Building Efficient Production Wells: The Long-Term Perspective on Operating Costs and Well Design

Introduction

A municipal, irrigation, or industrial water well is generally expected to be in service for many years and should be both efficient and productive throughout its useful life. Under most conditions, these are reasonable expectations if the well was designed and constructed of high-quality materials, i.e., well casing and well screen. However, an all-too-common scenario is for the owner, designer and/or well drilling contractor to focus a disproportionate amount of attention on the capital cost of the well rather than the long-term cost of its operation. By selecting a lesser grade materials, such as mill-slotted casing, in an attempt to reduce the "first cost" of the well, a well so designed will probably end up costing more to operate because of its inherent low efficiency. Over its lifetime, the well's low efficiency will lead to higher accumulated power costs that can easily eclipse whatever savings the owner may have once realized during the construction phase. Therefore, a more financially prudent approach would be to use high-quality well casing and screen to build an efficient well that will cost less to operate. This memorandum briefly explains the importance of well efficiency, its relationship to well design, and how building an efficient well will help to lower and control long-term operating costs.

Well Efficiency

Well efficiency (expressed as a percentage) is the ratio of the drawdown in the aquifer to the drawdown in the well. A typical range of efficient wells is from 70 to 80% (or greater). In an efficient well ground water flows from the source aquifer(s) through the surrounding gravel pack (if installed) and into the well through the well screen with a minimum of head loss. Head loss is synonymous with drawdown; it is the sum of aquifer loss, damage zone loss (e.g. filter cake), turbulent loss through the gravel pack, and well loss.

Factors pertinent to well efficiency are related to the well construction, the well screen, and well development. An efficient gravel-packed well would typically be: 1) constructed with gravel that is appropriately matched to the gradation of the aquifer(s); 2) completed with a type of well screen that inherently minimizes well loss; and 3) fully developed to remove residual drilling remnants, i.e., wall cake, drilling mud, and cuttings.

Head Loss and Well Screen

The relationship between head loss and well screen design has important implications to the operation of wells. In part, this is because over time the apertures in well screens become partially or completely clogged by various matter such as fine sediment, angular gravel and formation material, bacterial growth, and encrustation. When clogging occurs, the open area of a well screen is reduced, which causes an increase in the amount of head loss through the well screen. When this type of hydraulic change occurs, performance is affected and the well will exhibit a decline in specific capacity. (Specific capacity is defined as gallons per minute per foot of drawdown [gpm/ft]).

It is important to understand that some types of well screen are more prone to clogging than others due to the geometry of the screen openings. This is particularly true of mill-slotted casing, which can exhibit an acceptable level of efficiency when it is installed. Unfortunately, the efficiency of mill-slotted casing often declines precipitously as the slots close up, even if the well is gravel packed. By comparison, louvered screen with its downward-facing apertures actually 1) facilitates the stabilization of both gravel pack and aquifer formations, 2) controls clogging, and 3) promotes higher well efficiency. Similarly, wire-wrapped well screen exhibits high efficiency, on a par with louvered screen, and is particularly effective for fine-grained aquifers where aperture widths of 0.040" or less are needed. Empirical results from actual production wells have shown that the efficiencies of louvered screen and wire-wrapped screen are essentially the same (as explained our Technical Memorandum 004-1).

Operating Costs

A major benefit of an efficient well is its lower cost of operation. Generally speaking, an efficient well exhibits less drawdown and its pump requires less power, e.g., electrical or diesel fuel, to lift the water from its pumping level to ground level or other point of discharge. The following example illustrates the cost savings that are possible:

Assumptions:

Case 1: Well completed with mill-slotted casing. It operates with a total dynamic head (TDH) of 358 feet and an efficiency of 55%.

Case 2: Well completed with louvered screen. It operates with a TDH of 308 feet and an efficiency of 70%.

Where:

$$\text{Cost/Hour} = \frac{\text{gpm} \times \text{TDH} \times 0.746 \times \text{Cost/KWH}}{3960 \times \text{Efficiency}}$$

Parameter	Case 1	Case 2
Pumping Rate	1500 gpm	1500 gpm
Pumping Level	250 feet	300 feet
Discharge Pressure	58 feet	58 feet
Total Dynamic Head (TDH)	308 feet	358 feet
Power Cost	$0.10/KWH	$0.10 KWH
Well Efficiency	75%	65%
Annual Operation	4380 hours	4380 hours
Annual Cost	**$50,827**	**$68,168**

Based on this example, the 10% difference in efficiency and 50 feet less drawdown afforded by louvered screen well would result in an annual savings of $17,341.

Summary

Constructing a highly efficient well is an achievable objective that can pay substantial dividends. Three keys to successful well projects are: 1) carefully drill the well; 2) construct it

with inherently efficient type well screen (louvered or wire-wrapped); and 3) fully develop the well to maximize its production. An efficient well can be reasonably expected to save its owner money in power costs throughout its long lifetime. As shown in the example in this memorandum, the annual savings in power costs can be substantial. Such savings can quickly offset the cost differential between a highly efficient well screen (i.e., louvered or wire-wrapped) over a less efficient screen (i.e., mill-slotted casing).

References

Handbook of Ground Water Development, 1990, Roscoe Moss Company, John Wiley and Sons, New York, NY

Williams, D.E., 1985, “Modern Techniques in Well Design”, Journal AWWA. Vol. 77, No. 9.