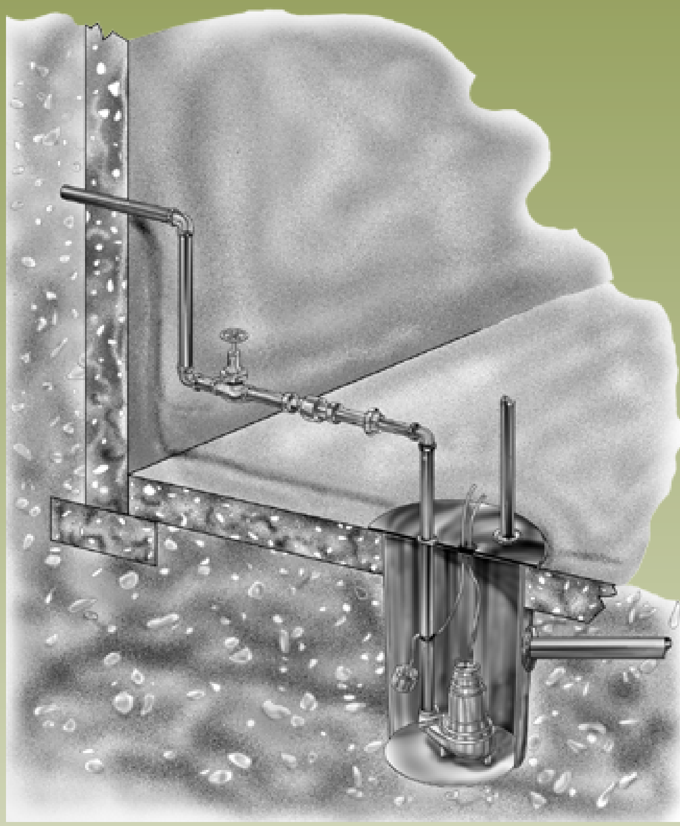
Wastewater

Guidelines for Sizing



Features

- These guidelines cover the steps which need to be taken to accurately select the correct sewage pump and applicable systems to use in sewage ejectors.

Work through the five steps below to size the system:

- System capacity (gpm required)
- Total head
- Pump selection
    - Solids handling
- Basin size
- Simplex/Duplex system

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System Capacity

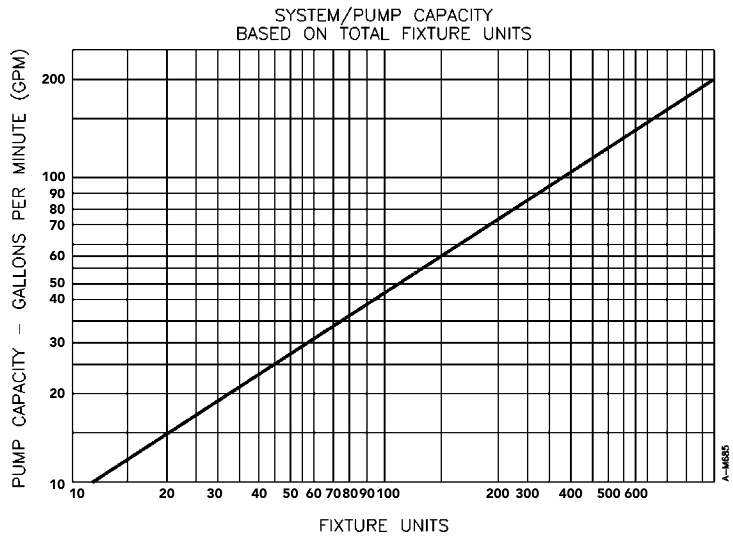
System Capacity refers to the rate of flow in gallons per minute (gpm) necessary to efficiently maintain the system. The "Fixture Unit" method is suggested for determining this figure. This approach assigns a relative value to each fixture or group of fixtures normally encountered. Determination of the required **System Capacity** is as follows:

- List all fixtures involved in the installation and using Figure 1, assign a Fixture Unit value to each. Add to obtain total.
- Referring to Figure 2, locate the total Fixture Unit amount along the horizontal axis of the graph and follow vertically until intersecting the plotted line. Read the **System Capacity** in gpm along the vertical axis.

Figure 1.

FIXTURE DESCRIPTION	UNIT VALUE	TOTAL USED
Bathroom group, consisting of lavatory, bathtub or shower and (direct flush) water closet	10	
Bathroom group, consisting of lavatory, bathtub or shower and (flush tank) water closet	6	
Bathtub with 1-1/2" trap	2	
Bathtub with 2" trap	3	
Bidet with 1-1/2" trap	3	
Dental unit or cuspidor	1	
Drinking fountain	1	
Dishwasher (domestic type)	2	
Kitchen sink (domestic)	2	
Kitchen sink (domestic with waste grinder)	3	
Lavatory with 1-1/2" trap	1	
Lavatory (barber or beauty shop)	2	
Laundry tray (2-compartment)	2	
Shower stall	2	
Shower (group), per head	3	
Sink (service type with floor drain)	3	
Sink (scullery)	4	
Sink (surgeons)	3	
Urinal (with flush valve)	8	
Urinal (with flush tank)	4	
Water closet (flush valve)	7	
Water closet (flush tank)	3	
Swimming pools (per 1000 gal. capacity)	1	
Unlisted fixture with 1-1/4" trap size	2	
Unlisted fixture with 1-1/2" trap size	3	
Unlisted fixture with 2" trap size	4	
Unlisted fixture with 2-1/2" trap size	5	
Unlisted fixture with 3" trap size	6	
Unlisted fixture with 4" trap size	7	
Water softener (domestic)	4	
Washing machine	2	
	TOTAL	

Figure 2.



Total Head

Total Head is a combination of two components — Static Head and Friction Head — and is expressed in feet (refer to Typical Installation illustration, Figure 3).

Static Head is the actual vertical distance measured from the minimum water level in the **Basin** to the highest point in the discharge piping.

Friction Head is the additional head created in the discharge system due to resistance to flow within its components. All straight pipe, fittings, valves, etc. have a friction factor which must be considered. These friction factors are converted to, and expressed as, equivalent feet of straight pipe, which can then be totaled and translated to Friction Head depending on the flow and pipe size. Basically, this is reduced to four steps.

1. It will be necessary to determine the discharge pipe size. In order to ensure sufficient fluid velocity to carry solids, (generally accepted to be 2' per second), flows should be at least:
   - 9 gpm through 1-1/4" pipe
   - 13 gpm through 1-1/2" pipe
   - 21 gpm through 2" pipe
   - 30 gpm through 2-1/2" pipe
   - 46 gpm through 3" pipe
2. The length of the discharge piping is measured from the discharge opening of the pump to the point of final discharge, following all contours and bends.
3. To determine the equivalent length of discharge piping represented by the various fittings and valves, refer to Figure 5 and total all values. Add this to the measured length of discharge pipe and divide by 100 to determine the number of 100' increments.
4. Refer to Figure 4 and find the required **Pump Capacity** (determined from Figure 2). Follow gallons per minute to pipe size being used. Multiply this number by the number of 100' increments.

Add the Static Head and Friction Head to determine **Total Head**.

Figure 3.

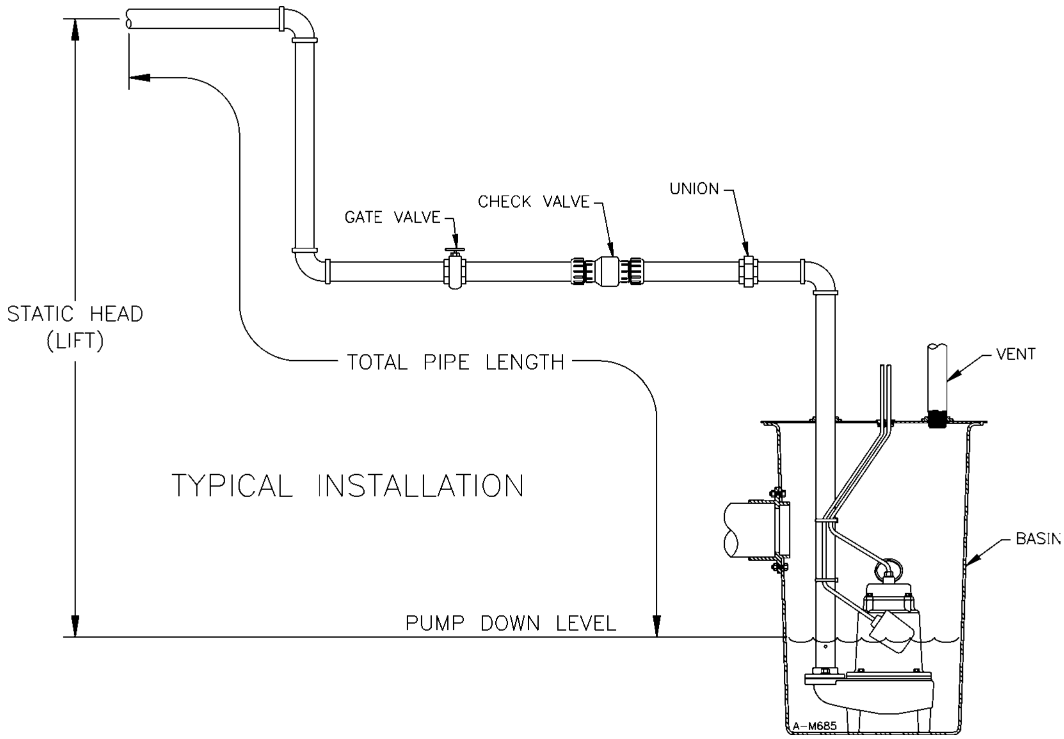


Figure 4.

PLASTIC PIPE: FRICTION LOSS (in feet of head) PER 100 FT						
REQ'D PUMP CAPACITY GPM	1-1/4" ft	1-1/2" ft	2" ft	2-1/2" ft	3" ft	4" ft
1						
2	.10					
3	.21	.10				
4	.35	.16				
5	.51	.24				
6	.71	.33	.10			
8	1.19	.55	.17			
10	1.78	.83	.25	.11		
15	3.75	1.74	.52	.22		
20	6.39	2.94	.86	.36	.13	
25	9.71	4.44	1.29	.54	.19	
30	13.62	6.26	1.81	.75	.26	
35	18.17	837	2.42	1.00	.35	.09
40	23.55	10.70	3.11	1.28	.44	.12
45	29.44	13.46	3.84	1.54	.55	.15
50		16.45	4.67	1.93	.66	.17
60		23.48	6.60	2.71	.93	.25
70			8.83	3.66	1.24	.33
80			11.43	4.67	1.58	.41
90			14.26	5.82	1.98	.52
100				7.11	2.42	.63
125				10.83	3.80	.95
150					5.15	1.33
175					6.90	1.78
200					8.90	2.27
250						3.36
300						4.85
350						6.53

Figure 5.

FRICTION FACTORS FOR PIPE FITTINGS IN TERMS OF EQUIVALENT FEET OF STRAIGHT PIPE						
NOMINAL PIPE SIZE	90° ELBOW	45° ELBOW	TEE (THROUGH FLOW)	TEE (BRANCH FLOW)	SWING CHECK VALVE	GATE VALVE
1-1/4	3.5	1.8	2.3	6.9	11.5	0.9
1-1/2	4.0	2.2	2.7	8.1	13.4	1.1
2	5.2	2.8	3.5	10.3	17.2	1.4
2-1/2	6.2	3.3	4.1	12.3	20.3	1.7
3	7.7	4.1	5.1	15.3	25.5	2.0

TOTAL HEAD REQUIRED		
(A) STATIC HEAD		
(B) TOTAL LENGTH OF PIPING		
(C) TOTAL FRICTION FACTORS OF FITTINGS		
(D) TOTAL (B+C)		
(E) DIVIDED (D) BY 100		
(F) HEAD LOSS PER 100 FT. OF PIPE (from Figure 4)		
(G) FRICTION HEAD (ExF)		
(H) TOTAL HEAD (A+G)		

Pump Selection

Every centrifugal pump has a unique performance curve. This curve illustrates the relationship of flow **(gpm)** to pressure **(Total Head)** at any point. The pump will operate at any point along this performance curve.

Pump capacity is therefore the flow the pump will generate at any specific pressure. The object is to select a pump whose performance curve passes either through or close to the design condition, preferably above. Refer to Figure 7.

Solids Handling

Solids Handling requirements may be determined by local codes and/or by the type of application and types of solids anticipated. Unless otherwise stated by codes, a sewage pump should have the capability of handling spherical solids of at least 2" in diameter in installations involving a water closet.

Basin Size

Basin selection is best accomplished by relating to required **System Capacity** as determined by the **Fixture Unit** method.

Figure 6 shows recommended basin diameters, assuming the normal pump differential (distance in inches between turn-on and turn-off), and running time ranges from 15 seconds to 4 minutes. **Basin** depth, however, should be at least 24" below basin inlet for most pumps and deeper where greater pumping differentials are anticipated.

NOTE: Since basin size is directly related to frequency of pump operation, it is important to select a basin of sufficient size to ensure that the pump does not short cycle.

The question of whether to use a **Simplex** or **Duplex** system depends on the type of installation and/or local codes. Generally, a determination can be made using the following guidelines.

1. Domestic: **Simplex System** is usually adequate.
2. Commercial: **Optional** — Depending on the type of business and the need for uninterrupted sanitary drainage facilities.
3. Public or Industrial: **Duplex System** is essential.

While you are sizing the system and before you select the pump, you will need to know and consider or make allowances for the following:

- Volts/Phase/Hertz — What is available?
- Will the pump share a circuit?
- Does the home, business, etc. have circuit breakers or fuses?
- What is the breaker or fuse Amp rating? Make sure it is enough.
- Check local or state codes for:
  - — Solid size requirements
  - — Amp ratings/circuit cord size/ratings or type
  - — Pipe material/size/depth to bury
  - — Tank size/location
- Are there plans for future expansion? As in, adding upstairs bath, basement plumbing, washing machine, etc.

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Figure 6.

BASIN SIZING

		BASIN DIAMETER (inches)					
		18"	**24"**	**30"**	**36"**	**42"**	**48"**
SYSTEM CAPACITY (GPM)	20						
	25						
	30						
	35						
	40						
	45						
	50						
	60						
	70						
	80						
	90						
	100						
	125						
	150						
	175						
	200						
	225						
GALLONS/FOOT OF BASIN DEPTH		13.2	23.9	36.7	52.9	72.0	94.0
GALLONS IN 2-1/2' OF BASIN DEPTH		33.0	59.7	91.7	132.2	180.0	235.0

Select minimum basin depth so that 2-1/2' of basin depth in gallons = Pump capacity in **gpm**

= Acceptable basin size

Example Sizing Problem

What **Pump Capacity** would be required to handle the drainage from a 4 bathroom home, also including a dishwasher, a washer, a laundry tray, a kitchen sink, water softener, basement shower, a 13,000 gallon pool, and a bar sink (1-1/2" trap)?

1. From Figure 1:

DESCRIPTION	FIXTURE UNITS
Four bathroom groups	24
Water softener	4
Dishwasher	2
Washing machine	2
Laundry tray	2
Kitchen sink with disposal	3
Basement shower	2
Swimming pool	13
Bar sink (unlisted 1-1/2")	3
FIXTURE UNITS TOTAL	**55**

2. Refer to Figure 2:

   Find 55 Fixture Units on the horizontal axis. Follow vertically until intersecting the line then horizontally to the left. The **Pump Capacity** on the vertical axis is 30 gpm.

Determine the **Total Head** of the installation illustrated in Figure 3, the Typical Installation Illustration:

1. That Static Head in this instance is 7'.
2. Friction Head:
   a. Since the required **Pump Capacity** in this illustration of 30 gpm is less than the 46 gpm necessary to carry solids through 3" pipe, 2" or 2-1/2" pipe should be used. If 3" pipe is preferred or required, a **Pump Capacity** of at least 46 gpm is required.
   b. Measurement of the length of the discharge pipe totals 200'.
   c. Refer to Figure 6 and note the friction factor in equivalent feet for each fitting:

3 - 90° elbows, 2"	16 - equivalent feet
1 - gate valve, 2"	1 - equivalent foot
1 - swing check valve, 2"	17 - equivalent feet
Total:	34 - equivalent feet

   Adding 34' to the measured pipe length, the total effective pipe length becomes 234' or 2.34 100' increments.
   d. Refer to Figure 4, find the 30 gpm required **Pump Capacity** on the left scale and follow over to the 2" PVC pipe size column. Friction Head is 1.8 x 2.34 = 4.2'.

3. Total Head Required:

   Total Head = Static Head + Friction Head

   Example:

   Total Head = 7 + 4.2

   Total Head = 11.2

Due to the existence of water closets in this installation, a pump with 2" **Solids Handling** capacity should be used unless otherwise specifically stated by applicable codes. Use Figure 7 to select pump.

To determine the **Basin** size, find the **Pump Capacity** (30 gpm) in the column on the left of Figure 6. Any **Basin** diameter of 18" or greater is acceptable.

Since this application is domestic, a **Simplex System** is sufficient.

Summary: Recommended selections for this installation would be a **Simplex System** utilizing an 18" or greater diameter **Basin** and a 2" **Solids Handling** pump capable of delivering at least 30 gpm at 11'.

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Summary Worksheet	
Number of Fixture Units	______________________
Flow Rate - Gallons Per Minute	______________________
Total Head Required	______________________
Pump Selection	______________________

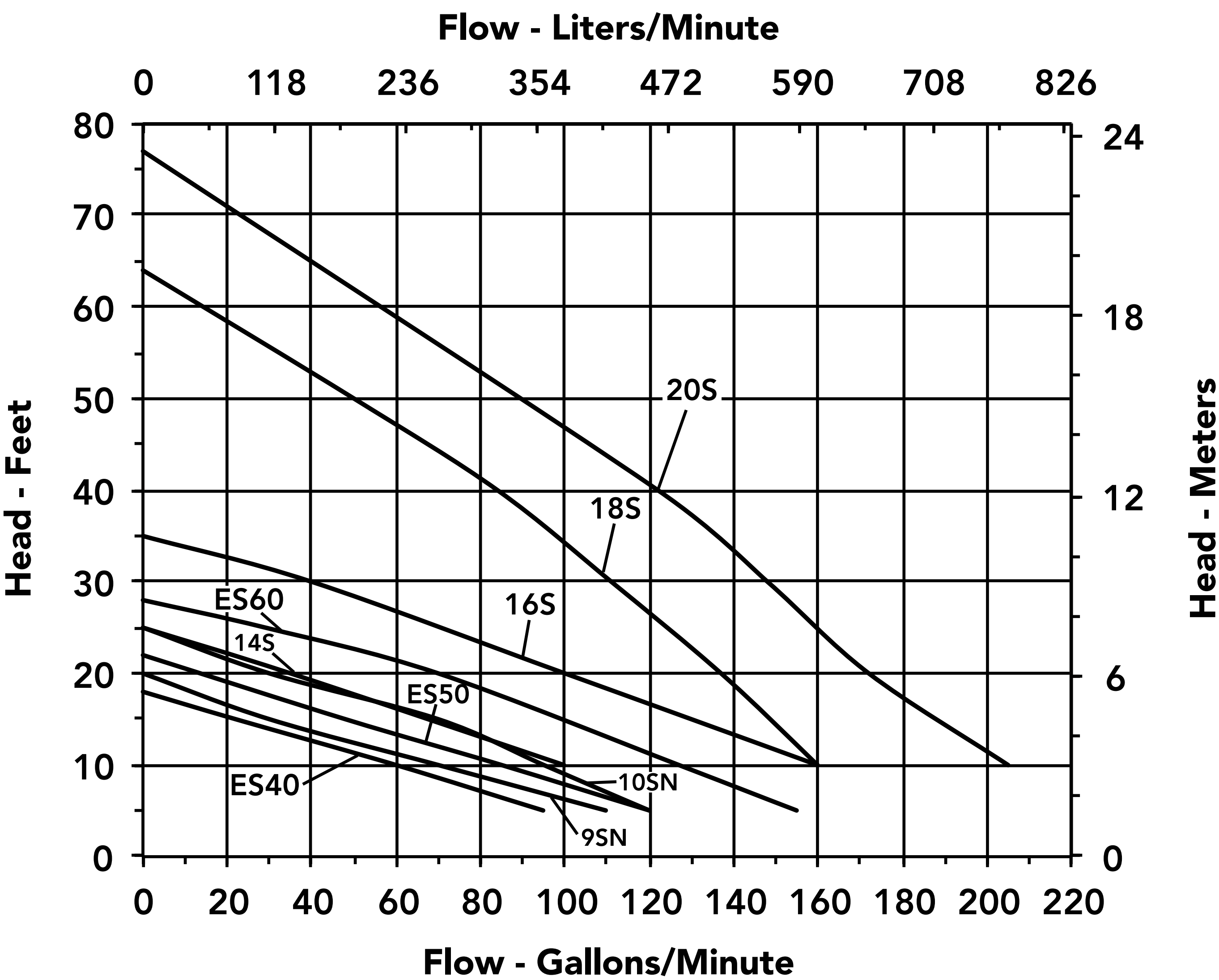
Typical Single Family Dwelling Sewage Pump Chart

Note: The data contained herein is for reference only. Proper sizing and selection of sewage pumps requires consideration of many factors. Always consult applicable local codes before installing any equipment. This chart is based on a residential application with not more than 34 fixture units (values assigned to each plumbing fixture). The TDH (Total Dynamic Head) of the system is calculated based on total vertical lift, horizontal length of discharge piping, and the friction losses for 2” diameter plastic pipe (3” diameter plastic pipe where the 16S pump is shown).

Total Length of Discharge Pipe in Feet

TOTAL VERT. LIFT	100'	150'	200'	250'	300'	350'	400'	450'	500'	550'	600'	650'	700'	750'	800'
	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM	TDH PUMP GPM
5'	6.3' 9SN 97 gpm	7.0' 9SN 95 gpm	7.5' 9SN 92 gpm	8.3' 9SN 88 gpm	8.9' 9SN 82 gpm	9.6' 9SN 77 gpm	10.2' 9SN 72 gpm	10.9' 9SN 67 gpm	11.5' 9SN 61 gpm	12.2' 9SN 54 gpm	12.8' 9SN 48 gpm	13.5' 9SN 43 gpm	14.1' 9SN 38 gpm	14.8' 9SN 32 gpm	15.4' 9SN 27 gpm
6'	7.3' 9SN 93 gpm	8.0' 9SN 89 gpm	8.6' 9SN 83 gpm	9.3' 9SN 78 gpm	9.9' 9SN 75 gpm	10.6' 9SN 69 gpm	11.2' 9SN 63 gpm	11.9' 9SN 57 gpm	12.5' 9SN 52 gpm	13.5' 9SN 43 gpm	13.8' 9SN 40 gpm	14.5' 9SN 33 gpm	15.1' 9SN 29 gpm	15.8' 9SN 25 gpm	16.4' 10SN 57 gpm
7'	8.3' 9SN 88 gpm	9.0' 9SN 81 gpm	9.6' 9SN 77 gpm	10.3' 9SN 70 gpm	10.9' 9SN 67 gpm	11.6' 9SN 59 gpm	12.2' 9SN 54 gpm	12.9' 9SN 47 gpm	13.5' 9SN 43 gpm	14.2' 9SN 36 gpm	14.8' 9SN 32 gpm	15.5' 9SN 26 gpm	16.1' 10SN 62 gpm	16.8' 10SN 54 gpm	17.4' 10SN 48 gpm
8'	9.3' 9SN 78 gpm	10.0' 9SN 76 gpm	10.6' 9SN 69 gpm	11.3' 9SN 62 gpm	11.9' 9SN 57 gpm	12.6' 9SN 50 gpm	13.2' 9SN 45 gpm	13.9' 9SN 39 gpm	14.5' 9SN 33 gpm	15.2' 9SN 28 gpm	15.8' 9SN 25 gpm	16.5' 10SN 56 gpm	17.1' 10SN 52 gpm	17.8' 10SN 46 gpm	18.4' 10SN 41 gpm
9'	10.3' 9SN 70 gpm	11.0' 9SN 65 gpm	11.6' 9SN 59 gpm	12.3' 9SN 53 gpm	12.9' 9SN 47 gpm	13.4' 9SN 44 gpm	14.2' 9SN 36 gpm	14.9' 9SN 30 gpm	15.5' 9SN 26 gpm	16.2' 10SN 60 gpm	16.8' 10SN 54 gpm	17.5' 10SN 48 gpm	18.1' 10SN 42 gpm	18.8' 10SN 39 gpm	19.4' 10SN 33 gpm
10'	11.3' 9SN 62 gpm	12.0' 9SN 56 gpm	12.6' 9SN 50 gpm	13.3' 9SN 44 gpm	13.9' 9SN 39 gpm	14.6' 9SN 33 gpm	15.2' 9SN 28 gpm	15.9' 10SN 62 gpm	16.5' 10SN 56 gpm	17.2' 10SN 50 gpm	17.8' 10SN 46 gpm	18.5' 10SN 40 gpm	19.1' 10SN 35 gpm	19.8' 10SN 32 gpm	20.4' 10SN 27 gpm
11'	12.3' 9SN 53 gpm	13.0' 9SN 46 gpm	13.6' 9SN 42 gpm	14.3' 9SN 35 gpm	14.9' 9SN 30 gpm	15.6' 9SN 25 gpm	16.2' 10SN 60 gpm	16.9' 1 10SN 53 gpm	17.5' 10SN 48 gpm	18.2' 10SN 42 gpm	18.8' 10SN 39 gpm	19.5' 10SN 33 gpm	20.1' 10SN 29 gpm	20.8' 10SN 25 gpm	21.4' 14S 27 gpm
12'	13.3' 9SN 44 gpm	14.0' 9SN 40 gpm	14.6' 9SN 33 gpm	15.3' 9SN 27 gpm	15.9' 10SN 62 gpm	16.6' 10SN 55 gpm	17.2' 10SN 50 gpm	17.9' 10SN 45 gpm	18.5' 10SN 40 gpm	19.2' 10SN 34 gpm	19.8' 10SN 32 gpm	20.5' 10SN 26 gpm	21.1' 14S 30 gpm	21.8' 14S 26 gpm	16.4' 16S 120 gpm*
13'	14.3' 9SN 35 gpm	15.0' 9SN 29 gpm	15.6' 9SN 25 gpm	16.3' 10SN 58 gpm	16.9' 10SN 53 gpm	17.6' 10SN 47 gpm	18.2' 10SN 42 gpm	18.9' 10SN 37 gpm	19.5' 10SN 33 gpm	20.2' 10SN 28 gpm	20.8' 10SN 25 gpm	22.0' 14S 25 gpm	17.6' 16S 113 gpm*	17.9' 16S 112 gpm*	18.2' 16S 111 gpm*
14'	15.3' 9SN 27 gpm	16.0' 10SN 61 gpm	16.6' 10SN 55 gpm	17.3' 10SN 49 gpm	17.9' 10SN 45 gpm	18.6' 14S 39 gpm	19.2' 10SN 34 gpm	19.9' 10SN 31 gpm	20.5' 10SN 26 gpm	21.2' 14S 29 gpm	21.8' 14S 26 gpm	17.6' 16S 113 gpm*	17.9' 16S 112 gpm*	18.2' 16S 111 gpm*	18.4' 16S 110 gpm*
15'	16.3' 10SN 58 gpm	17.0' 10SN 52 gpm	17.6' 10SN 47 gpm	18.3' 10SN 41 gpm	18.9' 10SN 37 gpm	19.6' 10SN 33 gpm	20.2' 10SN 28 gpm	20.9' 10SN 25 gpm	21.5' 14S 27 gpm	22.2' 14S 25 gpm	18.3' 16S 110 gpm*	18.6' 16S 109 gpm*	18.9' 16S 107 gpm*	19.2' 16S 105 gpm*	19.4' 16S 104 gpm*
16'	17.3' 10SN 49 gpm	18.0' 10SN 44 gpm	18.6' 10SN 39 gpm	19.3' 10SN 33 gpm	19.9' 10SN 31 gpm	20.6' 10SN 25 gpm	21.2' 14S 29 gpm	21.9' 14S 26 gpm	18.8' 16S 107 gpm*	19.1' 16S 105 gpm*	19.3' 16S 104 gpm*	19.6' 16S 103 gpm*	19.9' 16S 101 gpm*	20.2' 16S 98 gpm*	21.2' 16S 95 gpm*
17'	18.3' 10SN 41 gpm	19.0' 10SN 36 gpm	19.6' 10SN 33 gpm	20.3' 10SN 27 gpm	20.9' 10SN 25 gpm	21.6' 14S 26 gpm	22.2' 14S 25 gpm	19.5' 16S 103 gpm*	19.8' 16S 102 gpm*	20.0' 16S 100 gpm*	20.3' 16S 99 gpm*	20.6' 16S 98 gpm*	20.9' 16S 97 gpm*	21.2' 16S 95 gpm*	22.4' 16S 95 gpm*
18'	19.3' 10SN 33 gpm	20.0' 10SN 30 gpm	20.6' 10SN 25 gpm	21.3' 14S 28 gpm	21.9' 14S 26 gpm	19.9' 16S 101 gpm*	20.2' 16S 98 gpm*	20.5' 16S 98 gpm*	20.8' 16S 97 gpm*	21.1' 16S 96 gpm*	21.3' 16S 95 gpm*	22.6' 16S 93 gpm*	21.9' 16S 91 gpm*	22.2' 16S 90 gpm*	22.4' 16S 89 gpm*
19'	20.3' 10SN 27 gpm	21.0' 14S 30 gpm	21.6' 14S 26 gpm	22.3' 14S 25 gpm	20.7' 16S 98 gpm*	21.0' 16S 96 gpm*	21.2' 16S 95 gpm*	22.5' 16S 94 gpm*	21.8' 16S 92 gpm*	22.1' 16S 91 gpm*	22.3' 16S 90 gpm	22.6' 16S 86 gpm*	22.9' 16S 84 gpm*	23.2' 16S 82 gpm*	23.4' 16S 81 gpm*
20'	21.3' 14S 28 gpm	22.0' 14S 25 gpm	21.6' 16S 95 gpm*	21.9' 16S 95 gpm*	22.2' 16S 95 gpm*	22.5' 16S 88 gpm*	22.8' 16S 85 gpm*	23.1' 16S 83 gpm*	23.4' 16S 81 gpm*	23.7' 16S 80 gpm*	24.0' 16S 79 gpm*	24.3' 16S 78 gpm*	24.6' 16S 77 gpm*	24.9' 16S 76 gpm*	25.2' 16S 75 gpm*

Figure 7.



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