THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE AND LIFE SCIENCES
COOPERATIVE EXTENSION

AZ1581

September 2012

ARIZONA WELLS:
MAINTAINING AND TROUBLESHOOTING WELLS

Janick F. Artiola, Ph.D.; Kristine Uhlman, RG; and Gary L. Hix, RG

Introduction

Arizona has stringent permit and well construction requirements for new domestic water supply wells, but once a new well is drilled and equipped, the responsibility for the care of the well falls clearly on the well owner. Proper well care and maintenance of a well can have a positive effect on the wells yields and water quality in the years following its initial construction. Neglect of your water well and the associated equipment can lead to major maintenance expenses and compromise the quality of water coming from your well.

The Arizona Department of Water Resources (ADWR) website: **www.AzWater.gov/AzDWR/** can provide a wealth of information for the private domestic well owner about his/her well. Construction diagrams, geologic logs, and well equipment details of all permitted water wells in the state are required to be on file with the ADWR. Private well owners are encouraged to check their own well records on file with the ADWR, and keep that information up to date (Hix, 2011). Maintaining the current owner of record and well equipment information in the ADWR records is the responsibility of all Arizona registered well owners. Up-to-date records on aquifer characteristics, well construction, and pump equipment are necessary for efficient troubleshooting and repair of wells.

The Arizona Groundwater Management Act of 1980 defines wells having a pump capacity of not more than 35 gallons per minute (gpm) as "exempt wells" because exempt owners are not required to report how much water they pump. These wells are also exempt from most state health and safety regulations, including those regulations that require public supply wells to meet the US Environmental Protection Agency (EPA) Safe Drinking Water Quality standards (Artiola and Uhlman, 2009). Exempt wells are typically those used for domestic or household purposes, stock watering and landscape irrigation.

Domestic Well Yield and Aquifer Characteristics

A well's sustained yield is the rate at which a well can be pumped while ensuring that the water level is not drawn down to the pump intake, and it is typically reported as a gpm flow rate. To properly develop a groundwater resource, it is necessary to design and construct a well capable of yielding a pumping rate compatible with the needs of the well owner. Well yields are highly dependent on the characteristics of the aquifer, the construction of the well, and the maintenance of the well and pumping equipment.

Aquifer water flows in Arizona can be fast in sands, but slow in clay sediments within the desert valleys, hard rock along the Colorado Plateau, and mountain highlands. Wells located in coarse sand and gravel aquifers routinely result in high-yielding wells. Whereas, wells located in fine silt and clay, and bedrock aquifers can reduce groundwater flow into wells to less than 5 gallons per minute (gpm). For a detailed discussion of Arizona aquifer characteristics see Artiola and Uhlman, 2009.

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Figure 1. Typical Domestic Well System with Pressure Tank

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Figure 2. Typical Domestic Well System with Storage and Two Pressure Tanks, and Booster Pumps.

If the sustained yield of the well is insufficient for the landowner's immediate needs, water storage tanks and secondary booster systems are constructed to provide higher flow rates. If the sustained yield of the well and pumping equipment is sufficient for the homeowner's needs a smaller water system can provide the needed water.

Well Construction Affects Well Yield and Well Components

Well Screen

Domestic wells today are typically drilled with machinery that makes a borehole in the aquifer slightly larger than the well casing that is installed. The upper portion of the well casing is typically blank casing and the lower portion of the well casing is typically perforated or slotted (Fig. 3). The lower portion is called the screen section of the well, which allows for the movement of water into the well while reducing the transport of silt and sands into the well. If the slots in the screen are too small, aquifer sediment can clog the screen lowering the well yield. If the screen slots or perforations are too large, excessive amounts of silt and fine sand (grit) can enter the well, which can quickly wear out the pump moving parts, shortening its life.

Well Development

Immediately after the well is first drilled and constructed it is often necessary to remove all loose material, clays, sands generated and introduced during the well drilling process or naturally present in the vicinity of the screen that could prohibit or restrict the entrance of water into the well. This process is called well development and it is a critical step in the well construction process. This process typically brings natural aquifer material (coarse sands and gravels) in contact with the screened portion of the casing. This sorted portion of the aquifer outside the well then acts as a filter to limit the entrance of clays, silts and fine sands into the well. Wells drilled in hard rock formations may not require a screened section if the formation does not permit formation material to enter the pump at the permanent pump's average flow rate.

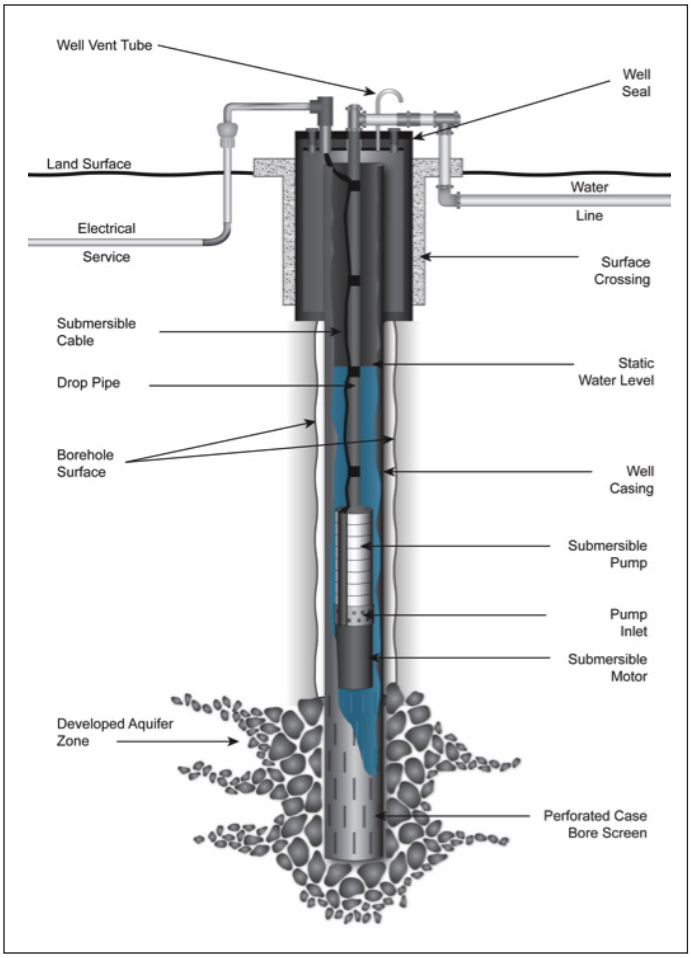

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Figure 3. Well Cross-section with Components.

Well Maintenance Issues

Note: ***The following issues require proper treatment and rehabilitation of a well, which should done by qualified and licensed water well or pump contractor.***

Scale Formation

The most common cause of a reduction in well performance is the development of scale within the well and screen. Similar to the deposits found inside a tea kettle, scale is the hard residue that coats the inside of pipes and the well screen as the result of precipitation of minerals composed of calcium and magnesium carbonates, which are light gray in color, and varying amounts of iron oxides (red).

Slime-Biofim

Naturally occurring iron bacteria can also cause plugging of the pores in the aquifer and the openings of the well screen. Bacteria can produce accumulations of bio-slime within the well and can increase the rate of scale precipitation, not unlike plaque buildup on your teeth. The combined effect of the growth of slime and precipitated mineral has been reported to reduce well yield by 75% within a year of well operation (Johnson Division, 1972).

Iron and Sulfur Reducing Bacteria

Occurrences of sulfur "rotten egg" smelling water, and iron staining are well known nuisances in many areas of Arizona. These bacteria often grow in low oxygen, high organic matter content aquifers. Well water can turn to a rusty red color when it comes into contact with air may give off an objectionable odor. The rust red residues in the water can stain clothes, appliances, and water fixtures.

Excessive growth of acid-producing bacteria inside metal well casings will damage these and other well components. These bacteria can corrode the steel drop pipe holding the submersible pump and motor in the well that conveys water to the surface. They can corrode a hole completely through the steel pipe, which allows the water being pumped to re-circulate inside the well preventing the pump from shutting off.

Wells located in aquifers known to have these microorganisms, should have components made of PVC plastic and/or stainless steel. The well owner may also have to install a sediment filter to remove aquifer particles and a permanganate filter to convert toxic and smelly sulfur chemicals into non-toxic, odorless sulfur chemicals, to control nuisance odors (Artiola and Uhlman 2009).

Sediment Accumulation

After many years of pumping water, sand, and silt can accumulate both inside and outside the screened portion of the well. As some of the perforations become plugged with rust, scale, and sediments drawn towards the well while pumping, the flow rate of water through the remaining screen perforations increases. This can bring even more and larger size aquifer materials through the remaining openings into the well, and possibly into the pump itself. The bottom portion of a domestic water well will slowly fill in with sediments after years of pumping and significantly reduce the sustained yield of the well.

Pump

A submersible pump that has been set too shallowly could draw-down water levels too quickly, requiring the pump to cycle on and off repeatedly as the water table rises and falls, seriously damaging the pump. If water table elevations have dropped since initial well construction, the sustained well yield will decline and the pump may rapid cycle or even run dry if not properly protected. The damage caused by rapid cycling and/or running dry often appears to the well owner as a decrease in well yield when it is actually a decrease in pump performance. Pumping abrasive material like fine sand with the well water causes damage to pump impellers reducing the real and apparent flow rates of the well.

Well Casing

Flakes of rust and scale are often found floating inside water wells due to oxidization of steel well casings and galvanized

Table 1. Common Well water symptoms, problems, and their possible explanations

Observed Symptom	Indication of a Problem	Possible Explanation/Solution
Increased cloudiness in the water as bubbles rise in a glass	Indication that the well is pumping both water and air	Pumping water level nearing pump inlet. Water mixed with air/ **Reduce the flow rate/ install a smaller pump/ deepen the well/ lower the pump**
Increased cloudiness in the water seen settling in a glass	Indication that the well is pumping very fine sediment.	Water entering well rapidly is carrying or stirring up sediments/ **redevelop the well/ reduce pumping rate/ raise the pump above bottom sediments**
Rapid cycling of the pump	Indication air-water ratio in pressure tank is out of balance	Ruptured bladder or water logged pressure tank/ **Add compressed air/ drain tank and refill/ replace tank**
Sudden increase in electrical consumption	Well pump running excessively	Undetected leak in delivery system causing pump to cycle more frequently/ **inspect plumbing for leaks/ isolate lines to find leaking section**
Rattling noise coming from system when operating	Broken valve part chattering in rapidly moving water	Broken spring in check valve in the water delivery system / replace check valve
Pump runs continuously or for long periods of time	System not reaching shut off pressure with high power demand	Hole or crack in pump drop pipe re-circulating water inside well/ **open drop pipe measure depth to water leak/ pull pump to replace leaking pipe**
Pump runs continuously or for long periods of time	System not reaching shut off pressure with low power demand	Low pumping water level in well, plugged pump inlet screen or worn pump parts/ **pull pump inspect & clean**
Pump runs for only a few seconds - then trips overloads	Pump motor drawing excessive power tripping overloads	Motor or electrical wiring shorting to ground***/ measure operating amps**
Pump does not come on at all	Motor not getting start signal from pressure switch	Insects inside pressure switch preventing contacts from closing***/ turn power off, clean contact points**
Pump does not come on at all	Motor not getting proper electrical power	Power off, circuit breaker tripped, blown fuse(s)*** /measure incoming voltage**
Water pressure goes to zero before pump comes on	System pressure out of balance with on-off setting	Excessive air pressure in bladder tank for pressure switch setting/ **reduce pre-charge pressure to two pounds less than come on pressure**

***High Voltage** Present! Well owners are cautioned when checking components where electrical power is present. It is recommended that they contact a licensed and qualified water well pump contractor if unfamiliar with electrical diagnostic procedures.

drop pipe. These flakes of rust and scale can build up on the pump inlet screen and make it more difficult for water to enter. Corrosion of galvanized pipe can produce holes in the drop pipe that allow water to escape back into the well while pumping. PVC well casings and PVC drop pipe help to reduce the occurrence of this cause of loss of well yield, but PVC may not be the most suitable material for all conditions.

Root invasion

Trees can grow roots into water wells between the borehole and the casing, which may cause an apparent loss of yield. Roots are known to enter well screens as deep as 100 feet in some Arizona aquifers. It is important to keep the area immediately surrounding your well clear of trees, brush and weeds that can invade your well. Trees growing over water a well can also create access problems when it comes time to remove the pump from the well.

Potential Health Risks Associated with Low Yielding Wells

A characteristic of low-yield wells may be rapid cycling and dramatic water level changes in the area of the well screen during pumping, which allows for the introduction of oxygen into the aquifer. Changes in aquifer geochemistry can occur when water-saturated geologic materials are exposed to oxygen. This can result in naturally occurring minerals dissolving into the groundwater (or forming new mineral deposits (scale) on well components). If the aquifer has sediments with arsenic minerals, an increase in the concentration of dissolved arsenic may occur inside the well potentially making the water unsafe to drink (Uhlman, 2008).

Dramatic water level changes may also induce biofilm accumulation that can allow for the growth of bacteria that can become a health concern. Studies show that private well often test positive for total coliforms, which indicate the possible presence of pathogens such as disease-causing bacteria and viruses. A positive test for *Escherichia coli* or *E. coli* a fecal indicator bacterium indicates that well water quality may be influenced by a source of animal or human waste such as a septic system. In regions of warm weather (southwest United States) growth of bacteria in a domestic well or inside above ground storage and booster tanks can become a food source for other organisms, such as the amoeba N. fowleri. Domestic wells and water storage and booster systems should be tested bi-annually for total coliforms and E.coli to insure the safety of the well water (Artiola and Uhlman, 2009).

Options for Correcting Well Performance

Surging and scrubbing the interior of the well piping and screen is the most efficient means by which to increase well yield after scale and/or slime formation. A licensed pump installer would mobilize a pump rig over the well, remove the pump and any interior plumbing, and scrub the well with equipment similar to a large bottlebrush. It is recommended that any pump maintenance activity that allows for open access to the well should include well surging and scrubbing to remove scale, slime, and other particulates from the screened portion of the well.

Shock-chlorination of a well exhibiting elevated bacterial contamination is used to remove bio-slime that may be plugging the well. Removing the pump and scrubbing the interior of the well piping best accomplish this. Care should be taken to adequately flush the well system after shock-chlorination because the introduction of chlorine can change the geochemistry of the aquifer and induce mobilization of naturally-occurring minerals, such as arsenic and lead. Elevated levels of chlorine are also detrimental to rubber diaphragms in captive air bladder tanks. It is also important to purge the well thoroughly after shock-chlorination to remove potentially toxic disinfection byproducts, which can be produced when chlorine chemicals come into contact and react with organic matter (slime and other carbon-based organic residues that may be present in the well components and/or aquifer water).

Deepening the well and lowering the pump when the water table has dropped. Any modification or deepening of water wells in Arizona requires applying for and obtaining a permit through the Arizona Department of Water Resources, just as if you were drilling a new well. Permits are not necessary to lower the pump in the well. However, if the well has to be deepened, the casing must be of a diameter and strength sufficient to accommodate the drill pipe and displaced cuttings during the deepening process. Lowering the pump in the well in order to recover lost productivity can be done to some extent, but not without some potential consequences. If the pump is lowered down into the screen zone, sediments may eventually bury the lower half of the pump where the motor is located, which may cause overheating. Also, if the intake portion of the pump is opposite the (screen) perforations, sand may enter the pump and damage it. Finally, a deeper well may need a new pump if the old pump lift capacity is exceeded.

Fracking open-borehole wells, such as those constructed in bedrock, may exhibit increased yield. This process, also known as "hydro-fracking", raises the water pressure within the borehole to induce fracturing of the rock. Increasing the number and frequency of fractures around the borehole allows for the interception of a greater number of water-bearing fractures and may increase yield.

Periodic maintenance of the inside of the well not only extends the useful life of the well it reduces pumping costs. Keeping the pumping equipment operating within its designed range can extend the life of the equipment

and the life of the well. Improperly maintained and operated equipment or down-hole problems within the well can quickly damage pumping equipment. When the true cause of a loss of performance of a well is not readily apparent, a well driller may use a submersible video camera to investigate the condition of the well casing and screen.

Summary

Domestic water well owners have the ultimate responsibility to maintain and protect their private water wells to insure long life and acceptable water quality. Recommended periodic inspections include the wellhead casing, the above ground equipment, the sound and cycles of operation as well as the color, odor, and taste of the water. Annual water quality testing is also important. Private well owners in Arizona have the extended responsibility of registering their wells with ADWR and maintaining their own well records (kept on file with the ADWR) that include but are not limited to the name and address of the current registered owner, and the latest well equipment data. (Hix, 2011)

Whenever the yield of the well appears to be declining, an owner should begin to investigate the cause of the loss of performance. It could be the well, the aquifer, or the pumping equipment. If the owner cannot make a determination of the cause, he or she should call a qualified licensed water well contractor or pump installer.

To assist the well owner, Table 1 lists some symptoms and associated problems that might be observed in the well or water. In addition, possible explanations and solutions to the problem(s) are offered, which the well owner should consider.

Portions of this text have been adapted from The University of Arizona Cooperative Extension Bulletin #AZ1537.

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THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE AND LIFE SCIENCES
TUCSON, ARIZONA 85721

JANICK F. ARTIOLA PH.D.
ASSOCIATE PROFESSOR AND WATER QUALITY SPECIALIST.
DEPARTMENT OF SOIL, WATER & ENVIRONMENTAL SCIENCES

KRISTINE ULHMAN, RG
FORMER AREA AGENT, NATURAL RESOURCES

GARY L. HIX, RG
PRESIDENT OF THE ARIZONA WATER WELL ASSOCIATION

CONTACT:
JANICK F. ARTIOLA PH.D.
jartiola@cals.arizona.edu

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