Hydro Siting

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Many people have access to some form of running water and are wondering just how much power, if any, can be produced from it. Almost any house site has solar electric potential (photovoltaic). Many sites also have some wind power available. But water power depends on more than the presence of water alone. A lake or well has no power potential. The water must be FLOWING. It also must flow from a high point to a low one and go through an elevation change of at least three or four feet to produce useable power. This is called the head or pressure, usually measured in feet or pounds per square inch (PSI). The flow is measured in gallons per minute (GPM) or for those blessed with larger flows, cubic feet per second (CFS).

At most sites, what is called run of river is the best mode of operation. This means that power is produced at a constant rate according to the amount of water available. Usually the power is generated as electricity and stored in batteries and can be tied to an existing PV or other system. The power can take other forms: shaft power for a saw, pump, grinder, etc.

Both head and flow are necessary to produce power. Even a few gallons per minute can be useful if there is sufficient head. Since power = Head x Flow, the more you have of either, the more power is available. A simple rule of thumb to estimate your power is Head (in feet) x Flow (in gpm)/10 = Power (in Watts). This will give you a rough idea of the power available at the average site and reflects an overall efficiency of 53%. This is a typical output for a well designed system. For example: if your head is 100 feet and the flow is 10 gpm, then 100 x l0/10 = 100 watts. Keep in mind this is power that is produced 24 hours a day. It is equivalent to a PV system of 400-500 watts - if the sun shines every day. Of course, the water may not run year round either. So it is apparent how a combined system can supply your power needs on a continuous basis.

Determining Head & Flow

Let's start with the head since that is easier than the flow and will give you confidence to continue. The best method to determine the head is also the easiest and can be used at any site. It is also very accurate. It involves using a length of hose or pipe in the neighborhood of 1/2" diameter. You can start anywhere along the brook and proceed upstream or down. First submerge the upstream end in the water and weigh it down with a rock or something similar. With the top end fixed in place underwater you move the rest of the pipe downstream. When you have reached the end, it is now time to start the water flow through the pipe. This may require you to suck on the end. Once flow is established and all air bubbles are removed, slowly raise the pipe upward until the flow ceases. When this point has been reached, use a tape measure to measure the distance from the end of the pipe to the surface of the water. This reading is the head for the stretch of brook. The pipe then becomes a convenient measure of horizontal run if you use a standard length like 100 feet. If you are working with a brook longer than your length of pipe, then simply carry the pipe to the next section to measure and repeat the procedure as required, starting where you ended before.

It is probably best to "map" more of the brook than you intend to use. This will give you a good overall idea of your site and may reveal some surprises.

Measuring flow is a little more difficult. This should probably be done in more than one place too. This is because most streams pick up water as they go. Therefore choosing the best spot for your system requires careful consideration of several things, There are several ways to measure flow; here are two. In both cases, the brook water must all pass through either a pipe or a weir. The weir system uses an opening that the water flows through and measuring the depth of water gives the flow. The first involves a technique very similar to the head measuring technique. You must divert all of the water into a short length of pipe. This will usually require the use of a dam in order to pack dirt around the intake end. Pipe size may be from 1" to 6" depending on the flow rate. Once that is done the water is directed into a bucket or other container of known volume. The time required to fill it is then noted and this is converted into GPM.

Many materials can be used for the weir but sheet metal is the easiest to make since the thickness is slight. Wood requires a beveled edge for accuracy. A stake is driven into the streambed a foot or so upstream of the weir and level with the bottom of the notch. This is the point the depth of water is measured since the level drops somewhat at the weir opening.

Water flow should be measured several times during the year. Once a month will give a good idea of how much power can be expected year round. The 50% efficiency rule applies to sites with heads greater than 30-40 feet or so. At lower heads everything becomes more difficult. Turbine and pipes become larger and speeds of rotation decrease.

The diameter and length of pipeline can now be determined once you have an idea of the potential power output of your site. It is assumed that you are planning on using a TURBINE and will generate ELECTRICITY. Other courses of action are possible but will not be discussed now. A rough average of the stream flow can be made after you have made measurements at different times of the year. Most sites will have periods of very high flow that don't last long and times of very low or no flow at all. You need a pipeline capable of handling a reasonable flow average.

Let us use an example of a typical site and see what is involved. Assume your measurements show that 100 feet of head is available over a distance of 1,500 feet. The water will be taken from the high end of the pipe and discharged at the low end through the turbine at a point as close to the brook as is reasonable. This will give you the maximum head available.
Exceptions to this will be where the discharge water is to be used for another purpose (aquaculture, irrigation). Assume for the example that a flow of 30 gpm is available most of the year. Any pipeline will produce maximum power when the pressure drop due to friction is 1/3 of the pressure when no water is flowing. The pressure available under conditions of water flow is called the NET or DYNAMIC head. The pressure under conditions of no flow is the STATIC head. The difference between these two is the loss due to friction. Therefore the larger the pipe the better. For the example you will require a pipeline that has no more than a head loss of 100/3 or 33.3 feet (over 1,500'), This is 33.3/15 or 2.22 feet of head loss per 100 feet of pipe. Since this flow rate will probably allow the use of fairly small pipe, let's use the chart for polyethylene. Two inch pipe gives a flow loss of .77 feet per 100 feet and 1 1/2 inch gives 2.59. From this information, the 1 1/2 inch looks a little small and with the 2 inch we can use up to almost 55 gpm before the power drops off (50gpm = 1.98' head loss and 55gpm = 2.36 feet head loss/100').

So the choice of 2 inch pipe will cause a pressure drop of .77/100 x 1,500 = 11.55' head loss or a NET head of 100 - 11.55 = 88.45 feet at a flow of 30 gpm.

Editor's Note: See pages 25 and 26 of this issue for Poly and PVC; Pipe Tables. We put them in the center as a tear out for your wall.

These can also be found in the Owner's Manual.

Water must be channeled into the intake end of the pipe. This may require a minimal dam sufficient to raise the water level a foot or so. It is useful to make a small pool off to one side of the main flow for this so that the trash (leaves, twigs, sand) will largely bypass the inlet. The inlet can be covered with window screen and need only be a simple wooden frame to support the screen and have a hole for the pipe to enter. . To facilitate draining the pipe, valves can be fitted as shown. A valve the size of the pipe can be installed just downstream of the intake. This is followed by a small air inlet valve to allow the water to exit and prevent pipe collapse. At the turbine end of the pipe a valve should be installed just before the turbine with a pressure gauge upstream of it. This will enable you to stop the flow and determine the pressure under both static and dynamic conditions. Another valve may be added on a tree to drain the pipe without running the turbine. A pressure relief valve can be added in higher pressure systems. Keep in mind that even if you are always careful to shut the stop valve slowly, the pressure can still rise suddenly for at least two reasons. A piece of trash may plug the nozzle or air pockets may discharge causing the water to speed up and then slow down abruptly when water hits the nozzle. Some respect for the forces involved will help protect your system.

Another area that may require protection is the aquatic environment your system intrudes upon. Remember that your water needs should not cause the stream level to become too low. Many areas also have legal guidelines for the use and diversion of stream water.