HOW TO KEEP YOUR WELL Supply RELIABLE (Understanding THE Symptoms)

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An Optimal Performing Well is Key to Sustaining a Reliable Groundwater Supply
Why is my well not producing enough water?

- **Pump performance problems?**
  Plenty of water in the ground, but the pump can’t produce it.

- **Well performance problems?**
  Pump is working fine, but there’s not enough water to pump.

- **Combination of both?**
Typical Well Problems

- Loss of Yield/Specific Capacity
- Decrease in Pressure
- Reduction in Operating Efficiency
- Increase in Pumping Cost
- Pump Failure/Corrosion
- Water Color/Quality Complaints
- Turbidity/Sand Entrainment or Air Entrainment
Look for these signs:

- Excessive Motor Heating
- Bearing Noise/Vibration/Cavitation
- Change in Amperage/Voltage
- Settlement/Cracking of Pump Base
- Pressure/Yield Decline
Consider the Wire to Water Efficiency of the Pump

\[
w/w \text{ eff.} = \frac{\text{gpm} \times \text{TDH}}{3960 \times \text{kW} \times 1.34}
\]

\text{gpm} = \text{gallons per minute}\n\text{TDH} = \text{Total dynamic head (feet)}\n\text{kW} = \text{Kilowatt input}\n
\text{Generally: Very good system is over 70\%}\n\text{Average system is 60 to 70\%}\n\text{Poor system is under 60\%}\n
Review Pump Performance

Figure 3
Factors That May Affect Long-Term Well Performance

- Screen /Pump Settings & Converging Flow
- Intake Interval Efficiency – Design & Adequate Initial Development (120% of Targeted Capacity)
- Aquifer Makeup Near Intake Zone (ex. stratigraphy; friability; mineralogy; fracture orientation, extent, and depth)
- Groundwater Quality
- Well Construction Materials and Compatibility
- Casing Setting/Formation Seal
Is the Well Deteriorating or Are Other Factors Affecting Performance?

- Yield variation due to temperature-induced viscosity changes associated with surface-water recharge
- Pumpage in excess of long-term recharge rate
- Changes in local water withdrawals or land use
- Well pumpage in excess of design capacity
May reflect “water mining” due to excessive pumping by a single well, or through a combination of wells in a single aquifer or watershed, or long-term drought impacts, or combination of all.
Unconsolidated Deposits Aquifer and Well Construction Deterioration Factors

- Well Construction Materials and Compatibility
- Aquifer Makeup (ex. stratigraphy)
- Screen and Pump Settings
- Intake Interval Efficiency
Groundwater Flow Towards A Pumping Screened Well

Ideal

Actual
Bedrock Aquifer and Well Construction Deterioration Factors

- Casing Setting/Formation Seal
- Major Water Bearing Fracture Topography and Infilling
- Depth of Major Water Bearing Fractures and Pump Setting (ex. Cascading, Air-Entrainment)
- Bedrock Makeup (ex. Friability, Mineralogy)
Groundwater Bearing Fracture Orientation Can Affect Well Yield And Performance

Vertical Water-Bearing Fractures

Sub-Horizontal Tabular Water-Bearing Fractures
Well Intake Deterioration Causes and Results

- (Geo)Chemical
  - Incrustation
  - Corrosion
- Physical
  - Particulate Migration
- Microbiological
  - Biofilm buildup
  - Chemical Precipitation
  - Corrosion
Some Common Chemical-Precipitates That Induce Well Plugging

Calcium Carbonate
Lower pH ground water dissolves calcium carbonate from the formation materials – reduced pressure in the well and gravel pack causes precipitation and scaling

Iron Oxides
Groundwater occurring under reduced conditions (anaerobic) and containing high dissolved iron, precipitates as it approaches well intake interval and becomes aerated and exposed to in-situ bacteria
Open Borehole Intake of Bedrock Well Showing Fracture Clogging by Precipitate Buildup
Influence of Entrance Velocity Changes Over Time and Resulting Increase in Blockage and Future Corrosion Sites
Corrosion

**HYDRAULIC-RELATED** generally caused by physical abrasion; self-aggravating with enlarged slots; over-pumping at rates in excess of design flows is the primary cause of hydraulic corrosion.

**CHEMICAL-RELATED** more of a problem in older wells, the modern use of stainless steel has minimized many of the problems formerly associated with brass screens.

**GALVANIC RELATED** generation of electrical currents caused by electron transfer between dissimilar metals through conductive water; usually occurs where casing and screen are joined, or where stressed by threading, welding or repeated impacts with pump or pump column (poor alignment).
GALVANIC CORROSION WITH IRON BACTERIA

A

Cathode

Fe(OH)₃

Fe²⁺

Anode

1. Cell starts
2. Iron bacteria keep pulling Fe²⁺ into solution.
   Cell does not stop.

Iron pipe wall

CORROSION TUBERCLE

B

Iron hydrate slime

Anaerobic corrosion bacteria attracted to anode

C

Sulfur-reducing bacteria

Iron bacteria slime

Tubercle begins to close

Iron pipe wall

CORROSION TUBERCLE (MATURE)

D

Second cell between O₂ "rich" water and O₂ "poor" interior

Sulfur and other corrosion products

Hardened iron hydrate

Acid products nearly through wall
Impacts of Corrosion on Well Screens
Particulate Migration can:

- Lead to formation collapse which can introduce finer sands from formations above the screen
- Allow particulates to form a nucleus for chemical incrustation
- Allow blocked screen openings to lead to higher entrance velocities, aggravating other problems
- Provide future source of sand entrainment and pump damage

Sand Buildup in Pump Impeller
Biofilms and Bacteria

corn cob formation

Crenothrix

polymer strands

Gallionella

Leptothrix

ferric oxide sheath

x2000  x6500

x400

x1200

x7500

x1000
SOME USEFUL TOOLS FOR IDENTIFYING WELL DETERIORATION
Specific Capacity Determination Considerations

- A primary indicator of a well’s operating performance (Q/s), expressed in gallons per minute per foot of drawdown (gpm/ft).
- Varies with pumping rate and pumping duration.
- Should be determined at least annually, preferably quarterly. If possible, should be determined following pump shutdown and adequate recovery.
- Should be determined for same rate (preferably design rate) and pumping duration (usually for one hour).
- Should be determined regularly by step-rate pumping test (minimally once per year) and compared to original test data – use a threshold of 80 to 85% (or greater if necessary) reduction to trigger need for rehabilitation.
Factors That Influence Drawdown and Affect Specific Capacity Values

\[ S_1 = \text{Drawdown due to aquifer} \]
\[ S_2 = \text{Drawdown due to well performance} \]
\[ S = \text{Total Drawdown} \]

\[ S = S_1 + S_2 \]
Specific Capacity Comparison From Step-Test Results

<table>
<thead>
<tr>
<th>Pumping Rate (gpm)</th>
<th>Specific Capacity (gpm/ft)</th>
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<tr>
<td>20</td>
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<td>90</td>
<td>0.20</td>
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</tbody>
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Diagnostic Step-Rate Test (9/95)

Initial Test (9/85)
Water Quality Analyses Can Help Identify Incrustation-Forming Environments and Constituents

Chemical testing of well water at wellhead or water-plant laboratory can be utilized to identify why scale-forming or plugging deposits are forming inside a well. This can be used to develop an appropriate maintenance program.
Bio-fouling can result from geochemically enhanced buildup and growth of bacteria or fungi in the aquifer, well borehole, or screen, and can ultimately impede the flow of water to a pumping well. Test results can be used to help identify a treatment methodology designed to address the resulting bacteriological impact of concern (ex. bioslime buildup).
Sand Pumping and/or Air Entrainment

- Can be occur in screened or bedrock wells
- Can be caused by poor well design, bio-fouling, corrosion, over-pumping
- Should be viewed as warning sign regarding overall health of your well (i.e., do something now)
Downhole Televiewing
**Routine Well And Pump Performance Monitoring Efforts That You, The Operator, Can Do**

_Determine and Record:_

- “Static” (non-pumping) Water Level (off for at least 8 hours)
- Pumping Water Level (pumping for at least 1 hour)
- Yield and Drawdown
- Specific Capacity
- Pump Pressure (operation observations, ex. noise)
- Monthly Schedule (preferred minimum)
OVERVIEW OF WELL REHABILITATION
Involves a variety of methods to physically break up precipitates and biomass, and subsequently remove the dislodged material from the well.

- Wire brushing
- Air lifting
- Surging
- Jetting
- Hydraulic Fracturing
- Ultrasonic Cleaning
- Carbon-Dioxide Injection (can also be used for fracturing)
Air Lifting
Surging
Jetting

- Grout
- Air line
- Casing
- Well screen
- Filter pack
- Water
- Movement
CO₂ Injection

Boreblast
Hydraulic/CO₂ Fracturing

- WATER
- AIR
- WELL
- PACKER
- BEDROCK FRACTURES

[Diagram of a well with labeled components: WATER, AIR, WELL, PACKER, BEDROCK FRACTURES]
Chemical Rehabilitation Techniques

Commonly used in conjunction with a physical rehabilitation process, typically surging, primarily to dissolve precipitates and also act as a biocide.

Typical rehabilitation chemicals include:
- Acids
- Surfactants/Dispersants (Commonly purchased as proprietary mixtures)
- Chlorine products
WELL REHABILITATION RESULTS

Change (Increase) In Specific Capacity
Specific Capacity And Redevelopment Effectiveness Over Time – A Case Of Two Wells

WELL 27: Redevelopment Effectiveness Persistent Over Time

WELL 29: Redevelopment Effectiveness Declining Over Time – Replacement Well Warranted

= Post-Redevelopment Specific Capacity
Increased Specific Capacity Results in:

- Increased Yield
- Reduced Drawdown and Lower TDH
- Less Energy per Gallon of Water

Example:

As well efficiency decreases from 16.7 gpm/ft to 10 gpm/ft, the operational cost increases by $2,600/year.
Performance of pumps and wells deteriorate over time.

The use of periodic static water level and specific capacity monitoring, and common data collection and graphing are important to maintaining a reliable water supply.

Performing routine monitoring of pump and well performance can help avoid unplanned shutdowns, and can save money by lengthening the service life of a pump and well.

Numerous diagnostic techniques are available to help identify causes of well-performance decline and options for rehabilitation and its effectiveness.
Questions?

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