Wastewater Pumps: Basics, Sizing, Rules of Thumb

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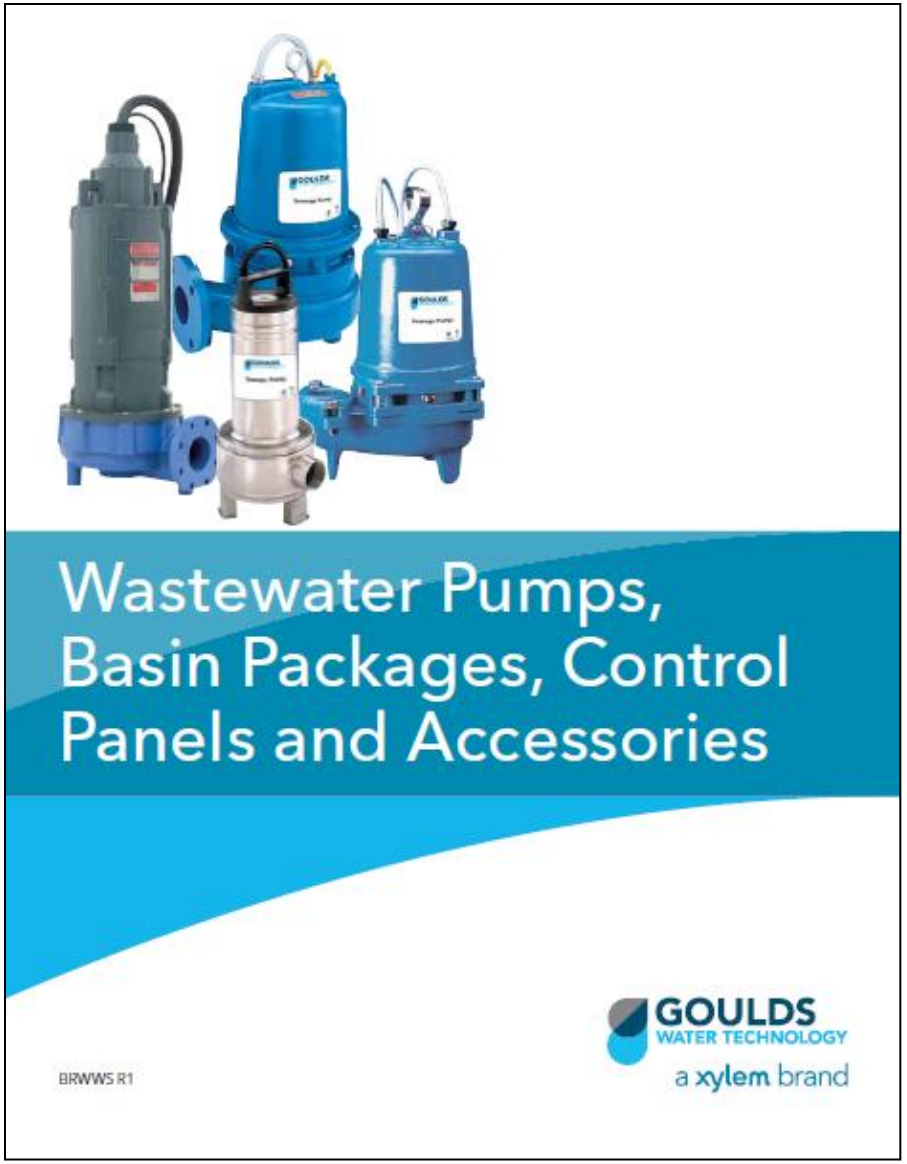
GOULDS WATER TECHNOLOGY
a xylem brand

Wastewater Fundamentals



Wastewater System

The function is to receive and collect “used water”, store it temporarily and move it to a collection system.

Wastewater pumps are designed to handle effluent with some solids; not solids with some effluent in it.

How a wastewater pump works

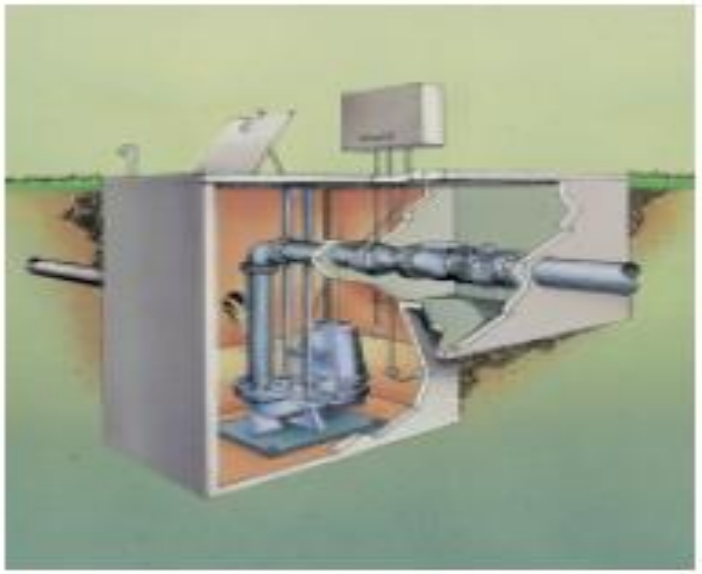
The wastewater pump is a centrifugal pump consisting of a rotary impeller working inside a stationary casing or volute. Its job is to pump wastewater uphill to a collection or receiving station.

The pump motor turns the impeller which transfers velocity to the liquid which surrounds it. This liquid is collected by the casing and directed to the discharge nozzle of the pump.

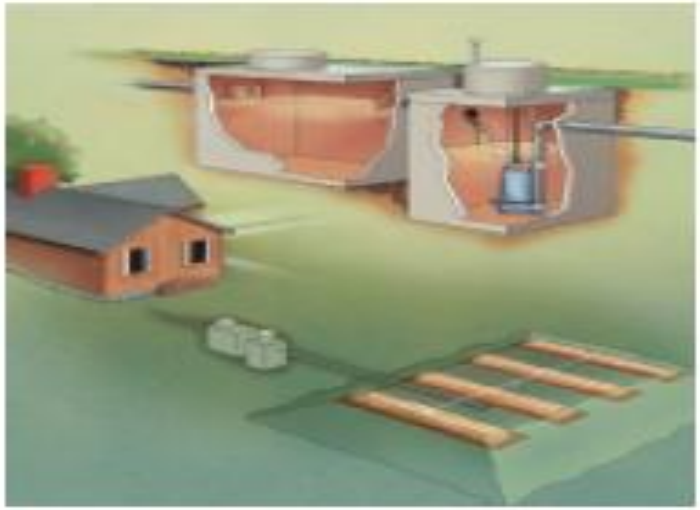
The submersible wastewater pump differs from normal centrifugals in that solids must be able to pass through the pump. This requires special open or “non-clog” impeller designs.

Typical Submersible Wastewater Systems

RESIDENTIAL (URBAN/RURAL)



SEWAGE LIFT STATION



MOUND SYSTEM (STEP - SEPTIC TANK EFFLUENT PUMP)

MUNICIPAL AND COMMERCIAL SEWAGE STATION

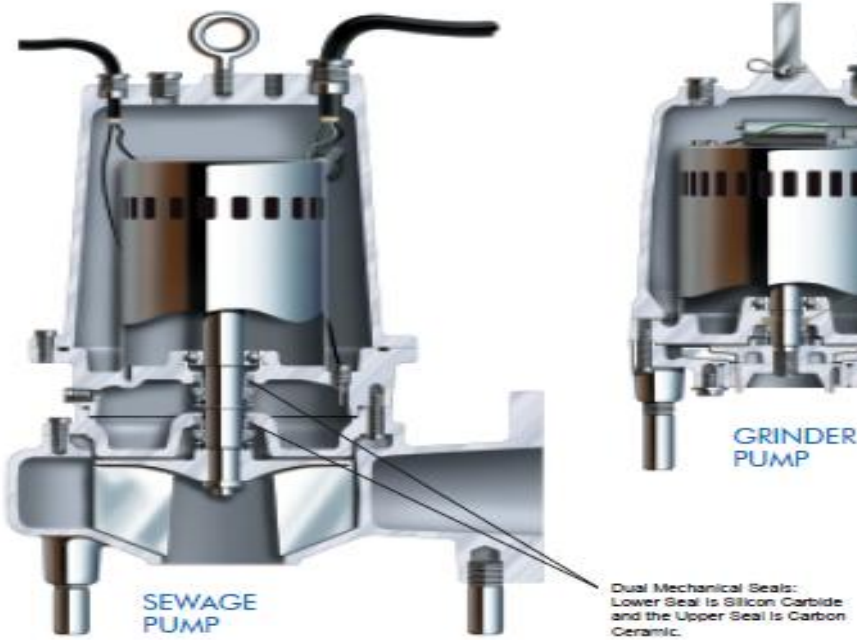
Types of Submersible Wastewater Pumps

- Industry requirements classify a pump as either a SUMP, EFFLUENT, SEWAGE or DEWATERING pump
- SSPMA (Submersible & Sewage Pump Mfr.'s Association) says the following:
  - Sump – up to ½" solids (not all are the same) clear water, solids not usually present
  - Effluent – up to 1" solids partially or completely treated wastewater flowing out of a septic tank or treatment plant
  - Sewage – 1-1/2" (most codes say 2") and larger Household wastewater which may contain human waste.
  - Grinders– Specialty pumps designed for applications where a gravity system is not practical. They are equipped with hardened stainless steel cutters which cut solids into small pieces, so that resulting residue can pumped under pressure through smaller diameter pipe

Types of Submersible Wastewater Pumps

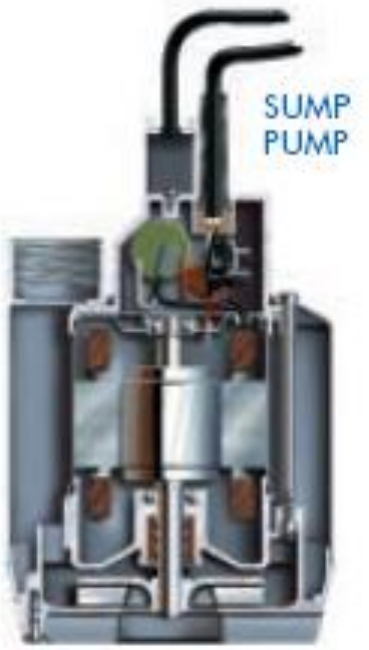
- Several Different “types” of pumps
- Closed impellers – most prone to clogging
- Semi-open impellers
- Vortex impellers
- Grinder (sometimes referred to as macerators)
- Dewatering Pumps

Types of Submersible Wastewater Pumps



Sump Pumps

- Generally used for basement draining from water that finds it's way under a foundation or similar low area
- Is a large DIY market – found at many home stores…

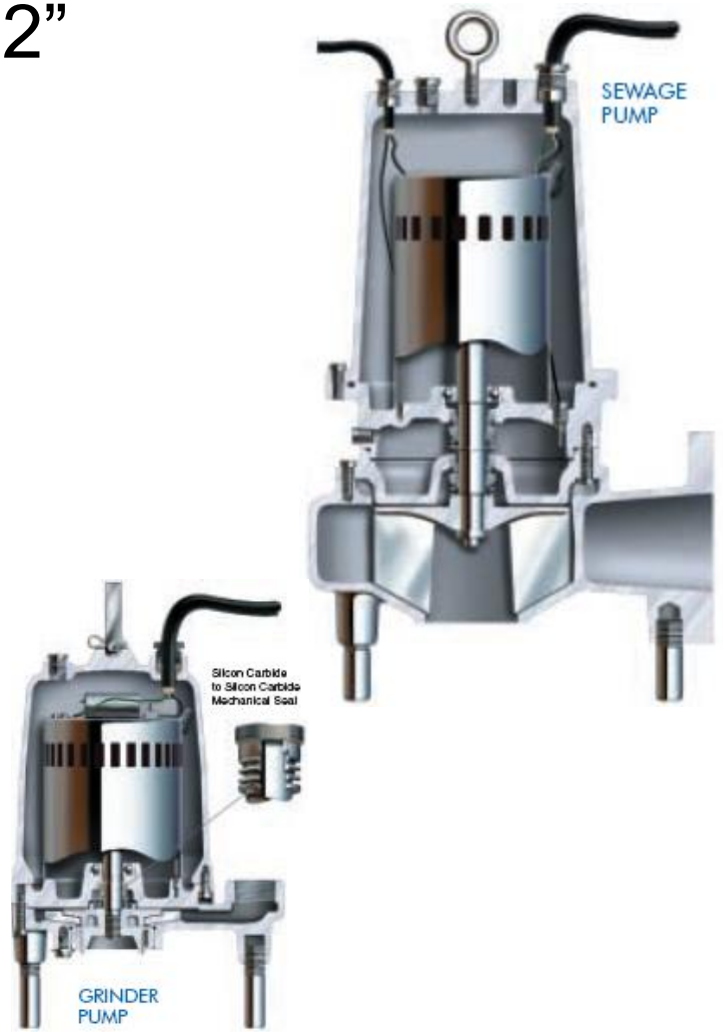


Effluent Pumps

- Dictated by local codes, but generally required in similar applications to the sump pump, but there is an increased chance of larger solids or undigested waste products (hair and lint)
- Much more likely to be found in the professional sales channel

Sewage Pumps

- Capable of handling 1-1/2”, 2” or even larger, required for unscreened and untreated waste
- Can be either a “solids handling” or grinder
- Sizing reflects Application
  - Grinder – High head – small pipe
  - Sewage – lower head – large pipe



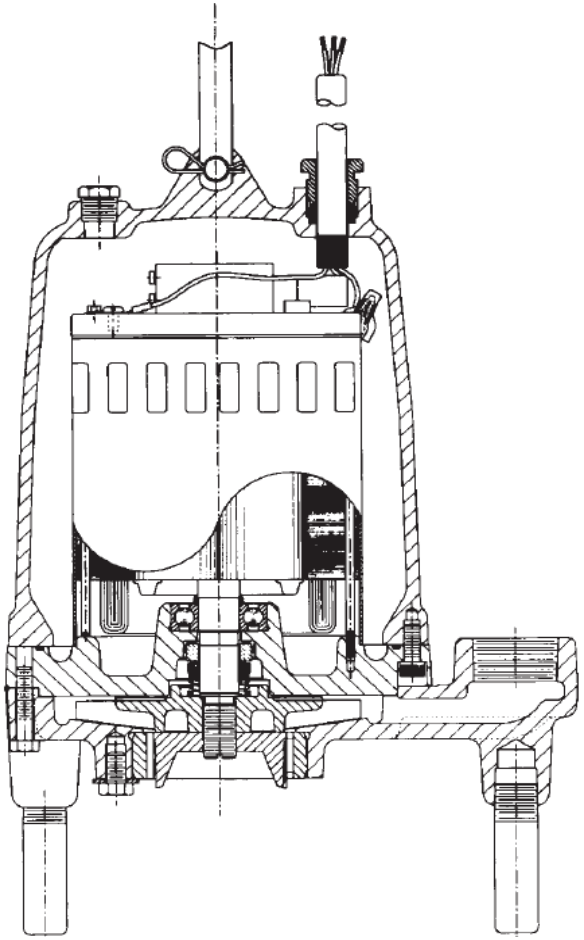
Grinder Pumps

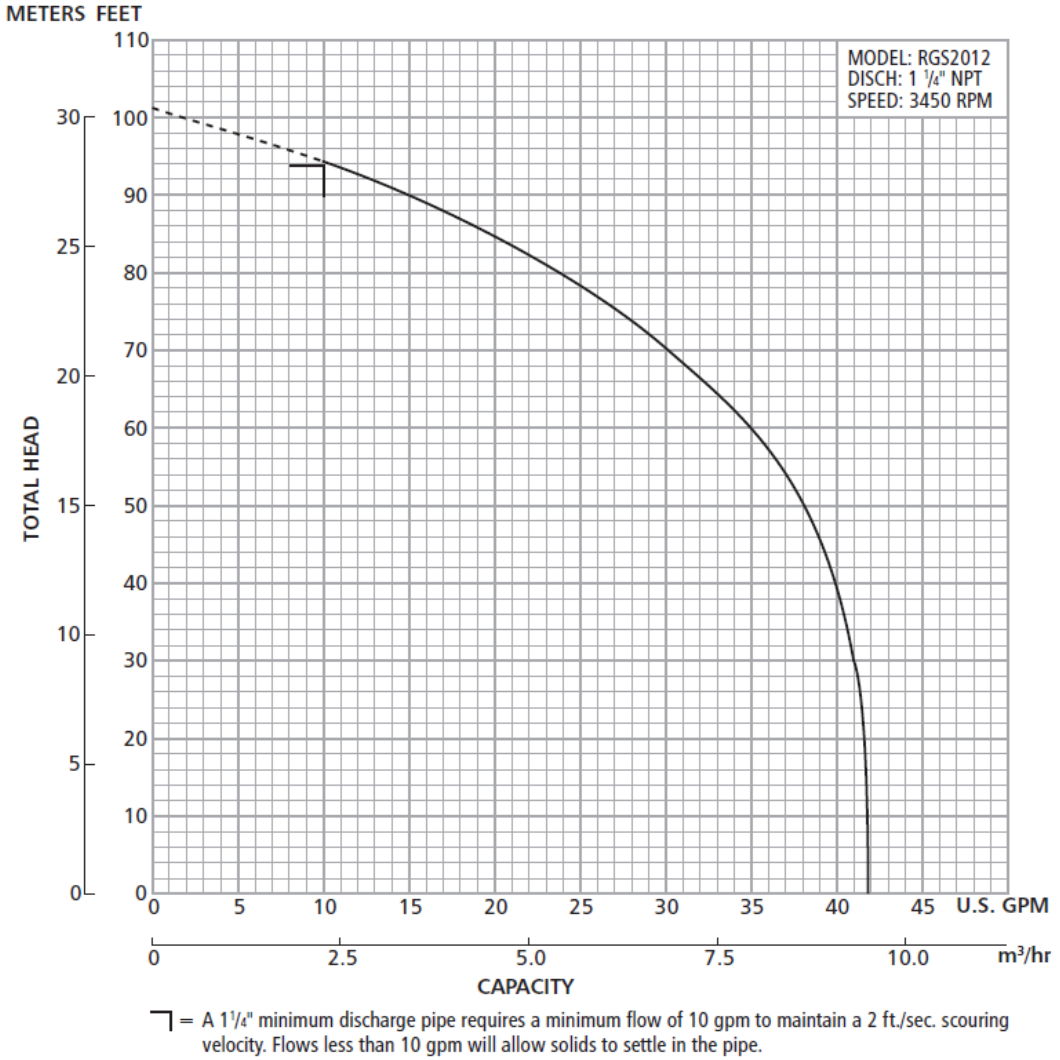
- Developed for a very specific purpose, generating a high head pressure and discharging through 1-1/4” pipe

Knife sharp edges will dull

- Will require maintenance and overhauls!!

Grinder Pumps





┐ = A 1¼" minimum discharge pipe requires a minimum flow of 10 gpm to maintain a 2 ft./sec. scouring velocity. Flows less than 10 gpm will allow solids to settle in the pipe.

Dewatering Pumps

- Used to dewater construction sites, should be portable and rugged!

- These are the only pumps that by design are rated to handle abrasives, grit and gravel!

Other Wastewater Basics

Floats

- Mechanically activated tilt switches w/ non mercury.
- Mercury no longer sold
- Pump vs. Panel Switches

TERMS TO KNOW

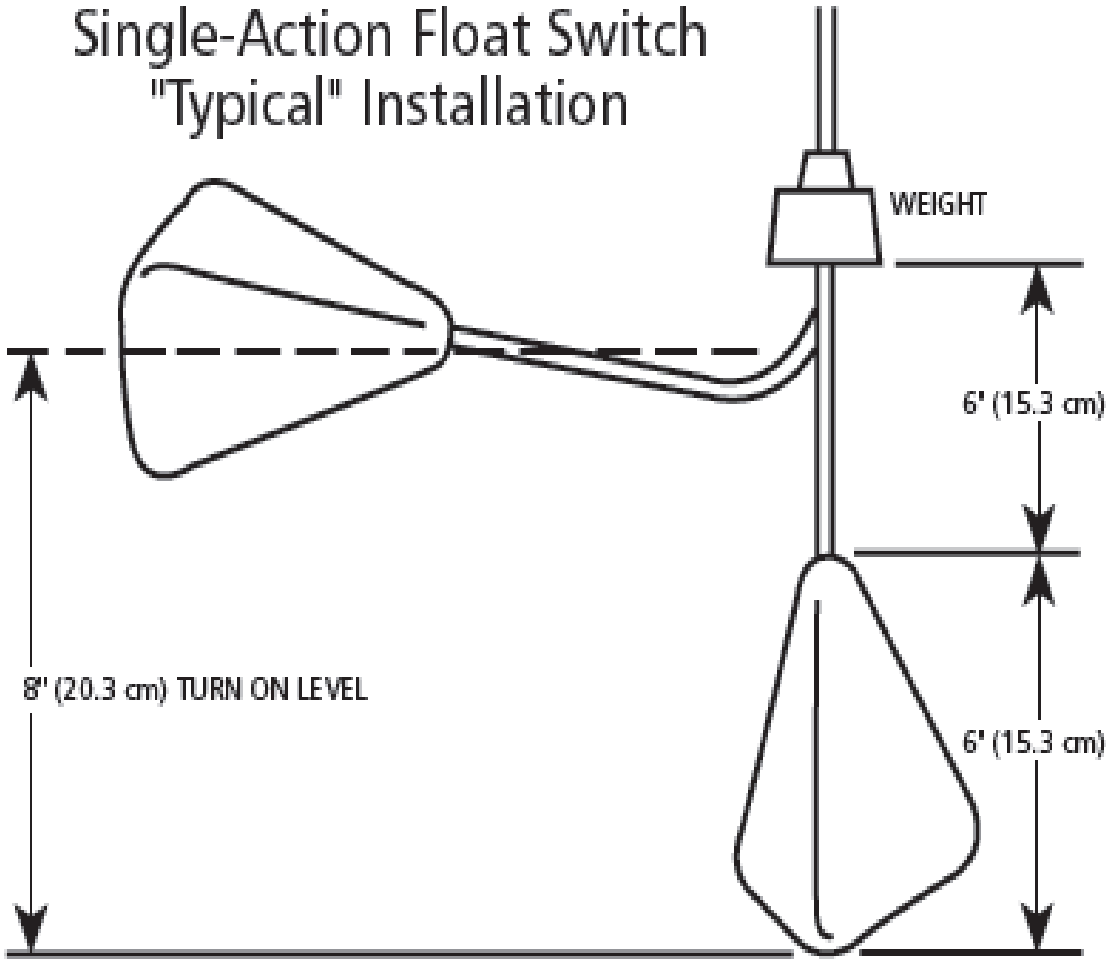
Pump Switches are used to directly control the operation of a pump. They are normally wide-angle switches which means they operate over a range of approximately 70° to 90°. Pump switches are available with piggyback plugs and with bare leads. Some can also be used with control panels.

Control Switches are designed to only control pumps when used with a control or alarm panel. They cannot handle the high starting amps and running amperage of a pump, only signal or control amperage.

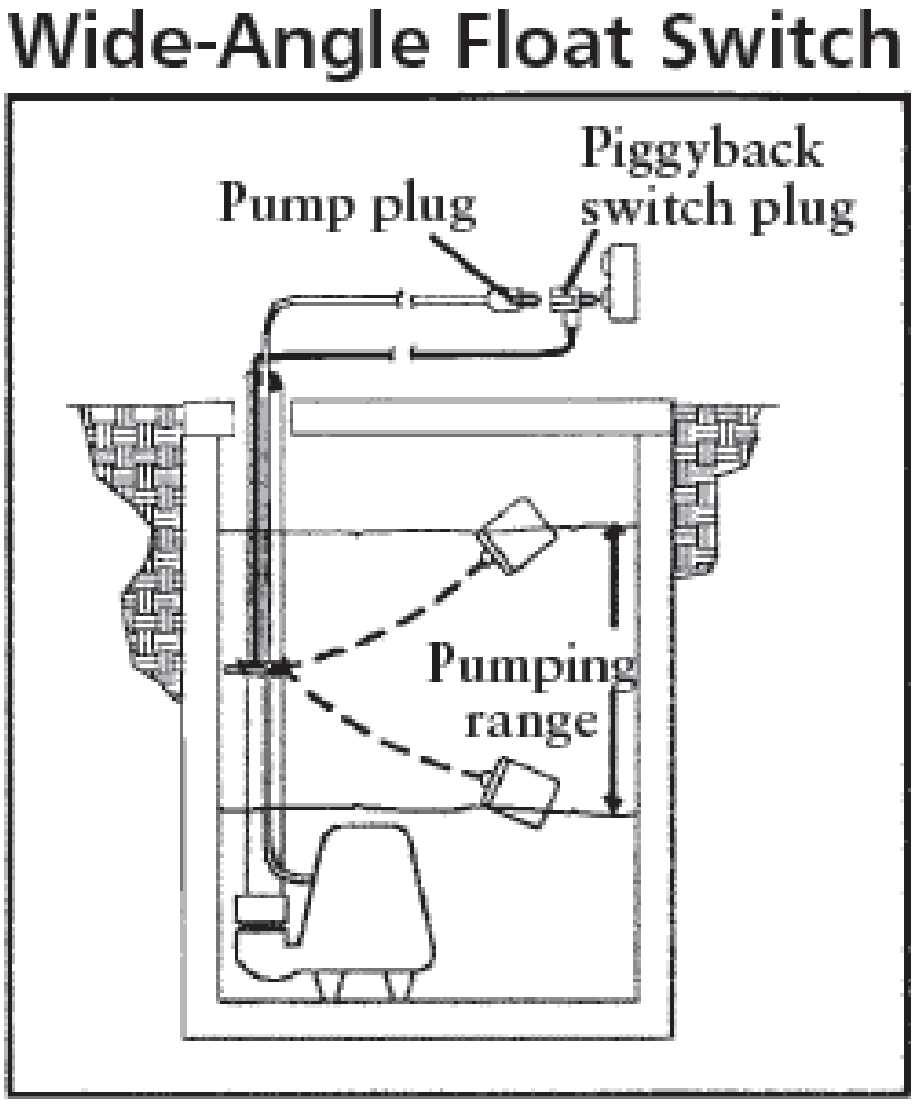
NO or Normally Open is a switch with contacts that are open in the hanging position. They are used to pump down or empty a tank.

NC or Normally Closed is a switch with contacts that are closed in the hanging position. They are used to pump up or fill a tank.

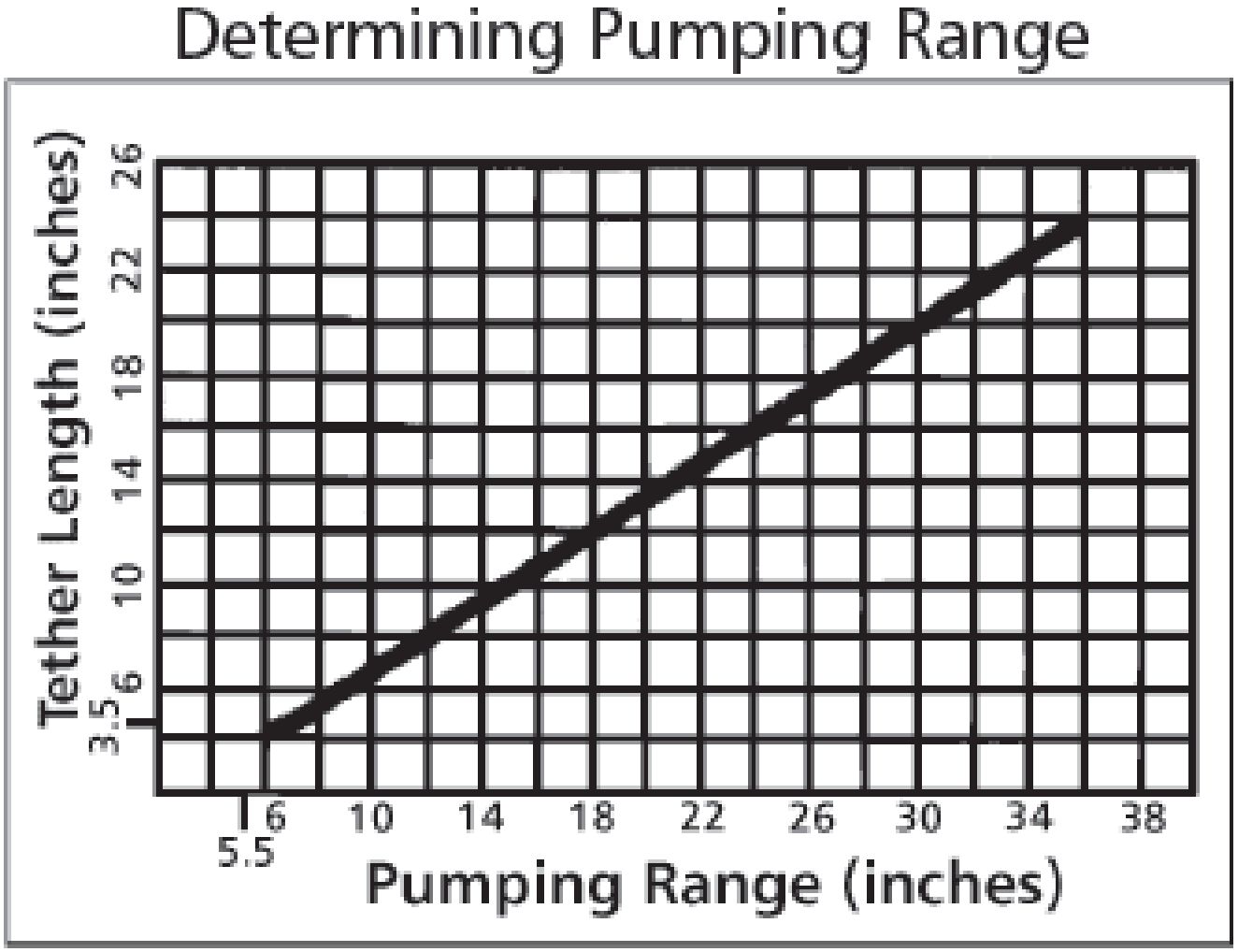
Float with Weight



Wide Angle Float



Pumping Range



Sizing Receiver Basin

FIBERGLASS BASIN

Order No.	Options ①	Dimensional Data			Approx.		Weight (lbs.)		
		A	B	C	Total Gallons	Gallons Per Inch	Fiberglass Standard Basin	with "F" suffix	with "S" suffix
A7-2436	F or S	24	36	26.5	65	1.81	40	60	107
A7-2448		24	48		84	1.75	50	70	117
A7-2460		24	60		102	1.70	59	79	126
A7-2472F	S	24	72		118	1.64	NA	89	136
A7-2484F		24	84		165	1.96	NA	116	163
A7-2496F		24	96		188	1.96	NA	125	172
~~A7-3036~~		~~30~~	~~36~~		~~110~~	~~3.00~~	~~46~~	~~80~~	~~148~~
A7-3048	F or S	30	48		137	2.85	59	92	160
A7-3060		30	60	32.5	169	2.82	90	104	172
A7-3072F	S	30	72		199	2.76	NA	147	214
A7-3084F		30	84		257	3.05	NA	162	230
A7-3096F		30	96		294	3.06	NA	177	245
A7-3636	F or S	36	36	38.5	159	4.41	64	103	195
A7-3648		36	48		200	4.17	78	118	210
A7-3660		36	60		246	4.10	93	132	224
A7-3672F	S	36	72		291	4.04	NA	207	299
A7-3684F		36	84		370	4.40	NA	226	318
A7-3696F		36	96		423	4.40	NA	244	336

This chart lists various basin sizes, dimensions and the amount of water per inch of basin height.

A 30” basin volume is 2.85 gallons per inch.

A 10” tether has a 14” pumping range: 14 x 2.85 = 39.9 gallons

Pipe Volume and Velocity

PIPE VOLUME AND VELOCITY

Storage of Water in Various Size Pipes

Pipe Size	Volume in Gallons per Foot	Pipe Size	Volume in Gallons per Foot
1¼	.06	6	1.4
1½	.09	8	2.6
2	.16	10	4.07
3	.36	12	5.87
4	.652		

Minimum Flow to Maintain 2ft./sec. *Scouring Velocity in Various Pipes

Pipe Size	Minimum GPM	Pipe Size	Minimum GPM
1¼	9	6	180
1½	13	8	325
2	21	10	500
3	46	12	700
4	80		

* Failure to maintain or exceed this velocity will result in clogged pipes. Based on schedule 40 nominal pipe.

Seals

Seals

SILICON CARBIDE VS. SILICON CARBIDE sealing faces for superior abrasive resistance, stainless steel metal parts, BUNA-N elastomers.

Carbon Ceramic Seals not as good in abrasive applications.

	Carbon Ceramic	Silicon Carbide	Performance Ratio
Hardness	600	2,700	4.5
Tensile Strength, PSI	6,000	45,000	7.5
Compression Strength, PSI	22,000	360,000	16.4
Temperature	525 F	3,000 F	5.7

Motors

Motors - Run Time

- ✓ Units up to 1½ HP should run a minimum of 1 minute.
- ✓ Two (2) HP and larger units should run a minimum of 2 minutes.

  - Run time allows motor to cool.
  - heat dissipates as motor runs.

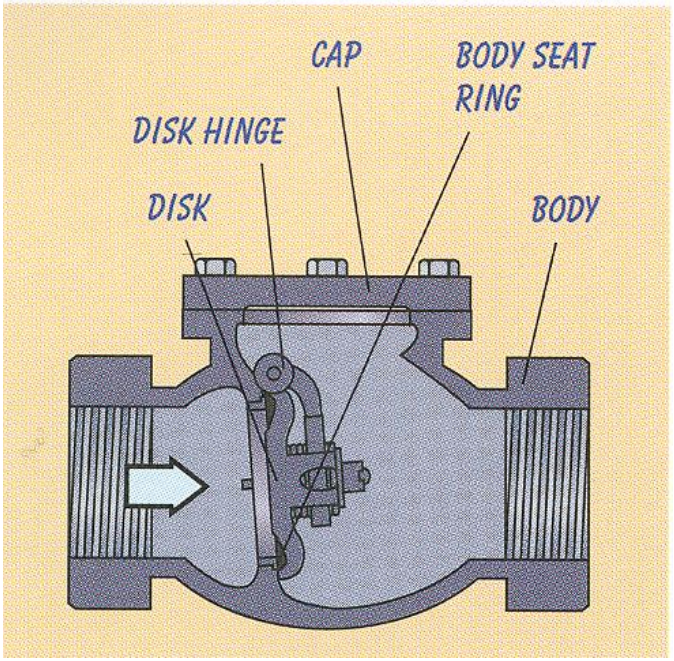
Relief Hole

- Important – Before pump installation. Drill a 3⁄16” (4.8mm) relief hole in the discharge pipe. It should be located within the wetwell, 2” (51mm) above the pump discharge but below the check valve.
- The relief hole allows any air to escape from the casing. Allowing liquid into the casing will insure that the pump can start when the liquid level rises.
- Unless a relief hole is provided, a bottom intake pump could “air lock” and will not pump water even though the impeller turns.

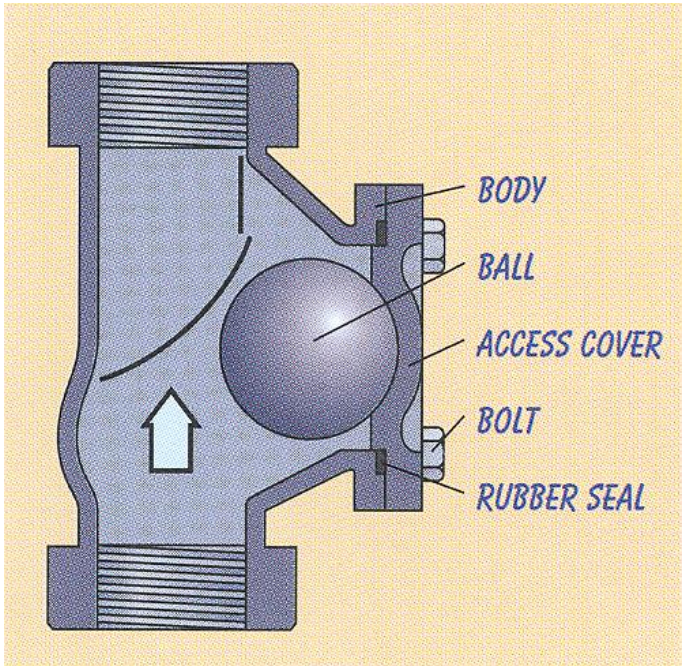
Install

- Install an adequately sized check valve matched to the solids handling capability of the pump to prevent fluid backflow. Backflow can allow the pump to “turbine” backwards and may cause premature seal and/or bearing wear.
- If the pump is turning backwards when it is called on to start the increased torque may cause damage to the pump motor and/or motor shaft and some single-phase pumps may actually run backwards.

Check Valves



Swing Check Valve
for horizontal installation



Ball Check Valve
for vertical installation

Sizing a Wastewater Pump

7 things you need to know in order to properly size a wastewater pump

1 - State and local codes

2 - Size of solids

3 - Required capacity

4 - Total Dynamic Head

5 - Receiver basin size

6 - Pipe size

7 - Electrical service

1. State and local codes

- State and local codes may require a specific type of wastewater system due to soil composition.
- Codes also may require electrical panels incorporating a number of safety and monitoring features.

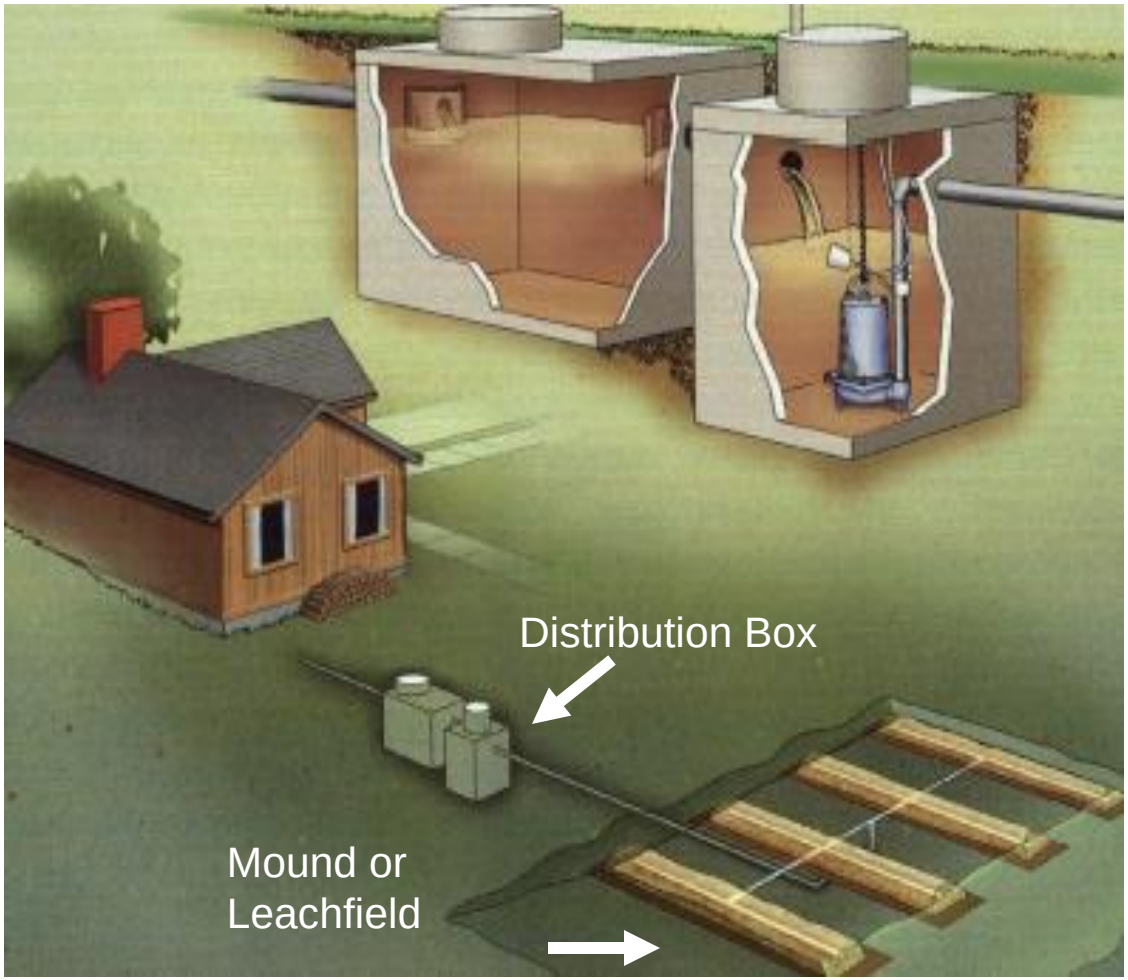
- Always check with the Environmental Health Department in the jurisdiction to determine what type of system and equipment is required

2. Size of solids

This will determine whether the application required a sump, effluent or sewage pump

- Sump – up to ½” solids (not all are the same) Clear water, solids not usually present
- Effluent – up to 1” solids Partially or completely treated wastewater flowing out of a septic tank or treatment plant
- Sewage – 1-1/2” (most codes say 2”) and larger household wastewater which may contain human waste.

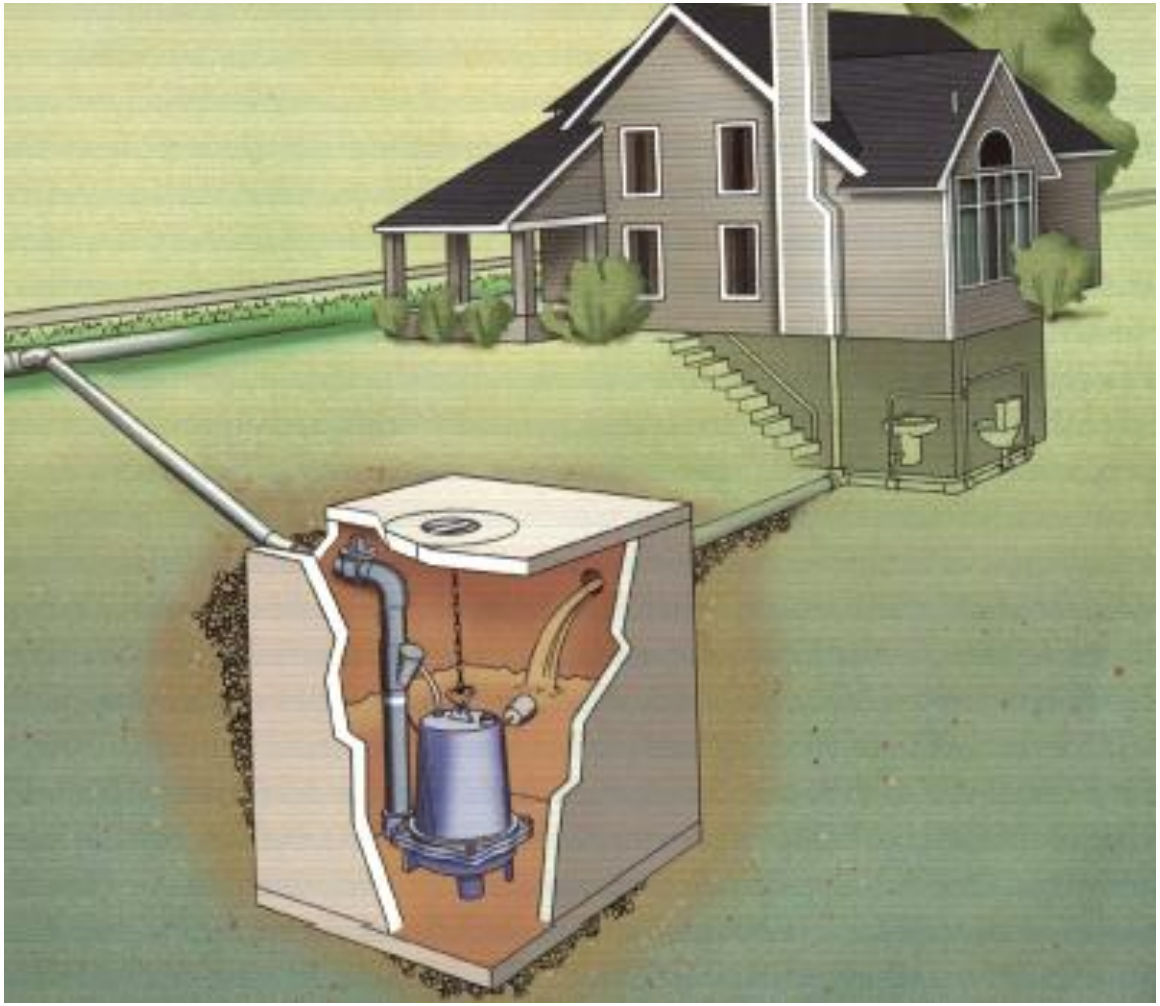
TYPICAL EFFLUENT APPLICATION



Effluent (3/4” solids) are pumped from a distribution box into a mound system or a Soil Treatment Area. Local codes may require this type of system

This is also a typical application for a time-dosing system.

TYPICAL SEWAGE APPLICATION

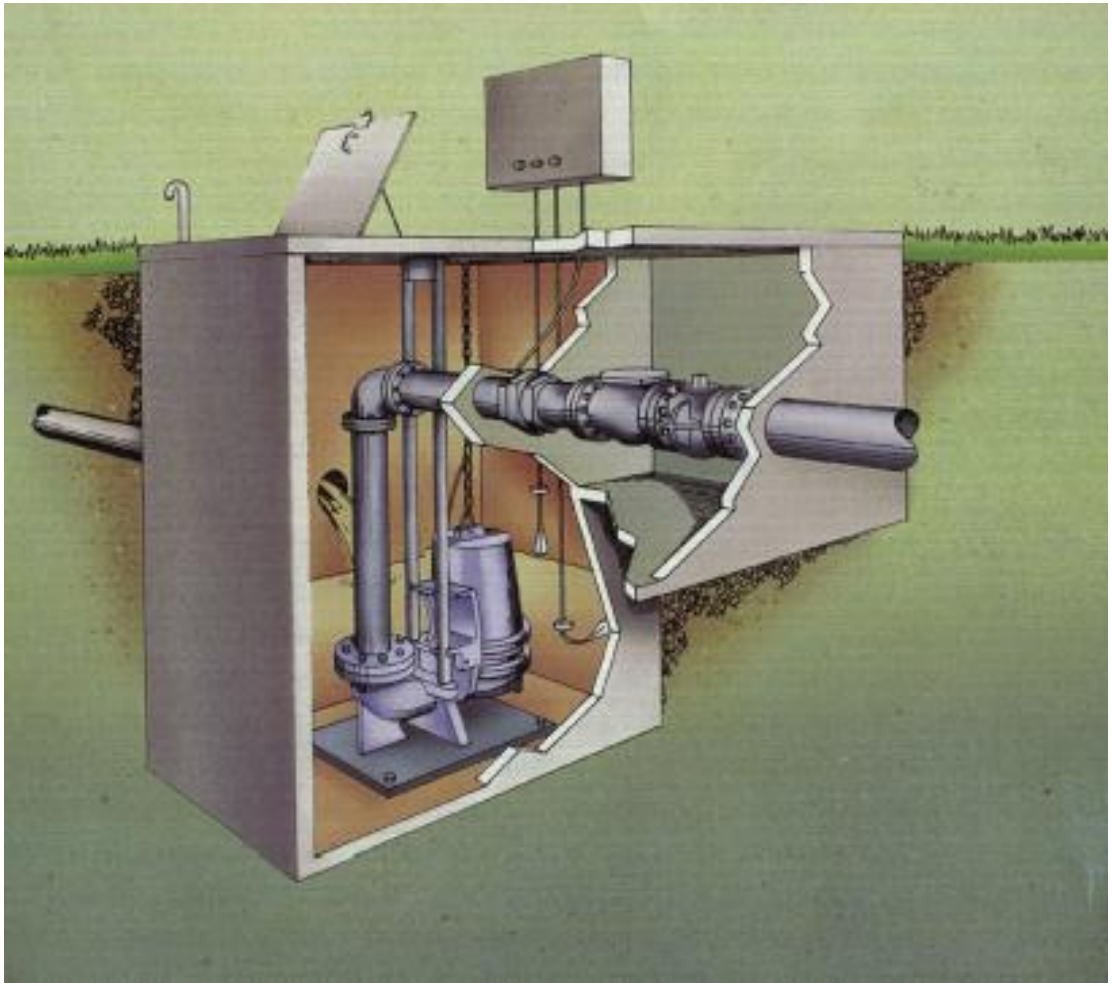


Residential System

2” Solids

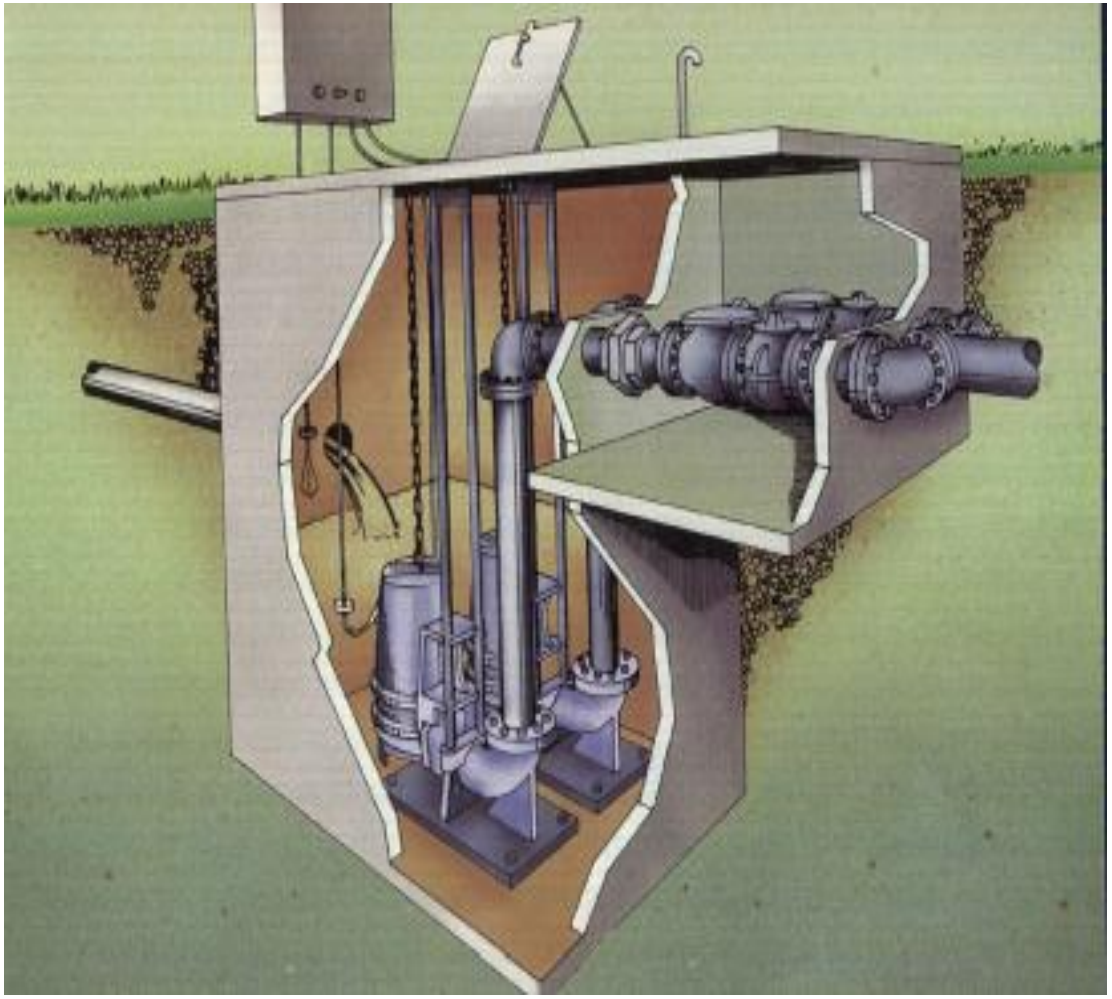
Wastewater is drained into basin which is then pumped to a gravity sewer system.

TYPICAL COMMERCIAL SEWAGE INSTALLATION



Sewage lift station equipped with one sewage pump, lifting sewage to a gravity feed collection system.

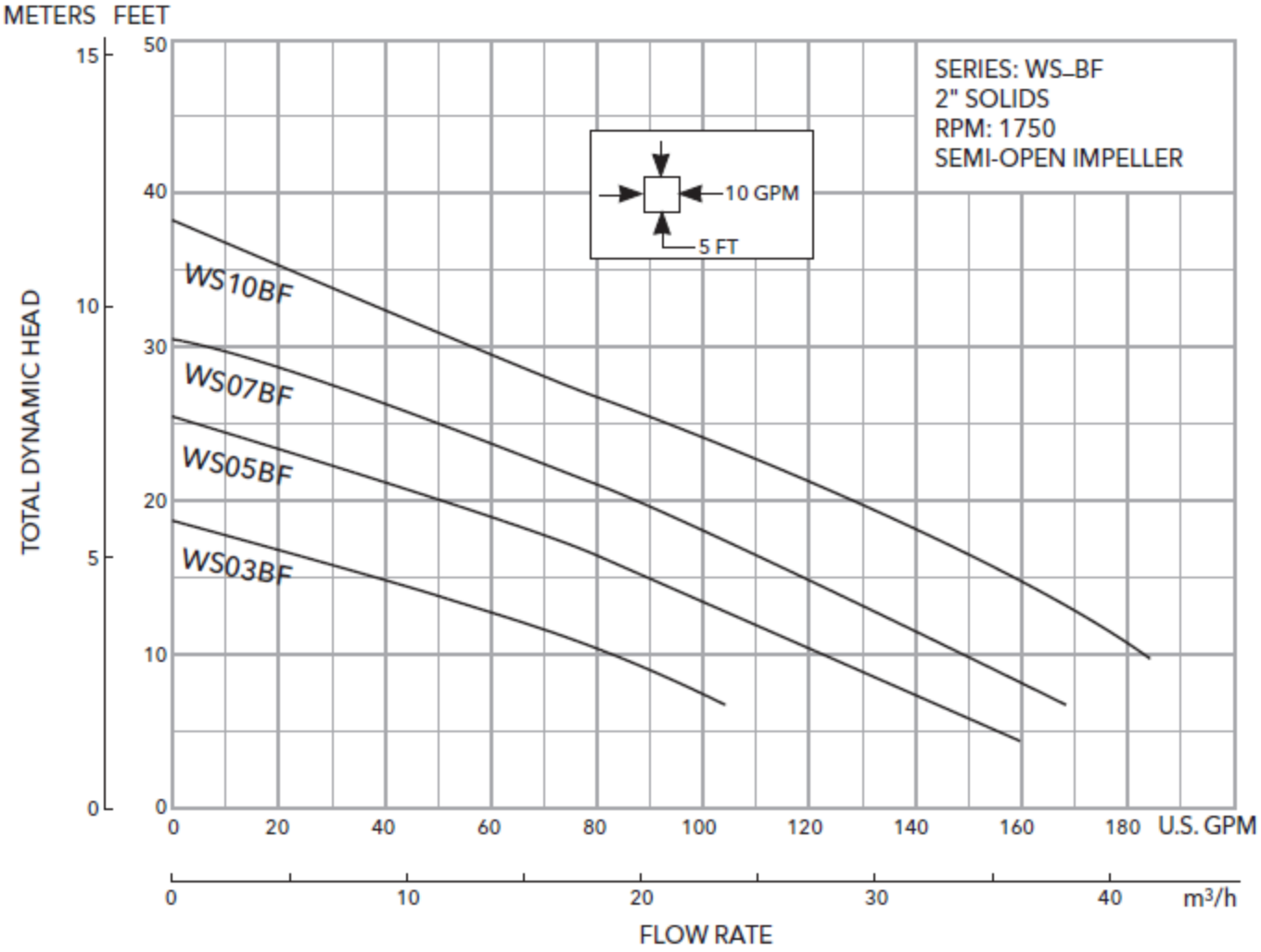
TYPICAL MUNICIPAL AND COMMERCIAL SEWAGE STATION



3+” Solids

Multiple pumps designed for heavy duty service

Pump Curves


METERS FEET
TOTAL DYNAMIC HEAD
15
10
5
0
50
40
30
20
10
0
SERIES: WS_BF
2" SOLIDS
RPM: 1750
SEMI-OPEN IMPELLER
10 GPM
5 FT
WS10BF
WS07BF
WS05BF
WS03BF
0 20 40 60 80 100 120 140 160 180 U.S. GPM
0 10 20 30 40 m³/h
FLOW RATE

Pump Hydraulics

- Before you can select the correct wastewater pump for a specific application you must have a general knowledge of Pump Hydraulics.

- Pump Hydraulics pertains to a centrifugal pump’s ability to produce the force (head) to deliver a required amount of wastewater to a specific location -

3. Capacity Requirements

This is the flow or discharge capacity required by the installation. While flow can vary from installation to installation the following rule of thumb will handle most situations

Residential Sizing

BATHROOM COUNT

Number of Bathrooms	Flow Rate per Minute
1	20
2	30
3	40
4	50
5	60
6	70

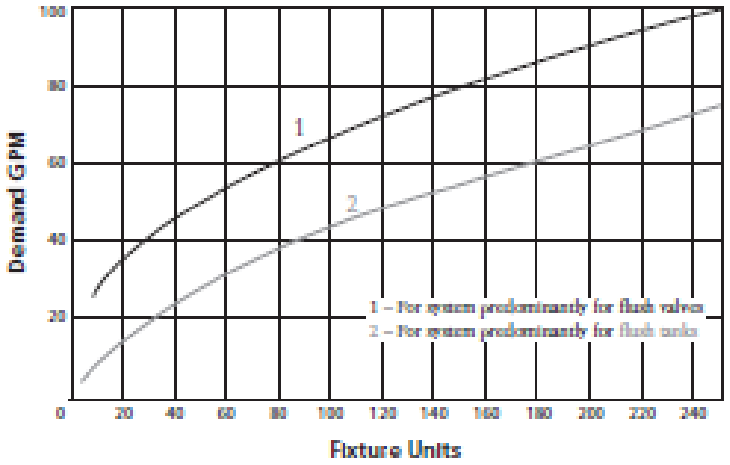
Capacity-Residential

FIXTURE COUNT V = Value style fixture T = Tank Style Fixture

Fixture	Type	Count
Toilet	V	6
Toilet	T	3
Lav Sink	V or T	1
Tub	V or T	2
Shower	V or T	2
Full Body Shower	Add Flow rate: 9 to 65 Gallons per minute to total	
Kitchen Sink	V or T	2
Dishwasher	V or T	4
Wash Machine	V or T	8
Bidet	V or T	3
Icemaker	V or T	3
Hose Bib	V or T	4

Fixture	Quantity	Count	Total Count
Toilets	3	3	9
Tub and Shower	2	4	8
Full body shower			15
Lav Sink		1	3
Kitchen Sink	1	2	2
Dishwasher	1	4	4
Icemaker	1	3	3
Wash Machine	1	8	8
Hose Bib	1	4	4
Total			56

PLUMBING WATER SYSTEMS



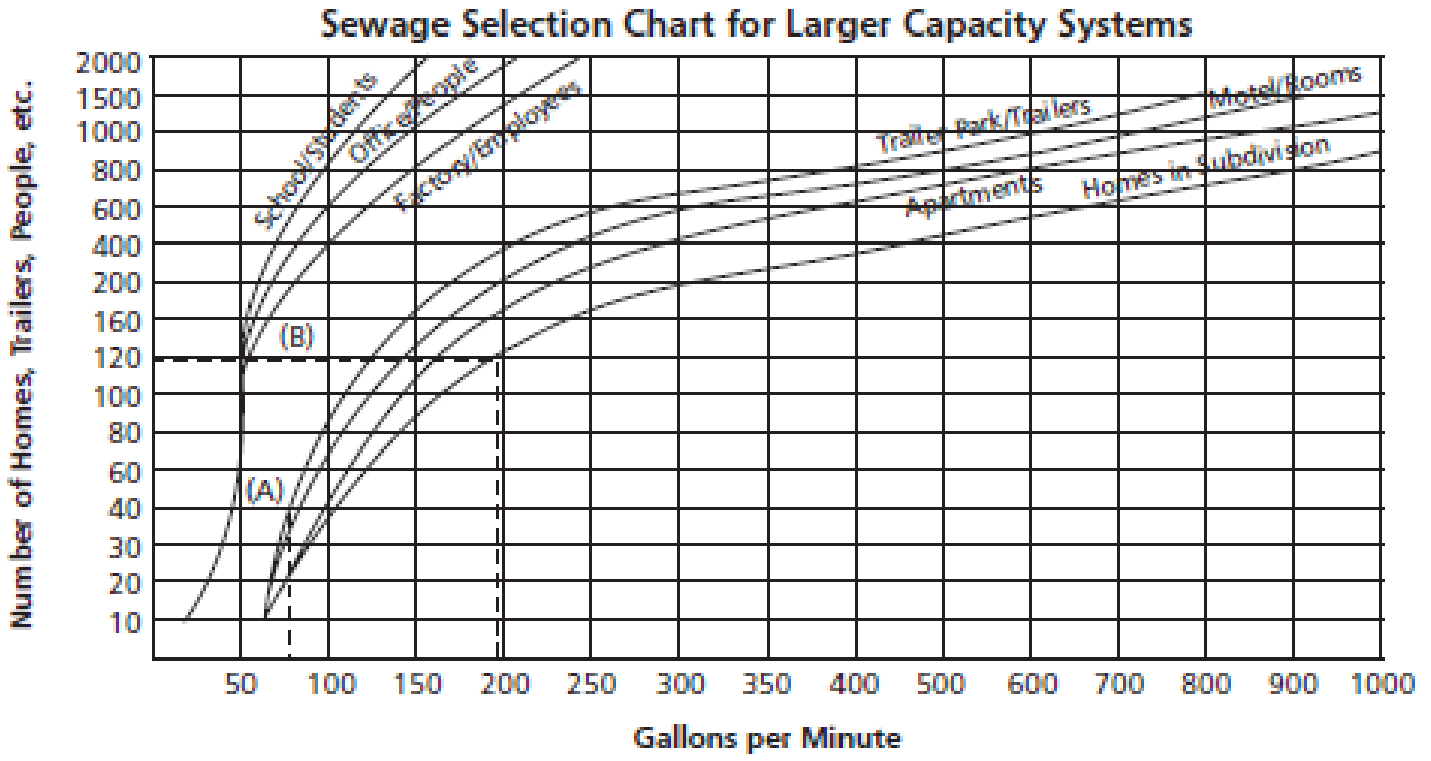
"Hunter" Estimate Curves for Demand Load

1 – Flush Valve Curve 2 – Flush Tank Curve

Capacity Requirements

Commercial Sizing

OCCUPANT SIZING



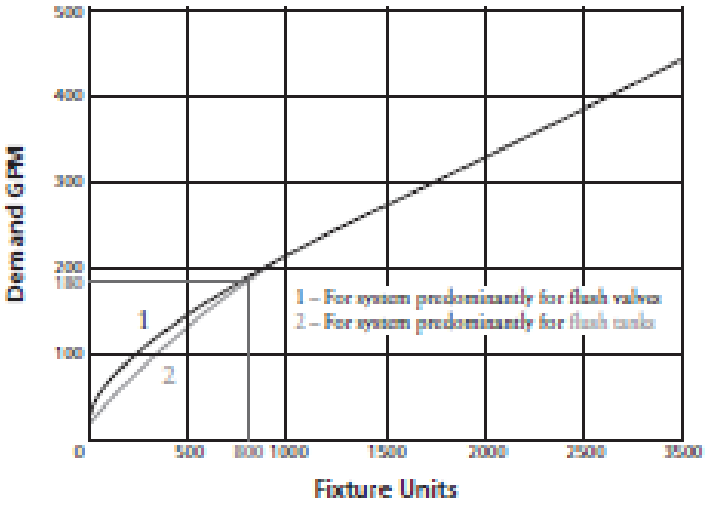
Capacity-Commercial

FIXTURE COUNT

Fixture	Type	Count
Toilet	V	10
Toilet	T	5
Pedestal Urinal	V or T	10
Stall Urinal	V or T	5
Lav Sink	V or T	3
Kitchen Sink	V or T	4
Tub	V or T	4
Shower	V or T	4
Dishwasher	V or T	4
Icemaker	V or T	3
Commercial Wash. Machine	V or T	6
Hose Bib - Commercial	V or T	6
Full Body Shower	Add Flow rate 9 to 65 Gallons per minute to total	

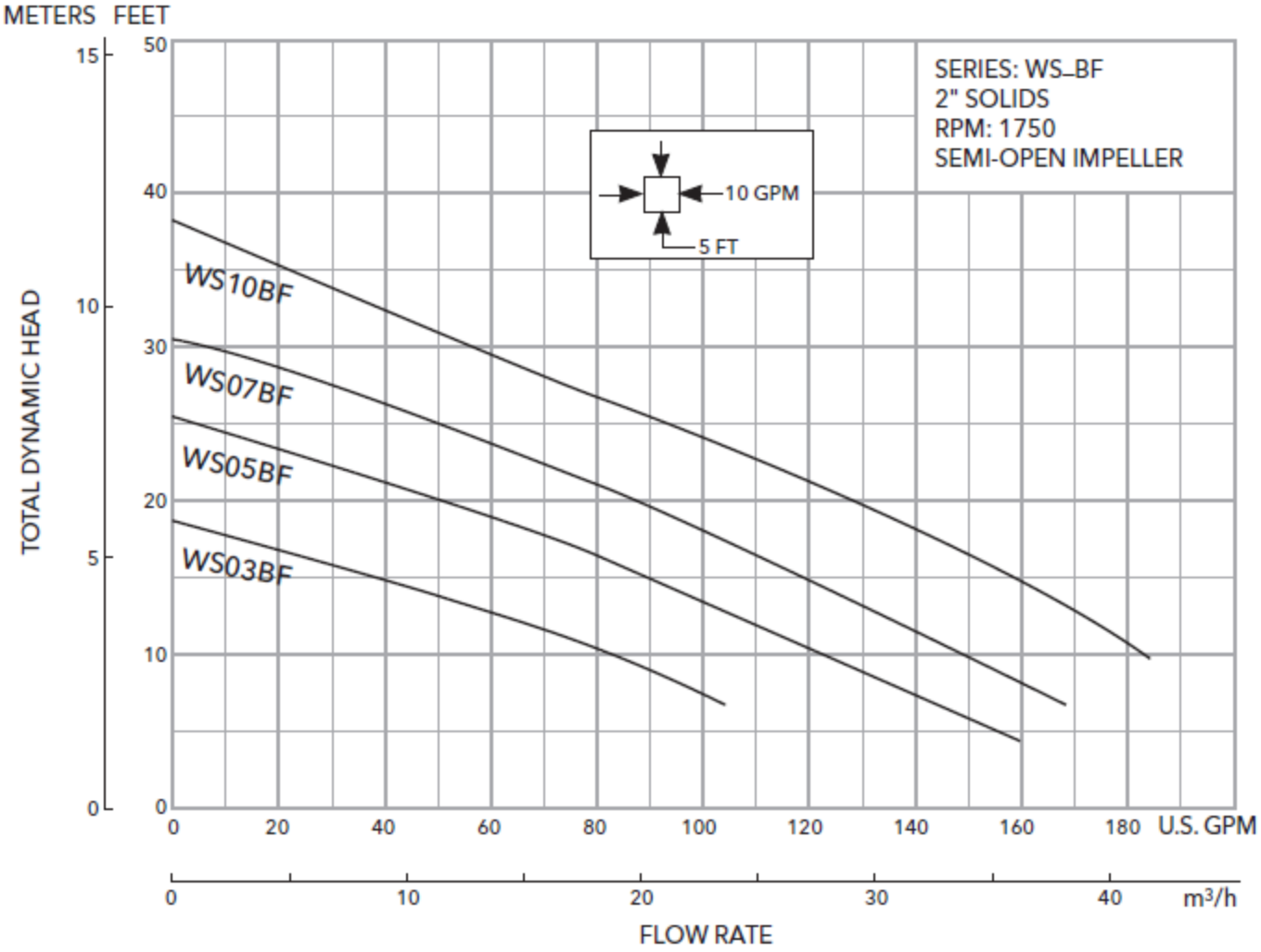
Fixture	Quantity	Count	Total Count
Toilet	50	10	500
Lav Sink	50	3	150
Shower	50	4	200
Full body shower	50	15	750
Dishwasher	50	4	200
Icemaker	50	3	150
Wash Machine	10	6	60
Dishwasher	10	4	40
Hose bib	2	6	12
Total			2062

PLUMBING WATER SYSTEMS



"Hunter" Estimate Curves for Demand Load

Pump Curves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SERIES: WS_BF
2" SOLIDS
RPM: 1750
SEMI-OPEN IMPELLER
10 GPM
5 FT
WS10BF
WS07BF
WS05BF
WS03BF
0 20 40 60 80 100 120 140 160 180 U.S. GPM
0 10 20 30 40 m³/h
FLOW RATE

4. Total Dynamic Head

Vertical lift

\+ Friction lift (loss)

\+ Pressure requirements

= Total Dynamic Head (TDH)

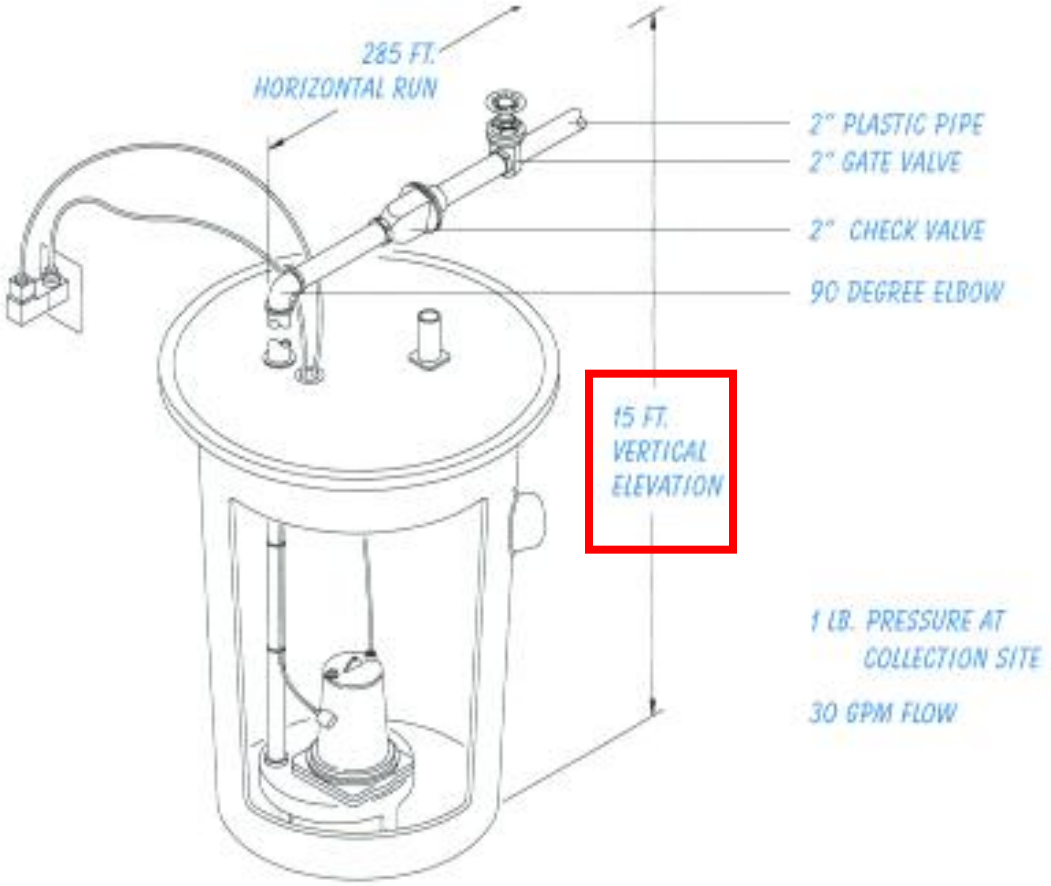
Total Dynamic Head

Vertical Lift (the distance from the pump inlet to the highest point in the discharge system)

+ Friction loss in piping

+ Pressure requirements

Vertical lift



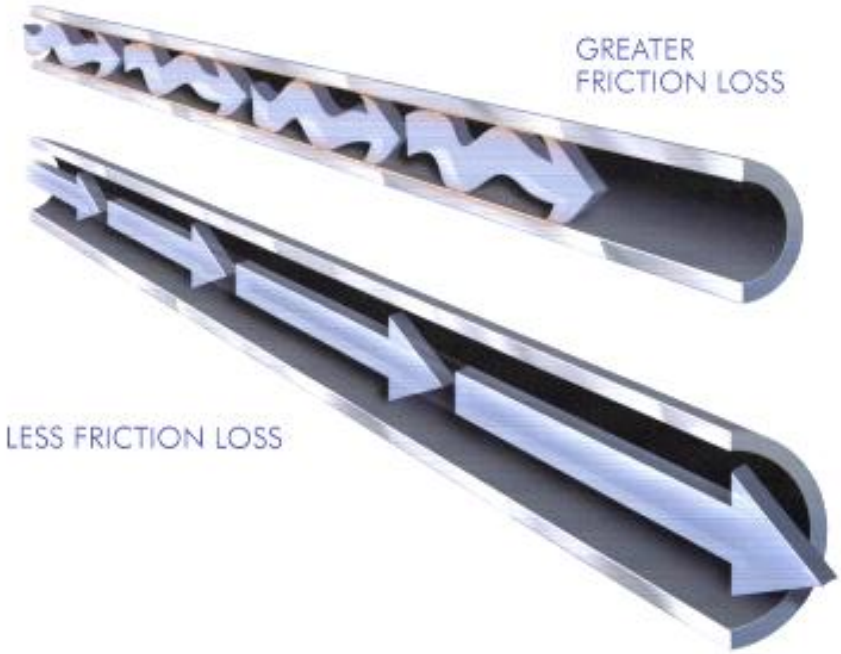
Elevation from pump to highest point in discharge system

15 Feet

Friction Loss

- *Friction loss* is the resistance created when liquid is flowed through the piping and fittings in the system.
- This resistance means extra work for the pump. Friction loss works against the pump.
- Therefore, it should be kept to a minimum.

Friction Loss- (Friction Head)



Friction loss increases as pipe length increases

Friction loss increases as flow rate increases

Friction loss decreases as pipe size increases

Friction Loss

Friction Loss

PLASTIC PIPE: FRICTION LOSS (IN FEET OF HEAD) PER 100 FT.

GPM	GPH	⅜"	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"
		ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
1	60	4.25	1.38	.356	.11						
2	120	15.13	4.83	1.21	.38	.10					
3	180	31.97	9.96	2.51	.77	.21	.10				
4	240	54.97	17.07	4.21	1.30	.35	.16				
5	300	84.41	25.76	6.33	1.92	.51	.24				
6	360		36.34	8.83	2.69	.71	.33	.10			
8	480		63.71	15.18	4.58	1.19	.55	.17			
10	600		97.52	25.98	6.88	1.78	.83	.25	.11		
15	900			49.68	14.63	3.75	1.74	.52	.22		
20	1,200			86.94	25.07	6.39	2.94	.86	.36	.13	
25	1,500				38.41	9.71	4.44	1.29	.54	.19	
30	1,800					13.62	6.26	1.81	.75	.26	
35	2,100					18.17	8.37	2.42	1.00	.35	.09
40	2,400					23.55	10.70	3.11	1.28	.44	.12
45	2,700					29.44	13.46	3.84	1.54	.55	.15
50	3,000						16.45	4.67	1.93	.66	.17
60	3,600						23.48	6.60	2.71	.93	.25
70	4,200							8.83	3.66	1.24	.33
80	4,800							11.43	4.67	1.58	.41

Friction Loss

Friction Loss

EQUIVALENT NUMBER OF FEET STRAIGHT PIPE FOR DIFFERENT FITTINGS

Size of fittings, Inches	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"	8"	10"
90° Ell	1.5	2.0	2.7	3.5	4.3	5.5	6.5	8.0	10.0	14.0	15	20	25
45° Ell	0.8	1.0	1.3	1.7	2.0	2.5	3.0	3.8	5.0	6.3	7.1	9.4	12
Long Sweep Ell	1.0	1.4	1.7	2.3	2.7	3.5	4.2	5.2	7.0	9.0	11.0	14.0	
Close Return Bend	3.6	5.0	6.0	8.3	10.0	13.0	15.0	18.0	24.0	31.0	37.0	39.0	
Tee-Straight Run	1	2	2	3	3	4	5						
Tee-Side Inlet or Outlet or Pitless Adapter	3.3	4.5	5.7	7.6	9.0	12.0	14.0	17.0	22.0	27.0	31.0	40.0	
Ball or Globe Valve Open	17.0	22.0	27.0	36.0	43.0	55.0	67.0	82.0	110.0	140.0	160.0	220.0	
Angle Valve Open	8.4	12.0	15.0	18.0	22.0	28.0	33.0	42.0	58.0	70.0	83.0	110.0	
Gate Valve-Fully Open	0.4	0.5	0.6	0.8	1.0	1.2	1.4	1.7	2.3	2.9	3.5	4.5	
Check Valve (Swing)	4	5	7	9	11	13	16	20	26	33	39	52	65
In Line Check Valve (Spring) or Foot Valve	4	6	8	12	14	19	23	32	43	58			

Example:

(A) 100 ft. of 2" plastic pipe with one (1) 90° elbow and one (1) swing check valve.

90° elbow – equivalent to 5.5 ft. of straight pipe
Swing check – equivalent to 13.0 ft. of straight pipe
100 ft. of pipe – equivalent to 100 ft. of straight pipe

118.5 ft. = Total equivalent pipe

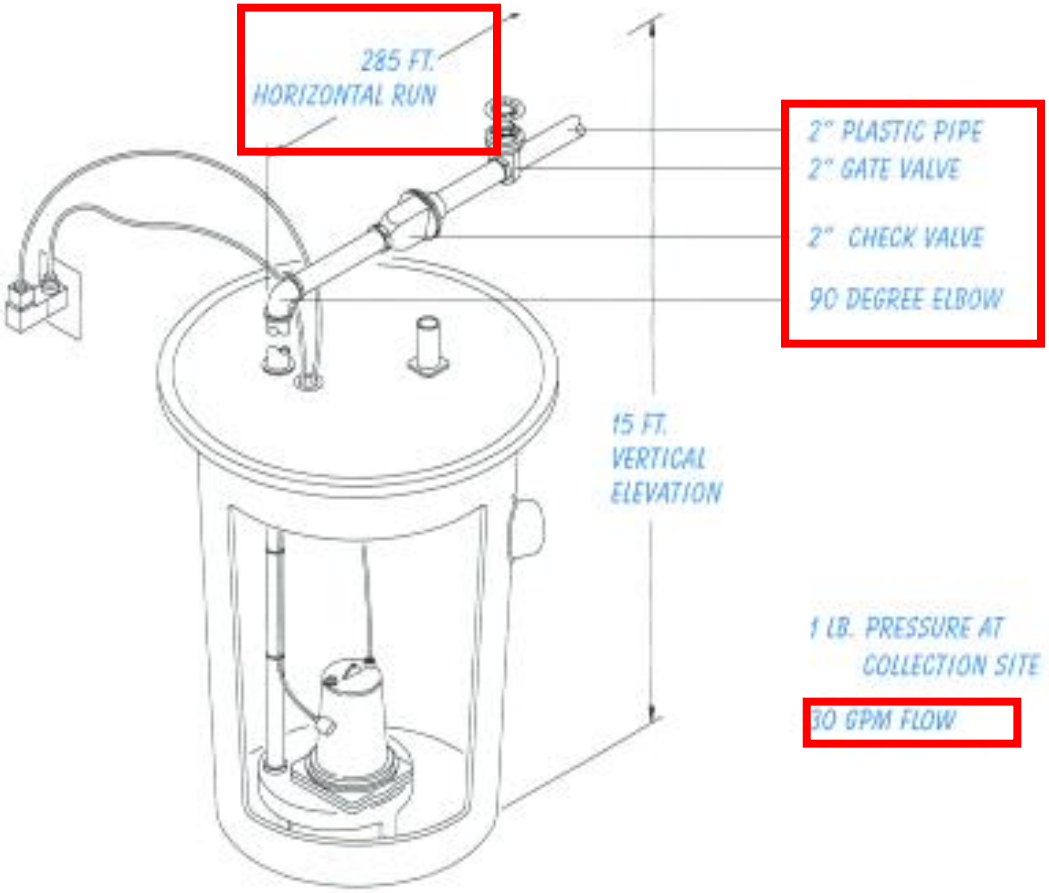
Figure friction loss for 118.5 ft. of pipe.

(B) Assume flow to be 80 GPM through 2" plastic pipe.

1. Friction loss table shows 11.43 ft. loss per 100 ft. of pipe.
2. In step (A) above we have determined total ft. of pipe to be 118.5 ft.
3. Convert 118.5 ft. to percentage 118.5 ÷ 100 = 1.185
4. Multiply 11.43
   x 1.185

   13.54455 or 13.5 ft. = Total friction loss in this system.

Friction Loss Calculation



Fittings

1 – 2” Gate Valve = 1.2 feet

1 – 2” Check Valve = 13.0 feet

1 – 2” 90 ell = 5.5 feet

Equivalent pipe run = 319.7 or 320 FT

Friction loss for this installation…

30 GPM flow through 2” PVC pipe

1.81 ft per 100 length

1.81 X 3.2 = 5.82 or 6 feet

6 Feet

4. Total Dynamic Head

Vertical lift

+ Friction lift

+ Pressure requirements

= Total Dynamic Head (TDH)

System Pressure

The amount of pressure that must be overcome at the collection site, such as the pressure in forced main wastewater piping.

Head is expressed in one of two ways

- ✓ Pressure (PSI) or Feet

TDH must always be expressed in either feet or psi. Never as a combination.

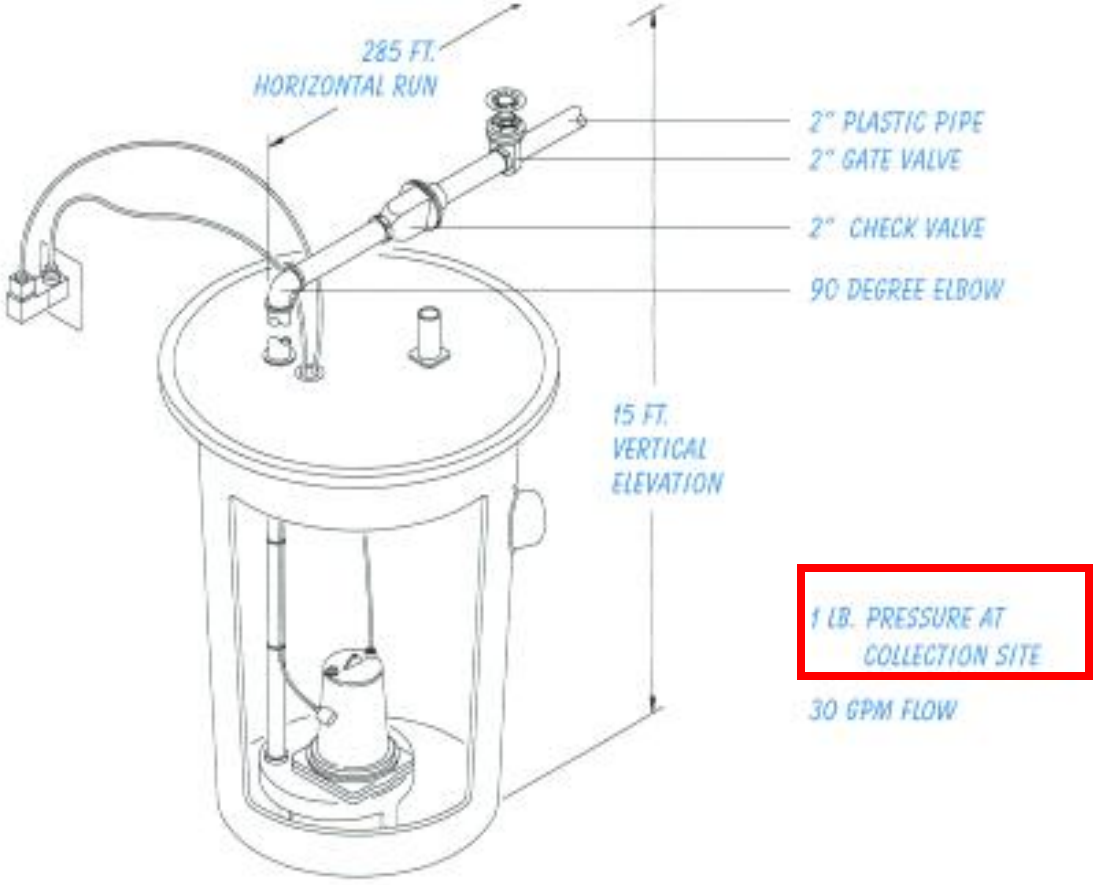
In wastewater applications TDH is normally expressed in feet.

One pound of pressure = 2.31 feet

To convert PSI to Feet multiply by 2.31

Pressure Requirements

Note: Normally service pressure is not a consideration. The total of the vertical distance, plus the friction losses is the required discharge head in feet.



Pressure Requirements

Convert lb's to Feet

1 LB X 2.31 = 2.31 or 3 feet

3 Feet

Total Dynamic Head

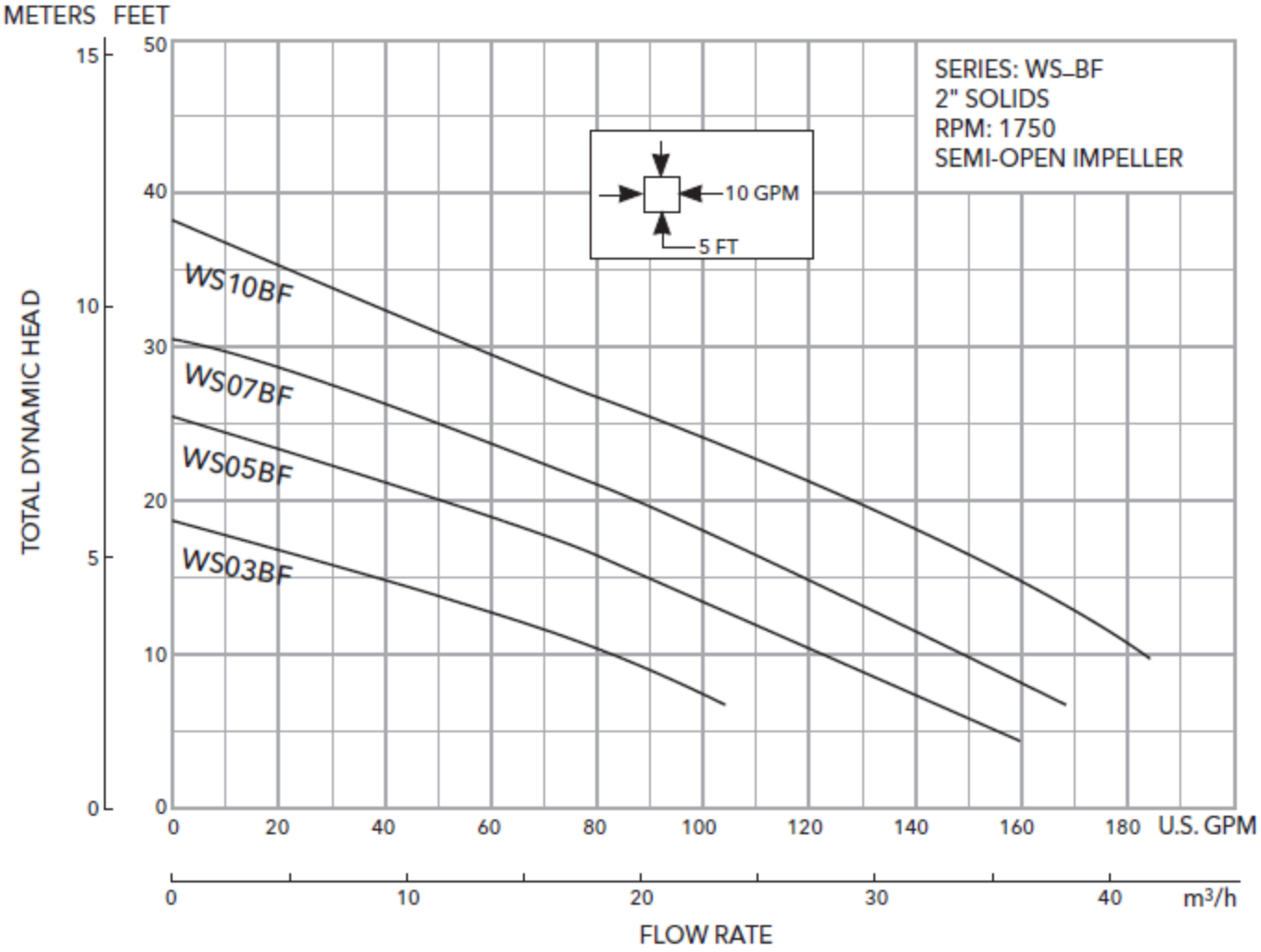
Vertical lift = 15 Ft

Friction Loss = 6 Ft

System Pressure = 3 Ft

TDH = 24 Ft

Pump Curves


METERS FEET
TOTAL DYNAMIC HEAD
15
10
5
0
50
40
30
20
10
0
SERIES: WS_BF
2" SOLIDS
RPM: 1750
SEMI-OPEN IMPELLER
10 GPM
5 FT
WS10BF
WS07BF
WS05BF
WS03BF
0 20 40 60 80 100 120 140 160 180 U.S. GPM
0 10 20 30 40 m³/h
FLOW RATE

5. Sizing receiver basin

✓Basin must be large enough to accommodate the pump, with room for switch(es) to swing freely.

✓Must provide adequate drawdown to assure at least a minimum run time(cycle time) for proper motor cooling.

✓Adequate run time and flow volume to evacuate the liquid stored in the pipe at least one time per pump on cycle.

✓Rule of thumb- basin should be 3 to 4 times pump capacity

Sizing Receiver Basin

FIBERGLASS BASIN

Order No.	Options ①	Dimensional Data			Approx.		Weight (lbs.)		
		A	B	C	Total Gallons	Gallons Per Inch	Fiberglass Standard Basin	with "F" suffix	with "S" suffix
A7-2436	F or S	24	36	26.5	65	1.81	40	60	107
A7-2448		24	48		84	1.75	50	70	117
A7-2460		24	60		102	1.70	59	79	126
A7-2472F	S	24	72		118	1.64	NA	89	136
A7-2484F		24	84		165	1.96	NA	116	163
A7-2496F		24	96		188	1.96	NA	125	172
~~A7-3036~~		~~30~~	~~36~~		~~110~~	~~3.00~~	~~46~~	~~80~~	~~148~~
A7-3048	F or S	30	48		137	2.85	59	92	160
A7-3060		30	60	32.5	169	2.82	90	104	172
A7-3072F	S	30	72		199	2.76	NA	147	214
A7-3084F		30	84		257	3.05	NA	162	230
A7-3096F		30	96		294	3.06	NA	177	245
A7-3636	F or S	36	36	38.5	159	4.41	64	103	195
A7-3648		36	48		200	4.17	78	118	210
A7-3660		36	60		246	4.10	93	132	224
A7-3672F	S	36	72		291	4.04	NA	207	299
A7-3684F		36	84		370	4.40	NA	226	318
A7-3696F		36	96		423	4.40	NA	244	336

This chart lists various basin sizes, dimensions and the amount of water per inch of basin height.

A 30” basin volume is 2.85 gallons per inch.

Sizing Receiver Basin

✓The basin must must provide enough drawdown capacity to provide a minimum run time (cycle time) for the pump. This will assure proper cooling of the motor.

✓Recommended run times for motors are *one minute* for motors through 1-1/2 HP, and *two minutes* for motors 2 HP and larger

✓***Rule of Thumb –*** Receiver should be 3 to 4 times pump capacity.

✓***Rule of Thumb*** **-** Min. Dia.Simplex = 24”, Duplex=36”

6. Pipe size

✓Discharge pipe must be capable of handling the size of solids in the system, and at least as big as the pump outlet.

✓The size of the piping will also affect the TDH (the larger the pipe the less the friction).

✓Pipe size must be adequate to maintain 2 ft per second scouring velocity to prevent pipe and fittings from clogging.

Pipe Volume and Velocity

PIPE VOLUME AND VELOCITY

Storage of Water in Various Size Pipes

Pipe Size	Volume in Gallons per Foot	Pipe Size	Volume in Gallons per Foot
1¼	.06	6	1.4
1½	.09	8	2.6
2	.16	10	4.07
3	.36	12	5.87
4	.652		

Minimum Flow to Maintain 2ft./sec. *Scouring Velocity in Various Pipes

Pipe Size	Minimum GPM	Pipe Size	Minimum GPM
1¼	9	6	180
1½	13	8	325
2	21	10	500
3	46	12	700
4	80		

* Failure to maintain or exceed this velocity will result in clogged pipes. Based on schedule 40 nominal pipe.

7. Electric Service

✓Submersible wastewater pumps are designed to run on single phase or three phase service. Single phase circuits provide 115, 208 or 240 volts. Three phase circuits provide 200, 230, 460 or 575 volts. The power company usually establishes the type of service available.

✓Motors that use three phase service require “heaters” or overload protection.

✓Pump motor and controls must be the same voltage, phase as the available service.

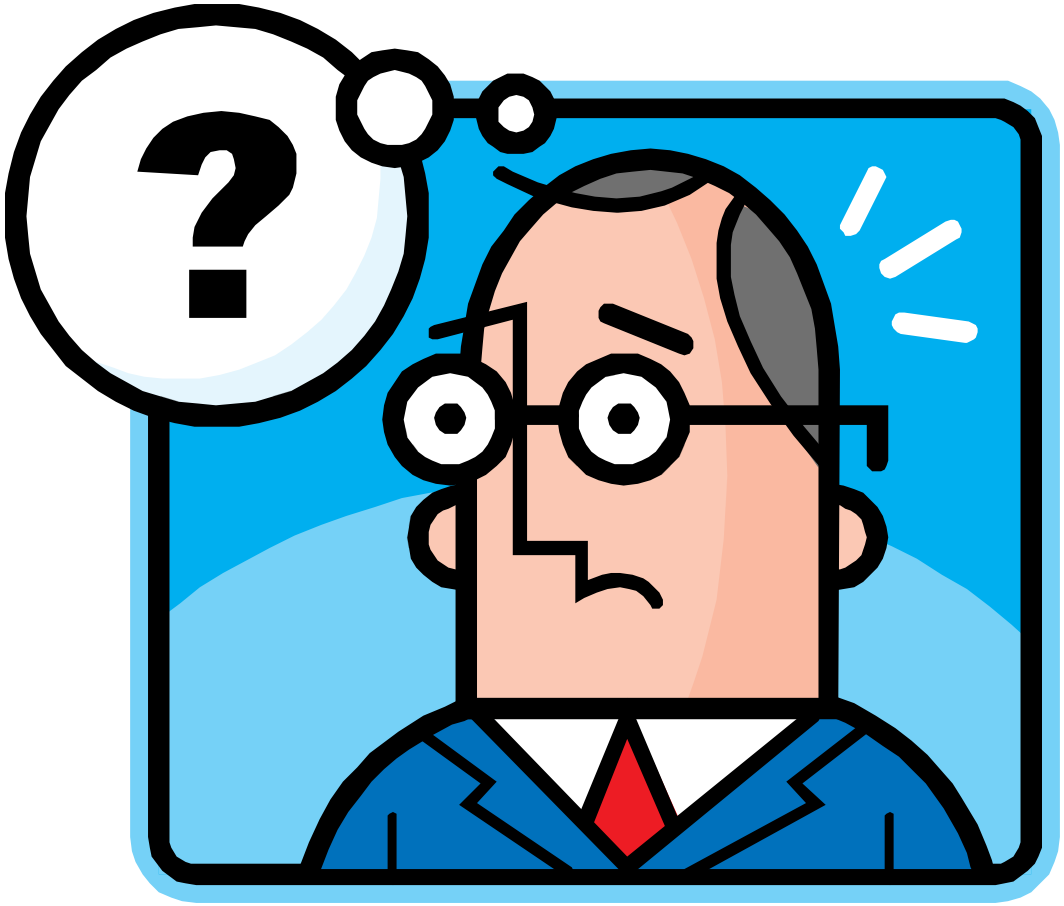
Panels

Picking a panel……

When choosing a panel you will need:

- **QUANTITY** of Pumps being used in a wastewater station
- **PHASE** of pump being used
- **VOLTAGE** of pump being used
- **AMP DRAW** of the pump model being used **OR HORSEPOWER** of pump being used
- **LOCATION** of panel installation

Plus Options!
Panel Selection Check List Is Available



Thank You!!

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