

ARIZONA WELLS: LOW YIELDING DOMESTIC WATER WELLS

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Arizona has stringent permit requirements for submitting a notice of intent to drill a new water supply well for domestic use. The construction diagram and geologic log of all wells in the state are recorded with the Arizona Department of Water Resources (ADWR). The ADWR website – www.AzWater.gov/AzDWR/ – provides a wealth of information for the private domestic well owner. Well owners are responsible for the repair and maintenance of their own wells and for monitoring water quality to assure safe drinking water.

The Arizona Groundwater Management Act of 1980 identifies wells having a pump capacity of not more than 35 gallons per minute (**gpm**) as “exempt wells” because owners are not required to report how much water they pump. These wells are also exempt from regulation, including those regulations requiring meeting drinking water standards. These wells are typically used for domestic or household purposes.

Domestic Well Yield and Aquifer Characteristics

Well yield is the rate at which a well can be pumped while ensuring that the pumping water-level is not drawn down to the pump intake. Well yield is reported as gpm. To 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 water well owner. Sufficient and sustained well yields are highly dependent

on the characteristics of the aquifer, the construction of the well, and the maintenance of the well.

Aquifer characteristics in Arizona can vary between highly transmissive (high yielding) sands to low-yielding clays within the desert valleys. Wells completed in very coarse sand and gravel aquifers routinely result in high-yielding wells. Whereas, wells completed in fine silt and clay or bedrock aquifers can retard groundwater flow to wells to less than 5 gpm.

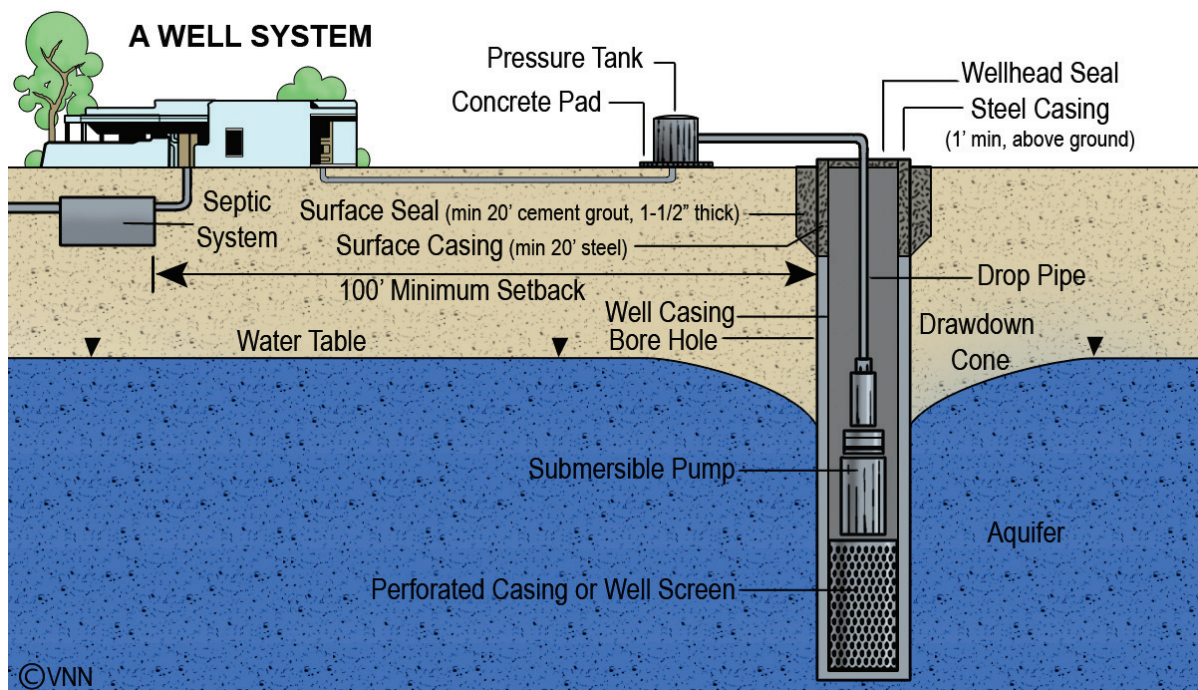


Figure 1: Domestic Well Components adapted from ADWR Well Owner's Guide (not to scale).

How Well Construction and Maintenance Affect Well Yield

Well construction is important when optimizing yield. The screened portion of the well allows for the movement of water into the well while reducing the transport of silt and sands into the well. An improperly sized screen (slots in the screen are too narrow or too wide) could allow sediment to clog the screen or grit (silt and fine sand) to damage the pump. A submersible pump set at a too shallow a depth could draw-down water levels too quickly, requiring the pump to cycle on and off repeatedly as the water table rises and falls, often damaging the pump. If water table elevations have dropped since initial well construction, well yield will decline.

The most common cause of a reduction in well yield is the development of scale within the well and screen, as shown in Figure 2. 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. Naturally occurring iron bacteria can cause plugging of the pores in the aquifer and the openings of the well screen. The bacteria produce accumulations of bio-slime within the well and 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).



Figure 2: Scale formation on well screen.

Potential Health Effects Associated with Low Yielding Wells

Pumps in low yielding wells are more likely to cycle on and off to meet water needs. Rapid and repeated water level changes in the area of the well screen allows for the introduction of oxygen in the aquifer. Changes in aquifer geochemistry can occur when water-saturated geologic materials are exposed to oxygen, and this can result in naturally occurring minerals dissolving into the

groundwater. If the aquifer material includes arsenic minerals, an increase in dissolved arsenic may occur (Uhlman, 2008).

In addition to the potential for loss of well yield, bio-slime accumulation can allow for the growth of bacteria that can become a serious health concern. *E. coli* bacteria is the most common bacteria encountered in domestic wells. It can originate from naturally occurring bacteria found in the soils, but the most common source of *E. coli* in water well systems is fecal *E. Coli* from an adjacent septic system. In regions of warm groundwater (southwestern United States) an overgrowth of bacteria in a domestic well can become a food source for other organisms, such as the amoeba *N. fowleri*. (Artiola and Uhlman, 2009). Domestic wells should be tested annually to assure drinking water standards are met.

Options for Correcting Low Yield Wells

Wells constructed in low yielding aquifers are candidates for well deepening and pump lowering if the static water table elevations have dropped. Open-borehole wells, such as those constructed in bedrock, may exhibit increased yield if 'fracked'. 'Hydro-fracking' consists of sealing portions of the well and increasing the pressure sufficiently 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.

Shock-chlorination of a well exhibiting elevated bacterial contamination reduces bio-slime that may be plugging the well. Well owners should not try to chlorinate their own wells but hire a qualified water well system contractor. 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. In addition, when chlorine chemicals come into contact with organic residues (such as slime), disinfection by-products are produced. These toxic chemicals must be flushed out of the well and/or home water distribution system to reduce contamination.

Anecdotal reports of well owners have evidenced limited success with the introduction of dry ice into the well. As the carbon dioxide (CO_2) bubbles from the dry ice, the water becomes more acidic, which dissolves some of the carbonate-based scale and lowers bacterial count. The agitation of the bubbling dry ice in the borehole is also assumed to loosen some particulate scale. Larger municipal wells are beginning to design large capacity water well systems to use pressurized CO_2 gas to sanitize well systems. The downside of the use of CO_2 is the acidification of the water, which increases pipe corrosion. Additional well cleaning and disinfection procedures are described by Schneiders (2003).

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 bottle brush. 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 domestic well.

The Arizona Water Well Association (<http://azwwa.org>) assists in developing state licensing requirements and maintains a list of qualified water well system contractors. Contact the AzWWA to find a licensed contractor near you.

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