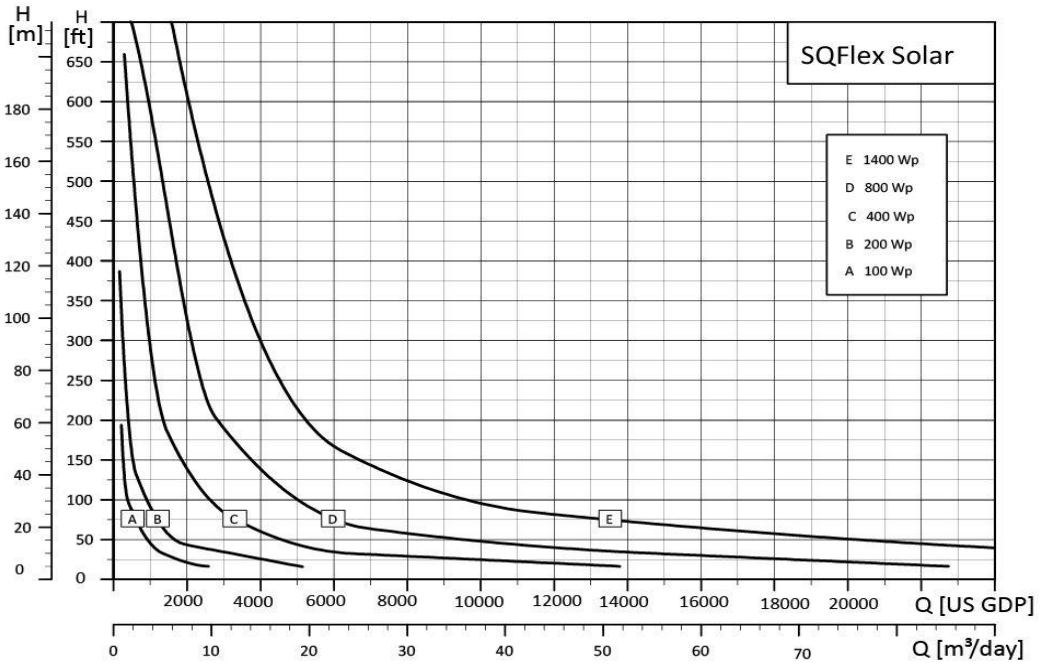
Workshop Exercise – Solar Water Pumping Systems

1. A small community consists of 20 people, assuming the daily water requirement is 15.85 US gallons per person. What is the total daily water requirement in US gallons per day?

2. The designer has determined that the site requires 317 US gallons of water per day and the total dynamic head has been estimated as 65.6ft. Assume the graph below gives the pumping capacities of various Grundfos SQFlex irradiation of 5kWh/m^2 on a fixed array frame. What is the minimum Grundfos SQFlex solar water pumping system model that is suitable?



3. The solar water pumping system daily flow volume is based on an irradiation of 5kWh/m^2 per day. The daily flow volume is directly proportional to the irradiation. The solar water pump curve shows for a specified head that the solar pumping system will provide 2642 US gallons per day at irradiation of 5kWh/m^2, what flow will the solar water pumping system provide at an irradiation of 4kWh/m^2?

4. A solar pumping system where the solar array is mounted on a tracking system will provide on average 1.3 times more volume of water per day for the same specified array wattage as that on the tracking system. If a tracking system will provide 3434 US gallons per day, what will a fixed array frame with same array size produce?

5. The designer has determined that the site requires 2642 US gallons of water per day and the total dynamic head has been calculated as 115ft. The site has irradiation of 5.5kWh/m^2 on a fixed array frame. Assume a tracking system produces 30% more flow than a stationary system and refer to the table below, what is the smallest array size suitable (answer in Watts)?

6.5kW/hr average performance tracking						
	System Size (watts)					
Head (ft)	200	400	600	800	1200	1600
16.4	8718	14001	26946	27474	29059	29587
32.8	6340	12152	21398	24568	27738	28531
49.2	4491	10303	12416	20870	25889	27474
65.6	3698	8189	11095	16379	23775	26153
82.0	2906	6604	9510	12944	21134	24568
98.4	2378	5283	8189	8982		
114.8	1849	4227	6868	7925		
131.2	1585	3170	3963			
147.6		2642	3434			
164.0		2113	2906			

Table 7b: Daily Flow in gallons for surface Mono Solar Water Pumping Systems

6. A village that comprises 100 people wish to use solar water pumping to meet their water requirements. The surface pump will be located 13 ft above river level. The suction pipe will be 26 ft in length. The water will be stored in a water tank that is located 164 ft away from the river and 50ft vertically above the location of the surface pump. There will be a foot valve in the suction pipe and a gate valve in the discharge pipe. The daily irradiation is 6.5 kWh/m^2 and the solar array will be mounted on a tracking array frame. The village requires minimum of 1321 US gallons of water per day.
   Use the equation:
   Total dynamic head = static head + friction head + velocity head

   Assume friction head is 16ft and velocity head of 3 ft.
   Assume the Mono pump model SRX CP25 has been chosen as the pump. The pump is capable of 7.4 US gallons/min and has inlet and outlet diameters of 1 inch (see diagram below).

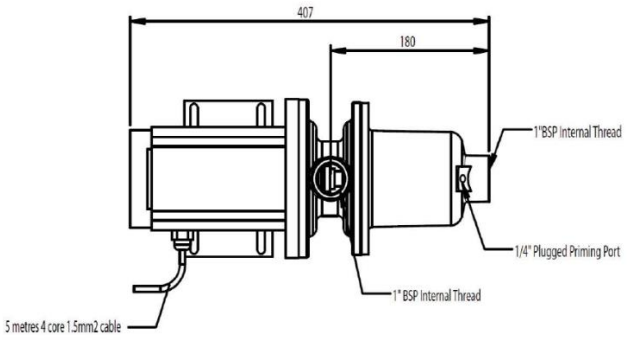


Figure 1: Mono Pump SRX CP25 schematic

   What is the total assumed dynamic head? _____ft

   Use the pipe table (6) provided. What pipe would you select so that friction losses is 16ft or less?
   _____

What is the friction loss in the pipe for the given distance? _____ft

What's the corresponding velocity (in feet/second) for the chosen pipe at the pump's maximum output? _____ft/s

To calculate friction loss in pipe fittings, this equation can be used: $= K \times v^2 / 2g$
Where g = 32.185 ft/s

K Values for Some Fittings (imperial)

Size (inches)	½	¾	1	1 ¼	1 ½	1 ¾	2	2 ½ to 3	4	6
Foot valve	11.3	10.50	9.7	9.3	8.80	Not supplied	8.00	7.6	7.1	6.30
Gate Valve	0.22	0.20	0.18	0.18	0.15	0.15	0.14	0.14	0.12	0.11

If a 1-inch poly pipe is used with the corresponding velocity of 2.74ft/s, what would be the friction head of the foot valve and the gate valve?
Foot valve: _____ft
Gate valve: _____ft

The total frictional head loss of the water piping system = Frictional head loss of suction pipe and discharge pipe + frictional head of a foot valve + frictional head loss of a gate valve.

What would be the total frictional head loss of the water piping system? _____ft

Velocity head is calculated with the equation = $v^2 / 2g$. What is the velocity head at this site? _____ft
What is the actual total dynamic head of the water pumping system? _____ft

Table 6: PSI Loss per 100 feet for Poly Pipe (tube)

Size	1/2"		¾"		1"		1 ¼"		1 ½"		2"		2 ½"	
ID	0.622		0.824		1.049		1.380		1.610		2.067		2.169	
Flow G.P.M	**Velocity F.P.S**	**PSI Loss**	**Velocity F.P.S**	**PSI Loss**	**Velocity F.P.S**	**PSI Loss**	**Velocity F.P.S**	**PSI Loss**	**Velocity F.P.S**	**PSI Loss**	**Velocity F.P.S**	**PSI Loss**	**Velocity F.P.S**	**PSI Loss**
1	1.05	0.49	0.6	0.12	0.37	0.04	0.21	0.01	0.155	0.00	0.095	0.00		
2	2.10	1.76	1.2	0.45	0.74	0.14	0.42	0.04	0.31	0.02	0.19	0.01		
3	3.16	3.73	1.8	0.95	1.11	0.29	0.63	0.08	0.47	0.04	0.29	0.01	0.20	0.00
4	4.21	6.35	2.4	1.62	1.48	0.50	0.84	0.13	0.62	0.06	0.38	0.02	0.26	0.01
5	5.27	9.60	3	2.44	1.85	0.76	1.05	0.20	0.78	0.09	0.48	0.03	0.33	0.01
6	6.32	13.46	3.6	3.43	2.22	1.06	1.26	0.28	0.93	0.13	0.57	0.04	0.40	0.02
7	7.38	17.91	4.2	4.56	2.59	1.41	1.47	0.37	1.09	0.18	0.67	0.05	0.46	0.02
8	8.43	22.93	4.8	5.84	2.96	1.80	1.68	0.47	1.24	0.22	0.76	0.07	0.53	0.03
9	9.49	28.52	5.4	7.26	3.33	2.24	1.89	0.59	1.40	0.28	0.86	0.08	0.60	0.03
10	10.54	34.67	6	8.82	3.7	2.73	2.1	0.72	1.55	0.34	0.95	0.10	0.66	0.04
11	11.60	41.36	6.6	10.53	4.07	3.25	2.31	0.86	1.71	0.40	1.05	0.12	0.73	0.05
12	12.65	48.60	7.2	12.37	4.44	3.82	2.52	1.01	1.86	0.48	1.14	0.14	0.80	0.06
14	14.76	64.65	8.4	16.46	5.18	5.08	2.94	1.34	2.17	0.63	1.33	0.19	0.93	0.08
16	16.87	82.79	9.6	21.07	5.92	6.51	3.36	1.71	2.48	0.81	1.52	0.24	1.07	0.10
18	18.98	102.97	10.8	26.21	6.66	8.10	3.78	2.13	2.79	1.01	1.71	0.30	1.20	0.13

Source: Hunter Industries (www.hunterindustries.com)