You Are Doing a Project for an NGO (Non-governmental Organization)

Water is "one of the world's great business opportunities," notes Fortune magazine. It "promises to be to the 21st century what oil was to the 20th." As of 2002, two companies, Vivendi and Suez, controlled about 70% of the world's private water-delivery systems and took in a combined annual revenue of $60 billion dollars.

The privatization of water began way back on December 14, 1853, when Napoleon Bonaparte's nephew, Napoleon III created by decree a water company called "CGE". The following year, this company received their first contract to supply water for the city of Lyons, France. In 1861, they acquired a 50 year contract to supply water for Paris, France. The company, which today is called Vivendi, purchased US Filter in 1999 for $6.2 billion. The "Culligan man" now works for Vivendi. Vivendi is headquartered in Paris, France. They own many companies in addition to water, including Universal Studios.

Suez is also based out of Paris, France and is part of the company that built the Suez Canal in Egypt. In 1999, Suez bought the US corporation United Water for $1 billion.

Politics of water

Like many poor countries in need of money, Ghana agreed to privatize local water systems as a condition for an International Monetary Fund (IMF) loan. How do you get investors? Just double the water rates. The people protested. Average annual income in Ghana is < $400 per year. The water bill can run about $110.00/year, or about 27% of income.

Bolivia's third-largest city had their water system "taken over" (AKA privatized) by USA's Bechtel Corporation. Water rates went up by 35%. People were paying 20% of their income just for water. The people protested, this led to riots, and 6 people were killed. Finally the Bolivian government voided Bechtel's contract and told company officials it could not guarantee their safety if they stayed in town.

Privatization of water systems has spawned protests in Paraguay, Panama, Brazil, Peru, Columbia, India, Pakistan, Hungary and South Africa. The IMF, the World Bank and private companies are changing water systems around the world. Let's look at another example in South Africa: under South Africa's "old" government, people could walk ½ to 2 mile to get water from an outdoor "free" community tap. The government changed in 1994 when apartheid ended. The "new" government wanted to privatize water and electricity. The World Bank suggested a policy of "total cost recovery" (i.e. water is not a "basic need" service subsidized by taxes, rather the users have to pay fees high enough to cover the cost of their usage).

The plan was to promise better water service, expand the water system to be closer to all the villages and houses, and provide safe water. Once Vivendi and Suez got involved, here is what actually happened: the plan was implemented in the summer of 2000. People who were poor to begin with were required to pay a "small charge" for their water. The people were paying as much as they could and then had to turn to traditional and untreated sources of water anyway.

Water meters were installed at houses. Community taps also had meters installed that used a prepaid debit card-like feature. When your card runs out, you buy another card to get more water. Some were trying to pay 30% of their income, and people who could not afford to pay had their water shut off. Soon after this policy went into effect, people began going back to unsafe water sources, and then getting sick. Within 2 ½ years of this policy going into effect, 117,147 South African citizens became sick with cholera, and 265 people died of it. Estimates are that now almost 300,000 have become sickened, nearly 300 died, and the trouble with cholera continues to this day. The government now has promised free basic water. However, a number of areas are not getting this water. Greater attention is being focused on helping the rural poor where the need is great.

I want to invite you to work for a non-Governmental Organization in South Africa.

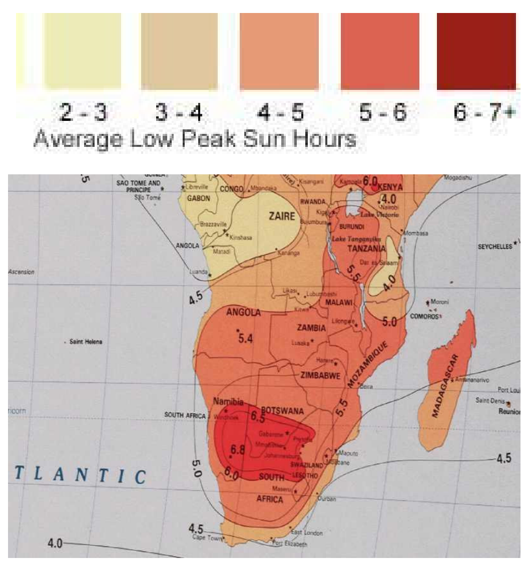
Request for help

Getting water from the stream

The government of South Africa has invited us to help a small remote village of 228 people in a province called, “KwaZulu-Natal”. The village people are just getting over being very sick with cholera and they need a clean water supply. They don’t want help from Vivendi or Suez, they want help from our organization. A relief agency has supplied them with some small portable water filters to just get by until we get there to help them. The village elders have been told that maybe some high school students from the USA could help them. They are excited to assist us.

The relief agency has drilled a well which supplies 20 gpm with a static water level (level to the top of the water) of 60 feet. They have installed the well casing only. They are too short-staffed to do more at this time. Because of the cholera epidemic in South Africa, the World Health Organization has allocated funds to do rural pilot projects in the hardest-hit areas. It is time for us to step in and offer our skills. Off to South Africa we go.

Here is what we know about the village we will be helping:



* There are 228 people (6 people per family and 38 families).
* They are in a remote part of Africa, and there is no electricity nearby.
* The area is hilly and this village sits near the base of a small hill that is about 150’ high.
* Local rainfall is 690mm per year. The rain usually comes during short periods of time. Otherwise, it is sunny a lot.
* The village is in an area that gets 5.5 average sun hours per day (see map).
* There is a dirt road that goes to the village and no stores located near the site. You need to bring in whatever you need to help.
* No river nearby. There are a few small, dirty-looking streams that they use for everything from washing clothes to drinking water.
* The well is located 250’ from the village at the base of their hill.
* The relief agency noted a great spot for a water storage tank, 300’ of walking distance up the hill with an elevation of 100’ above well for the placement of the storage tank. The total walking distance from the storage tank site to the village tap is 550’.

FACTS ABOUT WATER

1 cubic foot of water = 12" L x 12" W x 12"H = 1,728 cubic inches of water.

1 cubic foot = 7.5 gallons of water.

1 gallon of water = 8.3 pounds.

1 cubic foot of water = 62 pounds.

For every 2.31' of elevation in a water system you have 1 PSI (pounds per square inch)

1 gallon of water = 3,785 ml or 3.785 liters.

Heating water facts

Well water temperature out of the ground is usually about 50 F.

Shower water temp is usually about 107 F.

Hot water tanks heat water up to 120-160 F.

BTU = British thermal unit = energy needed to raise 1 pound of water, one degree F.

Calorie = energy needed to raise 1 gram of water, 1 degree C. (1gram of water = 1 ml).

Energy needed to heat 1 ml (1 gram) of water from freezing temp to boiling temp is 100 calories. 0 C is freezing temp and 100 C is boiling temp. It takes the same amount of energy to heat a gallon of water from 10 C (well water temp) to 25 C (room temp) as it does from 25 C to 40 C (nearly shower temp). This means that any amount of renewable energy we can use to heat our water will save on the total amount of electricity needed to run the hot water heater. Let the sun do some of the work or even all the work, depending on how much sun there is.

Temperature of the water flowing in solar hot water collectors. On a sunny summer day = 140-180 F. On a sunny and cold outside winter day = 120-150 F. On a cloudy and warm summer day = 70-90 F. On a cloudy and cold day = 50-60 F.

Heat of fusion = energy needed to convert 1 gram of ice to water that is at 0 C

= 80 calories. Room temp is 25 C, it takes 75 calories to raise 1 gram of water from 25 C to 100 C. That means it takes 7.2 times more energy to convert 1 ml (1 gram) of water to steam than to heat that same 1 ml of water from room temp to boiling temp.

Heat of vaporization = energy needed to convert 1 gram of water at 100 C to steam = 540 calories.

Stagnant solar hot water collectors will heat up to 450 F. This is why a solar hot water system needs a temperature controlled cut-out switch on the pump. The cut-out switch will shut off the pump. If the water keeps circulating and getting hotter and hotter while you are out of town, it will stop pumping water through the collector after it reaches 180 F.

Propylene-glycol changes chemical properties at 325 F.

PEX is a popular flexible domestic plastic water pipe that is used in new construction. It is rated at 190 F. Solar hot water systems can get hotter than 190 F, so this popular type of water pipe can not be used for solar applications.

A typical 80 gallon (300 liter) hot water tank uses about 215 million BTUs over its 10 year lifetime when used for a family of four. The electricity cost would be US $5,000 at 8 cents per KWH. Then you have to replace the hot water tank and do it all over again, unless you considered using a solar hot water system.

Facts About Electricity

Power cost in from Oregon Trail Electric is 6.1 cents per KWH.

KWH = KiloWatt hour = 1,000 watts of power used for one hour. If you turn on a 100 watt light bulb and leave it on for ten hours = 1 KWH = 1,000 watts. 100watts x 10 hours = 1,000 watts. If a family of four uses about 12,000 KWH/year or 1,000 KWH/month or 33.3 KWH/day. Their average electric bill per month would be 1,000 KWH x $.0736/KWH = $73.60/month.

Water pumping facts

Loss of pressure due to friction in the pipe is a factor in the delivery of water. Be sure to calculate the frictional loss for your specific run. Example: If you were to have a run 325 feet then you would take you 100 ft findings from this chart and multiply it by 3.25

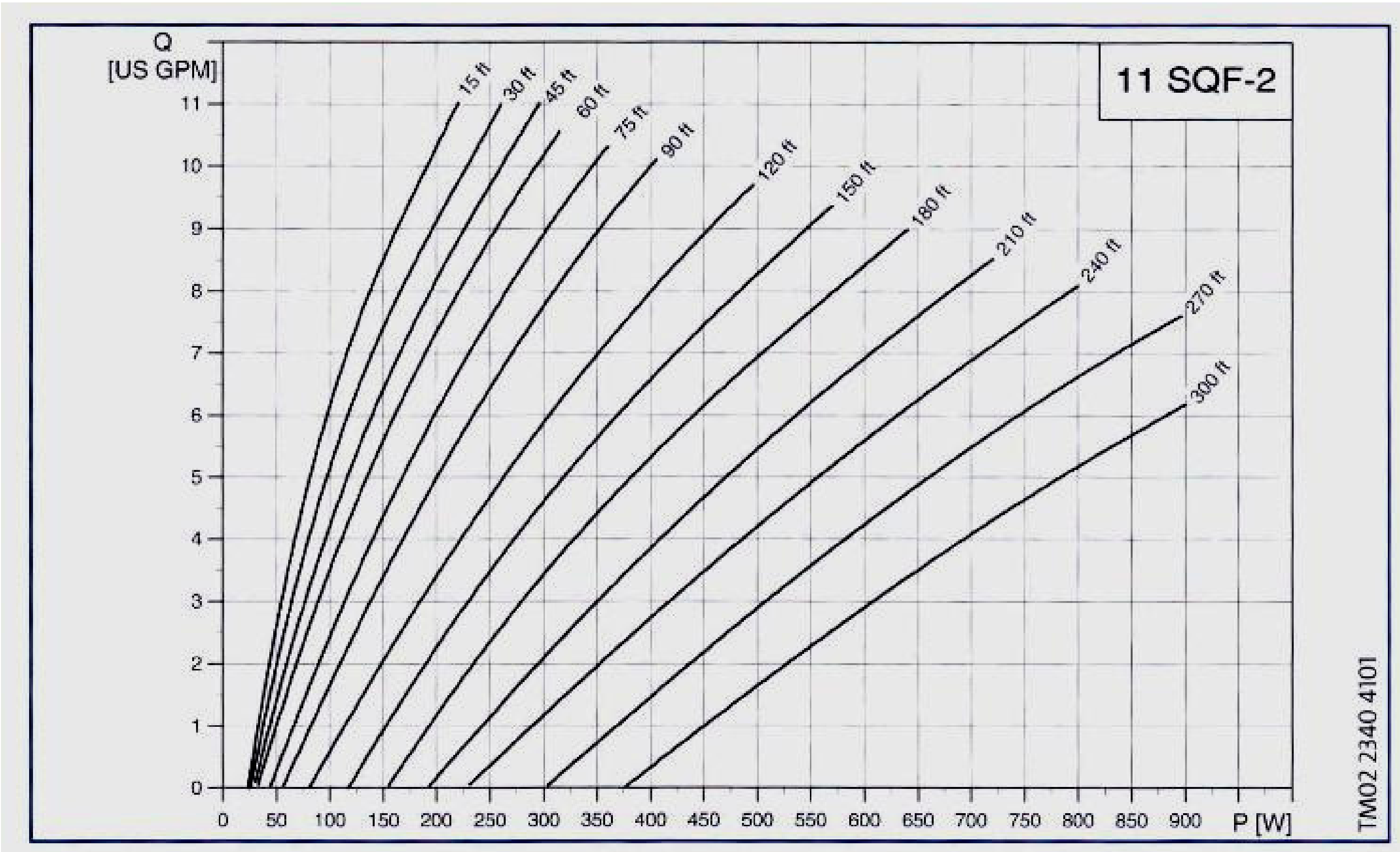
Friction loss in PSI
per 100' of Schedule 40 PVC Pipe

Flow	Nominal Pipe Diameter in Inches							
GPM	1/2	3/4	1	1 1/4	1 1/2	2	3	4
1	1.24	0.17	0.04	0.014				
2	4.47	0.62	0.15	0.052	0.02			
3	9.49x	1.32	0.33	0.11	0.05	0.01		
4	16.17x	2.25	0.55	0.19	0.08	0.02		
5	24.44x	3.39	0.84	0.28	0.12	0.03		
10	88.24x	12.27	3.03	1.02	0.42	0.1	0.01	
15	186.97x	26	6.41	2.17	0.89	0.22	0.03	0.007
20		44.29x	10.93	3.69	1.52	0.37	0.05	0.01
30		93.86x	23.15x	7.82x	3.22	0.79	0.11	0.03
40			39.44x	13.32x	5.48x	1.35	0.19	0.05
50			59.63x	20.14x	8.29x	2.05	0.28	0.07
60			83.58x	28.22x	11.62x	2.87x	0.39	0.09
70				37.54x	15.46x	3.81x	0.53	0.13
80				48.08x	19.8x	4.88x	0.68	0.17
90				59.81x	24.63x	6.08x	0.84	0.21
100					29.93x	7.38x	1.03	0.25
150					63.43x	15.64x	2.17x	0.54
200					108.07x	26.65x	3.71x	0.91
250						40.3x	5.6x	1.39x
300							7.85x	1.9x
400							13.38x	3.3x
	(x= not recommended, velocity over 5 fps)							

Remember that to calculate how much lift a water pump does, you measure the distance down the well to the water level and calculate your lift from that point (not at the level the pump is set). The depth that the pump is set in the well does not determine the amount of lift.

Grundfos 11 SQF-2 Pump Output Chart

Determine your maximum water output by calculating your flow in GPM with all water outlets fully open. You can estimate the flow rate of each faucet and shower by holding a 5 gallon bucket under it, and timing how long it takes to fill. Then multiply by the number of faucets and showers that can be used at once. Determine the total head, height of lift from the well plus the lift to the tank, and then use these calculations for the chart below to determine the maximum Power in Watts needed to operate the pump to meet your requirements.



Step 1: Size the water system

You have 228 people total. Each villager needs 10.5 gallons of water per day, for the following uses:

1) Drinking water - people need 5-7 gallons per week of drinking water.
2) Washing dishes - standard 14” x 16” basin filled 5” high is about 5 gallons. You need one for soapy water and one for rinse water, twice a day, a total of 20 gallons/day for each family.
3) Showers – each person can take a 5 minute shower every day. The low-flow shower head uses 1.85 GPM.
4) Water for cooking and miscellaneous uses - 10 gallons/family/day.
5) No irrigation or water for livestock is figured into this calculation.

The system will be laid out as follows:

6) We want to provide 8 showers and one community water tap.

OK, international aid workers, here we go.

1) How many gallons per minute do you need to pump for the population of the village?

Number of people in the village	How many gallons do you need per person per day (GPD/person)	How many gallons of water do you need for the village per day?	If using solar, how many hours of sunlight do you have for the pump to operate?	How many gallons per hour do you need to pump for this village	How many gallons per minute?
People	GPD	GPD	Hours	GPH	GPM

2) Size your solar array.

How many watts do you need from the chart to power the pump? How many solar panels? What are the rated watts* of the solar array? What are the actual watts that the solar array can provide?

* When you size your solar array, remember to de-rate the array output by 20%. Say you need 500 watts of power to run the pump. If you have 660 watts of rated power, you must subtract 20% or 120 watts (660 x .2 = 132) from your system to represent the actual power of 528 watts the system is capable of delivering to the final use. You can go above the power requirement some, but do not go under it.

What solar panels will you be using and what is the Amp., Volt, and Watt rating			How many watts are needed for the pump to supply the GPM that the village needs? (From chart)	How many solar panels do you need to wire in series to meet the demands of the pump?	What are the rated Amps, Volts, and Watts of your solar array?			What are the actual Amps, Volts, and Watts of your array after "derating" it?			After derating the system does the solar array that you have designed meet your wattage requirements to run your pump?	
Solar Panel			Watts	Panels	Amps	Volts	Watts	Amps	Volts	Watts	If yes	Go on
Amps	Volts	Watts									If no	recalculate

3) Size your water tank.

The water storage tank should hold at least one week's supply of water. You can plan on the water getting into the storage tank from both solar water pumping and rainfall collection.

What are the size dimensions of your water tank up on the hill at 100' elevation, and how many gallons does it hold? The cost of cement is quite high, so don't exceed 1000 gal. over your GPW requirement.

<table>
<tr><th>How many gallons of water are needed per day? (GPD)</th><th>How many gallons are needed per week? (GPW)</th><th colspan="3">Dimensions of tank?
L x W x H
-or-
πR^2 (if round)</th><th>How many gallons will your tank hold? (7.5 gallons of water per cubic foot)</th><th colspan="2">Does your tank hold enough water for one week without being more than 1000 gal over requirements?</th></tr>
<tr><td rowspan="2">GPD</td><td rowspan="2">GPW</td><td rowspan="2">L =</td><td rowspan="2">W =</td><td rowspan="2">H =</td><td rowspan="2"></td><td>If Yes:</td><td>Go on</td></tr>
<tr><td>If No:</td><td>Recalculate</td></tr>
</table>

4) **Figure out the PSI of your system at maximum load:**

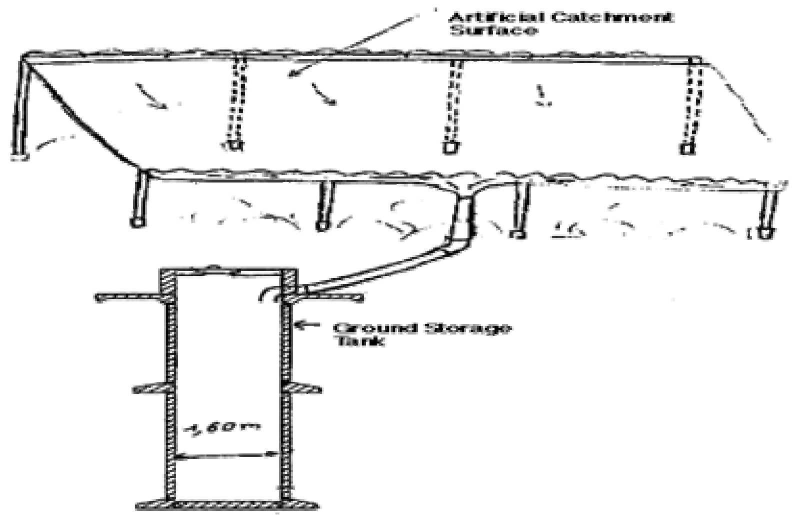
All showers are being used at once and the community tap is running. What is the calculated water pressure of the system at the tap? ***Assume that the tap is 100' below the top of the water level in the storage tank. Use the walking distance from the tank to calculate your frictional*** $PSI_{frictional\ loss}$. ***Schedule 40 PVC pipe is being used in this example.*** Determine what size pipe you should use from the friction loss chart. Do not go below 20 PSI for the system.

# of showers x 1.85 GPM	# of community taps x 5 GPM	Total maximum load of the system? GPM_{MAX}	How many feet of pipe do you need to run from the water from the tank to the village. (Use the walking distance)	From the PSI frictional loss chart select a size of pipe and determine the PSI frictional loss for your run	How many PSI (static pressure) do you have due to the 100' elevation if you get 1 PSI for every 2.31 feet of elevation	What is your PSI_{Net}? (dynamic pressure) PSI due to elevation minus the PSI of frictional loss	Is your PSI_{Net} (dynamic pressure) > 20 PSI? Try the next lowest size to be sure you don't waste funds for too large of pipe.
GPM	GPM	GPM	Ft	PSI	PSI	PSI	If Yes Go on
							If No Recalculate

Design a Water Catchment System

5) **What are the dimensions of your shed catchment roofs in your design and how many gallons do they provide when it has rained 1 inch?**

Shed roofs should collect at least 13% of your village's water tank capacity when 1 inch of rain falls. The roofs should not be too large due to budget constraints. Maximum size of a single shed roof should not exceed 30' x 30' due to local material availability and structural limitations. One cubic foot = 7.5 gallons of water



<table>
<tr><td rowspan="3">How many gallons does your village water tank hold?</td><td rowspan="3">What are the minimum requirements for your shed water collection system?
13% of your village water tank</td><td colspan="2">What is the estimated size of one of your shed roofs?
L x W</td><td rowspan="3">How many cubic inches of rainwater does your shed roof hold at 1" deep?</td><td>Calculate how many cubic inches are in a cubic foot 12" x 12" x 12" =</td><td rowspan="3">How many sheds do you need to meet your requirement of 13% of your village water tank?</td><td rowspan="3">What are the total cubic feet of water for all the sheds?</td></tr>
<tr><td rowspan="2">Feet</td><td rowspan="2">Inches</td><td>cu in</td></tr>
<tr><td>How many cubic feet of water can your shed roof hold?
(Square inches of roof divided by cubic inches in a cubic foot = cubic feet of water the shed roof can hold)</td></tr>
<tr><td rowspan="2">gal</td><td rowspan="2">gal</td><td rowspan="2">ft</td><td rowspan="2">in</td><td rowspan="2">cu in</td><td rowspan="2">cu ft</td><td rowspan="2">sheds</td><td>If Yes: You're Done
= :0)</td></tr>
<tr><td>If No: Recalculate</td></tr>
</table>