convey the same flow using smaller pipeline size at shallower depth.

Disadvantages

- If the power supply is interrupted, it can result in flooding upstream of the lift station and Sanitary Sewer Overflows (SSOs)
- Requires emergency backup equipment
- Creates hazards for operators

BASIC TYPES OF LIFT STATIONS

- Wet Well
- Dry Well

Direct Inline Pumping (DIP) System

- Special impeller design that reverses direction when clogging is sensed.

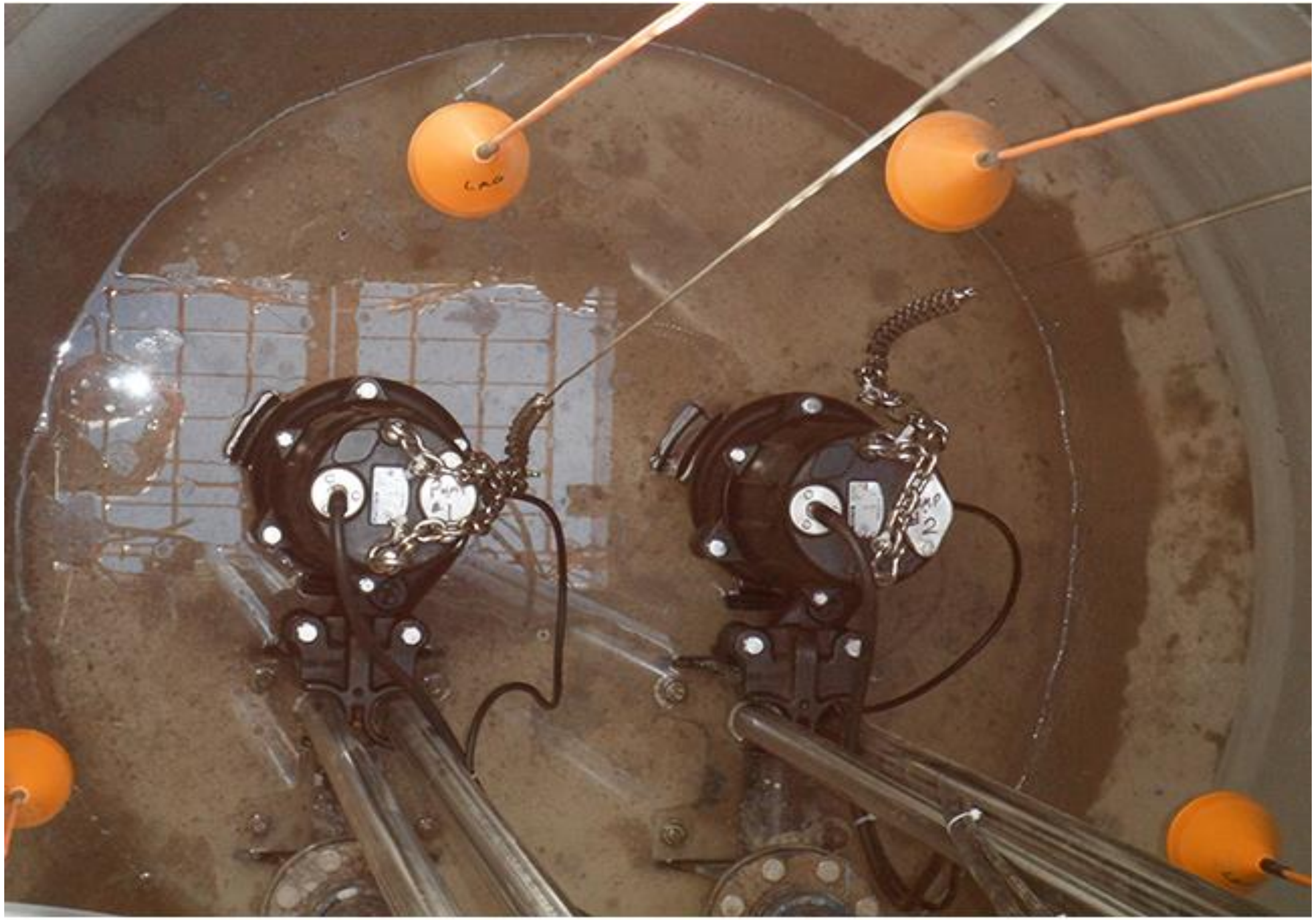
- One check valve and smaller footprint.

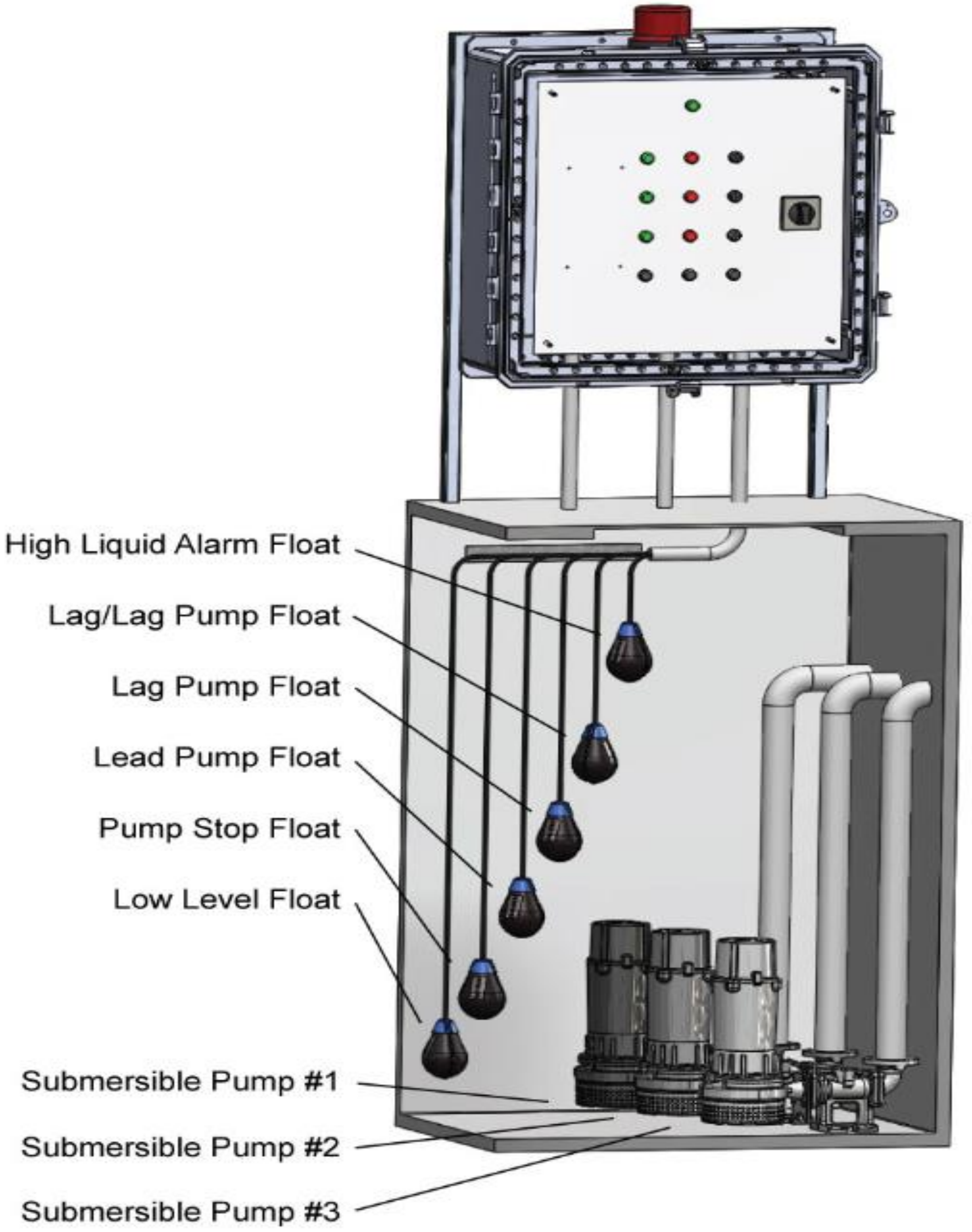
- No wet well.

Duplex pump installation

Two pumps in the lift station provides redundancy

The pumps are alternated as the lead and lag pump.



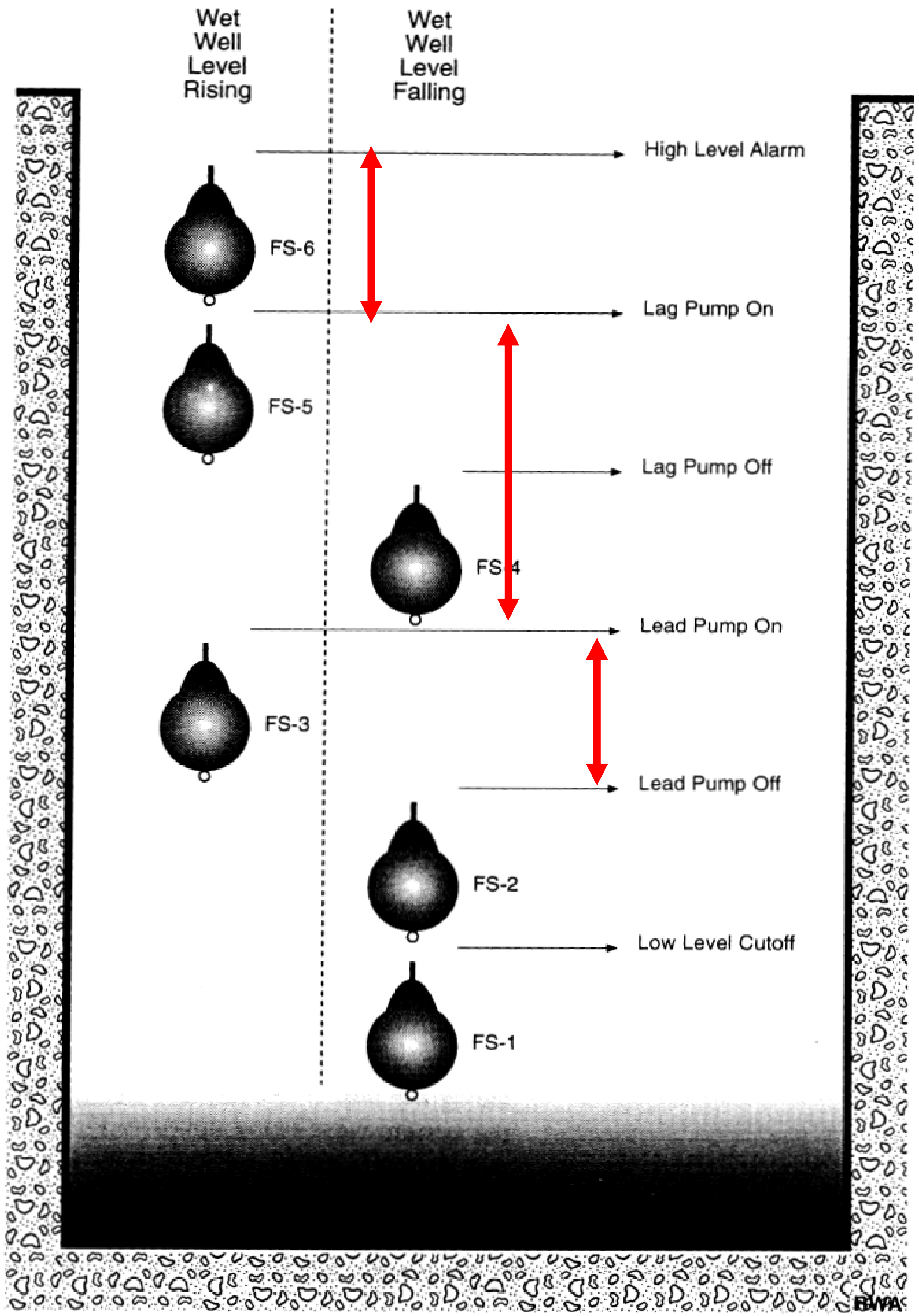

High Liquid Alarm Float
Lag/Lag Pump Float
Lag Pump Float
Lead Pump Float
Pump Stop Float
Low Level Float
Submersible Pump #1
Submersible Pump #2
Submersible Pump #3

Design Parameter Examples

High level alarm - 6" above lag pump minimum

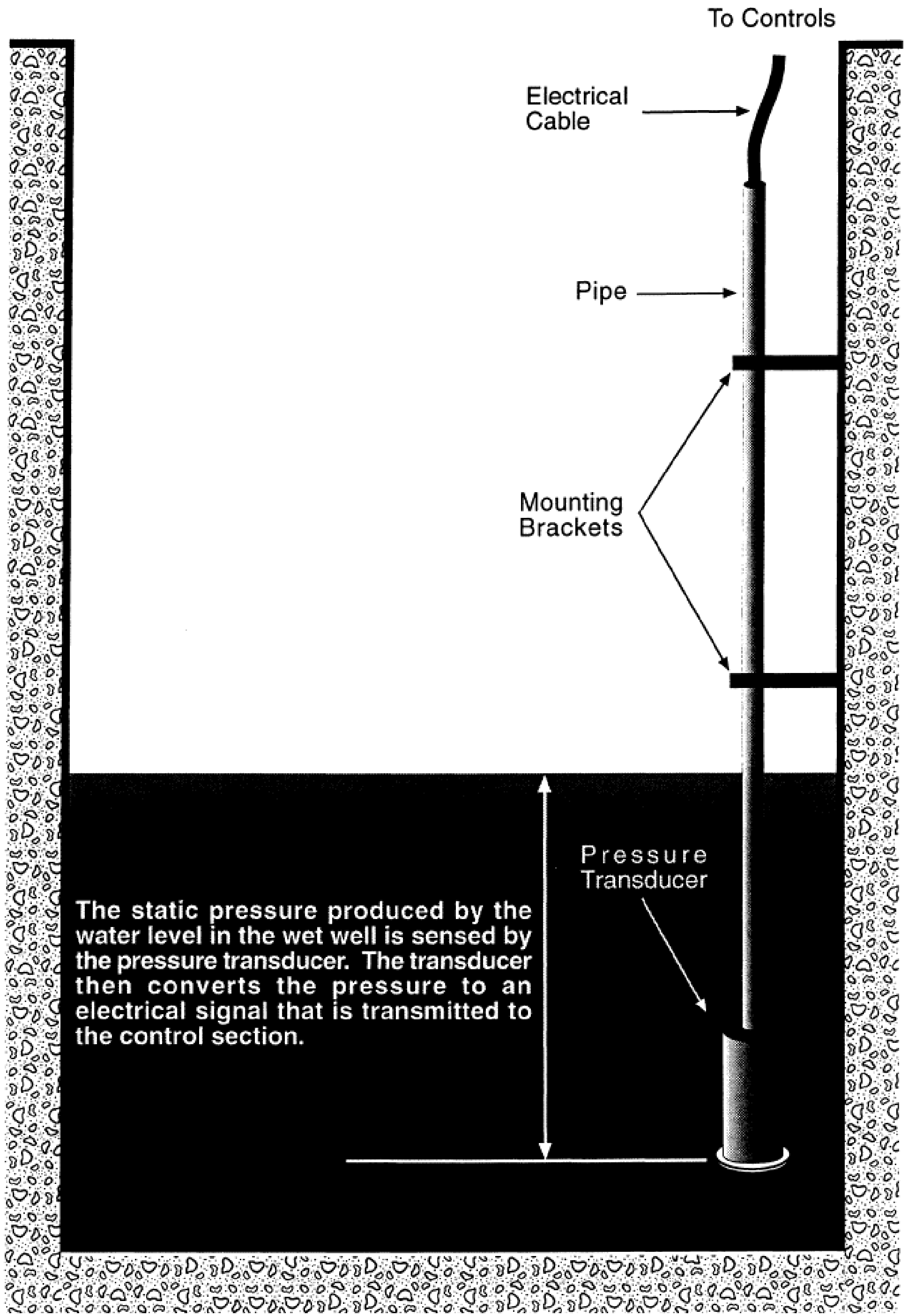
lag pump on – 12" above lead pump- minimum

lead pump on – set to handle normal flows at an acceptable cycling rate (max starts per hour)



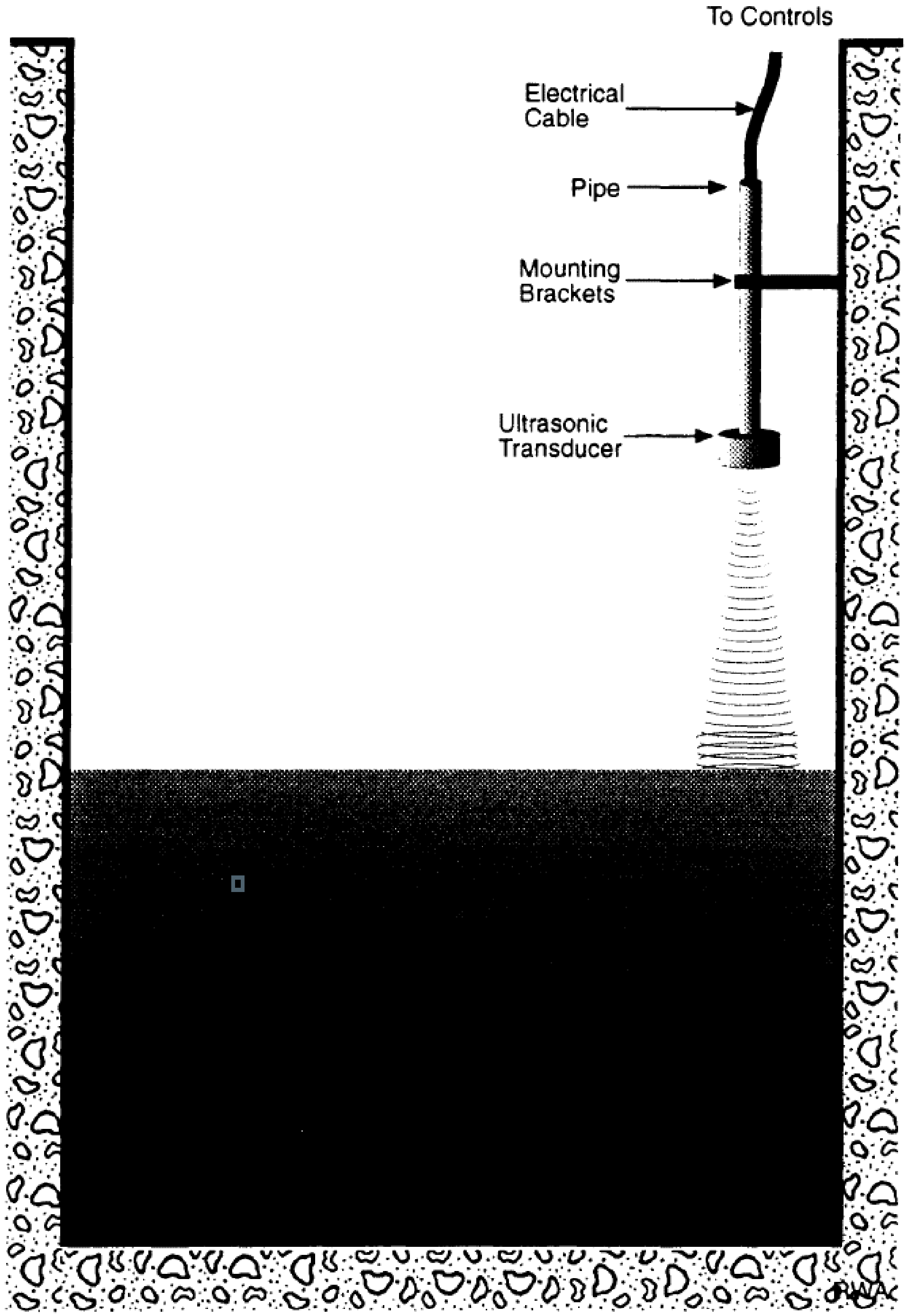
Lift Station Floats. Basic Wastewater Collection Systems. Minnesota Pollution Control Agency. (1995)

Pressure transducer for level and pump control.

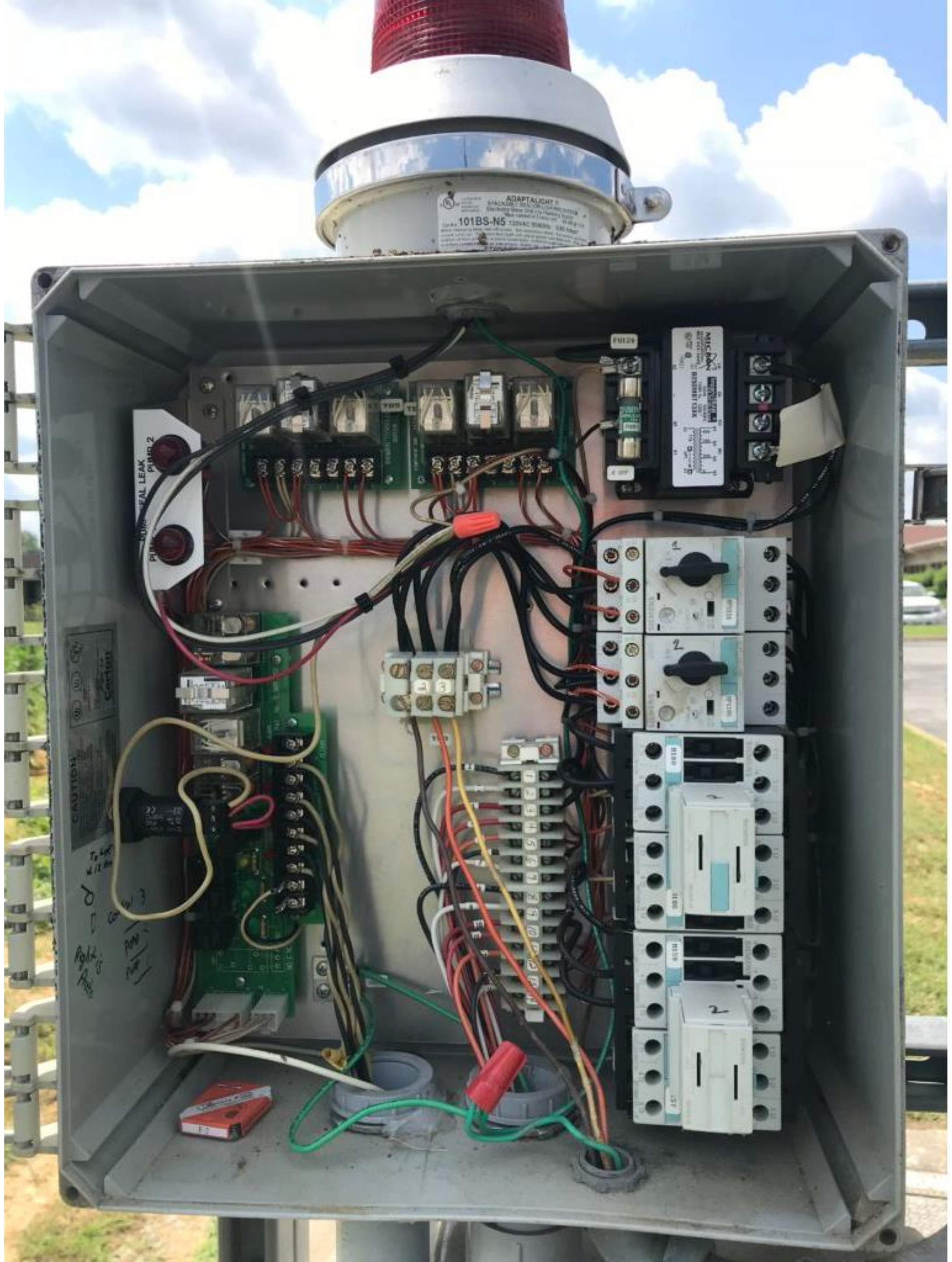


Transducer level sensor. Basic Wastewater Collection Systems. Minnesota Pollution Control Agency. (1995)

Ultrasonic transducer level and pump control



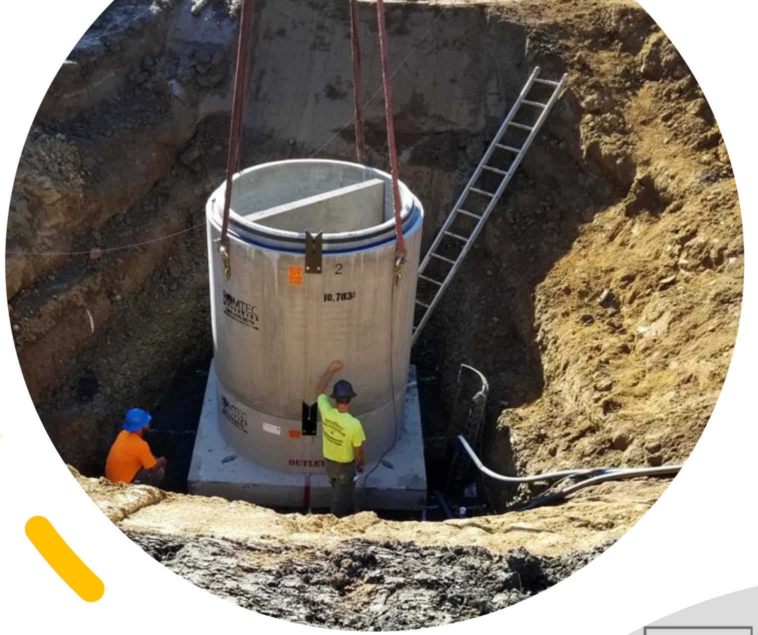
Ultrasonic level sensor. Basic Wastewater Collection Systems. Minnesota Pollution Control Agency. (1995)

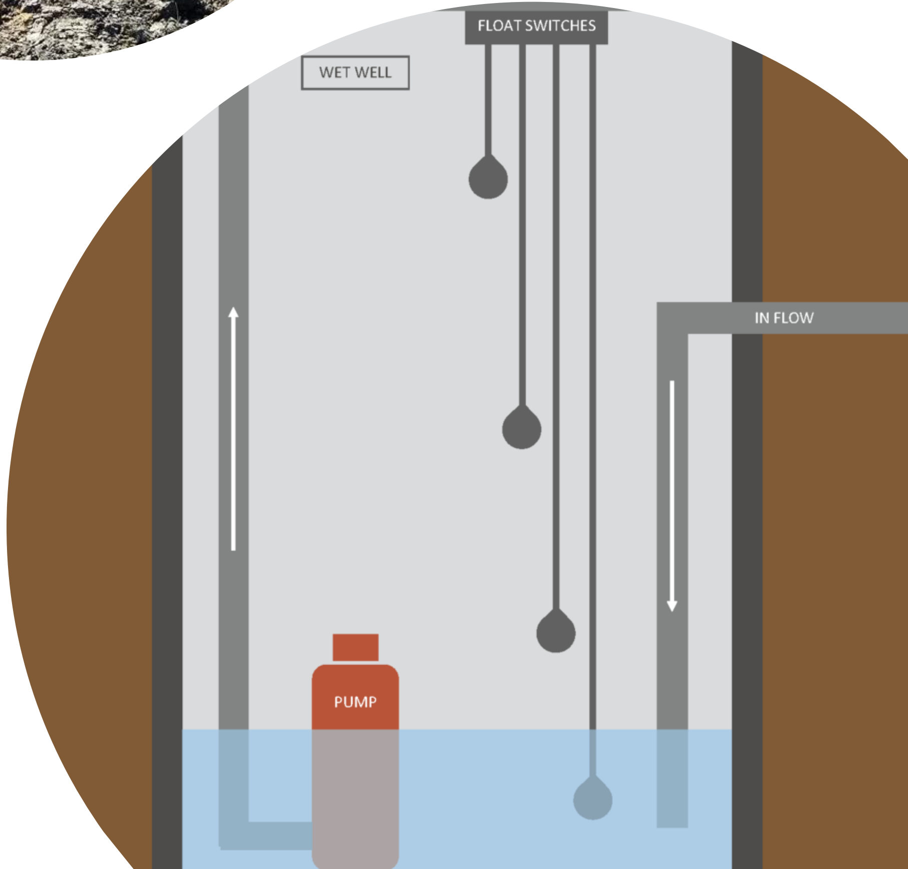


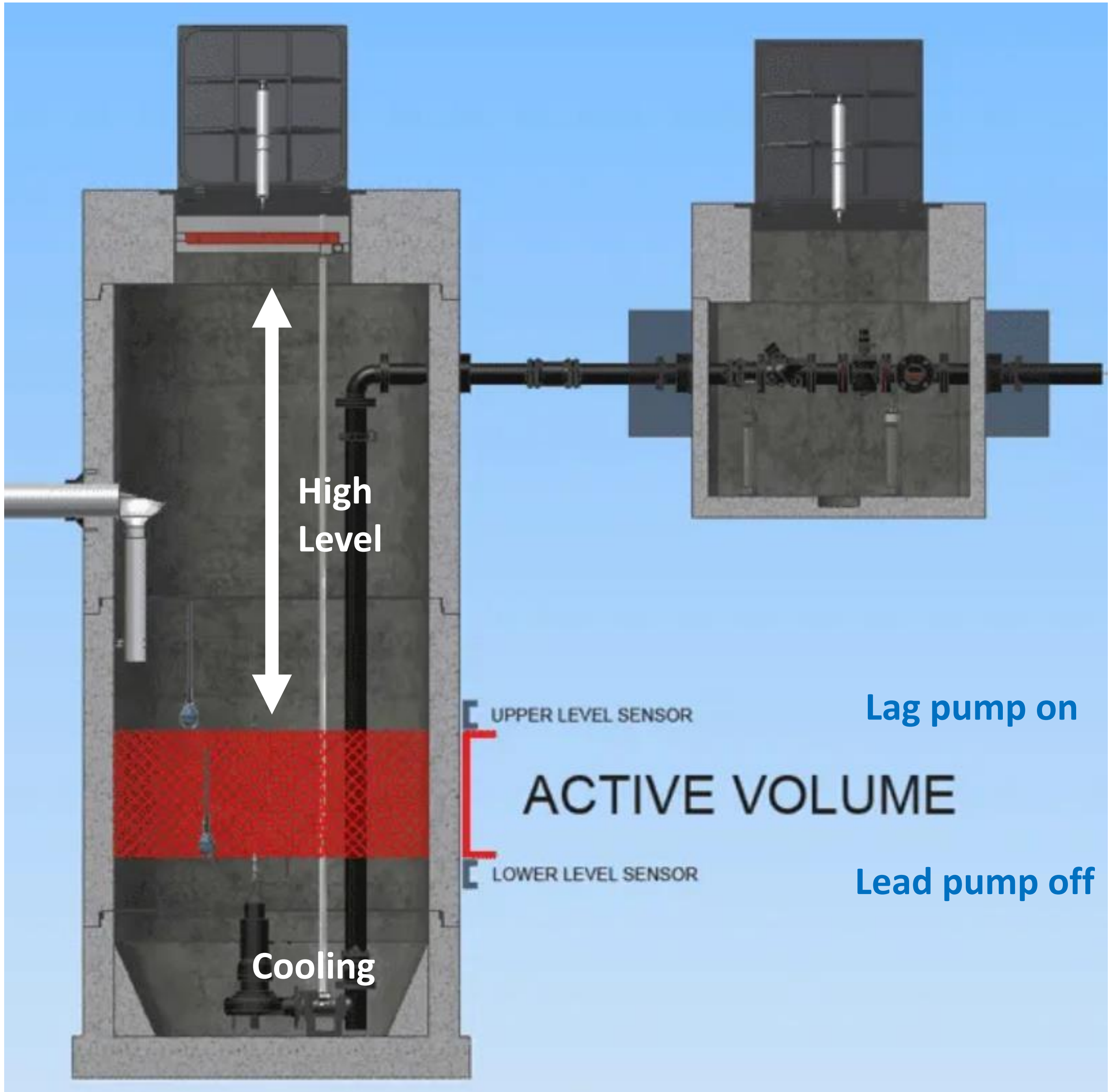
Stamie E. Lyttle C. https://www.lyttleco.com/uncategorized/pump-station-inspection-and-maintenance-our-30-point-report/

Size of wet well concepts

- Prevent rapid pump cycling while avoiding long detention time.
- Wet-well maximum detention time is typically 20 to 30 minutes.
- Use of variable frequency drives can lower wet-well detention times to 5 to 15 minutes.





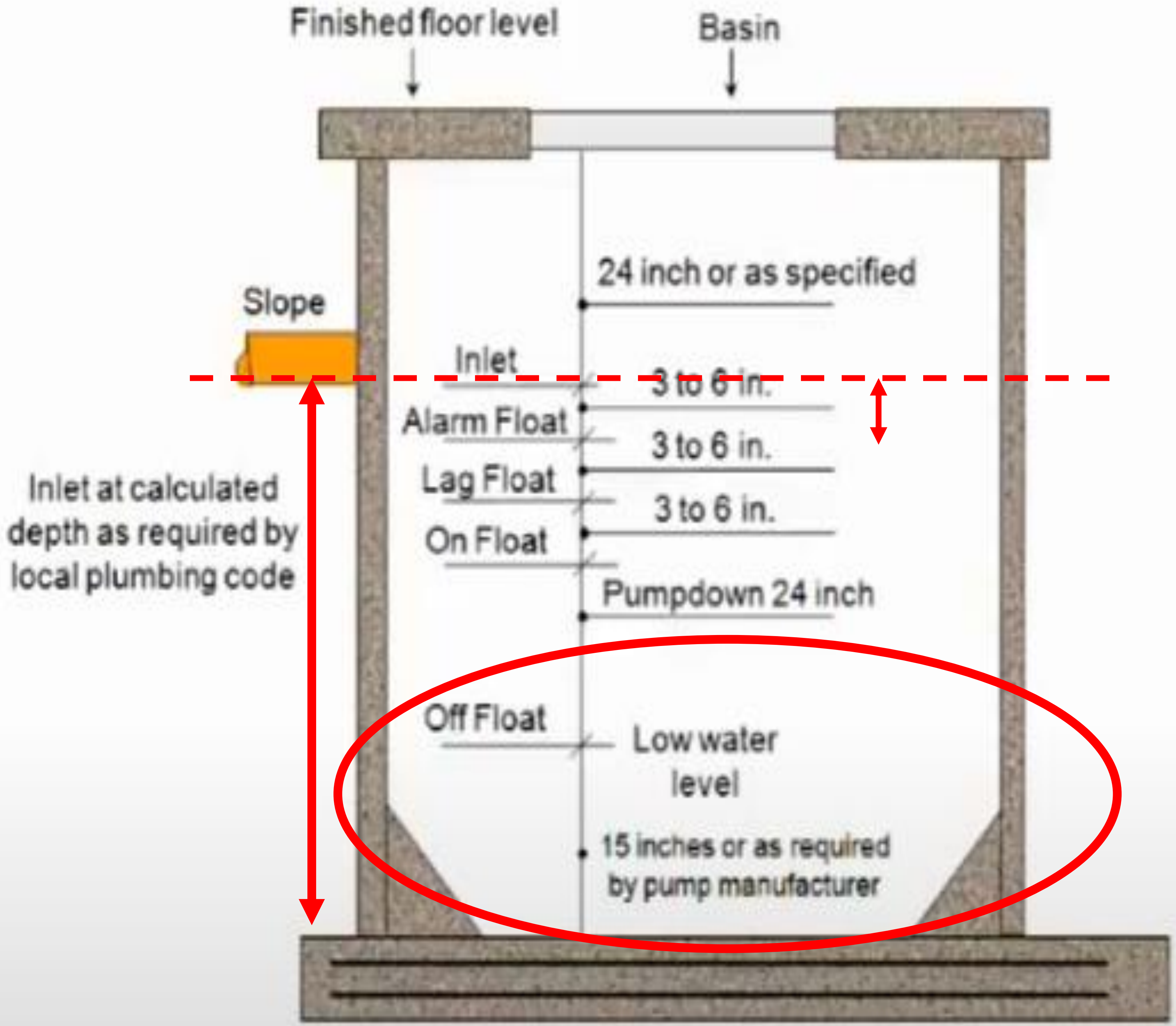


Active Volume – distance between the lead pump off and lag pump start levels

Design factors include –

- expected flows,
- Safety factor for peak flows and I&I
- maximum number of pump starts per hour allowable (6 to 10 starts per hour)

Pumping rate also depends on diameter of wet well

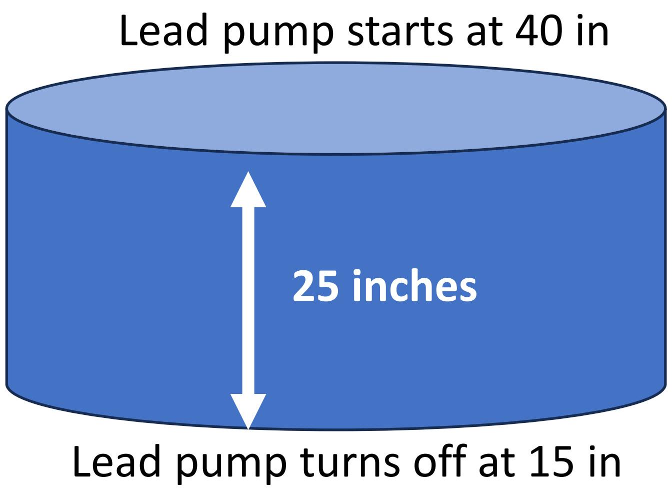


Finished floor level
Basin
24 inch or as specified
Slope
Inlet
3 to 6 in.
Alarm Float
3 to 6 in.
Lag Float
3 to 6 in.
On Float
Inlet at calculated depth as required by local plumbing code
Pumpdown 24 inch
Off Float
Low water level
15 inches or as required by pump manufacturer

Calculating volume

The lead pump for a lift station is designed to come on when the liquid level is 40 inches and turn off when the liquid level is 15 inches.

If the wet well is 6 feet in diameter, how many gallons are pumped in one cycle of the lead pump?



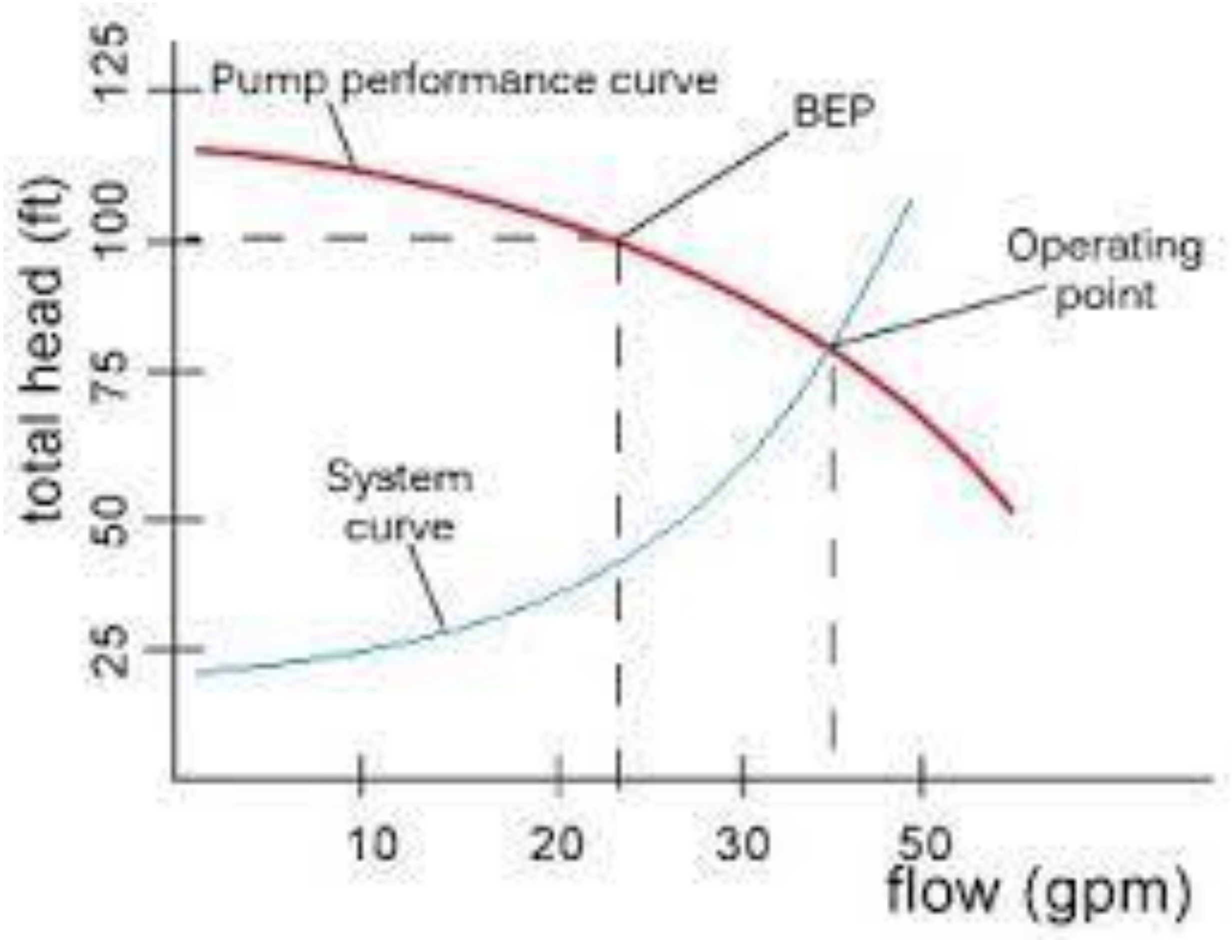
Volume = D x D x 0.785 x H x 7.48 gal/cf

Volume = 6ft x 6ft x 0.785 x [25/12] ft x 7.48 gal/cf
= **440.4 gallons**

Pumping rate for 6 starts per hour, and pump run time of 5 minutes (half the time)
440.4 gallons ÷ 5 min = 89 gallons per minute

General design parameters

- Average inflow and peak flow (gpm) coming into lift station
- Total Dynamic head requirements will be used to select pump.
- Flow velocity needs to be at least 2 feet per second (2fps)
- Comparison of pump performance curves to system curves (head and flow)



Calculating minimum flow for a 4-inch force main

Flow (cfs) = Area (ft²) x Velocity (fps)

Area of a 4-inch pipe in ft²

Area = Diam x Diam x 0.785

0.33 ft x 0.33 ft x 0.785 = **0.0855 ft²**

Minimum flow velocity = 2.0 fps

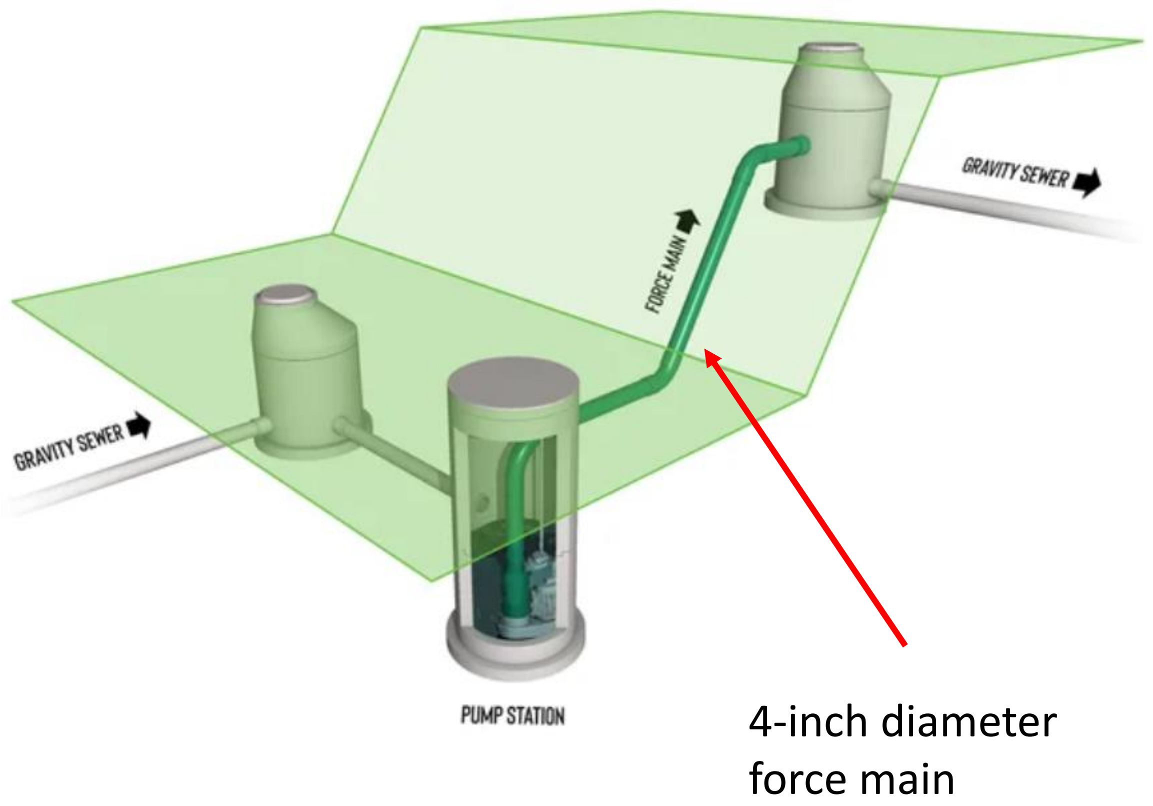
Minimum flow for 2 fps in 4-inch pipe in cfs

Flow (cfs) = Area (ft²) x Velocity (fps)

Flow (cfs) = 0.0855 ft² x 2.0 fps = **0.171 cfs**

Convert from CFS to gpm

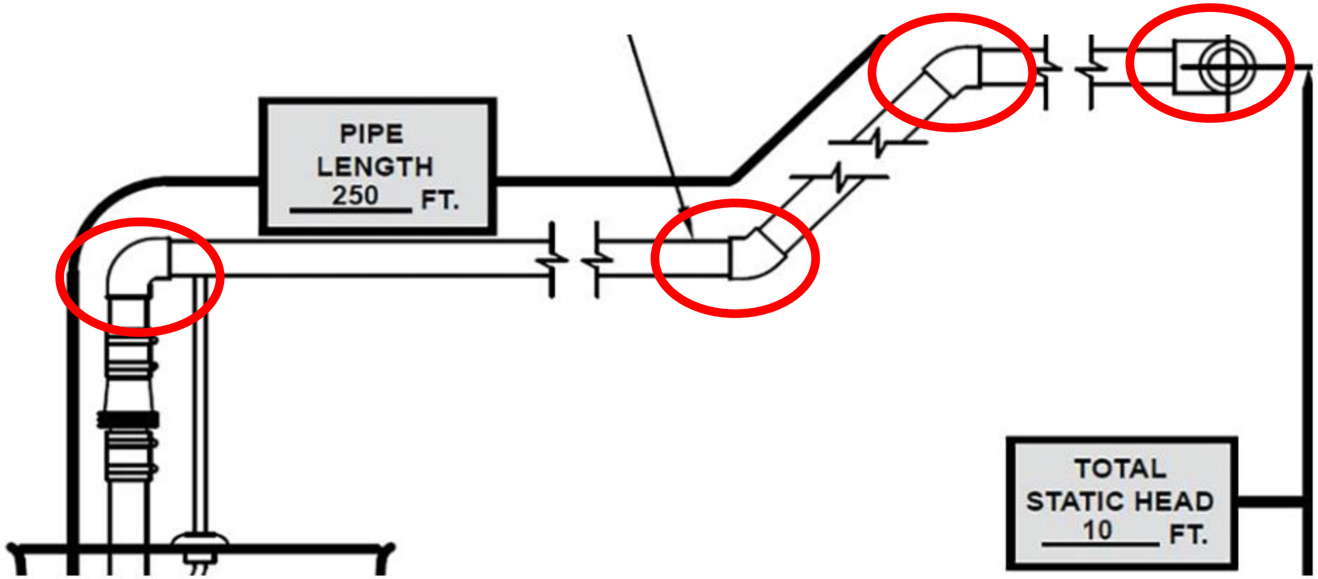
0.171 cfs x 60sec/min x 7.48 gal/c.f. = **76.7 GPM**



Fittings add resistance equivalent to a length of pipe (friction head).

	Nominal pipe size												
Fitting	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	6"	8"	10"	12"
90° elbow	1.6	2.1	2.6	3.5	4.0	5.2	6.2	7.7	10.1	15.2	20.0	25.1	29.8
45° elbow	0.8	1.1	1.4	1.8	2.2	2.8	3.3	4.1	5.4	8.1	10.6	13.4	15.9
Tee (thru flow)	1.0	1.4	1.8	2.3	2.7	3.5	4.1	5.1	6.7	10.1	13.3	16.7	19.9
Tee (branch Flow)	3.1	4.1	5.3	6.9	8.1	10.3	12.3	15.3	20.1	30.3	39.9	50.1	59.7
Check valve	5.2	6.9	8.7	11.5	13.4	17.2	20.6	25.5	33.6	50.5	66.5	83.6	99.0
Gate valve (full open)	0.4	0.6	0.7	0.9	1.1	1.4	1.7	2.0	2.7	4.0	5.3	6.7	8.0

Fitting	Equiv Pipe Length
90 deg elbow	10.1 ft
(2) 45 deg elbow	10.8 ft
Check valve	33.6
Gate valve	2.7
Pipe length	250 ft
Total	**307.2**



Feet Of Head Per 100 Ft. of Plastic Pipe

GPM	Pipe Diameter										
	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"	5"	6"
1	2.08	0.51									
2	4.16	1.02	0.55	0.14	0.07						
5	23.44	5.73	1.72	0.44	0.22	0.066	0.038	0.015			
7	43.06	10.52	3.17	0.81	0.38	0.11	0.051	0.021			
10	82.02	20.04	6.02	1.55	0.72	0.21	0.09	0.03			
15		42.46	12.77	3.28	1.53	0.45	0.19	0.07			
20		72.34	21.75	5.59	2.61	0.76	0.32	0.11	0.03		
25			32.88	8.45	3.95	1.15	0.49	0.17	0.04		
30			46.08	11.85	5.53	1.62	0.68	0.23	0.06	0.02	
35				15.76	7.36	2.15	0.91	0.31	0.08	0.03	
40				20.18	9.43	2.75	1.16	0.40	0.11	0.03	
45				25.10	11.73	3.43	1.44	0.50	0.13	0.04	
50				30.51	14.25	4.16	1.75	0.60	0.16	0.05	0.02
60					19.98	5.84	2.46	0.85	0.22	0.07	0.03
70						7.76	3.27	1.13	0.30	0.10	0.04
75						8.82	3.71	1.28	0.34	0.11	0.05
80						9.94	4.19	1.44	0.38	0.13	0.05
90						12.37	5.21	1.80	0.47	0.16	0.06
100						15.03	6.33	2.18	0.58	0.19	0.08

Example: *For 4" pipe with a flow of 100 GPM adds 0.58 feet of head for every 100 feet of pipe.*

307.2 ft* x *0.58ft./100ft* = *1.78 ft

Force main is constructed of 250 linear feet of 4-inch PVC pipe. Friction head is 1.78 ft, the total vertical lift is 10 feet and discharge pressure is 40 psi. Calculate the total system head.

Total head = friction head + elevation head + discharge head

Friction head

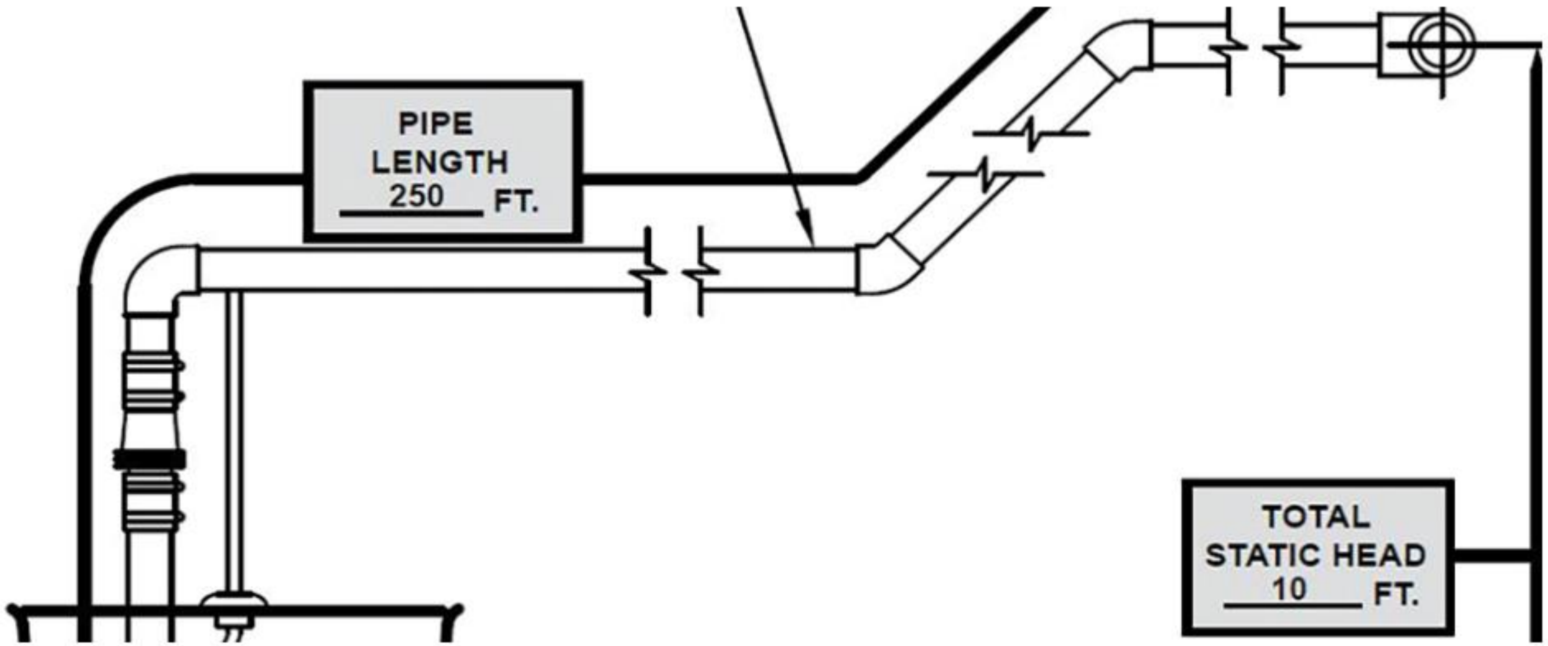
$$\frac{307.2 \text{ feet} \times 0.58}{100 \text{ feet}} = 1.78 \text{ ft}$$

Elevation head = 10 ft

Discharge pressure head

40 psi x 2.31 ft/psi =92.4 **ft**

Total System Head = 104.2 ft



PUMP HORSEPOWER

Pump motor horsepower can be calculated using the following three values:

- The pump flow in gallons per minute. (100 gpm)
- The pumping head in feet, and (104.2 ft)
- The efficiency of the pump and motor. (70%)

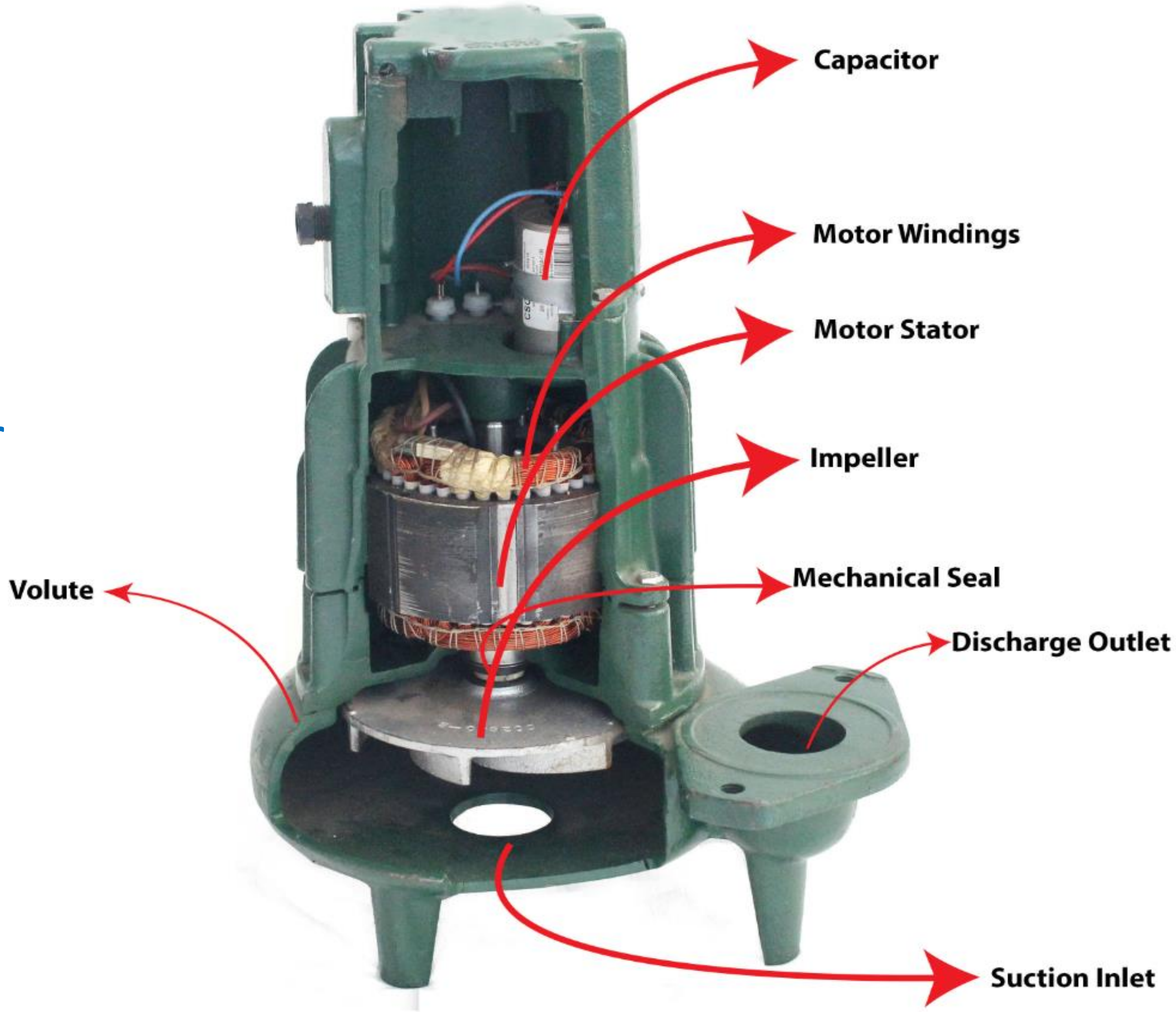
Motor Horsepower calculation

$$HP = \frac{\text{Flow (GPM) x Head (Ft.)}}{\text{3960 GPM-Ft./HP x pump eff\% x motor eff \%}}$$

$$HP = \frac{\text{100 gpm x 104.2 ft}}{3.960 \times 0.7} = \mathbf{3.8\ HP}$$

Note that normal velocities range from 2 to 5 fps – which would change horsepower requirements.

Pump inside diameter to allow the average size of waste solids to pass through. Normally 2.5 inches or larger



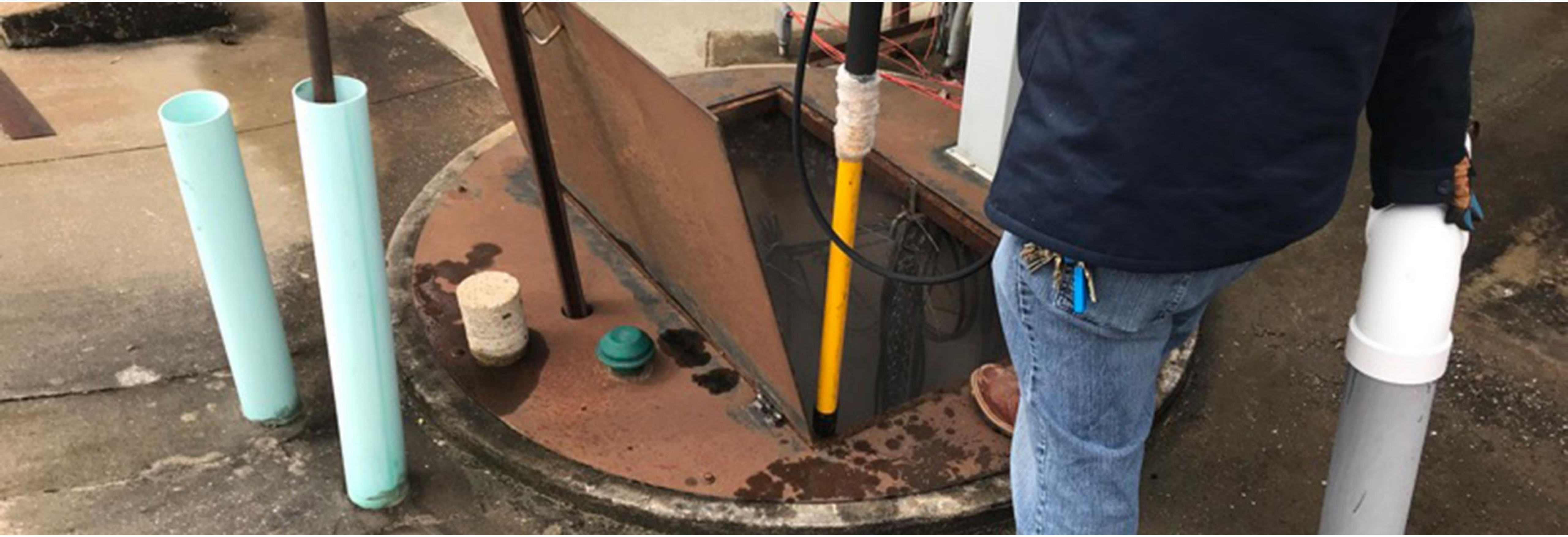
Grinder pumps can not generally handle rags, diapers, or plastics

There are a variety of designs





Testing float switches by lifting each float



Aqualis. https://www.aqualisco.com/service/life-station-maintenance-and-repair/lift-station-repairs/


PUMP 1 HOUR METER
PUMP 2 HOUR METER
480 VOLTS
COMMUNICATION FAIL

Hour meter readings

- Installation of an hour meter on each motor can provide a record of how long each pump has run, and can also indicate the amount of wastewater being pumped through the system.
- A record of the motor hours, along with dates and times when maintenance was performed should be kept.

Hand-Off-Auto (HOA) Switch

Each pump has a (HOA) switch.

The hand position (H) runs the pump (in manual mode)

The automatic position (A) runs the pump off the level sensors.

Drawdown test

A drawdown test is simply a way to periodically check the flow rate of each pump.

Each pump is operated on hand to empty a known volume of wastewater from the wet well and is timed.

$$\frac{\text{Gallons pumped}}{\text{Time in minutes}} = \textbf{Actual gpm}$$

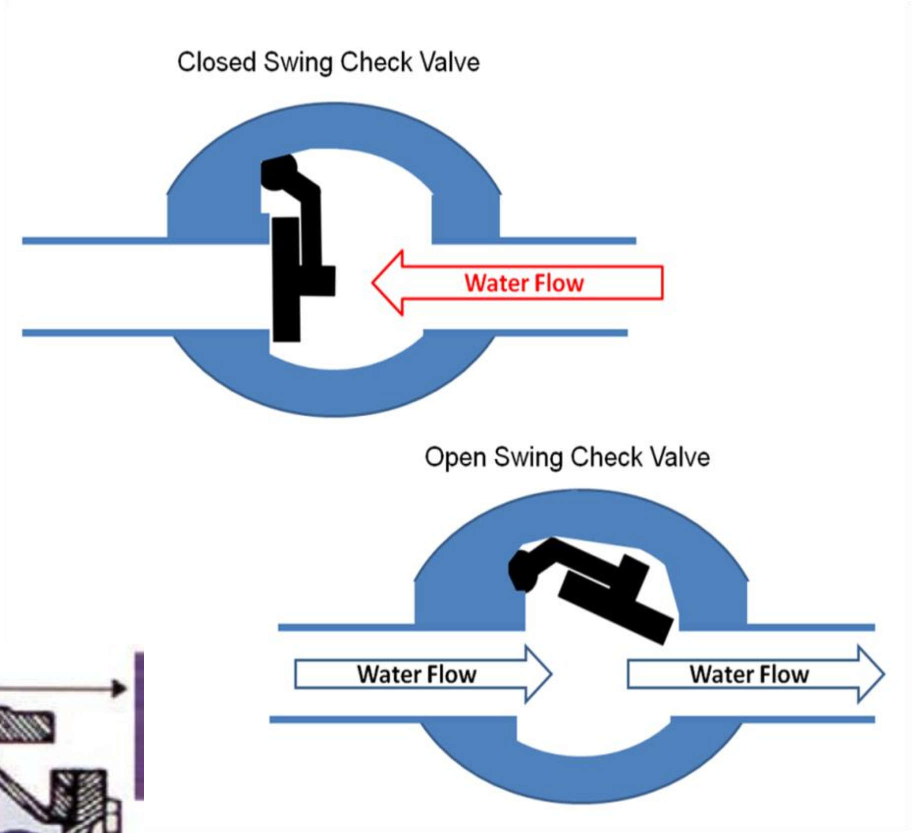
$$\textbf{Pump Efficiency \%} = \frac{\text{Actual gpm}}{\text{Rated gpm}} \times 100\%$$

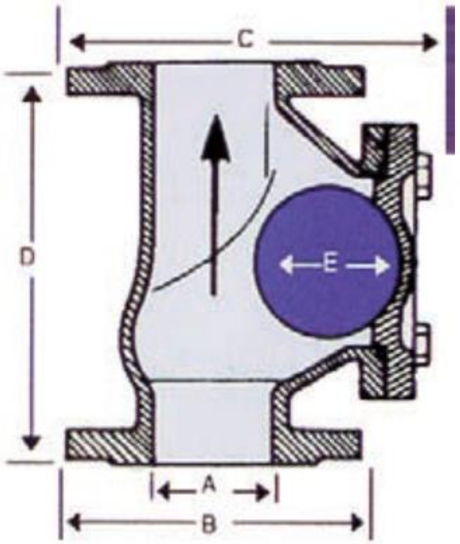
Metering

- Magnetic meters use sensors to disperse a magnetic field into the force main.
- Water atoms passing through the magnetic field, create voltage

Increased run time of lift pump – possible causes

- Partially clogged or blocked check valve allowing sewage to flow back into the lift station.
- Inflow and infiltration
- Higher water use or population increase
- Bar screens or grinders can minimize pump clogging problems.





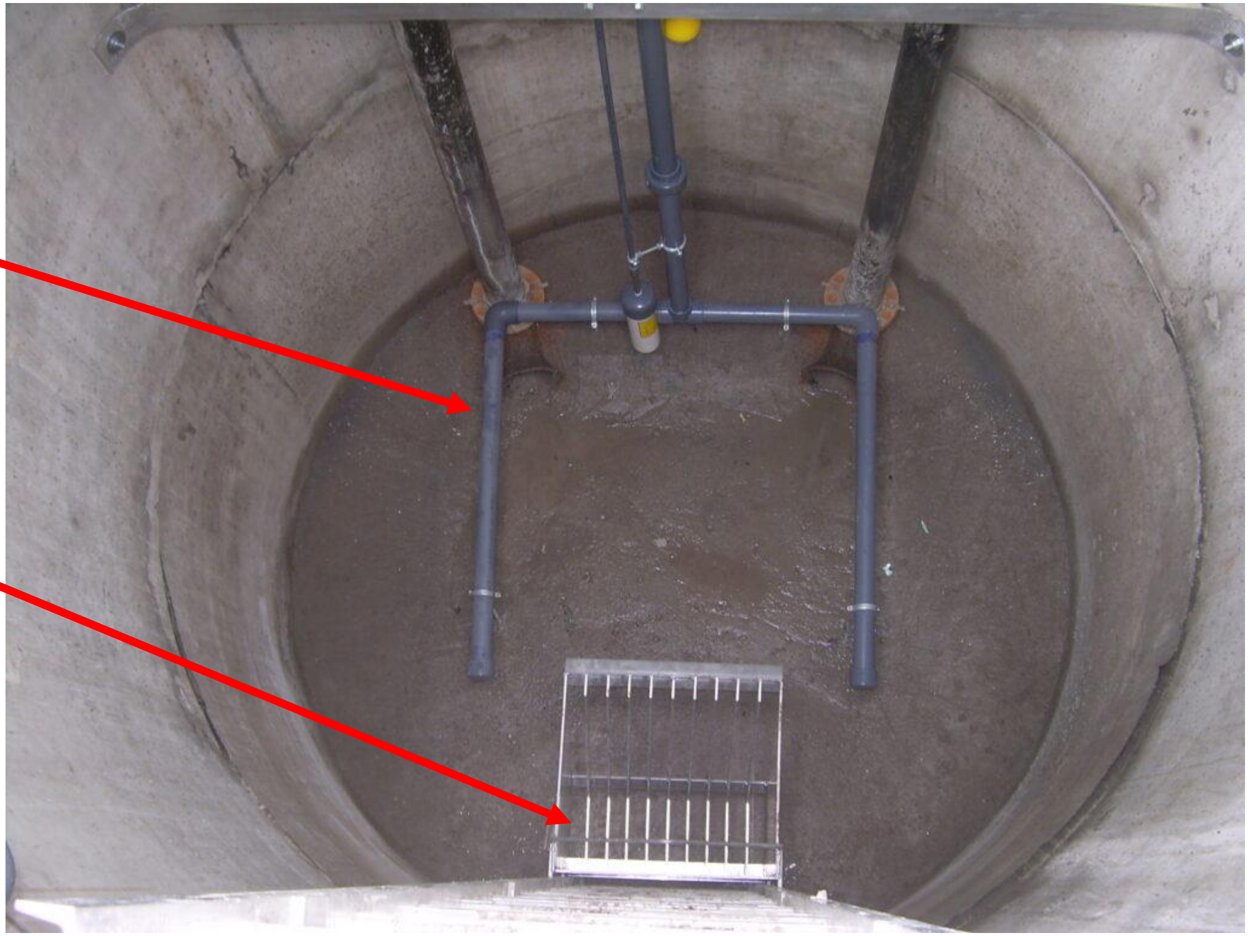
Fats, rags, oils, grease

Determine the type of problem.

a) **Wastewater solids**: grinder pumps
b) **Fats and oils**: ensure grease traps installed and clean more frequently
c) **Rags**: Bar screens, specialized pumps

Use of aeration to break up grease.

Bar screen to collect rags.



Pressure gage on wastewater force main

- Increasing pressure over time can indicate the force main, or components is becoming clogged with grease or debris and needs to be cleaned.
- Decreasing pressure can indicate a leak.

Back up Generator

Transfer switch – disconnects from grid and connects to generator.

Can be automatic or manually actuated.

Bypass pumping unit

Lift stations must have piping connections for bypass hookup

Time to spill

Knowing the rise in inches given a particular inflow rate.

Can help predict when lift stations should be pumped in an emergency situation when using a mobile unit.

Based upon diameters and depths
18" = 1.1 gallons / inch depth
24" = 2.0 gallons / inch depth
30" = 3.06 gallons / inch depth
36" = 4.4 gallons / inch depth
48" = 7.83 gallons / inch depth
60" = 12.24 gallons / inch depth
72" = 17.63 gallons / inch depth

Example: **A 36-inch diameter manhole contains a level of wastewater that is 96 inches below the maximum allowed height. The current inflow is 20 gallons per minute.**

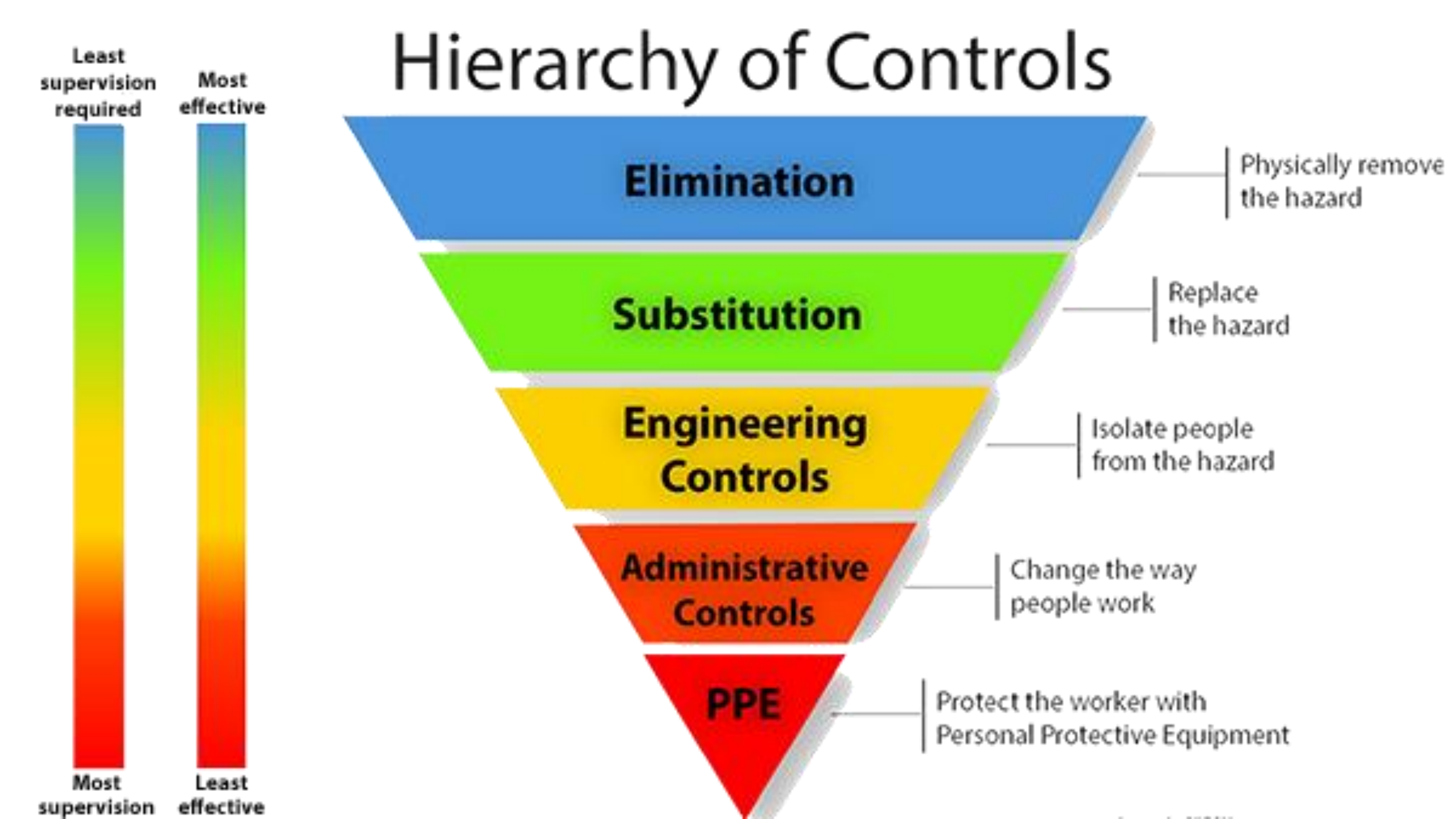
Maximum gallons before full: **4.4** gallons per inch x **96** inches = **422 gallons**
Maximum time before pumping = **422 gal ÷ 20 gpm** = **21 minutes**

Lift station safety hazards

- Insufficient Oxygen
- Explosive and toxic gases
- Poor footing caused by grease or slimes
- Unsafe ladders, stairs, and walkways
- Electrical hazards
- Inadequate drainage

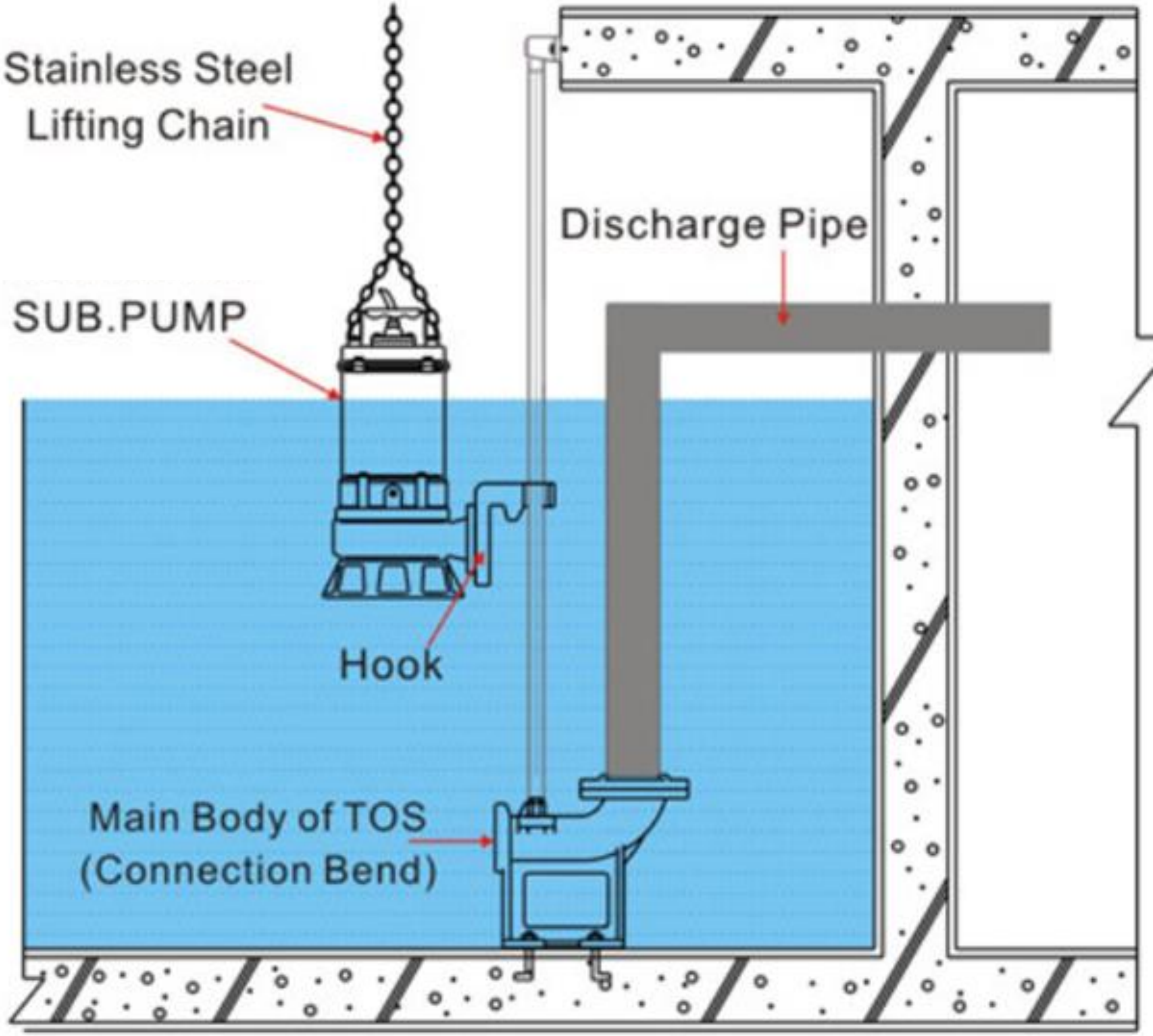
Ventilation for confined space entry

- **Ventilation required to prevent accumulation of toxic or explosive gases.**
- Dry-well ventilation codes typically require six continuous air changes per hour
- Wet-wells typically require 12 continuous air changes per hour.


Hierarchy of Controls
Least supervision required
Most effective
Most supervision
Least effective
Elimination
Substitution
Engineering Controls
Administrative Controls
PPE
Physically remove the hazard
Replace the hazard
Isolate people from the hazard
Change the way people work
Protect the worker with Personal Protective Equipment

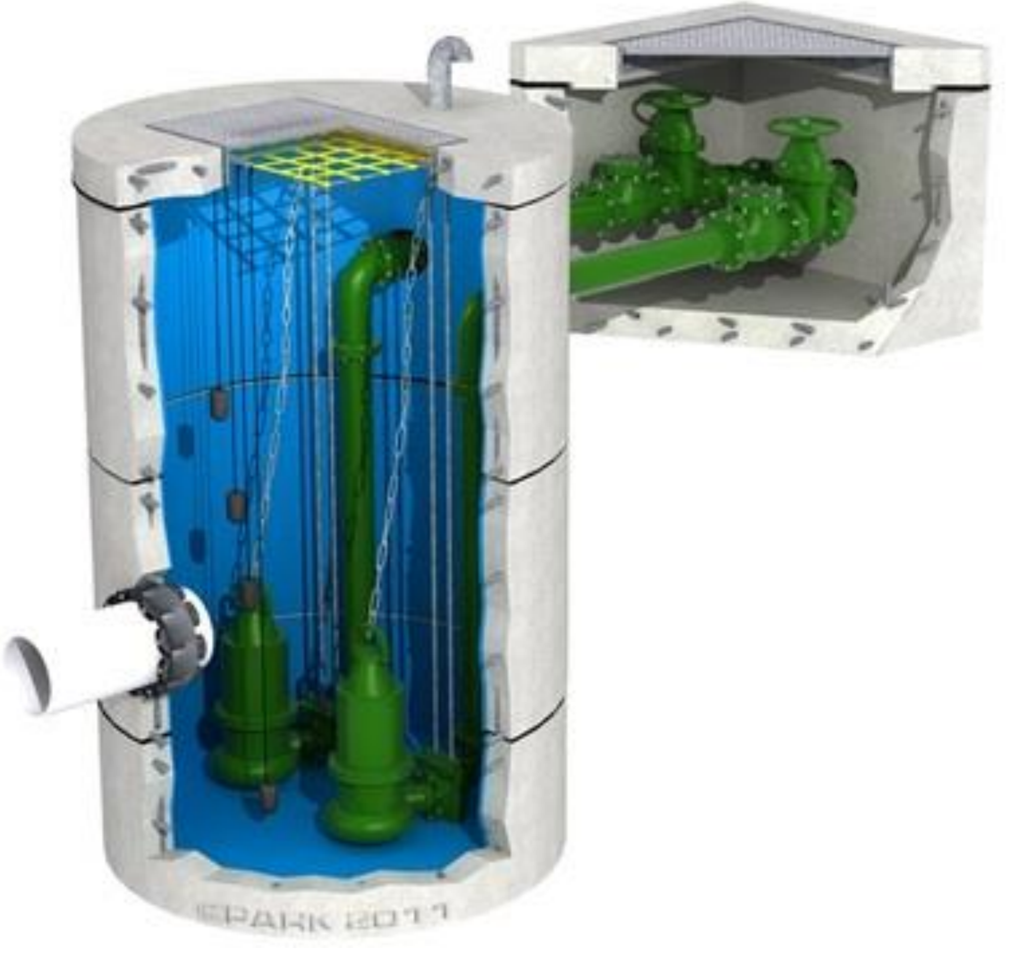
Design makes a major impact on operator exposure to hazards

Non-entry removal of submersible pumps



Wet Well – Submersibles. Basic Wastewater Collection Systems. Minnesota Pollution Control Agency. (1995)

Redesign



What can we conclude?

1. **Establish** an inspection program to monitor and assess lift stations
2. **Be proactive** in preparing for emergencies
3. **Redesign** to reduce exposure to hazards
4. **Facilitate** continued learning and infrastructure improvement

Thank you for participating

Share 1 thing you enjoyed learning about today in the chat

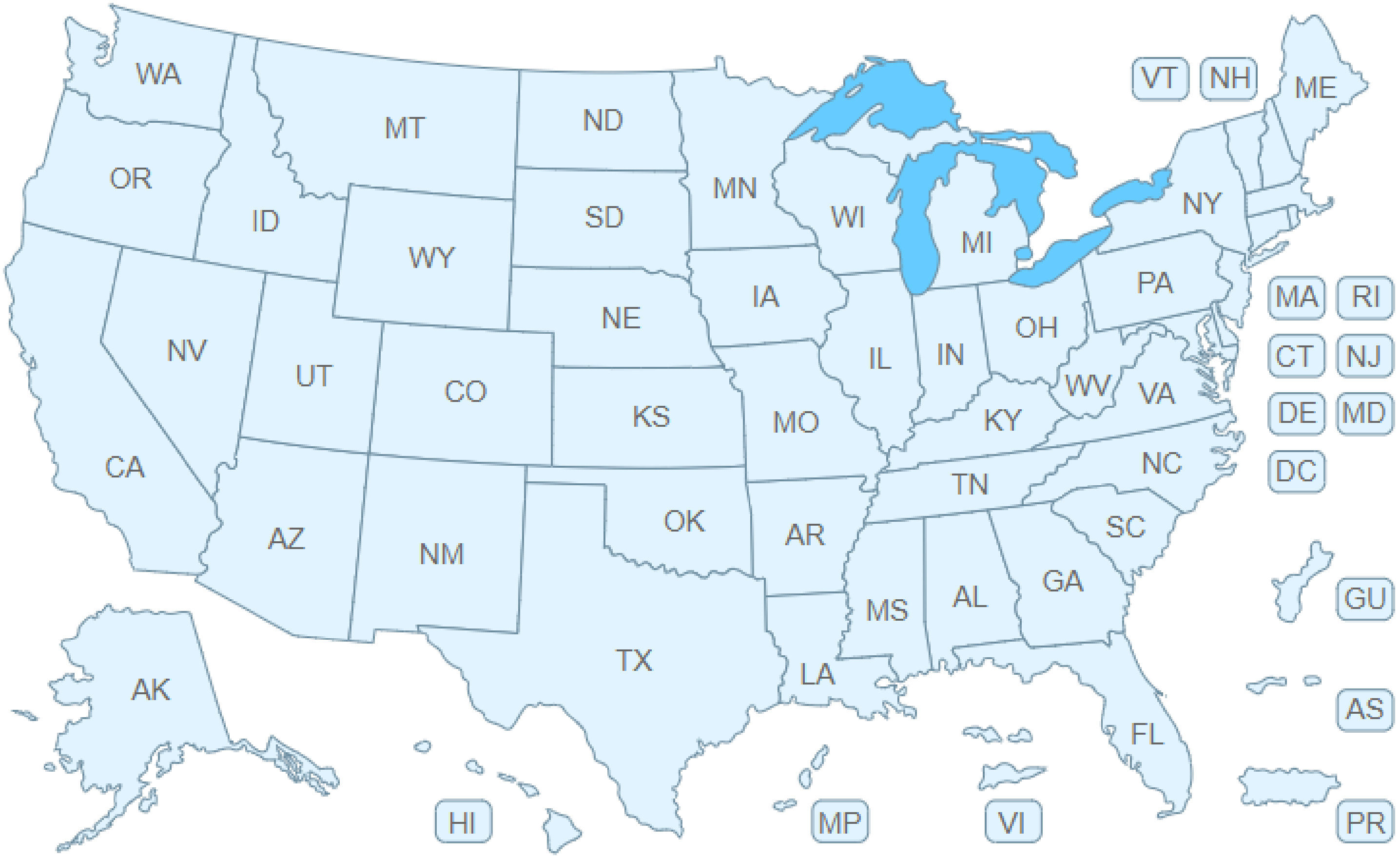
We're now open for questions

EFCN Funding Sources by State or Territory

https://efcnetwork.org/resources/funding-tables/

Provides

- Current loan and grant programs
- Eligibilities and terms
- Contact information



Contacts

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