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

Pump Performance Review

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

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

gpm = gallons per minute
TDH = Total dynamic head (feet)
kW = Kilowatt input

Generally: Very good system is over 70%
Average system is 60 to 70%
Poor system is under 60%

Review Pump Performance

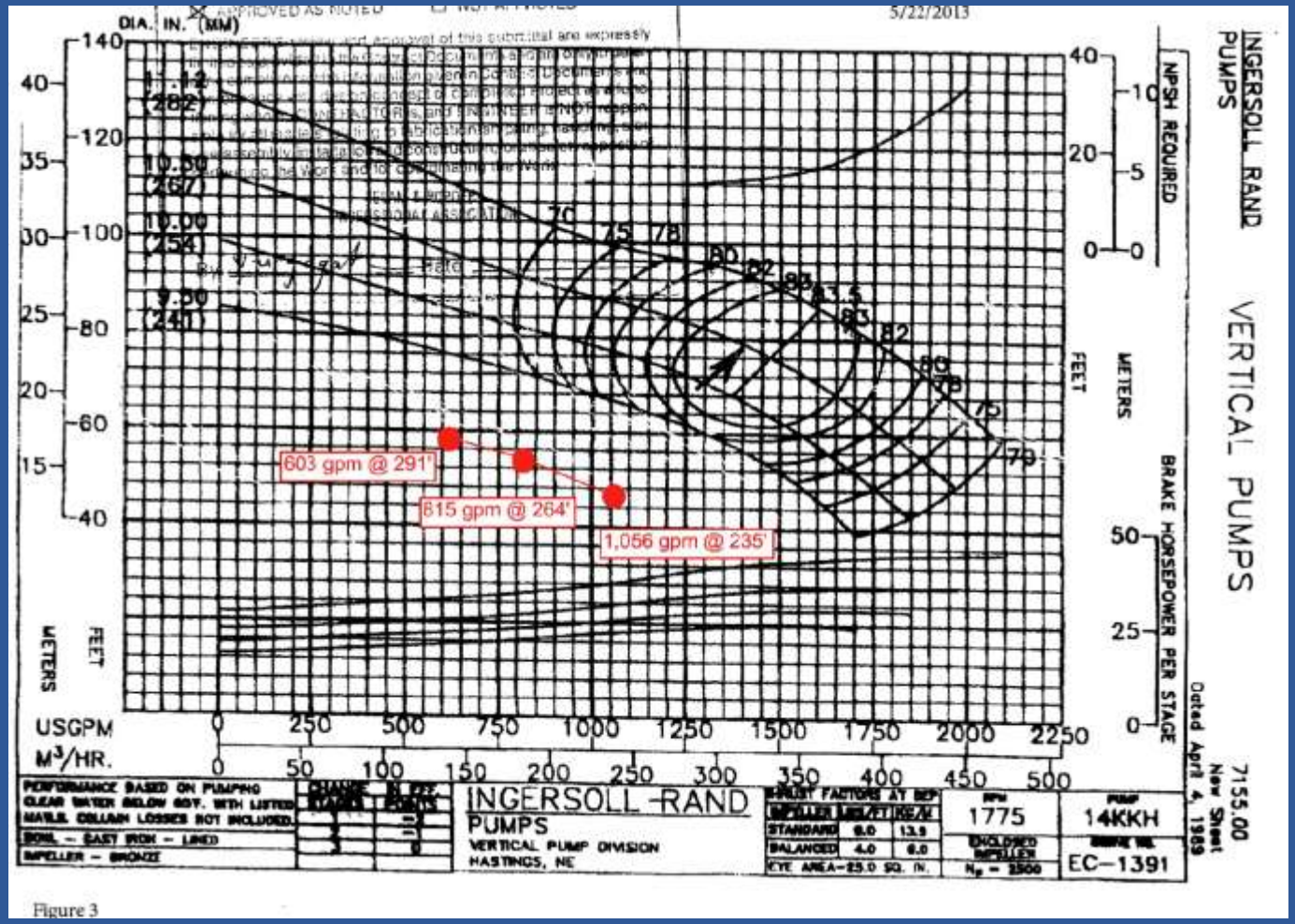


Figure 3

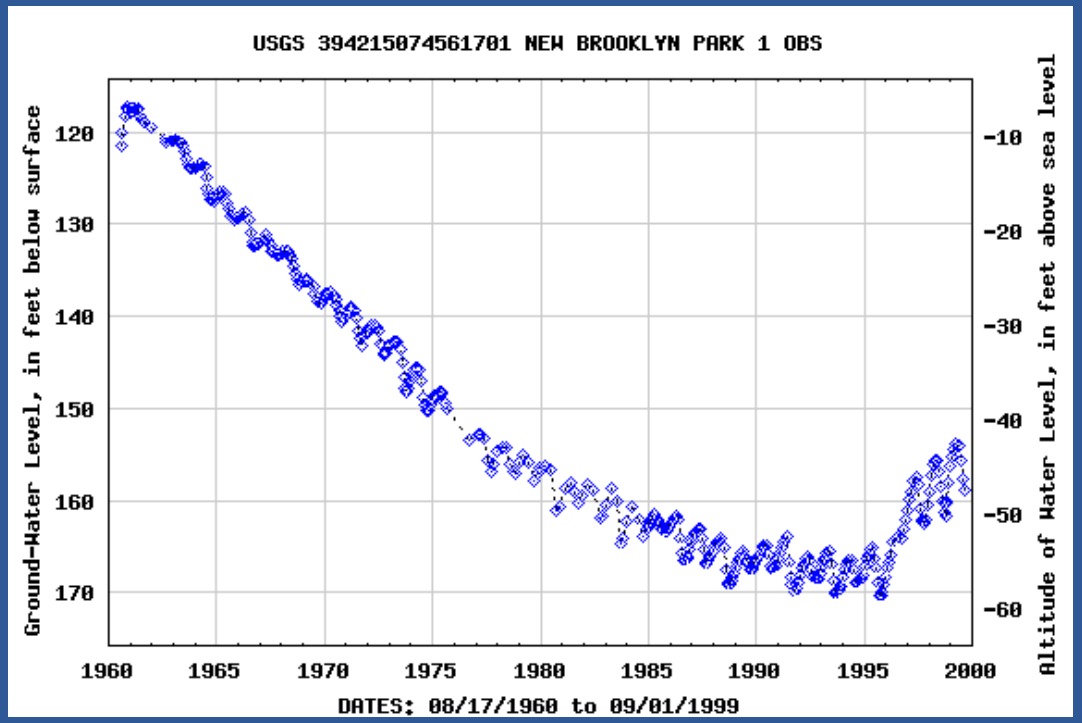
Factors That May Affect Long-Term Well Performance

- 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

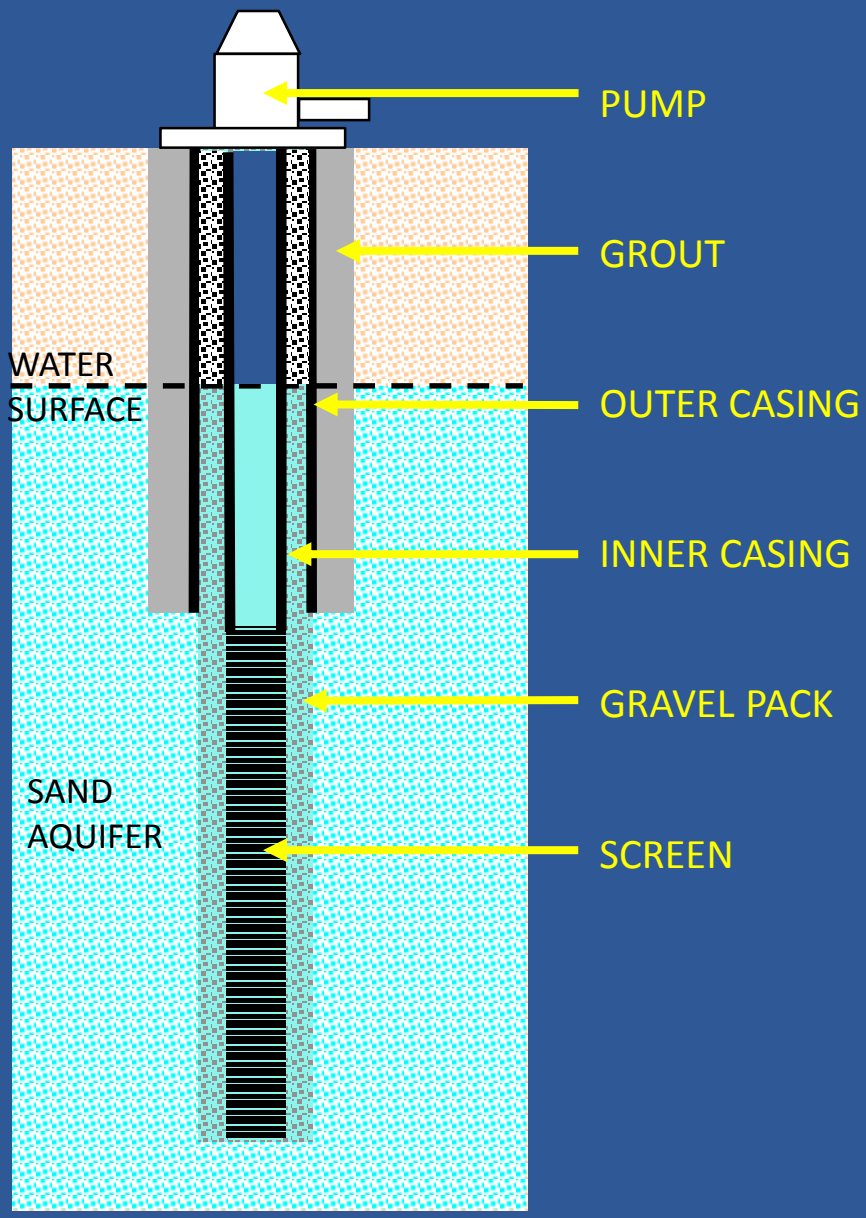
Is the Well Deteriorating or Are Other Factors Affecting Performance ?

- 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

Long-Term Static Water Level Decline



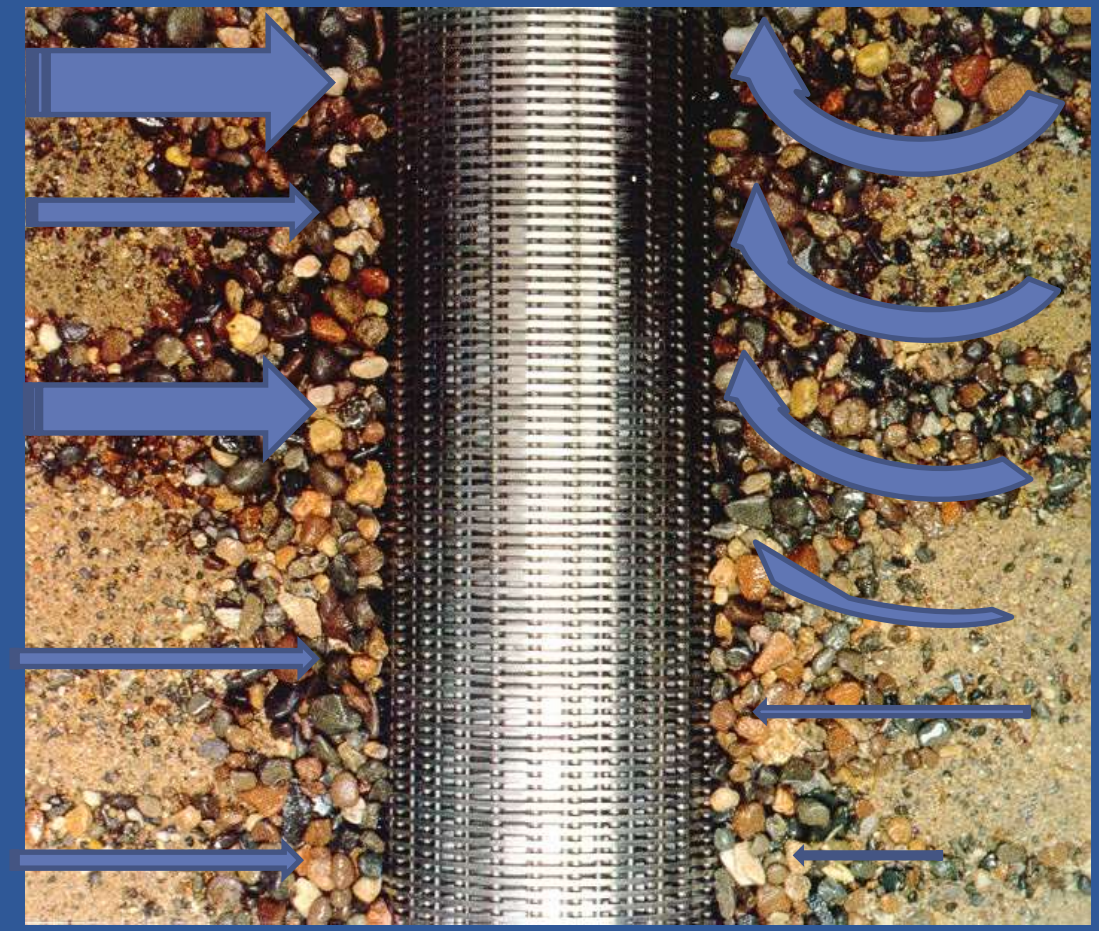
May reflect “water mining” due to excessive pumping by a single well, or through a combination of wells in a single aquifer or watershed, or long-term drought impacts, or combination of all.



Unconsolidated Deposits Aquifer and Well Construction Deterioration Factors

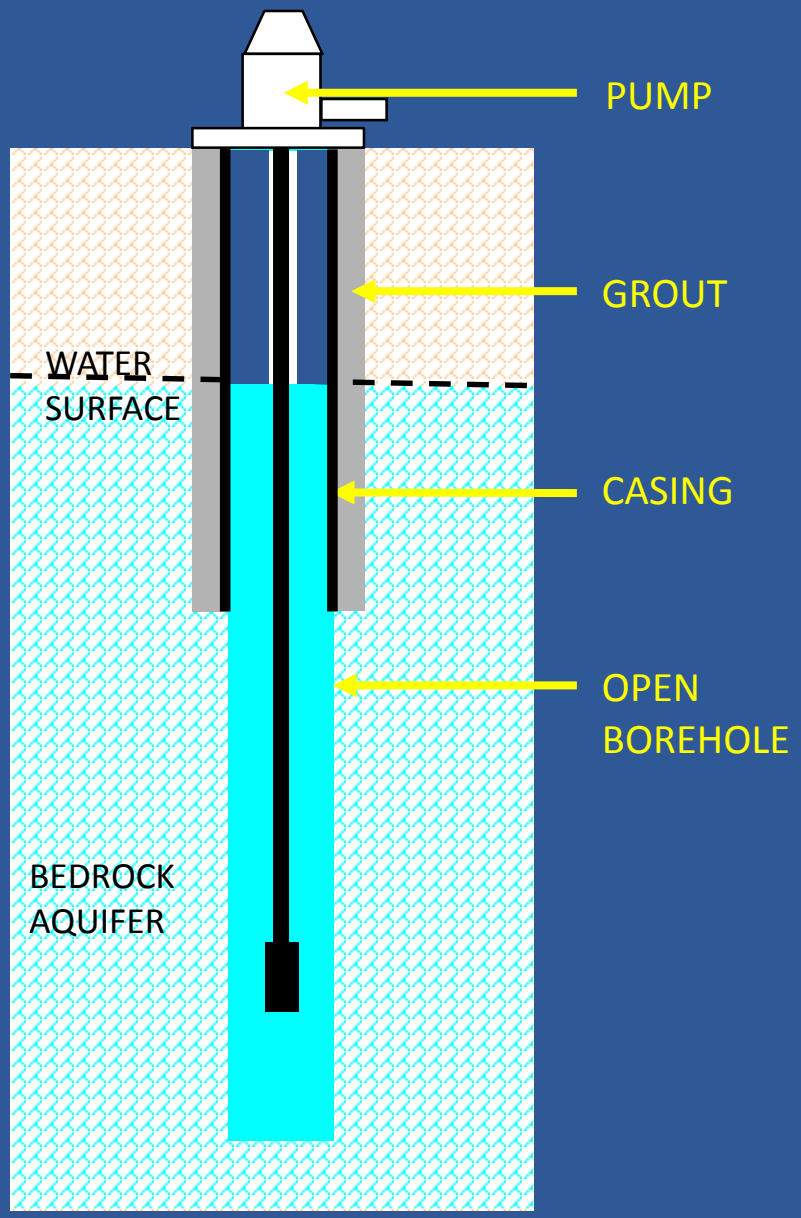
- Well Construction Materials and Compatibility
- Aquifer Makeup (ex. stratigraphy)
- Screen and Pump Settings
- Intake Interval Efficiency

Groundwater Flow Towards A Pumping Screened Well



Ideal

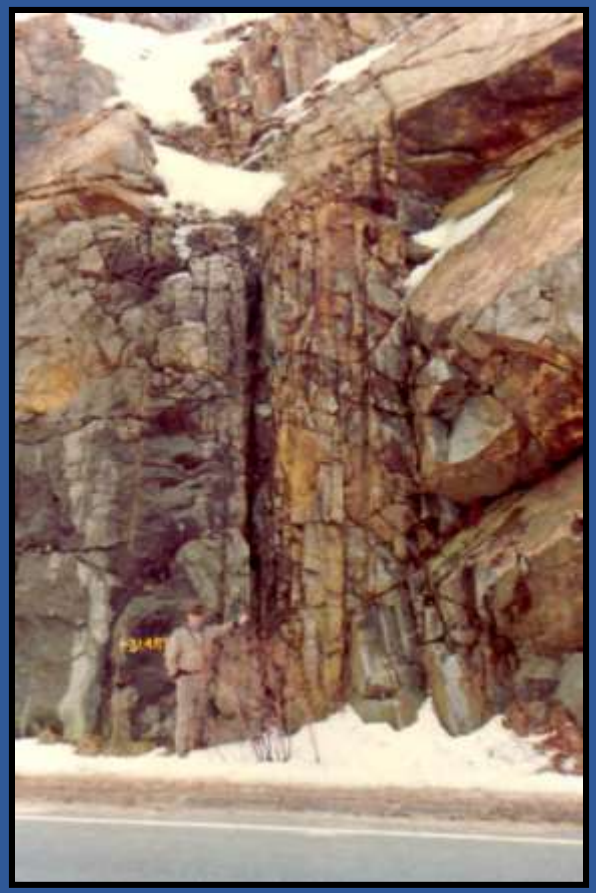
Actual



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

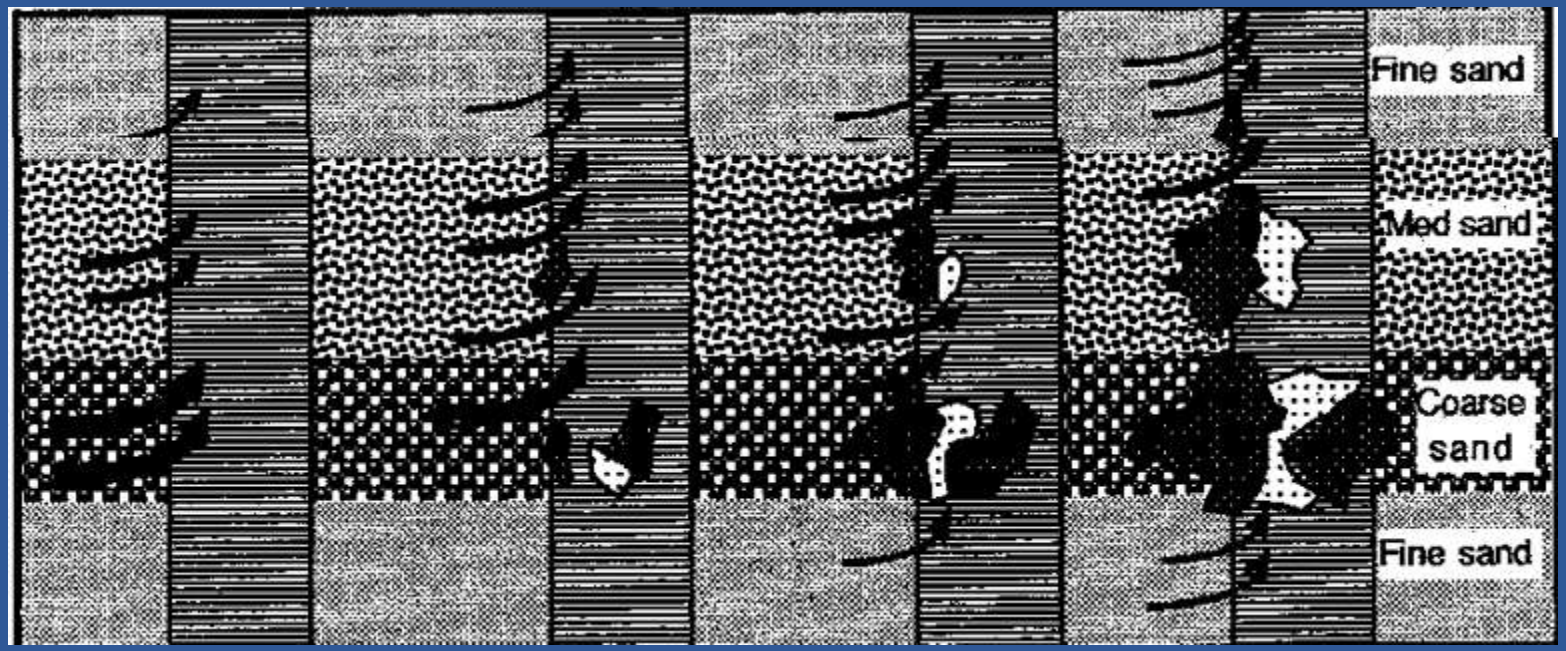
- (Geo)Chemical
  - Incrustation
  - Corrosion
- Physical
  - Particulate Migration
- Microbiological
  - Biofilm buildup
  - Chemical Precipitation
  - Corrosion

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



Initial → Current

Corrosion

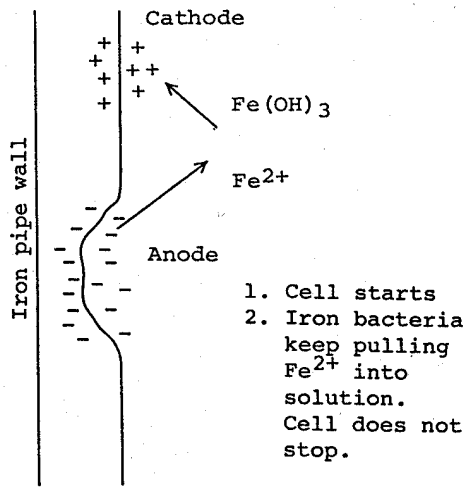
HYDRAULIC-RELATED generally caused by physical abrasion ; self-aggravating with enlarged slots ; over-pumping at rates in excess of design flows is the primary cause of hydraulic corrosion

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)

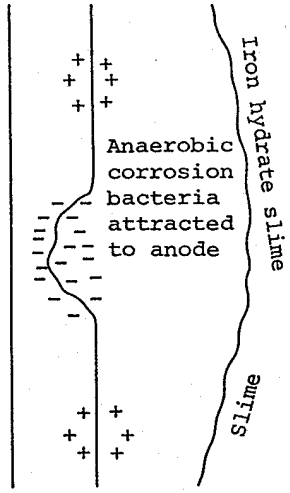
GALVANIC CORROSION WITH IRON BACTERIA

A



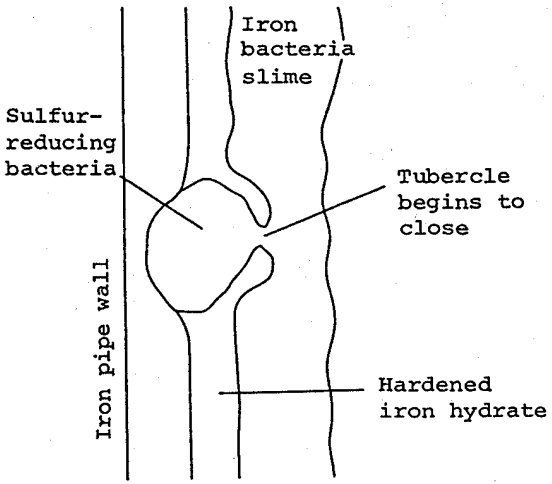
CORROSION TUBERCLE

B



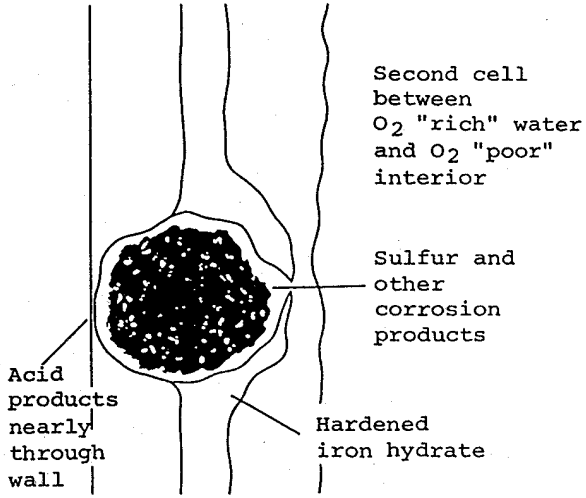
CORROSION TUBERCLE

C



CORROSION TUBERCLE (MATURE)

D



Impacts of Corrosion on Well Screens

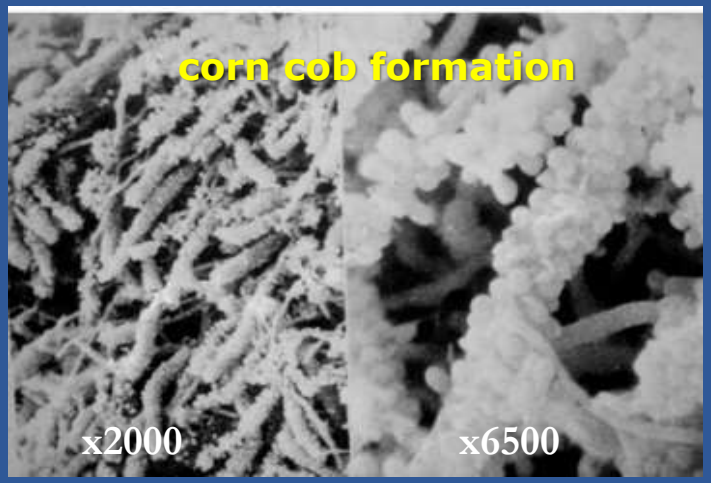
Particulate Migration

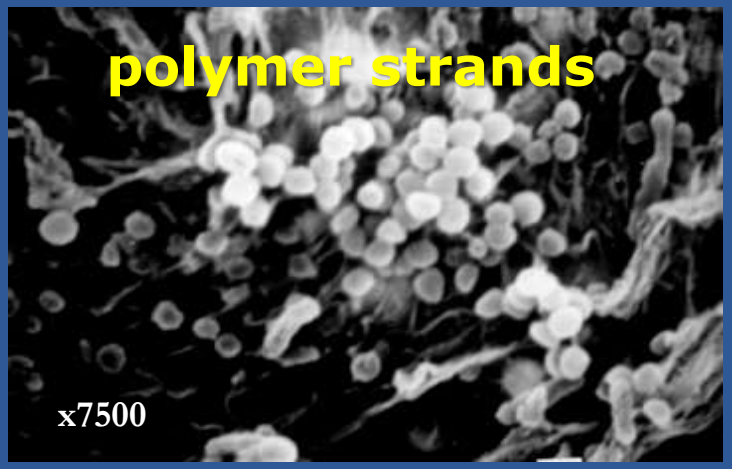
Particulate Migration can:

- 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

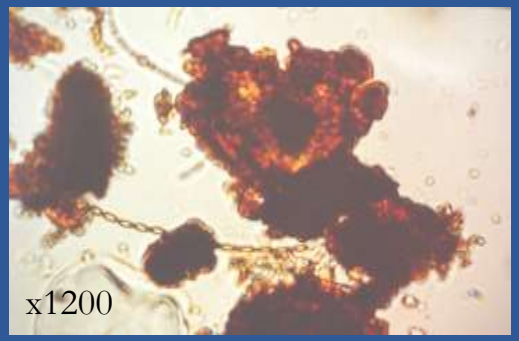
Biofilms and Bacteria



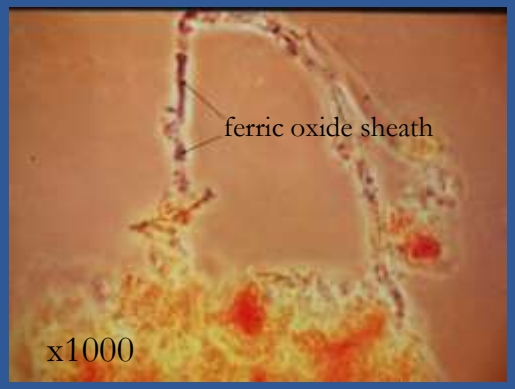


Crenothrix

Gallionella



Leptothrix

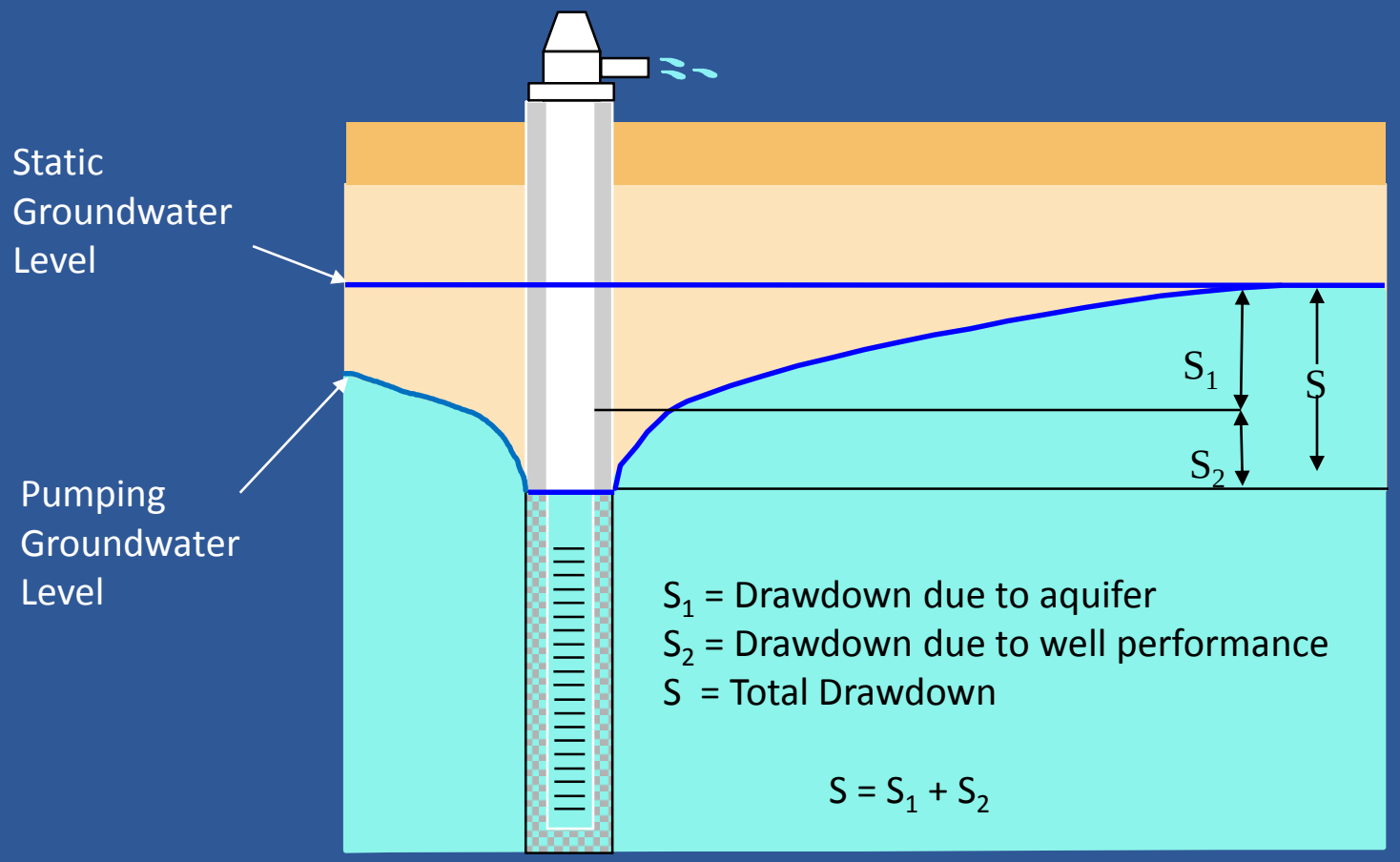


SOME USEFUL TOOLS FOR IDENTIFYING WELL DETERIORATION

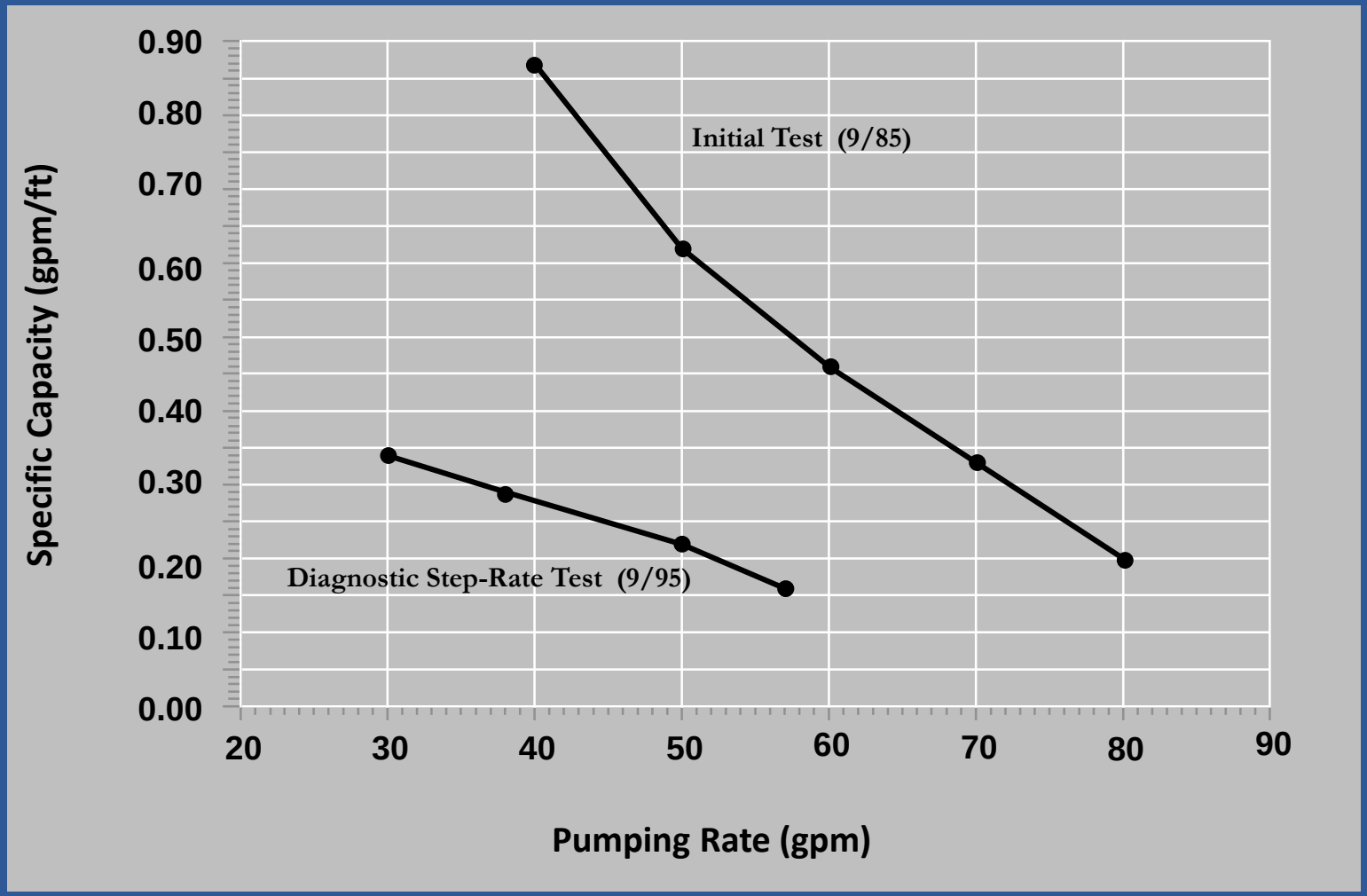
Specific Capacity Determination Considerations

- 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



Specific Capacity Comparison From Step-Test Results



Water Quality Analyses Can Help Identify Incrustation-Forming Environments and Constituents

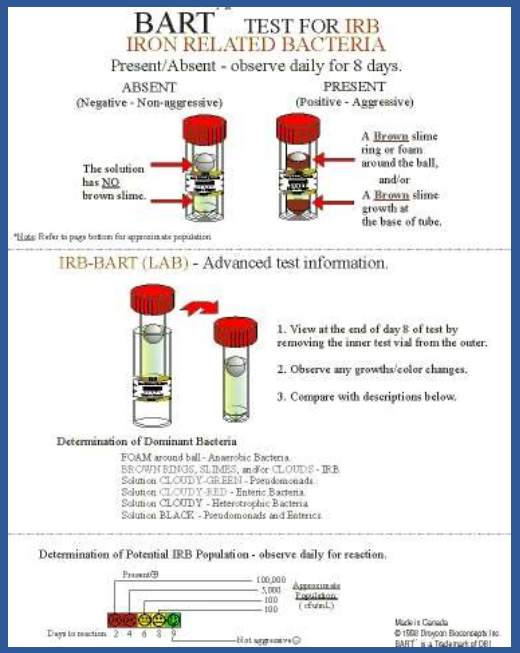
Chemical testing of well water at wellhead or wat water-plant laboratory can be utilized to identify why scale-forming or plugging deposits are forming inside a well.

This can be used to develop an appropriate maintenance program.

Microbiological Activity Testing

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.

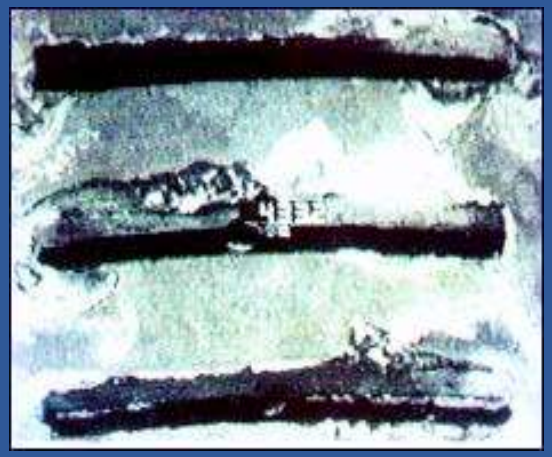
Test results can be used to help identify a treatment methodology designed to address the resulting bacteriological impact of concern (ex. bioslime buildup).



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)

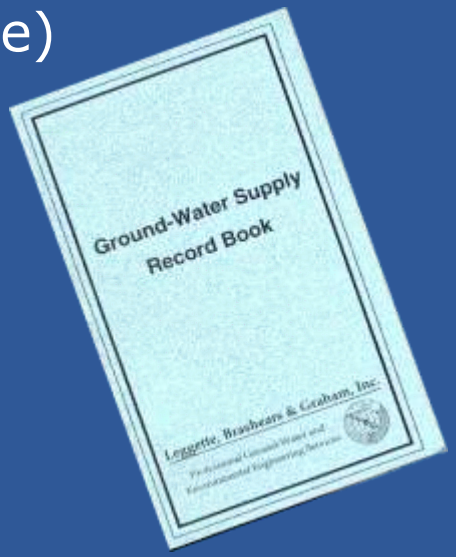
Downhole Televiewing



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)



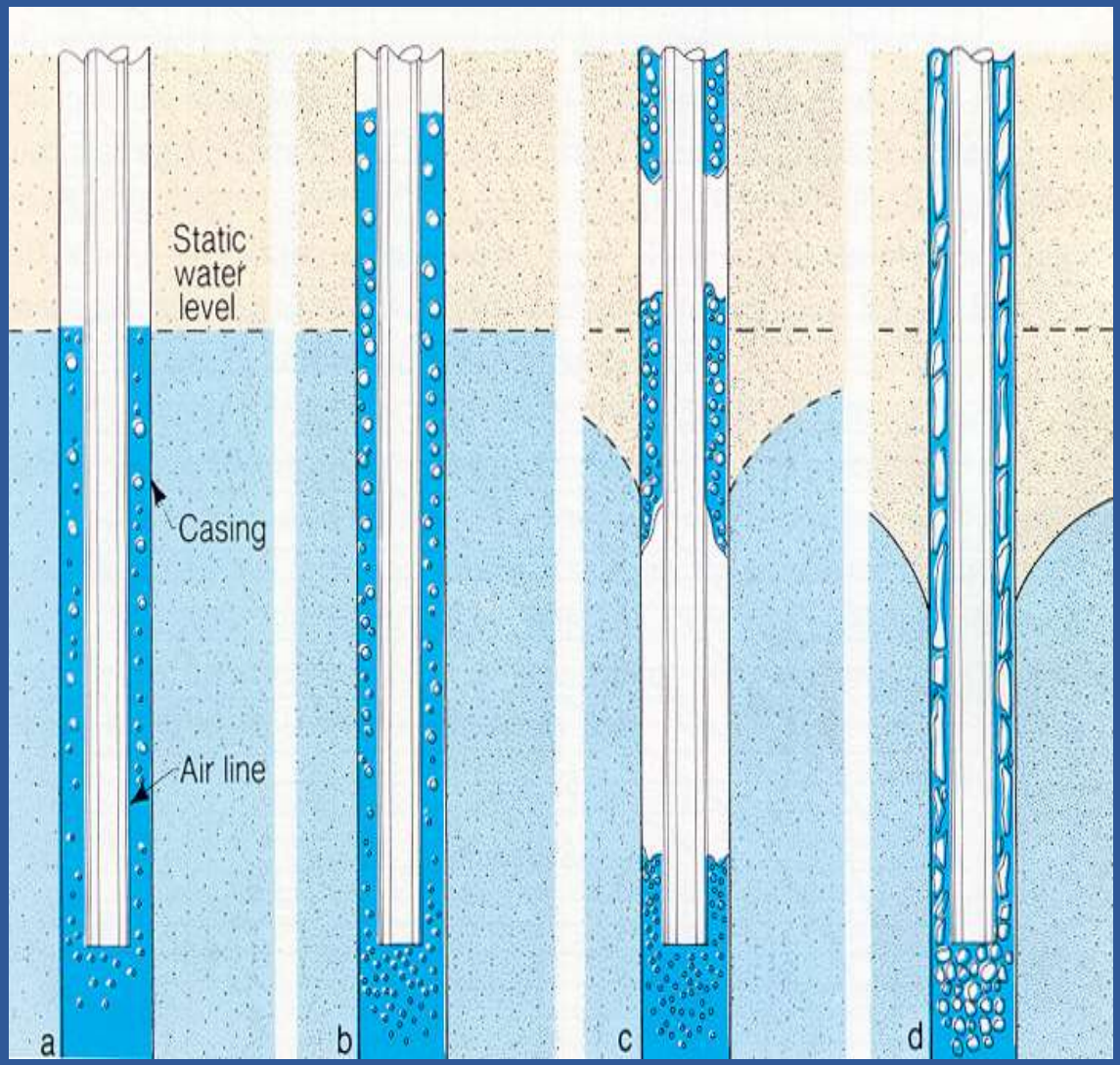
OVERVIEW OF WELL REHABILITATION

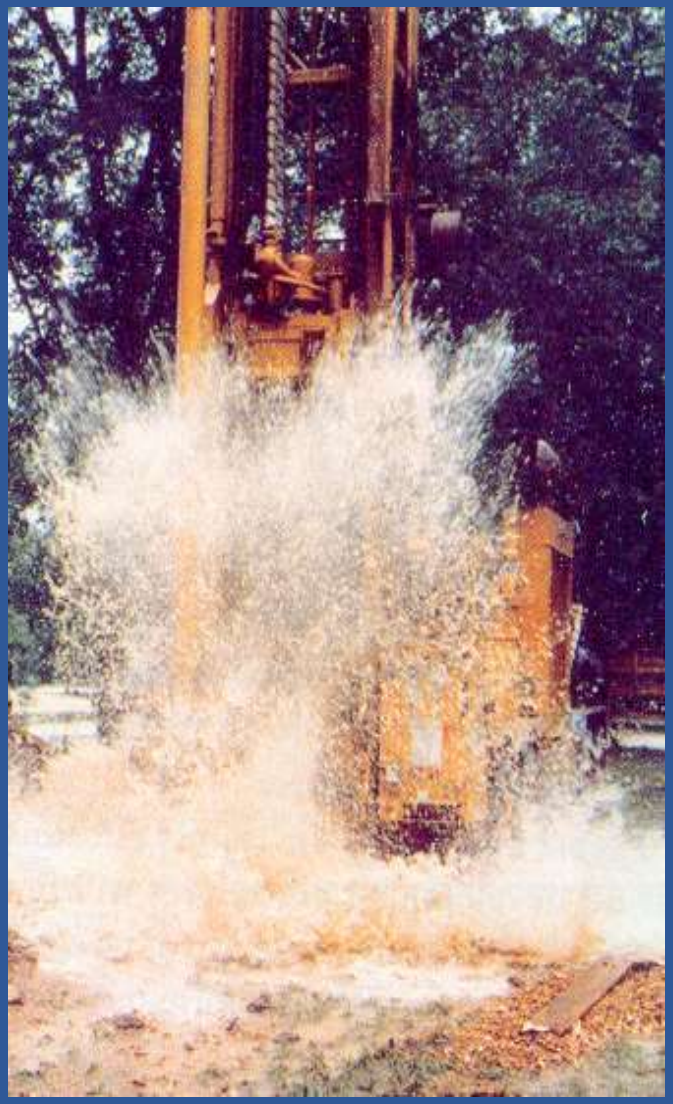
Physical Well Rehabilitation Techniques

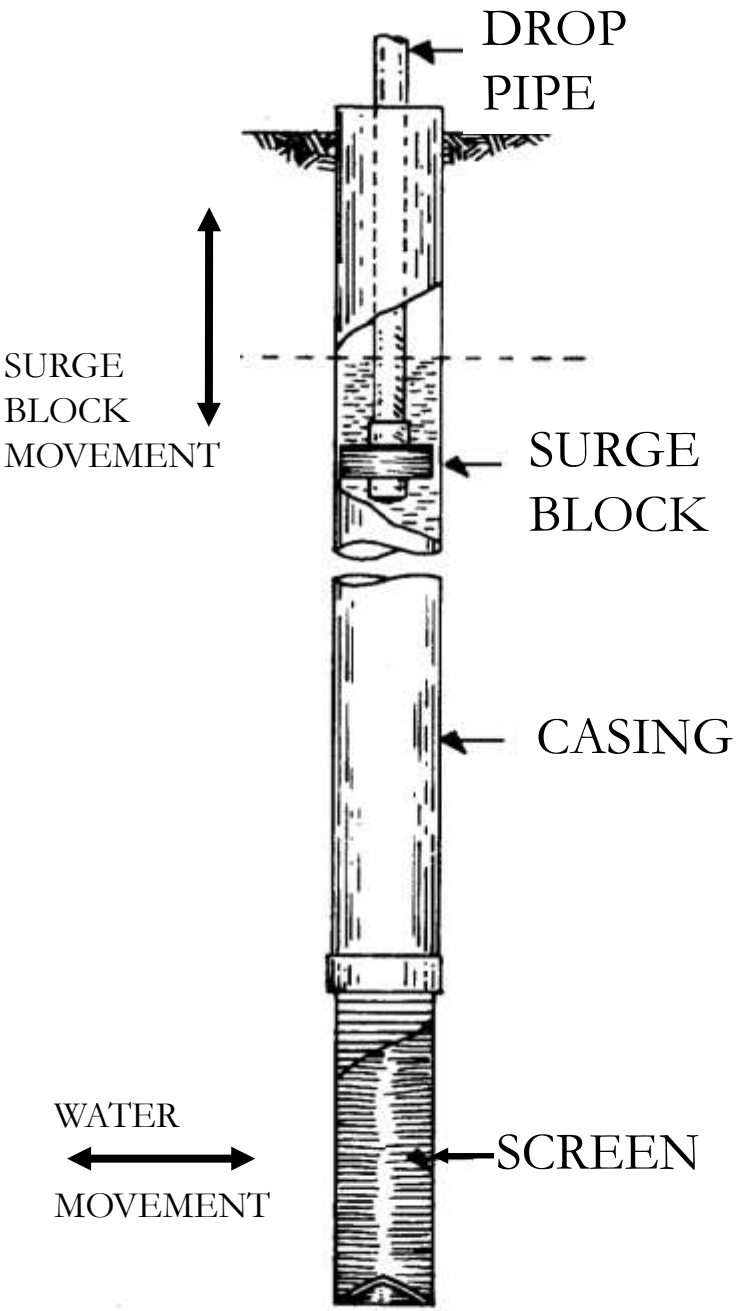
Involves a variety of methods to physically breakup precipitates and biomass, and subsequently remove the dislodged material from the well.

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

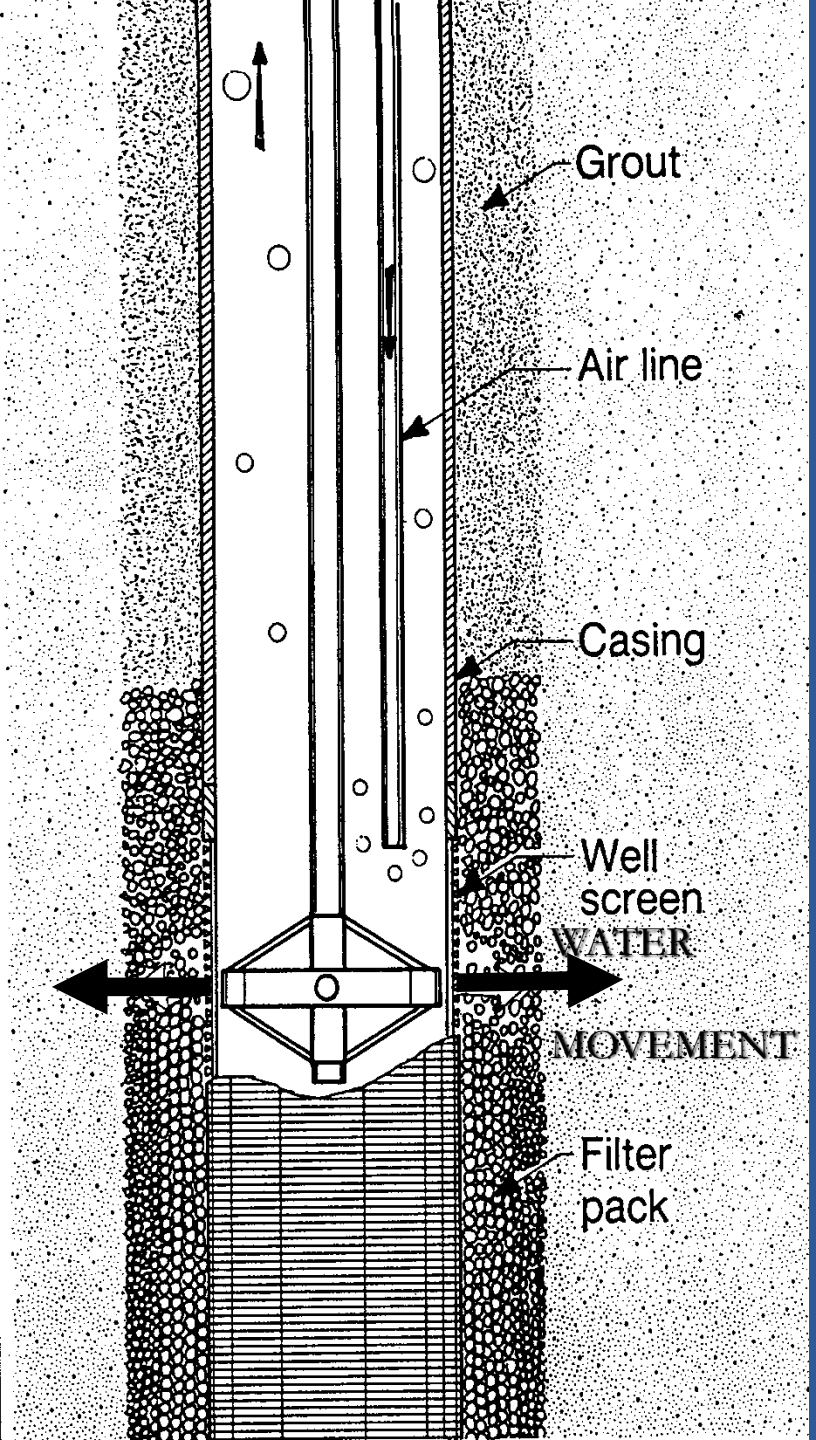
Air Lifting





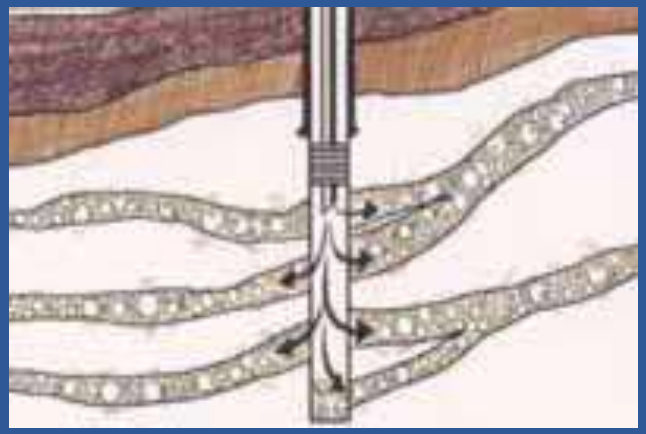

DROP
PIPE
SURGE
BLOCK
MOVEMENT
SURGE
BLOCK
CASING
WATER
MOVEMENT
SCREEN

Surging

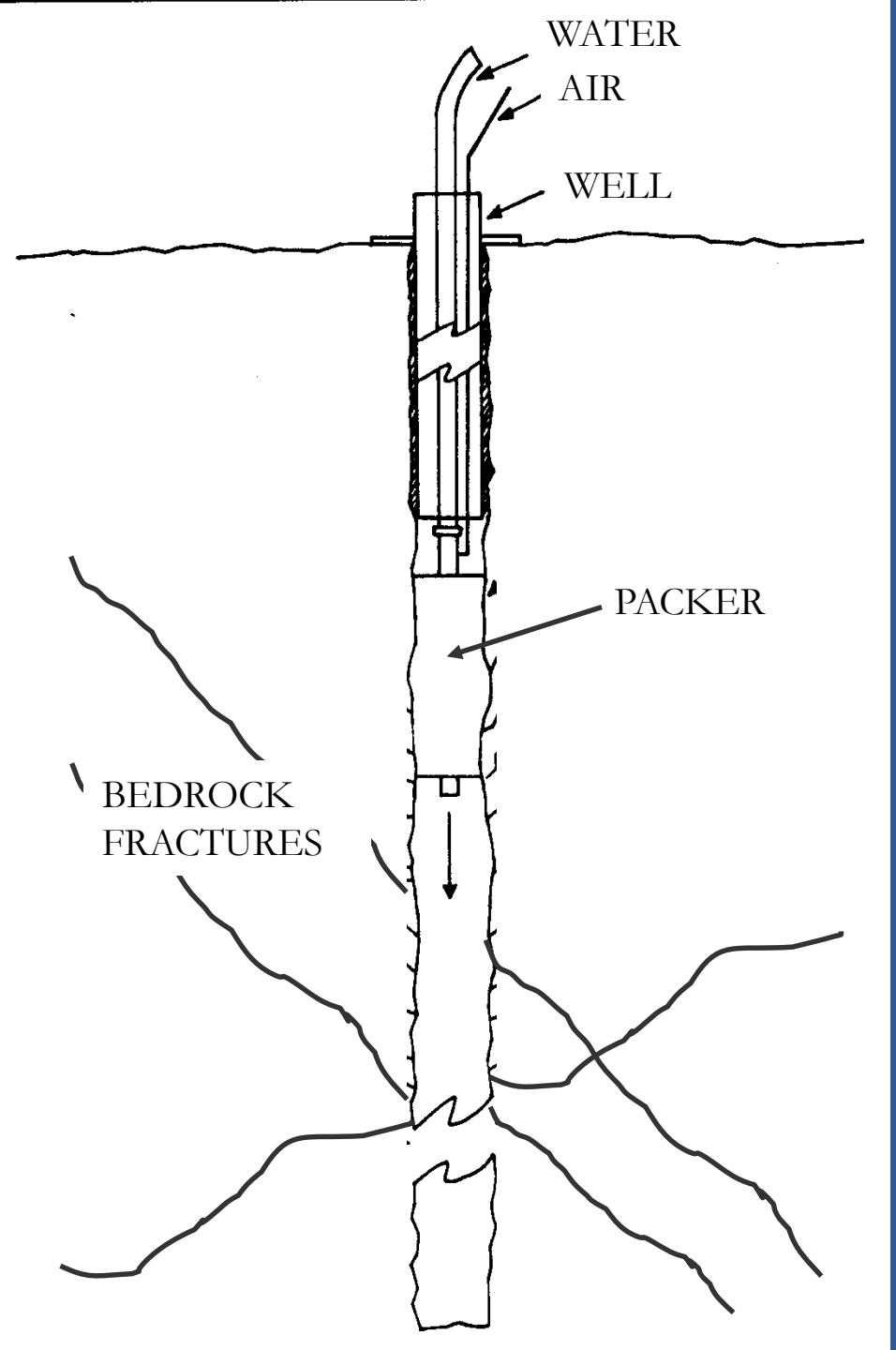

Grout
Air line
Casing
Well
screen
WATER
MOVEMENT
Filter
pack

Jetting

CO_2 Injection



Boreblast



Hydraulic/CO_2 Fracturing

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

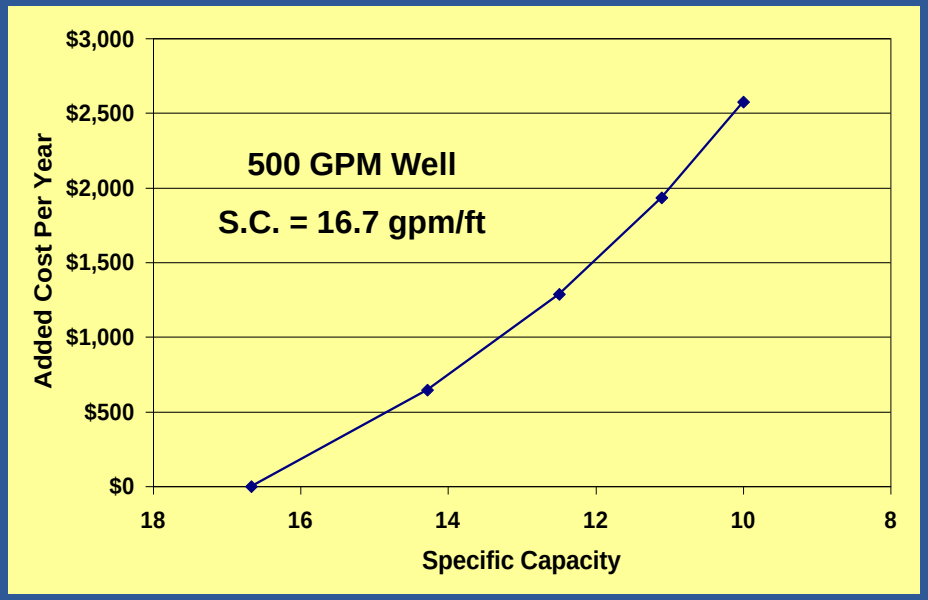
Redevelopment Economics

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



Summary

- 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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