SUEZ

PNWS - AWWA

Asset Management Approach to Well Maintenance

Presenter: Michael Judkins

May 2, 2019

SUEZ Water Well Rehabilitation

- New “Conceptual” Approach to Understanding Well Plugging
- Innovative Well Rehabilitation Technologies
- Annual Treatment Approach to Well Maintenance
- SUEZ Comprehensive Asset Management Program

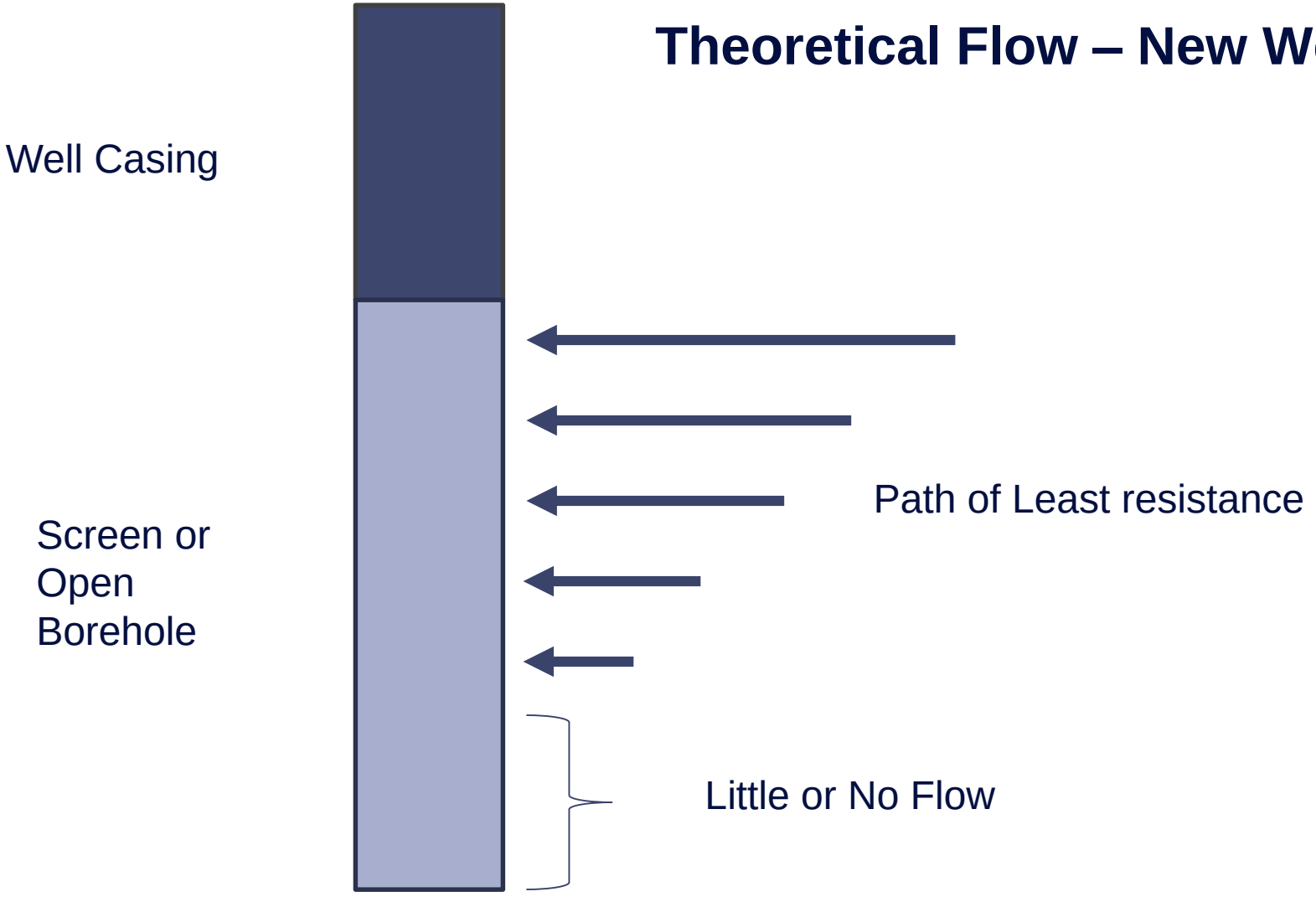
A New “Conceptual” Approach to Understanding Well Plugging:

- Water Well Industry understands the need to monitor and Record well performance. Historical Trends show continual decline.
- The Industry has been forever seeking the most effective Well Rehabilitation Techniques to Clean Wells.
- We must conceptualize the physical changes down hole as we cannot directly witness.
- Return to a “simple” approach of cleaning the interior surfaces, dislodging and disrupting the sedimentation in the pore space, and properly developing out the formation to regain efficiency.

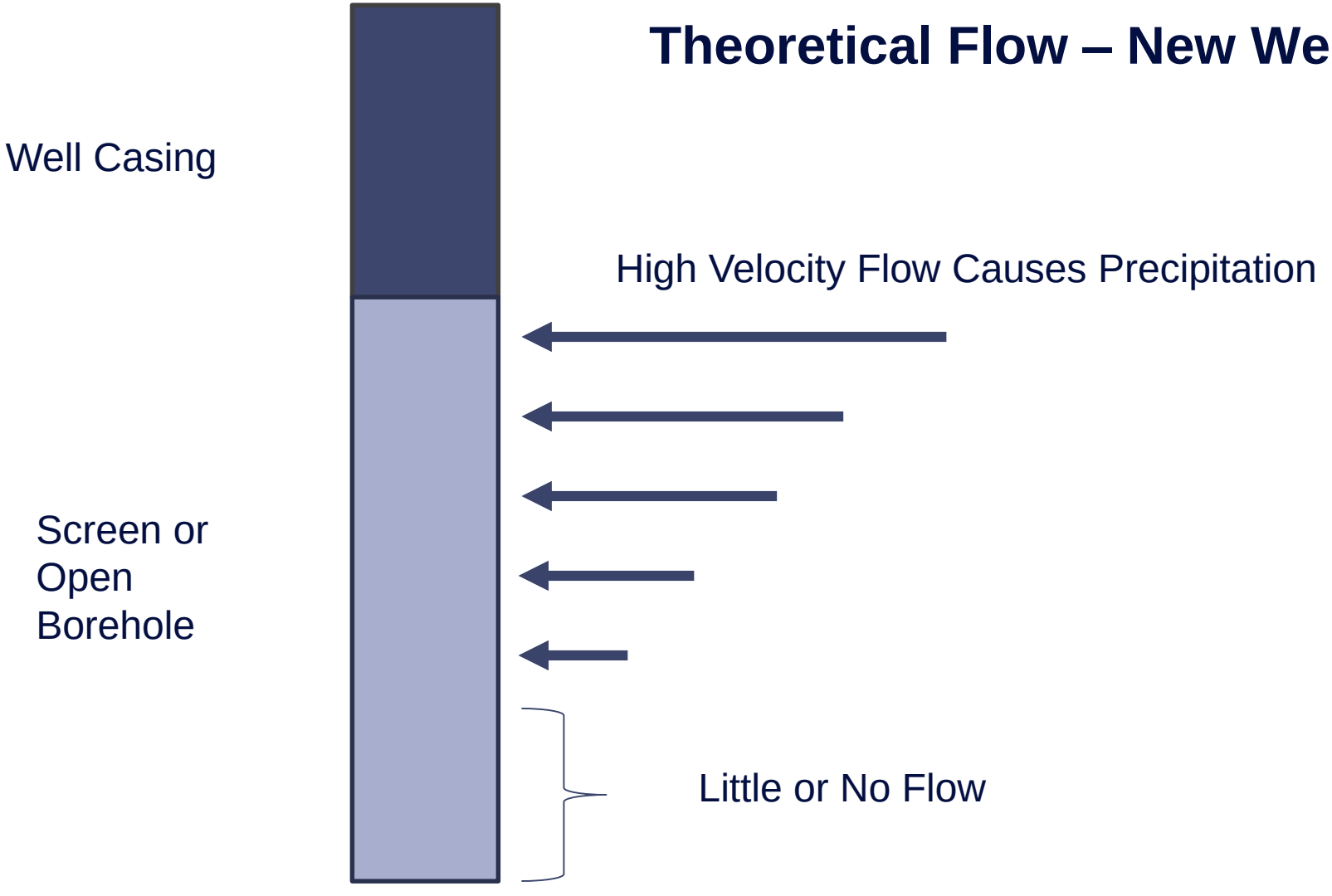
How we “Conceptualize” the Real Issue with Well Plugging:

- **Prior to Well Construction:**
  - Formations are a relatively Pristine Environment.
  - Water Moves very Slow unless induced.
  - Naturally Occurring Bacteria have minimal food source, remain free floating.
- **Post Well Construction:**
  - We alter the environment introducing energy and nutrients.
  - Rapid flow from pumping causes changes in pressure, temperature and the introduction of oxidants induces mineral precipitation.
  - The mineral deposition creates elevated food source for bacteria.

Theoretical Flow – New Well



Theoretical Flow – New Well



Precipitants Become Lodged in Available Pore Space

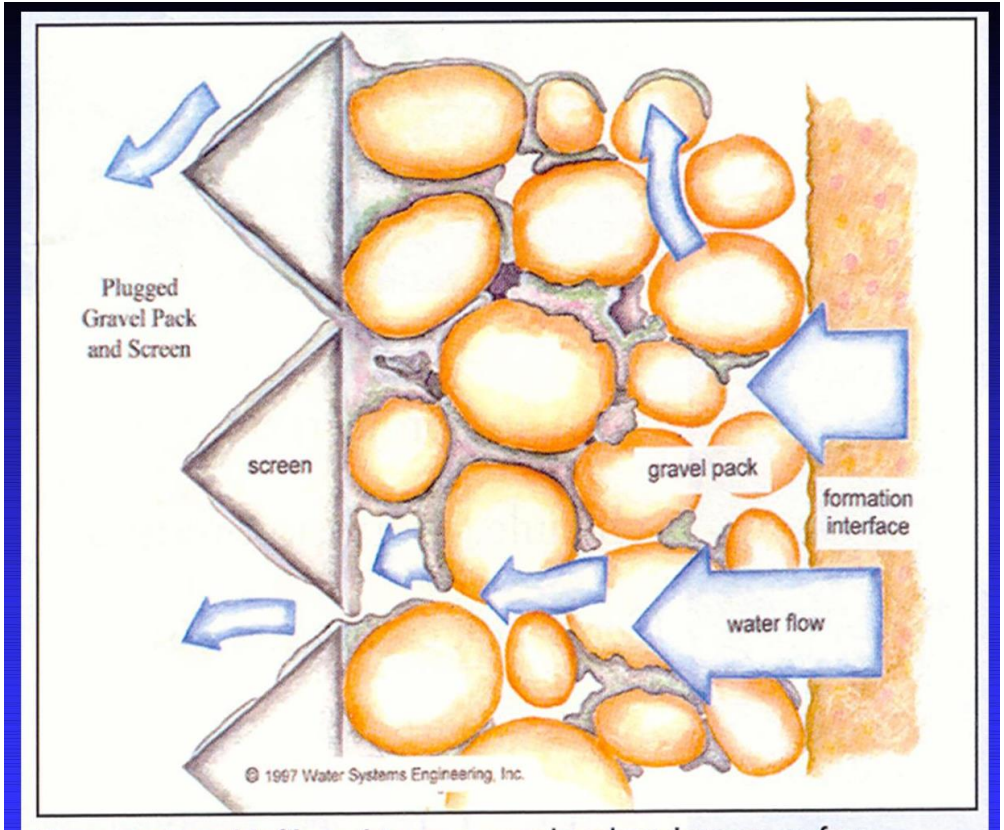


Figure 2. How biofilm exists on a gravel pack and screen surface.

Formation Acts like a Primary Filter

- **Mineralogical Plugging:**
  - Precipitation: as water is exposed to oxidation, changes in temperature and pressure, minerals deposit in pore space.
- **Bacteriological Plugging:**
  - Natural Occurring Background Bacteria.
  - Introduction of Oxygen and a Food Source.
  - Excessive Growth of Colony Consumes Pore Space.
- **Mechanical Plugging**
  - Loose sand and silt particulates become trapped as they travel toward borehole.

Well Plugging Similar to Typical Sand Filter in Operation

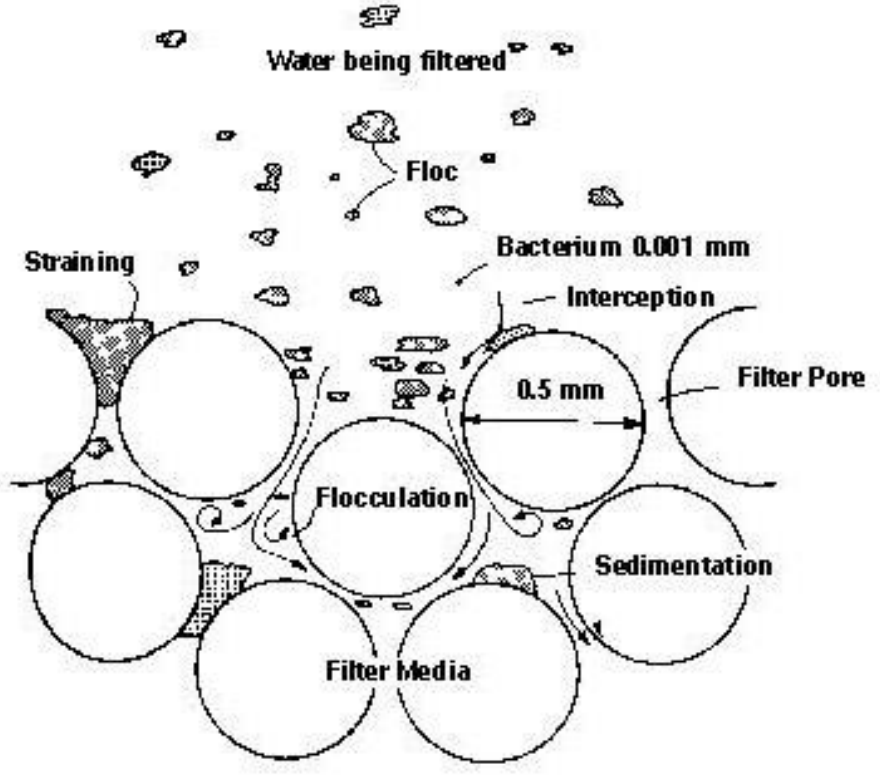


Figure 1. Schematic diagram illustrating straining, flocculation, and sedimentation actions in a granular-media filter.

Raw Water

↓

Oxidation

↓

Filtration

↓

Treated Water

↓

Conceptual Well Cleaning: Sand Filter Backwash Cycle

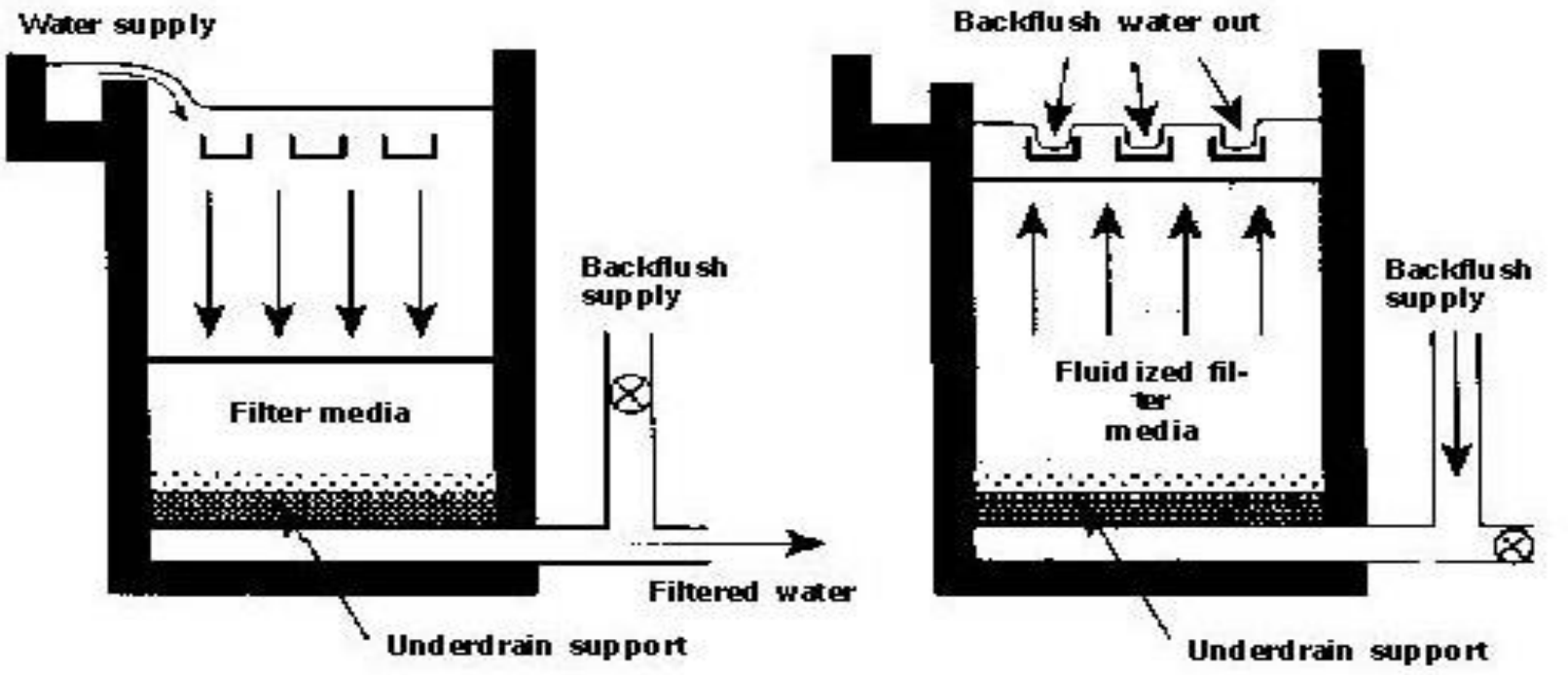
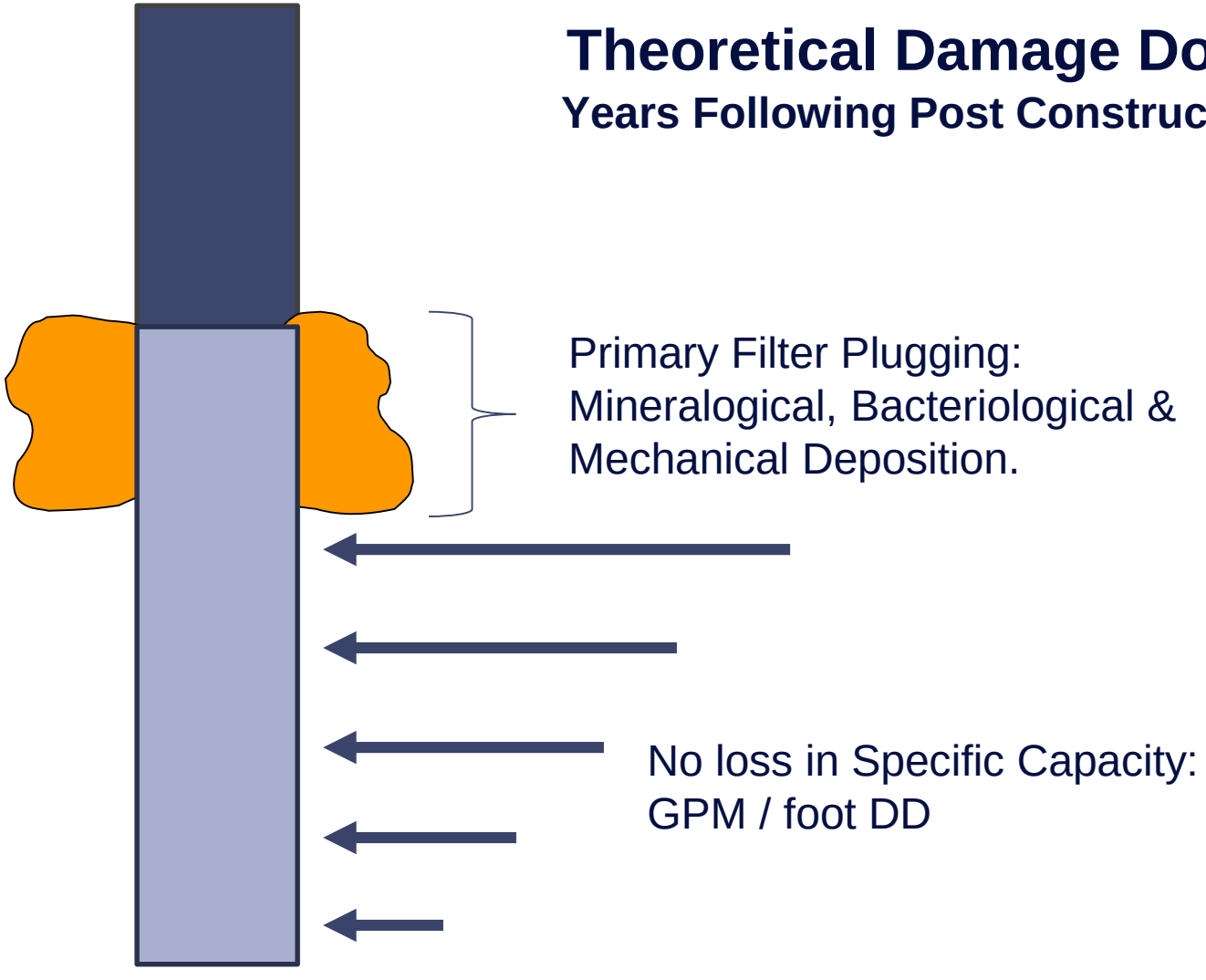


Figure 2. Cross-section of a rapid sand filter.

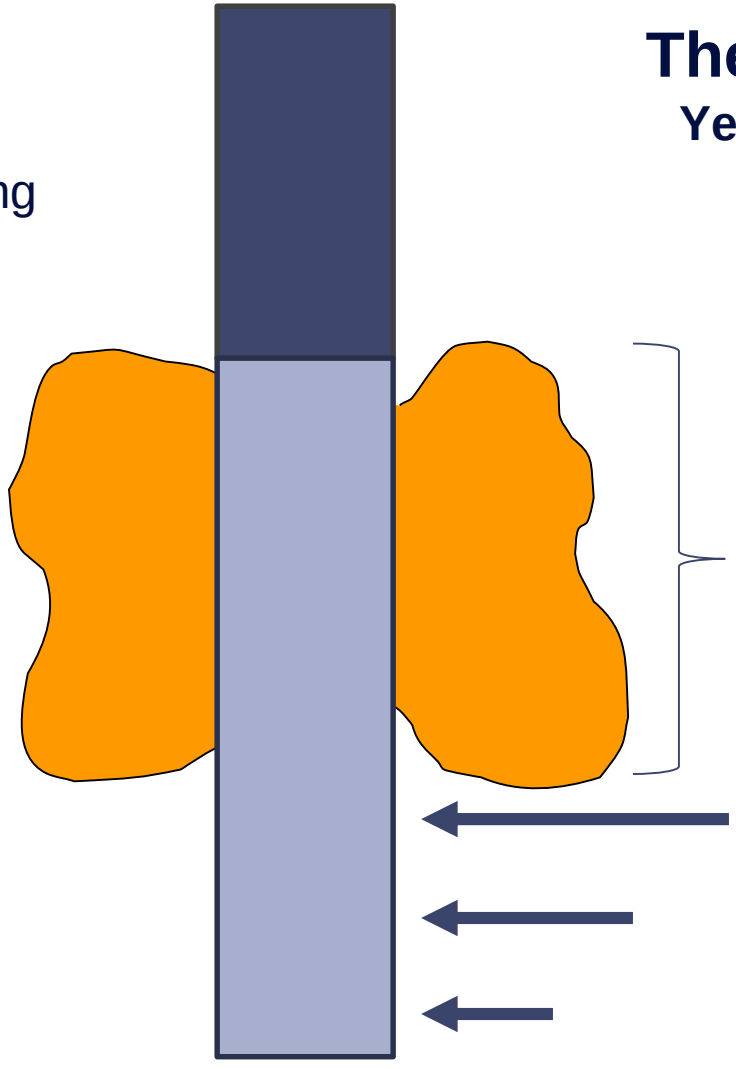
Theoretical Damage Done

Years Following Post Construction



Theoretical Loss of Capacity

Years and Years Post Construction



Well Efficiency – Specific Capacity (SC)

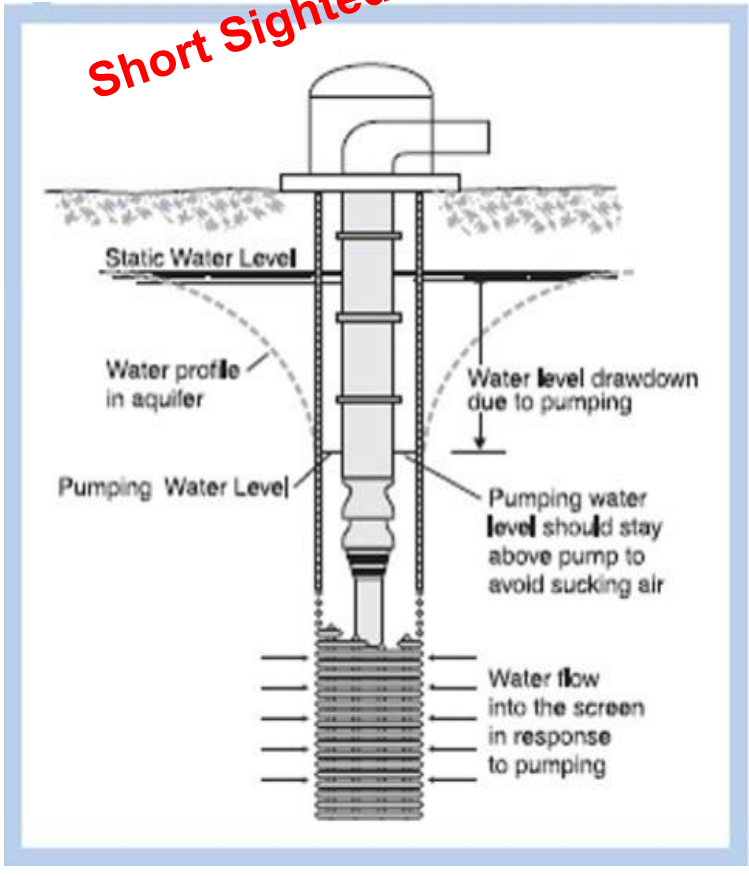
Capacity: Gallons per Minute (GPM)

Static Water Level (SWL): Well Idle 8 hrs.

Pumping Level (PL): Stabilized Capacity.

Drawdown (DD): Pumping Level – Static Water Level.

Specific Capacity:
SC = GPM / foot DD



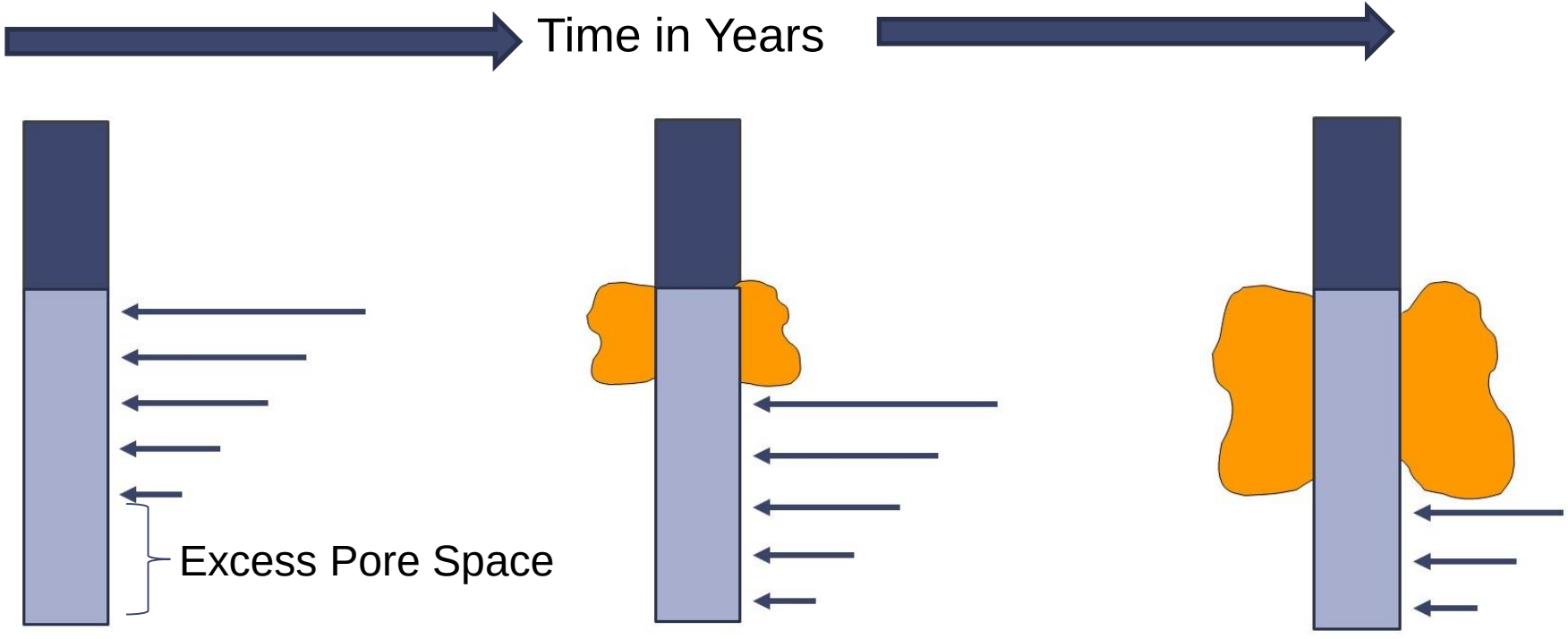
New Theory on Water Well Plugging

Industry Standard is a “Run to Failure” Approach

Damage is already Done!

- Loss in Specific Capacity not recordable until excessive plugging already exists.
- The more pugging, the more energy required to remove.
- If not addressed, we cannot create sufficient energy to remove deposition, which can result in a total loss of well asset.
- If a utility is not maintaining a well through preventative maintenance, budget for well replacement costs. $$$$

Specific Capacity - Delay



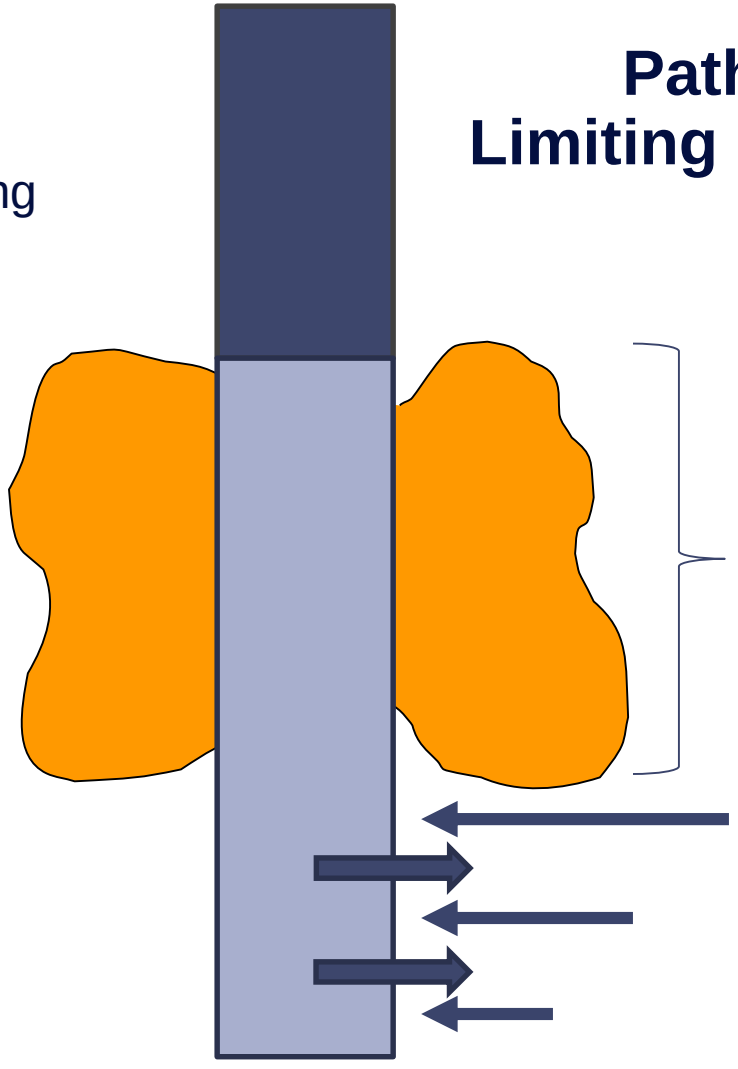
No Plugging
S.C. = X

Plugging
S.C. = X

Plugging
S.C. < X

Path of Least Resistance Limiting Rehabilitation Technology Effectiveness

Well Casing



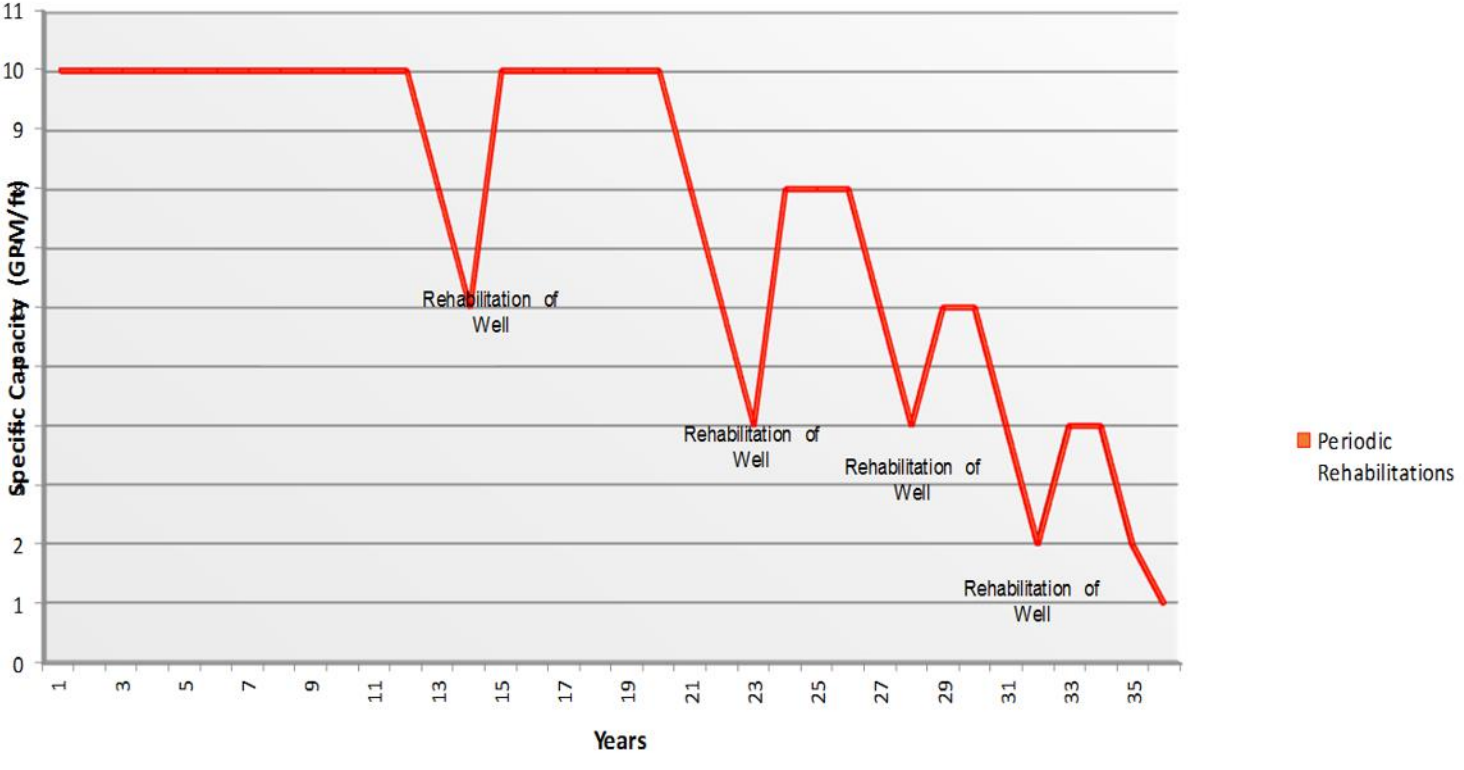
Screen or Open Borehole

Excessive Plugging Formation: Mineralogical, Bacteriological & Mechanical Deposition.

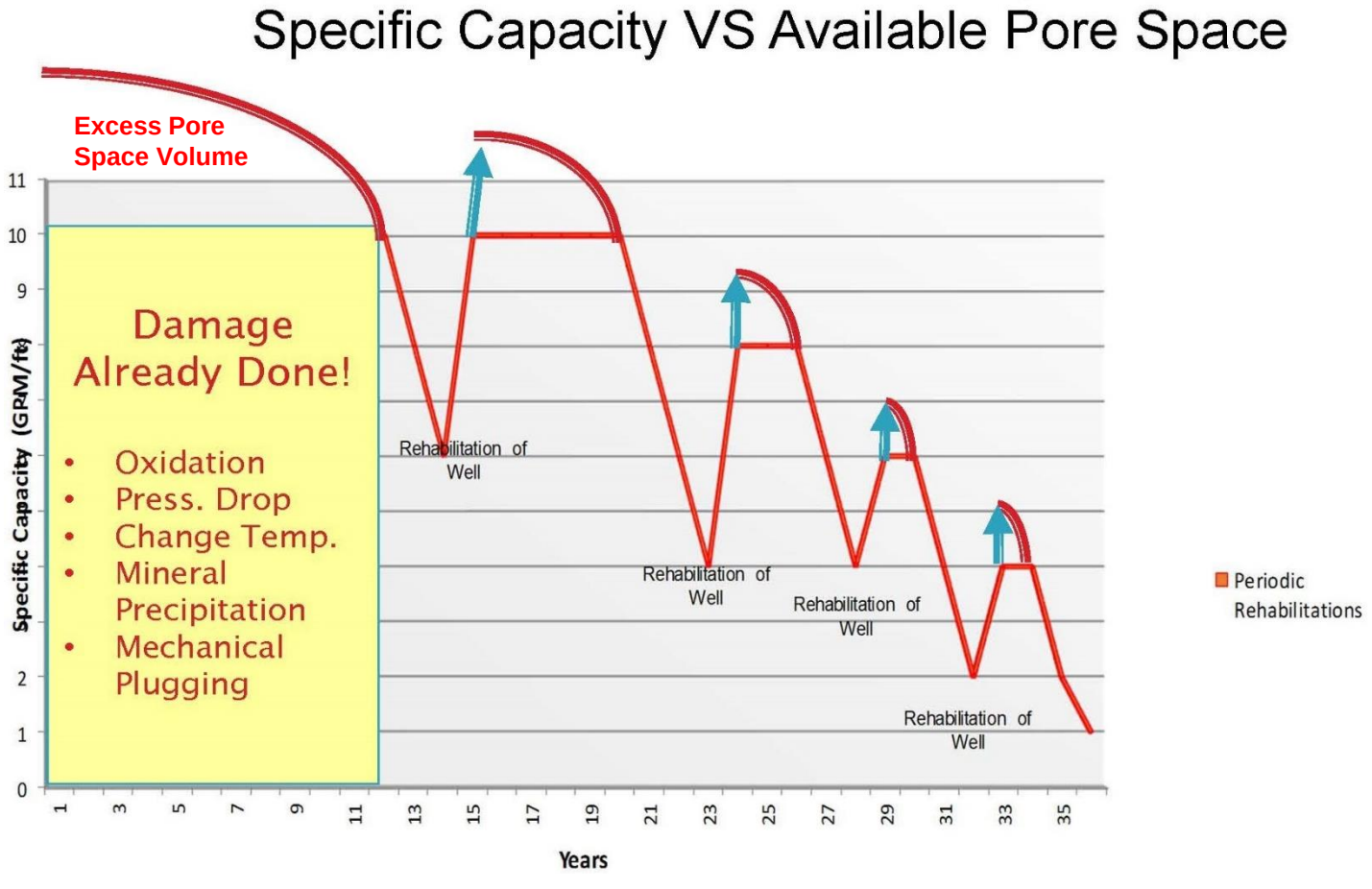
Where well produces flow, It will accept flow…..

Common Industry Theory

Decline of Specific Capacity Over Time



SUEZ Industry Theory



Innovative Well Rehabilitation Technologies

- **Conceptual Approach to Well Rehabilitation:**
  - Treat formation as a Primary filter.
  - Better understand the limitations of the technologies.
  - Utilize innovative technologies and techniques.
  - Overcome “Path of Least Resistance”.
  - Develop a clear understanding of what makes a well “Clean”.

The Standard Industry Well Rehabilitation Procedure

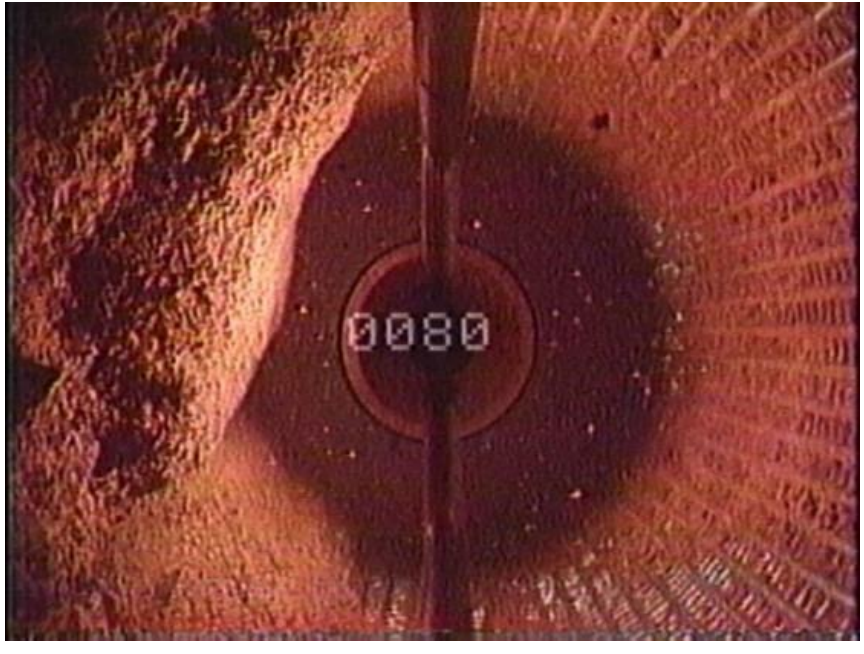
- Pre Pump Test
- Pull Pump
- Pre Television Survey
- Wire Brush
- Well Rehabilitation
- Post Television Survey
- Pump Installation
- Post Pump Test
- Report

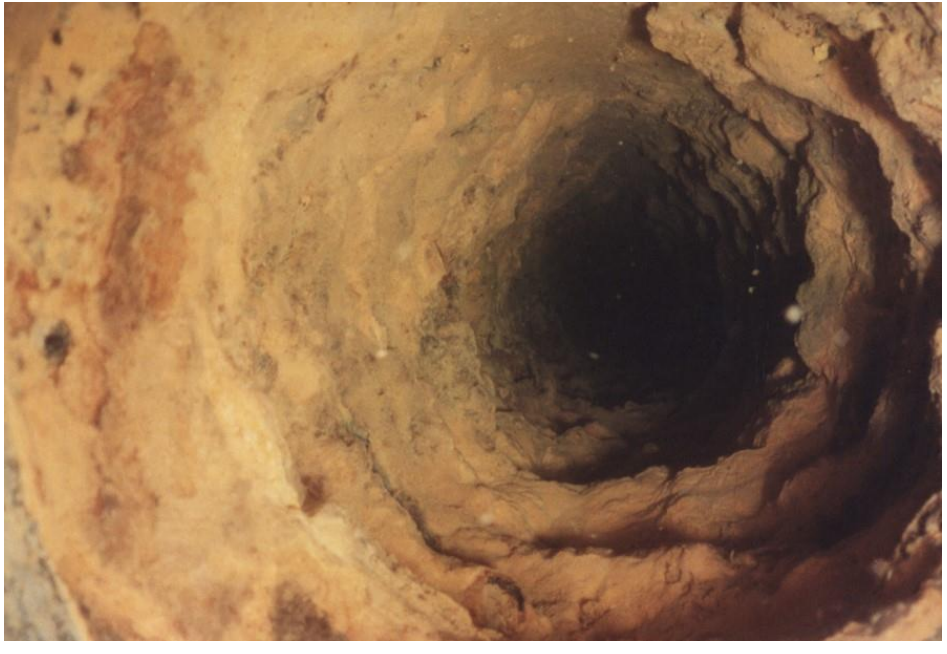
The SUEZ Comprehensive Well Rehabilitation Procedure

- Pre Pump Test
- Pull Pump
- Pre Television Survey
- Wire Brush
- Well Rehabilitation Technologies
  - Aqua Freed (Preferred Methodology)
  - Airburst, Hy-RIP, Etc.
- Surge Development
- Post Television Survey
- Pump Installation
- Post Pump Test
- Report

Well Televising:

Borehole is Visual Representation of Pore Space Plugging.





Similar to Watermain Plugging

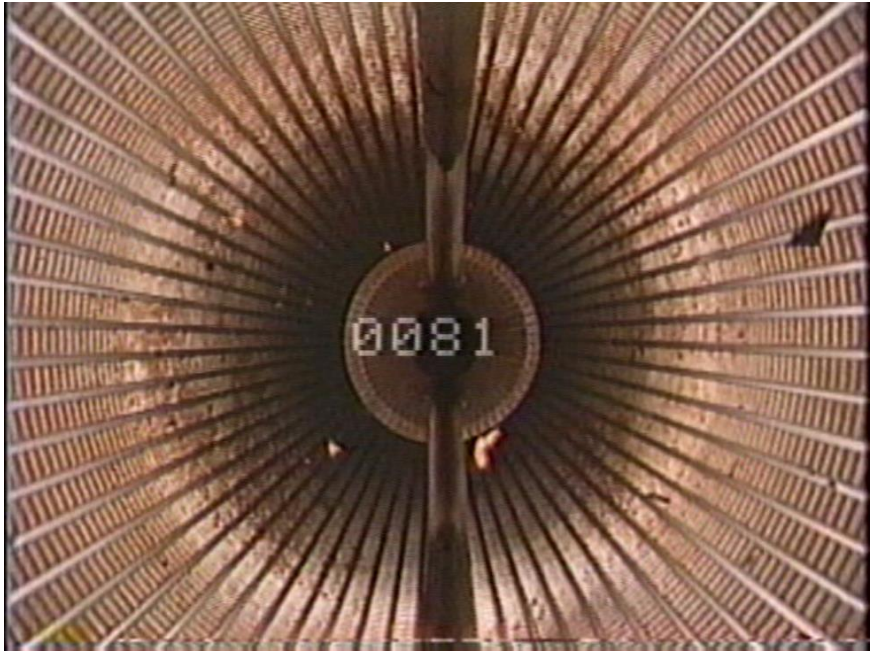
Wire Brush

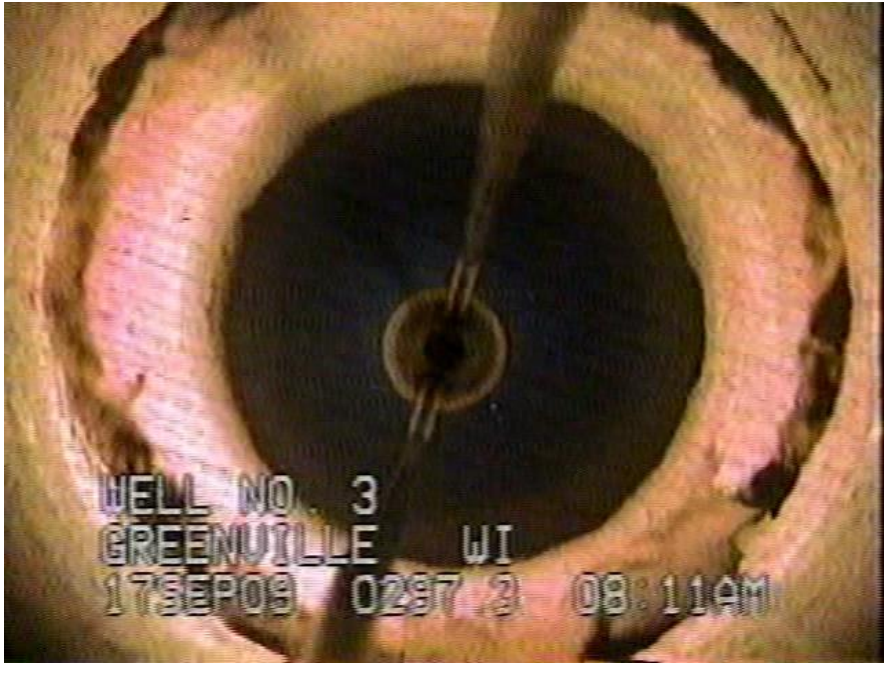
Removed Exposed Deposition:

- Expedite Removal.
- Minimize expenditure of treatment energies.

Open Rock Hole

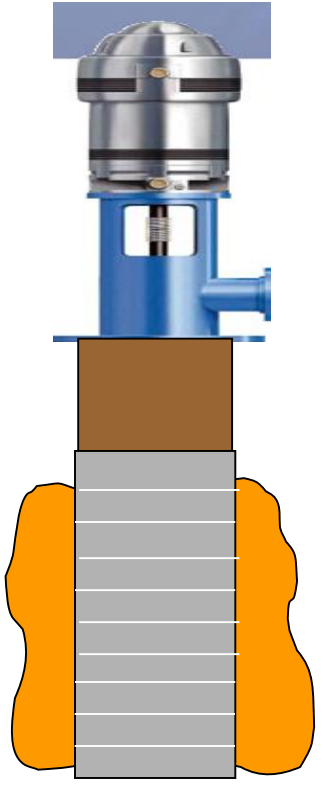
A Clean Screen or Borehole is Traditionally Considered a Success!



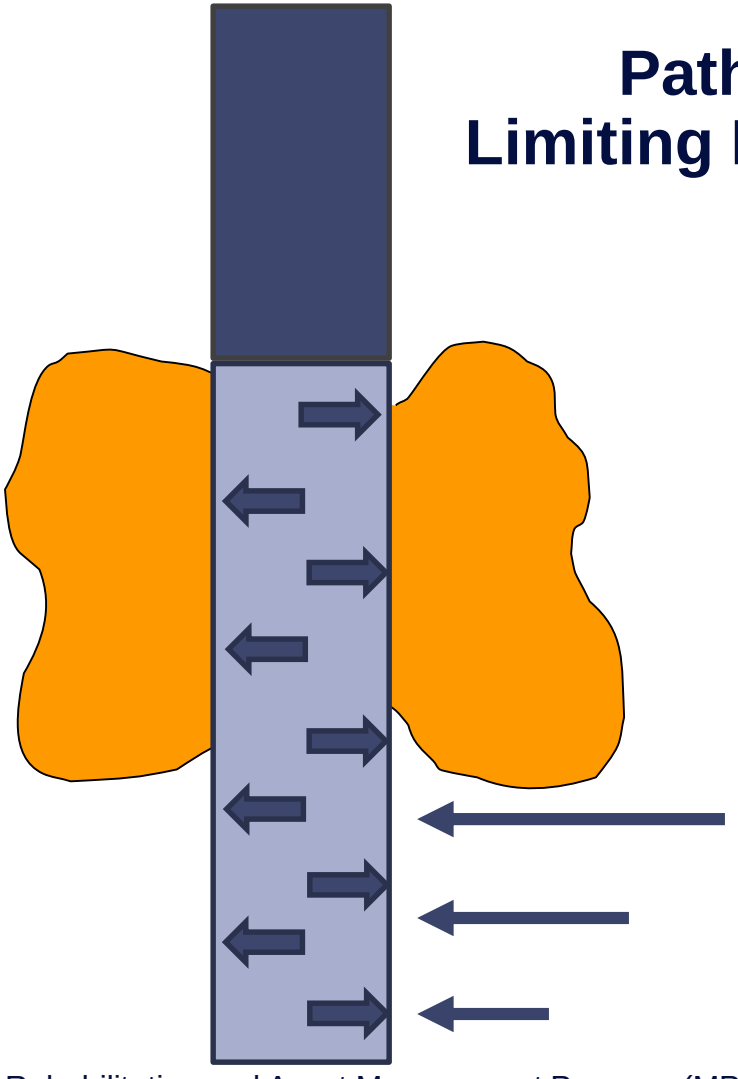


Mineral and Bacteriological deposition in Pore Space.

Plugging on exterior of well screen



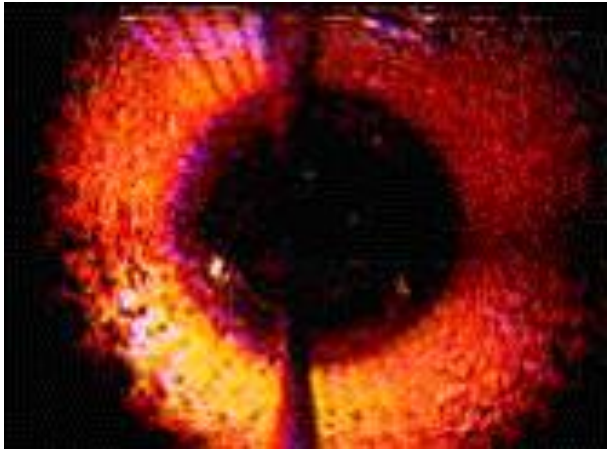
Path of Least Resistance Limiting Rehabilitation Technology Effectiveness

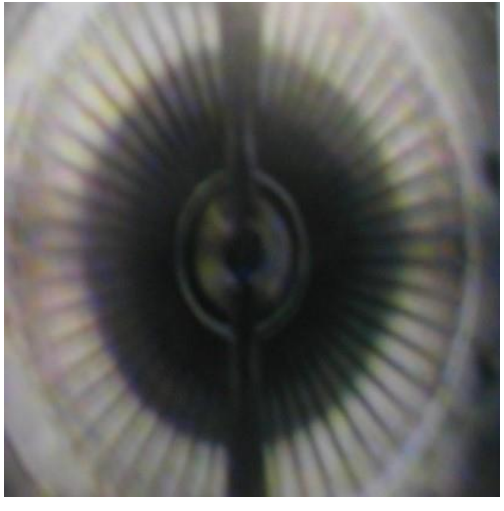


Rehabilitation Technology Energy must Penetrate Entire Formation.

Aqua Freed® Well Rehabilitation

- Effective Rehabilitation Technology
- Environmentally Safe
- Excellent Penetration of Energy
- Broad Based Application
- Excellent at Removal of Bacterial and Mineral Deposits





How AQUA FREED® Works:

Energy released during Phase Changes:

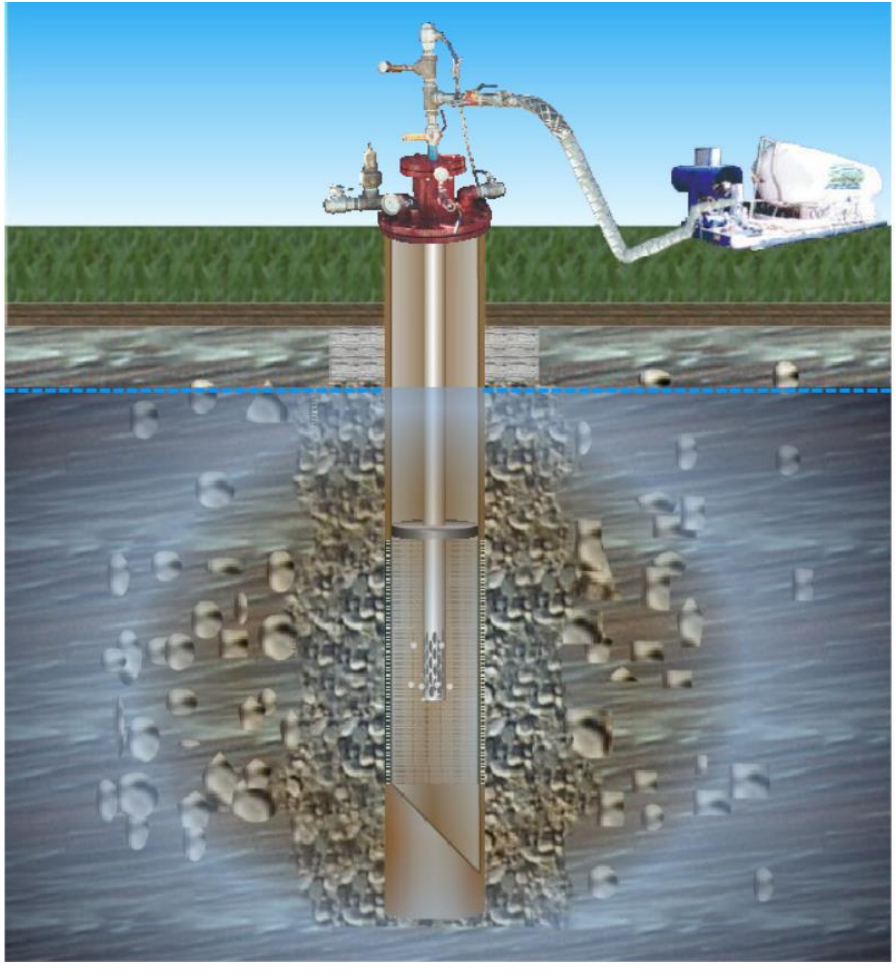
Liquid to Gas (570 Times Volume Expansion)
Liquid to Solid
Solid to gas (Sublimation)

Carbon Dioxide has surfactant properties that help penetrate the aquifer as well as scale & biofilm

Formation of Carbonic Acid (H_2CO_3) a mild acid (Approx. pH=5) allowing some dissolution of scale

Pore Water Freezing allowing scale and biofouling to be dispersed

How AQUA FREED® Works:



AQUA FREED®

- Inject CO2 in Gaseous State to Evacuate Water from Borehole and Pore Space to Minimize Freeze Off
- Follow with Liquid CO2 to Recognize Rapid Expansion into Pore Space
- Overwhelms Path of Least Resistance causing full Penetration
- Mechanical and Chemical Rehabilitation

AirBurst Technology

Underwater photo of Bolt Air Gun
taken 15/1000 of a second after firing

- Shallow or Deep Wells, Excessive Mineralization
- Overcomes Path of Least Resistance through Pinpoint Energy Delivery
- Mechanical Rehabilitation
- Utilize in Conjunction with Chemistries

AirBurst Technology

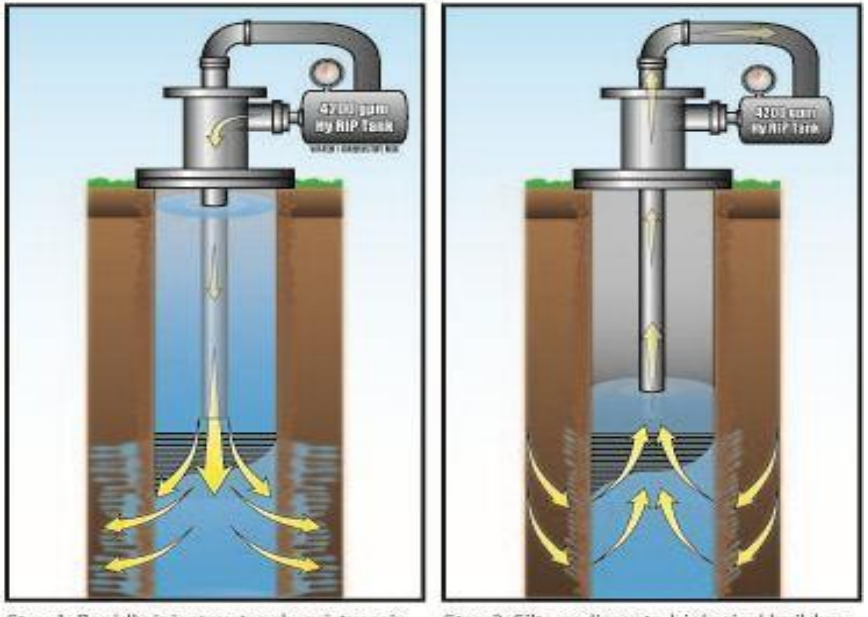
AirBurst Technology

AirBurst Technology

AirBurst Technology

Hy-RIP™ Technology

The Powerful Rehabilitation and Development Process for all water well types



Step 1: Rapidly inject water chemistry mix into formation through the screen and into the aquifer where treatment is most critical.

Step 2: Silts, sediments, biological buildup is removed to improve overall efficiency. Repeat steps with specific chemisty.

- Shallow Wells, Excessive Mineralization
- Mechanical and Chemical Rehab method
- Overwhelms path of least resistance causing full penetration

Hy-RIP® Technology

- Extend casing and seal well head
- Install temp submersible pump
- Assemble injection and discharge line

Hy-RIP® Technology

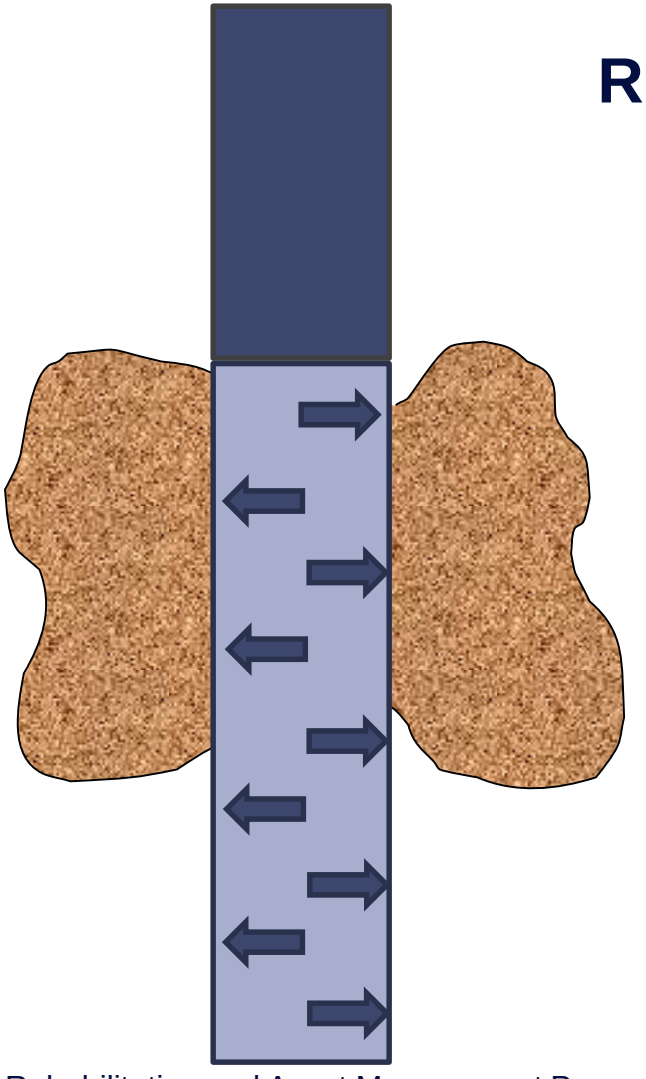
High Rate Injection Process

- 3000 gallon tank
- Diesel drive horz pump
- 4500 GPM @ 45 psi

Typical Well Rehabilitation Oversight

- **Selected Well Rehabilitation Technologies “Pros”**
  - Effectively distribute development energy throughout borehole, overcoming “path of least resistance” concerns
  - Effectively dislodge and disrupt debris within formation pore space
- **Selected Well Rehabilitation Technologies “Cons”**
  - Relatively ineffective at creating a “forward” backwashing action
  - Simply pumping well to waste is too low of an energy and causes debris to repack in pore space causing short lived results

Rehabilitation Technology Limitations



Rehabilitation Technology Energies Dislodge and Disrupt but Do Not Remove Debris.

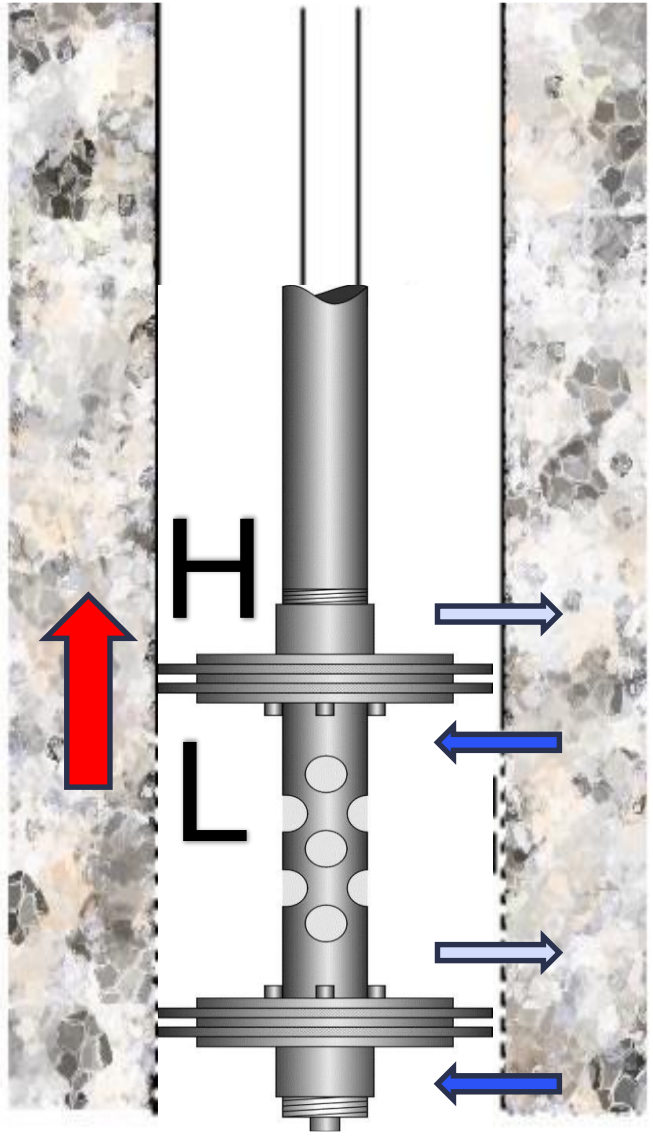
Post Rehabilitation Surge Block Development:

- Old School Technology
- Effective at causing pinpoint energy to draw debris from formation
- Draws Debris Loosened During Rehab Process into Borehole for Extraction

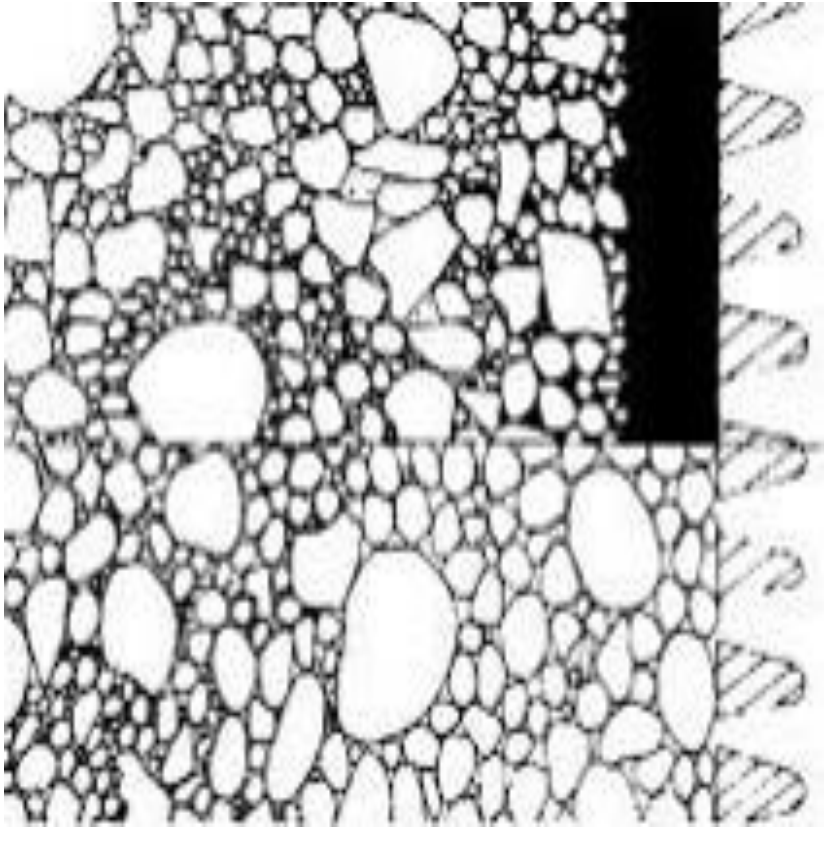
Important: This step not Performed in Traditional Rehabilitation. Too Costly.

Surge Block Development:

- High Pressure / Low Pressure above or below disc.
- Draws Debris Loosened During Rehab into Borehole for Extraction.
- Critical to Achieve 3-5 feet per second stroke speed.
- Critical to pump while surging to remove debris.



Reclaiming Pore Space is Critical to Regaining Well Yield



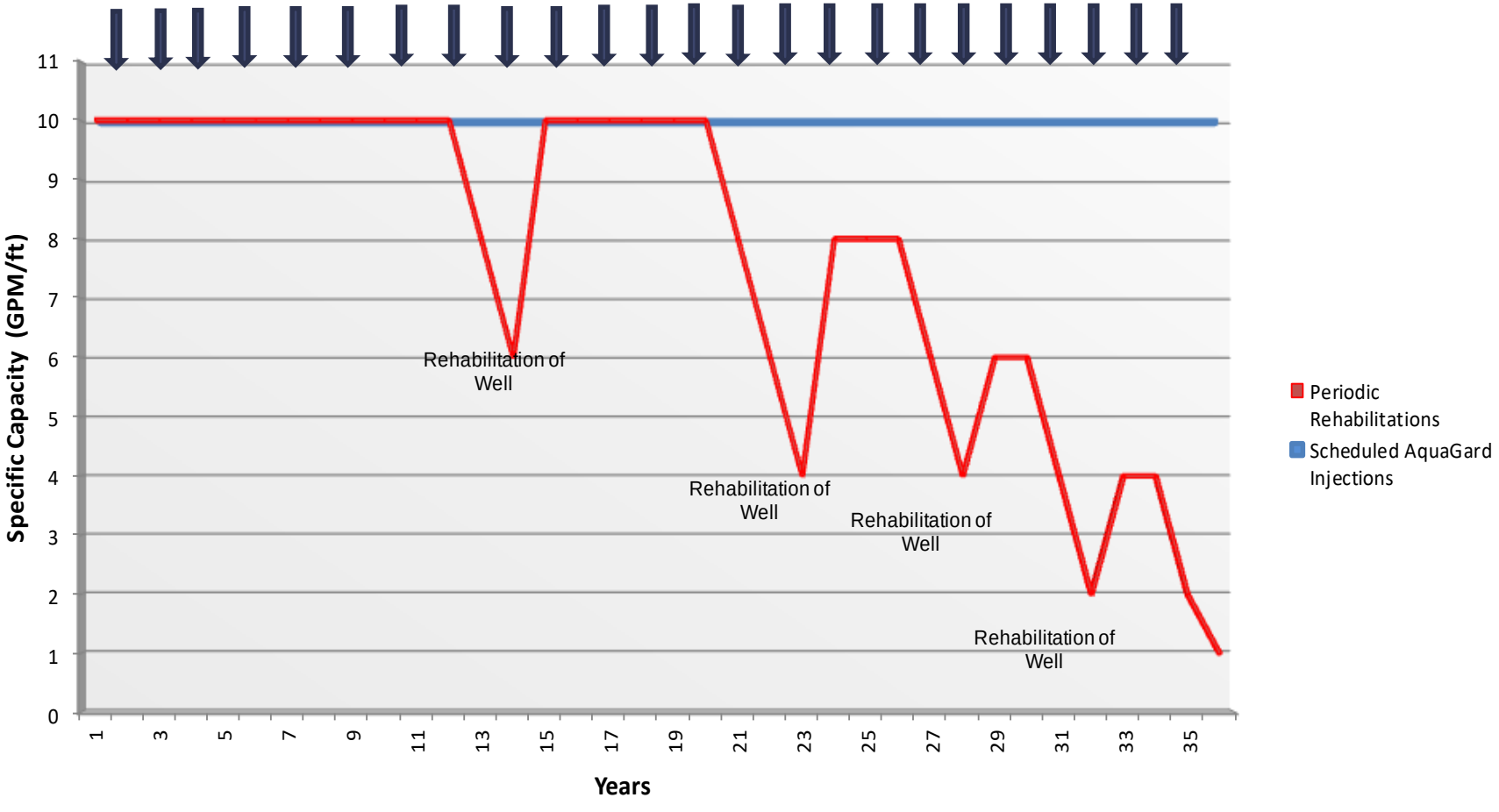
Pre Surge Block Development.
Pores contain loose debris.

Post Surge Block Development.
Pore Space Restored.

Annual Treatment Approach to Well Maintenance

- **Conceptual Approach to Well Rehabilitation:**
  - Treat formation as a Primary filter.
  - Simulate a “Backwashing” Sequence on a Periodic and Predetermined Basis to Manage Pore Space Volume.
  - Create Cost Effective Rehabilitation Energy Downhole without the need for pump removal.

Perform Periodic Maintenance to Maintain Pore space vs Run to Failure

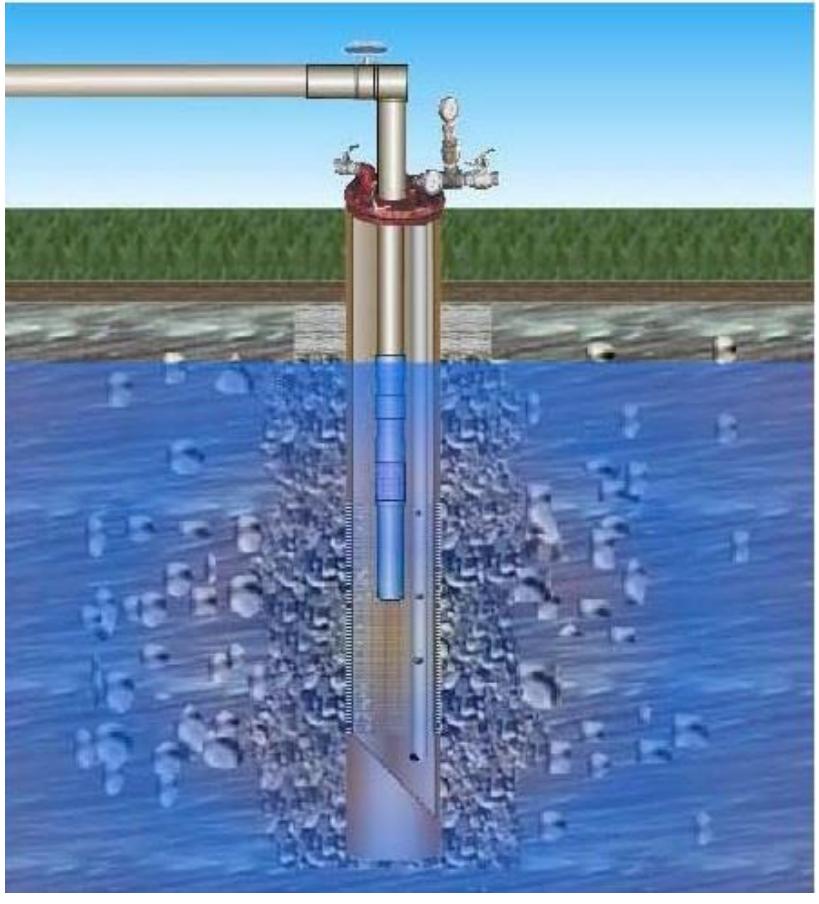


Retrofit well head with Well Maintenance Equipment to allow high energy time based treatments

- **Aqua Gard® Annual Well Maintenance**
  - 1” SS pipe permanently mounted in well.
  - Pressure tight seal at surface.

- **Hy-RIP™ Annual Well Maintenance**
  - Injection port permanently mounted through casing/pedestal.
  - Pressure tight seal at surface

AQUA GARD™



- Permanently mount 1” SS Injection Pipe into Well.
- Annual Injections of CO2 in Gaseous State Followed by Liquid CO2 to Recognize Rapid Expansion into Pore Space
- Dislodge and disrupt debris before solidified into Scale
- Cost Effective Mechanical and Chemical Rehabilitation “without” Pump Removal

Aqua Gard™ Installation

Lineshaft Turbine Pump:

- Seal between discharge Head and pedestal
- Dedicated injection port through head or pedestal.

Aqua Gard™ Installation

Submersible Pump:

- Seal between discharge Head and pedestal
- Dedicated injection port through seal plate.

Aqua Gard™ Installation

Submersible Pump:

- Refabricate Pitless.
- Dedicated injection port through head or plate.

Hy-RIP (High Rate Injection Process)

Additional Benefits to Annual Well Maintenance

- **Start back at the source:**
  - Stabilized Water Quality
    - Fluctuations caused by Plugged Formation Creating different downhole blend
    - Bacteriologic Cycles (sloughing)
  - Improved Efficiency
    - Reduced Power consumption
    - Reduced and Stabilized Chemical Consumption
    - Stabilized Filter Operation
    - Distribution System Maintenance
  - Improved Well and Pump Performance Knowledge
    - Scheduled Maintenance

SUEZ Full Wells Asset Management Program

- **SUEZ Well MP:**
  - Our Water Well Maintenance Program is an All-inclusive Preventative Maintenance Program that covers all well assets, and includes initial rehabilitation, annual cleanings, future rehabilitations and pump and motor repairs/replacement, to maintain a guaranteed performance for a fixed annual fee.

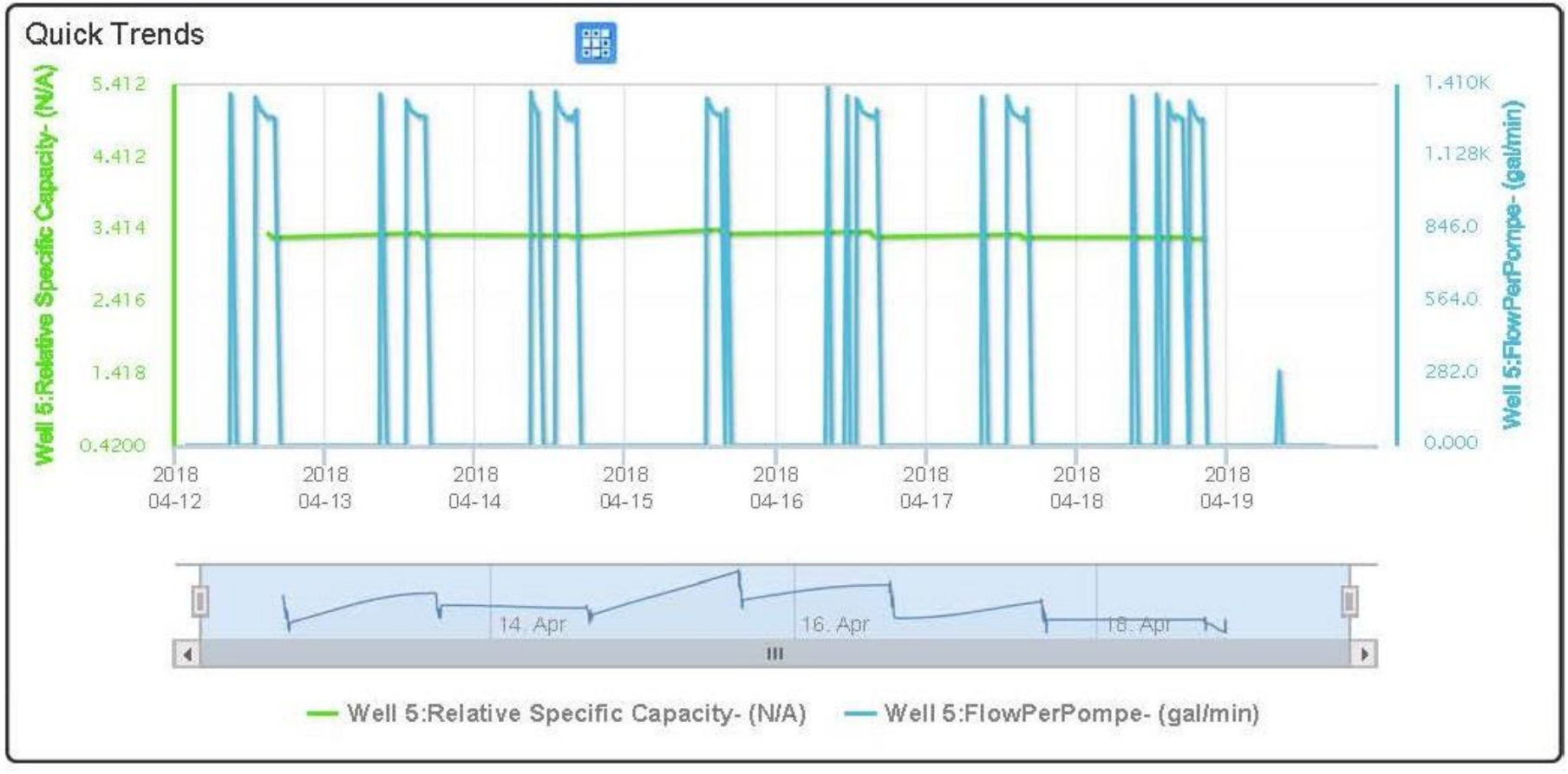
The SUEZ Comprehensive Well Rehabilitation Procedure

- Pre Pump Test
- Pull Pump
- Pre Television Survey
- Wire Brush
- Well Rehabilitation Technologies
  - Aqua Freed (Preferred Methodology)
  - Airburst, Hy-RIP, Etc.
- Surge Development
- Post Television Survey
- Retrofit Well Head with Annual Maintenance Equipment
- InSight Remote Monitoring
- Pump Installation
- Post Pump Test
- Report

InSight


EMPOWERMENT/ COLLABORATION
Analysis
Visualization
Alarming
Reporting
Online measurements
Offline measurements
Increased production efficiency
Energy and water reduction
Enhanced monitoring for greater asset performance
Maximized logistical efficiencies
Superior communication
Reduced emissions

Insight Data Screens



Insight

- **InSight is a readymade and available platform specifically designed to monitor “any” asset and cause an alarm or desired response if a KPI changes.**
- **SCADA system to monitor all parameters not required, but assists with facilitation.**
- **Flexibility of offering – Customizable.**
- **Allows continuous monitoring of assets in support of pump performance warranty and specific capacity guarantee.**
- **Automated regulatory report filing capabilities.**
  - Manual data entry capabilities if sensors not available.
- **App solution for hand held phones and devices.**
- **Bolt on offering to other assets like tanks or filters.**

Questions?

PNWS - AWWA

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