ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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Determining the Yield of a Residential Well

Homeowners should know basic information about their private well. Important factors include depth to ledge, overall depth, diameter, and safe yield. Even if historical data concerning a well's yield exists, it may no longer be correct due to many reasons including nearby blasting or earthquakes, mineral deposition in or near the well, the development of the upland recharge area, or the presence of new wells installed into the same water resource. Reassessing the current yield of your well is valuable if there is concern that the well's yield has decreased, or to document current yield if you are concerned that nearby future development will impact your well's capacity.

The purpose of this document is to describe a procedure by which a homeowner can document the current maximum yield of their well, whether that well is newly installed or has been in use for some time. Most of this document pertains to bedrock wells, also called drilled or artesian wells. Please see page 6 for a brief discussion concerning yield testing of dug wells.

CONCEPT OF WELL YIELD

Safe Yield

In general, the "safe yield" of a well is its dependable and continuous output during a sustained drought condition. Determining the long-term "safe yield" of a well for a community public water system requires a more detailed process beyond the scope of this document. This document simplifies the yield testing process for a private well.

Overview of a Well's Safe Yield Test

Determining the current yield or maximum safe yield of a well is a process that identifies the equilibrium between the maximum amount of water that can be pumped out of a well, and the amount of water that recharges back into the well from the surrounding bedrock fractures. Establishing this equilibrium requires the continuous pumping of the well for an extended period of time. During this pumping period measurements are made of both the rate at which water is being pumped out of the well, and the resultant water level drawdown within the well. This relationship results in greater drawdown within the well with greater pumpage.

An equilibrium is achieved when the water level within the well stops dropping for a given discharge rate. The period of time required to reach this equilibrium varies from a few hours to days. Once equilibrium is achieved, the less pumpage the less the drawdown. Achieving this equilibrium is the critical condition during a yield pump test.

There are hundreds of combinations of drawdown and discharge rates that will reach an equilibrium. The maximum safe yield of a well is that pumping rate and its associated drawdown where no further lowering of the water table is prudent, and where equilibrium has occurred. It is common to maintain the water level in the well at least 25 feet above the top of the submersible pump. This depth of water over the pump provides a reasonable level of safety for dry conditions, and provides for full cooling of the electrical submersible motor.

If the water level within the well continues to drop to the level of the intake of the pump without stabilization occurring, the pumpage from the well is exceeding the natural recharge rate of the surrounding rock. If this happens, the pumping rate is excessive and must be reduced, or damage to the electric motor is likely and air will be drawn into the pump.

Yield Testing New Or Existing Wells

Determining the safe yield of a well is an involved process. It is possible that a pump test can be done by a homeowner; however, DES recommends that the process be discussed with your pump company or well driller since specialized equipment and modifications to your existing plumbing will be needed.

For a new bedrock well, a yield test can be performed immediately after the drilling has been completed, and before the well is connected to the house. This yield estimate is done by blowing compressed air into the well. The air rises lifting the water with it and allowing the well yield to be estimated. A more accurate method consists of installing either a temporary or permanent pump in the well. The value of installing a temporary pump is that it will allow greater accuracy when finally selecting your permanent pump, and the temporary pump avoids damage to the permanent pump from rock chips left over from the well installation.

For an existing well that is in use, it is necessary to create an "artificial" water demand on the home's plumbing system so that the well pump will run continuously. When performing a yield test on an in-use well, you can maintain minimum pressure within the home by either continual manual adjusting the exterior faucet(s) that are flowing or (temporarily) installing one or more (adjustable) pressure relief valve(s) on outside faucet(s). **When creating this high demand do not discharge this water through interior faucets, since excessive in-house water flow may lead to overload of the septic tank and leach field.** If pressure relief valves are used, they should be adjusted to a setting that will flow water when the pressure in the plumbing is adequate. As demand inside the home increases and the pressure on the plumbing system drops these valves will close sufficiently to maintain adequate flow/pressure on inside plumbing.

Preliminary Information

Whether testing a new or an existing well, certain **background information** must be obtained to allow setting up the pump test and to ensure meaningful results. Homeowner records or the records of the pump installer, and/or well driller, can provide much of this information. The needed information is specified below. Write that information in the spaces provided below, and on the pump test record at the end. When referencing depth measurements it is common practice to measure from the top of the well casing. The casing normally protrudes above the ground surface by a foot or two. Use the top of the well casing to make any future measurements.

Preliminary Information:

a) Date well was drilled: _____

b) Total depth of the well: _____ feet

c) Yield of well when drilled (i.e., yield determined by the well driller):_____gallons per minute

d) Date that the current pump was installed: _____Brand Name _____ Model # _____

e) Depth at which the pump was set: _____ feet below casing top

f) Depth down to natural non-pumped water level (called static water level): _____ feet; date _____.
Note: If the static water level is not known, it will be necessary to turn off the pump to allow the water level in the well to rebound to its natural non pumped level. Measure the water level rebound until the rate of change is less than 1-inch per hour. The length of time the pump must be turned off will vary and may range from a few hours to an entire day. Measuring water levels is described below on page 4.

g) Maximum anticipated pumping rate: _____ gallons per minute.
Note: Although not always available, it would be helpful to know the maximum pumping rate that the pump can produce based on the total system lift. This information must be supplied by the pump installer. This will come in handy later in testing the well when you are measuring drawdown and adjusting the pumping rate.

Appropriate Discharge Location
Whether a new or existing well, the water pumped from the well must be discharged to an appropriate location that **will not** flow towards or recharge back into the well being pumped. Appropriate discharge locations include streams, ponds, and wetlands. In each of these cases, the area needs to be naturally wet all year round. If the pumped water flows or recharges back into the well, this would lead to "double counting" of the pumpage, and an over estimation of the well's yield.

For testing of existing in-use wells, lengths of garden hose can be connected to outside faucets to direct the water to an appropriate disposal location. For new wells not connected to the house, black PVC piping is commonly used to direct water to an appropriate location.

Conducting the Yield Test
During the yield test, record all data on the pumping test log as provided at the end of the document. The major steps in conducting the yield test are outlined below:

Step 1 – Obtain the preliminary information specified above.

Step 2 – Lay out discharge lines to appropriate discharge location(s).

Step 3 – Begin Testing: For an existing in-use well - begin the test by opening the appropriate number of exterior faucets. For a new well - begin the test by turning on the temporary well pump.

Step 4 – Measure the discharge **rate of the pump** and **water level drawdown** in the well. Measurements should be made on at least **an hourly basis**. Record these measurements along with the date and time each reading was taken.
Note: Methods for obtaining drawdown measurements are described below. The **pumping rate** is typically measured in **gallons per minute**, and is the rate of water being pumped out of the well. This will diminish with time. The **water level drawdown** is measured in **feet**, and is the

distance down to the water in the well as measured from some reference point, such as the top of the well casing. Drawdown (lowering of the water table) will increase with time.

Step 5 – Continue pumping until an equilibrium is achieved. Equilibrium is achieved when the water level in the well is drawn down to within 10-25 feet of the top of the pump and the water level either ceases to drop, or the water level drops at a rate of less than 1-inch per hour. If this condition exists, **the testing can be stopped**.
Note: You may have to alter the pumping rate several times in order to match "pumpage out" to "recharge in" until you can achieve an equilibrium that produces the maximum yield from the well. In some wells, you may not be able to increase the pumping rate to fully lower the drawdown any further due to the limited size of the pump or plumbing. Under this condition, you have determined an equilibrium for a known pumping rate that is noticeably less than the well's ultimate safe yield.

Altering the pumping rate:
If the water level in the well has been drawn down to within 10-25 feet of the top of the pump, and the water level continues to drop at a rate greater than 1-inch per hour, equilibrium has not been achieved. Under this condition you must reduce the rate at which water is being pumped out of the well. This can be done by reducing the number of faucets that are flowing or increasing the resistance setting on the pressure relief valve(s). Continue to monitor the water level in the well per Step 4 above. You may note that the water level will rebound due to a decreased pumping rate. Do not allow the water in the well to be drawn down to the pump intake, since this will result in overheating and potential burn out of the electric motor. Continue pumping until a new equilibrium is reached per Step 5 above.

If the water level in the well is only partially drawn down, and you feel that the well can produce more water, then increase the pumping rate. To increase the rate you can open up more outside faucets and/or decreasing the relief setting on the pressure relief valves allowing more water to escape. Continue to monitor the water level per Step 4 above. Continue pumping until a new equilibrium is reached per Step 5 above.

Devices to Measure Water Level Drawdown in Wells
Measuring the water level drawdown in a bedrock well will likely be the most difficult and/or expensive portion of the pump test, and will require the use of a sophisticated measuring device.

Most homeowners do not have a drawdown device installed in their well. Devices for measuring drawdown in deep wells are briefly discussed below. Please discuss the type of devices available with your well driller or pump installer.

Air Tubes
If an air tube is not already installed in your well, this measuring method will require "removing" the pump from the well. An air tube is a plastic tube, approximately 1/4 inch diameter installed in the well with the lower end open and positioned at the same depth as the pump. The depth of the end of the tube below the top of the well casing **must be known**. A pressure gauge with a dial, typically calibrated in pounds per square inch (psi), is attached at the top of the tube. The air tube method uses the relationship that every 1 pound per square inch of pressure in the tube will displace 2.31 feet (vertically measured) of water from the tube. The equipment configuration consists of a source of pressurized air, an opened ended air tube attached to the side of the well pump assembly, and a pressure gauge. In use, the compressed air forces the water out of the tube and ultimately bubbles out the open end. The maximum reading in the gauge (in psi) times 2.31ft/psi equals the water level in feet **above the open** end of the tube. To convert to a

drawdown measurement, subtract this reading from the length of the tube **below the top** of the well.

To calculate the water level drawdown in the well use the following formula:
_____ feet - (_____ psi x 2.31) = _____feet
(Length of Open Ended Air Tube) (minus) (Pressure Gauge Reading times 2.31) = (Water Level Below Top of Casing)

Example: If the open end of an air tube was installed to a depth of 300 feet below the top of the well casing and the pressure gauge reads 38 psi, the depth to the water level as measured from the top, of the casing would be 213 feet **below** the top of the well casing (i.e., 300 feet - (38 psi x 2.31 ft/psi) = 213 feet).

An Electronic Water Level Meter
Electronic water level meters are the most common means, used by scientists, of measuring the water level in a well, and are more accurate than the air line method. This method also requires that a tube (called a stilling tube) to be installed in the well. The stilling tube is typically a plastic tube, approximately 1-inch inside diameter, lowered into the well with the lower end open and installed below the water to a depth approximately equal to the pump. The tube can sometimes be snaked down the well to the appropriate depth; however, the numerous obstacles in the well normally require the pump be pulled to install the tube.

The stilling tube guides the water level probe down into the well through the maze of wires, wire guide centering devices, and the torque arrester installed in the well. Without the tube, the probe would become hung-up on the many fittings associated with a submersible pump assembly. Since the tube is open at the end, water within the tube will rise or fall equal to the water level in the well. The electronic water level meter probe will identify the water level immediately upon contact with the water surface due to the difference in electrical conductivity between the water and the air. Markings on the probe wire give the drawdown level.

A Pressure Transducer
Pressure transducers are the most expensive means of measuring water levels, but are the most accurate, and offer the ability to obtain continuous water level readings. This method also requires a large diameter stilling tube similar to the electronic water level meter described above. Pressure transducers measure the weight of the column of water above the probe, and then convert that weight to the equivalent feet of water. By referencing the probe to a known depth from the top of the well casing, the pressure transducer will calculate the water level drawdown directly.

A Sonic Device
This device is by far the easiest to use by a lay person, and does not require the installation of an air tube or stilling tube. This device is expensive and typically would be owned by a pump company or well driller. This device sends a sound wave down into the well. The sound wave bounces off the water surface and reflects back to the device. The instrument measures the time it takes for the sound wave to travel down the well and back, and then calculates the depth to the water from the instrument. This device is compatible with existing wells and functions accurately in spite of the various obstacles, such as wire or piping within the well casing. The disadvantage is that the device may provide erroneous or no data if substantial cascading water is present in the well.

Drawdown is Not Measured
This is not a device, but a concept. In this option, the drawdown is not directly measured, and

thus stabilization of the drawdown must be inferred. The procedure consists of pumping the well for several days and assuming, by inference, that the drawdown has stabilized **somewhere above** the pump intake. You must be confident that the well pump has a lower output than the well's yield to utilize this test method. This assumption is critical, in that, if the pump output is larger than the well yield, the pump will eventually dewater the well, causing overheating and potential burning out the electric motor. This method produces information that can be disputed, and thus is the least desirable for some applications.

Devices to Measure the Pumping Rate of the Well
The pumping rate of the well can be measured using either a direct reading flow meter, or a stop-watch-and-bucket technique. If you have more than one discharge line, you must measure the discharge at each outlet, and then add them together to determine the total pumping rate of the well.

Most homeowners do not have a flow meter installed on an existing in-use well. For a new well not connected to the home, your well driller or pump installer can install a flow meter on the discharge line. Flow meters function much like the speedometer/odometer on an automobile. They provide you with a direct reading of the flow rate, typically in gallons-per-minute, and record the total gallons pumped during the test.

A more simple method is the stop-watch-and-bucket method. This approach measures how many minutes it takes to fill a container of known volume. The pumping rate in gallons-per-minute is then calculated by dividing the bucket's capacity by the number of elapsed minutes. The larger the container the more accurate the measurement. For systems with two or more wells, the yield test should be carried out on all wells at **the same time**. This will prevent "double counting" if both wells draw from the same groundwater source.

Documenting the Results of the Pump Test
Before starting the test, determine how to conduct the test and the type of information that will be, recorded on the pumping test log provided. A good record keeping system is important. Without a good system, you will lose much of the value of the pump test.

Dug Wells
The process for determining the safe yield in dug wells is the same, but much easier. In dug wells the water level can be easily measured by placing a graduated stick in the well and taking direct readings. For dug wells, the reasonable water level above the pump intake is one to two feet.

For More Information
Please contact the Drinking Water and Groundwater Bureau and the New Hampshire Water Well Board at (603) 271-2513 or dwgbinfo@des.nh.gov or visit our website at www.des.nh.gov/dwgb. All of the bureau's fact sheets are on-line at www.des.nh.gov/dwg.htm.

Please contact the Laboratory Services Unit at (603) 271-3445 or (603) 271-3446 or go to www.des.nh.gov/lab.

Note: This fact sheet is accurate as of October 2007. Statutory or regulatory changes, or the availability of additional information after this date may render this information inaccurate or incomplete.