WELL SCREENS

Introduction

A well screen is a filtering device that serves as the intake portion of wells constructed in unconsolidated or semi-consolidated aquifers. The screen permits water to enter the well from the saturated aquifer, prevents sediment from entering the well, and serves structurally to support the aquifer material. The importance of a proper well screen cannot be overemphasized when considering the efficiency of a well and the log-term cost to its owner.

Well screens are manufactured from a variety of materials and range from crude hand-made contrivances to highly efficient and long-life models made on machines. The value of a screen depends on how effectively it contributes to the success of a well. Important screen criteria and functions include:

Criteria:

1. large percentage of open area
2. non clogging slots
3. resistant to corrosion
4. sufficient column and collapse strength

Functions:

1. easily developed
2. minimal incrusting tendency
3. low head loss through the screen
4. control sand pumping in all types of aquifers

Continuous-Slot Screen

The continuous-slot screen is widely used throughout the world for water, oil, and gas wells, and is the dominant screen type used in the water well industry. It is made by winding rolled wire, triangular in cross section, around a circular array of longitudinal rods. The wire is attached to the rods by welding. Welded screens are commonly fabricated from stainless steel.

Slot openings are manufactured by spacing successive turns of the outer wire to produce the desired slot size. Slot openings have been designated by numbers which correspond to the width of the openings in thousandths of an inch. A No. 10 slot screen, for example, is an opening of 0.010 inch.

Continuous-slot screens provide more intake area per unit area of screen surface than any other type. This type of screen has maximum open area. For best well efficiency, the percentage of open area in a screen should be the same as, or great than, the average porosity of the aquifer material. Water flows more freely through a screen with a large intake area compare to one with limited open area. The entrance velocity is low, therefore head loss for the screen is at a minimum, thus minimizing drawdown in the well.

Other Types of Well Screens

Several other types of well screen exist. Some are manufactured and others are hand perforated from casing or other materials. These screens may be adequate in some geologic formations, but may provide only marginal success under many other hydrogeological conditions. Limited open area, poor slot configuration, and short-lived screen material contribute to their limited success.

Slotted Plastic Pipe

Slotted plastic pipe is also use to screen wells in some areas particularily in clay rich soils where no aquifer zone can be identified. Slotted plastic screens are not affected by corrosive water, are easy to install, and are relatively inexpensive. Slotted plastic screens have less than half the open are of continuous-slot screens. In addition, plastic pipe materials are from 1/6 to 1/10 as strong as stainless steel well screens.

Well Points

Well points are made of a variety of types and sizes. The welded continuous slot screen is made as a well point by attached a forged-steel point to the lower end of a screen and a threaded pipe shank to the upper end. This type of construction is the most efficient hydraulically. The most common sizes are 1 ¼ inch or 2 inch. They are constructed of either low-carbon steel or stainless steel. Although they can withstand hard driving, they should not be twisted while being driven or used in areas where boulders or large stones are expected.

Slot Size & Sieve Analysis

Slot size selection is a critical step in assuring maximum well performance. The screen is typically designed to hold back 50 percent of the formation, and the entrance velocity of the screen should not exceed 1/10 or .1 foot per second. The velocity is calculated by dividing the well yield in gpm by the screen open area in square inches.

The slot size of the screen is based on a size analysis of the formation samples. By analyzing the component sizes of the grains in the sample, a grain-size distribution curve can be drawn. Several methods can be used to obtain information on the grain size distribution. The most widely used method involves passing the materials through a stacked set of brass or stainless steel sieves.

During the sieving process, each sieve filters out a certain percentage of the entire sample; the finest material collects in the bottom pan. Sieve analysis not only provides the basis for determining the slot size, but also other factors affecting screened well design. Sieve analysis is also used for filter pack design.

Screen Installation

There are different types of screen installation methods used, although certain procedures may be more practical or more economical in certain areas or when particular drilling rigs are used. The exact procedures to be followed when installing a well screen depend on the nature of the aquifer materials, the method used to drill the well, the dimensions of the borehole, the hydraulic conditions in the aquifer, and the casing and screen materials.

Pull-Back Method

The pull-back method of screen installation is a safe method of installation that reduces problems resulting from heaving sediment, sloughing of the borehole walls, and setting the screen at the wrong depth. This method also permits the screen to be removed and replaced, if necessary without disturbing the sanitary grout seal outside the well casing.

The pull-back method involves installing the casing to the full depth of the well, lowering (telescoping) the well screen inside the casing, and then pulling back or lifting the casing far enough to expose the screen to the water-bearing formations. The casing must be strong enough to be set the full depth of the well and then be pulled back the length of the screen.

Some contractors use a rise pipe (blank) attached to the top of the screen so the entire screen can be exposed without slipping out of the bottom of the casing. On top of the screen, a neoprene packer is installed to provide a sand-tight seal between the top of the screen and the casing. Two or more packers are used in series to eliminate problems caused by small deviations in the dimensions of the casing or packer resulting from improper handling.

Single String Installation

Sometimes the screens are attached directly to the bottom of the casing. Screens that are smaller in diameter than the casing can be welded or threaded directly to the casing by mounting a cone adaptor or flared weld ring to the top of the screen. Screens that are the same size as the casing can be welded or threaded directly to the bottom of the casing. The casing and screen are then set in the hole. For naturally developed wells, the formation is induced to cave in around the screen and casing immediately after the screen is set. When wells are filter packed, the pack material is placed before the formation is induced to cave.

Filter Packed Wells

Many wells are designed for a filter pack, thereby altering the screen installation process. Filter-packed wells different from naturally developed wells in that a silica sand is placed around the well screen to a predetermined thickness. The geologic conditions, drilling method, and type of screen determine whether a filter pack should be used.

The filter pack provides both filtration and stabilization of the screen. The main objective of filter-packing is to install material more permeable than the native formation into the area immediately around well screen. The advantages of filter-packing a well are: greater porosity, higher hydraulic conductivity, higher yield, reduced entrance velocity, reduced sand pumping, and easier grouting. Filter pack must be chlorinated prior to placing it into the open annulus to insure that contaminants are not introduced into the well during the filter-packing process.

WELL DEVELOPMENT

Introduction

By definition, well development is the act of repairing damage to the formation caused by drilling procedures and increasing the porosity and permeability of the materials surrounding the intake of the well.

Well development is confined mainly to a zone immediately adjacent to the well where the formation has been disturbed during drilling.

All new wells should be developed before being put into production to achieve sand-free water at the highest specific capacity. Maintaining a high specific capacity assures that the well will be energy efficient.

Factors that Affect Development

There are two major completion methods – natural development and filter packing. The completion method is chosen based on the aquifer, type of drilling rig, and type of screen.

In natural development, a highly permeable zone is created around the screen from materials in the formation. Development removes most particles smaller than the screen openings, leaving the coarsest material in place. A little farther out, some medium-sized grains remain mixed with coarse material. Beyond that zone, the material gradually grades back to the original character of the formation. Finer particles brought into the screen in this process are removed. Development continues until fines are no longer removed from the formation. Development stabilizes the formation and prevents further movement of sediment. Following development, water moving toward the screen encounters sediment with increasing hydraulic conductivity and porosity. More water can be removed from the well, and the well will be more efficient.

In filter packing, a special sand having high porosity and permeability is place in the annulus between the screen and the natural formation. Development of the disturbed formation outside the pack is still mandatory to achieve maximum specific capacity.

Well Development Methods

There are different types of development methods used based on aquifer type and type of drilling rig. Unfortunately, some development techniques are still used in situations where other, more recently developed procedures would produce better results. Any development procedure should be able to clean the well so that sand in the water is kept to a minimum.

<u>Air Development by Surging and Pumping</u>

Many driller used compressed air to develop wells in consolidated and unconsolidated formations.   Alternating surging and pumping with air has grown with rotary drilling. In air surging, air is injected into the well to lift the water to the surface. As it reaches the top of the casing, the air supply is shut off, allowing the aerated water column to fall thus forcing water in and out of the screen. Air-lift pumping is used to pump the well periodically to remove sediment from the screen or borehole, and is accomplished by installing an air line inside a pipe in the well.

High-Velocity Jetting

Development by high-velocity jetting may be done with either water or air. Jetting with water is almost always accompanied by simultaneous air-lift pumping so that clogging of the formation does not occur. This dual process is one of the most effective methods of well development. The jetting procedure consists of operating a horizontal water jet inside the screen so that water shoots out through the screen openings.

Jetting with air is an alternative to water jetting. If water is not readily available, air jetting is a practical procedure that produces good results. Air jetting initiates air-lift pumping, which helps remove sediment from the well.

Mechanical Surging

Mechanical surging is another method of development which forces water to flow into and out of a screen by operating a plunger up and down in the casing. The tool commonly used is a surge block or plunger. A heavy bailer may be used to produce the surging action, but it is not as effecting as the surge block. The initial surging action should be gentle, allowing any material blocking the screen to break up, go into suspension, and then move into the well. The force exerted on the formation depends on the length of the stroke and the velocity of the surge block. As water begins to move easily both into and out of the screen, the surging tool is usually lowered in steps to just above the screen.

Overpumping

Overpumping is the simplest method of removing fines from the water bearing formations. It is pumping at a higher rate than the well will be pumped when put into service. Any well that can be pumped sand free at a higher rate can be pumped sand free at a lower rate. Overpumping, by itself, seldom produces an efficient well or full stabilization of the aquifer because most of the development action takes place in the most permeable zones closest to the top of the screen.

Backwashing

Effective development procedures should cause reversals of flow through the screen openings that will agitate the sediment, remove the finer fraction, and then rearrange the remaining formation particles. Reversing the direction of the flow breaks down the bridging between large particles and across screen openings that results when the water flows in only one direction. Backwashing breaks down bridging, and the inflow then moves the fine material toward the screen and into the well.

A surging action consists of alternately lifting a column of water a significant distance above the pumping water level and letting the water fall back into the well. The pump should be started at reduced capacity and gradually increased to full capacity to minimize the danger of sand-locking the pump.

Although overpumping and backwashing is used widely, and in certain situations may produce good results, their success in high capacity wells is limited when compared to other development methods.

Summary

Patience, intelligent observation, and the right tools are required to develop a well correctly. Developing beyond the minimum time to remove fines will help to increase the chances of obtaining a coliform-free water supply. Well development is not expensive, considering the often remarkable results that can be obtained in improving yields and eliminating sand pumping. Similarly, aquifer development is often overlooked as an effective way to increase yields substantially.

The source of information for this chapter was “Groundwater and Wells”, Second Edition, by Fletcher G. Driscoll, Ph.D.