

Brackish Water Purification Systems

(12/29/2007)

How does one set up an emergency water purification system that uses minimum power to work with brackish water after a PS? What does one need to know? What strategy does one use to pull together the components in a short period of time? How can it all be made cost effective so the common man can afford it? How much preparation is needed? These and more questions will be attempted to be addressed in the following write-up.

Distillation is an excellent method of producing good water and is highly recommended. It is very expensive in terms of the amount of energy used. Distillation was well covered earlier. Separation by freezing will not be covered in this report. Portable hand operated methods to the extent they are usefully have been previously covered. What will be covered now are ways of filtering and purifying water using about 200 to 400 times less energy than distillation for use at a base site.

Many may not have the energy available for doing distillation. So alternatives become appropriate. A good energy efficient brackish water purification system will have the following minimum components.

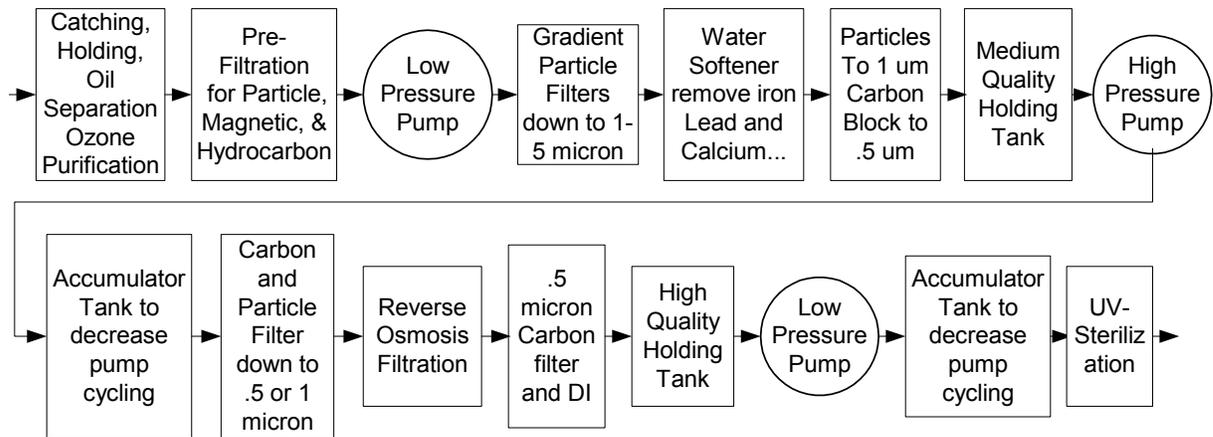
- Container(s) to collect and hold rain or run off water (plastic garbage cans, hole in ground lined with plastic, 55 gallon tanks, etc)
- Strong magnet to attract iron and other ferromagnetic metals and pull them out of solution.
- Ozone bubbled through the water to kill pathogens and reduce heavy metals.
- Settling tank to separate oil and dirt. Oil floats to top and runs out an over flow. Dirt and heavy particles settle on the bottom of the tank. Good water is drawn out from in-between.
- Gradient particle filters down to about .5 micron. Gradient mesh cloths could be stuffed into a 4" pipe as one example. A sand filter or a commercial filter element could be used.
- Method of moving water (gravity, electric pump or hand pump)
- Way to precipitate small or dissolved unwanted heavy metals. (water softeners, ion exchange, Ozone, and Magnets)
- Way to bring the pH back in range if very different from neutral especially if acid. (if acid add ashes, Calcite, or use Ozone)
- Way to remove very-very small particles out of the water. (ceramic filters, reverse osmosis, DI demineralization resins filters, and distillation)
- Way to remove hydro carbons (oil etc) and bad smells. A Carbon filter elements, or could be as simple as a plastic garbage can full of crushed charcoal that the water is run slowly through. Ozone bubbled through water will also remove smells.
- Sterilization or killing of parasitic organisms like bacteria, viruses, etc (passed by UV-light source, or add an item like chlorine, iodine, colloidal silver, Grape fruit seed extract or bubbling ozone gas through the water).
- Container to collect the output, so the process can be done slowly or at its own best most efficient rate yet water can be easily obtained from it.

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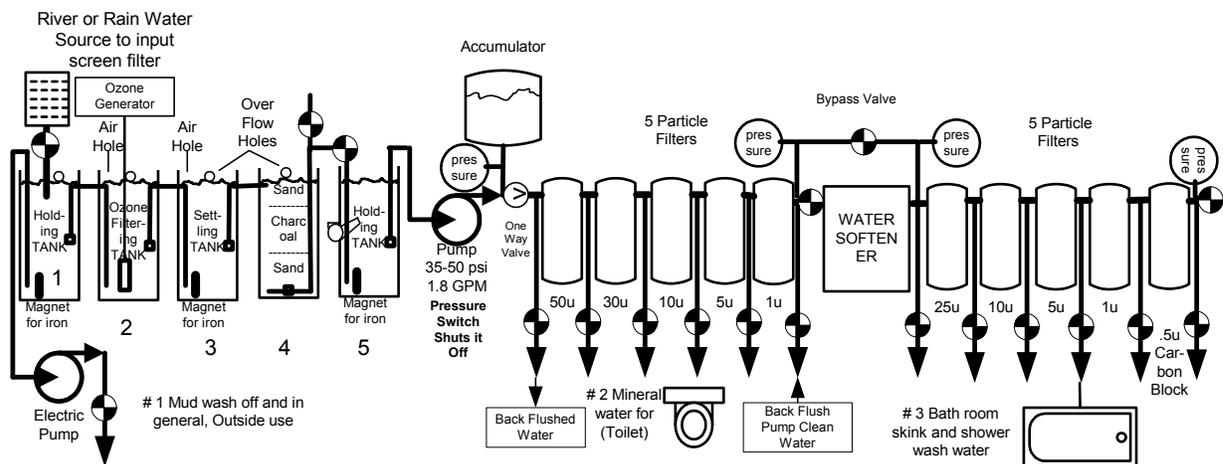
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A block diagram of the major functional components would look like:

Functional Flow of Needed Water Purification Items



In more detail it might look like the following:



Water flows in from an up hill source and is controlled by a ball valve. The planned near continuous over flowing of the settling tank allows for the removal of floating oil and debris. Magnets are used to help remove Iron. Ozone is bubbled as needed to kill pathogens and remove heavy metals. An alternative to this would be to run the water through a UV-light filter to kill pathogens between tank one and two.

Sand and ground charcoal is used to remove small partials and hydrocarbons (oils). Commercial 10" filter elements are used to remove small partials and more hydrocarbons and some lead. The water softener removes more Iron, and hardness (calcium). This is to make the RO process more efficient. Three types or qualities of water can be taped off as needed.

The pressure gauges are used to tell when the filters need to be back washed. The many valves or water faucet tap off points allow for bypassing (skipping filters or components not needed)

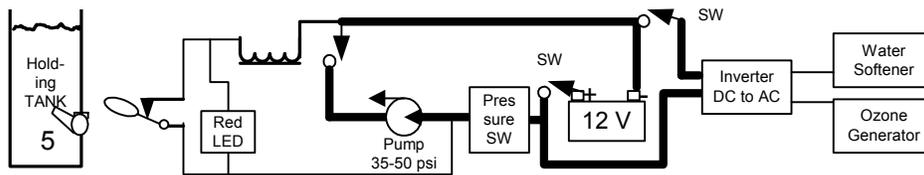
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and allow for backwashing of each filter element independently without removing it from the cartridge. It also allows for many different qualities of water to be used as needed.

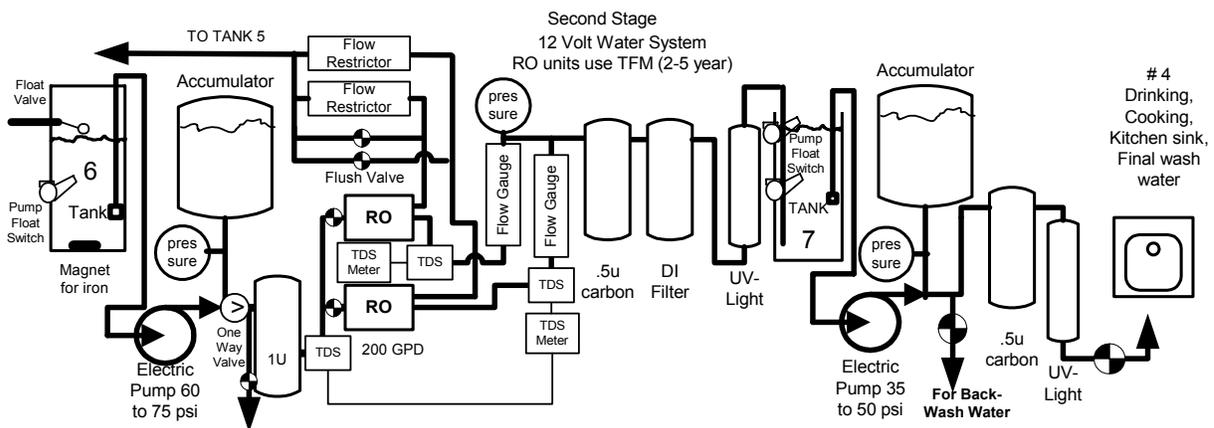
For the holding tanks use 55 gallon containers, trash cans, or 5 gallon buckets depending on scale of operation. Grind with a large meat grinder or pound up raw wood barbecue charcoal to small chunks. Don't get briquets (they have a non-charcoal binder) or any charcoal that is presoaked with hydrocarbons to make it easy to light. Put a separating cloth or screen between the sand and ground charcoal. Put some sand under and then on top to hold the carbon down from floating. This is set up so it can be backwashed as needed.

Electrical diagram for the first pump is:



The Water Softener and Ozone generator is hooked up to a separate inverter and is turned on by hand as needed. As power permits both are run nearly consciously. The 12 Volt Relay is normal open with no power applied and typically is a SPST (single pole/single throw). Each on-off switch has in series a fuse (not shown) of appropriate size for the circuit. The tank float switches were boat bilge pump switches (15 amp max). The pressure switch comes with the pump.

Plumbing diagram for the Reverse Osmosis (RO) or second half is:



Multiple RO membranes can be put in parallel to get the desired GPD. The "flush valve" is used to flush buildup on the membrane to waste. It is used as often as needed to help keep the membrane from clogging up. The flow restrictor size is matched to the GPD rating for the membrane (see below for more explanation). A flow restrictor and flow volume measurement gauges help keep the ratio of good water to waste water at about 22% or 1 (good) to 3.5 (waste) ratio. The measurement of total dissolved solids (TDS) meter helps keep track of the efficiency of the process.

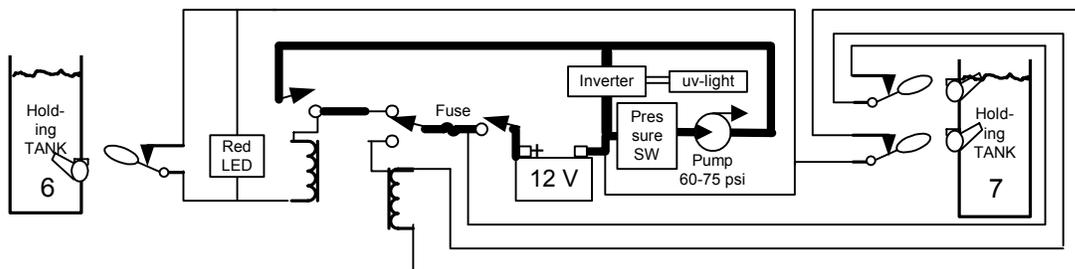
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The carbon filter removes any hydrocarbons that have made it to this point. The DI or demineralization resin bead filter takes out any remaining dissolved minerals and takes the PPM to zero. The result is stored in a tank and pumped on demand for drinking and food preparation. The UV-Light does a final sterilization of pathogens.

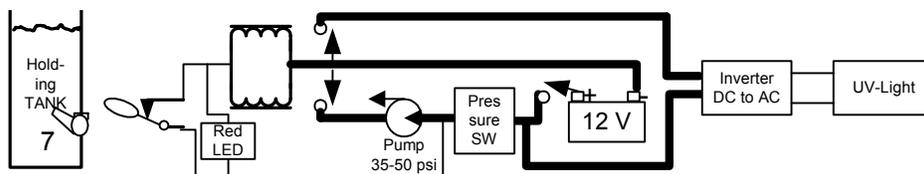
The good news is that “off the shelf” house hold RO units have gone down in price and up in GPD (gallon per day) over the last number of years. In many cases one can get a replacement membrane that brings the old 10-15 GPD unit up to 75 or 100 GPD rate. The price of the membrane is about \$30-\$40. Household RO systems that produce 100 to 200 GPD now cost about the same as the 10-15 GPD units of 5 years ago. Searching on eBay is a good way to find these. Start with a good basic RO unit and add up front more items as described in this report. If one wants to venture into new territory’s there is even a 700 GPD tankless Merlin Reverse Osmosis Water Filter that sells for about \$375.

Electrical for the RO Pump:



Two 12 Volt Relays with one normal closed for no power applied and is typically a SPDT (single pole/double throw). When the top switch in tank 7 closes the pump turns off (tank full) and doesn't turn on until the bottom float switch in tank 7 (output) turns off (low in water). The pump can also turn off if tank 6 (input) is switched off. In this case the red light turns on to indicate source water is low.

Pump wiring for the last or delivery pump:



The pressure is adjusted on all of the pumps to be as big a range as possible to minimize on/off cycling with-out undue maximum pressure (also causes max amps). The Accumulator tanks are as big as possible considering cost. Bladder tanks are preferred however one can use the typical 2-5 gallon water pressure tanks supplied with some RO units. I suggest one use several in parallel to compensate for the slow flow through the small inlet tank fittings. Orient the tank with the outlet at the bottom so air will be trapped in it to act as a bladder.

One can use a typical low cost RV pump for the low pressure 35 to 40 or 50 psi maximum high volume needs. This would be for everything except the RO membrane pump. They would be

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used for the low quality wash water and for final delivery of the pure drinking water. These pumps are typically rated at 2-3 GPM 30 to 45 psi. ShurFlo pump Examples are: 2093-204-413 self-priming, 2.0 gpm, 30psi, 5.5 amps; Auto Demand Pump 2088-422-144 2.5 GPM 40 PSI; or 2000-422-444 45 PSI. Another example would be to use a higher pressure pump and adjust the pressure switch to a lower setting to get longer life out of the unit. An example of this is Shurflo 12 volt Industrial pump part number 8000-443-236 maximum pressure 60 psi. Adjust shut off pressure down to say 40 psi at 1.38 GPM at 5.6 amps.

http://www.shurflo.com/pages/gen/site_map.htm.

Water Softener

The water softener can be as simple as a holding tank where the water flows through the resin beads (like for charcoal filter only smaller). One can buy the resin on-line eBay for about \$100/1cuft or 50 lbs. One could take the container off-line and back flush with salt once in a while to regenerate it. One would fill the container with a high concentration of salt water and let it sit for about 30-40 min while stirring it up occasionally. Then one would wash the salt off the resin beads and put the filter back on-line. From time to time testing the TDS (total dissolved solids) of the input and output would determine how often regeneration would be needed. When the TDS starts to go up on the output one would know it's time to regenerate.

A small version of a rebuildable cartridge that fits within a 10" cartridge filter can be purchased. It is a plastic container that one can replace the beads in and put it back in the filter cartridge. See <http://stores.ebay.com/H20-Science> for where to get this rebuildable removable cartridge. They are made primary for DI and Carbon replacement granular particles. However there is no reason why one couldn't use water softener resin beads. These beads can last up to 10 years of regeneration as long as you have salt available. Non-reusable cartridges can be purchased at <http://www.filterwater.com/showproduct.aspx?productid=101&affiliateid=10050>

Water Hardness: Calcium and magnesium are two minerals which make water "hard." Both of these minerals are classed as "contaminants," but that's a poor choice in terminology, for calcium is essential in our diet! A softener merely exchanges one group of non-toxic elements for another group of non-toxic elements. Water hardness is measured either in grains per gallon (GPG) or as calcium hardness in milligrams per liter (mg/l) or parts per million (ppm). GPG is based on calcium hardness. To convert from calcium hardness ppm, just divide by a factor of 17.2 and this gives you hardness in GPG. A soft or slightly hard water has up to 3.5 GPG (60 ppm); moderately hard water runs from 3.5 to 10.5 GPG (60 to 180 ppm); and very hard water is greater than 10.5 GPG (180 ppm). Metro water is on the low side of moderately hard at 4.1 GPG (that is 70 mg/l (or ppm) of calcium hardness. Purchase a TDS hand held meter to measure your Hardness.

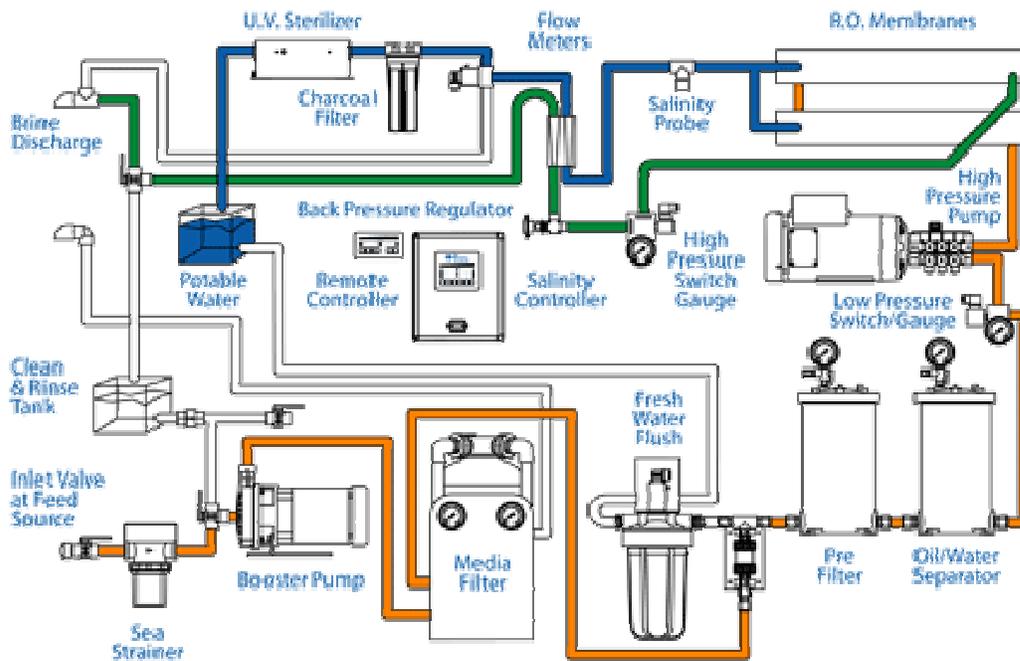
Water softeners resin beads use about 1 lb of salt to regenerate for about 3,800 gal of good water produced. This is depending on hardness of the water. Non-electric water softeners do not have the problem electric ones have. When the electricity goes off, the electric softeners loose track of the amount of water volume that has flowed since the last regeneration cycle. When the electricity comes back on they do an automatic regeneration cycle. The bottom line is to make your own or purchase a non-eclectic type of water softener.

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Sea Water RO

A RO unit that works for making fresh water out of salt water operates at a much higher pressure (600 to 1000 psi) and might look like the following. These are usually rather pricy.



For the type of salt water systems available and how they work see:

<http://www.cruisingworld.com/article.jsp?ID=44957&typeID=397&catID=572>

Ventura 150 is a very efficient fresh water maker and produces 150 gal/day at 17 watt-hr/gal running off 12 Volt DC. Also check out the Aquifer 150. It is a portable rugged water maker engineered for the mobile conditions in remote areas where good water is essential. The Aquifer 150 system makes 150 gallons of purified fresh drinking water every day in almost any climate. Both of these have a much lower cost than most marine RO units.

<http://www.spectrawatermakers.com/>

Ozone Water Treatment

This is done by bubbling Ozone Gas made from air passing over a strong UV light source through water. This is not to be confused with passing water over a UV light source to kill water born pathogens. Both have there place in water purification. Ozone Gas bubbled though water will kill pathogens and also it will take out heavy metals and bad smells.

Municipal water companies have used ozone technology to treat large quantities of water for many years because of its effectiveness in purifying and conditioning water. California state law now requires ozonation as the final step before bottled drinking water is packaged. The International Bottled Water Association also requires ozonation prior to bottling.

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The Benefits of bubbling Ozone through water are:

- Kill bacteria on contact thousands of times faster than chlorine or bromine.
- Kill virus on contact.
- Kill algae spores, fungus, mold and yeast spores.
- Precipitate heavy metals.
- Remove excess iron, manganese, and sulfur by a process known as micro-flocculation, thus conditioning the water naturally without chemical additives.
- Remove color and odor, leaving a fresh, healthy bouquet.
- Reduce scale build-up on equipment such as pipes

The level of contaminants that can be removed by use of Ozone in a single tank is typically: Iron to ~10ppm, Manganese to ~1ppm, Hydrogen Sulfide up to ~25ppm. Twin tanks in service have successfully removed Iron to ~55ppm, Manganese to ~16ppm, H₂S to over ~100ppm. It will also raise the PH of your water if it is in the acidic range (below a PH of 7.0) and stabilize the PH in the 7.5 range.

Ozone is made up of 3 atoms of oxygen and is unstable soon to become O₂. This makes it one of nature's very powerful disinfecting and deodorizing agents. The Half life of Ozone in air is on the order of hours and the order of minutes when dissolved in water. Ozone Dissolves over 12 times more readily into water than pure oxygen. The result of this decay is much higher than normal concentrations of pure Oxygen dissolved in water.

Use a holding tank size such that as a rule, the maximum usage per day will never exceed 25% of the tank capacity. Ozone gas is heavier than air and will accumulate around the holding tank. Do not breathe the accumulated Ozone gas for an extended period of time.

Ozone will not remove nitrates (typical when water is contaminated by fertilizer run off), sodium, sulfates, total dissolved solids, chlorides, and fluoride. These contaminants can be removed by reverse osmosis or distillation. Pre-treating the water with the Ozone will dramatically reduce the maintenance required on the reverse osmosis.

A typical unit that performs this function can be found at <http://www.tripleo.com/default.htm>. Once one understands how it works. It can be made simply by passing air over a UV-light germicidal lamp light source. A small fish tank pulse pump can be used to supply the air.

Best Membrane to Use

I recommend using FILMTEC reverse osmosis membrane element TW30-1812-75 – rated at 75 GPD & 50 PSI (77 degree F). They make a 100 GPD but the salt rejection is only 90% where as the 75 GPD filter element is 98%. The operating pressure range is 40 psi to 145 psi with a maximum of 300 psi. The operating temperature is 40 to 100 degree F with a maximum of 113 degree F. Dimensions fit a standard home housing: 1.8" Diameter by 12" long. Weight 15 oz. Membrane life: 2-5 years. Works up to a maximum of 2000 ppm dissolved solids. A 10 degree temperature increase or decrease will increase or decrease the flow rate by 15 GPD (20%).

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The flow rate of Individual 75 GPD at 50 psi “TW30-1812-75” elements may vary by as much as 20%. The flow rate at 60 psi is about 93 GPD, 70 psi – 110 GPD, 80 psi – 128 GPD, and 90 psi – 145 GPD. A good optimal PSI is 65 to 72 PSI and a temperature of 70 degrees.

Any Ozone and Chlorine greater than .1 ppm will harm and degrade the RO Membrane. The membrane will operate between pH 2 to 11 and effective cleaning can be done at PH 1 and 12 to 13 (up to 30 min). Experience with FILMTEC membranes has shown that the alkaline cleaning should precede the acid cleaning. Furthermore, the pH of the cleaning solution should be maintained in the pH range of 12 to 13 throughout the cleaning cycle.

TW30-1812-XXX TW is for house hold use and 30 is the FT30 membrane type (very good type also used in commercial models). 1812 says it's 1.8 inches diameter and 12 inches long (a standard for home units). XXX is the gallons per day rating at 50 psi. Keep the membrane dry for long term storage. For more info see http://www.dow.com/liquidseps/prod/prd_film.htm

I choose to design around 2 - 75 GPD membranes both running in parallel connection. This means the pump will need to produce the good water and the waste water in a ratio of about 3.5 to 4 to 1. Thus the total water needing to be pumped is $1 + 3.5 \text{ or } 4 = 4.5$ to 5 times the two filter rate of 150 GPD (2×75) at 50 psi. This gives a total volume of 675 to 750 GPD. For design purposes we will use the higher number.

In like manner one can calculate and get that at 50 psi use 750 GPD, at 60 psi use 930 GPD, at 70 psi use 1100 GPD, at 80 psi use 1280 GPD and at 90 psi use 1450 GPD. To get GPM divide by ($24 \times 60 = 1440$). This gives at 50 psi use .52 GPM, at 60 psi use .646 GPM, at 70 psi use .764 GPM, at 80 psi use .889 GPM and at 90 psi use 1.0 GPM. This is for 77 deg F. If planning to run at 67 degree then drop the GPM by 20% this gives 50 psi use .42 GPM, at 60 psi use .52 GPM, at 70 psi use .61 GPM, at 80 psi use .71 GPM and at 90 psi use .80 GPM.

Now to find a pump that will work.

By searching though Shurflo pump specifications for a 12 volt DC pump that can run continually, able to run dry without hurting it, is self priming, will work to at least 90 psi and matches the volume flow found to be needed in the above paragraphs on membrane flow. See <http://www.depcopump.com/datashurflo.htm> The following table summarizes the key features to compare.

Model Number	Self-Prim up to xx ft.	Max pressure PSI	Running Motor Temp F	Output PSI	Flow GPM	Amps at 12 Volts	PSI for 77 degree F	PSI for 67 degree F
8000-941-260	9	145	155	60	0.84	5		
Bypass type				70	0.78	5.4	75	
Continuous				80	0.75	5.8		84
				90	0.66	6.2		
				100	0.57	6.5		

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8005-942-220	5	130	185	60	1.15	6		
Bypass type				70	1.07	6.6		
Continuous				80	0.97	7.2	86	
				90	0.81	7.7		91
				100	0.62	8.2		
8000-543-290	5	100	200	60	1.02	7.3		
Non-Bypass				70	0.97	7.7		
Continuous				80	0.93	8	84	
				90	0.89	8.4		98
				100	0.84	8.8		
8000-543-138	10	100	195	60	1.22	6.5		
8000-543-238				70	1.16	7.1		
Non-Bypass				80	1.11	7.6		
Intermittent				90	1.03	8.3	92	
Pressure SW 80-100 psi Adjustable				100	0.96	8.7		106

Because the pump flow gets less with pressure and the membrane flow becomes more with pressure there is an estimated intersection of the two curves and thus an estimated operating point. This pressure is shown in the last two columns for the temperature range of 67 to 77 degrees. The top pump (8000-941-260) gives the closest match to the intended operating pressure of 65 to 72 psi. It also gives the lowest operating temperature and uses the least amount of amps or power and has a good input lift distance. A pressure regulator and/or a maximum pressure switch could be used but is probably not needed unless low temperatures become a possibility. As an alternative one could rig up a needle valve bypass to leak a bit of pressure to the low side of the pump if the temperature goes too low and the pressure too high.

Flojet and Aquatec makes pumps that did not quite match the flow rates and DC voltage that are needed. They were found to be 120 VAC with 24 VAC transformer noted for your reference. Aquatec 5800 delivers .25 GPM to 1.5 GPM, using 25W to 100W, maximum 130 psi. The Aquatec 6800 delivers .38 or .45 LPM at 80 psi max. The Aquatec 8800 delivers 1, 1.2 or 1.4 LPM at 80 psi max. The big disadvantage is that they all run on 120 VAC. They are noted in passing as a less desirable possibility.

DI or Demineralization Resin

DI stands for Demineralization by Ion Exchange. It is a mixed bed of beads of Anion and Cation resins. Ions, salts or minerals can be entirely removed from water to near 0 PPM. Typical capacity of a Vertical 10" filter cartridge is 6,800 ppm. If TDS (total dissolved solids) out of the membrane measure 20 ppm then 6,800 divided by 20 ppm = 340 gallons before it runs out of capacity to take minerals out of water. A DI can be used stand alone without a RO unit in front of it; however, it will not last very long depending on the TDS PPM. As far as I know this resin can not be recharged like water softener beads. However water softener beads can be used in the same rebuildable cartridge to make a rechargeable reusable water softener filter.

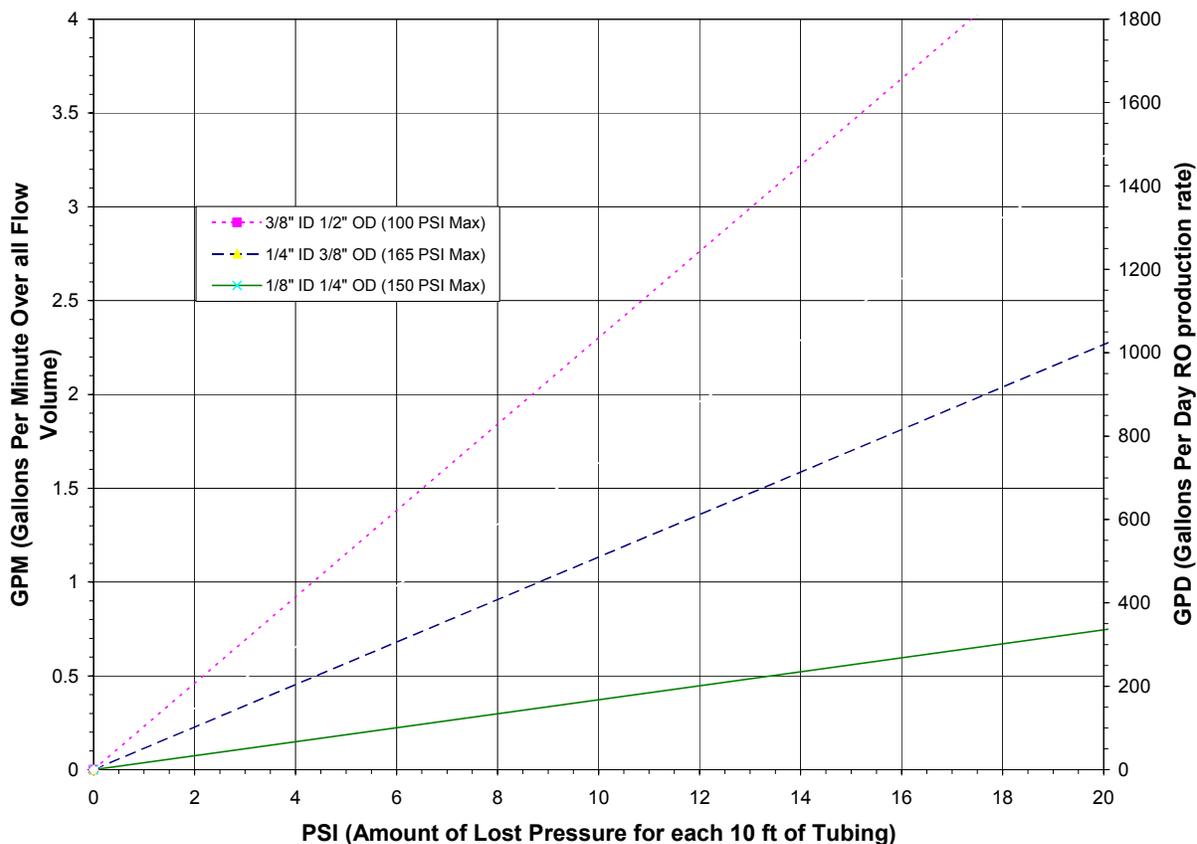
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Choosing Tubing Size

How to determine the size tubing to use based on expected flow rate: As an example say one is building a 200 GPD RO unit. Can .25 inch OD (outside dimensions) tubing be used? We can see from the chart below that for every 10 ft of .25 inch OD tubing used the pressure will drop by 12 PSI. So the answer is yes we can as long as one keeps the over all length of this size tubing short. We can also compensate for tubing pressure drop by boosting the pump pressure by 1.2 psi/ft of length used. Any flow greater than this and one should use the next size bigger tubing or 3/8" OD.

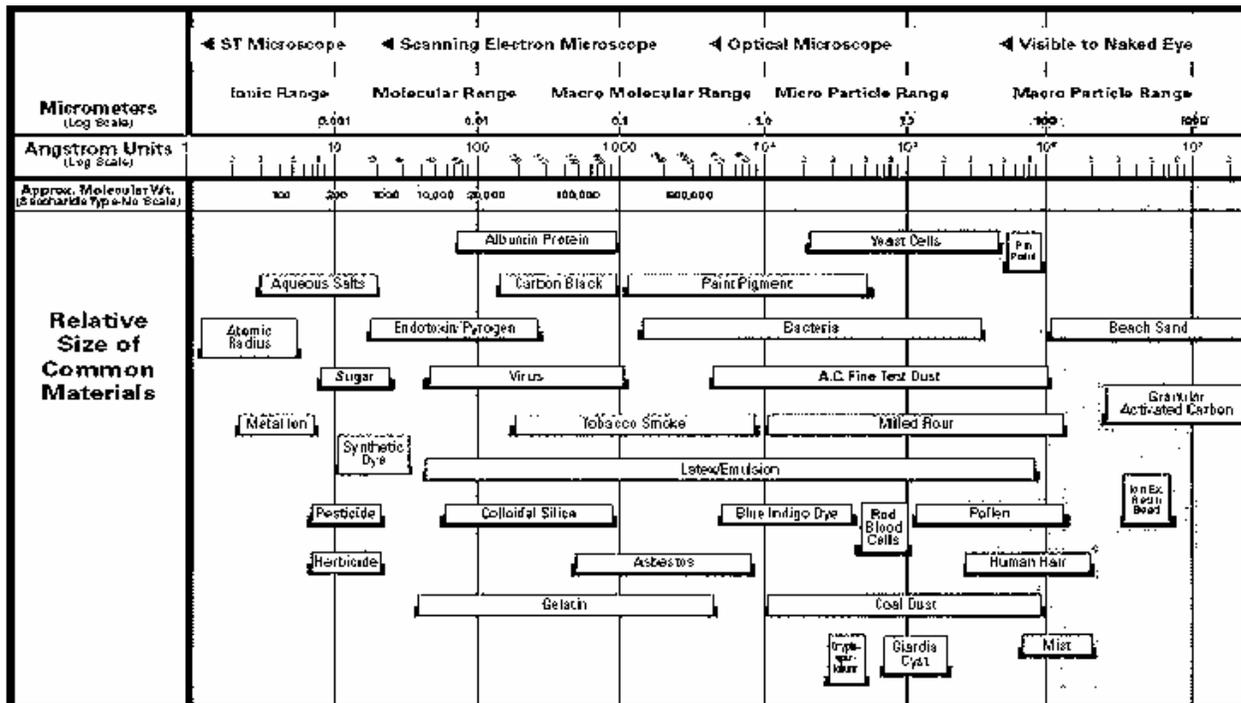
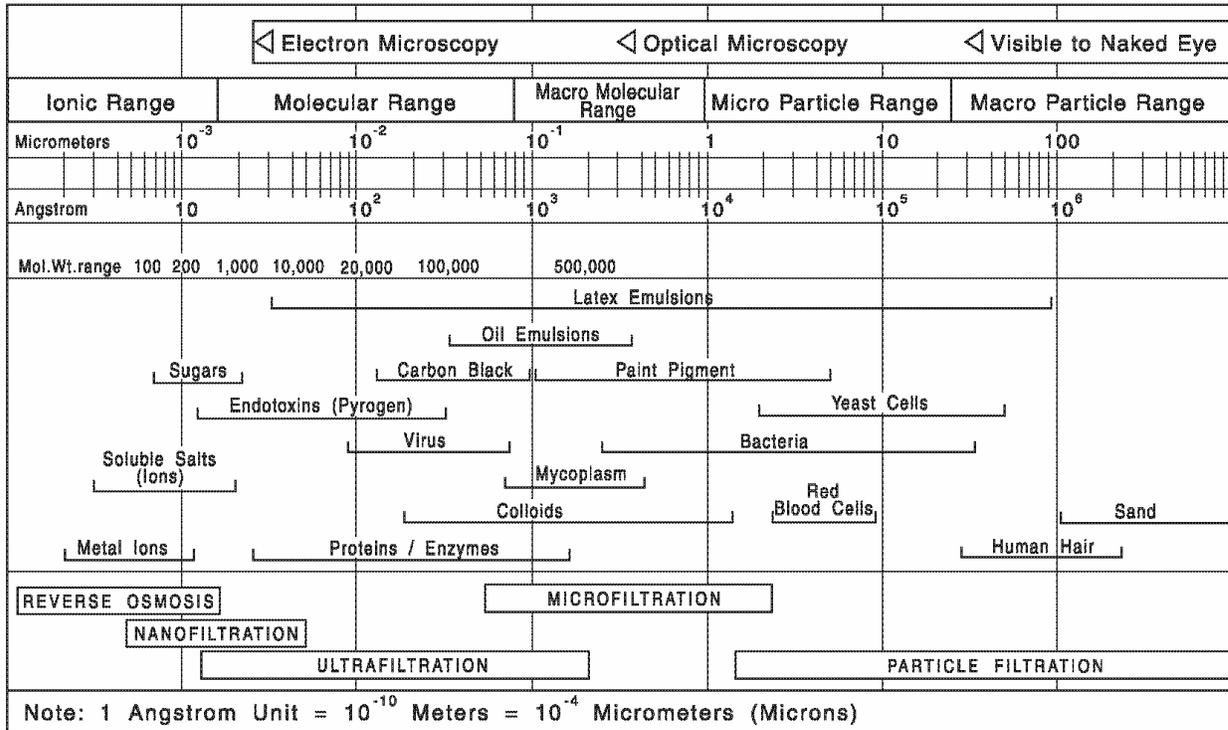
Amount of Lost Pressure Due to Plastic Tubing Friction



The following illustrates where reverse osmosis membranes (.0001 to .0015 micron) fits in the relative size of common materials. From http://www.hfpurewater.com/reverse_osmosis.htm Don't get thrown off by the word "reverse" in the name of "reverse osmosis". The bottom line is it is a material that has very small holes and one needs to use a high pressure to get the water separated from the dissolved larger particles. The holes are just a bit bigger than water molecules. RO is just like any other particle filter only with smaller holes.

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In practice, a fraction of the living bacteria can and do pass through RO membranes through minor imperfections, or bypass the membrane entirely through tiny leaks in surrounding seals. Thus, complete RO systems should include additional water treatment stages that use ultraviolet light or ozone to prevent microbiological contamination. For more info see http://en.wikipedia.org/wiki/Reverse_osmosis

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Tribal knowledge

Chlorine and Ozone gas will degrade membranes and a lot of both is not good for water softener resin. Remove them if present in water before the RO membranes, water softeners and carbon filters. Carbon filters and/or “UV-Light with water passing by it” will take ozone and chlorine out of water solution. The carbon get hot as the Ozone reacts with it. Letting the water with Ozone sit while going from one holding tank to another will allow the Ozone to change to normal oxygen due to its short half life of minutes. If needed, passing Ozone water through a UV-Light filter positioned just before the RO filter will remove the remaining chlorine and ozone from the water rendering it harmless. For more info see http://www.daytonwatersystems.com/productsHTML/L1_TechInfo.htm near the end of the page.

Ozone can be removed by aeration using cascade, packed column or air diffusion. This method strips off the ozone to the atmosphere, so proper venting must be employed for safety reasons. Removal of ozone can also be accomplished with the addition of hydrogen peroxide (H2O2). It is just noted for completeness in passing and not a practical method for a primitive environment.

The reason for doing sterilization up front is to avoid growth in down stream filters and tanks. In general if possible use the UV-Light or ozone sterilization again at the end of the process is recommended. Light in the range of 200nm to 300nm (nanometer) is used for UV-Light germicidal sterilization disrupting metabolism and reproduction by altering the DNA.

Very high or very low pH can degrade the membrane. Low or acid pH will bring the water softening process to a halt. Bring the pH of the water close to between normal 7 or a bit basic before filtering. Ozone bubbling through the water will help do this.

Iron Bacteria (not to be confused with dissolved iron) causes water softener problems. Kill it up front with Ozone or UV-Light before it gets to the water softener.

For a simple description of how reverse osmosis filters work see: <http://www.aquamarineinc.net/content/Rotheory.html> or http://www.fresh-water-filters.com/reverse_osmosis.html

All RO systems use some type of flow restricting device to apply pressure to the membrane. By restricting the flow rate to the drain the system applies proper pressure to the membrane. RO process doesn't work below about 40 PSI. In this case all the water is dumped to waste water. Storage of RO filter elements should be done in a sealed air free bag. There are solutions that can be purchased from marine manufactures that will put it into storage while wet.

Flow restrictor size list:

Reverse Osmosis Membrane Size	ML Per Minute	Approximate Ratio- Waste/Product (Home Use)
8 – 20 GPD	150	4:1

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25 GPD	250	3.5:1
36 GPD	350	3.5:1
50 GPD	500	3.5:1
75 GPD	750	3.5:1
100 GPD	1000	3.5:1
150 GPD	1,200	3.5:1

An adjustable flow restrictor can be made by using a T-valve and adjusting the flow through to get approximately 3.5 to 1 water flow ratio for waste water to good water. Flow rate can be measured by timing how fast it fills a bucket of known size.

Water Well Problems and their Cure:

http://www.water-treatment.org.uk/well_water.html

Water Treatment Processes:

http://www.water-treatment.org.uk/swimming_treatment_processes.html

Lessons Learned While Implementing a Water Purification System

See above for a detailed report for of electrical, flow diagrams and their description. This report is follow-up notes on our implementation of the above generalized report.

The whole unit was constructed along one side inside a 40 foot shipping container. The input water was from up the hill and the output tanks were down the hill. The container is relatively level now but could change after a PS to be tipped more (like the slope of the hill) if it slides down the hill a bit. If this happens the tanks should still work as long as the final tilt is not too much. If needed we can block up tanks that become too low after the PS. Wood lids were made to help keep dirt and bacteria in the air from settling out into the tanks. In the picture one is setting beside the blue 55 gallon tanks about half way down.



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We used a 1600 gallon storage tank for the input number one tank to capture run off water (input on top) from up the hill. A hole was drilled in the side and a pipe was run to the outside of the shipping container to act as an overflow or a way back to waste to avoid overflow inside the shipping container.



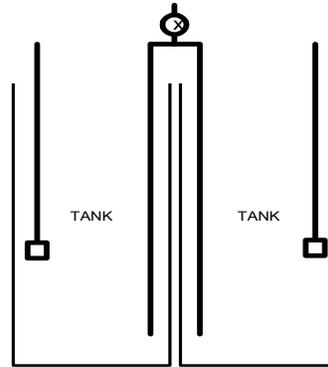
The 1600 gallon container is much taller than the first 55 gallon settling container and expected to fill to a higher level. Thus a ½ inch tank float valve was used in the second tank or the first 55 gallon container to keep it from overflowing. A hose runs between the two.



The rest of the holding tanks were made from 55 gallon plastic containers. We had enough of these to double up and use two of these as if the combination were one holding tank. A siphon is used to connect these tanks together so both tanks act as one. To start the siphon going one would pump the air out until one sees water in the clear plastic tubing then shut off the ball valve (as show in the picture).

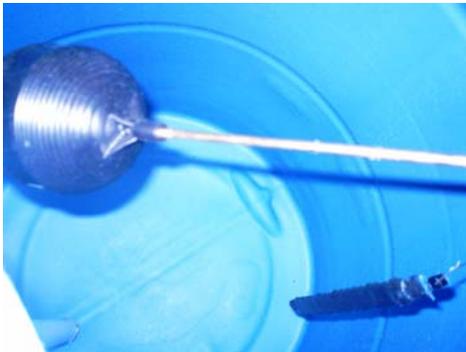
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2 Tanks with siphon
to work as one Tank

Magnets were placed inside and the siphon cross over pipe for the settling tank. Magnets were also placed hanging in the tank near the flow of water input and output for first few tanks. These were neodymium disks 3/8" diameter by 1/8". They were sandwiched between two plumbers straps with heat shrink tubing around it. Each end was sealed from water getting in by use of silicon II sealer.



Feed throughs for the tanks were constructed of 1.25" PVC threaded pipe adaptors (see above). A hole was drilled in the side of the plastic tanks. A threaded male and female PVC pipe connector was screwed together with a rubber washer on each side of the tank. Silicon II was used to seal the connection.

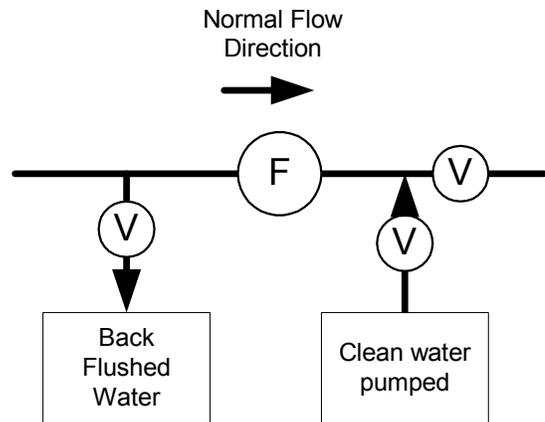
Natural Cowboy brand charcoal will be ground up and used in this third tank for removing hydrocarbons. A platform with fine screen mesh will be used at the bottom of this tank to support the charcoal. The charcoal is pounded with a hammer or ground up using a large hand meat grinder until it is relatively small particles (between sand and p-gravel size).

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The water faucets between filters give complete flexibility. One can tap off different qualities of water for different purposes. These faucets also can be used for back washing filter elements without taking them out of the cartridge.



Backflow of filters can be accomplished by pumping good water in a backwards direction through each of the filters that need it. The way to tell if a filter needs backwashing is to monitor the pressure drop across the filters. The pressure drop of a new filter under normal flow is then compared to the measured pressure after much use. Once the pressure drop across any one filter gets to the point of significantly slowing the flow then it is time to clean it. Note the pressure gauges shown hooked to the water faucets are to measure pressure drop. They can be moved down the line to monitor and find slow flowing filters.



The way the unit is made, one can backwash 1 to 6 filters at a time. Normally we would recommend backwashing only one at a time. However there are times when one will backwash 2 or more at a time to save clean water.

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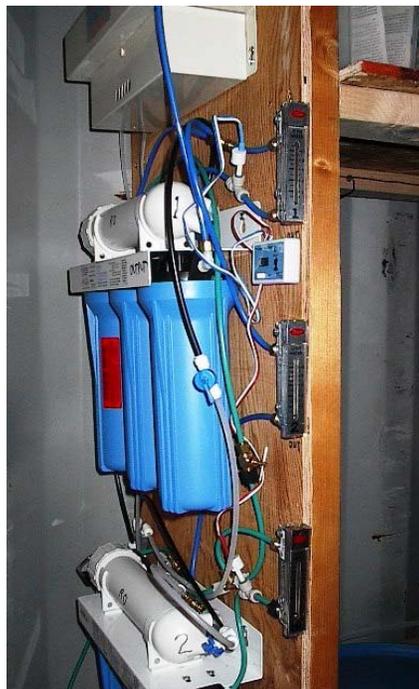
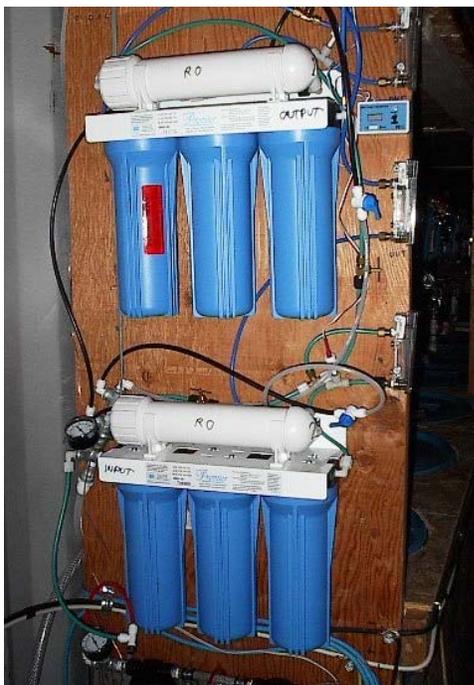
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The water softener in our case is a WaterBoss unit that was purchased in 2002. It has the disadvantage of needing a small amount of electricity to monitor volume of water flow. If the power goes off it will flush the filter with salt. Instead of supplying it with electricity we will use it in a mode where we keep track of time and water quality coming out of it. Once it is not doing it's job then we will initiate a back flush with salt water to regenerate it by supplying power to the controller for the time needed (about 30 to 40 min). The water softener is shown in picture in the center and on the right.



Shown in the center is the pump with it's accumulator that is used to push water through the filters above and the water softener.

We used two very common standard RO units hooked in parallel. They were purchased 6 years earlier as 15 GPD (Gallons Per Day) units. A replacement RO filter element was purchased that changed the output flow to 75 GPD. With both RO units in parallel and higher operating pressure the results are between 150 to 200 GPD.



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The RO pump will turn on and run when the water level gets low enough to flip the float switch in the lower part of tank 7. The top switch in tank 7 will shut off the pump and when this tank is full. If the low water switch in source of water tank 6 is tripped it will shut down the pump so it doesn't run dry.



The bilge pump float switch only turns on or closes circuit when the float is up. This is independent of the mounted orientation of the switch. If one puts it in upside down, it will still function the same way. It is open circuited when the float is down.

We used typical RV pumps for the low pressure high volume needs. They were used for the low quality wash water and for final delivery of the pure drinking water. These pumps are rated at 2-3 GPM (part number 2000-422-444 13.7 VDC 5 amps 45 PSI Shurflo). The high pressure shut off on the pump can be adjusted with an Alan wrench. The pressure is recommended to keep as low as possible so as to use less power and provide less wear and tear on the pumps. One can purchase whatever the current best price model from ebay.com (at this time I see as low as 49\$). These pumps and their size and model are not critical. Shurflo strainers (model 255) 100 mesh were used on the input of all pumps to keep debris out of the pumps.



Twenty to Thirty Amp (rating of breaker electrical switch contacts) car relays were purchased from eBay.com. I do not recommend using an old automobile's starter switch relay. They draw way too much current through the coil when closed (up to several amps). The small relays used to control lights and fans in cars are much better to use and have an 80 to 100 ohm coil which results in a bit over .1 amps wasted flow through the coil when closed.

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The water pumps were kept as low as possible to the water level in the tank that was being pumped. This was to avoid loss of water (avoids needing priming with water) in the pump while turned off for extended periods of time.

The bladders in the accumulators need to be inflated to the same pressure that the pump turns on at (that is the lowest PSI). This pressure needs to be checked at regular intervals.

The RO pump is a low volume with a small accumulator (optional) that runs all the time when the RO filters are working. It has a pressure regulator in the line on the output that keeps the pressure from getting too high. Optimum running pressure is 60-80 PSI.



Due to the UV light being turned on only part of the time during pumping of output water, there is a possibility of it taking a number of seconds to warm up. This could allow some pathogens to get by the sterilization chamber. There is also the possibility of contamination getting in the last storage tank. As a result it was decided that the water should pass by a UV light going into and out of this last tank as a safety.

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The current before PS measured amount of Total Dissolved Solids (TDS) rain water at my site is currently 1 to 4 PPM. This is if the rain was captured without touching the ground. If it was captured from puddles on the ground then it was in the range of 11 PPM. If we pulled it from underground then it was up to 210 PPM.

The bottom line is if one collects rain water before it touches the ground one can expect to have closer to distilled water than any other water that has been in contact with the ground. If water runs on the surface or soaks into the ground it will have more time in contact with the ground and thus more dissolved solids.

We expect this to be true as well after a pole shift (PS). After the PS there may be more floating solids in the rain water especially in the way of volcanic ash. However if one captures it before it touches the ground there will still be relatively less dissolved in that water than after it has been in contact with the ground.

Floating partials are easy to filter out it's when it is dissolved that it gets harder. Dissolving into water takes place with time for many elements. So a rule of thumb is: "Capture rain water as close to the source of falling out of the sky as one can". If possible minimize water contact and time with the ground.

Bulk Filter Correction Media

This link is a good source for pH and other correcting filter media by the bag.

<http://www.aquascience.net/filtermedia.htm> I plan to use Calcite pellets from this site. It is expected that the rain water will be acid after the PS. Sulfur from volcanic activity thrown into the air combines with water to produce sulfuric acid. The pH of the rain water where I am at now is 5.5 or acid. The RO filters can handle this much acid but the water softener resin beads don't like it (it turns off the softening process).

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Appendix

The following are useful Conversions when working with water purification:

General:	
Conversions	Abbreviations
ppm = mg/L	ppm = parts per million
1mg/L = 1,000 microgram/L	mg/L = milligrams per liter
1ppm = 1,000ppb	ppb = parts per billion
cc = ml	cc = cubic centimeters
1ml = 1g water	g = gram
1% = 10,000ppm	ml = milliliters
1% = g/100mL	ppt or 0/00 = parts per thousand
1ppt = 1,000ppm	ppb = parts per billion
1% = 10ppt	ug/g = microgram/gram
0.1% = 1g/L	1ug/g = 1ppm
1000ppb = 1ppm	g/L = gram per liter

Hardness:	
Conversions	Abbreviations
1gpg = 17.1ppm CaCO ₃	gpg = grains per gallon
	CaCO ₃ = calcium carbonate

Alkalinity:	
Conversions	Abbreviations
1dKh = 17.9ppm CaCO ₃	dKh = German degrees of hardness (also shown as Kh)
1 meq/L = 50ppm CaCO ₃	meq/L = milli equivalents per liter

Conductivity/TDS (total dissolved solids):
Conductivity Units:
uS = microSiemens = mhos/cm = micromhos per centimeter
mS = milliSiemens = mmhos/cm = millimhos per centimeter
(mhos and Siemens are the same)
TDS Units:
ppm = parts per million
ppt = parts per thousand

Weight:	
Conversions	Abbreviations
16oz = 1lb	7000 grains = 1lb
0.454kg = 1lb	kg = kilograms
454g = 1lb	mg = milligrams
1kg = 1000g	g = grams
1g = 1000mg	28.349g = 1oz

Conductivity/TDS Conversions:
1mS = 1,000uS
1ppt = 1,000ppm
uSiemens x 0.7 = ppm

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Temperature:
$(1.8 \times ^\circ\text{C}) + 32 = ^\circ\text{F}$
$(^\circ\text{F} - 32) \times 0.56 = ^\circ\text{C}$
Volume:
15ml = 1/2oz
250ml = 8oz
3800ml = 1 gallon
30ml = 1oz
500ml = 1pint
60ml = 2oz
1000ml = 1quart
120ml = 4oz
2000/2500ml = 1/2 gallon
3.78L = 1gal
128oz = 1gal
2pt = 1qt
4qt = 1gal
qt = quart
pt = pint

What Are the Effects of Lead?

Exposure to low levels of lead over an extended period of time can have severe effects. Too much lead can damage your brain, kidneys, nervous system, and red blood cells. Those at the greatest risk, even with short-term exposure, are young children and pregnant women.

According to the U.S. Environmental Protection Agency (EPA), lead dosage that would have little effect on an adult can harm a small child. Lead in drinking water can be a problem for infants whose diet consists of liquids-such as baby formula made with water. Since they are growing, children absorb lead more rapidly than adults. That lead can then impair a child's development, resulting in learning disabilities or stunted growth.

<http://www.bae.ncsu.edu/programs/extension/publicat/wqwm/he395.html>

Health Considerations

The presence of iron and manganese in water is not considered health problem. In fact, small concentrations are essential to human health. However, high concentrations of iron may give the water an unpleasant metallic taste while still being safe to drink. When iron combines with tea, coffee, and alcoholic beverages, it produces an unappetizing inky, black appearance and a harsh, offensive taste. Vegetables cooked in iron-contaminated water turn dark and look unappetizing.

Iron and manganese are minerals found in drinking water supplies. These minerals will not harm you, but they may cause reddish-brown or black stains on clothes or household fixtures. Under guidelines for public water supplies set by the Environmental Protection Agency (EPA), iron and manganese are considered secondary contaminants. Secondary standards apply to substances in

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water that cause offensive taste, odor, color, corrosion, foaming, or staining but have no direct affect on health. The standard Secondary Maximum Contaminant Level (SMCL) for iron is 0.3 milligrams per liter (mg/L or ppm) and 0.05 mg/L for manganese. Private water supplies are not subject to federal standards, but these standards can be used as guidelines to evaluate the quality of water from wells or springs.

Iron bacteria (a harmless bacteria), occur in soil, groundwater, and some surface waters. Iron bacteria are considered harmless to health, however, they may give water an off taste or color, cause splotchy yellow stains on laundry, and clog water systems. Iron bacteria usually appear as stringy, slimy, mucous-like substances suspended in fresh water and may be colored brown, red, or white. They thrive on iron in the sink or metal parts of the water system and are most easily seen on the inside surface of the toilet tank.

Sources for Various parts

For various RO piece parts or components check out:

<http://airwaterice.com/>

<http://www.waterfiltersonline.com/parts-department.asp>

<http://stores.ebay.com/H20-Science>

For a source of cost effective filter elements to include .5 um Carbon Block at about \$6.00/each in quality including the price of shipping and sediment filters for about \$1.20/each down to 1 um see: <http://stores.ebay.com/H2O-SPLASH>

BILGE PUMP FLOAT SWITCH see

<http://stores.ebay.com/Stuff4boats>